CLIVAR/Carbon A10

NOAAS Ronald H. Brown
28 August 2011 – 31 October 2011
Cape Town, South Africa – Rio de Janeiro, Brazil

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Preliminary Cruise Report

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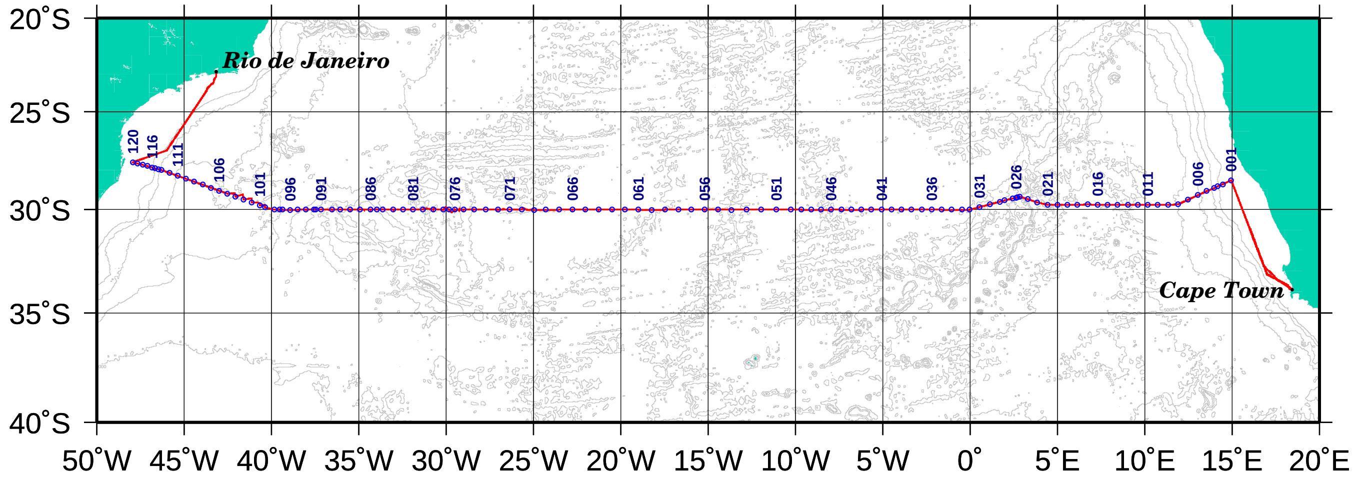

CLIVAR/Carbon A10 Cruise Track

Introduction

CLIVAR/Carbon A10 in the South Atlantic on NOAA ship Ronald H. Brown was completed successfully during the period 28 August 2011–31 October 2011. This cruise is part of a decadal series of repeat hydrography sections jointly funded by NOAA-OGP and NSF-OCE as part of the U.S. 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, high-quality water column measurements to study physical and chemical changes over time. The 2011 A10 expedition began in Cape Town, South Africa and ended in Rio de Janeiro, Brazil. Various academic institutions and NOAA research laboratories participated on the cruise. The A10 section ran nominally along the 30°S from approximately 17°W to 48°W, repeating the section previously occupied in 1992 and 2003. A total of 120 full water column CTD/O_2/LADCP/rosette casts were completed along the A10 transect with nominal ~30 nautical mile (nm) spacing, with closer spacing near boundaries. Approximately 2,800 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, pH, carbon isotopes (^{14}C), dissolved organic carbon (DOC), density, phytoplankton, tritium, ^{18}O, and helium.

Underway data collection included upper-ocean current measurements from the shipboard ADCP, surface oceanographic (temperature, salinity, PCO_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 from CCHDO, under *Atlantic Ocean Datasets*:

http://cchdo.ucsd.edu/data_access/show_cruise?ExpoCode=33RO20100308

Acknowledgements

The successful completion of the cruise relied on dedicated assistance from many individuals both on shore and on the NOAA ship Ronald H. Brown as well as throught CLIVAR. Funded investigators in the project and members of the CLIVAR Repeat Hydrography/CO_2 program were instrumental in planning and executing the cruise. The participants in the cruise showed dedication and camaraderie during their 36 days at sea and unusual delay of the start of the cruise. Officers and crew of the Ronald H. Brown exhibited a high degree of professionalism and assistance to accomplish the mission and to make us feel at home during the voyage. Chief Survey Technician Jonathan Shannahoff and Electronics Technician Jeff Hill contributed to the success of this cruise through their able deck handling, stewardship of shipboard scientific gear and troubleshooting experience.

The US Repeat Hydrography / CO_2 Program is sponsored by NOAA’s Office of Climate Observation. In particular, we wish to thank program managers David Legler (NOAA), Eric Itsweire (NSF/OCE), for their moral and financial support in the effort.

Clearance was requested and granted from the sovereign nations of Namibia and Brazil for research conducted in their territorial waters. The collaboration in the research effort is greatly appreciated.

Background

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 the assessment of 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, that 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. Specific information about this cruise can be found at: http://www.aoml.noaa.gov/ocd/gcc/a10. The informal "blog" that recounted some to the cruise highlights can be found at: http://clivar-a10.blogspot.com/

CLIVAR/Carbon A10 Participating Institutions

Abbreviation	Institution
AOML	Atlantic Oceanographic and Meteorological Laboratory - NOAA
CPO	Climate Program Office - NOAA
FSU	Florida State University
FURG	Universidade Federal do Rio Grande
LDEO	Lamont-Doherty Earth Observatory/Columbia University
PMEL	Pacific Marine Environmental Laboratory - NOAA
RSMAS	Rosentstiel School of Marine and Atmospheric Science/University of Miami
SIO	Scripps Institution of Oceanography/University of California at San Diego
UCSB	University of California Santa Barbara
UCI	University of California Irvine
U Hawaii	University of Hawaii at Manoa
UW-Madison	University of Wisconsin at Madison
WHOI	Woods Hole Oceanographic Institution

Principal Programs of CLIVAR/Carbon A10

Analysis	Institution	Principal Investigator	email
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Underway surface ocean, meteorological and bathymetry data	NOAA	Ship personnel	

Scientific Personnel CLIVAR/Carbon A10

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Total CO_2 (DIC)	Robert Castle	AOML	robert.castle@noaa.gov
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CFCs/SF_6/ ^{14}C	Alan Foreman	Scripps	aforeman@ucsd.edu
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Total Alkalinity/pH	Carmen Rodriguez	RSMAS	crodriguez@rsmas.miami.edu
Total Alkalinity/pH	Valentina Caccia	RSMAS	valecaccia@yahoo.com
Helium/Tritium/ ^{18}O	Anthony Dachille	LDEO	dachille@ldeo.columbia.edu
DOC/ ^{14}C	Alysha Coppola	UCI	acoppola@uci.edu
HPLC/Phytoplankton	Luciano Costa de Lacerda Azevedo	FURG	lclazevedo@gmail.com
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Measurement Program Summary

After a 29-day delay, NOAA Ship Ronald H. Brown departed Cape Town, South Africa on 26 September 2011 at approximately 1400 UTC and arrived in Rio de Janeiro, Brazil on 31 October 2011.

A total of 120 stations were occupied during the A10 cruise. A total of three test casts (Sta. 998, 997 and 996) were occupied on the transit from Cape Town to the eastern end of the A10 section, which was run from east to west. Data from a total 121 CTD/O2/LADCP/rosette casts (including 1 reoccupation at station 035) were collected. Fifteen Argo floats and ten surface drifters were also deployed. CTD/O2 data, LADCP data, and water samples (up to 24) were collected on most rosette casts. In most cases each cast came to within 10 meters of the bottom (see Appendix).

A 24 position, 10-11 liter bottle rosette frame was used on this cruise (NOAA/AOML's yellow frame). 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, total CO_2 (DIC), total alkalinity, and pH on most of the samples. Additional samples were collected for ^3He, tritium, ^{14}C, Black Carbon, phytoplankton and DOC. The CTD rosstte/water sampler collected a total of 2,816 water sample measurements during the cruise. The distribution of the bottle samples during the course of the cruise can be seen in Figures 1 and 2.

A10 Hydrographic Measurements Program

The distribution of bottle samples is illustrated in Figures 1-2 below.

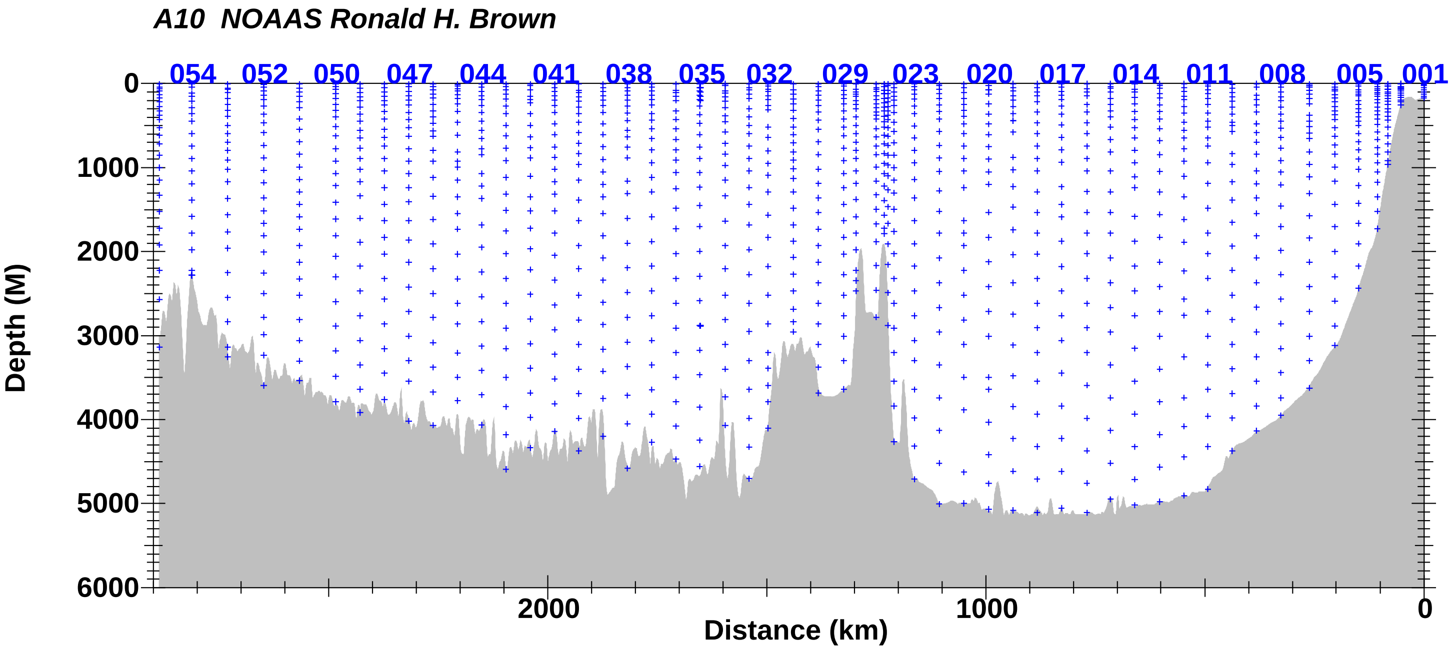


Figure 1 A10 Sample distribution, stations 1-55.

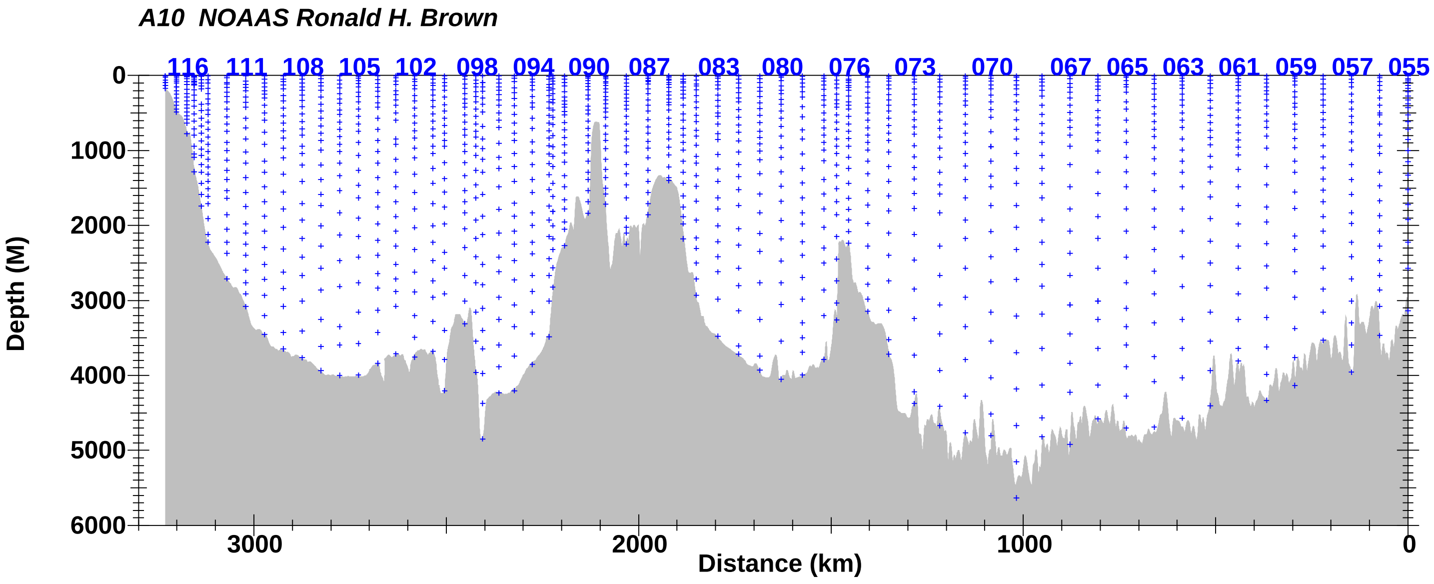


Figure 2 A10 Sample distribution, stations 55-120.

Bottle Sampling and Data Processing

Water Sampling

The NOAA Ship Ronald H. Brown has two Markey DESH-5 winches. The Aft winch was used for stations 13-17, 20-45 and 49-51. The Forward winch was used for all other stations, including the second (successful) cast of station 51. Most rosette casts were lowered to within 8-20 meters of the bottom, using both the altimeter to determine distance. Details of these bottom approaches can be found in the Appendix.

Rather than close the bottles at the same (standard) depths at each station, sampling plans were designed to stagger the vertical levels in rotation throughout the depths on each station throughout A10. The goal was to provide better coverage and spatial patterns for later gridding of the various data sets.

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

The 24-place SBE32 carousel had few problems other than occasional issues with releasing individual bottle lanyards, causing mis-tripped bottles on a number of casts.

Bottle Sampling

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

- Chlorofluorocarbons (CFCs)
- ^{3}He
- O_2
- pH
- Dissolved Inorganic Carbon (DIC)
- Total Alkalinity (TAlk)
- ^{14}C, Black Carbon
- Density
- Dissolved Organic Carbon (DOC)
- ^{18}O
- Tritium
- Nutrients
- Salinity
- Phytophlankton

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

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

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

Bottle Data Processing

Shipboard CTDO data were re-processed automatically at the end of each deployment using SIO/ODF CTD processing software v.5.1.5-4. The raw CTDO data and bottle trips acquired by SBE SeaSave on the Windows XP workstation were copied onto the Linux database and web server system. Pre-cruise calibration data were applied to CTD Pressure, Temperature and Conductivity sensor data, then the data were processed to a 0.5-second time series. A 2-decibar down-cast pressure series was created from the time series; CTDO data from downcasts were matched along isopycnals to upcast trips and extracted, then fit to bottle O_2 data at trips. The pressure series data were used by the web service for interactive plots, sections and on-board CTDO data distribution; the 0.5 second time series data were also available for distribution through the web service.

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

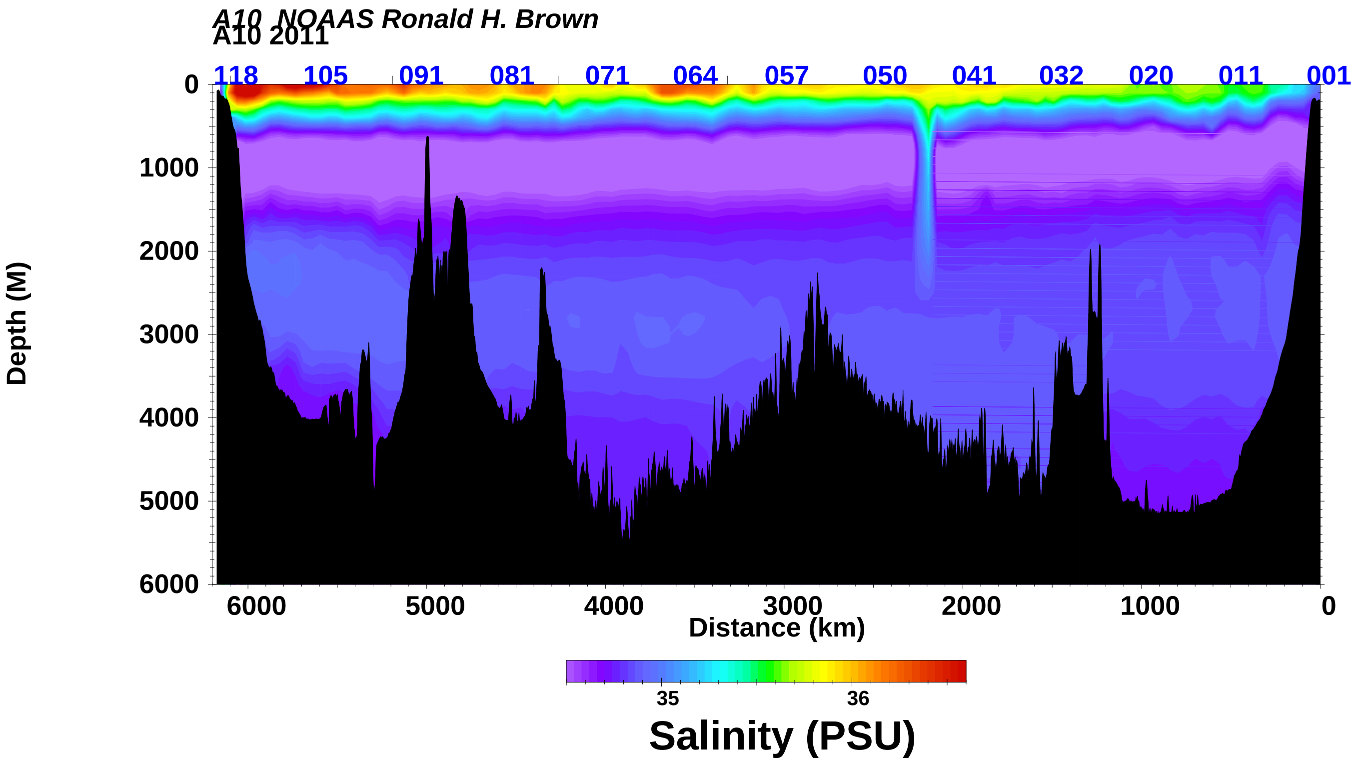
Water samples collected and properties analyzed shipboard were managed centrally in a relational database (PostgreSQL-8.1.18-2_el5_4.1) run on a Linux system. A web service (OpenACS-5.3.2-3 and AOLServer-4.5.1-1) front-end provided ship-wide access to CTD and water sample data. Web-based facilities included on-demand arbitrary property-property plots and vertical sections as well as data uploads and downloads.

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

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

Various consistency checks and detailed examination of the data continued throughout the cruise. A summary of Bottle Data Quality Codes and sampling comments are included in the Appendix.

1. Salinity



Equipment and Techniques

A single Guildline Autosal, model 8400B salinometer (S/N 60843), located in salinity analysis room, was used for all salinity measurements. The salinometer readings were logged on a computer using Ocean Scientific International’s logging hardware and software. The Autosal’s water bath temperature was set to 24°C, which the Autosal is designed to automatically maintain. 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 using the ship’s clean power to prevent any electrical noise issues.

Salinity analyses were performed after samples had equilibrated to laboratory temperature, usually at least 24 hours after collection. The salinometer was standardized for each group of samples analyzed (usually 2 casts and up to 50 samples) using two bottles of standard seawater: one at the beginning and 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

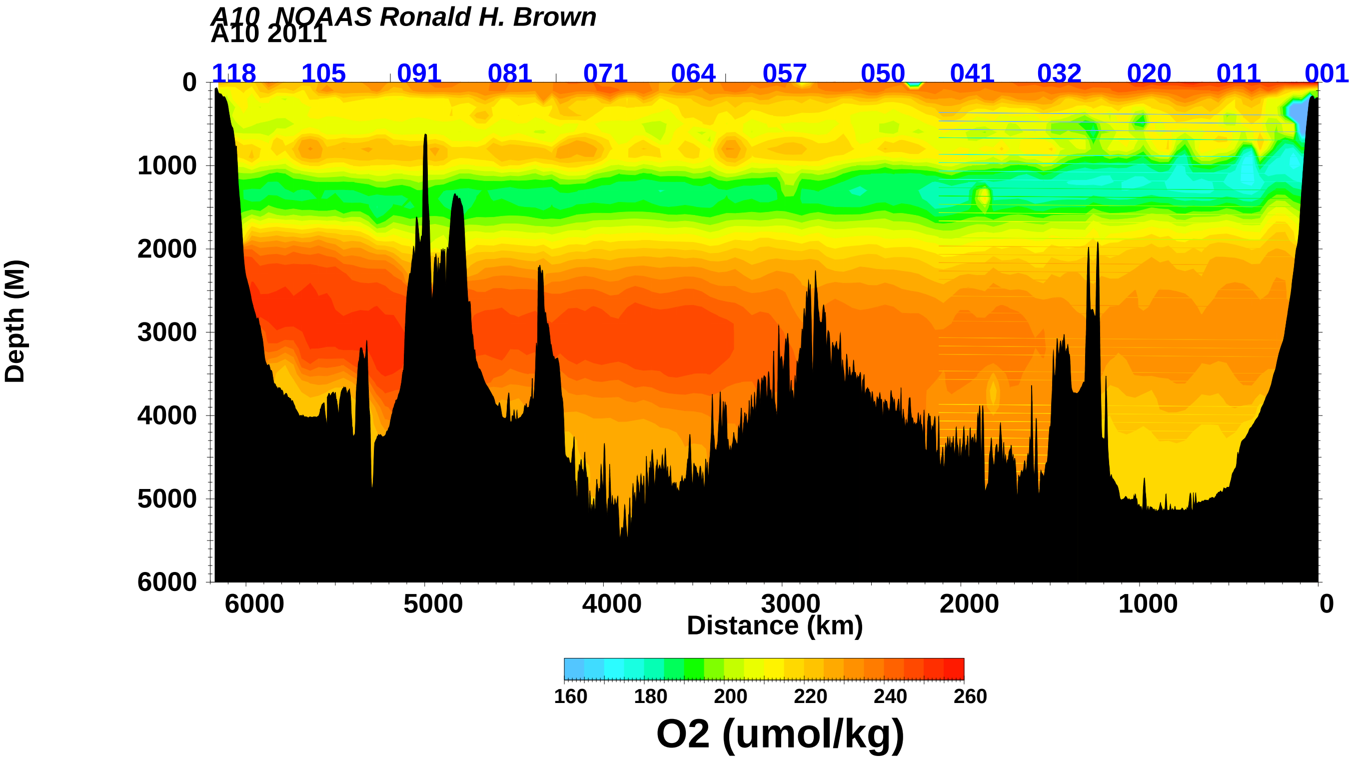
IAPSO Standard Seawater Batch P-152 was used to standardize all casts.

Sampling and Data Processing

The salinity samples were collected in 200 ml Kimax high-alumina borosilicate bottles that had been rinsed at least three times with sample water prior to filling. The bottles were sealed with custom-made plastic insert thimbles and Nalgene screw caps. This assembly provides very low container dissolution and sample evaporation. Prior to sample collection, inserts were inspected for proper fit and loose inserts replaced to insure an airtight seal. Laboratory temperature was also monitored electronically throughout the cruise. PSS-78 salinity [UNES81] was calculated for each sample from the measured conductivity ratios. The offset between the initial standard seawater value and its reference value was applied to each sample. Then the difference (if any) between the initial and final vials of standard seawater was applied to each sample as a linear function of elapsed run time. The corrected salinity data was then incorporated into the cruise database. When duplicate measurements were deemed to have been collected and run properly, they were averaged and submitted with a quality flag of 6.

On A10, 2749 salinity measurements were taken and approximately 120 vials of standard seawater (SSW) were used. A duplicate sample was drawn from each cast to determine total analytical precision.

2. Oxygen Analysis



Equipment and Techniques

Dissolved oxygen analyses were performed with an automated titrator using amperometric end-point detection [Lang10]. Sample titration , data logging, and graphical display were performed with a PC running a LabView program written by Ulises Rivero of AOML. Lab temperature was maintained at 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 [Carp65], with modifications by Culberson et al. [Culb91], was used. Four replicate 10 ml iodate standards were run every 3-4 days. The reagent blank determined as the difference between V_1 and V_2, 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 C. Langdon [Lang10].

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. Latex gloves were worn during sample collection for the same reason. 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. The draw temperatures were used to calculate umol/kg concentrations, and provide a diagnostic check of Niskin bottle integrity. 1 ml of $MnCl_2$ and 1 ml of NaOH/NaI were added immediately after drawing the sample was concluded using a ThermoScientific REPIPET II. The flasks were then stoppered and shaken well. Deionized water (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 2,730.

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

Thiosulfate normality was calculated at the laboratory temperature for each run.

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.

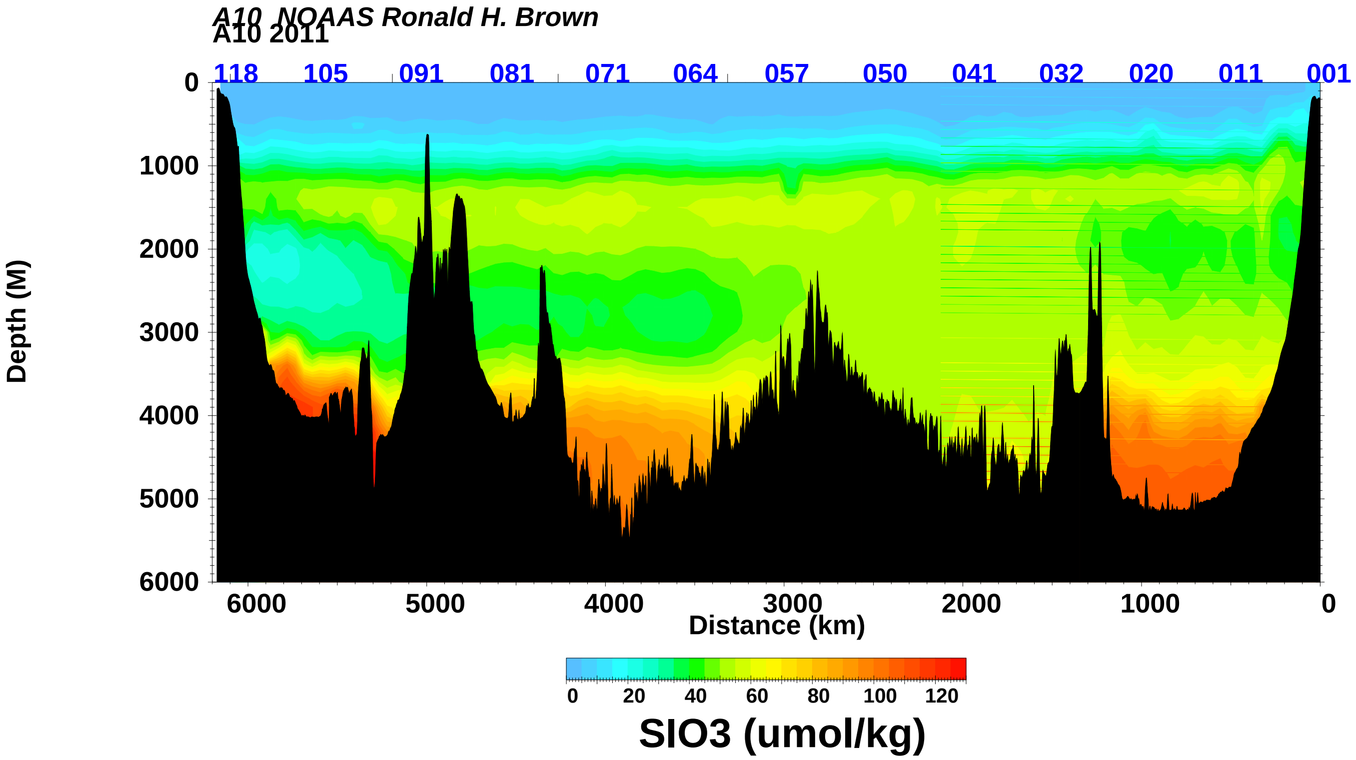
Duplicate Samples

A total of 232 sets of duplicates were run, two for each station. The average standard deviation of all sets was 0.2 umol/kg.

Problems

Eight oxygen flasks were removed and replaced with different flasks during the cruise, after it was noted that the stoppers did not fit tightly. The following flasks were replaced 6, 7, 9, 14, 47, 48, 49, 54.

3. Nutrients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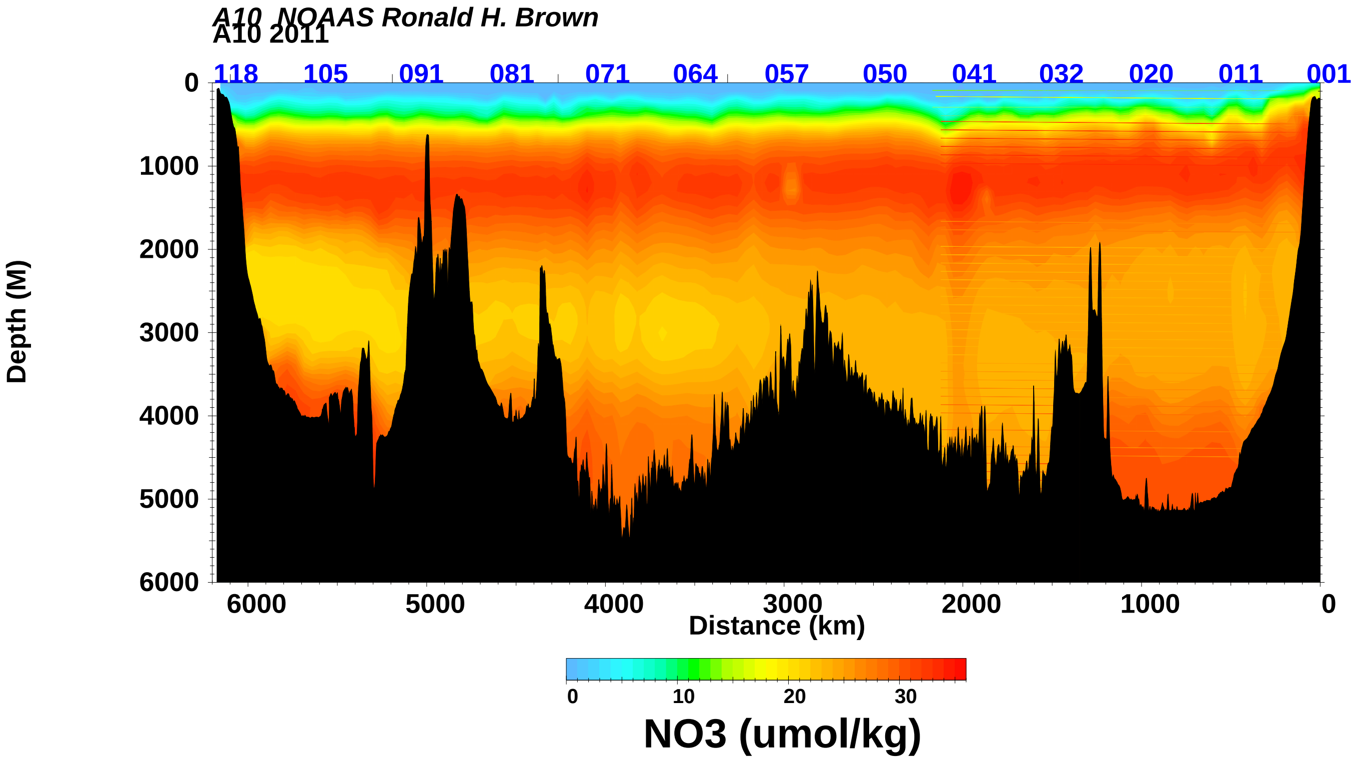
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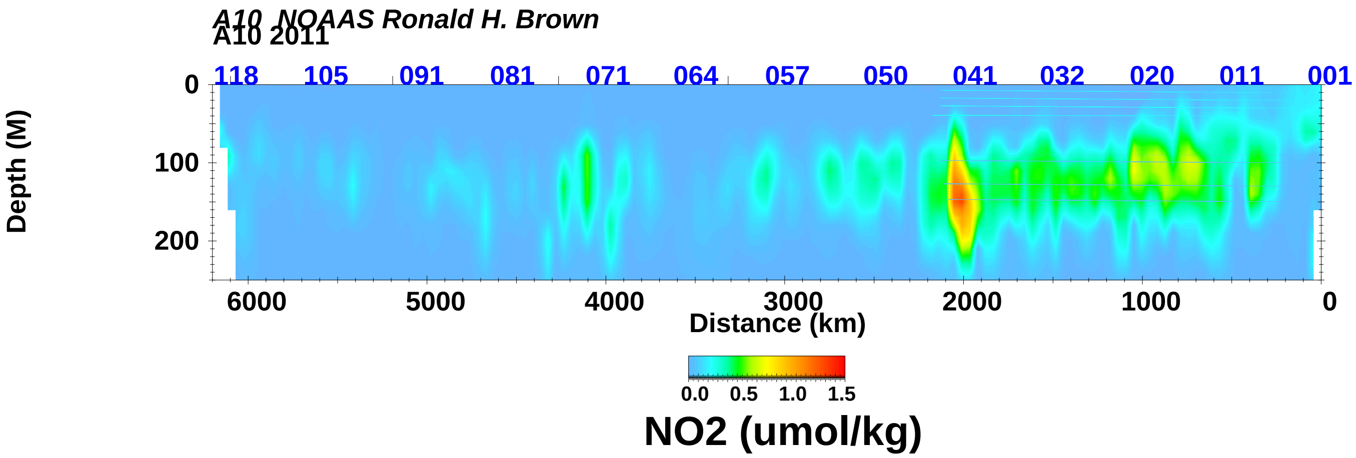
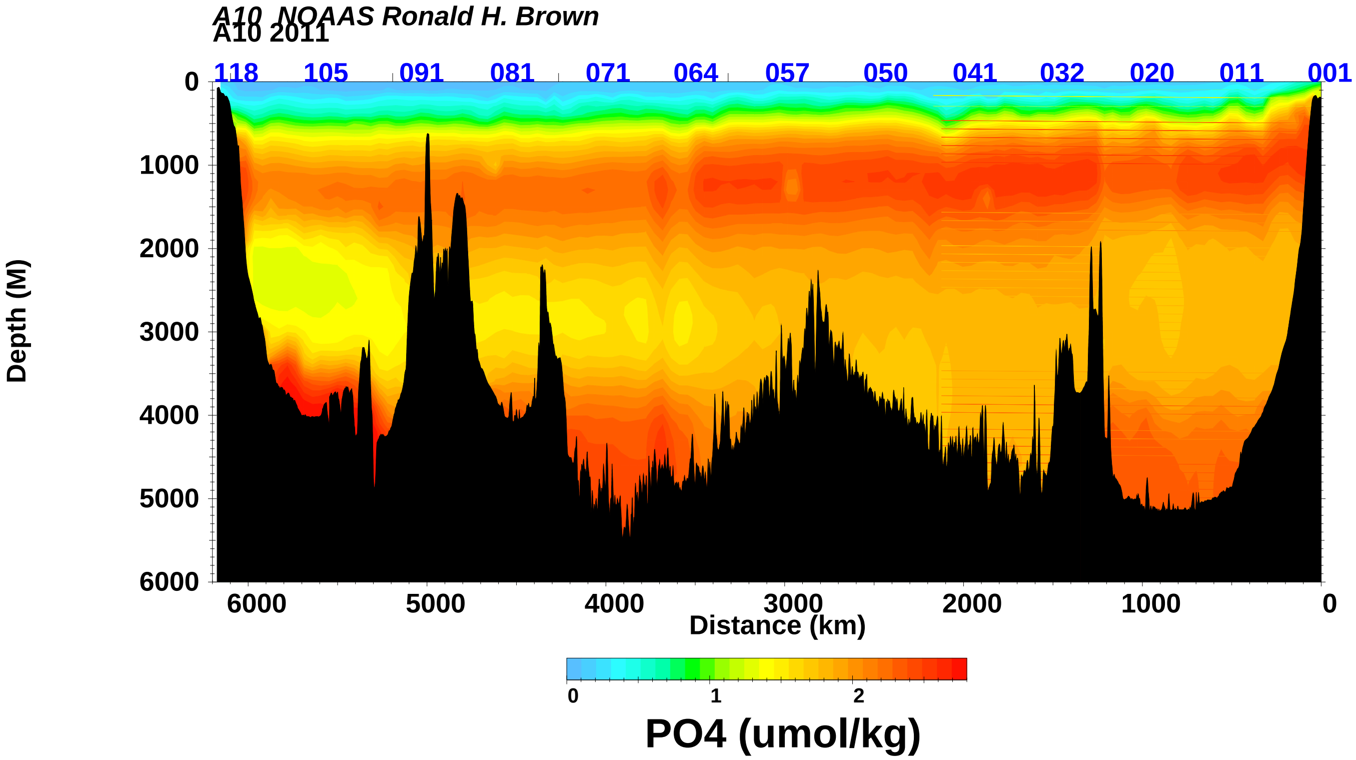




Sampling

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 analysis protocols for the WOCE hydrographic program as set forth in the manual by L.I. Gordon, et al. [Gord94]

Analytical Methods

Over the entire A10 transect, 2749 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 was 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, CRM standards, samples, replicates, working standards, and standard and distilled water blanks. Replicates were usually run for 4-7 Niskin bottles from each cast, at varying depths, 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.

Standardization

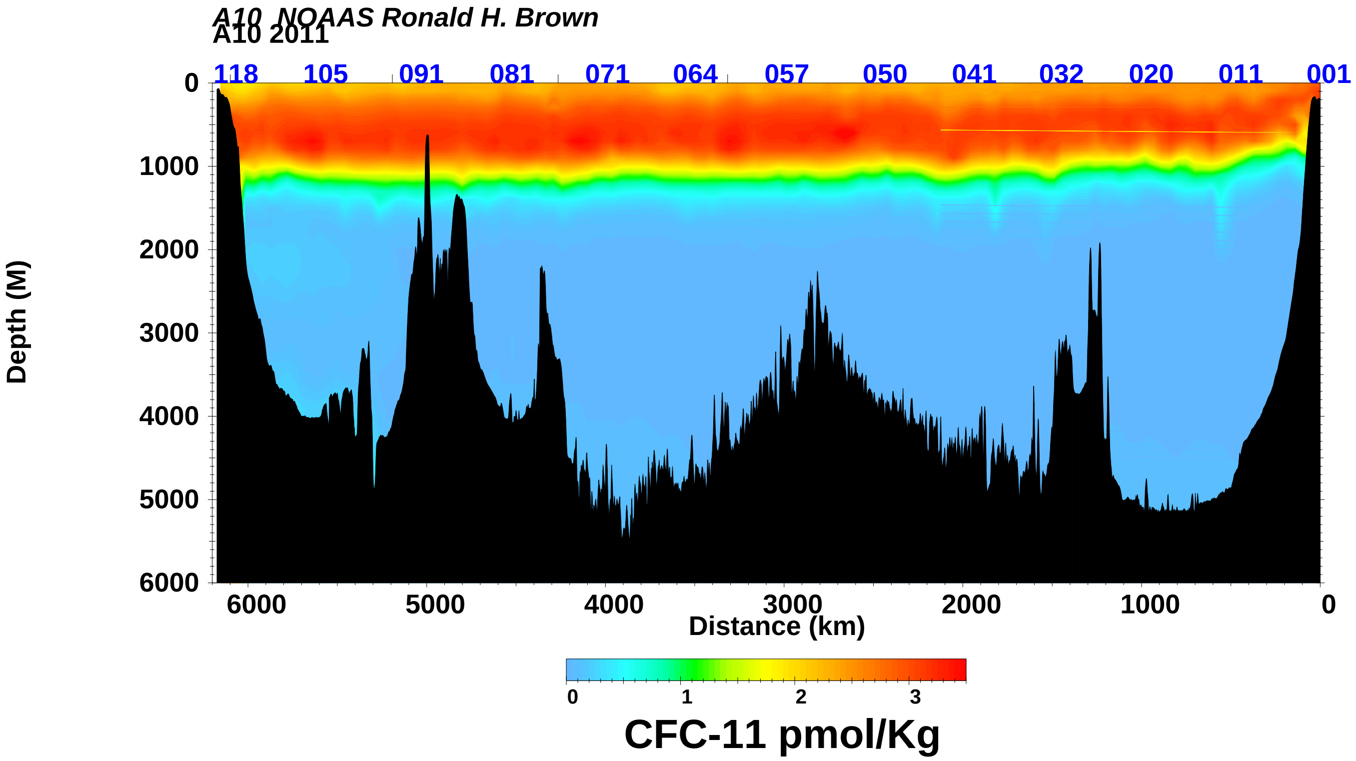
A mixed stock standard consisting of silicic acid, phosphate and nitrate was prepared by dissolving high purity standard materials (KNO_3, KH_2PO_4 and Na_2SiF_6) in deionized water using a two step dilution for phosphate and nitrate. This standard was stored at room temperature. A nitrite stock standard 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.

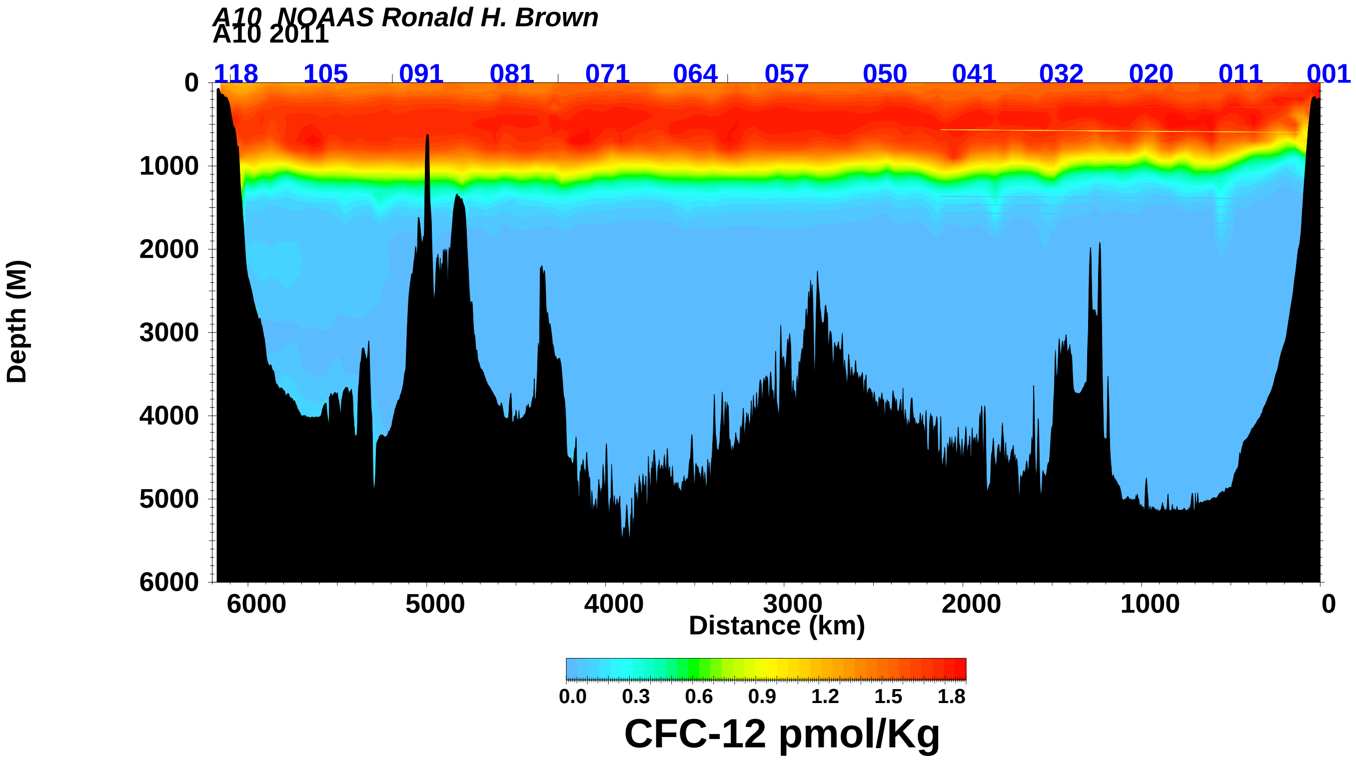
Additionally, a standard comparison was done with CRM standards from *The General Environmental Technos Co. LTD* of Osaka, Japan. These were run as part of an evaluation of the standards to test their feasibility for use as a universal nutrient standard.

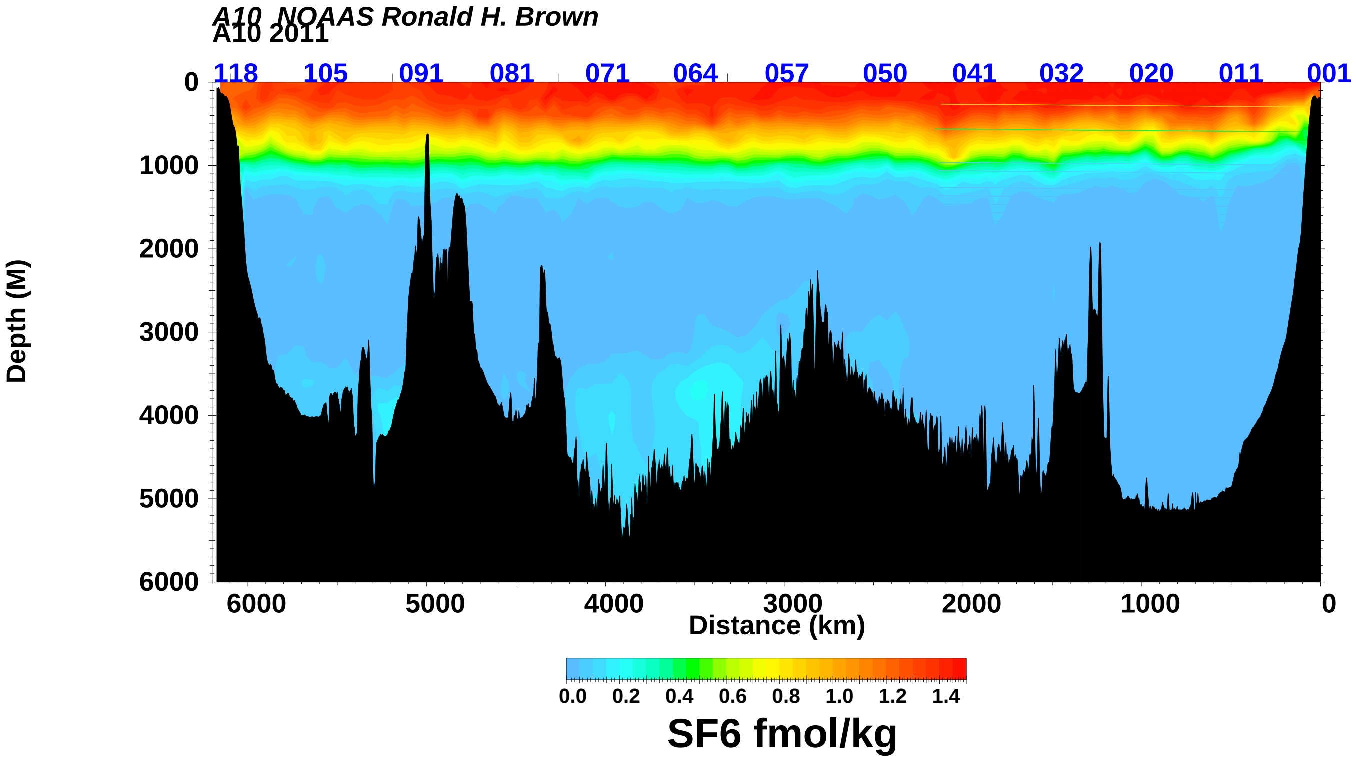
Problems

There were no significant problems encountered on this cruise with either the equipment, reagents or the ships systems. On a recent CLIVAR cruise, (A13.5) problems were encountered with using the ship’s water for the preparation of the Imidazole buffer. On this cruise, water directly from the ship’s evaporation system was subsequently run through a Millipore Milli-Q™ system to obtain water of very high purity. This water was used to prepare all primary and secondary mixed standards and reagents and no problems were noted.

4. Chlorofluorocarbons (CFCs) and Sulfur Hexafluoride (SF_6)







Sampling

A PMEL analytical system [Bull08] was used for CFC-11, CFC-12 and sulfur hexafluoride (SF_6) analyses on the CLIVAR A10 expedition. Aproximately 2300 samples of dissolved CFC-11, CFC-12 and SF_6 ('CFC/SF_6') were analysed.

In general, the analytical system performed well on the cruise. Typical dissolved SF_6 concentrations in modern surface water are 1-2 fmol/kg 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 were approximately 0.02 fmol/kg. 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 were collected in bottles designed with a modified end-cap to minimize the contact of the water sample 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 SF_6 analysis were the first samples drawn from the bottles. Care was taken to coordinate the sampling of CFC/SF_6 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/SF_6 samples were drawn directly through the stopcocks of the bottles into 250 ml precision glass syringes equipped with three-way plastic stopcocks. The syringes were immersed in a holding tank of clean surface seawater held at 10°C until 20 minutes before being analyzed. At that time, the syringe was placed in a bath of surface seawater heated to 30°C.

For atmospheric sampling, a 75 m length of 3/8" OD Dekaron tubing was run from the CFC van located on the fantail to the bow of the ship. A flow of air was drawn through this line into the main laboratory using an Air Cadet pump. The air was compressed in the pump, with the downstream pressure held at 1.5 atm. using a back pressure regulator. A tee allowed a flow of 100 ml/min of the compressed air to be directed to the gas sample valves of the CFC/SF_6 analytical systems, while the bulk flow of the air (>7 l/min) was vented through the back-pressure regulator. Air samples were analyzed only when the relative wind direction was within 60 degrees of the bow of the ship to reduce the possibility of shipboard contamination. Analysis of bow air was performed at 10 locations along the cruise track. At each location, at least five air measurements were made to determine the precision of the measurements.

Analysis

Concentrations of CFC/SF_6 in air samples, seawater, and gas standards were measured by shipboard electron capture gas chromatography (EC-GC) using techniques modified from those described by Bullister and Weiss[Bull88] and Bullister and Wisegarver [Bull08] as outlined below. For seawater 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/SF_6 free purge gas through the sparging chamber for a period of 6 minutes at 150 ml/min. Water vapor was removed from the purge gas during passage through an 18 cm long, 3/8" diameter glass tube packed with the desiccant magnesium perchlorate. The sample gases were concentrated on a cold-trap consisting of a 1/16" OD stainless steel tube with a 2.5 cm section packed tightly with Porapak Q (60-80 mesh), a 15 cm section packed with Carboxen 1000 and a 2.5 cm section packed with MS5A. A Neslab Cryocool CC-100 was used to cool the trap to -65°C. After 6 minutes of purging, the trap was isolated, and it was heated electrically to 175°C. The sample gases held in the trap were then injected onto a precolumn (45 cm of 1/8" O.D. stainless steel tubing packed with 80-100 mesh Porasil B, held at 80°C) for the initial separation of CFC-12, CFC-11, SF_6 and CCL_4 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, 80°C) and into the analytical column #1 (210 cm of 1/8" OD stainless steel tubing packed with MS5A and held at 80°C), the outflow from the first precolumn was diverted to the second analytical column (180 cm 1/8" OD stainless steel tubing packed with Porasil B, 80-100 mesh, held at 80°C). The gases remaining after $CClSub4$ had passed through the first pre-column, were backflushed from the pre column and vented. After CFC-12 had passed through the second pre-column, a flow of Argon-Methane (95:5) was used to divert the N2O to a third analytical column (2 m , Hayesep B, 120°C). Column #3 and the second pre-column were held in a Shimadzu GC8 gas chromatograph with an electron capture detector (ECD) held at 330°C. Columns #1, #2, and the first precolumn were in another Shimadzu GC8 gas chromatograph with ECD. The outflow from column #2 was directed to a Shimadzu Mini2 gas chromatograph (no column) with the ECD held at 250°C.

The analytical system was calibrated frequently using a standard gas of known CFC/SF_6 composition. Gas sample loops of known volume were thoroughly flushed with standard gas and injected into the system. The temperature and pressure were 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/SF_6 free gas) were injected and analyzed in a similar manner. The typical analysis time for seawater, air, standard or blank samples was 11 minutes. Concentrations of the CFC-11 and CFC-12 in air, seawater samples, and gas standards are reported relative to the SIO98 calibration scale[Prin00].

Concentrations of SF_6 in air, seawater samples, and gas standards are reported relative to the CMDL calibration scale. Concentrations in air and standard gas are reported in units of mole fraction CFC in dry gas, and are typically in the parts per trillion (ppt) range. Dissolved CFC concentrations are given in units of picomoles per kilogram seawater (pmol/kg) and SF_6 concentrations in fmol/kg. 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 for 6 minutes, the purging efficiency for all 3 gases was > 99%.

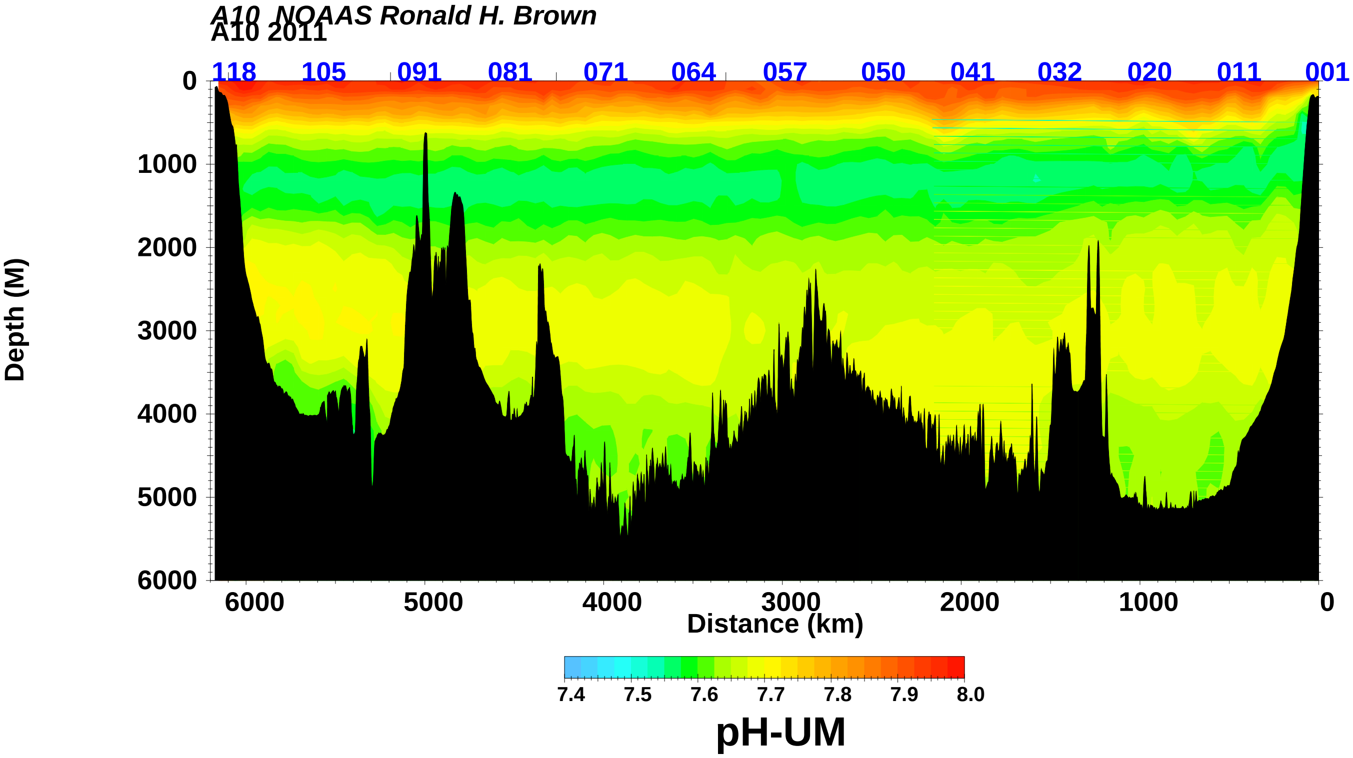
On this expedition, based on the analysis of more than 150 pairs of duplicate samples, we estimate precisions (1 standard deviation) of about 1% or 0.002 pmol/kg (whichever is greater) for both dissolved CFC-11 and CFC-12 measurements. The estimated precision for SF_6 was 2% or 0.02 fmol/kg, (whichever is greater). Overall accuracy of the measurements (a function of the absolute accuracy of the calibration gases, volumetric calibrations of the sample gas loops and purge chamber, errors in fits to the calibration curves and other factors) is estimated to be about 2% or 0.004 pmol/kg for CFC11 and CFC-12 and 4% or 0.04 fmol/kg for SF_6).

Analysis Problems

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).

5. pH



Sampling

Samples were collected in 50ml borosilicate glass syringes rinsing 2 times and equilibriated to 25°C before analysis. Three duplicates were collected from each station: one from the bottom, one at the 0_2 minimum, and one at the surface. All data should be considered preliminary.

Analysis

pH (umol/kg H_2O) on the seawater scale was measured using a Agilent 8453 spectrophotometer according to the methods outlined by Clayton and Byrne [Clay93] A RTE17 water bath maintained spectrophotometric cell temperature at 25.0°C. A 10cm flow through cell was filled automatically using a Kloehn 6v syringe pump. The sulfonephthalein indicator m-cresol purple (mCP) was also injected automatically by the Kloehn 6v syringe pump into the spectrophotometric cells, and the absorbance of light was measured at three different wavelengths (434 nm, 578 nm, 730 nm). The ratios of absorbances at the different wavelengths were input and used to calculate pH on the total and seawater scales, incorporating temperature and salinity into the equations. The equations of Dickson and Millero [Dick87] , Dickson and Riley [Dick79] , and Dickson [Dick90] were used to convert pH from total to seawater scales. Salinity data were obtained from the conductivity sensor on the CTD and were later corroborated by shipboard measurements. Temperature of the samples was measured immediately after spectrophotometric measurements using a Guildline 9540 digital platinum resistance thermometer.

Reagents

The mCP indicator dye was a concentrated solution of 2.0 mM with an R = 1.61350.

Standardization

The precision of the data can be accessed from measurements of duplicate samples, certified reference material (CRM) Batch 96 and 112 (Dr. Andrew Dickson, UCSD) and TRIS buffers. CRMs were measured every odd station and TRIS buffers were measured every station. The mean and standard deviation for the CRMs was 7.8687 ± 0.0075 (Batch 96; n=18) and 7.8626 ± 0.0104 (Batch 112; n=29).

Data Processing

Addition of the indicator affects the pH of the sample, and the degree to which pH is affected is a function of the pH difference between the seawater and indicator. Therefore, a correction is applied for each batch of dye. To obtain this correction factor, all samples throughout the cruise were measured after two consecutive additions of mCP. From these two measurements, a change in absorbance ratio per mL of mCP indicator is calculated. R was calculated using the absorbance ratio (R_m) measured after the initial indicator addition from:

$$R = R_m + (-0.00173 + 0.000382\, R_m)\, V_{ind} \quad (1)$$

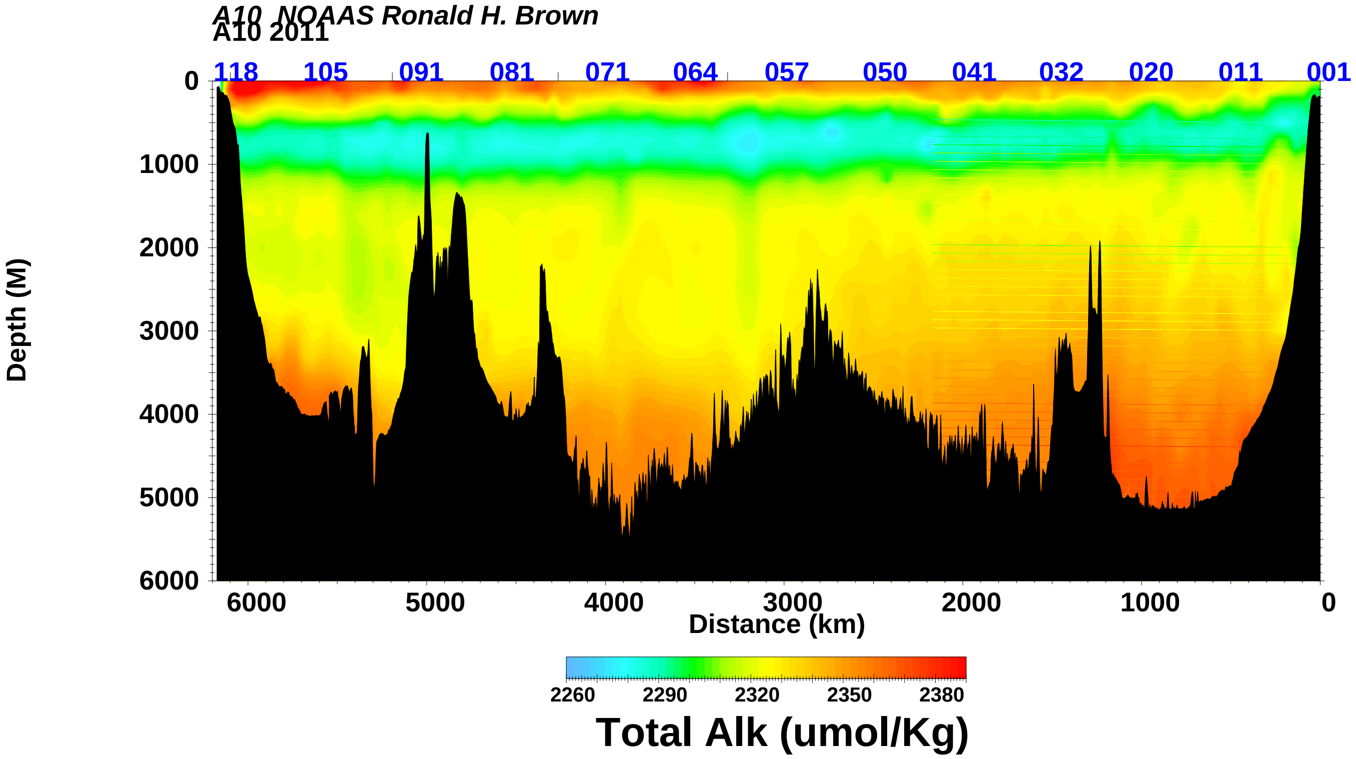
$$R = R_m + (-0.00254 + 0.000571\, R_m)\, V_{ind} \quad (2)$$

where V_{ind} is the volume of mCP used. Clayton and Byrne [Clay93] calibrated the mCP indicator using TRIS buffers [Rame77] and the equations of Dickson [Dick93]. These equations are used to calculate pH_t, the total scale in units of moles per kilogram of solution.

Problems

Communication problems were noticed between the pH instrument and the analysis program at station 26. These problems persisted until station 28 when it was decided to replace the Kloehn and re-program the pH instrument. Samples were not analyzed from stations 28 through 33 for pH while the instrument and communications were being repaired. At station 34 the pH instrument communication with the analysis program was repaired and pH sampling resumed.

6. Total Alkalinity



Sampling

The sampling scheme was full casts (24 Niskins) on all stations. When this was not possible, half-casts were taken and alkalinity was sampled according to the DIC scheme. All casts had 3 duplicate samples drawn; one from the near the bottom, the oxygen minimum, and surface Niskin. Samples were drawn from Niskin bottles into 500 ml borosilicate flasks using silicone tubing that fit over the petcock to avoid contamination of DOC samples. Bottles were rinsed a minimum of two times and filled from the bottom, overflowing half of a volume while taking care not to entrain any bubbles.

Approximately 15 ml of water was withdrawn from the flask by arresting the sample flow and removing the sampling tube, thus creating a small expansion volume and reproducible headspace. The sample bottles were sealed at a ground glass joint with a glass stopper. The samples were thermostated at 25°C before analysis.

Analysis

The total alkalinity of seawater (TAlk) was evaluated from the proton balance at the alkalinity equivalence point, pHequiv = 4.5 at 25°C and zero ionic strength in one kilogram of sample. The method utilizes a multi-point hydrochloric acid titration of seawater according to the definition of total alkalinity [Dick81]. The potentiometric titrations of seawater not only give values of TAlk but also those of DIC and pH, respectively, from the volume of acid added at the first end point and the initial EMF, E0. Two titration systems, A and B were used for TAlk analysis. Each of them consists of a Metrohm 665 Dosimat titrator, an Orion 720A pH meter and a custom designed plexiglass water-jacketed titration cell [Mill93]. Both the seawater sample and acid titrant were temperature equilibrated to a constant temperature of 25±0.1°C with a water bath (Neslab, model RTE-10). The water-jacketed cell is similar to the cells used by Bradshaw and Brewer [Brad88] except a larger volume (approx. 200 ml) is employed to increase the precision. Each cell has a fill and drain valve which increases the reproducibility of the volume of sample contained in the cell. A typical titration recorded the EMF after the readings became stable (deviation less than 0.09 mV) and then enough acid was added to change the voltage a pre-assigned increment (13 mV). A full titration (25 points) takes about 15-20 minutes. The electrodes used to measure the EMF of the sample during a titration consisted of a ROSS glass pH electrode (Orion, model 810100) and a double junction Ag, AgCl reference electrode (Orion, model 900200).

Reagents

A single 50-l batch of 0.25 m HCl acid was prepared in 0.45 m NaCl by dilution of concentrated HCl, AR Select, Mallinckrodt, to yield a total ionic strength similar to seawater of salinity 35.0 (I = 0.7 M). The acid was standardized by a coulometric technique [Mari68][Tayl59] , and verified with alkalinity titrations on seawater of known alkalinity. The calibrated molarity of the acid used was 0.24178 ±0.0001 M HCl. The acid was stored in 500-ml glass bottles sealed with Apiezon® L grease for use at sea.

Standardization

The volumes of the cells used were determined to ±0.03 ml during the initial set up by multiple titrations using seawater of known total alkalinity and CRM. Calibrations of the burette of the Dosimat with water at 25°C indicate that the systems deliver 3.000 ml (the approximate value for a titration of 200 ml of seawater) to a precision of ±0.0004 ml, resulting in an error of ±0.3 umol/kg in TAlk. The reproducibility and precision of measurements are checked using low nutrient surface seawater and Certified Reference Material (Dr. Andrew Dickson, Marine Physical Laboratory, La Jolla, California), Batch 96 and 112. CRMs were utilized in order to account for instrument drift and to maintain measurement precision. Duplicate analyses provide additional quality assurance and were taken from the same Niskin bottle. Duplicates were either both measured on system A, both on system B, or one each on A and B.

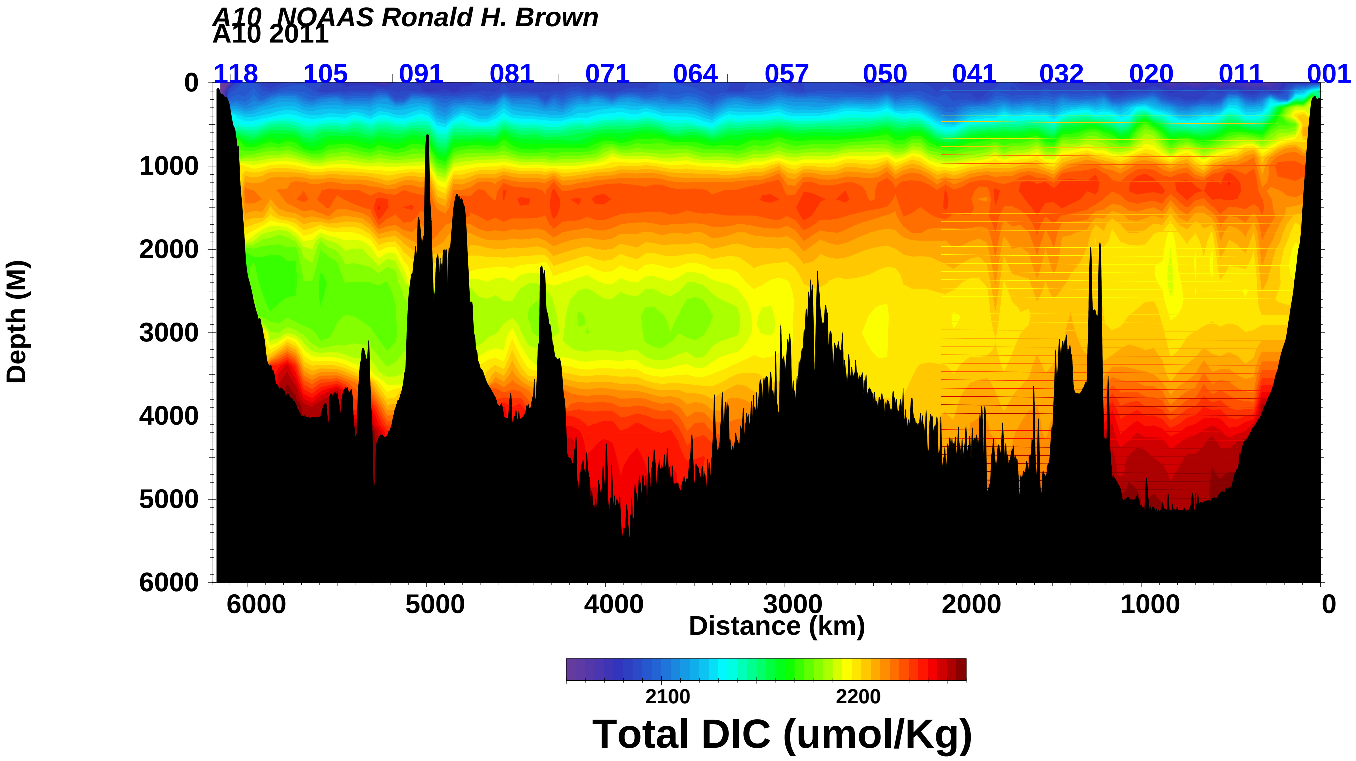
Data Processing

An integrated program controls the titration, data collection, and the calculation of the carbonate parameters (TAlk, pH, and DIC). The program is patterned after those developed by Dickson [Dick81], Johansson and Wedborg [Joha82], and U.S. Department of Energy [DOE94]. The program uses a Levenberg-Marquardt nonlinear least-squares algorithm to calculate the TAlk, DIC, and pH from the potentiometric titration data.

Problems

No major problems occurred throughout the cruise. During a rough storm that occured near station 88, the rocking of the ship caused the lid of cell A to come out of alignment. New cell volumes were calibrated for both cells.

7. Dissolved Inorganic Carbon (DIC)



Sampling

Samples were drawn from Niskin 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.

On this cruise more than 2300 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. The replicate samples were interspersed throughout the station analysis for quality assurance and integrity of the coulometer cell solutions.

Analysis

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 et al. [John85] [John87] [John92] 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 [Wilk93]. 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.

Problems

While both systems worked very well during the cruise, they both had unusually high blanks. Normally the blank is less than 30, but we were forced to run them with blanks in the 40-70 range. The beginning of the cruise was delayed for 4 weeks because of engine problems that required shipment of parts from the U.S. and during this time extensive tests were performed to determine the cause of the high blanks. No leaks or sources of CO_2 could be found to account for the problem. The most likely cause was the use of 2 year old anode solution. By the time all other causes were eliminated, there was not enough time to order new solution and have it shipped to Cape Town. Since the high blanks were not caused by leaks in the system, the values computed should be accurate. Comparison of the deep water values (below 2000 meters) with those obtained on the 2003 A10 cruise do not show a significant difference, however they will require a careful post-cruise quality control check.

Other problems were relatively minor. The water bath failed during the extended Cape Town in-port, but the spare worked reliably for the duration of the cruise. Communication errors between the instruments and their controlling laptop computers occurred several times. Also several solenoid valves failed and had to be replaced.

A total of 2393 samples were analyzed for discrete dissolved inorganic carbon. The total dissolved inorganic carbon data reported to the database directly from the ship are to be considered preliminary until a more thorough quality assurance can be completed shore side.

8. Dissolved Organic Carbon (DOC)

DOC and TDN samples were taken from every Niskin bottle at approximately every other station. 1380 samples were taken from 61 stations in total. Samples from depths shallower than 500 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 for laboratory analysis.

9. Radiocarbon ^{14}C

Radiocarbon in DIC

A total of 40 samples were collected in 250 ml air-tight glass bottles. 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 to flush its full 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 caps are re-tightened as they reach room temperature. The filled bottles are stored inside the ship’s laboratory prior to being loaded into a container and shipped back to the United States for analysis.

Radiocarbon in DOC

A total of 43 samples were collected in 1 liter Boston round bottles. Samples from depths shallower than 400m were filtered through previously combusted GF/F filters. Samples from deeper depths were not filtered. The bottles and caps were rinsed 3 times with about 50 ml each of water from the Niskin bottle. The bottle was filled to about 85% full and capped using a piece of Teflon sheet between bottle top and the cap. The filled bottles were stored inside the

PI’s freezer (-20°C) at an angle. All samples will shipped back to the United States for analysis.

Radiocarbon in Black Carbon in DOC

A total of 56 samples were collected in 1 gallon glass bottles. At 73°W and 35°W, 25 L were collected at the surface and approximately 50L were collected at depth. Deep samples at the Mid Atlantic Ridge were also collected. Samples from depths shallower than 400 m were filtered through previously combusted GF/F filters. Samples from deeper depths were not filtered. The bottles and caps were rinsed 3 times with about 100 ml each of water from the Niskin bottle. The bottle was filled to about 85% full and capped using a piece of Teflon sheet between the bottle top and the cap. The filled bottles were frozen at an angle inside the PI’s freezer (-20°C). All samples will shipped back to the United States for analysis.

10. Density

Density samples were taken at five stations during the cruise, sampling the full cast (Stations 17, 43, 61, 81, 105). The samples were drawn into 125 mL HDPE bottles rinsing twice before filling. These samples will be analyzed for density using an Anton-Parr vibrating densitometer and re-analyzed for salinity (to account for any evaporation) back in Miami.

11. Tritium, Helium and ^{18}O

Helium samples were taken from designated Niskins in 90 cc 316 type stainless steel gas tight vessels with valves. The samples were then extracted into aluminum silicate glass storage vessels within 24 hours using the at sea gas extraction system. The helium samples are to be shipped to the Lamont-Doherty Earth Observatory of Columbia University Nobel Gas Lab for mass spectrometric measurements. A corresponding one-liter water sample was collected from the same Niskin as the helium sample in a preprocessed glass bottle for degassing back at the shore based laboratory and subsequent tritum determination by ^{3}He in-growth method. ^{18}O samples were collected and shipped to LDEO for analysis.

During A10, 18 stations were sampled, collecting 347 samples for tritium, 424 samples for helium and 290 samples for ^{18}O analysis. No duplicate samples were taken.

12. Phytoplankton

Phytoplankton pigments by HPLC

On CLIVAR/Carbon A10, at least three water samples were collected on each station: one at the surface, one at the chlorphyll maximum (determined by the fluorometer profile on the CTD package), and one at the base of this fluorescence peak. In order to better characterize fluorometer profiles at the top of the water column, samples from 5 depths (0, 50, 100, 150, 200m) were collected from approximately every 12th station. The water samples (1.5-3 L) were filtered onto Whatman GF/F filters (nominal pore size 0.7 um and 25 mm diameter), under vacuum pressure (< 5" Hg). When complete, the filters were immediately stored in liquid nitrogen. These frozen samples were then shipped to shore for analysis. The phytoplankton pigments will be determined by HPLC (High-Performance Liquid Chromatography). This technique allows one to distinguish the main pigments that characterize different phytoplankton groups. The pigments are identified by comparison between their retention peaks and absorption characteristics in the HPLC using known standards.

Radiance/Irradiance Profiler

At every daytime station in which there were favorable weather and sea conditions, bio-optical data were measured using a Satlantic Radiance/Irradiance Profiler. This system, which was deployed off the stern, is equipped with Hyperspectral Ocean Colour Radiometer (HyperOCR) sensors as well as auxiliary sensors for measuring pressure, tilt, temperature and condutivity. The HyperOCT sensors measure radiance and irradiance profiles on 256 channels with wavelength from 350 to 800nm. The data are downloaded in real-time to a computer running SatView, Satlantic's data logging and display program. The profiler was operated on two different modes: Free-Fall Mode and Surface Mode.

Free-Fall Mode

For the Free-Fall Mode, the profiler was sent about 20 meters away from the ship (to avoid the ship's shadow) before being allowed to freely sink down to 30 meters. During this free fall, profiles were made measuring upwelling radiance (Lu) and downwelling irradiance (Ed). The ratio Lu/Ed is used to calculate the Remote sensing reflectance (Rrs). The Rrs is a measurement used to estimate the substances present in the water (e.g. chlorophyll). This procedure consisted of two casts, one with the pressure tare done on deck and the other with the pressure tare done on the sea surface.

Surface Mode

For the Surface Mode, the system was equipped with a flotation collar and inverted such that it becomes an upwelling irradiance sensor. Downwelling irradiance (Ed) measurements were made by a separate surface reference sensor, which was set on the top of a van on the fantail. In this mode the profiler measured the surface upwelling irradiance (Eu) and the upwelling radiance (Lu) for 10 minutes. The Irradiance reflectance was calculated by the ratio Eu/Ed which is similar to Rts. Those measurements were also used to calculate the Q Factor (Eu/Lu) which was then used to calculate the Normalized upwelling radiance (Lwn). '.RE

Deployments

SVP Drifter Deployments

A total of ten 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 table shows the location of each SVP deployment made on CLIVAR/Carbon A10.

Deployment #	Latitude	Longitude	Station
1	-29.75	9.03	13
2	-29.75	5.58	19
3	-29.35	2.83	24
4	-30	-0.03	32
5	-30	-3.36	38
6	-30	-15.19	56
7	-30.0167	-18.24	60
8	-30	-21.27	64
9	-30	-24.29	68
10	-30	-27.73	73

Argo Float Deployments

Fifteen ARGO profiling CTD floats were launched during this cruise at the request of the 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 fifteen floats were deployed successfully. A sixteenth float was not deployed because it failed on startup. The following table shows the location of each Argo Float deployment made on CLIVAR/Carbon A10.

Deployment #	Latitude	Longitude	Station
1	-29.75	5.58	19
2	-29.35	2.83	24
3	-30	-0.03	32
4	-30	-3.36	38
5	-30	-7.38	45
6	-30	-10.26	50
7	-30	-12.56	54
8	-30	-19	61
9	-30	-21.27	64
10	-30	-24.29	68
11	-30	-27.04	72
12	-30	-29.82	76
13	-30	-33.62	83
14	-30	-37.15	90
15	-30	-39.83	98

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APPENDIX

Cast Bottom Data

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

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

A ’-999’ for any of these values indicates an instrument error in which no data was given.

Table 12.1 A10 Cast bottom data

SSS/CC	Date & Time	Latitute & Longitude	BathyDepth	DAB	CTDDepth	CTDPres
001/02	2011-09-28 06:04:38	28 30.7650 S 14 56.9514 E	174	9.8	170	171.2
002/01	2011-09-28 09:19:41	28 42.9558 S 14 27.9870 E	263	9.8	256.3	258.3
003/01	2011-09-28 11:40:54	28 49.0176 S 14 11.0178 E	-999	8	964	973.2
004/01	2011-09-28 14:35:24	28 55.0140 S 13 58.0488 E	1738	10.5	1727.8	1747.7
005/01	2011-09-28 18:44:03	29 3.9282 S 13 32.9532 E	2175	11.7	2435.8	2468.3
006/01	2011-09-28 23:49:10	29 16.0218 S 13 3.0984 E	3139	14.8	3116.3	3163
007/01	2011-09-29 05:51:58	29 29.9964 S 12 28.4958 E	3640	9.4	3626.9	3685.6
008/01	2011-09-29 11:58:20	29 43.9902 S 11 54.0288 E	3968	10.1	3956.8	4023.7
009/03	2011-09-29 19:42:51	29 45.0858 S 11 19.5390 E	4144	8.8	4137.2	4208.9
010/01	2011-09-30 01:49:48	29 45.0366 S 10 45.0162 E	4371	8.9	4373.3	4451.6
011/01	2011-09-30 13:37:38	29 45.0060 S 10 10.4604 E	4844	10.5	4829.6	4921.4
012/01	2011-09-30 20:07:58	29 44.9832 S 9 35.9934 E	-999	10.1	4906.2	5000.3
013/01	2011-10-01 04:55:30	29 45.0342 S 9 1.5330 E	-999	9.6	4979.9	5076.2
014/01	2011-10-01 11:12:46	29 45.0210 S 8 27.0342 E	5007	11.2	5018.6	5116.1
015/01	2011-10-01 17:22:36	29 45.0492 S 7 52.5138 E	4932	10.6	4947.4	5042.6
016/01	2011-10-01 23:35:55	29 45.0330 S 7 18.0504 E	-999	9.6	5112.1	5212.4
017/01	2011-10-02 05:54:31	29 44.0754 S 6 43.4784 E	-999	7.6	5057.6	5156.3
018/01	2011-10-02 13:29:52	29 45.0030 S 6 9.0030 E	5099	10	5110.4	5210.9
019/01	2011-10-02 21:34:18	29 45.0264 S 5 34.5276 E	5068	10.2	5083.7	5183.3
020/01	2011-10-03 06:43:43	29 44.9670 S 5 0.0348 E	5059	10	5068.2	5167.4
021/01	2011-10-03 13:11:50	29 45.0030 S 4 25.4982 E	4985	10.1	4997.5	5094.3
022/01	2011-10-03 19:32:39	29 38.0760 S 3 51.0522 E	4993	10.9	5005.9	5103
023/01	2011-10-04 01:41:56	29 28.0116 S 3 18.0276 E	4694	10.3	4711	4799.2
024/01	2011-10-04 07:29:21	29 21.2280 S 2 50.3646 E	4256	9.9	4261.8	4337
025/01	2011-10-04 11:44:18	29 23.0334 S 2 41.9958 E	2859	10.9	2877.8	2918.9
026/01	2011-10-04 15:04:45	29 24.0114 S 2 36.9774 E	1795	9.8	1785.6	1806.2
027/01	2011-10-04 18:31:10	29 26.0502 S 2 26.0262 E	-999	10.6	2781	2820.1
028/01	2011-10-04 23:01:17	29 31.9842 S 1 58.0284 E	2425	9.6	2469.3	2502.2
029/01	2011-10-05 03:19:18	29 35.9808 S 1 41.5260 E	3648	9	3640.4	3699.2
030/01	2011-10-05 08:57:42	29 43.9938 S 1 6.9444 E	3695	9.9	3686.3	3746.2
031/01	2011-10-05 14:16:51	29 52.0038 S 0 32.5164 E	2963	12.3	2953.3	2996.1
032/01	2011-10-05 19:44:51	30 0.0270 S 0 1.9674 W	4088	10.7	4103	4173.7
033/01	2011-10-06 01:08:42	30 1.0194 S 0 28.9962 W	4690	9.2	4703.8	4791.5
034/01	2011-10-06 06:56:37	30 1.0260 S 1 3.5268 W	3905	9	4067.9	4137.7

SSS/CC	Date & Time	Latitute & Longitude	BathyDepth	DAB	CTDDepth	CTDPres
035/01	2011-10-06 12:15:25	29 59.9994 S 1 37.9830 W	4576	1686	2881.6	2922.8
035/02	2011-10-06 16:21:34	29 59.4492 S 1 39.1668 W	4539	10.7	4557.3	4640.8
036/01	2011-10-06 22:40:32	29 59.9814 S 2 12.5220 W	4391	10	4473.7	4554.7
037/01	2011-10-07 04:29:57	30 0.0138 S 2 46.9686 W	4267	9.7	4271.4	4346.7
038/01	2011-10-07 10:23:51	30 0.0204 S 3 21.5154 W	4573	9.8	4582	4666.2
039/01	2011-10-07 16:19:16	29 59.9940 S 3 56.0232 W	4226	9.4	4200.9	4274.2
040/01	2011-10-07 22:14:22	30 0.0534 S 4 30.5358 W	4363	10.7	4372.9	4451
041/01	2011-10-08 04:03:31	29 59.7894 S 5 5.0586 W	4138	9.8	4138.7	4210.2
042/01	2011-10-08 09:57:15	30 0.0150 S 5 39.6066 W	4329	10.3	4337.1	4414.1
043/01	2011-10-08 16:15:55	30 0.1848 S 6 14.6604 W	-999	10.3	4591.4	4675.6
044/01	2011-10-08 22:30:34	30 1.0788 S 6 48.5142 W	4058	10.1	4064	4133.5
045/01	2011-10-09 04:38:22	30 0.1218 S 7 22.8294 W	3916	27	3773.7	3835.7
046/01	2011-10-09 18:35:20	29 59.9718 S 7 57.5028 W	4125	9.6	4069.3	4139.1
047/01	2011-10-10 03:47:21	30 1.0122 S 8 31.8690 W	4071	9.3	4016.2	4084.6
048/01	2011-10-10 12:05:22	30 1.0428 S 9 6.5778 W	3794	9.9	3762.2	3824
049/01	2011-10-10 19:54:43	29 59.9346 S 9 41.0442 W	3905	14	3918.2	3984.1
050/01	2011-10-11 01:45:14	29 59.9970 S 10 15.4554 W	3838	9.4	3787.2	3849.7
051/02	2011-10-12 14:30:54	30 0.0066 S 11 7.0530 W	3577	11	3535.2	3591.4
052/01	2011-10-12 22:26:34	30 0.0120 S 11 57.6804 W	-999	14.7	3593.5	3651.1
053/01	2011-10-13 06:32:05	30 0.0024 S 12 48.8040 W	3295	9.8	3251.7	3301.1
054/01	2011-10-13 14:22:26	30 0.0018 S 13 39.8148 W	2310	20	2281.4	2310.6
055/01	2011-10-13 21:32:41	30 0.0540 S 14 25.5870 W	3060	10.7	3138	3184.8
056/01	2011-10-14 04:59:41	30 0.0252 S 15 11.3028 W	3420	10	3467.7	3522.2
057/01	2011-10-14 13:11:34	29 59.9910 S 15 57.0180 W	4003	10.4	3957.5	4024.4
058/01	2011-10-14 20:14:33	29 59.9574 S 16 42.7566 W	3604	7.8	3530.2	3586.1
059/01	2011-10-15 03:23:24	29 59.9982 S 17 28.4778 W	4190	10	4134.6	4206.1
060/01	2011-10-15 11:10:45	30 1.0080 S 18 14.1786 W	4389	9.6	4333.3	4410.4
061/01	2011-10-15 17:54:45	29 59.9766 S 18 59.9646 W	3918	9.5	3809.6	3872.5
062/01	2011-10-16 01:29:08	30 0.0234 S 19 45.2292 W	4378	10.1	4403.8	4482.8
063/01	2011-10-16 08:31:45	30 0.0546 S 20 30.5838 W	4507	10.4	4570.4	4654.2
064/01	2011-10-16 16:56:47	29 59.9892 S 21 15.8094 W	4752	9.9	4689.3	4776.6
065/01	2011-10-17 01:15:27	29 59.9922 S 22 1.2966 W	4746	12.2	4704.8	4792.5
066/01	2011-10-17 09:02:15	30 0.0054 S 22 46.6740 W	4655	9.8	4584.3	4668.5
067/01	2011-10-17 17:44:07	29 59.9850 S 23 31.9260 W	4945	10.2	4921.3	5015.8
068/01	2011-10-18 01:13:29	30 1.0086 S 24 17.3148 W	-999	10.1	4819.9	4911.2
069/01	2011-10-18 08:54:44	30 1.0170 S 24 58.6452 W	5715	9.5	5638.5	5756.4
070/01	2011-10-18 18:47:03	29 59.9076 S 25 39.6342 W	4843	9.4	4803.3	4894.1
071/01	2011-10-19 02:08:01	29 59.8968 S 26 21.0594 W	4824	9.2	4764.2	4853.9
072/01	2011-10-19 09:26:36	30 0.0762 S 27 2.3418 W	4650	9.6	4670.7	4757.6
073/01	2011-10-19 17:01:58	29 59.9016 S 27 43.7364 W	4423	9.5	4377.7	4456
074/01	2011-10-19 23:31:20	29 59.9868 S 28 25.5096 W	3747	10.7	3718.5	3779.1
075/01	2011-10-20 06:04:35	30 0.2262 S 28 59.1636 W	3188	8.4	3149	3195.9
076/01	2011-10-20 11:54:06	30 0.0036 S 29 29.9406 W	2262	10.5	2235.7	2264
077/01	2011-10-20 16:45:49	30 0.0330 S 29 49.1346 W	3296	9.4	3261.5	3311
078/01	2011-10-20 22:40:04	30 0.0192 S 30 10.1184 W	3838	9.9	3787.3	3849.6
079/01	2011-10-21 04:36:41	29 59.9820 S 30 44.5152 W	4053	9.4	4000	4067.9
080/01	2011-10-21 10:55:18	29 59.9898 S 31 19.0116 W	-999	10.1	4055	4124.4
081/01	2011-10-21 16:37:01	29 59.9952 S 31 53.5050 W	3984	10.1	3930.8	3996.8
082/01	2011-10-21 22:06:42	29 58.9794 S 32 27.9834 W	3764	9.8	3714.1	3774.5
083/01	2011-10-22 03:32:24	30 0.0060 S 33 2.4924 W	3521	9.8	3477.5	3532
084/01	2011-10-22 08:43:35	29 59.9748 S 33 37.0416 W	2953	10.5	2929	2971
085/01	2011-10-22 12:36:46	30 0.0366 S 33 58.0422 W	2205	9.4	2181	2208.2

SSS/CC	Date & Time	Latitute & Longitude	BathyDepth	DAB	CTDDepth	CTDPres
086/01	2011-10-22 16:05:52	30 0.1362 S 34 20.7492 W	1419	10.6	1401.2	1415.8
087/01	2011-10-22 20:10:45	30 0.0066 S 34 55.0458 W	1881	10.3	1856.3	1878
088/01	2011-10-23 00:30:17	30 0.0612 S 35 29.5266 W	2246	11.7	2249.1	2277.6
089/01	2011-10-23 04:52:18	29 59.1246 S 36 3.9090 W	1700	8.6	1716	1735.4
090/01	2011-10-23 09:03:26	30 0.1662 S 36 32.0370 W	1858	9.2	1833.2	1854.5
091/01	2011-10-23 13:57:35	29 59.9886 S 37 8.7252 W	2289	9.4	2274.1	2303
092/01	2011-10-23 18:58:28	29 59.9994 S 37 28.0194 W	2848	10.2	2824.3	2864.1
093/01	2011-10-24 00:09:23	30 0.0330 S 37 33.9798 W	3524	10.5	3485.9	3540.7
094/01	2011-10-24 05:16:13	30 0.0174 S 38 0.9864 W	3916	9.1	3856.8	3920.8
095/01	2011-10-24 11:21:36	30 0.0114 S 38 29.9958 W	4255	10	4202.7	4276.1
096/01	2011-10-24 19:29:08	30 1.0104 S 38 54.9912 W	4300	9.7	4232.7	4306.9
097/01	2011-10-25 00:52:17	30 0.0018 S 39 23.0226 W	4934	10.1	4846	4938.2
098/01	2011-10-25 06:21:53	30 0.0078 S 39 31.9956 W	4020	9.5	3960	4026.8
099/01	2011-10-25 11:16:40	30 0.0084 S 39 49.9674 W	3364	12.1	3310.9	3361.6
100/01	2011-10-25 16:46:54	29 53.0244 S 40 21.8736 W	4268	10.3	4201.4	4274.7
101/01	2011-10-25 22:42:51	29 47.0082 S 40 39.0774 W	3735	11.3	3681.2	3740.8
102/01	2011-10-26 04:43:49	29 38.1030 S 41 7.2132 W	3809	9.4	3757.2	3818.7
103/01	2011-10-26 11:42:58	29 29.2314 S 41 35.4204 W	3774	135.6	3712.6	3773
104/01	2011-10-26 21:38:18	29 20.7240 S 42 2.8140 W	2539	12.5	3842	3905.7
105/01	2011-10-27 07:01:17	29 11.3184 S 42 31.9950 W	4068	10.3	3995.8	4063.5
106/01	2011-10-27 12:32:20	29 2.4216 S 43 0.2424 W	4073	9.6	3999.9	4067.8
107/01	2011-10-27 18:00:08	28 53.4852 S 43 28.5498 W	-999	11.1	3936.5	4002.7
108/01	2011-10-27 23:44:03	28 44.6058 S 43 56.7444 W	3834	10.3	3763.7	3825.5
109/01	2011-10-28 05:07:41	28 35.7000 S 44 24.9912 W	3715	9.2	3649.4	3708.3
110/01	2011-10-28 10:18:45	28 26.7864 S 44 53.2254 W	3511	9.8	3454.3	3508.5
111/01	2011-10-28 15:33:17	28 17.8320 S 45 21.4986 W	3135	10.8	3082.4	3127.8
112/01	2011-10-28 20:18:41	28 8.9094 S 45 49.7262 W	2753	10.7	2710	2747.4
113/01	2011-10-29 01:02:12	28 0.0042 S 46 18.0162 W	2266	10.3	2223.9	2251.8
114/01	2011-10-29 05:50:40	27 56.9964 S 46 28.0032 W	-999	10.1	1742.7	1762.3
115/01	2011-10-29 10:13:41	27 55.0182 S 46 39.0426 W	1307	9.1	1285.6	1298.5
116/01	2011-10-29 13:38:46	27 52.0098 S 46 50.0628 W	-999	9.6	777.8	784.4
117/01	2011-10-29 15:58:05	27 48.0360 S 47 5.9814 W	501	10.5	486.6	490.3
118/01	2011-10-29 18:02:28	27 44.0028 S 47 22.8090 W	177	10.8	174.1	175.2
119/01	2011-10-29 20:01:51	27 40.1676 S 47 40.1256 W	117	10.7	122.1	122.8
120/01	2011-10-29 22:03:50	27 35.9868 S 47 56.9232 W	92	10.7	94.1	94.7

Bottle Data Quality Code Summary and Comments

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

Table 12.2 A10 Water Sample Quality Code Summary

Property	1	2	3	4	5	6	7	8	9	Total
Bottle	0	2764	11	13	0	0	0	0	28	2816
blackc	46	0	0	0	0	0	0	0	0	46
CFC-11	0	2297	2	10	19	0	0	0	6	2334
CFC-12	0	2296	3	10	19	0	0	0	6	2334
CCl_4	0	775	1525	9	19	0	0	0	6	2334
SF_6	0	2279	14	16	19	0	0	0	6	2334
^3He	424	0	0	0	0	0	0	0	0	424
Ammonium	0	0	0	0	2749	0	0	0	0	2749
o18o16	290	0	0	0	0	0	0	0	0	290
O_2	0	2728	0	1	1	0	0	0	0	2730
ph	0	2420	53	29	81	0	0	0	1	2584
pigments	378	0	0	0	0	0	0	0	0	378
DIC	0	1816	30	8	14	253	0	0	272	2393
Total Alkalinity	0	2364	161	23	52	0	0	0	7	2607
DOC	1380	0	0	0	0	0	0	0	0	1380
TDN	1380	0	0	0	0	0	0	0	0	1380
Tritium	347	0	0	0	0	0	0	0	0	347
Nitrate	0	2733	0	0	16	0	0	0	0	2749
Nitrite	0	2733	0	0	16	0	0	0	0	2749
Phosphate	0	2733	0	0	16	0	0	0	0	2749
Silicic Acid	0	2733	0	0	16	0	0	0	0	2749
Salinity	0	2558	33	5	37	114	0	0	2	2749

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

Table 12.3 A10 Bottle Quality Codes and Comments

Station /Cast	Sample Number	Property	Quality Code	Comment
1/2	205	Bottle	2	Spigot ring snapped. Samples acceptable.
1/2	205	Salinity	3	Salt high vs CTDS. High gradient zone.
2/1	107	Salinity	3	Salt high vs CTDS. High gradient zone.
2/1	108	Bottle	2	Small leak on 8 at stopcock.
2/1	108	Salinity	3	Salt high vs CTDS. High gradient zone.
3/1	112	Bottle	2	Niskin 12 slightly dripping at stopcock.
4/1	112	Bottle	2	Still leaking. Replace seals.
5/1	108	Bottle	2	Stopcock dripping.
8/1	108	Bottle	3	Vent valve open.
8/1	109	Bottle	9	Bumped open niskin on recovery. Skipped.

Station /Cast	Sample Number	Property	Quality Code	Comment
9/3	312	Bottle	2	Slow leak.
10/1	101	Bottle	2	Water possibly leaked in during a ˜40m slip of winch. Samples acceptable.
10/1	102	Bottle	2	Water possibly leaked in during a ˜40m slip of winch. Samples acceptable.
10/1	103	Bottle	2	Water possibly leaked in during a ˜40m slip of winch. Samples acceptable.
10/1	104	Bottle	2	Water possibly leaked in during a ˜40m slip of winch. Samples acceptable.
10/1	105	Bottle	2	Water possibly leaked in during a ˜40m slip of winch. Samples acceptable.
10/1	106	Bottle	2	Water possibly leaked in during a ˜40m slip of winch. Samples acceptable.
10/1	107	Bottle	2	Water possibly leaked in during a ˜40m slip of winch. Samples acceptable.
10/1	108	Bottle	2	Water possibly leaked in during a ˜40m slip of winch. Samples acceptable.
10/1	109	Bottle	2	Water possibly leaked in during a ˜40m slip of winch. Samples acceptable.
10/1	110	Bottle	2	Water possibly leaked in during a ˜40m slip of winch. Samples acceptable.
10/1	111	Bottle	2	Water possibly leaked in during a ˜40m slip of winch. Samples acceptable.
10/1	112	Bottle	2	Water possibly leaked in during a ˜40m slip of winch. Samples acceptable.
10/1	113	Bottle	2	Bottle tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
10/1	114	Bottle	2	Bottle tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
10/1	115	Bottle	2	Bottle tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
10/1	116	Bottle	2	Bottle tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
10/1	117	Bottle	2	Bottle tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
10/1	118	Bottle	2	Bottle tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
10/1	119	Bottle	2	Bottle tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
10/1	120	Bottle	2	Bottle tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
10/1	121	Bottle	2	Bottle tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
10/1	122	Bottle	2	Bottle tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
10/1	123	Bottle	2	Bottle tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
10/1	124	Bottle	2	Bottle tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
11/1	106	Bottle	2	Stop cock on 6 was pushed in.
11/1	119	Salinity	2	Salt low vs CTDS. High gradient zone.
11/1	120	Salinity	2	Salt low vs CTDS. High gradient zone.
12/1	120	Bottle	2	Dripping leak.
13/1	123	Bottle	2	Leaky bottle.
15/1	119	Salinity	3	Salt high vs CTDS. High gradient zone.
15/1	120	Salinity	3	Salt high vs CTDS. High gradient zone.
15/1	124	Bottle	3	Lanyard caught in bottom. Serious leak.
16/1	108	Bottle	2	Niskni dripping slowly.
16/1	120	Bottle	2	Slight leak.
17/1	105	Bottle	2	Slight leak after first use.
17/1	123	Bottle	2	Dripping on recovery.
18/1	105	Bottle	2	Leaking nozzle.
18/1	112	Bottle	2	Leaking nozzle.
19/1	115	Bottle	4	Lost communication. Fired bottles manually. Depths uncertain.
19/1	115	Salinity	4	Likely mistrip. O2 values also consistent with mistrip.
19/1	116	Bottle	4	Lost communication. Fired bottles manually. Depths uncertain.
19/1	116	Salinity	4	Likely mistrip. O2 values also consistent with mistrip.
19/1	117	Bottle	4	Lost communication. Fired bottles manually. Depths uncertain.
19/1	118	Bottle	4	Lost communication. Fired bottles manually. Depths uncertain.
19/1	119	Bottle	4	Lost communication. Fired bottles manually. Depths uncertain.
19/1	120	Bottle	2	eaking
19/1	121	Bottle	4	Lost communication. Fired bottles manually. Depths uncertain.
19/1	122	Bottle	4	Lost communication. Fired bottles manually. Depths uncertain.
19/1	123	Bottle	2	Valve not closed.
19/1	124	Bottle	4	Lost communication. Fired bottles manually. Depths uncertain.

Station /Cast	Sample Number	Property	Quality Code	Comment
20/1	122	Bottle	4	Niskin 22 didn’t fire. Skipped and fired 23 instead. 22 and 23 likely have the same water.
20/1	122	Salinity	3	Same value as 23. Consistent with being tripped with 23.
20/1	123	Bottle	4	Niskin 22 didn’t fire. Skipped and fired 23 instead. 22 and 23 likely have the same water.
20/1	124	Bottle	4	Closed at 20db instead of at surface.
21/1	124	Salinity	5	Sample not reported.
26/1	111	Salinity	3	Salt high vs CTDS. High gradient zone.
26/1	116	Salinity	3	Salt high vs CTDS. High gradient zone.
26/1	117	Salinity	3	Salt high vs CTDS. High gradient zone.
27/1	106	Salinity	5	Sample not reported.
27/1	124	Salinity	5	Sample not reported.
28/1	103	Bottle	2	Slightly dripping.
28/1	105	Bottle	2	Stopcock is loose.
28/1	113	Salinity	3	Salt low vs CTDS. High gradient zone.
28/1	114	Salinity	3	Salt low vs CTDS. High gradient zone.
28/1	115	Salinity	3	Salt low vs CTDS. High gradient zone.
28/1	119	Bottle	3	Valve is open.
29/1	109	Bottle	9	Lanyard caught in bottom lid. Major leak. No samples taken.
30/1	120	Salinity	3	Salt low vs CTDS. High gradient zone.
31/1	118	Salinity	3	Salt high vs CTDS. High gradient zone.
33/1	120	Salinity	3	Salt low vs CTDS. High gradient zone.
35/2	212	Bottle	3	Drip. Serious leaking.
36/1	112	Bottle	3	ripping
37/1	112	Bottle	2	ripping
37/1	123	Bottle	2	ripping
38/1	110	Bottle	9	Lanyard caught in bottom endcap.
39/1	111	O2	4	Both O2,Salt values are way off profile.
39/1	111	Salinity	4	Both O2,Salt values are way off profile.
41/1	121	Salinity	3	Salt high vs CTDS.
42/1	116	Salinity	3	Samples 16,17 seem to have been interchanged. Switched back.
42/1	117	Salinity	3	Samples 16,17 seem to have been interchanged. Switched back.
42/1	122	Bottle	3	Lanyard caught. Leaking.
42/1	123	Bottle	2	Small drip but stopped.
43/1	113	Bottle	2	Sea snot.
43/1	114	Salinity	3	Questionable value.
43/1	123	Bottle	2	Top vent open slightly.
44/1	122	Bottle	9	Lanyard caught in bottom endcap.
45/1	104	Bottle	3	Valve not closed.
45/1	106	Salinity	3	Samples seem to have been drawn from previous niskin (eg-5 on 4). Fixed.
45/1	107	Salinity	3	Samples seem to have been drawn from previous niskin (eg-5 on 4). Fixed.
45/1	108	Salinity	3	Samples seem to have been drawn from previous niskin (eg-5 on 4). Fixed.
45/1	109	Salinity	3	Samples seem to have been drawn from previous niskin (eg-5 on 4). Fixed.
45/1	110	Salinity	3	Samples seem to have been drawn from previous niskin (eg-5 on 4). Fixed.
45/1	111	Salinity	3	Samples seem to have been drawn from previous niskin (eg-5 on 4). Fixed.
45/1	112	Salinity	3	Samples seem to have been drawn from previous niskin (eg-5 on 4). Fixed.
45/1	113	Salinity	3	Samples seem to have been drawn from previous niskin (eg-5 on 4). Fixed.
45/1	114	Salinity	3	Samples seem to have been drawn from previous niskin (eg-5 on 4). Fixed.
45/1	115	Salinity	3	Samples seem to have been drawn from previous niskin (eg-5 on 4). Fixed.
45/1	116	Salinity	3	Samples seem to have been drawn from previous niskin (eg-5 on 4). Fixed.
45/1	117	Salinity	3	Samples seem to have been drawn from previous niskin (eg-5 on 4). Fixed.

Station /Cast	Sample Number	Property	Quality Code	Comment
45/1	118	Salinity	3	Samples seem to have been drawn from previous niskin (eg-5 on 4). Fixed.
45/1	119	Salinity	3	Samples seem to have been drawn from previous niskin (eg-5 on 4). Fixed.
46/1	123	Bottle	2	Valve not closed.
48/1	118	Salinity	3	Salt low vs CTDS. High gradient zone.
48/1	119	Salinity	3	Salt low vs CTDS. High gradient zone.
48/1	120	Salinity	3	Salt low vs CTDS. High gradient zone.
48/1	121	Salinity	3	Salt low vs CTDS. High gradient zone.
49/1	103	Bottle	2	arm
51/2	203	TAlk	4	small bubble in cell
52/1	116	O2	4	Value looks to be off by half. Analytical or sampling problems are likely
52/1	118	TAlk	3	cell slow to close
53/1	118	Salinity	3	Salt low vs CTDS. High gradient zone.
53/1	119	Salinity	3	Salt low vs CTDS. High gradient zone.
53/1	120	Salinity	3	Salt low vs CTDS. High gradient zone.
54/1	122	Salinity	3	Salt low vs CTDS. High gradient zone.
55/1	117	Bottle	2	Valve not closed.
55/1	118	Salinity	3	Salt low vs CTDS. High gradient zone.
55/1	119	Salinity	3	Salt low vs CTDS. High gradient zone.
55/1	120	Salinity	3	Salt low vs CTDS. High gradient zone.
55/1	124	Bottle	3	Lanyard caught in bottom cap.
55/1	124	O2	5	Oxygen not reported.
56/1	111	Bottle	4	Unusually warm. Suspected leak or mistrip.
56/1	111	Salinity	4	Likely drawn from niskin 9.
56/1	112	Bottle	3	Lanyard form Niskin 11 caught in cap.
56/1	123	Bottle	3	Valve open.
58/1	121	Salinity	3	Samples seem to have been interchanged. Switched.
58/1	122	Salinity	3	Samples seem to have been interchanged. Switched.
58/1	122	TAlk	4	bubble in cell
60/1	101	TAlk	3	unreliable titrations for station
60/1	117	Salinity	3	Samples seem to have been interchanged. Switched.
60/1	118	Salinity	3	Samples seem to have been interchanged. Switched.
61/1	117	Salinity	4	Likely drawn from niskin 18. O2 doesn’t have similar error so misdraw likely.
62/1	121	Bottle	2	Valve not tight.
69/1	117	Salinity	4	Sample or analysis error likely.
71/1	115	Salinity	3	Samples 15,16 seem to have been interchanged. Switched.
71/1	116	Salinity	3	Samples 15,16 seem to have been interchanged. Switched.
71/1	119	Salinity	3	Samples 19,20 seem to have been interchanged. Switched.
71/1	120	Salinity	3	Samples 19,20 seem to have been interchanged. Switched.
72/1	115	Salinity	3	Samples 15,16 seem to have been interchanged. Switched.
72/1	116	Salinity	3	Samples 15,16 seem to have been interchanged. Switched.
73/1	114	Salinity	3	Samples 14,15 seem to have been interchanged. Switched.
73/1	115	Salinity	3	Samples 14,15 seem to have been interchanged. Switched.
74/1	118	Bottle	9	Lanyard from niskin 17 caught in 18’s bottom cap.
83/1	109	Bottle	3	Vent valve open.
93/1	103	Bottle	9	Vent valve open.
93/1	118	Salinity	4	Likely drawn from niskin 19.
96/1	124	Bottle	3	Lanyard caught in bottom end cap. Removed and reseated cap.
97/1	123	Bottle	4	Accidentally fired at same depth as Niskin 22.
99/1	124	Bottle	3	Lanyard from 23 caught in bottom endcap.
101/1	113	Salinity	3	Samples likely interchanged. Switched.
101/1	114	Salinity	3	Samples likely interchanged. Switched.

Station /Cast	Sample Number	Property	Quality Code	Comment
107/1	115	Bottle	2	Sea snot on nozzle.
108/1	124	Salinity	4	Draw or analysis error likely.
109/1	110	Salinity	3	Likely drawn from Niskin 11. Switched.
109/1	111	Salinity	3	Likely drawn from Niskin 12. Switched.
109/1	112	Salinity	3	Likely drawn from Niskin 10. Switched.
113/1	122	Bottle	2	ripping

References

Joyc94.

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