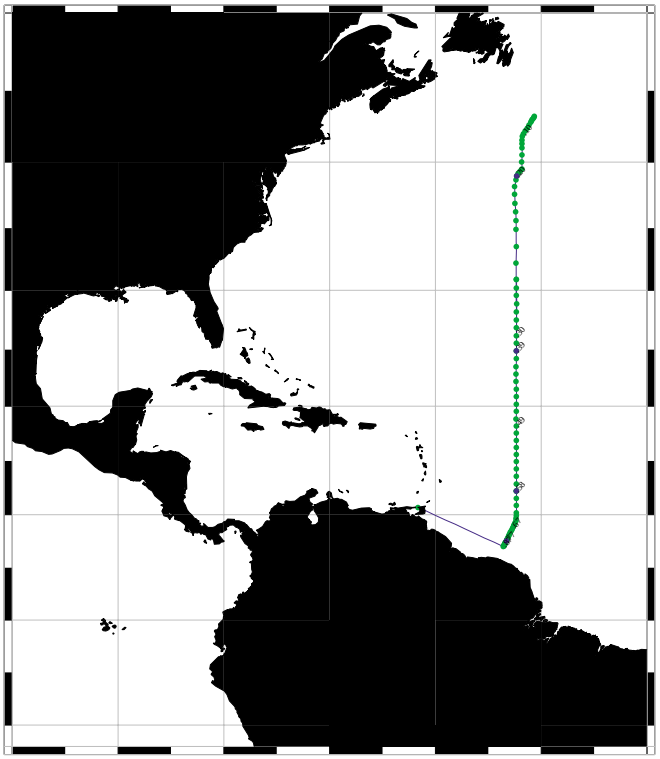
CRUISE REPORT: A20_2003a

(Updated: APR 2009)

Highlights



WHP Cruise Summary Information

WOCE section designation	**A20_2003a**
Expedition designation (ExpoCode)	**316N200309**
Chief Scientists and their affiliation	**Dr. John Toole / WHOI** **Dr. Alison MacDonald / WHOI**
Dates	2003 September 22 - 2003 October 20
Ship	*R/V Knorr*
Ports of call	Woods Hole, Ma. - Port of Spain, Trinidad
Number of stations	88
Stations' Geographic boundaries	43°14.98'N 61°38.8'W 50°36.97'W 6°58.63'N
Floats and drifters deployed	5 profiling ARGO floats
Moorings deployed or recovered	0
Contributing Authors	None listed
Data Submitted by:	Oceanographic Data Facility Scripps Institution of Oceanography La Jolla, Ca 92093-0214

WHP Cruise and Data Information

Click on headings below to locate primary reference or use navigation tools above. (Shaded headings were not available when this report was assembled)

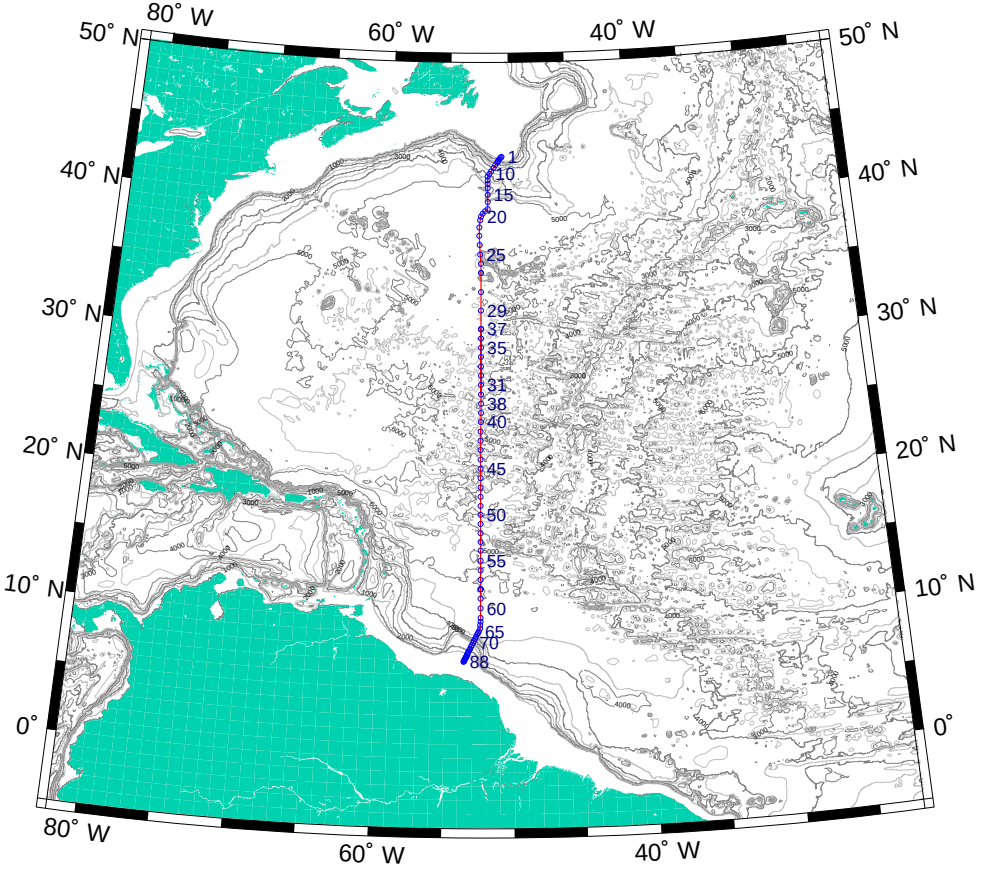
Cruise Summary Information	**Hydrographic Measurements**
Description of scientific program	**CTD Data**
	CTD - general
Geographic boundaries of the survey	CTD - pressure
Cruise track SIO PI	CTD - temperature
Description of stations	CTD - conductivity/salinity
Description of parameters sampled	CTD - dissolved oxygen
Bottle depth distributions (figures)	
Floats and drifters deployed	**Bottle Data**
Moorings deployed or recovered	Salinity
	Oxygen
Principal Investigators for all measurements	Nutrients
Cruise Participants	CFCs
	Helium
Problems and goals not achieved	Tritium
Other incidents of note	Radiocarbon
	CO_2 system parameters
Underway Data Information	Other parameters
Navigation	**DQE Reports**
Bathymetry	CTD
Acoustic Doppler Current Profiler (ADCP)	S/O_2/nutrients
Thermosalinograph and related measurements	CFCs
XBT and/or XCTD	^{14}C
Meteorological observations	
Atmospheric chemistry data	
Acknowledgments	**Data Processing Notes**

References

Measurement Techniques

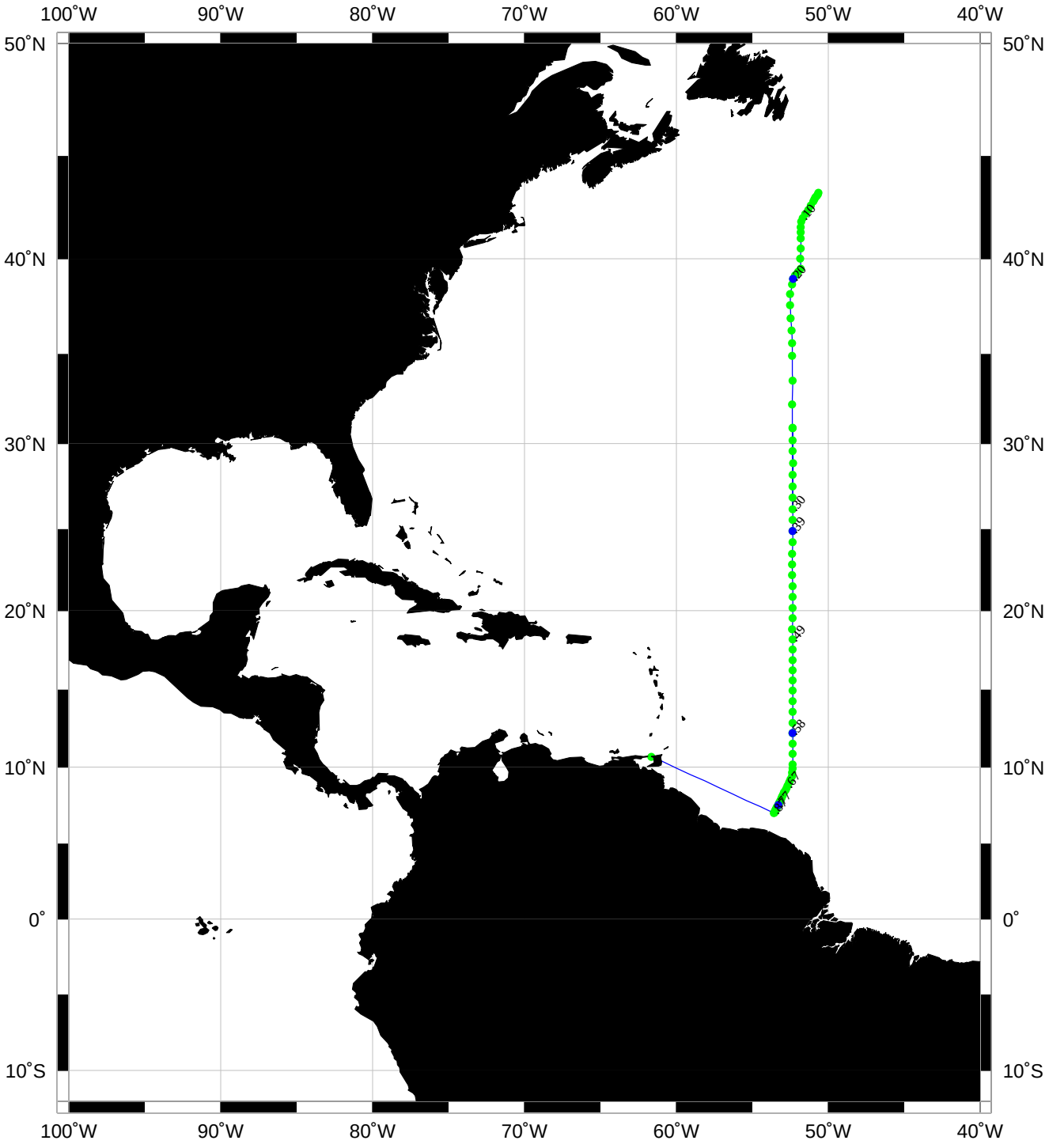
Dissolved Inorganic Carbon

A20-2003a • *R/V Knorr* • Toole / MacDonald



Submitted by ODF

Station locations for A20_2003a • Toole/MacDonald



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Summary

A hydrographic survey consisting of LADCP/CTD/rosette sections and float deployments in the western North Atlantic was carried out September to October 2003. The R/V Knorr departed Woods Hole, Ma. on 22 September 2003. A total of 88 LADCP/CTD/Rosette stations were occupied, and 5 profiling ARGO floats were deployed from 24 September - 18 October. Water samples (up to 36), LADCP and CTD data were collected in most cases to within 10 meters of the bottom. Salinity, dissolved oxygen and nutrient samples were analyzed from every bottle sampled on the rosette. The cruise ended in Port of Spain, Trinidad on 20 October 2003.

Introduction

Knorr cruise 173 was conceived to reoccupy two meridional hydrographic sections in the western North Atlantic as part of the CLIVAR/Global Carbon Program of repeat hydrography. The section designated "A20" by the World Ocean Circulation Program that lies nominally along 52° 20'W was sampled during leg 1. The return leg to Woods Hole reoccupied the A22 section along 66° W. Meridional hydrographic sections near 52° W had been made on three occasions prior to our cruise: in the 1950's, 1980's, and in 1997. The sampling plan for the 2003 occupation was simply to make a full-depth hydrographic station at (virtually) each site sampled in 1997. (The extremely tight station spacing at the northern end of the section done in 1997 was relaxed slightly in 2003.)

A sea-going science team gathered from ten oceanographic institutions around the U.S. participated on the cruise. Several other science programs were supported with no dedicated cruise participant. The science party and their responsibilities are listed below:

Science party and responsibilities

John Toole	Chief Scientist	WHOI
Alison Macdonald	Co-Chief Scientist	WHOI
Rebecca Zanzig	Student participant	UW

Hydrographic Operations and Data Analysis

Scott Allen		SIO
Ruth Curry		WHOI
Frank Delahoyde		SIO
Carl Mattson		SIO

Water sample analysts

John Calderwood	Oxygen	SIO
Bettina Sohst	Oxygen	UCSC
Susan Becker	Nutrients	SIO
Erik Quiroz	Nutrients	U. Southern Miss.
Deborah LeBel	CFC	LDEO
James Happell	CFC	RSMAS
Eugene Gorman	CFC	LDEO
Ryan Ghan	CFC	LDEO
Marilyn Roberts	DIC	PMEL
Kevin Sullivan	DIC	AOML
George Anderson	TALK	SIO
J. Martin Hernandez Ayon	TALK	SIO
Josh Curtis	He-3/Tritium	WHOI
Norm Nelson	CDOM,DOC,DON	UCSB

Jonathan Klamberg	CDOM,DOC,DON	UCSB
Stuart Goldberg	CDOM,DOC,DON	UCSB
Tim Newberger	LADCP	LDEO

R/V Knorr Science Technicians

Robert Laird
Amy Simoneau

Other science programs

Shipboard ADCP	Eric Firing	U. Hawaii
	Jules Hummon	U. Hawaii
Surface C14	Ann McNichol	WHOI
	Robert Key	Princeton
C13 profiles	Paul Quay	UW
Profiling ARGO floats	Allyn Clarke	BIO, Canada
Transmissometer profiles	Wilf Gardner	TAMU

Cruise Narrative

Skirting Hurricane Fabian during her transit from the Mediterranean, the R/V Knorr arrived back in Woods Hole on schedule and was available for loading during the week of September 15. Most groups took full advantage of this time to set up and test their instrumentation. Fortunately the threat that Hurricane Isabel would disrupt these activities was averted when that storm passed well inland of the Cape. Departure from Woods Hole occurred at 1300 local on September 22 in fine weather.

Unlike in 1997 when the section was staged out of Halifax, Nova Scotia, we were immediately faced with a 3-day transit to the head of the section at the southern tip of the Grand Banks. Enroute to the Banks, a full-depth test station was occupied in approximately 4000 m of water on Sept. 24. Station 1 of the A20 section was occupied in the evening of September 25.

Study of satellite-derived sea surface temperature images, both relayed from shore and captured directly aboard Knorr with the Terascan system, suggested the presence of a warm water flare extending north from the Gulf Stream that nearly paralleled our planned station track. We therefore diverged from the 1997 station plan at station 11, orienting the next set of casts along 51° 48' W to sample east of the flare. After grazing the western edge of a small Gulf Stream Ring, the section extended south on this meridian within a trough (southward meander) of the Stream until intersecting the "North Wall" at station 17. Shipboard ADCP data showed strong surface currents directed to the Southeast here, and so the station track was adjusted to the Southwest to cross the Gulf Stream more-or-less perpendicularly to the flow. As the surface currents turned more zonal with distance south, the section track was oriented more meridionally.

Profiling drifting floats supplied by Allyn Clarke (Bedford Institute of Oceanography) were deployed at predetermined sites along this segment of the A20 track. During this period, Hurricane Juan formed and moved north to our west, eventually striking Haifax, Nova Scotia.

By station 26 at Lat. 35.5° N we were across the main core of the Gulf Stream and back on the 1997 station plan that placed stations every 40 nmi through the center of the subtropical gyre. But intensifying to our east was Hurricane Kate that forecasts showed would soon intersect our cruise track. Hoping to extend south of her projected course, station spacing was widened to 80 nmi (skipping every other planned station) between latitudes 34.8° and 33.5° N (Stas. 27-29). Facing increasing winds and swells, the planned station at 30° 51'N was deferred and we ran south to escape the storm.

Sampling resumed with Station 30 situated at 26.2° N on the nominal A20 meridian, with subsequent stations directed back to the north at 40 nmi spacing. By adjusting weight on the water-sampler frame and reducing lowering/raising rates on the sea cable, we were able to slowly work our way back to the

deferred station site despite rather confused swell and wave conditions. Sea cable re-terminations were required after several of these stations to remove wire kinks presumably caused by snap loading of the sea cable caused by ship roll/heave. Upon completion of the station at 30° 51' N (number 37) we transited back south to resume working the line. During the transit (referred to by one New Englander as a "school snow day") many of the science party and crew put up with very poor radio reception to cheer the Red Sox to victory in Game 5 against the A's. Station 38 at Lat. 25.5° N was occupied in the late afternoon of October 7 in much improved weather and sea conditions.

The station work was continued south as planned along the nominal A20 longitude to station 64 in excellent weather conditions. Thereafter, the cruise track was directed to the southwest in order to perpendicularly cross the bathymetric contours off the Surinam coast. At this time, tropical storm/hurricane Nicholas began to form east of our track about Longitude 48° W. Fortunately it was far enough west and north of our position that it did not impact our sampling. However, dense cloud cover and rain were experienced for the fi rst time on the cruise, impacting the UCSB incubation experiments.

During the up-cast of Station 66, one of the electrical conductors in the sea cable developed a short to ground. The underwater package was recovered and operations were shifted to the other winch/wire system. A second cast was made at this site to pick up the upper-ocean water samples that were missed after the wire problem. Just landward of Station 66, we crossed into the territorial waters of Surinam. All underway data fi les were closed and reopened at this point to facilitate delivery of territorial-waters data to Surinam. During station work on the evening of October 17/18 the R/V Knorr contingent of Red Sox Nation was agonized by their team's loss of ALCS game 7 to the Yankees.

Hydrographic sampling on the A20 line was completed on October 18 at 02:51 GMT with station 88 at 6° 59.0' N, 53° 34.2' W in 77 m of water. The vessel was then directed to Trinidad, arriving off Port O'Spain in the morning of October 20. R/V Knorr was secured quayside by 09:10 and was cleared shortly thereafter.

Apart from the three stations that were skipped about the middle of the subtropical gyre when we were running from Hurricane Kate, all other planned hydrographic stations were successfully occupied. The science parties and the offi cers and crew of the R/V Knorr are to be commended for their hard work and careful measurements. All of the sampling teams were briefed on the schedule for submitting preliminary and fi nal data sets and agreed to meet the target submission dates.

1. Description of Measurement Techniques

1.1. CTD/Hydrographic Measurements Program

The basic CTD/hydrography program consisted of salinity, dissolved oxygen and nutrient measurements made from bottles taken on CTD/rosette casts, plus pressure, temperature, salinity, dissolved oxygen and transmissometer from CTD profi les. A total of 92 CTD/rosette casts were made, usually to within 10 meters of the bottom. No major problems were encountered during the operation. The distribution of samples is illustrated in fi gures 1.1.0, 1.1.1, 1.1.2, and 1.1.3.

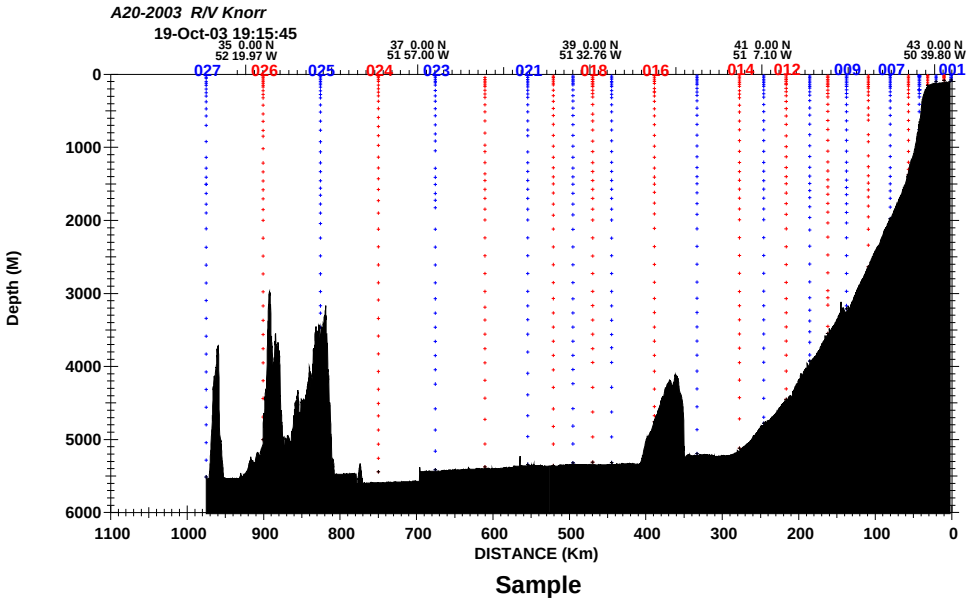

Figure 1.1.0 Sample distribution, stations 1-27.

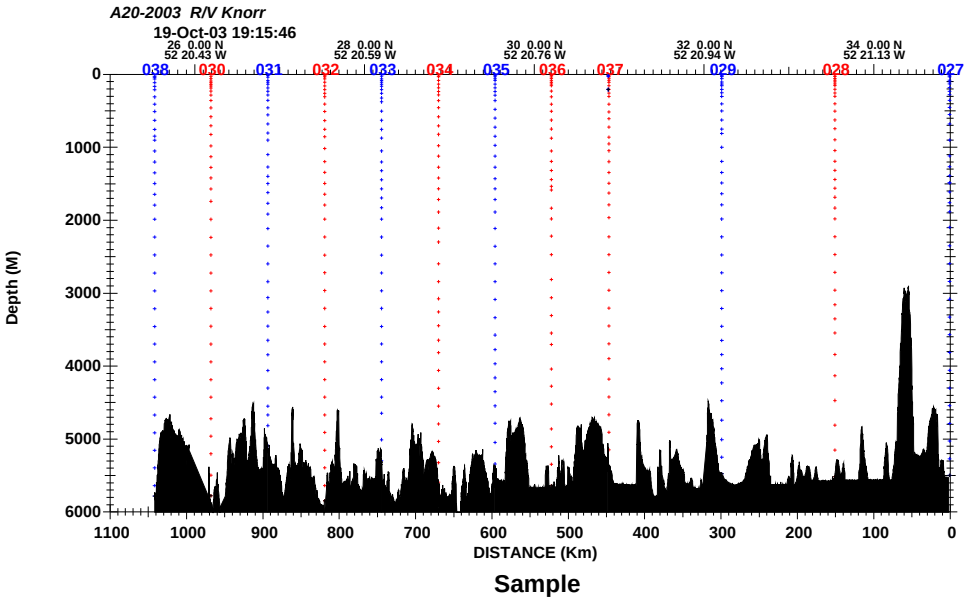

Figure 1.1.1 Sample distribution, stations 27-38.

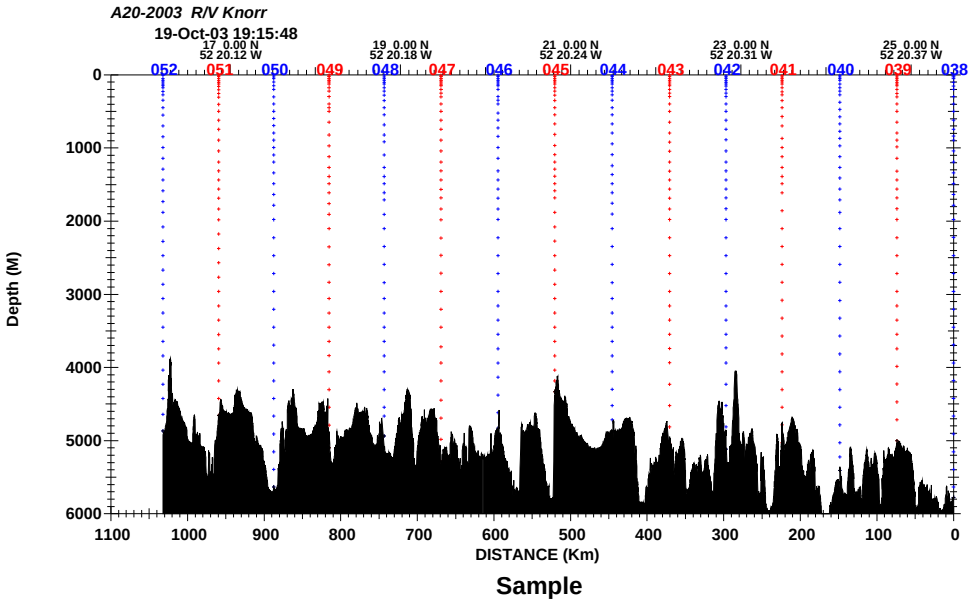

Figure 1.1.2 Sample distribution, stations 38-52.

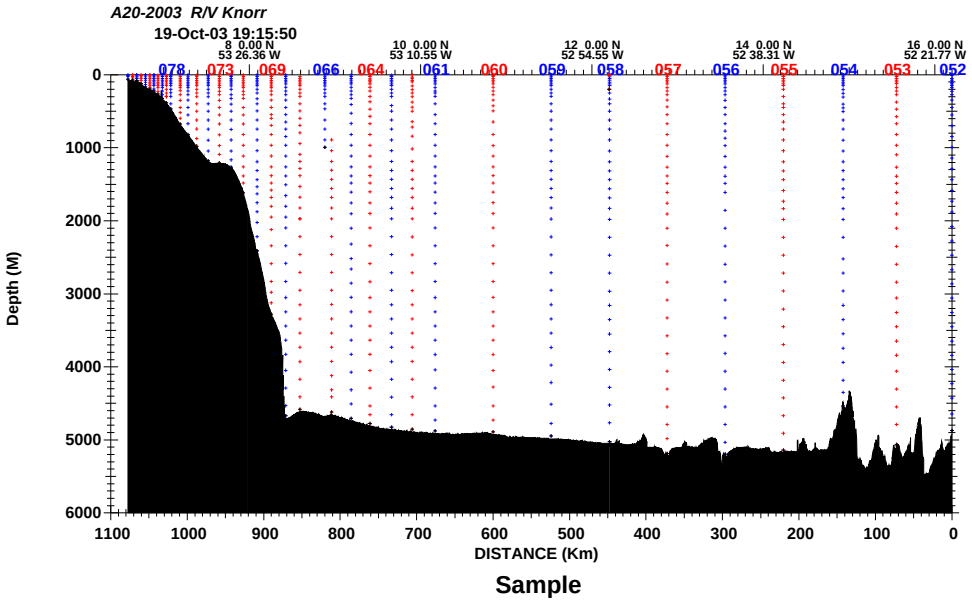

Figure 1.1.3 Sample distribution, stations 52-88.

1.2. Water Sampling Package

LADCP/CTD/rosette casts were performed with a package consisting of a 36-bottle rosette frame (ODF), a 36-place pylon (SBE32) and 36 10-liter Bullister bottles (ODF). Underwater electronic components consisted of a Sea-Bird Electronics (SBE) 9*plus* CTD (ODF #474) with dual pumps, dual temperature (SBE3), dual conductivity (SBE4), dissolved oxygen (SBE43), transmissometer (Wetlabs C-Star) and fluorometer (Seapoint Sensors); an SBE35RT Digital Reversing Thermometer, RDI LADCPs (Workhorse 300khz/Broadband 150khz) and a Simrad 1007 altimeter.

The CTD was mounted horizontally along one side of the bottom center of the rosette frame. The SBE sensors and pumps were deployed horizontally along the CTD pressure case, as were the transmissometer and fluorometer. The LADCP battery pack was mounted alongside and outboard from

the CTD. The LADCPs were vertically mounted inside the bottle rings on the opposite side of the frame from the CTD and LADCP battery pack, with one set of transducers pointing down, the other up. The SBE35RT temperature sensor was mounted horizontally on a support strut, within 0.25 meters of the CTD pump intakes. The altimeter was mounted on the inside of support strut outboard from the LADCP battery pack.

The rosette system was suspended from a UNOLS-standard three-conductor 0.322" electro-mechanical sea cable. The R/V Knorr's starboard-side CTD winch was used on stations 1-11 and 30-66. This winch developed mechanical problems on cast 11/1, and a sea cable short on cast 66/1. The port-side CTD winch was used on stations 12-29 and 66-88. The sea cable on this winch developed numerous kinks due to storm surge twisting, particularly on cast 36/1. Several sea cable reterminations were made on this cruise.

The deck watch prepared the rosette 10-20 minutes prior to each cast. All valves, vents and lanyards were checked for proper orientation. The bottles were cocked and all hardware and connections rechecked. Once stopped on station, the LADCP was turned on and the rosette moved into position under the starboard boom via an air-powered cart and tracks. As directed by the deck watch leader, the CTD was powered-up and the data acquisition system started. Two stabilizing tag lines were threaded through rings on the rosette frame, and syringes were removed from the CTD sensor intake ports. The deck watch leader directed the winch operator to raise the package, the boom and rosette were extended outboard and the package quickly lowered into the water. The tag lines were removed and the package was lowered to 10 meters. The CTD console operator then directed the winch operator to bring the package close to the surface, pause for typically 30 seconds and begin the descent.

Each rosette cast was lowered to within 10-20 meters of the bottom (with a few exceptions).

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. No bottles were changed or replaced on this leg, although parts of a few of them were replaced or repaired.

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

Routine CTD maintenance included soaking the conductivity and CTD DO sensors in distilled water between casts to maintain sensor stability. Rosette maintenance was performed on a regular basis. O-rings were changed as necessary and bottle maintenance was performed each day to insure proper closure and sealing. Valves were inspected for leaks and repaired or replaced as needed.

1.3. Underwater Electronics Packages

CTD data were collected with a SBE9*plus* CTD (ODF #474). This instrument provided pressure, dual temperature (SBE3), dual conductivity (SBE4), dissolved oxygen (SBE43), transmissometer (Wetlabs C-Star), fluorometer (Seapoint Sensors) and altimeter (Simrad 1007) channels. CTD #474 supplied a standard Sea-Bird format data stream at a data rate of 24 frames/second (fps).

Sea-Bird SBE32 36-place Carousel Water Sampler	S/N 0187
Sea-Bird SBE35RT Digital Reversing Thermometer	S/N 0034
Sea-Bird SBE9*plus* CTD	S/N 09P9852-0474
Paroscientifi c Digiquartz Pressure Sensor	S/N 69008
Sea-Bird SBE3*plus* Temperature Sensor	S/N 03P-4138 (Primary)
Sea-Bird SBE3*plus* Temperature Sensor	S/N 03P-2359 (Secondary)
Sea-Bird SBE4C Conductivity Sensor	S/N 04-2419 (Primary)
Sea-Bird SBE4C Conductivity Sensor	S/N 04-1908 (Secondary 1/1-1/17)
Sea-Bird SBE4C Conductivity Sensor	S/N 04-2572 (Secondary 18/1-57/1)
Sea-Bird SBE4C Conductivity Sensor	S/N 04-2319 (Secondary 58/1-88/1)
Sea-Bird SBE43 DO Sensor	S/N 43-0255
Wetlabs C-Star Transmissometer	S/N 507DR
Seapoint Sensors Fluorometer	S/N 2273
Simrad 1007 Altimeter	S/N 0201075
RDI Workhorse 300khz LADCP	S/N 3898-XR
RDI Workhorse 300khz LADCP	S/N 3898-VXR
RDI Workhorse 300khz LADCP	S/N 149
RDI Workhorse 300khz LADCP	S/N 150
RDI Workhorse 300khz LADCP	S/N 754
RDI Broadband 150khz LADCP	S/N 1546
LADCP Battery Pack	

Table 1.3.0 A20 Rosette Underwater Electronics.

The CTD was outfi tted with dual pumps. Primary temperature, conductivity and dissolved oxygen were plumbed on one pump circuit and secondary temperature and conductivity on the other. The primary temperature and conductivity sensors (T1 #4138 and C1 #2419) were used for reported CTD temperatures and conductivities on casts 1/1-1/57. The secondary temperature and conductivity sensors (T2 #2359 and C2 #2319) were used on casts 58/1-88/1.

The SBE9 CTD and the SBE35RT Digital Reversing Thermometer were both connected to the SBE32 36-place pylon providing for single-conductor sea cable operation. All 3 sea cable conductors were connected together to improve reliability. Power to the SBE9 CTD, SBE32 pylon, and SBE35RT was provided through the sea cable from the SBE11*plus* deck unit in the main lab. The Simrad altimeter and LADCP were powered by battery packs.

1.4. Navigation and Bathymetry Data Acquisition

Navigation data were acquired (at 1-second intervals) from the ship's Seanav GPS receiver by one of the Linux workstations beginning September 22. Data from the ship's Knudsen 320B/R Echosounder (12 KHz transducer) were also acquired, corrected using Carter tables [Cart80] and merged with the navigation. The Knudsen bathymetry data were noisy and subject to washing out on station when the bow thrusters were engaged.

Bathymetric data from the ship's multibeam (SeaBeam) echosounder system were also logged by the R/V Knorr's underway system.

1.5. Real-Time CTD Data Acquisition System

The CTD data acquisition system consisted of an SBE-11*plus* deck unit and four networked generic PC workstations running RedHat 9 Linux. Each PC workstation was confi gured with a color graphics display, keyboard, trackball, 60 GB disk, CD-R and CDRW drives. Two of the four systems also had 8 additional RS-232 ports via a Rocketport PCI serial controller. The systems were networked through 2 100BaseTX ethernet switches which were also connected to the ship's network. These systems were available for real-time operational and CTD data displays, as well as providing for CTD and hydrographic data management and backup. Hardcopy capability was provided by a networked HP 1600CM color printer.

One of the workstations was designated the CTD console and was connected to the CTD deck unit via RS-232. The CTD console provided an interface for controlling CTD deployments as well as real-time

operational displays for CTD and rosette trip data, GPS navigation, bathymetry and the CTD winch.

CTD deployments were initiated by the console watch once the ship was stopped on station. A console operations log was maintained by the watch containing a description of each deployment, a record of every attempt to close a bottle and any pertinent comments. The deployment software presented the operator with a short dialog instructing them to turn on the deck unit, examine the on screen raw data display for stable CTD data and to notify the deck watch that this was accomplished. When the deck watch was ready to put the rosette over the side, the console watch was notifi ed and the CTD data acquisition started. Time, GPS position and bottom depth were automatically logged at 1 second resolution. Both raw and processed (2 Hz time-series) CTD data were automatically backed up by one of the other workstations via ethernet. The deployment software display changed to indicate that a cast was in progress. A processed data display appeared, as did a rosette bottle trip display and control for closing bottles. Various real-time plots were then initiated to display the progress of the deployment.

Once the deck watch had deployed the rosette, the winch operator would immediately lower it to 10 meters. The CTD pumps were confi gured with an 8 second startup delay, and would be on by this time. The console operator would check the CTD data for proper operation, then instruct the winch operator to bring the package to the surface and then descend to a target depth (wire-out). The lowering rate was normally 60 meters/minute for this package, depending on sea cable tension and 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 decided where to trip bottles on the up cast, noting this on the console log. The altimeter channel, CTD depth, wire-out and bathymetric depth were monitored to determine the distance of the package from the bottom. The on-screen winch and altimeter displays allowed the watch to refi ne the target wire-out relayed to the winch operator and safely approach to within 10-20 meters of the bottom.

Bottles were closed on the up cast by operating a "point and click" graphical trip control button. The data acquisition system responded with trip confi rmation messages and the corresponding CTD data in a rosette bottle trip window on the display. All tripping attempts were noted on the console log. The console watch then directed the winch operator to raise the package up to the next bottle trip location. The console watch was also responsible for creating a sample log for the deployment which was used to record the correspondence between rosette bottles and analytical samples taken.

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

1.6. CTD Data Processing

ODF CTD processing software consists of over 30 programs running in a Unix run-time environment. The initial CTD processing program (ctdrtd/ctdba) is used either in real-time or with existing raw CTD data to:

- Convert raw CTD scans into scaled engineering units, and assign the data to logical channels
- Filter various channels according to specifi ed criteria
- Apply sensor- or instrument-specifi c response-correction models
- Decimate the channels according to specifi ed criteria
- Store the output time-series in a CTD-independent format

Once the CTD data are reduced to a standard format time-series, they can be manipulated in various ways. Channels can be additionally fi ltered. The time-series can be split up into shorter time-series or pasted together to form longer time-series. A time-series can be transformed into a pressure-series, or into a larger-interval time-series. The pressure, temperature and conductivity laboratory calibration coeffi cients are applied during the creation of the initial time-series. Oxygen conversion equation coeffi cients and any adjustments to pressure, temperature or conductivity are maintained in separate fi les and are applied whenever the data are accessed.

The CTD data acquisition software acquired and processed the data in real-time, providing calibrated, processed data for interactive plotting and reporting during a cast. The 24 Hz data from the CTD were

filtered, response-corrected and decimated to a 2.0 Hz time-series. Sensor correction and calibration models were applied to pressure, temperature, conductivity and O_2. Rosette trip data were extracted from this time-series in response to trip initiation and confirmation signals. The calibrated 2.0 Hz time-series data, as well as the 24 Hz raw data, were stored on disk and were backed up via ethernet to a second system. At the end of the cast, various consistency and calibration checks were performed, and a 2-db pressure-series of the down cast was generated and subsequently used for reports and plots.

CTD data were examined graphically at the completion of deployment for potential problems. The two CTD temperature sensors were compared, intercompared with the SBE35RT Digital Reversing Thermometer and checked for sensor drift. CTD conductivity sensors were compared and monitored by examining differences between CTD values and check-sample conductivities. Additionally, deep theta-salinity comparisons were made between down and up casts as well as adjacent deployments. The CTD O_2 sensor data were calibrated to bottle check-sample data.

The sea cable/winch problems on this cruise did not significantly affect the CTD data, any noise being filtered out during the data acquisition. No additional filtering was done on any of the CTD data.

The initial 10 M yo in each deployment resulting from lowering then raising the package to the surface to start the pumps was removed during the generation of the 2.0 db pressure-series.

Density inversions can be induced in high-gradient regions by ship-generated vertical motion of the rosette. Detailed examination of the raw data shows significant mixing can occur in these areas because of "ship roll". To minimize density inversions, a "ship-roll" filter which disallowed pressure reversals was applied during the generation of all 2.0 db pressure-series down-cast data.

1.7. CTD Laboratory Calibration Procedures

Laboratory calibrations of the CTD pressure, temperature and conductivity sensors were used to generate Sea-Bird conversion equation coefficients applied by the data acquisition software at sea.

Pressure calibrations were last performed on CTD #474 at the ODF Calibration Facility (La Jolla) 26 August 2003, immediately prior to A20-2003.

The Paroscientific Digiquartz pressure transducer (S/N 69008) was calibrated in a temperature-controlled water bath to a Ruska Model 2400 Piston Gauge Pressure Reference. Calibration curves were measured at 4 temperatures from -1.38 to 29.30° C to two maximum loading pressures (1191 and 6081 decibars).

The SBE3*plus* temperature sensors (primary S/N 03-4138, secondary S/N 03-2359) were calibrated at SBE on 08 August 2003.

The SBE4 conductivity sensors (primary S/N 04-2419, secondaries S/Ns 04-1908, 04-2572 and 04-2319) were calibrated on 08 August 2003, 08 August 2003, 08 August 2003 and 03 May 2003 at SBE respectively..

The SBE35RT Digital Reversing Thermometer (S/N 0034) was calibrated on 05 April 2002 at SBE.

Laboratory pressure, temperature and conductivity calibrations will be repeated post-cruise.

1.8. CTD Shipboard Calibration Procedures

CTD #474 was used for all A20-2003 casts. Secondary temperature and conductivity sensors served as calibration checks for the primary temperature and conductivity on casts 1/1-57/1, and were used for reported data (the primary temperature and conductivity sensors serving as calibration checks) on casts 58/1-88/1. The SBE35RT Digital Reversing Thermometer served as an independent temperature calibration check. *In-situ* salinity and dissolved O_2 check samples collected during each rosette cast were used to calibrate CTD conductivity and dissolved O_2.

1.8.1. CTD Pressure

Pressure sensor conversion equation coefficients derived from the pre-cruise pressure calibration were applied to raw pressures during each cast. No additional adjustments were made to the calculated pressures, but the pressure was lagged (tc=1.4 secs) on casts 1/1-57/1 to better match the T1/C1 response due to pump alignment problems.

Residual offsets at the beginning and end of each cast (the difference between the first/last pressures in-water and 0) were monitored during the cruise to check for shifts in the pressure calibration. All residual differences were 0.5 decibar or less.

There was no apparent shift in pressure calibration during the cruise. This will be verified by a post-cruise laboratory pressure calibration.

1.8.2. CTD Temperature

Temperature sensor calibration coefficients were derived from the pre-cruise calibrations and applied to raw primary and secondary temperatures.

Two independent metrics of calibration accuracy were examined. The primary and secondary temperatures were compared at each rosette trip, and the SBE35RT and primary temperatures were compared at each rosette trip. These comparisons are summarized in figures 1.8.2.0 and 1.8.2.1.

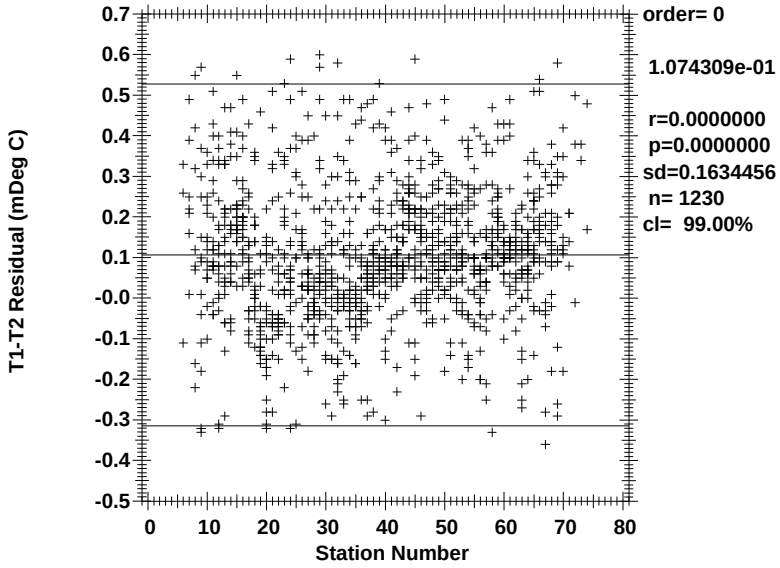

Figure 1.8.2.0 Primary and secondary temperature comparison, p>1000db.

The comparison between primary and secondary temperatures shows a small (0.00011 °C) mean calibration offset, well within the reported accuracy of the SBE temperature calibrations.

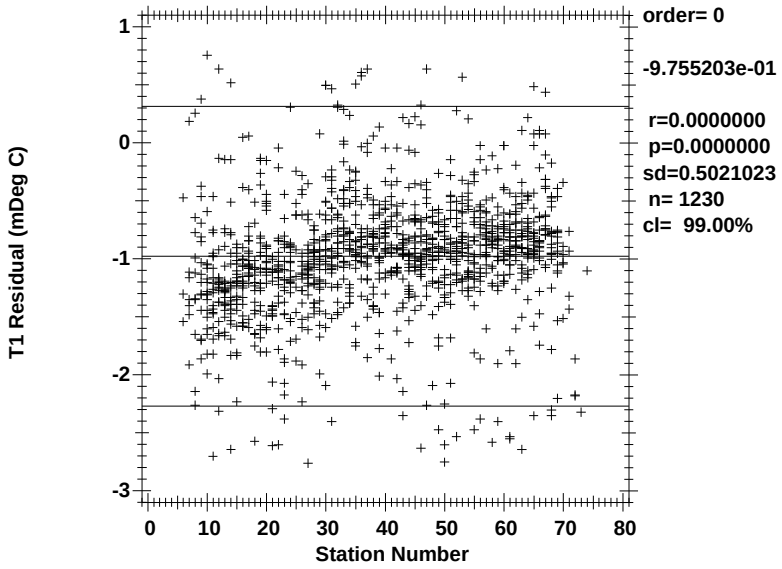

Figure 1.8.2.1 Primary and SBE35RT temperature comparison, p>1000db.

The comparison between SBE35RT and T1 temperatures shows a distinct linear trend as well as a mean difference of -0.00098° C. Given the age of the SBE35 calibration (05 April 2002) and the unlikelihood that both T1 and T2 would track so closely if they were both drifting, these differences are attributed to the SBE35RT.

1.8.3. CTD Conductivity

Conductivity sensor conversion equation coeffi cients were derived from the pre-cruise calibrations and applied to raw primary and secondary conductivities.

Three secondary conductivity sensors were used on A20: #1908 (1/1-17/1), #2572 (18/1-57/01) and #2319 (58/1-88/1). The fi rst two secondary sensors were replaced because of excessive noise and drift. The third sensor was stable. Prior to cast 58/1 C1-C2 conductivity differences were not a useful metric of calibration accuracy.

The primary conductivity sensor (#2419) was fairly stable and noise-free. Comparisons to bottle salinities showed a mean conductivity correction slope of -0.000309376 and well-behaved offset groupings. The conductivity correction offsets are summarized in fi gure 1.8.3.0.

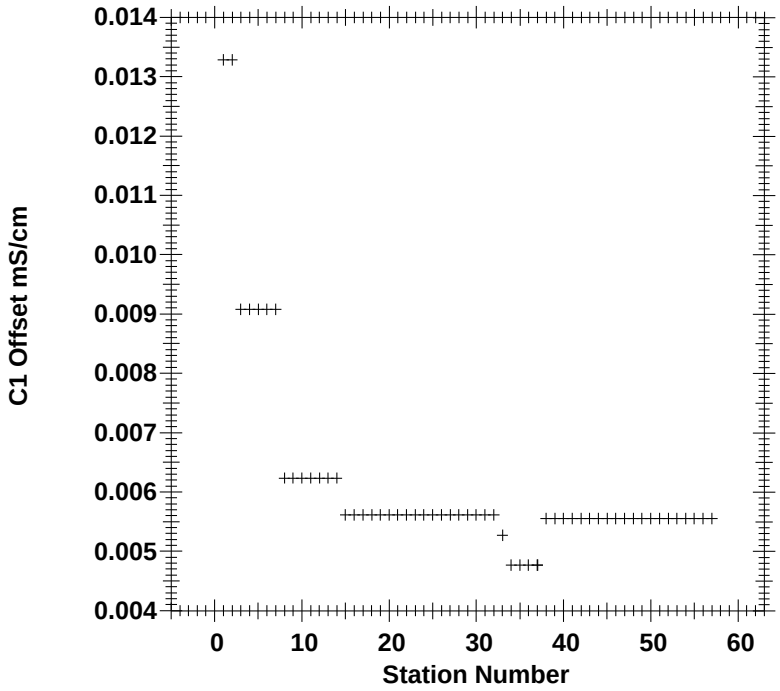

Figure 1.8.3.0 Primary conductivity correction offsets.

Comparisons of the stable secondary conductivity sensor (#2319) to bottle salinities showed no signifi cant conductivity correction slope and a minor constant offset of 0.00021 mS/cm.

A systematic uniform offset of 0.0015 PSU between downcast and upcast C1 salinities was observed prior to cast 58/1. This was attributed to the sensor and pump confi guration (horizontal) and the location of the P1 pump exhaust port (˜30° from vertical, per SBE specs). Both P1 and P2 pumps were rotated so that the exhaust ports were aligned horizontally and the C1 salinity offset was reduced to ˜0.0007 PSU. C2 exhibited almost no offset. This discrepancy was perhaps due to the inclusion of the SBE43 DO sensor in the P1 circuit. As a result of this experiment, T2 and C2 were used for reported salinities and temperatures on casts 58/1-88/1. Correcting T1/C1 salinities for casts 1/1-57/1 was done by applying a lag (tc=1.4 seconds) to pressure.

The salinity residuals after applying the shipboard calibration are summarized in fi gures 1.8.3.1 and 1.8.3.2.

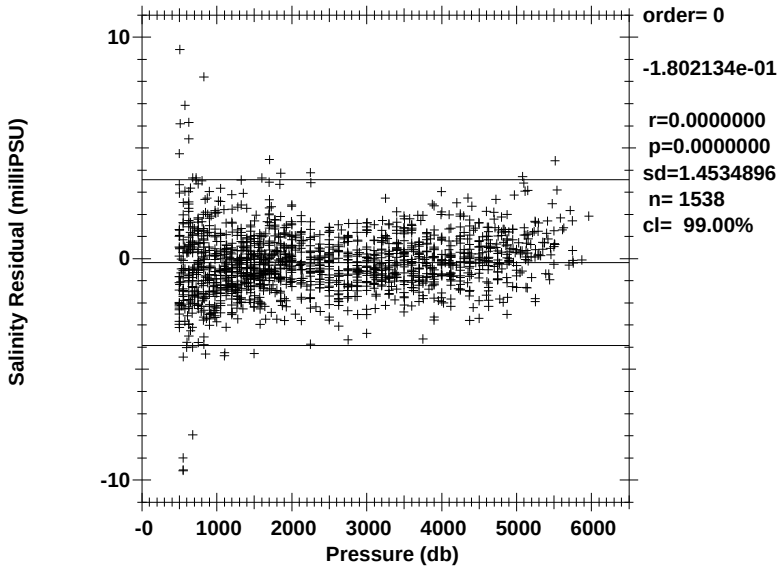

Figure 1.8.3.1 C1 and C2 salinity residuals by pressure, p>500db.

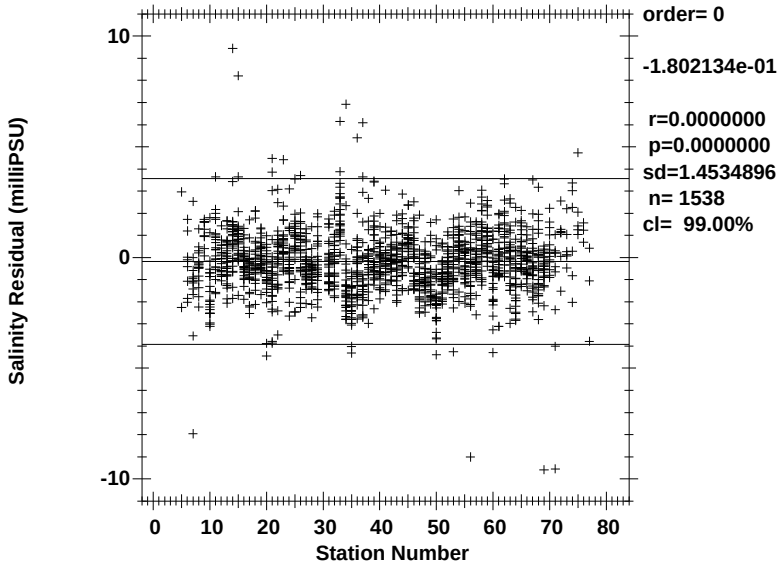

Figure 1.8.3.2 C1 and C2 salinity residuals by station, p>500db.

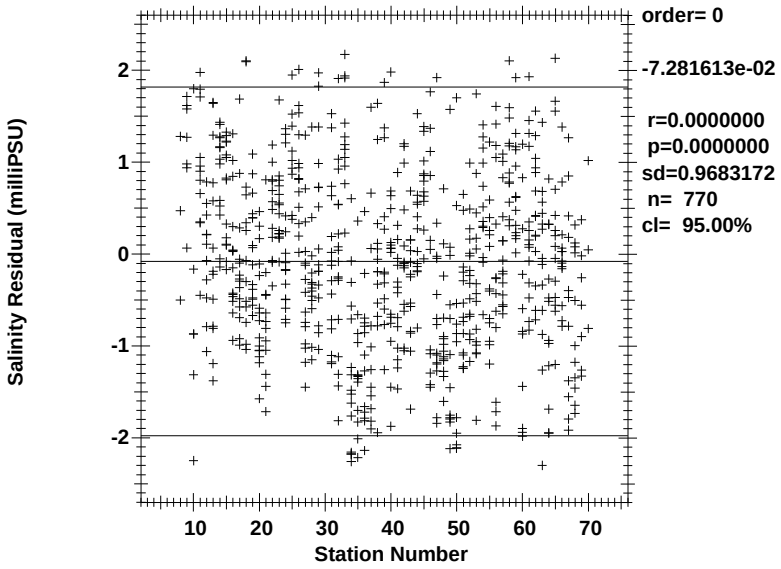

Figure 1.8.3.3 C1 and C2 salinity residuals by station, p>2000db.

Excluding thermocline and gradient values (early and late stations were shallow and also excluded), figure 1.8.3.3 represents an estimate of the salinity accuracy of CTD #474. The 95% confidence limit is ±0.0019 PSU, in agreement with the generally accepted limit of repeatability for bottle salinities (±0.002PSU).

1.8.4. CTD Dissolved Oxygen

One SBE43 dissolved O_2 (DO) sensor was used for this cruise (#43-0225). The sensor was plumbed into the P1/T1/C1 intake line in a horizontal configuration after C1 and before P1 (per SBE spec).

One characteristic of this type of sensor (membrane-covered polarigraphic oxygen detector or MPOD) is a flow dependence. Non-pumped sensors of this type exhibit a significantly decreased response at bottle stops. The pumped SBE43 reduces but does not eliminate this problem, perhaps due to pump or flow rate variations in the primary sensor circuit. DO sensor calibration to check samples is somewhat problematic as sensor data from the bottle stop does not provide a representative comparison.

The DO sensor calibration method used for this cruise was to match down-cast CTD DO data to up-cast bottle trips along isopycnal surfaces, then to minimize the residual differences between the *in-situ* check sample values and CTD O_2 using a non-linear least-squares fitting procedure. Since this technique only calibrates the down-cast, only the 2.0 pressure series downcast data contain calibrated CTD O_2.

A small (<0.02 ml/l) but significant non-linearity apparent in the O_2 residuals as a function of pressure was corrected with an additional empirical 4th-order polynomial pressure correction. The explanation for this non-linearity requires further investigation.

Figures 1.8.4.0, 1.8.4.1 and 1.8.4.2 show the residual differences between bottle and calibrated CTD O_2 for all points excluding the thermocline and surface gradients. Figure 1.8.4.3 shows the residual differences for pressures > 1000 db.

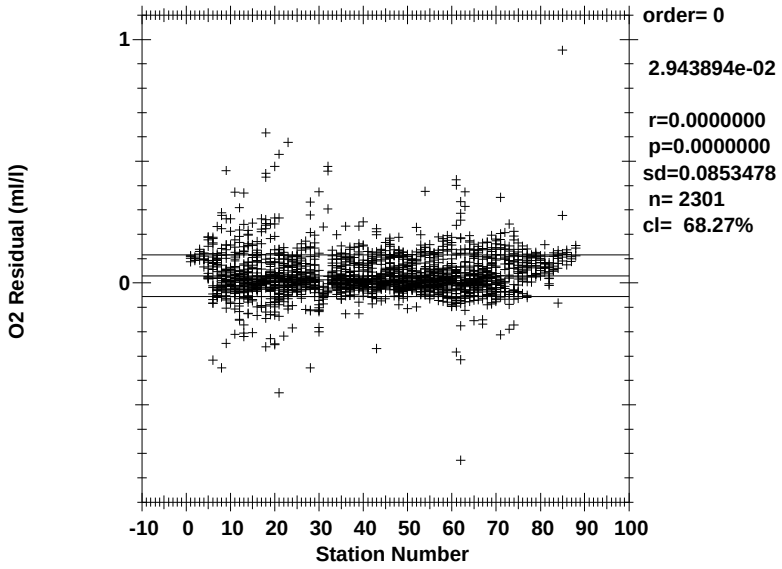

Figure 1.8.4.0 O_2 residuals by station number.

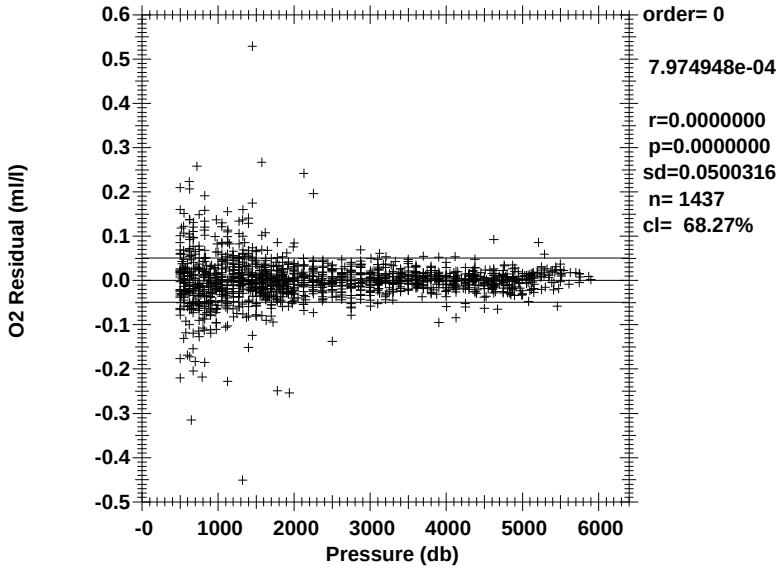

Figure 1.8.4.1 O_2 residuals by pressure.

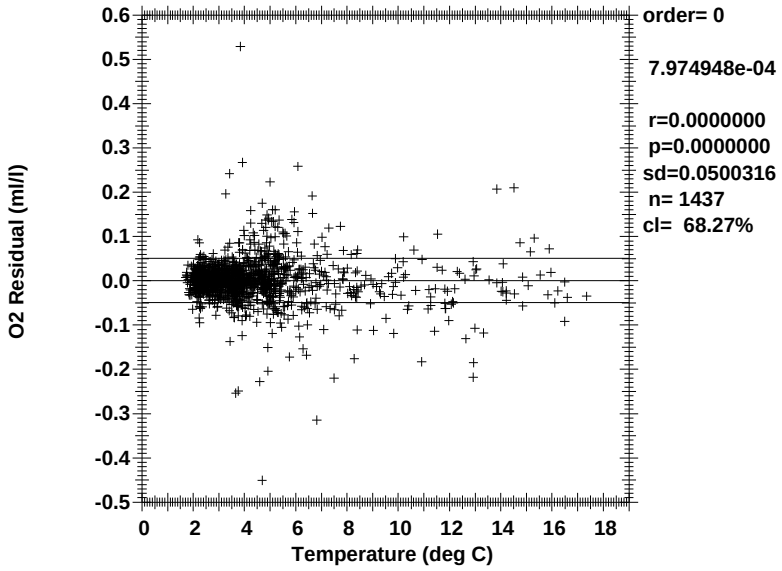

Figure 1.8.4.2 O_2 residuals by temperature.

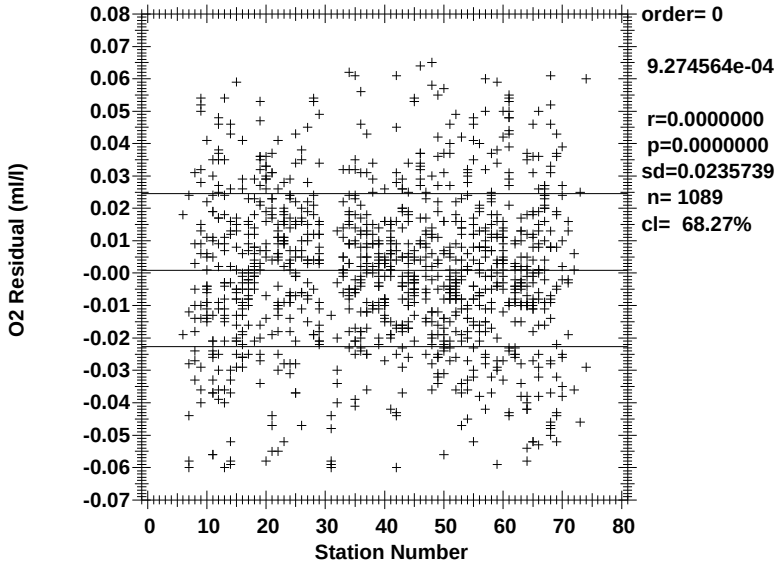

Figure 1.8.4.3 O_2 residuals by station number, p>1000db .

The standard deviations of 0.050 ml/l for all oxygens and 0.027 ml/l for deep oxygens are only intended as indicators of how well the up-cast bottle O_2 and down-cast CTD O_2 match. ODF makes no claims regarding the precision or accuracy of CTD dissolved O_2 data.

The general form of the ODF O_2 conversion equation follows Brown and Morrison [Brow78] and Millard [Mill82], [Owen85]. ODF models membrane and sensor temperatures with lagged CTD temperatures. *In-situ* pressure and temperature are fi ltered to match the sensor response. Time-constants for the pressure response τ_p, and two temperature responses τ_{Ts} and τ_{Tf} are fi tting parameters. The O_c gradient, dO_c/dt, is approximated by low-pass fi ltering 1st-order O_c differences. This gradient term attempts to correct for reduction of species other than O_2 at the sensor cathode. The time-constant for this fi lter, τ_{og}, is a fi tting parameter. Oxygen partial-pressure is then calculated:

$$O_{pp} = [c_1 O_c + c_2] \cdot f_{sat}(S,T,P) \cdot e^{(c_3 P_l + c_4 T_f + c_5 T_s + c_6 \frac{dO_c}{dt})} \quad (1.8.4.0)$$

where:

O_{pp} = Dissolved O_2 partial-pressure in atmospheres (atm);
O_c = Sensor current (μamps);
$f_{sat}(S,T,P)$ = O_2 saturation partial-pressure at S,T,P (atm);
S = Salinity at O_2 response-time (PSUs);
T = Temperature at O_2 response-time (° C);
P = Pressure at O_2 response-time (decibars);
P_l = Low-pass fi ltered pressure (decibars);
T_f = Fast low-pass fi ltered temperature (° C);
T_s = Slow low-pass fi ltered temperature (° C);
$\frac{dO_c}{dt}$ = Sensor current gradient (μamps/secs).

1.9. Bottle Sampling

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

- CFCs
- O_2
- He_3
- DIC/Total Alkalinity
- DOC/DON/DCNS/CDOM
- Tritium
- I_{129}
- C_{13} and C_{14}
- Nutrients
- Salinity

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

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

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

1.10. Bottle Data Processing

Bottle data processing began with sample drawing, and continued iteratively until the data were considered to be problem-free. One of the most important pieces of information, the sample log sheet, was fi lled out during sample drawing and served both as a sample inventory and as a guide for the technicians in carrying out their analyses. Any problems observed with the rosette before or during the sample drawing were noted on this form, including indications of bottle leaks, out-of-order drawing, etc. Additional clues regarding bottle tripping or leak problems were found by individual analysts as the samples were analyzed and the resulting data processed and checked.

The next stage of processing began after individual analyses were associated with rosette bottles and their CTD-derived parameters (pressure, temperature, conductivity, etc.). The rosette cast and bottle numbers were the primary identification for all ODF-analyzed samples taken from the bottle. At this stage, bottle tripping problems were usually identified and resolved, sometimes resulting in changes to the pressure, temperature and other CTD properties associated with the bottle. All CTD information for each bottle trip (confirmed or not) was retained, so resolving bottle tripping problems consisted of correlating CTD trip data with the rosette bottles.

Diagnostic comments from the sample log, and notes from analysts and data processors were associated with each deployment as part of the quality control procedure. Sample data from bottles suspected of leaking were checked to see if the properties were consistent with the CTD profile and with adjacent stations. The analysts reviewed and sometimes revised their data as additional calibration or diagnostic results became available.

Quality coding of CTD and water samples was done using a coding scheme developed for the World Ocean Circulation Experiment (WOCE) Hydrographic Programme (WHP) [Joyc94]. Based on the outcome of investigations of the various comments in the quality files, WHP water sample codes were selected to indicate the reliability of the individual parameters affected by the comments. WHP bottle codes were assigned where evidence showed the entire bottle was affected, as in the case of a leak, or a bottle trip at other than the intended depth.

WHP water bottle quality codes were assigned as defined in the WOCE Operations Manual [Joyc94] with the following additional interpretations:

2	No problems noted.
3	Leaking. *An air leak large enough to produce an observable effect on a sample is identified by a code of 3 on the bottle and a code of 4 on the oxygen. (Small air leaks may have no observable effect, or may only affect gas samples.)*
4	Did not trip correctly. *Bottles tripped at other than the intended depth were assigned a code of 4. There may be no problems with the associated water sample data.*
5	Not reported. *No water sample data reported. This is a representative level derived from the CTD data for reporting purposes. The sample number should be in the range of 80-99.*
9	The samples were not drawn from this bottle.

WHP water sample quality flags were assigned using the following criteria:

1	The sample for this measurement was drawn from the water bottle, but the results of the analysis were not *(yet)* received.
2	Acceptable measurement.
3	Questionable measurement. *The data did not fit the station profile or adjacent station comparisons (or possibly CTD data comparisons). No notes from the analyst indicated a problem. The data could be acceptable, but are open to interpretation.*
4	Bad measurement. *The data did not fit the station profile, adjacent stations or CTD data. There were analytical notes indicating a problem, but data values were reported. Sampling and analytical errors were also coded as 4.*
5	Not reported. *There should always be a reason associated with a code of 5, usually that the sample was lost, contaminated or rendered unusable.*
9	The sample for this measurement was not drawn.

WHP water sample quality flags were assigned to the CTDSAL (CTD salinity) parameter as follows:

2	Acceptable measurement.
3	Questionable measurement. *The data did not fit the bottle data, or there was a CTD conductivity calibration shift during the up-cast.*
4	Bad measurement. *The CTD up-cast data were determined to be unusable for calculating a salinity.*
7	Despiked. *The CTD data have been filtered to eliminate a spike or offset.*

WHP water sample quality flags were assigned to the CTDOXY (CTD O_2) parameter as follows:

1	Not calibrated. *Data are uncalibrated.*
2	Acceptable measurement.
3	Questionable measurement.
4	Bad measurement. *The CTD data were determined to be unusable for calculating a dissolved oxygen concentration.*
5	Not reported. *The CTD data could not be reported, typically when CTD salinity is coded 3 or 4.*
7	Despiked. *The CTD data have been filtered to eliminate a spike or offset.*
9	Not sampled. *No operational CTD O_2 sensor was present on this cast.*

Note that CTDOXY values were derived from the down-cast pressure-series CTD data and matched to the up-cast bottle data along isopycnal surfaces. If the CTD salinity is footnoted as bad or questionable, the CTD O_2 is not reported.

1.11. Salinity Analysis

Equipment and Techniques

Two Guildline Autosal Model 8400A salinometers (S/N 57-263 and 57-266) located in the forward analytical lab were used for measuring salinity on all stations (57-263: 1/1-1/8, 11/1-30/1, 53/1-59/1; 57-266: 10/1, 31/1-52/1,60/1-88/1). The salinometers were modified by ODF to contain an interface for computer-aided measurement. The water bath temperatures were set and maintained at a value near the laboratory air temperature. They were set at 24° C for the entire leg.

The salinity analyses were performed after samples had equilibrated to laboratory temperature, usually within 16-36 hours after collection. A temperature-controlled waterbath was used to assist sample equilibration. The salinometer was standardized for each group of analyses (1-7 casts, up to ~50 samples) using at least one fresh vial of standard seawater per group. A computer (PC) prompted the analyst for control functions such as changing sample, flushing, or switching to "read" mode. The salinometer cell was flushed and results were logged by the computer until two successive measurements met software criteria for consistency. These values were then averaged for a final result.

Sampling and Data Processing

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

PSS-78 salinity [UNES81] was calculated for each sample from the measured conductivity ratios. The difference (if any) between the initial vial of standard water and one run at the end as an unknown was applied linearly to the data to account for any drift. The data were incorporated into the cruise database. 2530 salinity measurements were made and approximately 60 vials of standard water were used. The estimated accuracy of bottle salinities run at sea is usually better than ±0.002 PSU relative to the particular standard seawater batch used.

Laboratory Temperature

The temperature in the salinometer laboratory varied from 20.9 to 25.8° C, during the cruise. The air temperature change during any single run of samples was less than ±1.2° C.

Standards

IAPSO Standard Seawater (SSW) Batches P-140 and P-141 were used to standardize all salinity measurements.

1.12. Oxygen Analysis

Equipment and Techniques

Dissolved oxygen analyses were performed with an ODF-designed automated oxygen titrator using photometric end-point detection based on the absorption of 365nm wavelength ultra-violet light. The titration of the samples and the data logging were controlled by PC software. Thiosulfate was dispensed by a Dosimat 665 buret driver fitted with a 1.0 ml buret. ODF used a whole-bottle modified-Winkler titration following the technique of Carpenter [Carp65] with modifications by Culberson *et al.* [Culb91], but with higher concentrations of potassium iodate standard (~0.012N) and thiosulfate solution (~65 gm/l). Pre-made liquid potassium iodate standards were run at the beginning of each session of analyses, which typically included from 1 to 3 stations. Reagent/distilled water blanks were determined every other day or more often if a change in reagents required it to account for presence of oxidizing or reducing agents. The auto-titrator generally performed well. A leak in the thiosulfate delivery tubing affected samples on 26/1-28/1, 30/1, 32/1-33/1 and 38/1.

Sampling and Data Processing

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

The samples were analyzed within 1-6 hours of collection, then the data were incorporated into the cruise database.

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

As samples warmed up to room temperature they would occasionally degas which would cause a noisy endpoint due to gas bubbles in the light path. 2503 oxygen measurements were made.

The blank volumes and thiosulfate normalities were smoothed (linear fits) at the end of the cruise and the oxygen values recalculated.

Volumetric Calibration

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

Standards

Liquid potassium iodate standards were prepared and bottled in ODF's chemistry laboratory prior to the cruise. The normality of the liquid standard was determined at ODF by calculation from weight. A single standard batch was used during A20-2003. Potassium iodate was obtained from Acros Chemical Co.

and was reported by the supplier to be >99.4% pure. All other reagents were "reagent grade" and were tested for levels of oxidizing and reducing impurities prior to use.

1.13. Nutrient Analysis

Equipment and Techniques

Nutrient analyses (phosphate, silicate, nitrate and nitrite) were performed on an ODF-modified 4-channel Technicon AutoAnalyzer II, generally within one hour after sample collection. Occasionally samples were refrigerated up to 4 hours at ~4° C. All samples were brought to room temperature prior to analysis.

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

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

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

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

Sampling and Data Processing

Nutrient samples were drawn into 45 ml polypropylene, screw-capped "oak-ridge type" centrifuge tubes. The tubes were cleaned with 10% HCl and rinsed with sample 2-3 times before filling. Standardizations were performed at the beginning and end of each group of analyses (typically one cast, up to 36 samples) with an intermediate concentration mixed nutrient standard prepared prior to each run from a secondary standard in a low-nutrient seawater matrix. The secondary standards were prepared aboard ship by dilution from primary standard solutions. Dry standards were pre-weighed at the laboratory at ODF, and transported to the vessel for dilution to the primary standard. Sets of 6-7 different standard concentrations were analyzed periodically to determine any deviation from linearity as a function of concentration for each nutrient analysis. A correction for non-linearity was applied to the final nutrient concentrations when necessary.

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

Nutrients, reported in micromoles per kilogram, were converted from micromoles per liter by dividing by sample density calculated at 1 atm pressure (0 db), *in situ* salinity, and an assumed laboratory temperature of 25° C.

2540 nutrient samples were analyzed. The pump tubing was changed 2 times.

Standards

Primary standards for silicate (Na_2SiF_6) and nitrite ($NaNO_2$) were obtained from Johnson Matthey Chemical Co.; the supplier reported purities of >98% and 97%, respectively. Primary standards for nitrate (KNO_3) and phosphate (KH_2PO_4) were obtained from Fisher Chemical Co.; the supplier reported purities of 99.999% and 99.999%, respectively. The effi ciency of the cadmium column used for nitrate was monitored throughout the cruise and ranged from 99-100%.

No major problems were encountered with the measurements. The temperature of the laboratory used for the analyses ranged from 20.9° C to 25.5° C, but was relatively constant during any one station (±1.5° C).

References

Arms67.

Armstrong, F. A. J., Stearns, C. R., and Strickland, J. D. H., “The measurement of upwelling and subsequent biological processes by means of the Technicon Autoanalyzer and associated equipment,” *Deep-Sea Research,* 14, pp. 381-389 (1967).

Bern67.

Bernhardt, H. and Wilhelms, A., “The continuous determination of low level iron, soluble phosphate and total phosphate with the AutoAnalyzer,” *Technicon Symposia,* I, pp. 385-389 (1967).

Brow78.

Brown, N. L. and Morrison, G. K., “WHOI/Brown conductivity, temperature and depth microprofi ler,” Technical Report No. 78-23, Woods Hole Oceanographic Institution (1978).

Carp65.

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

Cart80.

Carter, D. J. T., “Computerised Version of Echo-sounding Correction Tables (Third Edition),” Marine Information and Advisory Service, Institute of Oceanographic Sciences, Wormley, Godalming, Surrey. GU8 5UB. U.K. (1980).

Culb91.

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 Offi ce (Aug 1991).

Gord92.

Gordon, L. I., Jennings, J. C., Jr., Ross, A. A., and Krest, J. M., “A suggested Protocol for Continuous Flow Automated Analysis of Seawater Nutrients in the WOCE Hydrographic Program and the Joint Global Ocean Fluxes Study,” Grp. Tech Rpt 92-1, OSU College of Oceanography Descr. Chem Oc. (1992).

Joyc94.

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

Mill82.

Millard, R. C., Jr., “CTD calibration and data processing techniques at WHOI using the practical salinity scale,” Proc. Int. STD Conference and Workshop, p. 19, Mar. Tech. Soc., La Jolla, Ca. (1982).

Owen85.

Owens, W. B. and Millard, R. C., Jr., “A new algorithm for CTD oxygen calibration,” *Journ. of Am. Meteorological Soc.,* 15, p. 621 (1985).

UNES81.

UNESCO, “Background papers and supporting data on the Practical Salinity Scale, 1978,” UNESCO Technical Papers in Marine Science, No. 37, p. 144 (1981).

2. Lowered Acoustic Doppler Current Profiler

Velocity profi les were obtained during the standard hydrographic casts of the Knorr A20 cruise using self contained ADCPs (Acoustic Doppler Current Profi lers) attached to the CTD rosette. Dual WH300 ADCPs (RDI Instruments Inc.) were used for Stations 1 through 37 and the test station 999. A single broadband 150 khz ADCP (RDI Instruments Inc.) was used for stations 38 through 84. Lowered ADCP data for stations 85 through 88 was not collected given that these stations were too shallow to obtain meaningful information. An experimental high power version of the WH300 ADCP was used on casts 1-11 and initially exhibited promising (higher range) results. Unfortunately a failed transducer on that instrument required that it be replaced with a standard WH300 ADCP for subsequent casts.

Based on the instrument range and the magnitude of the error associated with the velocity estimates, the dual WH300 ADCPs performed well in the high back-scatter region on the northern portion of the transect. The range of these instruments declined steadily and the velocity error increased as the ship proceeded south into lower back-scatter waters, requiring the switch to the higher powered broadband 150 khz instrument after station 37. While the performance of the broadband 150 khz instrument was adequate in the low back-scatter waters of the main gyre, the range and velocity error steadily improved as the ship made progress south. Poor velocity estimates in the upper 200 meters of the water column is common when profiling with a single ADCP and is not entirely understood. This proved to be the case when the single BB150 ADCP was used during this cruise. The hull mounted ADCP data will be used to fill in for the poor surface data that was obtained while using the single BB150 ADCP. Additional post processing will be done to optimize the threshold settings that will allow our bottom tracking routines to decrease the error in the velocity estimates when the paired WH300 ADCPs were used. However, preliminary examination of the velocity profiles indicates good correlation with the geostrophic velocities computed from the temperature and salinity data.

3. Chromophoric DOM

Our goals are to determine chromophoric dissolved matter (CDOM) distributions over a range of oceanic regimes on meridional sections of the CO2/CLIVAR Repeat Hydrography survey, and: to quantify and parameterize CDOM production and destruction processes with the goal of mathematically constraining the cycling of CDOM. CDOM is a poorly characterized organic matter pool that interacts with sunlight, leading to the production of climate-relevant trace gases, attenuation of solar ultraviolet radiation in the water column, and an impact upon ocean color that can be quantified using satellite imagery. We believe that the global distribution of CDOM in the open ocean is controlled by microbial production and solar bleaching in the upper water column. We are testing these hypotheses by a combination of field observation and controlled experiments. We are also interested in the deep-sea reservoir of CDOM and its origin and connection to surface waters and are making the first large-scale survey of the abundance of CDOM in the deep ocean.

Activities on A20 and A22:

We are collecting samples of seawater for absorption spectroscopy on one deep ocean cast (24 depths) each day. CDOM is typically quantified as the absorption coefficient at a particular wavelength or wavelength range (we are using 325 nm). We determine CDOM at sea by measuring absorption spectra (280-730 nm) of 0.2um filtrates using a liquid waveguide spectrophotometer with a 200cm cell. We are concurrently collecting samples for bacterial abundance, dissolved organic carbon, dissolved organic nitrogen (see below), and carbohydrates to compare the distribution of these quantities to that of CDOM. In surface waters (< 300m) we are also estimating bacterial productivity of field samples by measuring the uptake of bromo-deoxyuridine (BRDU). At selected stations (continental slope, subtropical, and tropical stations) we will collect extra seawater for a) microbial culture experiments and b) solar bleaching experiments. In these experiments we will examine the rate of CDOM production relative to microbial productivity in culture, and quantify the rate of solar bleaching of CDOM near the surface. Because of the connections to light availability and remote sensing, we are collecting samples for pigment analysis (HPLC), chlorophyll a (fluorometric), and particulate absorption (spectrophotometric) when possible. We are also deploying a Satlantic free-fall profiling spectroradiometer (ca. once per day) to quantify the underwater light field, and we have a Satlantic surface irradiance meter continuously logging the solar spectrum during daylight hours. Fluorometric analysis is being done at sea after 48 hour extractions.

Also:

We are collecting samples for dissolved organic carbon and dissolved organic nitrogen analysis, which are a core part of the CO2/CLIVAR project. The PIs for this part of the study are D. Hansell (U. Miami) and C. Carlson (UCSB), who can provide more details. We are collecting and freezing approximately 150ml (each) from 24 depths on each A cast. Samples in the upper 1000m are filtered (using GF/F glass fiber filters) at the time of collection. These samples will be analyzed at UCSB after the end of the A22 leg.

4.1 Dissolved Organic Carbon Analyses

(Craig A. Carlson)

Collection:

All samples were collected directly from the Niskin Bottles. Because particulate organic carbon (POC) concentrations in the surface waters can be elevated all sampltes collected from the upper 500 m were filtered. Water was filtered through a combusted GF/F housed in an acid washed polycarbonate filter cartridge attached directly the Niskin bottle spigot. Water below 500 m was not filtered because greater than 98% or the total organic carbon is DOC. All samples were collected directly into an acid washed and Nanopure flushed high density polyethylene (HDPE) bottles (60ml). Samples were immediately placed upright in a -20°C freezer and samples were shipped to shore laboratory packed in dry ice. All samples were kept frozen at -20°C in an organic (volatile) free environment.

Analysis:

All DOC samples were analyzed via high temperature combustion using Shimadzu TOC-V in shore based laboratory at the University of California, Santa Barbara. The operating conditions of the Shimadzu TOC-V were slightly modified from the manufacturer's model system. The condensation coil was removed and the head space of an internal water trap was reduced to minimize the system's dead space. The combustion tube contained 0.5 cm Pt pillows placed on top of Pt alumina beads to improve peak shape and to reduce alteration of combustion matrix throughout the run. CO_2 free carrier gas was produced with a Whatman® gas generator (Carlson et al. 2004). Samples were drawn into 5 ml injection syringe and acidified with 2M HCL (1.5%) and sparged for 1.5 minutes with CO_2 free gas. Three to five replicate 100 µl of sample were injected into combustion tube heated to 680° C. The resulting gas stream was passed though a several water and halide traps, the CO_2 in the carrier gas was analyzed with a non-dispersive infrared detector and the resulting peak area was integrated with Shimadzu chromatographic software. Injections continued until the at least three injection meet the system specified range of a SD of 0.1 area counts, CV ≤2% or best 3 of 5 injections.

Extensive conditioning of the combustion tube with repeated injections of low carbon water (LCW) and deep seawater was essential to minimize the machine blanks. After conditioning, the system blank was assessed with UV oxidized low carbon water. The system response was standardized with a four-point calibration curve of potassium hydrogen phthalate solution in LCW. All samples were systematically referenced against low carbon water, deep Sargasso Sea reference waters (2600 m) and surface Sargasso Sea water every 6 – 8 analyses (Hansell and Carlson 1998). The standard deviation of the deep and surface references analyzed throughout a run generally have a coefficient of variation ranging between 1-3% over the 3-7 independent analyses (number of references depends on size of the run) (see Hansell 2005) . Daily reference waters were calibrated with DOC CRM provided by D. Hansell (University of Miami). The UCSB DOC laboratory exchanges references and samples with the Hansell DOC laboratory to ensure similar performance of DOC systems and comparability of data.

DOC calculation
μMC = (average sample area – average machine blank area) / (slope of std curve)

References:

Carlson, C.A., S.J. Giovannoni, D.A. Hansell, S.J. Goldberg, R. Parsons, and K. Vergin. 2004. Interactions between DOC, microbial processes, and community structure in the mesopelagic zone of the northwestern Sargasso Sea. *Limnology and Oceanography* 49: 1073-1083.

Hansell, D.A. 2005. Dissolved organic carbon reference material program. EOS, Transactions, American Geophysical Union 86: 318-319.

Hansell, D.A. and C.A. Carlson. 2001a. Biogeochemistry of total organic carbon and nitrogen in the Sargasso Sea: Control by convective overturn. *Deep Sea Research II* 48 (8-9): 1649-1667.

4.2 Dissolved Inorganic Carbon (DIC)

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 CO2 (gas) by addition of excess hydrogen to the seawater sample, and the evolved CO2 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-. CO2 is thus measured by integrating the total change required to achieve this.

The coulometers were each calibrated by injecting aliquots of pure CO2 (99.995%) by means of an 8-port valve outfitted with two sample loops. The instruments were calibrated at the beginning, middle, and end of each station with a set of the gas loop injections.

Secondary standards were run throughout the cruise on each analytical system; these standards were Certified Reference Materials (CRMs) consisting of poisoned, filtered, and UV irradiated seawater supplied by Dr. A. Dickson of Scripps Institution of Oceanography (SIO), and were determined shoreside manometrically. Despite equipment problems in the beginning of the cruise, the overall accuracy and precision for the CRMs on both instruments combined was 1.0±1.7 µmol/kg respectively (n=88). Preliminary DIC data reported to the database have not yet been corrected to the Batch 61 CRM value, but a more careful quality assurance to be completed shoreside will have final data corrected to the secondary standard on a per instrument basis.

Samples were drawn from the Niskin-type bottles into cleaned, precombusted 500-mL Pyrex bottles using Tygon tubing. Bottles were rinsed once and filled from the bottom, overflowing half a volume, and care was taken not to entrain any bubbles. The tube was pinched off and withdrawn, creating a 5-mL headspace, and 0.2 mL of saturated HgCl2 solution was added as a preservative. The sample bottles were sealed with glass stoppers lightly covered with Apiezon-L grease, and were stored at room temperature for a maximum of 12 hours prior to analysis.

Over 1600 samples were analyzed for DIC; full profiles were completed at the 'A' stations, with replicate samples taken from the surface, oxygen minimum, and bottom Niskin-type bottles. At a minimum, replicate surface samples were taken at every 'B' stations, and when time permitted, additional depths to 1000m were sampled. The replicate samples were run at different times during the station analysis for quality assurance of the integrity of the coulometer cell solutions. No systematic differences between the replicates were observed.

REFERENCES:

Johnson, K.M., A.E. King, and J.McN. Sieburth (1985): Coulometric DIC analyses for marine studies: An introduction. Mar. Chem., 16, 61-82.

Johnson, K.M., P.J. Williams, L. Brandstrom, and J.McN. Sieburth (1987): Coulometric total carbon analysis for marine studies: Automation and calibration. Mar. Chem., 21, 117-133.

Johnson, K.M. (1992): Operator's manual: Single operator multiparameter metabolic analyzer (SOMMA) for total carbon dioxide (CT) with coulometric detection. Brookhaven National Laboratory, Brookhaven, N.Y., 70 pp.

Johnson, K.M., K.D. Wills, D.B. Butler, W.K. Johnson, and C.S. Wong (1993): Coulometric total carbon dioxide analysis for marine studies: Maximizing the performance of an automated continuous gas extraction system and coulometric detector. Mar. Chem., 44, 167-189.

Wilke, R.J., D.W.R. Wallace, and K.M. Johnson (1993): Water-based gravimetric method for the determination of gas loop volume. Anal. Chem. 65, 2403-2406.

5. Argo Float Deployments

At the request of Dr. Allyn Clarke of the Bedford Institute of Oceanography, five free-drifting, profiling floats were launched during the 2003 A20 occupation. A total of eight Metocean Provor floats were shipped to

Woods Hole one week prior to our departure. A BIO technician, Murray XXXX traveled to WHOI and initiated the floats' operation program. A subset of 5 of these were deployed on A20; the others are to be launched during A22. Operationally, the units were activiated during the up-cast of pre-selected stations by the removal of a magnet from the instrument pressure vessel. Then, as the R/V Knorr began to move off the station, the float was lowered into the sea using a slip line off the vessel stern. Though awkward to carry out given the Knorr's deck arrangement, we belive that all five systems were succesfully deployed. The table below gives launch details:

Serial no.	Date	Time	CTD no.	Lat.	Lon.
MT-111	Sep 26	1524 Z	8	42 25.79 N	51 18.51 W
MT-107	Sep 27	0521 Z	11	41 50.22 N	51 46.96 W
MT-116	Sep 27	2319 Z	14	41 3.52 N	51 46.60 W
MT-109	Sep 29	1645 Z	20	38 56.52 N	52 15.08 W
MT-110	Oct 01	0325 Z	25	36 13.91 N	52 24.01 W

Bromodeoxyuridine incorporation rates as a proxy for prokaryotic production.
Standard Operating Procedure
Carlson Lab, UCSB

Prepping and quantifying BrdU standards:

For each cruise, BrdU standards are prepped and quantified 1-2 months before departure. These standards consist of raw seawater from the Santa Barbara channel incubated for 8-12 hours with 20nmol L^{-1} BrdU. Incubations are done in parallel with three reagents: radiolabeled BrdU, radiolabeled TdR, and cold BrdU. Every 2-3 hours subsamples from quadruplicate incubations are frozen to halt incorporation. Radiolabeled incubations are extracted in parallel using both centrifugation (Smith and Azam 1992) and filtration (Nelson and Carlson 2005) techniques. Filtered radiolabeled samples are cut into single-well rectangles and placed into centrifuge tubes filled with scintillation cocktail for quantification in parallel with centrifuged samples. Time-course relationships are developed for each substrate to ensure linear substrate uptake rates and estimate differential substrate uptake rates. Dilution series for the final timepoint are measured to ensure linearity of calculated concentrations. Final concentration of the non-radioactive standards for use on cruise immunoblots is measured as the mean final calculated fmol mL^{-1} concentration of the filtered, radiolabeled BrdU samples.

Ancillary data associated with every standard prep consists of the following: 1) Rate of uptake of radiolabeled BrdU and TdR as measured by centrifugation and filtration extraction procedures, 2) Linearity of serial dilution of radiolabeled BrdU using filter extraction; to be compared with linearity of chemiluminescence of serial dilution of Cold BrdU by comparing identical Hot and Cold filters, 3) Loss of BrdU substrate during filtration process by comparing timepoints between filter and centrifuge extraction methods, 4) Quantification in fmol mL^{-1} of final BrdU standard with variance quantified by comparing 11 separate filtrations of undiluted 12hr. radiolabeled standard.

Preparation of Cruise Sampling Blots:

Water from each sampling point is aliquoted into quadruplicate 2mL incubations in microcentrifuge tubes and amended with BrdU to a final concentration of 20nM. Tubes are incubated at in situ temperatures for 8-12h followed by rapid freezing to halt incubation. Tubes are thawed within 1 month and the full 2mL is filtered onto charged Nylon blotting paper using a slot blotter. Typically each blot is prepped with quadruplicate samples from 8 depths at a single lat/long station, along with parallel duplicate serial dilutions of two separate standards on the same blot. Immediately after filtration blots are taken through a series of treatments designed to lyse cells and bind DNA to the charged nylon membrane (Nelson and Carlson 2005). Briefly, each blot is placed face down momentarily on filter paper soaked with a strongly basic Lysis Buffer, then incubated face up on the soaked filter paper for ten minutes. This process is repeated using a Nuetralization Buffer, then again on a nucleic acid fixative called FixDenat (Roche Molecular Products). Finally, the blot is baked at 85°C for 1 hour and stored in a sealed plastic bag.

Development of Chemiluminescent Immunoblots:

Upon return to laboratory, baked immunoblots are stored up to 9 months at room temperature or refrigerated in plastic bags. Blots are developed according to the HRP-chemiluminescence protocols outlined in Nelson and Carlson (2005). Briefly, each blot is placed into a polystyrene

tray and incubated shaking at 60rpm for 1hr in blocking buffer, 3hrs in antibody buffer, two times five minutes wash buffer, and two times five minutes Maleic Acid Buffer. Blots are then removed from liquid and placed on the lid of the incubation tray. 1mL each of the two Pierce Supersignal Femto reagents are mixed and the 2mL final reagent is immediately pipetted onto the blot to cover all available surfaces. The blot is incubated exactly 2min before a paper towel is placed over the surface to absorb the development reagent. After development the blot will remain chemiluminescent for about 30min, but is strongest in the first 5-10 min after developing. The blot is immediately photographed and quantified as follows using a BioRad Versadoc or similar chemiluminescent dark CCD-imager. Using 60s exposures, maximum aperture size, and "Chemiluminescent Hi-Sensitivity", the blot is photographed repeatedly until all wells are squarely within the viewfinder (this makes quantification more straightforward). Using the Transform Fuction, adjusting the High slider will permit visualization of low-concentration wells. When blot is correctly centered, a 300s exposure is taken and used to quantify the concentration of BrdU in each well.

Analysis of Chemiluminescent Immunoblot Images:

Quantity One software is used to analyze all immunblots. Standardized rectangular grids are drawn around filtration points on the blotting membrane and chemiluminescence is quantified as intensity per well. Duplicate serial dilutions of standards on each blot are used to develop a linear regression relating chemiluminescent intensity to concentration of BrdU. Quadruplicate incubations of seawater with BrdU are analyzed for each sample as described above, and wells which present a BrdU concentration >1 standard deviation above the mean of the four incubations are removed from the analysis. BrdU incorporation rates are calculated as concentration divided by incubation duration for each sample, and may be related to rates of TdR incorporation using the regression detailed in Nelson and Carlson (2005).

Reference:

Nelson, C. E., & Carlson, C. A. (2005). A nonradioactive assay of bacterial productivity optimized for oligotrophic pelagic environments. Limnology and Oceanography-Methods, 3, 211-220.

Dissolved Combined Neutral Sugar Samples
Standard Operating Procedure
Carlson Lab UCSB

Cleaning procedures: Glassware, Glass Fiber Filters (G/FF), and collection vials

All glassware and G/FFs used were combusted at 450 ^{o} C and 400 ^{o} C respectively for 3 hours. High density polyethylene collection bottles (HDPE) were cleaned with 5-10 % hydrochloric acid (HCl) and nanopure water (Barnstead Thermoline). Polycarbonate tubes used for neutralization were pre-cleaned with MeOH, 5% HCl, 0.5 M NaOH, nanopure water and dried prior to usage.

Sample collection and storage

Samples were filtered through combusted 47 mm G/FFs and collected in 60 mL high density polyethylene (HDPE) bottles. All sample bottles were rinsed 3x with sample filtrate before filling.

Samples were stored at - 20 ^{o} C shipboard prior to being shipped to UCSB for further storage then analysis.

Hydrolysis, Neutralization and Desalting

Extraction of DCNS samples followed the methodology of Borch and Kirchman (1997), with slight modification of hydrolysis time and neutralization. Prior to hydrolysis, 4 mL of sample water was aliquoted into combusted 5 mL glass ampules (Wheaton) Ampules were then flame sealed and samples were hydrolyzed (0.85 M H_2SO_4) at 100 ^{o} C for 21 hours.

Samples were cooled to room temperature and neutralized in 30 mL polycarbonate tubes filled with 0.427 g of combusted (450 ^{o} C for 3 hours) $CaCO_3$. A series of vortexing and mixing followed to bring pH levels to ~ 6. Tubes were vortexed 1 minute, placed on a shaker table for 15 minutes (vigorous shaking), and vortexed again for 30 seconds. Samples were then placed in an ultracentrifuge for 30 minutes at 14000 RPM's. The supernatant was pipetted into combusted 7 mL glass scintillation vials equipped with teflon lined caps. Samples were refridgerated (4 ^{o} C no longer than 2-3 days) in the dark until desalting.

Helium gas was used to flush/collect during all desalting steps. Samples were desalted in 20 mL HDPE columns (BioRad) that were cleaned with full bed volumes of NaOH (0.5 M), HCl (5-10%), and nanopure water. Columns were loaded with 7 mL of mixed anion (AG 2-X8) and cation (AG 50W-X8) exchange resin (BioRad) then flushed 3x with two bed volumes of nanopure water. Resin was primed 3x (and immediately flushed) with 400 uL of sample before 900 uL of sample was added to the resin for 7 minutes. Desalted samples were then collected in combusted 20 mL scintillation vials. All samples were refridgerated (4 ^{o} C no longer than 2-3 days) in the dark until HPLC analysis.

Analysis of DCNS using HPLC-PAD

DCNS were analyzed using a Dionex Bio-LC 600 equipped with a GS-50 pump, ED-50 detector, and AS-50 autosampler. Peaknet 6 integration software was used for data collection. Sugars were isocratically eluted at 18mM NaOH (50% w/w, Fisher), and separated with a CarboPac PA-10 analytical and guard columns. The electrochemical detector was equipped with an Au working electrode and a pH reference electrode. A 200 mM NaOH post wash was used to minimize $CaCO_3$ buildup on the columns.

System Performance and Sample Standardization

System performance was monitored with a known Dionex mono-standard of 6 sugars every 8th sample. A mono-standard mix of 7 sugars (Absolute Standards, Inc.) was used to calculate unknown sample sugar concentrations. Standards were run in duplicate and subjected to the same extraction procedure above. A 4-point standard curve was used to calculate unkowns (10, 75, 125, 250 nM). Deep and surface reference seawater samples from the Santa Barbara Channel were extracted (reps of 3 each) each run to monitor the efficiency of the hydrolysis, neutralization, and desalting steps.

Various terms on spreadsheet:

DCNS: is the sum of all individual sugars and refers to dissolved combined neutral sugars after hydrolyses.
FUC: concentration of fucose after hydrolyses.

RHAM: concetration of rhamnose after hydrolysis
ARAB: concentration of arabanose after hydrolysis
GAL: concetration of galactose after hydrolysis
GLU: concentration of glucose after hydrolysis
MAN: concentration of mannose after hydrolysis

Reference:

Borch, N. H. and D. L. Kirchman (1997). "Concentration and composition of dissolved combined neutral sugars (polysaccharides) in seawater determined by HPLC-PAD." Marine Chemistry **57**: 85-95.

Enumerating various microbial concentration via Flow Cytometry
Standard Operating Procedure
Carlson UCSB

Seawater samples were collected in the field from Niskin bottles into sterile cryovials and immediately preserved with fresh Paraformaldehdye stock at a 0.2% final concentration. Samples were left to fix 10 minutes at room temperature, then for long-term storage were placed immediately into liquid nitrogen to preserve fluorescence.

Samples were analyzed via the method of Campbell (2001) using a Becton Dickinson FACSCalibur flow cytometer. Internal calibration of the FCM system is carried out using commercially available fluorescent polystyrene beads of uniform size. Initial conditions are established by running sheath fluid consisting of particle free seawater, prepared by double filtering seawater through 0.22um disposable filters. For analysis of autotrophic picoplankton 5ul of calibration beads are added to 0.5ml of sample volume. For non-autofluorescent populations, the nucleic acid stain SYBR Green was added to samples to distinguish populations of heterotrophic bacteria cells. Oligotrophic ocean samples are run on high flow rate (60ul/min) for 2-4 minutes and 10 000 events collected per population. Blanks consisting of filtered seawater are also run at the standard settings used for analysis.

Flow cytometric listmode data is processed and analyzed using software to quantify the abundance and optical properties of individual populations of picoplankton. Cell abundance for each population (N) in a field sample is calculated in cells/ml from the equation:

$$N = C / (T \times R) \times CF \times 1000ul/ml$$

where C is the number of events acquired for a specified population, T is the duration of analysis in minutes, R is the sample delivery rate in ul/min, and CF is a correction factor accounting for dilution of sample.

Various terms on spreadsheet:

BACT: refers to concentration (cell /L) of non pigmented “heterotrophic bacterioplankton”
PRO: refers to concentration (cell /L) of prochlorophytes
PEUK: refers to concentration (cell /L) of pigmented picoeukaryotes
SYN: refers to concentration (cell /L) of *Synechococcus* species

Reference:

Campbell, Lisa 2001. Flow Cytometric Analysis of Autotrophic Picoplankton. *Methods in Microbiology,* Vol. 30: 317-343.

Data Processing Notes

Date	Contact	Data Type	Event	Summary
10/29/03	Delahoyde	CTD	Submitted	Includes headers

Format for A22 2db pressure-series downcast CTD data:

Pressure	(decibars)
Temperature	(ITS-90 Deg C)
Salinity	(PSS-78)
Dissolved O2	(uM/kg)
Potential Temperature	(ITS-90 Deg C)
Sigma Theta	
Transmissometer	(0-5Volts)

02/04/04	Delahoyde	Cruise Report	Submitted	
02/11/04	Delahoyde	BTL	Submitted	Preliminary data, PI names

These data were provided by:

PARAMETER/PROGRAM	NAME	EMAIL ADDRESS
Chief Scientist	John Toole-WHOI	jtoole@whoi.edu
Co-Chief Scientist	Alison McDonnald-WHOI	amacdonald@whoi.edu
CTDO/S/O2/Nutrients	James Swift-SIO	jswift@ucsd.edu
DIC	Dick Feely- PMEL	feely@pmel.noaa.gov
CFC	William Smethie-LDEO	bsmeth@ldeo.columbia.edu
TALK	Andrew Dickson-SIO	adickson@ucsd.edu
CDOM, DOC, DON	Craig Carlson-UCSB	carlson@lifesci.ucsb.edu
He/Tr	William Jenkins-WHOI	wjenkins@whoi.edu
Surface C14	Ann McNichol-WHOI	amcnichol@whoi.edu
Surface C14	Robert Key-Princeton	key@princeton.edu
C13 profiles	Paul Quay-UW	pdquay@u.washington.edu

The data included in these files are preliminary, and are subject to final calibration and processing. They have been made available for public access as soon as possible following their collection. Users should maintain caution in their interpretation and use. Following American Geophysical Union recommendations, the data should be cited as: data provider(s), cruise name or cruise ID, data file name(s), CLIVAR and Carbon Hydrographic Data Office, La Jolla, CA, USA, and data file date. For further information, please contact one of the parties listed above or whpo@ucsd.edu. Users are also requested to acknowledge the NSF/NOAA-funded U.S. Repeat Hydrography Program in publications resulting from their use.

02/11/04	Diggs	CTD/SUM	Update needed	CTD Reformatted/SUM probs

I have placed the A20 2003 data online with a webpage. Once we've straightened out the datahist and table generation situation, we will be able to place this page in the online tables for the Atlantic.

WEBPAGE: http://whpo.ucsd.edu/data/co2clivar/atlantic/a20/a20_2003a/index.htm

WOCE Formatted Files:
CTD files were format corrected to include the new WHPO generated expocode as was the sumfile. the bottle file had incorrect NO_DATA values and was reformatted as well. The new expocode was included in the bottle file for consistency.

WHP-Exchange files:
The Sumfile from ODF has minor formatting issues which preclude the translation of the bottle and CTD data into WHP-Exchange. I will attend to these problems when I return on Tuesday, 2/17/04.

Data Processing Notes

Date	Contact	Data Type	Event	Summary
02/11/04	Diggs	Cruise ID	Expocode Changed	now 316N200309 (was 316N173/1)

The A20 data is formally online at a new location:

http://whpo.ucsd.edu/data/co2clivar/atlantic/a20/a20_2003a/index.htm

You'll notice that the expocode for the WHPO website is now 316N200309 (was 316N173/1). This is consistent with the way the WHPO/CCHDO now keeps records and assigns expedition codes. Each cruise has an NODC shipcode, then the 4-digit year and the 2-digit month taken from the first date of the cruise. We realize that this may cause problems for individuals who refer to A20 by the old expocode.

02/20/04	Diggs	CTD/BTL/SUM	Website Updated:	Data online

The CTD data for A22 (2003) are now available on-line through all links from the whpo.ucsd.edu webpage. In addition, ted and I have fixed all of the normal links so that both the A20 and A22 cruises (both versions of each) are accessible from all of the normal links on the WHPO website.

04/14/04	Kappa	Cruise Report	Submitted	PDF & ASCII Versions

04/14/04 Kappa DOC Updated Cruise Report as follows:
Produced an ASCI version of the original PDF report
Added WHPO/CCHDO Summary pages to PDF and ASCI reports
Added internal links to figures and WHPO/CCHDO sections in PDF report
Added he WHPO/CCHDO-generated Station Location Plot to PDF report
Added these Data Processing Notes to the PDF and ASCI reports

05/24/04	Roberts	TCARBN Report	Submitted	Data Recalculated

I have submitted my final A20/A22 data to WHP, and have included revised documentation with it. The documentation includes discussion of the final data processing, including recalculation of the TCARBN files using bottle salinities, as well as our secondary standards (CRMs) corrections. (the Documentation section) has the original cruise report.

06/10/04	Kozyr	TCARBN	DQE begun	Data from Marilyn Roberts

I wanted to let you know that I received the DIC measurements for Repeat Sections A20 and A22 from Marilyn Roberts, PMEL. These measurement were adjusted for CRM measurements and went through preliminary quality control at PMEL. I will have done our routine quality evaluation for these data and will send you new data as soon as I finish.

06/21/04	Kozyr	TCARBN	Submitted	Data are Final

I have submitted 2 files to WHPO with the corrected TCO2 values for merging to the master file. I hope you like the format of the files. The quality flags changed a bit too, so please merge the flags as well. However, I have a few questions to the TCO2 PI regrading some quality flags, so they might change in a future. TALK corrected values will be sent to CDIAC in a few weeks by Andrew Dickson per our conversation today.

The file:	a20tco2_whpo.txt - 131976 bytes
has been saved as:	20040621.084208_KOZYR_A20_a20tco2_whpo.txt
in the directory:	20040621.084208_KOZYR_A20
The data disposition is:	Public
The bottle file has the following parameters:	TCO2
The file format is:	WOCE Format (ASCII)
The archive type is:	NONE - Individual File
The data type(s) is:	Bottle Data (hyd)

The file contains these water sample identifiers:

Cast Number (CASTNO)	Station Number (STATNO)
Bottle Number (BTLNBR)	Sample Number (SAMPNO)

KOZYR, ALEX would like the following action(s) taken on the data:
Merge Data
Any additional notes are:
This is a file with corrected parameters of TCO2 for section A20. A22 is comming soon.

Data Processing Notes

Date	Contact	Data Type	Event	Summary
06/23/04	Kozyr	BTL	Update needed	Question with sta 23, btl 36
	There is a problem in the a20_2003ahy.txt file with station 23 bottle 36 line which reads like this: 23 1 36 36 3.2 3.2 25.1581 36.4222 207.1 25.1574 36.4297 206.6 0.65 0.15 0.00 0.03 9.919 0.4612036.300 2381.522222222244422.0 Could you please check this out and let me know what are the correct data for this bottle, or may be we should get this bottle out of set.			
06/29/04	Bartolacci	BTL	Data file corrected	as per A.Kozyr's email
	I have fixed the error found by Alex Kozyr in the A20_2003a bottle file described in the email below. The original data PI's file did not have this error in it and the entire sample/bottle line of data was replaced with the original line. It is unclear at this point what caused the erroneous values in the online woce file. The new file was checked with wocecvt to find no errors and was placed online. original file was renamed and moved to the original directory.			
07/08/04	Bartolacci	TCARBN	Website Updated:	Data Online
	I have merged the new DIC values sent by Alex Kozyr, into the A20_2003a bottle file. No other edits were made to the bottle file. Data merged with no errors. File was format checked with wocecvt and moved to parent directory. Old file was renamed and moved to original directory. exchange and netcdf files were generated. All opened in JOA with no errors.			
07/13/04	Bartolacci	CTD	Website Updated:	Data Online
	Edits made to CTD files for a20_2003a: • Edited all station file header line parameters No. Headers to NO. HEADERS • Edited date parameter in headers of station files 30, 33, 36, 45, 58, and 66 to match sumfile date. • Ran wctcvt with no errors. • Converted files to both exchange and netcdf with no errors. NOTE- station file 89 cast 1 is an empty file. This is true of original file obtained from data originator as well. Inquiry on this station file will be sent to data originator. At present it will be removed from the ctd zip file and converted format files online.			
08/17/04	Davis	Cruise Report	Website Updated:	pdf & txt cruise reports online
11/11/04	Willey	CFCs	Submitted	Final/Public Data
	The file: A20_2003_CFCs_FINAL_headers.dat - 183300 bytes has been saved as: 20041111.130455_WILLEY_A20 2003_A20_2003_CFCs_FINAL_headers.dat in the directory: 20041111.130455_WILLEY_A20 2003 The data disposition is: Public The bottle file has the following parameters: CFC-11, CFC-12, CFC-113, CCL4 The file format is: Plain Text (ASCII) The archive type is: NONE - Individual File The data type(s) is: Bottle Data (hyd) The file contains these water sample identifiers: Cast Number (CASTNO) Station Number (STATNO) Bottle Number (BTLNBR) WILLEY, DEBRA would like the following action(s) taken on the data: Merge Data Place Data Online Any additional notes are: Ascii file of CFCs from A20 2003. Generally, odd stations were sampled and analyzed by UM/ RSMAS and even stations sampled and analyzed by Lamont.			

Data Processing Notes

Date	Contact	Data Type	Event	Summary
11/24/04	Anderson	CFCs	Website Updated:	WOCE/Exchange/NetCDF files

Debra Willey submitted final cfc11, cfc12, cfc113, and ccl4 data on Nov. 11, 2004. These final data have been merged into the data file.

Sta. 37, cast 1, bottle 12 had a value of 2.000 and a Q flag of 0 for ccl4. Debra checked and sent a new value of 0.429 and a Q flag of 2.

Also a problem with sta. 23, cast 1, bottle 36. Cfc12 value is way out of acceptable range and exchange program would not accept, even though the Q flag was 4 (bad measurement). I had to edit the value into both the .hyd and .csv files. Made new exchange and netcdf files and put online.

12/17/04	Kozyr	TCARBN	Data Status Check	Data are Final & OnLine

A20 and A22 (2003):

I have the final TCO2 data from Marilyn Roberts, I merged these data into WHPO format, made our QA-QC work, and sent the data to CCHDO on June 22, I have automatic confirmation on receiving these data. I've checked CCHDO web site for A20/A22 and noticed that the final TCO2 data were incorporated to the bottle data files.

Andrew Dickson is still working on his Total Alkalinity data for A20/A22 sections. I've sent Andrew a message a few days ago with question about a status of his TALK data, but did not have a reply yet. The TALK numbers in CCHDO bottle data file are preliminary and will be adjusted as soon as I get the data from Andrew and work on merging and QC.

03/04/05	Smethie	CFCs	Update needed	Questionable data points

Since submission of the final CFC data for the repeat of WOCE line A20 (Kn173/1), Sept 22 - Oct 20, 2003, we have found some data points that are questionable and should be flagged as such. All CFC data for station 38 and for bottles 24, 26, 32, 34, 35, 36 of station 40 should be flagged as questionable.

03/07/05	Willey	CFCs	Update needed	Will re-submit

Last week, William Smethie sent changes to the A20 (2003) CFC data for stations 38 and 40. Today when I began to make changes to my files, I realized that I needed to do some work to make the appropriate changes to station 38... There are several bottles where both RSMAS and Lamont took samples (i.e., duplicates). These are usually averaged and given a flag of 6, or in the case where one lab's sample is questionable and one is good, the good one is used. This means that rather than flagging all of station 38 CFCs with a quality byte of 3, there are several bottles where the RSMAS data can be used. So, in a nutshell, I will be re-submitting data for station 38 this week, as soon as I make the changes.

03/09/05	Willey	CFCs	Submitted	Data Update:

The file: A20_2003_CFCs.csv - 116259 bytes
has been saved as: 20050309.085410_WILLEY_A20_A20_2003_CFCs.csv
in the directory: 20050309.085410_WILLEY_A20

The data disposition is:	Public
The bottle file has the following parameters:	CFC-11, CFC-12, CFC-113, CCL4
The file format is:	WHP Exchange
The archive type is:	NONE - Individual File
The data type(s) is:	Bottle Data (hyd)

The file contains these water sample identifiers:
- Cast Number (CASTNO)
- Station Number (STATNO)
- Bottle Number (BTLNBR)

WILLEY, DEBRA would like the following action(s) taken on the data:
- Merge Data

Any additional notes are:
- This is a RE-submission of the CFC values that were originally sent on 11/11/2004. Corrections were made to stations 38 and 40.

Data Processing Notes

Date	Contact	Data Type	Event	Summary
04/20/05	Nelson	CDOM	Submitted	Final Data
	Final CDOM Data from 2003's A20 and A22 lines.			
08/22/05	Toole	Underway	Submitted	Documentation also provided
	The attached matlab-format file holds all the underway data collected on this leg. The two .txt files hold documentation as provided me by the Knorr's science tech. Not all variables listed in the documentation were actually logged. Hopefully the variable names in the mat file are understandable. Please forward to Shawn as appropriate, and let me know if anyone has any questions.			
10/25/05	Carlson	DOC	Submitted	Final data w/ Qual flags
	The DOC data for A20 and A22 are finally complete. The long delay was largely due to the fact that for a long stretch our machines were down but all the problems have been resolved and all the samples were run when the machines were stable and performing well. Attached are final DOC data and the quality flags for the A20 and A22 lines. For a while we have been trying to submit via the web but have not been able through the submit page so I thought I would forward the files directly to you. Because this page is not working I am not sure if you need any other info associated with this data...so if you need mor info please let me know. The final DOC data in these files are reported as µmol / L. I assigned quality flags according to the WHP codes. There were a few samples from each line that were misplaced or missing so I have entered a 5 as a quality flag for those sample.			
10/25/05	Carlson	DOC	Submitted	DOC data report
	Here is the documentation for DOC collection and analyses. Let me know if you need any other info.			
02/07/06	Jenkins	HELIUM	Analysis Completed	Data Processing Pending
	We have also completed the helium analyses for the A20 and A22 cruises, and I hope to submit those results shortly. I had hoped to complete the data processing prior to the Ocean Sciences meeting, but may have to do it afterward.			
02/14/06	Dunworth	C13/C14	Submitted	by email
	Jenkins is still processing the tritium, and hasn't begun the helium.			
11/09/06	Carlson	BACT	Submitted	Microbe concentra/Neutral sugars
	Here are several additional ancillary data that accompany the core CDOM data (already submitted) for A20 and A22. They include concentrations of microbes in the upper 250 m, bromodioxyuridine incorporation rates (proxy for microbial production) and concentrations of dissolved combined neutral sugars for A20. I have also included brief standard operating procedures for each parameter. Again these are level III ancillary data to the bigger CDOM data set. These data analyses are extremely labor intensive to generate and were just recently completed, QC'd and finalized. I am not sure how they are to be incorporated into the larger data sets but wanted to make sure data center received these final data.			
05/22/06	Carlson	Cruise Report	Submitted	DOC report
	Here is the documentation for DOC collection and analyses. Let me know if you need any other info			
05/31/06	Anderson	DOC	Website Updated:	No exchange file yet
	May 31, 2006 a20_2003a, 316N200309 Merged the DOC sent by C. Carlson on Oct. 25, 2005 into the online file. There were no apparent problems. The WOCE to EXCHANGE STILL needs to have DOC added, so I DID NOT MAKE A NEW EXCHANGE file.			
11/15/06	Kozyr	CO2	Submitted	Data status summary
	Here are the latest update on the Carbon Data status at CCHDO and CDIAC. A20_2003: TCO2 - OK; TALK - no final data from Dickson; DOC - final data were not merged in the exchange file at CCHDO.			

Data Processing Notes

Date	Contact	Data Type	Event	Summary
11/25/06	Carlson	BACT	Submitted	Microbial Abundance data
	File: A20_BACT_11-20-06.txt Type: txt Status: Public Name: Carlson, Craig Institute: University of California Santa Barbara Country: uSA Expo:316N200309 Line: A20_2003 Date: 03/10 Action:Place Data Online Notes: Microbial Abundance data from A20			
11/25/06	Carlson	BrdU	Submitted	Bacterial production data from A20
	File: A20_BrdU_11-20-06.txt Type: txt Status: Public Name: carlson, Craig Institute: university of California Santa Barbara Country: uSA Expo:316N200309 Line: A20-2003 Date: 03/10 Action:Place Data Online Notes: Bacterial production data from A20			
11/25/06	Carlson	DCNS	Submitted	Dissolved combined Neutral Sugar
	Action:Place Data Online Notes: Dissolved combined Neutral Sugar data for A20			
12/13/06	Jenkins	He/Tr/Neon	Submitted	Data are Final
	Please find attached a spreadsheet containing the helium isotope, helium and neon analytical results for A20_2003, A22_2003, and P02_2004. Hopefully the tables are self-explanatory, but please let me know if there are any questions. I will be working on and sending the accompanying tritium data in the near future, and will then work on sending you the A20_1997 and A22_1997 data. File: RH2 Tritium Submission.csv Type: Status: Public Name: Jenkins, William Institute: WHOI Country: USA Expo: 316N200309 Line: A20 Date: 09/2003 Action: Place Data Online Notes:			
01/10/07	Jenkins	TRITUM	Update needed	Computational error
	We have just discovered a computational error in about 2 dozen of the tritium analysis results I submitted for A20/22. The changes are quite significant and should be corrected. How would I go about doing this?			
11/19/07	Jenkins	HELIUM	Submitted	Data are public
	Helium Submission.csv Type: Status: public Name: Jenkins, William J Institute: WHOI Country: USA Expo: 316N200309 Line: A20 Date: 2003-09-22 Action: Place Online			
12/19/07	Carlson	TDN	Submitted	Upper 300 m
	Name: Carlson, Craig Institute: UCSB Country: USA Expo: 316N200309 Line: A20 Date: 2003-09-01 Action: Merge Data Notes: Attached are total dissolved nitrogen data determined for the upper 300 m. These data are used in combination with nitrate and nitrite to calculate DON. TDN is reported because that's the parameter actually measured. These are ancillary data to the larger DOC data sets already submitted.			

Data Processing Notes

Date	Contact	Data Type	Event	Summary
01/15/08	Bartolocci	Citations	Website Updated	added to all online files
	Citations have been added to all online files for a20_2003a. File was pre-pended to the comment lines at the beginning of the bottle exchange file and zipped together with all other product files (all ctd, and bottle netcdf). All files are online.			
02/15/08	Kozyr	DOC/TDN	Submitted	Second submission
	Status: public Name: Kozyr, Alex Institute: CDIAC/ORNL Country: USA Expo: 316N200309 Line: A20_2003 Date: 2003-09-22 Action Merge Data, Place Online Notes: Here are the DOC and TDN data. I've submitted DOC measurements before for this cruise but do not see these numbers mearged yet, so I send them again.			
04/04/08	Key	C13/14	Submitted	Public
	I resubmitted the data to you today (2 files) via the web site. Format of these may be easier for you to merge and the data now has the QC flags.			
04/18/08	Johnson, Mary	CTD	Update needed	Various errors
	Errors found by ODF in CTDO data submitted 2003/2004 for CLIVAR A20/A22: • CTDTEMP data reported were IPTS68, but labeled as ITS90 • CTDOXY data did not have corrections applied properly, likely due to a scripting error. The top 10-20db are very skewed for most stations, and deep data are occasionally affected as well. • Transmissometer data were not included with the CTD data originally, • Fluorometer data were not block-averaged and are not reported. Corrected CTDO data files were submitted by ODF to CCHDO on 3/18/2008. Uncalibrated transmissometer data are also included, pending updates by Wilf Gardner (TAMU). Fluorometer data were collected with the CTD, but not block-averaged; they are not reported.			
07/28/08	Kozyr	ALKALI	Submitted	Correction of 6/23/08 data file
	This is the corrected and final TALK (Alkalinity) data I received from Andrew Dickson on 07/25/2008 and flags for merging into the master file. Please, let me know when the data will be available online after the merging.			
06/23/08	Kozyr	ALKALI	Submitted	Data are final
	Here are the final TALK data from Andrew. I will send the metadata file as soon as I get it from Andrew ti include it in the report. Please, merge the TALK numbers ASAP as these data are due so much behind.			
04/08/09	Kappa	Cruise Report	Submitted	new sections added
	Reports added to this document include: • Dissolved Organic Carbon Analyses • Bromodeoxyuridine incorporation rates as a proxy for prokaryotic production • Dissolved Combined Neutral Sugar Samples • Enumerating various microbial concentration via Flow Cytometry Expanded these Data Processing Notes Converted Cruise Report to PDF and Text formats			

Data Processing Notes

Date	Contact	Data Type	Event	Summary
01/15/08	Bartolocci	Citations	Website Updated	added to all online files

2009.03.28 DBK
Merging Notes for a20_2003a bottle file

The following parameters were merged using the new merge_exchange_bot.rb created by Justin Fields. Parameters were merged into exchange bottle file only at this time, the WOCE formatted bottle file is not up to date.

ALKALI:
These data were sent by Alex Kozyr on 2008.07.28. Header TALK was edited to ALKALI. Data were merged with no problems.

TDN, DOC:
These data were sent by Alex Kozyr on 2008.02.15. Data were merged with no problems.

DELC14, DELC13:
Delc14 and error, and delc13 data were sent by Bob Key on 2008.04.17 Header was edited to reflect CCHDO parameter names and units were added to file before merging. Missing values were edited from -9 to -999 before merging. Data were merged with no apparent problems.

**NOTE:These data were remerged after it was brought to our attention that delc13 had incorrect precision on our parameter table.

HE, DELHE3, NEON:
DELHE3,HELIUM,NEON and their associated error and flag values were sent by Bill Jenkins on 2007.11.19. Headers names were edited to CCHDO parameter names and units were added. Data were merged with no apparent problems.

**NOTE: It should be noted that the data history reflects an entry by Bill Jenkins for TRITUM (tritium) data. This entry pertains to the previous occupation of line A20 (1997). There were no TRITUM data submitted for this cruise. There was mention of drawing a sample for analysis in the bottle sampling protocol in the doc file for this cruise, however there is no mention that samples were drawn and analyzed for tritium.

BRDU:
BrdU data were sent by Craig Carlson on 2006.11. File was edited for use in merge code: line/feed carriage returns were edited into file, header parameters and units were edited to reflect CCHDO parameter names, missing values for data and flags were added to previously blank entries. Flags for valid values were edited from "1" to "2". Several stations had incorrect cast number associated with the station/cast/sample values : edited station 20/2 to 20/1 for samples 7, 5, 3. Stn/cst/samp 37/-9/-9 was deleted as it contained no data values. Five entries of 37/1/-9 were deleted as they all contained no data at all. The duplicate entry for 37/1/6 was deleted as neither entry contained data. After these edits, data merged with no apparent problems.

DCNS:
This file contained DCNS, FUCO, RHAM, ARABI, GLAA, GLUC, MAN data sent by Craig Carlson on 2006.11.20. File was edited for use in merge code: line feed/carriage returns were added, all parameter and units headers were edited to reflect CCHDO parameters names, missing values and flags were added to previously blank entries, flags for valid values were edited from "0" to "2", however it was assumed that all values possessing a flag "4" were truly accurate and were left as-is. Several stations had incorrect cast number associated with the station/cast/sample values : edited station 20/2 to 20/1 for samples 7, 5, 3. Stn/cst/samp 37/-9/-9 was deleted as it contained no data values. Five entries of 37/1/-9 were deleted as they all contained no data at all. The duplicate entry for 37/1/6 was deleted as neither entry contained data. Entire file was edited after these changes, to

Data Processing Notes

contain only data necessary for the merge code to operate. After these edits, data merged with no apparent problems.

BACT:
BACT, PEUK, SYNN, PROC data sent by Craig Carlson on 2006.11.20. File was edited for use in merge code: line feed/carriage returns were added, all parameter and units headers were edited to reflect CCHDO parameters names, missing values and flags were added to previously blank entries, flags for valid values were edited from "1" to "2", deleted all lines which contained no cast, station, sample numbers which also held no values for bacteria data, deleted all lines which contained duplicate sample numbers and black spaces for values. Edited cast from 2 to 1 for station 20 samples 7,5,3. Stations 63, 64, 65, 51 all contained cast 2 and were changed to cast 1 to match original bottle and summary files. Entire file was edited after these changes, to contain only data necessary for the merge code to operate. After these edits, data merged with no apparent problems.

CDOM:
CDOM data for 325, 340, 380, 412 nm and spectral slope CDOMSL, CDOMSN were submitted by Norm Nelson on 2005.04.20. The header was edited to reflect CCHDO parameter names. Fewer samples were submitted in the file than contained in the CCHDO bottle file. Missing values were added as such into the bottle file. Values for CDOMSL and CDOMSN at station 37 cast 1 samples 34, 35 were reported as NaN's with flags of "2". In order to merge the rest of the data, these values were changed to -999.0 with a flag of "5" (not reported). An email was sent to Norm Nelson requesting further advice on how to report these two values. Data were merged with no apparent problems.

Final file was loaded into JOA without error and plots of all parameters were made to identify any errors as a result of merging. None were apparent.

Final file containing all merged parameters named a20_2003a_mergd_doc_tdn_alk_hene_c1314 _bct_cns_bdu_cdom_hy1.csv indicates the order in which parameters were merged. This file was renamed a20_2003a_hy1.csv, citation information prepended to the top of the file, and file was placed back online.

NOTE: this file did not convert to netcdf due to unknown errors.

At this time, the WOCE formatted bottle file is not up to date with these merged and added parameters. I will attempt to make as complete a file as possible using the new exchange_to_woce conversion code created by Justin Fields and indicate to Jerry Kappa when this has been successfully completed.