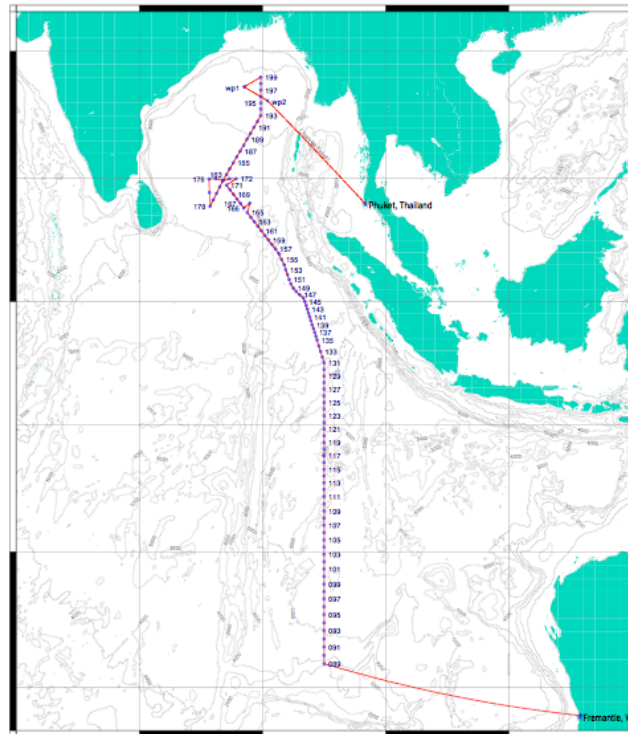


# CRUISE REPORT: I09N\_2007

(Updated: 01 JUL 2017)

## A. HIGHLIGHTS



### A.1. CRUISE SUMMARY INFORMATION

CLIVAR/CO2/WHP designation	<b>I09N</b>		
Expedition Designation	<b>33RR20070322</b>		
Chief Scientist	<b>Janet Sprintall/SIO*</b>		
Co-Chief Scientist	<b>Sabine Mecking**</b>		
Cruise Dates	22 March 2007 to 01 May 2007		
Ship	<i>R/V Roger Revelle</i>		
Ports of Call	Fremantle, Australia to Phuket, Thailand		
Number of stations	111		
Stations Geographic boundaries	85° 39.44' E	18° 0.19' N	95° 0.87' E
		28° 18.8' S	
Floats and drifters deployed	14 Argo floats deployed		
Moorings deployed or recovered	0		
Contributing Authors	none cited		

#### Chief Scientists' Contact Information

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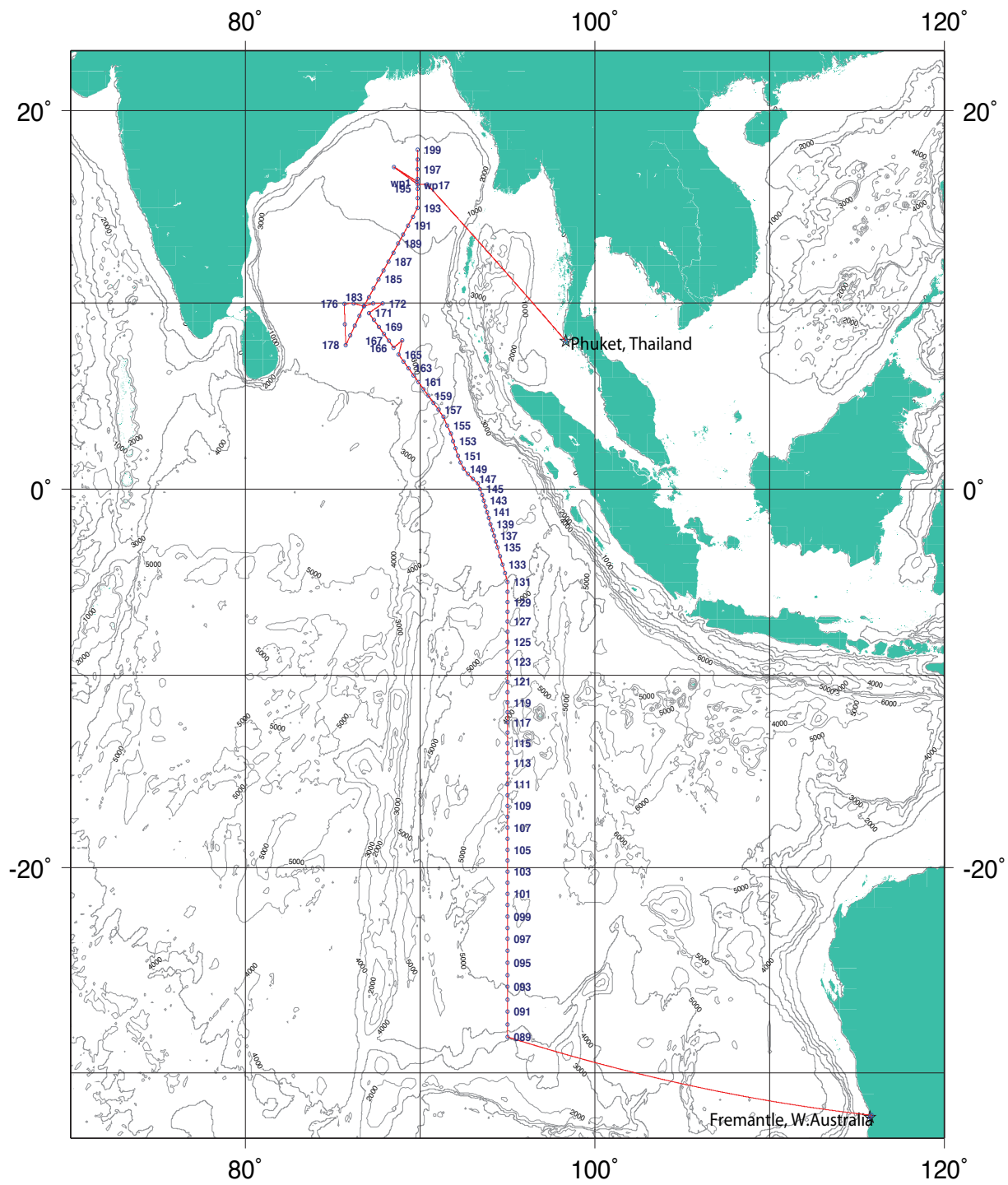
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# Station Locations • I09N\_2007 • Sprintall • *R/V Revelle*



## **A.2. Cruise Summary**

The R/V Roger Revelle completed a hydrographic survey of CLIVAR/CO<sub>2</sub> section I9N in the Indian Ocean, nominally along 95°E (between 28°S and 4°S) and up into the Bay of Bengal, from 22 March to 01 May 2007 ([Figure 1](#)). The 41 day cruise began at 0800 22 March 2007 from Fremantle, Western Australia and ended at 0800 01 May 2007 in Phuket Thailand.

A total of 111 stations were occupied. The station numbers were consecutive with those from the I8S cruise (Chief Scientist Jim Swift) that was occupied just prior to I9N from 2 February to 17 March 2007. The first cast of I9N, Station 89, was a reoccupation of the I8S Station 88. Station spacing was nominally 30 nm apart, except at the equator where station spacing was 20 nm. Stations 89 through 147 are exact repeats of the 1995 WOCE I9N Stations 155 to 212. Our transect then deviated slightly westwards from WOCE I9N to avoid the Indonesian EEZ, before angling northwestward up into the Bay of Bengal. Stations 172 through 176 are reoccupations of 1995 WOCE I1E Stations 991,990,989 (also WOCE I9N Station 268), 987 and 986. Stations 178 through 193 followed the original WOCE I9N section Station 260 to 271 across the north-eastward central axis of the Bay of Bengal. Station 182 repeated station 174 as well as the corresponding WOCE I1 (989) and WOCE I9N (268) stations. After a short northward section from Station 193, our station sampling ended at Station 199 in ~2000 m water depth.

Each station consisted of a CTD/LADCP/rosette cast to within 10-15 m of the bottom. Water samples (usually 36-bottles) at each station were analyzed for salinity, nutrients, dissolved oxygen, dissolved inorganic carbon, total alkalinity, dissolved organic matter, colored dissolved organic matter, chlorofluorocarbons, helium/tritium, particulate organic carbon, carbon-14, bacteria and chlorophyll. Trace metal casts to 1000m were conducted at approximately every other station for a total of 49 trace metal casts. The trace metal casts were conducted near the same locations as the CTD profiles and were either before or after the full-depth casts depending on time of day. Optical profiles were collected once each day when on station, generally near 12:00-14:00 local time. Argo floats were deployed at 14 locations upon departure from a station. Underway surface pCO<sub>2</sub>, temperature, conductivity, dissolved oxygen, fluorometer, meteorological, aerosol and multi-beam acoustical bathymetric measurements were also made along the cruise track. No major problems were encountered on the cruise and all major cruise objectives were achieved.

## **A.3. List of Principal Investigators and Cruise Participants**

Thirty-four scientists from 10 oceanographic institutions participated in the cruise. Several other science programs were supported with no dedicated cruise participant. The principal investigators, the science team and their responsibilities are listed in [Table 1](#). Two foreign observers from Bangladesh also participated in the cruise.

**Table 1:** Research projects, principal investigators and participants on I9N.

<b>Research Project/ Principal Investigator(s)</b>	<b>I9N Participants</b>	<b>Participants' email</b>
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Chief Scientist Support	Erica Key (RSMAS) Kyla Drushka (SIO/UCSD)	<a href="mailto:ekkey@rsmas.miami.edu">ekkey@rsmas.miami.edu</a> <a href="mailto:kdrushka@ucsd.edu">kdrushka@ucsd.edu</a>
CTD/Hydrography/Data Management/Jim Swift (SIO)	Kristin Sanborn (STS/SIO/UCSD)	<a href="mailto:ksanborn@ucsd.edu">ksanborn@ucsd.edu</a>
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	Dan Schuller (STS/SIO/UCSD)	<a href="mailto:dan@odf.ucsd.edu">dan@odf.ucsd.edu</a>
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#### A.4. Scientific Program and Cruise Highlights

The I9N cruise is part of a decadal series of repeat hydrography sections jointly funded by the National Science Foundation and NOAA Office of Global Programs as part of the Climate Variability and Predictability Study (CLIVAR) CO<sub>2</sub> Repeat Hydrography Program (<http://ushydro.ucsd.edu>). The CLIVAR repeat hydrography program focuses on the need to monitor inventories of CO<sub>2</sub>, heat and freshwater and their transports in the ocean. Earlier programs in the 1990s under WOCE and JGOFS have provided baseline observational fields for these parameters. The new CLIVAR measurements will serve as a structure for assessing changes in the ocean's physical and biogeochemical cycle in response to natural and/or man-induced activity.

A total of 111 stations were undertaken during CLIVAR I9N, with the location of the discrete bottle samples at each cast shown in [Figure 1](#). A description of the techniques, calibrations and preliminary data quality control for all hydrographic measurements of CLIVAR I9N can be found in Section C. Here we briefly describe the oceanographic regimes and conditions along the CLIVAR I9N transect, with a focus primarily on the CTD measurements.

The meridional CLIVAR I9N transect passed through four distinct climatic regimes: the subtropical gyre, the Indonesian Throughflow plume, the equatorial regime and the Bay of Bengal. In each of these four regimes, the surface to intermediate water mass and biogeochemical characteristics are fairly distinctive.

The subtropical Indian Ocean is distinguished by a relatively salty surface layer, with a mid-thermocline maximum in oxygen and CFCs that corresponds to the Subtropical Mode Water, and the salinity minimum of the Antarctic Intermediate Water (AAIW) found at 750 to 1100 m depth.

The distinctively fresh surface to intermediate waters of the Indonesian Throughflow are found from ~15°S to 11°S. In the upper few hundred meters of the surface layer, the frontal change from the salty to fresh water was dramatic and occurred over Stations 108 to 110. Below the surface, at depths from ~150 to 400 m, temperature, salinity and oxygen showed evidence of strong interleaving between the different subtropical and tropical water masses that mix at these latitudes. Between about 15°S and 11.5°S we crossed a bullet of freshwater from ~800 to 1200 m depth, that is the characteristic signature of the Indonesian Intermediate Water. We also found maxima in silicate, phosphate and CFC in this intermediate water mass, and these property characteristics help to distinguish it from the AAIW found at the same depth range further south.

In the equatorial regime, between 2.5°S and the equator, the LADCP data showed a relatively strong (~0.5 m/s) and fresh (~34) westward current from the surface to ~100 m depth, and a core of equally strong westward flow centered around 400-500 m depth that is separated from the surface flow by relatively weak and saltier (35.5) eastward flow. At around 1400-1500 m depth, there is a core of eastward flow found at ~2°S. These “stacked” equatorial jets of relatively deep alternating flow are perhaps the Indian Ocean counterparts of those known to exist in the Pacific equatorial zone. Interestingly, there appears to be no significant flow shown in the L-ADCP data at these depths north of the equator.

In the Bay of Bengal the upper surface waters are the freshest (< 34) and among the warmest (> 28°C) observed along the I9N transect. Oxygen and CFCs are close to equilibrium with the atmosphere in the surface layer, but drop to near zero below the thermocline. Although the surface layer is well mixed in temperature down to about 50-80 m depth, there is much structure in the salinity with lots of local maxima and minima over the same depth range and a weak salinity maximum in the thermocline. In the deeper layers, close to the bottom, a weak oxygen maximum and a slight trace of CFC probably indicates the presence of the ventilated Antarctic Bottom Waters that circulates through the deep water gaps of the Ninety-east Ridge. Finally, there is a benthic layer in the Bay of Bengal (Gordon et al., 2002) that is characterized by high silicate, nitrate and phosphate, but low oxygen concentrations within 100 m off the bottom. This layer was most apparent on the “bow-tie” and adjacent stations 166-186 that were undertaken in the western part of the Bay of Bengal.

By design, the combined CLIVAR I8S/I9N section, between 60°S and 4°N, is a reoccupation of the WOCE I8S section undertaken in December-January 1995 (PI Mike McCartney) and the I9N section undertaken

in January-March 1995 (PI Arnold Gordon). A preliminary investigation into property differences between the 1995 and 2007 cruises suggest a freshening trend observed in the AAIW throughout the subtropical region with the northern most extent marked by the southern boundary of the Indonesian Throughflow Waters. Interestingly there is no apparent corresponding oxygen trend observed in this water mass. Other decadal trends will no doubt come to light with a more thorough investigation of the full data set.

#### **A.5. Major Problems and Goals Not Achieved**

Specific problems with individual measurements on CLIVAR I9N are discussed in Section B and C below. No significant problems were encountered with the ship engine, winch or CTD gear.

#### **A.6. Other Incidents of Note.**

The deepest casts of the cruise were Stations 108-100 between 16°S and 17.5°S, with bottom depths of 6000-6200m. Because of the pressure limitations of the L-ADCP battery and the fluorometer (rated to 6000 db), the deepest bottle at each of these stations were fired at a maximum wire-out of 6000m, leaving the bottom 85-175m unsampled. A similar data gap occurred on WOCE I9N in 1995, probably for the same reasons.

In between Stations 165 and 166, we made a brief stop for repairs of meteorological sensors (anemometer, rain gauge and air-temperature/relative humidity gauge) on a NOAA Atlas buoy located at 8°N, 90°E.

On 19 April 2007 (around Station 169) we were informed by Ship's Scheduling that the U.S Department of State (DoS) would not give us permission for our cruise applications 2006-092 and 2006-111 to sample in Bangladesh waters. The official notification from DoS:

"The U.S. needs to remain neutral regarding other States' unresolved maritime boundaries. There are no maritime boundaries established in the research areas identified for cruise applications 2006-092 and 2006-111. In such a situation, marine scientific research cannot be conducted without the prior consent of the relevant coastal States in the area (in this case, India, Bangladesh, and Burma). To do otherwise may put the research cruise in the middle of a dispute if one of the coastal States believes it should have been asked to grant permission. The research cannot occur as proposed in the applications because we did not obtain acceptable clearances from all relevant countries. There was no clearance obtained from Burma. India's authorization was not acceptable because it provided restrictions on the release of research data that are inconsistent with U.S. policy."

Because of this, stations had to be missed at the end of the cruise, and we readjusted our original sampling plan in the Bay of Bengal to include the "bow-tie" section from Stations 172 to 176 (reoccupation of I1E stations) and then Stations 178 to 182 that extended the original WOCE I9N section through the central axis of the Bay of Bengal. Stations 174 and 182 were duplicate stations on CLIVAR I9N, and also reoccupations of Station 268 (WOCE I9N) and Station 989 (WOCE I1E). We completed our sampling at Station 199 at 18°N, 89°51'E in ~2100 m water depth.

After our last station we undertook a short bathymetric survey of the 2500 m isobath between 17°7'N; 88°30'E and 16°13'N; 90°24'E in international waters.



## B. HYDROGRAPHIC MEASUREMENTS - DESCRIPTIONS, TECHNIQUES AND CALIBRATIONS

### Summary

A hydrographic survey consisting of Rosette/CTD/LADCP sections, bio-optical casts, trace metals rosette sections, underway shipboard ADCP, float deployments in the northeast Indian Ocean was carried out in March to May 2007. The R/V Revelle departed Fremantle, Australia on 22 March 2007. A total of 111 stations were occupied. 111 Rosette/CTD/LADCP casts, 49 Trace Metals Rosette casts and 31 bio-optical casts were made, and 14 ARGO floats were deployed from 26 March to 27 April 2007. Water samples (up to 36) and CTD data were collected on each Rosette/CTD/LADCP cast, in most cases to within 10-20 meters of the bottom. Salinity, dissolved oxygen and nutrient samples were analyzed for up to 36 water samples from each cast of the principal Rosette/CTD/LADCP program. Water samples were also measured for DIC, Total Alkalinity, CFCs and CDOM, and samples were collected for DOC/DON, POC, Helium/Tritium, and C13/C14. Underway surface pCO<sub>2</sub>, temperature, conductivity, dissolved oxygen, fluorometer, meteorological and multibeam acoustical bathymetric measurements were made. The cruise ended in Phuket, Thailand on 1 May 2007.

### Introduction

A sea-going science team gathered from 8 oceanographic institutions participated on the cruise. Several other science programs were supported with no dedicated cruise participant. The science team and their responsibilities are listed below.

Duties	Name	Affiliation	email
Chief Scientist	Janet Sprintall	UCSD/SIO	jsprintall@ucsd.edu
Co-Chief Scientist	Sabine Mecking	UWashington	smecking@apl.washington.edu
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Data/Salinity/Deck	Melinda (Mindy) Kelley	UCSD/SIO/ST/ODF	mskelley@ucsd.edu
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## B.1. CTD/Hydrographic Measurements Program

### Description of Measurement Techniques

The basic CTD/hydrographic measurements consisted of salinity, dissolved oxygen and nutrient measurements made from water samples taken on Rosette/CTD/LADCP casts, plus pressure, temperature, conductivity/salinity, dissolved oxygen, transmissometer and fluorometer from CTD profiles. A total of 111 Rosette/CTD/LADCP casts were made, usually to within 10-20m of the bottom. No major problems were encountered during the operation. The distribution of samples is illustrated in figures 1.0 and 1.1.

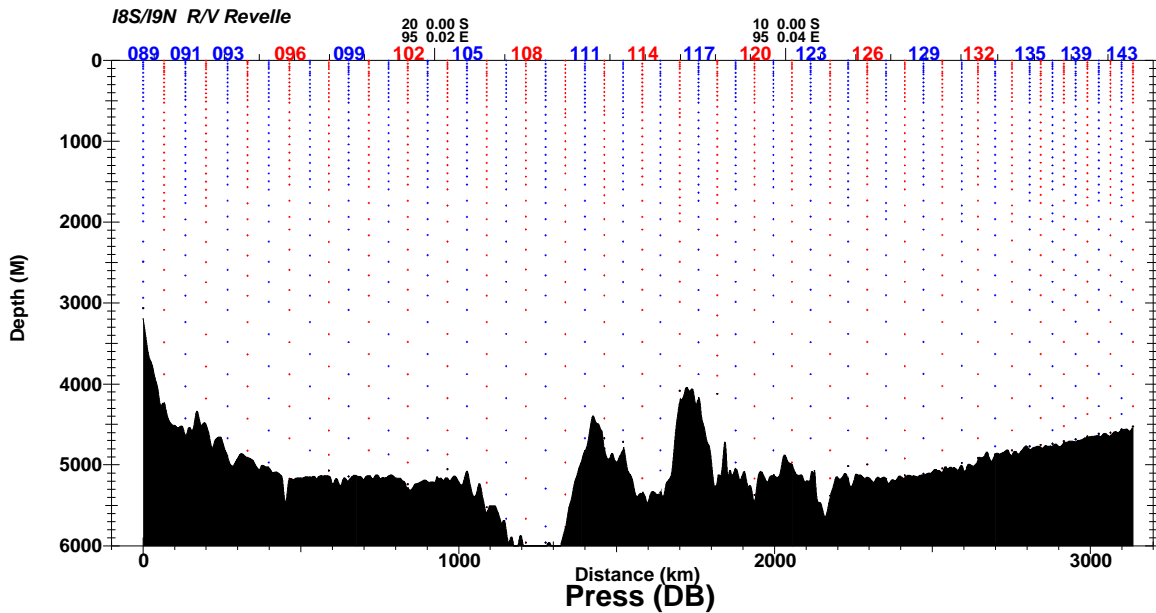


Figure 1.0 Sample distribution, stations 89-144.

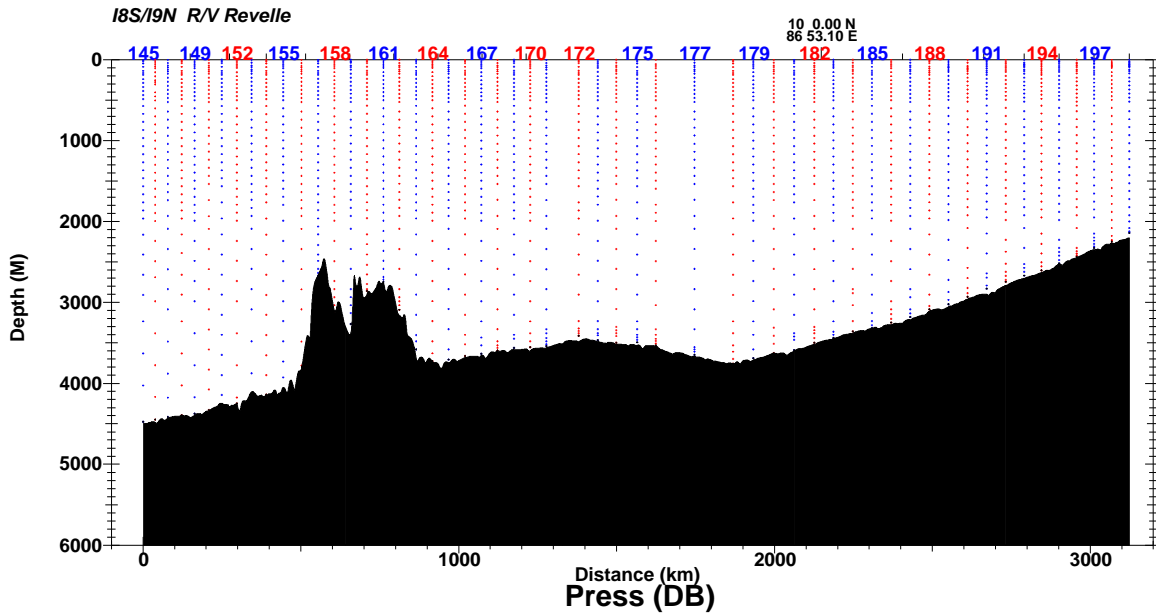


Figure 1.1 Sample distribution, stations 145-199.

#### B.1.1. Water Sampling Package

Rosette/CTD/LADCP casts were performed with a package consisting of a 36-bottle rosette frame (SIO/STS), a 36-place carousel (SBE32) and 36 10.4L, issuing 10.0L when the spigot is used for sampling, Bullister bottles (SIO/STS). Underwater electronic components consisted of a Sea-Bird Electronics SBE9plus CTD (SIO/STS #381) with dual pumps, dual temperature (SBE3plus), dual conductivity (SBE4C), dissolved oxygen (SBE43), transmissometer (Wetlabs), fluorometer (Wetlabs CDOM), altimeter (Simrad) and LADCP (RDI). The bottle in position 34 was of older design with a sampling volume of 9.2L.

The CTD was mounted vertically in an SBE CTD cage attached to the bottom of the rosette frame and located to one side of the carousel. The SBE4C conductivity, SBE3plus temperature and SBE43 Dissolved oxygen sensors and their respective pumps and tubing were mounted vertically as recommended by SBE on a bracket adjacent to the CTD cage. Pump exhausts were attached to the sensor bracket on the side opposite from the sensors and directed downward. The transmissometer and fluorometer were mounted horizontally along the bottom of the rosette frame. The altimeter was mounted on the inside of the bottom frame ring. The RDI LADCP was mounted vertically on one side of the frame between the bottles and the CTD. Its battery pack was located on the opposite side of the frame, mounted on the bottom of the frame.

Heights referenced to bottom of rosette frame	
Temperature sensors	8 cm
SBE35	11 cm
Altimeter	4 cm
Transmissometer	12 cm
CDOM Fluorometer	3 cm
Pressure Sensor	28 cm
Inner bottle midline	115 cm
Outer bottle midline	120 cm
BB LADCP XDCR Face midline	9 cm
Zero tape	3 m

The rosette system was suspended from a UNOLS-standard three-conductor 0.322" electro-mechanical sea cable. The sea cable was reterminated at the beginning of I9N, no additional terminations were performed. The R/V *Revelle's* forward starboard-side Markey winch was used for all casts.

The deck watch prepared the rosette 10-30 minutes prior to each cast. The bottles were cocked and all valves, vents and lanyards were checked for proper orientation. Once stopped on station, the rosette was moved out from the aft hanger to the deployment location under the squirt boom block using an air-powered cart and tracks. The CTD was powered-up and the data acquisition system in the computer lab started when directed by the deck watch leader. The rosette was unstrapped from its tiedown location on the cart. Tag lines were threaded through the rosette frame and syringes were removed from the CTD intake ports. The winch operator was directed by the deck watch leader to raise the package, the squirt boom and rosette were extended outboard and the package quickly lowered into the water. The tag lines were removed and the package was lowered to 10 meters, by which time the sensor pumps had turned on. The winch operator was then directed to bring the package back to the surface (0 winch wireout) and to begin the descent.

Each rosette cast was lowered to within 8-15 meters of the bottom, using the altimeter, winch wireout, CTD depth and echosounder depth to determine the distance. One cast was lowered to within 3 meters of the bottom and three casts lowered to 6000m, the pressure limit of some of the package instrumentation.

During the up cast the winch operator was directed to stop the winch at each bottle trip depth. The CTD console operator waited 30 seconds before tripping a bottle to insure the package wake had dissipated and the bottles were flushed, then an additional 10 seconds after each bottle closure to insure that stable CTD comparison data had been acquired. Some bottle flushing issues were being observed in the data, so from Station 107 onward, the CTD console operators waited 40 seconds for bottles between 1500m and the surface. Once the next-to-last bottle had been closed, the deck watch leader directed the package to the surface for the last bottle trip.

Standard sampling depths were used throughout CLIVAR I9N. These standard depths were staggered every station using 3 sampling schemes.

Recovering the package at the end of the deployment was essentially the reverse of launching, with the additional use of poles and snap-hooks to attach tag lines. The rosette was secured on the cart and moved into the aft hanger for sampling. The bottles and rosette were examined before samples were taken, and anything unusual noted on the sample log.

Each bottle on the rosette had a unique serial number. This bottle identification was maintained independently of the bottle position on the rosette, which was used for sample identification. Various parts of bottles were occasionally changed or repaired.

Routine CTD maintenance included soaking the conductivity and DO sensors in fresh water between casts to maintain sensor stability and occasionally putting dilute Triton-X solution through the conductivity sensors to eliminate any accumulating biofilms. Rosette maintenance was performed on a regular basis. O-rings were changed and lanyards repaired as necessary. Bottle maintenance was performed each day to insure proper closure and sealing. Valves were inspected for leaks and repaired or replaced as needed.

### **B.1.2. Underwater Electronics Packages**

CTD data were collected with a SBE9plus CTD (STS/ODF #381). This instrument provided pressure, dual temperature (SBE3), dual conductivity (SBE4), dissolved oxygen (SBE43), CDOM fluorometer (Wetlabs), transmissometer (Wetlabs) and altimeter (Simrad 807) channels. The CTD supplied a standard SBE-format data stream at a data rate of 24 frames/second.

Sea-Bird SBE32 36-place Carousel Water Sampler	3216715-0187
Sea-Bird SBE9 <i>plus</i> CTD	0381
Paroscientific Digiquartz Pressure Sensor	S/N 58952
Sea-Bird SBE11 <i>plus</i> Deck Unit	11P41717-0727
Sea-Bird SBE3 <i>plus</i> Temperature Sensor	S/N 03P-4588 (Primary)
Sea-Bird SBE3 <i>plus</i> Temperature Sensor	S/N 03P-4226 (Secondary)
Sea-Bird SBE4C Conductivity Sensor	S/N 04-3176 (Primary)
Sea-Bird SBE4C Conductivity Sensor	S/N 04-3058 (Secondary)
Sea-Bird SBE43 DO Sensor	S/N 43-1129
Sea-Bird SBE5 Pump	S/N 05-4160 (Primary)
Sea-Bird SBE5 Pump	S/N 05-4377 (Secondary)
Sea-Bird SBE35 Reference Temperature Sensor	S/N 35-0035
Wetlabs CDOM Fluorometer	S/N FLCDRD-428
Wetlabs CStar Transmissometer	S/N CST-327DR
Simrad 807 Altimeter	S/N 4051
RDI LADCP, UH BB 150	S/N 1546

**Table 1.2.0** CLIVAR I9N Rosette Underwater Electronics.

The CTD was outfitted with dual pumps. Primary temperature, conductivity and dissolved oxygen were plumbed into one pump circuit and secondary temperature and conductivity into the other. The sensors were deployed vertically. The primary temperature and conductivity sensors (T1 #03P-4588 and C1 #04-3176) were used for reported CTD temperatures and conductivities on all casts. The secondary temperature and conductivity sensors were used as calibration checks for all other casts. A SBE35RT reference temperature sensor was connected to the SBE32 carousel and recorded a temperature for each bottle closure. These temperatures were used as additional CTD calibration checks.

The SBE9*plus* CTD was connected to the SBE32 36-place carousel providing for single-conductor sea cable operation. The sea cable armor was used for ground (return). Power to the SBE9*plus* CTD (and sensors), SBE32 carousel and Simrad 807 altimeter was provided through the sea cable from the SBE11*plus* deck unit in the main lab.

### **B.1.3. Navigation and Bathymetry Data Acquisition**

Navigation data were acquired at 1-second intervals from the ship's GP90 GPS receiver by a Linux system beginning March 22.

Bathymetric data were logged from the Ship's Simrad EM120 multibeam echosounder system and merged with the navigation time series. These depths were corrected using sound velocity profiles derived from CTD casts.

### **B.1.4. CTD Data Acquisition and Rosette Operation**

The CTD data acquisition system consisted of an SBE-11*plus* (V2) deck unit and three networked generic PC workstations running CentOS-4.4 Linux. Each PC workstation was configured with a color graphics display, keyboard, trackball and DVD+RW drive. One of the systems also had 8 additional RS-232 ports via a Control Rocketport PCI serial controller. The systems were interconnected through a 1000BaseTX ethernet switch which was also connected to the ship's network. These systems were available for real-time operational and CTD data displays, and provided for CTD and hydrographic data management and backup.

One of the workstations was designated the CTD console and was connected to the CTD deck unit via RS-232. The CTD console provided an interface and operational displays for controlling and monitoring a CTD deployment and closing bottles on the rosette. Another of the workstations was designated as the website and database server and maintained the hydrographic database for I9N. All three systems were used to maintain redundant backups of the data.

CTD deployments were initiated by the console watch after the ship had stopped on station. The watch maintained a console operations log containing a description of each deployment, a record of every

attempt to close a bottle and any relevant comments. The deployment and acquisition software presented a short dialog instructing the operator to turn on the deck unit, to examine the on-screen CTD data displays and to notify the deck watch that this was accomplished.

Once the deck watch had deployed the rosette, the winch operator lowered it to 10 meters. The CTD sensor pumps were configured with an 8-second startup delay after detecting seawater conductivities, and were usually on by this time. The console operator checked the CTD data for proper sensor operation, waited an additional 60 seconds for sensors to stabilize, then instructed the winch operator to bring the package to the surface and descend to a specified target depth (wire-out). The profiling rate was no more than 30m/min to 50m, no more than 45m/min to 200m and no more than 60m/min deeper than 200m, depending on sea cable tension and sea state.

The progress of the deployment and CTD data quality were monitored through interactive graphics and operational displays. Bottle trip locations were transcribed onto the console and sample logs. The sample log was used later as an inventory of samples drawn from the bottles. The altimeter channel, CTD depth, winch wire-out and bathymetric depth were all monitored to determine the distance of the package from the bottom, usually allowing a safe approach to within 10-20 meters.

Bottles were closed on the up cast by operating an on-screen control. The winch operator was given a target wire-out for the bottle stop, proceeded to that depth and stopped. Bottles were tripped 30-40 seconds after stopping to allow the rosette wake to dissipate and the bottles to flush. The winch operator was instructed to proceed to the next bottle stop at least 10 seconds after closing bottles to insure that stable CTD data were associated with the trip and to allow the SBE35RT tertiary temperature sensor time to make a measurement.

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

#### **B.1.5. CTD Data Processing**

Shipboard CTD data processing was performed automatically during each Rosette/CTD/LADCP deployment, and at the end of each Trace Metals rosette deployment using SIO/ODF CTD processing software. The Trace Metals rosette contained its own CTD and carousel. These data were acquired using SBE SeaSave software, then copied to a Linux workstation for further processing. No shipboard calibration was done for Trace Metals rosette CTD data.

Processing was performed during data acquisition for Rosette/CTD/LADCP deployments. The raw CTD data were converted to engineering units, filtered, response-corrected, calibrated and decimated to a more manageable 0.5-second time-series. The laboratory calibrations for pressure, temperature and conductivity were applied at this time. The 0.5-second time-series data were used for real-time graphics during deployments, and were the source for CTD pressure and temperature associated with each rosette bottle. Both the raw 24 Hz data and the 0.5-second time-series were stored for subsequent processing. During the deployment the data were backed up to another Linux workstation.

Processing was performed after data acquisition for Trace Metals rosette deployments. The raw CTD data and bottle trips acquired by SBE SeaSave on the Windows XP workstation were copied onto the Linux database and web server workstation and processed to a 0.5-second time series, then bottle trip values were extracted.

At the completion of a deployment a sequence of processing steps were performed automatically. The 0.5-second time-series data were checked for consistency, clean sensor response and calibration shifts. A 2-decibar pressure-series was then generated from the down cast. Both the 2-decibar pressure-series and 0.5-second time-series data were made available for downloading, plotting and reporting on the shipboard cruise website.

Rosette/CTD/LADCP CTD data were routinely examined for sensor problems, calibration shifts and deployment or operational problems. The primary and secondary temperature sensors (SBE3plus) were compared to each other and to the SBE35 temperature sensor. CTD conductivity sensors (SBE4C) were compared to each other, then calibrated by examining differences between CTD and check-sample conductivity values. The CTD dissolved oxygen sensor data were calibrated to check-sample data.

Additional theta-Salinity and theta-O<sub>2</sub> comparisons were made between down and up casts as well as with adjacent deployments. Vertical sections were made of the various properties derived from sensor data and checked for consistency.

Few CTD acquisition or data processing problems were encountered during I9N.

A total of 111 casts were made using the 36-place CTD/LADCP rosette, and 49 casts using the 12-place Trace Metals rosette.

#### B.1.6. CTD Sensor Laboratory Calibrations

Laboratory calibrations of the CTD pressure, temperature, conductivity and dissolved oxygen sensors were performed prior to CLIVAR I9N. The calibration dates are listed in table 1.6.0.

Sensor	S/N	Calibration Date	Calibration Facility
Paroscientific Digiquartz Pressure	58952	17-December-2006	SIO/ODF
Sea-Bird SBE3plus T1 Temperature	03P-4588	14 December 2006	SBE
Sea-Bird SBE3plus T2 Temperature	03P-4226	14 December 2006	SBE
Sea-Bird SBE4C C1 Conductivity	04-3176	30 November 2006	SBE
Sea-Bird SBE4C C2 Conductivity	04-3058	30 November 2006	SBE
Sea-Bird SBE43 Dissolved Oxygen	43-1129	05 December 2006	SBE

**Table 1.6.0** CLIVAR I9N CTD sensor laboratory calibrations.

#### B.1.7. CTD Shipboard Calibration Procedures

CTD #381 was used for all Rosette/CTD/LADCP casts on I9N. The CTD was deployed with all sensors and pumps aligned vertically, as recommended by SBE. The primary temperature and conductivity sensors (T1 & C1) were used for all reported CTD data for all casts, with the secondary sensors (T2 & C2) serving as calibration checks. The SBE35RT Digital Reversing Thermometer (S/N 3528706-0035) served as an independent calibration check for T1 and T2. *In-situ* salinity and dissolved O<sub>2</sub> check samples collected during each cast were used to calibrate the conductivity and dissolved O<sub>2</sub> sensors.

##### B.1.7.1. CTD Pressure

The Paroscientific Digiquartz pressure transducer (S/N 58952) was calibrated in December 2006 at the SIO/ODF Calibration Facility. Calibration coefficients derived from the calibration were applied to raw pressures during each cast. Residual pressure offsets (the difference between the first and last submerged pressures) and CTD pressure readings on-deck were monitored to check for calibration shifts. The offset was 0.7-0.8db during the test cast, and it was noted that the offsets from the end of the preceding I8S leg were similar. A -0.5db offset was applied to CTD pressure data for every cast after the test cast. The residual pressure offsets for all I9N casts were 0-0.3db at cast start, and -0.2-0db at cast end. No additional adjustments were made to the calculated pressures.

##### B.1.7.2. CTD Temperature

A single primary temperature sensor (T1 = SBE3plus, S/N 03P-4588) and secondary sensor (T2 = SBE3plus, S/N 03P-4226) served the entire cruise. Calibration coefficients derived from the pre-cruise calibrations, plus shipboard temperature corrections determined during the preceding I8S leg for the same sensors, were applied to raw primary and secondary temperatures during each cast.

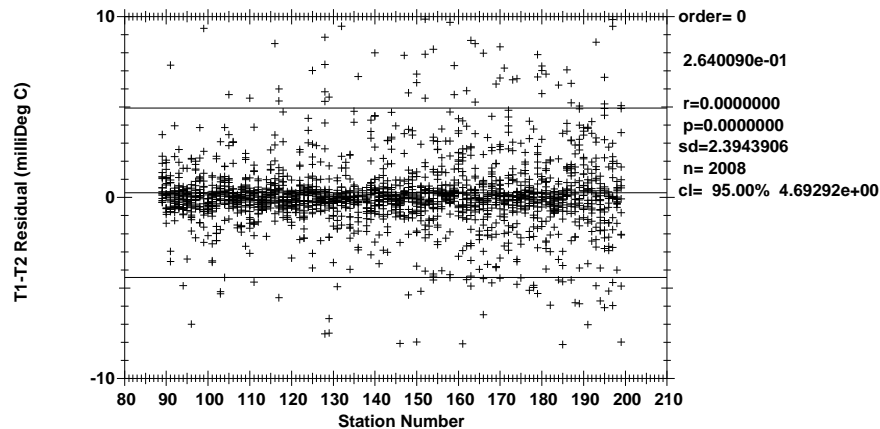
The SBE35RT Digital Reversing Thermometer is an internally-recording temperature sensor that operates independently of the CTD. It is triggered by the SBE32 carousel in response to a bottle closure. According to the Manufacturer's specifications the typical stability is 0.001° C/year. The SBE35RT on I9N was set to internally average over approximately one ship roll period (8 seconds). It was located equidistant between T1 and T2 with the sensing element aligned in a plane with the T1 and T2 sensing elements.

Two independent metrics of calibration accuracy were examined. The primary and secondary temperatures were compared at each bottle closure, and the SBE35RT temperatures were compared to primary and secondary temperatures at each bottle closure. During I8S, all three temperatures were within ±0.001° C, with the SBE35RT between T1 and T2. Deep residual differences for I9N, after applying

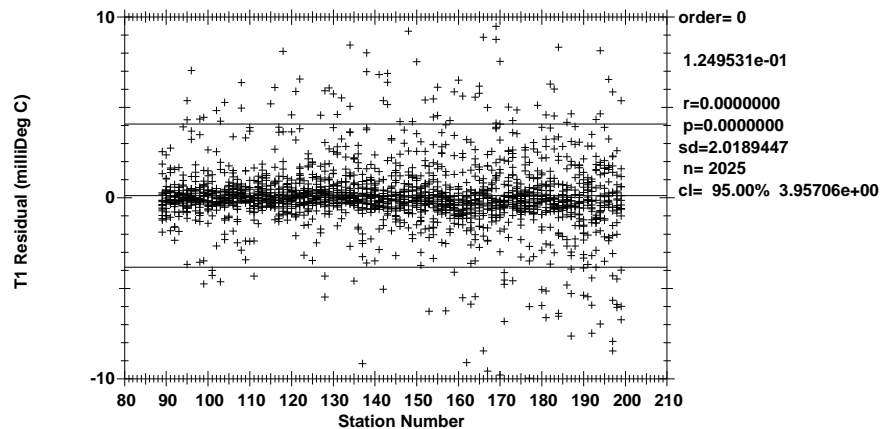
I8S corrections, showed no evidence of drift for T1 with time, requiring only a small offset, approximately  $+0.0003^{\circ}\text{C}$ . T2 drifted slowly with time, requiring a slightly increasing offset with each cast, then apparently stabilized midway through the leg. ( $+0.00045^{\circ}\text{C}$  at station 89 to  $+0.0008^{\circ}\text{C}$  at station 141 until the end of the leg).

A secondary response to pressure was corrected for both SBE3*plus* sensors on I8S. This was re-checked on I9N, and required a small adjustment for both sensors: casts 1200m deeper were available on I9N to define the deeper end of the fit better. The deep-end adjustment was about  $+0.00039$  and  $+0.00032^{\circ}\text{C}$  for T1 and T2, respectively; the second-order adjustment changed surface temperatures by less than  $0.001^{\circ}\text{C}$ . The first-order temperature-dependent correction from I8S was not adjusted for either sensor.

The deep residual differences after correction are shown in figures 1.7.2.0 and 1.7.2.1.



**Figure 1.7.2.0 T1-T2 by station (P>1000db).**



**Figure 1.7.2.1 SBE35RT-T1 by station (P>1000db).**

The 95% confidence limit for the mean lower-gradient differences is  $\pm 0.0048^{\circ}\text{C}$  for T1-T2, and  $\pm 0.0040^{\circ}\text{C}$  for SBE35RT-T1.

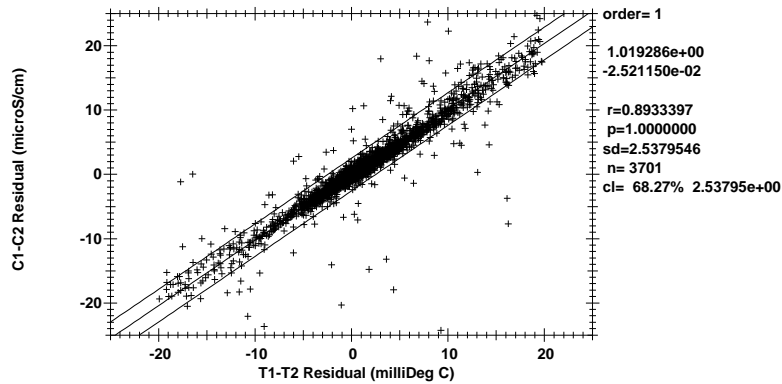
### B.1.7.3. CTD Conductivity

A single primary conductivity sensor (C1 = SBE4C, S/N 04-3176) and secondary conductivity sensor (C2 = SBE4C, S/N 04-3058) served for the entire cruise. Conductivity sensor calibration coefficients derived from the pre-cruise calibrations, plus shipboard conductivity corrections determined during the preceding I8S leg for the same sensors, were applied to raw primary and secondary conductivities.

Comparisons between the primary and secondary sensors and between each of the sensors to check sample conductivities (calculated from bottle salinities) were used to derive conductivity corrections. To

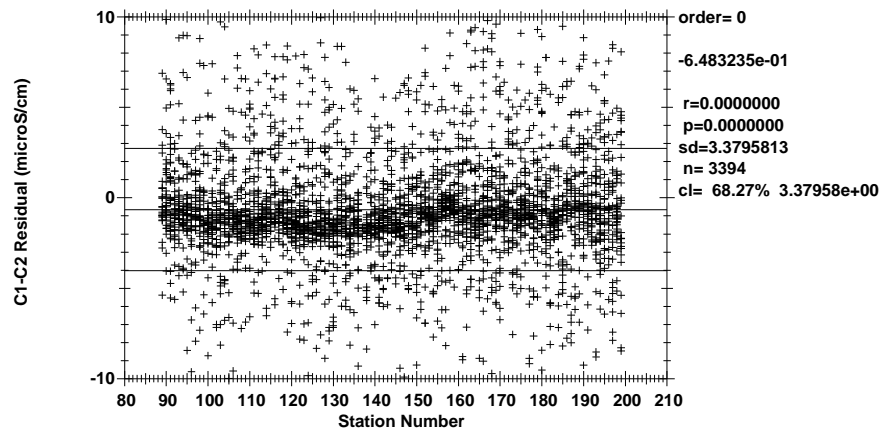


reduce the contamination of the comparisons by package wake, differences between primary and secondary temperature sensors were used as a metric of variability and used to qualify the comparisons. The coherence of this relationship is illustrated in figure 1.7.3.0.

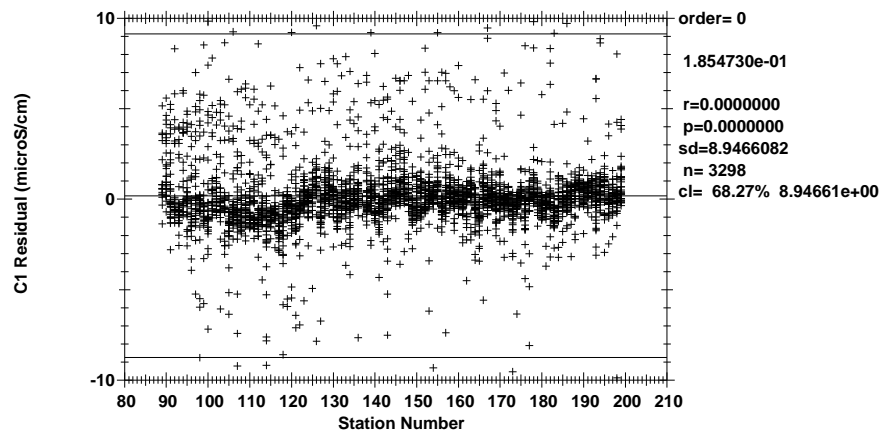


**Figure 1.7.3.0** C1-C2 by T1-T2, all points.

The uncorrected comparison between the primary and secondary sensors is shown in figure 1.7.3.1, and between C1 and the bottle conductivities in 1.7.3.2.



**Figure 1.7.3.1** Uncorrected C1 minus C2 conductivity differences by cast ( $-0.01^{\circ}\text{C} \leq T1-T2 \leq 0.01^{\circ}\text{C}$ ).



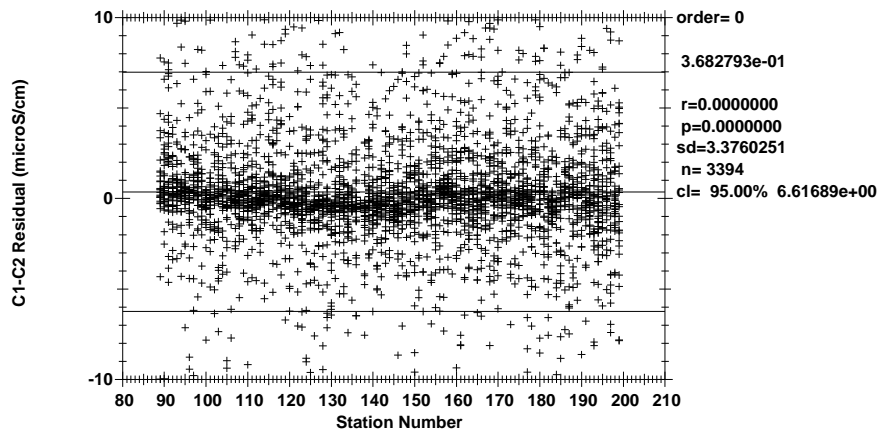
**Figure 1.7.3.2** Uncorrected Bottle minus C1 residual conductivity differences by cast ( $-0.01^{\circ}\text{C} \leq T1-T2 \leq 0.01^{\circ}\text{C}$ ).

Deep conductivity residuals, after applying I8S corrections (same offset for every cast), indicated that both conductivity sensors required a slowly increasing offset with time. Cumulative I9N C1 and C2 drifts

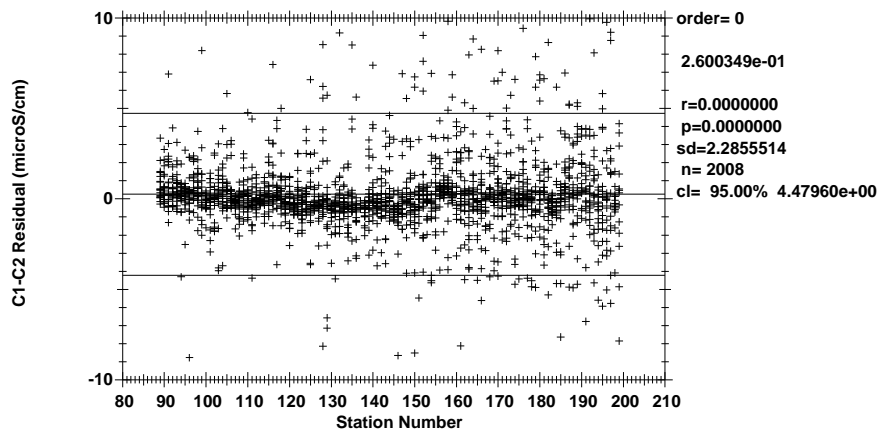
totalled +0.0009 and +0.0013 mS/cm, respectively, over 111 casts.

Only C2 exhibited a first-order pressure response during I8S. No further pressure-dependent corrections to C1 or C2 were warranted during I9N. However, both sensors exhibited the need for more correction at the surface than deep, on the order of +0.0013 and +0.0019 mS/cm more to surface conductivities for C1 and C2, respectively. This was best characterized by applying a second-order conductivity-dependent correction to each that left deep data essentially unchanged and pulled the shallow data closer to a 0 residual.

The comparison of the primary and secondary conductivity sensors by cast after applying shipboard corrections are summarized in figures 1.7.3.3 and 1.7.3.4.

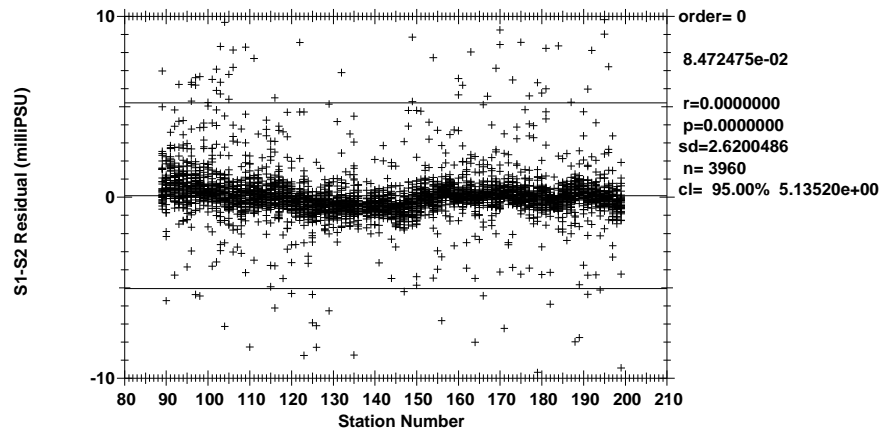


**Figure 1.7.3.3** Corrected C1 minus C2 conductivity differences by cast ( $-0.01^{\circ} \text{C} \leq T_1 - T_2 \leq 0.01^{\circ} \text{C}$ ).

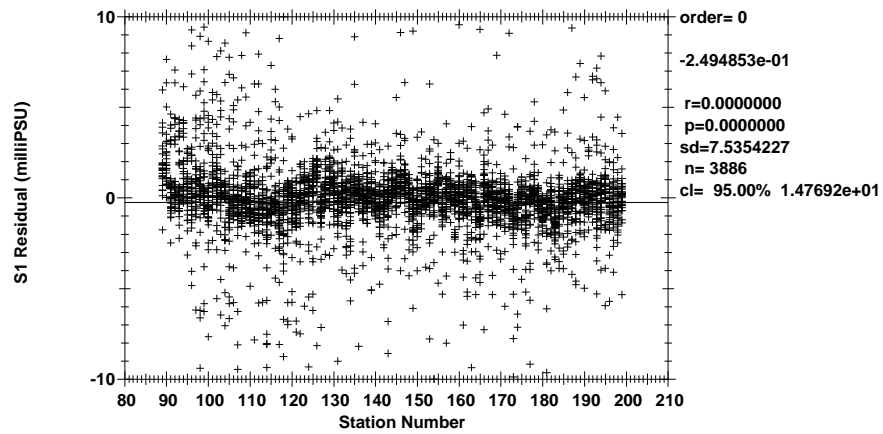


**Figure 1.7.3.4** Corrected C1 minus C2 conductivity differences by cast (Pressures > 1000db).

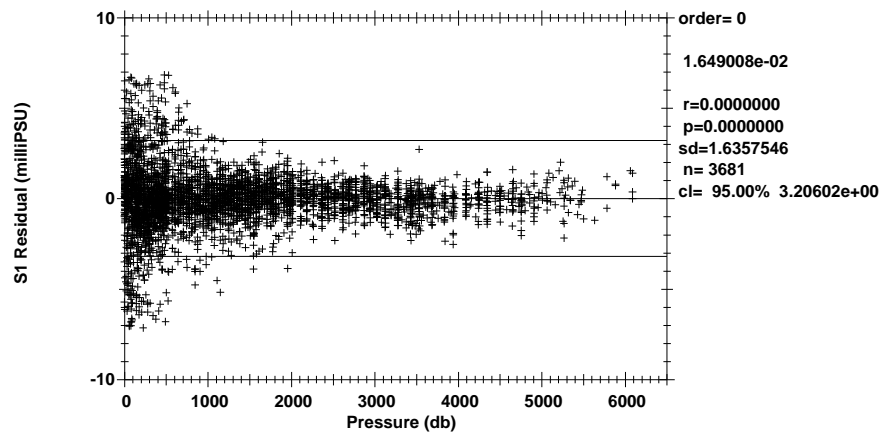
Salinity residuals after applying shipboard T1/C1 corrections are summarized in figures 1.7.3.5 through 1.7.3.9. Only CTD and bottle oxygen data with "acceptable" quality codes are included in the differences. Figures 1.7.3.0-1.7.3.2 show the residual differences between bottle and calibrated CTD  $\text{O}_2$  where both CTD and bottle oxygen data are coded "acceptable". Note that a 4,2 standard deviation rejection filter was applied to the BottleSalt-S1 differences in the pressure-dependence plot before plotting, to eliminate larger values in higher-gradient regions. This shows a more realistic picture of any residual pressure dependence.



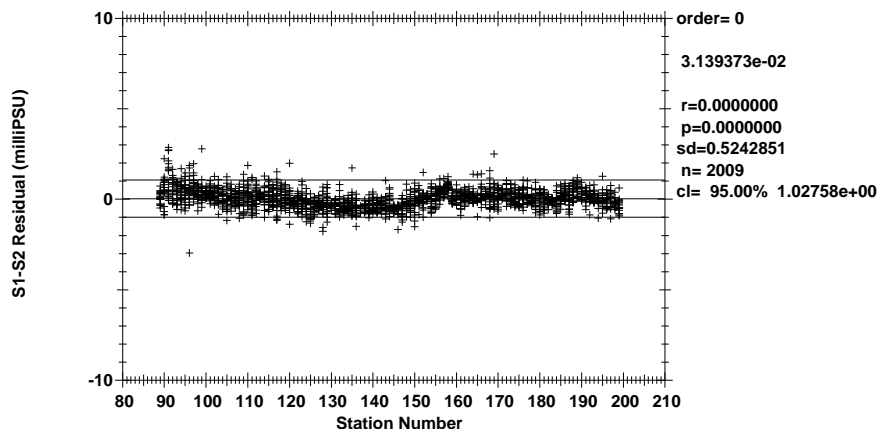
**Figure 1.7.3.5** Corrected S1 minus S2 salinity differences by cast (all Pressures)



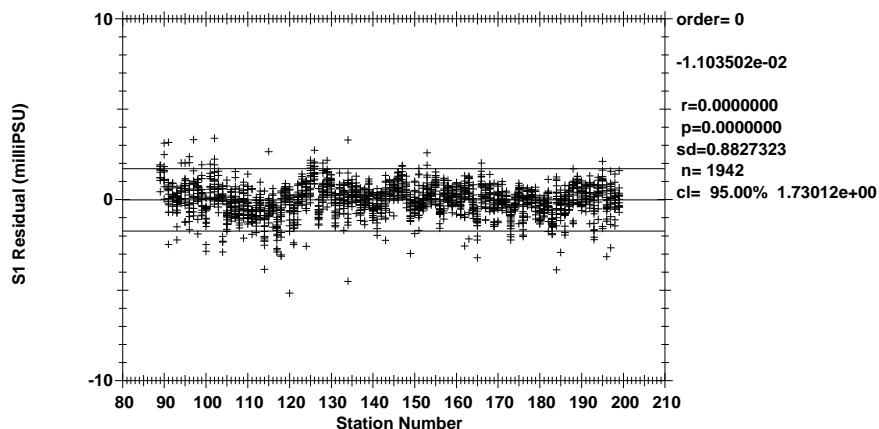
**Figure 1.7.3.6** Salinity residuals by cast (all Pressures).



**Figure 1.7.3.7** Salinity residuals by pressure (after 4,2 std.dev. rej. filter applied to differences).



**Figure 1.7.3.8** Corrected S1 minus S2 salinity differences by cast (Pressure > 1000 db)



**Figure 1.7.3.9** Salinity residuals by cast (Pressure > 1000 db).

Figures 1.7.3.8 and 1.7.3.9 represent estimates of the deep salinity accuracy of CLIVAR I9N. The 95% confidence limits are  $\pm 0.0010$  PSU relative to S2, and  $\pm 0.0018$  PSU relative to the bottle salts. Tables of T1/C1 corrections applied to I9N (non-Trace Metal) CTD casts can be found in [Appendix A](#).

#### B.1.7.4. CTD Dissolved Oxygen

A single SBE43 dissolved  $O_2$  (DO) sensor was used during this cruise (S/N 43-1129). The sensor was plumbed into the primary T1/C1 pump circuit after C1.

The DO sensors were calibrated to dissolved  $O_2$  check samples at bottle stops by calculating CTD dissolved  $O_2$  then minimizing the residuals using a non-linear least-squares fitting procedure. The fitting procedure determined the calibration coefficients for the sensor model conversion equation, and was accomplished in stages. The time constants for the exponential terms in the model were first determined for each sensor. These time constants are sensor-specific but applicable to an entire cruise. Next, casts were fit individually to check sample data. The resulting calibration coefficients were then smoothed and held constant during a refit to determine sensor slope and offset.

Standard and blank values for bottle oxygen data were smoothed and the bottle oxygen recalculated prior to the final fitting of CTD oxygen. The time-constants and coefficients used to correct I9N CTD Oxygen data are listed in [Appendix B](#).

[Figures 1.7.4.0-1.7.4.2](#) show the residual differences between bottle and calibrated CTD  $O_2$  where both CTD and bottle oxygen data are quality-coded "acceptable". A 4,2 standard deviation rejection filter was applied to the oxygen differences for the pressure-dependence plot to eliminate larger values in higher-gradient regions; this shows a more realistic picture of any residual pressure dependence. The deep residuals plot has some larger differences in earlier casts from a deeper region of high-gradient oxygen.

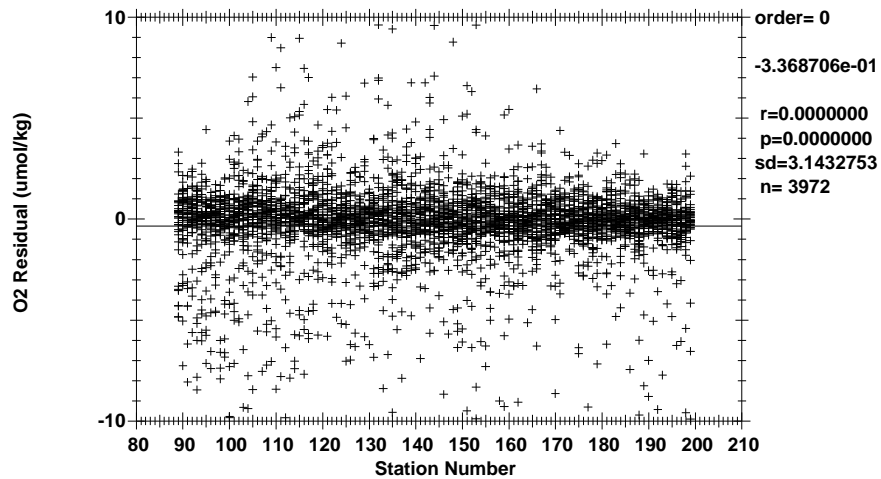


Figure 1.7.4.0 O<sub>2</sub> residuals by cast (all Pressures).

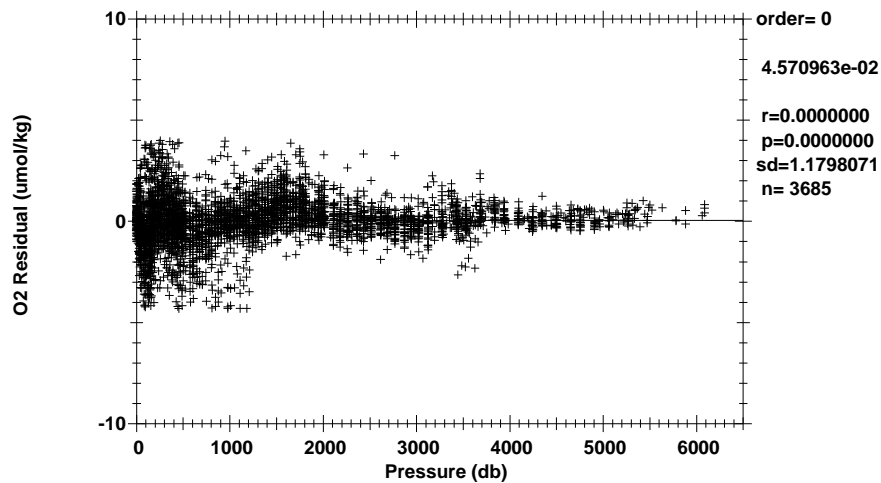


Figure 1.7.4.1 O<sub>2</sub> residuals by pressure (after 4,2 std.dev. rej. filter applied to differences).

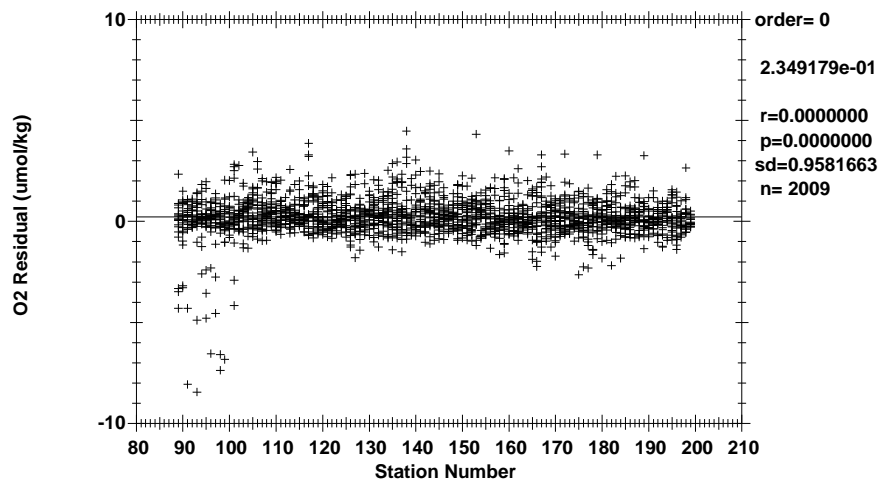


Figure 1.7.4.2 O<sub>2</sub> residuals by cast (Pressure>1000db).

The standard deviations of 3.143 umol/kg for all oxygens and 0.958 umol/kg for deep oxygens are only presented as general indicators of goodness of fit. 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 for Clark cells follows Brown and Morrison [Brow78] and Millard [Mill82], [Owen85]. ODF models membrane and sensor temperatures with lagged CTD temperatures and a lagged thermal gradient. *In-situ* pressure and temperature are filtered to match the sensor response. Time-constants for the pressure response  $\tau_p$ , two temperature responses  $\tau_{Ts}$  and  $\tau_{Tf}$ , and thermal gradient response  $\tau_{dT}$  are fitting parameters. The thermal gradient term is derived by low-pass filtering the difference between the fast response ( $T_f$ ) and slow response ( $T_s$ ) temperatures. This term is SBE43-specific and corrects a non-linearity introduced by analog thermal compensation in the sensor. The  $O_c$  gradient,  $dO_c/dt$ , is approximated by low-pass filtering 1st-order  $O_c$  differences. This gradient term attempts to correct for reduction of species other than  $O_2$  at the sensor cathode. The time-constant for this filter,  $\tau_{og}$ , is a fitting parameter. Dissolved  $O_2$  concentration is then calculated:

$$O_2 ml/l = [c_1 O_c + c_2] \cdot f_{sat}(S, T, P) \cdot e^{(c_3 P_f + c_4 T_f + c_5 T_s + c_6 \frac{dO_c}{dt} + c_7 dT)} \quad (1.7.4.0)$$

where:

$O_2 ml/l$	= Dissolved $O_2$ concentration in ml/l;
$O_c$	= Sensor current ( $\mu$ amps);
$f_{sat}(S, T, P)$	= $O_2$ saturation concentration at S,T,P (ml/l);
$S$	= Salinity at $O_2$ response-time (PSUs);
$T$	= Temperature at $O_2$ response-time ( $^{\circ}$ C);
$P$	= Pressure at $O_2$ response-time (decibars);
$P_f$	= Low-pass filtered pressure (decibars);
$T_f$	= Fast low-pass filtered temperature ( $^{\circ}$ C);
$T_s$	= Slow low-pass filtered temperature ( $^{\circ}$ C);
$\frac{dO_c}{dt}$	

## **B.2. LADCP**

Lowered Acoustic Doppler Current Profiler (LADCP)  
Shipboard Acoustic Doppler Current Profiler (SADCP)  
High-resolution Doppler Sonar System (HDSS)  
R/V Roger Revelle, March 29 – April 2, 2007

Primary Onboard Personnel: Debra Tillinger, Lamont-Doherty Earth Observatory (LDEO)  
debrat@ldeo.columbia.edu

Principal Investigator: Andreas Thurnherr, LDEO

Additional Personnel: Jules Hummon, University of Hawaii  
Bruce Huber, LDEO

### **B.2.1. Summary**

One downward looking LADCP was mounted on the CTD rosette frame and collected data at every station. Preliminary processing was completed during the cruise using the LDEO LADCP software. The most striking LADCP result was the resolution of the equatorial current structure including an eastward jet at 1400 db with velocities up to 20 cm/s. The LADCP also showed an inverted “u” shape of westward current from 4 degrees south to 4 degrees north, with a maximum depth of 2000 db and a 300 db minimum just south of the equator ([Figure 1](#)). Velocities were lower and uncertainties higher in regions of low backscatter away from the equator. SADCP data were logged through station 115 on 4 April, after which time the SADCP disk failed. After a four hour delay, the SADCP resumed logging data. However, part of the disk was damaged and the data could not be accessed on board. Final processing will include these data. The HDSS system functioned well for most of the cruise and the data from that system will be processed at Scripps Institute of Oceanography (SIO).

### **B.2.2. Equipment**

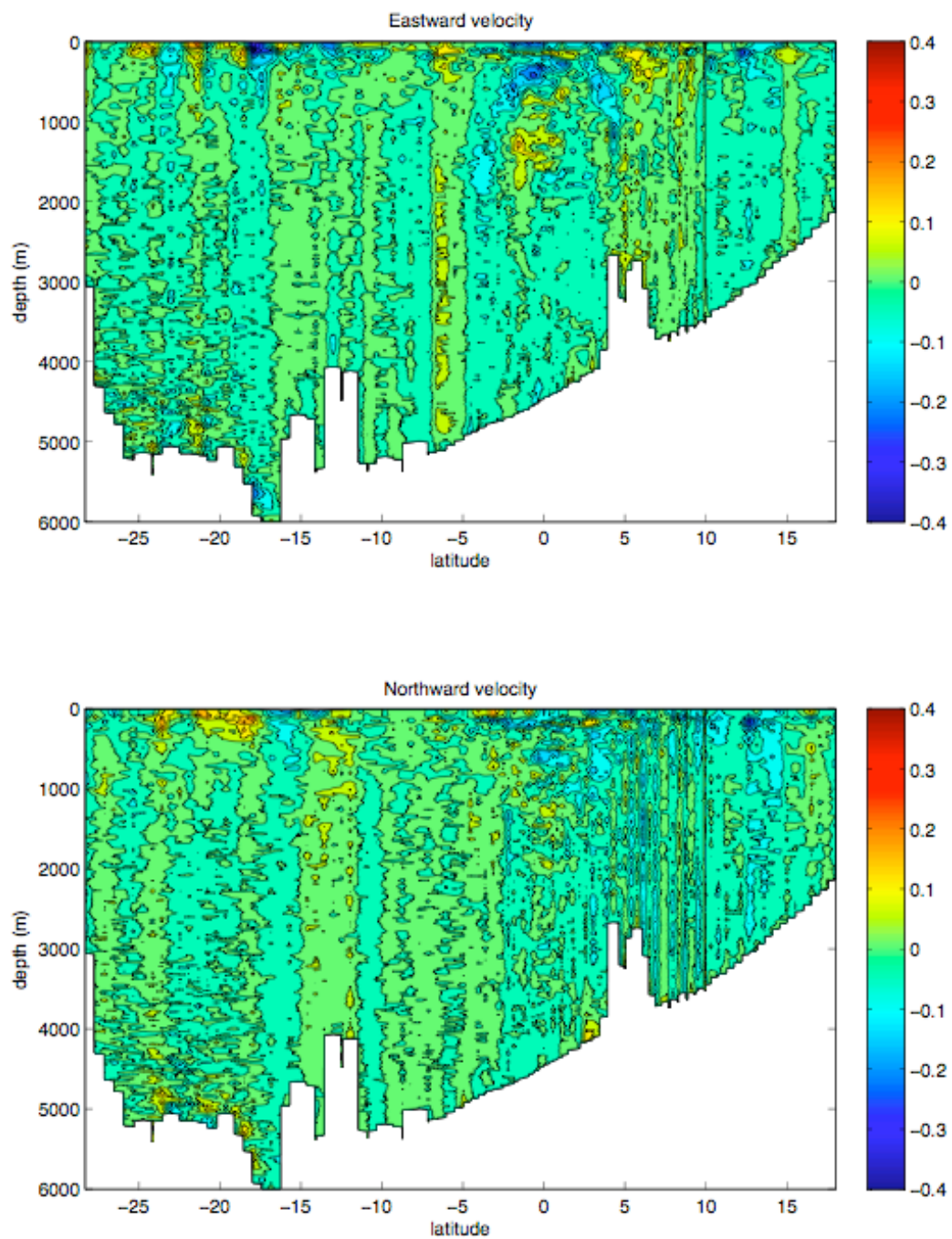
A Teledyne RD Instruments broadband 150kHz (BB150) ADCP was mounted on the rosette frame but not attached to the CTD cable. It used a Deep Sea Power and Light 48V lead-acid gel cell rechargeable battery that was charged after each cast. On deck communication with the LADCP was accomplished via an RS-232 cable connected through a Keyspan 4-port RS-232 to USB converter attached to a Mac Mini running Mac OS 10.4.8.

The BB150 is an older instrument with a lower frequency and thus a greater profiling range than the newer LADCPs. The plan for this cruise was to use the BB150 for as long as it worked and then replace it with a pair of 300 kHz “work horse” ADCPs, one of which is a higher-powered prototype (WH300 and HP-WH300). Despite problems on I8S, the BB150 performed well for the entire cruise and did not need to be replaced. This was fortunate as the HP-WH300 was found to have a damaged bulkhead connector and a replacement part was not available. The remaining WH300 is most likely too weak to work as a stand-alone.

The R/V Revelle has three Doppler sonars. The primary SADCP is a Teledyne RD Instruments 150 kHz narrowband instrument. It is operated by an SIO-owned rack mount unit running the University of Hawaii Data Acquisition System (UHDAS). UHDAS requires data from the NB150, the gyro heading (for reliability), the Ashtech heading (for accuracy), and GPS position.

The other two Doppler sonars on board are the 50 kHz and 140 kHz HDSS. They were designed at SIO to gather high-quality ocean velocity and shear measurements and will be processed there.





**Figure 1: Zonal (top) and meridional (bottom) velocity with latitude along I9N from the inverse solution of the LADCP measurements.**

### B.2.3. Sampling

The LADCP was deployed at all CTD stations. A command file was uploaded to the instrument approximately five minutes before each deployment. Sampling parameters are detailed in Table 1.

Ensembles per burst	2
Pings per ensemble	1
Time per burst	2.6 s
Time per ensemble	1 s
Time between pings	0 s
Number of depth cells	32
Bin size	8 m*
Blank after transmit	16 m
Transmit length	16 m
Ambiguity velocity	330 cm/s

\* The bin size was changed to 10m at station 108 to improve resolution. No change in data quality was noticed, so it was returned to 8m at station 117.

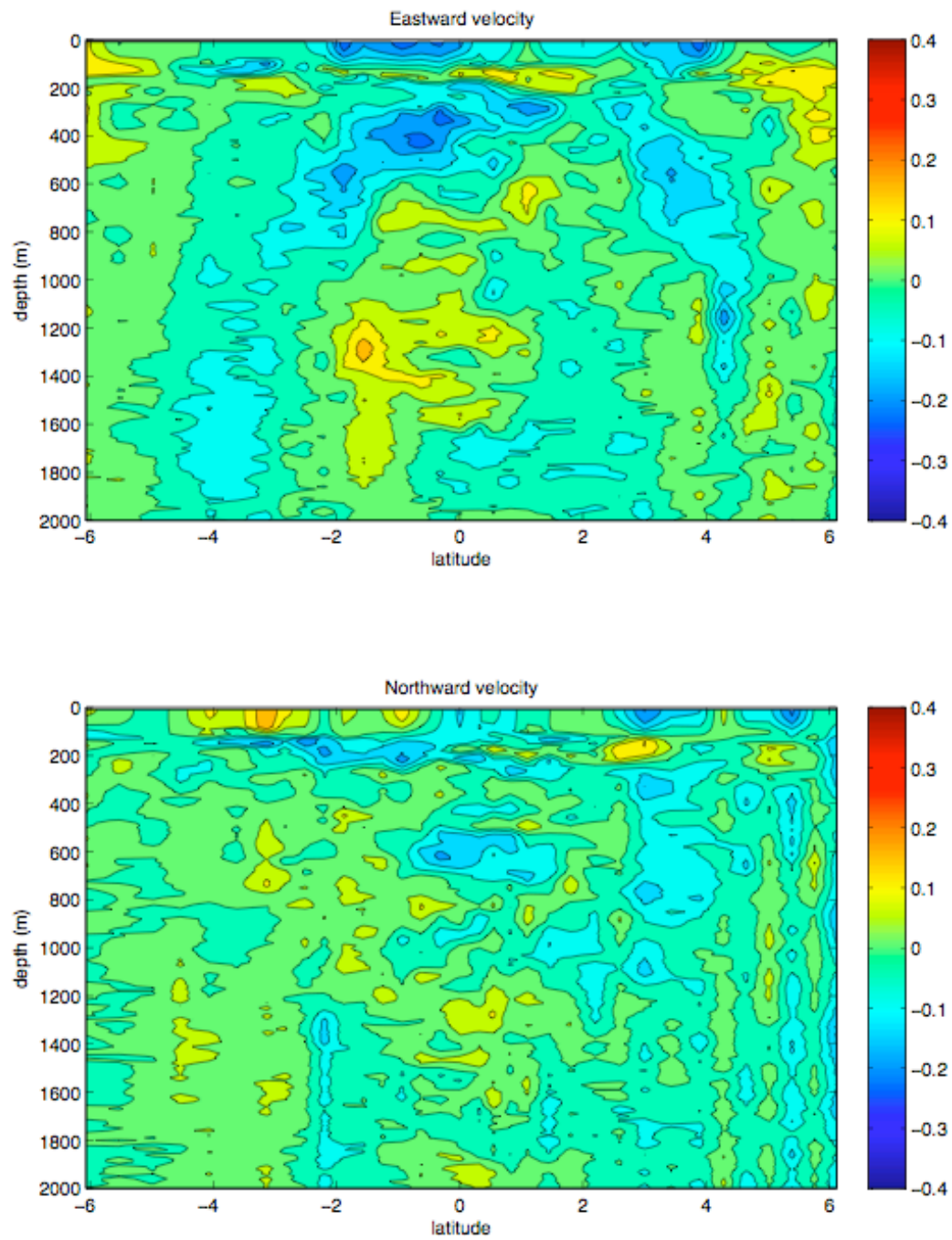
The SADCP and HDSS ran continuously during the cruise with the exception of short periods during which they received repairs.

### B.2.4. Preliminary Processing

Data were processed using the LDEO LADCP software version IX written by Martin Visbeck and Andreas Thurnherr. The LDEO software produces both an inverse and a shear solution., with the inverse solution considered the more reliable of the two. CTD and GPS data were incorporated into the processing at all stations. SADCP data were used when available (stations 89-115). Once the remaining SADCP data are recovered from the damaged disk, they can be used to re-process the LADCP data.

### B.2.5. Preliminary Results

Velocity data from the inverse solution are presented in [Figure 1](#). Most of the transect shows velocities slower than 10 cm/s. The upper 2000 meters of the transect shows alternating zonal jets near the equator. These are shown in greater detail in [Figure 2](#). These are characterized by an inverted “u” shape of westward velocities from 10 cm/s up to 30 cm/s. At 1300 m there is a strong eastward jet with a maximum velocity of nearly 20 cm/s. [Figure 3](#) shows surface currents along the length of the cruise track. [Figure 4](#) shows the error velocity and the shear-derived velocities for comparison. The error velocity, which is the range of possible inverse solution, is low for most of the transect but reaches 0.3 cm/s between -27 and -20 degrees, an area with few scatterers and rough bathymetry. The shear solution shows less detail than the inverse solution but agrees in overall structure. The area of highest difference also occurs near the rough bathymetry of -27 to -20 degrees.



**Figure 2: Inverse solution of the LADCP zonal (top) and meridional (bottom) velocity for the equatorial region of the CLIVAR I9N transect.**

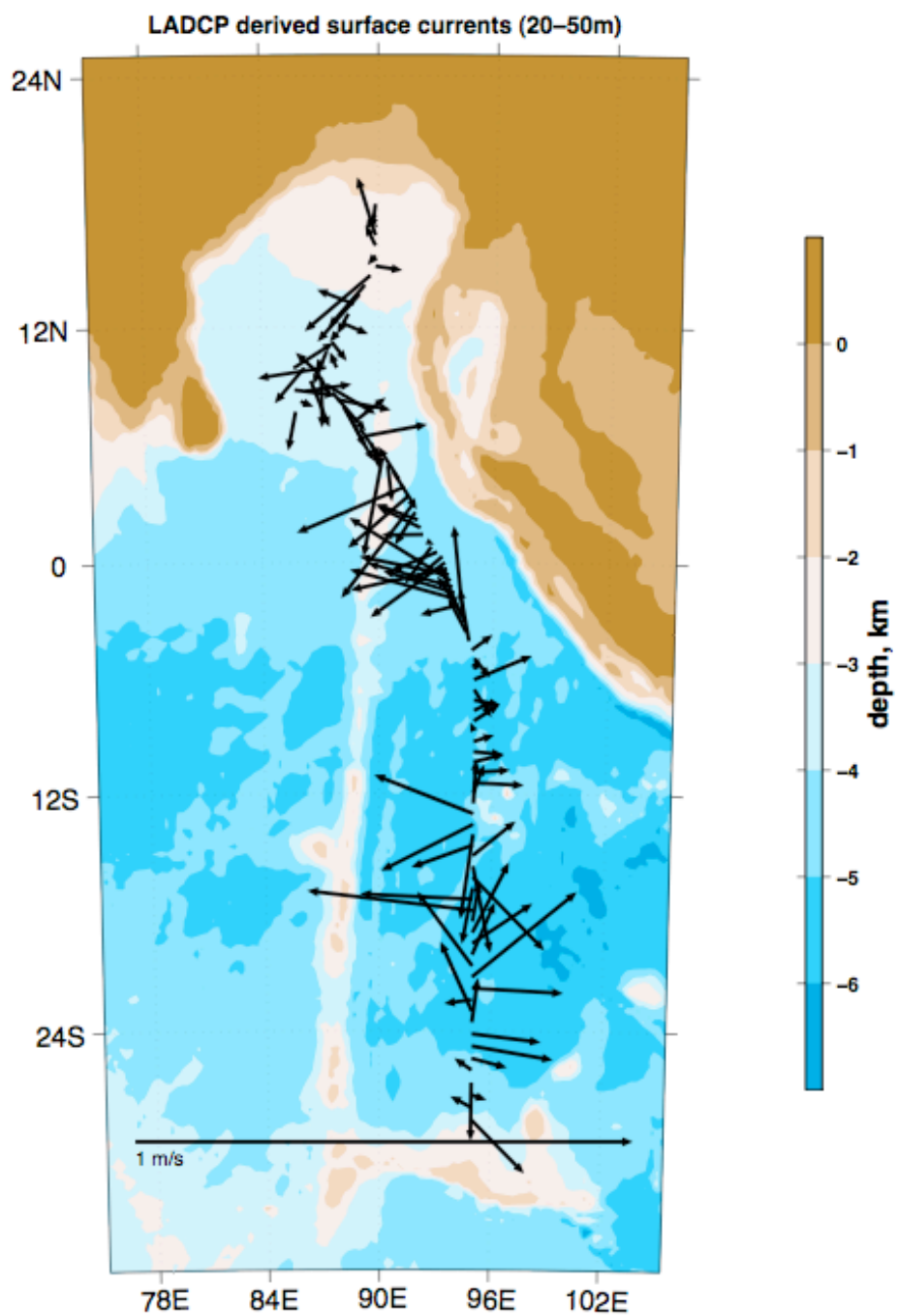
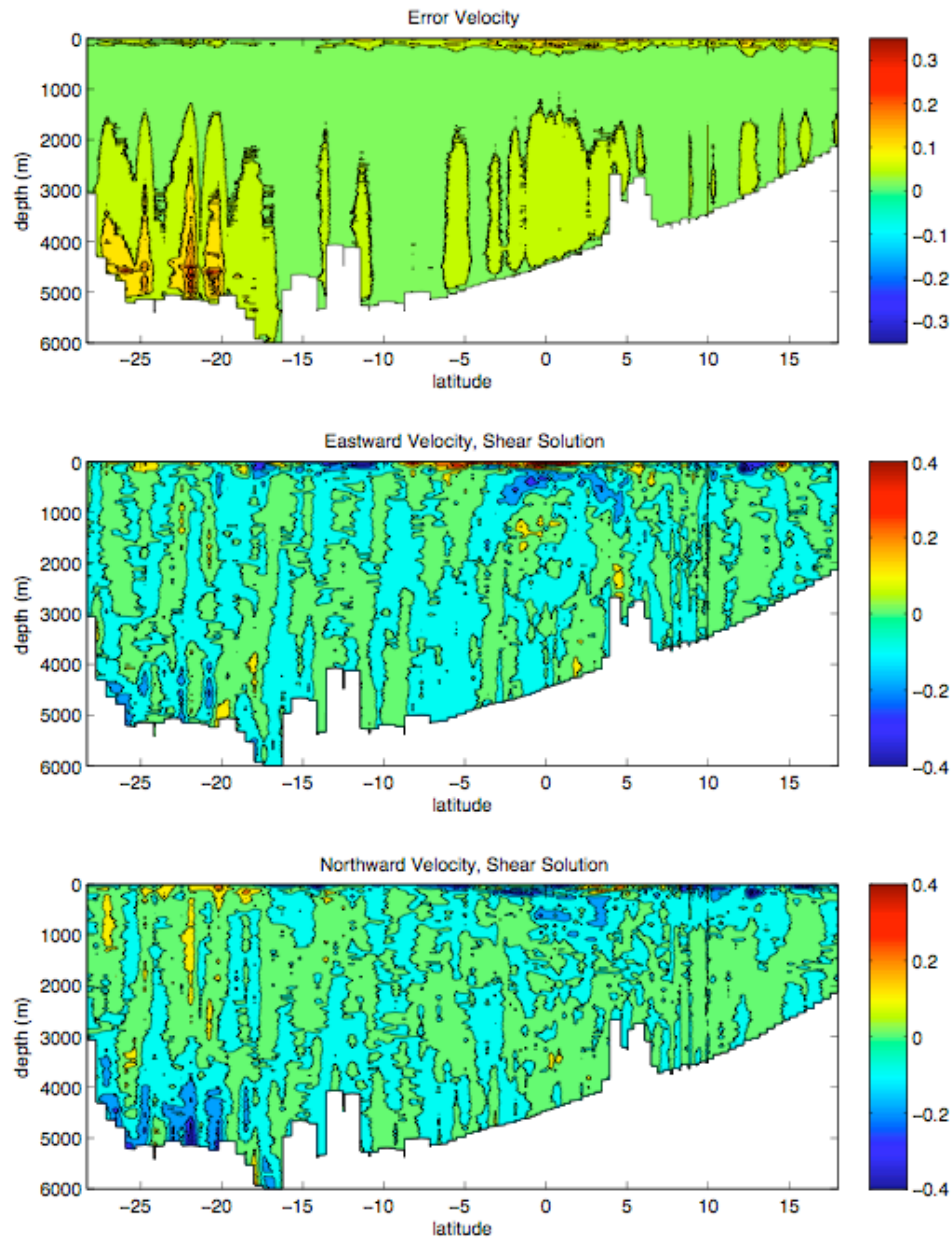


Figure 3: Currents averaged over 20-50 m along CLIVAR I9N from the LADCP velocity measurements.



**Figure 4: Zonal (top) and meridional (bottom) velocity along CLIVAR I9N determined from the shear solution of the LADCP velocity measurements.**

#### **B.2.6. Files and Directories**

The LADCP datasets should contain the following directories, which contain everything that is needed in order to re-process the LADCP data:

<b>raw</b>	raw data, instrument-setup command files, communication logfiles
<b>CTD</b>	CTD time series and profiles used for LADCP processing
<b>SADCP</b>	shipboard ADCP data used for LADCP processing
<b>processed</b>	processed data files and processing figures



## Bottle Sampling

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

- CFCs
- $^3\text{He}$
- $\text{O}_2$
- Dissolved Inorganic Carbon (DIC)
- Total Alkalinity
- $^{13}\text{C}$  and  $^{14}\text{C}$
- Dissolved Organic Carbon (DOC) and Dissolved Organic Nitrogen (DON)
- Tritium
- Nutrients
- CDOM
- POC
- Salinity

At Station 98, the sampling order was changed slightly, Tritium was sampled after other samples were collected. This was changed again at Station 114 and Tritium was sampled before salinity. The correspondence between individual sample containers and the rosette bottle position (1-36) 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 management.

## Bottle Data Processing

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

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

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

Table 1.9.0 shows the number of samples drawn and the number of times each WHP sample quality flag was assigned for each basic hydrographic property:

Rosette Samples Stations 89-199								
	Reported levels	1	2	3	4	5	7	9
Bottle	3993	0	3991	0	1	0	0	1
CTD Salt	3993	0	3993	0	0	0	0	0
CTD Oxy	3988	0	3988	0	0	0	0	5
Salinity	3990	0	3888	30	72	1	0	2
Oxygen	3988	0	3972	8	8	4	0	1
Silicate	3989	0	3948	39	2	2	0	2
Nitrate	3989	0	3974	12	3	2	0	2
Nitrite	3989	0	3987	0	2	2	0	2
Phosphate	3989	0	3985	2	2	2	0	2

**Table 1.9.0** Frequency of WHP quality flag assignments.

Additionally, all WHP water bottle/sample quality code comments are presented in [Appendix C](#). Various consistency checks and detailed examination of the data continued throughout the cruise.

### B.3. Salinity Analysis

#### Equipment and Techniques

Two Guildline Autosol 8400A salinometers (S/N 57-396, 53-503) located in the hydro lab, were used for salinity measurements. Autosol 57-396 was first employed at the start of the expedition, it developed a cell fouling problem and 53-503 was used while the other autosol was being repaired. Autosol 53-503 had a tendency to have a slight drift during a sample reading. While 53-503 was being used as the primary salinometer, the electrodes were replaced in the conductivity cell from 57-396. After the cell was reassembled and reinstalled, a check was performed with the results of a salinity run from this machine readings stable and reliable with the CTD. Autosol 57-396 was then used as the primary machine. These salinometers were configured by SIO/STS to provide an interface for computer-aided measurement.

The salinity analyses were performed after samples had equilibrated to laboratory temperature, usually within 6-8 hours after collection. The salinometers were standardized for each group of analyses (usually 1-2 casts, up to ~75 samples) using at least two fresh vials of standard seawater per group. Once it was determined that the salinometer was providing stable readings, standardization was performed every 24 hours and additionally if a bath temperature change occurred. Salinometer measurements were made by computer, the analyst prompted by the software to change samples and flush.

#### Sampling and Data Processing

A total of 3990 salinity measurements were made (586 for Trace Metals) and approximately 164 vials of standard seawater (IAPSO SSW) were used.

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

PSS-78 salinity [UNES81] was calculated for each sample from the measured conductivity ratios. The difference (if any) between the initial vial of standard water and the next one run as an unknown was applied as a linear function of elapsed run time to the data. The corrected salinity data were then incorporated into the cruise database.



The estimated accuracy of bottle salinities run at sea is usually better than  $\pm 0.002$  PSU relative to the particular standard seawater batch used. The 95% confidence limit for residual differences between the bottle salinities and calibrated CTD salinity relative to SSW batch P-147 was  $\pm 0.0067$  PSU for all acceptable salinities, and  $\pm 0.0014$  PSU for salinities deeper than 2500db.

### Laboratory Temperature

The water bath temperature was set and maintained at a value near the laboratory air temperature. The following table provide a summary of the bath and lab temperature ranges. The temperature in the salinometer laboratory varied from  $\sim 17$  to  $26^\circ\text{C}$ , during the cruise. The lab temperature dropped to  $\sim 17^\circ\text{C}$  when the ship's engineers cleared a clogged cooling pipe. The air temperature change during any particular run varied from  $-1.6$  to  $+1.3^\circ\text{C}$  with one run varying by  $3.1^\circ\text{C}$ .

Station	Serial Number	Bath Temp	Lab Temp Range
89-93	57-396	24	21.9-23.6
94-105/2	53-503	24	22.1-23.9
105/1-112	53-503	27	24.1-25.7
113-132	57-396	27	22.6-26.2
133-142	57-396	21	16.8-21.4
143-199	57-396	24	20.7-22.7

Salinometer Bath and Lab Temperatures I9N

### Standards

IAPSO Standard Seawater Batch P-147 was used to standardize all casts.

### Comparison of 2007 reoccupied Stations

Comparison of deep water on reoccupied Stations 88 versus 89.					
STN	SAMP	PRESS	TEMP	SALINITY	
NBR	NBR	DBARS	ITS-90		DIFF
88	308	1913.3	2.5057	34.7056	
89	308	1913.0	2.4883	34.7058	-0.0002
88	307	2013.4	2.4006	34.7114	
89	307	2013.7	2.3335	34.7155	-0.0041
88	306	2266.7	2.0769	34.7247	
89	306	2265.3	2.0712	34.7263	-0.0016
88	304	2519.1	1.8278	34.7298	
89	305	2517.8	1.8542	34.7306	-0.0008
88	305	2519.1	1.8280		
89	304	2520.6	1.8506	34.7316	
88	303	2773.1	1.6241	34.7296	
89	303	2772.4	1.6555	34.7309	-0.0013
88	302	2974.9	1.4853	34.7267	
89	302	2974.6	1.5241	34.7291	-0.0024
88	301	3100.8	1.4595	34.7265	
89	301	3104.1	1.4718	34.7283	-0.0017

### Comparison of deep water on reoccupied Stations 174 versus 182.

STN	SAMP	PRESS	TEMP	SALINITY	
NBR	NBR	DBARS	ITS-90		DIFF
174	209	2364.5	2.2768	34.7603	
182	109	2364.5	2.2766	34.7585	0.0018
174	208	2615.2	2.0031	34.7459	
182	108	2617.3	2.0034	34.7458	0.0000
174	207	2869.3	1.8200	34.7381	
182	107	2869.1	1.8156	34.7383	-0.0001
174	206	3121.7	1.6737	34.7320	
182	106	3123.2	1.6681	34.7315	0.0005
174	205	3345.6	1.5395	34.7263	
182	105	3346.5	1.5379	34.7268	-0.0005
174	204	3390.5	1.5130	34.7263	
182	104	3386.7	1.5170	34.7260	0.0003
174	203	3426.4	1.4898	34.7250	
182	103	3427.3	1.4858	34.7248	0.0002
174	202	3461.4	1.4658	34.7242	
182	102	3488.6	1.4627	34.7236	0.0006
174	201	3547.3	1.4674	34.7238	
182	101	3548.1	1.4671	34.7219	0.0018

## B.4. Oxygen Analysis

### Equipment and Techniques

Dissolved oxygen analyses were performed with an SIO/ODF-designed automated oxygen titrator using photometric end-point detection based on the absorption of 365nm wavelength ultra-violet light. The titration of the samples and the data logging were controlled by PC LabView software. Thiosulfate was dispensed by a Dosimat 665 buret driver fitted with a 1.0 ml buret. ODF used a whole-bottle modified Winkler titration following the technique of Carpenter [Carp65] with modifications by Culberson *et al.* [Culb91], but with higher concentrations of potassium iodate standard (~0.012N) and thiosulfate solution (~55 gm/l). Pre-made liquid potassium iodate standards were run every day (approximately every 2-4 stations), unless changes were made to the system or reagents. Reagent/distilled water blanks were determined every day or more often if a change in reagents required it to account for presence of oxidizing or reducing agents.

### Sampling and Data Processing

5975 oxygen measurements were made. Samples were collected for dissolved oxygen analyses soon after the rosette was brought on board. Using a Tygon and silicone drawing tube, nominal 125ml volume-calibrated iodine flasks were rinsed 3 times with minimal agitation, then filled and allowed to overflow for at least 3 flask volumes. The sample drawing temperatures were measured with an electronic resistance temperature detector (RTD) embedded in the drawing tube. These temperatures were used to calculate  $\mu\text{mol/kg}$  concentrations, and as a diagnostic check of bottle integrity. Reagents ( $\text{MnCl}_2$  then  $\text{NaI/NaOH}$ ) 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 1-4 hours of collection, and the data incorporated into the cruise database.

Thiosulfate normalities were calculated from each standardization and corrected to 20° C. The 20° C normalities and the blanks were plotted versus time and were reviewed for possible problems. The blanks and thiosulfate normalities for each batch of thiosulfate were smoothed (linear fits) in two groups during 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 volume is detected. The volumetric flasks used in preparing standards were volume-calibrated by the same method, as was the 10 ml Dosimat buret used to dispense standard iodate solution.

### Standards

Liquid potassium iodate standards were prepared in 6 liter batches and bottled in sterile glass bottles at ODF's chemistry laboratory prior to the expedition. The normality of the liquid standard was determined by calculation from weight. The standard was supplied by Alfa Aesar and has a reported purity of 99.4-100.4%. All other reagents were "reagent grade" and were tested for levels of oxidizing and reducing impurities prior to use.

### Comparison of 2007 reoccupied Stations

#### Comparison of deep water on reoccupied Stations 88 versus 89.

STN	SAMP	PRESS	TEMP	O2	
NBR	NBR	DBARS	ITS-90	UMOL/KG	DIFF
88	308	1913.3	2.5057	158.4	
89	308	1913.0	2.4883	159.7	-1.3
88	307	2013.4	2.4006	161.4	
89	307	2013.7	2.3335	164.0	-2.6
88	306	2266.7	2.0769	171.5	
89	306	2265.3	2.0712	171.4	0.1
88	304	2519.1	1.8278	178.0	
89	305	2517.8	1.8542	177.9	0.1
88	305	2519.1	1.8280		
89	304	2520.6	1.8506	177.9	
88	303	2773.1	1.6241	183.8	
89	303	2772.4	1.6555	182.5	1.3
88	302	2974.9	1.4853	185.8	
89	302	2974.6	1.5241	185.0	0.8
88	301	3100.8	1.4595	187.0	
89	301	3104.1	1.4718	187.0	0.0

**Comparison of deep water on reoccupied Stations 174 versus 182.**

STN	SAMP	PRESS	TEMP	O2	
NBR	NBR	DBARS	ITS-90	UMOL/KG	DIFF
174	209	2364.5	2.2768	126.0	
182	109	2364.5	2.2766	125.5	0.5
174	208	2615.2	2.0031	133.5	
182	108	2617.3	2.0034	133.4	0.1
174	207	2869.3	1.8200	140.6	
182	107	2869.1	1.8156	140.5	0.1
174	206	3121.7	1.6737	147.2	
182	106	3123.2	1.6681	147.4	-0.2
174	205	3345.6	1.5395	157.9	
182	105	3346.5	1.5379	157.6	0.3
174	204	3390.5	1.5130	159.1	
182	104	3386.7	1.5170	158.5	0.6
174	203	3426.4	1.4898	158.7	
182	103	3427.3	1.4858	158.5	0.2
174	202	3461.4	1.4658	157.0	
182	102	3488.6	1.4627	153.1	3.9
174	201	3547.3	1.4674	152.8	
182	101	3548.1	1.4671	152.5	0.3

## B.5. 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 to two hours after sample collection.

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.

Explicit corrections for *carryover* in nutrient analyses are not made. In a typical AutoAnalyzer system, sample to sample carryover is (p1-2% of the concentration difference between samples. This effect is minimized by running samples in order of increasing depth such that concentration differences between samples are minimized. The initial surface samples were run twice since these samples followed standard peaks.

## Sampling and Data Processing

4576 nutrient samples were analyzed of these 586 were analyzed for Trace Metal casts.

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 7 different standard concentrations were analyzed periodically to determine any deviation from linearity as a function of absorbance for each nutrient analysis. A correction for non-linearity was applied to the final nutrient concentrations when necessary. A correction for the difference in refractive indices of pure distilled water and seawater was periodically determined and applied. In addition, a "deep seawater" high nutrient concentration check sample was run with each station as an additional check on data quality. The pump tubing was changed 3 times.

After each group of samples was analyzed, the raw data file was processed to produce another file of response factors, baseline values, and absorbances. Final nutrient concentrations were then determined from this file. 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 a per-analysis measured analytical temperature.

## Standards

Primary standards for silicate ( $\text{Na}_2\text{SiF}_6$ ) and nitrite ( $\text{NaNO}_2$ ) were obtained from Johnson Matthey Chemical Co.; the supplier reported purities of >98% and 97%, respectively. Primary standards for nitrate ( $\text{KNO}_3$ ) and phosphate ( $\text{KH}_2\text{PO}_4$ ) were obtained from Fisher Chemical Co.; the supplier reported purities of 99.999% and 99.999%, respectively. The efficiency 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 23.0° C to 24.5° C.

**Comparison of 2007 reoccupied Stations**

<b>Comparison of deep water on reoccupied Stations 88 versus 89.</b>									
STN	SAMP	PRESS	TEMP	SiO3		NO3		PO4	
NBR	NBR	DBARS	ITS-90	UMOL/KG	DIFF	UMOL/KG	DIFF	UMOL/KG	DIFF
88	308	1913.3	2.5057	99.85		33.35		2.35	
89	308	1913.0	2.4883	98.93	0.92	33.06	0.29	2.34	0.01
88	307	2013.4	2.4006	101.25		33.16		2.34	
89	307	2013.7	2.3335	101.39	-0.14	32.95	0.21	2.33	0.01
88	306	2266.7	2.0769	105.43		32.55		2.28	
89	306	2265.3	2.0712	105.87	-0.44	32.53	0.02	2.28	0.00
88	304	2519.1	1.8278	109.41		32.23		2.26	
89	305	2517.8	1.8542	109.14	0.33	32.23	0.00	2.26	0.00
88	305	2519.1	1.8280						
89	304	2520.6	1.8506	109.55		32.27		2.26	
88	303	2773.1	1.6241	113.21		32.13		2.24	
89	303	2772.4	1.6555	112.82	0.40	32.16	-0.03	2.25	-0.01
88	302	2974.9	1.4853	117.02		32.17		2.25	
89	302	2974.6	1.5241	116.52	0.50	32.21	-0.04	2.26	-0.01
88	301	3100.8	1.4595	117.83		32.17		2.25	
89	301	3104.1	1.4718	117.75	0.08	32.25	-0.08	2.26	-0.01

<b>Comparison of deep water on reoccupied Stations 174 versus 182.</b>									
STN	SAMP	PRESS	TEMP	SiO3		NO3		PO4	
NBR	NBR	DBARS	ITS-90	UMOL/KG	DIFF	UMOL/KG	DIFF	UMOL/KG	DIFF
174	209	2364.5	2.2768	135.14		35.71		2.57	
182	109	2364.5	2.2766	134.31	0.83	35.62	0.09	2.56	0.01
174	208	2615.2	2.0031	138.18		35.51		2.52	
182	108	2617.3	2.0034	137.31	0.87	35.42	0.09	2.52	0.00
174	207	2869.3	1.8200	139.38		35.22		2.49	
182	107	2869.1	1.8156	139.10	0.28	35.10	0.12	2.49	0.00
174	206	3121.7	1.6737	140.99		35.02		2.46	
182	106	3123.2	1.6681	140.29	0.70	34.90	0.12	2.46	0.00
174	205	3345.6	1.5395	138.31		34.54		2.40	
182	105	3346.5	1.5379	138.65	-0.34	34.40	0.14	2.40	0.00
174	204	3390.5	1.5130	138.07		34.48		2.39	
182	104	3386.7	1.5170	139.03	-0.96	34.39	0.09	2.39	0.00
174	203	3426.4	1.4898	139.68		34.38		2.39	
182	103	3427.3	1.4858	140.21	-0.53	34.43	-0.05	2.39	0.00
174	202	3461.4	1.4658	142.72		34.62		2.40	
182	102	3488.6	1.4627	146.05	-3.33	34.87	-0.25	2.41	-0.01
174	201	3547.3	1.4674	147.00		35.06		2.42	
182	101	3548.1	1.4671	146.84	0.16	34.92	0.14	2.42	0.00

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## B.6. CFC Measurements

Chlorofluorocarbon (CFC) Measurements during CLIVAR I9N

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Samplers and Analysts: David Cooper, Eugene Gorman and Suzanne Rab Green

The CFC measurements during I9N follow on from those made during I8S, using the same instrumentation and techniques. Samples for the analyses of dissolved CFC-11 and CFC-12 were drawn from approximately 2500 water samples collected during the expedition. Water samples were collected in modified niskin bottles with an end-cap designed to minimize the contact of the water sample with O-rings after closing. Water samples for CFC were the first samples drawn from the 10-liter bottles. Care was taken to coordinate the sampling of CFCs with other samples to minimize the time between the initial opening of each bottle and the completion of sample drawing. In most cases, dissolved oxygen and He samples were collected within several minutes of the initial opening of each bottle. To minimize contact with air, the CFC samples were drawn directly through the stopcocks of the 10-liter bottles into 250 ml precision glass syringes equipped with three-way plastic stopcocks. The syringes were immersed in a holding tank of clean surface seawater held at approximately 0 degrees Centigrade until 30 minutes before being analyzed. At that time, the syringe was placed in a bath of surface seawater heated to 25 degrees C.

For atmospheric sampling, a ~100 m length of 3/8" OD Dekaron tubing was run from the CFC, van located on the fantail, to the bow of the ship. A flow of air was drawn through this line into the main laboratory using a Kadet pump. The air was compressed in the pump, with the downstream pressure held at ~1.5 atm. using a backpressure regulator. A tee allowed a flow (100 ml min<sup>-1</sup>) of the compressed air to be directed to the gas sample valves of the CFC analytical systems, while the bulk flow of the air (>7 l min<sup>-1</sup>) was vented through the backpressure regulator. Air samples were only analyzed when the relative wind direction was within 60 degrees of the bow of the ship to reduce the possibility of shipboard contamination. Analysis of bow air was performed at several locations along the cruise track. At each location, at least five measurements were made to increase the precision. The measured concentrations are reported in [Tables 1 and 2](#). Concentrations of CFC-11 and CFC-12 in air samples, seawater, and gas standards were measured by shipboard electron capture gas chromatography (EC-GC) using techniques modified from those described by Bullister and Weiss (1988).

For seawater analyses, water was transferred from a glass syringe to a glass sparging chamber (~190 ml). The dissolved gases in the seawater sample were extracted by passing a supply of CFC-free purge gas through the sparging chamber for a period of 6 minutes at 175 ml min<sup>-1</sup>. Water vapor was removed from the purge gas during passage through an 18 cm long, 3/8" diameter glass tube packed with the desiccant magnesium perchlorate. The sample gases were concentrated on a cold-trap consisting of a 1/16" OD stainless steel tube with a ~5 cm section packed tightly with Porapak Q (60-80 mesh) and a 22 cm section packed with Carboxen 1004. A Neslab cryocool was used to cool the trap, to -70C. After 6 minutes of purging, the trap was isolated, and it was heated electrically to ~175 C. The sample gases held in the trap were then injected onto a pre-column (~60 cm of 1/8" O.D. stainless steel tubing packed with 80-100 mesh Porasil B, held at 80 C) for the initial separation of CFC-12 and CFC-11 from later eluting peaks. After the F12 had passed from the pre-column through the second pre-column (5 cm of 1/8" O.D. Stainless steel tubing packed with MS5A, 80 C) and into the analytical column #1 (~170 cm of 1/8" OD stainless steel tubing packed with MS5A and held at 80 C) the outflow from the first pre-column was diverted to the second analytical column (~150 cm 1/8" OD stainless steel tubing packed with Carbograph 1AC, 80-100 mesh, held at 100 C). After CFC-11 had passed through the first pre-column, the remaining gases were backflushed from the pre-column and vented. Column #1 and the pre-columns were in a Shimadzu GC8 gas chromatograph with electron capture detector (340 C). Column #2 was in a Shimadzu Mini2 gas chromatograph, also with electron capture detector (250 C).

Both of the analytical systems were calibrated frequently using a standard gas of known CFC composition. Gas sample loops of known volume were thoroughly flushed with standard gas and injected into the system. The temperature and pressure was recorded so that the amount of gas injected could be calculated. The procedures used to transfer the standard gas to the trap, pre-

column, main chromatographic column, and EC detector were similar to those used for analyzing water samples. Four sizes of gas sample loops were used. Multiple injections of these loop volumes could be made to allow the system to be calibrated over a relatively wide range of concentrations. Air samples and system blanks (injections of loops of CFC-free gas) were injected and analyzed in a similar manner. The typical analysis time for seawater, air, standard or blank samples was ~11 minutes. Concentrations of the CFCs in air, seawater samples, and gas standards are reported relative to the SIO98 calibration scale (Cunnold et. al., 2000). Concentrations in air and standard gas are reported in units of mole fraction CFC in dry gas, and are typically in the parts per trillion (ppt) range. Dissolved CFC concentrations are given in units of picomoles per kilogram seawater (pmol kg<sup>-1</sup>). CFC concentrations in air and seawater samples were determined by fitting their chromatographic peak areas to multi-point calibration curves, generated by injecting multiple sample loops of gas from a working standard (PMEL cylinder 45186) into the analytical instrument. The response of the detector to the range of moles of CFC passing through the detector remained relatively constant during the cruise. Full-range calibration curves were run at intervals of 4-5 days during the cruise. Single injections of a fixed volume of standard gas at one atmosphere were run much more frequently (at intervals of ~90 minutes) to monitor short-term changes in detector sensitivity.

Based on the analysis of duplicate samples, we estimate precisions (1 standard deviation) of less than 1% or 0.005 (whichever is greater) for both dissolved CFC-11 and CFC-12 measurements. A very small number of water samples had anomalously high CFC concentrations relative to adjacent samples. These samples occurred sporadically during the cruise and were not clearly associated with other features in the water column (e.g., anomalous dissolved oxygen, salinity, or temperature features). This suggests that these samples were probably contaminated with CFCs during the sampling or analysis processes. Measured concentrations for these anomalous samples are included in the preliminary data, but are given a quality flag value of either 3 (questionable measurement) or 4 (bad measurement). A quality flag of 5 was assigned to samples which were drawn from the rosette but never analyzed due to a variety of reasons (e.g., leaking stopcock, plunger jammed in syringe barrel).

In addition to the samples analyzed using the PMEL system, some samples were taken early in the cruise for separate and comparative analysis using the Lamont-Doherty Earth Observatory (LDEO) CFC/SF6 system. The basic principle of operation is very similar to the PMEL system. Duplicate samples taken for the two systems are in good agreement, with error estimates no larger than for duplicate samples taken for either system. No distinction between the sources of the CFC data was noted in the preliminary data submission. A total of 2449 samples are reported from the PMEL system and 141 samples from the LDEO system. Data for F113 were submitted in the 141 LDEO samples. Where both systems were used, the PMEL data are reported.

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## B.7. DIC Measurements

### Total CO<sub>2</sub> Measurements

Samples for TCO<sub>2</sub> measurements were drawn according to procedures outlined in the Handbook of Methods for CO<sub>2</sub> Analysis (DOE 1994) from 10.4-L Niskin bottles (except Niskin 34, 9.6 L) into cleaned 300-mL glass bottles. Bottles were rinsed and filled from the bottom, leaving 6 mL of headspace; care was taken not to entrain any bubbles. After 0.12 mL of 50% saturated HgCl<sub>2</sub> 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.

TCO<sub>2</sub> samples were collected at every degree from 36 depths with three replicate samples. Some samples were also collected at every half-degree. The replicate seawater samples were taken from the surface, 1000 m, and bottom Niskin bottles and run at different times during the cell. No systematic difference between the replicates was observed. A total of 2526 samples for TCO<sub>2</sub> were collected and analyzed during the cruise.

The TCO<sub>2</sub> analytical equipment was set up in a seagoing laboratory van. The analysis was done by coulometry with two analytical systems (PMEL1 and PMEL2) used simultaneously on the cruise. Each system consisted of a coulometer (UIC, Inc.) coupled with a single operator multi-parameter metabolic analyzer (SOMMA) inlet system developed by Kenneth Johnson (Johnson et al. 1985, 1987, 1993, and 1999; Johnson 1992) now retired from Brookhaven National Laboratory (BNL). In the coulometric analysis of TCO<sub>2</sub>, all carbonate species are converted to CO<sub>2</sub> (gas) by addition of excess hydrogen ion (acid) to the seawater sample, and the evolved CO<sub>2</sub> gas is swept into the titration cell of the coulometer with pure air or compressed nitrogen, where it reacts quantitatively with a proprietary reagent based on ethanolamine to generate hydrogen ions. In this process, the solution changes from blue to colorless, which triggers a current through the cell and causes coulometrical generation of OH<sup>-</sup> ions at the anode. The OH<sup>-</sup> ions react with the H<sup>+</sup>, and the solution turns blue again. A beam of light is shone through the solution, and a photometric detector at the opposite side of the cell senses the change in transmission. Once the percent transmission reaches its original value, the coulometric titration is stopped, and the amount of CO<sub>2</sub> that enters the cell is determined by integrating the total charge during the titration.

The coulometers were calibrated by injecting aliquots of pure CO<sub>2</sub> (99.995%) by means of an 8-port valve outfitted with two sample loops with known gas volumes bracketing the amount of CO<sub>2</sub> extracted from the water samples for the two PMEL systems.

The stability of each coulometer cell solution was confirmed three different ways: the Certified Reference Material (CRM), Batch 78, supplied by Dr. A. Dickson of SIO, was measured at the beginning, gas loops in the beginning and at the end, and the duplicate samples at the beginning, middle, and end of each cell solution. The coulometer cell solution was replaced after 25 mg of carbon was titrated, typically after 9–12 hours of continuous use.

The pipette volume was determined by taking aliquots at known temperature of distilled water from the volumes. The weights with the appropriate densities were used to determine the volume of the pipettes.

Calculation of the amount of CO<sub>2</sub> injected was according to the CO<sub>2</sub> handbook (DOE 1994). The concentration of CO<sub>2</sub> ([CO<sub>2</sub>]) in the samples was determined according to:

$$[CO_2] = \text{Cal. factor} * \frac{(\text{Counts} - \text{Blank} * \text{Run Time}) * K \mu\text{mol/count}}{\text{pipette volume} * \text{density of sample}}$$

where Cal. Factor is the calibration factor, Counts is the instrument reading at the end of the analysis, Blank is the counts/minute determined from blank runs performed at least once for each cell solution, Run Time is the length of coulometric titration (in minutes), and K is the conversion factor from counts to μmol.

The instrument has a salinity sensor, but all TCO<sub>2</sub> values were recalculated to a molar weight (μmol/kg) using density obtained from the CTD's salinity sensor. The TCO<sub>2</sub> values were corrected for dilution by 0.12 mL of 50% saturated HgCl<sub>2</sub> used for sample preservation. The total water volume of the sample bottles was 302.55 mL (calibrated by Dana Greeley, PMEL). The correction factor used for dilution was

1.0004. A correction was also applied for the offset from the CRM. This correction was applied for each cell using the CRM value obtained in the beginning of the cell. The results underwent initial quality control on the ship using property plots: TCO<sub>2</sub>-Depth, TCO<sub>2</sub>-Potential Temperature, TCO<sub>2</sub>-Salinity, TCO<sub>2</sub>- NO<sub>3</sub>; TCO<sub>2</sub>-SiO<sub>3</sub>, TCO<sub>2</sub>-PO<sub>4</sub>, TCO<sub>2</sub>- TALK, and TCO<sub>2</sub>-pH. Also TCO<sub>2</sub>-LAT-Depth contour plots were used to analyze the quality of the data.

The overall performance of the instruments was good during the cruise. Valve 8 malfunctioned at the station 95 on PMEL1. It was replaced. The acid delivery malfunctioned on PMEL2 during the station 172 due to pinched tubing. The PMEL2 coulometer stopped counting during the station 180.

## B.8. TA Measurements

### Total Alkalinity Analyses

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### Sampling:

Samples were drawn from 10-l Niskin bottles into 500 ml borosilicate flasks using silicone tubing that fit over the petcock to avoid contamination of DOC samples. Bottles were rinsed a minimum of two times and filled from the bottom, overflowing a quarter of a volume while taking care not to entrain any bubbles. Approximately 15 ml of water was withdrawn from the flask by arresting the sample flow and removing the sampling tube, thus creating a small expansion volume and a reproducible headspace. The sample bottles were sealed at a ground glass joint with a glass stopper. The samples were thermostated at 25°C before analysis. Periodically, multiple duplicate samples were drawn with a specific focus on photic zone and region of high dissolved organic carbon (DOC). The purpose was to determine the difference in Total Alkalinity after filtration with a 0.45 µm nylon membrane filter.

**Table 1:** Preliminary quality control of total alkalinity

Total number of samples:	2459
Questionable (QC=3):	9
Bad (QC=4):	13
Not Reported (QC=5):	20
Duplicate (QC=6):	283
Set of Filtered/unfiltered:	142

### **Analyzer Description:**

The total alkalinity of seawater (TAlk) was evaluated from the proton balance at the alkalinity equivalence point,  $\text{pH}_{\text{equiv}} = 4.5$  at  $25^\circ\text{C}$  and zero ionic strength in one kilogram of sample. The method utilizes a multi-point hydrochloric acid titration of seawater according to the definition of total alkalinity (Dickson, 1981). The potentiometric titrations of seawater not only give values of TAlk but also those of DIC and pH, respectively from the volume of acid added at the first end point and the initial emf, E0.

Two titration systems, A and B were used for TAlk analysis. Each of them consists of a Metrohm 665 Dosimat titrator, an Orion 720A pH meter and a custom designed plexiglass water-jacketed titration cell (Millero et al., 1993b). Both the seawater sample and acid titrant were temperature equilibrated to a constant temperature of  $25 \pm 0.1^\circ\text{C}$  with a water bath (Neslab, model RTE-17). The water-jacketed cell is similar to the cells used by Bradshaw and Brewer (1988) except a larger volume (~200 ml) is employed to increase the precision. Each cell has a fill and drain valve which increases the reproducibility of the volume of sample contained in the cell. A typical titration recorded the EMF after the readings became stable (deviation less than 0.09 mV) and then enough acid was added to change the voltage a pre-assigned increment (13 mV). A full titration (~25 points) takes about 20 minutes. The electrodes used to measure the EMF of the sample during a titration consisted of a ROSS glass pH electrode (Orion, model 810100) and a double junction Ag, AgCl reference electrode (Orion, model 900200).

### **Reagents:**

A single 50-l batch of ~0.25 M HCl acid was prepared in 0.45 M NaCl by dilution of concentrated HCl, AR Select, Mallinckrodt, to yield a total ionic strength similar to seawater of salinity 35.0 ( $I \approx 0.7$  M). The acid was standardized by a coulometric technique (Marinenko and Taylor, 1968; Taylor and Smith, 1959) and verified with alkalinity titrations on seawater of known alkalinity. Furthermore, Andrew Dickson's laboratory performed an independent determination of the acid molality on sub-samples. The calibrated molality of the acid used was  $0.2648 \pm 0.0001$  M HCl. The acid was stored in 500-ml glass bottles sealed with Apiezon® L grease for use at sea.

### **Standardization:**

The volumes of the cells used were determined to  $\pm 0.03$  ml in port at Fremantle by multiple titrations using seawater of known total alkalinity and CRM. Calibrations of the burette of the Dosimat with water at  $25^\circ\text{C}$  indicate that the systems deliver 3.000 ml (the approximate value for a titration of seawater) to a precision of  $\pm 0.0004$  ml, resulting in an error of  $\pm 0.3 \mu\text{mol}\cdot\text{kg}^{-1}$  in TAlk. The reproducibility and precision of measurements are checked using low nutrient surface seawater and Certified Reference Material (Dr. Andrew Dickson, Marine Physical Laboratory, La Jolla, California), Batch 78. CRM were utilized in order to account for instrument drift and to maintain measurement precision. Opened CRM bottles, referred as 'old' were given by the DIC analysts. These opened bottles were used to rinse the cell before using the new CRM bottles. Duplicate analyses provide additional quality assurance and were taken from same Niskin bottle. Duplicates were either measured on the same instrument, A or B, or measured on both systems, A and B.

The assigned values of the Certified Reference Material provided by A. Dickson of SIO is:

Batch 78:      Total Alkalinity:  $2185.57 \pm 0.45 \mu\text{mol}\cdot\text{kg}^{-1}$       Salinity: 33.285

### **Data Processing:**

An integrated program controls the titration, data collection, and the calculation of the carbonate parameters (TAlk, pH, and DIC) (Millero et al., 1993a). The program is patterned after those developed by Dickson (1981), Johansson and Wedborg (1982), and U.S. Department of Energy (DOE) (1994). The program uses a Levenberg-Marquardt nonlinear least-squares algorithm to calculate the TAlk, DIC, and from the potentiometric titration data.

**Table 2:** Comparison of the measured alkalinity of the CRM and the certified value

CRM	Instrument A	Instrument B
Total number of sets:	96	101
Standard deviation (new):	$\pm 2.9 \mu\text{mol}\cdot\text{kg}^{-1}$ (n=49)	$\pm 2.9 \mu\text{mol}\cdot\text{kg}^{-1}$ (n=53)
Standard deviation (old):	$\pm 6.5 \mu\text{mol}\cdot\text{kg}^{-1}$ (n=47)	$\pm 3.1 \mu\text{mol}\cdot\text{kg}^{-1}$ (n=48)

**Table 3:** Comparison of total alkalinity from the same Niskin bottle

Replicates	Instrument A	Instrument B	Between Systems
Total number of sets:	94	118	68
Number of sets used:	84	109	64
Standard deviation:	$\pm 0.8 \mu\text{mol}\cdot\text{kg}^{-1}$	$\pm 0.8 \mu\text{mol}\cdot\text{kg}^{-1}$	$\pm 1.5 \mu\text{mol}\cdot\text{kg}^{-1}$

**Table 4:** Comparison of total alkalinity between filtered and unfiltered samples

Filtered/Unfiltered	Instrument A
Total number of sets:	142
Number of sets used:	137
Standard deviation:	$\pm 1.31 \mu\text{mol}\cdot\text{kg}^{-1}$

Note: Outliers were determined if the differences were one and a half times larger than the standard deviation. The number omitted is the difference between the total number of set and the sets used.

### Problems:

After the first station, 89, instrument A was shut down as its power supply was wrongly wired and was considered as a fire hazard. Many thanks to the ET on board, Robert Palomares who rewired the power supply, correctly this time, which allowed us to use two instruments. Occasionally, if the two systems were to fill their cell at the same time, the piston of instrument B would not fail closing the valves. Because of this problem, the sampling bottle would drain and seawater would be lost. Sporadically, a solenoid valve at the bottom of the titration cell would fail to engage or disengage, resulting in the loss of the sample or a failed titration due to a poor rinse or an air bubble.

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## **B.9. pH Discrete Measurements**

### Discrete and Underway pH Analyses

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Data Reduction:	Mareva Chanson (03:00 – 15:00), mchanson@rsmas.miami.edu

### **Sampling:**

Underway samples were taken from March 23 – 25, every 6 hours. A flowing seawater line was connected to a Seabird model 45 to measure the insitu salinity and to the automated pH analyzer. Every 10 minutes, salinity was recorded and pH was measured.

For discrete pH measurements, two methods were performed on the seawater samples. From stations 89 to 123, samples were drawn into 50 ml glass syringes using polycarbonate Luer-lock valves that fit in the petcock for the fully automated pH analyzer. After failure of the automated system, from stations 124 to 199, samples were drawn into 10 cm cylindrical glass spectrophotometric cells and were processed manually. The syringes were rinsed a minimum of three times and filled while taking care not to entrain any bubbles. The samples were thermostated at 25°C before analysis.

### **Analyzer Description:**

Measurements of the pH of seawater, on the total scale ( $\text{pH}_t$ ) were first made using multi-wavelength spectrophotometric techniques of Clayton and Byrne (1993). The conversion of the  $\text{pH}_t$  ( $\text{mol/kg}_{\text{H}_2\text{O}}$ ) to the seawater scale ( $\text{mol/kg}_{\text{sol}}$ ) can be made using equations of Dickson and Millero (1987), Dickson and Riley (1979), and Dickson (1990).

Sulphonphthalein indicators such as m-cresol purple (mCP), thymol blue, and cresol red are suitable for the determination of pH. The system is patterned after the standard operating procedure developed by the U.S. Department of Energy (DOE) (1994) and utilizes mCP. This fully automated system performs discrete analysis of pH samples approximately every 12 minutes on a sample volume of 25 ml. A microprocessor controlled syringe and sampling valve aspirates and injects the seawater sample into the 10 cm optical cell at a precisely controlled rate. The syringe rinses and primes the optical cell with 20 ml of sample and the software permits five minutes for temperature stabilization. A refrigerated circulating temperature bath (Neslab, model RTE-17) regulates the temperature of the sample at  $25 \pm 0.01^\circ\text{C}$ . An Agilent 8453 UV/VIS spectrophotometer measures background absorbance of the sample. The automated syringe and sampling valves aspirates 4.90 ml seawater and 0.008 ml of indicator and injects the mixture into the cell. After the software permits five minutes for temperature stabilization, a Guildline 9540 digital platinum resistance thermometer measures the temperature and the spectrophotometer acquires the absorbance at 434, 578 and 730 nm. For the manual analysis, a Gilmont micro burette was used to inject the indicator into the spectrophotometric cells.

**Reagents:**

A concentrated solution, 2.0 mM, of mCP (C<sub>21</sub>H<sub>18</sub>O<sub>3</sub>S) dye solution of known pH<sub>t</sub> = 7.91 and R = 1.625 at 25°C.

**Standardization:**

A precision of better than 0.001 pH units is possible with care, specifically with regard to temperature equilibration and sample handling. Measurements made on duplicate samples, TRIS buffers and Certified Reference Material, Batch 78 (Dr. Andrew Dickson, Marine Physical Laboratory, La Jolla, California) provide validation of the precision and accuracy. Duplicate analyses provide additional quality assurance and were taken from same Niskin bottle.

Batch 78:	pH <sub>sws</sub> @ 25°C	7.870 ± 0.005 (n = 19)
	Salinity	33.285

**Data Processing:**

The pH<sub>t</sub> of the sample is perturbed by the addition of the indicator. The magnitude of this perturbation is a function of the difference between the seawater and indicator acidity. A correction factor applied for each batch of dye adjusts for this perturbation. For a 4.90 ml sample of seawater, 0.008 ml of mCP is added and the absorbance ratio measured. From a second addition of mCP and a second absorbance ratio measurement, a change in the absorbance ratio per ml of added indicator (DR) is calculated. The value of the absorbance ratio (R<sub>m</sub>) measured subsequent to the initial addition of the indicator was used to calculate R from:

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

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

where V<sub>ind</sub> is the volume of mCP used. Clayton and Byrne (1993) calibrated the mCP indicator using TRIS buffers (Ramette et al., 1977) and the equations of Dickson (1993). These equations are used to calculate pH<sub>t</sub>, the total scale in units of moles per kilogram of solution.

**Table 5:** Preliminary quality control of pH measured on the automated and manual system

	Overall	Automated System	Manual Analysis
Total number of samples	2480	772	1708
Questionable (QC=3)	40	31	9
Bad (QC=4)	25	11	14
Lost (QC=5)	116	82	34
Duplicate (QC=6)	278	76	202

**Table 6:** Preliminary accuracy and precision of pH measured on the automated system

CRM	7.848 ± 0.006 (n=4)
TRIS Buffer	8.081 ± 0.006 (n=38)
Duplicates	± 0.006

**Table 7:** Preliminary accuracy and precision of pH measured on the manual system

CRM	7.871 ± 0.005 (n=44)
TRIS Buffer	8.081 ± 0.006 (n=40)
Duplicates	± 0.002



Note: The instrumental software automatically runs a duplicate analysis when the baseline absorbance at 730 nm is beyond a set threshold, thus a large number of omitted duplicate results. Duplicate samples whose difference was three times larger than the standard deviation were omitted from the analyses. The number omitted is the difference between the total number of sets and the sets used.

### **Problems:**

Occasionally, samples drawn from the syringe entrained an air bubble because the valve was improperly opened, tubing was pinched, or the syringe plunger was dry and became stuck in the barrel. Sporadically the software would lose communication with the microprocessor-controlled syringe pumps and pause analysis; the problem was resolved by following the steps outlined in the software to reestablish communication. The ambient temperature of the hydrolab reached 30°C and stayed like that for almost 3 weeks. This caused the valves not to function properly and were drawing samples from the wrong syringe. The Automated analyzer was shut down after station 123 and replaced by the manual one.

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#### **B.10. Discrete pCO<sub>2</sub>**

#### **B.11. Carbon/Oxygen Isotopes.**

##### <sup>14</sup>C Sampling

<sup>14</sup>C samples were taken at ~ every 4 stations. 472 samples were taken in total. Bottles were cleaned at WHOI before the cruise. Samples were taken and sealed for storage according to the instructions provided by WHOI (1). Samples will be shipped back to WHOI for <sup>13</sup>C and <sup>14</sup>C analyses.

(1) Measuring <sup>14</sup>C in seawater total CO<sub>2</sub> by accelerator mass spectrometry, WHP Operation and Methods, July, 2003.

#### **B.12. Dissolved Organic Carbon/Dissolved Organic Nutrients**

##### DOC sampling

DOC samples were taken from every Niskin bottles at every other station. 1870 samples were taken from 52 stations in total. Samples from up to 250 m were filtered through GF/F filters using in-line filtration. Samples from deeper depths were not filtered. High density polyethylene 60 ml sample bottles were 10% HCl cleaned and Milli-Q water rinsed. Filters were combusted at 450°C for overnight. Filter holders were 10% HCl cleaned and Milli-Q water rinsed. Samples were introduced into the sample bottles by a pre-cleaned silicone tubing. Bottles were rinsed by sample for 3 times before filling. 40-50 ml of water were taken for each sample. Samples were kept frozen in the ship's freezer room. Frozen samples will be shipped back by express shipping to RSMAS for DOC analysis.

#### **B.13. CDOM, chlorophyll, bacterial suite**

Chromophoric DOM -- A Photoactive Tracer of Geochemical Process

PIs: D. Siegel, N. Nelson, C. Carlson, University of California, Santa Barbara  
Support: NASA Ocean Biology and Biogeochemistry; NSF Chemical Oceanography  
Field Team (I8S): N. Nelson (PI), D. Menzies (Sr. Engineer)  
Field Team (I9N): C. Swan (GS), E. Wallner (GS)

#### **Project Goals:**

Our goals are to determine chromophoric dissolved matter (CDOM) distributions over a range of oceanic regimes on selected sections of the CO<sub>2</sub>/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, and relative rates of advection and remineralization in intermediate and deep waters. Furthermore, changes in the optical properties of CDOM and its relationship with DOC over time suggest the use of CDOM as an indicator of the prevalence of refractory DOC in the deep ocean. 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 I8S and I9N:**

##### Profiling Instruments

Once each day we cast a hand-deployed free-fall Satlantic MicroPro II multichannel UV/Visible spectroradiometer. This instrument has 14 upwelling radiance sensors and 14 downwelling irradiance sensors in wavelength bands ranging from 305 to 683 nm. The package also mounts a WetLabs ECO chlorophyll fluorometer, plus ancillary sensors including X-Y tilt, internal and external temperatures. The instrument is allowed to trail away behind the port-side stern, then free-falls to 150m and is hand-

recovered. We are using the radiometric data to study the effects of CDOM on the underwater light environment, to validate satellite ocean radiance sensor data, and to develop new algorithms employing satellite and in situ optical sensor data to retrieve ocean properties such as CDOM light absorbance, chlorophyll concentration, and particulate backscattering.

On the core CTD we deploy a WetLabs UV fluorometer (Ex 370 nm, Em 460 nm), which stimulates and measures fluorescence of CDOM. We are evaluating the use of this instrument to supplement or enhance bottle CDOM measurements, as bottle samples often do not have the depth resolution needed to resolve the observed strong near-surface gradients in CDOM concentration, and on cruises such as this we are not able to sample CDOM on every station. Differences between the fluorescence and absorption profiles may reveal gradients in chemical composition of CDOM. On I8S the fluorometer has performed very well: problems with temperature compensation encountered on P16N have been corrected. Signal to noise ratios remain low for the open ocean areas that we are studying.

This fluorometer is ganged to a WetLabs C-star 660 nm 0.25m pathlength beam transmissometer belonging to Dr. Wilford Gardner, TAMU. The transmissometer is used to gauge particle load in the water column, which can be calibrated to produce estimates of particulate carbon. Decline of the particle load with depth can then be related to POC flux, another element of the carbon system.

### **Bottle Samples**

CDOM is at present quantified by its light absorption properties. We are collecting samples of seawater for absorption spectroscopy on one deep ocean cast 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 0.2µm filtrates using a liquid waveguide spectrophotometer with a 200cm cell. On I8S and I9N duplicate samples were collected at a rate of ca. 2 samples per cast. RMS differences in absorption coefficient at 325 nm between the duplicate samples were just over 0.003 m<sup>-1</sup>, which is ca. 4% of the average absorption coefficient at that wavelength.

We also concurrently collect samples for bacterial abundance and DOM characterization (including carbohydrate and neutral sugar analysis) 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), a non-radioactive alternative to the standard bacterial productivity technique using tritiated thymidine. We also filter large volume samples (2L) at 6 depths in the upper 1000m for later bacterial DNA analysis. (The Trace Metals group provides us with unfiltered water from their casts for this measurement.)

Because of the connections to light availability and remote sensing, we collect bottle samples in the top 200m for chlorophyll analysis in addition to surface samples (from the ship's uncontaminated seawater system) for chlorophyll, carotenoid, and mycosporine-like amino acid pigment analysis (HPLC) and particulate absorption (spectrophotometric). We are sporadically collecting large volume (ca. 2L) samples for CDOM photolysis experiments back at UCSB, and occasionally collecting large volume samples for POC analysis to compare with transmissometer data. We have the cooperation again of the Trace Metals group for the large-volume subsurface samples from their Go-Flo bottles. We are only analyzing the CDOM and chlorophyll a at sea and the rest of the samples we prepare and store for analysis on shore.

#### **B.14. Helium-tritium**

Helium samples were collected in stainless steel containers with pneumatic valves (“bunnies”). To draw a sample, two pieces of tubing are attached to the ends of the container, and one end is attached to the spigot on the Niskin bottle. The sample is held vertically above the water level in the Niskin bottle, the valve is opened to establish flow, and the sample is lowered over a ten- to twenty-second period to establish gravity flow. The relatively slow entry of the water into the container minimizes trapped air and bubble formation. The amount of water flushed through the tube is about six volumes. During the flush period, the container is tapped to remove bubbles. The pneumatic valves are closed and the sample is stored until it can be further processed.

After all samples were collected, the helium samples were degassed and extracted into glass vials for analysis in the shore-based laboratory. In general, the extraction and degassing procedures were executed with several (~8) samples in parallel, with extraction or degassing sections coupled to a common vacuum manifold.

Tritium samples were collected in 1 liter flint glass bottles, sealed with caps fitted with high density polyethylene cones to minimize water vapor transpiration. To achieve a minimum contamination, the bottles were pretreated to remove adsorbed water. The bottles are sealed with argon inside. After the tritium samples were collected they are sealed and returned to the shore-based laboratory for analysis.

During the cruise a total of XXX stations were occupied, yielding a total of XXX samples of helium and XXX samples of tritium.

#### **B.15. Trace Metals**

Trace Metals Group; April 28, 2007

Personnel: Department of Oceanography, SOEST, University of Hawaii:  
William T. Hiscock, Mariko Hatta

Department of Oceanography, Florida State University:  
William M. Landing, Kathleen J. Gosnell

Sea water samples for on board trace metal determinations were collected using 12 L Go-Flo bottles on a 12-place rosette system equipped with a SeaBird 911 CTD, oxygen sensor and a Wet Labs FL-1 fluorometer. The rosette package was deployed from the stern of the ship with the Go-Flo bottles in the open configuration using a 4 conductor Kevlar cable sheathed in polyurethane. The package was lowered at  $\sim 30 \text{ m min}^{-1}$  to 100 m and then at  $\sim 50 \text{ m min}^{-1}$  to  $\sim 10 \text{ m}$  below the target depth of the deepest bottle. As the package was raised back through the water column the Go-Flo bottles were tripped individually at pre-assigned depths while the package was moving at  $\sim 10\text{--}30 \text{ m min}^{-1}$ . The depths that the bottles were tripped was one of three sampling patterns that were designed to match the three sampling schemes used by the main hydrography program.

Upon package recovery the Go-Flo bottles were taken from the rosette into the trace metal sampling van for sub sampling. Unfiltered sub-samples were collected directly from each bottle for salinity and nutrient determinations and also to ensure that each Go-Flo bottle had closed at the correct depth. Unfiltered samples were collected from every fifth station for archive purposes at UH and FSU. Filtered sub-samples were collected from each bottle through a 47mm in-line Nuclepore polycarbonate track-etched disc filters,  $0.4 \mu\text{m}$ , after attaching the bottles to a 10 psi filtered air supply.

During the cruise a total of 49 stations were occupied, yielding a total of 586 samples.

Filtered samples were collected from each depth for shipboard analysis of dissolved Fe, Al, Mn using the University of Hawaii flow-injection system. A complete data set for dissolved Fe, Al and Mn was obtained from the UH FIA analytical system on 586 samples collected on 49 stations for the entire leg (March 25 to April 26, 2007). We collected archived samples from each trace metal cast (49 stations, 586 samples) for FSU shore-based analysis of dissolved Mn, Fe, Co, Ni, Cu, Zn, Cd, and Pb using isotope dilution

Inductively-Coupled Plasma Mass Spectrometry (ICPMS). The Total Suspended Matter from each trace metal cast was collected on 47 mm 0.4 um Nuclepore filters for Energy Dispersive X-Ray Fluorescence (EDXRF) analysis of total particulate Si, Mn, Fe, and Al (Dr. Joe Resing at NOAA/PMEL). In addition, subsamples from the trace metal rosette for DNA and CDOM analysis by the UCSB group on numerous casts. Details (dates, stations, casts) can be found in the UCSB group cruise report.

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**B.16. Optical Casts**

See B10 CDOM, bacterial etc. section

## C. Underway Measurements

### C.1. Shipboard ADCP and HDF5

See B.2 LADCP report.

### C.2. Argo Floats

Fourteen Web Research APEX floats were launched for Dr. Steve Riser at the University of Washington in Seattle. The floats are part of the U.S. ARGO program that is a global network of 3000 profiling floats. The floats are designed to sink to a depth of about 2000m. They then cruise at depth for about 10 days before returning to the surface. During the descent and ascent of the floats, temperature, salinity, and with some floats oxygen profiles are measured and recorded. At the surface, before the next dive begins, the acquired data and position of the float are transmitted via satellite. The life time of the floats in the water is 4-5 years.

Except for the first two floats on I9N, all floats were pressure activated which means that they could be launched without prior startup in the lab. Each float was launched upon departure from the station closest to the nominal latitude given by Steve Riser for deployment. Immediately following deployment, an email was sent to Steve Riser to report the exact time and position of the float. The first two floats (id 3025 and 3026) were new prototypes with carbon fiber hulls that did not contain pressure activation system. They were started in port shortly before the cruise departed Fremantle. Unfortunately, these two floats, once deployed, did not communicate back to shore which is most likely due to insufficient testing at the manufacturer before delivery of this new model. Communication with all other floats deployed worked properly. A few of the floats contained oxygen sensors. The launch information is shown in the table below.

Launch time	Float Type	FloatId	Station	Lat.	Lon.
20070327:041500	A2Apf8Sbe41	3025	91	6.44S	95° 0.14E
20070328:204400	A2Apf8Sbe41	3026	96	8.21S	95° 0.60E
20070330:184800	Apex260Apf9aSbe41	5217	102	20°45.70S	95° 0.30E
20070401:105000	Apex260Apf9aSbe41	0009	107	17°58.03S	95° 0.59E
20070403:022200	Apex260Afp9aSbe41	5126	112	15°10.11S	94°59.86E
20070404:235800	Apex260Afp9aSbe41	5127	118	11°56.85S	95°00.24E
20070406:223000	Apex260Afp9aSbe41	5156	124	8°43.92S	95° 0.81E
20070408:140900	Apex260Afp9aSbe41	5157	129	4.11S	95° 0.34E
20070410:102300	Apex260N2Apf9iSbe41cpldo	5209	135	3°7.57S	94°25.66E
20070415:084400	Apex260N2Apf9aSbe41Optode	5128	154	3°0.93N	91°45.09E
20070417:074300	Apex260Afp9aSbe41	5159	162	6°7.43N	89°37.49E
20070419:143300	Apex260N2Apf9iSbe41cpldo	5210	170	9°5.99N	87°20.59E
20070425:194500	Apex260N2Apf9aSbe41Optode	5130	193	15°0.28N	89°50.06E
20070426:172900	Apex260Afp9aSbe41	5161	197	17°0.13N	89°51.20E

In addition to the fourteen floats deployed on I9N, there were two floats that did not pass the pre-cruise testing performed in port. These floats were shipped back to Seattle before the cruise started. Their information is given below.

Float Type	FloatId	Nom. Lat.
Apex260Afp9aSbe41	5160	0°
Apex260Afp9aSbe41	5158	12°N

### C.3. NOAA/PMEL Underway pCO<sub>2</sub>

Equipment and Analytical Techniques: Underway pCO<sub>2</sub> System (Version 2.5) AOML:

The shipboard automated underway pCO<sub>2</sub> system is situated in the hydrolab. It runs on an hourly cycle during which three gas standards, eight headspace samples from the equilibrator, and three ambient air samples are analyzed. The system consists of an equilibrator box where surface seawater from the bow intake is equilibrated with headspace, a valve box that contains the infrared analyzer, and a computer and interface boards that control valves and log sensors.

The equilibrator is a cylindrical Plexiglas™ chamber approximately 22.5 cm high and 8.8 cm wide. Surface seawater flows through a spiral spray head in the top at a rate of  $2 \pm 0.5$  l/min. The water spray through the ~0.5-l headspace and the turbulence of the water streams impinging on the surface of 0.5 l of water cause the gases in water and headspace to equilibrate. Excess water flows through an outlet at the bottom of the equilibrator into an over-the-side drain. Two vents in the top of the equilibrator insure that the headspace remains at the measured laboratory pressure. Headspace gas circulates in a closed loop driven by a KNF pump at  $150 \pm 50$  ml/min. From the equilibrator the gas passes through a condenser, a column of magnesium perchlorate, a mass flow meter (MFM), a  $1.0 \mu\text{m}$  Acro® disk filter, the 12 ml sample cell of a Licor™ Model 6251 non-dispersive infrared analyzer (IR), and back into the equilibrator headspace.

A second KNF pump draws marine air from an intake on the bow mast through 100 m of 0.95 cm (= 3/8") OD Dekoron™ tubing at a rate of 6-8 l/min. A filter of glass wool at the intake prevents particles from entering the gas stream. At designated times, the program diverts  $175 \pm 25$  ml/min of air from this line into the Licor sample cell for analysis. Excess marine air empties into a rotometer on the front panel of the valve box.

Both sample streams (equilibrator headspace and marine air) are analyzed bone dry. They pass first through a cold trap (condensor) at 30 C and then through a column of magnesium perchlorate. Standard gases also run through the magnesium perchlorate.

A custom developed program run under LabView™ controls the system and graphically displays air and water XCO<sub>2</sub> readings. The program logs the voltage and temperature of the infrared analyzer, water flow, gas flows, equilibrator temperature, and barometric pressure. The program writes all of this data to disk at the end of each measurement phase.

The details of instrumental design can be found in Wanninkhof and Thoning (1993), Ho et al. (1995), and Feely et al. (1998).

#### **Sampling Cycle:**

The system runs on an hourly cycle during which three standard gases, three marine air samples, and eight surface water samples (from the equilibrator headspace) are analyzed on the schedule listed below. A Valco multi-port valve selects the gas to be analyzed. Each measurement phase starts by flowing either standard (@~50ml/min), equilibrator headspace (@~150 ml/min), or marine air (@~175 ml/min) through the Licor. Fifteen seconds before the end of each phase, a solenoid valve stops the gas flow. Ten seconds later, the program logs all sensors and writes the data to disk.

**Table 2.14:** Hourly sampling cycle for the underway pCO<sub>2</sub> system (version 2.5).

Minutes after the Hour	Sample
4	Low standard
8	Mid standard
12	High standard
16.5	Water (= headspace of equilibrator)
21	Water
25.5	Water
30	Water
34	Air (marine air from the bow line)
38	Air
42	Air
46.5	Water
51	Water
55.5	Water
60	Water

**Standards:**

The unit is standardized every hour with three compressed air standards containing known amounts of CO<sub>2</sub> gas in (natural) air. The standard gases are purchased from NOAA/CMDL in Boulder and are directly traceable to the WMO scale.

The standards used on the cruise are:

Mole Fraction

Tank #      CO<sub>2</sub> (ppm) (= XCO<sub>2</sub>)

CA06827    284.71

CA05334    380.98

CA06380    448.29

**Units:**

All XCO<sub>2</sub> values are reported in parts per million (ppm), and fCO<sub>2</sub> values are reported in micro atmospheres ( $\mu$ atm).

**Data Availability:**

The system ran well during the entire cruise from March 22 to April 27. The data will be posted on the web approximately 1 month after the end of the cruise at:

<http://www.aoml.noaa.gov/ocd/gcc/index.php>

**References**

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#### **C.4. FSU Aerosol Sampling**

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##### **Aerosol Sampling**

Aeolian transport and deposition of soluble aerosol Fe is believed to influence phytoplankton primary productivity in the majority of the open ocean (far from Fe inputs from rivers and coastal sediments). The purpose of the FSU aerosol sampling program is primarily to measure the concentration of total aerosol Fe, and to quantify the aerosol Fe fractions that are soluble in natural surface seawater and in ultra-pure deionized water. Additional analyses are conducted on the samples in an effort to understand the atmospheric processes that yield differences in the aerosol Fe solubility.

The aerosol sampling equipment consists of four replicate filter holders deployed on a 20' fold-down aerosol tower mounted on the forward, starboard corner of the 03 deck of the ship. One of the replicate filters (0.4 micrometer Nuclepore polycarbonate track-etched) is used for total aerosol measurements (see below); one replicate filter (0.45 micrometer polypropylene) is used to quantify the seawater-soluble fraction; one replicate filter (0.45 micrometer polypropylene) is used to quantify the ultra-pure deionized water soluble fraction; and one replicate filter (0.45 micrometer polypropylene) is used for precision (QA) tests or stored as a backup sample. Size-fractionated aerosols are also collected for 72 hour intervals starting every fourth day using a MOUDI cascade impactor (>3.2 micrometer, 1.0-3.2 micrometer, 0.56-1.0 micrometer, 0.056-0.56 micrometer).

Air is pulled through the filters using two high-capacity vacuum pumps. The sampling is controlled by a Campbell Scientific CR10 datalogger that immediately shuts off the flow when the wind might blow stack exhaust forward towards the sampling tower, or when the wind drops below 0.5 m/s. Air flow is measured using Sierra mass-flow meters.

We have collected 24-hour integrated aerosol samples each day for the entire leg (March 25 to April 26, 2007) for the following analyses:

- Total aerosol Si, Al, Fe (to be analyzed using Energy Dispersive X-Ray Fluorescence by Dr. Joe Resing at NOAA/PMEL).
- Seawater-soluble aerosol Al and Fe (to be run back at FSU).
- Ultra-pure water soluble Si, Al, Ti, Fe, chloride, sulfate, nitrate, sodium (to be run back at FSU). The MOUDI size-fractionated aerosol filters are also leached with ultra-pure water for these same analytes.

##### **Other Sampling**

We collected archived samples from each trace metal cast (49 stations, 588 samples) for FSU shore-based analysis of dissolved Mn, Fe, Co, Ni, Cu, Zn, Cd, and Pb using isotope dilution ICPMS.

The Total Suspended Matter from each trace metal cast was collected on 47 mm 0.4 um Nuclepore filters for EDXRF analysis of total particulate Si, Mn, Fe, and Al (Joe Resing, NOAA/PMEL).

Rain was collected on 8 different days, often with enough volume to filter an aliquot for comparison between total and dissolved trace elements. The samples were filtered and frozen for analyses at FSU for soluble Si, Al, Ti, Fe, chloride, sulfate, nitrate, and sodium.

We took subsamples from our rosette sampling for DNA and CDOM analysis by the UCSB group on numerous casts. Details (dates, stations, casts) can be found in the UCSB group cruise report.

### C.5. Thermosalinograph, Meteorological, Navigation and Bathymetry

As cruise clivari9n got underway and entered international waters from Fremantle, Australia underway science data instrumentation systems were activated and science data collection was commenced. That date and time was approximately 7 PM, March 22, 2007, local time. Data collection from that instrumentation was terminated at approximately 5 PM, local time, April 28, 2007.

The underway seawater system sensor instrumentation provide the following:

- Sea Surface Temperature
- Thermosalinograph
- Oxygen
- Fluorometer
- Flowmeter

The accuracy specifications for that instrumentation is as follows:

Instrumentation	Range	Accuracy
Thermosalinograph	-5 to +35 Deg C	+/- 0.01 Deg C
Oxygen	120% surf saturation	2%
Fluorometer	0.03 to 75 ug/l	unspecified
Flowmeter	0.27 - 18.9 LPM	+/- 1.0%FS

Meteorological sensor instrumentation provides the following measurement and accuracy:

Parameter	Range	Accuracy
Air Temperature	-50 to +50 deg C	+/- 0.3 deg C
Barometric Pressure	800 to 1060 mb	+/- 0.5 mb
Relative Humidity/	RH 0-100%	+/- 1.5%
Air Temperature	-40 to +60 deg C	+/- 0.2 deg C
Wind Speed/	Dir 0-360 deg	+/- 2.0 deg
Direction	Spd 0-70 m/s	+/- 0.1 m/s
Long Wave Radiation	3.5-50 um	+/- 1% linearity
Short Wave Radiation	305-2800 nm	+/- 0.25% linearity
Surface PAR	400-700 nm	unspecified
Precipitation	0-50 mm	+/- 1.0 mm

Navigation systems consisting of the following GPS systems: Furuno GP90, Ashtech ADU2, Trimble D200, Trimble Accutime, and MX421 were operated through out the cruise. Stable platform systems consisting of the Marinus, Phins and Sperry Mk37 gyro packages were operated.

The Kongsberg EM120 Multibeam Bathymetric Sonar system was activated upon entering international waters March 22, 2007. It operated throughout the cruise. That system was supported by both the CTD data collection as well as the XBT system to provide Sound Velocity Profile correction tables. A SVP was created and entered to the EM120 system on a daily basis. Upon leaving Fremantle and before the cruise had arrived at the first CTD cast station the XBT system was used to create the SVPs. At that time three XBT releases were done with one failure. The system worked fine. Near the end of the cruise, after CTD casts had been terminated and during the Bangladesh survey one additional XBT was released for a SVP. Otherwise the CTD casts was user to create the SVPs on a daily basis. Data collection from the EM120 was terminated promptly at 5 PM on April 28, 2007.

Additionally the Bell Aerospace BGM-3 Gravimeter was activated upon entering international waters on March 22, 2007. It was continuously operated until the end of the cruise at 5 PM, April 28, 2007.

#### **D. Acknowledgements.**

The scientific party of the I9N cruise would like to express sincere thanks to Captain Dave Murline and all of the crew of the R/V Roger Revelle for their outstanding work in support of our cruise.

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## Appendix A

### CLIVAR I9N: CTD Temperature and Conductivity Corrections Summary

PRT Response Time used for all casts: 0LAG secs

Sta/ Cast	IPTS-68 Temperature Coefficients $corT = tp2 \cdot P^2 + tp1 \cdot P + t1 \cdot T + t0$				Conductivity Coefficients $corC = c2 \cdot C^2 + c1 \cdot C + c0$		
	tp2	tp1	t1	t0	c2	c1	c0
089/03	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002573
090/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002581
091/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002589
092/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002598
093/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002606
094/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002614
095/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002622
096/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002631
097/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002639
098/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002647
099/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002655
100/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002663
101/03	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002672
102/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002680
103/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002688
104/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002696
105/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002704
106/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002713
107/03	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002721
108/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002729
109/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002737
110/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002746
111/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002754
112/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002762
113/03	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002770
114/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002778
115/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002787
116/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002795
117/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002803
118/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002811
119/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002820
120/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002828
121/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002836
122/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002844
123/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002852
124/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002861
125/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002869
126/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002877
127/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002885
128/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002893

Sta/ Cast	IPTS-68 Temperature Coefficients $corT = tp2 \cdot P^2 + tp1 \cdot P + t1 \cdot T + t0$				Conductivity Coefficients $corC = c2 \cdot C^2 + c1 \cdot C + c0$		
	tp2	tp1	t1	t0	c2	c1	c0
129/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002902
130/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002910
131/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002918
132/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002926
133/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002935
134/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002943
135/03	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002951
136/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002959
137/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002967
138/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002976
139/03	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002984
140/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.002992
141/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003000
142/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003009
143/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003017
144/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003025
145/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003033
146/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003041
147/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003050
148/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003058
149/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003066
150/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003074
151/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003083
152/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003091
153/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003099
154/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003107
155/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003115
156/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003124
157/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003132
158/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003140
159/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003148
160/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003156
161/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003165
162/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003173
163/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003181
164/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003189
165/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003198
166/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003206
167/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003214
168/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003222
169/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003230
170/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003239
171/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003247
172/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003255
173/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003263

Sta/ Cast	IPTS-68 Temperature Coefficients $corT = tp2 * P^2 + tp1 * P + t1 * T + t0$				Conductivity Coefficients $corC = c2 * C^2 + c1 * C + c0$		
	tp2	tp1	t1	t0	c2	c1	c0
174/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003272
175/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003280
176/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003288
177/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003296
178/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003304
179/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003313
180/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003321
181/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003329
182/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003337
183/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003345
184/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003354
185/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003362
186/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003370
187/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003378
188/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003387
189/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003395
190/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003403
191/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003411
192/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003419
193/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003428
194/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003436
195/03	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003444
196/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003452
197/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003461
198/01	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003469
199/02	-5.3050e-11	7.2800e-08	4.0109e-04	-0.000653	5.77963e-06	-2.89198e-04	0.003477





## Appendix B

### Summary of CLIVAR I9N CTD Oxygen Time Constants (time constants in seconds)

Temperature		Pressure	O <sub>2</sub> Gradient	dT Gradient
Fast( $\tau_{TF}$ )	Slow( $\tau_{TS}$ )	( $\tau_p$ )	( $\tau_{og}$ )	( $\tau_{dT}$ )
10.00	100.00	16.00	1.00	400.00

### CLIVAR I9N: Conversion Equation Coefficients for CTD Oxygen (refer to Equation 1.7.4.0)

Sta/ Cast	O <sub>c</sub> Slope (c <sub>1</sub> )	Offset (c <sub>2</sub> )	P <sub>i</sub> coeff (c <sub>3</sub> )	T <sub>i</sub> coeff (c <sub>4</sub> )	T <sub>s</sub> coeff (c <sub>5</sub> )	$\frac{dO_c}{dt}$ coeff (c <sub>6</sub> )	T <sub>dT</sub> coeff (c <sub>7</sub> )
089/03	5.3652e-04	2.8777e-03	2.8408e-04	-2.2830e-01	1.4081e-04	6.3488e-07	-0.00386889
090/01	5.3644e-04	1.2012e-02	-8.3131e-03	-2.2125e-01	1.3301e-04	1.5025e-06	0.00195106
091/01	5.4713e-04	3.7961e-03	-1.4517e-03	-2.3366e-01	1.3405e-04	-1.7560e-08	0.0013851
092/02	5.7632e-04	2.6561e-03	-1.8696e-03	-2.6238e-01	1.3453e-04	2.1770e-06	0.0133887
093/02	5.6759e-04	-3.3301e-03	4.5423e-03	-2.5419e-01	1.3505e-04	2.3339e-06	0.0105387
094/01	5.7197e-04	-1.9070e-03	2.9361e-03	-2.5426e-01	1.3277e-04	1.2138e-06	0.0111804
095/02	5.5593e-04	2.1882e-03	-3.1609e-04	-2.3890e-01	1.3355e-04	6.7196e-07	0.000892855
096/01	5.7050e-04	-1.1588e-03	2.0907e-03	-2.5291e-01	1.3352e-04	2.3995e-06	0.00596837
097/02	5.7396e-04	3.6561e-03	-2.5639e-03	-2.5173e-01	1.3136e-04	4.2541e-07	0.00420441
098/01	5.5095e-04	3.0765e-04	1.7040e-03	-2.2995e-01	1.3146e-04	1.4236e-06	0.00153869
099/02	5.6621e-04	2.6379e-03	-1.5668e-03	-2.4068e-01	1.2918e-04	1.9965e-06	0.00238324
100/01	5.8665e-04	2.2863e-03	-1.9688e-03	-2.6304e-01	1.3107e-04	1.6129e-06	0.004848
101/03	5.6738e-04	5.7382e-03	-4.3431e-03	-2.4513e-01	1.3176e-04	1.6754e-06	0.000516714
102/01	5.9454e-04	3.6942e-03	-3.6397e-03	-2.7214e-01	1.3212e-04	1.4317e-06	0.00714462
103/01	5.6415e-04	-4.4206e-04	1.9067e-03	-2.3905e-01	1.2978e-04	1.7608e-06	0.00724561
104/02	5.7561e-04	-5.3741e-03	6.3532e-03	-2.5000e-01	1.2959e-04	3.5504e-07	0.0153311
105/02	5.9332e-04	5.9163e-03	-5.9690e-03	-2.6636e-01	1.2960e-04	1.0818e-06	0.00147518
106/01	5.7200e-04	-3.8388e-03	4.6755e-03	-2.4112e-01	1.2702e-04	1.6361e-06	0.0144435
107/03	5.6736e-04	-1.7095e-02	1.8064e-02	-2.3516e-01	1.2605e-04	5.0009e-06	0.032636
108/01	5.7334e-04	1.6611e-03	-5.0405e-04	-2.4979e-01	1.3221e-04	1.4348e-06	0.00175771
109/01	5.7582e-04	3.3452e-03	-2.2185e-03	-2.5214e-01	1.3264e-04	5.2150e-07	0.00099213
110/02	5.8951e-04	2.2254e-02	-2.1939e-02	-2.6342e-01	1.3159e-04	8.3933e-07	-0.0204049
111/02	5.7813e-04	-5.4335e-03	5.8318e-03	-2.4491e-01	1.2706e-04	2.9303e-06	0.0172679
112/01	5.8872e-04	2.4458e-02	-2.4074e-02	-2.5981e-01	1.3015e-04	1.3666e-06	-0.017138
113/03	5.9481e-04	-1.7543e-03	1.6177e-03	-2.6118e-01	1.2694e-04	2.2103e-06	0.00930109
114/01	5.8434e-04	-2.1381e-03	2.0686e-03	-2.5017e-01	1.2656e-04	4.3718e-06	0.0159788
115/01	5.8406e-04	7.3334e-03	-6.9042e-03	-2.5380e-01	1.2899e-04	5.6835e-07	0.0112612
116/02	5.8321e-04	3.7175e-03	-3.0880e-03	-2.5465e-01	1.3030e-04	5.8681e-07	0.0031972
117/02	5.8197e-04	1.0102e-03	-7.7089e-04	-2.4518e-01	1.2412e-04	-1.1375e-06	0.0227193
118/01	5.8442e-04	3.0172e-03	-2.7544e-03	-2.5184e-01	1.2698e-04	4.2532e-07	0.00692597
119/01	5.9000e-04	1.3097e-02	-1.2775e-02	-2.5964e-01	1.2888e-04	3.6167e-07	-0.00579383
120/01	5.7779e-04	5.5001e-03	-4.7840e-03	-2.4539e-01	1.2743e-04	2.1188e-07	0.00779941
121/01	5.7931e-04	1.1455e-02	-1.0830e-02	-2.4480e-01	1.2615e-04	-3.9796e-07	0.0113107
122/01	5.7671e-04	-6.4348e-03	7.0885e-03	-2.3919e-01	1.2441e-04	-7.0033e-08	0.0302915

Sta/ Cast	$O_c$ Slope ( $c_1$ )	Offset ( $c_2$ )	$P_l$ coeff ( $c_3$ )	$T_r$ coeff ( $c_4$ )	$T_s$ coeff ( $c_5$ )	$\frac{dO_c}{dt}$ coeff ( $c_6$ )	$T_{dT}$ coeff ( $c_7$ )
123/02	5.8011e-04	3.5016e-03	-3.1801e-03	-2.4726e-01	1.2757e-04	1.6027e-06	0.00741551
124/01	5.8234e-04	5.5948e-03	-5.3840e-03	-2.4442e-01	1.2410e-04	8.2980e-07	0.0202557
125/01	5.7231e-04	1.7766e-02	-1.6325e-02	-2.4138e-01	1.2850e-04	4.2633e-07	-0.00242562
126/01	5.7143e-04	2.3407e-04	4.5907e-04	-2.2899e-01	1.2066e-04	6.5735e-08	0.0420254
127/02	5.7807e-04	2.7294e-02	-2.6662e-02	-2.4599e-01	1.2812e-04	9.2679e-07	-0.0252536
128/01	5.9471e-04	1.6581e-02	-1.6024e-02	-2.6231e-01	1.2841e-04	8.0136e-07	-0.0129792
129/01	5.8624e-04	9.8883e-03	-9.6515e-03	-2.4774e-01	1.2414e-04	7.4120e-08	0.0126704
130/01	5.8229e-04	1.3642e-04	3.5322e-04	-2.4776e-01	1.2634e-04	4.5956e-05	0.0161247
131/01	5.7970e-04	8.6789e-03	-7.9156e-03	-2.4302e-01	1.2470e-04	1.1431e-06	0.00636248
132/01	5.8614e-04	2.5070e-02	-2.4383e-02	-2.5003e-01	1.2517e-04	1.2530e-06	0.00645922
133/02	5.8946e-04	9.4695e-03	-9.3197e-03	-2.5041e-01	1.2421e-04	2.0906e-06	-0.00264115
134/01	5.8856e-04	1.6091e-02	-1.5616e-02	-2.5337e-01	1.2640e-04	2.4989e-06	-0.0107501
135/03	5.9170e-04	-5.0216e-03	4.6302e-03	-2.4848e-01	1.2076e-04	3.8876e-07	0.0357597
136/01	5.9143e-04	-2.2600e-03	2.2110e-03	-2.5402e-01	1.2462e-04	7.5903e-06	0.0167296
137/01	5.9796e-04	6.6422e-03	-6.8483e-03	-2.5697e-01	1.2254e-04	3.7425e-06	0.00481287
138/01	5.8071e-04	1.7244e-03	-1.1735e-03	-2.4343e-01	1.2422e-04	4.2070e-06	0.016299
139/03	5.7835e-04	1.6079e-02	-1.5224e-02	-2.4694e-01	1.2764e-04	2.6855e-06	-0.00216057
140/01	5.8047e-04	1.8457e-02	-1.7787e-02	-2.4849e-01	1.2752e-04	3.5044e-06	-0.0113498
141/01	5.7759e-04	1.4677e-02	-1.4032e-02	-2.4386e-01	1.2693e-04	8.5783e-07	-0.00719668
142/01	5.8650e-04	1.2381e-02	-1.2273e-02	-2.4530e-01	1.2152e-04	1.5867e-06	0.0100417
143/02	5.8806e-04	1.3747e-02	-1.3740e-02	-2.4769e-01	1.2241e-04	5.2545e-06	0.013534
144/01	5.9350e-04	1.4873e-02	-1.5132e-02	-2.5385e-01	1.2304e-04	4.7481e-06	-0.00182326
145/02	5.9205e-04	1.7804e-02	-1.7747e-02	-2.5556e-01	1.2520e-04	2.4204e-06	-0.0202419
146/01	5.9242e-04	9.9998e-03	-9.9454e-03	-2.5860e-01	1.2728e-04	6.5593e-06	-0.0191579
147/02	5.8758e-04	8.4572e-04	-8.9882e-04	-2.5367e-01	1.2720e-04	5.8921e-07	3.41883e-05
148/02	5.8021e-04	6.4417e-03	-5.9946e-03	-2.4472e-01	1.2543e-04	4.7623e-06	0.0160267
149/01	5.7763e-04	6.8194e-03	-6.4371e-03	-2.3803e-01	1.2338e-04	6.0053e-06	0.0115684
150/01	5.7785e-04	5.6121e-03	-5.1127e-03	-2.4349e-01	1.2658e-04	9.2058e-07	0.0144825
151/01	5.9345e-04	-3.1609e-03	3.0755e-03	-2.5465e-01	1.2346e-04	1.5499e-06	0.0143859
152/01	5.8606e-04	2.8229e-02	-2.7785e-02	-2.5016e-01	1.2523e-04	1.3586e-06	-0.0235823
153/01	5.7976e-04	1.7579e-03	-1.4478e-03	-2.4132e-01	1.2452e-04	1.5281e-06	0.0281637
154/02	5.8144e-04	1.6383e-02	-1.5836e-02	-2.4801e-01	1.2757e-04	3.2309e-07	-0.0137057
155/01	5.7429e-04	1.3229e-02	-1.2407e-02	-2.4128e-01	1.2804e-04	1.4122e-06	0.00429502
156/02	5.8396e-04	1.5346e-02	-1.5176e-02	-2.4386e-01	1.2286e-04	-1.1720e-07	0.00447595
157/01	6.1793e-04	9.2679e-03	-1.0672e-02	-2.6900e-01	1.1100e-04	1.5711e-06	-0.00748641
158/01	5.7855e-04	1.6396e-02	-1.5033e-02	-2.5875e-01	1.3824e-04	3.4458e-06	-0.0602948
159/01	5.9885e-04	1.2136e-02	-1.2527e-02	-2.6421e-01	1.2453e-04	4.9639e-07	-0.0567697
160/01	6.0900e-04	1.4182e-02	-1.5474e-02	-2.4760e-01	9.9486e-05	3.0146e-06	0.0352118
161/01	6.2066e-04	3.0455e-02	-3.2046e-02	-2.6351e-01	1.0430e-04	4.3494e-06	0.0101765
162/02	6.3379e-04	1.7084e-02	-1.9178e-02	-2.6737e-01	9.7843e-05	2.2267e-06	0.00338996
163/01	5.6300e-04	4.0430e-02	-3.8583e-02	-2.4465e-01	1.3699e-04	3.1236e-06	-0.0835
164/02	6.1508e-04	9.7829e-03	-1.0795e-02	-2.6932e-01	1.1624e-04	2.4378e-06	-0.0196635
165/01	5.9747e-04	5.3677e-02	-5.3632e-02	-2.6677e-01	1.2627e-04	-4.6797e-07	-0.140384
166/01	5.6143e-04	4.2826e-02	-4.0207e-02	-2.5992e-01	1.5147e-04	1.1363e-06	-0.214795
167/02	6.1621e-04	6.0241e-02	-6.1711e-02	-2.6427e-01	1.1095e-04	1.9025e-06	-0.0222878
168/01	6.1420e-04	1.7736e-02	-1.8900e-02	-2.6004e-01	1.0862e-04	1.8004e-07	0.0366017

Sta/ Cast	$O_c$ Slope ( $c_1$ )	Offset ( $c_2$ )	$P_I$ coeff ( $c_3$ )	$T_f$ coeff ( $c_4$ )	$T_s$ coeff ( $c_5$ )	$\frac{dO_c}{dt}$ coeff ( $c_6$ )	$T_{dT}$ coeff ( $c_7$ )
169/02	5.6562e-04	4.9546e-02	-4.7599e-02	-2.4926e-01	1.3844e-04	2.4710e-06	-0.129197
170/01	5.8764e-04	2.1996e-02	-2.1336e-02	-2.5563e-01	1.2612e-04	4.1622e-07	-0.0532475
171/01	6.0602e-04	6.8111e-02	-6.9176e-02	-2.4847e-01	1.0499e-04	-1.3091e-06	0.0244595
172/01	5.7213e-04	1.8968e-02	-1.7669e-02	-2.4999e-01	1.3545e-04	5.4106e-07	-0.0837079
173/02	5.9620e-04	2.3151e-02	-2.3420e-02	-2.5264e-01	1.1775e-04	1.2481e-06	0.00102797
174/02	5.8698e-04	4.7057e-02	-4.6316e-02	-2.5213e-01	1.2436e-04	-1.5223e-06	-0.0459638
175/01	5.8766e-04	3.8911e-02	-3.8536e-02	-2.5156e-01	1.2216e-04	3.4786e-07	-0.030567
176/01	5.8924e-04	4.0399e-02	-3.9943e-02	-2.5612e-01	1.2426e-04	2.7744e-07	-0.0689111
177/01	5.8776e-04	3.2218e-02	-3.1727e-02	-2.5791e-01	1.2734e-04	2.0887e-06	-0.0738375
178/01	6.0431e-04	1.0416e-02	-1.2950e-02	-2.0815e-01	7.6521e-05	2.1608e-06	0.252092
179/01	6.0559e-04	1.1567e-02	-1.2660e-02	-2.4943e-01	1.0675e-04	6.8433e-07	0.0725385
180/01	5.7673e-04	2.2997e-02	-2.2340e-02	-2.4854e-01	1.2882e-04	1.8045e-06	-0.039961
181/01	5.7839e-04	3.7581e-02	-3.6468e-02	-2.5392e-01	1.3212e-04	8.8227e-07	-0.0739325
182/01	5.7837e-04	3.6779e-02	-3.5905e-02	-2.4796e-01	1.2714e-04	1.4118e-07	-0.0276708
183/02	6.0147e-04	7.6783e-03	-8.1972e-03	-2.6194e-01	1.2021e-04	1.3604e-06	-0.0409681
184/01	5.8704e-04	1.8229e-02	-1.8040e-02	-2.5875e-01	1.2918e-04	2.1643e-06	-0.0712392
185/02	5.7289e-04	2.7199e-02	-2.5925e-02	-2.5233e-01	1.3601e-04	1.3454e-06	-0.0931157
186/01	5.6038e-04	4.3637e-03	-2.3648e-03	-2.4162e-01	1.3851e-04	1.5129e-06	-0.0595107
187/02	5.4820e-04	2.3046e-02	-2.0343e-02	-2.3882e-01	1.4650e-04	-3.5106e-08	-0.100162
188/01	5.3956e-04	4.1952e-02	-3.8679e-02	-2.3721e-01	1.5295e-04	1.0881e-06	-0.14822
189/02	5.6391e-04	3.0128e-02	-2.8084e-02	-2.4793e-01	1.3922e-04	2.1712e-06	-0.115256
190/01	5.6014e-04	4.8614e-02	-4.6870e-02	-2.4033e-01	1.3674e-04	5.2363e-07	-0.082301
191/02	5.3596e-04	4.1808e-02	-3.8135e-02	-2.3486e-01	1.5400e-04	9.1696e-07	-0.135573
192/01	5.1062e-04	2.5451e-02	-1.9973e-02	-2.2632e-01	1.7344e-04	9.2629e-07	-0.160517
193/02	4.5709e-04	3.1535e-02	-2.2895e-02	-2.0206e-01	2.0577e-04	6.0301e-07	-0.258497
194/01	7.1290e-04	2.6575e-02	-3.2608e-02	-3.0390e-01	5.8487e-05	1.1324e-06	0.0868364
195/03	6.0011e-04	8.6421e-03	-8.9941e-03	-2.5703e-01	1.1590e-04	3.5264e-06	-0.0153117
196/01	5.2210e-04	2.9805e-02	-2.5444e-02	-2.2464e-01	1.5818e-04	4.5945e-07	-0.135011
197/02	5.6617e-04	3.6813e-02	-3.5097e-02	-2.4777e-01	1.3351e-04	4.3874e-07	-0.127959
198/01	4.9785e-04	1.9117e-02	-1.3107e-02	-2.1679e-01	1.8102e-04	2.3037e-06	-0.152496
199/02	5.7061e-04	3.7022e-02	-3.5559e-02	-2.4442e-01	1.2683e-04	5.9365e-07	-7.7645e-02



## Appendix C

### CLIVAR I9N: Bottle Quality Comments

Comments from the Sample Logs and the results of STS/ODF's investigations are included in this report. Units stated in these comments are degrees Celsius for temperature, Unless otherwise noted, milliliters per liter for oxygen and micromoles per liter for Silicate, Nitrate, Nitrite, and Phosphate. The sample number is the cast number times 100 plus the bottle number. Investigation of data may include comparison of bottle salinity and oxygen data with CTD data, review of data plots of the station profile and adjoining stations, and re-reading of charts (i.e. nutrients).

Station	Sample Quality			
/Cast	No.	Property	Code	Comment
89/3	301	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Station 88 was a reoccupation. Oxygen and nutrients, except as noted, are acceptable. During analysis of Station 93 found a problem with the salinometer. Code salinity bad.
89/3	302	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Station 88 was a reoccupation. Oxygen and nutrients, except as noted, are acceptable. During analysis of Station 93 found a problem with the salinometer. Code salinity bad.
89/3	303	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Station 88 was a reoccupation. Oxygen and nutrients, except as noted, are acceptable. During analysis of Station 93 found a problem with the salinometer. Code salinity bad.
89/3	304	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Station 88 was a reoccupation. Oxygen and nutrients, except as noted, is acceptable. Bottles 4 and 5 were tripped at the same depth, oxygen and nutrients show little difference, salinity is 0.001. The difference is within the accuracy of the measurement. During analysis of Station 93 found a problem with the salinometer. Code salinity bad.
89/3	305	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Station 88 was a reoccupation. Oxygen and nutrients, except as noted, is acceptable. Bottles 4 and 5 were tripped at the same depth, oxygen and nutrients show little difference, salinity is 0.001. The difference is within the accuracy of the measurement. During analysis of Station 93 found a problem with the salinometer. Code salinity bad.
89/3	306	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Station 88 was a reoccupation. Oxygen and nutrients, except as noted, are acceptable. During analysis of Station 93 found a problem with the salinometer. Code salinity bad.
89/3	307	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Station 88 was a reoccupation. Oxygen and nutrients, except as noted, are acceptable. During analysis of Station 93 found a problem with the salinometer. Code salinity bad.
89/3	310	po4	3	PO4 high; no corresponding no3 feature. Real peak; no analytical problems noted. Code PO4 questionable.
89/3	313	po4	3	PO4 high; no corresponding no3 feature. Real peak; no analytical problems noted. Code PO4 questionable.

Station /Cast	Sample No.	Quality Property	Code	Comment
89/3	320	bottle	2	Ran out of water after CDOM, no salinity sample. Oxygen and nutrients are acceptable. Spigot was very tight, samplers could not close quickly enough, so the bottle ran out of water. Salinity was not sampled.
90/1	101	salt	4	Bottle salinity is high compared with CTD. Found a problem with salinometer. Oxygen and nutrients are acceptable. Code salinity bad.
90/1	102	salt	4	Bottle salinity is high compared with CTD. Found a problem with salinometer. Oxygen and nutrients are acceptable. Code salinity bad.
90/1	103	salt	4	Bottle salinity is high compared with CTD. Found a problem with salinometer. Oxygen and nutrients are acceptable. Code salinity bad.
90/1	104	salt	4	Bottle salinity is high compared with CTD. Found a problem with salinometer. Oxygen and nutrients are acceptable. Code salinity bad.
90/1	105	salt	4	Bottle salinity is high compared with CTD. Found a problem with salinometer. Oxygen and nutrients are acceptable. Code salinity bad.
90/1	106	salt	4	Bottle salinity is high compared with CTD. Found a problem with salinometer. Oxygen and nutrients are acceptable. Code salinity bad.
90/1	107	salt	4	Bottle salinity is high compared with CTD. Found a problem with salinometer. Oxygen and nutrients are acceptable. Code salinity bad.
90/1	107	sio3	2	SiO3 high compared with adjoining stations and station profile. Oxygen and nutrient are acceptable. 7-8 agree with Stations 91 thru 93, 4-6 agree with Station 89. Nutrient analyst: 106-104 are low. Corresponding high feature in o2. All peaks real.
90/1	108	salt	4	Bottle salinity is high compared with CTD. Found a problem with salinometer. Oxygen and nutrients are acceptable. Code salinity bad.
90/1	108	sio3	2	SiO3 high compared with adjoining stations and station profile. Oxygen and nutrient are acceptable. 7-8 agree with Stations 91 thru 93, 4-6 agree with Station 89. Nutrient analyst: 106-104 are low. Corresponding high feature in o2. All peaks real.
90/1	120	bottle	2	Leaking from bottom endcap. Oxygen, as well as salinity and nutrients, is acceptable. Leak did not seem to have an affect on the samples.
90/1	132	o2	2	Oxygen low compared with adjoining stations, agrees with CTDO. Oxygen, as well as salinity and nutrients, is acceptable.
90/1	132	salt	2	Bottle salinity is high compared with CTD. Oxygen appears low. Salinity agrees with down trace, feature seen in CTD salinity and oxygen. Salinity, as well as oxygen and nutrients, is acceptable.
91/1	102	salt	4	Bottle salinity is low compared with CTD and adjoining stations. During analysis of Station 93 found a problem with salinometer. Oxygen and nutrients are acceptable. Code salinity bad.
91/1	104	salt	2	Bottle salinity is high compared with CTD and adjoining stations. 3 attempts for a good salinity reading. Additional reading resolved salinity difference. Salinity, as well as oxygen and nutrients, is acceptable.
91/1	107	o2	4	Oxygen high, 0.1, compared with CTDO and adjoining stations. Salinity and nutrients are acceptable. Oxygen analyst: Rechecked end point; no analytical problems noted. Code oxygen bad.
91/1	108	sio3	2	SiO3 low compared with adjoining stations and station profile. Nutrient analyst: There is a corresponding high feature in oxygen, although not quite as obvious.
91/1	109	sio3	2	SiO3 low compared with adjoining stations and station profile. Nutrient analyst: There is a corresponding high feature in oxygen, although not quite as obvious.

Station /Cast	Sample No.	Quality Property	Code	Comment
91/1	110	sio3	2	SiO3 low compared with adjoining stations and station profile. Nutrient analyst: There is a corresponding high feature in oxygen, although not quite as obvious.
91/1	115	salt	2	Bottle salinity is high compared with CTD and adjoining stations. 3 attempts for a good salinity reading. Additional reading resolved salinity difference. Salinity, as well as oxygen and nutrients, is acceptable.
91/1	117	o2	2	Oxygen appears low compared with adjoining stations, relationship with higher SiO3. Oxygen and well as salinity, except as noted on 18, and nutrients are acceptable.
91/1	118	o2	2	Oxygen appears low compared with adjoining stations, relationship with higher SiO3. Oxygen and well as salinity, except as noted on 18, and nutrients are acceptable.
91/1	118	salt	4	Bottle salinity is low compared with CTD and adjoining stations. During analysis of Station 93 found a problem with salinometer. Oxygen and nutrients are acceptable. Code salinity bad.
91/1	120	bottle	2	Leaking from endcap. Oxygen, as well as salinity and nutrients, is acceptable. Leak from endcap did not affect samples.
91/1	122	salt	2	Salinity samples 22-31 were off one level. Salinity analyst did not report any bottles left upside down. Operator error, corrected and salinity, as well as oxygen and nutrients, is acceptable.
91/1	124	salt	2	Bottle salinity is low compared with CTD and adjoining stations. 4 attempts for a good salinity reading. Additional reading resolved salinity difference. Salinity, as well as oxygen and nutrients, is acceptable.
91/1	127	salt	2	Bottle salinity is low compared with CTD and adjoining stations. 5 attempts for a good salinity reading. Additional reading resolved salinity difference. Salinity, as well as oxygen and nutrients, is acceptable.
92/2	201	bottle	2	Leaking slightly, no comment as to from what point. Suspect that sampler needs to pull harder on the spigot. Oxygen does appear slightly high, but within accuracy of measurement. Freon sampled duplicates on this bottle. Nutrients are acceptable, salinity is bad due to a salinometer problem.
92/2	201	salt	4	Bottle salinity is high compared with CTD. 3 attempts for a good salinity reading. During analysis of Station 93, a problem was detected with the salinometer. Oxygen and nutrients are acceptable. Code salinity bad.
92/2	202	salt	4	Bottle salinity is low compared with CTD and station profile. During analysis of Station 93, a problem was detected with the salinometer. Oxygen and nutrients are acceptable. Code salinity bad.
92/2	204	no3	3	NO3 high, no corresponding high PO4. Oxygen and other nutrients are acceptable. Nutrient analyst: Anomolously high, but real peak. No analytical errors noted. Code NO3 questionable.
92/2	204	salt	4	Bottle salinity is low compared with CTD. During analysis of Station 93, a problem was detected with the salinometer. 3 attempts for a good salinity reading. Oxygen and nutrients are acceptable. Code salinity bad.
92/2	206	salt	4	Bottle salinity is low compared with CTD. During analysis of Station 93, a problem was detected with the salinometer. Oxygen and nutrients are acceptable. Code salinity bad.
92/2	207	no3	4	NO3 low, no corresponding low PO4. Oxygen and other nutrients are acceptable. Nutrient analyst: Bad peak, read by hand. Code NO3 bad.
92/2	207	salt	4	Bottle salinity is low compared with CTD. During analysis of Station 93, a problem was detected with the salinometer. Oxygen and nutrients, except NO3, are acceptable. Code salinity bad.

Station /Cast	Sample No.	Quality Property	Code	Comment
92/2	210	o2	4	Oxygen higher than CTDO and adjoining stations, no corresponding SiO3 feature. Salinity and nutrients are acceptable. Oxygen analyst: Rechecked endpoint: Graph not good. Code oxygen bad.
92/2	216	salt	4	Bottle salinity is high compared with CTD. 5 attempts for a good salinity reading. During analysis of Station 93, a problem was detected with the salinometer. Oxygen and nutrients are acceptable. Code salinity bad.
92/2	218	sio3	2	SiO3 low, no corresponding high oxygen. Salinity, oxygen and nutrients are acceptable. Nutrient analyst: Real peak. No analytical errors noted, within specs of measurement.
92/2	226	o2	2	Oxygen redrawn, bubble in flask. Oxygen, as well as salinity and nutrients, is acceptable.
92/2	227	salt	4	Bottle salinity is low, 2 units, compared with CTD. During analysis of Station 93, a problem was detected with the salinometer. Oxygen and nutrients are acceptable. Code salinity bad.
92/2	229	salt	4	Bottle salinity is low compared with CTD. During analysis of Station 93, a problem was detected with the salinometer. 3 attempts for a good salinity reading. Oxygen and nutrients are acceptable. Code salinity bad.
92/2	234	CTDT1	3	SBE35RT-CTDT1/CTDT2-CTDT1 difference is +0.21/+0.17 deg.C (high gradient). Code CTDT1 questionable.
93/2	201	bottle	2	Bottle drips if the valve is not pulled out enough. Oxygen appears slightly high, within accuracy of measurement, and SiO3 is low.
93/2	201	no3	2	NO3 high, no corresponding high PO4. Salinity and, SiO3 appears low, nutrients are acceptable. Oxygen is slightly high, but within accuracy of measurement. Nutrient analyst: All are real peaks and within accuracy of AA. Nutrients are acceptable.
93/2	226	o2	2	Oxygen sample re-draw, bubble in flask. Oxygen, as well as salinity and nutrients, is acceptable.
93/2	234	o2	2	Sample was overtitrated and backtitrated. Rechecked titration plot: looks good. Oxygen similar to CTDO. Oxygen, as well as salinity and nutrients, is acceptable.
94/1	101	salt	4	Bottle salinity is high compared with CTD. Salinometer switched before this station analysis session, found to have a problem which was resolved within the next couple of stations. Oxygen and nutrients are acceptable unless otherwise noted. Code salinity bad.
94/1	102	salt	4	See sample 1 salinometer comment. Code salinity bad.
94/1	103	salt	4	See sample 1 salinometer comment. Code salinity bad.
94/1	104	salt	4	See sample 1 salinometer comment. Code salinity bad.
94/1	105	salt	4	See sample 1 salinometer comment. Code salinity bad.
94/1	106	salt	4	See sample 1 salinometer comment. Code salinity bad.
94/1	107	salt	4	See sample 1 salinometer comment. Code salinity bad.
94/1	108	salt	4	See sample 1 salinometer comment. Code salinity bad.
94/1	110	salt	4	Bottle salinity is high compared with CTD. See salinometer comment noted with sample 1. Oxygen and nutrients are acceptable. Code salinity bad.
94/1	125	no3	2	NO3 high, corresponding high PO4 feature. Salinity and oxygen and nutrients are acceptable. Nutrient analyst: Real peak, no analytical errors noted.
95/2	201	no3	2	NO3 low, corresponding low PO4, also reasonable low SiO3 high oxygen relationship. Salinity is high compared with CTD and adjoining stations, still working on problems with salinometer, however, suspect operator error. Nutrient analyst: Real peaks, no analytical errors noted. Code salinity bad.



Station /Cast	Sample No.	Quality Property	Code	Comment
95/2	201	salt	4	Bottle salinity is high, 0.01, compared with CTD. 3 attempts for a good salinity reading. Salinometer temperature issues which are resolved by Station 97. Oxygen and nutrients are acceptable. Code salinity bad.
95/2	205	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Salinometer problems which are resolved by Station 97. Within accuracy of measurement. Salinity, oxygen and nutrients are acceptable.
95/2	207	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Salinometer problems which are resolved by Station 97. Oxygen and nutrients are acceptable. Code salinity bad.
95/2	208	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Salinometer problems which are resolved by Station 97. Within accuracy of measurement. Salinity, oxygen and nutrients are acceptable.
95/2	209	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Salinometer problems which are resolved by Station 97. Oxygen and nutrients are acceptable. Code salinity bad.
95/2	210	salt	2	3 attempts for a good salinity reading. Additional reading gave better agreement with CTD and adjoining stations. Salinity, oxygen and nutrients are acceptable.
95/2	212	salt	2	3 attempts for a good salinity reading. Additional reading gave better agreement with CTD and adjoining stations. Salinity, oxygen and nutrients are acceptable.
95/2	217	o2	2	Oxygen appears low, but agrees with CTDO. Oxygen, as well as salinity and nutrients, is acceptable.
95/2	223	salt	2	4 attempts for a good salinity reading. Additional reading gave better agreement with CTD and adjoining stations. Salinity, oxygen and nutrients are acceptable.
95/2	224	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Salinometer problems which are resolved by Station 97. Oxygen and nutrients are acceptable. Code salinity bad.
95/2	226	salt	2	3 attempts for a good salinity reading. Additional reading gave better agreement with CTD and adjoining stations. Salinity, oxygen and nutrients are acceptable.
96/1	101	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Salinometer problems which are resolved by Station 97. Oxygen and nutrients are acceptable. Code salinity bad.
96/1	102	no3	2	NO3 slightly high, no corresponding high PO4. Salinity, oxygen and other nutrients are acceptable. Nutrient analyst: Real peak. No analytical problems noted.
96/1	106	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Salinometer problems which are resolved by Station 97. Oxygen and nutrients are acceptable. Code salinity bad.
96/1	108	no3	2	NO3 low, no corresponding low PO4. Salinity, oxygen and other nutrients are acceptable. Nutrient analyst: Real peak. No analytical problems noted.
96/1	117	po4	2	PO4 high, no corresponding high NO3. Salinity, oxygen and other nutrients are acceptable. Nutrient analyst: Corresponding yet smaller feature in SiO3 and oxygen. Real peak; no analytical problems noted.
97/2	201	no3	2	NO3 lower than adjoining stations. Nutrient analyst: NO3 and PO4 are okay. No analytical problems. 201-203 are right on. Oxygen shows a similar pattern.

Station /Cast	Sample No.	Quality Property	Code	Comment
97/2	201	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Salinometer problem with sample temperature. Oxygen and nutrients are acceptable. Code salinity bad.
97/2	202	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Salinometer problem with sample temperature. Oxygen and nutrients are acceptable. Code salinity bad.
97/2	203	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Salinometer problem with sample temperature. Oxygen and nutrients are acceptable. Code salinity bad.
97/2	207	salt	2	Bottle salinity is high compared with CTD agrees with adjoining stations. Within accuracy of the measurement. Salinity, as well as oxygen and nutrients, is acceptable.
97/2	208	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Within accuracy of the measurement. Salinity, as well as oxygen and nutrients, is acceptable.
97/2	225	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
97/2	228	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
97/2	230	o2	2	Oxygen appears high compared with adjoining stations, but agrees with CTDO. Oxygen, as well as salinity and nutrients, is acceptable.
98/1	101	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Salinometer problem with sample temperature. Oxygen and nutrients are acceptable. Code salinity bad.
98/1	103	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Suspect salinometer problem with sample temperature. Salinity within accuracy of measurement. Salinity, oxygen and nutrients are acceptable.
98/1	111	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Gradient, salinity, oxygen and nutrients are acceptable.
98/1	117	o2	4	Bubble introduced during second shake before analysis and sample contaminated. Oxygen higher than both CTDO and adjoining stations. Salinity and nutrients are acceptable. Code oxygen bad.
98/1	120	salt	2	Bottle salinity is low compared with CTD and adjoining stations. Gradient, salinity, oxygen and nutrients are acceptable.
99/2	207	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Within accuracy of measurement. Salinity, oxygen and nutrients are acceptable.
99/2	210	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Gradient, looks like a bottle flushing issue, salinity, oxygen and nutrients are acceptable.
99/2	221	CTDT2	3	SBE35RT-CTDT2 or CTDT1-CTDT2 difference is +0.025 deg.C (deep). Code CTDT2 questionable.
99/2	223	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Gradient, salinity, oxygen and nutrients are acceptable.
99/2	236	o2	2	Oxygen redrawn, bubbles in flask. Oxygen, as well as salinity and nutrients, is acceptable for a surface bottle.
100/1	101	o2	2	Oxygen draw temperature high, probably due to slow equilibration of temperature probe. Adjusted temperature, as per in-situ data and next bottle. Oxygen, as well as salinity and nutrients, is acceptable. Salinity is within accuracy of measurement.

Station /Cast	Sample No.	Quality Property	Code	Comment
100/1	108	salt	4	Bottle salinity is high compared with CTD and adjoining stations. 3 attempts for a good salinity reading. Additional readings resolve the large difference, 0.01, but still does not agree. Oxygen and nutrients are acceptable. Code salinity bad.
100/1	117	bottle	2	Spigot trickled when vent was opened, stopped after ~5 seconds, when stop cockle turned. Salinity is a little low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
101/3	301	salt	3	Bottle salinity is high compared with CTD and adjoining stations. Lab temperature increased during the run. Oxygen and nutrients are acceptable. Code salinity questionable.
101/3	302	salt	3	Bottle salinity is high compared with CTD and adjoining stations. Lab temperature increased during the run. Oxygen and nutrients are acceptable. Code salinity questionable.
101/3	303	salt	3	Bottle salinity is high compared with CTD and adjoining stations. Lab temperature increased during the run. Oxygen and nutrients are acceptable. Code salinity questionable.
101/3	307	salt	4	Bottle salinity is high compared with CTD and adjoining stations. 3 attempts for a good salinity reading. Lab temperature increased during the run. Oxygen and nutrients are acceptable. Code salinity bad.
101/3	308	salt	3	Bottle salinity is high compared with CTD and adjoining stations. Lab temperature increased during the run. Oxygen and nutrients are acceptable. Code salinity questionable.
101/3	309	salt	3	Bottle salinity is high compared with CTD and adjoining stations. Lab temperature increased during the run. Oxygen and nutrients are acceptable. Code salinity questionable.
101/3	310	salt	3	Bottle salinity is high compared with CTD and adjoining stations. Lab temperature increased during the run. Oxygen and nutrients are acceptable. Code salinity questionable.
101/3	331	o2	2	Oxygen appears high compared with adjoining profile and CTDO down trace, agrees with the up trace. Oxygen, as well as salinity and nutrients, is acceptable.
102/1	102	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Within accuracy of measurement. Salinity, as well as oxygen and nutrients, is acceptable.
102/1	110	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
102/1	111	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
102/1	128	salt	2	Bottle salinity is low compared with CTD and adjoining stations. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
103/1	110	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
103/1	111	salt	2	Bottle salinity is high compared with CTD. 3 attempts for a good salinity reading. Additional reading resolved salinity difference. Salinity, as well as oxygen and nutrients, is acceptable.
103/1	128	salt	2	Bottle salinity is high compared with CTD. 3 attempts for a good salinity reading. Additional reading resolved salinity difference. Salinity, as well as oxygen and nutrients, is acceptable.
103/1	132	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
104/2	201	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Suspect sample temperature not perfect for analysis. Oxygen and nutrients are acceptable, NO3 is slightly higher and SiO3 slightly low. Code salinity bad.
104/2	205	salt	2	Bottle salinity is low compared with CTD and adjoining stations. Salinity within accuracy of the measurement. Salinity, as well as oxygen and nutrients, is acceptable.
104/2	206	salt	2	Bottle salinity is low compared with CTD and adjoining stations. Salinity within accuracy of the measurement. Salinity, as well as oxygen and nutrients, is acceptable.
104/2	209	salt	2	Bottle salinity is low compared with CTD and adjoining stations. Deep salinity maximum, suspect flushing problem. Within accuracy of measurement. Salinity, as well as oxygen and nutrients, is acceptable.
104/2	221	no2	4	Nutrients are exactly the same, 21 appears to be drawn from bottle 20. Code nutrients bad.
104/2	221	no3	4	Nutrients are exactly the same, 21 appears to be drawn from bottle 20. Code nutrients bad.
104/2	221	po4	4	Nutrients are exactly the same, 21 appears to be drawn from bottle 20. Code nutrients bad.
104/2	221	sio3	4	Nutrients are exactly the same, 21 appears to be drawn from bottle 20. Code nutrients bad.
104/2	226	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
104/2	228	no3	2	NO3, PO4 and SiO3 lower than adjoining stations. Similar feature seen in oxygen. Salinity gradient agrees with CTD. Nutrient analyst: Real peaks. No analytical problems. Station 105 has similar pattern.
105/2	206	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Within accuracy of measurement. NO3 and SiO3 slightly high on station profile. Salinity, as well as oxygen and nutrients, is acceptable.
105/2	228	no3	2	NO3, and PO4 lower than adjoining stations, SiO3 lower with corresponding higher oxygen. Salinity gradient agrees with CTD. Similar feature in Station 104.
105/2	228	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
105/2	233	salt	2	Bottle salinity is low compared with CTD and adjoining stations. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
106/1	111	salt	3	Bottle salinity is high compared with CTD and adjoining stations. No analytical problems noted. Oxygen and nutrients are acceptable. Code salinity questionable.
106/1	130	o2	2	Oxygen high compared with adjoining stations and CTDO down trace, agrees with the up trace. Oxygen, as well as salinity and nutrients, is acceptable.
107/3	301	salt	2	Bottle salinity is high compared with CTD and adjoining stations. No analytical problems noted, within accuracy of measurement. Salinity, as well as oxygen and nutrients, is acceptable.
107/3	302	salt	2	Bottle salinity is high compared with CTD and adjoining stations. No analytical problems noted, within accuracy of measurement. Salinity, as well as oxygen and nutrients, is acceptable.
107/3	305	salt	2	Bottle salinity is high compared with CTD and adjoining stations. 3 attempts for a good salinity reading. Additional reading resolved salinity difference. Salinity, as well as oxygen and nutrients, is acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
108/1	117	salt	3	Bottle salinity is high compared with CTD and adjoining stations. No analytical problems noted. oxygen and nutrients are acceptable. Code salinity questionable.
109/1	103	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Within accuracy of the measurement. Salinity, as well as oxygen and nutrients, is acceptable.
109/1	106	salt	3	Bottle salinity is high compared with CTD and adjoining stations. No analytical problems noted. Oxygen and nutrients are acceptable. Code salinity questionable.
109/1	134	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, are acceptable.
110/2	201	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Within accuracy of measurement. Salinity, as well as oxygen and nutrients, is acceptable.
110/2	232	salt	2	Bottle salinity is low compared with CTD. Lots of structure in CTD salinity. Salinity, as well as oxygen and nutrients, is acceptable.
110/2	235	salt	5	Salinity sample lost, bottle stand did not hold and sample fell, spilling everywhere.
111/2	202	salt	2	Bottle salinity is high compared with CTD and adjoining stations. 4 attempts for a good salinity reading. Additional reading resolved salinity difference. Salinity, as well as oxygen and nutrients, is acceptable.
111/2	223	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Suspect analyst missed a reading, resolved mixup and salinity difference. Salinity, as well as oxygen and nutrients, is acceptable.
111/2	224	salt	2	Bottle salinity is low compared with CTD and adjoining stations. Suspect analyst missed a reading, resolved mixup and salinity difference. Salinity, as well as oxygen and nutrients, is acceptable.
111/2	225	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Suspect analyst missed a reading, could not resolve mixup and salinity is low compared with CTD. Oxygen and nutrients are acceptable. Code salinity bad.
111/2	228	salt	2	Bottle salinity is high compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
112/1	102	o2	2	Oxygen redrawn, bubbles in flask. Oxygen, as well as salinity and nutrients, is acceptable.
113/3	307	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Within accuracy of measurement. Salinity, as well as oxygen and nutrients, is acceptable.
113/3	329	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
114/1	102	salt	2	Bottle salinity is low compared with CTD and adjoining stations. May have had a sample temperature issue, much of the salinity run is noisy. Within the accuracy of the measurement. Oxygen and nutrients are acceptable.
114/1	104	salt	4	Bottle salinity is low compared with CTD and adjoining stations. May have had a sample temperature issue, much of the salinity run is noisy. Oxygen and nutrients are acceptable. Code salinity bad.
114/1	105	salt	2	Bottle salinity is low compared with CTD and adjoining stations. Within accuracy of measurement, although much of the salinity run is noisy. Salinity, as well as oxygen and nutrients, is acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
114/1	106	o2	3	Oxygen low compared with CTDO and adjoining stations. Rechecked endpoint: No analytical problems noted. No corresponding increase in SiO3. SiO3 exhibits an unexpected low in value for 106. NO3 and PO4 are acceptable. Code oxygen questionable.
114/1	106	salt	4	Bottle salinity is high compared with CTD and adjoining stations. May have had a sample temperature issue, much of the salinity run is noisy. Code salinity bad.
114/1	107	o2	3	Oxygen low compared with CTDO and adjoining stations. Rechecked endpoint: No analytical problems noted. No corresponding SiO3 feature. Nutrients are acceptable. Code oxygen questionable.
114/1	133	bottle	2	Bottle was misfilled at 170 meters, bottles 32 and 33 were filled at the same depth. Salinities agree by 0.002, oxygen by 0.006, NO3 0.01, PO4 and SiO3 agree exactly with one another.
114/1	133	o2	2	Sample was overtitrated and backtitrated. Rechecked titration plot: looks good. Oxygen similar to CTDO. Oxygen, as well as salinity and nutrients, is acceptable.
114/1	135	salt	2	Bottle salinity is low compared with CTD. Lots of structure at the surface. Salinity, as well as oxygen and nutrients, is acceptable.
114/1	136	bottle	2	There is no surface bottle due to the misfill of bottle 33; bottle 36 was filled at 35 meters.
115/1	130	o2	2	Oxygen redrawn due to false bubbles, bubbles in the glass itself. Oxygen, as well as salinity and nutrients, is acceptable.
116/2	206	no3	2	NO3 low, no corresponding PO4 feature. Salinity, oxygen and other nutrients are acceptable. Nutrient analyst: Real peak. No analytical problems noted.
116/2	232	no3	2	NO3 low, corresponding low PO4, salinity also high with corresponding SiO3 and oxygen. Nutrient Analyst: Corresponding o2 max. Both real peaks. No analytical errors noted.
117/2	201	po4	2	PO4 high, no corresponding NO3 feature. SiO3 high, no corresponding low oxygen feature. Nutrient analyst: N:P ratio looks good. Slight low feature in oxygen. On edge of AA capability. Salinity, oxygen and nutrients are acceptable.
117/2	215	o2	2	Oxygen draw temperature for sample 15 was missed. Calculated approximate draw temperature for conversion to kg units, acceptable.
117/2	228	o2	5	Oxygen was lost during analysis, buret tip was not in flask. No CTDO, coded not sampled because bottle oxygen is lost.
118/1	101	no3	2	NO3 high, no corresponding PO4 feature. Salinity, oxygen and other nutrients are acceptable. Nutrient analyst: Real peak. No analytical problems noted. Edge of AA capability.
118/1	127	reft	3	SBE35RT-CTDT1 or SBE35-CTDT2 difference is -0.74 deg.C. Code SBE35RT questionable.
118/1	130	o2	2	Oxygen high compared with CTDO, but similar to adjoining stations. Rechecked endpoint: No analytical problems noted. No corresponding SiO3 feature. Data Processor: Bottle oxygen agrees with up trace. Oxygen, as well as salinity and nutrients, is acceptable.
118/1	131	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
118/1	135	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
119/1	101	no3	2	NO3 high, 0.1, no corresponding PO4 feature. Salinity, oxygen and other nutrients are acceptable. Nutrient analyst: N:P ratio looks good. Real peak. No analytical errors noted.

Station /Cast	Sample No.	Quality Property	Code	Comment
119/1	102	salt	2	Bottle salinity is high compared with CTD and adjoining stations. No analytical problem noted, all of the deep salinities appear high by 0.001. Within accuracy of measurement. Salinity, as well as oxygen and nutrients, is acceptable.
119/1	110	salt	3	Bottle salinity is high compared with CTD and adjoining stations, agrees with the secondary sensor. No analytical problem noted. Oxygen and nutrients are acceptable. Code salinity questionable.
119/1	119	o2	2	Oxygen flask, 1539, switched during sampling with 13, 1413. This is not a problem, just a note of interest. Oxygen is acceptable.
119/1	128	o2	2	Oxygen appears high compared with CTDO and Stations 120 and 121. Agrees with CTD up trace and close to Station 118. Oxygen as well, as salinity and nutrients, is acceptable.
119/1	135	o2	2	Sample was overtitrated and backtitrated. Rechecked titration plot: looks good. Oxygen similar to CTDO. Oxygen, as well as salinity and nutrients, is acceptable.
119/1	136	salt	4	Bottle salinity is low compared with CTD and adjoining stations. It was pouring rain when the sample was collected. Oxygen and nutrients are acceptable. Code salinity bad.
120/1	110	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Salinity is within the accuracy of the measurement. Salinity, as well as oxygen and nutrients, is acceptable.
120/1	133	salt	2	Bottle salinity is high compared with CTD. Salinity, as well as oxygen and nutrients, is acceptable.
121/1	105	sio3	3	SiO3 for sample 1-8 were rerun for SiO3. SiO3 is high. Nutrient analyst: 104-peak looks good, no analytical error noted. 105-106 questionable peak. Code SiO3 questionable.
121/1	106	sio3	3	SiO3 for sample 1-8 were rerun for SiO3. SiO3 is high. Nutrient analyst: 104-peak looks good, no analytical error noted. 105-106 questionable peak. Code SiO3 questionable.
121/1	120	salt	3	Bottle salinity is low compared with CTD and adjoining stations, although it does agree with Station 120. No analytical problem found. Oxygen and nutrients are acceptable. Code salinity questionable.
121/1	135	reft	3	SBE35RT-CTDT1/SBE35-CTDT2 difference is +0.38/+0.45 deg.C (high gradient). Code SBE35RT questionable.
121/1	135	salt	3	Bottle salinity is low compared with CTD. Large gradient, 0.4, suspect salinometer was not flushed enough times between higher sample, 0.6 higher. Oxygen and nutrients are acceptable. Code salinity questionable.
122/1	108	salt	2	Bottle salinity is high compared with CTD and adjoining stations. No analytical problems found, within accuracy of measurement. Salinity, as well as oxygen and nutrients, is acceptable.
122/1	132	salt	3	Bottle salinity is high compared with CTD and adjoining stations. No analytical problems found, sample could have been run too fast. Oxygen and nutrients are acceptable. Code salinity questionable.
122/1	133	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Salinity agrees with the secondary conductivity sensor. Salinity, as well as oxygen and nutrients, is acceptable.
122/1	136	bottle	2	Bottle tripped partially out of the water. Oxygen, salinity and nutrients are acceptable.
123/2	201	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Deep salinity samples all appear high, but within accuracy of measurement and agree with secondary sensor. Salinity, oxygen and nutrients are acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
123/2	203	sio3	2	SiO3 low, ~1.0, compared with adjoining stations, no corresponding oxygen feature. Within accuracy of the measurement. Salinity, oxygen and nutrients are acceptable. Nutrient analyst: Real peak. No analytical error noted.
123/2	207	no3	2	NO3 high, as much as 0.03, compared with adjoining stations. PO4 has a similar feature, but agrees with adjoining stations. Salinity, oxygen and other nutrients are acceptable. Nutrient analyst: Real peak. No analytical error noted. N:P ratio looks good. Leave NO4 as is.
123/2	208	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Deep salinity samples all appear high, but within accuracy of measurement and agree with secondary sensor. Salinity, oxygen and nutrients are acceptable.
123/2	210	salt	2	Bottle salinity is high compared with CTD, 0.002, and low compared with adjoining stations. Deep salinity samples all appear high, but within accuracy of measurement and agree with secondary sensor. CTD shows a low feature, suspect that this could be a bottle flushing problem or difference between CTD and bottle location. Salinity, oxygen and nutrients are acceptable.
123/2	220	salt	3	Bottle salinity is low compared with CTD. This bottle has been problematic, oxygen is acceptable. When full sampling is done, Stations 121 and 123, salinity has been low, on Station 125 salinity was high. Code salinity questionable.
123/2	231	salt	2	Bottle salinity is low compared with CTD. Lots of structure, salinity, as well as oxygen and nutrients, is acceptable.
123/2	233	salt	2	Bottle salinity is low compared with CTD. Lots of structure, salinity, as well as oxygen and nutrients, is acceptable.
123/2	234	salt	2	Bottle salinity is high compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
123/2	235	salt	2	Bottle salinity is low compared with CTD and adjoining stations. Gradient, oxygen high and agrees with CTDO. Salinity, as well as oxygen and nutrients, is acceptable.
124/1	135	salt	2	Bottle salinity is high compared with CTD agrees with adjoining stations for a shallow sample. Lots of structure in the CTD data. Salinity, as well as oxygen and nutrients, is acceptable.
125/1	102	salt	2	Bottle salinity is high compared with CTD, agrees with adjoining stations and secondary sensor. Salinity, as well as oxygen and nutrients, is acceptable.
125/1	105	salt	2	Bottle salinity is high compared with CTD and adjoining stations and secondary sensor. Salinity, as well as oxygen and nutrients, is acceptable.
125/1	107	salt	2	Bottle salinity is high compared with CTD agrees with adjoining stations and secondary sensor. Within accuracy of measurement. Salinity, as well as oxygen and nutrients, is acceptable.
125/1	108	salt	2	Bottle salinity is high compared with CTD agrees with adjoining stations and secondary sensor. Within accuracy of measurement. Salinity, as well as oxygen and nutrients, is acceptable.
125/1	109	salt	2	Bottle salinity is high compared with CTD agrees with adjoining stations and secondary sensor. Within accuracy of measurement. Salinity, as well as oxygen and nutrients, is acceptable.
125/1	110	salt	2	Bottle salinity is high compared with CTD agrees with adjoining stations and secondary sensor. Salinity, as well as oxygen and nutrients, is acceptable.
125/1	111	salt	2	Bottle salinity is high compared with CTD agrees with adjoining stations and secondary sensor. Salinity, as well as oxygen and nutrients, is acceptable.
125/1	112	salt	2	Bottle salinity is high compared with CTD agrees with adjoining stations and secondary sensor. Salinity, as well as oxygen and nutrients, is acceptable.



Station /Cast	Sample No.	Quality Property	Code	Comment
125/1	113	salt	2	Bottle salinity is high compared with CTD agrees with adjoining stations and secondary sensor. Salinity, as well as oxygen and nutrients, is acceptable.
125/1	114	salt	2	Bottle salinity is high compared with CTD agrees with adjoining stations and secondary sensor. Salinity, as well as oxygen and nutrients, is acceptable.
125/1	120	salt	3	Bottle salinity is high compared with CTD. This bottle has been problematic, oxygen is acceptable. When full sampling is done, Stations 121 and 123, salinity has been low, on Station 125 salinity was high. Code salinity questionable.
125/1	126	bottle	2	Spigot partially open. Salinity, oxygen and nutrients agree with adjoining stations.
126/1	101	no3	3	NO3 high, 0.03, compared with adjoining station. No similar feature in PO4. Salinity, oxygen and other nutrients are acceptable. Code NO3 questionable. Nutrient analyst:Real peak. No analytical errors noted.
126/1	101	salt	2	Bottle salinity is high compared with CTD agrees with secondary sensor. Salinity, as well as oxygen and nutrients, except NO3, is acceptable.
126/1	102	salt	2	Bottle salinity is high compared with CTD agrees with secondary sensor. Within accuracy of measurement. Salinity, as well as oxygen and nutrients, is acceptable.
126/1	103	salt	2	Bottle salinity is high compared with CTD agrees with secondary sensor. Salinity, as well as oxygen and nutrients, is acceptable.
126/1	104	salt	4	Bottle salinity is high compared with CTD and low with adjoining stations. The bottle was upright in the box however, it was not full. Suspect sampling error. Code salinity bad.
126/1	105	salt	2	Bottle salinity is high compared with CTD, agrees with adjoining stations and secondary sensor. Salinity, as well as oxygen and nutrients, is acceptable.
126/1	106	salt	2	Bottle salinity is high compared with CTD, agrees with adjoining stations and secondary sensor. Salinity, as well as oxygen and nutrients, is acceptable.
126/1	107	salt	2	Bottle salinity is high compared with CTD, agrees with adjoining stations and secondary sensor. Salinity, as well as oxygen and nutrients, is acceptable.
126/1	108	salt	2	Bottle salinity is high compared with CTD, agrees with adjoining stations and secondary sensor. Salinity, as well as oxygen and nutrients, is acceptable.
126/1	109	salt	2	Bottle salinity is high compared with CTD, agrees with adjoining stations and secondary sensor. Salinity, as well as oxygen and nutrients, is acceptable.
126/1	110	salt	2	Bottle salinity is high compared with CTD, agrees with adjoining stations and secondary sensor. Salinity, as well as oxygen and nutrients, is acceptable.
126/1	135	reft	3	SBE35RT-CTDT1/SBE35-CTDT2 difference is -0.11/-0.22 deg.C (high gradient). Code SBE35RT questionable.
126/1	135	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
128/1	105	no2	9	Nutrient tube brought to lab empty.
128/1	105	no3	9	
128/1	105	po4	9	
128/1	105	sio3	9	
129/1	101	salt	2	Bottle salinity is high compared with CTD, agrees with adjoining stations and secondary sensor. Salinity, as well as oxygen and nutrients, is acceptable.
129/1	103	salt	2	Bottle salinity is high compared with CTD, agrees with adjoining stations and secondary sensor. Salinity, as well as oxygen and nutrients, is acceptable.
129/1	105	salt	2	Bottle salinity is high compared with CTD, agrees with adjoining stations and secondary sensor, within accuracy of measurement. Salinity, as well as oxygen and nutrients, is acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
129/1	107	salt	2	Bottle salinity is high compared with CTD, agrees with adjoining stations and secondary sensor. Salinity, as well as oxygen and nutrients, is acceptable.
129/1	110	salt	2	Bottle salinity is high compared with CTD, agrees with adjoining stations and secondary sensor. Salinity, as well as oxygen and nutrients, is acceptable.
129/1	136	salt	2	Bottle salinity is low compared with CTD, acceptable with adjoining stations. Salinity, as well as oxygen and nutrients, is acceptable.
130/1	106	salt	2	Bottle salinity is high compared with CTD and adjoining stations. 3 attempts for a good salinity reading. Additional readings resolve difference. Salinity, as well as oxygen and nutrients, is acceptable.
130/1	134	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
131/1	101	salt	3	Bottle salinity is high compared with CTD and adjoining stations, and secondary comparison. Oxygen and nutrients are acceptable. Code salinity questionable.
131/1	125	salt	3	Bottle salinity is low compared with CTD, both down and up trace, and adjoining stations. Feature seen in oxygen which CTDO confirms, no features in nutrients. Could be bottle flushing issue. Oxygen and nutrients are acceptable. Code salinity questionable.
132/1	101	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	102	o2	3	Oxygen higher than CTDO and adjoining stations. Oxygen analyst: No corresponding SiO3 feature. Nutrients acceptable. Rechecked endpoint: no analytical problems noted. Code oxygen questionable.
132/1	102	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	103	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	104	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	105	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	106	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	107	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	108	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	109	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	110	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Gradient, salinity, as well as oxygen and nutrients, except SiO3, is acceptable.
132/1	110	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	111	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	112	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	113	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	114	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.

Station /Cast	Sample No.	Quality Property	Code	Comment
132/1	115	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	116	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	117	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	118	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	119	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	120	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	121	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	122	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	123	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	124	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	125	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	126	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	127	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	128	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	129	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	130	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	131	CTDT2	3	SBE35RT-CTDT2/CTDT1-CTDT2 difference is +0.14/+0.18 deg.C (high gradient). Code CTDT2 questionable.
132/1	131	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	132	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	133	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	134	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	135	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, except SiO3, is acceptable.
132/1	135	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
132/1	136	sio3	3	SiO3 profile looks high. Investigation did not reveal any analytical problems. Code SiO3 questionable.
133/2	234	salt	2	Bottle salinity is high compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
134/1	107	salt	2	Bottle salinity is high compared with CTD agrees with adjoining stations. Within accuracy of the measurement. Salinity, as well as oxygen and nutrients, is acceptable.
134/1	110	salt	2	Bottle salinity is high compared with CTD. Slight gradient, salinity, as well as oxygen and nutrients, is acceptable.
134/1	126	o2	5	Oxygen lost, flask broken and not analyzed. No CTDO, coded not sampled because bottle oxygen is lost.
134/1	135	salt	2	Bottle salinity is low compared with CTD. Could be the 1 meter bottle vs. CTD location. Salinity, as well as oxygen and nutrients, is acceptable.
135/3	305	salt	2	Bottle salinity is high compared with CTD, agrees with adjoining stations. Within accuracy of measurements. Salinity, as well as oxygen and nutrients, is acceptable.
135/3	306	salt	2	Bottle salinity is high compared with CTD, agrees with adjoining stations. Within accuracy of measurements. Salinity, as well as oxygen and nutrients, is acceptable.
136/1	108	sio3	2	SiO3 low, no corresponding oxygen feature. Salinity, oxygen and nutrients are acceptable. Nutrient analyst: Checked and corrected, still low, but within accuracy, leave as is.
137/1	102	no3	3	NO3 deep profile looks low. Nutrient Analyst: 102-103 and 105-107 look ~0.2 low. Real peaks. No analytical errors noted.
137/1	103	no3	3	NO3 deep profile looks low. Nutrient Analyst: 102-103 and 105-107 look ~0.2 low. Real peaks. No analytical errors noted.
137/1	105	no3	3	NO3 deep profile looks low. Nutrient Analyst: look ~0.2 low. Real peaks. No analytical errors noted. Code NO3 questionable.
137/1	106	no3	3	NO3 deep profile looks low. Nutrient Analyst: look ~0.2 low. Real peaks. No analytical errors noted. Code NO3 questionable.
137/1	107	no3	3	NO3 deep profile looks low. Nutrient Analyst: look ~0.2 low. Real peaks. No analytical errors noted. Code NO3 questionable.
138/1	134	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
139/3	307	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Suspect samples run too quickly through cell. Salinity, as well as oxygen and nutrients, is acceptable.
139/3	308	salt	2	Bottle salinity is high compared with CTD and adjoining stations. 3 attempts for a good salinity reading. Additional reading resolved salinity difference, suspect samples run too quickly through cell. Salinity, as well as oxygen and nutrients, is acceptable.
139/3	309	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Suspect samples run too quickly through cell. Salinity, as well as oxygen and nutrients, is acceptable.
140/1	103	bottle	9	Bottle opened by recovery hook, water poured out. CTDO not reported because there is no bottle oxygen.
140/1	109	no3	3	NO3 high, ~0.06, no corresponding PO4 feature. Salinity, oxygen and other nutrients are acceptable. Nutrient analyst: Real peak. No analytical error noted. Code NO3 questionable.
140/1	127	o2	2	Oxygen appears low compared with adjoining stations, agrees with the CTDO. Oxygen, as well as salinity and nutrients, is acceptable.
140/1	129	o2	2	Oxygen appears high compared with CTDO and adjoining stations, agrees with the CTDO up trace. Oxygen, as well as salinity and nutrients, is acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
141/1	101	salt	2	Bottle salinity is high compared with CTD agrees with adjoining stations. CTD salinity has a slight low feature. Salinity, as well as oxygen and nutrients, is acceptable.
141/1	105	salt	2	Bottle salinity is high compared with CTD agrees with adjoining stations. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
141/1	106	salt	2	Bottle salinity is high compared with CTD agrees with adjoining stations. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
141/1	134	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
142/1	106	salt	2	Bottle salinity is high compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
143/2	203	salt	3	Bottle salinity is high compared with CTD and adjoining stations. Oxygen and nutrients are acceptable. Code salinity questionable.
143/2	209	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
143/2	226	bottle	2	Freon sampler reports that spigot was open, but did not appear to leak. Oxygen, as well as salinity and nutrients, is acceptable.
144/1	131	salt	2	Bottle salinity is high compared with CTD. Probably physical location difference of bottle and CTD. Salinity, as well as oxygen and nutrients, is acceptable.
144/1	134	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
144/1	136	bottle	2	Raining on recovery of rosette. Salinity, oxygen and nutrients are acceptable.
145/2	204	salt	4	Bottle salinity is low compared with CTD and adjoining stations. No analytical problems, could be sampling issue. Oxygen and nutrients are acceptable. Code salinity bad.
145/2	213	salt	4	Bottle salinity is high compared with CTD and adjoining stations. No analytical problems found. Oxygen and nutrients are acceptable. Code salinity bad.
145/2	226	o2	4	Sample was overtitrated and backtitrated. Oxygen higher than both CTDO and adjoining stations. Rechecked endpoint: plot no good. No corresponding SiO3 feature. Nutrients are acceptable. Code oxygen bad.
145/2	230	reft	3	SBE35RT-CTDT1/SBE35-CTDT2 difference is -0.14/-0.24 deg.C (high gradient). Code SBE35RT questionable.
146/1	109	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Suspect sample analyzed too slow, within accuracy of measurement. Salinity, as well as oxygen and nutrients, is acceptable.
146/1	119	salt	2	Bottle salinity is high compared with CTD and adjoining stations. 6 attempts for a good salinity reading. Analyst read the wrong sample, issue resolved. Salinity, as well as oxygen and nutrients, is acceptable.
146/1	121	sio3	3	SiO3 low, ~ 3, no corresponding oxygen feature. Salinity, oxygen and other nutrients are acceptable. Code SiO3 questionable. Nutrient analyst: Strong gradient region. Real peak- no analytical errors noted.
146/1	126	o2	2	Oxygen less than both CTDO and adjoining stations. Rechecked endpoint: No analytical problems noted. No corresponding SiO3 feature. Nutrients are acceptable. Processor: Difference between down and up, oxygen is acceptable.
146/1	133	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
147/2	201	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Samples were run before they had time to equilibrate to lab/bath temperature. Oxygen and nutrients are acceptable. Code salinity bad.
147/2	207	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Samples were run before they had time to equilibrate to lab/bath temperature. Oxygen and nutrients are acceptable. Code salinity bad.
147/2	209	no3	3	NO3 high, ~ 0.2, no corresponding PO4, SiO3 low. Salinity, and oxygen acceptable. Code NO3 questionable. Nutrient analyst: Real peak-no analytical errors noted.
147/2	212	sio3	2	SiO3 low, ~ 2, no corresponding O2, within precision of measurement. Salinity, and oxygen acceptable. Nutrient analyst: o2 is slightly low at this level. Real peak- no analytical errors noted.
148/2	217	salt	4	Bottle salinity is low compared with CTD and adjoining stations. 3 attempts for a good salinity reading. Additional readings did not resolve salinity difference, must have been a salt crystal. Oxygen and nutrients are acceptable. Code salinity bad.
148/2	227	o2	2	Oxygen appears high compared with CTDO and adjoining stations. Salinity and nutrients are acceptable. Code oxygen questionable. Rechecked endpoint: No analytical problems noted and graph is good. Re-plotted and sample value is similar to adjoining stations. Code oxygen acceptable.
148/2	233	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
149/1	107	o2	4	Oxygen higher than both CTDO and adjoining stations. Rechecked endpoint: Bad graph, non-recoverable. Salinity and nutrients are acceptable. Code oxygen bad.
149/1	109	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
149/1	122	o2	2	Oxygen slightly less than both CTDO and adjoining stations. Rechecked endpoint: looks OK. Processor: Oxygen agrees with CTDO up trace. Oxygen, as well as salinity and nutrients, is acceptable.
149/1	123	o2	2	Oxygen less than both CTDO and adjoining stations. Rechecked endpoint: No analytical problems noted and graph is good. Corresponding SiO3 feature. Nutrients acceptable. Processor: Oxygen agrees with CTDO up trace. Oxygen, as well as salinity and nutrients, is acceptable.
149/1	123	sio3	2	SiO3 high, ~ 3, corresponding oxygen feature. Salinity, oxygen and nutrients are acceptable. Agrees with Station 153. Nutrient analyst: Strong gradient region. Real peak-no analytical errors noted.
149/1	132	CTDS1	2	Bottle-CTDC1 difference is -0.23 PSU (high gradient). BottleSalt-CTDS1 is less than -0.01 PSU in gradient, so code CTDS1 acceptable; matches up with CTDT1.
149/1	132	CTDT1	2	SBE35RT-CTDT1/CTDT2-CTDT1 difference is +0.20/+0.17 deg.C (high gradient). BottleSalt-CTDS1 is less than -0.01 PSU in gradient, so code CTDT1 acceptable; matches up with CTDC1.
150/1	102	o2	2	Debris in oxygen flask. Oxygen, as well as salinity and nutrients, is acceptable.
150/1	105	no3	3	NO3 higher than adjoining stations. Slight corresponding oxygen feature. Other nutrients are acceptable. No analytical problems noted and peak looks good. Code NO3 questionable.
150/1	106	no3	3	NO3 higher than adjoining stations: Slight corresponding oxygen feature. Other nutrients are acceptable. No analytical problems noted and peak looks good. Code NO3 questionable.

Station /Cast	Sample No.	Quality Property	Code	Comment
150/1	107	no3	3	NO3 higher than adjoining stations. Slight corresponding oxygen feature. Other nutrients are acceptable. No analytical problems noted and peak looks good. Code NO3 questionable.
150/1	119	salt	4	Bottle salinity is high compared with CTD and adjoining stations. 4 attempts for a good salinity reading. Additional readings did not resolve difference. Oxygen and nutrients are acceptable. Code salinity bad.
150/1	122	o2	2	Biology in oxygen sample. Oxygen, as well as salinity and nutrients, is acceptable.
150/1	125	o2	2	Oxygen appears low compared with adjoining stations. Agrees well, for a shallow bottle, with CTDO up trace.
150/1	133	CTDT2	3	CTDT1-CTDT2 difference is +0.27 deg.C (high gradient). Code CTDT2 questionable.
150/1	133	reft	3	SBE35RT-CTDT1 difference is +0.12 deg.C (high gradient). Code SBE35RT questionable.
150/1	134	salt	2	Bottle salinity is high compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
150/1	136	reft	3	SBE35RT-CTDT1/SBE35-CTDT2 difference is +0.24/+0.30 deg.C (surface). Code SBE35RT questionable.
151/1	117	no3	2	NO3 low, no corresponding PO4 feature. Salinity, oxygen and nutrients are acceptable. Nutrient analyst: Slight corresponding po4 feature. Real peak- no analytical error noted.
151/1	121	sio3	2	SiO3 high, ~ 5, no corresponding oxygen feature. Salinity, oxygen and nutrients are acceptable. Agrees with Station 154. Nutrient analyst: o2 min at this level. Real peak- no analytical errors noted
151/1	130	salt	2	Bottle salinity is low compared with CTD. No analytical problems found. Gradient, salinity, oxygen and nutrients are acceptable.
151/1	134	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Appears to be an analytical/salinometer problem. Oxygen and nutrients are acceptable. Code salinity bad.
151/1	135	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Appears to be an analytical/salinometer problem. Oxygen and nutrients are acceptable. Code salinity bad.
151/1	136	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Appears to be an analytical/salinometer problem. Oxygen and nutrients are acceptable. Code salinity bad.
152/1	130	no3	2	NO3 high, ~ 3, corresponding PO4 feature. Salinity, oxygen and nutrients are acceptable. Nutrient analyst: corresponding po4 and o2 feature. Real peak- no analytical errors noted.
152/1	132	no3	2	NO3 high, ~ 10, corresponding PO4 feature. Salinity, oxygen and nutrients are acceptable. Nutrient analyst: corresponding po4 and o2 feature. Real peak- no analytical errors noted
152/1	132	salt	2	Bottle salinity is low compared with CTD and adjoining stations. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
152/1	133	CTDT1	3	SBE35RT-CTDT1/CTDT2-CTDT1 difference is +0.29/+0.22 deg.C (high gradient). Code CTDT1 questionable.
152/1	133	salt	2	Bottle salinity is low compared with CTD and adjoining stations. No analytical problem noted, appears there was sufficient flushing after a higher conductivity on the previous sample. Gradient, salinity, as well as oxygen and nutrients, is acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
153/1	105	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Within accuracy of measurement. Salinity, as well as oxygen and nutrients, is acceptable.
153/1	125	o2	2	Oxygen appears high compared with CTDO and adjoining stations. Agrees with CTDO up trace. Oxygen, as well as salinity and nutrients, is acceptable.
153/1	133	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
154/2	205	salt	4	Bottle salinity is low compared with CTD and adjoining stations. 3 attempts for a good salinity reading. Additional reading did not resolve salinity difference. Oxygen and nutrients are acceptable. Code salinity bad.
154/2	208	salt	2	Bottle salinity is high compared with CTD and adjoining stations. 3 attempts for a good salinity reading. Additional reading resolved salinity difference. Salinity, as well as oxygen and nutrients, is acceptable.
154/2	235	salt	2	Bottle salinity is low compared with CTD and adjoining stations. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
155/1	102	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Within accuracy of measurement. Salinity, as well as oxygen and nutrients, is acceptable.
155/1	105	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Within accuracy of measurement. Salinity, as well as oxygen and nutrients, is acceptable.
155/1	108	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Within accuracy of measurement. Salinity, as well as oxygen and nutrients, is acceptable.
155/1	132	salt	2	Bottle salinity is high compared with CTD, adjoining stations and CTD down trace. Salinity, as well as oxygen and nutrients, is acceptable.
155/1	133	salt	2	Bottle salinity is high compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
156/2	232	salt	2	Bottle salinity is high compared with CTD. Salinity structure, salinity, as well as oxygen and nutrients, is acceptable.
157/1	109	salt	4	Bottle salinity is low compared with CTD and adjoining stations. Sample was analyzed too quickly, not giving it enough time to come to equilibration. Oxygen and nutrients are acceptable. Code salinity bad.
158/1	103	salt	2	Bottle salinity is high compared with CTD and adjoining stations. 3 attempts for a good salinity reading. Additional reading resolved salinity difference. Salinity, as well as oxygen and nutrients, is acceptable.
158/1	111	po4	2	PO4 low, corresponding NO3, oxygen high, but agrees with CTDO. No other parameters sampled on this bottle. Salinity, and oxygen acceptable. Nutrient analyst: Real peaks- no analytical errors noted.
158/1	131	po4	2	PO4 low. Nutrient analyst: Corresponding NO3, SiO3, and oxygen signal. Real peaks- no analytical errors noted.
158/1	133	salt	2	Bottle salinity is low compared with CTD and adjoining stations. Salinity structures, salinity, as well as oxygen and nutrients, is acceptable.
158/1	134	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
159/1	132	salt	2	Bottle salinity is high compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.



Station /Cast	Sample No.	Quality Property	Code	Comment
160/1	118	o2	4	Oxygen low compared to CTDO and adjoining stations, no corresponding SiO3 feature. Salinity and nutrients are acceptable. Oxygen analyst: Forgot to lower buret tip into flask; had to abort end point. System appears to have given small shot, between 0.003 and 0.004ml, when redone before actually aborting. Value will be incorrect low.
160/1	134	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
161/1	102	salt	4	Bottle salinity is high compared with CTD and adjoining stations. Sample appears to be run too fast, machine diagnostic confirm a problem. Oxygen and nutrients are acceptable. Code salinity bad.
161/1	106	no3	2	NO3 high, no corresponding PO4. Nutrient analyst: Real peak; no analytical errors noted. Nutrients, as well as salinity and oxygen, are acceptable.
161/1	108	o2	5	Sample analysis was aborted after Stop Thio button was accidentally clicked. Thus final titer volume not acquired; oxygen lost. No CTDO, coded not sampled because bottle oxygen lost.
161/1	129	po4	2	PO4 high. Nutrient analyst: Corresponding NO3, SiO3, and oxygen signal. Real peaks- no analytical errors noted.
161/1	134	salt	2	Bottle salinity is high compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
162/2	205	salt	2	Bottle salinity is high compared with CTD and adjoining stations. 4 attempts for a good salinity reading. Additional readings resolved salinity difference. Salinity, as well as oxygen and nutrients, is acceptable.
162/2	209	o2	4	Sample overtitrated and backtitrated. End point rechecked: bad graph. Oxygen higher than CTDO and does not agree with trend descending water column of adjoining stations. No corresponding SiO3 feature. Nutrients acceptable. Code oxygen bad.
162/2	221	o2	2	Sample was overtitrated and backtitrated. Rechecked endpoint: Graph good. Oxygen slightly higher than CTDO but similar to adjoining stations. Oxygen is acceptable.
162/2	226	no3	2	NO3 low, ~ 2, corresponding low PO4, low SiO3, high oxygen, but relationship does not fall on curve. Nutrient analyst: Real peaks- no analytical errors noted.
162/2	230	o2	2	Sample was overtitrated and backtitrated. Rechecked endpoint: Graph good. Oxygen slightly higher than CTDO and similar to low oxygen (minimum) trend in adjoining stations. Oxygen is acceptable.
163/1	102	o2	3	Sample was overtitrated and backtitrated. Endpoint: Flat Graph...slope close to zero...not good. Oxygen slightly higher than CTDO, but follows pattern of adjoining stations. Slight similar corresponding SiO3 and NO3 features at adjoining stations. Oxygen code questionable.
163/1	105	salt	3	Bottle salinity is high compared with CTD and adjoining stations. Structure seen in nutrients and oxygen, acceptable. Code salinity questionable.
163/1	107	salt	3	Bottle salinity is high compared with CTD and adjoining stations. Suspect sample run a little too fast. Structure seen in nutrients and oxygen, acceptable. Code salinity questionable.
163/1	108	o2	5	Oxygen flask damaged before analysis and sample contaminated. Oxygen lost. No CTDO because bottle oxygen lost.
163/1	116	o2	2	Sample was overtitrated and backtitrated. Rechecked endpoint: Graph good. Oxygen agrees with CTDO and adjoining stations. Oxygen is acceptable.
163/1	126	o2	2	Sample was overtitrated and backtitrated. Rechecked endpoint: graph not very good...quite flat. However, Oxygen agrees with CTDO and adjoining stations. Oxygen is acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
163/1	128	o2	2	Sample was overtitrated and backtitrated. Rechecked endpoint: Graph good. Oxygen agrees with both CTDO and adjoining stations. Nutrients acceptable. Oxygen is acceptable.
163/1	129	o2	2	Sample was overtitrated and backtitrated. Rechecked endpoint: Graph good. Oxygen agrees with both CTDO and adjoining stations. Nutrients acceptable. Oxygen is acceptable.
163/1	130	o2	2	Sample was overtitrated and backtitrated. Rechecked endpoint: Graph not very good...quite flat. However, Oxygen agrees with both CTDO and adjoining stations. Oxygen is acceptable.
163/1	132	o2	3	Sample was overtitrated and backtitrated. Rechecked endpoint: Graph not very good. Oxygen higher than CTDO at exact depth, but agrees with O2 concentration slightly above in the water column...hence sample water may be mixed with water higher in the water column. Oxygen agrees with trend in upper waters at adjoining stations. Oxygen code questionable.
164/2	202	salt	2	Bottle salinity is high compared with CTD and adjoining stations. 3 attempts for a good salinity reading. Additional readings resolved salinity difference. Salinity, as well as oxygen and nutrients, is acceptable.
164/2	207	o2	2	Graph started higher than normal on voltage. Rechecked endpoint: Graph good. Oxygen similar to both CTDO and adjoining stations. Oxygen is acceptable.
164/2	236	salt	3	Bottle salinity is high compared with CTD and adjoining stations. No analytical problem found, suspect difference between location of bottle versus CTD. Oxygen and nutrients are acceptable. Code salinity questionable.
165/1	104	o2	2	Oxygen appears to have had a voltage shift that dropped UV source strength. Rechecked endpoint: Graph good. Oxygen similar to both CTDO and adjoining stations. Oxygen is acceptable.
165/1	107	sio3	2	SiO3 high. Nutrient Analyst: Corresponding low o2 at this level. Real peak- no analytical errors noted.
165/1	131	o2	2	Bottom portion of graph distorted as bubble came out of solution in UV path. Rechecked endpoint: Graph good. Oxygen similar to both CTDO and adjoining stations. Oxygen is acceptable.
166/1	131	reft	3	SBE35RT-CTDT1/SBE35-CTDT2 difference is +0.14/+0.21 deg.C (high gradient). Code SBE35RT questionable.
166/1	133	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
167/2	207	o2	2	Sample was overtitrated and backtitrated. outgassing microbubbles severely distorted UV path. Oxygen does appear slightly high. Salinity and nutrients are acceptable. Oxygen analyst: Rechecked endpoint: graph not very good. However, oxygen agrees with both CTDO and adjoining stations. Oxygen is acceptable.
167/2	234	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
168/1	114	po4	2	PO4 low, NO3 is slightly lower compared with adjoining stations. Nutrients, as well as salinity and oxygen, are acceptable. Nutrient Analyst: Real peaks. No analytical errors noted.
168/1	134	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
168/1	135	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
169/2	211	CTDT2	3	SBE35RT-CTDT2/CTDT1-CTDT2 difference is +0.075/+0.053 deg.C. Code CTDT2 questionable.
170/1	109	salt	3	Bottle salinity is low compared with CTD and adjoining stations. Could be a bottle flushing issue. Oxygen and nutrients are acceptable. Code salinity questionable.
170/1	132	salt	2	Bottle salinity is low compared with CTD. Salinity structure, salinity, as well as oxygen and nutrients, is acceptable.
171/1	132	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
171/1	133	reft	3	SBE35RT-CTDT1/SBE35-CTDT2 difference is +0.14/+0.21 deg.C (high gradient). Code SBE35RT questionable.
171/1	134	salt	2	Bottle salinity is high compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
172/1	102	bottle	2	Vent open, leaked when oxygen pulled spigot. Oxygen, as well as salinity and nutrients, is acceptable.
172/1	133	salt	2	Bottle salinity is high compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
173/2	209	salt	4	Bottle salinity is low compared with CTD and adjoining stations. Salinity run was a little noisy. Oxygen and nutrients are acceptable. Code salinity bad.
173/2	210	salt	4	Bottle salinity is low compared with CTD and adjoining stations. Salinity run was a little noisy. Oxygen and nutrients are acceptable. Code salinity bad.
174/2	209	salt	3	Bottle salinity is high compared with CTD and adjoining stations. 3 attempts for a good salinity reading. Additional reading did not resolve salinity difference. Oxygen and nutrients are acceptable. Code salinity questionable.
174/2	236	reft	3	SBE35RT-CTDT1/SBE35-CTDT2 difference is +0.22/+0.33 deg.C (surface). Code SBE35RT questionable.
174/2	236	salt	3	Bottle salinity is high compared with CTD and adjoining stations. Oxygen and nutrients are acceptable. Code salinity questionable.
175/1	132	salt	2	Bottle salinity is low compared with CTD. Salinity agrees with the down trace, likely "shed wake". Salinity, as well as oxygen and nutrients, is acceptable.
175/1	133	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
176/1	104	salt	2	Bottle salinity is high compared with CTD and adjoining stations. 4 attempts for a good salinity reading. Additional reading resolved salinity difference.
176/1	109	salt	3	Bottle salinity is low compared with CTD and adjoining stations. Oxygen and nutrients are acceptable. Code salinity questionable.
176/1	119	no2	4	Oxygen higher than CTDO and dissimilar in descending trend to adjacent stations. Rechecked endpoint: No analytical errors noted and graph is good. SiO3 for 119 also exhibits a value higher than adjoining stations and is questionable. Code bottle did not trip as scheduled and samples bad.
176/1	119	no3	4	
176/1	119	o2	4	
176/1	119	po4	4	Bottle salinity is low compared with CTD and adjoining stations. Code bottle did not trip as scheduled, salinity and other samples bad.
176/1	119	salt	4	
176/1	119	sio3	4	4 attempts for a good salinity reading. Additional reading resolved salinity difference. Salinity, as well as oxygen and nutrients, is acceptable.
176/1	124	salt	2	
176/1	133	salt	4	4 attempts for a good salinity reading. Suspect operator error, from program diagnostics could be sample 32 that sat too long. Oxygen and nutrients are acceptable. Code salinity bad.

Station /Cast	Sample No.	Quality Property	Code	Comment
177/1	133	salt	2	Bottle salinity is high compared with CTD, agrees with down trace, likely "shed wake". Gradient, different structure seen in CTD trace. Salinity, as well as oxygen and nutrients, is acceptable.
178/1	111	bottle	2	Vent may have been open, CFC could not remember. It has been stated that all valves were checked two times before deployment. salinity, oxygen and nutrients are acceptable.
179/1	133	salt	2	Bottle salinity is low compared with CTD and adjoining stations. There is a lot of structure in the CTD trace, probably "shed wakes". Salinity, as well as oxygen and nutrients, is acceptable.
179/1	134	salt	2	Bottle salinity is low compared with CTD and adjoining stations. There is a lot of structure in the CTD trace, probably "shed wakes". Salinity, as well as oxygen and nutrients, is acceptable.
179/1	136	salt	2	Bottle salinity is low compared with CTD. There is a lot of structure in the CTD trace, probably "shed wakes". Salinity, as well as oxygen and nutrients, is acceptable.
180/1	102	salt	2	Bottle salinity is high compared with CTD and adjoining stations. 3 attempts for a good salinity reading. Additional readings resolved salinity difference. Salinity, as well as oxygen and nutrients, is acceptable.
180/1	107	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Additional readings resolved salinity difference. Salinity, as well as oxygen and nutrients, is acceptable.
180/1	110	salt	4	Bottle salinity is low compared with CTD and adjoining stations. 3 attempts for a good salinity reading. Additional readings did not resolve salinity difference. Suspect an operator error. Oxygen and nutrients are acceptable. Code salinity bad.
180/1	133	salt	2	Bottle salinity is low compared with CTD. Salinity appears to be drawn from bottle 34, but value agrees with structure of trace. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
180/1	135	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
181/1	134	salt	2	Bottle salinity is low compared with CTD. Structure seen in CTD. Salinity, as well as oxygen and nutrients, is acceptable.
182/1	114	no3	2	NO3 low compared with adjoining stations and reoccupation 174, PO4 has corresponding feature, but SiO3 and oxygen do not show the same.
182/1	133	salt	2	Bottle salinity is high compared with CTD. Structure in CTD, salinity, as well as oxygen and nutrients, is acceptable.
183/2	205	salt	4	Bottle salinity is high compared with CTD and adjoining stations. No analytical problem noted. Oxygen and nutrients are acceptable. Code salinity bad.
184/1	105	salt	2	Bottle salinity is high compared with CTD and adjoining stations. No analytical problem noted. Salinity from this bottle was low on the Station 183, but looks good on 185. Within accuracy of measurement, salinity, as well as oxygen and nutrients, is acceptable.
184/1	120	salt	3	Bottle salinity is low compared with CTD and agrees with 183, but not with down or up CTD trace. No analytical problem noted. Oxygen and nutrients are acceptable. Code salinity questionable.
184/1	132	bottle	2	Vent was open. Oxygen, as well as salinity and nutrients, is acceptable.
184/1	133	salt	2	Bottle salinity is low compared with CTD. Probably difference between bottle vs. CTD physical locations, looks reasonable for shallow water with adjoining stations. Salinity, as well as oxygen and nutrients, is acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
184/1	134	salt	2	Bottle salinity is low compared with CTD. Probably difference between bottle vs. CTD physical locations, looks reasonable for shallow water with adjoining stations. Salinity, as well as oxygen and nutrients, is acceptable.
184/1	135	salt	2	Bottle salinity is low compared with CTD. Probably difference between bottle vs. CTD physical locations, looks reasonable for shallow water with adjoining stations. Salinity, as well as oxygen and nutrients, is acceptable.
184/1	136	salt	2	Bottle salinity is low compared with CTD. Probably difference between bottle vs. CTD physical locations, looks reasonable for shallow water with adjoining stations. Salinity, as well as oxygen and nutrients, is acceptable.
185/2	201	salt	3	Bottle salinity is high compared with CTD and adjoining stations. No analytical problems noted. Salinity just within accuracy of the measurement. Oxygen and nutrients are acceptable, NO3 a little high, but has corresponding PO4 feature. Code salinity questionable.
185/2	206	o2	2	O2 flask order switched with sample 207. Flask number for sample 206 for this station is 1697 from box 5. Oxygen is acceptable.
185/2	207	o2	2	O2 flask order switched with sample 206. Flask number for sample 207 for this station is 1706 from box 5. Oxygen is acceptable.
185/2	217	no2	5	Missed 2 sample tubes when loading carousel, samples dumped before error noticed. Code nutrients samples lost.
185/2	217	no3	5	Missed 2 sample tubes when loading carousel, samples dumped before error noticed. Code nutrients samples lost.
185/2	217	po4	5	Missed 2 sample tubes when loading carousel, samples dumped before error noticed. Code nutrients samples lost.
185/2	217	sio3	5	Missed 2 sample tubes when loading carousel, samples dumped before error noticed. Code nutrients samples lost.
185/2	218	no2	5	Missed 2 sample tubes when loading carousel, samples dumped before error noticed. Code nutrients samples lost.
185/2	218	no3	5	Missed 2 sample tubes when loading carousel, samples dumped before error noticed. Code nutrients samples lost.
185/2	218	po4	5	Missed 2 sample tubes when loading carousel, samples dumped before error noticed. Code nutrients samples lost.
185/2	218	sio3	5	Missed 2 sample tubes when loading carousel, samples dumped before error noticed. Code nutrients samples lost.
185/2	229	o2	2	Overtitrated and backtitrated. Oxygen analyst's notes: filamental debris in sample. Oxygen agrees with both CTDO and adjoining stations. Rechecked endpoint: Graph is good. Oxygen is acceptable.
185/2	233	salt	2	Bottle salinity is low compared with CTD. Gradient and salinity structure, salinity, as well as oxygen and nutrients, is acceptable.
185/2	235	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
186/1	131	o2	2	Oxygen analyst's notes: power spike during read gave 1 erroneous value not used in slope computation. Oxygen value agrees with CTDO and pattern in adjoining stations. Rechecked endpoint: No analytical problems noted and graph is good. Oxygen is acceptable.
186/1	135	o2	2	Oxygen appears high compared with CTDO down trace and adjoining stations, agrees with the up trace. Oxygen, as well as salinity and nutrients, is acceptable.
186/1	135	salt	2	Bottle salinity is high compared with CTD. Gradient, agrees with adjoining stations. Salinity, as well as oxygen and nutrients, is acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
186/1	136	salt	3	Bottle salinity is high compared with CTD and adjoining stations. Bottle may not have been flushed well enough. Oxygen and nutrients are acceptable. Code salinity questionable.
187/2	233	bottle	2	Grease on bottle. Bottles were inspected and grease was not found inside. Salinity, oxygen and nutrients are acceptable.'
187/2	234	salt	2	Bottle salinity is low compared with CTD. Package was undulating about 1 meter during bottle trip causing "shed wakes". Salinity, as well as oxygen and nutrients, is acceptable.
188/1	103	salt	2	Bottle salinity is high compared with CTD and adjoining stations. No analytical problems noted, within accuracy of measurement. Salinity, as well as oxygen and nutrients, is acceptable.
188/1	104	salt	2	Bottle salinity is high compared with CTD and adjoining stations. No analytical problems noted, within accuracy of measurement. Salinity, as well as oxygen and nutrients, is acceptable.
188/1	134	o2	3	Oxygen high compared with CTDO and adjoining stations. Oxygen analyst: Rechecked endpoint: No analytical problems noted and graph is good. No corresponding SiO3 feature. Nutrients are acceptable. Code oxygen questionable.
188/1	135	bottle	2	Tripped when partially exposed at the surface, CFC said ~ 4" air in top of bottle. Oxygen, as well as salinity and nutrients, is acceptable.
189/2	201	salt	2	Bottle salinity is high compared with CTD and adjoining stations. This salinity run did appear to be a little high, but no analytical reason. Within accuracy of measurement, salinity, as well as oxygen and nutrients, is acceptable.
189/2	203	salt	2	Bottle salinity is high compared with CTD and adjoining stations. This salinity run did appear to be a little high, but no analytical reason. Within accuracy of measurement, salinity, as well as oxygen and nutrients, is acceptable.
189/2	204	bottle	2	Bottle was leaking from the bottom end cap. Salt and nutrients were sampled right away when leak was noted by oxygen sampler. Inspected bottle caps. Biological debris found on lower cap o-ring and brown gooeey stain on lower seal surface of bottle. Removed debris, cleaned bottle seal surfaces, replaced both end cap o-rings. Inspection of bottle interior found no traces of debris. Oxygen, as well as salinity and nutrients, is acceptable.
189/2	205	salt	2	Bottle salinity is high compared with CTD and adjoining stations. This salinity run did appear to be a little higher, but no analytical reason. Within accuracy of measurement, salinity, as well as oxygen and nutrients, is acceptable.
189/2	207	salt	2	Bottle salinity is high compared with CTD and adjoining stations. This salinity run did appear to be a little higher, but no analytical reason. Within accuracy of measurement, salinity, as well as oxygen and nutrients, is acceptable.
189/2	232	salt	2	Bottle salinity is low compared with CTD. Gradient, package creating "shed wakes" affecting the CTD, deeper higher salinity. Salinity, as well as oxygen and nutrients, is acceptable.
189/2	233	salt	2	Bottle salinity is low compared with CTD. Gradient, package creating "shed wakes" affecting the CTD, deeper higher salinity. Salinity, as well as oxygen and nutrients, is acceptable.
189/2	234	salt	2	Bottle salinity is low compared with CTD. Gradient, package creating "shed wakes" affecting the CTD, deeper higher salinity. Salinity, as well as oxygen and nutrients, is acceptable.
190/1	105	salt	2	Bottle salinity is high compared with CTD agrees with adjoining stations. Full sampling from this bottle, CFC, PH, TALK, DIC and CDOM seems to occasionally give higher bottle salinity. Salinity, as well as oxygen and nutrients, is acceptable.

Station /Cast	Sample No.	Quality Property		Code	Comment
190/1	107	salt		2	Bottle salinity is high compared with CTD agrees with adjoining stations. Salinity, as well as oxygen and nutrients, is acceptable.
190/1	109	o2		3	Oxygen high, ~ 0.07, compared with CTDO and adjoining stations. Code oxygen questionable. Oxygen analyst: Rechecked endpoint: No analytical problems noted and graph is good.
190/1	132	salt		2	Bottle salinity is high compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
191/2	203	salt		2	Bottle salinity is high compared with CTD and adjoining stations. 3 attempts for a good salinity reading. Additional reading resolved salinity difference. Salinity, as well as oxygen and nutrients, is acceptable.
191/2	204	salt		2	Bottle salinity is high compared with CTD and adjoining stations. 3 attempts for a good salinity reading. Additional readings resolved salinity difference. Salinity, as well as oxygen and nutrients, is acceptable.
191/2	205	salt		4	Bottle salinity is high compared with CTD and adjoining stations. 4 attempts for a good salinity reading. Additional readings did not resolve salinity difference. This bottle occasionally exhibits higher salinity, it seemed it was with large sampling, which was not the case on this stations. Oxygen and nutrients are acceptable. Code salinity bad.
191/2	233	salt		2	Bottle salinity is low compared with CTD. Agrees with down trace, structure in CTD and variations which appear to be caused by "shed wakes". Salinity, as well as oxygen and nutrients, is acceptable.
192/1	104	salt		2	Bottle salinity is high compared with CTD agrees with adjoining stations. Within accuracy of measurement, salinity, as well as oxygen and nutrients, is acceptable.
192/1	105	salt		2	Bottle salinity is high compared with CTD agrees with adjoining stations. Within accuracy of measurement, this bottle has been giving high values intermittently. Salinity, as well as oxygen and nutrients, is acceptable.
192/1	114	bottle		2	Bottle is leaking. Salinity, oxygen and nutrients are acceptable.
192/1	134	salt		2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
192/1	135	salt		2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
194/1	101	salt		2	Bottle salinity is high compared with CTD agrees with adjoining stations. Salinity, as well as oxygen and nutrients, is acceptable.
194/1	102	bottle		2	Leaking from the bottom end cap. The lanyard was stuck between bottle and end cap (leak fixed on deck). Oxygen, as well as salinity and nutrients, is acceptable.
194/1	130	o2		2	Oxygen overtitrated and backtitrated. Oxygen value agrees with both CTDO and adjoining stations. Rechecked endpoint: Graph is good. Oxygen is acceptable.
194/1	133	salt		2	Bottle salinity is high compared with CTD. Gradient, agrees with down trace. Salinity, as well as oxygen and nutrients, is acceptable.
195/3	302	salt		2	Bottle salinity is high compared with CTD agrees with adjoining stations. Deep gradient, salinity, as well as oxygen and nutrients, is acceptable.
195/3	303	salt		3	Bottle salinity is high compared with CTD and adjoining stations. No analytical problems noted. Oxygen and nutrients are acceptable. Code salinity questionable.
195/3	335	salt		2	Bottle salinity is high compared with CTD. Structure in CTD trace, salinity, as well as oxygen and nutrients, is acceptable.
196/1	133	salt		2	Bottle salinity is high compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
196/1	134	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
196/1	135	salt	2	Bottle salinity is high compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
197/2	233	salt	2	Bottle salinity is high compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
197/2	234	salt	2	Bottle salinity is high compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
198/1	104	o2	3	Oxygen is higher than both CTDO and adjoining stations. Rechecked endpoint: No analytical problems noted and graph is good. No corresponding SiO3 feature. Nutrients are acceptable. Oxygen is questionable.
198/1	118	o2	2	Oxygen was overtitrated and backtitrated. Oxygen value agrees with both CTDO and adjoining stations. Rechecked endpoint: Graph is good. Oxygen is acceptable.
198/1	133	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
198/1	135	salt	2	Bottle salinity is high compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
199/2	230	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
199/2	231	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
199/2	232	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.
199/2	234	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity, as well as oxygen and nutrients, is acceptable.