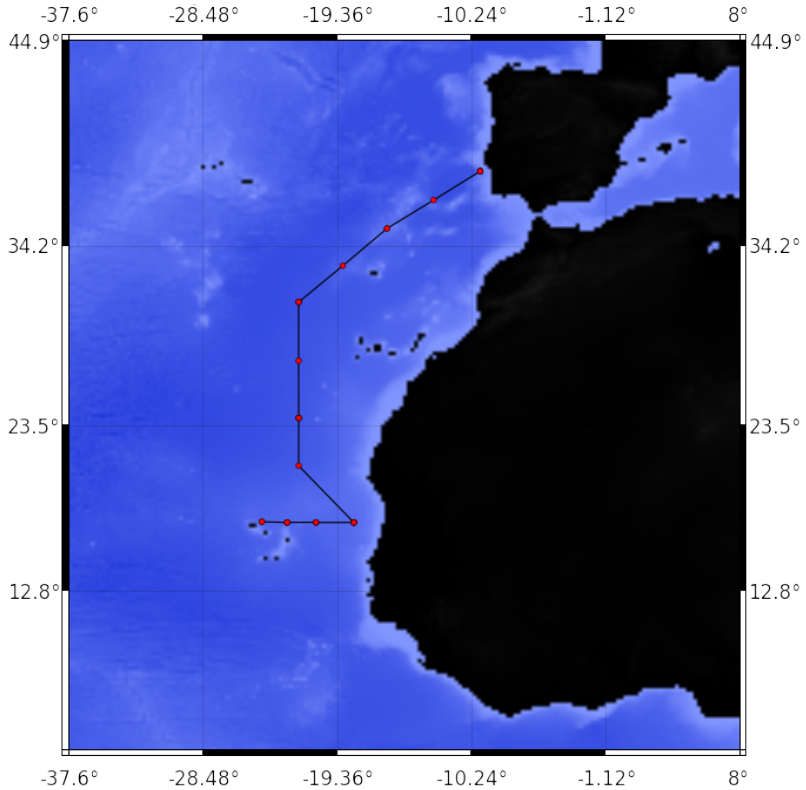
CRUISE REPORT: GT10

(Updated OCT 2013)



Highlights

Cruise Summary Information

WOCE Section Designation	**GT10**
Expedition designation (ExpoCodes)	**316N20101015**
Chief Scientists	**William Jenkins / WHOI**
Dates	2010 OCT 15 - 2010 NOV 5
Ship	*R/V KNORR*
Ports of call	Lisboa, Portugal - Porto Grande (Mindelo), Cabo Verde
Geographic Boundaries	38° 19' 41" N 24° 29' 59"W 9° 39' 36"W 17° 21' 1"
Stations	12
Floats and drifters deployed	0
Moorings deployed or recovered	0

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Links To Select Topics

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

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

GEOTRACES 2010

R/V Knorr, KN199-4

15 October 2010 - 5 November 2010

Lisboa, Portugal - Porto Grande (Mindelo), Cabo Verde

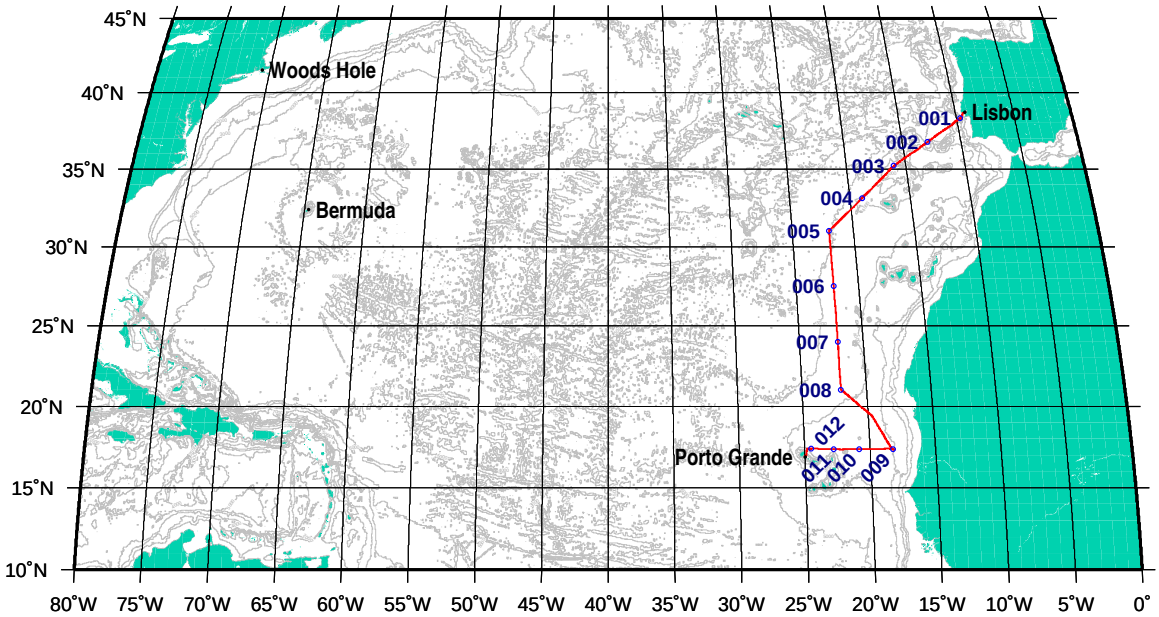
Chief Scientist: Dr. William Jenkins

Woods Hole Oceanographic Institution

Co-Chief Scientists:

Dr. Edward Boyle - Dr. Gregory Cutter

Woods Hole Oceanographic Institution - Old Dominion University



Cruise Report
5 March 2011

Data Submitted by:

Oceanographic Data Facility and Research Technicians
Shipboard Technical Support/Scripps Institution of Oceanography
La Jolla, CA 92093-0214

Summary

A hydrographic survey consisting of Rosette/CTD sections and Bio-Optical casts in the mid-latitude eastern Atlantic Ocean was carried out during October-November 2010. The R/V Knorr departed Lisboa, Portugal on 15 October 2010. Only 12 of the planned 36 stations were occupied due to mechanical failure of the R/V Knorr's propulsion system between stations 8 and 9, near the southeastern-most point of the cruise track. The cruise ended in Porto Grande (Mindelo), Cabo Verde on 5 November 2010.

Introduction

A sea-going science team gathered from 10 oceanographic institutions participated on the cruise. The programs and PIs, and the shipboard science team and their responsibilities, are listed below.

Principal Programs of GEOTRACES 2010

ODU/15L GoFlo CTDO/Rosette			
Program	Affiliation*	Princ. Investigator	email
CTD/Rosette Data NanoMolar Nutrients As Sb Se AP	ODU	Gregory Cutter	gcutter@odu.edu
Salinity Nutrients	UCSD/SIO	James H. Swift	jswift@ucsd.edu
Mercury	WHOI	Carl Lamborg	clamborg@whoi.edu
Fe Al Mn	UH	Chris Measures	chrism@soest.hawaii.edu
Mn V Ga REE	USM	Alan Shiller	alan.shiller@usm.edu
Pb, Pb Isotopes Polarographic Zn	MIT	Ed Boyle	eaboyle@mit.edu
SFE	MIT RSMAS	Ed Boyle Jingfeng Wu	eaboyle@mit.edu jwu@rsmas.miami.edu
Cobalt	WHOI WHOI	Mak Saito Abigail Noble	msaito@whoi.edu anoble@whoi.edu
Fe Fe(II)	ODU	Peter Sedwick	psedwick@odu.edu
Silver	UCSC	Celine Gallon	gallon@etox.ucsc.edu
L1/K1/L2/K2 of Fe and Cu	BIOS	Kristen Buck	kristen.buck@bios.edu
Dissolved Trace Metals: Al Cd Co Cu Ga Fe Pb Mn Ni Sc Ag Ti Zn	UCSC	Ken W. Bruland	bruland@ucsc.edu
Particulate/Cellular Trace Metals: Al P Mn Fe Co Ni Cu Zn Cd DCM	BLOS	Benjamin Twining	btwining@bigelow.org
Dissolved/Particulate Trace Metals: Mn Fe Co Ni Cu Zn Cd Pb	FSU	William Landing	wlanding@fsu.edu
Dissolved Trace Metals: Fe Al Zn Cd Mn	RSMAS	Jingfeng Wu	jwu@rsmas.miami.edu
Copper	USC	James Moffett	jmoffett@usc.edu
d ^{56}Fe d ^{57}Fe	SC	Seth John	sjohn@geol.sc.edu
Osmium	DART	Mukul Sharma	mukul.sharma@dartmouth.edu
Titanium	BU/URI	Rick Murray	rickm@bu.edu
Zirconium Hafnium	UBC UBC	Jason McAlister Kristin Orians	jmcalist@eos.ubc.ca korians@eos.ubc.ca

* Affiliation abbreviations listed on page 5

SIOR/30L Niskin CTD/Rosette			
Program	Affiliation*	Princ. Investigator	email
CTD/Rosette Data diss.O_2 Salinity Nutrients On-Board Data Website Data Management	UCSD/SIO	James H. Swift	jswift@ucsd.edu
CFCs SF_6	LDEO	William Smethie	bsmeth@ldeo.columbia.edu
$^3He/^4He$ diss.He ^3H, Ne	WHOI	William Jenkins	wjenkins@whoi.edu
^{14}C ^{13}C	UW WHOI/NOSAMS	Paul Quay William Jenkins	pdquay@u.washington.edu wjenkins@whoi.edu
DIC Total Alkalinity	RSMAS BIOS	Frank Millero Nick Bates	fmillero@rsmas.miami.edu nick.bates@bios.edu
$^{18}O-H_2O$	INETI UChicago	Antje Voelker Albert Colman	antje.voelker@ineti.pt asc25@uchicago.edu
AOP casts DOC POC CDOM AP SPM Chl.a HPLC Pigments	NASA	Stanford Hooker	Stanford.B.Hooker@nasa.gov
^{234}Th ^{238}U	WHOI	Ken Buesseler	kbuesseler@whoi.edu
$_{226}Ra$	WHOI SC	Matthew Charette Willard S. Moore	mcharette@whoi.edu moore@geol.sc.edu
DNA comp. of pico-cyanobacteria	MIT	Penny Chisholm	chisholm@mit.edu
DNA comp. of N-fixing organisms	IFM-GEOMAR	Julie LaRoche	jlaroche@ifm-geomar.de
d $^{15}N-NO_3$ d $^{18}O-NO_3$	WHOI PU	Karen L. Casciotti Daniel M. Sigman	kcasciotti@whoi.edu sigman@princeton.edu
Thiols	WHOI	Carl Lamborg	clamborg@whoi.edu
Barium	OSU	Kelly Falkner	kfalkner@coas.oregonstate.edu
^{232}Th ^{230}Th Pa ^{232}Th Colloids	LDEO UMN URI WHOI	Robert F. Anderson Larry Edwards Brad Moran Laura Robinson	boba@ldeo.columbia,edu edwar001@umn.edu moran@gso.uri.edu lrobinson@whoi.edu
Neodymium	LDEO SC	Steven Goldstein Howie Sher	steveg@ldeo.columbia.edu hscher@geol.sc.edu
REE (Rare Earth Elems.)	UH	Katharina Pahnke	kpahnke@hawaii.edu
^{210}Po ^{210}Pb	UDEL	Thomas M. Church	tchurch@udel.edu
Si Isotopes	UCSB	Mark A. Brzezinski	mark.brzezinski@lifesci.ucsb.edu
Plutonium	LDEO	Bob Anderson	boba@ldeo.columbia.edu

* Affiliation abbreviations listed on page 5

McL-Prof McLane *in situ* **Pump Profiles**			
Program	Affiliation*	Princ. Investigator	email
SBE19 CTD Data ^{234}Th ^{238}Th	WHOI	Ken Buesseler	kbuesseler@whoi.edu
Radium Isotopes	WHOI SC	Matthew Charette Willard S. Moore	mcharette@whoi.edu moore@geol.sc.edu
Particulate Th Pa	LDEO URI UMN WHOI	Robert F. Anderson Brad Moran Larry Edwards Laura Robinson	boba@ldeo.columbia.edu moran@gso.uri.edu edwar001@umn.edu lrobinson@whoi.edu
Particulate/Cellular Trace Metals: Al P Mn Fe Co Ni Cu Zn Cd	BLOS	Benjamin Twining	btwining@bigelow.org
Particulate Trace Metals: Fe Aa Mn Cd Cu Zn POC $CaCO_3$ bSi	WHOI	Phoebe J. Lam	pjlam@whoi.edu
Particulate ^{210}Pb ^{210}Po	WSU	Mark Baskaran	ag4231@wayne.edu

* Affiliation abbreviations listed on page 5

Towed Surface Fish			
Program	Affiliation*	Princ. Investigator	email
Trace Metals: Al Sc Ti Mn Fe Co Ni Cu Zn Ga Ag Cd Pb	UCSC	Ken W. Bruland	bruland@ucsc.edu
Particulate/Cellular Trace Metals: Al P Mn Fe Co Ni Cu Zn Cd Phytoplankton	BLOS	Benjamin Twining	btwining@bigelow.org
NanoMolar Nutrients As AP Se	ODU	Gregory Cutter	gcutter@odu.edu
Dissolved/Particulate Trace Metals: Mn Fe Co Ni Cu Zn Cd Pb	FSU	William Landing	wlanding@fsu.edu
Aerosol-derived Dissolved Fe	UAF	Ana M. Aguilar-Islas	amaguilarislas@alaska.edu
Aerosol Leaching Studies Trace Metal Conc.: Mn V Ga REE	USM	Alan Shiller	alan.shiller@usm.edu
Large Volume Particles	WHOI	Phoebe J. Lam	pjlam@whoi.edu
Dissolved Zn	MIT	Ed Boyle	eaboyle@mit.edu
Fe Fe(II)	ODU	Peter Sedwick	psedwick@odu.edu
Mercury	WHOI	Carl Lamborg	clamborg@whoi.edu

* Affiliation abbreviations listed on page 5

Miscellaneous Sampling			
Program	Affiliation*	Princ. Investigator	email
Aerosols (3 systems) Rain Sampler - Mercury	FSU	William Landing	wlanding@fsu.edu
Aerosol Sampler - Dissolved Fe	UAF	Ana M. Aguilar-Islas	amaguilarislas@alaska.edu
Ship's Underway Sensors	WHOI	Knorr SSSG Technicians	sssg@knorr.whoi.edu

* Affiliation abbreviations listed on page 5

Shipboard Scientific Personnel on GEOTRACES 2010

Name	Affiliation	Shipboard Duties	Shore Email
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Gregory Cutter	ODU	Co-Chief Scientist	gcutter@odu.edu
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Katlin Bowman	WHOI	Mercury	bowman.49@wright.edu
Kristen Buck	BIOS	Diss.Fe/Fe Speciation	kristen.buck@bios.edu
Gonzalo Carrasco Rebaza	MIT	Labile Zn	gcarrasc@odu.edu
Joaquin Chaves Cedeño	NASA	CDOM/DOC/POC/Chl.a	joaquin.chaves@ssaihq.com
Jessica Fitzsimmons	MIT	GoFlo Sampling	jfitzsimmons@whoi.edu
Eugene Gorman	LDEO	CFCs/SF6	egorman@ldeo.columbia.edu
Mariko Hatta	UH	Al/Fe/Mn	mhatta@hawaii.edu
Christopher Hayes	LDEO	Th/Pa/Nd/REE	cth@ldeo.columbia.edu
Jeremy Jacquot	USC	Copper, DNA Sampling	jacquot@usc.edu
Mary Carol Johnson	UCSD/SIO	Data Manager	mcj@ucsd.edu
Carl Lamborg	WHOI	Mercury/Thiols	clamborg@whoi.edu
Robert Laird	WHOI	SSSG Tech.	rlaird@whoi.edu
Christopher Measures	UH	Al/Fe/Mn	chrism@soest.hawaii.edu
Paul Morris	WHOI	McLane Pumps	pmorris@whoi.edu
Peter Morton	FSU	GoFlo Sampling	pmorton@fsu.edu
Abigail Noble	WHOI	Cobalt	anoble@whoi.edu
Daniel Ohnemus	WHOI	McLane Pumps	dan@whoi.edu
Stephanie Owens	WHOI	McLane Pumps, U/Ra Sampling	sowens@whoi.edu
Katharina Pahnke	UH	Th/Pa/Nd/REE	kpahnke@hawaii.edu
Robert Palomares III	UCSD/SIO	ET/Salinity/Deck	rpalomares@ucsd.edu
Sara Rauschenberg	BLOS	Partic./Cell. TM	srauschenberg@bigelow.org
Rachel Shelley	FSU	Aerosols	rachel.shelley@plymouth.ac.uk
Geoffrey Smith	UCSC	Towed Fish	geosmit@ucsc.edu
Bettina Sohst	ODU	FeII	bsohst@odu.edu
Moulaye Mohamed Wagne	IMROP	Observer	TBA
Oliver Wurl	ODU	Antimony/Arsenic	owurl@odu.edu
Anton Zafereo	WHOI	SSSG Tech.	azafereo@whoi.edu
Kuanbo Zhou	WHOI	McLane Pumps	kbzhou@xmu.edu.cn
Louise Zimmer	ODU	NanoNutrients/GT-C Console	lzimmer@odu.edu

* Affiliation abbreviations are listed on page 5

KEY to Institution Abbreviations	
BIOS	Bermuda Institute of Ocean Sciences
BLOS	Bigelow Laboratory for Ocean Sciences
BU	Boston University
DART	Dartmouth College
FSU	Florida State University
IFM-GEOMAR	Leibniz-Institut für Meereswissenschaften an der Universität Kiel
IMROP	Mauritanian Institute for Oceanographic Research and Fisheries
INETI	Instituto Nacional de Engenharia, Tecnologia e Inovação (Portugal)
LDEO	Lamont-Doherty Earth Observatory
MIT	Massachusetts Institute of Technology
NASA	National Aeronautics and Space Administration
ODU	Old Dominion University
PU	Princeton University
SC	University of South Carolina
SSSG	Shipboard Scientific Services Group (WHOI)
STS/ODF	Shipboard Technical Support/Oceanographic Data Facility (UCSD/SIO)
STS/RT	Shipboard Technical Support/Research Technicians (UCSD/SIO)
UAF	University of Alaska, Fairbanks
UBC	University of British Columbia
UCSB	University of California, Santa Barbara
UCSC	University of California, Santa Cruz
UCSD/SIO	University of California, San Diego/Scripps Institution of Oceanography
UDEL	University of Delaware
UH	University of Hawaii
UMN	University of Minnesota
UM/RSMAS	University of Miami/Rosenstiel School of Marine and Atmospheric Science
URI	University of Rhode Island
USC	University of Southern California
USM	University of Southern Mississippi
UW	University of Washington
WHOI	Woods Hole Oceanographic Institution
WSU	Wayne State University

Description of Measurement Techniques

1. CTD/Hydrographic Measurements Program

Two types of Rosette/SBE9*plus* CTD casts (34 SIOR/30L-Niskin and 19 GT-C/15L-GoFlo) were made at 12 station locations during GEOTRACES 2010. 8 shallow and 8 deep McLane pump profiles were done at all Full and Super Stations, with an SBE19*plus* CTD attached to the end of the wire. 3-4 Apparent Optical Properties (AOP) casts were done mid-day (local time) on 10 different days at 9 station locations, between other casts whenever possible.

Station Type	Station Nos.	Total Casts	Cast Types
Super	1, 9	10	3 Deep SIOR/30L Niskin 3 Shallow SIOR/30L Niskin 1 Deep GT-C/15L GoFlo 1 Shallow GT-C/15L GoFlo 1 Deep McLane Pump 1 Shallow McLane Pump
Full	3, 5, 7, 10-12	7	1 Deep SIOR/30L Niskin 2 Shallow SIOR/30L Niskin 1 Deep GT-C/15L GoFlo 1 Shallow GT-C/15L GoFlo 1 Deep McLane Pump 1 Shallow McLane Pump
Demi	2, 4, 6, 8	1-2	1 Shallow SIOR/30L Niskin 1 Shallow GT-C/15L GoFlo (exc. Sta. 4)

Table 1.0 GEOTRACES 2010 Station/Cast Summary

Hydrographic measurements consisted of salinity and nutrient water samples taken from each Rosette cast, plus dissolved oxygen from each SIOR Rosette cast. In addition, salinity samples were taken from the surface pump at one SIOR ^{234}Th cast per station, and from Niskins attached to each McLane pump on deep pump casts only. Pressure, temperature, conductivity/salinity, dissolved oxygen, transmissometer and fluorometer data were recorded from all CTD/Rosette profiles. The distribution of samples is shown in figure 1.0.

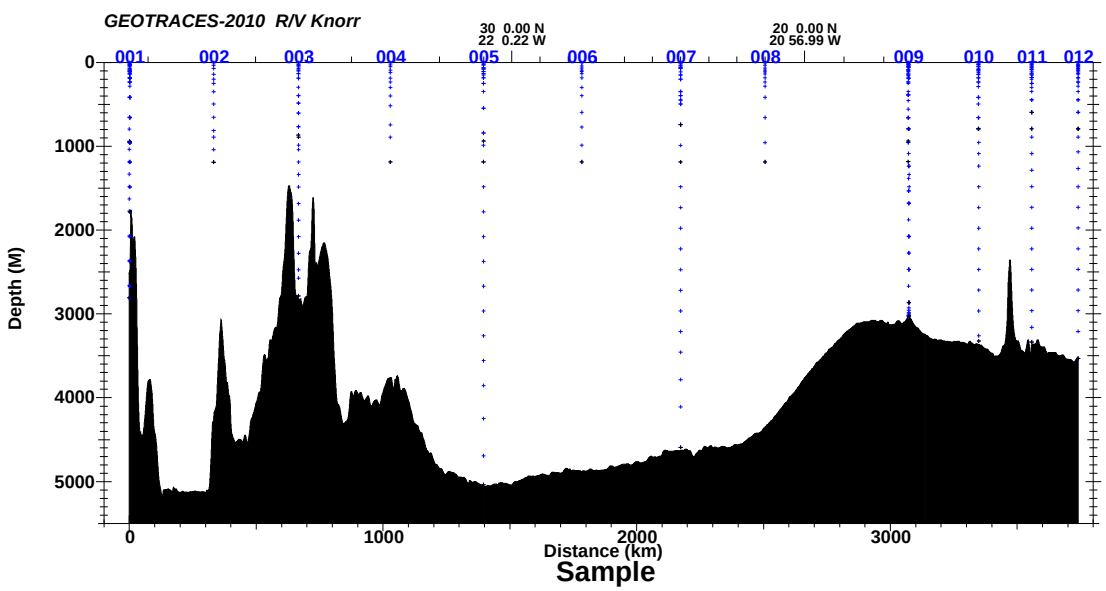

Figure 1.0 GEOTRACES 2010 Sample distribution, stations 1-12.

1.1. SIOR/30L-Niskin Water Sampling Package

SIOR/30L-Niskin Rosette/CTD casts were performed with a package consisting of a 12-bottle rosette frame (SIO/STS), a 24-place carousel (SBE32) and 12 30L General Oceanics bottles with an absolute volume of 30L each. Underwater electronic components consisted of a Sea-Bird Electronics SBE9*plus* CTD with dual pumps (SBE5), dual temperature (SBE3*plus*), reference temperature (SBE35RT) dual conductivity (SBE4C), dissolved oxygen (SBE43), transmissometer (WET Labs CStar), fluorometer (Seapoint SCF) and altimeter (Tritech LPRA-200 or Simrad 807).

The CTD was mounted horizontally in an SBE CTD cage attached to and centered on the bottom of the rosette frame, allowing free flow of water to the temperature sensor. The SBE3*plus* temperature, SBE4C conductivity and SBE43 dissolved oxygen sensors and their respective pumps and tubing were mounted horizontally in the CTD cage. The transmissometer was mounted horizontally, and the fluorometer was mounted horizontally near the bottom of the rosette frame. The altimeter was mounted on the inside of the bottom frame ring.

The rosette system was suspended from a UNOLS-standard three-conductor 0.322" electro-mechanical sea cable. The sea cable was terminated at the beginning of GEOTRACES 2010. The R/V Knorr's Markey DESH-5 winch was used for all casts.

The deck watch prepared the rosette 5-15 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 forward hangar to the deployment location under the squirt boom using an air-powered cart and tracks. The CTD was powered-up and the data acquisition system started from the main lab. Tag lines were threaded through the rosette frame and syringes were removed from CTD intake ports. The rosette was unstrapped from the air-powered cart. The winch operator was directed by the deck watch leader to raise the package. The A-frame and rosette were extended outboard and the package was quickly lowered into the water. Tag lines were removed and the package was lowered to 10 meters, until the console operator determined that the sensor pumps had turned on and the sensors were stable. The winch operator was then directed to bring the package back to the surface, re-zero the wireout and start the descent.

Most rosette casts were lowered to within 15-20 meters of the bottom, using the altimeter, winch wireout, CTD depth and echosounder depth to determine the distance.

For each up cast, the winch operator was directed to stop the winch at up to 12 pre-determined sampling depths, determined by the GEOTRACES program participants prior to the cruise. To ensure that package shed wake had dissipated, the CTD console operator waited 30 to optimally 60 seconds prior to tripping sample bottles. An additional 10-second wait was required after tripping a bottle before moving to the next consecutive trip depth, to allow the SBE35RT time to take its readings. The deck watch leader directed the package to the surface after the last bottle trip.

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 to the deck mounted air tuggers. The rosette was secured on the cart and moved into the forward hangar for sampling. The bottles and rosette were examined before samples were taken, and anything unusual was noted on the sample log.

Each bottle on the rosette had a unique serial number, independent of the bottle position on the rosette. Sampling for specific programs was outlined on sample log sheets prior to cast recovery or at the time of collection.

Routine CTD maintenance included soaking the conductivity and oxygen sensors in fresh water between casts to maintain sensor stability, and putting dilute 0.1% Triton-X solution through the conductivity sensors to eliminate any accumulating bio-films. Rosette maintenance was performed on a regular basis. Valves and o-rings were inspected for leaks. The rosette, CTD and carousel were rinsed with fresh water as part of the routine maintenance.

1.2. SIOR Underwater Electronics and Laboratory Calibrations

The SIOR SBE9*plus* CTD supplied a standard SBE-format data stream at a data rate of 24 frames/second. The sensors and instruments used during GEOTRACES 2010, along with pre-cruise laboratory calibration information, are listed below. Copies of the pre-cruise calibration sheets for various sensors are included in Appendix D.

Instrument/Sensor	Mfr./Model*	Serial Number	CTD Channel	Pre-Cruise Calibration Date	Pre-Cruise Calibration Facility*
Carousel Water Sampler	SBE32 (24-Pl.)	3252161-0699	n/a		
CTD	SBE9*plus*	09P39801-0796	n/a		
Pressure	Paroscientific Digiquartz 401K-105	796-98627	Freq.2	28-Apr-2010	SIO/STS
Primary					
Temperature (T1)	SBE3*plus*	03P-4532	Freq.0	24-Aug-2010	SIO/STS
Conductivity (C1)	SBE4C	04-1879	Freq.1	19-Aug-2010	SBE
Dissolved Oxygen	SBE43	43-1129	Aux2/V2	19-Aug-2010	SBE
Pump	SBE5T	05-4377	n/a		
Secondary					
Temperature (T2)	SBE3*plus*	03P-4588	Freq.3	22-Jul-2010	SIO/STS
Conductivity (C2)	SBE4C	04-2659	Freq.4	19-Aug-2010	SBE
Pump	SBE5T	05-3626	n/a		
Transmissometer	WETLabs C-Star	CST-492DR	Aux3/V4	01-Mar-2010	WETLabs
Chlorophyll Fluorometer	Seapoint	SCF2775	Aux4/V6	*ca*17-Dec-2009	Seapoint
Altimeter (except sta.12/6)	Tritech LPRA-200	221666	Aux1/V0		
Altimeter (sta.12/6 ONLY)	Simrad 807	9711091	Aux1/V0		
Reference Temperature	SBE35RT	3528706-0035	n/a	20-Jun-2009	SBE
Deck Unit (in lab)	SBE11*plus* V2	11P52161-0788	n/a		

*SBE = Sea-Bird Electronics

Table 1.2.0 GEOTRACES 2010 SIO Rosette Underwater Electronics.

An 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 SBE35RT was utilized per the manufacturer's specifications and instructions, as described in SBE's manual (*http://www.seabird.com/pdf_documents/manuals/36_015.pdf*).

The SBE9*plus* CTD was connected to the SBE32 24-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 Tritech LPRA-200 or Simrad 807 altimeter was provided through the sea cable from the Knorr's SBE11*plus* deck unit in the main lab.

1.3. Navigation and Bathymetry Data Acquisition

Navigation data were acquired at 1-second intervals from the ship's Furuno 1850 GPS receiver by a Linux system beginning October 15, 2010, starting a few hours before the ship departed Lisboa, Portugal until after the ship docked in Porto Grande, Cabo Verde on November 5. A few acquisition gaps during the cruise were filled in with 1-minute GPS data stored on the Knorr's underway system.

Bathymetric data were acquired from the Knudsen 12KHz single-beam echosounder, but not stored in the Knorr's underway system. Due to the untimely zapping of the primary SIO/STS acquisition system, underway depths were not recorded electronically, as there was only one non-USB serial input available for the laptop re-purposed to take its place.

The reported bottom depths associated with SIOR-30L Niskin rosette casts were recorded manually on the Console Logs during deployments. Depths were also manually recorded at the start of each deep McLane Pump cast.

1.4. SIOR CTD Data Acquisition and Rosette Operation

A Linux desktop PC CTD data acquisition system was set up for the SIOR rosette, and successfully ran a test cast between Lisboa and station 1. However, it refused to power-on following the lab fire on the other side of the bulkhead while the ship transited to Station 1. The backup Linux desktop PC had not functioned properly since arriving at the ship (mentally "too slow" to accomplish anything useful). Switching power supplies between the two systems did not resolve the power-on problem, and station 1 was imminent. So the R/V Knorr's CTD acquisition system was updated with the latest SBE SEASOFT software as the ship arrived at station 1, and set up to acquire all SIOR casts.

The SIOR CTD data acquisition system consisted of an SBE-11*plus* V2 Deck Unit (SIO's) and a networked generic PC workstation (R/V Knorr's) running Windows 2000(SP3). The PC was connected to the CTD Deck Unit via IEEE-488 (CTD signal) and RS-232 (modem channel for carousel communication). SBE Seasave V 7.20g software was used to set up and acquire data, to monitor the deployment and to close bottles on the rosette. A NMEA 0183 feed from the ship was added to the deck unit; ship's position, date/time and bottle-trip information were added to the data stream by the deck unit or Seasave software.

A Dell laptop PC running CentOS-5.5 Linux was re-configured to post-process CTD data for both rosettes, and to run a website and database server to update and maintain the hydrographic database for GEOTRACES 2010. It also acquired and stored navigation data directly from the ship's GPS receiver to associate with various events during the cruise. The PC also synced with the ship's timeserver on a regular basis to keep accurate UTC time.

SIOR CTD deployments were initiated by the console watch after the ship stopped on station. The acquisition program was started and the deck unit turned on at least 2 minutes prior to package deployment. 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.

After the deck watch had deployed the rosette, the winch operator lowered it to 10 meters. The CTD sensor pumps were configured with a 5-second startup delay after detecting seawater conductivities. The console operator checked the CTD data for proper sensor operation and waited 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 in the top 100m, and no more than 60m/min deeper than 100m, 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, allowing a safe approach to within 15-20 meters.

Bottles were closed on the up cast by operating an on-screen control. The winch operator was directed to slow to 30m/min at 100m above the target depth, then the final wireout was adjusted using the altimeter reading. Bottles were optimally tripped 60 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 ensure that stable CTD data were associated with the trip and to allow the SBE35RT temperature sensor to make a measurement.

After the last bottle was closed, the console operator directed the winch operator and 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.

1.5. SIOR CTD Data Processing

Shipboard CTD data processing was performed automatically at the end of each deployment using SIO/STS CTD processing software v.5.1.6-1. Raw CTD data and bottle trips acquired by SBE Seasave on both Windows 2000 workstations (SIOR and GT-C) were copied onto the Linux database and web server

system, providing a backup of the raw data. Pre-cruise laboratory calibrations were applied, then CTD data were processed into a 0.5-second time series, bottle trips were extracted, and a 1-decibar down-cast pressure series of the data was created. The pressure-series data were used by the web service for interactive plots, sections and CTD data distribution. Time-series data, and eventually basic up-cast pressure-series data, were also available for distribution through the website.

SIOR CTD data were examined at the completion of each deployment for clean corrected sensor response and any calibration shifts. As bottle salinity and oxygen results became available, they were used to refine shipboard conductivity and oxygen sensor calibrations.

Theta-S and theta-O_2 comparisons were made between down and up casts as well as between groups of adjacent deployments. Vertical sections of measured and derived properties from sensor data were checked for consistency.

The Tritech altimeter was used for 33 SIOR casts, until it failed to work at the start of the 34th/last cast (station 12 cast 6). The rosette was brought back aboard, where the altimeter was changed out for the backup Simrad altimeter; the cast was re-started within half an hour. After recovery of the SIOR rosette on this last cast, it was observed that the rosette frame was cracked in several places and required repair before any further deployments. It was later determined that the Tritech altimeter had flooded.

1.6. SIOR CTD Shipboard Calibration Procedures

CTD #796 was used for all SIOR Rosette/CTD casts during GEOTRACES 2010. The CTD was deployed with all sensors and pumps aligned horizontally, due to limited vertical clearance inside the 12-place/30L rosette. The primary temperature sensor (T1/03P-4532) and conductivity sensor (C1/04-1879) were used for all reported CTD data.

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_2 check samples collected during each cast were used to calibrate the conductivity and dissolved O_2 sensors.

1.6.1. CTD Pressure

The Paroscientific Digiquartz pressure transducer (S/N 796-98627) was calibrated in April 2010 at the SIO/STS Calibration Facility. The calibration coefficients provided on the report were used to convert frequencies to pressure; then the calibration correction slope and offset were applied to the converted pressures during each cast. Pre- and post-cast on-deck/out-of-water pressure offsets varied from -0.34 to -0.11 dbar before the casts, and -0.47 to -0.19 dbar after the casts. No adjustments were made to calculated pressures.

1.6.2. CTD Temperature

The same primary (T1/03P-4532) and secondary (T2/03P-4588) temperature sensors were used during all GEOTRACES 2010 casts. Calibration coefficients derived from the pre-cruise calibrations, plus shipboard temperature corrections determined during the cruise, were applied to raw primary and secondary sensor data during each cast.

A single SBE35RT was used as a tertiary temperature check. It was located equidistant between T1 and T2 with the sensing element aligned in a plane with the T1 and T2 sensing elements. 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 GEOTRACES 2010 was set to internally average over a 4.4 second period.

Two independent metrics of calibration accuracy were examined. At each bottle closure, the primary and secondary temperature were compared with each other and with the SBE35RT temperatures.

A single temperature correction was required for each sensor during GEOTRACES 2010. Both primary and secondary temperature sensors exhibited a linear pressure response compared to the SBE35RT. To prevent skewing at the deep end, the pressure-dependent slope for each temperature sensor was determined by giving 10x weight to the 2 casts that exceeded 4500 dbars (005/06 and 007/06), but

included data from all casts. Offsets for both temperature sensors remained fairly stable through-out the cruise.

The final corrections for both temperature sensors used on GEOTRACES 2010 are summarized in Appendix A. All corrections made to CTD temperatures had the form:

$$T_{cor} = T + tp_1 P + t_0$$

Residual temperature differences after correction are shown in figures 1.6.2.0 through 1.6.2.4.

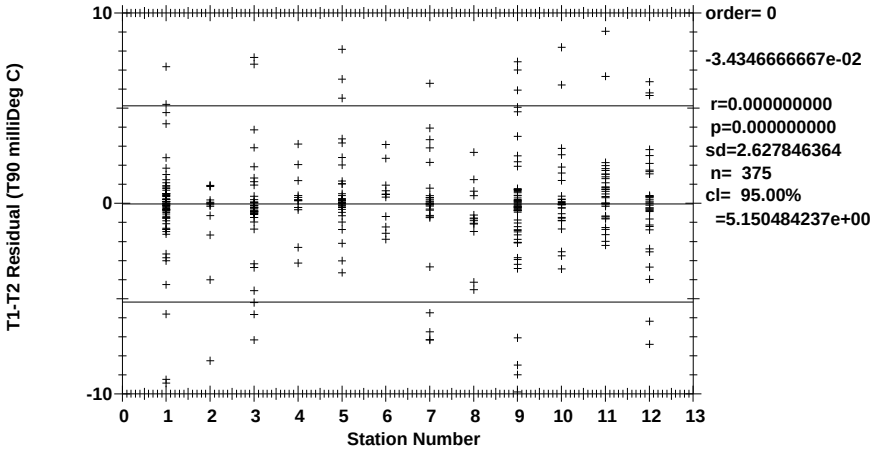

Figure 1.6.2.0 T1-T2 by station (-0.01°C $\leq T1 - T2 \leq$ 0.01°C).

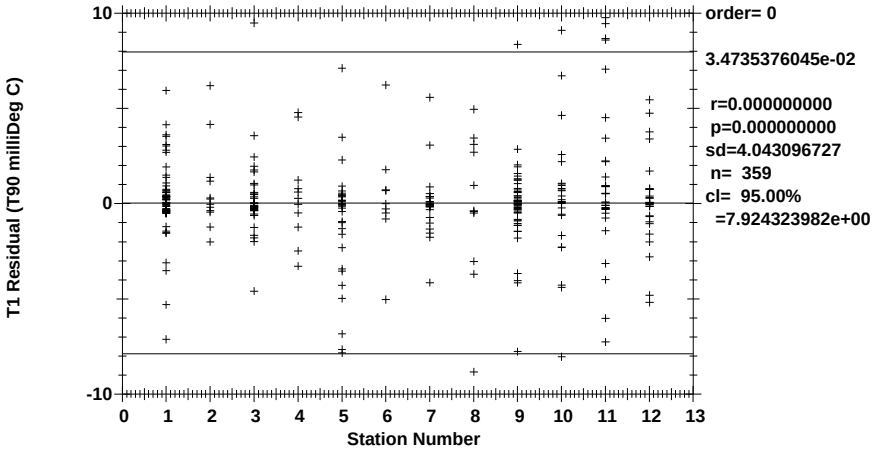

Figure 1.6.2.1 SBE35RT-T1 by station (-0.01°C $\leq T1 - T2 \leq$ 0.01°C).

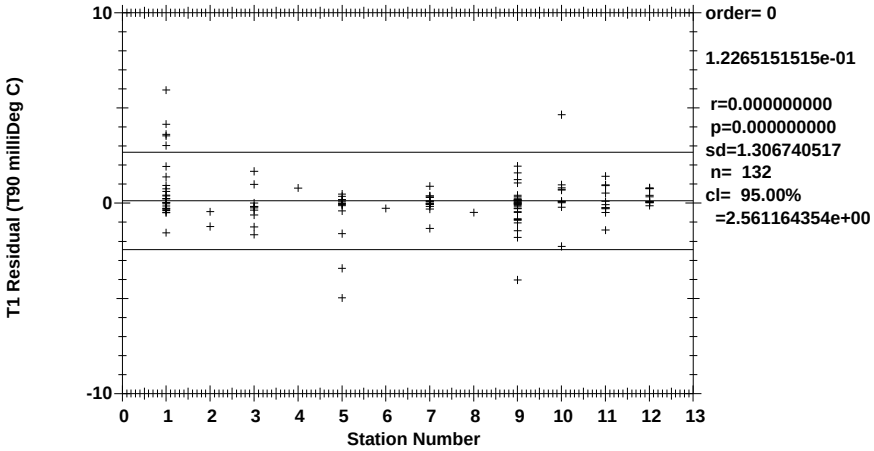

Figure 1.6.2.2 Deep SBE35RT-T1 by station (Pressure >= 1000dbar).

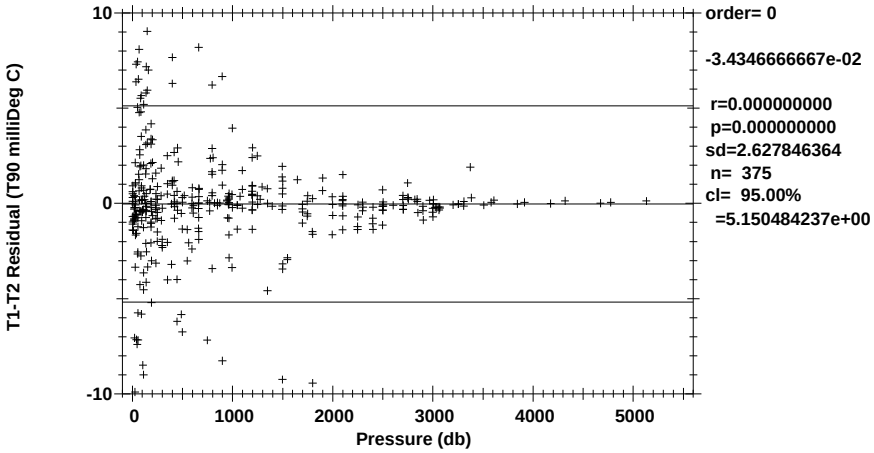

Figure 1.6.2.3 T1-T2 by pressure (-0.01°C $\leq T1 - T2 \leq$ 0.01°C).

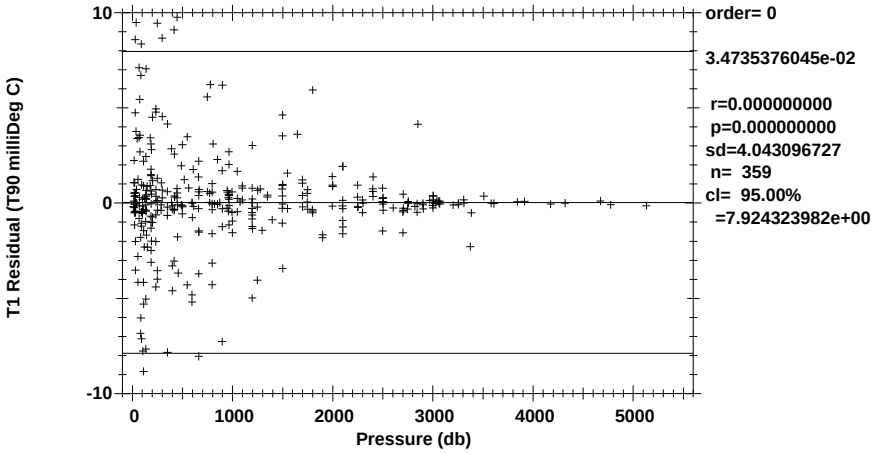

Figure 1.6.2.4 SBE35RT-T1 by pressure (-0.01°C $\leq T1 - T2 \leq$ 0.01°C).

The 95% confidence limits for the mean low-gradient differences are ±0.00515°C for T1-T2, ±0.00792°C for SBE35RT-T1. The 95% confidence limit for deep temperature residuals (where pressure > 1000db) is ±0.00298°C for T1-T2 and ±0.00256°C for SBE35R T-T1.

1.6.3. CTD Conductivity

The same primary (C1/04-1879) and secondary (C2/04-2659) conductivity sensors were used during all GEOTRACES 2010 casts. Calibration coefficients derived from the pre-cruise calibrations were applied to convert raw frequencies to conductivity. Shipboard conductivity corrections, determined during the cruise, were applied to primary and secondary conductivity data for each cast.

Corrections for both CTD temperature sensors were finalized before analyzing conductivity differences. Two independent metrics of calibration accuracy were examined. At each bottle closure, the primary and secondary conductivity were compared with each other. Each sensor was also compared to conductivity calculated from check sample salinities using CTD pressure and temperature.

The differences between primary and secondary temperature sensors were used as filtering criteria to reduce the contamination of conductivity comparisons by package wake. The coherence of this relationship is shown in figure 1.6.3.0.

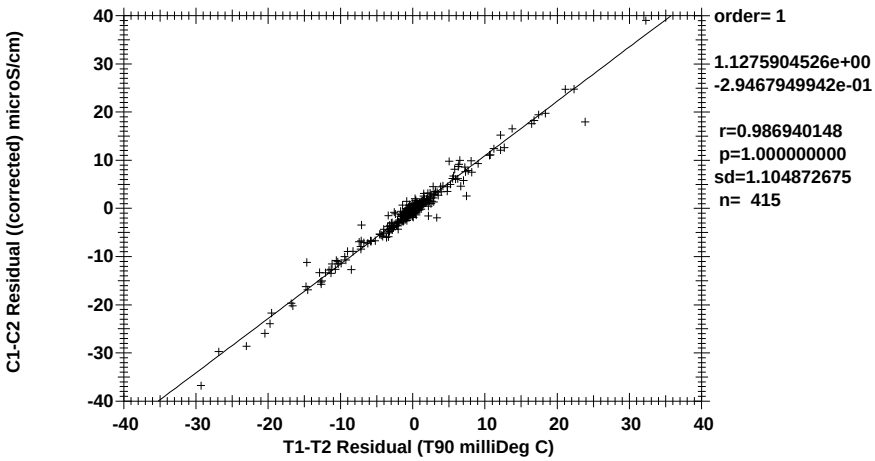

Figure 1.6.3.0 Coherence of conductivity differences as a function of temperature differences.

Uncorrected conductivity comparisons are shown in figures 1.6.3.1 through 1.6.3.3.

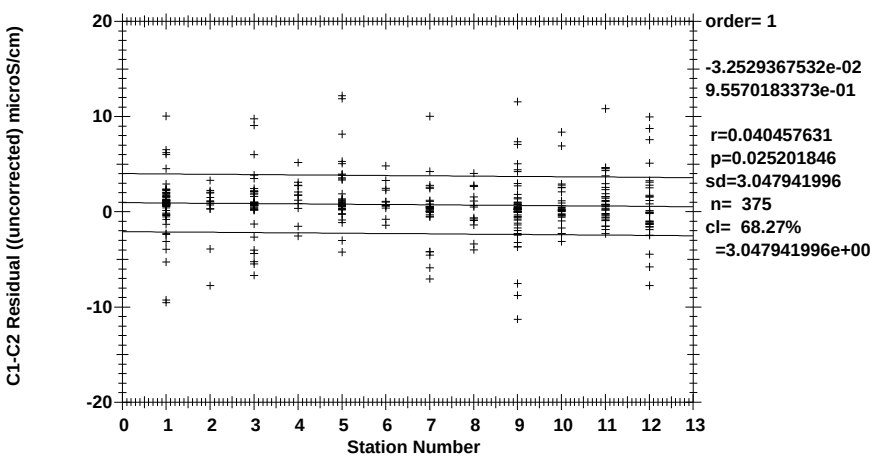

Figure 1.6.3.1 SIOR Uncorrected $C1-C2$ by station (-0.01°C $\leq T1-T2 \leq$ 0.01°C).

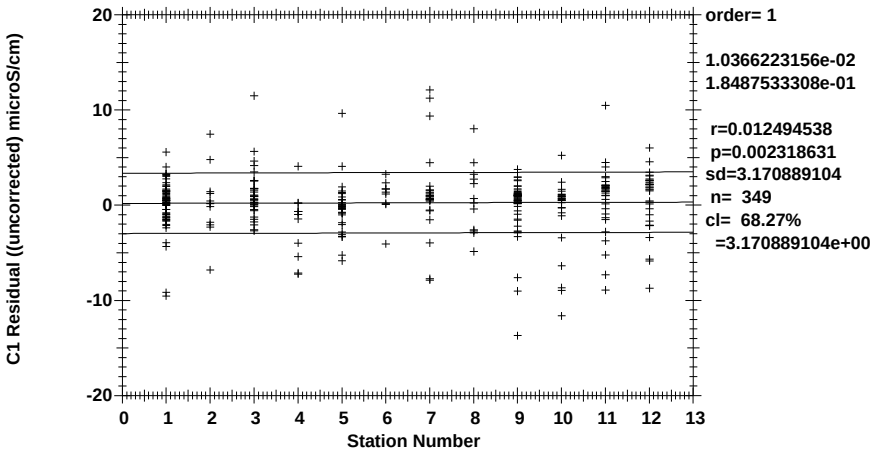

Figure 1.6.3.2 SIOR Uncorrected $C_{Bottle} - C1$ by station (-0.01°C $\leq T1 - T2 \leq$0.01°C).

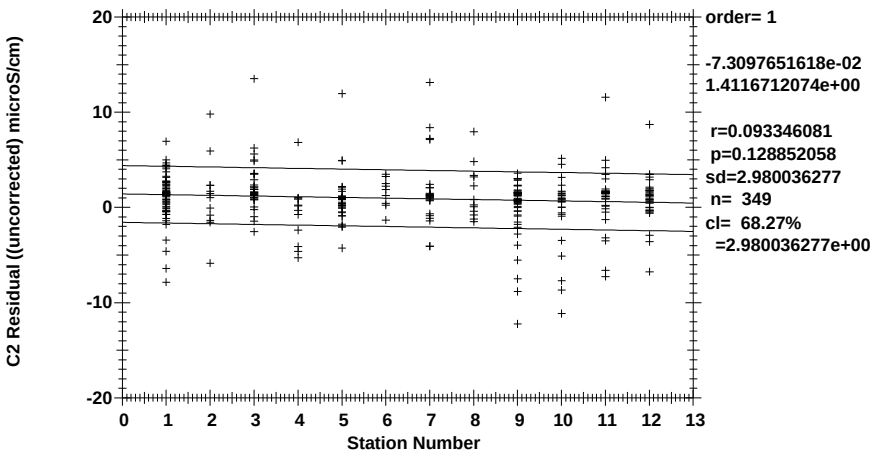

Figure 1.6.3.3 SIOR Uncorrected $C_{Bottle} - C2$ by station (-0.01°C ≤T1-T2≤0.01°C).

Offsets for each C sensor were determined using $C_{Bottle} - C_{CTD}$ differences in a deep pressure range (1200-3000 dbars) that would include deep data from all Full and Super stations. Station 5 was excluded from this preliminary offset calculation because the differences were low for both C1 and C2 vs bottle data (indicating a bottle salinity issue). Stations 11 and 12 were also excluded from the calculation because of an apparent drift in C1 starting somewhere during station 11.

After conductivity offsets were applied to all casts (including 5, 11 and 12), linear pressure responses were evident for each conductivity sensor. C1 and C2 pressure-dependent corrections were determined separately, using $C_{Bottle} - C1_{CTD}$ differences for stations 1-10 only, where pressures were deeper than 1200 dbars and T1-T2 differences were within $\pm$0.005°C. Excluding shallower values corrected deep conductivity data without skewing the shallow data.

After the pressure dependency was corrected, stations 11 and 12 were re-examined to determine appropriate adjustments to C1 offsets for each cast. Deep Theta-S overlays showed that deep CTD data overlaid well for S1 on the last 4 stations, but not for S2. GT-C CTD data were examined at this point, and both sensor pairs clearly shifted like the SIOR Theta2/S2 plots and bottle data. Adjustments to C1 offsets for stations 11 and 12 were determined using C2 data. Results for the shallower casts were inconclusive; but the deeper casts required adjustment: +0.0008 mS/cm for station 11 cast 6, and +0.002 mS/cm for station 12 cast 6. In addition, offsets of +0.0012 and +0.0016 mS/cm were applied to station 12 casts 2 and 4, respectively, assuming a steady drift between the two deeper casts.

$C_{Bottle} - C_{CTD}$ differences were then evaluated for response to temperature and/or conductivity, which typically shifts between pre- and post-cruise SBE laboratory calibrations. C1 required a linear correction

as a function of conductivity, but C2 results showed no clear dependency. C1 conductivity slope was adjusted using C2-C1 differences, then the C1 offset was shifted slightly to match bottle data. C1 offsets for stations 11 and 12 were re-checked: station 12/4 was adjusted back by -0.0002 mS/cm to align better with the rest of the casts.

The residual conductivity differences after correction are shown in figures 1.6.3.4 through 1.6.3.15.

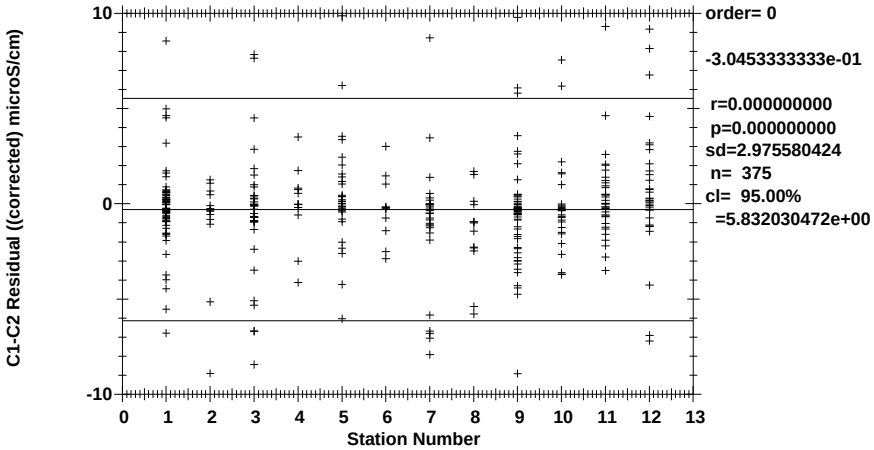

Figure 1.6.3.4 SIOR Corrected $C1-C2$ by station (-0.01°C ≤T1-T2≤0.01°C).

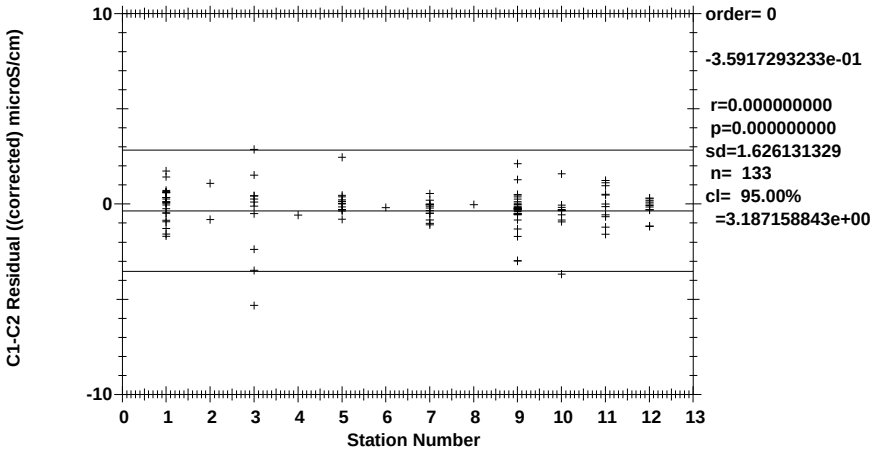

Figure 1.6.3.5 SIOR Deep Corrected $C1-C2$ by station (Pressure >= 1000dbar).

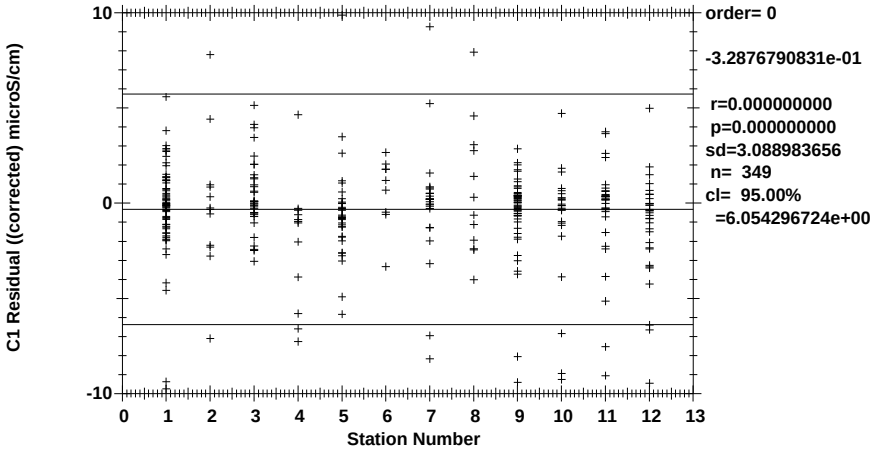

Figure 1.6.3.6 SIOR Corrected $C_{Bottle} - C1$ by station (-0.01°C ≤T1-T2≤0.01°C).

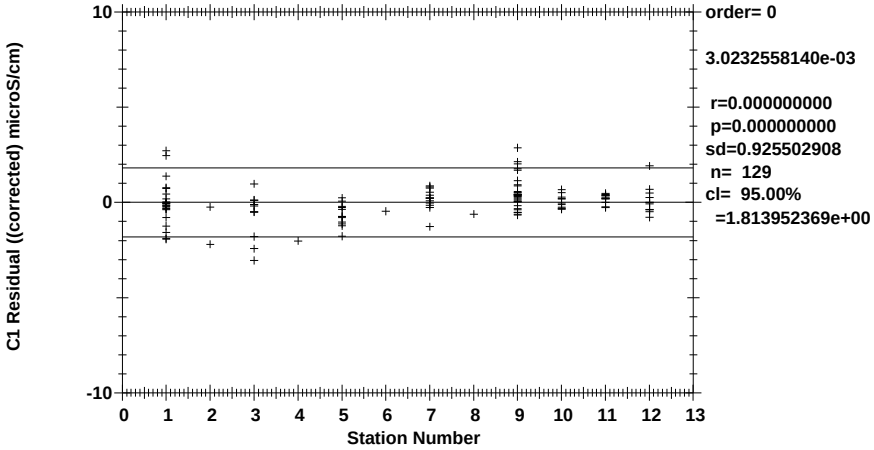

Figure 1.6.3.7 SIOR Deep Corrected $C_{Bottle} - C1$ by station (Pressure >= 1000dbar).

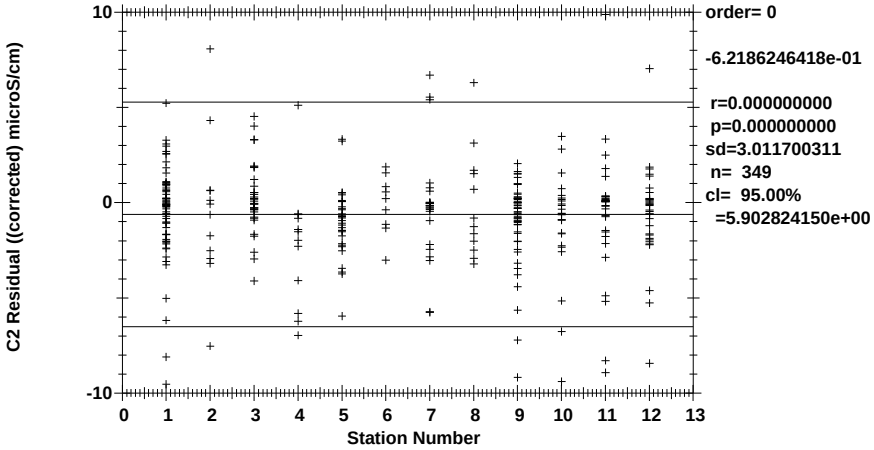

Figure 1.6.3.8 SIOR Corrected $C_{Bottle} - C2$ by station (-0.01°C ≤T1-T2≤0.01°C).

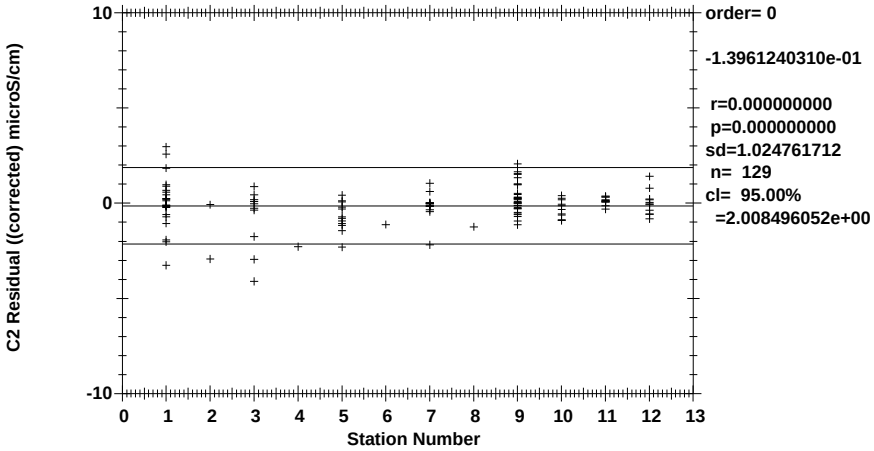

Figure 1.6.3.9 SIOR Deep Corrected $C_{Bottle} - C2$ by station (Pressure >= 1000dbar).

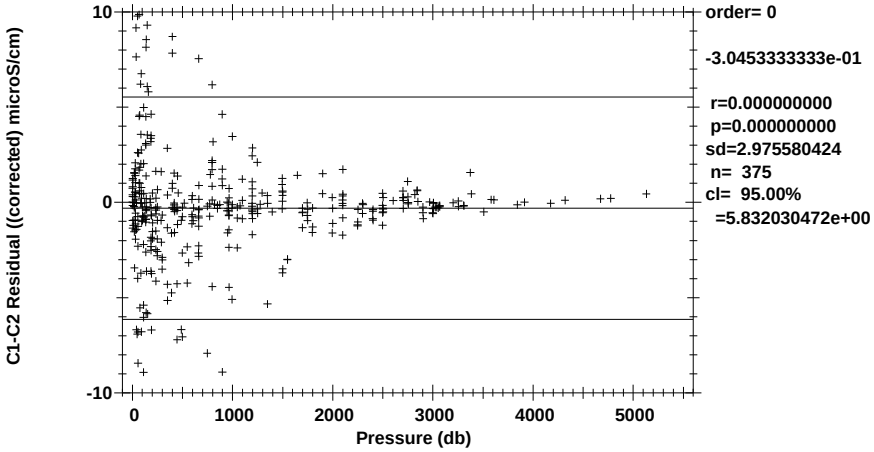

Figure 1.6.3.10 SIOR Corrected $C1 - C2$ by pressure (-0.01°C ≤T1-T2≤0.01°C).

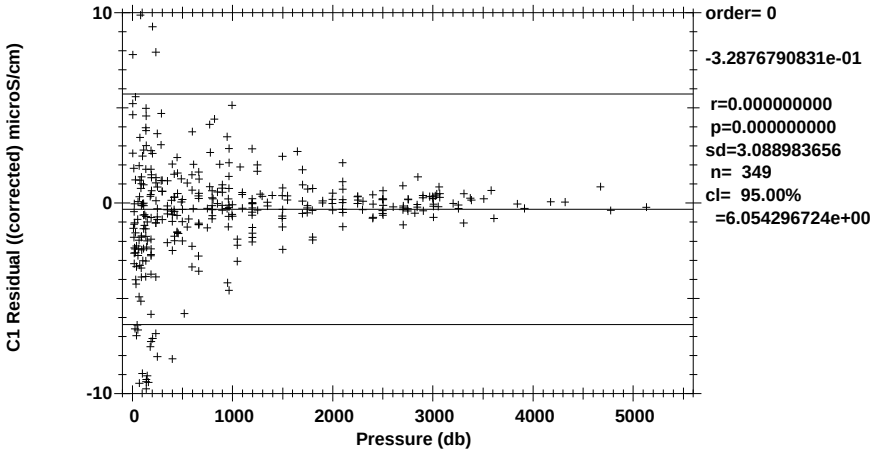

Figure 1.6.3.11 SIOR Corrected $C_{Bottle} - C1$ by pressure (-0.01°C ≤T1-T2≤0.01°C).

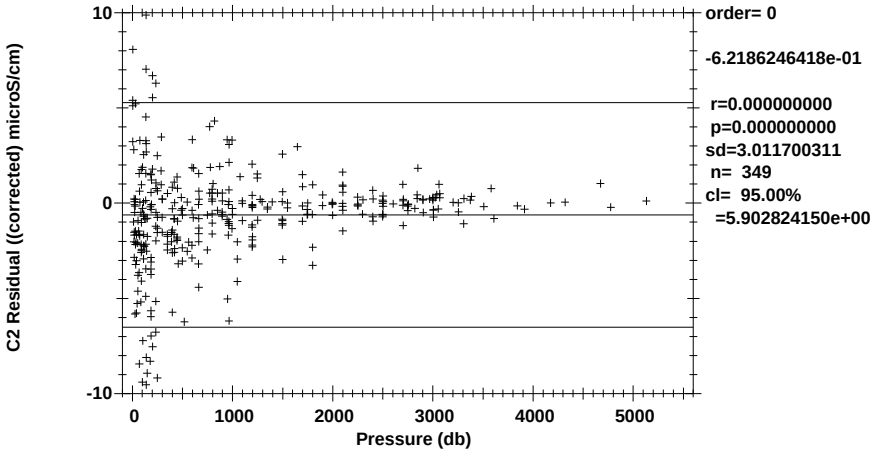

Figure 1.6.3.12 SIOR Corrected $C_{Bottle} - C2$ by pressure (-0.01°C ≤T1-T2≤0.01°C).

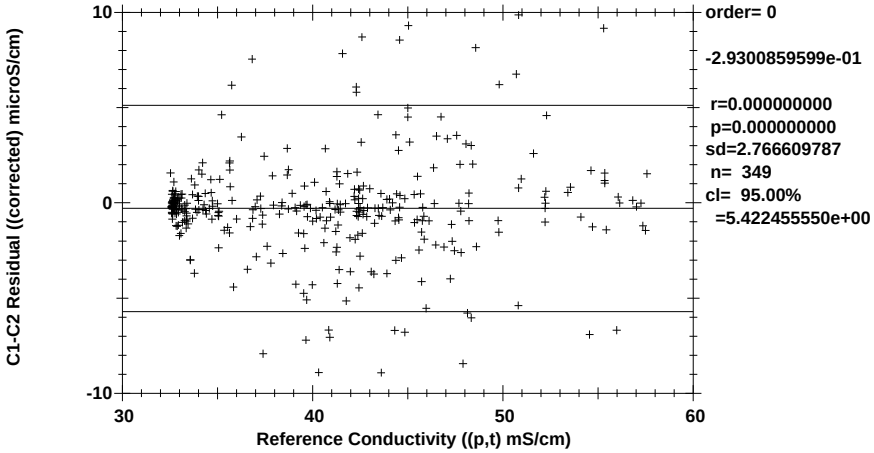

Figure 1.6.3.13 SIOR Corrected $C1 - C2$ by conductivity (-0.01°C ≤T1-T2≤0.01°C).

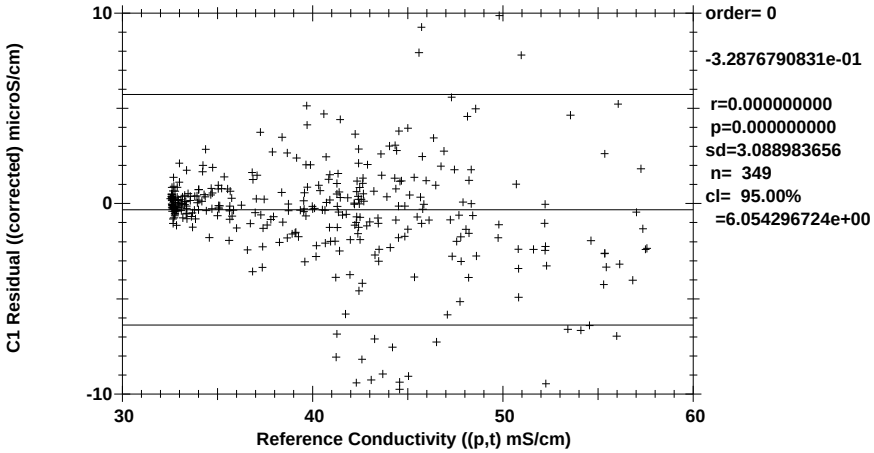

Figure 1.6.3.14 SIOR Corrected $C_{Bottle} - C1$ by conductivity (-0.01°C ≤T1-T2≤0.01°C).

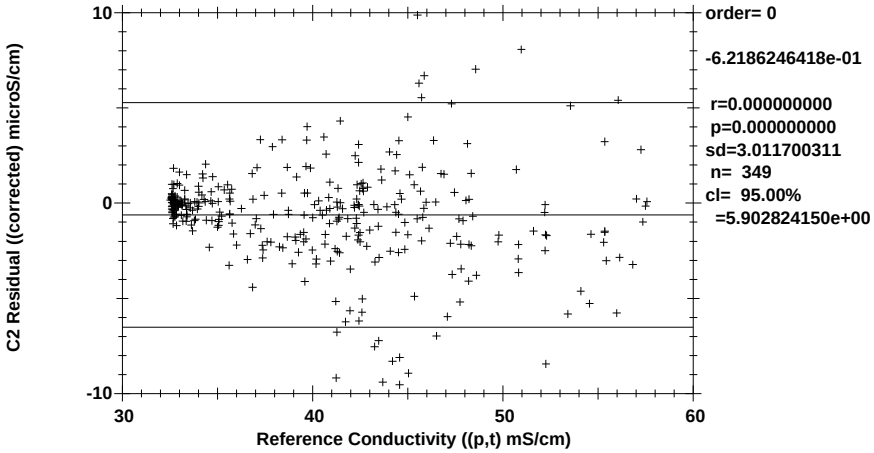

Figure 1.6.3.15 SIOR Corrected $C_{Bottle} - C2$ by conductivity (-0.01°C ≤T1-T2≤0.01°C).

The final corrections for all conductivity sensors used on GEOTRACES 2010 are summarized in Appendix A. Corrections made to all conductivity sensors had the form:

$$C_{cor} = C + cp_1P + c_1C + c_0$$

Salinity residuals after applying shipboard P/T/C corrections are summarized in figures 1.6.3.16 through 1.6.3.18. Only CTD and bottle salinity data with "acceptable" quality codes are included in the differences.

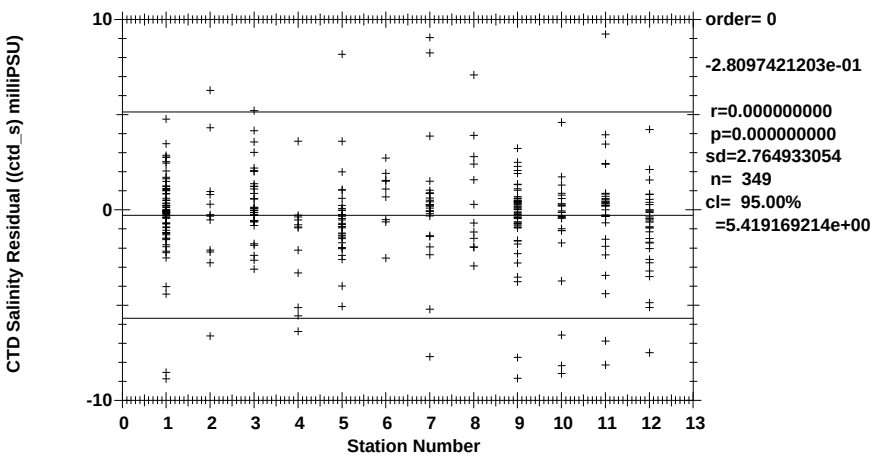

Figure 1.6.3.16 Salinity residuals by station (-0.01°C ≤T1-T2≤0.01°C).

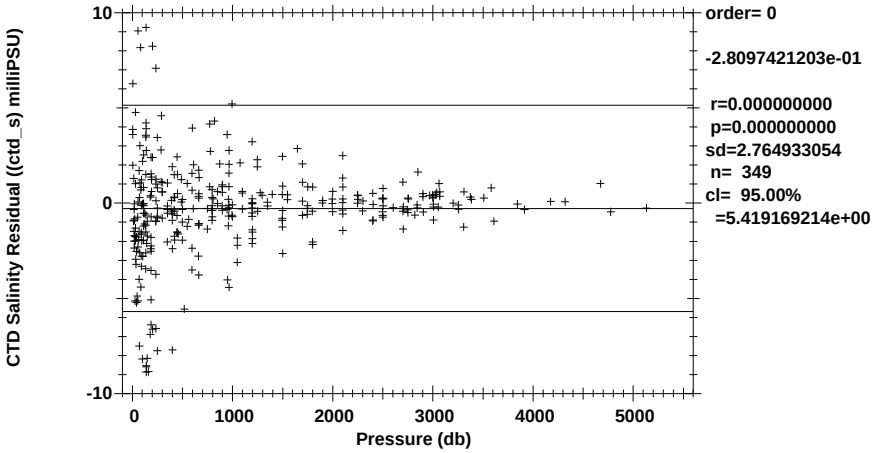

Figure 1.6.3.17 Salinity residuals by pressure (-0.01°C ≤T1-T2≤0.01°C).

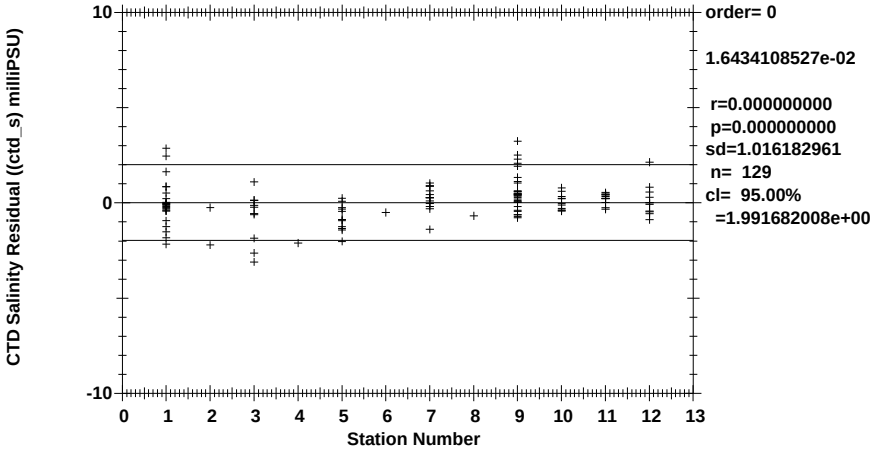

Figure 1.6.3.18 Deep Salinity residuals by station (Pressure >= 1000dbar).

Figures 1.6.3.17 and 1.6.3.18 represent estimates of the salinity accuracy of GEOTRACES 2010. The 95% confidence limits are ±0.0020 PSU relative to bottle salinities for deep salinities, and ±0.0054 PSU relative to bottle salinities for all salinities, where T1-T2 is within ±0.01°C.

1.6.4. CTD Dissolved Oxygen

A single SBE43 dissolved O_2 sensor (DO/43-1129) was used during GEOTRACES 2010. The sensor was plumbed into the primary T1/C1 pump circuit after C1.

The DO sensor was calibrated to dissolved O_2 check samples taken at bottle stops by matching the down cast CTD data to the up cast trip locations on isopycnal surfaces, then calculating CTD dissolved O_2 using a DO sensor response model and minimizing the residual differences from the check samples. A non-linear least-squares fitting procedure was used to minimize the residuals and to determine sensor model coefficients, and was accomplished in three stages.

The time constants for the lagged terms in the model were first determined for the sensor. These time constants are sensor-specific but applicable to an entire cruise. Next, casts were fit individually to check sample data. Consecutive casts were checked on plots of Theta vs O_2 to check for consistency.

Standard and blank values for check sample oxygen titration data were smoothed, and the oxygen values recalculated, prior to the final fitting of CTD oxygen.

CTD dissolved O_2 residuals are shown in figures 1.6.4.0-1.6.4.2.

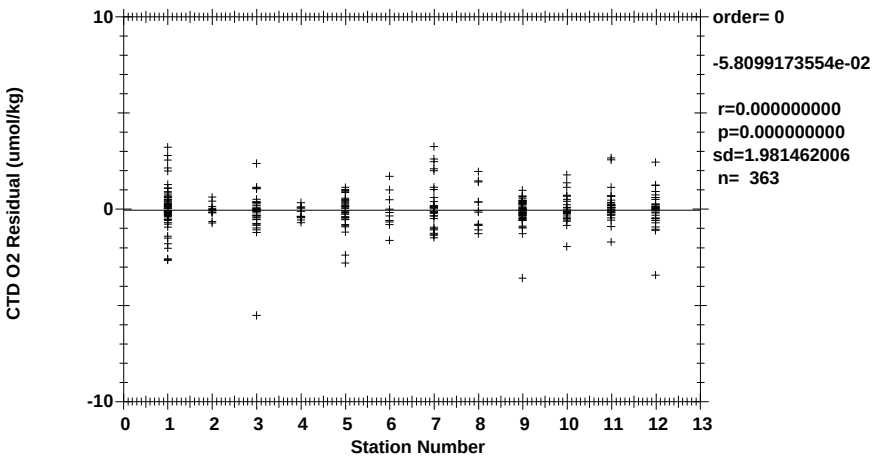

Figure 1.6.4.0 O_2 residuals by station (-0.01°C ≤T1-T2≤0.01°C).

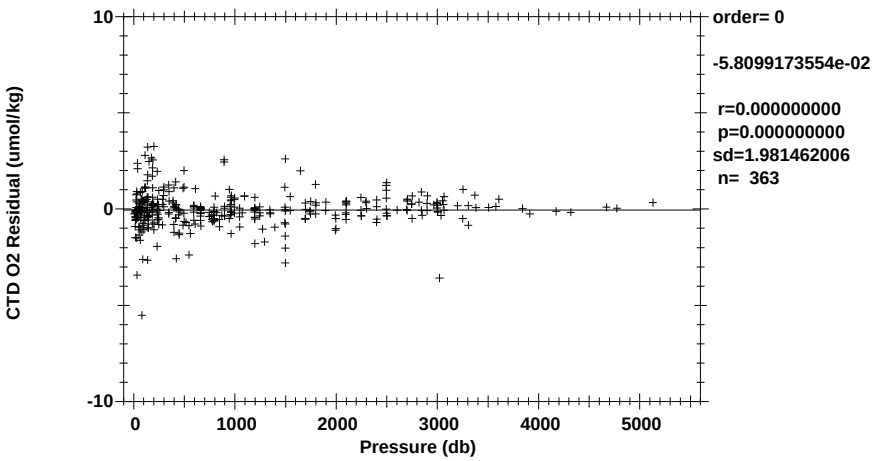

Figure 1.6.4.1 O_2 residuals by pressure (-0.01°C ≤T1-T2≤0.01°C).

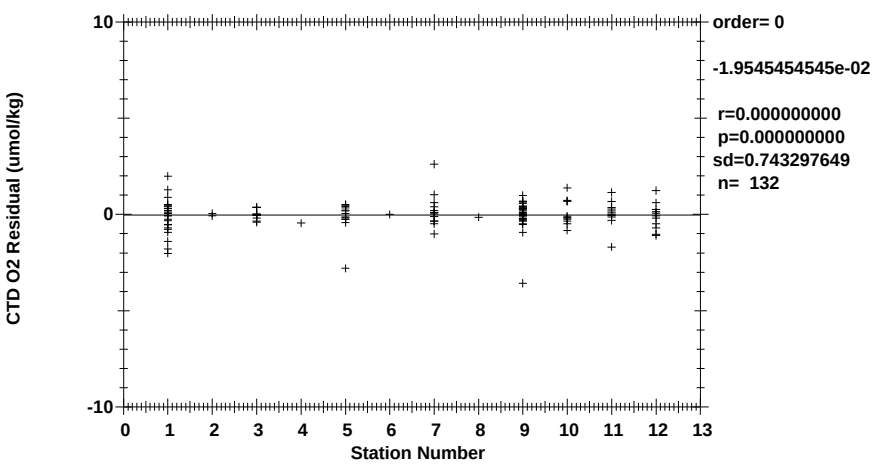

Figure 1.6.4.2 Deep O_2 residuals by station (Pressure >= 1000dbar).

The standard deviations of 1.98 μmol/kg for all oxygens and 0.74 μmol/kg for deep oxygens are only presented as general indicators of goodness of fit. SIO/STS makes no claims regarding the precision or accuracy of CTD dissolved O_2 data.

The general form of the SIO/STS DO sensor response model equation for Clark cells follows Brown and Morrison [Brow78], and Millard [Mill82], [Owen85]. SIO/STS models DO sensor secondary responses with lagged CTD data. *In situ* pressure and temperature are filtered to match the sensor responses. Time constants for the pressure response (τ_p), a slow (τ_{Tf}) and fast (τ_{Ts}) thermal response, package velocity (τ_{dP}), thermal diffusion (τ_{dT}) and pressure hysteresis (τ_h) are fitting parameters. Once determined for a given sensor, these time constants typically remain constant for a cruise. The thermal diffusion term is derived by low-pass filtering the difference between the fast response (T_s) and slow response (T_l) temperatures. This term is intended to correct non-linearities in sensor response introduced by inappropriate analog thermal compensation. Package velocity is approximated by low-pass filtering 1st-order pressure differences, and is intended to correct flow-dependent response. Dissolved O_2 concentration is then calculated:

$$O_2 ml/l = [C_1 V_{DO} e^{(C_2 \frac{P_h}{5000})} + C_3] \cdot f_{sat}(T, P) \cdot e^{(C_4 T_l + C_5 T_s + C_7 P_l + C_6 \frac{dO_c}{dt} + C_8 \frac{dP}{dt} + C_9 dT)} \qquad (1.6.4.0)$$

where:

$O_2 ml/l$	Dissolved O_2 concentration in ml/l;
V_{DO}	Raw sensor output;
C_1	Sensor slope
C_2	Hysteresis response coefficient
C_3	Sensor offset
$f_{sat}(T, P)$	O_2 saturation at T,P (ml/l);
T	*in situ* temperature (°C);
P	*in situ* pressure (decibars);
P_h	Low-pass filtered hysteresis pressure (decibars);
T_l	Long-response low-pass filtered temperature (°C);
T_s	Short-response low-pass filtered temperature (°C);
P_l	Low-pass filtered pressure (decibars);
$\frac{dO_c}{dt}$	Sensor current gradient (μamps/sec);
$\frac{dP}{dt}$	Filtered package velocity (db/sec);
dT	low-pass filtered thermal diffusion estimate (T_s - T_l).
$C_4 - C_9$	Response coefficients.

CTD $O_2 ml/l$ data are converted to μmol/kg units on demand.

1.7. SIOR Bottle Sampling

At the end of each rosette deployment water samples were drawn from the 30L Niskin bottles in the following order:

SIOR/30L-Niskin Cast Sampling Order							
Parameters Sampled	Demi Shallow	Super/Full (Nd/230Th) Shallow	Super/Full (Nd/230Th) Deep	Super/Full (234Th/Ra/Pigs) Shallow	Super Only (Pb-Po/Pu/Si) Shallow	Super Only (Pb-Po/Pu/Si) Deep	Pu Deep
CFCs, SF_6	x	x	x				
^3He	x	x	x				
O_2	x	x	x	x	x	x	x
Nutrients	x	x	x	x	x	x	x
Salinity	x	x	x	x	x	x	x
^{14}C and ^{13}C		x	x				
^3H	x	x	x				
DIC / Total Alk.		x	x				
$^{18}O-H_2O$		x	x				
HPLC Pigments				x			
^{234}Th				x			
^{238}U				x			
^{226}Ra				x			
Chisholm DNA		x		x			
LaRoche DNA		x					
DOC / POC CDOM / AP SPM / Chl.a		x	x				
d $^{15}N-NO_3$	x	x	x				
Thiols		x	x				
Ba		x	x				
Th / Pa / Nd REE(UH)		x	x		(x)		
Pb-Po					x	x	
Si Isotopes					x	x	
Pu					x	x	x

The correspondence between individual sample containers and the rosette bottle position from which the sample was drawn was recorded on the sample log for the cast. These bottle positions were numbered 1-12 for the SIOR/30L Niskin Rosette, and "13" for samples drawn from the Radium UW pump and associated with SIOR casts. This log also included any comments or anomalous conditions noted about the rosette and bottles.

Normal sampling practice for the 30L Niskin rosette 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.

1.8. STS/ODF Bottle Data Processing

Water samples collected and properties analyzed shipboard were centrally managed in a relational database (PostgreSQL 8.1.21-1) running on a CentOS-5.5 Linux system. A web service (OpenACS 5.4.2 and AOLServer 4.5.1-1) front-end provided ship-wide access to CTD and water sample data. Web-based facilities included on-demand arbitrary property-property plots and vertical sections as well as data uploads and downloads.

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

Analytical results were provided on a regular basis by STS, and by other analytical groups near the end of the cruise, then 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 Hydrographic Programme (WHP) [Joyc94].

Table 1.8.0 shows the number of samples drawn and the number of times each WHP sample quality flag was assigned for each basic hydrographic property:

STS/ODF Samples Stations 1- 12								
	Reported levels	WHP Quality Codes 1	2	3	4	5	7	9
Bottle	928		927					1
SIOR CTD Salt	408		408					
SIOR CTD Oxy	408		408					
Salinity	917		869	48		6		5
Oxygen	420		418	2				
Silicate	912		911		1			5
Nitrate	912		912					5
Nitrite	912		912					5
Phosphate	912		910	2				5

Table 1.8.0 Frequency of WHP quality flag assignments.

Additionally, data investigation comments are presented in Appendix C.

Various consistency checks and detailed examination of the data continued throughout the cruise.

1.9. Salinity

Equipment and Techniques

A single Guildline Autosal 8400B salinometer (S/N 69-180) located in the Knorr's O1 lab was used for all salinity measurements. This salinometer had been modified to include a communication interface for computer-aided measurement, a higher capacity pump and three temperature sensors. Two of these sensors were used to measure air and bath temperatures; the third was used to check sample bottle temperature.

Samples were analyzed after they had equilibrated to laboratory temperature, usually within 12-29 hours after collection. The salinometer was standardized for each group of analyses, 36 to 60 samples, using at least two fresh vials of standard seawater per group.

Salinometer measurements were aided by a computer using LabVIEW software developed by SIO/STS. The software maintained a log of each salinometer run, including salinometer settings and air and bath temperatures. The air temperature was displayed and monitored using a 48-hour strip-chart in order to observe cyclical changes. The program also guided the operator through the standardization procedure and making sample measurements. The analyst was prompted to change samples and flush the cells

between readings.

Normal standardization procedures included flushing the cell at least 2 times with a fresh vial of IAPSO Standard Seawater (SSW), setting the flow rate as low as possible during the last fill, and monitoring the STD dial setting. If the STD dial changed by 10 units or more since the last salinometer run (or during standardization), another vial of SSW was opened and the standardization procedure was repeated to verify the setting.

Samples were run using 2 flushes before the final fill. The computer determined the stability of a measurement and prompted for additional readings if there appeared to be drift. The operator could annotate problems in the salinometer log, and routinely added comments about cracked sample bottles, loose thimbles, salt crystals, sample volume or anything unusual about the sample or analysis.

Cases of samples were stacked next to the Autosal while equilibrating to room temperature. The temperature of the deepest sample (coldest) and surface sample (warmest) were monitored to determine when the case was ready to be analyzed.

Sampling and Data Processing

A total of 952 salinity measurements were made, including 35 underway samples, surface pump samples from 12 SIO casts (one at each station), and 48 samples from Niskins on 7 of the 8 deep McLane pump casts. 6 additional sample bottles from station 1 were cracked/broken due to overfilling and not able to be analyzed.

Salinity samples were drawn into 200 ml Kimax high-alumina borosilicate bottles, which were rinsed three times with the sample prior to filling. The bottles were sealed with custom-made plastic insert thimbles and kept closed with 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 and equilibration times 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 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 measured ratios. The corrected salinity data were then incorporated into the cruise database.

Data processing included double checking that the station, sample and box number had been correctly assigned, and reviewing the data and log files for operator comments. The salinity data were compared to CTD salinities and were used for shipboard sensor calibration.

Laboratory Temperature

The salinometer water bath temperature was maintained slightly higher than ambient laboratory air temperature at 24 °C . The ambient air temperature varied from 22.0 to 25.4 °C during the cruise.

The ambient room temperature also maintained a steady observable 24-hour cycle that was dependent on environmental conditions. There were occasional temperature spikes that brought the room temperature above bath temperature. At these times, or when room temperature was on the daily rise, an analysis run would be delayed until room temperature had again stabilized below bath temperature. This meant runs were usually done between 2200 and 0700 local time.

Standards

IAPSO Standard Seawater (SSW) Batch P-151 was used to standardize all runs. Approximately 42 bottles of SSW were used during GEOTRACES 2010.

1.10. Oxygen Analysis

Equipment and Techniques

Dissolved oxygen analyses were performed with an SIO/STS 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 developed by SIO/STS. 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 daily. Reagent/distilled water blanks were also determined daily, or more often if a change in reagents required it to account for the presence of oxidizing or reducing agents.

Sampling and Data Processing

420 oxygen measurements were made from the SIO 30L Niskin rosette. Samples were collected for dissolved oxygen analyses soon after the rosette was brought on board. Two different 24-flask cases were alternated by cast to minimize flask calibration issues, if any. 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 μmol/kg concentrations, and as a diagnostic check of bottle integrity. Reagents ($MnCl_2$ then $NaI/NaOH$) were added to fix the oxygen before stoppering. The flasks were shaken twice (10-12 inversions each time) to assure thorough dispersion of the precipitate: once immediately after drawing, and then again after about 20 minutes.

The samples were analyzed within 24 hours of collection, and the data were incorporated into the cruise database.

Thiosulfate normalities were calculated from each standardization and corrected to 20°C. The thiosulfate normalities and blanks were monitored for possible drifting or possible problems when new reagents were used.

Bottle oxygen data were reviewed, ensuring station, cast, bottle number, flask, and draw temperature were entered properly. Any comments made during analysis were also reviewed, making certain that any anomalous actions were investigated and resolved. Occasionally, an incorrect end point was encountered. The analyst had provisions available through the software to check the raw data and have the program recalculate a correct end point. This happened a few times for this data set. The occurrence is usually attributed to debris in the water bath.

After the data were uploaded to the database, oxygen was graphically compared with CTD oxygen and adjoining stations. Any suspicious-looking points were reviewed and comments were made regarding the final outcome of the investigation. These investigations and final data coding are reported in Appendix C.

Volumetric Calibration

Oxygen flask volumes were determined gravimetrically with degassed deionized water to determine flask volumes at ODF's chemistry laboratory. This was 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 (lot B05N35) 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.

1.11. Nutrient Analysis

Equipment and Techniques

Nutrient analyses (phosphate, silicate, nitrate+nitrite, nitrite) were performed on a Seal Analytical continuous-flow AutoAnalyzer 3 (AA3). After each run, the charts were reviewed for any problems during the run, any blank was subtracted, and final concentrations (micromoles/liter) were calculated.

The analytical methods used are described by Gordon *et al.* [Gord92] Hager *et al.* [Hage68] and Atlas *et al.* [Atla71].

Silicate

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 flowcell and the absorbance measured at 660nm.

Reagents

Tartaric Acid (ACS Reagent Grade)

200g tartaric acid dissolved in DW and diluted to 1 liter volume. Stored at room temperature in a polypropylene bottle.

Ammonium Molybdate

10.8g Ammonium Molybdate Tetrahydrate dissolved in 1000ml dilute H_2SO_4*.

*(Dilute H_2SO_4 = 2.8ml conc H_2SO_4 to a liter DW). Added 3 drops 15% ultra pure SDS per liter of solution.

Stannous Chloride (ACS Reagent Grade)

Stock solution:

40g of stannous chloride dissolved in 100 ml 5N HCl. Refrigerated in a polypropylene bottle.

Working solution:

5 ml of stannous chloride stock diluted to 200 ml final volume with 1.2N HCl. Made up daily and stored at room temperature when not in use in a dark polypropylene bottle.

NOTE: Oxygen introduction was minimized by swirling rather than shaking the stock solution.

Nitrate + Nitrite

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 flowcell and the absorbance measured at 540nm. The same technique was employed for nitrite analysis, except the cadmium column was not present.

Reagents

Sulfanilamide (ACS Reagent Grade)

10g sulfanilamide dissolved in 1.2N HCl and brought to 1 liter volume. Added 5 drops of 40% surfynol 465/485 surfactant. Stored at room temperature in a dark polypropylene bottle.

N-(1-Naphthyl)-ethylenediamine dihydrochloride (N-1-N) (ACS Reagent Grade)

1g N-1-N in DIW, dissolved in DW and brought to 1 liter volume. Added 2 drops 40% surfynol 465/485 surfactant. Stored at room temperature in a dark polypropylene bottle. Discarded if the solution turned dark reddish brown.

Imidazole Buffer (ACS Reagent Grade)

13.6g imidazole dissolved in ~3.8 liters DIW. Stirred for at least 30 minutes until completely dissolved. Added 60 ml of NH_4Cl + $CuSO_4$ mix (see below). Added 4 drops 40% Surfynol 465/485 surfactant. Using a calibrated pH meter, adjusted to pH of 7.83-7.85 with 10% (1.2N)HCl(about 20-30ml of acid, depending on exact strength). Final solution brought to 4L with DIW. Stored at room temperature.

NH_4Cl **+** $CuSO_4$ **mix**:

2g cupric sulfate dissolved in DIW, brought to 100 ml volume (2%) 250g ammonium chloride dissolved in DIW, brought to 1 liter volume. Added 5ml of 2% $CuSO_4$ solution to the NH_4Cl stock.

Note: 40% Surfynol 465/485 is 20% 465 plus 20% 485 in DIW.

Prepared solution at least one day before use to stabilize.

Phosphate

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 de velopment, then passed through a flowcell and the absorbance measured at 820nm.

Reagents

Ammonium Molybdate (ACS Reagent Grade)

H_2SO_4 solution:

420 ml of DIW poured into a 2 liter Ehrlenmeyer flask or beaker, this flask or beaker was placed into an ice bath. SLOWLY added 330 ml of conc H_2SO_4. This solution gets VERY HOT!!

27g ammonium molybdate dissolved in 250ml of DIW. Brought to 1 liter volume with the cooled sulfuric acid solution. Added 5 drops of 15% ultra pure SDS surfactant. Stored in a dark polypropylene bottle.

Dihydrazine Sulfate (ACS Reagent Grade)

6.4g dihydrazine sulfate dissolved in DIW, brought to 1 liter volume and refrigerated.

Sampling and Data Processing

912 nutrient samples from all GoFlo and 30L Niskin rosette casts at 12 stations were analyzed. In addition, 94 underway nutrient samples were analyzed. New pump tubes were installed at the start of the cruise. One set of primary/secondary standards were made up over the course of the cruise. They were compared to two different sets of standards brought from shore to ensure continuity between standards. The standards were also compared to standards from another group from Old Dominion University. The cadmium column reduction efficiency was check periodically and ranged between 98%-100%.

Nutrient samples were drawn into 40 ml polypropylene screw-capped centrifuge tubes. The tubes and caps were cleaned with 10% HCl and rinsed once with de-ionized water and 2-3 times with sample before filling. Samples were analyzed within twelve hours after sample collection, allowing sufficient time for all samples to reach room temperature. The centrifuge tubes fit directly onto the sampler.

Nutrients, reported in micromoles per kilogram, were converted from micromoles per liter by dividing by sample density calculated at 1 atm pressure (0 db), *in situ* salinity, and an assumed lab temperature of 20°C.

Standards and Glassware

Primary standards for silicate (Na_2SiF_6), nitrate (KNO_3), nitrite ($NaNO_2$), and phosphate (KH_2PO_4) were obtained from Johnson Matthey Chemical Co. and/or Fisher Scientific. The supplier reports purities of >98%, 99.999%, 97%, and 99.999%, The standards were dried for approx 4hrs and allowed to cool down in a desiccator before they were weighed out to 0.01mg. The dry standard is diluted to 1L and the temperature of the solution was recorded. The exact weight, the temperature, and the calibrated volume of the flask were then used to calculate the concentration of the primary standard, and how much of this standard was needed for the desired concentration of secondary standard. The new standards were compared to the old before use. Standardizations were performed at the beginning of each group of analyses with working standards prepared prior to each run from a secondary. The secondary standards were prepared aboard ship by dilution from dry, pre-weighed primary standards. A set of 7 different standard concentrations (Table 1.11.0) were analyzed periodically to determine the deviation from linearity, if any, as a function of concentration for each nutrient.

std	N+N	PO4	SiO3	NO2
1)	0.0	0.0	0.0	0.0
2)	7.75	0.6	30	0.25
3)	15.50	1.2	60	0.50
4)	23.25	1.8	90	0.75
5)	31.00	2.4	120	1.00
6)	38.75	3.0	150	1.25
7)	46.50	3.6	180	1.50

Table 1.11.0 GEOTRACES 2010 Standard Concentrations (μmol/L)

All glass volumetric flasks and pipettes were gravimetrically calibrated prior to the cruise. The primary standards were dried and weighed prior to the cruise. The exact weight was noted for future reference. When primary standards were made, the flask volume at 20°C, the weight of the powder, and the temperature of the solution were used to buoyancy-correct the weight, calculate the exact concentration of the solution, and determine how much of the primary was needed for the desired concentrations of secondary standard.

All the reagent solutions, primary and secondary standards were made with fresh distilled deionized water (DIW).

Working standards were made up in low nutrient seawater (LNSW). LNSW was collected off the coast of California and filtered before use at sea.

All data were initially reported in micromoles/liter. NO3, PO4, and NO2 were reported to two decimal places, and SIL to one. Accuracy was based on the quality of the standards, and is listed with instrument precision in Table 1.11.1:

Nutrient Reported	Accuracy (μmol/L)	Precision (μmol/L)
NO3	0.05	0.05
PO4	0.004	0.004
SIL	2-4	1
NO2	0.05	0.01

Table 1.11.1 GEOTRACES 2010 Nutrient Accuracy and Precision

The detection limits for the methods/instrumentation are shown in Table 1.11.2: (in micromoles/liter):

Nutrient Measured	Detection Limit (μmol/L)
NO3+NO2	0.02
PO4	0.02
Sil	0.5
NO2	0.02

Table 1.11.2 GEOTRACES 2010 Nutrient Detection Limits

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Appendix A

GEOTRACES 2010: CTD Temperature and Conductivity Corrections Summary

Sta/ Cast	ITS-90 Temperature Coefficients corT = tp1∗corP + t0 tp1	t0	Conductivity Coefficients corC = cp1∗corP + c1∗C + c0 cp1	c1	c0
001/01	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
001/03	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
001/05	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
001/07	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
001/08	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
001/10	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
002/01	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
003/02	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
003/04	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
003/06	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
004/01	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
005/02	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
005/04	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
005/06	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
006/02	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
007/02	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
007/04	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
007/06	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
008/02	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
009/01	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
009/03	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
009/05	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
009/06	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
009/09	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
009/10	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
010/02	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
010/04	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
010/06	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
011/02	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
011/04	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004099
011/06	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.004899
012/02	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.005299
012/04	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.005699
012/06	-1.8445e-07	-0.001339	-1.75750e-07	-8.67000e-05	0.005899

Appendix B

Summary of GEOTRACES 2010 CTD Oxygen Time Constants

(time constants in seconds)

Pressure Hysteresis (τ_h)	Temperature Long(τ_{Tl})	Temperature Short(τ_{Ts})	Pressure Gradient (τ_p)	O_2 Gradient (τ_{og})	Velocity (τ_{dP})	Thermal Diffusion (τ_{dT})
150.0	300.0	2.0	0.50	8.00	0.00	275.0

GEOTRACES 2010: Conversion Equation Coefficients for CTD Oxygen

(refer to Equation 1.6.4.0)

Sta/ Cast	O_c Slope (c_1)	Offset (c_3)	P_h coeff (c_2)	T_l coeff (c_4)	T_s coeff (c_5)	P_l coeff (c_6)	$\frac{dO_c}{dt}$ coeff (c_7)	$\frac{dP}{dt}$ coeff (c_8)	T_{dT} coeff (c_9)
001/01	5.261e-04	-0.236	0.147	-3.825e-04	7.786e-03	1.474e-04	3.038e-04	0	-0.015822
001/03	4.948e-04	-0.054	-0.275	2.545e-03	-1.594e-03	1.304e-04	6.895e-03	0	0.017483
001/05	4.062e-04	-0.245	0.280	1.861e-02	5.619e-03	2.899e-04	-2.076e-04	0	-0.038357
001/07	6.834e-04	-0.326	-0.046	-1.712e-03	-3.875e-03	1.459e-04	-1.484e-03	0	0.007459
001/08	5.797e-04	-0.161	-0.247	-4.052e-03	1.320e-03	1.390e-04	7.259e-03	0	0.007660
001/10	4.609e-04	-0.109	0.820	7.120e-04	6.150e-03	-3.786e-05	-1.189e-03	0	-0.017089
002/01	4.875e-04	-0.199	-0.119	4.777e-03	4.489e-03	2.385e-04	-2.247e-03	0	-0.009458
003/02	2.080e-04	-0.069	2.001	3.558e-02	9.441e-03	6.759e-05	-9.742e-04	0	-0.049939
003/04	4.316e-04	-0.108	-0.109	1.077e-02	-5.858e-04	2.152e-04	2.365e-03	0	0.001695
003/06	5.929e-04	-0.246	-0.053	8.160e-04	-9.463e-04	1.638e-04	2.287e-03	0	0.004806
004/01	2.339e-04	-0.105	1.825	3.716e-02	4.154e-03	7.352e-05	2.233e-03	0	-0.046831
005/02	4.081e-04	-0.183	0.933	1.643e-02	-6.006e-04	8.137e-05	2.263e-04	0	-0.015620
005/04	4.625e-04	-0.226	0.527	2.456e-02	-1.487e-02	1.837e-04	3.090e-03	0	-0.003771
005/06	6.072e-04	-0.228	0.056	1.206e-02	-1.606e-02	1.133e-04	4.861e-03	0	0.014431
006/02	4.374e-04	-0.193	1.295	1.301e-02	-1.742e-04	-5.551e-05	3.994e-03	0	-0.018974
007/02	9.002e-04	-0.344	-1.086	-1.498e-02	-2.329e-03	2.471e-04	1.760e-03	0	0.027980
007/04	4.081e-04	-0.145	0.036	2.468e-03	1.048e-02	2.091e-04	1.489e-03	0	-0.019339
007/06	6.138e-04	-0.261	0.055	-1.657e-02	1.517e-02	1.256e-04	1.053e-04	0	-0.014188
008/02	7.072e-04	-0.323	-0.422	-1.209e-02	5.882e-03	2.024e-04	-4.367e-03	0	-0.009458
009/01	8.669e-04	-0.372	-0.675	-2.200e-02	8.868e-03	1.457e-04	3.694e-03	0	0.001915
009/03	1.387e-04	-0.062	4.121	7.258e-02	-2.026e-02	5.569e-05	3.004e-03	0	-0.008612
009/05	2.853e-04	-0.125	1.033	2.359e-02	2.250e-03	3.044e-04	5.396e-03	0	-0.030044
009/06	6.044e-04	-0.237	-0.084	-7.831e-03	6.044e-03	1.578e-04	7.897e-03	0	0.006177
009/09	6.310e-04	-0.267	0.090	-5.795e-03	2.936e-03	1.053e-04	4.567e-03	0	0.001205
009/10	6.239e-04	-0.278	0.134	-3.417e-03	1.847e-03	1.040e-04	3.344e-03	0	-0.004483
010/02	3.883e-04	-0.174	0.893	1.612e-02	2.665e-04	1.410e-04	2.858e-03	0	-0.020374
010/04	4.875e-04	-0.224	1.220	7.080e-03	5.655e-04	-1.411e-04	4.639e-03	0	-0.024302
010/06	6.344e-04	-0.273	0.228	-7.103e-03	3.948e-03	6.860e-05	-1.103e-02	0	-0.004966
011/02	3.593e-04	-0.168	2.347	2.096e-02	-1.587e-03	-2.156e-04	2.099e-03	0	-0.026221
011/04	2.334e-04	-0.053	2.232	2.349e-02	6.791e-03	7.582e-05	4.657e-03	0	0.007877
011/06	5.945e-04	-0.233	0.023	-1.749e-02	1.649e-02	1.318e-04	-7.565e-03	0	-0.008409
012/02	7.396e-04	-0.358	0.019	-5.411e-03	-1.632e-03	1.218e-05	4.859e-03	0	-0.017744
012/04	5.469e-04	-0.224	-0.195	2.978e-04	2.217e-03	2.478e-04	2.203e-03	0	-0.001328
012/06	5.947e-04	-0.247	0.019	1.337e-03	-1.947e-03	1.419e-04	3.547e-03	0	0.003857

Appendix C

GEOTRACES 2010: Bottle Quality Comments

Comments from the Sample Logs and the results of SIO/STS's data investigations are included in this report. Units stated in these comments are degrees Celsius for temperature, micromoles per kilogram 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 /Cast	Sample No.	Quality Property	Code	Comment
1/1	102	po4	3	PO4 value low, no analytical problems noted; code PO4 questionable
1/1	104	bottle	2	Sample Log: "drip at bottom - small spigot"
1/1	110	o2	2	Sample Log: "O2 draw temperature sensor failed last 3 bottles, no reading"
1/1	111	bottle	2	Sample Log: "bottom end cap leaking"
1/1	111	o2	2	Sample Log: "O2 draw temperature sensor failed last 3 bottles, no reading"
1/1	112	o2	2	Sample Log: "O2 draw temperature sensor failed last 3 bottles, no reading"
1/3	302	salt	3	Salinity 0.02 high vs CTDS1/CTDS2; code salinity questionable.
1/3	311	bottle	2	Sample Log: "bottom cap weeping after vent and spigot both opened"
1/3	311	salt	3	Salinity 0.075 high vs CTDS1/CTDS2; code salinity questionable.
1/3	313	bottle	2	Sample Log: "sample 13 from surface pump after cast"
1/3	313	salt	3	Surface Pump Salinity 0.015 high vs CTDS; code salinity questionable for calibration purposes.
1/5	501	o2	2	Bottles 1 and 2 tripped at the same level, o2 values are/should be the same.
1/5	502	o2	2	Bottles 1 and 2 tripped at the same level, o2 values are/should be the same.
1/5	502	po4	3	Questioned due to outlier in Redfield Ratio. Nutrient Analyst: "PO4 may be ˜0.1 low." Code phosphate questionable.
1/5	507	o2	3	Oxygen is 3 umol/kg low vs CTDO, but same value as bottle 6 oxygen. Sample probably mis-drawn from niskin 6, code oxygen questionable.
1/7	701	o2	2	Bottle 2 oxygen 1 umol/kg higher than bottle 1, tripped at same level. Within WOCE specs, code both acceptable.
1/7	702	o2	2	Bottle 2 oxygen 1 umol/kg higher than bottle 1, tripped at same level. Within WOCE specs, code both acceptable.
1/7	709	bottle	2	Sample Log: "leaking at spigot when drawing water"
1/7	710	salt	3	Deep Salinity 0.004 low vs CTDS1/CTDS2; code salinity questionable.
1/8	801	geo	2	GEOTRACES number assignments were apparently recorded in reverse on sample log. Niskins 1-12 are now assigned GEOTRACES numbers 5132-5143 (were 5143-5132).
1/8	801	o2	2	Bottle 2 oxygen 0.7 umol/kg higher than bottle 1, tripped at same level. Within WOCE specs, code both acceptable.
1/8	802	geo	2	GEOTRACES number assignments were apparently recorded in reverse on sample log. Niskins 1-12 are now assigned GEOTRACES numbers 5132-5143 (were 5143-5132).
1/8	802	o2	2	Bottle 2 oxygen 0.7 umol/kg higher than bottle 1, tripped at same level. Within WOCE specs, code both acceptable.
1/8	803	geo	2	GEOTRACES number assignments were apparently recorded in reverse on sample log. Niskins 1-12 are now assigned GEOTRACES numbers 5132-5143 (were 5143-5132).

Station /Cast	Sample No.	Quality Property	Code	Comment
1/8	804	geo	2	GEOTRACES number assignments were apparently recorded in reverse on sample log. Niskins 1-12 are now assigned GEOTRACES numbers 5132-5143 (were 5143-5132).
1/8	805	geo	2	GEOTRACES number assignments were apparently recorded in reverse on sample log. Niskins 1-12 are now assigned GEOTRACES numbers 5132-5143 (were 5143-5132).
1/8	806	geo	2	GEOTRACES number assignments were apparently recorded in reverse on sample log. Niskins 1-12 are now assigned GEOTRACES numbers 5132-5143 (were 5143-5132).
1/8	807	geo	2	GEOTRACES number assignments were apparently recorded in reverse on sample log. Niskins 1-12 are now assigned GEOTRACES numbers 5132-5143 (were 5143-5132).
1/8	807	salt	3	Salinity 0.015 low vs CTDS; code salinity questionable.
1/8	808	geo	2	GEOTRACES number assignments were apparently recorded in reverse on sample log. Niskins 1-12 are now assigned GEOTRACES numbers 5132-5143 (were 5143-5132).
1/8	809	geo	2	GEOTRACES number assignments were apparently recorded in reverse on sample log. Niskins 1-12 are now assigned GEOTRACES numbers 5132-5143 (were 5143-5132).
1/8	810	geo	2	GEOTRACES number assignments were apparently recorded in reverse on sample log. Niskins 1-12 are now assigned GEOTRACES numbers 5132-5143 (were 5143-5132).
1/8	811	geo	2	GEOTRACES number assignments were apparently recorded in reverse on sample log. Niskins 1-12 are now assigned GEOTRACES numbers 5132-5143 (were 5143-5132).
1/8	812	geo	2	GEOTRACES number assignments were apparently recorded in reverse on sample log. Niskins 1-12 are now assigned GEOTRACES numbers 5132-5143 (were 5143-5132).
2/1	112	salt	3	Salinity 0.016 low vs CTDS; code salinity questionable.
3/2	209	salt	2	Salt Analyst: "(BTL9) Rim chip, seal not compromised". Small Salinity/CTDS differences, code salinity acceptable.
3/4	401	sio3	4	Silicate value high, peak looks odd; code silicate bad.
3/4	411	salt	3	Salinity 0.02 low vs CTDS; code salinity questionable.
3/4	413	bottle	2	Sample Log: "sample 13 from surface pump after cast"
3/4	413	salt	3	Surface Pump Salinity 0.125 low vs CTDS; code salinity questionable.
3/6	609	reft	3	Deep SBE35 Temp. 0.02/0.025 low vs CTDT1/T2; SBE35 reading unstable, code Ref.Temp. questionable.
3/6	609	salt	3	Deep Salinity 0.01 low vs CTDS; code salinity questionable.
4/1	113	bottle	2	Sample Log: "sample 13 from surface pump after cast"
5/2	211	salt	3	Salinity 0.065/0.06 low vs CTDS1/S2; code salinity questionable.
5/4	411	o2	2	Oxygen 12 umol/kg high vs CTDO, but in a high gradient; code oxygen acceptable.
5/4	411	salt	3	Salinity 0.02/0.015 low vs CTDS1/S2; code salinity questionable.
5/4	413	bottle	2	Sample Log: "sample 13 from surface pump after cast"
5/6	602	o2	2	Sample Log: "oxygen draw temp 3 deg.C higher than expected". Oxygen value matches CTDO, code oxygen acceptable.
5/6	605	salt	2	Salt Analyst: "(BTL5) Thimble popped out with cap". Small Salinity/CTDS differences, code salinity acceptable.
5/6	612	salt	3	Deep Salinity 0.007 high vs CTDS; code salinity questionable.
6/2	211	salt	3	Salinity 0.015 low vs CTDS; code salinity questionable.
6/2	213	bottle	2	Sample Log: "sample 13 from surface pump after cast"

Station /Cast	Sample No.	Quality Property	Code	Comment
6/2	213	salt	3	Surface Pump Salinity 0.015 high vs CTDS; code salinity questionable for calibration purposes.
7/2	209	salt	3	Salinity 0.018 low vs CTDS; code salinity questionable.
7/4	408	CTDS2	3	CTDC1/C2 difference is 0.09; code ctds2 questionable so not used for calibration comparisons.
7/4	408	reft	3	SBE35 Temp. 0.035/0.04 low vs CTDT1/T2; SBE35 reading unstable, code Ref.Temp. questionable.
7/4	408	salt	3	Salinity 0.025/0.015 low vs CTDS1/S2; code salinity questionable.
7/4	410	reft	3	SBE35 Temp. 0.02/0.025 low vs CTDT1/T2; SBE35 reading unstable, code Ref.Temp. questionable.
7/4	410	salt	3	Salinity 0.03 low vs CTDS; code salinity questionable.
7/4	413	bottle	2	Sample Log: "sample 13 from surface pump after cast"
8/2	204	salt	2	Salinity a bit high but OK due to high gradient zone.
8/2	205	salt	2	Salinity a bit high but OK due to high gradient zone.
8/2	209	o2	2	Oxygen high compared to CTDO. In a gradient; code acceptable.
8/2	210	o2	2	Oxygen high compared to CTDO. In a gradient; code acceptable.
8/2	213	bottle	2	Sample Log: "sample 13 from surface pump after cast"
8/2	213	salt	3	Surface Pump Salinity 0.013 high vs CTDS; code salinity questionable for calibration purposes.
9/1	109	reft	3	SBE35 Temp. reading somewhat unstable; code Ref.Temp. questionable.
9/1	112	salt	3	Salinity 0.115/0.120 high vs CTDS1/S2; code salinity questionable.
9/3	308	reft	3	SBE35 Temp. 0.15/0.20 high vs CTDT1/T2, reading somewhat unstable; code Ref.Temp. questionable.
9/3	310	salt	3	Salinity 0.03/0.035 low vs CTDS1/S2; code salinity questionable.
9/3	311	salt	3	Salinity 0.02 low vs CTDS; code salinity questionable.
9/3	312	salt	3	Salinity 0.035/0.04 high vs CTDS1/S2; code salinity questionable.
9/5	510	reft	3	SBE35 Temp. 0.30/0.20 low vs CTDT1/T2, reading somewhat unstable; code Ref.Temp. questionable.
9/5	510	salt	3	Salinity 0.04 high vs CTDS; code salinity questionable.
9/5	511	salt	3	Salinity 0.04 high vs CTDS; code salinity questionable.
9/5	513	bottle	2	Sample Log: "sample 13 from surface pump after cast"
9/5	513	salt	3	Surface Pump Salinity 0.023 high vs CTDS; code salinity questionable.
9/6	605	salt	3	Deep Salinity 0.008 high vs CTDS; code salinity questionable.
9/6	610	bottle	2	Sample Log: "Vent not closed".
9/6	612	o2	3	Oxygen is 8 umol/kg low compared to CTDO; code oxygen questionable.
9/9	910	bottle	2	Sample Log: "Vent open".
9/10	1011	reft	3	SBE35 Temp. reading very unstable, code Ref.Temp. questionable.
9/10	1011	salt	3	Salinity 0.016 low vs CTDS; code salinity questionable.
9/10	1012	salt	3	Salinity 0.035 high vs CTDS; code salinity questionable.
10/2	208	salt	3	Salinity 0.015 low vs CTDS; code salinity questionable.
10/2	211	reft	3	SBE35 Temp. 0.065/0.025 high vs CTDT1/T2; SBE35 reading unstable, code Ref.Temp. questionable.
10/2	211	salt	3	Salinity 0.02 high vs CTDS; code salinity questionable.
10/2	212	reft	3	SBE35 Temp. 0.125/0.105 high vs CTDT1/T2; SBE35 reading very unstable, code Ref.Temp. questionable.
10/4	405	reft	3	SBE35 Temp. 0.015/0.03 high vs CTDT1/T2; SBE35 reading somewhat unstable, code Ref.Temp. questionable.
10/4	409	reft	3	SBE35 Temp. 0.025/0.020 low vs CTDT1/T2; SBE35 reading somewhat unstable, code Ref.Temp. questionable.
10/4	409	salt	3	Salinity 0.02 low vs CTDS in gradient.
10/4	410	bottle	2	Sample Log: "Vent not closed".

Station /Cast	Sample No.	Quality Property	Code	Comment
10/4	410	reft	3	SBE35 Temp. 0.060/0.40 low vs CTDT1/T2; SBE35 reading very unstable, code Ref.Temp. questionable.
10/4	411	reft	3	SBE35 Temp. 0.125/0.105 low vs CTDT1/T2; SBE35 reading very unstable, code Ref.Temp. questionable.
10/4	411	salt	3	Salinity 0.035 high vs CTDS; code salinity questionable.
10/4	413	bottle	2	Sample Log: "sample 13 from surface pump after cast"
10/4	413	salt	3	Surface Pump Salinity 0.02 high vs CTDS at 5db.
11/2	210	reft	3	SBE35 Temp. reading unstable; code Ref.Temp. questionable.
11/2	211	reft	3	SBE35 Temp. 0.025 high vs CTDT1/T2, reading somewhat unstable; code Ref.Temp. questionable.
11/2	212	salt	3	Salinity 0.025 high vs CTDS; code salinity questionable.
11/4	409	o2	2	Oxygen low compared to CTDO; in a gradient, code acceptable.
11/4	409	salt	3	Salinity 0.018 low vs CTDS; code salinity questionable.
11/4	410	reft	3	SBE35 Temp. reading very unstable; code Ref.Temp. questionable.
11/4	410	salt	3	Salinity 0.045/0.055 low vs CTDS1/S2; code salinity questionable.
11/4	411	salt	3	Salinity 0.015 high vs CTDS; code salinity questionable.
11/4	413	bottle	2	Sample Log: "sample 13 from surface pump after cast"
11/4	413	salt	3	Surface Pump Salinity 0.013 high vs CTDS; code salinity questionable for calibration purposes.
12/4	403	o2	2	Oxygen Analyst: "Oxygen flask 1552 with stopper 1616." Bottle and CTD oxygens are within 0.5 umol/kg, code oxygen acceptable.
12/4	404	o2	2	Oxygen Analyst: "Oxygen flask 1616 with stopper 1552." Bottle and CTD oxygens are within 0.5 umol/kg, code oxygen acceptable.
12/4	407	reft	3	SBE35 Temp. reading very unstable; code Ref.Temp. questionable.
12/4	407	salt	3	Salinity 0.02 high vs CTDS; code salinity questionable.
12/4	408	o2	2	Oxygen high compared to CTDO. In a gradient; code acceptable.
12/4	409	o2	2	Oxygen high compared to CTDO. In a gradient; code acceptable.
12/4	410	o2	2	Sample Log: "Re-draw o2 sample (flask failure)".
12/4	413	bottle	2	Sample Log: "sample 13 from surface pump after cast"
12/4	413	salt	3	Surface Pump Salinity 0.018 high vs CTDS; code salinity questionable for calibration purposes.

Appendix D

GEOTRACES 2010: Pre-Cruise Sensor Laboratory Calibrations

SIOR CTD 796 Sensors - Table of Contents			
CTD Sensor	Manufacturer and Model No.	Serial Number	Appendix D Page (Un-Numbered)
*PRESS (Pressure)	Digiquartz 401K-105	98627	1-3
*T1 (Primary Temperature)	Sea-Bird SBE3*plus*	03P-4532	4
*C1 (Primary Conductivity)	Sea-Bird SBE4C	04-1879	5
*O2 (Dissolved Oxygen)	Sea-Bird SBE43	43-1129	6
T2 (Secondary Temperature)	Sea-Bird SBE3*plus*	03P-4588	7
C2 (Secondary Conductivity)	Sea-Bird SBE4C	04-2659	8
*TRANS (Transmissometer)	WETLabs C-Star	CST-492DR	9
*FLUOR (Chlorophyll Fluorometer)	Seapoint	SCF2775	10
*REFT (Reference Temperature)	Sea-Bird SBE35	3528706-0035	11

* data reported for these sensors during GEOTRACES 2010

Pressure Calibration Report
STS/ODF Calibration Facility

SENSOR SERIAL NUMBER: 0796
CALIBRATION DATE: 28-APR-2010
Mfg: Seabird Model: SBE9P CTD Prs s/n: 98627

C1= -4.966752E+4
C2= 6.336320E-1
C3= 1.687135E-2
D1= 3.894407E-2
D2= 0.000000E+0
T1= 2.989461E+1
T2= -1.333351E-4
T3= 3.935809E-6
T4= 3.875265E-9
T5= 0.000000E+0
AD590M= 1.28520E-2
AD590B= -8.71454E+0
Slope = 1.00000000E+0
Offset = 0.00000000E+0

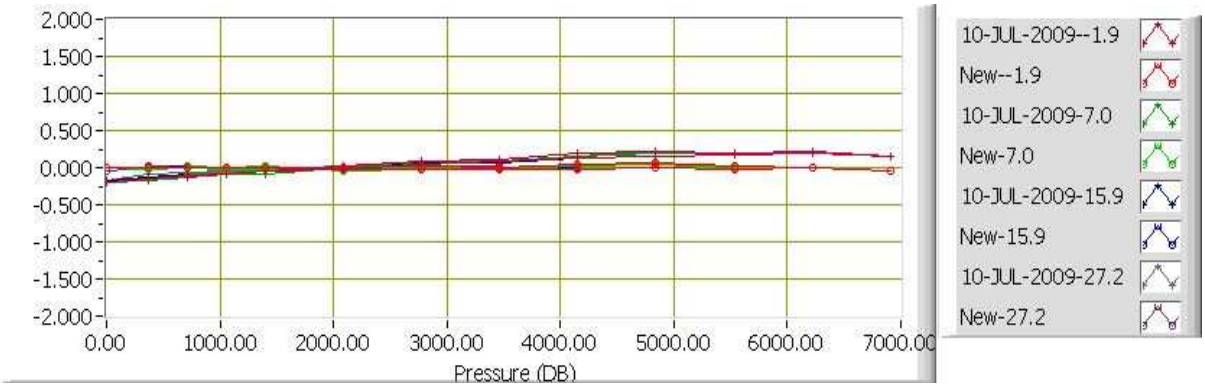
Calibration Standard: Mfg: Ruska Model: 2400 s/n: 34336
t0=t1+t2*td+t3*td*td+t4*td*td*td
w = 1-t0*t0*f*f
Pressure = (0.6894759*((c1+c2*td+c3*td*td)*w*(1-(d1+d2*td)*w)-14.7)

SBE9 Freq	Ruska	SBE9 New_Coefs	Ruska-SBE9 Prev_Coefs	Ruska-SBE9 New_Coefs	Tprs	Bath_Temp
33455.655	0.18	0.18	-0.20	-0.00	-1.50	-1.85
33633.285	365.06	365.06	-0.16	0.00	-1.50	-1.85
33799.885	709.32	709.32	-0.12	0.00	-1.50	-1.85
33965.543	1053.58	1053.58	-0.08	0.00	-1.50	-1.85
34130.281	1397.87	1397.87	-0.05	0.00	-1.50	-1.85
34457.031	2086.48	2086.47	0.01	0.01	-1.49	-1.85
34780.240	2775.17	2775.15	0.08	0.02	-1.49	-1.85
35100.024	3463.91	3463.91	0.10	-0.00	-1.49	-1.85
35416.438	4152.73	4152.68	0.19	0.05	-1.48	-1.85
35729.615	4841.61	4841.55	0.22	0.06	-1.48	-1.85
36039.646	5530.55	5530.54	0.20	0.01	-1.48	-1.85
36346.583	6219.56	6219.56	0.21	0.00	-1.48	-1.85
36650.538	6908.64	6908.69	0.16	-0.05	-1.48	-1.85
36346.585	6219.56	6219.56	0.20	-0.00	-1.48	-1.85
36039.659	5530.55	5530.56	0.18	-0.01	-1.48	-1.85
35729.641	4841.61	4841.62	0.16	-0.01	-1.49	-1.85
35416.464	4152.73	4152.74	0.13	-0.01	-1.49	-1.85
35100.033	3463.91	3463.93	0.08	-0.02	-1.49	-1.85
34780.258	2775.17	2775.19	0.04	-0.02	-1.50	-1.85
34457.043	2086.48	2086.50	-0.02	-0.02	-1.50	-1.85
34130.281	1397.87	1397.87	-0.05	0.00	-1.50	-1.85
33965.543	1053.58	1053.58	-0.08	0.00	-1.50	-1.85
33799.891	709.32	709.33	-0.13	-0.01	-1.50	-1.85
33633.285	365.06	365.06	-0.16	0.00	-1.50	-1.85
33456.694	0.18	0.19	-0.20	-0.01	6.71	6.96

Pressure Calibration Report
STS/ODF Calibration Facility

33634.354	365.06	365.07	-0.17	-0.01	6.71	6.96
33800.977	709.32	709.32	-0.12	0.00	6.73	6.96
33966.666	1053.58	1053.59	-0.10	-0.01	6.75	6.96
34131.437	1397.87	1397.90	-0.08	-0.03	6.76	6.96
34458.227	2086.48	2086.49	0.00	-0.01	6.78	6.96
34781.496	2775.17	2775.18	0.05	-0.01	6.81	6.96
35101.318	3463.91	3463.93	0.09	-0.02	6.81	6.96
35417.790	4152.73	4152.72	0.15	0.01	6.84	6.96
35731.008	4841.61	4841.58	0.20	0.03	6.86	6.96
36041.085	5530.55	5530.56	0.18	-0.01	6.86	6.96
35731.009	4841.61	4841.57	0.21	0.04	6.89	6.96
35417.794	4152.73	4152.71	0.16	0.02	6.89	6.96
35101.327	3463.91	3463.92	0.09	-0.01	6.91	6.96
34781.511	2775.17	2775.19	0.04	-0.02	6.91	6.96
34458.254	2086.48	2086.51	-0.03	-0.03	6.91	6.96
34131.437	1397.87	1397.86	-0.04	0.01	6.94	6.96
33966.676	1053.58	1053.57	-0.08	0.01	6.94	6.96
33800.988	709.32	709.30	-0.10	0.02	6.96	6.96
33634.364	365.06	365.05	-0.14	0.01	6.96	6.96
33457.133	0.18	0.18	-0.18	0.00	16.33	15.88
33634.827	365.06	365.06	-0.14	0.00	16.33	15.88
33801.477	709.32	709.29	-0.08	0.03	16.34	15.88
33967.206	1053.58	1053.58	-0.08	0.00	16.34	15.88
34132.000	1397.87	1397.86	-0.04	0.01	16.35	15.88
34458.879	2086.48	2086.50	-0.02	-0.02	16.35	15.88
34782.197	2775.17	2775.17	0.06	0.00	16.35	15.88
35102.089	3463.91	3463.93	0.07	-0.02	16.35	15.88
35418.620	4152.73	4152.72	0.13	0.01	16.35	15.88
35102.083	3463.91	3463.91	0.09	-0.00	16.35	15.88
34782.206	2775.17	2775.19	0.04	-0.02	16.34	15.88
34458.882	2086.48	2086.51	-0.03	-0.03	16.33	15.88
34132.000	1397.87	1397.86	-0.04	0.01	16.33	15.88
33967.209	1053.58	1053.59	-0.08	-0.01	16.33	15.88
33801.477	709.32	709.29	-0.08	0.03	16.33	15.88
33634.813	365.06	365.03	-0.11	0.03	16.33	15.88
33456.641	0.18	0.22	-0.16	-0.04	27.01	27.17
33634.365	365.06	365.06	-0.10	0.00	27.03	27.17
33801.066	709.32	709.31	-0.06	0.01	27.07	27.17
33966.840	1053.58	1053.60	-0.06	-0.02	27.08	27.17
34131.676	1397.87	1397.88	-0.03	-0.01	27.10	27.17
34458.627	2086.48	2086.49	0.01	-0.01	27.13	27.17
34782.039	2775.17	2775.17	0.05	-0.00	27.17	27.17
35101.995	3463.91	3463.89	0.10	0.02	27.18	27.17
34782.029	2775.17	2775.16	0.07	0.01	27.20	27.17
34458.620	2086.48	2086.49	0.01	-0.01	27.22	27.17
34131.661	1397.87	1397.87	-0.02	-0.00	27.23	27.16
33966.812	1053.58	1053.57	-0.03	0.01	27.25	27.17
33801.053	709.32	709.32	-0.07	-0.00	27.27	27.17
33634.336	365.06	365.05	-0.08	0.01	27.27	27.17
33456.582	0.18	0.15	-0.10	0.03	27.28	27.17

Pressure Calibration Report
STS/ODF Calibration Facility



Temperature Calibration Report
STS/ODF Calibration Facility

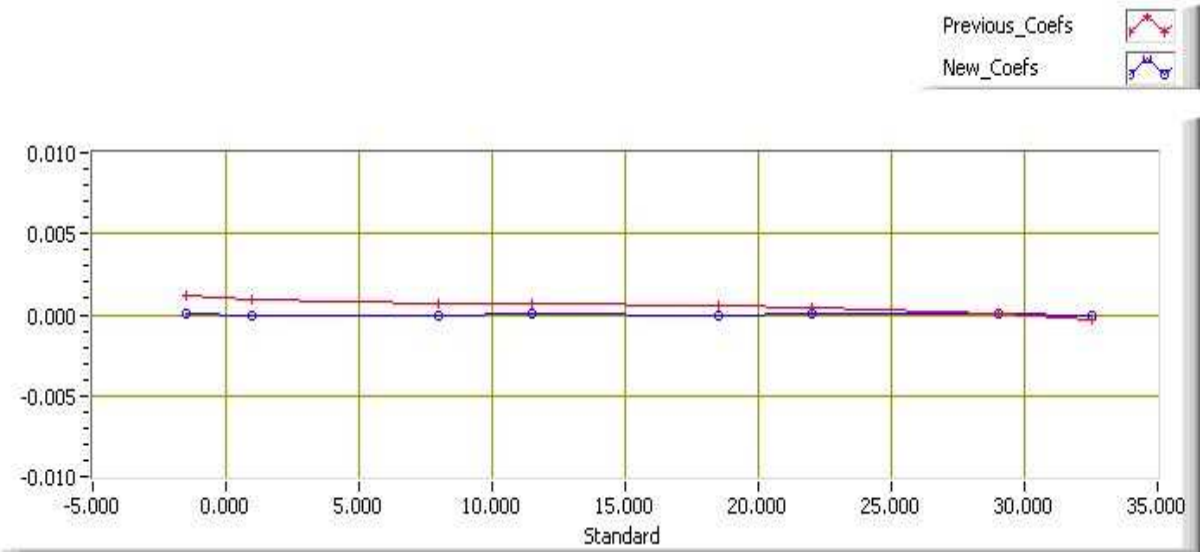
SENSOR SERIAL NUMBER: 4532
CALIBRATION DATE: 24-Aug-2010
Mfg: Seabird Model: 03
Previous cal: 17-Dec-09
Calibration Tech: CAL

ITS-90_COEFFICIENTS	IPTS-68_COEFFICIENTS
g = 4.41584730E-3	a = 4.41606506E-3
h = 6.46663514E-4	b = 6.46880652E-4
i = 2.16380505E-5	c = 2.16707009E-5
j = 1.66931224E-6	d = 1.67075746E-6

f0 = 1000.0 Slope = 1.0 Offset = 0.0

Calibration Standard: Mfg: ASL Model: F18 s/n: 245-5149
Temperature ITS-90 = 1/{g+h[ln(f0/f)]+i[ln2(f0/f)]+j[ln3(f0/f)]} - 273.15 (℃)
Temperature IPTS-68 = 1/{a+b[ln(f0/f)]+c[ln2(f0/f)]+d[ln3(f0/f)]} - 273.15 (℃)
T68 = 1.00024 * T90 (-2 to -35 Deg C)

SBE3 Freq	SPRT ITS-90	SBE3 ITS-90	SPRT-SBE3 Old_Coefs	SPRT-SBE3 New_Coefs
3248.4327	-1.5047	-1.5047	0.00121	0.00004
3434.8348	0.9956	0.9957	0.00090	-0.00006
3997.8053	7.9980	7.9980	0.00066	-0.00000
4302.8090	11.5004	11.5003	0.00067	0.00006
4960.8736	18.4965	18.4965	0.00050	-0.00005
5315.3056	21.9969	21.9969	0.00048	0.00001
6076.4991	28.9982	28.9982	0.00008	0.00001
6484.1022	32.5002	32.5002	-0.00032	-0.00001



Temperature Calibration Report
STS/ODF Calibration Facility

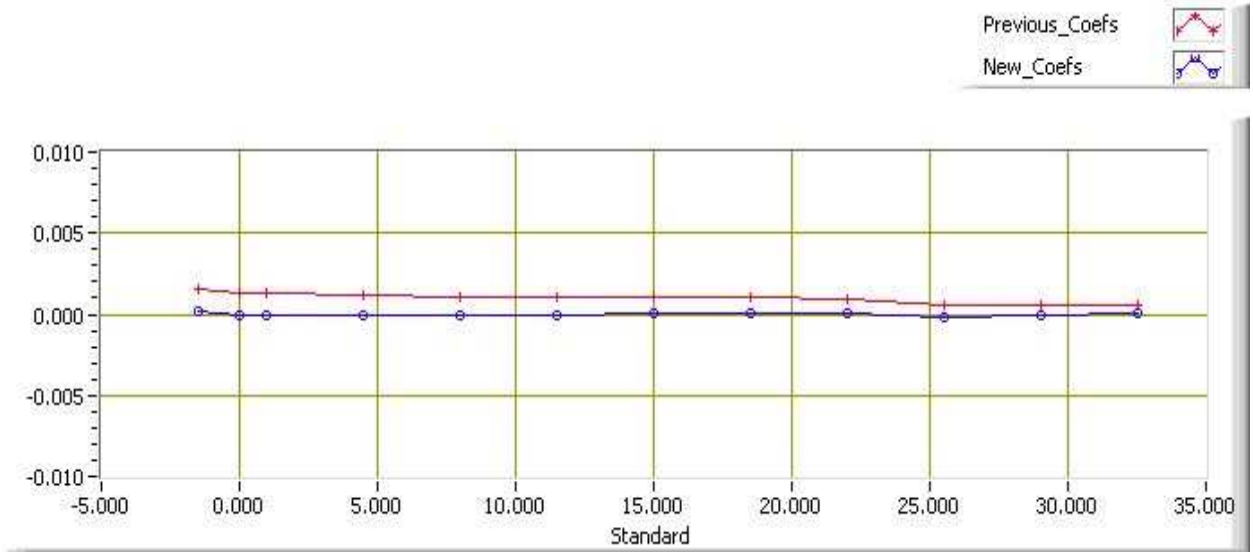
SENSOR SERIAL NUMBER: 4588
CALIBRATION DATE: 22-Jul-2010
Mfg: Seabird Model: 03
Previous cal: 11-Dec-09
Calibration Tech: CAL

ITS-90_COEFFICIENTS	IPTS-68_COEFFICIENTS
g = 4.35526936E-3	a = 4.35546699E-3
h = 6.37553467E-4	b = 6.37762788E-4
i = 2.06334865E-5	c = 2.06650994E-5
j = 1.70475225E-6	d = 1.70614304E-6

f0 = 1000.0 Slope = 1.0 Offset = 0.0

Calibration Standard: Mfg: ASL Model: F18 s/n: 245-5149
Temperature ITS-90 = 1/{g+h[ln(f0/f)]+i[ln2(f0/f)]+j[ln3(f0/f)]} - 273.15 (℃)
Temperature IPTS-68 = 1/{a+b[ln(f0/f)]+c[ln2(f0/f)]+d[ln3(f0/f)]} - 273.15 (℃)
T68 = 1.00024 * T90 (-2 to -35 Deg C)

SBE3 Freq	SPRT ITS-90	SBE3 ITS-90	SPRT-SBE3 Old_Coefs	SPRT-SBE3 New_Coefs
2981.0220	-1.5057	-1.5058	0.00159	0.00013
3083.8900	-0.0004	-0.0003	0.00131	-0.00007
3153.2620	0.9945	0.9946	0.00129	-0.00006
3406.3560	4.4956	4.4956	0.00117	-0.00004
3673.7660	7.9973	7.9973	0.00109	-0.00004
3955.8930	11.4997	11.4997	0.00107	0.00000
4252.3010	14.9933	14.9932	0.00109	0.00007
4564.9200	18.4964	18.4963	0.00108	0.00011
4893.0900	21.9970	21.9969	0.00097	0.00007
5237.5620	25.4993	25.4995	0.00061	-0.00019
5598.1210	28.9984	28.9985	0.00056	-0.00010
5975.7710	32.5007	32.5006	0.00057	0.00011



SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 1879
CALIBRATION DATE: 19-Aug-10

SBE4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS

```
g = -4.16240295e+000
h =  5.39624726e-001
i = -8.54369380e-004
j =  7.06222981e-005
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  3.04246884e-007
b =  5.36487445e-001
c = -4.15187219e+000
d = -7.83646923e-005
m =  5.7
CPcor = -9.5700e-008 (nominal)
```

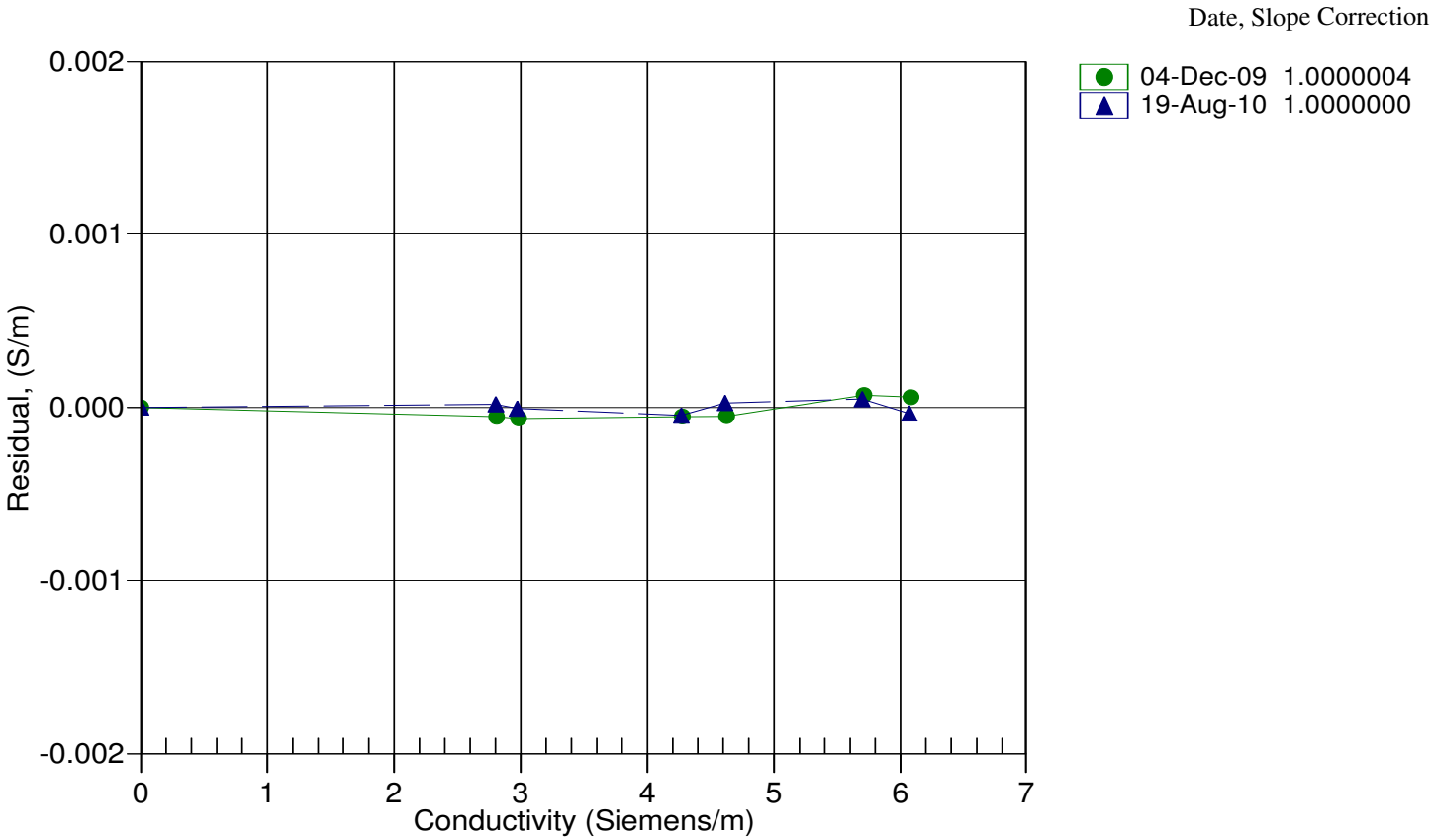
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREO (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.78204	0.00000	0.00000
-1.0001	34.7580	2.80031	7.73768	2.80033	0.00002
0.9999	34.7587	2.97150	7.94053	2.97149	-0.00001
14.9999	34.7606	4.26549	9.33039	4.26545	-0.00005
18.4999	34.7603	4.61173	9.66790	4.61176	0.00002
29.0001	34.7592	5.69403	10.65229	5.69408	0.00005
32.5000	34.7524	6.06611	10.96964	6.06607	-0.00004

Conductivity = $(g + hf^2 + if^3 + jf^4) / 10(1 + \delta t + \varepsilon p)$ Siemens/meter

Conductivity = $(af^m + bf^2 + c + dt) / [10 (1 + \varepsilon p)$ Siemens/meter

t = temperature[°C)]; p = pressure[decibars]; δ = CTcor; ε = CPcor;

Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 2659
CALIBRATION DATE: 19-Aug-10

SBE4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS

```
g = -1.01174230e+001
h =  1.42637784e+000
i = -1.24299608e-003
j =  1.63380565e-004
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  3.57683948e-006
b =  1.42329018e+000
c = -1.01113916e+001
d = -8.39160383e-005
m =  5.3
CPcor = -9.5700e-008 (nominal)
```

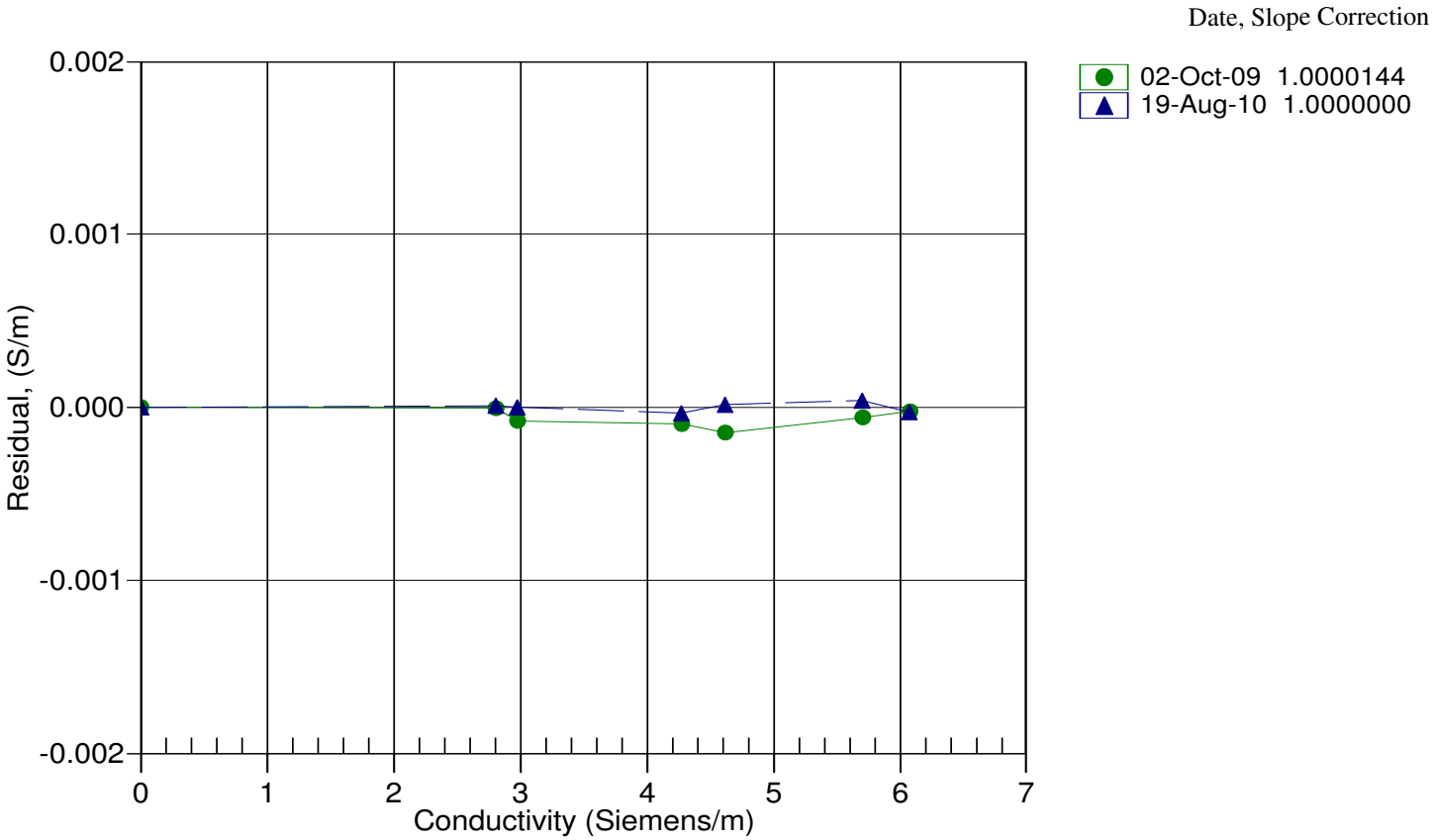
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREO (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.66530	0.00000	0.00000
-1.0001	34.7580	2.80031	5.17339	2.80032	0.00001
0.9999	34.7587	2.97150	5.28819	2.97150	0.00000
14.9999	34.7606	4.26549	6.08588	4.26546	-0.00003
18.4999	34.7603	4.61173	6.28208	4.61175	0.00002
29.0001	34.7592	5.69403	6.85888	5.69407	0.00004
32.5000	34.7524	6.06611	7.04613	6.06608	-0.00003

Conductivity = $(g + hf^2 + if^3 + jf^4) / 10(1 + \delta t + \varepsilon p)$ Siemens/meter

Conductivity = $(af^m + bf^2 + c + dt) / [10 (1 + \varepsilon p)$ Siemens/meter

t = temperature[°C)]; p = pressure[decibars]; δ = CTcor; ε = CPcor;

Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 1129
CALIBRATION DATE: 19-Aug-10p

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS

Soc = 0.4884
Voffset = -0.5262
Tau20 = 1.71

A = -3.6810e-003
B = 1.2255e-004
C = -2.3836e-006
E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS

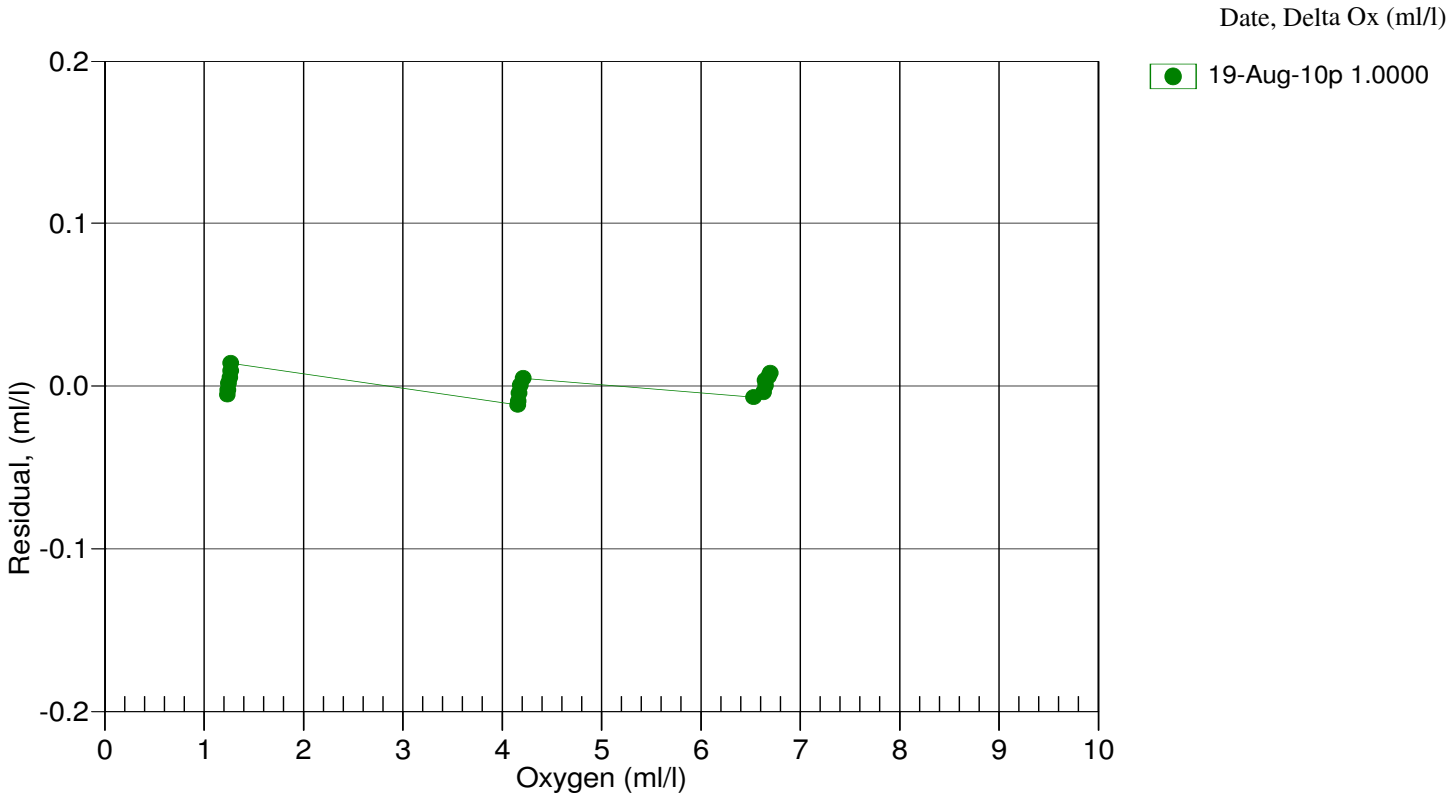
D1 = 1.92634e-4 H1 = -3.30000e-2
D2 = -4.64803e-2 H2 = 5.00000e+3
H3 = 1.45000e+3

BATH OX (ml/l)	BATH TEMP ITS-90	BATH SAL PSU	INSTRUMENT OUTPUT(VOLTS)	INSTRUMENT OXYGEN(ml/l)	RESIDUAL (ml/l)
1.23	2.00	0.01	0.787	1.23	-0.01
1.24	6.00	0.02	0.823	1.24	-0.00
1.25	12.00	0.02	0.876	1.25	0.00
1.26	20.00	0.02	0.952	1.26	0.01
1.27	26.00	0.02	1.014	1.28	0.01
1.27	30.00	0.02	1.058	1.28	0.01
4.16	2.00	0.01	1.409	4.14	-0.01
4.16	6.00	0.02	1.520	4.15	-0.01
4.17	12.00	0.02	1.693	4.17	-0.00
4.18	20.00	0.02	1.933	4.18	0.00
4.19	26.00	0.02	2.125	4.19	0.00
4.21	30.00	0.02	2.270	4.21	0.00
6.53	30.00	0.02	3.225	6.52	-0.01
6.63	20.00	0.02	2.756	6.63	-0.00
6.64	12.00	0.02	2.388	6.65	0.00
6.65	26.00	0.02	3.063	6.65	0.00
6.68	6.00	0.02	2.127	6.69	0.01
6.70	2.00	0.01	1.955	6.71	0.01

Oxygen (ml/l) = Soc * (V + Voffset) * (1.0 + A * T + B * T^2 + C * T^3) * OxSol(T,S) * exp(E * P / K)

V = voltage output from SBE43, T = temperature [deg C], S = salinity [PSU] K = temperature [deg K]

OxSol(T,S) = oxygen saturation [ml/l], P = pressure [dbar], Residual = instrument oxygen - bath oxygen



PO Box 518
620 Applegate St.
Philomath, OR 97370

WET Labs

(541) 929-5650
Fax (541) 929-5277
www.wetlabs.com

C-Star Calibration

Date March 1, 2010 S/N# CST-492DR Pathlength 25 cm

	Analog meter
V_d	0.060 V
V_{air}	4.831 V
V_{ref}	4.714 V

Temperature of calibration water	23.9 °C
Ambient temperature during calibration	22.8 °C

Relationship of transmittance (Tr) to beam attenuation coefficient (c), and pathlength (x, in meters): $\mathbf{Tr = e^{-cx}}$

To determine beam transmittance: $\mathbf{Tr = (V_{sig} - V_{dark}) / (V_{ref} - V_{dark})}$

To determine beam attenuation coefficient: $\mathbf{c = -1/x * \ln (Tr)}$

V_d Meter output with the beam blocked. This is the offset.
V_{air} Meter output in air with a clear beam path.
V_{ref} Meter output with clean water in the path.
Temperature of calibration water: temperature of clean water used to obtain V_{ref}.
Ambient temperature: meter temperature in air during the calibration.
V_{sig} Measured signal output of meter.

Calibration Record

Date:	December 17, 2009
Sensor Type:	Seapoint Chlorophyll Fluorometer
Serial Number(s):	2775

A comparative calibration was performed using a calibrated reference fluorometer. The reference fluorometer was calibrated with the cultured algae Isochrysis galbana.

This Seapoint Chlorophyll Fluorometer meets or exceeds the specifications stated in the supplied User Manual.

If you have any questions please contact me at 603/642-4921 or seapoint@seapoint.com

12/17/09

Signature Date

Seapoint Sensors, inc.
PO Box 368 • Exeter, NH 03833 • USA
Tel: (603) 642-4921 • Fax: (603) 642-4922
seapoint@seapoint.com • www.seapoint.com

SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0035
CALIBRATION DATE: 20-Jun-09p

SBE 35 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

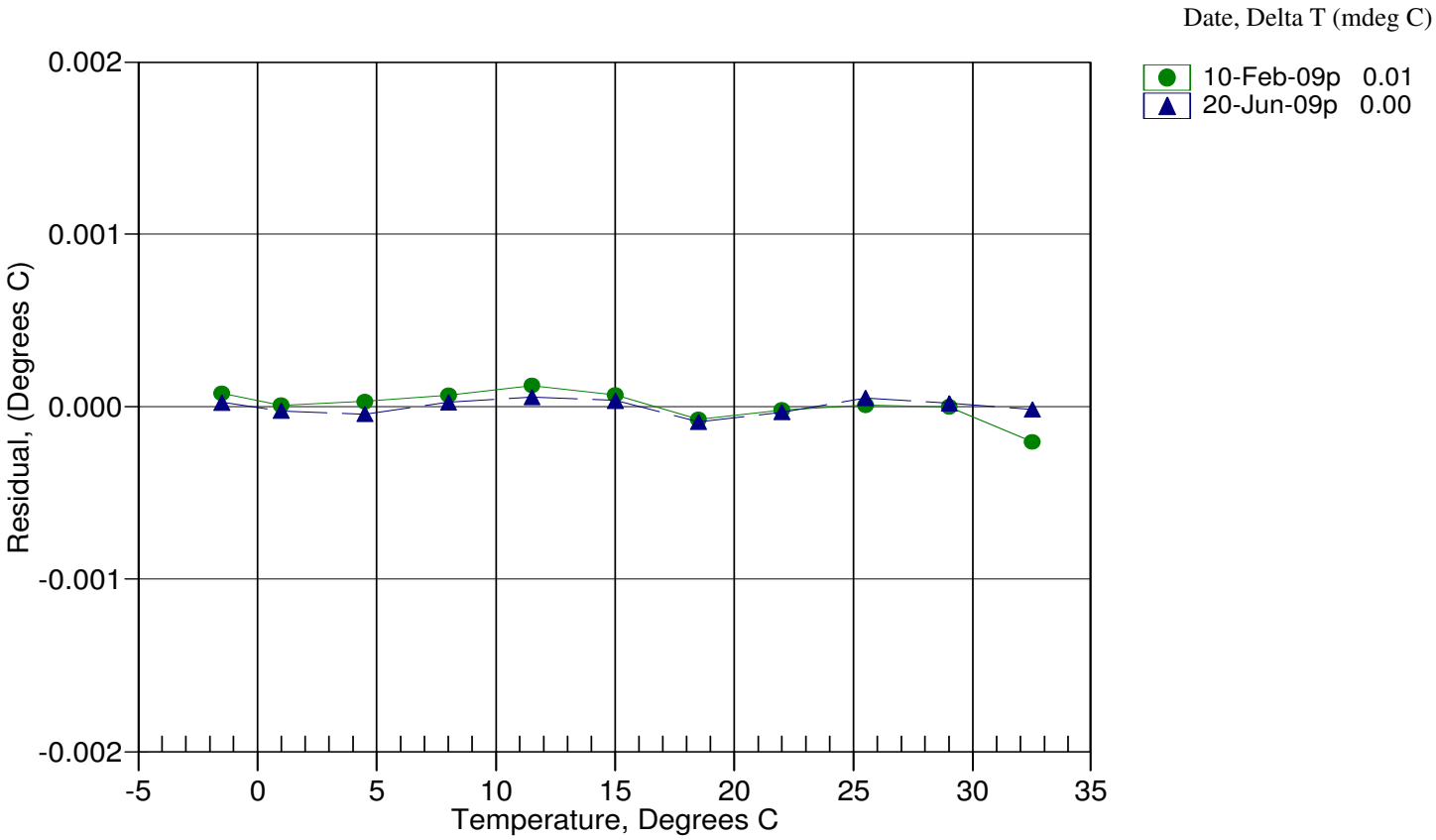
ITS-90 COEFFICIENTS

```
a0 =  4.09600050e-003
a1 = -1.08847098e-003
a2 =  1.69276343e-004
a3 = -9.47988704e-006
a4 =  2.04256264e-007
```

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT (n)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.499970	658851.07	-1.499946	0.000024
0.999960	590493.07	0.999934	-0.000026
4.499960	507714.48	4.499916	-0.000044
7.999960	437724.73	7.999986	0.000026
11.500010	378405.83	11.500064	0.000054
15.000040	328007.39	15.000076	0.000036
18.500020	285081.27	18.499930	-0.000090
22.000030	248423.06	21.999997	-0.000033
25.499960	217040.24	25.500009	0.000049
28.999950	190104.98	28.999970	0.000020
32.499930	166927.85	32.499912	-0.000018

Temperature ITS-90 = $1/\{a0 + a1[ln(n)] + a2[ln^2(n)] + a3[ln^3(n)] + a4[ln^4(n)]\} - 273.15$ (°C)

Residual = instrument temperature - bath temperature



CCHDO Data Processing Notes

Date	Person	Data Type	Action	Summary
2013-08-07	Johnson, Mary	CTD	Submitted	to go online (1st half)

These are the first half of what GEOTRACES calls "NAZT" (North Atlantic Zonal Transsect), which was cut short due to a broken shaft on the Knorr after station 12. The transsect was resumed from the other direction in 2011, with stations again starting from "1". These are the CTD data from the "SIOR" rosette only. Jim Swift has the bottle exchange files to review, and will submit them separately.

| 2013-08-07 | Swift, Jim | BTL | Submitted | to go online (1st half) |

These are edited versions of the BCO-DMO files for the ODF rosette data from the two US GEOTRACES Atlantic cruise legs, here containing only the routine hydrography data. The ocean carbon data will be provided when they are available.

| 2013-08-07 | Swift, Jim | BTL | Re-submitted | to go online (1st half) |

These are edited version of the bottle data files at BCO-DMO for the ODF and Cutter rosettes from the two US GEOTRACES Atlantic cruises. The files contain only the routine hydrographic data. The ocean carbon data from the ODF rosette casts will be added when available. ODF rosette bottle data files have "SIOR" in the file name. Cutter rosette bottle data files have "GT-C" in the file name.

| 2013-08-16 | Staff, CCHDO | CTD | Website Update | Available under 'Files as received' |

The following files are now available online under 'Files as received', unprocessed by the CCHDO.
gt10_CruiseReport.zip
gt10_ct1.zip

| 2013-08-16 | Staff, CCHDO | BTL | Website Update | Available under 'Files as received' |

The following files are now available online under 'Files as received', unprocessed by the CCHDO.
gt10_GT-C_edit_hy1.csv

| 2013-08-16 | Staff, CCHDO | BTL | Website Update | Available under 'Files as received' |

The following files are now available online under 'Files as received', unprocessed by the CCHDO.
gt10_SIOR_edit_hy1.csv

| 2013-08-20 | Lee, Rox | maps | Website Update | Map created |

```
==============================
316N20101015 processing - Maps
==============================
2013-08-20
R Lee
.. contents:: :depth: 2
Process
=======
Changes
-------
- Map created from gt10_SIOR_edit_hy1.csv
Merge
-----
Directories
===========
:working directory:
  /data/co2clivar/atlantic/316N20101015/original/2013.08.20_maps_RJL
:cruise directory:
  /data/co2clivar/atlantic/316N20101015
Updated Files Manifest
======================
- 316N20101015_trk.gif
- 316N20101015_trk.jpg
```

2013-10-14 Berys, Carolina CTD Website Update Exchange and netCDF files online

```
==============================
316N20101015 processing - CTD
==============================
2013-10-14
C Berys
.. contents:: :depth: 2
Submission
==========
============ ================== ========== ========= ====
filename     submitted by       date       data type id
============ ================== ========== ========= ====
gt10_ct1.zip Mary Carol Johnson 2013-08-07 CTD       1045
============ ================== ========== ========= ====
Parameters
----------
gt10_ct1.zip
~~~~~~~~~~~~
- CTDPRS [1]_
- CTDTMP [1]_
- CTDSAL [1]_
- CTDOXY [1]_
- TRANSM [1]_
- FLUORM [1]_
- DEPTH [1]_ [3]_
- CTDNOBS
- CTDETIME
.. [1] parameter has quality flag column
.. [2] parameter only has fill values/no reported measured data
.. [3] not in netCDF
Process
=======
Changes
-------
gt10_ct1.zip
~~~~~~~~~~~~
- files renamed
Conversion
----------
======================= ==================== =======================
file                    converted from       software
======================= ==================== =======================
316N20101015_nc_hyd.zip 316N20101015_hy1.csv hydro 0.8.0-50-g4bae068
======================= ==================== =======================
All converted files opened in JOA with no apparent problems.
Directories
===========
:working directory:
  /data/co2clivar/atlantic/316N20101015/original/2013.10.14_CTD_CBG
:cruise directory:
```

```
  /data/co2clivar/atlantic/316N20101015
Updated Files Manifest
======================
- 316N20101015_ct1.zip
- 316N20101015_nc_ctd.zip
```

2013-10-29 Kappa, Jerry CrsRpt Website Update PDF version online

I've placed a new PDF version of the cruise report:

316N20101015_do.pdf

into the directory: co2clivar/atlantic/316N20101015/ .

It includes all the reports provided by the cruise PIs, summary pages and CCHDO data processing notes, as well as a linked Table of Contents and links to figures, tables and appendices.