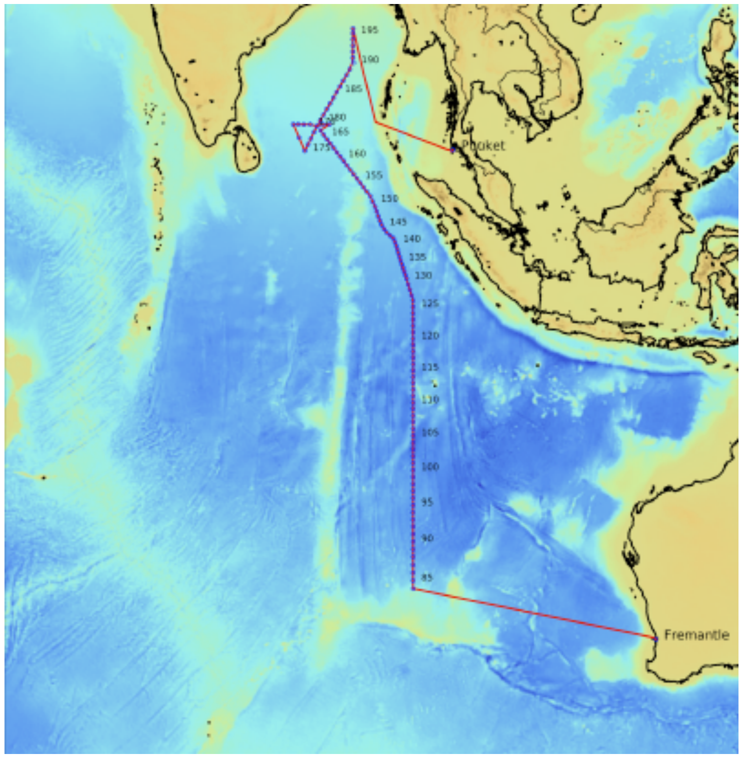
CRUISE REPORT:
I09N *(Updated OCT 2016)*



Highlights

Cruise Summary Information

Section Designation	**I09N**
Expedition designation (ExpoCodes)	**33RR20160321**
Chief Scientists	**Leticia Barbero**
Dates	**2016 MAR 21 – 2016 APR 28**
Ship	*R/V Roger Revelle*
Ports of call	Fremantle, Australia - Phuket, Thailand
Geographic Boundaries	17° 53' N 84° 45' 9.72" E 95° 0' 2.5" E 28° 18' 46.8" S
Stations	113
Floats and drifters deployed	8 Argo floats deployed
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 Report of the 2016 I09N US GO-SHIP Reoccupation

Release Draft 1

Leticia Barbero

July 29, 2016

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CHAPTER ONE

GO-SHIP I09N 2016 HYDROGRAPHIC PROGRAM

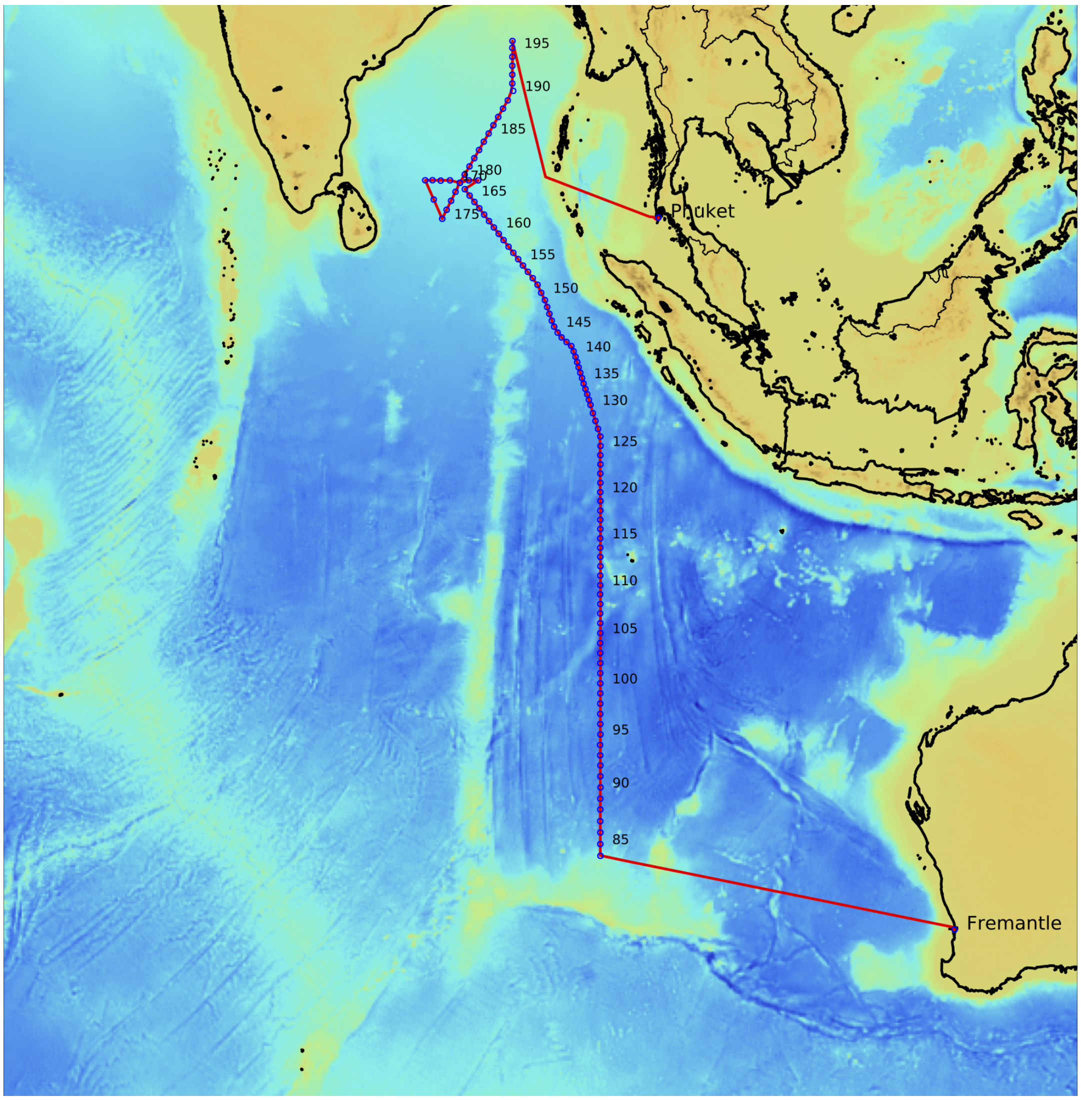
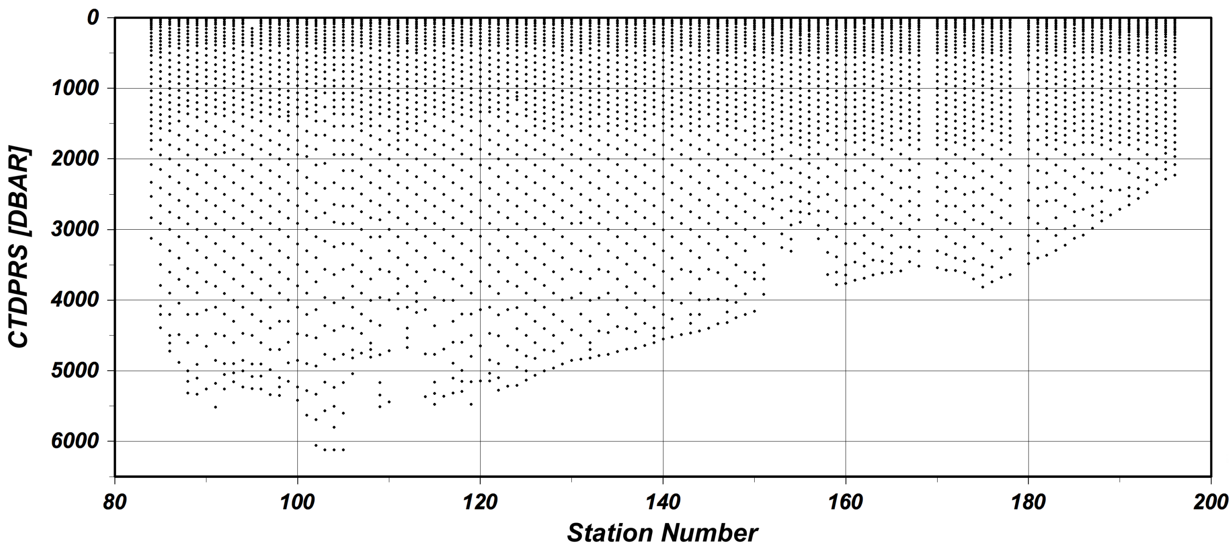


Fig. 1.1: Cruise track of I09N

The Indian Ocean I09N repeat hydrographic line was reoccupied for the US Global Ocean Carbon and Repeat Hydrography Program. Reoccupation of the I09N transect occurred on the *R/V Roger Revelle* from March 21st, 2016 to April 28th, 2016. The survey of I09N consisted of *CTDO*, rosette, *LADCP*, chipod, water samples and underway measurements. The ship departed from the port of Fremantle, Western Australia and completed the cruise in the port of Cape Panwa on the island of Phuket, Thailand.

A total of 113 stations were occupied with one CTDO/rosette/LADCP/chipod package. 1 repeat station from the previ-ous section leg I08S station number 83 was the I09N initial station 84. 113 stations 117 CTDO/rosette/LADCP/ chipod casts including 1 test cast performed, for the most part, a reoccupation of I09N-2007 and detailed in the following sec-tions. 8 Argo/O_2 floats were deployed on I09N and detailed in the Argo section of the cruise report. 3 trace metal casts were complete from the aft A-frame and detailed in the “Phytoplankton, 15N/13C and Trace Metals” section of the cruise report. 26 successful spectroradiometer (optics) casts were performed through the cruise, also detailed in the “CDOM, Chlorophyll A and Spectroradiometer" section of the cruise report.



CTDO data and water samples were collected on each CTDO, rosette, LADCP and chipod cast, usually with in 10 meters of the bottom. Water samples were measured on board for salinity, dissolved oxygen, nutrients, *DIC*, pH, total alkalinity and *CFCs*/*SF6*. Additional water samples were collected and stored for shore analyses of δO^{18}, δN^{15} and δO^{18} in NO^3, *DOC*/*TDN*, 13C/14C, *CDOM*, phytoplankton pigments, *POC*, *HPLC*, *AP*, DNA, dPOC/dPON, d NO^3/NO^3, d NO_2^-/NO_2, NH_4^+, cell counts, urea and bacterial abundance.

A sea-going science team assembled from 17 different institutions and participated in the collection and analysis of this data set. The programs, principal investigators, science team, responsibilities, instrumentation, analysis and analytical methods are outlined in the following cruise document.

1.1 Programs and Principal Investigators

Program	Affiliation	Principal Investigator	Email
CTDO Data, Salinity, Nutrients, Dissolved O_2	*UCSD*, *SIO*	Susan Becker, Jim Swift	sbecker@ucsd.edu, jswift@ucsd.edu
Total CO_2 (DIC), Underway pCO_2	*AOML*, *NOAA*	Rik Wanninkhof	Rik.Wanninkhof@noaa.gov
Total Alkalinity, pH	*UCSD*, *SIO*	Andrew Dickson	adickson@ucsd.edu
ADCP	*UH*	Jules Hummon	Hummon@hawaii.edu
LADCP	*LDEO*, *UH*	Andreas Thurnherr, William Smethie, David Ho	ant@ldeo.columbia.edu, bsmeth@ldeo.columbia.edu, ho@hawaii.edu
CFCs, SF_6	*LDEO*	Peter Schlosser	schlosser@ldeo.columbia.edu
DOC, TDN	*UCSB*	Craig Carlson	carlson@lifesci.ucsb.edu
Transmissometry	*TAMU*	Wilf Gardner	wgardner@ocean.tamu.edu
Chipod	*OSU*, *UCSD*	Jonathan Nash, Jen Mackinnon	nash@coas.oregonstate.edu, jmackinnon@ucsd.edu
CDOM, *HPLC*, *POC*	*UCSB*	Norm Nelson	norm@icess.ucsb.edu
13C/14C	*WHOI*, *Princeton*	Ann McNichol, Robert Key	amcnichol@whoi.edu, key@princeton.edu
δO^{18}	*LDEO*	Peter Schlosser	schlosser@ldeo.columbia.edu
δN^{15} and δO^{18} in NO^3	*WHOI*	Chawalit Charoenpong	ccharoenpong@whoi.edu
Genomics/ *POC*	*UCI*	Adam Martiny	amartiny@ucsi.edu
Phytoplankton, δN^{15} /13C	*Bigelow*	Mike Lomas	mlomas@bigelow.org
Trace Metals	*Bigelow*	Benjamin Twining	btwining@bigelow.org
Argo/O2 Floats	*UW*, *PMEL*	Greg Johnson	shaun.dolk@noaa.gov
Bathymetry, Underway Thermosalinograph	*UCSD*, *SIO*	Bruce Applegate	bapplegate@ucsd.edu

1.2 Science Team and Responsibilities

Duty	Name	Affiliation	Email Address
Chief Scientist	Letticia Barbero	*AOML*	leticia.barbero@noaa.gov
Co-Chief Scientist	Carmen Rodriguez	*UCSD*	crodriguez@rsmas.miami.edu
CTD Watchstander, NO^3 Isotopes	Chawalit Charoenpong	*WHOI*	ccharoenpong@whoi.edu
CTD Watchstander, Weather	Amanda Fay	*U. Wisconsin*	arfay@wisc.edu
CTD Watchstander, Chipods	Karina Khazmutdinova	*FSU*	kk11m@my.fsu.edu
CTD Watchstander, LADCP	Patrick Mears	Coastal Carolina	patrickamears@gmail.com
Res Tech	Matthew Durham	*UCSD*	mjdurham@ucsd.edu
Res Tech	John Edward Cumminskey	*UCSD*	jecummiskey@ucsd.edu
Computer Tech	Brent Devries	*UCSD*	bdevries@ucsd.edu
Nutrients, *ODF* supervisor, *SOCCOM* floats	Susan Becker	*UCSD ODF*	sbecker@ucsd.edu
Nutrients	John Ballard	*UCSD ODF*	jrballar@ucsd.edu
CTDO Processing, Database Management	Courtney Schatzman	*UCSD ODF*	cschatzman@ucsd.edu
Salts, ET, Deck	Sergey Tepyuk	*UCSD SEG*	sergey1@ucsd.edu

Continued on next page

Table 1.1 – continued from previous page

Duty	Name	Affiliation	Email Address
Dissolved O_2, Database Management	Andrew Barna	*UCSD ODF*	abarna@gmail.com
Dissolved O_2, Database Support	Joseph Gum	*UCSD ODF*	jgum@ucsd.edu
SADCP, *LADCP*	Takaya Uchida	*LDEO*	tuchida@ldeo.columbia.edu
DIC, underway pCO2	Robert Castle	*AOML*	robert.castle@noaa.gov
DIC	Morgan Ostendorf	*PMEL*	morgan.ostendorf@noaa.gov
CFCs, SF6	Eugene Gorman	*LDEO*	egorman@ldeo.columbia.edu
CFCs, SF6	Benjamin Hickman	*LDEO*	hickmanb@hawaii.edu
CFCs, SF6 student	Molly Martin	*RSMAS*	mmmartin@rsmas.miami.edu
Total Alkalinity	David Cervantes	*UCSD*	d1cervantes@ucsd.edu
Total Alkalinity	Ellen Briggs	*UCSD*	ebriggs@ucsd.edu
pH	Stephanie Mumma	*UCSD*	stephaniemumma@hotmail.com
CDOM	Erick Stassinos	*UCSB*	norm@icess.ucsb.edu
CDOM	Jeremy Kravitz	*U. Puerto Rico*	jeremy.kraviz@gmail.com
DOC, *TDN*, Radio Carbon	Jacqui Comstock	*UCSB*	jacquicomstock@gmail.com
Phytoplankton, 15N/13C	Steven Baer	*Bigelow*	sbaer@bigelow.org
Genomics/*POM*	Cathy Garcia	*UCI*	catgar@uci.edu
Genomics/*POM*	Nathan Garcia	*UCI*	n8garcia@gmail.com
Trace Metals	Sara Rauschenberg	*Bigelow*	srauschenberg@bigelow.org

1.3 Underwater Sampling Package

CTDO/rosette/LADCP/chipod casts were performed with a package consisting of a 36 bottle rosette frame, a 36-place carousel and 36 Bullister style Niskin bottles with an absolute volume of 10.4L. Underwater electronic components primarily consisted of a SeaBird Electronics pressure sensor and housing unit with dual exhaust, dual pumps, dual temperature, a reference temperature, dual conductivity, dissolved oxygen, transmissometer, chlorophyll fluorometer and altimeter. LADCP and chipods instruments were deployed with the CTD/rosette package and their use is outlined in sections of this document specific to their titled analysis.

CTD was mounted horizontally in the CTDO/rosette/LADCP/chipod for all stations. The cages were mounted at the bottom of the rosette frame, and located to one side of the carousel. The temperature, conductivity, dissolved oxygen, respective pumps and exhaust tubing were mounted to the CTD housing as recommended by SBE. The reference temperature sensor was mounted between the primary and secondary temperature sensors at the same level as the intake tubes for the exhaust lines. The transmissometers were mounted horizontally. The fluorometers and altimeters were mounted vertically inside the bottom ring of the rosette frame. The 300 KHz bi-directional Broadband LADCP (RDI) units, when in use, were mounted vertically on the top and bottom sides of the frame. The LADCP battery pack was also mounted on the bottom of the frame.

Equipment	Model	S/N	Cal Date	Sta	Resp Party
Rosette	36-place	Yellow	_	84-196	*STS*/*ODF*
CTD	SBE9+	831	_	84-194	*STS*/*ODF*
Pressure Sensor	Digiquartz	99677	Nov 17, 2015	84-194	*STS*/*ODF*
Primary Temperature	SBE3+	32166	Nov 17, 2015	84-194	*STS*/*ODF*
Primary Conductivity	SBE4C	43399	Nov 10, 2015	84-112	*STS*/*ODF*
Primary Conductivity	SBE4C	43023	Dec 1, 2015	113-114	*STS*/*ODF*
Primary Conductivity	SBE4C	43207	Jan 20, 2016	115-122	*STS*/*ODF*
Primary Conductivity	SBE4C	42819	Jan 21, 2016	115-122	*STS*/*ODF*
Primary Pump	SBE5	55011	_	84-194	*STS*/*ODF*
Secondary Temperature	SBE3+	34226	Nov 17, 2015	84-194	*STS*/*ODF*
Secondary Conductivity	SBE4C	41919	Nov 10, 2015	84-102	*STS*/*ODF*
Secondary Conductivity	SBE4C	43215	Nov 10, 2015	103-196	*STS*/*ODF*
Secondary Pump	SBE5	54128	_	84-194	*STS*/*ODF*
Transmissometer	Cstar	CST-1636DR	Oct 8, 2016	84-194	*TAMU*
Fluorometer Chloro	WetLabs	FLRTD-2050	_	84-194	*STS*/*ODF*
Primary Dissolved Oxygen	SBE43	431138	Nov 19, 2015	84-97, 105-196	*STS*/*ODF*
Primary Dissolved Oxygen	SBE43	430848	Nov 19, 2015	98-104	*STS*/*ODF*
Secondary Dissolved Oxygen	SBE43	430197	Feb 09, 2016	99-100, 106	*STS*/*ODF*
Secondary Dissolved Oxygen	SBE43	431138	Nov 19, 2015	101-104	*STS*/*ODF*
Secondary Dissolved Oxygen	SBE43	430875	Nov 20, 2015	105	*STS*/*ODF*
Secondary Dissolved Oxygen	SBE43	430275	Jan 21, 2016	107	*STS*/*ODF*
Carousel	SBE32	_	_	84-194	*STS*/*ODF*
Reference Temperature	SBE35	_	_	84-127, 131-194	*STS*/*ODF*

The CAST6 aft winch deployment system was successfully used for all stations. 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 I09N-2016. A mechanical termination was completed after station/cast 114/02. An electrical re-termination took place after station/cast 115/02 due to signal failure at ~3000 dbar up-cast.

The deck watch prepared the rosette 10-30 minutes prior to each cast. The bottles were cocked and all valves, vents and lanyards were checked for proper orientation. LADCP technician would check for LADCP battery charge, prepare instrument for data acquisition and disconnect cables. The chipod battery was monitored for charge and connectors were checked for fouling and connectivity. Every 20 stations, the transmissometer windows were cleaned and an on deck blocked and un-blocked voltage readings were recorded prior to the cast. Once stopped on station, the Marine Technician would check the sea state prior to cast and decide if conditions were acceptable for deployment.

Recovering the package at the end of the deployment was essentially the reverse of launching. The rosette, CTD and carousel were rinsed with fresh water frequently. CTD maintenance included rinsing de-ionized water through both plumbed sensor lines between casts. On average, once every 20 stations, 1% Triton-x solution was also rinsed through both conductivity sensors. The rosette was routinely examined for valves and o-rings leaks, which were maintained as needed.

Some complications were overcome to complete CTDO/rosette/LADCP/chipod station casts for I09N. Carousel communications issues were noted at the tail end of a few full ocean depth casts. We had some communications issues after a few full ocean depth casts, and found that the carousel’s bulkhead connector appeared to have some damage. This was only noticed when the surface bottle at the top of stations/casts 125/01, 126/01 and 127/01 would't trip. The carousel would lose communication (the pressure of the deeper casts was holding the connector seated in place later allowing seawater ingress towards the surface where pressure decreased as the cast progressed). Since we do not have a spare 36 place carousel we have worked to repair this connection by creating supports for the connector with heat shrink. We used a straight cable while repairs to the damaged Y-cable were made. The Y-cable enables communication with the SBE35 reference temperature sensor. While the Y-cable was repaired (sta: 127-133) we did not have data from SBE35. Since these repairs, we did not have any more communications errors with the carousel. However, during the troubleshooting for this issue, another carousel issue came up with bottle #12 failing to fire on station/casts 127/03, 130/02, 131/02, 133/01 and 134/01. Our first suspicion was just a sticky latch, but no amount of cleaning or swapping of latches was reliably solving the problem. Closer inspection of the magnet/solenoid for bottle 12 showed some of the seal starting to protrude from the solenoid housing surface. As the stations are starting to get closer together and shallower, losing a single bottle depth did not seem to be a major issue for science, so rather than risk further damage to the carousel by attempting surgery on the damaged seal we removed bottle 12 from the rosette and bottle firing sequence and continued operating with 35 bottles. Shorty following the events with carousel trigger 12, the seals at bottle position #5 (sta: 150) and #20 (sta: 180) were found to be extruding as well. Both of these bottle positions were taken out of the firing sequence as well. Finally bottle 35 showed some leakage during a couple of casts and was swapped with the replacement bottle from position 5 to resolve the issue.

CHAPTER TWO

CRUISE NARATIVE

2.1 Summary

The US GO-SHIP I09N 2016 repeat hydrography cruise took place in the Indian Ocean from March 21 through April 28, 2016. This I09N cruise track was a repeat of the 2007 occupation and is the northern extension of the I08S cruise which took place February 14 to March 17, 2016 on the *R/V Roger Revelle*. This hydrographic survey of the Indian Ocean included: rosette casts with mounted CTD/DO/LADCP/Chi-pods/Fluorometer/Transmissometer; bio-optical casts; trace metal casts; underway shipboard ADCP and pCO2/fluorescence/T/S measurements; underway sampling for biochemical measurements (HPLC/AP/NH_4/PO*/ nitrogen isotopic composition of POM); as well as ARGO float and XBT deployments. Mobilization onto the *R/V Revelle* occurred on March 18th in Fremantle, Australia and the cruise departed Fremantle on March 21st, 2016 at 13:24 (local). The *R/V Revelle* arrived to Phuket, Thailand on April 28, 2016 at 08:00.

The general I09N cruise track is meridional, heading north along the 95E longitude line until approximately 5S, where the occupation veers northwesterly in order to stay within international waters (see figure in front page of this report).

Following the cruise track of the 2007 I09N, we reoccupied the so-called “bow-tie” section in the Bay of Bengal, which is a triangular track extending zonally from roughly 85-90E on 10N, and meridionally from roughly 7-10N on 86/85E. The zonal transect along 10N starting on station 167 is a reoccupation of stations from WOCE line I01E, which was only occupied once in 1995. Given the time availability at that point we decided to extend the transect as far west as international waters would allow, and we added two extra stations to our cruise, a reoccupation of stations 981 and 980 of the I01E line. This brought our total number of stations from 111 to 113.

The location of stations 190 and 196 had to be slightly modified with respect to their counterparts on I09N 2007 because they fell within the EEZ of India. 190 was moved slightly westward, while 196, our northernmost station, was moved about 7’ south, to 17.883N instead of 18.0N.

Sampling occurred at 20-30 nm-intervals from March 25 through April 24. A total of 113 stations were occupied and 116 CTD/rosette casts were deployed. The CTD/rosette package (CTD/DO/LADCP/Chi-pod/fluorometer/transmissometer) was deployed to within 10-15m of the bottom on 110 stations. Stations 103-105 were deeper than 6000m. Due to pressure limitations of the equipment installed on the rosette, the deepest bottle was fired at 6000m on these stations, regardless of actual depth. A similar gap occurred during the 1995 and 2007 occupations for similar reasons. At stations 97, 127, and 162 (termed “Regional Stations,”) an additional rosette was deployed to a depth near 200m for the collection of biochemical samples. Approximately once per day, if the weather and timing were conducive to sampling, separate trace metal casts (28 total) and bio-optical casts (23 total) were deployed from the aft deck.

Water samples from the rosette/CTD package were collected in up to 36 10L Bullister bottles at all stations providing water samples for CFCs/SF6, dissolved oxygen, Total DIC, pH, Total Alkalinity, nutrients, salinity, DOC, DO14C, CDOM, Chl-a, HPLC, AP, POC, δ15N2, N2, N2O, isotopic composition of NO3-, NO2- and NH4- isotopes, DNA composition. Underway surface pCO2, temperature, salinity, dissolved oxygen, multi-beam bathymetry and meteorological measurements were collected, as well as a suite of biochemical samples for subsequent analysis. Approximately once per day, at the same stations where trace metals casts were conducted, 3 bottles from the CTD were tripped at 20 meters to be dedicated to genomics and nutrient uptake rate incubation experiments.

Eight Argo floats were deployed throughout the cruise. XBTs were deployed on all days that CTD casts were not performed (underway in international waters) and they provided upper water column temperature profiles for calibration of the multi-beam. The cruise ended in Phuket, Thailand on April 28, 2016 with deMOB occurring on April 29, 2016.

A highlight of this cruise has been the number of collaborations and potential new projects that have sprouted between scientists from different institutions (UC Irvine, Bigelow and WHOI) for biogeochemical studies in the Bay of Bengal using underway surface water from the science seawater line and left-over water from the CTDs (these samples have been added to the sample log for keeping track).

2.2 Issues / Goals not Achieved

No major problems were experienced during the cruise and all science goals were successfully achieved. In fact, the excellent weather and performance of the equipment allowed us to add two extra "bonus" stations along 10N, extending the reoccupation of I01E as far west as international waters would allow us.

The following are some minor issues experienced during the cruise: On Sunday April 3rd, while on station 115, we had a loss of communications with the CTD which was then at 3000 m depth and coming up. We recovered the package and determined that one of the conductor cables had shorted. We switched to an alternate one in the winch and proceeded with sampling, redoing a cast on station 115. There were no further communication issues after that.

In the second half of the cruise, 3 Niskin bottles had to be taken out of the rosette because of extruded seals on the magnets that trigger the closing of the bottles. At that point our deepest stations had been completed and the remaining ones were shallower. Our replacement carousel was a 24-bottle position, so it was preferable to keep using the 36-bottle carousel with 33 Niskins. Given the depths of the stations, this did not significantly impact the vertical resolution of the profiles.

2.3 Acknowledgements

The successful completion of the cruise relied on dedicated assistance from many individuals on shore and on the UNOLS ship *Roger Revelle*. Funded investigators in the project and members of the GO-SHIP executive committee, Lynne Talley, Greg Johnson and Jim Swift in particular, were instrumental in the successful planning and executing of the cruise. The participants in the cruise showed dedication and camaraderie during their 39 days at sea, often spending time from their off shift to assist other colleagues. Officers and crew of the *Roger Revelle* exhibited a high degree of professionalism and assistance to accomplish the mission and to make us feel at home during the long voyage. Captain Chris Curl oversaw a smoothly running ship and engaged with the scientific party. The expertise and professionalism of the restechs on board is greatly acknowledged. Their expert instrument and infrastructure troubleshooting experience ensured that any maintenance to our equipment was performed with minimal time loss, if any. All officers, deck crew, engineers, and galley staff contributed to the success of this long cruise. Their assistance is gratefully acknowledged.

The U.S. GO-SHIP is sponsored by the National Science Foundation and the NOAA Climate Observation Division of the Climate Program Office (COD/CPO).

Clearance was requested and granted from the sovereign nation of Australia for research conducted in their declared territorial waters. Their permission to execute the research effort in the waters surrounding Cocos Islands was critical for the repeat occupation and is greatly appreciated.

CHAPTER

THREE

CTDO AND HYDROGRAPHIC ANALYSIS

3.1 CTDO and Bottle Data Acquisition

The CTD data acquisition system consisted of an SBE-11+ (V2) deck unit and a networked generic PC workstation running Windows 7 2009 SBE SeaSave v.7.18c software was used for data acquisition and to close bottles on the rosette.

CTD deployments were initiated by the console watch operators (CWO) after the ship had stopped on station. The watch maintained a CTD Cast logs for each attempted cast containing a description of each deployment event.

Once the deck watch had deployed the rosette, the winch operator would lower it to 10 meters. The CTD sensor pumps were configured to start 10 seconds after the primary conductivity cell reports salt water in the cell. The CWO checked the CTD data for proper sensor operation, waited for sensors to stabilize, and instructed the winch operator to bring the package to the surface in good weather or 5 meters in high seas. The winch was then instructed to lower the package to the initial target wire-out at no more than 30m/min to 100m and no more than 60m/min after 100m depending on sea-cable tension and the sea state.

The CWO monitored the progress of the deployment and quality of the CTD data through interactive graphics and operational displays. The altimeter channel, CTD pressure, wire-out and center multi-beam depth were all monitored to determine the distance of the package from the bottom. The winch was directed to slow decent rate to 30m/min 100m from the bottom and 10m/min 30m from the bottom. The bottom of the CTD cast was usually to within 10-20 meters of the bottom determined by altimeter data. For each up-cast, the winch operator was directed to stop the winch at up to 36 predetermined sampling pressures. These standard depths were staggered every station using 3 sampling schemes. The CTD CWO waited 30 seconds prior to tripping sample bottles, to ensure package shed wake had dissipated. An additional 15 seconds elapsed before moving to the next consecutive trip depth, which allowed for the SBE35RT to record bottle trip temperature.

After the last bottle was closed, the CWO directed winch to recover the rosette. Once out of the water the CWO terminated the data acquisition, turned off the deck unit and assisted with rosette sampling.

Additionally, the watch created a sample log for the deployment which would be later used to record the depths bottles were tripped as well as correspondence between rosette bottles and analytical samples drawn.

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

Each bottle on the rosette had a unique serial number, independent of the bottle position on the rosette. Sampling for specific programs were outlined on sample log sheets prior to cast recovery or at the time of collection. The bottles and rosette were examined before samples were drawn. Any abnormalities were noted on the sample log, stored in the cruise database and reported in the APPENDIX.

3.2 CTDO Data Processing

Shipboard CTD data processing was performed after deployment using SIO/ODF CTD processing software v.5.1.0. CTD acquisition data were copied onto the Linux system and database, then processed to a 0.5-second time-series. CTD data at bottle trips were extracted, and a 2-decibar down-cast pressure series created. The pressure series data set was submitted for CTD data distribution after corrections outlined in the following sections were applied.

A total of 113 CTD stations were occupied including one test station. A total of 116 CTDO/rosette/LADCP/chipod casts were completed. 113 standard CTDO/rosette/LADCP/chipod casts, 3 trace metal program casts, one test cast. We had one aborted cast not included in completed cast count. 194 successful CTD casts were complete in combination with the I08S portion of this cruise. The 36-place (CTD #831) rosette was used for all station/casts.

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.

Temperature, salinity and dissolved 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.

A number of issues were encountered during I09N-2016 that directly impacted CTD analysis. Issues that directly impacted bottle closures, such as carousel communication problems, were detailed in the Underwater Sampling Package section of this report. Temperature, conductivity and oxygen analytical sensor issues are details in the following respective sections.

3.3 Pressure Analysis

Laboratory calibrations of CTD pressure sensors were performed prior to the cruise. Dates of laboratory calibration are recorded on the underway sampling package table and calibration documents are provided in the APPENDIX.

The Paroscientific Digiquartz pressure transducer S/N: 831-99677 was calibrated on November 17th, 2015 at the SIO/ Calibration Facility. The lab calibration coefficients provided on the calibration report were used to convert frequencies to pressure. Initially SIO/ pressure lab calibration slope and offsets coefficients were applied to cast data. A shipboard calibration offset was applied to the converted pressures during each cast. These offsets were determined by the pre and post-cast on-deck pressure offsets. The pressure offsets were applied per configuration cast sets.

- CTD Serial 831-99677; Station Set 84-196

	Start P (dbar)	End P (dbar)
Min	-0.3	0.0
Max	0.0	0.3
Average	-0.2	0.2
Applied Offset		-0.215

An offset of -0.215 was applied to every cast performed by CTD 831. On-deck pressure reading for CTD 831 varied from -0.3 to 0.0 dbar before the casts, and 0.0 to 0.3 dbar after the casts. Before and after average difference was -0.2 and 0.2 dbar respectively. The overall average offset before and after cast was -0.4 dbar.

3.4 Temperature Analysis

Laboratory calibrations of temperature sensors were performed prior to the cruise at the SIO/ Calibration Facility. Dates of laboratory calibration are recorded on the underway sampling package table and calibration documents are provided in the APPENDIX.

The pre-cruise laboratory calibration coefficients were used to convert SBE3plus frequencies to 90 temperature. Additional shipoard calibrations were performed to correct sensor bias. Two independent metrics of calibration accuracy were used to determine sensor bias. At each bottle closure, the primary and secondary temperature were compared with each other and with a SBE35RT reference temperature sensor.

The SBE35RT Digital Reversing Thermometer is an internally-recording temperature sensor that operates independently of the CTD. The SBE35RT was located equidistant between the two SBE3plus temperature sensors. The SBE35RT 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 was set to internally average over a 5 second period.

A functioning SBE3plus sensor typically exhibit a consistent predictable well modeled response. The response model is second order with respect to pressure, a first order with respect to temperature and a first order with respect to time. The functions used to apply shipboard calibrations are as follows.

$$T_{cor} = T + D_1 P_2 + D_2 P + D_3 T_2 + D_4 T + \text{Offset}$$

$$T_{90} = T + tp_1 P + t_0$$

$$T_{90} = T + aP_2 + bP + cT_2 + dT + \text{Offset}$$

Temperature corrected coefficients for each station are provided in the APPENDIX. Corrected temperature differences are shown in the following figures.

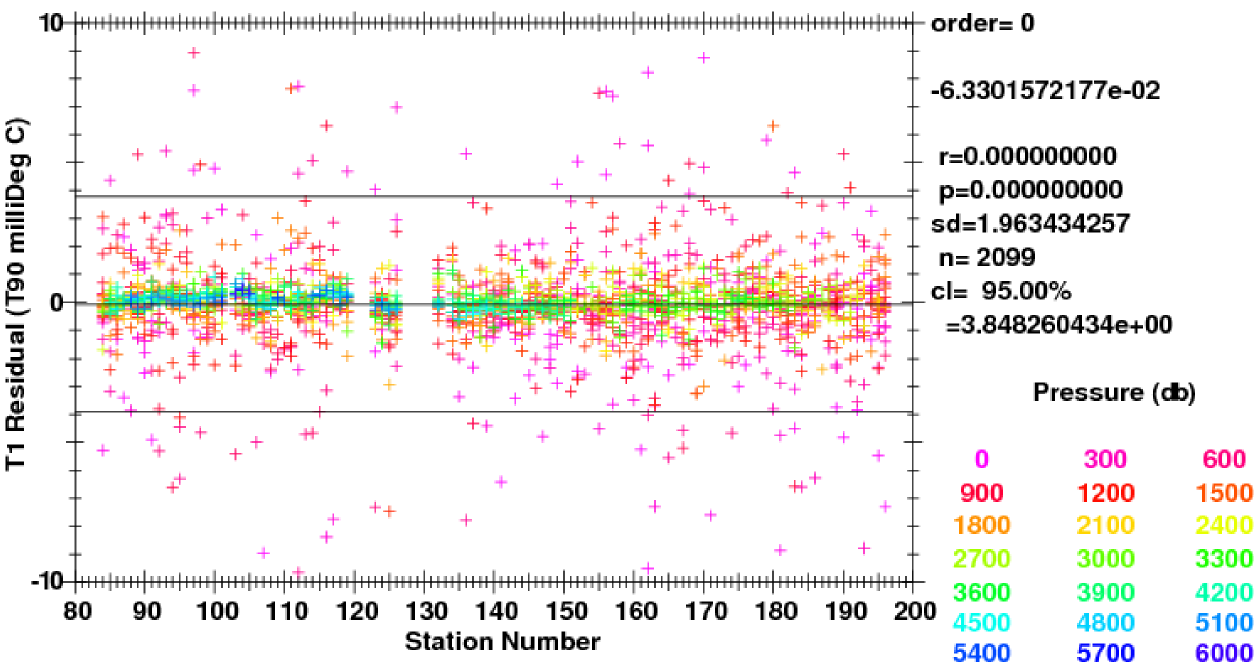


Fig. 3.1: SBE35RT-T1 by station (-0.002°C ≤ T1-T2 ≤ 0.002°C).

The 95% confidence limits for the mean low-gradient (values -0.002°C ≤ T1-T2 ≤ 0.002°C) differences are ±0.0038°C for SBE35RT-T1, ±0.0040°C for SBE35RT-T2 and ±0.0017°C for T1-T2. The 95% confidence limits for the deep temperature residuals (where pressure ≥ 2000dbar) are ±0.00087°C for SBE35RT-T1, ±0.00010°C for SBE35RT-T2 and ±0.0011°C for T1-T2.

Minor complications impacted the temperature sensor data used for the I09N cruise. The SBE35RT sensor was bypassed with a straight cable when carousel communication issues arose. As a result of carousel communications issues, temperature difference data is missing for stations 127-132. The carousel communication issues are detailed in the Underwater Sampling Package section of the report. The exhaust system pumps shut off on up-cast when

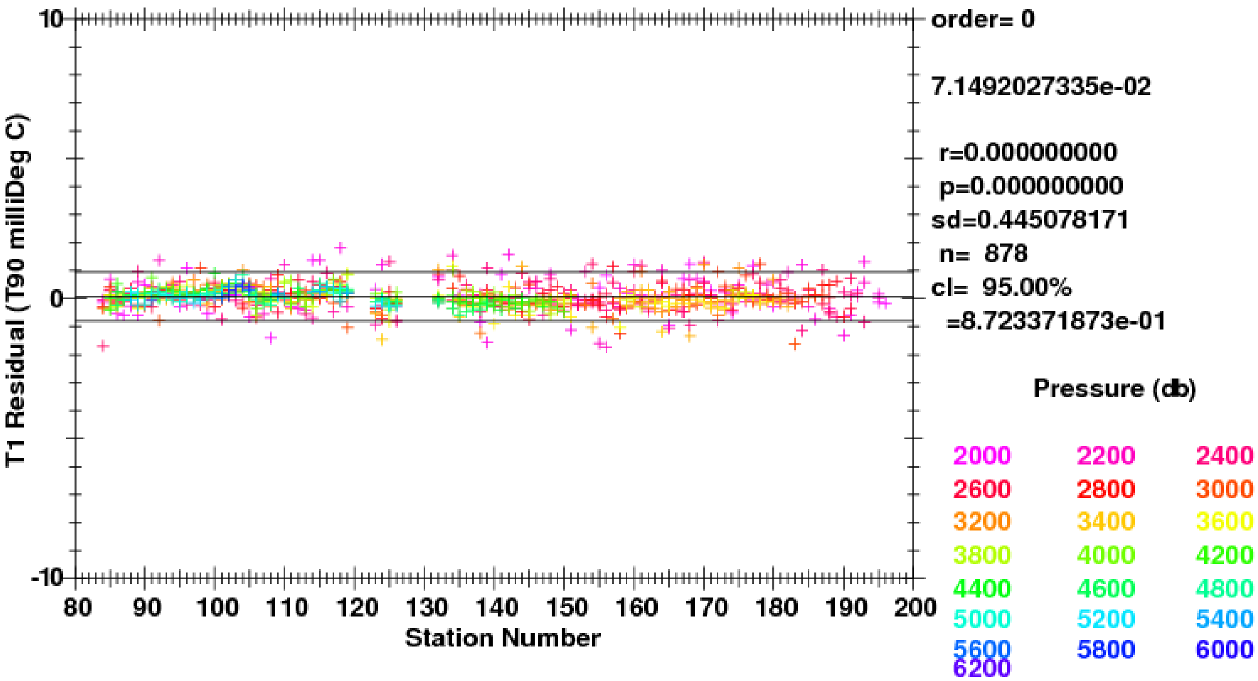


Fig. 3.2: Deep SBE35RT-T1 by station (Pressure ≥ 2000dbar).

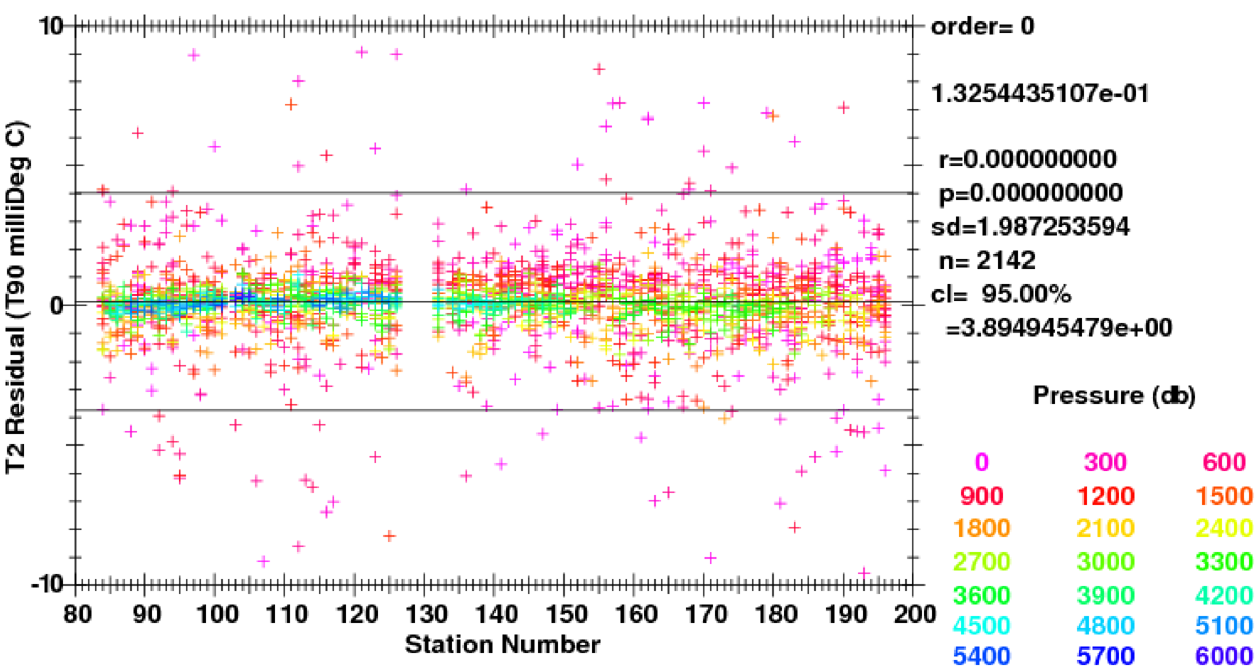


Fig. 3.3: SBE35RT-T2 by station (-0.002°C ≤ T1-T2 ≤ 0.002°C).

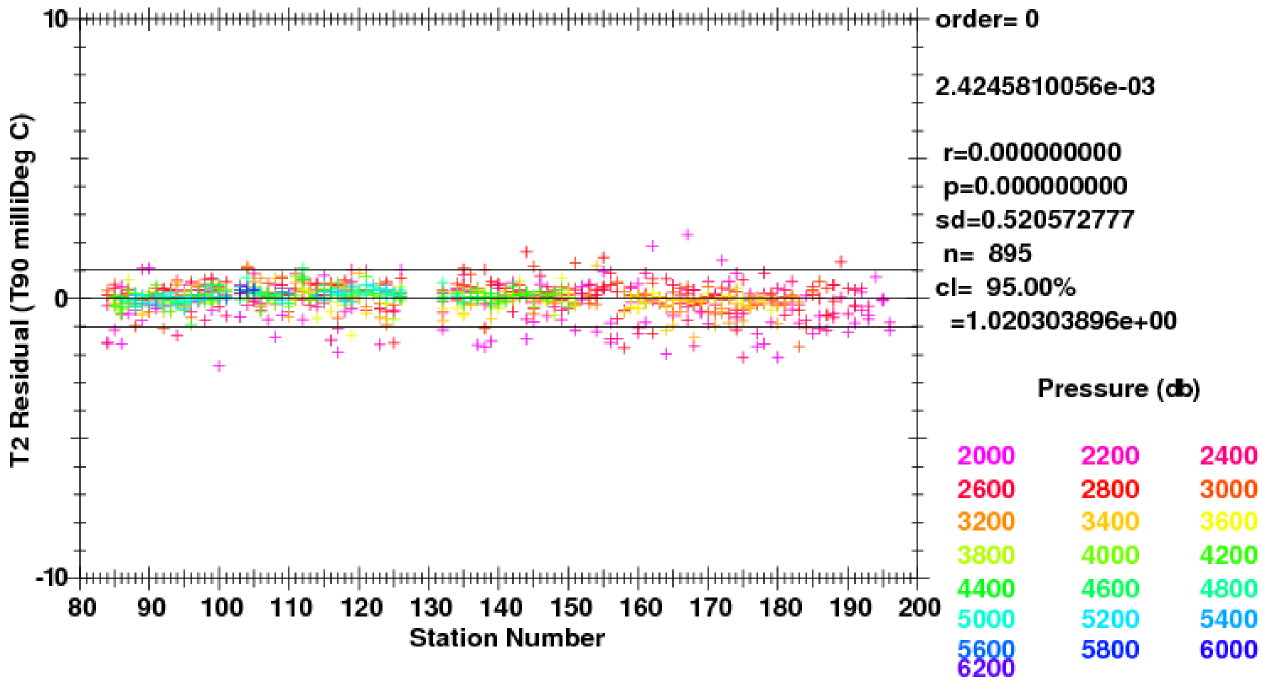


Fig. 3.4: Deep SBE35RT-T2 by station (Pressure ≥ 2000dbar).

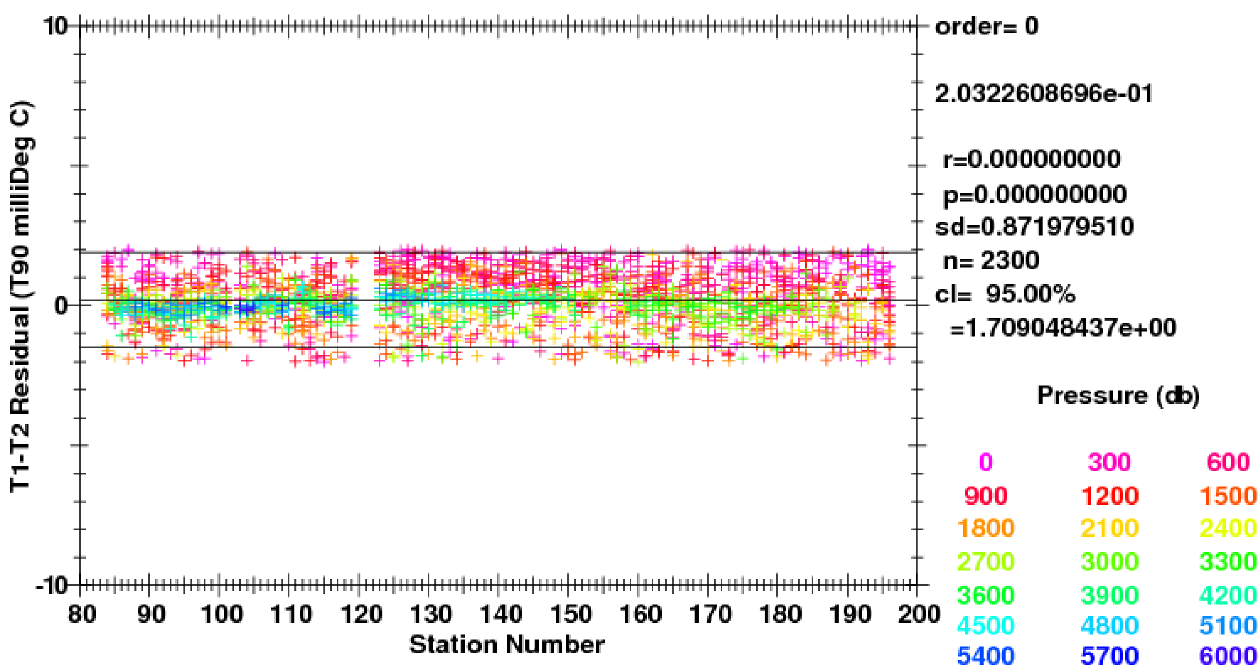


Fig. 3.5: T1-T2 by station (-0.002°C ≤ T1-T2 ≤ 0.002°C).

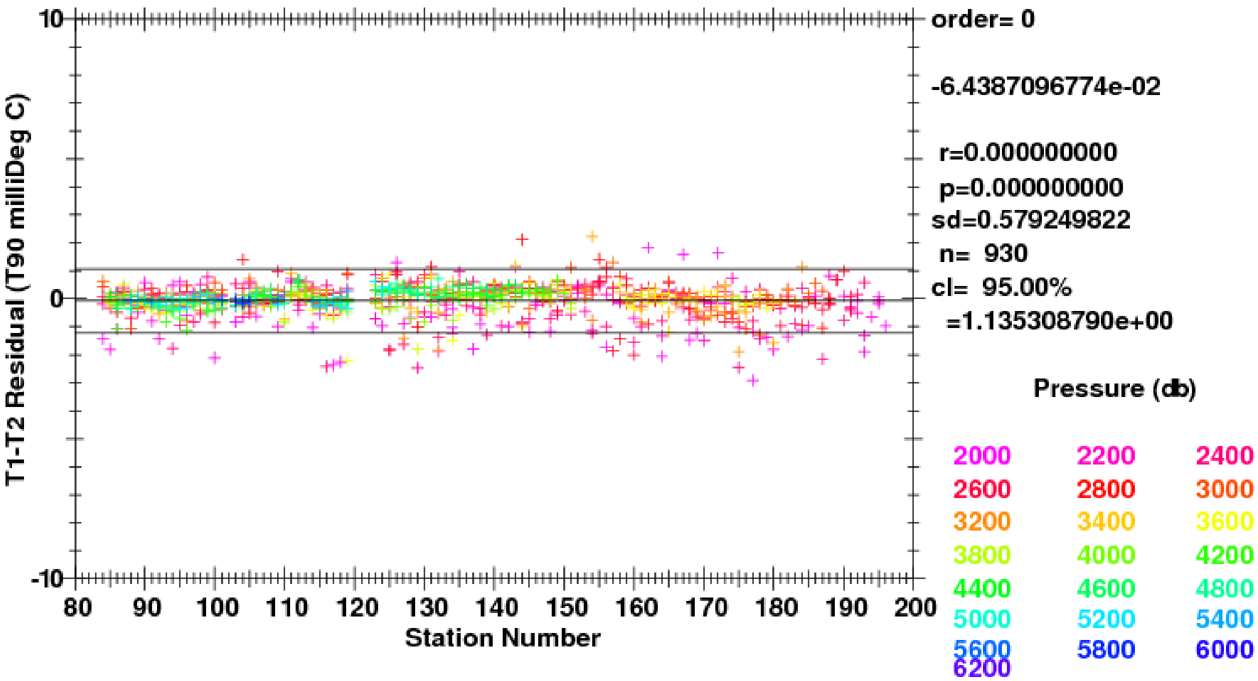


Fig. 3.6: Deep T1-T2 by station (Pressure ≥ 2000dbar).

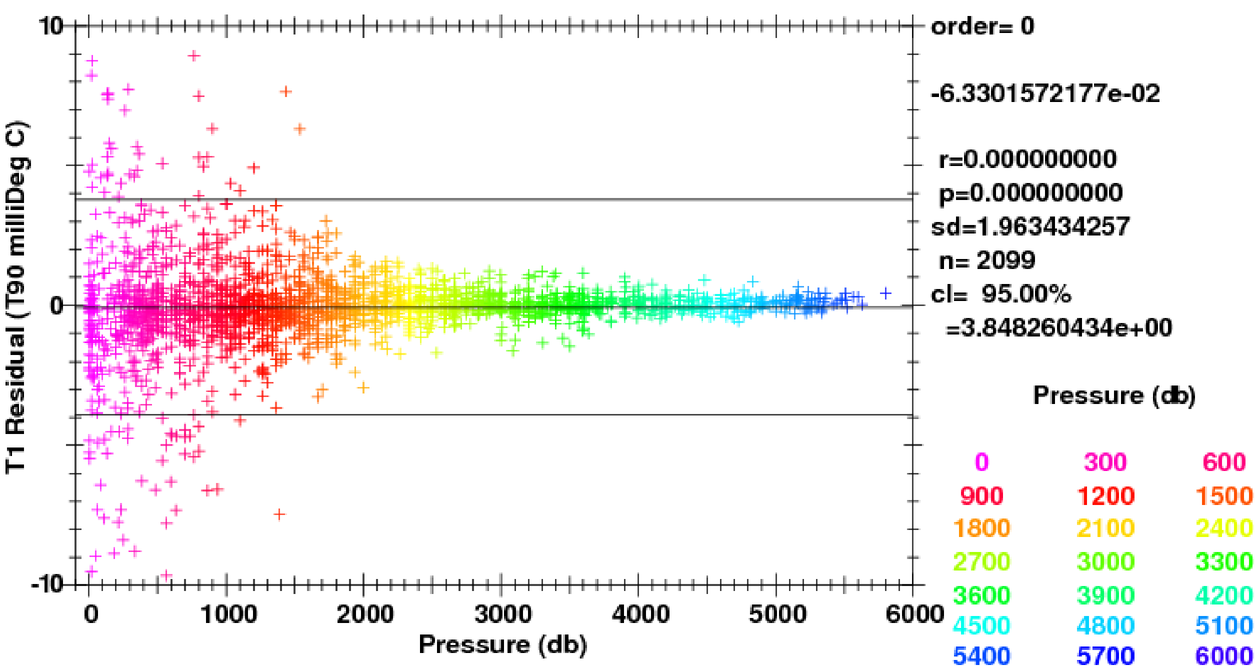


Fig. 3.7: SBE35RT-T1 by pressure (-0.002°C ≤ T1-T2 ≤ 0.002°C).

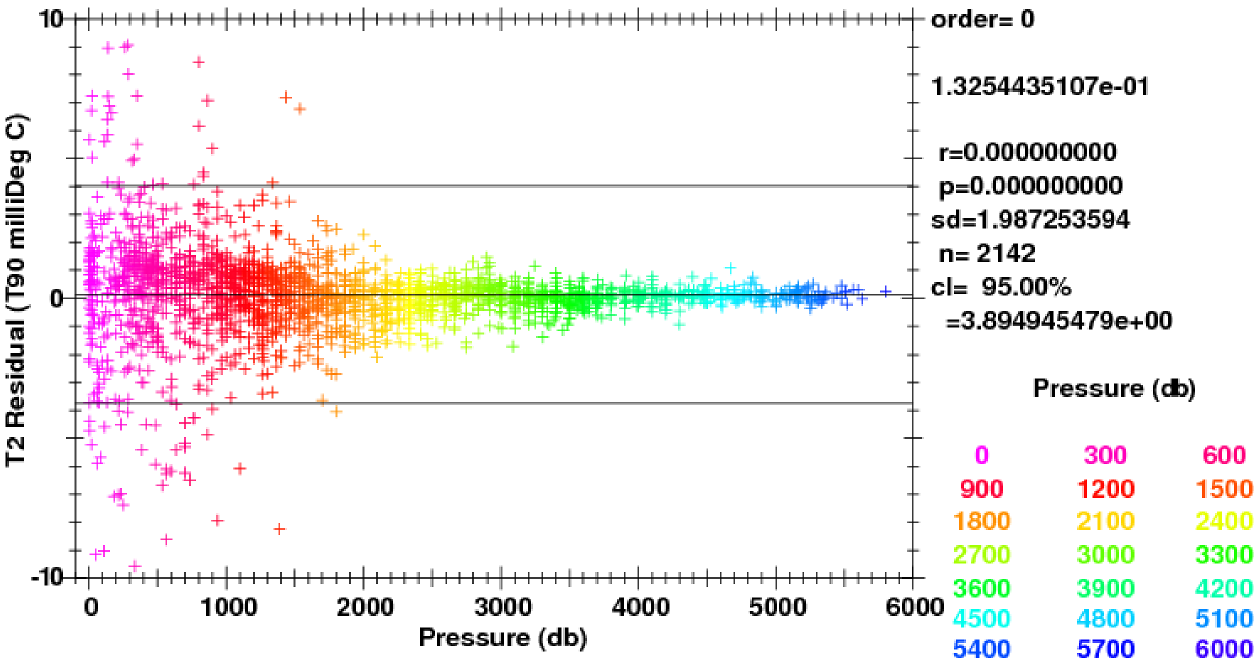


Fig. 3.8: SBE35RT-T2 by pressure (-0.002°C ≤ T1-T2 ≤ 0.002°C).

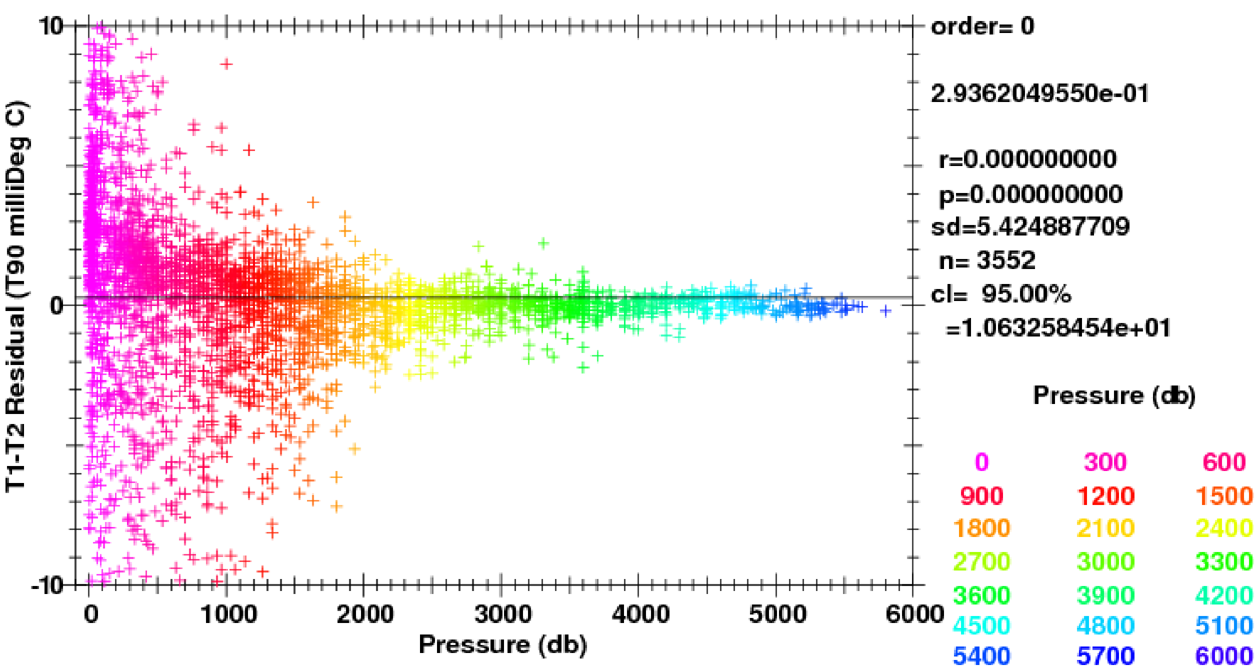


Fig. 3.9: T1-T2 by pressure (-0.002°C ≤ T1-T2 ≤ 0.002°C).

the primary conductivity sensor failed on stations 120, 121 and 122. Those complications are detailed in the following section. The pump failure resulted in poor flow through ventilation of the temperature sensors par-ticularly in the primary sensors. The secondary temperature data were reported for station data 120-122. The resulting affected sections of data have been coded and documented in the quality code APPENDIX.

3.5 Conductivity Analysis

Labortory calibrations of conductivity sensors were performed prior to the cruise at the SeaBird Calibration Facility. Dates of laboratory calibration are recorded on the underway sampling package table and calibration documents are provided in the APPENDIX.

The pre-cruise laboratory calibration coefficients were used to convert SBE4C frequencies to mS/cm conductivity values. Additional ship-board calibrations were performed to correct sensor bias. Corrections for both pressure and 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 con-tamination of conductivity comparisons by package wake. The coherence of this relationship is shown in the following figure.

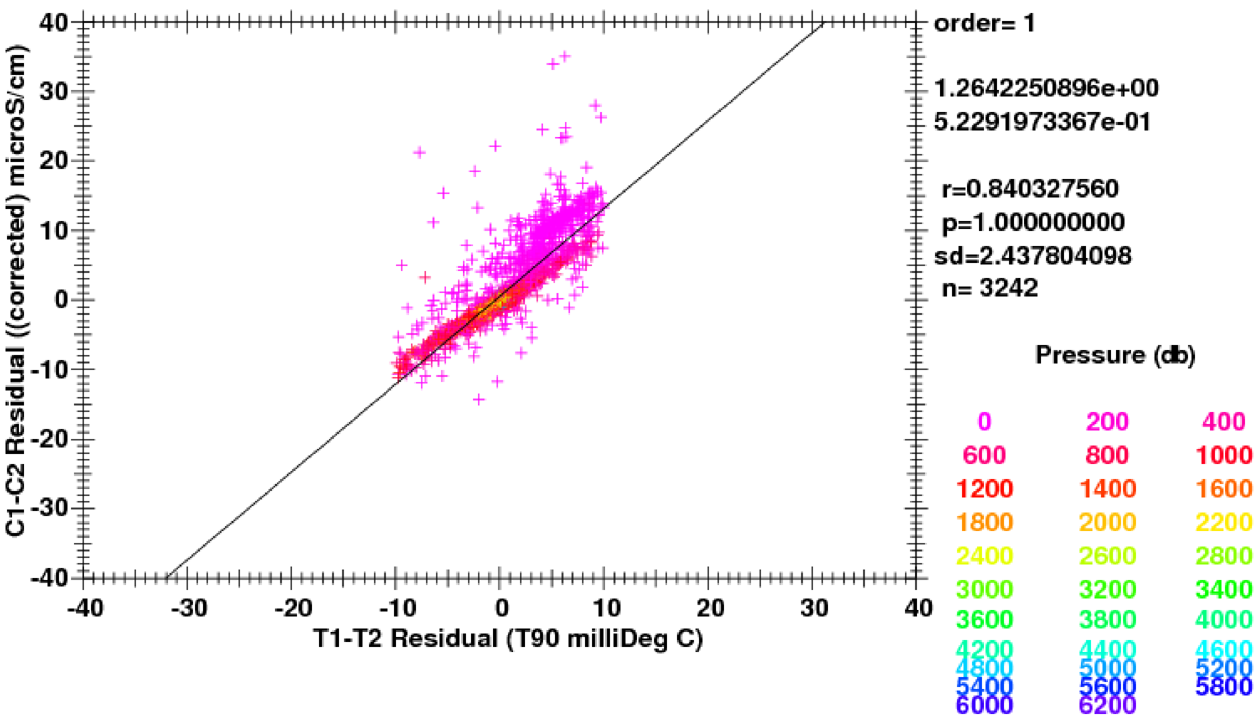


Fig. 3.10: Coherence of conductivity differences as a function of temperature differences.

Uncorrected conductivity comparisons are shown in the following figures: *Uncorrected CBottle - C1 by station (-0.002°C T1-T2 0.002°C).* through *Uncorrected C1-C2 by station (-0.002°C T1-T2 0.002°C).*.

The residual conductivity differences after correction are shown in figures: *Corrected CBottle - C1 by station (-0.002° C T1-T2 0.002°C).* through *Corrected C1-C2 by conductivity (-0.002°C T1-T2 0.002°C).*.

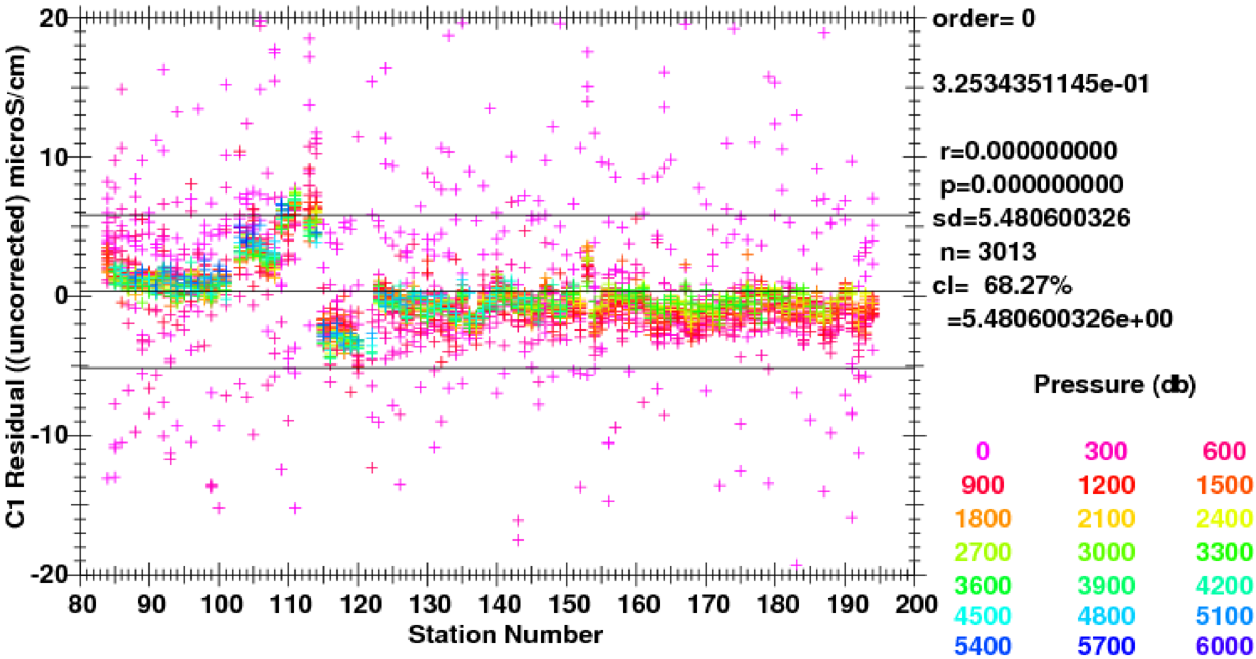


Fig. 3.11: Uncorrected C_{Bottle} - C1 by station (-0.002°C ≤ T1-T2 ≤ 0.002°C).

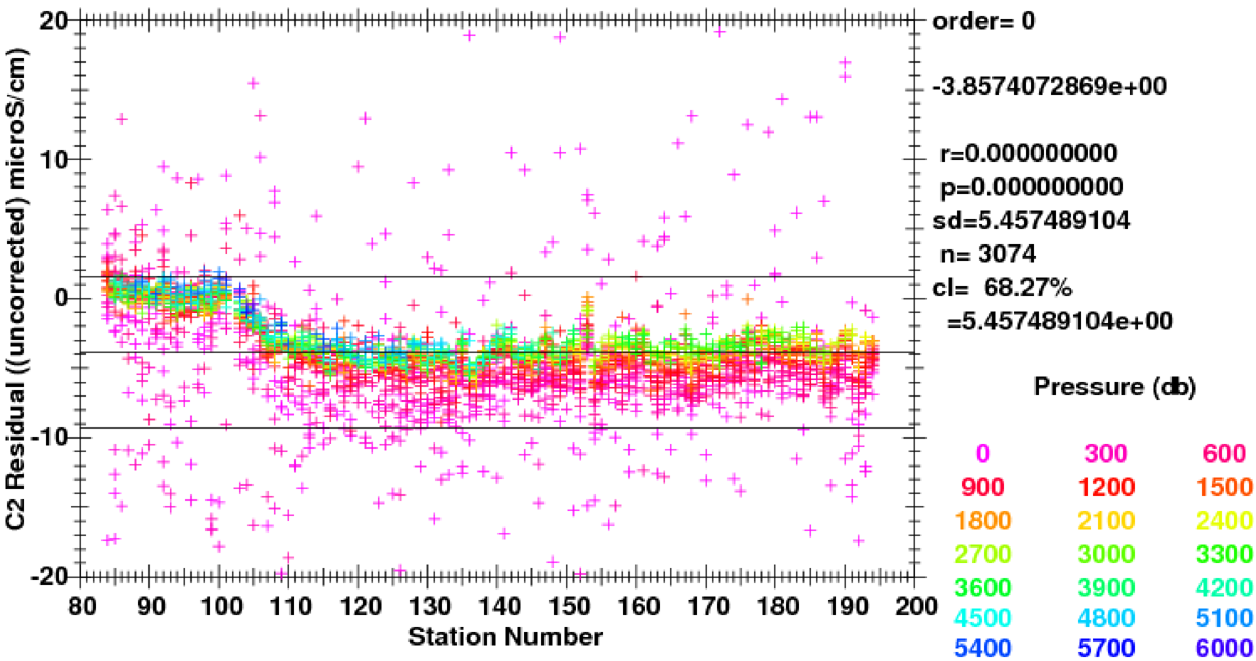


Fig. 3.12: Uncorrected C_{Bottle} - C2 by station (-0.002°C ≤ T1-T2 ≤ 0.002°C).

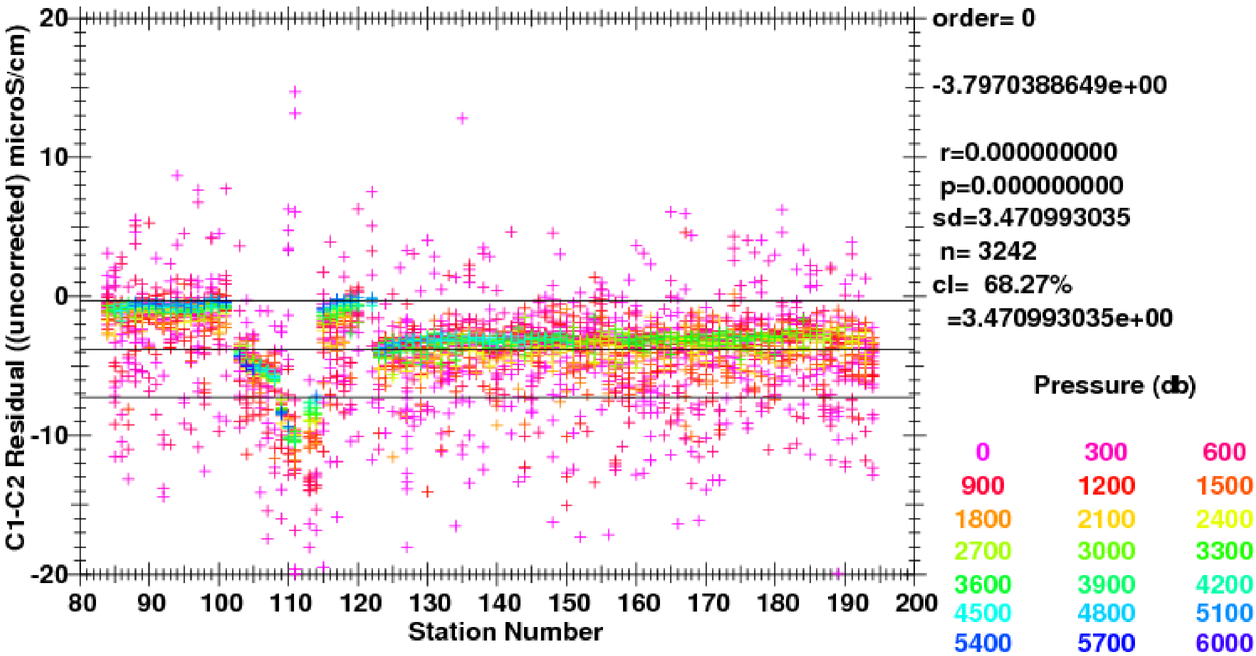


Fig. 3.13: Uncorrected C1-C2 by station (-0.002°C ≤ T1-T2 ≤ 0.002°C).

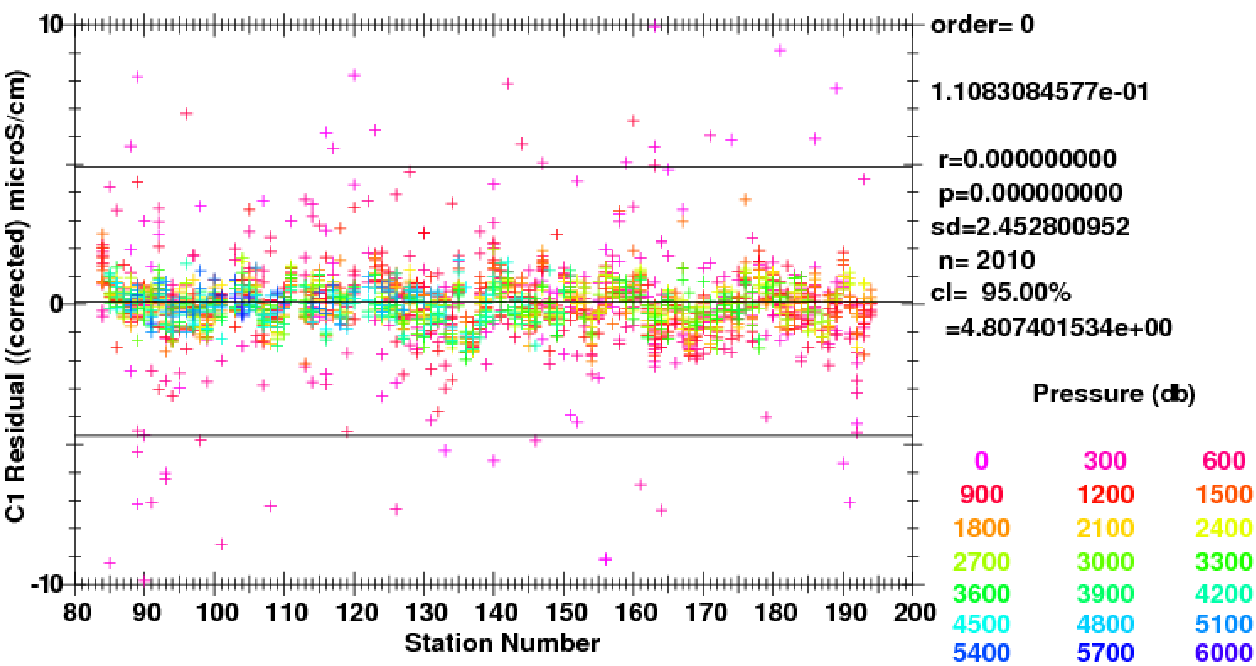


Fig. 3.14: Corrected C_{Bottle} - C1 by station (-0.002°C ≤ T1-T2 ≤ 0.002°C).

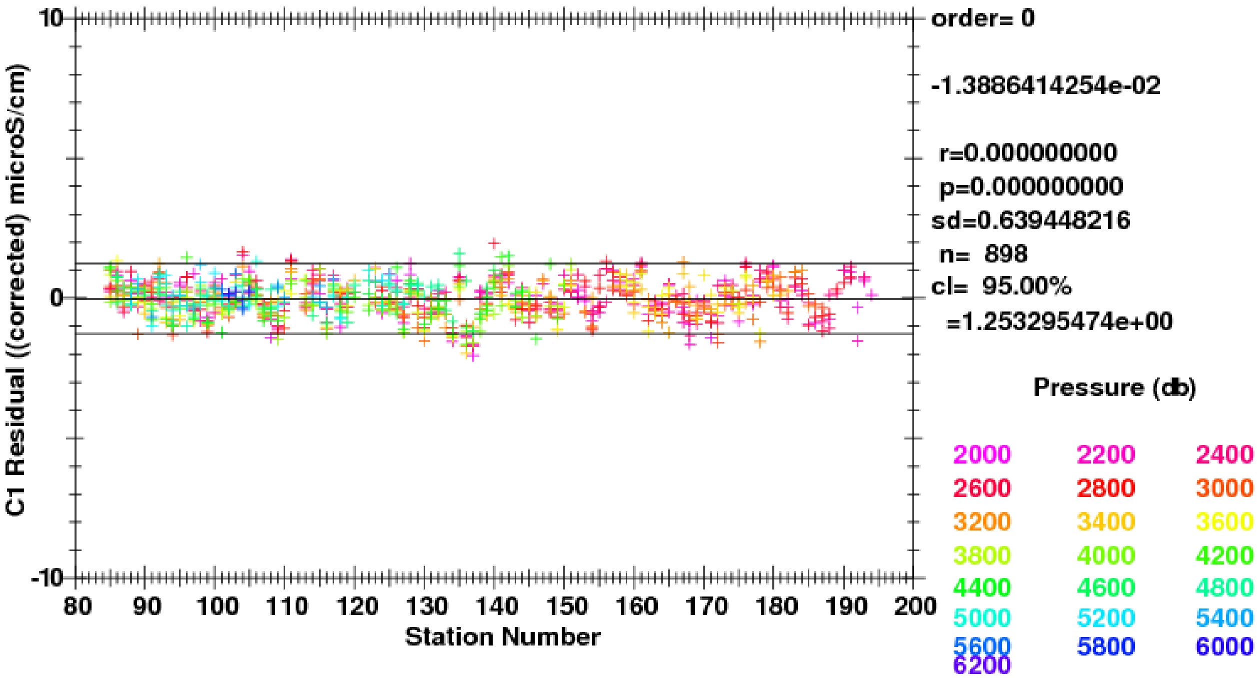


Fig. 3.15: Deep Corrected C_{Bottle} - C1 by station (Pressure >= 2000dbar).

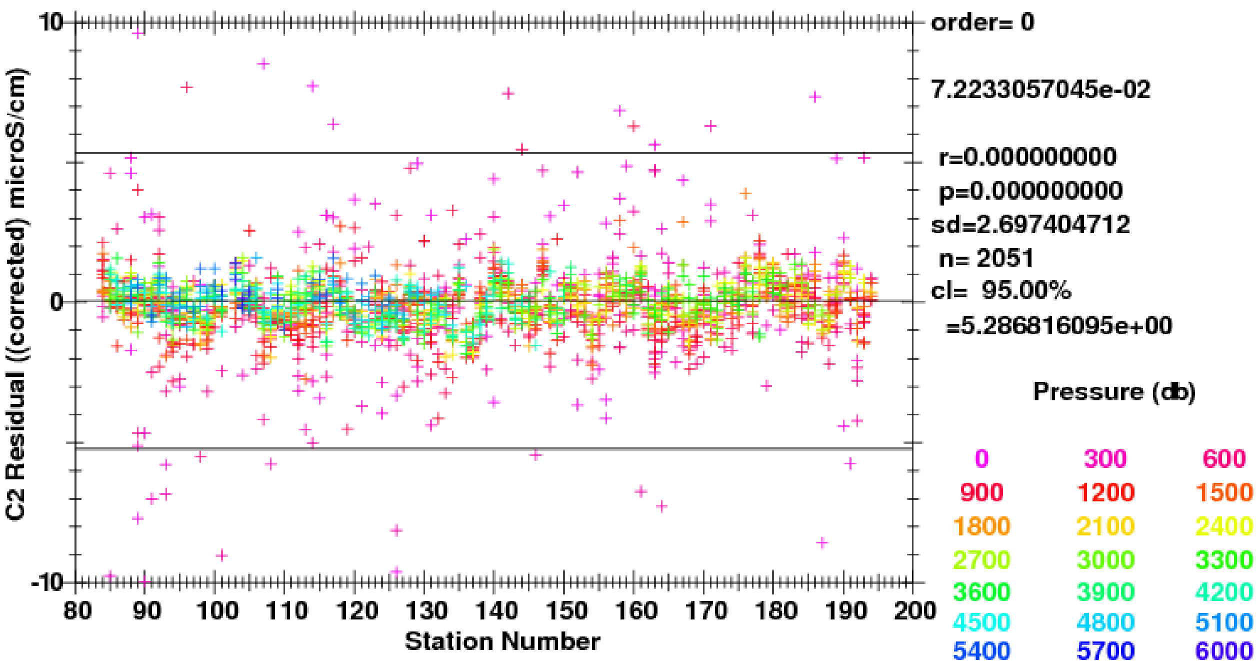


Fig. 3.16: Corrected C_{Bottle} - C2 by station (-0.002°C $\leq$ T1-T2 $\leq$ 0.002°C).

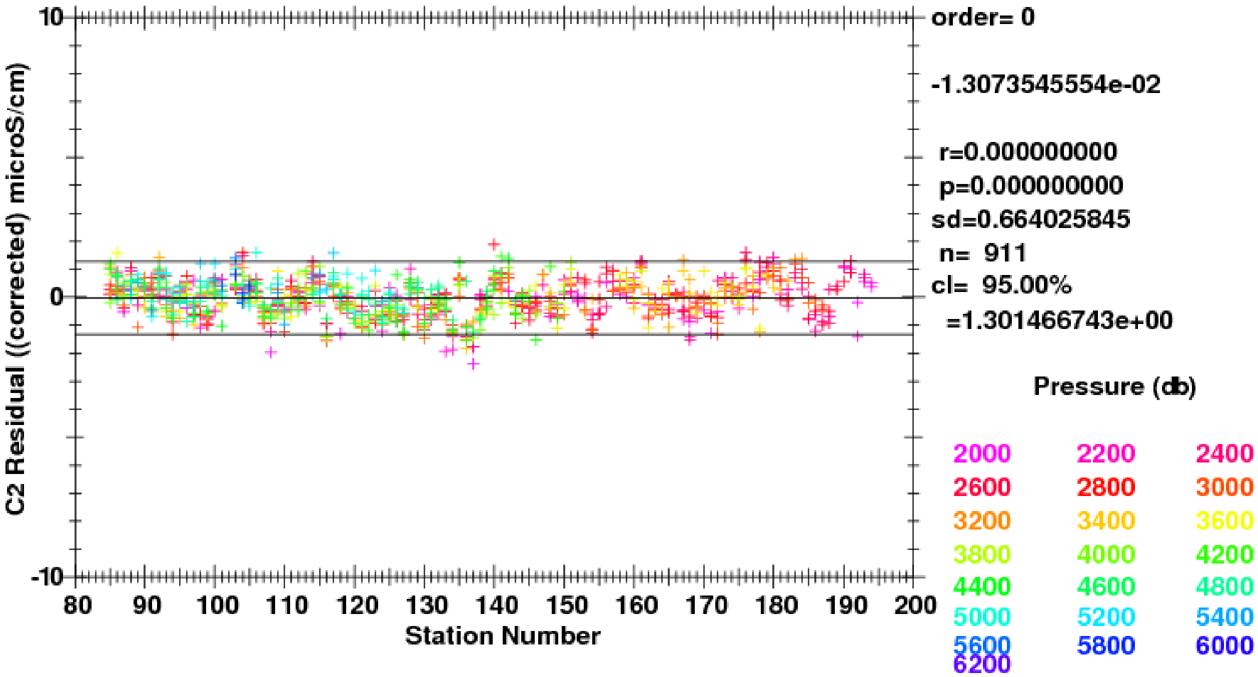


Fig. 3.17: Deep Corrected C_{Bottle} - C2 by station (Pressure >= 2000dbar).

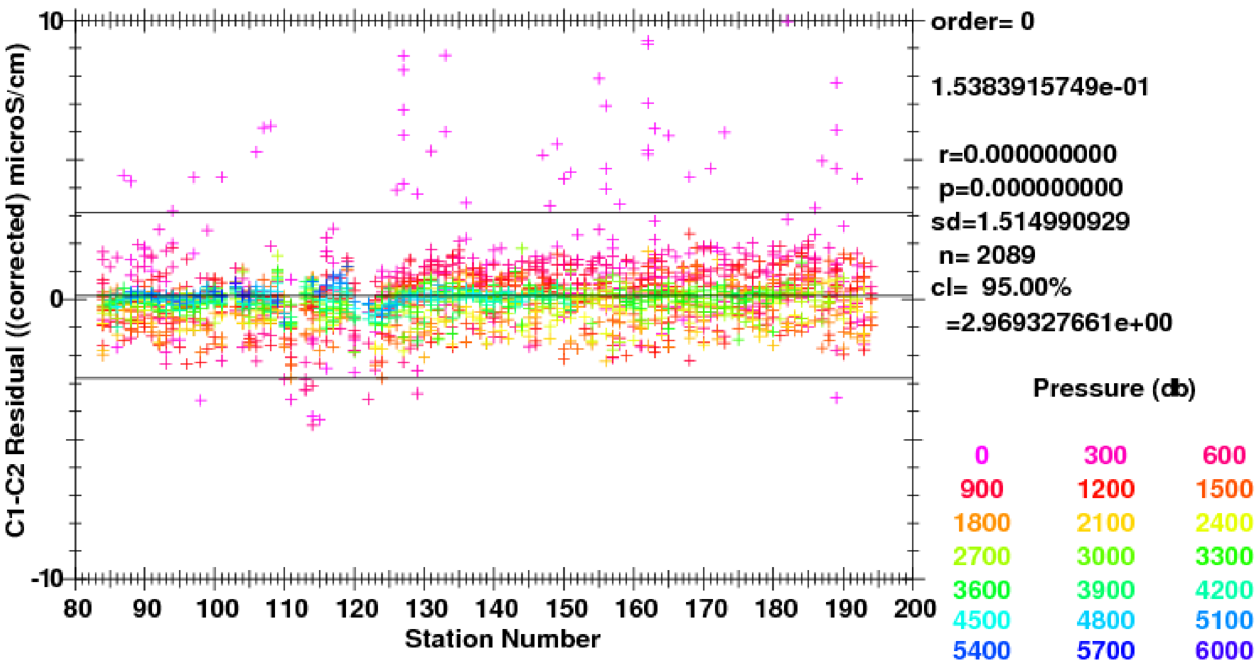


Fig. 3.18: Corrected C1-C2 by station (-0.002°C $\leq$ T1-T2 $\leq$ 0.002°C).

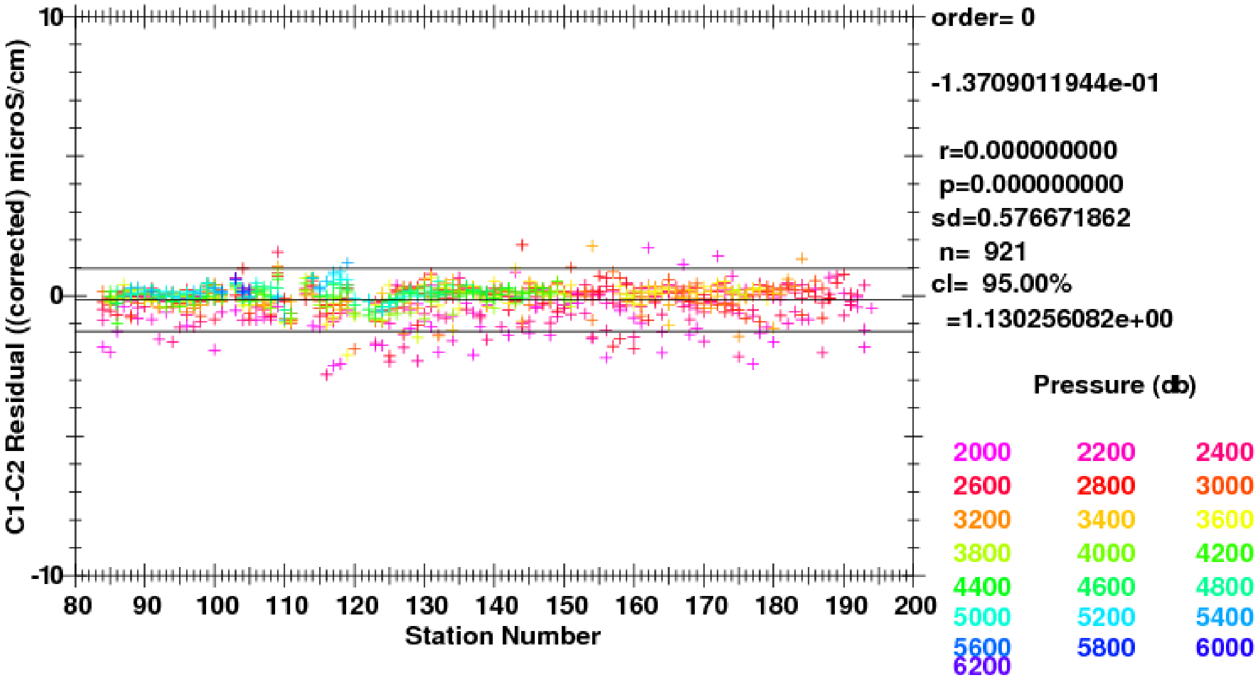


Fig. 3.19: Deep Corrected C1-C2 by station (Pressure >= 2000dbar).

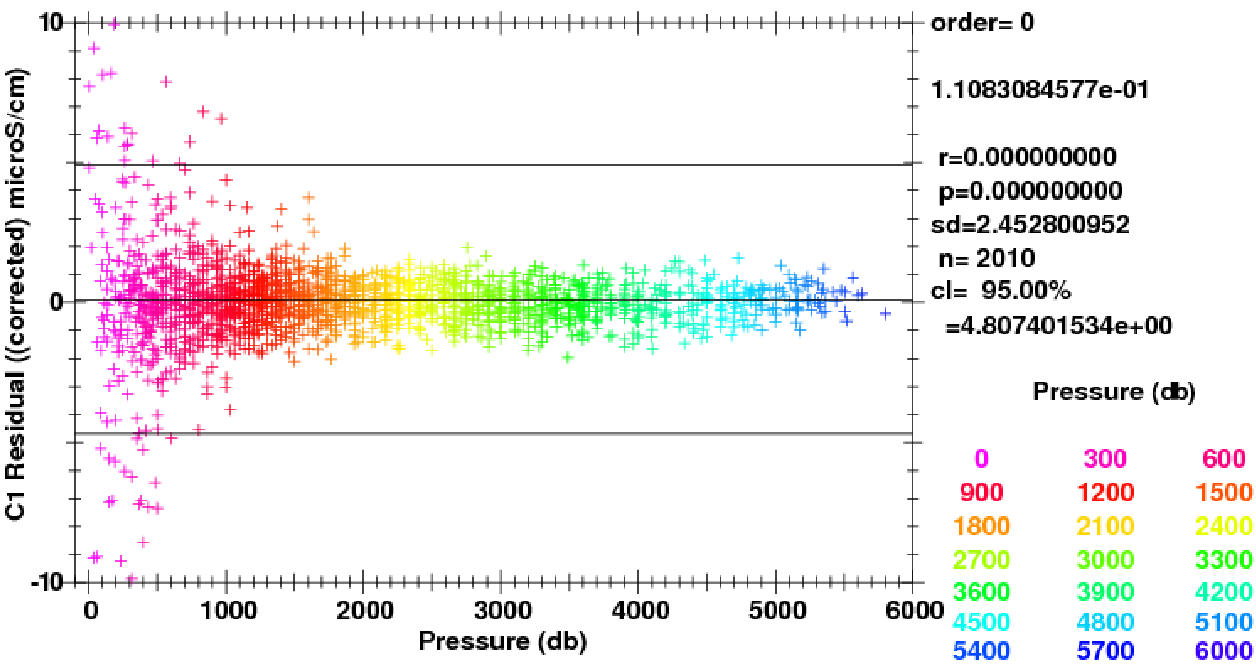


Fig. 3.20: Corrected C_{Bottle} - C1 by pressure (-0.002°C ≤ T1-T2 ≤ 0.002°C).

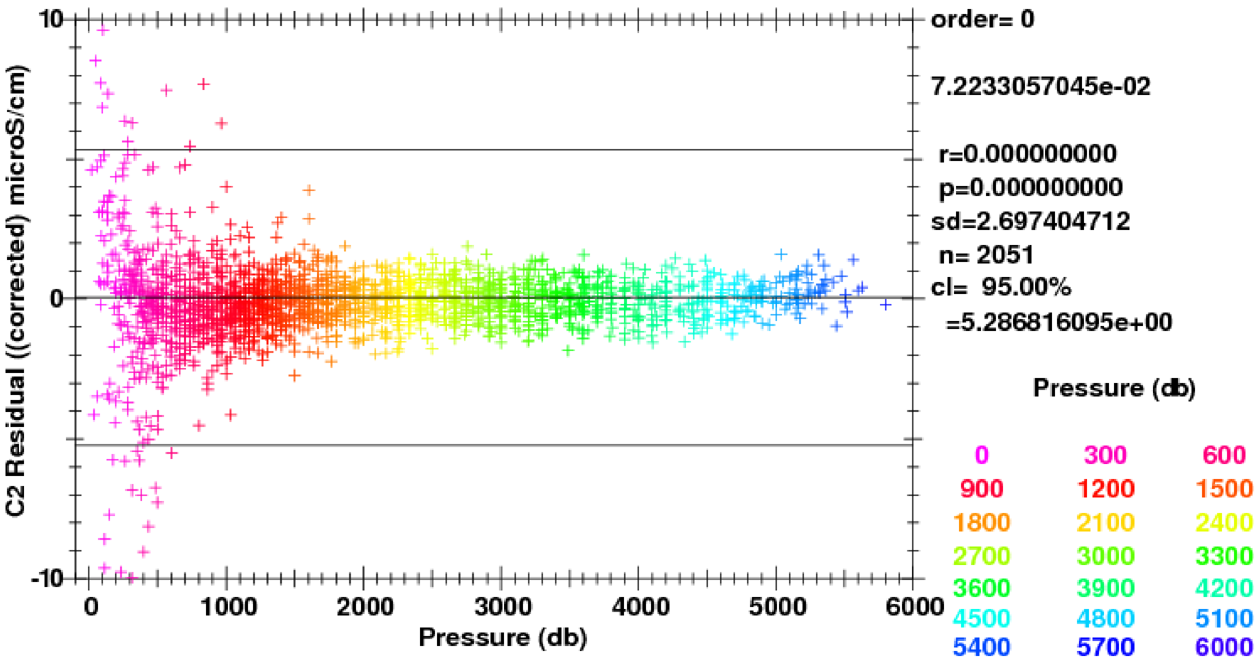


Fig. 3.21: Corrected C_{Bottle} - C2 by pressure (-0.002°C $\leq$ T1-T2 $\leq$ 0.002°C).

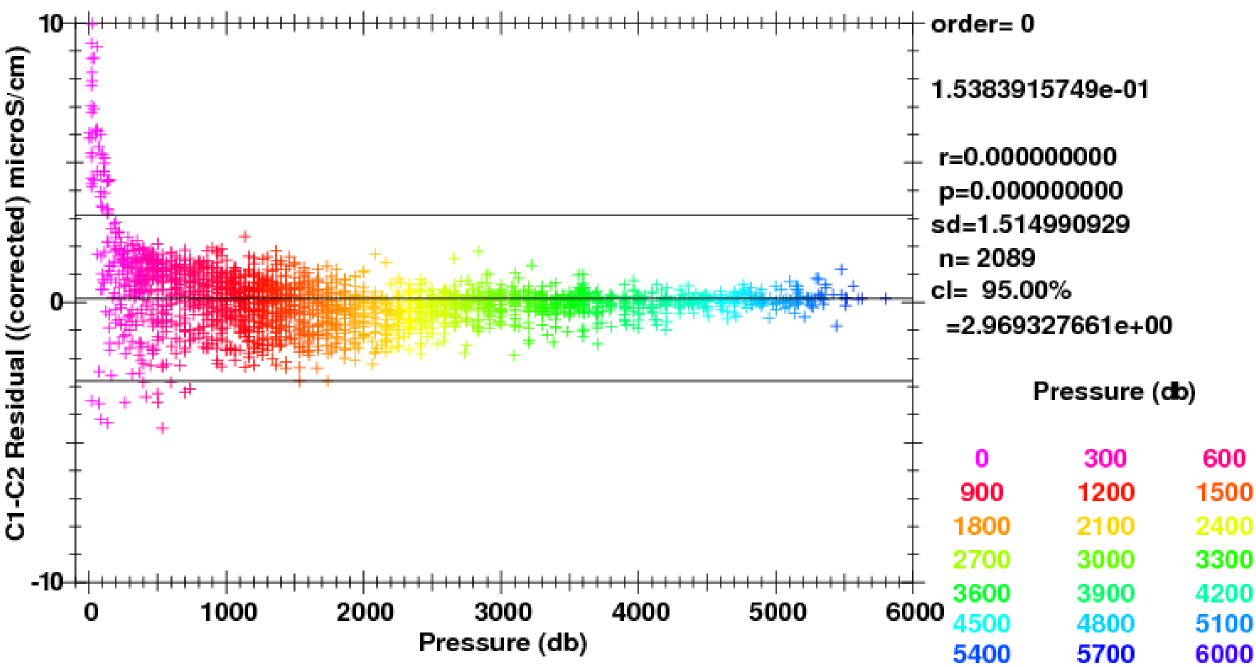


Fig. 3.22: Corrected C1-C2 by pressure (-0.002°C $\leq$ T1-T2 $\leq$ 0.002°C).

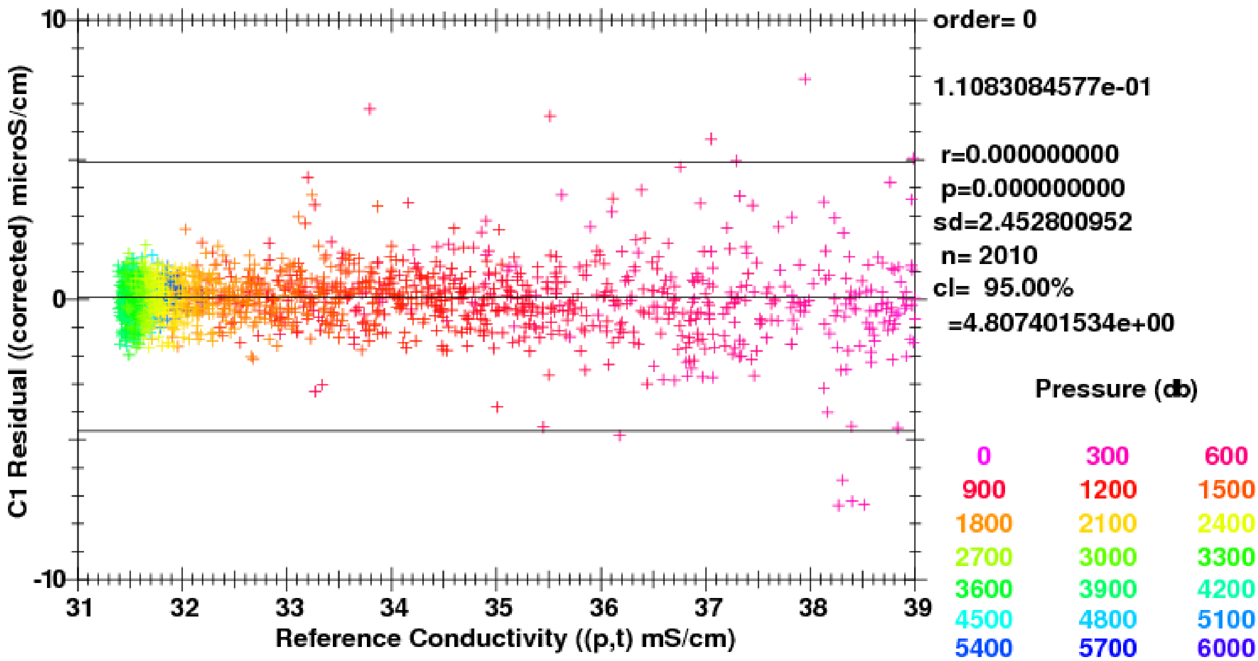


Fig. 3.23: Corrected C_{Bottle} - C1 by conductivity (-0.002°C ≤ T1-T2 ≤ 0.002°C).

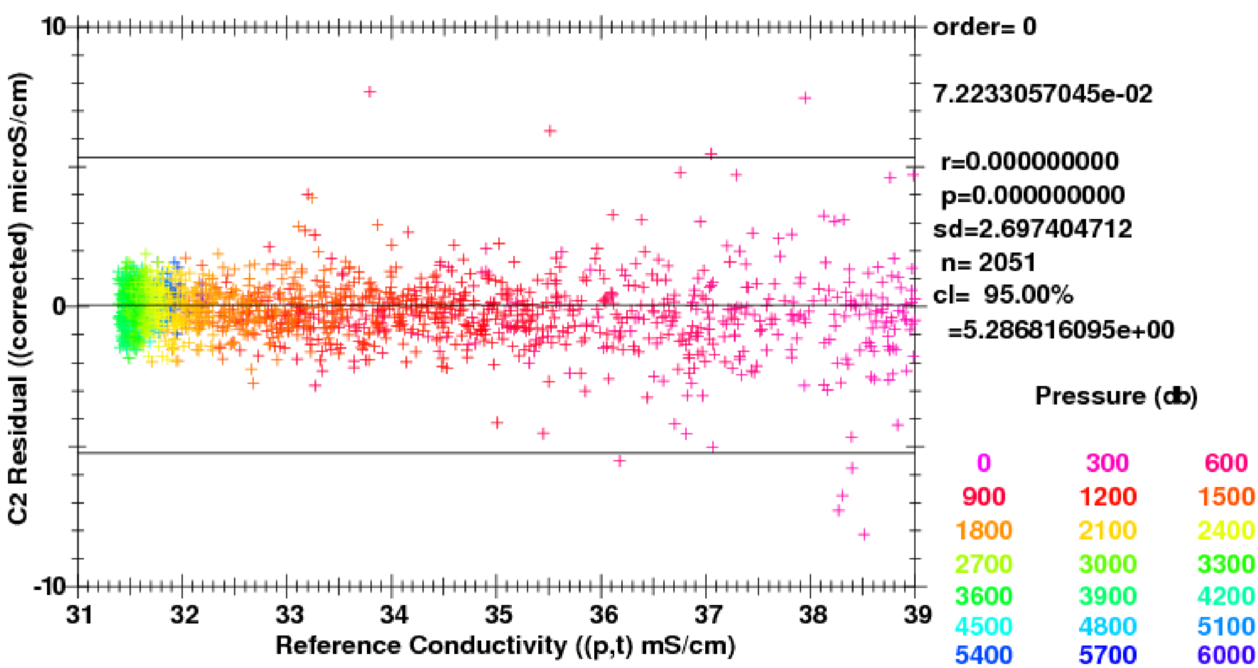


Fig. 3.24: Corrected C_{Bottle} - C2 by conductivity (-0.002°C ≤ T1-T2 ≤ 0.002°C).

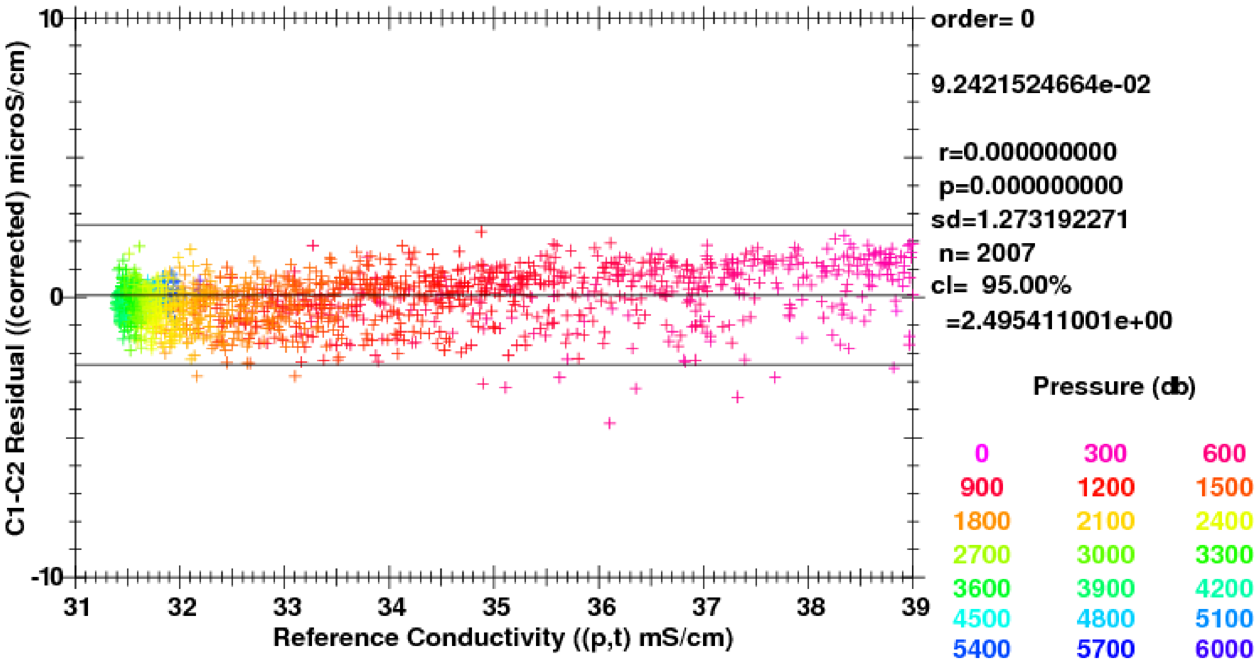


Fig. á.25: áorrected á1-C2 áy áonductivity á-0.002°C ≤á1-T2 ≤á.002°C).

A functioning SBE4C sensor typically exhibits a predictable modeled response. Offsets for each C sensor were determined using C_{Bottle} - C_{CTD} differences in a deeper pressure range (500 or more dbars). After conductivity offsets were applied to all casts, response to pressure, temperature and conductivity were examined for each conductivity sensor. The response model is second order with respect to pressure, a first order with respect to temperature, first order with respect to conductivity and a first order with respect to time. The functions used to apply shipboard calibrations are as follows.

The final corrections for all conductivity sensors used on this cruise are summarized in APPENDIX (TO BE MADE AVAILABLE LATER ON SHORE) Corrections made to all conductivity sensors are of the form:

$$C{:}sub{:}\ cor = C + cp_2 P^2 + cp_1 P + c_1 C + c_0$$

Salinity residuals after applying shipboard P/T/C corrections are summarized in the following figures. Only CTD and bottle salinity data with "acceptable" quality codes are included in the differences. Quality codes and comments are also published in the APPENDIX.

The 95% confidence limits for the mean low-gradient (where -0.002°C ≤T1-T2 ≤0.002°C) differences are ±0.0040°C for salnity-C1. The 95% confidence limits for the deep salinity residuals (where pressure ≥2000dbar) are ±0.00154 for salinity-C1.

A number of issues affected conductivity and calculated CTD salinities during this cruise. we suffered a number of unique conductivity failures throughout the cruise as follows: a secondary conductivity sensor (S/N:41919) failed at the bottom of our deep 5900+ m cast on 102/01. * primary conductivity sensor (S/N: 3399) failed in a similar fashion at the bottom of cast 112/01 * Primary conductivity sensor (S/N: 3023) was found to have a significant drift and replaced after cast 114/01 * Primary conductivity sensor (S/N: 3207) had pressure dependent irregularities that presented like data signal spikes on cast 120/02. The connectors were examined and reseated. The problem occurred again on 121/02 at which time the cable was replaced. The problem persisted on station 122/01 and the sensor was finally replaced.

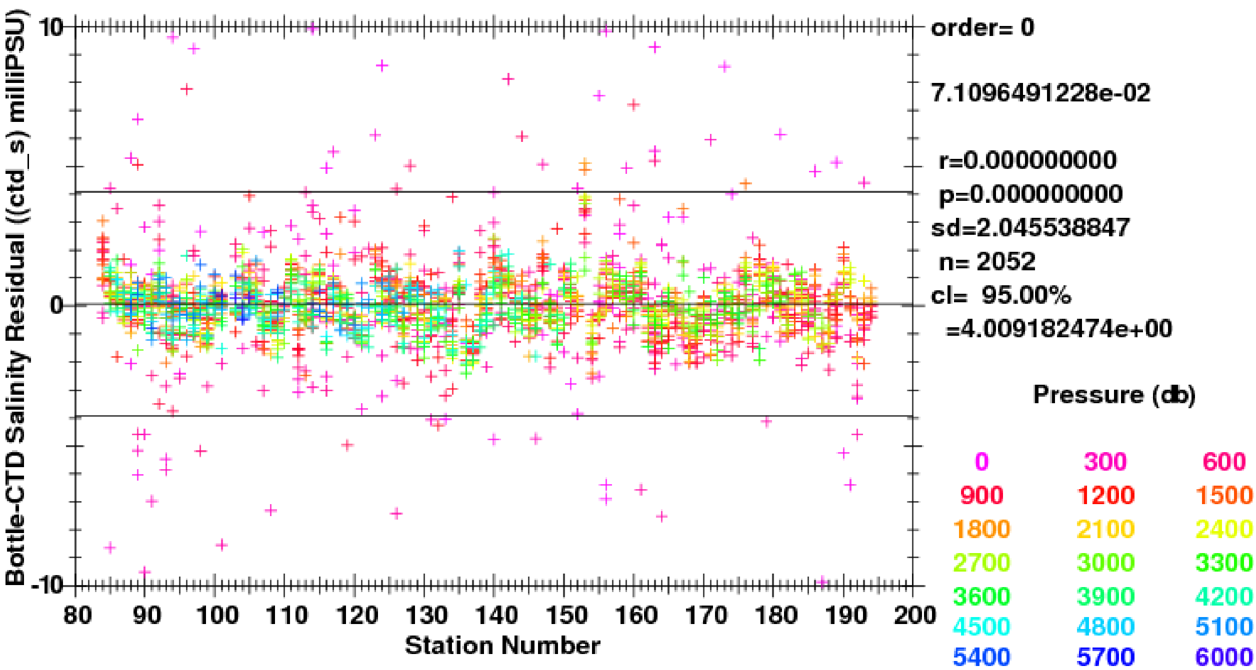


Fig. 3.26: Salinity residuals by station (-0.002°C ≤ T1-T2 ≤ 0.002°C).

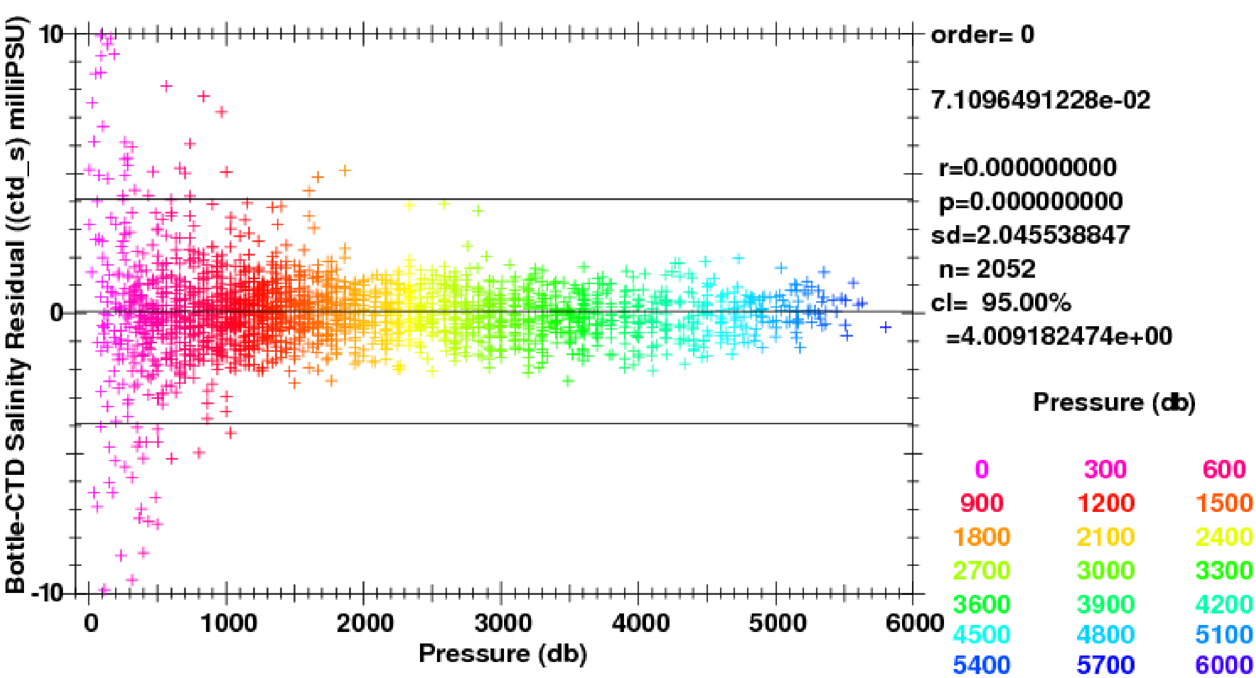


Fig. 3.27: Salinity residuals by pressure (-0.002°C ≤ T1-T2 ≤ 0.002°C).

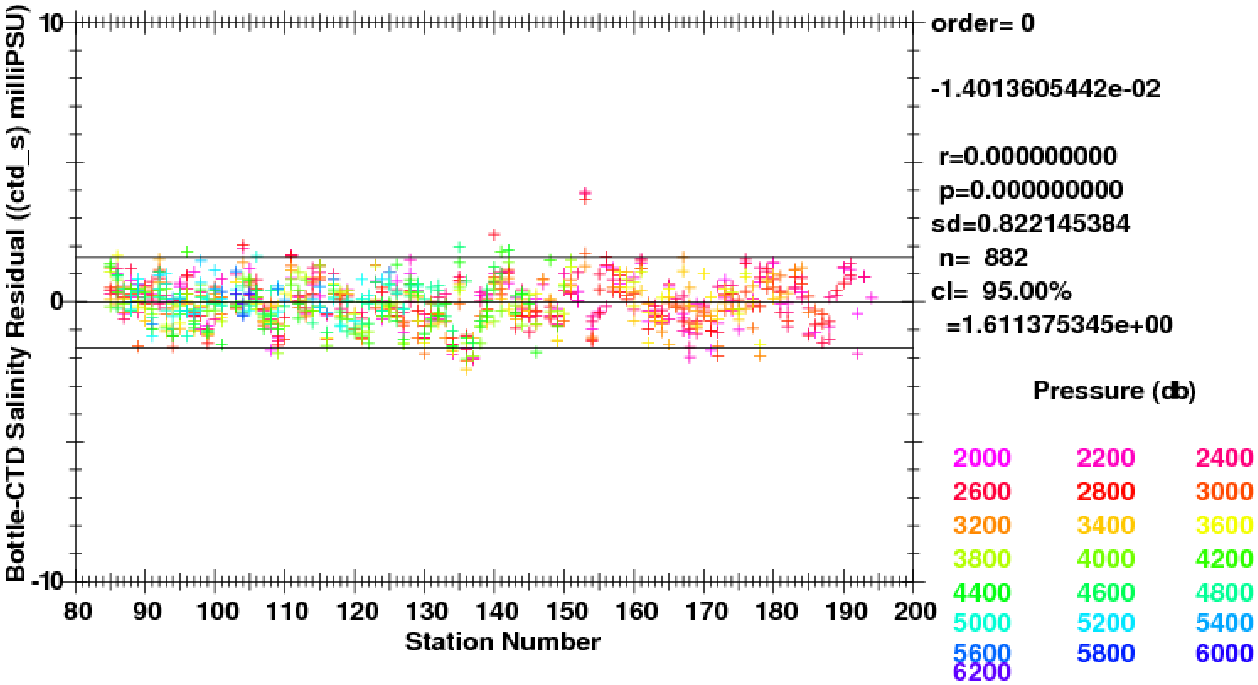


Fig. 3.28: Deep Salinity residuals by station (Pressure >= 2000dbar).

3.6 CTD Dissolved Oxygen

Laboratory calibrations of the dissolved oxygen sensors were performed prior to the cruise at the SeaBird Calibration Facility. Dates of laboratory calibration are recorded on the underway sampling package table and calibration documents are provided in the APPENDIX.

The pre-cruise laboratory calibration coefficients were used to convert SBE43 frequencies to µmol/kg oxygen values for acquisition only. Additional shipboard fittings were performed to correct for the sensors non-linear response. Corrections for pressure, temperature and conductivity sensors were finalized before analyzing dissolved oxygen data. The SBE43 sensor data were compared to dissolved O_2 check samples taken at bottle stops by matching the down cast CTD data to the up cast trip locations along isopycnal surfaces. CTD dissolved O_2 was then calculated using Clark Cell MPOD O_2 sensor response model for Beckman/SensorMedics and SBE43 dissolved O_2 sensors. The residual differences of bottle check value versus CTD dissolved O_2 values are minimized by optimizing the SIO DO sensor response model coefficients with a Levenberg-Marquardt non-linear least-squares fitting procedure.

The general form of the SIO DO sensor response model equation for Clark cells follows Brown and Morrison *[Mill82]* and Owens *[Owen85]* SIO 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-linearity 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:

$$O_2\text{ml/l} = \left[C_1 \cdot V_{\text{DO}} \cdot e^{C_2 \frac{P_h}{5000}} + C_3\right] \cdot f_{\text{sat}}(T,P) \cdot e^{\left(C_4 t_l + C_5 t_s + C_7 P_l + C_6 \frac{dO_c}{dT} + C_8 \frac{dP}{dTt} + C_9 dT\right)}$$

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)|O2| 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)
- dO_c / dt Sensor current gradient (μamps/sec)
- 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 dissolved O_2 residuals are shown in the following figures *O2 residuals by station (-0.01°C T1-T2 0.01°C).* through *Deep O2 residuals by station (Pressure >= 2000dbar).*.

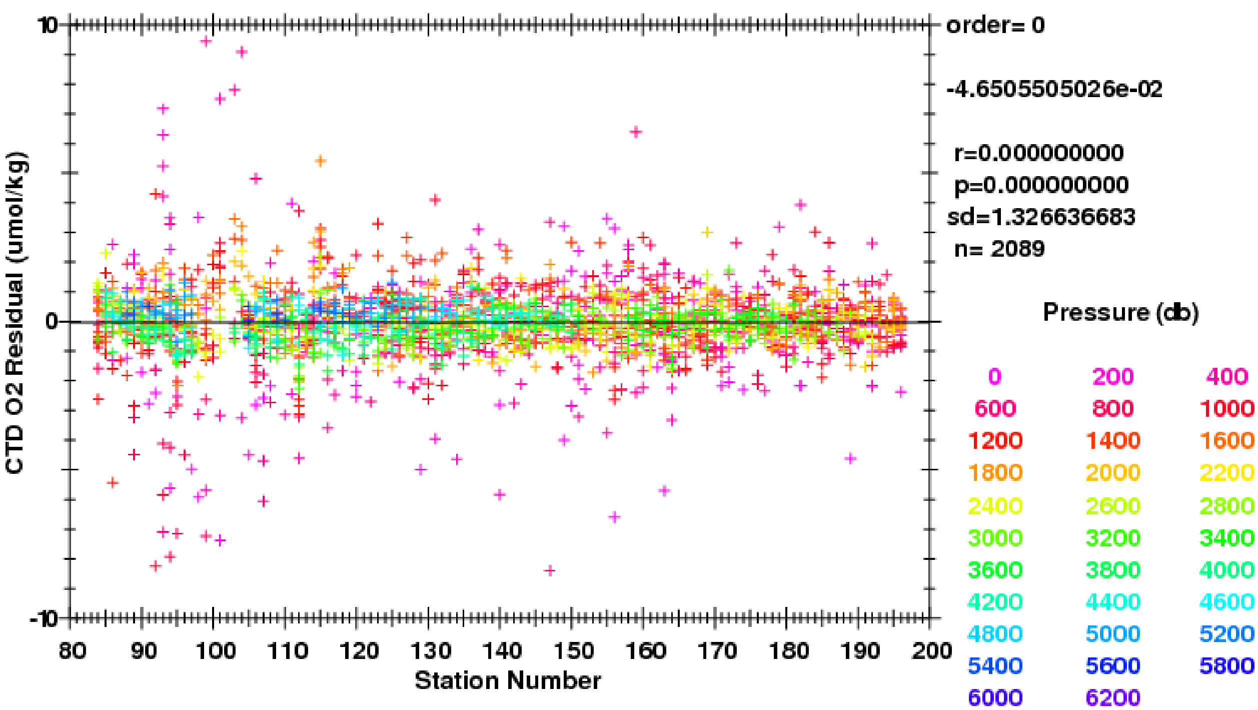


Fig. 3.29: O_2 residuals by station (-0.01°C ≤ T1-T2 ≤ 0.01°C).

The standard deviations of 1.58 (μmol/kg) for all oxygens and 0.65 (μmol/kg) for deep oxygens are only presented as general indicators of goodness of fit. SIO makes no claims regarding the precision or accuracy of CTD dissolved O_2 data.

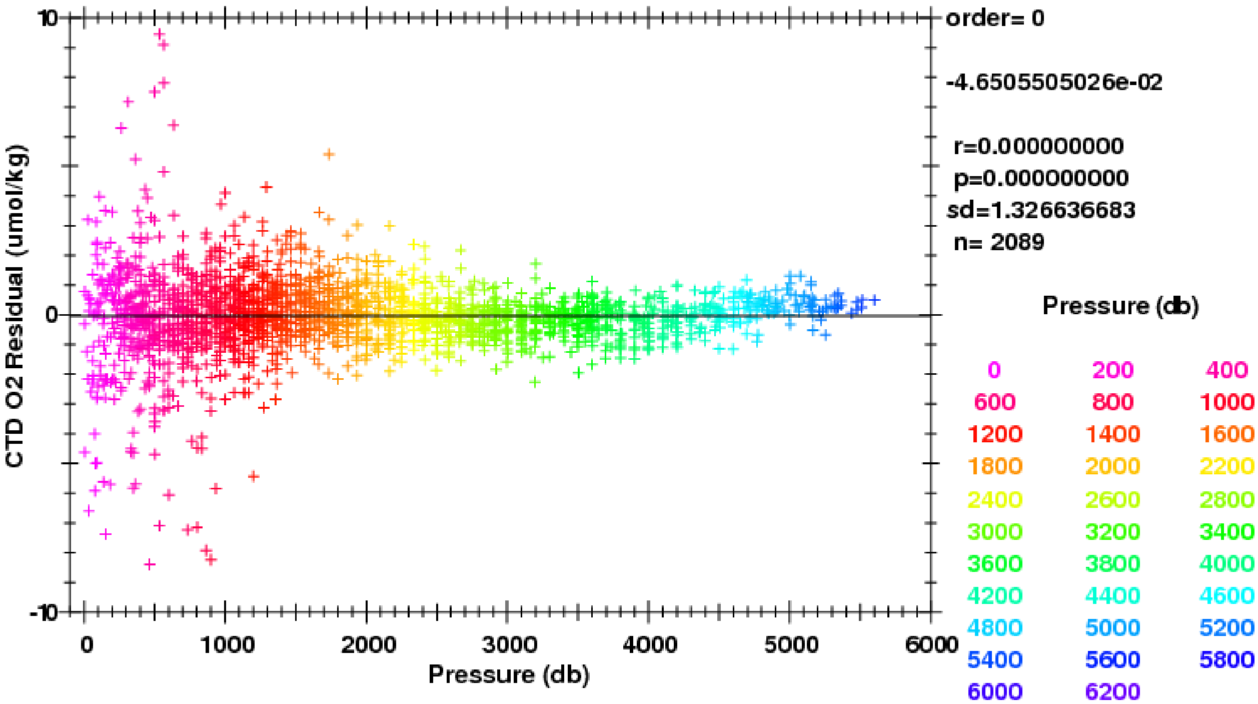


Fig. 3.30: O_2 residuals by pressure (-0.01°C ≤ T1-T2 ≤ 0.01°C).

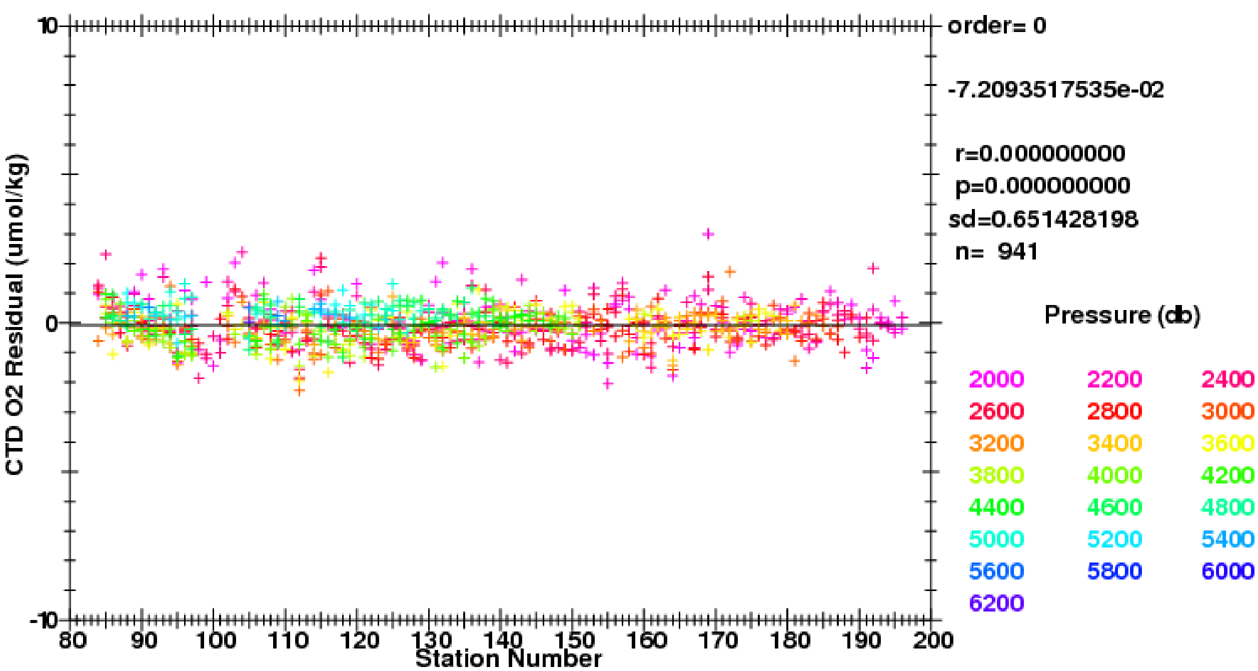


Fig. 3.31: Deep O_2 residuals by station (Pressure >= 2000dbar).

A few minor problems with acquisition of data complicated the CTD dissolved oxygen fits as follows: SBE43 (S/N: 431138) data signal was steadily growing noisier with each progressive cast. It was replaced after station/cast 97/01 with SBE43 (S/N: 430848), which appeared to have an even worse signal past 3500 dbar on down cast. A secondary SBE43 (S/N:430197) sensor was added to AUX 3 on station/cast 100/01 and both primary SBE43 (S/N: 430848) and secondary presented the same deep cast gradual increase of signal to noise ratio. Both sensors were moved to AUX 2 on station/cast 101/02 and symptoms persisted. We rerouted the exhaust lines from both sensors to vent slightly higher than initially set on station cast 102/01. This solved this issue. SBE43 (S/N: 431138) had a stronger signal and was moved back to the primary position on station/cast 105/01. All compromised data signals were recorded and coded in the data files. The bottle trip levels affected by the signals are reflected in the bottle data comments section of the APPENDIX.

CHAPTER FOUR

SALINITY

4.1 Equipment and Techniques

A single Guildline Autosal, model 8400B salinometer (S/N 65-740) located in salinity analysis room, was used for all salinity measurements. The autosal was recently calibrated before the last cruise, I08S. The salinometer readings were logged on a computer using in house LabView program developed by Carl Mattson. The Autosal's water bath temperature was set to 21℃, until station 135. After which the Autosal was set to 24℃ due to the rising ambient tempertures of the Northern Indian Ocean. The laboratory's temperature was also set and maintained to just below 21° C until station 135 and just below 24℃ after. This is to ensure stabilize reading values and improve accuracy. Salinity analyses were performed after samples had equilibrated to laboratory temperature, usually 8 hours after collection. The salinometer was standardized for each group of samples analyzed (usually 2 casts and up to 72 samples) using two bottles of standard seawater: one at the beginning and end of each set of measurements. The salinometer output was logged to a computer file. The software prompted the analyst to flush the instrument's cell and change samples when appropriate. Prior to each run a sub-standard flush, approximately 200 ml, of the conductivity cell was conducted to flush out the DI water used in between runs. For each calibration standard, the salinometer cell was initially flushed 6 times before a set of conductivity ratio reading was taken. For each sample, the salinometer cell was initially flushed at least 3 times before a set of conductivity ratio readings were taken.

IAPSO Standard Seawater Batch P-158 was used to standardize all casts.

4.2 Sampling and Data Processing

The salinity samples were collected in 200 ml Kimax high-alumina borosilicate bottles that had been rinsed at least three times with sample water prior to filling. The bottles were sealed with custom-made plastic insert thimbles and Nalgene screw caps. This assembly provides very low container dissolution and sample evaporation. Prior to sample collection, inserts were inspected for proper fit and loose inserts replaced to insure an airtight seal. Laboratory temperature was also monitored electronically throughout the cruise. PSS-78 salinity [UNESCO1981] was calculated for each sample from the measured conductivity ratios. The offset between the initial standard seawater value and its reference value was applied to each sample. Then the difference (if any) between the initial and final vials of standard seawater was applied to each sample as a linear function of elapsed run time. The corrected salinity data was then incorporated into the cruise database.

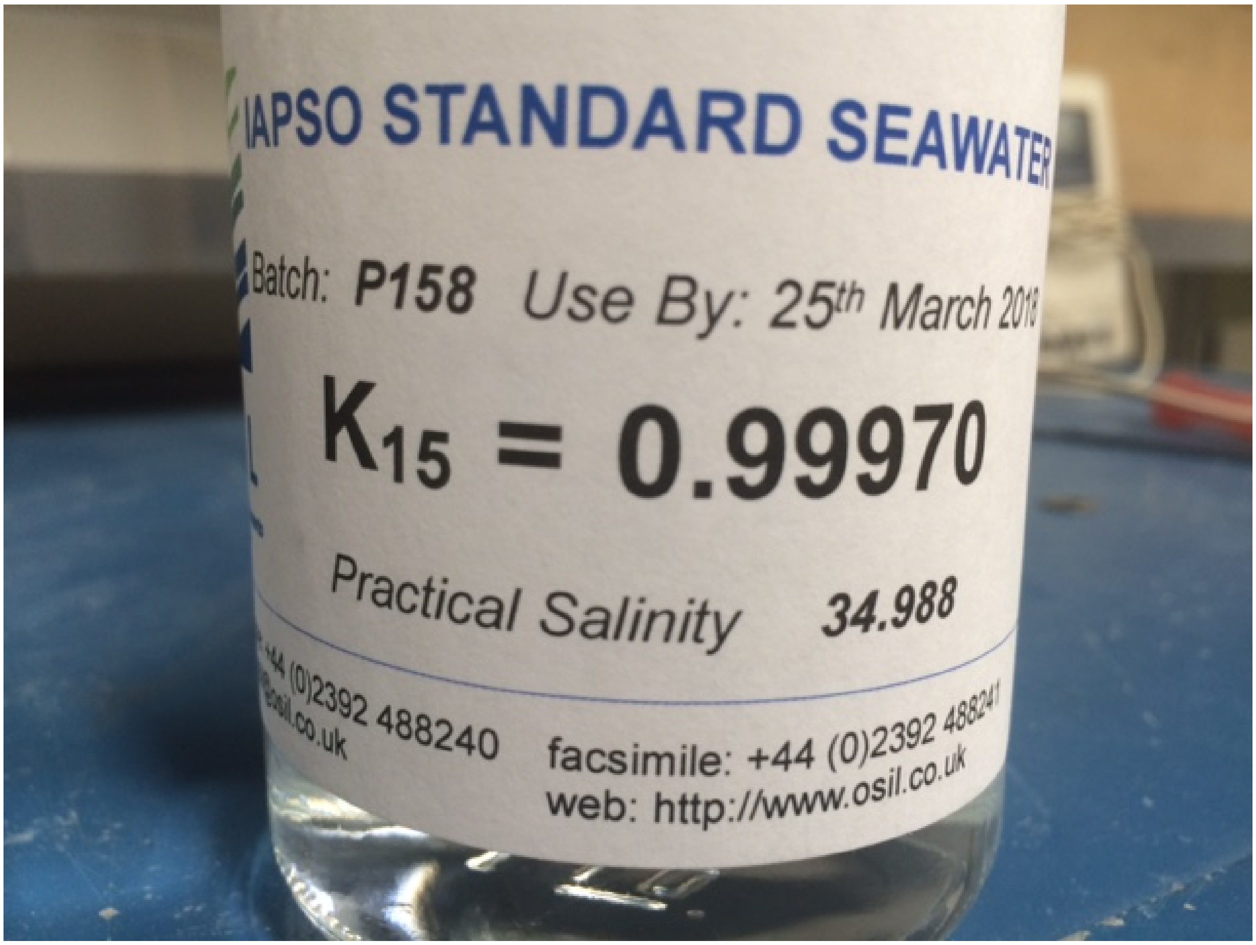


Fig. 4.1: Salinity standard IAPSO Batch P-158

CHAPTER

FIVE

NUTRIENTS

PIs

- Susan Becker
- James Swift

Technicians

- Susan Becker
- John Ballard

5.1 Summary of Analysis

- 3887 samples from 113 ctd stations
- The cruise started with new pump tubes and they were changed prior to stations 115 and 166.
- 4 sets of nitrate, phosphate, and silicate Primary/Secondary standards were made up over the course of the cruise.
- 2 sets of Primary and 26 sets of Secondary nitrite and ammonia standards were made up over the course of the cruise.
- The cadmium column efficiency was checked periodically and ranged between 88%-100%. A new column was put on if the efficiency fell below 97%.

5.2 Equipment and Techniques

Nutrient analyses (phosphate, silicate, nitrate+nitrite, and nitrite) were performed on a Seal Analytical continuous-flow AutoAnalyzer 3 (AA3). The methods used are described by Gordon et al *[Gordon1992]* Hager et al. *[Hager1972]*, and Atlas et al. *[Atlas1971]*. Details of modification of analytical methods used in this cruise are also compatible with the methods described in the nutrient section of the GO-SHIP repeat hydrography manual (Hydes et al., 2010) *[Hydes2010]*.

5.3 Nitrate/Nitrite Analysis

A modification of the Armstrong et al. (1967) *[Armstrong1967]* procedure was used for the analysis of nitrate and nitrite. For nitrate analysis, a seawater sample was passed through a cadmium column where the nitrate was reduced to nitrite. This nitrite was then diazotized with sulfanilamide and coupled with N-(1-naphthyl)-ethylenediamine to form a red dye. The sample was then passed through a 10mm flowcell and absorbance measured at 540nm. The procedure was the same for the nitrite analysis but without the cadmium column.

REAGENTS

Sulfanilamide Dissolve 10g sulfamilamide in 1.2N HCl and bring to 1 liter volume. Add 2 drops of 40% surfynol 465/485 surfactant. Store at room temperature in a dark poly bottle.

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

N-(1-Naphthyl)-ethylenediamine dihydrochloride (N-1-N) Dissolve 1g N-1-N in DIW, bring to 1 liter volume. Add 2 drops 40% surfynol 465/485 surfactant. Store at room temperature in a dark poly bottle. Discard if the solution turns dark reddish brown.

Imidazole Buffer Dissolve 13.6g imidazole in ~3.8 liters DIW. Stir for at least 30 minutes to completely dissolve. Add 60 ml of CuSO4 + NH4Cl mix (see below). Add 4 drops 40% Surfynol 465/485 surfactant. Let sit overnight before proceeding. Using a calibrated pH meter, adjust to pH of 7.83-7.85 with 10% (1.2N) HCl (about 10 ml of acid, depending on exact strength). Bring final solution to 4L with DIW. Store at room temperature.

NH4Cl + CuSO4 mix Dissolve 2g cupric sulfate in DIW, bring to 100 m1 volume (2%). Dissolve 250g ammonium chloride in DIW, bring to l liter volume. Add 5ml of 2% CuSO4 solution to this NH4Cl stock. This should last many months.

5.4 Phosphate Analysis

Ortho-Phosphate was analyzed using a modification of the Bernhardt and Wilhelms (1967) *[Bernhardt1967]* method. Acidified ammonium molybdate was added to a seawater sample to produce phosphomolybdic acid, which was then reduced to phosphomolybdous acid (a blue compound) following the addition of dihydrazine sulfate. The sample was passed through a 10mm flowcell and absorbance measured at 820nm (880nm after station 59, see section on analytical problems for details).

REAGENTS

Ammonium Molybdate H2SO4 sol'n Pour 420 ml of DIW into a 2 liter Ehrlenmeyer flask or beaker, place this flask or beaker into an ice bath. SLOWLY add 330 ml of conc H2SO4. This solution gets VERY HOT!! Cool in the ice bath. Make up as much as necessary in the above proportions.

Dissolve 27g ammonium molybdate in 250ml of DIW. Bring to 1 liter volume with the cooled sulfuric acid sol'n. Add 3 drops of 15% DDS surfactant. Store in a dark poly bottle.

Dihydrazine Sulfate Dissolve 6.4g dihydazine sulfate in DIW, bring to 1 liter volume and refrigerate.

5.5 Silicate Analysis

Silicate was analyzed using the basic method of Armstrong et al. (1967). Acidified 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. The sample was passed through a 10mm flowcell and measured at 660nm.

REAGENTS

Tartaric Acid Dissolve 200g tartaric acid in DW and bring to 1 liter volume. Store at room temperature in a poly bottle.

Ammonium Molybdate Dissolve 10.8g Ammonium Molybdate Tetrahydrate in 1000ml dilute H2SO4. (Dilute H2SO4 = 2.8ml conc H2SO4 or 6.4ml of H2SO4 diluted for PO4 moly per liter DW) (dissolve powder, then add H2SO4) Add 3-5 drops 15% SDS surfactant per liter of solution.

Stannous Chloride stock: (as needed)

Dissolve 40g of stannous chloride in 100 ml 5N HCl. Refrigerate in a poly bottle.

NOTE: Minimize oxygen introduction by swirling rather than shaking the solution. Discard if a white solution (oxychloride) forms.

working: (every 24 hours) Bring 5 ml of stannous chloride stock to 200 ml final volume with 1.2N HCl. Make up daily - refrigerate when not in use in a dark poly bottle.

5.6 Ammonium Analysis

Fluorometric method Ammonia is analyzed using the method described by Kerouel and Aminot *[Kerouel1997]*. The sample is combined with a working reagent made up of ortho-phthalaldehyde, sodium sulfite and borate buffer and heated to 75degC. Fluorescence proportional to the NH4 concentration is emitted at 460nm following excitation at 370nm.

REAGENTS

Ortho-phthalaldehyde stock (OPH): Dissolve 8g of ortho-phthalaldehyde in 200mls ethanol and mix thoroughly. Store in a dark glass bottle and keep refrigerated.

Sodium sulfite stock: Dissolve 0.8g sodium sulfite in DIW and dilute up to 100ml. Store in a glass bottle, replace weekly.

Borate buffer Dissolve 120g disodium tetraborate in DIW and bring up to 4L volume.

Working reagent: In the following order and proportions combine: 1L borate buffer 20ml stock orthophthalaldehyde, 2 ml stock sodium sulfite, 4 drops 40% Surfynol 465/485 surfactant and mix. Store in a glass bottle and protect from light. Replace weekly. Make this up at least one day prior to use. Store in dark bottle and protect from outside air/nh4 contamination.

5.7 Sampling

Nutrient samples were drawn into 40 ml polypropylene screw-capped centrifuge tubes. The tubes and caps were cleaned with 10% HCl and rinsed 2-3 times with sample before filling. Samples were analyzed within 1-3 hours after sample collection, allowing sufficient time for all samples to reach room temperature. The centrifuge tubes fit directly onto the sampler.

5.8 Data collection and processing

Data collection and processing was done with the software (ACCE ver 6.10) provided with the instrument from Seal Analytical. After each run, the charts were reviewed for any problems during the run, any blank was subtracted, and final concentrations (micro moles/liter) were calculated, based on a linear curve fit. Once the run was reviewed and concentrations calculated a text file was created. That text file was reviewed for possible problems and then converted to another text file with only sample identifiers and nutrient concentrations that was merged with other bottle data.

5.9 Standards and Glassware calibration

Primary standards for silicate (Na2SiF6), nitrate (KNO3), nitrite (NaNO2), and phosphate (KH2PO4) were obtained from Johnson Matthey Chemical Co. and/or Fisher Scientific. The supplier reports purities of >98%, 99.999%, 97%, and 99.999 respectively.

All glass volumetric flasks and pipettes were gravimetrically calibrated prior to the cruise. The primary standards were dried and weighed out to 0.1mg prior to the cruise. The exact weight was noted for future reference. When primary standards were made, the flask volume at 20C, 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. Primary and secondary standards were made up every 7-10days. The new standards were compared to the old before use.

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

Standardizations were performed at the beginning of each group of analyses with working standards prepared prior to each run from a secondary. Working standards were made up in low nutrient seawater (LNSW). LNSW used for this cruise was deep water collected at a test station at the beginning of the cruise track. The actual concentration of nutrients in this water was empirically determined during the standardization calculations.

The concentrations in micro-moles per liter of the working standards used were:

-	N+N (uM)	PO_4 (uM)	SIL (uM)	NO_2 (uM)	NH_4 (uM)
0	0.0	0.0	0.0	0.0	0.0
3	15.50	1.2	60	0.50	2.0
5	31.00	2.4	120	1.00	4.0
7	46.50	3.6	180	1.50	6.0

5.10 Quality Control

All final data was reported in micro-moles/kg. NO^3, PO_4, NO_2 and NH_4 were reported to two decimals places and SIL to one. Accuracy is based on the quality of the standards the levels are:

NO^3	0.05 µM (micro moles/Liter)
PO_4	0.004 µM
SIL	2-4 µM
NO_2	0.05 µM
NH_4	0.03 µM

As is standard ODF practice, a deep calibration "check" sample was run with each set of samples to estimate precision within the cruise. The data are tabulated below.

Parameter	Concentration (µM)	stddev
NO^3	31.00	0.17
PO_4	2.14	0.02
SIL	98.9	0.55

SIO/ODF has been using Reference Materials for Nutrients in Seawater (RMNS) on repeat Hydrography cruises as another estimate of accuracy and precision for each cruise since 2009. The accuracy and precision (standard deviation) for this cruise were measured by analysis of a RMNS with each run. The RMNS preparation, verification, and suggested protocol for use of the material are described by Aoyama *[Aoyama2006] [Aoyama2007]*, *[Aoyama2008]* and Sato *[Sato2010]*. RMNS batch BV was used on this cruise, with each bottle being used twice before being discarded and a new one opened. Data are tabulated below.

Parameter	Concentration	stddev	assigned conc	diff
-	(µmol/kg)	-	(µmol/kg)	-
NO^3	35.19	0.17	35.36	0.16
PO_4	2.49	0.02	2.498	0.008
Sil	101.5	0.55	102.2	0.71
NO_2	0.05	0.003	0.047	-0.002

5.11 Analytical problems

Distilled deionized water was checked for all nutrients during cruise after reporting a POC filter change warning. All nutrient levels were below detection limit and good for duration of cruise.

Sulfite reagent was replaced once due to degradation in detected in OPA working reagent. Occasional phosphate baseline drifts and jumps were mitigated with periodic soap and bleach cleaning.

CHAPTER

SIX

OXYGEN ANALYSIS

PIs

- Susan Becker
- James Swift

Technicians

- Andrew Barna
- Joseph Gum

6.1 Equipment and Techniques

Dissolved oxygen analyses were performed with an SIO/ODF-designed automated oxygen titrator using photometric end-point detection based on the absorption of 365nm wavelength ultra-violet light. The titration of the samples and the data logging were controlled by PC LabView software. Thiosulfate was dispensed by a Dosimat 765 buret driver fitted with a 1.0 ml burette. ODF used a whole-bottle modified-Winkler titration following the technique of Carpenter *[Carpenter1965]* with modifications by *[Culberson1991]* but with higher concentrations of potassium iodate standard approximately 0.012N, and thiosulfate solution approximately 55 gm/l. Pre-made liquid potassium iodate standards were run every day (approximately every 4-5 stations), unless changes were made to the system or reagents. Reagent/distilled water blanks were determined every day or more often if a change in reagents required it to account for presence of oxidizing or reducing agents.

6.2 Sampling and Data Processing

3884 oxygen measurements were made. Samples were collected for dissolved oxygen analyses soon after the rosette was brought on board. Using a 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 umol/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) to assure thorough dispersion of the precipitate, once immediately after drawing, and then again after about 30-40 minutes.

The samples were analyzed within 2-14 hours of collection, and the data incorporated into the cruise database.

Thiosulfate normalities were calculated for each standardization and corrected to 20 deg C. The 20 deg C normalities and the blanks were plotted versus time and were reviewed for possible problems. The blanks and thiosulfate normalities for each batch of thiosulfate were stable enough that no smoothing was necessary.

6.3 Volumetric Calibration

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

6.4 Standards

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

6.5 Narrative

All equipment was set up on the previous leg, I08S. Reagents were made once the ship was underway and evap water was available.

Standards were run about every 24 hours during the transit to the first station, 84, to monitor thiosulfate stability. Underway samples were also being collected and analyzed during the transit.

After station 125, the thiosulfate was replaced with a new batch.

No samples were lost due to analytical error.

CHAPTER

SEVEN

TOTAL ALKALINITY

PI

- Andrew G. Dickson – Scripps Institution of Oceanography

Technicians

- David Cervantes
- Ellen Briggs (Graduate Student)

7.1 Total Alkalinity

The total alkalinity of a sea water sample is defined as the number of moles of hydrogen ion equivalent to the excess of proton acceptors (bases formed from weak acids with a dissociation constant K $\leq$ 10–4.5 at 25°C and zero ionic strength) over proton donors (acids with K > 10–4.5) in 1 kilogram of sample.

7.2 Total Alkalinity Measurement System

Samples are dispensed using a Sample Delivery System (SDS) consisting of a volumetric pipette, various relay valves, and two air pumps controlled by LabVIEW 2012. Before filling the jacketed cell with a new sample for analysis, the volumetric pipette is cleared of any residual from the previous sample with the aforementioned air pumps. The pipette is then rinsed with new sample and filled, allowing for overflow and time for the sample temperature to equilibrate. The sample bottle temperature is measured using a DirecTemp thermistor probe inserted into the sample bottle and the volumetric pipette temperature is measured using a DirecTemp surface probe placed directly on the pipette. These temperature measurements are used to convert the sample volume to mass for analysis.

Samples are analyzed using an open cell titration procedure using two 250 mL jacketed cells. One sample is undergoing titration while the second is being prepared and equilibrating to 20°C for analysis. After an initial aliquot of approximately 2.3-2.4 mL of standardized hydrochloric acid (~0.1M HCl in ~0.6M NaCl solution), the sample is stirred for 5 minutes while air is bubbled into it at a rate of 200 scc/m to remove any liberated carbon dioxide gas. A Metrohm 876 Dosimat Plus is used for all standardized hydrochloric acid additions. After equilibration, ~19 aliquots of 0.04 ml are added. Between the pH range of 3.5 to 3.0, the progress of the titration is monitored using a pH glass electrode/reference electrode cell, and the total alkalinity is computed from the titrant volume and e.m.f. measurements using a non-linear least-squares approach (*[Dickson2007]*). An Agilent 34970A Data Acquisition/Switch Unit with a 34901A multiplexer is used to read the voltage measurements from the electrode and monitor the temperatures from the sample, acid, and room. The calculations for this procedure are performed automatically using LabVIEW 2012.

7.3 Sample Collection

Samples for total alkalinity measurements were taken at all I09N Stations (84-196). Two Niskin bottles at each station were sampled twice for duplicate measurements except for stations where 15 or less Niskin bottles were sampled. Using silicone tubing, the total alkalinity samples were drawn from Niskin bottles into 250 mL Pyrex bottles, making sure to rinse the bottles and Teflon sleeved glass stoppers at least twice before the final filling. A headspace of approximately 3 mL was removed and 0.06 mL of saturated mercuric chloride solution was added to each sample for preservation. After sampling was completed, each sample's temperature was equilibrated to approximately 20°C using a Thermo Scientific RTE water bath.

7.4 Problems and Troubleshooting

The *R/V Roger Revelle* is a fantastic research vessel. However, our electrodes appeared to continually pick up larger than expected interference from the lab's neighboring instruments or the ship itself. Electrode plots could show increased electrode sensitivity over time. Luckily, enough electrodes were brought on I09N so this never resulted in a bad measurement. Any unusual measurements (poor electrode plot / profile outlier) were always reran.

Normally after samples are collected, they are placed into a water bath to equilibrate the sample temperature near 20° C, the temperature at which the sample is measured. This is normally fine when the lab temperature is within 2°C of 20°C. The lab temperature for I09N was normally near 25°C. This constantly delayed the titration start times. To remedy the situation, we equilibrated the sample temperatures to 15°C in a water bath so when it met the 25°C room, it wouldn't get too warm waiting for its titration to begin.

Near the end of I09N, a suspected clog in the Sample Delivery System prevented samples from being dispensed normally into their cells, causing smaller samples sizes of unknown volumes. Pipette Board A on the SDS was replaced with Pipette Board B and sample flow resumed appropriate and reliable continuity. However, shortly after switching in Pipette Board B, a leaky valve was discovered. Although no measurements were affected because of the operators' quick responses, the valve was replaced to prevent any future samples from being lost.

7.5 Quality Control

Dickson laboratory Certified Reference Material (CRM) Batch 152 and Batch 153 were used to determine the accuracy of the total alkalinity analyses. The total alkalinity certified value for each batch is:

- Batch 152 2216.94 ± 0.60 μmol/kg (33;16)
- Batch 153 2225.59 ± 0.77 μmol/kg (32;16)

The cited uncertainties represent the standard deviation. Figures in parentheses are the number of analyses made (total number of analyses; number of separate bottles analyzed).

At least one reference material was analyzed at every I09N stations resulting in 110 reference material analyses. On I09N, the measured total alkalinity value for each batch is:

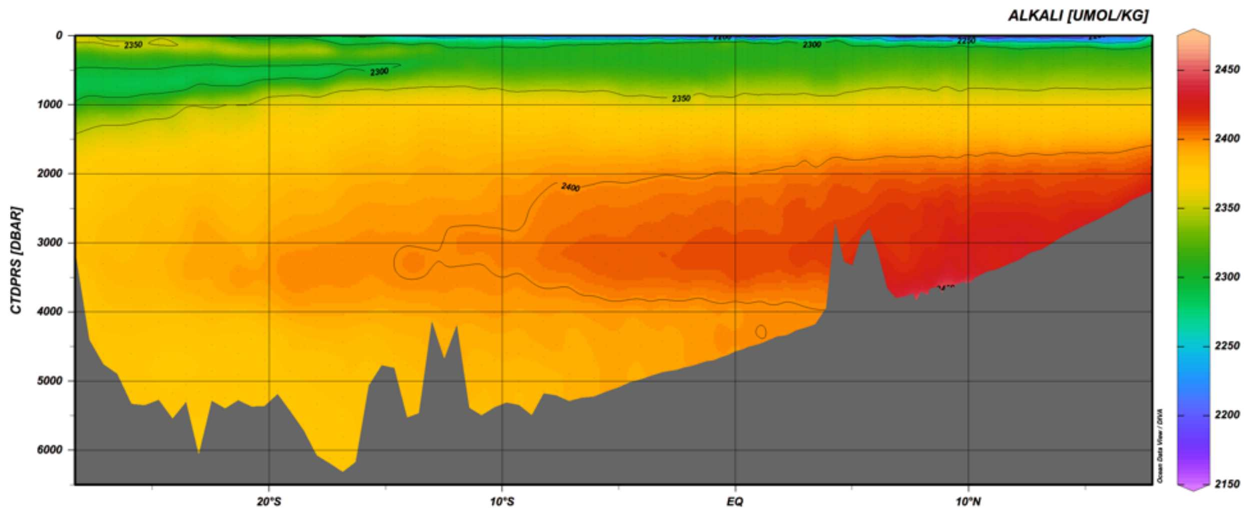
- Batch 152 2216.75 ± 0.66 μmol kg-1 (57) [mean ± std. dev. (n)]
- Batch 153 2225.03 ± 0.43 μmol kg-1 (14) [mean ± std. dev. (n)]

If greater than 15 Niskin bottles were sampled at a station, two Niskin bottles on that station were sampled twice to conduct duplicate analyses. If 15 or less Niskin bottles were sampled at a station, only one Niskin on that station was sampled twice for duplicate analyses. The standard deviation for the duplicates measured on I09N is:

Duplicate Standard Deviation ± 0.84 µmol kg–1 (177) [± std. dev. (n)]

The total alkalinity measurements for each I09N station were compared to measurements taken from the neighboring I09N 2016 stations and the I09N 2007 stations of similar if not identical coordinates.

2671 total alkalinity values were submitted for I09N. The total alkalinity of the entire transect is shown as a section in :ref: *talk-figure*. Although most corrections have been applied and it is unlikely that any additional corrections will need to be performed, this data should be considered preliminary until a more thorough analysis of the data can take place on shore, especially during the stations where the SDS Pipette Boards were having problems.



Section of total alkalinity along I09N (Stations 84 to 196).

CHAPTER

EIGHT

DISSOLVED INORGANIC CARBON (DIC)

PI's

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Technicians

- Robert Castle (NOAA/AOML)
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8.1 Sample collection

Samples for DIC measurements were drawn (according to procedures outlined in the PICES Publication, *Guide to Best Practices for Ocean CO2 Measurements [Dickson2007]*) from Niskin bottles into 294 ml borosilicate glass bottles using silicone tubing. The flasks were rinsed once and filled from the bottom with care not to entrain any bubbles, overflowing by at least one-half volume. The sample tube was pinched off and withdrawn, creating a 6 ml headspace, followed by 0.16 ml of saturated $HgCl_2$ solution which was added as a preservative. The sample bottles were then sealed with glass stoppers lightly covered with Apiezon-L grease and were stored at room temperature for a maximum of 12 hours.

8.2 Equipment

The analysis was done by coulometry with two analytical systems (AOML 3 and AOML 4) used simultaneously on the cruise. Each system consisted of a coulometer (CM5015 UIC Inc) coupled with a Dissolved Inorganic Carbon Extractor (DICE). The DICE system was developed by Esa Peltola and Denis Pierrot of NOAA/AOML and Dana Greeley of NOAA/PMEL to modernize a carbon extractor called SOMMA (*[Johnson1985]*, *[Johnson1987]*, *[Johnson1993]*, *[Johnson1992]*, *[Johnson1999]*).

The two DICE systems (AOML 3 and AOML 4) were set up in a seagoing container modified for use as a shipboard laboratory on the aft main working deck of the *R/V Roger Revelle*.

8.3 DIC Analysis

In coulometric analysis of DIC, all carbonate species are converted to CO_2 (gas) by addition of excess hydrogen ion (acid) to the seawater sample, and the evolved CO_2 gas is swept into the titration cell of the coulometer with pure air or compressed nitrogen, where it reacts quantitatively with a proprietary reagent based on ethanolamine to generate hydrogen ions. In this process, the solution changes from blue to colorless, triggering a current through the cell and causing coulometrical generation of OH^- ions at the anode. The OH^- ions react with the H^+ and the solution turns blue again. A beam of light is shone through the solution, and a photometric detector at the opposite side of the cell senses the change in transmission. Once the percent transmission reaches its original value, the coulometric titration is stopped, and the amount of CO_2 that enters the cell is determined by integrating the total change during the titration.

8.4 DIC Calculation

Calculation of the amount of CO2 injected was according to the CO2 handbook *[DOE1994]*. The concentration of CO2 ([CO2]) in the samples was determined according to:

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

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

The instrument uses a default value of 35.00 for salinity, but all DIC values were recalculated to a molar weight (µmol/kg) using density obtained from the CTD's salinity when available, otherwise (in about 32 cases) from the bottle salinity. The DIC values were corrected for dilution due to the addition of 0.16 ml of saturated $HgCl_2$ used for sample preservation. The total water volume of the sample bottles was 288 ml (calibrated by Esa Peltola, AOML). The correction factor used for dilution was 1.00055. A correction was also applied for the offset from the CRM. This additive correction was applied for each cell using the CRM value obtained at the beginning of the cell. The average correction was 0.91 µmol/kg for AOML 3 and 5.16 µmol/kg for AOML 4.

The coulometer cell solution was replaced after 25 – 30 mg of carbon was titrated, typically after 9 – 12 hours of continuous use. Normally the blank is in the 40 - 50 range.

8.5 Calibration, Accuracy, and Precision

The stability of each coulometer cell solution was confirmed three different ways.

1. Gas loops were run at the beginning of each cell
2. CRM's supplied by Dr. A. Dickson of SIO, were measured near the beginning; middle and end of each cell
3. Duplicate samples from the same niskin were run throughout the life of the cell solution.

Each coulometer was calibrated by injecting aliquots of pure CO2 (99.999%) by means of an 8-port valve *[Wilke1993]* outfitted with two calibrated sample loops of different sizes (~1ml and ~2ml). The instruments were each separately calibrated at the beginning of each cell with a minimum of two sets of these gas loop injections.

The accuracy of the DICE measurement is determined with the use of standards (Certified Reference Materials (CRMs), consisting of filtered and UV irradiated seawater) supplied by Dr. A. Dickson of Scripps Institution of Oceanography (SIO). The CRM accuracy is determined manometrically on land in San Diego and the DIC data reported to the data base have been corrected to this batch 152 or 153 CRM value. The CRM certified value for batch 152 is 2020.88 µmol/kg and for batch 153 is 2017.95 µmol/k.

The precision of the two DICE systems can be demonstrated via the replicate samples. Approximately 7% of the Niskins sampled were duplicates taken as a check of our precision. These replicate samples were interspersed through-out the station analysis for quality assurance and integrity of the coulometer cell solutions. The average absolute difference from the mean of these replicates is 1.69 µmol/kg (n=257, stdev=1.51). No major systematic differences between the replicates were observed.

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

Calibration data during this cruise:

UNIT	L Loop	S Loop	Pipette	Ave CRM1	Std Dev
AOML 3	1.003698	1.001461	27.927 ml	-0.91, N= 59	3.12
AOML 4	0.999765	0.999121	29.306 ml	-5.16, N= 60	1.53

8.6 Underway DIC Samples

Underway samples were collected from the flow thru system in the forward Main Lab during transit. Discrete DIC samples were collected approximately every 4 hours. A total of 19 discrete DIC samples including duplicates were collected while underway.

8.7 Summary

The overall performance of the analytical equipment was good during the cruise. There was one minor problem with AOML-3 that occurred near the equator when the gas sampling valve became obstructed. This caused an approximately 3 hour delay while the problem was repaired.

There were 2899 samples analyzed and 2648 DIC values submitted from 113 CTD casts which means that there is a DIC value for approximately 65% of the niskins tripped. The DIC data reported to the database directly from the ship are to be considered preliminary until a more thorough quality assurance can be completed shore side.

CHAPTER

NINE

DISCRETE PH ANALYSES

PI

- Dr. Andrew Dickson

Cruise Participant

- David Cervantes
- Stephanie Mumma

9.1 Sampling

Samples were collected in 250 mL Pyrex glass bottles and sealed using grey butyl rubber stoppers held in place by aluminum-crimped caps. Each bottle was rinsed two times and allowed to overflow by one additional bottle volume. Prior to sealing, each sample was given a 1% headspace and poisoned with 0.02% of the sample volume of saturated mercuric chloride ($HgCl_2$). Samples were collected only from Niskin bottles that were also being sampled for both total alkalinity and dissolved inorganic carbon in order to completely characterize the carbon system. Additionally, two duplicate samples were collected from almost all stations for quality control purposes.

9.2 Analysis

pH was measured spectrophotometrically on the total hydrogen scale using an Agilent 8453 spectrophotometer and in accordance with the methods outlined by Carter et al., 2013 *[Carter2013]*. A Kloehn V6 syringe pump was used to autonomously fill, mix, and dispense sample through the custom 10cm flow-through jacketed cell. A Thermo NESLAB RTE-7 recirculating water bath was used to maintain the cell temperature at 25.0°C during analyses, and a YSI 4600 precision thermometer and probe were used to monitor and record the temperature of each sample immediately after the spectrophotometric measurements were taken. The indicator meta-cresol purple (mCP) was used to measure the absorbance of light measured at two different wavelengths (434 nm, 578 nm) corresponding to the maximum absorbance peaks for the acidic and basic forms of the indicator dye. A baseline absorbance was also measured and subtracted from these wavelengths. The baseline absorbance was determined by averaging the absorbances from 725-735nm. The ratio of the absorbances was then used to calculate pH on the total scale using the equations outlined in Liu et al., 2011 *[Liu2011]*. The salinity data used was obtained from the conductivity sensor on the CTD.

9.3 Reagents

The mCP indicator dye was made up to a concentration of approximately 2.0mM and a total ionic strength of 0.7 M. A total of 2 batches were used during Leg 1 of the cruise. The pHs of these batches was adjusted with 0.1 M solutions of HCl and NaOH (in 0.6 M NaCl background) to approximately 7.3, measured with a pH meter calibrated with NBS buffers. The indicator was obtained from Dr. Robert Byrne at the University and Southern Florida and was purified using the flash chromatography technique described by Patsavas et al., 2013 *[Patsavas2013]*.

9.4 Data Processing

An indicator dye is itself an acid-base system that can change the pH of the seawater to which it is added. Therefore, it is important to estimate and correct for this perturbation to the seawater's pH for each batch of dye used during the cruise. To determine this correction, multiple bottles from each station were measured twice, once with a single addition of indicator dye and once with a double addition of indicator dye. The measured absorbance ratio (R) and an isosbestic absorbance (A_{iso}) were determined for each measurement, where:

$$R = \frac{A_{578} - A_{\text{base}}}{A_{434} - A_{\text{base}}}$$

and

$$A_{\text{iso}} = A_{488} - A_{\text{base}}$$

The change in R for a given change in A_{iso}, $\Delta R/\Delta A_{\text{iso}}$, was then plotted against the measured R-value for the normal amount of dye and fitted with a linear regression. From this fit the slope and y-intercept (b and a respectively) are determined by:

$$\Delta R/\Delta A_{\text{iso}} = bR + a$$

From this the corrected ratio (R') corresponding to the measured absorbance ratio if no indicator dye were present can be determined by:

$$R' = R - A_{\text{iso}}(bR + a)$$

9.5 Problems and Troubleshooting

Many of the samples had a high dissolved gas content and degassed when brought to room temperature. This could be clearly seen in the formation of bubbles inside the sealed sample bottles and in the spectrophotometric pH system (Kloehn syringe pump, sample tubing, and the 10 cm cell). Bubbles were especially difficult to eliminate in the Kloehn syringe pump, which would accumulate large bubbles at the top after running a number of samples in each station. Efforts were made to reduce bubble formation by verifying all pump fittings were tight, slowing down the speed of the syringe pump, and holding samples below 25°C. When bubbles formed during station analysis, they were cleared by the aforementioned methods between samples. Bubbles were also cleared from the syringe after every station by flushing with ethanol, followed by DI water. This method of flushing with ethanol and DI water proved to be effective and removed bubbles when accumulated. These bubbles appeared to have no affect on the samples' pH values.

The Labview software that controls the automated pH system crashed three times during I09N, resulting in the loss of data for three samples. The uncorrected pH values were documented in the pH lab notebook but the usually generated data line is not available to apply the necessary dye correction. These three data points were flagged as questionable because they could not be corrected.

Near the end of I09N, the sample outlet tube of the cell sprang a slow leak overnight when the system was not being used. Luckily, no damage by the leak was done to the cell, spectrophotometer, or any of the pH System's components.

9.6 Standardization/Results

The precision of the data was assessed from measurements of duplicate analyses, replicate analyses (two successive measurements on one bottle), and certified reference material (CRM) Batch 152 and Batch 153 (provided by Dr.

Andrew Dickson, UCSD). Two duplicate and two replicate measurements were performed on every station when at least fifteen Niskins were sampled. If less than fifteen Niskins were sampled, only one duplicate and one replicate measurement were performed. CRMs were measured at the beginning and ending of each day. The precision statistics for I09N are:

- Duplicate precision ± 0.00046 (n=182)
- Replicate precision ± 0.00082 (n=177)
- B152 7.8706 ± 0.00066 (n=37)
- B152 within-bottle SD ± 0.00020 (n=37)
- B153 7.8948 ± 0.00073 (n=29)
- B153 within-bottle SD ± 0.00023 (n=29)

The pH measurements for each I09N station were compared to measurements taken from the neighboring I09N 2016 stations and the I09N 2007 stations of similar if not identical coordinates.

2671 pH values were submitted for I09N. The pH of the entire transect is shown as a section in *pH Section*. Although most corrections have been applied and it is unlikely that any additional corrections will need to be performed, this data should be considered preliminary until a more thorough analysis of the data can take place on shore.

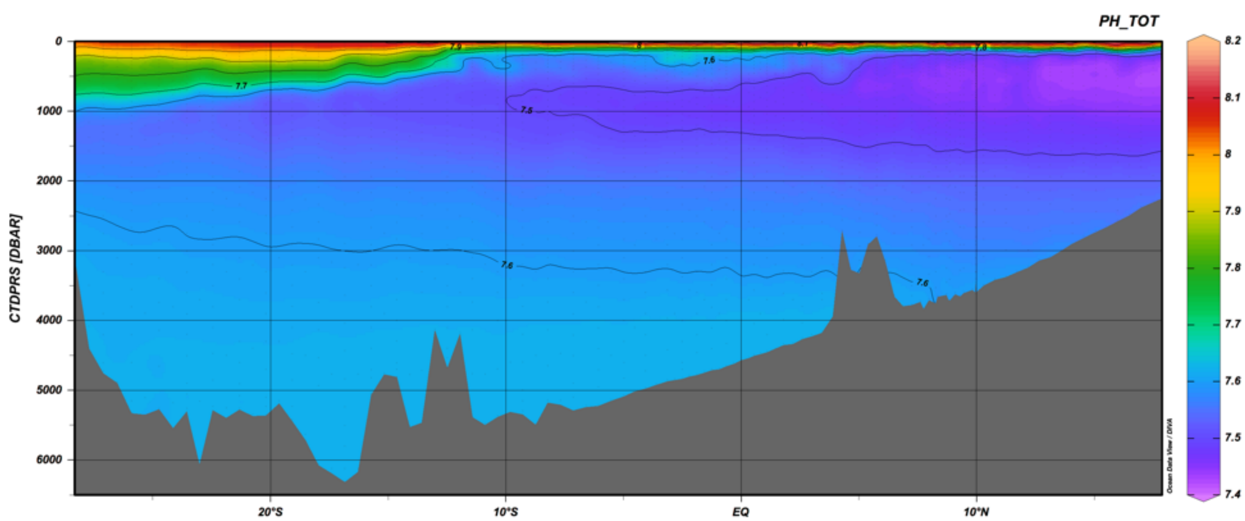


Fig. 9.1: pH Section
Section of pH on the total scale at 25.0°C along I09N (Stations 84 to 196).

CHAPTER

TEN

CFC-11, CFC-12, CFC-113, AND SF_6

Analysts

- Eugene Gorman (LDEO)
- Ben Hickman (LDEO)
- Molly Martin (RSMAS)

10.1 Sample Collection

All samples were collected from depth using 10.4 liter Niskin bottles. None of the Niskin bottles used showed a CFC contamination throughout the cruise. All bottles in use remained inside the CTD hanger between casts.

Sampling was conducted first at each station, according to WOCE protocol. This avoids contamination by air introduced at the top of the Niskin bottle as water was being removed. A water sample was collected from the Niskin bottle petcock using viton tubing to fill a 300 ml BOD bottle. The viton tubing was flushed of air bubbles. The BOD bottle was placed into a plastic overflow container. Water was allowed to fill BOD bottle from the bottom into the overflow container. The stopper was held in the overflow container to be rinsed. Once water started to flow out of the overflow container the overflow container/BOD bottle was moved down so the viton tubing came out and the bottle was stoppered under water while still in the overflow container. A plastic cap was snapped on to hold the stopper in place. One duplicate sample was taken on every other station from random Niskin bottles. Air samples, pumped into the system using an Air Cadet pump from a Dekoron air intake hose mounted high on the foremast were run when time permitted. Air measurements are used as a check on accuracy.

10.2 Equipment and Technique

CFC-11 and CFC-12 were measured on most of the 96 stations for a total of xxxx samples. Due to the non conservative nature of F113 it was not measured on this trip. From the beginning this system was not capable of measuring SF6: all attempts to measure SF6 failed. Equipment problems led to a failure to sample some stations.

Analyses were performed on a gas chromatograph (GC) equipped with an electron capture detector (ECD). Samples were introduced into the GC-EDC via a purge and dual trap system. 202 ml water samples were purged with nitrogen and the compounds of interest were trapped on a main Porapack N/Carboxen 1000 trap held at ~ -20°C with a Vortec Tube cooler. After the sample had been purged and trapped for 6 minutes at 250ml/min flow, the gas stream was stripped of any water vapor via a magnesium perchlorate trap prior to transfer to the main trap. The main trap was isolated and heated by direct resistance to 150°C. The desorbed contents of the main trap were back-flushed and transferred, with helium gas, over a short period of time, to a small volume focus trap in order to improve chromatographic peak shape. The focus trap was Porapak N and is held at ~ -20°C with a Vortec Tube cooler. The focus trap was flash heated by direct resistance to 180°C to release the compounds of interest onto the analytical pre-columns. The first precolumn was a 5 cm length of 1/16” tubing packed with 80/100 mesh molecular sieve 5A. This column was used to hold back N2O and keep it from entering the main column. The second precolumn was the first 5 meters of a 60 m Gaspro capillary column with the main column consisting of the remaining 55 meters. The analytical pre-columns were held in-line with the main analytical column for the first 50 seconds of the chromatographic run. After 35 seconds, all of the compounds of interest were on the main column and the pre-column was switched out of line and back-flushed with a relatively high flow of nitrogen gas. This prevented later eluting compounds from building up on the analytical column, eventually eluting and causing the detector baseline signal to increase.

The samples were stored at room temperature and analyzed within 6 hours of collection. At the end of every station water measurements were followed by a purge blank, standard, and system blank. The surface sample was held after measurement and was sent through the process in order to "restrip" it to determine the efficiency of the purging process.

10.3 System performance

Troubles were many; they were deep as a well. I doubt there is a heaven but I now know there is a hell. It's the Miami CFC system - used on the *Revelle*. It made me want to holler; it made me want to yell. With that experience, I bid you all farewell. Why I never became a poet is not hard to tell.

10.4 Calibration

A gas phase standard, 33780, was used for calibration. The concentrations of the compounds in this standard are reported on the SIO 2005 absolute calibration scale. 5 calibration curves were run over the course of the cruise. Estimated accuracy is $\pm 2\%$. Precision for CFC-12, CFC-11 rror bars will be substantially higher on several stations which will be noted in the final report. Estimated limit of detection is 1 fmol/kg for CFC-11, 3 fmol/kg for CFC-12.

CHAPTER ELEVEN

UNDERWAY PCO_2 ANALYSIS

PI's

- Rik Wanninkhof (NOAA/AOML)
- Denis Pierrot (UM/CIMAS)

Technicians

- Robert Castle (NOAA/AOML)

An automated underway pCO_2 system from AOML was installed in the Hydro Lab of the RV Roger Revelle. The design of the instrumental system is based on Wanninkhof and Thoning *[Wanninkhof1993]* and Feely et al. *[Feely1998]*, while the details of the instrument and of the data processing are described in Pierrot, et.al. *[Pierrot2009]*.

The repeating cycle of the system included 4 gas standards, 5 ambient air samples, and 100 headspace samples from its equilibrator every 3 hours. The concentrations of the standards range from 233 to 463 ppm CO_2 in compressed air. These field standards were calibrated with primary standards that are directly traceable to the WMO scale. A gas cylinder of ultra-high purity air was used every 18 hours to set the zero of the analyzer.

The system included an equilibrator where approximately 0.6 liters of constantly refreshed surface seawater from the bow or mid-ship intake was equilibrated with 0.8 liters of gaseous headspace. The water flow rate through the equilibrator was 1.5 to 2.2 liters/min.

The equilibrator headspace was circulated through a non-dispersive infrared (IR) analyzer, a LI-COR™ 6262, at 50 to 120 ml/min and then returned to the equilibrator. When ambient air or standard gases were analyzed, the gas leaving the analyzer was vented to the lab. A KNF pump constantly pulled 6-8 liter/min of marine air through 100 m of 0.95 cm (= 3/8") OD Dekoron™ tubing from an intake on the bow mast. The intake had a rain guard and a filter of glass wool to prevent water and larger particles from contaminating the intake line and reaching the pump. The headspace gas and marine air were dried before flushing the IR analyzer.

A custom program developed using LabView™ controlled the system and graphically displayed the air and water results. The program recorded the output of the IR analyzer, the GPS position, water and gas flows, water and air temperatures, internal and external pressures, and a variety of other sensors. The program recorded all of these data for each analysis.

The system worked well through out the cruise.

Table 11.1: Standard Gas Cylinders

Cylinder#	ppm CO2
JAO2646	233.46
JAO2264	326.18
JAO2285	406.05
JAO2280	463.00

CHAPTER

TWELVE

ISOTOPIC COMPOSITION OF NITROGEN SPECIES

PI

- Chawalit "Net" Charoenpong

Samples from Niskin bottles and underway system were taken for analyses of isotopic composition of multiple nitrogen (N) ions/compounds with the goals to determine the isotopic distribution of N species in the study region and to understand the cycling of N on the I09N transect traversing through different oceanic regimes including the subtropical gyre, equatorial upwelling and the Bay of Bengal. Natural abundance isotopic composition is a powerful tool to elucidate the sources and the processes and reactions that affect the compounds of interest. No onboard analysis was carried out and all samples will be analyzed back in the Wankel lab for stable isotope biogeochemistry at WHOI.

12.1 Dissolved N gases (N_2O and N_2)

Nitrous oxide gas (N_2O) is an intermediate compound in many N reactions and more importantly it is a potent greenhouse gas. The sample will be analyzed for its concentration and isotopes (δ^{15}N-N_2O, δ^{18}O-N_2O and site preference—isotopic asymmetry of the N_2O molecule). With this information, we can deduce the flux of N_2O at the air-sea interface and determine the microbial processes responsible for its production. Nitrogen gas (N_2), on the other hand, is an inert gas for most part of the ocean where the water is oxygenated. This make it a conservative tracer for different water masses as it records the history of water parcels when they were last in contact with the atmosphere. However, under anoxic condition, N_2 is a product of several microbially-mediated reactions including denitrification and anaerobic ammonium oxidation (anammox). Hence, concentration and isotopic composition (δ^{15}N-N_2) will help deduce the source of N_2 and rates of these processes.

Parameters

- δ^{15}N-N_2O
- δ^{18}O-N_2O
- N_2O site preference
- [N_2O]
- N_2/Ar ratio
- δ^{15}N-N_2

Sampling Procedure: Samples were collected using borosilicate septum bottles by filling directly from the Niskin bottles. Capping with butyl rubber stoppers were done while all bottles were completely underwater. Great care was taken to ensure absence of any bubbles and samples were poisoned with saturated $HgCl_2$ to stop biological activities.

Analysis: High precision measurements of N_2/Ar and δ^{15}N-N_2 were made on septum sealed samples using on-line gas extraction system coupled to a multicollector continuous-flow isotope ratio mass spectrometer (CF-IRMS) as described in *[Charoenpong2014]*. O_2 was removed from the samples prior to δ^{15}N-N_2 analysis using a CuO/Cu reduction column placed in a 500°C furnace to avoid interferences caused by interaction between O_2, N_2 and their fragments within the IRMS ion source. Additional purge and trap system similar to that previously described in *[McIlvin2010]* will be used for N_2O analysis.

12.2 Nitrate and Nitrite

Nitrate (NO_3^-) is the dominant dissolved inorganic nitrogen ions. Like other nutrients, it is depleted in the surface due to biological consumption and abundant in the ocean interior due to remineralization. By looking at the dual isotopes of NO_3^- ($\delta^{15}N$ and $\delta^{18}O$), we can effectively constrain the nutrient utilization in the euphotic zone and its loss process in the OMZ. Nitrite (NO_2^-), on the other hand, is typically found spatially constrained within close proximity to the deep chlorophyll maxima (DCM) in the open ocean—primary nitrite maxima. In addition, we can also find secondary nitrite maxima deeper down in the intense OMZ. Interestingly, the latter feature (though pronounced in other OMZs including the Arabian Sea) is lacking in the Bay of Bengal.

Parameters

- $\delta^{15}N$-NO_3^-
- $\delta^{18}O$-NO_3^-
- $\delta^{15}N$-NO_2^-
- $\delta^{18}O$-NO_2^-

Sampling Procedure: Samples for NO_3^- isotopic analysis (30ml HDPE bottles) were preserved by mild acidification with hydrochloric and sulfuric acid to pH 2 to 3 while samples for NO_2^- isotopic analysis (60mL HDPE bottles) were preserved by raising the pH with NaOH until the sample reaches the pH of 12.5. These steps are in place to ensure the retention of the $\delta^{15}N$ and $\delta^{18}O$ signatures. Samples bottles were stored at room temperature until analysis.

Analysis: The denitrifier method (*[Casciotti2002]*; *[Sigman2001]*) and the azide method (*[McIlvin2010]*) will be used to analyze NO_3^- and NO_2^- respectively. These methods quantitatively convert NO_3^-/NO_2^- to N_2O before being extracted and purified (as in *[McIlvin2010]*) before being analyzed by the IRMS.

12.3 Ammonium

Ammonium (NH_4^+) is produced from the organic N degradation and consumed by multiple processes including NH_4^+ assimilation, nitrification and anammox. Typically found in submicromolar concentration in the open ocean notably around the same depths as the primary nitrite maxima, NH_4^+ is one of the N species that is most poorly constrained in terms of isotopic composition. Previous studies (e.g., Sama et al., in prep) indicates several pockets of high NH_4^+ (up to 0.5uM) in the Bay of Bengal.

Parameter

- $\delta^{15}N$-NH_4^+

Sampling procedure: Sample water was filled directly into 500-mL glass media bottles. Care was taken to ensure minimal contamination (e.g., no cigarette smoke or no painting near the sampling area). A ammonia trap consisting of a pre-combusted (500°C for 4 h) and acidified (20 μL of 2 N H2SO4) GF/D glass fiber filter sandwiched between two sealed Teflon membranes (the passive ammonia diffusion method as described in *[Sigman1997]*), was added to the bottles. Prior to closing the bottles, pH was raised above 9.2 by adding combusted magnesium oxide powder (MgO). Samples were kept agitated on at room temperature for at least 5 days before the traps were removed and kept frozen inside clean 1.2mL cryogenic vials until analysis.

Analysis: Persulfate oxidation (*[Knapp2005]*) and the denitrifier method (*[Sigman2001]*) will be used for the analysis of $\delta^{15}N$-NH_4^+. In short, the NH_4^+ in the trap will be oxidized to NO_3^- using persulfate reagents and then converted to N_2O before the introduction to the IRMS.

Potential problem: Ammonium concentrations on this cruise as analyzed on board by the nutrient team were typically below the detection limit for most part of the transect. Even within the Bay of Bengal where higher [NH_4^+] is expected, we could not find high enough [NH_4^+] to warrant accurate isotopic measurements.

12.4 Suspended particulate organic matter (POM)

The isotopic composition of particulate organic matter reflects the balance between the source of N and the isotopic fractionation during assimilation. Here I use size fractionation to separate different phytoplankton group to investigate whether there is potentially a difference of N source between the larger and small size fractions.

Parameters:

- δ^{15}N-suspended POM
- δ^{13}C-suspended POM

Sampling Procedure: Suspended particulate organic matter was collected from either the underway system or the Niskin bottles. Pre-filtration with 200-micron Nitex mesh was in place to remove larger zooplankton. Two size fractions were collected using GF/A (1.6 micron) and GF/F (0.7 micron) filters. Most samples are from underway (5m intake) and around deep chlorophyll maxima. Samples are kept frozen until analysis.

Analysis: Filters will first be kept inside a jar with concentrated HCl overnight to remove any particulate inorganic carbon (i.e., calcium carbonate) and then analyzed using elemental analyzer coupled with IRMS (EA-IRMS). In short, they will be combusted and organic carbon and nitrogen will be converted into their gas phases: CO_2 and N_2, respectively. In the case where there is too little biomass retained on the filters, the persulfate oxidation coupled with the denitrifier method (as described earlier) will be used instead.

CHAPTER THIRTEEN

$\delta^{18}O$ SAMPLING

PIs

- Peter Schlosser (LDEO)
- Lynne Talley (SIO)

Samples for $\delta^{18}O$ were taken by the CTD-watch for Schlosser and Talley. A total of 1073 brown glass bottles were used to collect XX ml samples according to the protocol provided.

1. The sample bottles came stored in annotated boxes that were each labeled with a box number (1-20) as it was filled samples.
2. The container with the empty sample bottles and documentation was kept in the forward bio-lab. Before the return of the CTD to the deck, 36 bottles were prepared with Bullister bottle numbers written in the caps. The 24 bottle plastic rack, which sat in a plastic basin (both provided) was filled with the empty bottles. The 12 extra bottles were placed upright in the basin.
3. Seawater was taken directly from the Bullister bottles using the tube provided. Sample bottles were rinsed once with seawater from the Bullister prior to sampling.
4. After sampling the 36 bottles were taken back to the forward bio-lab where they were dried with paper towels, caps were tightened and wrapped in tape, and labels were filled out and applied.
5. The sample ID's, Bullister bottle numbers, date and box number were recorded on a log sheet provided. After all sampling was complete this log sheet was converted to the electronic version, which will be sent to the PIs.

The agreed upon sampling plan followed the basic outline of the I06S sampling provided by Robert Key (Princeton) with concentrated sampling at the southernmost stations and less concentrated to the north. The table below summarizes the sampling.

Note: Note there was a mix up in the assigning ID numbers so there are IDs 432A,B. and C and 452A, and B.

dO18 Box	dO18 ID	dO18 ID	STA#	CAST	DATE (UTC)	# SAMPLES	LAT	LON	DEPTH (m)
START-END	START	END							
1-1	1	19	1	1	19-Feb-16	19	-66.6027	78.3815	468
1-1	20	40	2	3	19-Feb-16	21	-66.4997	78.2986	953
1-2	41	67	3	1	19-Feb-16	27	-66.45	78.2494	1497
2-2	68	98	4	1	19-Feb-16	31	-66.4	78.1993	1979
2-3	99	132	5	1	20-Feb-16	34	-66.2999	78.1253	2731
3-4	133	168	6	1	20-Feb-16	35	-66.15	78.0102	3009
4	169	203	7	2	20-Feb-16	35	-65.6248	78.8085	3313

Continued on next page

Table 13.1 – continued from previous page

dO18 Box	dO18 ID	dO18 ID	STA#	CAST	DATE (UTC)	# SAMPLES	LAT	LON	DEPTH (m)
4-5	204	239	8	1	20-Feb-16	35	-65.1	79.6066	3525
5-6	240	275	9	1	21-Feb-16	36	-64.5799	80.3926	3667
6	276	311	10	1	21-Feb-16	36	-64.05	81.2022	3700
6-7	312	347	11	1	21-Feb-16	35	-63.535	82.0005	3450
7	348	378	12	1	21-Feb-16	31	-63.003	82.0103	2748
8	379	402	13	1	22-Feb-16	23	-62.5003	82.0002	1919
8	403	429	15	1	22-Feb-16	27	-61.4999	82.0002	2175
8-9	430	451	16	1	22-Feb-16	24	-61	82.0005	1858
9	452	475	19	2	23-Feb-16	25	-59.5002	82.0003	1706
9-10	476	496	20	2	23-Feb-16	21	-59.0001	82	1291
10	497	518	21	1	24-Feb-16	22	-58.6101	82.0101	1549
11	519	553	25	1	24-Feb-16	35	-57.5131	82.5226	4438
11	554	589	26	1	25-Feb-16	36	-57.3209	82.7791	4240
11-12	590	625	29	1	25-Feb-16	36	-56.058	84.2612	4822
12-13	626	661	32	1	26-Feb-16	36	-54.7862	85.6644	4712
13	662	697	33	1	26-Feb-16	36	-54.367	86.1421	4641
13-14	698	733	35	1	28-Feb-16	36	-53.5264	87.0235	4602
14-15	734	761	37	1	28-Feb-16	28	-52.531	87.954	4405
15	762	796	40	1	1-Mar-16	35	-51.037	89.3503	4141
15-16	797	832	43	1	1-Mar-16	36	-49.5429	90.7469	3868
16-17	833	868	44	1	2-Mar-16	36	-49.0449	91.2121	3815
17	869	903	47	1	2-Mar-16	35	-47.551	92.6087	3616
17-18	904	936	48	1	3-Mar-16	33	-47.053	93.0739	3490
18	937	970	51	1	3-Mar-16	33	-45.559	94.4702	3219
19	971	1003	52	1	3-Mar-16	33	-44.992	95.0002	2903
19-20	1003	1037	55	1	4-Mar-16	34	-43.068	95.0001	3168
20	1038	1073	58	1	5-Mar-16	36	-41.1441	95.0003	3564

CHAPTER FOURTEEN

CDOM

UCSB Global CDOM Group

- Eric Stassinos, Earth Research Institute UCSB, Technician
- Jeremy Kravitz, U. Puerto Rico, Volunteer Graduate Student

14.1 Chromophoric Dissolved Organic Matter (CDOM)

Sampling: We nominally sampled one cast per day, on the cast nearest the overpass times of the ocean color instrument bearing satellites Aqua (MODIS) and NPP (VIIRS). Each Niskin bottle would be sampled, with two randomly selected replicates.

Preparation: The standard method involves collecting 60 mL samples into glass EPA vials, then filtering the samples at low vacuum pressure (-0.05 MPa) through 25mm 0.2 micron Nuclepore filters which have been preconditioned with ultrapure water to remove organic contaminants. For the underway samples we used 0.2 micron nylon ZenPure cartridge filters to remove particles. Sample vials are rinsed with the filtrate and the filtrate is returned to the vial. Filtered samples are stored at 4°C until analysis (*[Nelson2007]*, *[Nelson2009]*).

Original plan was to analyze samples at sea using the WPI UltraPath 200cm liquid waveguide cell spectrophotometer system. However the cell developed an air leak on I08S that could not be corrected in-field, so we opted to collect samples to return to UCSB for analysis. We collected 16 samples and two replicates on each cast, filtered and stored them. CDOM samples will be returned from Phuket Thailand to UCSB.

We collected samples on 16 stations, for a total of 288 samples with 32 being replicates.

Analysis: Filtered seawater samples are analyzed for absorption in the 250-734 nm range using a WPI UltraPath spectrophotometer system. The UltraPath is a single-beam spectrophotometer system consisting of a UV-Visible light source, a 200 cm liquid waveguide cell, and a diode array spectrometer. Samples (appx. 12 mL volume) are injected into the cell using a peristaltic pump. Light is introduced to the cell via a fiber-optic and travels the length of the cell because of total internal reflection, as in a fiber optic filament. Absorbance is calculated by computing the logarithm of the spectrum of transmitted light through a sample divided by the spectrum of transmitted light through a reference solution (in this case ultrapure water prepared each day with our Barnstead Nanopure Diamond UV system using potable water as input). Because of the difference in real refractive index between seawater and ultrapure water the raw data have an apparent negative absorbance signal that must be removed before computing absorption coefficient (m^{-1}) (as absorbance x 2.303/l, where l is the effective pathlength of the cell, *[Nelson2007]*).

For this expedition we are testing a new protocol for CDOM absorption spectra measurement and refractive index correction as part of a NASA methodological development effort. The protocol involves measuring standard solutions of Suwanee River Fulvic Acid ~0.25 mg/L and sodium chloride at 30 and 40 g/L to monitor instrument performance and obtain data for correction of apparent absorption due to refractive differences between ultrapure water and seawater.

Selected CDOM absorption data from discrete wavelengths will be submitted to CCHDO upon completion of quality control. More complete data sets including raw data and processing code will be available via the NASA bio-optical field data SeaBASS (seabass.gsfc.nasa.gov).

14.2 Chlorophyll a

Sampling: We collected ~500mL samples from the top 6 depths on the mid day CTD cast associated with out radiometer deployment and CDOM sampling, one cast daily, total of approximately 192 samples.

Preparation: Samples were collected into 500mL brown HDPE bottles and were subsequently filtered onto 25mm 0.45μm pore nitrocellulose filters. The filters were placed in polypropylene Falcon tubes and extracted 48 hours at 4°C temperature in 10 mL of 90% acetone (with Barnstead Nanopure UV prepared water); and were shaken after 24 hours to ensure complete filter dissolution.

Analysis: The acetone extracts were analyzed using the acidification technique *[Mueller2003]* on a Turner Designs AU-10 fluorometer with the standard chlorophyll fluorescence set. The fluorescence (in relative units) was measured before (Rb) and after (Ra) acidification with two drops of 10% HCl. Chlorophylla was computed according to the standard formula:

$$\mathrm{Chla}(\mu\mathrm{g/l}) = (\tau/\tau - 1)\mathrm{Fd}(\mathrm{Rb} - \mathrm{Ra})$$

Where τ is the fluorescence ratio of pure chlorophyll a to pure phaeophytin a and Fd is the calibration coefficient (μg/L). τ and Fd for each of the three sensitivity ranges of the instrument were determined in August 2014 by Janice Jones and Nathalie Guillocheau, UCSB; using solutions of pure Anacystis nidulans chlorophyll a (Sigma) in 90% acetone.

HIGH Tau =	1.9539
MED Tau =	1.9496
LOW Tau =	1.8885
Med/High Tau =	1.9520
Low/Med Tau =	1.9274
overallavg Tau =	1.9393

	[Chla] Rb	[Chla] ((tau/(tau-1))*(Rb-Ra))	Slope
HIGH Fd =	0.138925422	0.138925422	0.142718147
MED Fd =	0.138626676	0.138626676	0.141249987
LOW Fd =	0.126879138	0.126879138	0.128316741
Med/High Fd =	0.1388	0.138794721	0.141417549
Low/Med Fd =	0.1344	0.134354844	0.141000945
overallavgFd =	0.1364	0.136411604	0.141201691

Instrument performance was checked daily with a Turner Designs solid fluorescence standard. No apparent trend was observed.

Preliminary Results: Preliminary quality control based on phaeophytin a to chlorophyll a ratios suggest almost all samples collected to date from shallower than 200m were good. Samples collected at 200m and below were effectively zero in most cases, putting a tentative lower limit for chlorophyll determination at 0.01 mg/m^3. Results show a general trend of increasing subsurface chlorophyll concentrations and a shallower deep chlorophyll a maximum as stations progressed from south of the equator to the Bay of Bengal. The largest deep chlorophyll a maximum concentrations were observed just north of the equator between ranges of ~0.5-0.7 mg/m^3 while surface concentration ranges remained low under 0.1 mg/m^3 and reaching below 0.04 mg/m^3.

Problems: All values of computed chlorophyll a were within normal values for the region. One sample was omitted (station 104/1, sample 35, flagged 5) due to a contaminated filter pad. All other samples were flagged as 2 for high confidence in the values.

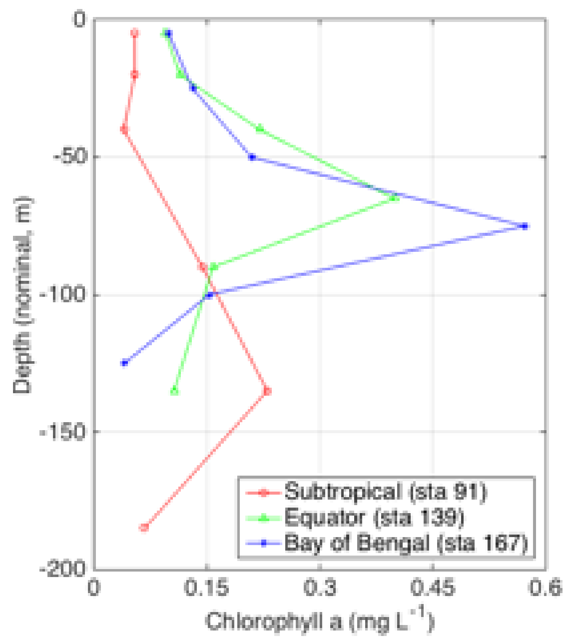


Fig. 14.1: Chlorophyll a profiles from Station 91 (-24.1S), Station 139 (-0.32S) and station 167 (9.97N).

14.3 CDOM Rosette Fluorometer

Equipment and Techniques: On I08S, a WETLabs CDOM fluorometer FLCDRTD was deployed on the rosette. The instrument exhibited unusual offsets in the data output between 1200 and 1500 db, that were not resolved before the instrument was lost with the rosette on February 22. There was not a replacement for the instrument on this leg.

Sampling and Analysis: Instrument data are saved as analog volts DC and are vicariously calibrated post cruise using laboratory-measured fluorescence spectra standardized to quinine sulfate fluorescence equivalents (ppb) of archived samples using a Horiba Jobin Yvon Fluoromax-4 (*[Nelson2009]*, *[Nelson2016]*).

14.4 Spectroradiometer casts

Acquisition: Each day near local noon (with one exception; see below) we deployed a Biospherical C-OPS profiling spectroradiometer system (system 023) off the port quarter. The instrument measures downwelling irradiance and upwelling radiance in 19 channels stretching from the UV-B to the NIR wavebands. The system includes a surface reference unit with matching channels and a shadowband system for measuring direct and diffuse contributions to total irradiance. All instruments acquire data at 15 Hz. The profiler is hand deployed and recovered to allow drift away from the ship to avoid shadow influence. The maximum depth reached on every profile was approximately 100 m.

Data Processing: Collected data are subjected to quality control for tilt and surface irradiance change during the profile *[Mueller2003]* and derived products include attenuation coefficient spectra and water-leaving radiance reflectance (for ocean color remote sensing data validation). Resulting products will be made available via NASA's field bio-optics archive SeaBASS (seabass.gsfc.nasa.gov).

```
C-OPS cast summary to 04/24/16

Cast 084/2
Cast Start: 25-Mar-2016  06:04:23 UT
```

```
Cast End  : 25-Mar-2016  06:18:26 UT
Max Depth : 98.6

Cast 088/1
Cast Start: 26-Mar-2016  06:03:64 UT
Cast End  : 26-Mar-2016  06:16:46 UT
Max Depth : 102.1

Cast 091/2
Cast Start: 27-Mar-2016  08:11:24 UT
Cast End  : 27-Mar-2016  08:25:04 UT
Max Depth : 98.9

Cast 97/05
Cast Start: 29-Mar-2016 06:05:48 UT
Cast End  : 29-Mar-2016 06:17:56 UT
Max Depth : 110.8 m

101/2
Cast Start: 30-Mar-2016 06:01:15 UT
Cast End  : 30-Mar-2016 06:14:30 UT
Max Depth : 101.2 m

104/2
Cast Start: 31-Mar-2016 08:13:06 UT
Cast End  : 31-Mar-2016 08:26:21 UT
Max Depth : 99.9 m

108/1
Cast Start: 01-Apr-2016 07:45:44 UT
Cast End  : 01-Apr-2016 07:59:19 UT
Max Depth : 106.3 m

111/2
Cast Start: 02-Apr-2016 08:02:33 UT
Cast End  : 02-Apr-2016 08:17:00 UT
Max Depth : 97.5 m

115/01
Cast Start: 03-Apr-2016 06:43:39 UT
Cast End  : 03-Apr-2016 06:57:18 UT
Max Depth : 82.1 m

121/1
Cast Start: 05-Apr-2016 08:11:00 UT
Cast End  : 05-Apr-2016 08:26:59 UT
Max Depth : 90.6 m

124/2
Cast Start: 06-Apr-2016 08:24:41 UT
Cast End  : 06-Apr-2016 08:40:25 UT
Max Depth : 91.4 m

127/6
Cast Start: 07-Apr-2016 08:02:47 UT
Cast End  : 07-Apr-2016 08:15:09 UT
Max Depth : 108.3 m
```

```
131/1
Cast Start: 08-Apr-2016 05:46:28 UT
Cast End  : 08-Apr-2016 06:00:34 UT
Max Depth : 107.0 m

135/1
Cast Start: 09-Apr-2016 07:32:35 UT
Cast End  : 09-Apr-2016 07:46:07 UT
Max Depth : 108.5 m

139/1
Cast Start: 10-Apr-2016 06:00:40 UT
Cast End  : 10-Apr-2016 06:16:17 UT
Max Depth : 71.4 m

143/1
Cast Start: 11-Apr-2016 07:08:05 UT
Cast End  : 11-Apr-2016 07:28:24 UT
Max Depth : 106.9 m

146/2
Cast Start: 12-Apr-2016 07:06:23 UT
Cast End  : 12-Apr-2016 07:18:41 UT
Max Depth : 109.7 m

150/2
Cast Start: 13-Apr-2016 08:21:17 UT
Cast End  : 13-Apr-2016 08:35:04 UT
Max Depth : 101.6 m

154/2
Cast Start: 14-Apr-2016 06:12:45 UT
Cast End  : 14-Apr-2016 06:27:10 UT
Max Depth : 96.5 m

159/2
Cast Start: 15-Apr-2016 08:29:53 UT
Cast End  : 15-Apr-2016 08:42:27 UT
Max Depth : 122.0 m

167/1
Cast Start: 17-Apr-2016 08:20:20 UT
Cast End  : 17-Apr-2016 08:33:47 UT
Max Depth : 110.4 m

175/1
Cast Start: 19-Apr-2016 08:59:40 UT
Cast End  : 19-Apr-2016 09:07:41 UT
Max Depth : 116.0 m

183/1
Cast Start: 21-Apr-2016 08:24:10 UT
Cast End  : 21-Apr-2016 08:37:53 UT
Max Depth : 84.1 m

186/2
Cast Start: 22-Apr-2016 05:30:41 UT
Cast End  : 22-Apr-2016 05:43:57 UT
```

```
Max Depth : 108.3 m

190/2
Cast Start: 23-Apr-2016 06:32:35 UT
Cast End  : 23-Apr-2016 06:47:34 UT
Max Depth : 111.3 m

195/2
Cast Start: 24-Apr-2016 08:19:34 UT
Cast End  : 24-Apr-2016 08:34:16 UT
Max Depth : 70.2 m
```

Problems: A manufacturing defect caused excessive stress on the termination of the underwater cable for the instrument which caused a failure in the communications and loss of two stations samples. After repairs to the cable, problems with excessive heat, and a motor position error on the deck unit caused complications with two other casts leading to aborted profiles. Deck unit heating issues were minimized by reducing power to the unit.

14.5 Underway optics system

Equipment and Techniques: We installed our underway inherent optical property measuring system in the hydro lab and supplied it with ship's uncontaminated seawater at appx 10 L/min. The system includes a computer-controlled valve that switches between whole water and a 0.2 μm filter (ZenPure nylon cartridge) which feeds an MSRC vortex debubbler. The debubbled water is supplied through a PVC manifold to a SeaBird TSG and an array of optical instruments: a WETLabs ECO BB3 backscattering sensor installed in a custom light trap (Slade et al. 2010), a WETLabs AC-S hyperspectral absorption and attenuation meter, a Sequoia Scientific LISST 100X type B laser diffraction particle counter/sizer, and a Satlantic in-situ FIRe in vivo fluorescence excitation/relaxation sensor.

Analysis: The system includes a computer-controlled data acquisition system that automatically switches between filtered and whole water supply to the instruments on a user-defined schedule. The filtered seawater baseline is used to correct the instrument data for calibration and offset drift, variable CDOM, and temperature effects *[Slade2010]*. With the system operating in unfiltered mode the instruments are sampled at 1 Hz and data are generally collected in one minute bins. It takes around 15 minutes to completely flush the system following a switch two or from filter mode, so no data collection takes place during this time period. Approximately five "filter" periods are scheduled each day. Instruments are also powered off for one minute in ten to mitigate overheating and to extend lamp life.

System optics were cleaned each day using isopropanol and the filter cartridge was changed on alternate days.

Data from the system require extensive post processing and quality control, which will be performed on land. Resulting data will be made available via NASA's field bio-optics archive SeaBASS (seabass.gsfc.nasa.gov).

14.6 POC sampling

Sampling: Large volume HPLC/AP/POC samples were processed on our filtration rig approximately every 5 days depending on water budget. Samples were stored in our liquid nitrogen Dewar during the cruise. We collected ~2 L samples into polyethylene sample bottles from four depths defined by sharp profile gradients in beam transmission data from the CTD. Samples were typically drawn above 300m bracketing transmissometer features and one at 2000m.

Preparation: Samples were filtered onto precombusted 25 mm GF/F glass fiber filters at < -0.05 MPa vacuum pressure. The filters were folded into foil packets and immediately frozen in liquid nitrogen. The samples will be returned to UCSB via liquid nitrogen dry shipper.

Analysis: POC samples will be analyzed for C and N content at the UCSB Marine Science Institute Analytical Laboratory. Samples are acidified, combusted at 100 °C and analyzed using a Control Equipment, Inc. CEC440HA el-

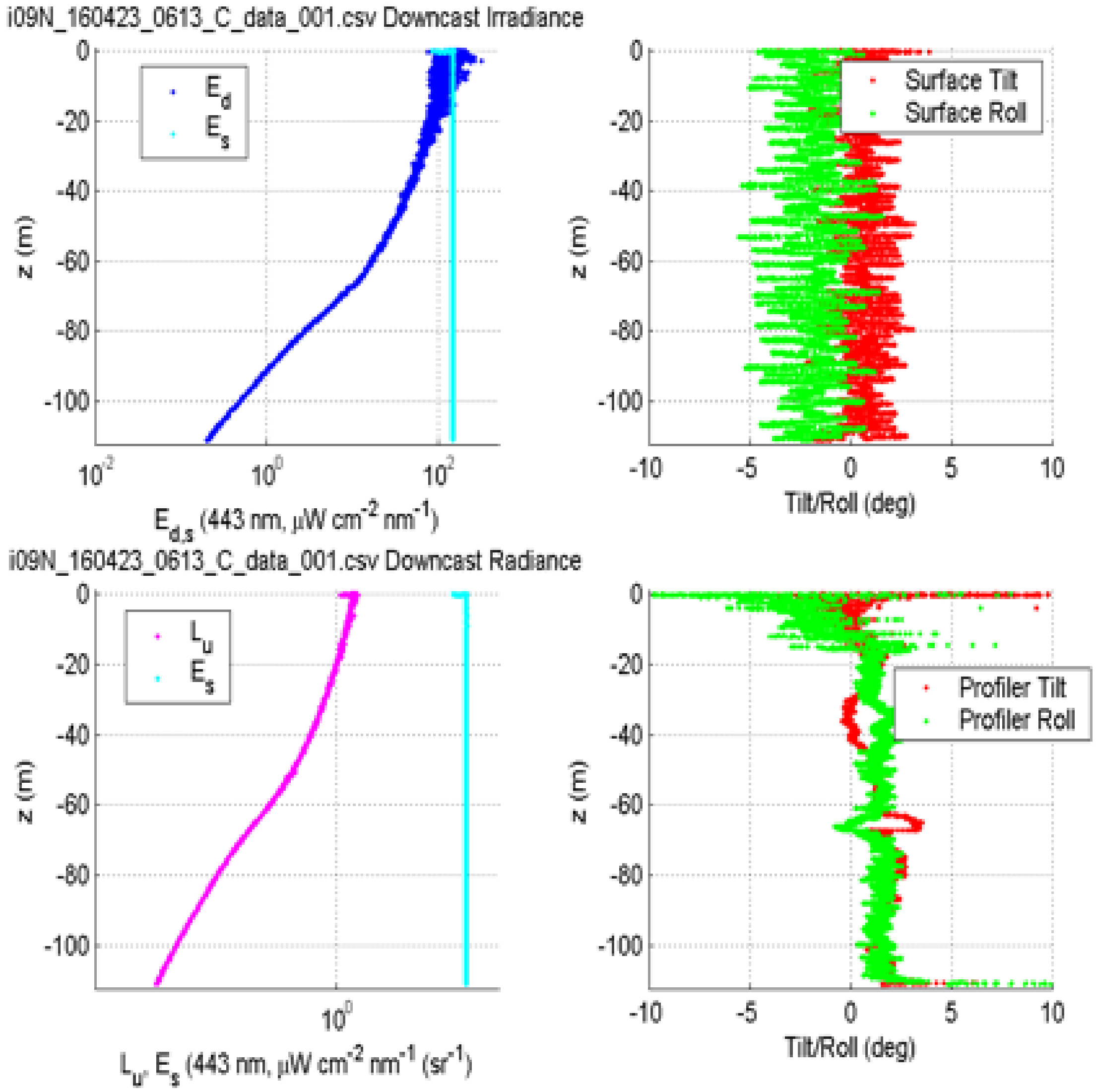


Fig. 14.2: C-OPS

C-OPS- 443 nm downwelling irradiance (top left) and upwelling radiance (lower left), station 190, cast 2. 443 nm surface irradiance collected at the same moment is shown in cyan. Surface unit (ship) and profiler tilt and roll are shown in the right-hand panels. Strong inflections in the profiles (shown on a logarithmic scale) are due to the presence of a chlorophyll maximum near 70m.

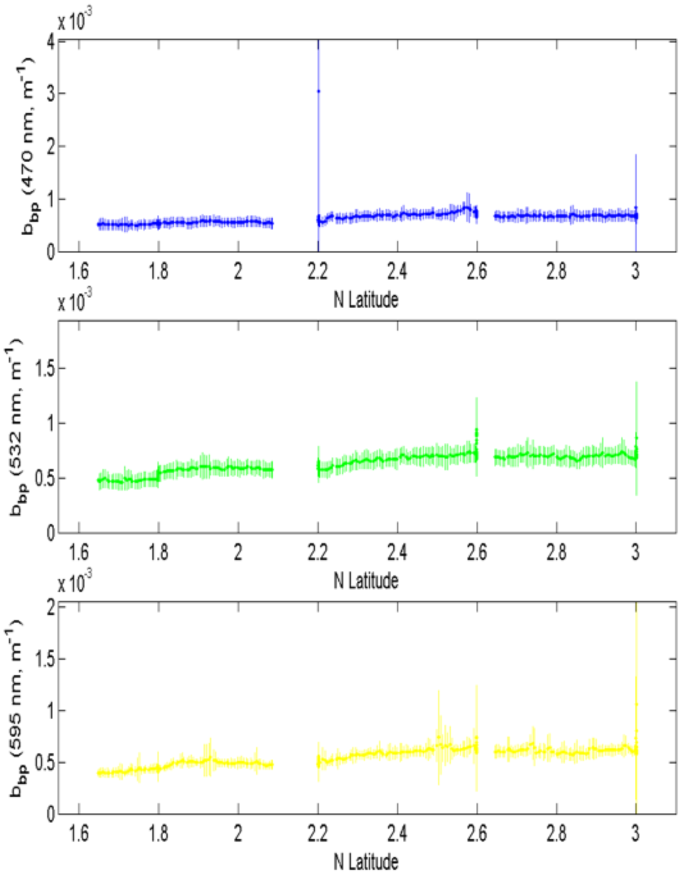


Fig. 14.3: Particulate backscattering coefficient from the southernmost end of the transit and beginning of the section. Note near exact overlap of the section south of 66.3S

emental analyzer (http://msi.ucsb.edu/services/analytical-lab/instruments/organic-elemental-analyzer-chn). Detection limits are approximately 2 μg carbon and 5 μg nitrogen.

HPLC samples will be analyzed by Crystal Thomas at the NASA Goddard Spaceflight Center HPLC lab (Greenbelt, MD). The full suite of measurements, procedures, and quality control information is available at: http://oceancolor.gsfc.nasa.gov/cms/

14.7 Phytoplankton Pigments and Particulate Absorption

Sampling: Once daily, in approximate synchronization with our C-OPS casts and satellite overpasses we collected samples from the ship's uncontaminated seawater supply for shore analysis of phytoplankton pigments via HPLC and for particulate absorption spectra (AP). ~2 L samples were collected into polyethylene sample bottles.

Preparation: Samples were filtered onto 25 mm GF/F glass fiber filters and frozen in liquid nitrogen *[Mueller2003]*. The samples will be returned for analysis to UCSB (AP) and to NASA GSFC (HPLC).

Analysis: Particulate absorption spectra of the AP sample filters are measured a Shimadzu UV-2401 spectrophotometer with an integrating sphere attachment, using a moistened GF/F filter as a blank. Absorbance of filters is converted to absorption coefficient spectra using the Quantitative Filter Technique *[Mueller2003]* using multiple scattering corrections developed by Nelson et al. *[Nelson1998]*.

Samples for phytoplankton pigment analysis will be analyzed at NASA GSFC by the Ocean Ecology Laboratory Field Support Group (http://oceancolor.gsfc.nasa.gov/cms/hplc/). Acetone extracts of the particles collected on GF/F filters will be separated using an HP HPLC system with a C8 column, and detected using a diode array spectrophotometer system to confirm pigment identity. Resulting data will be made available via NASA's field bio-optics archive SeaBASS (seabass.gsfc.nasa.gov).

CHAPTER

FIFTEEN

DISSOLVED ORGANIC CARBON

PI Craig Carlson (UCSB)

Technician Jacqueline Comstock

Dissolved Organic Carbon (DOC) samples were collected from all Niskin bottles at all even numbered stations, as well as station 1. A total of 1415 samples were collected from 43 stations. At each sampled station, one duplicate sample was taken from a random depth. Samples from 500m and shallower in the water column were filtered through a 47mm in-line GF/F filter. All samples were rinsed 3 times with seawater, collected in 40 mL glass EPA vials, and stored at 4°C. 65µl of 4N Hydrochloric acid were added to preserve samples.

Sample vials were prepared for this cruise by soaking in 10% Hydrochloric acid, followed by 3 times rinse with DI water. The vials were then combusted at 450°C for 4 hours to remove any organic matter. Vial caps were cleaned by soaking in DI water overnight, followed by a 3 times rinse, and then left out to air dry.

Sampling goals for this cruise were to continue long term monitoring of DOC distribution throughout the water column, in order to help better understand biogeochemical cycling in global oceans.

CHAPTER

SIXTEEN

CARBON ISOTOPES IN SEAWATER (14/13C)

PI Ann McNichol (WHOI)

Technician Jacqueline Comstock

A total of 352 samples were collected from 16 stations. Ten stations were partially sampled (16 samples) while the rest were full cast (32 samples). Duplicates were collected at six different stations. Samples were collected in 500 ml airtight glass bottles. Using silicone tubing, the flasks were rinsed 2 times with the seawater from the correspondent Niskin bottle. While keeping the tubing at the bottom of the flask, the flask was filled and flushed by allowing it to overflow one and a half times its full volume. Once the sample was taken, a small amount (about 30 cc) of water was removed to create a headspace and 100 ul of 50% saturated mercuric chloride solution was added in the sampling bay. In order to avoid contamination, gloves were used during all collection, handling, and storage processes. Sample handling was done on a clean table covered with plastic trash bags.

After all samples were collected from a station the glass stoppers were dried and greased with Apiezon-M grease to ensure an air tight seal. The stoppers were secured with a rubber band which wrapped over the entire bottle. The samples were stored in AMS crates or boxes inside the ship's main laboratory during the cruise. The samples will be shipped to WHOI for analysis.

The radiocarbon/DIC content of seawater (DI14C) is measured by extracting the inorganic carbon as CO2 gas, converting the gas to graphite, then counting the number of 14C atoms in the sample directly using an accelerator mass spectrometer (AMS).

Radiocarbon values will be reported as 14C using established procedures modified for AMS applications. The 13C/ 12C of the CO2 extracted from seawater is measured relative to the 13C/ 12C a CO2 gas standard calibrated to the PDB standard using an isotope radio mass spectromete (IRMS) at NOSAMS.

CHAPTER

SEVENTEEN

PHYTOPLANKTON, 15N/13C AND TRACE METALS

PI

- Mike Lomas (Bigelow)
- Banjamine Twining (Bigelow)

Technician

- Steven Baer
- Sara Rauschenberg

The goal of this project is to supplement the GO-SHIP data set with measurements of microbial abundance and diversity, dissolved and particulate iron (Fe), along with nitrogen (N) uptake rates in the surface waters across the central Indian Ocean.

Trace metal clean water was collected from the surface water (20m) at 25 stations. Additional depths were sampled at 6 of these stations, creating four-point depth profiles of the upper 200m (stations 97, 110, 127, 162, and 189). Samples for dissolved, particulate, and cellular Fe were collected at each of the 25 stations. In total, 42 dissolved Fe, 42 particulate Fe, and 65 cellular Fe samples will be brought back to Bigelow Laboratory for later analysis.

At these same 25 stations, water was collected from the "main" rosette at 20m depth for measurement of chlorophyll a, urea, and total dissolved phosphorus concentrations, and nutrient uptake incubations. For measurement of N uptake rates, duplicate 2 L bottles were set up with tracer additions of stable-isotopically labeled ammonium, nitrate, and urea. Additionally, stable-isotopically labeled bicarbonate was added to each bottle for measurement of inorganic carbon (C) uptake rates (i.e. primary production). Bottles were incubated on deck for six hours in ambient light and temperature conditions, before being filtered over GF/F filters (nominal pore size = 0.7 μm), or concentrated via CellTraps (Memteq Co. UK) for later separation by a high-speed sorting flow cytometer for analysis of taxon-specific uptake rates.

Samples for small phytoplankton (*Prochlorococcus, Synechococcus*, pico- and nano-eukaryotes) and bacterial abundance were obtained from euphotic zone depths, fixed with paraformaldehyde, and frozen for flow cytometry analysis on shore. An additional Niskin was reverse-concentrated and analyzed immediately onboard with a FlowCAM (Fluid Imaging Systems, Inc.) for enumeration of larger (>10 μm) phytoplankton.

The transect data will provide an overall picture to latitudinal gradients in trace metals and biological diversity. Additionally, this project breaks the central Indian Ocean into three major biogeochemical regimes: Inter Monsoon Gyre in the North, a region from ~0-10°S, and the Indian Southern Subtropical Gyre in the south. A series of incubations and bioassays were set up in the center of each of these biogeochemical regions: stations 97, 127, and 162. These stations were "regional stations". Each regional station collected samples for biological diversity and Fe at depths representing both the surface and the deep chlorophyll maximum. In addition, samples were collected for taxon-specific cellular quotas of C, N, and phosphorus (P). The incubations at the regional stations included the same uptake rates as described above for the 25 surface water stations. An additional set of bottles were incubated for the generation of kinetics curves of ammonium, nitrate, and urea. This consists of tracer additions of stable-isotopically labeled N, along with increasing amounts of unlabeled substrate to generate uptake rates across a spectrum of concentrations (from 0.05 – 5.0 μM).

Bioassays were conducted to test for N, P, or Fe limitation of phytoplankton growth. Triplicate trace-metal clean bottles were inoculated with ammonium, phosphate, Fe, all three nutrients together, or none (control). Bottles were incubated in the on-deck incubator for three days. Initial and daily samples were taken for nutrient analysis (performed by S. Becker and J. Ballard), variable chlorophyll fluorescence (F_v/F_m), and preserved samples for flow cytometry counts of bacteria and phytoplankton. At the conclusion of the bioassay, additional samples were collected to measure chlorophyll a, cellular Fe, and particulate organic C.

CHAPTER

EIGHTEEN

PLANKTON GENOMIC ANALYSIS

Cruise Participant Cathy Garcia

The Martiny lab at UC Irvine, in collaboration with the Lomas and Twining labs at Bigelow Laboratory of Ocean Science, have the goal to link diversity to biogeochemical cycles in the Indian Ocean. The Lomas group focused on phytoplankton diversity and nutrient uptake, Twining on trace metal parameters, and Martiny on particulate organic matter (POM) ratios and metagenomics.

Both institutions collected samples from a full cast at three “regional stations”. These were identified as the Indian Southern Subtropical Gyre, an equatorial upwelling region at 10°S, and an Inter Monsoon Gyre in the Bay of Bengal. The subtropical gyre surface nutrient concentrations were below detection limit. A shoaling of the nutricline occurred in the upwelling region, approximately 12°S to 5°S. The Bay of Bengal station is near a large oxygen minimum zone and freshwater inputs from river runoff. The stations took place at approximately20°S, 5°S, and 8°N to capture representative stations within each region. Triplicate samples for POM) with its constituents of carbon (POC), nitrogen (PON), and phosphorus (POP), were collected at 20m. Duplicate samples for DNA were collected at 20m and the deep chlorophyll maximum (DCM), as described below.

Along the entire IO9N transect, we had a goal to establish very high latitudinal resolution of genomics and POM data. Utilizing the ship’s flow-through seawater system, water was collected at each station and approximately halfway between each station, giving a sampling resolution of 1/4 to 1/2 degree for the entire transect. On average samples were taken 2-3 hours apart. Giving a high degree of temporal as well as spatial resolution. Additionally, we collected water at 15 stations between Fremantle, Australia and the first station at 28°S = station 84.

Triplicate samples for POM were filtered through 30μm nylon mesh into 8L polycarbonate carboys, which were rinsed once with sample water. Eight liters were filtered through a GF/F filter (nominal pore size = 7 um) for POM and chemical oxygen demand each. At the same time, duplicate genomics samples were obtained from the flow-through system. Ten liters of unfiltered seawater was collected into 10L cubitainers and passed through 0.22um Sterivex filters. The entire microbial community larger than 0.22um was preserved and frozen for future metagenomic analysis. These DNA samples will help identify the diversity of the microbial population. Gene frequency of identifiable nutrient uptake genes will assist in understanding patterns of nutrient regimes and potential links to the surface microbial community.

POP	POC/POC	Oxygen Demand	Genomics	Fv/Fm
705 GF/F filters	705 GF/F filters	351 GF/F filters	600 Sterivex filters	Continuous Station 173 onwards

In addition to the regional and underway sampling, genomics samples were collected at or below the deep chlorophyll maximum (DCM). Below the DCM was chosen to target the primary nitrite layer. This occurred at all odd numbered stations between April 2nd and April 28th (stations 113 to 195). In collaboration with Chawalit Charoenpong from Woods Hole Oceanographic Institution, DNA samples to identify ammonia oxidizing and/or nitrifying populations were obtained from the oxygen minimum zone, lower oxycline, and upper oxycline from the rosette from selected Bay of Bengal stations beginning at station 149.

CHAPTER

NINETEEN

LADCP

PI Dr. Andras Thurnherr

Cruise Participant Takaya Uchiya

Lowered Acoustic Doppler Current Profiler (LADCP) data were collected on all stations (84-XXXX). For all profiles a dual head system was used consisting of a downlooker and an uplooker. All profiles were sent daily to A. Thurnherr for shore-based processing and QC. Preliminary processing for horizontal velocity was also performed onboard using the LDEO_IX software (www.ldeo.columbia.edu/LADCP). *ladcp-figure*. and *ladcp-figure*. show the zonal and meridional velocity components, respectively, including the profiles from cruise leg 1 (I08S). Due to instrument problems no LADCP data were collected on leg-1 stations 14-27 and, in addition, the data quality of horizontal velocities on stations 28-59 were low. The upper panels show the upper ocean down to 800m using data from the ship-board ADCP (SADCP) because the data are continuous; the lower panels show the horizontal velocities from the LADCP.

The figures clearly show strong horizontal velocities in the Antarctic Circumpolar Current (ACC) (~45-57S) and in the zonal equatorial undercurrent region near the Equator. Additionally there are strong currents around the Broken Plateau (30S). Based on satellite data, the Broken Plateau coincides with the southern edge of a wedge of high surface eddy kinetic energy (EKE) apparently emanating from the western coast of Australia (e.g. Jia et al., 2011) [Jia2011]. Regions with high vertical kinetic energy (VKE) derived from our LADCP data do not seem to propagate southern of the Broken Plateau consistent with the results by Jia et al., 2011 [Jia2011]. The west coast of Australia is an upwelling zone, which results in baroclinically unstable conditions, making it potentially the source for the high EKE emanating from the Australian coast. Menezes et al., 2014 [Menzenes2014] also emphasize three separate eastward “jets” near the surface in the Wharton Sea and the SADCP velocities near the surface seem quite consistent with this inference. Based on solely the data from the present cruise, we cannot determine whether the northwestward flow along the southern flank of the Broken Plateau is part of the mean circulation or a transitory feature.

The vertical shear of the horizontal velocity, buoyancy frequency and the local Richardson number for the upper 300m are shown in *ladcp-figure* and *ladcp-figure*. The buoyancy frequency was derived using temperature and salinity data from the CTD and the Thermodynamic Equation of Seawater - 2010 (TEOS-10: https://github.com/TEOS-10/python-gsw) package.

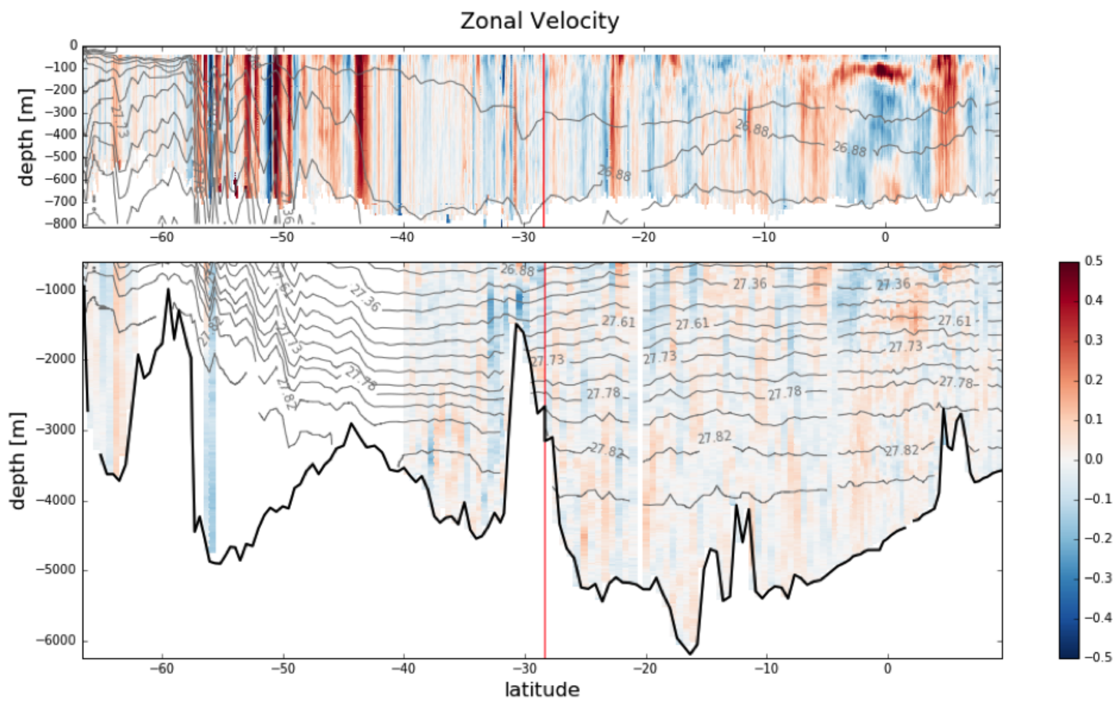


Fig. 19.1: Zonal velocity [m/s] acquired from the LADCP (upper panel SADCP, lower panel LADCP). The potential density contours (grey solid lines), topography (black solid line) and the intersection of the two cruise legs (red solid line) are shown. Due to instrument problems and data quality issues, LADCP data are masked out on stations 14-59.

The Richardson number was defined as:

$$R_i = N^2/(du/dz)^2 + (dv/dz)^2$$

and the vertical resolution of the Richardson number was restricted by the SADCP data with vertical scales of 10m. The Richardson number is an indicator of how susceptible the water column is to shear instability. It is interesting that we see low values right around the equator, due to the large vertical shear of horizontal velocities. The ACC region also has low values due to small buoyancy frequency. We also show the mixed-layer depth (MLD) which was derived as the depth at which the potential density exceeded by 0.1 kg/m3 from the surface value following Fernández-Castro et al., 2014 [Fernández2014]. As expected the MLD is deep in the ACC region, agreeing quite well with the MLD provided by Dong et al., 2008 [Dong2008], and shallows up towards the equator.

Post-cruise processing and additional QC will be conducted at LDEO. At that point it will be determined which profiles are of sufficient quality for inclusion in the final CLIVAR ADCP archives.

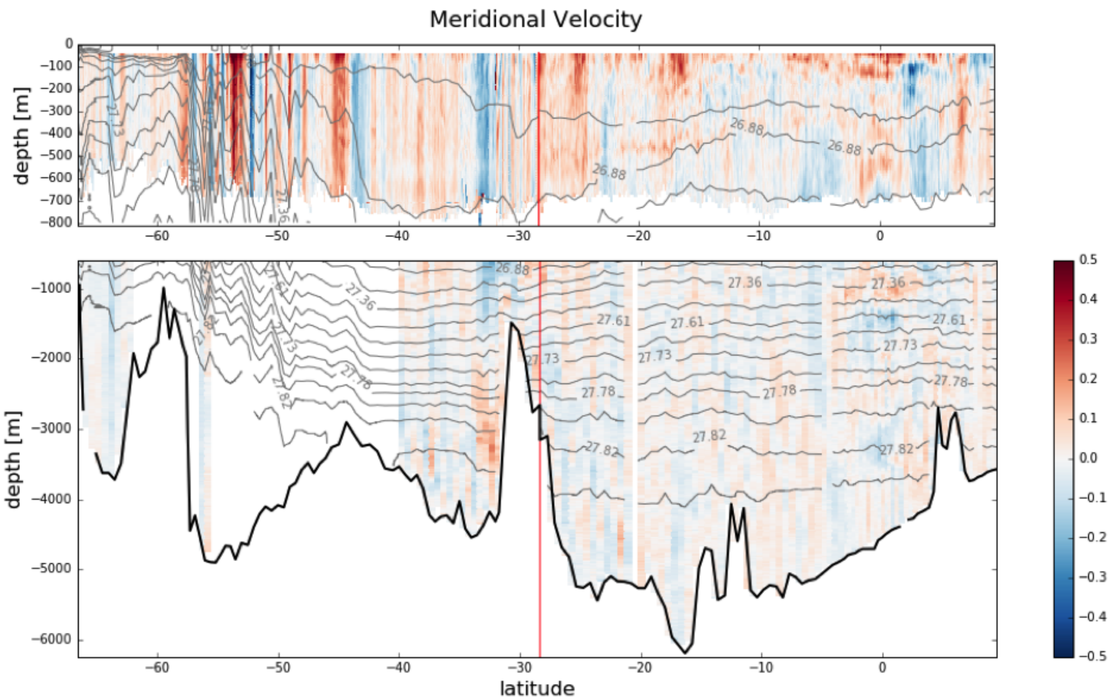


Fig. 19.2: Meridional velocity [m/s] acquired from the ADCP (upper panel SADCP, lower panel LADCP). The potential density contours (grey solid lines), topography (black solid line) and the intersection of the two cruise legs (red solid line) are shown. Due to instrument problems and data quality issues, LADCP data are masked out on stations 14-59.

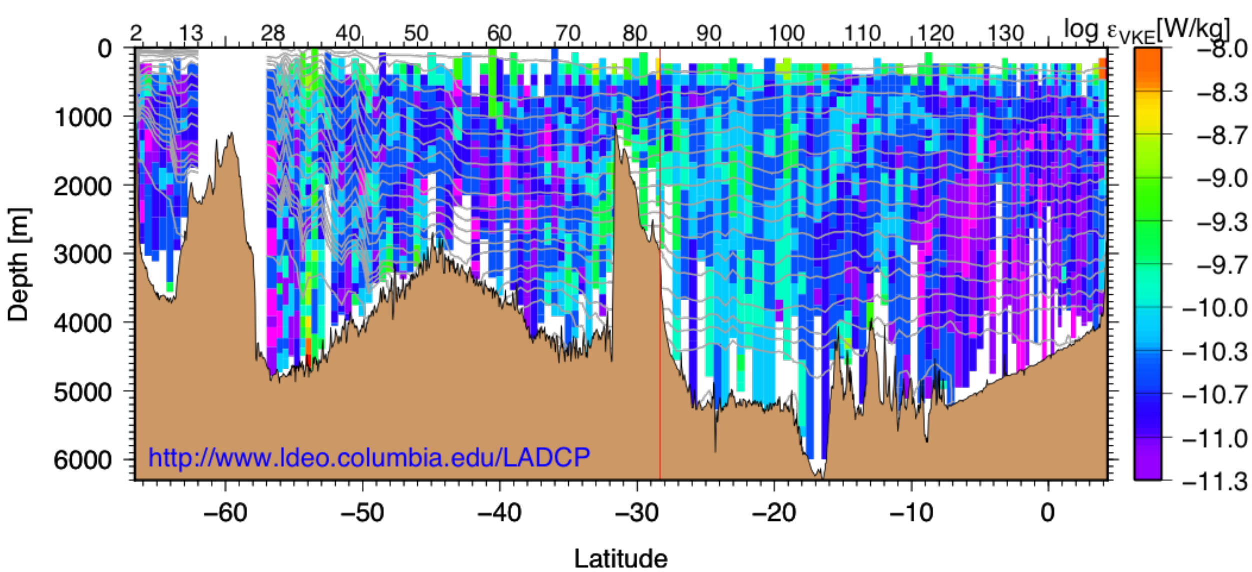


Fig. 19.3: LADCP-derived turbulence levels (W/kg) from vertical velocity measurements, using a novel finestructure parameterization method (Thurnherr et al., GRL 2015), which yields unbiased results at latitudes of 10 degrees and higher but overestimates turbulence levels close to the equator. Grey contours show equally spaced neutral surfaces. The red vertical line separates the two cruise legs.

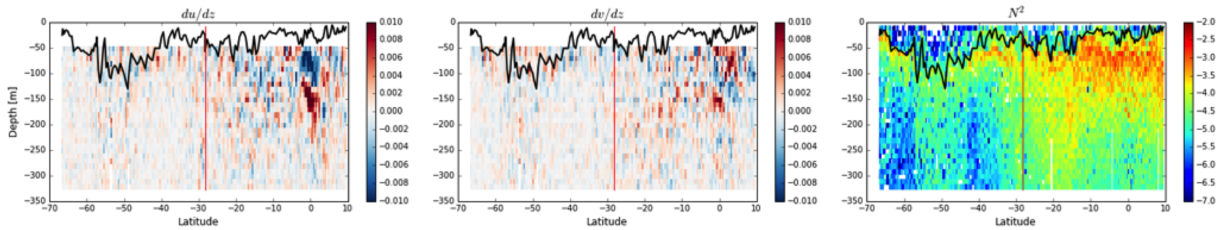


Fig. 19.4: Figure 4. Vertical shear of the zonal velocity (left), meridional velocity (middle) from the SADCP and buoyancy frequency in log10 scale from CTD (right). The black line shows the MLD and the red vertical line separates the two cruise legs. The top 40 meters of velocity has been masked out due to low data quality.

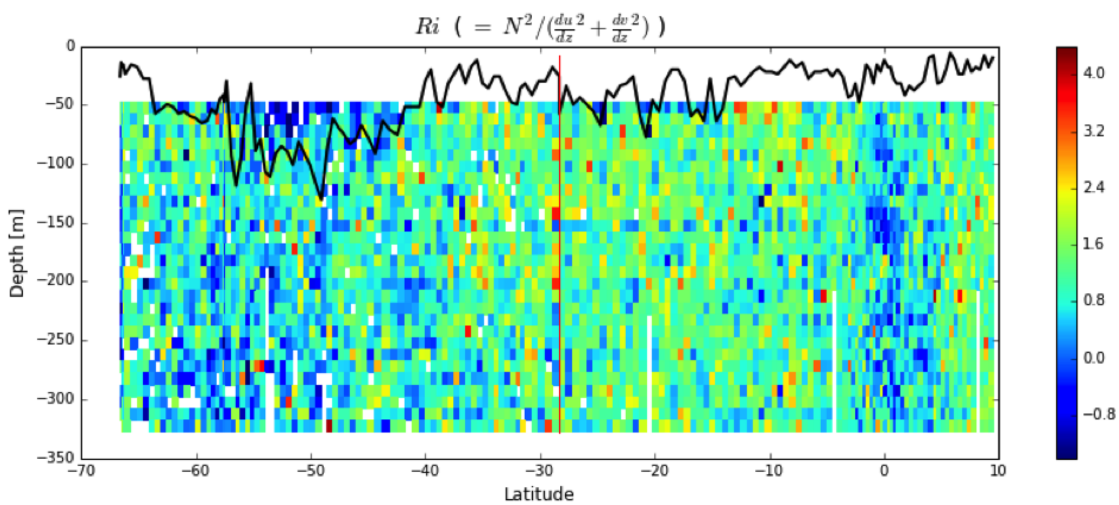


Fig. 19.5: Richardson number in log10 scale. The black line shows the MLD and the red vertical line separates the two cruise legs. The top 40 meters has been masked out due to low quality of velocity data.

CHAPTER TWENTY

CHIPODS

PI Jonathan Nash

Cruise Participant Karina Khazmutdinova

20.1 Overview

Chipods are independent, internally-recording devices that measure the dissipation rate of temperature variance (chi) from a shipboard CTD. From this, the turbulent diffusivity of heat (K) is computed, which is an important quantity for quantifying vertical mixing in the ocean. Chipods are self-contained, robust and record temperature and derivative signals from FP07 thermistors at 100 Hz; they also record sensor motion at the same sampling rate. Details of the measurement and our methods for processing chi can be found in Moum and Nash [2009] (Moum, J., and J. Nash, Mixing Measurements on an Equatorial Ocean Mooring, Journal of Atmospheric and Oceanic Technology, 26(2), 317–336, 2009). In an effort to expand our global coverage of deep ocean turbulence measurements, the ocean mixing group at Oregon State University has supported chipod measurements on all of the major global repeat hydrography cruises since Dec 2013.

20.2 System Configuration and Sampling

Three chipods were mounted on the rosette to measure temperature (T), its time derivative (dT/dt), and x and z (horizontal and vertical) accelerations at a sampling rate of 100 Hz. Two chipods were oriented such that their sensors pointed upward (Chipod Figure A). The third one was pointed downwards (Chipod Figure B). Chipod pressure cases, containing the logger board and batteries, are showed on Chipod Figure C.

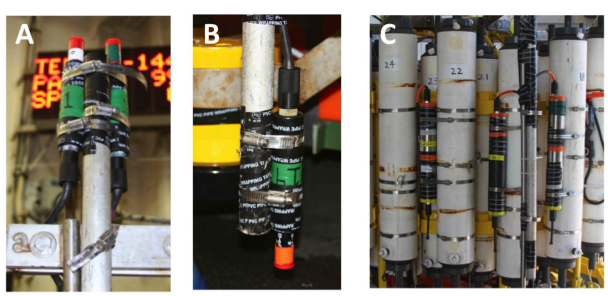


Fig. 20.1: Chipod Figure A, B and C

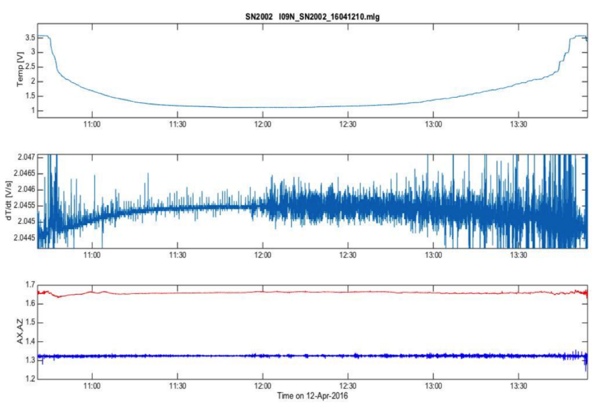
The up-looking sensors were positioned higher than the Niskin bottles on the rosette in order to avoid measuring turbulence generated by flow around the rosette and/or its wake while its profiling speed oscillates as a result of swell-induced ship-heave. The down-looking sensors were positioned as far from the frame as possible and as close to the leading edge of the rosette during descent as possible to avoid measuring turbulence generated by the rosette frame and lowered ADCP.

Below is a table describing the chipod configuration used, along with the component's serial numbers. Several replacements were made during the cruise. Memory cards were replaced in pressure case SN2009 and SN1013. Temperature sensor 13-05D on pressure case SN2002 was replaced with sensor 10-06D on station 111, likely because the sensor bead of 13-05D developed a crack/leak.

Logger Board	Pressure	Sensor	Sensor	Up/Down	Cast Used
SN	Case SN	SN	Holder SN	Looker	
2002	Ti44-12	13-05D 10-06D	14 14	Down Down	084-110 111-196
2009	Ti44-12	11-25D	10	Up	084-196
1003	Ti44-11	14-34D	15	Up	084-196

20.3 Data

Chipods were quite independent, and easy to manage during the cruise. Chipods were turned on by connecting the sensors to the pressure cases in the beginning of the cruise and were continuously taking measurements for 39 days. Data was uploaded every three-four days to check if the sensors are functioning properly. The figure below shows typical cast measurements from a down-looking sensor.



20.4 Chipod issues: Mini-logger freezing when downloading data

Occasionally the mini-logger software used to download data from chipods froze while downloading the data. As a result, the downloaded data from the casts would look gibberish, unphysical. Apparently this is a known problem and that the recorded data has been properly logged and can be covered once the units have been shipped back to Oregon. If one or two files could not be downloaded, the units would be power-cycled and the chipod would continue recording and the next files would look normal.

CHAPTER

TWENTYONE

ARGO FLOAT DEPLOYMENTS

PI Greg Johnson (UW, PMEL)

21.1 Overview

Eight Argo profiling CTD floats were deployed during this cruise at the request of the University of Washington and NOAA's Pacific Marine Environmental Laboratory (PMEL). These floats are part of the Argo array, a global network of over 3000 profiling floats. The floats are designed to sink to a depth of 1000m. They then drift freely at depth for ten days, before sinking to 2000m and then immediately rising to the surface, collecting CTD data as they rise. Conductivity (salinity), temperature, and pressure are measured and recorded at various levels during each float ascent. At the surface, before the next dive begins, the acquired data is transmitted to shore via satellite, along with a location estimate taken while the float sits at the surface. The typical lifetime of the floats in the water is about four years. All Argo float data is made publicly available on the web in real-time at http://www.usgodae.org/argo/argo.html.

When in position, each float was launched by carefully lowering it into the water using a hand-held line strung through the deployment collar. Deployments were done after the completion of the CTD station nearest to the requested deployment location, immediately after the ship had turned, and begun its course to the next station and had reached a speed of approximately one knot. All eight floats were deployed successfully. An e-mail report was sent to UW and PMEL, to report the float ID number, exact float deployment time, location, and deployer's name(s). The following table shows the location of each Argo Float deployment made on GO-SHIP I09N.

No	Float ID	I09N stn	Latitude	Longitude	Date and time (UTC)	Deployers
1	UW 9758	85	-27.71°	95° E	3/25/16 13:05	Matt Durham & Cathy Garcia
2	UW 9737	90	-24.73°	95° E	3/27/16 01:00	Ted Cummiskey & Chawalit Charoenpong
3	UW 9768	98	-20.20°	95° E	3/29/16 13:30	Matt Durham & Patrick Mears
4	PMEL 0597	105	-16.27°	95° E	3/31/16 15:49	Matt Durham & Leticia Barbero
5	UW 9763	107	-15.17°	95° E	4/1/16 04:53	Ted Cummiskey & Amanda Fay
6	PMEL 0593	118	-9.28°	95° E	4/4/16 13:30	Matt Durham & Karina Khazmutdinova
7	PMEL 0591	132	-2.51°	94.24° E	4/8/16 17:45	Ted Cummiskey & David Cervantes
8	PMEL 0598	148	2.60°	91.89° E	4/12/16 19:54	Ted Cummiskey & Stephanie Mumma

Note: Table: Summary of the deployment time and locations of each float.

CHAPTER TWENTYTWO

STUDENT STATEMENTS

22.1 Chawalit Charoenpong

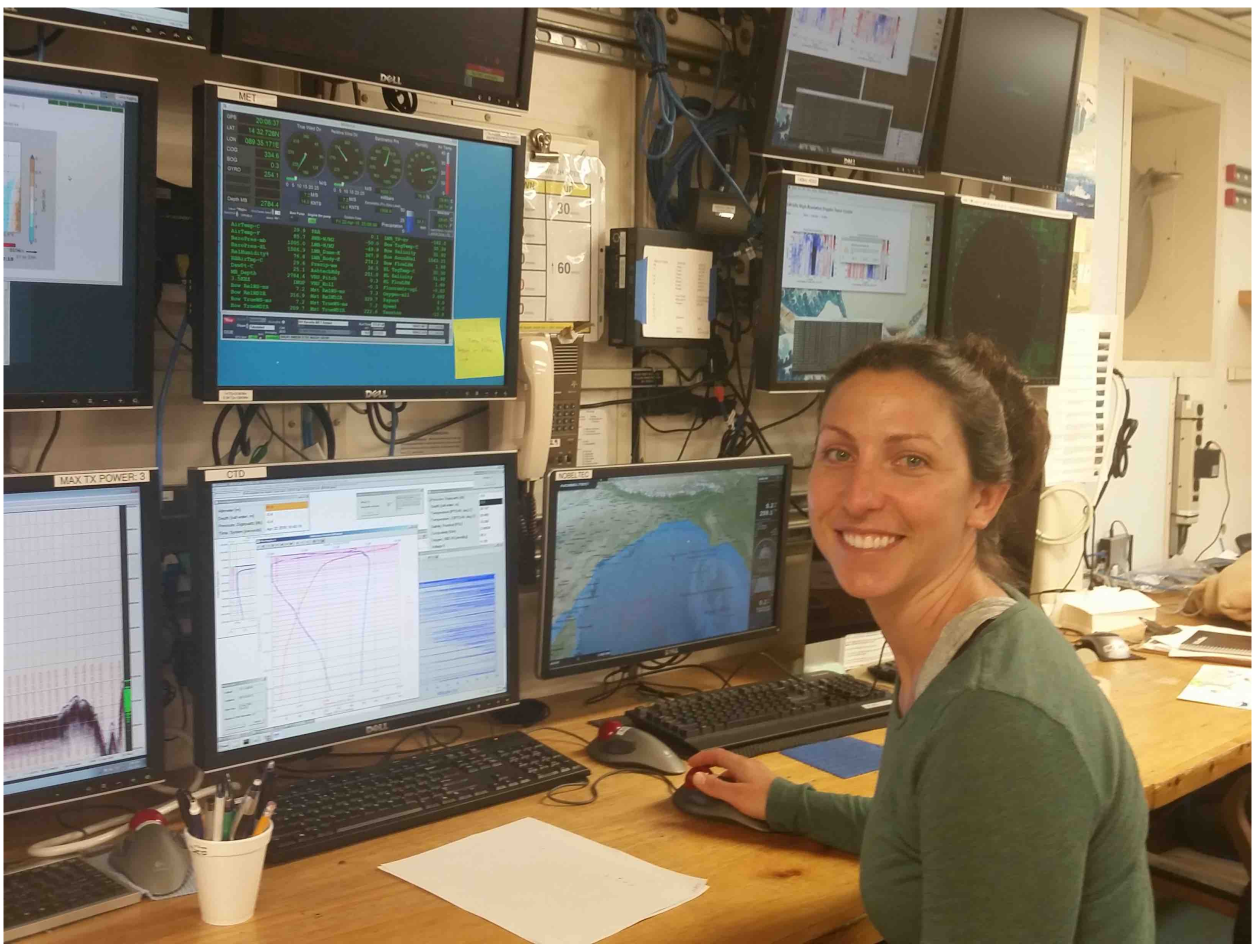
I09N has been a fantastic 40-day cruise for me! I have been in several oceanographic cruises in the past but this is the first time as a CTD watch-stander. This experience has given me a great appreciation for those who work tirelessly to ensure that the science party gets the water from the right depths and things are kept in order during sampling. Preparing the rosette before deployment may look like an easy task but it is essential to the success in water sample collection. Also, I had a chance to help out with the sampling for several parameters including salinity, radiocarbon, alkalinity and DIC. The 12-hour shifts from midnight to noon sounded long but time really flew by as things were constantly happening.

I also have my own project on this cruise as I sample for the isotopic composition of multiple nitrogen species in the Nitrate δ15N and δ18N Sampling section of this report. Doing this on top of the CTD duty was challenging but I managed it through a lot of help and encouragement from my fellow CTD watch-stander and others. Our two co-chief scientists have been fantastic in accommodating this sampling and sharing my excitement throughout the cruise.

One other aspect that I enjoyed tremendously on this cruise was the interaction I had with fellow scientists. I have learned so much from talking with them and seeing how different analyses were carried out on board. In collaboration with scientists from University of California, Irvine and Bigelow Laboratory for Ocean Sciences, I initiated three small projects that we carried out together to: (1) Look at the isotopic ratios and stoichiometry of suspended particles from different size fractions from the underway seawater system and in water samples collected from the Niskin bottles. (2) Quantify the relative gene abundance of the anaerobic ammonium oxidizing bacteria (anammox) in the Bay of Bengal oxygen minimum zone (OMZ). (3) Look at the microbial community residing in the deep chlorophyll maxima (DCM) through metagenomics.

Finally, I would like to thank Leticia Barbero for accepting my application to participate on this cruise and making my sample collection for nitrogen biogeochemistry possible. I look forward to being involved in the future GO-SHIP campaigns!

22.2 Amanda Fay



What an incredible 5 weeks aboard the *R/V Revelle*! This was my second GO-SHIP cruise experience, this time serving as a CTD-watchstander on the I09N cruise from Fremantle, Australia to Phuket, Thailand. The experience gained from my last cruise definitely aided in making the transition to ship-life smoother, and the calm seas were much appreciated by all onboard. Working with the Cast6 winch was a new experience, but the expertise and abilities of our wonderful restechs and winch handlers made things go efficiently. As a CTD-watchstander I spent much of my time in the computer lab, monitoring the instruments on the rosette during the downcast, and firing the Niskin bottles on the upcast. My co-watchstander and I spent many hours googling watermasses and sharing papers and textbooks in order to learn about the circulation patterns we were seeing as we transited north through this dynamic region (what's that blip at 230db from? Why does the oxygen level increase right above the seafloor?). His expertise in nitrogen cycling was an asset and I learned much from him during our time at the computer.

Once the rosette was back onboard, our work moved outside. My tasks alternated between sampling for alkalinity and/or salinity, and serving as sample cop, as well as the music coordinator for our midnight to noon shift. The camaraderie and teamwork displayed during sampling was impressive. Everyone pitched in to make the process quick and smooth, especially when breakfast time approached. Samplers would often stay longer to help with salinity, and our chief and co-chief were consistently outside, always willing to lend a hand with samples. Prepping the rosette for deployment was probably my least favorite task, but as time went on and our callouses grew thicker, the strains on our fingers and arms subsided as we increased out proficiency at getting all the bottles cocked and ready to go.

Another task I took on during the cruise was to download daily updates of weather maps in order to keep the crew abreast of what ocean conditions would be like over the upcoming days. I updated a script initially produced by the CTD-watchstanders on I08S, to accommodate our more northern cruise track and schedule of stations. We enjoyed watching the storms pass ahead and behind our track, and also marveled at a prominent cyclone developing in the western part of the basin. Turns out, it was the strongest tropical cyclone ever on record in the Indian Ocean, Tropical cycle Fantala, with winds exceeding 175 mph. The category 4/5 storm persisted for over a week, fueled by above average sea surface temperatures in the area. We all were thankful that our cruise track did not put us anywhere near that dangerous storm.

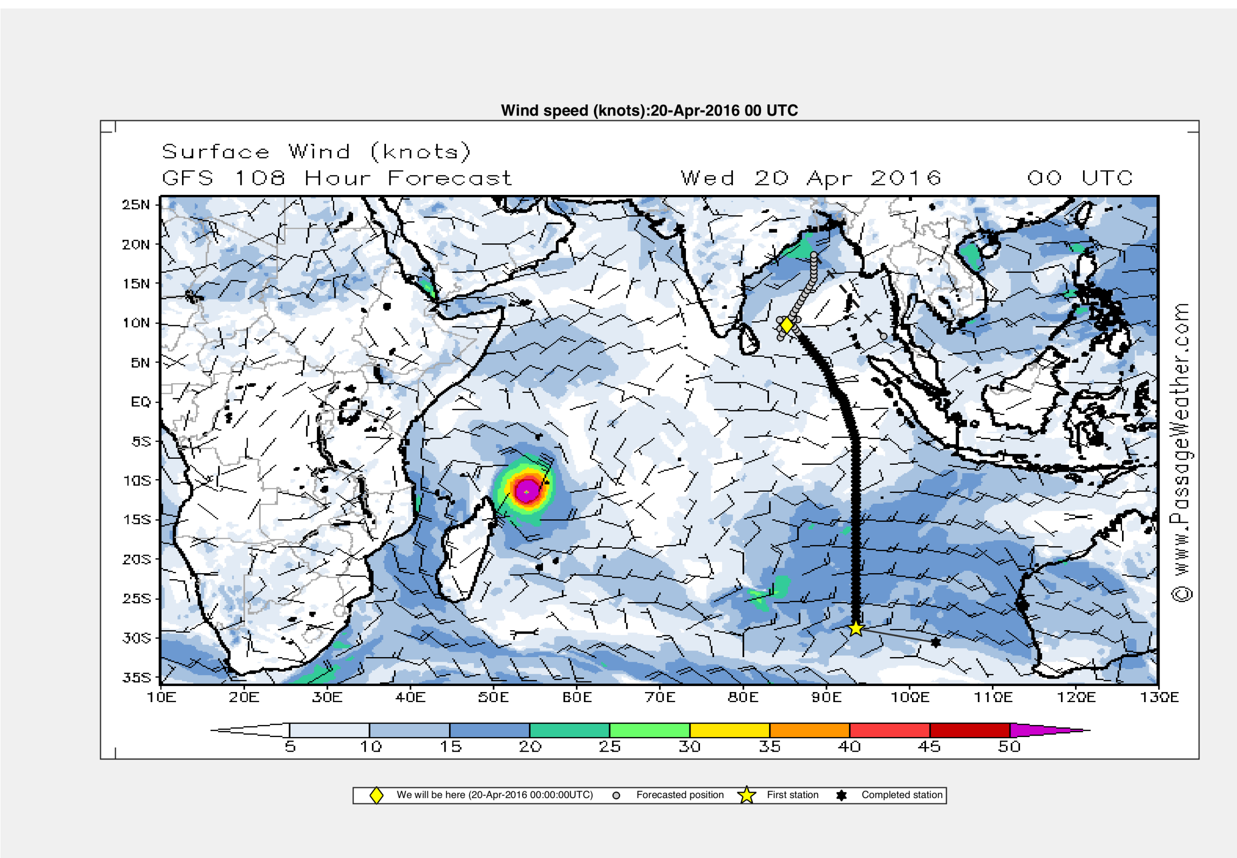


Fig. 22.1: Tropical cyclone fantala, wind speed.

Outside of my watchstander duties, I maintained a blog on my personal website as an outreach project (fayamanda.weebly.com). Many of my friends are elementary and middle school science teachers. Their classes followed

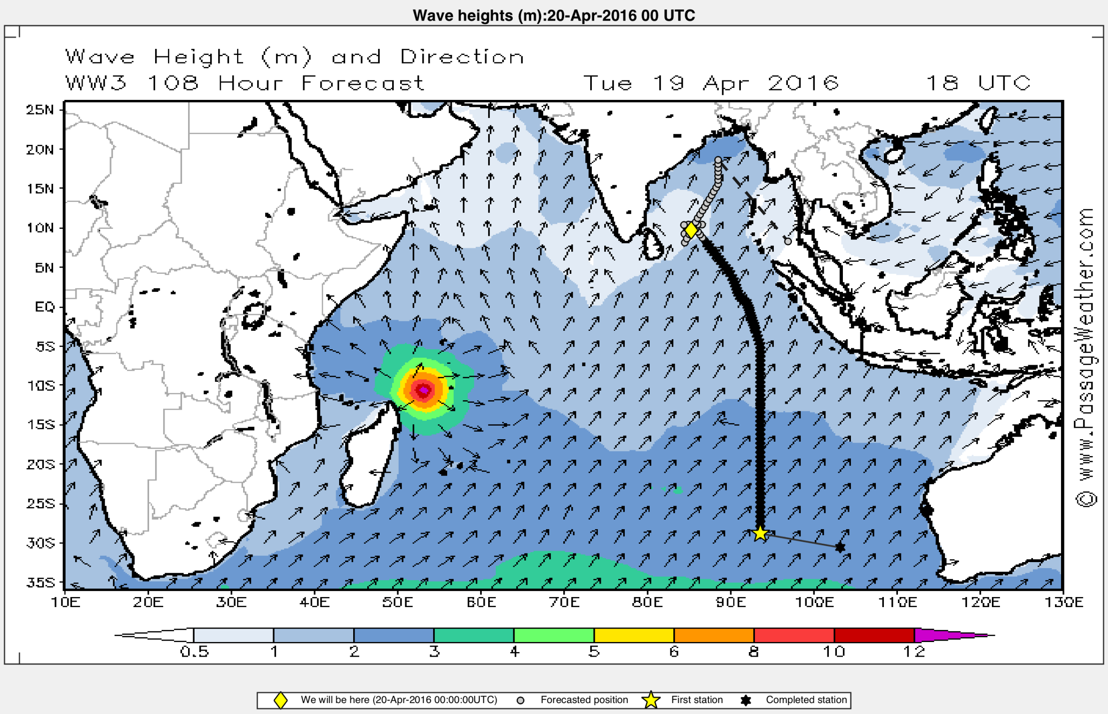


Fig. 22.2: Tropical cyclone fantala, wave height.

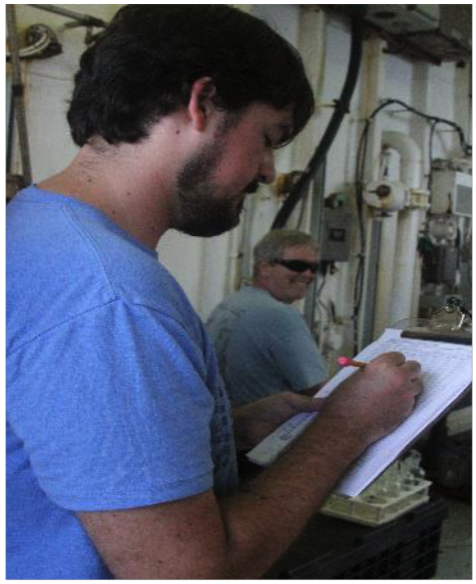
along during our adventures and when I return, I plan to go present in their classrooms, answering questions and encouraging the students to consider the broad spectrum of potential areas of study in the earth sciences.

I was lucky enough to share my CTD-watch shift with a Thai national, currently working on his PhD at WHOI. This offered me the chance to learn and practice Thai phrases and hear about the history and customs of the Thai people. What a great addition to the cruise! I think everyone would agree that the relationships built onboard are the highlights of the cruise and something I will cherish for years to come.

22.3 Karina Khazmutdinova

As CTD-watchers, Patrick and I were in charge of preparing the rosette and making sure it will come back with all the Niskin bottles full of water for samplers. In the beginning of the cruise we had to switch around a few oxygen sensors and I became a master of redoing hose clumps and zip tides. Most of our shifts went smoothly and we got into the CTD-watchers routine pretty quickly. My other duty on the ship was uploading data from the chipods and troubleshooting the problems if chipods data didn't look normal.

Being on board of the RV Revelle has been an amazing experience! Unfortunately, we saw more trash floating in the ocean than the wildlife. However, seeing flying fish playing by the ship was incredible. Star gazing was my favorite thing to do after the shift especially in the Southern hemisphere! We were blessed with calm weather and there were a few days when the ocean was so flat that it was hard to believe that we are in the middle of the Indian Ocean. I truly enjoyed being back at the sea! Had met incredible people, had learned a lot and enjoyed doing the science right at the spot!



22.4 Patrick Mears

My duties as a CTD watch stander primarily included preparing the rosette for deployment, monitoring its decent while recording regions of interest for the samplers, coordinating stops with the winch operator to match specific depths according to a sampling scheme, and coordinating sample collecting once it is on deck and occasionally assisting with sample collection. I also assisted the Research Technician in replacing sensors and conducting minor maintenance on the rosette when needed. In addition to those duties, I was also responsible for setting up the LADCP before each deployment on my watch and downloading the data after each cast.

APPENDIX

A

ABBREVIATIONS

AOML Atlantic Oceanographic and Meteorological Laboratory

AP Particulate Absorbtion Spectra

Bigelow Bigelow Laboratory for Ocean Sciences

CDOM Chromophoric Dissolved Organic Matter

CFCs Chlorofluorocarbons

CTDO Conductivity Temperature Depth Oxygen

DIC Dissolved Inorganic Carbon

DOC Dissolved Organic Carbon

ETHZ Edgenössische Technische Hochschule Zürich

FSU Florida Stats University

HPLC High-Performance Liquid Chromatography

LDEO Lamont-Doherty Earth Observatory - Columbia University

LADCP Lowered Accoustic Doppler Profiler

NOAA National Oceanographic Atmospheric Administration

MBARI Monterey Bay Aquarium Research Institute

ODF Ocean Data Facility

OSU Oregon State University

PMEL Pacific Marine Environmental Laboratory

POC Particulate Organic Carbon

POM Particulate Organic Matter

Princeton Princeton University

RSMAS Rosenstiel School of Marine and Atmospheric Science - UM

SEG Shipboard Electronics Group

SF6 Sulfur Hexafluoride

SIO Scripps Institution of Oceanography

SOCCOM The Southern Ocean Carbon and Climate Observations and Modeling project. http://soccom.princeton.edu/

STS Shipboard Technical Support - SIO

TAMU Texas Agricultural and Mechanical Engineering University

TDN Total Dissolved Nitorgen

U Colorado University of Colorado

UCSB University of California Santa Barbara

UCSD University of California San Diego

UCI University of California Irvine

U. Puerto Rico University of Puerto Rico

UH University of Hawaii

UM University of Miami

UNSW University of New South Wales

UW University of Washington

UWA University of Western Australia

U. Wisconsin University of Wisconson

VUB Vrije Universiteit Brüssel

WHOI Woods Hole Oceanographic Institution

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APPENDIX

B

BOTTLE QUALITY COMMENTS

Station	Cast	Bottle	Param	Code	Comment
100/01	101	ctdDissolved O2	4	cms	CTDDO signal failed after 4480 dbar. Code bad.
100/01	102	ctdDissolved O2	4	cms	CTDDO signal failed after 4480 dbar. Code bad.
100/01	103	ctdDissolved O2	4	cms	CTDDO signal failed after 4480 dbar. Code bad.
100/01	104	ctdDissolved O2	4	cms	CTDDO signal failed after 4480 dbar. Code bad.
100/01	105	ctdDissolved O2	3	cms	CTDDO signal started to fail after 2260 dbar. Code questionable.
100/01	106	ctdDissolved O2	3	cms	CTDDO signal started to fail after 2260 dbar. Code questionable.
100/01	107	ctdDissolved O2	3	cms	CTDDO signal started to fail after 2260 dbar. Code questionable.
100/01	108	ctdDissolved O2	3	cms	CTDDO signal started to fail after 2260 dbar. Code questionable.
100/01	109	ctdDissolved O2	3	cms	CTDDO signal started to fail after 2260 dbar. Code questionable.
100/01	110	ctdDissolved O2	3	cms	CTDDO signal started to fail after 2260 dbar. Code questionable.
100/01	126	Salinity	3	cms	Salinity value low vs CTDT1/CTDT2. Code questionable.
100/01	129	CTD T2 Temperature	3	cms	CTDT2 low vs. SBE35/CTDT1. Code questionable.
100/01	132	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
100/01	132	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
100/01	132	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
100/01	133	CTD T2 Temperature	3	cms	CTDT2 low vs. SBE35/CTDT1. Code questionable.
101/02	201	ctdDissolved O2	4	cms	Signal failed after 4150. Code bad.
101/02	202	ctdDissolved O2	4	cms	Signal failed after 4150. Code bad.
101/02	203	ctdDissolved O2	4	cms	Signal failed after 4150. Code bad.
101/02	204	ctdDissolved O2	4	cms	Signal failed after 4150. Code bad.
101/02	205	ctdDissolved O2	4	cms	Signal failed after 4150. Code bad.
101/02	206	ctdDissolved O2	3	cms	Signal started to fail after 3000 dbar. Code questionable.
101/02	207	ctdDissolved O2	3	cms	Signal started to fail after 3000 dbar. Code questionable.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
101/02	208	ctdDissolved O2	3	cms	Signal started to fail after 3000 dbar. Code questionable.
101/02	209	ctdDissolved O2	3	cms	Signal started to fail after 3000 dbar. Code questionable.
101/02	211	Salinity	4	cms	Salinity value high for this part of density profile and water column. Code bad.
101/02	227	Salinity	3	cms	Salinity value low vs CTDT1/CTDT2. High gradient. Code questionable.
101/02	231	Salinity	3	cms	Salinity value low vs CTDT1/CTDT2. High gradient. Code questionable.
101/02	233	ctdc2	3	cms	CTDC2 value low vs Salinity/CTDC1. Code questionable.
102/01	101	ctdDissolved O2	4	cms	Signal failed after 4950 dbar. Code bad.
102/01	102	ctdDissolved O2	4	cms	Signal failed after 4950 dbar. Code bad.
102/01	103	ctdDissolved O2	4	cms	Signal failed after 4950 dbar. Code bad.
102/01	104	ctdDissolved O2	3	cms	Signal started to fail after 4100 dbar. Code questionable.
102/01	105	ctdDissolved O2	3	cms	Signal started to fail after 4100 dbar. Code questionable.
102/01	106	ctdDissolved O2	3	cms	Signal started to fail after 4100 dbar. Code questionable.
102/01	101	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	102	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	103	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	104	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	105	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	106	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	107	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	108	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	109	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	110	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	111	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	112	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	113	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	114	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	115	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	116	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	117	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	118	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	119	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	120	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	121	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	122	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	123	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	124	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	125	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	126	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	127	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	128	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
102/01	129	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	130	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	131	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	132	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	133	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	134	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	135	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	136	CTD T2 Temperature	4	cms	CTDC2 sensor failed at Bottletom of cast.
102/01	134	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
102/01	134	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
102/01	134	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
103/01	101	ctdDissolved O2	4	cms	Signal failed after 4750 dbar. Code bad.
103/01	102	ctdDissolved O2	4	cms	Signal failed after 4750 dbar. Code bad.
103/01	103	ctdDissolved O2	4	cms	Signal failed after 4750 dbar. Code bad.
103/01	104	ctdDissolved O2	3	cms	Signal starts to fail after 4210 dbar. Code questionable.
103/01	105	ctdDissolved O2	3	cms	Signal starts to fail after 4210 dbar. Code questionable.
103/01	115	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Likely not equilibrated. code bad.
103/01	124	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
103/01	125	CTD T2 Temperature	3	cms	Unstable values in all three temperature sensors. Code questionable.
103/01	125	CTD T1 Temperature	3	cms	Unstable values in all three temperature sensors. Code questionable.
103/01	125	Reference T	3	cms	Unstable values in all three temperature sensors. Code questionable.
103/01	125	Salinity	3	cms	Salinity value high vs CTDC1/CTDC2. High gradient. Code questionable.
103/01	127	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. High gradient. Likely not equilibrated. code bad.
103/01	129	Salinity	3	cms	Salinity value high vs CTDC1/CTDC2. High gradient. Code questionable.
103/01	129	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
103/01	130	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
104/01	101	ctdDissolved O2	4	cms	Signal failed after 5000 dbar. Code bad.
104/01	102	ctdDissolved O2	4	cms	Signal failed after 5000 dbar. Code bad.
104/01	103	ctdDissolved O2	4	cms	Signal failed after 5000 dbar. Code bad.
104/01	104	ctdDissolved O2	4	cms	Signal failed after 5000 dbar. Code bad.
104/01	105	ctdDissolved O2	3	cms	Signal starts to fail after 3900 dbar. Code questionable.
104/01	106	ctdDissolved O2	3	cms	Signal starts to fail after 3900 dbar. Code questionable.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
104/01	107	ctdDissolved O2	3	cms	Signal starts to fail after 3900 dbar. Code questionable.
104/01	111	Bottle	4	slog	Mistrip
104/01	111	Salinity	3	slog	Mistrip
104/01	111	Dissolved O2	3	slog	Mistrip
104/01	111	PhospHate	3	slog	Mistrip
104/01	111	Silicate	3	slog	Mistrip
104/01	111	Nitrate	3	slog	Mistrip
104/01	111	nDissolved O2	3	slog	Mistrip
104/01	125	Bottle	5	slog	Did not fire.
104/01	129	Dissolved O2	2	cms	Bottle value matches up-cast. Not used in fit. Code good.
104/01	128	Salinity	3	cms	Salinity value low vs CTDC1/CTDC2. Feature; code questionable.
104/01	130	CTD T2 Temperature	3	cms	CTDT2 value low vs SBE35/CTDT1. Code questionable.
105/01	111	Salinity	4	cms	Salinity value is high for this part of profile. Does not match density profile. Code bad.
105/01	112	Dissolved O2	4	cms	Bottle value is high for profile and adjacent casts. No supporting feature in Dissolved O2 or other parameters. Code bad. Trip issue with carousel.
105/01	127	Salinity	3	cms	Hold for calib. Salinity value matches up-cast Code good.
105/01	122	Bottle	2	slog	Brown spot on spigot.
105/01	131	CTD T2 Temperature	3	cms	CTDT2 value low vs SBE35/CTDT1. Code questionable.
106/01	117	CTD T2 Temperature	3	cms	CTDT2 value high vs SBE35/CTDT1. Code questionable.
106/01	126	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
106/01	126	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
106/01	126	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
106/01	127	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. code bad.
106/01	130	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Likely not equilibrated. code bad.
106/01	130	Salinity	3	cms	Unstable values in salinity/CTDC1/CTDC2. Code questionable.
106/01	130	ctdc1	3	cms	Unstable values in salinity/CTDC1/CTDC2. Code questionable.
106/01	130	ctdc2	3	cms	Unstable values in salinity/CTDC1/CTDC2. Code questionable.
106/01	133	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
106/01	133	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
106/01	133	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
107/01	111	CTD T1 Temperature	3	cms	CTDT1 value low vs SBE35/CTDT2. code questionable.
107/01	115	CTD T1 Temperature	3	cms	CTDT1 value high vs SBE35/CTDT2. code questionable.
107/01	126	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
107/01	126	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
107/01	126	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
107/01	127	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
107/01	129	CTD T1 Temperature	3	cms	CTDT1 value low vs SBE35/CTDT2. code questionable.
107/01	131	CTD T2 Temperature	3	cms	CTDT2 value low vs SBE35/CTDT1. code questionable.
107/01	132	CTD T2 Temperature	3	cms	CTDT2 value low vs SBE35/CTDT1. code questionable.
108/02	227	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
108/02	230	CTD T2 Temperature	3	cms	CTDT2 value high vs SBE35/CTDT1. code questionable.
109/01	102	Bottle	3	slog	Bottle not sealed.
109/01	121	Dissolved O2	4	cms	Bottle value does not match profile or adjacent casts. No supporting feature in Dissolved O2 or other parameters. Code bad.
109/01	130	CTD T2 Temperature	3	cms	CTDT2 value high vs SBE35/CTDT1. Code questionable.
109/01	133	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
109/01	133	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
109/01	133	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
110/01	105	Salinity	4	cms	Salinity value high for this part of the cast. Does not match density profile. code bad.
110/01	108	CTD T1 Temperature	3	cms	CTDT1 value low vs SBE35/CTDT2. Code questionable.
110/01	109	CTD T2 Temperature	3	cms	CTDT2 value low vs SBE35/CTDT1. Code questionable.
110/01	124	CTD T2 Temperature	3	cms	CTDT2 value low vs SBE35/CTDT1. Code questionable.
110/01	126	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
110/01	126	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
110/01	126	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
110/01	128	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Likely not equilibrated. code bad.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
110/01	129	CTD T1 Temperature	3	cms	CTDT1 value low vs SBE35/CTDT2. Code questionable.
110/01	130	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
110/01	130	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
110/01	130	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
111/01	126	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
111/01	126	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
111/01	126	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
111/01	126	Dissolved O2	2	cms	Bottle va;ue matches up-cast feature. Code good.
111/01	132	Salinity	3	cms	High variation at surface. Unstable density profile and mismatch. Code questionable.
111/01	133	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
111/01	133	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
111/01	133	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
112/01	134	Dissolved O2	4	cms	Bottle value high for profile and adjacent casts. Code bad.
112/01	133	Dissolved O2	3	cms	Bottle value matches up=cast. Code good.
112/01	101	Salinity	4	cms	Salinity value is low vs CTDC2 and density profile. code bad.
112/01	101	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	102	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	103	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	104	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	105	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	106	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	107	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	108	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	109	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	110	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	111	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	112	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	113	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	114	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	115	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	116	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	117	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	118	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	119	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	120	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	121	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
112/01	122	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	123	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	124	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	125	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	126	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	127	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	128	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	129	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	130	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	131	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	132	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	133	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	134	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	135	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	136	ctdc1	4	cms	Sensor failed on 1000m down-cast. Code bad.
112/01	133	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Likely not equilibrated. code bad.
112/01	135	CTD T1 Temperature	3	cms	CTDT1 value high vs SBE35/CTDT2. Code questionable.
112/01	136	Bottle	2	slog	Bottle accidentally sampled first. All gasses sampled 35 first.
113/01	110	CTD T1 Temperature	3	cms	CTDT1 value low vs SBE35/CTDT2. Code questionable.
113/01	126	CTD T1 Temperature	3	cms	CTDT1 value low vs SBE35/CTDT2. Code questionable.
113/01	130	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. High gradient. Sensor likely not equilibrated. Code bad.
113/01	131	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. High gradient. Sensor likely not equilibrated. Code bad.
113/01	133	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. High gradient. Sensor likely not equilibrated. Code bad.
113/01	133	ctdc2	3	cms	CTDC2 value high vs Salinity/CTDC1. Code questionable.
114/02	221	CTD T1 Temperature	3	cms	CTDT1 value low vs SBE35/CTDT2. Code questionable.
114/02	227	Salinity	4	cms	Unusually high shallow salinity value. Does not match density profile.
114/02	231	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. High gradient. Sensor likely not equilibrated. Code bad.
115/03	304	Salinity	4	cms	Salinity value high vs CTDC1/CTDC2 and density profile. Value better matches Bottletle 6. Possibly mis-sampled. Code bad.
115/03	304	ctdc1	3	cms	CTDC1 value low vs Salinity/CTDC2. Code questionable.
115/03	332	Reference T	4	cms	SBE35 value is high vs CTDT1/CTDT2. High gradient. Sensor likely not equilibrated. Code bad.
115/03	333	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. Code questionable.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
115/03	333	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. Code questionable.
115/03	333	Reference T	3	cms	Unstable temperatures in all three sensors. Code questionable.
115/03	334	CTD T2 Temperature	3	cms	CTDT2 value is low vs CTDT1/SBE35. Code questionable.
115/03	335	CTD T2 Temperature	3	cms	CTDT2 value is low vs CTDT1/SBE35. Code questionable.
115/03	336	Bottle	3	slog	Bottle vent not closed.
116/01	105	Salinity	4	cms	Salinity value is low for this part of the cast and density profile. Code bad.
116/01	125	Bottle	2	cms	Stop cocks found pushed in when CFCs began sampling. No leaks.
116/01	126	Bottle	2	cms	Stop cocks found pushed in when CFCs began sampling. No leaks.
116/01	128	CTD T2 Temperature	3	cms	CTDT2 value is low vs CTDT1/SBE35. Code questionable.
116/01	129	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. Code questionable.
116/01	129	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. Code questionable.
116/01	129	Reference T	3	cms	Unstable temperatures in all three sensors. Code questionable.
116/01	130	Reference T	4	cms	SBE35 value is high vs CTDT1/CTDT2. High gradient. Sensor likely not equilibrated. Code bad.
116/01	131	CTD T2 Temperature	3	cms	CTDT2 value is high vs CTDT1/SBE35. Code questionable.
117/01	108	Salinity	4	cms	Salinity value high for this part of profile. Value better matches 109. Possibly mis-sampled.
117/01	110	Salinity	4	cms	Salinity value low for this part of profile. Value better matches 109. Possibly mis-sampled.
117/01	116	Salinity	4	cms	Salinity value low for this part of profile. Value better matches 119. Possibly mis-sampled.
117/01	131	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. code bad.
117/01	132	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
117/01	132	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
117/01	132	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
117/01	133	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
117/01	133	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
117/01	133	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
117/01	134	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
117/01	134	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
117/01	134	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
117/01	135	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
117/01	135	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
117/01	135	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
118/01	101	Salinity	4	cms	Salinity value high vs CTDC1/CTDC2 and density profile. code bad.
118/01	131	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
118/01	131	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
118/01	131	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
118/01	133	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
118/01	133	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
118/01	133	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
118/01	134	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
119/01	101	Salinity	4	cms	Salinity value high vs CTDC1/CTDC2. Does not fit density profile. Code bad.
119/01	123	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
119/01	131	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
119/01	131	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
119/01	131	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
119/01	132	CTD T2 Temperature	3	cms	CTDT2 value high vs SBE35/CTDT1. Code questionable.
119/01	133	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
119/01	133	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
119/01	133	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
119/01	134	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. code bad.
120/02	207	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	208	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	209	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	210	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
120/02	211	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	212	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	213	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	214	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	215	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	207	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
120/02	208	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
120/02	209	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
120/02	210	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
120/02	211	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
120/02	212	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
120/02	213	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
120/02	214	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
120/02	215	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
120/02	207	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	208	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	209	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	210	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	211	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	212	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	213	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	214	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	215	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	207	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	208	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	209	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	210	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	211	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	212	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	213	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	214	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	215	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
120/02	229	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. code questionable.
120/02	230	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
120/02	230	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
120/02	230	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
120/02	231	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
120/02	231	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
120/02	231	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
121/02	201	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	202	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	203	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.

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Station	Cast	Bottle	Param	Code	Comment
121/02	204	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	205	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	206	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	207	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	208	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	209	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	210	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	211	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	212	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	213	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	214	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	215	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	216	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	217	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	218	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	219	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	220	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	212	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
121/02	213	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
121/02	214	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
121/02	215	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
121/02	216	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
121/02	217	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
121/02	212	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	213	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	214	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	215	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	216	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	217	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	212	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
121/02	213	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
121/02	214	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
121/02	215	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
121/02	216	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
121/02	217	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
121/02	212	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
121/02	213	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
121/02	214	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
121/02	215	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
121/02	216	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
121/02	217	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
121/02	220	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	221	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	222	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	223	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	224	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	225	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	226	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	227	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.

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Station	Cast	Bottle	Param	Code	Comment
121/02	228	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	229	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	230	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	231	CTD T1 Temperature	3	cms	CTDT1 value high cs CTDT2/SBE35. Code questionable.
121/02	232	CTD T1 Temperature	3	cms	CTDT1 value high cs CTDT2/SBE35. Code questionable.
121/02	235	CTD T2 Temperature	3	cms	CTDT2 value high cs CTDT1/SBE35. Code questionable.
121/02	231	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	232	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	233	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	234	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	235	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	236	ctdc1	4	cms	C1 failed. Pumps turned off on up-cast only.
121/02	231	CTD T1 Temperature	3	cms	CTDT1 value high cs CTDT2/SBE35. Code questionable.
121/02	231	CTD T1 Temperature	3	cms	CTDT1 value high cs CTDT2/SBE35. Code questionable.
121/02	231	CTD T1 Temperature	3	cms	CTDT1 value high cs CTDT2/SBE35. Code questionable.
121/02	231	CTD T1 Temperature	3	cms	CTDT1 value high cs CTDT2/SBE35. Code questionable.
121/02	231	CTD T1 Temperature	3	cms	CTDT1 value high cs CTDT2/SBE35. Code questionable.
122/01	101	Bottle	4	cms	Mis-trip.
122/01	101	Dissolved O2	3	cms	Mis-trip.
122/01	101	nDissolved O2	3	cms	Mis-trip.
122/01	101	Nitrate	3	cms	Mis-trip.
122/01	101	Silicate	3	cms	Mis-trip.
122/01	101	PhospHate	3	cms	Mis-trip.
122/01	101	Salinity	3	cms	Mis-trip
122/01	107	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	108	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	109	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	110	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	111	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	112	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	113	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	114	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	115	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	116	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	117	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	118	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	119	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	120	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	121	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	122	CTD T1 Temperature	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	107	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
122/01	108	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
122/01	109	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
122/01	110	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
122/01	111	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
122/01	112	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
122/01	113	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
122/01	114	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
122/01	115	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
122/01	116	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
122/01	117	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
122/01	118	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
122/01	119	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
122/01	120	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
122/01	121	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
122/01	122	CTD T2 Temperature	4	cms	C1 failed. Pumps turned off on up-cast only.
122/01	107	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	108	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	109	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	110	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	111	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	112	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	113	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	114	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	115	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	116	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	117	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	118	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	119	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	120	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	121	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	122	ctdc1	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	107	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	108	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	109	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	110	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	111	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	112	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	113	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	114	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	115	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	116	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	117	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	118	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	119	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	120	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	121	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	122	ctdc2	5	cms	C1 failed. Pumps turned off on up-cast only.
122/01	131	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.

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Station	Cast	Bottle	Param	Code	Comment
122/01	131	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
122/01	131	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
122/01	132	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
122/01	132	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
122/01	132	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
122/01	133	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
122/01	133	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
122/01	133	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
122/01	134	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. code good.
123/01	101	ctdc1	3	cms	CTDC1 value low vs CTDC2/Salinity. Code questionable.
123/01	113	Salinity	4	cms	Salinity value low vs CTDC1/CTDC2. Does not agree with density profile. Code bad.
123/01	128	CTD T2 Temperature	3	cms	CTDT2 value low vs SBE35/CTDT1. Code questionable.
123/01	130	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
123/01	130	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
123/01	130	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
123/01	131	CTD T1 Temperature	3	cms	CTDT1 value low vs SBE35/CTDT2. Code questionable.
123/01	131	ctdc2	3	cms	CTDC2 value high vs CTDC1/Salinity. Code questionable.
124/01	130	CTD T1 Temperature	3	cms	CTDT1 value low vs SBE35/CTDT2. Code questionable.
124/01	131	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
124/01	131	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
124/01	131	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
124/01	133	Bottle	3	slog	Vent not closed all the way.
124/01	133	Salinity	3	cms	Salinity value high vs CTDC1/CTDC2. Bottle vent not closed all the way. Possible contamination. Code questionable.
125/01	136	Bottle	5	slog	Bottle did not close.
125/01	132	CTD T2 Temperature	3	cms	CTDT2 value high vs SBE35/CTDT1. Code questionable.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
125/01	133	CTD T2 Temperature	3	cms	CTDT2 value high vs SBE35/CTDT1. Code questionable.
125/01	134	CTD T1 Temperature	3	cms	CTDT1 value high vs SBE35/CTDT2. Code questionable.
125/01	133	ctdc1	3	cms	Unstable values in salinity CTDC1 and CTDC2. Code questionable.
125/01	133	ctdc2	3	cms	Unstable values in salinity CTDC1 and CTDC2. Code questionable.
125/01	133	Salinity	3	cms	Unstable values in salinity CTDC1 and CTDC2. Code questionable.
125/01	134	ctdc1	3	cms	Unstable values in salinity CTDC1 and CTDC2. Code questionable.
125/01	134	ctdc2	3	cms	Unstable values in salinity CTDC1 and CTDC2. Code questionable.
125/01	134	Salinity	3	cms	Unstable values in salinity CTDC1 and CTDC2. Code questionable.
126/01	134	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
126/01	134	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
126/01	134	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
126/01	136	Bottle	5	slog	Bottle not closed.
127/03 127/05	301	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	302	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	303	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	304	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	305	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	306	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	307	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	308	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	309	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	310	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	311	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	312	Bottle	5	slog	Bottle did not fire/close.
127/03 127/05	312	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
127/03 127/05	313	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	314	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	315	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	316	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	317	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	318	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	319	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	320	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	321	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	322	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	323	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	324	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	325	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	326	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	327	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	328	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	329	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	330	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	331	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	332	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	333	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	334	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	335	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	336	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	506	CTD T1 Temperature	3	cms	Unstable values in Bottleh recording temperature sensors. Code questionable.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
127/03 127/05	506	CTD T2 Temperature	3	cms	Unstable values in Bottleh recording temperature sensors. Code questionable.
127/03 127/05	501	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	502	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	503	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	504	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	505	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	506	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	507	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	508	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	509	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	510	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	511	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	512	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	513	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	514	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	515	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	516	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	517	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	518	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	519	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	520	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	521	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	522	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	523	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	524	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
127/03 127/05	525	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	526	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	527	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	528	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	529	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	530	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	531	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	532	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	533	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	534	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	535	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
127/03 127/05	536	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	101	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	102	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	103	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	104	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	105	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	106	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	107	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	108	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	109	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	110	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	111	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	112	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	113	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
128/01	114	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	115	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	116	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	117	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	118	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	119	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	120	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	121	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	122	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	123	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	124	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	125	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	126	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	127	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	128	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	129	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	130	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	131	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	132	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	133	Salinity	3	cms	Unstable values in salinity CTDC1 & CTDC2. Code questionable.
128/01	133	ctdc1	3	cms	Unstable values in salinity CTDC1 & CTDC2. Code questionable.
128/01	133	ctdc2	3	cms	Unstable values in salinity CTDC1 & CTDC2. Code questionable.
128/01	133	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	134	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
128/01	135	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
128/01	136	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	101	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	102	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	103	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	104	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	105	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	106	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	107	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	108	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	109	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	110	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	111	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	112	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	113	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	114	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	115	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	116	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	117	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	118	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	119	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	120	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	121	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	122	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	123	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	124	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
129/01	125	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	126	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	127	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	128	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	129	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	130	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	131	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	132	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	133	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	134	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	135	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
129/01	136	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	212	Bottle	5	slog	Bottle did not fire/trip.
130/02	230	Salinity	3	cms	Unstable values in salinity CTDC1 & CTDC2. Code questionable.
130/02	230	ctdc1	3	cms	Unstable values in salinity CTDC1 & CTDC2. Code questionable.
130/02	230	ctdc2	3	cms	Unstable values in salinity CTDC1 & CTDC2. Code questionable.
130/02	230	CTD T1 Temperature	3	cms	Unstable values in Bottleh working sensors. Code questionable.
130/02	230	CTD T2 Temperature	3	cms	Unstable values in Bottleh working sensors. Code questionable.
130/02	201	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	202	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	203	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	204	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	205	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	206	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	207	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
130/02	208	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	209	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	210	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	211	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	212	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	213	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	214	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	215	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	216	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	217	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	218	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	219	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	220	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	221	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	222	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	223	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	224	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	225	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	226	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	227	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	228	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	229	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	230	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	231	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	232	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
130/02	233	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	234	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	235	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
130/02	236	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	212	Bottle	5	cms	Bottle did not trip/fire. Latch replaced after cast.
131/02	201	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	202	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	203	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	204	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	205	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	206	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	207	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	208	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	209	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	210	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	211	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	212	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	213	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	214	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	215	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	216	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	217	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	218	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	219	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	220	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
131/02	221	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	222	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	223	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	224	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	225	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	226	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	227	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	228	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	229	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	230	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	231	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	232	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	233	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	234	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	235	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
131/02	236	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
132/02	213	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE345. Code questionable.
132/02	229	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
132/02	230	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
132/02	231	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
132/02	232	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
132/02	233	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
132/02	134	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
132/02	235	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.
132/02	236	Reference T	5	cms	Carousel communication problems. Straight cable used in favor of Y-cable. Unable to get sbe35 data.

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Station	Cast	Bottle	Param	Code	Comment
133/01	104	Salinity	4	cms	Salinity value low vs CTDC1/CTDC2. Low vs density for this part of profile./ Code bad.
133/01	109	ctdc1	3	cms	CTDC1 value low vs CTDC2/Salinity.Code questionable.
133/01	112	Bottle	5	cms	Bottle did not fire/trip.
133/01	130	Salinity	3	cms	Unstable values in Salinity CTDC1 & CTDC2. Code questionable.
133/01	130	ctdc1	3	cms	Unstable values in Salinity CTDC1 & CTDC2. Code questionable.
133/01	130	ctdc2	3	cms	Unstable values in Salinity CTDC1 & CTDC2. Code questionable.
133/01	101	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	102	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	103	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	104	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	105	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	106	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	107	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	108	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	109	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	110	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	111	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	112	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	113	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	114	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	115	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	116	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	117	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	118	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	119	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.

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Station	Cast	Bottle	Param	Code	Comment
133/01	120	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	121	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	122	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	123	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	124	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	125	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	126	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	127	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	128	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	129	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	130	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	131	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	132	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	133	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	134	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	135	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
133/01	136	Reference T	5	cms	Y-cable replaced; however sbe35 memory was full and trip data for station 133 was over written.
134/01	103	Salinity	4	cms	Salinity value low vs CTDC1/CTDC2. Low value vs density and better matches Bottletle trip 1. Possible mis-sample.
134/01	109	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
134/01	112	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
134/01	112	Bottle	5	cms	Bottle did not fire/trip. Bottle not used any more after this cast.
134/01	133	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
134/01	133	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
134/01	133	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
134/01	136	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Code bad.

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Station	Cast	Bottle	Param	Code	Comment
135/02	201	ctdc2	3	cms	CTDC2 value low vs CTDC1/Salinity. Code questionable.
135/02	219	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
135/02	219	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
135/02	219	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
135/02	234	Reference T	4	cms	SBE35 value read low vs CTDT1/CTDT2. Code bad.
136/01	114	Bottle	4	cms	mis-trip
136/01	114	Dissolved O2	3	cms	mis-trip
136/01	114	Salinity	3	cms	mis-trip
136/01	114	nDissolved O2	3	cms	mis-trip
136/01	114	Nitrate	3	cms	mis-trip
136/01	114	Silicate	3	cms	mis-trip
136/01	114	PhospHate	3	cms	mis-trip
136/01	116	Bottle	4	cms	mis-trip
136/01	116	Salinity	4	cms	mis-trip
136/01	116	Dissolved O2	3	cms	mis-trip
136/01	116	Nitrate	3	cms	mis-trip
136/01	116	nDissolved O2	3	cms	mis-trip
136/01	116	Silicate	3	cms	mis-trip
136/01	116	PhospHate	3	cms	mis-trip
136/01	119	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
136/01	133	Salinity	3	cms	Hold for calib. Salinity sample matches upcast. Code good.
136/01	134	Salinity	3	cms	Hold for calib. Salinity sample matches upcast. Code good.
137/01	102	Salinity	4	cms	Unstable lab temperatures. Code bad.
137/01	103	Salinity	4	cms	Unstable lab temperatures. Code bad.
137/01	105	Salinity	4	cms	Unstable lab temperatures. Code bad.
137/01	107	Salinity	4	cms	Unstable lab temperatures. Code bad.
137/01	108	CTD T1 Temperature	3	cms	Unstable temperature values in all three sensors. Code questionable.
137/01	108	CTD T2 Temperature	3	cms	Unstable temperature values in all three sensors. Code questionable.
137/01	108	Reference T	3	cms	Unstable temperature values in all three sensors. Code questionable.
137/01	108	Salinity	4	cms	Unstable lab temperatures. Code bad.
137/01	110	Reference T	4	cms	SBE35 reads anomalous value. Sensor wait-time likely not observed. Code bad.
137/01	119	Reference T	3	cms	SBE35 value low vs CTDT1/CTDT2. Code questionable.
137/01	124	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
137/01	125	Reference T	3	cms	Unstable temperature values in all three sensors. Code questionable.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
137/01	125	CTD T1 Temperature	3	cms	Unstable temperature values in all three sensors. Code questionable.
137/01	125	CTD T2 Temperature	3	cms	Unstable temperature values in all three sensors. Code questionable.
137/01	134	Salinity	3	cms	Hold for calib. Salinity matches up-cast. High gradient. Code good.
138/01	107	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
138/01	117	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
138/01	118	Reference T	5	cms	Trip confirmation issues in sbe35. No data recorded for trips 18-36.
138/01	119	Reference T	5	cms	Trip confirmation issues in sbe35. No data recorded for trips 18-36.
138/01	120	Reference T	5	cms	Trip confirmation issues in sbe35. No data recorded for trips 18-36.
138/01	121	Reference T	5	cms	Trip confirmation issues in sbe35. No data recorded for trips 18-36.
138/01	122	Reference T	5	cms	Trip confirmation issues in sbe35. No data recorded for trips 18-36.
138/01	123	Reference T	5	cms	Trip confirmation issues in sbe35. No data recorded for trips 18-36.
138/01	124	Reference T	5	cms	Trip confirmation issues in sbe35. No data recorded for trips 18-36.
138/01	125	Reference T	5	cms	Trip confirmation issues in sbe35. No data recorded for trips 18-36.
138/01	126	Reference T	5	cms	Trip confirmation issues in sbe35. No data recorded for trips 18-36.
138/01	127	Reference T	5	cms	Trip confirmation issues in sbe35. No data recorded for trips 18-36.
138/01	128	Reference T	5	cms	Trip confirmation issues in sbe35. No data recorded for trips 18-36.
138/01	129	Reference T	5	cms	Trip confirmation issues in sbe35. No data recorded for trips 18-36.
138/01	130	Reference T	5	cms	Trip confirmation issues in sbe35. No data recorded for trips 18-36.
138/01	131	Reference T	5	cms	Trip confirmation issues in sbe35. No data recorded for trips 18-36.
138/01	132	Reference T	5	cms	Trip confirmation issues in sbe35. No data recorded for trips 18-36.
138/01	133	Reference T	5	cms	Trip confirmation issues in sbe35. No data recorded for trips 18-36.
138/01	134	ctdc2	3	cms	CTDC2 value high vs CTDC1/Salinity. Code questionable.
138/01	134	Reference T	5	cms	Trip confirmation issues in sbe35. No data recorded for trips 18-36.
138/01	135	Reference T	5	cms	Trip confirmation issues in sbe35. No data recorded for trips 18-36.
138/01	136	Reference T	5	cms	Trip confirmation issues in sbe35. No data recorded for trips 18-36.

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Station	Cast	Bottle	Param	Code	Comment
139/02	218	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. code questionable.
139/02	234	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
139/02	234	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
139/02	234	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
140/01	108	Salinity	4	cms	Salinity value low vs CTDC1/CTDC2 and this part of density profile. Code bad.
140/01	118	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
140/01	123	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
140/01	127	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
140/01	133	CTD T1 Temperature	4	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
140/01	134	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
140/01	134	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. High gradient. Code good.
141/01	109	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Likely not equilibrated. code bad.
141/01	110	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
141/01	121	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. code questionable.
141/01	123	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. code questionable.
141/01	131	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. code questionable.
141/01	132	CTD T1 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. code questionable.
141/01	134	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
141/01	134	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
141/01	134	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
142/01	115	Reference T	3	cms	Unstable value in all three sensors. Slight feature here. Code questionable.
142/01	115	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Slight feature here. Code questionable.
142/01	115	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Slight feature here. Code questionable.
142/01	125	Salinity	4	cms	Salinity value low for cast and density profile. Possible contamination. Code bad.
142/01	128	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Likely not equilibrated. Code bad.

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Station	Cast	Bottle	Param	Code	Comment
142/01	130	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. code questionable.
142/01	130	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. High gradient. Code good.
142/01	132	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. High gradient. Code good.
143/02	209	Salinity	4	cms	Salinity value high vs CTDC1/CTDC2 and this part of density profile. Code bad.
143/02	210	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
143/02	232	Salinity	3	cms	Hold for calib. Salinity value matches up-cast feature. Code good.
143/02	233	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. High gradient code good.
143/02	234	Salinity	4	cms	Salinity value low for cast and density profile. Possible mis-sample or contamination. Code bad.
143/02	235	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. High gradient code good.
144/01	104	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
144/01	104	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
144/01	104	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
144/01	110	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. code questionable.
144/01	131	Reference T	3	cms	Unstable value in all three sensors. Slight feature here. Code questionable.
144/01	131	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Slight feature here. Code questionable.
144/01	131	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Slight feature here. Code questionable.
144/01	133	Reference T	3	cms	Unstable value in all three sensors. Slight feature here. Code questionable.
144/01	133	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Slight feature here. Code questionable.
144/01	133	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Slight feature here. Code questionable.
144/01	134	Reference T	3	cms	Unstable value in all three sensors. Slight feature here. Code questionable.
144/01	134	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Slight feature here. Code questionable.
144/01	134	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Slight feature here. Code questionable.
145/01	121	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. code questionable.
145/01	129	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. code questionable.
145/01	130	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. High gradient. Code good.

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Station	Cast	Bottle	Param	Code	Comment
146/01	116	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
146/01	130	Reference T	3	cms	Unstable value in all three sensors. Slight feature here. Code questionable.
146/01	130	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Slight feature here. Code questionable.
146/01	130	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Slight feature here. Code questionable.
146/01	132	Reference T	3	cms	Unstable value in all three sensors. Slight feature here. Code questionable.
146/01	132	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Slight feature here. Code questionable.
146/01	132	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Slight feature here. Code questionable.
146/01	134	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. High gradient. Code good.
147/01	101	Salinity	4	cms	Salinity value high vs CTDC2/SBE35. Sample not reached lab temperature. Code bad.
147/01	102	Salinity	4	cms	Salinity value high vs CTDC2/SBE35. Sample not reached lab temperature. Code bad.
147/01	103	Salinity	4	cms	Salinity value high vs CTDC2/SBE35. Sample not reached lab temperature. Code bad.
147/01	104	Salinity	4	cms	Salinity value high vs CTDC2/SBE35. Sample not reached lab temperature. Code bad.
147/01	107	Salinity	4	cms	Salinity value high vs CTDC2/SBE35. Sample not reached lab temperature. Code bad.
147/01	108	Salinity	4	cms	Salinity value high vs CTDC2/SBE35. Sample not reached lab temperature. Code bad.
147/01	110	Salinity	4	cms	Salinity value high vs CTDC2/SBE35. Sample not reached lab temperature. Code bad.
147/01	129	Dissolved O2	2	cms	Bottle value matches up-cast. Code good.
147/01	134	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
147/01	135	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
148/01	133	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
148/01	134	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
148/01	134	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
149/02	213	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
149/02	228	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
149/02	231	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
149/02	231	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
150/01	105	Bottle	5	cms	Bottle did not fire/trip.

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Station	Cast	Bottle	Param	Code	Comment
150/01	108	CTD T1 Temperature	3	cms	Unstable value in all three temperature sensors. Code questionable.
150/01	108	CTD T2 Temperature	3	cms	Unstable value in all three temperature sensors. Code questionable.
150/01	108	Reference T	3	cms	Unstable value in all three temperature sensors. Code questionable.
150/01	110	Bottle	3	cms	Bottle leaking. Vent open.
150/01	116	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
150/01	117	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
150/01	117	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
150/01	117	ctdc2	3	cms	Unstable temperatures in all three sensors. code questionable.
150/01	133	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
150/01	134	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
150/01	134	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
150/01	134	ctdc2	3	cms	Unstable temperatures in all three sensors. code questionable.
151/01	113	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
151/01	116	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
152/01	101	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
152/01	101	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
152/01	101	ctdc2	3	cms	Unstable temperatures in all three sensors. code questionable.
152/01	108	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
152/01	108	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
152/01	108	ctdc2	3	cms	Unstable temperatures in all three sensors. code questionable.
152/01	131	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
152/01	131	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
152/01	131	ctdc2	3	cms	Unstable temperatures in all three sensors. code questionable.
152/01	133	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
153/01	101	Salinity	4	cms	Salinity value does not match profile or adjacent casts. Sample not given enough time to reach lab temperature. code bad.

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Station	Cast	Bottle	Param	Code	Comment
153/01	102	Salinity	4	cms	Salinity value does not match profile or adjacent casts. Sample not given enough time to reach lab temperature. code bad.
153/01	103	Salinity	4	cms	Salinity value does not match profile or adjacent casts. Sample not given enough time to reach lab temperature. code bad.
153/01	104	Salinity	4	cms	Salinity value does not match profile or adjacent casts. Sample not given enough time to reach lab temperature. code bad.
153/01	105	Salinity	4	cms	Salinity value does not match profile or adjacent casts. Sample not given enough time to reach lab temperature. code bad.
153/01	106	Salinity	4	cms	Salinity value does not match profile or adjacent casts. Sample not given enough time to reach lab temperature. code bad.
153/01	107	Salinity	4	cms	Salinity value does not match profile or adjacent casts. Sample not given enough time to reach lab temperature. code bad.
153/01	108	Salinity	4	cms	Salinity value does not match profile or adjacent casts. Sample not given enough time to reach lab temperature. code bad.
153/01	109	Salinity	4	cms	Salinity value does not match profile or adjacent casts. Sample not given enough time to reach lab temperature. code bad.
153/01	110	Salinity	4	cms	Salinity value does not match profile or adjacent casts. Sample not given enough time to reach lab temperature. code bad.
153/01	111	Salinity	4	cms	Salinity value does not match profile or adjacent casts. Sample not given enough time to reach lab temperature. code bad.
153/01	106	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
153/01	116	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
153/01	127	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
153/01	128	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
153/01	128	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
153/01	128	ctdc2	3	cms	Unstable temperatures in all three sensors. code questionable.
153/01	130	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.
153/01	130	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
153/01	130	ctdc2	3	cms	Unstable temperatures in all three sensors. code questionable.
154/01	119	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
154/01	110	Salinity	5	cms	Sample missing.
154/01	132	Bottle	3	cms	Bottle leak. Vent open.
155/01	105	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. code questionable.
155/01	108	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. code questionable.
155/01	132	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
155/01	132	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
155/01	132	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
155/01	133	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
155/01	133	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
155/01	133	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
155/01	134	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
155/01	134	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
155/01	134	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
156/01	104	Salinity	4	cms	Salinity value too low for this part of density profile. Mis-sampled. Code bad.
156/01	119	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SSBE35. Code questionable.
156/01	129	Reference T	4	cms	SBE35 value high low vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
156/01	131	Reference T	4	cms	SBE35 value high low vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
157/01	105	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SSBE35. Code questionable.
157/01	120	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SSBE35. Code questionable.
157/01	123	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SSBE35. Code questionable.
157/01	127	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SSBE35. Code questionable.
157/01	132	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SSBE35. Code questionable.
157/01	133	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
157/01	134	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
157/01	134	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
157/01	134	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
158/02	205	Salinity	3	cms	Salinity value high vs CTDC1/CTDC2 and density profile. Code bad.
158/02	230	CTD T1 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
158/02	231	CTD T1 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
158/02	232	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
158/02	232	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
158/02	232	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
158/02	232	Bottle	4	cms	Mis-trip.
158/02	232	Dissolved O2	3	cms	Mis-trip
158/02	232	Salinity	3	cms	Mis-trip
158/02	232	PhospHate	3	cms	Mis-trip
158/02	232	Silicate	3	cms	Mis-trip
158/02	232	nDissolved O2	3	cms	Mis-trip
158/02	232	Nitrate	3	cms	Mis-trip
159/01	106	Salinity	4	cms	Salinity value low vs CTDC1/CTDC2 and for this part of density profile. Code bad.
159/01	113	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Sensor likely not equilibrated. Code bad.
160/01	113	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Sensor likely not equilibrated. Code bad.
160/01	116	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
160/01	132	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
160/01	132	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
160/01	132	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
160/01	133	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
160/01	134	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
160/01	134	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Sensor likely not equilibrated. Code bad.
160/01	135	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
161/01	113	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
161/01	116	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
161/01	121	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
161/01	127	Salinity	4	cms	Salinity value low for CTDC1/CTDC2 and this part of density profile. Code bad.

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Station	Cast	Bottle	Param	Code	Comment
161/01	128	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
161/01	133	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
161/01	134	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
161/01	135	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
162/02 162/04	404	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
162/02 162/04	417	Reference T	4	cms	SBE35 value read high vs CTDT1/CTDT2. Code bad.
162/02 162/04	424	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
162/02 162/04	424	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
162/02 162/04	424	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
162/02 162/04	429	Reference T	4	cms	SBE35 value read high vs CTDT1/CTDT2. Sensor likely not equilibrated. Code bad.
162/02 162/04	431	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
162/02 162/04	432	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
162/02 162/04	432	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
162/02 162/04	433	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
162/02 162/04	433	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
162/02 162/04	433	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
162/02 162/04	434	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
162/02 162/04	202	Reference T	3	cms	Unstable value in all three sensors. Surface currents. Code questionable.
162/02 162/04	202	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Surface currents. Code questionable.
162/02 162/04	202	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Surface currents. Code questionable.
162/02 162/04	203	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Surface currents. Code questionable.
162/02 162/04	205	Reference T	3	cms	Unstable value in all three sensors. Surface currents. Code questionable.
162/02 162/04	205	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Surface currents. Code questionable.
162/02 162/04	205	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Surface currents. Code questionable.
162/02 162/04	201	Reference T	4	cms	SBE35 value read high vs CTDT1/CTDT2. Sensor likely not equilibrated. Code bad.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
162/02 162/04	204	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Surface currents. Code questionable.
162/02 162/04	208	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Surface currents. Code questionable.
162/02 162/04	210	Reference T	3	cms	Unstable value in all three sensors. Surface currents. Code questionable.
162/02 162/04	210	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Surface currents. Code questionable.
162/02 162/04	210	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Surface currents. Code questionable.
162/02 162/04	217	Reference T	3	cms	Unstable value in all three sensors. Surface currents. Code questionable.
162/02 162/04	217	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Surface currents. Code questionable.
162/02 162/04	217	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Surface currents. Code questionable.
162/02 162/04	219	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Surface currents. Code questionable.
162/02 162/04	222	Reference T	4	cms	SBE35 value read low vs CTDT1/CTDT2. Sensor likely not equilibrated. Code bad.
162/02 162/04	223	Reference T	4	cms	SBE35 value read high vs CTDT1/CTDT2. Sensor likely not equilibrated. Code bad.
162/02 162/04	224	Reference T	4	cms	SBE35 value read high vs CTDT1/CTDT2. Sensor likely not equilibrated. Code bad.
162/02 162/04	228	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Surface currents. Code questionable.
162/02 162/04	227	Reference T	3	cms	Unstable value in all three sensors. Surface currents. Code questionable.
162/02 162/04	227	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Surface currents. Code questionable.
162/02 162/04	227	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Surface currents. Code questionable.
162/02 162/04	230	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Surface currents. Code questionable.
162/02 162/04	231	Reference T	4	cms	SBE35 value read low vs CTDT1/CTDT2. Sensor likely not equilibrated. Code bad.
162/02 162/04	234	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Surface currents. Code questionable.
162/02 162/04	235	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Surface currents. Code questionable.
162/02 162/04	236	Reference T	3	cms	Unstable value in all three sensors. Surface currents. Code questionable.
162/02 162/04	236	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Surface currents. Code questionable.
162/02 162/04	236	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Surface currents. Code questionable.
163/01	101	Salinity	4	cms	Salinity value high vs CTDC1/CTDC2 and this part of density profile. Sample value closure to btl 3. Probably mis-sampled. Code bad.

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Station	Cast	Bottle	Param	Code	Comment
163/01	114	Salinity	4	cms	Salinity value high vs CTDC1/CTDC2 and this part of density profile. Sample value closure to btl 15. Probably mis-sampled or ran out of order. Code bad.
163/01	135	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
164/01	132	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
164/01	134	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
164/01	130	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
164/01	134	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
164/01	136	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
165/01	105	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
165/01	132	CTD T2 Temperature	3	cms	CTDT1 value high vs CTDT1/SBE35. Code questionable.
165/01	133	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
165/01	133	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
165/01	133	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
166/01	101	Salinity	4	cms	Salinity value high vs CTDC1/CTDC2 and this part of density profile. Code bad.
166/01	119	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
166/01	124	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
166/01	129	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
166/01	129	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
166/01	129	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
166/01	131	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
166/01	136	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
167/01	119	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
167/01	116	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
167/01	117	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
167/01	131	Reference T	3	cms	Unstable value in all three sensors. Code questionable.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
167/01	131	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
167/01	131	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
167/01	132	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
167/01	132	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
167/01	132	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
167/01	133	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
167/01	134	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
167/01	135	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
167/01	135	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
167/01	136	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
168/01	109	Salinity	4	cms	Salinity value high vs CTDC1/CTDC2 and density profile. Code bad.
168/01	111	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
168/01	114	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
168/01	118	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
168/01	122	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
168/01	130	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
168/01	130	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
168/01	131	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
168/01	132	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
169/01	116	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
169/01	124	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
169/01	129	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
169/01	130	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
169/01	131	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
169/01	132	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
169/01	133	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
169/01	133	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
169/01	134	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
170/01	108	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
170/01	113	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
170/01	123	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
170/01	128	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
170/01	130	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
170/01	131	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
170/01	131	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
170/01	131	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
170/01	132	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
170/01	133	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
170/01	134	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
170/01	135	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
171/01	106	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
171/01	110	Salinity	4	cms	Salinity value high vs CTDC1/CTDC2 and density profile. Code bad.
171/01	111	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
171/01	116	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
171/01	117	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
171/01	130	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
171/01	133	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
171/01	134	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
171/01	135	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
172/01	111	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.

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Station	Cast	Bottle	Param	Code	Comment
172/01	113	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
172/01	114	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
172/01	120	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
172/01	123	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
172/01	129	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
172/01	130	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Sensor likely not equilibrated. Code bad.
172/01	132	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
172/01	131	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
172/01	132	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Sensor likely not equilibrated. Code bad.
172/01	134	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
172/01	136	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
173/01	110	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
173/01	114	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
173/01	117	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
173/01	117	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
173/01	117	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
173/01	120	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
173/01	127	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
173/01	128	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
173/01	129	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
173/01	131	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
173/01	131	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
173/01	131	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
173/01	132	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
173/01	132	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
173/01	132	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
173/01	133	Salinity	3	cms	Unstable values in salinity CTDC1 and CTDC2. Time variant surface feature. Code questionable.
173/01	133	ctdc1	3	cms	Unstable values in salinity CTDC1 and CTDC2. Time variant surface feature. Code questionable.
173/01	133	ctdc2	3	cms	Unstable values in salinity CTDC1 and CTDC2. Time variant surface feature. Code questionable.
173/01	133	Reference T	4	cms	SBE35 value read low vs CTDT1/CTDT2. Sensor likely not equilibrated. Code bad.
173/01	134	Reference T	4	cms	SBE35 value read low vs CTDT1/CTDT2. Sensor likely not equilibrated. Code bad.
173/01	135	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
174/01	110	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
174/01	131	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
174/01	132	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
174/01	132	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
174/01	132	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
174/01	133	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
175/02	207	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
175/02	214	Salinity	5	cms	Salinity value missing for this Bottletle.
175/02	231	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
175/02	231	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
175/02	231	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
175/02	232	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
175/02	232	ctdc1	3	cms	CTDC1 value high vs CTDC2/Salinity. Code questionable.
175/02	235	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
175/02	235	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
175/02	235	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
176/01	126	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
176/01	129	Reference T	3	cms	Unstable value in all three sensors. Code questionable.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
176/01	129	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
176/01	129	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
176/01	131	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
176/01	134	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
176/01	135	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
176/01	132	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
177/01	111	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
177/01	117	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
177/01	131	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
177/01	133	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
177/01	133	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
177/01	133	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
177/01	135	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
177/01	135	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
178/01	131	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
178/01	132	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
178/01	132	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
178/01	132	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
178/01	134	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
178/01	135	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
178/01	133	Salinity	3	cms	Hold for calib. Salinity matches up-cast. Code good.
178/01	134	Salinity	3	cms	Hold for calib. Salinity matches up-cast. Code good.
178/01	135	Salinity	3	cms	Hold for calib. Salinity matches up-cast. Code good.
179/01	114	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
179/01	114	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
179/01	114	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
179/01	115	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
179/01	116	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
179/01	124	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
179/01	128	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
179/01	129	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
179/01	131	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
179/01	133	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
179/01	136	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
180/01	109	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
180/01	109	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
180/01	109	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
180/01	116	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
180/01	117	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
180/01	127	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
180/01	120	Bottle	5	cms	Bottle did not fire/trip.
180/01	132	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Cod good.
180/01	133	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
180/01	133	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
180/01	133	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
180/01	134	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
180/01	134	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
181/01	129	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
181/01	130	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
181/01	131	Reference T	5	cms	Data upload error. Memory over written.
181/01	132	Reference T	5	cms	Data upload error. Memory over written.

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Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
181/01	132	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
181/01	133	Reference T	5	cms	Data upload error. Memory over written.
181/01	134	Reference T	5	cms	Data upload error. Memory over written.
181/01	135	Reference T	5	cms	Data upload error. Memory over written.
181/01	136	Reference T	5	cms	Data upload error. Memory over written.
182/01	114	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
182/01	131	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
182/01	132	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
182/01	133	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
182/01	135	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
183/02	233	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
183/02	202	ctdc2	3	cms	CTDC2 value low vs CTDC1/Salinity. Code questionable.
184/01	101	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Sensor likely not equilibrated. Code bad.
184/01	103	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Sensor likely not equilibrated. Code bad.
184/01	130	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
184/01	134	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
184/01	135	ctdc1	3	cms	CTDC1 value low vs CTDC2/Salinity. Code questionable.
184/01	136	ctdc1	3	cms	CTDC1 value low vs CTDC2/Salinity. Code questionable.
185/01	107	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
185/01	127	CTD T2 Temperature	3	cms	CTDT1 value high vs CTDT1/SBE35. Code questionable.
185/01	129	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
185/01	130	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
185/01	130	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
185/01	133	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
185/01	135	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
186/01	113	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
186/01	127	Bottle	3	cms	Leak. Vent not closed.
186/01	128	Bottle	3	cms	Leak. Vent not closed.

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Station	Cast	Bottle	Param	Code	Comment
186/01	129	Bottle	3	cms	Leak. Vent not closed.
186/01	129	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. code questionable.
186/01	131	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. code questionable.
186/01	132	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. code questionable.
186/01	134	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
186/01	135	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
186/01	135	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Sensor likely not equilibrated. code bad.
187/01	109	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
187/01	109	Salinity	4	cms	Salinity value high vs CTDC1/CTDC2 and density profile. Code bad.
187/01	113	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
187/01	114	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
187/01	116	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
187/01	123	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
187/01	127	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
187/01	128	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
187/01	129	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
187/01	130	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
187/01	131	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Sensor likely not equilibrated. Code bad.
187/01	132	Reference T	3	cms	Unstable value in all three sensors. Code questionable.
187/01	132	CTD T1 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
187/01	132	CTD T2 Temperature	3	cms	Unstable value in all three sensors. Code questionable.
187/01	133	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
188/01	101	Bottle	4	cms	Mis-trip
188/01	101	Salinity	3	cms	Mis-trip
188/01	101	Dissolved O2	3	cms	Mis-trip
188/01	101	nDissolved O2	3	cms	Mis-trip
188/01	101	Nitrate	3	cms	Mis-trip
188/01	101	PhospHate	3	cms	Mis-trip
188/01	101	Silicate	3	cms	Mis-trip

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Station	Cast	Bottle	Param	Code	Comment
188/01	110	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
188/01	129	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
188/01	133	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
189/02	208	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
189/02	227	Reference T	3	cms	Unstable values in all three sensors. Code questionable.
189/02	227	CTD T1 Temperature	3	cms	Unstable values in all three sensors. Code questionable.
189/02	227	CTD T2 Temperature	3	cms	Unstable values in all three sensors. Code questionable.
189/02	228	ctdc2	3	cms	CTDC2 value low vs CTDC1/Salinity. Code questionable.
189/02	230	ctdc1	3	cms	CTDC1 value low vs CTDC2/Salinity. Code questionable.
189/02	231	ctdc1	3	cms	CTDC1 value low vs CTDC2/Salinity. Code questionable.
189/02	232	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
190/01	117	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
190/01	119	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
190/01	121	Dissolved O2	2	cms	Sample value matches up-cast. Code good.
190/01	127	Reference T	3	cms	Unstable values in all three sensors. Code questionable.
190/01	127	CTD T1 Temperature	3	cms	Unstable values in all three sensors. Code questionable.
190/01	127	CTD T2 Temperature	3	cms	Unstable values in all three sensors. Code questionable.
190/01	130	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
190/01	131	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
190/01	131	Dissolved O2	2	cms	Sample value matches up-cast. Code good.
190/01	132	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
190/01	132	Dissolved O2	2	cms	Sample value matches up-cast. Code good.
190/01	134	ctdc1	3	cms	CTDC1 value high vs CTDC2/Salinity. Code questionable.
191/01	107	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
191/01	127	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
191/01	128	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.

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Station	Cast	Bottle	Param	Code	Comment
191/01	129	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
191/01	130	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
191/01	132	Reference T	3	cms	Unstable values in all three sensors. Code questionable.
191/01	132	CTD T1 Temperature	3	cms	Unstable values in all three sensors. Code questionable.
191/01	132	CTD T2 Temperature	3	cms	Unstable values in all three sensors. Code questionable.
191/01	134	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
192/01	101	Salinity	4	cms	Salinity value better matches Bottletle 2. Possibly mis-sampled. Code bad.
192/01	127	Reference T	3	cms	Unstable values in all three sensors. Code questionable.
192/01	127	CTD T1 Temperature	3	cms	Unstable values in all three sensors. Code questionable.
192/01	127	CTD T2 Temperature	3	cms	Unstable values in all three sensors. Code questionable.
192/01	130	Reference T	4	cms	Unstable values in all three sensors. Code questionable.
192/01	130	CTD T1 Temperature	4	cms	Unstable values in all three sensors. Code questionable.
192/01	130	CTD T2 Temperature	4	cms	Unstable values in all three sensors. Code questionable.
192/01	132	Salinity	3	cms	Hold for calib. Salinity value matches up-cast.
192/01	133	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
193/01	107	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
193/01	119	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
193/01	126	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
193/01	128	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. Code bad.
193/01	129	Reference T	3	cms	Unstable values in all three sensors. Code questionable.
193/01	129	CTD T1 Temperature	3	cms	Unstable values in all three sensors. Code questionable.
193/01	129	CTD T2 Temperature	3	cms	Unstable values in all three sensors. Code questionable.
193/01	130	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
193/01	131	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
193/01	132	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.

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Station	Cast	Bottle	Param	Code	Comment
194/02	201	Reference T	3	cms	Unstable values in all three sensors. Code questionable.
194/02	201	CTD T1 Temperature	3	cms	Unstable values in all three sensors. Code questionable.
194/02	201	CTD T2 Temperature	3	cms	Unstable values in all three sensors. Code questionable.
194/02	202	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Not equilibrated. Code bad.
194/02	203	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
194/02	225	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
194/02	227	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
194/02	228	Reference T	3	cms	Unstable values in all three sensors. Code questionable.
194/02	228	CTD T1 Temperature	3	cms	Unstable values in all three sensors. Code questionable.
194/02	228	CTD T2 Temperature	3	cms	Unstable values in all three sensors. Code questionable.
194/02	229	ctdc1	3	cms	CTDC1 value high vs CTDC2/Salinity. Code questionable.
195/01	131	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Not equilibrated. Code bad.
195/01	132	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT2/SBE35. Code questionable.
195/01	133	Reference T	4	cms	SBE35 value low vs CTDT1/CTDT2. Not equilibrated. Code bad.
196/01	101	CTD T1 Temperature	3	cms	CTDT1 value low vs CTDT2/SBE35. Code questionable.
196/01	131	CTD T1 Temperature	3	cms	CTDT1 value high vs CTDT2/SBE35. Code questionable.
196/01	134	ctdc1	3	cms	CTDC1 value high vs CTDC1/Salinity. Code questionable.
196/01	134	Dissolved O2	3	cms	Bottle value matches up-cast. Code good.
084/02	202	Salinity	4	cms	Salinity value high vs CTDC1/CTDC2. Sample temperatures likely not stabilize before running analysis. Code bad.
084/02	203	Salinity	4	cms	Salinity value high vs CTDC1/CTDC2. Sample temperatures likely not stabilize before running analysis. Code bad.
084/02	204	Salinity	4	cms	Salinity value high vs CTDC1/CTDC2. Sample temperatures likely not stabilize before running analysis. Code bad.
084/02	205	Salinity	4	cms	Salinity value high vs CTDC1/CTDC2. Sample temperatures likely not stabilize before running analysis. Code bad.
084/02	206	Salinity	4	cms	Salinity value high vs CTDC1/CTDC2. Sample temperatures likely not stabilize before running analysis. Code bad.

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Station	Cast	Bottle	Param	Code	Comment
085/01	125	Bottle	2	slog	Pin on 25 bent.
086/01	102	Dissolved O2	2	cms	Oxygen value low for this part of profile and adjacent casts. Supporting parameters do not show similar feature. Code questionable.
086/01	121	CTD T2 Temperature	3	cms	CTDT2 value is low vs CTDT1/SBE35. Code questionable.
086/01	125	CTD T1 Temperature	3	cms	CTDT2 value is low vs CTDT1/SBE35. Code questionable.
086/01	126	Reference T	3	cms	SBE35 value is high vs CTDT1/SBE35. Code questionable.
086/01	130	CTD T1 Temperature	3	cms	CTDT2 value is low vs CTDT1/SBE35. Code questionable.
086/01	132	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. Code questionable.
086/01	132	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. Code questionable.
086/01	132	Reference T	3	cms	Unstable temperatures in all three sensors. Code questionable.
086/01	134	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. Code questionable.
086/01	134	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. Code questionable.
086/01	134	Reference T	3	cms	Unstable temperatures in all three sensors. Code questionable.
087/02	219	CTD T2 Temperature	3	cms	CTDT2 value is high vs CTDT1/SBE35. Code questionable.
087/02	220	CTD T1 Temperature	3	cms	CTDT1 value is low vs CTDT2/SBE35. Code questionable.
087/02	224	CTD T1 Temperature	3	cms	CTDT1 value is low vs CTDT2/SBE35. Code questionable.
087/02	225	CTD T1 Temperature	3	cms	CTDT1 value is low vs CTDT2/SBE35. Code questionable.
087/02	229	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. Code questionable.
087/02	229	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. Code questionable.
087/02	229	Reference T	3	cms	Unstable temperatures in all three sensors. Code questionable.
087/02	231	CTD T2 Temperature	3	cms	CTDT2 value is high vs CTDT1/SBE35. Code questionable.
088/02	208	Bottle	2	slog	Black stuff on spigot.
088/02	223	Reference T	3	cms	SBE35 value is high vs CTDT1/CTDT2. Code questionable.
088/02	232	Reference T	3	cms	SBE35 value is high vs CTDT1/CTDT2. Code questionable.
088/02	233	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. Code questionable.
088/02	233	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. Code questionable.

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Station	Cast	Bottle	Param	Code	Comment
088/02	233	Reference T	3	cms	Unstable temperatures in all three sensors. Code questionable.
089/01	134	Bottle	5	slog	Bottle did not close completely.
089/01	134	CTD T1 Temperature	3	cms	CTDT1 value is high vs CTDT2/SBE35. Code questionable.
090/02	201	Salinity	4	cms	Salinity value high for this part of the water column. Does not match density profile. Code bad.
090/02	209	Reference T	4	cms	SBE35 value is high vs CTDT2/CTDT1. Likely not equilibrated. Code bad.
090/02	219	CTD T2 Temperature	3	cms	CTDT2 value is high vs SBE35/CTDT1. Code questionable.
090/02	220	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. Code questionable.
090/02	220	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. Code questionable.
090/02	220	Reference T	3	cms	Unstable temperatures in all three sensors. Code questionable.
090/02	231	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. Code questionable.
090/02	231	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. Code questionable.
090/02	231	Reference T	3	cms	Unstable temperatures in all three sensors. Code questionable.
091/01	131	CTD T2 Temperature	3	cms	CTDT2 value high vs SBE35/CTDT1. Code questionable.
092/01	128	Dissolved O2	2	cms	Bottle value matches up-cast not down-cast. Not used in fit. Code good.
092/01	127	Reference T	3	cms	Unstable values in all three sensors. code questionable.
092/01	127	CTD T1 Temperature	3	cms	Unstable values in all three sensors. code questionable.
092/01	127	CTD T2 Temperature	3	cms	Unstable values in all three sensors. code questionable.
092/01	133	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. code questionable.
093/01	116	Dissolved O2	3	cms	Bottle value high vs CTDO and adjacent profile. Code questionable.
093/01	134	Bottle	5	slog	Bottle did not fire. Software not responding.
093/01	132	CTD T2 Temperature	3	cms	CTDT2 value low vs CTDT1/SBE35. Code questionable.
093/01	133	Reference T	3	cms	Unstable values in all three sensors. Code questionable.
093/01	133	CTD T1 Temperature	3	cms	Unstable values in all three sensors. Code questionable.
093/01	133	CTD T2 Temperature	3	cms	Unstable values in all three sensors. Code questionable.
094/01	129	Reference T	4	cms	SBE35 value high vs CTDT1/CTDT2. Likely not equilibrated. Code bad.

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Station	Cast	Bottle	Param	Code	Comment
095/03	328	Salinity	2	cms	Salinity value corrected per analysts note. ANALYST (ST): For station #95 the Bottletle #29 was processed twice by mistake instead of Bottletle#28. The actual readings from Bottletle #28 were taken later after run without recording to the file. The actual readings for Bottletle#28 station #95 are: 2.02241 first run and 2.02243 second run.
095/03	329	Reference T	4	cms	SBE35 value is high vs CTDT1/CTDT2. High gradient. Sensor likely not equilibrated. Code bad.
095/03	331	Bottle	4	slog	Trip confirmation not available through software. Cable replaced after cast. Appears to have fixed this communications issue.
095/03	332	Bottle	5	slog	Trip confirmation not available through software. Cable replaced after cast. Appears to have fixed this communications issue.
095/03	333	Bottle	5	slog	Trip confirmation not available through software. Cable replaced after cast. Appears to have fixed this communications issue.
095/03	334	Bottle	5	slog	Trip confirmation not available through software. Cable replaced after cast. Appears to have fixed this communications issue.
095/03	335	Bottle	5	slog	Trip confirmation not available through software. Cable replaced after cast. Appears to have fixed this communications issue.
095/03	336	Bottle	5	slog	Trip confirmation not available through software. Cable replaced after cast. Appears to have fixed this communications issue.
096/01	102	Salinity	4	cms	Salinity value high vs CTDC1/CTDC2. Does not match density profile. Code bad.
096/01	105	ctdc2	3	cms	CTDC2 value low vs salinity/CTDC1. Code questionable.
096/01	126	Reference T	4	cms	SBE35 value is high vs CTDT1/CTDT2. High gradient. Sensor likely not equilibrated. Code bad.
096/01	128	Reference T	4	cms	SBE35 value is high vs CTDT1/CTDT2. High gradient. Sensor likely not equilibrated. Code bad.
096/01	129	Reference T	4	cms	SBE35 value is high vs CTDT1/CTDT2. High gradient. Sensor likely not equilibrated. Code bad.
096/01	130	Reference T	4	cms	SBE35 value is high vs CTDT1/CTDT2. High gradient. Sensor likely not equilibrated. Code bad.
096/01	133	Salinity	3	cms	Hold for calib. Small time dependent salinity feature at surface. Down-cast different than up-cast. Code salinity value good but do not use in fitting.
097/02 097/04	423	Reference T	3	cms	Unstable values in all three sensors. Code questionable.

Continued on next page

Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
097/02 097/04	423	CTD T1 Temperature	3	cms	Unstable values in all three sensors. Code questionable.
097/02 097/04	423	CTD T2 Temperature	3	cms	Unstable values in all three sensors. Code questionable.
097/02 097/04	429	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
097/02 097/04	430	CTD T2 Temperature	3	cms	CTDT2 value high vs CTDT1/SBE35. Code questionable.
097/02 097/04	433	Reference T	3	cms	Unstable values in all three sensors. Code questionable.
097/02 097/04	433	CTD T1 Temperature	3	cms	Unstable values in all three sensors. Code questionable.
097/02 097/04	433	CTD T2 Temperature	3	cms	Unstable values in all three sensors. Code questionable.
097/02 097/04	433	Salinity	3	cms	Hold for calib. Salinity value matches up-cast. Code good.
098/01	101	ctdDissolved O2	4	cms	CTDDO signal failed after 3500 dbars. Code bad.
098/01	102	ctdDissolved O2	4	cms	CTDDO signal failed after 3500 dbars. Code bad.
098/01	103	ctdDissolved O2	4	cms	CTDDO signal failed after 3500 dbars. Code bad.
098/01	104	ctdDissolved O2	4	cms	CTDDO signal failed after 3500 dbars. Code bad.
098/01	105	ctdDissolved O2	4	cms	CTDDO signal failed after 3500 dbars. Code bad.
098/01	106	ctdDissolved O2	4	cms	CTDDO signal failed after 3500 dbars. Code bad.
098/01	107	ctdDissolved O2	4	cms	CTDDO signal failed after 3500 dbars. Code bad.
098/01	108	ctdDissolved O2	4	cms	CTDDO signal failed after 3500 dbars. Code bad.
098/01	125	CTD T2 Temperature	3	cms	CTDT2 low vs. SBE35/CTDT1. Code questionable.
098/01	127	CTD T2 Temperature	3	cms	CTDT2 high vs. SBE35/CTDT1. Code questionable.
098/01	130	CTD T2 Temperature	3	cms	CTDT2 high vs. SBE35/CTDT1. Code questionable.
098/01	131	Salinity	3	cms	Salinity value low vs CTDT1/CTDT2. High gradient. code questionable.
098/01	132	CTD T2 Temperature	3	cms	CTDT2 low vs. SBE35/CTDT1. Code questionable.
099/01	101	ctdDissolved O2	4	cms	Signal failed at 4000 dbar. Code bad.
099/01	102	ctdDissolved O2	4	cms	Signal failed at 4000 dbar. Code bad.
099/01	103	ctdDissolved O2	4	cms	Signal failed at 4000 dbar. Code bad.
099/01	104	ctdDissolved O2	4	cms	Signal failed at 4000 dbar. Code bad.
099/01	105	ctdDissolved O2	4	cms	Signal failed at 4000 dbar. Code bad.
099/01	106	ctdDissolved O2	3	cms	Signal started to fail at 2600 dbar. Code questionable.
099/01	107	ctdDissolved O2	3	cms	Signal started to fail at 2600 dbar. Code questionable.
099/01	108	ctdDissolved O2	3	cms	Signal started to fail at 2600 dbar. Code questionable.
099/01	109	ctdDissolved O2	3	cms	Signal started to fail at 2600 dbar. Code questionable.
099/01	131	Reference T	3	cms	Unstable temperatures in all three sensors. code questionable.

Continued on next page

Table B.1 – continued from previous page

Station	Cast	Bottle	Param	Code	Comment
099/01	131	CTD T1 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
099/01	131	CTD T2 Temperature	3	cms	Unstable temperatures in all three sensors. code questionable.
099/01	133	CTD T2 Temperature	3	cms	CTDT2 low vs. SBE35/CTDT1. Code questionable.

APPENDIX

C

CALIBRATION DOCUMENTS

Pressure Calibration Report
STS/ODF Calibration Facility

SENSOR SERIAL NUMBER: 0831
CALIBRATION DATE: 17-NOV-2015
Mfg: SEABIRD Model: 09P CTD Prs s/n: 99677

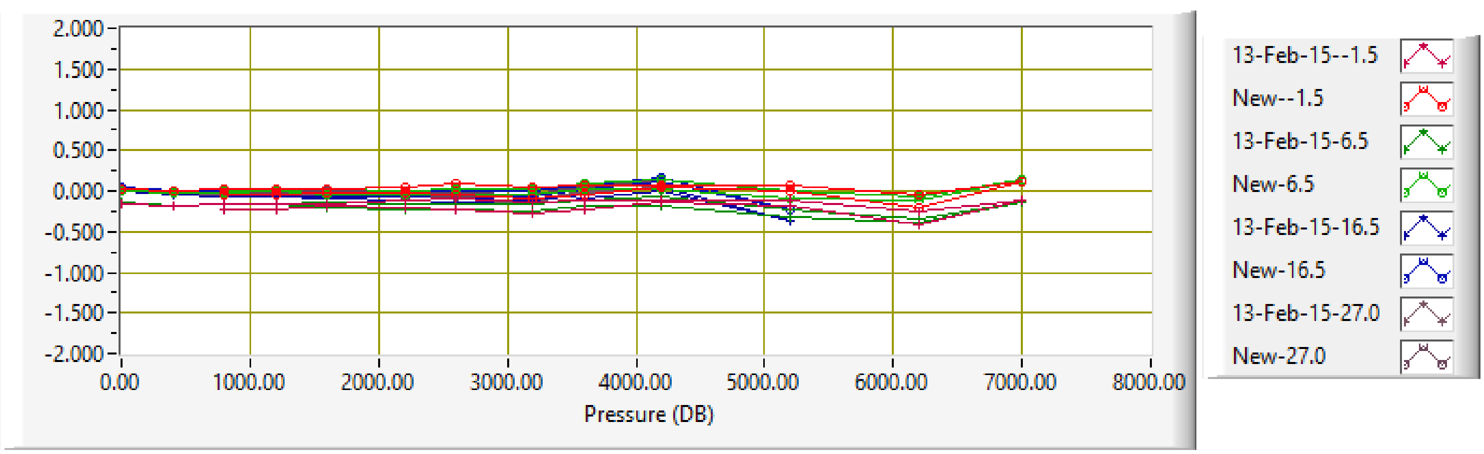
C1= -4.345638E+4
C2= -2.285116E-1
C3= 9.849962E-3
D1= 3.362284E-2
D2= 0.000000E+0
T1= 3.004593E+1
T2= -4.406140E-4
T3= 3.956775E-6
T4= 4.712297E-9
T5= 0.000000E+0
AD590M= 1.28916E-2
AD590B= -8.23481E+0
Slope = 1.00000000E+0
Offset = 0.00000000E+0

Calibration Standard: Mfg: FLUKE   Model: P3125   s/n: 70856
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)

Sensor Output	Standard	Sensor New_Coefs	Standard-Sensor Prev_Coefs	Standard-Sensor NEW_Coefs	Sensor_Temp	Bath_Temp
33288.082	0.16	0.13	-0.16	0.03	0.01	-1.521
33509.413	400.20	400.20	-0.19	-0.00	0.03	-1.521
33729.050	800.22	800.21	-0.17	0.02	0.02	-1.520
33947.078	1200.23	1200.22	-0.17	0.01	0.03	-1.521
34163.522	1600.25	1600.23	-0.16	0.02	0.03	-1.521
34485.276	2200.29	2200.23	-0.13	0.06	0.03	-1.521
34697.885	2600.32	2600.23	-0.10	0.08	0.03	-1.521
35014.062	3200.34	3200.30	-0.14	0.04	0.03	-1.521
35222.998	3600.33	3600.27	-0.12	0.06	0.03	-1.520
35533.779	4200.32	4200.26	-0.12	0.06	0.03	-1.521
36044.903	5200.33	5200.25	-0.11	0.08	0.03	-1.521
36547.856	6200.33	6200.39	-0.26	-0.06	0.03	-1.521
36944.357	7000.29	7000.18	-0.11	0.11	0.03	-1.520
36547.916	6200.29	6200.51	-0.42	-0.22	0.03	-1.520
36044.950	5200.34	5200.34	-0.19	-0.00	0.03	-1.521
35533.806	4200.35	4200.31	-0.15	0.04	0.03	-1.521
35223.051	3600.33	3600.37	-0.22	-0.04	0.02	-1.521

Sensor Output	Standard	Sensor New_Coefs	Standard-Sensor Prev_Coefs	Standard-Sensor NEW_Coefs	Sensor_Temp	Bath_Temp
35014.112	3200.32	3200.40	-0.26	-0.08	0.02	-1.520
34697.938	2600.30	2600.34	-0.22	-0.04	0.02	-1.521
34485.317	2200.29	2200.32	-0.21	-0.03	0.01	-1.520
34163.541	1600.27	1600.28	-0.19	-0.01	0.01	-1.520
33947.110	1200.24	1200.29	-0.24	-0.05	0.01	-1.520
33729.072	800.22	800.26	-0.22	-0.04	0.01	-1.521
33509.416	400.20	400.23	-0.22	-0.03	0.00	-1.521
33291.672	0.16	0.16	-0.14	0.01	7.90	6.487
33513.010	400.20	400.22	-0.18	-0.02	7.91	6.487
33732.673	800.22	800.24	-0.17	-0.01	7.91	6.487
33950.707	1200.23	1200.22	-0.15	0.01	7.91	6.487
34167.172	1600.25	1600.23	-0.14	0.02	7.93	6.487
34488.980	2200.29	2200.29	-0.17	0.00	7.93	6.487
34701.612	2600.31	2600.30	-0.17	0.01	7.93	6.487
35017.792	3200.35	3200.32	-0.16	0.03	7.93	6.487
35226.747	3600.36	3600.28	-0.11	0.08	7.94	6.487
35537.531	4200.37	4200.23	-0.06	0.15	7.94	6.487
36048.783	5200.39	5200.38	-0.22	0.01	7.95	6.488
36551.745	6200.37	6200.45	-0.34	-0.08	7.96	6.488
36948.251	7000.34	7000.19	-0.14	0.15	7.96	6.488
36551.759	6200.36	6200.48	-0.38	-0.12	7.96	6.488
36048.817	5200.36	5200.44	-0.31	-0.08	7.96	6.487
35537.586	4200.35	4200.32	-0.18	0.03	7.96	6.487
35226.779	3600.34	3600.32	-0.18	0.02	7.96	6.487
35017.842	3200.33	3200.38	-0.24	-0.05	7.97	6.487
34701.658	2600.30	2600.35	-0.23	-0.05	7.97	6.487
34489.025	2200.28	2200.33	-0.22	-0.05	7.98	6.487
34167.225	1600.25	1600.29	-0.20	-0.04	7.98	6.487
33950.743	1200.24	1200.24	-0.16	0.00	7.98	6.487
33732.706	800.23	800.24	-0.16	-0.01	7.98	6.487
33513.038	400.20	400.21	-0.16	-0.01	7.98	6.488
33295.454	0.16	0.12	-0.01	0.04	18.14	16.495
33516.821	400.20	400.19	-0.05	0.01	18.14	16.495
33736.523	800.23	800.23	-0.06	0.00	18.14	16.495
33954.594	1200.25	1200.24	-0.05	0.01	18.14	16.495
34171.091	1600.28	1600.27	-0.06	0.01	18.14	16.495
34492.935	2200.33	2200.32	-0.08	0.00	18.14	16.496
34705.598	2600.35	2600.35	-0.08	0.00	18.14	16.496
35021.828	3200.39	3200.39	-0.11	-0.01	18.14	16.496
35230.791	3600.40	3600.33	-0.04	0.07	18.14	16.496
35541.590	4200.40	4200.24	0.04	0.16	18.14	16.495
36053.018	5200.40	5200.62	-0.37	-0.22	18.14	16.496
35541.603	4200.38	4200.26	-0.01	0.12	18.14	16.495
35230.800	3600.36	3600.35	-0.09	0.02	18.14	16.495
35021.836	3200.35	3200.41	-0.16	-0.06	18.14	16.495

Sensor Output	Standard	Sensor New_Coefs	Standard-Sensor Prev_Coefs	Standard-Sensor NEW_Coefs	Sensor_Temp	Bath_Temp
34705.601	2600.31	2600.35	-0.13	-0.04	18.14	16.495
34492.946	2200.30	2200.34	-0.12	-0.04	18.14	16.495
34171.103	1600.27	1600.30	-0.10	-0.02	18.14	16.495
33954.603	1200.25	1200.26	-0.08	-0.01	18.14	16.496
33736.529	800.24	800.25	-0.07	-0.01	18.13	16.495
33516.830	400.20	400.21	-0.07	-0.01	18.12	16.495
33298.301	0.16	0.11	0.00	0.06	28.52	27.002
33519.713	400.20	400.20	-0.04	0.01	28.53	27.002
33739.446	800.24	800.23	-0.05	0.00	28.53	27.002
33957.557	1200.25	1200.26	-0.06	-0.01	28.53	27.002
34174.078	1600.28	1600.28	-0.05	0.01	28.54	27.002
34495.975	2200.32	2200.34	-0.08	-0.02	28.55	27.001
34708.671	2600.34	2600.37	-0.09	-0.03	28.55	27.002
35024.945	3200.37	3200.42	-0.11	-0.04	28.56	27.002
35233.917	3600.38	3600.31	-0.00	0.07	28.57	27.001
35544.777	4200.38	4200.25	0.06	0.13	28.57	27.002
35233.928	3600.37	3600.32	-0.02	0.04	28.58	27.001
35024.954	3200.35	3200.42	-0.13	-0.07	28.58	27.002
34708.687	2600.32	2600.39	-0.13	-0.07	28.58	27.001
34495.996	2200.30	2200.36	-0.12	-0.07	28.58	27.001
34174.100	1600.26	1600.30	-0.09	-0.04	28.58	27.001
33957.567	1200.24	1200.26	-0.07	-0.02	28.59	27.001
33739.465	800.23	800.25	-0.07	-0.01	28.59	27.001
33519.731	400.20	400.20	-0.05	-0.00	28.59	27.001
33298.315	0.16	0.10	0.01	0.06	28.60	27.002



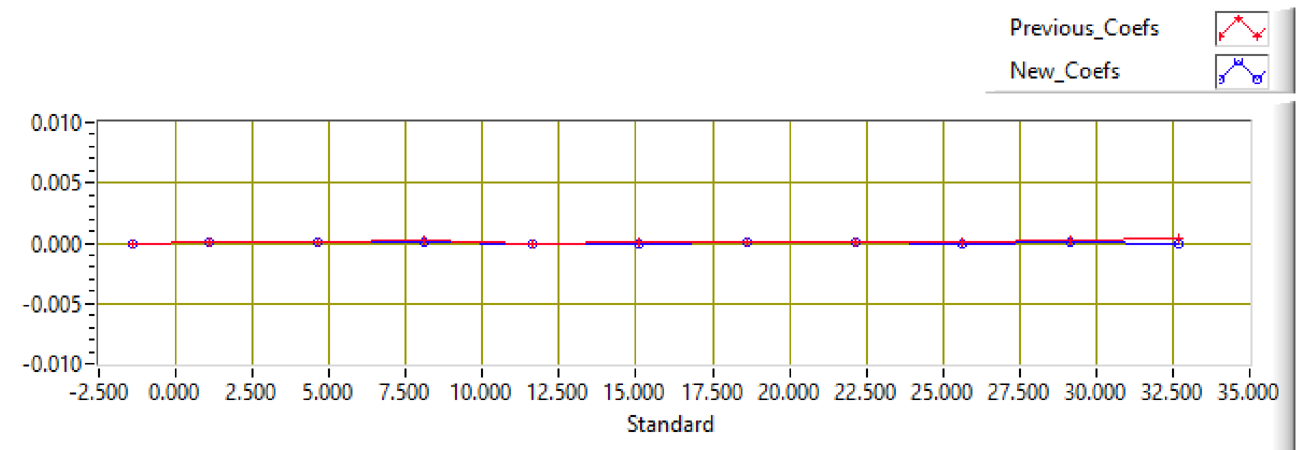
Temperature Calibration Report
STS/ODF Calibration Facility

SENSOR SERIAL NUMBER: 2166
CALIBRATION DATE: 17-Nov-2015
Mfg: SEABIRD   Model: 03
Previous cal: 21-May-15
Calibration Tech: CAL

ITS-90_COEFFICIENTS	IPTS-68_COEFFICIENTS ITS-T90	
g = 4.34268728E-3	a = 4.34288064E-3	
h = 6.45929292E-4	b = 6.46139969E-4	
i = 2.32633976E-5	c = 2.32961239E-5	
j = 2.17044750E-6	d = 2.17200665E-6	
f0 = 1000.0	Slope = 1.0	Offset = 0.0

Calibration Standard: Mfg: Isotech   Model: MicroK100   s/n: 291088-2
Temperature ITS-90 = 1/{g+h[ln(f0/f)]+i[ln2(f0/f)]+j[ln3(f0/f)]} - 273.15 (°C)
Temperature IPTS-68 = 1/{a+b[ln(f0/f)]+c[ln2(f0/f)]+d[ln3(f0/f)]} - 273.15 (°C)
T68 = 1.00024 * T90 (-2 to -35 Deg C)

SBE3 Freq	SPRT ITS-T90	SBE3 ITS-T90	SPRT-SBE3 OLD_Coefs	SPRT-SBE3 NEW_Coefs
2893.9333	-1.4091	-1.4091	-0.00013	-0.00004
3059.8115	1.0954	1.0953	0.00007	0.00004
3303.5425	4.6030	4.6030	0.00012	0.00001
3560.8636	8.1099	8.1099	0.00018	0.00006
3832.2692	11.6176	11.6177	-0.00001	-0.00011
4117.4450	15.1184	15.1185	0.00004	-0.00002
4418.1060	18.6288	18.6287	0.00010	0.00007
4733.6286	22.1367	22.1367	0.00006	0.00003
5064.6867	25.6464	25.6465	0.00001	-0.00007
5410.8338	29.1504	29.1503	0.00028	0.00005
5773.6901	32.6615	32.6615	0.00046	-0.00002



Sea-Bird Electronics, Inc.

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SENSOR SERIAL NUMBER: 3399
CALIBRATION DATE: 10-Nov-15

SBE 4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

```
g =  -1.01577650e+001
h =   1.53709781e+000
i =  -2.63336443e-003
j =   2.84699598e-004
```

```
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

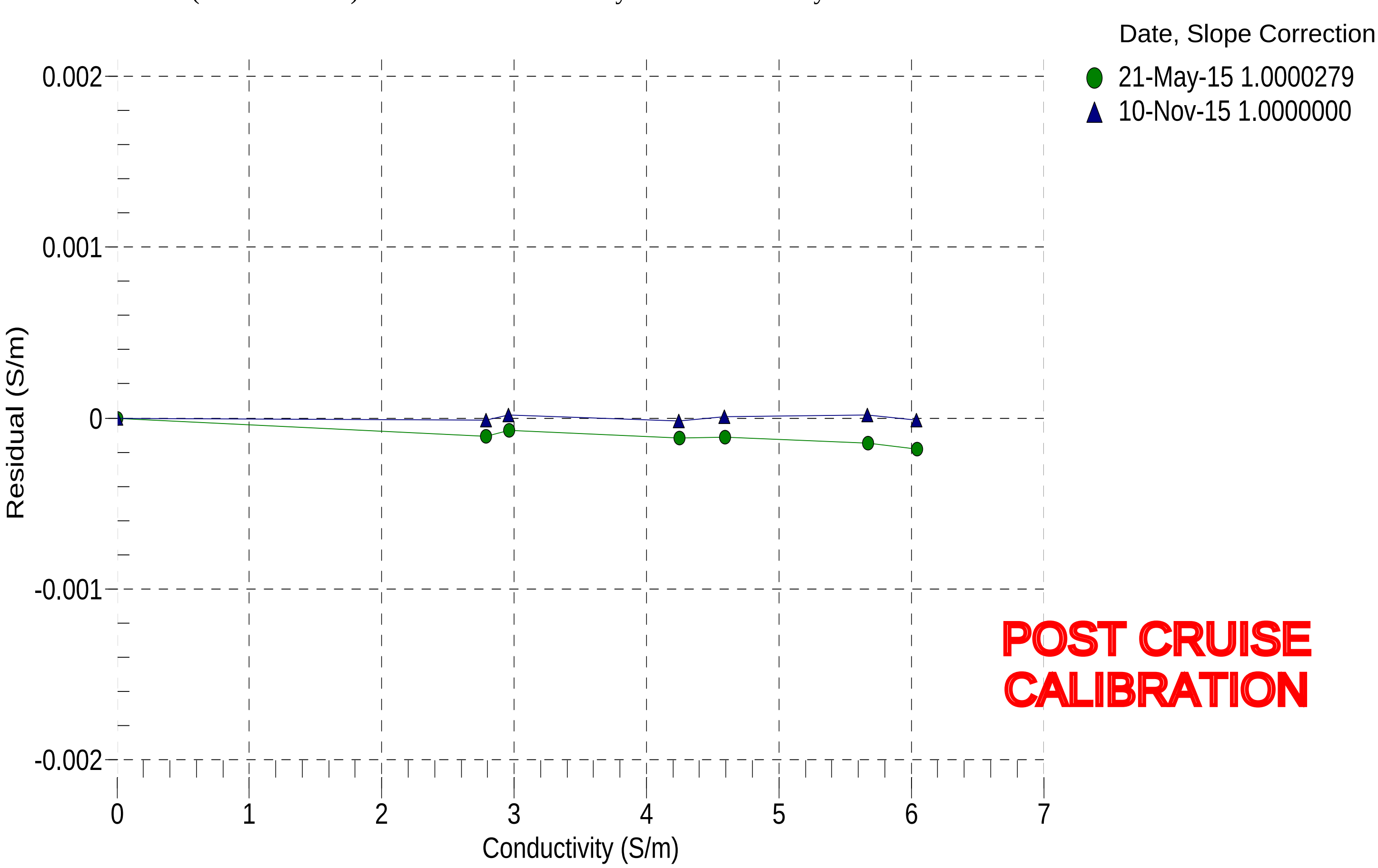
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.57478	0.00000	0.00000
-1.0001	34.5758	2.78699	4.98373	2.78698	-0.00001
0.9999	34.5759	2.95736	5.09414	2.95738	0.00002
14.9999	34.5765	4.24529	5.86130	4.24527	-0.00002
18.4999	34.5762	4.58993	6.05000	4.58994	0.00001
28.9999	34.5750	5.66722	6.60475	5.66723	0.00002
32.4999	34.5684	6.03762	6.78487	6.03761	-0.00001

f = Instrument Output (kHz)

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

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) /10 (1 + \delta * t + \varepsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



POST CRUISE CALIBRATION

Sea-Bird Electronics, Inc.

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Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 3023
CALIBRATION DATE: 01-Dec-15

SBE 4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:
g = -9.88423243e+000
h = 1.42709744e+000
i = 1.53440913e-004
j = 6.70552381e-005

CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

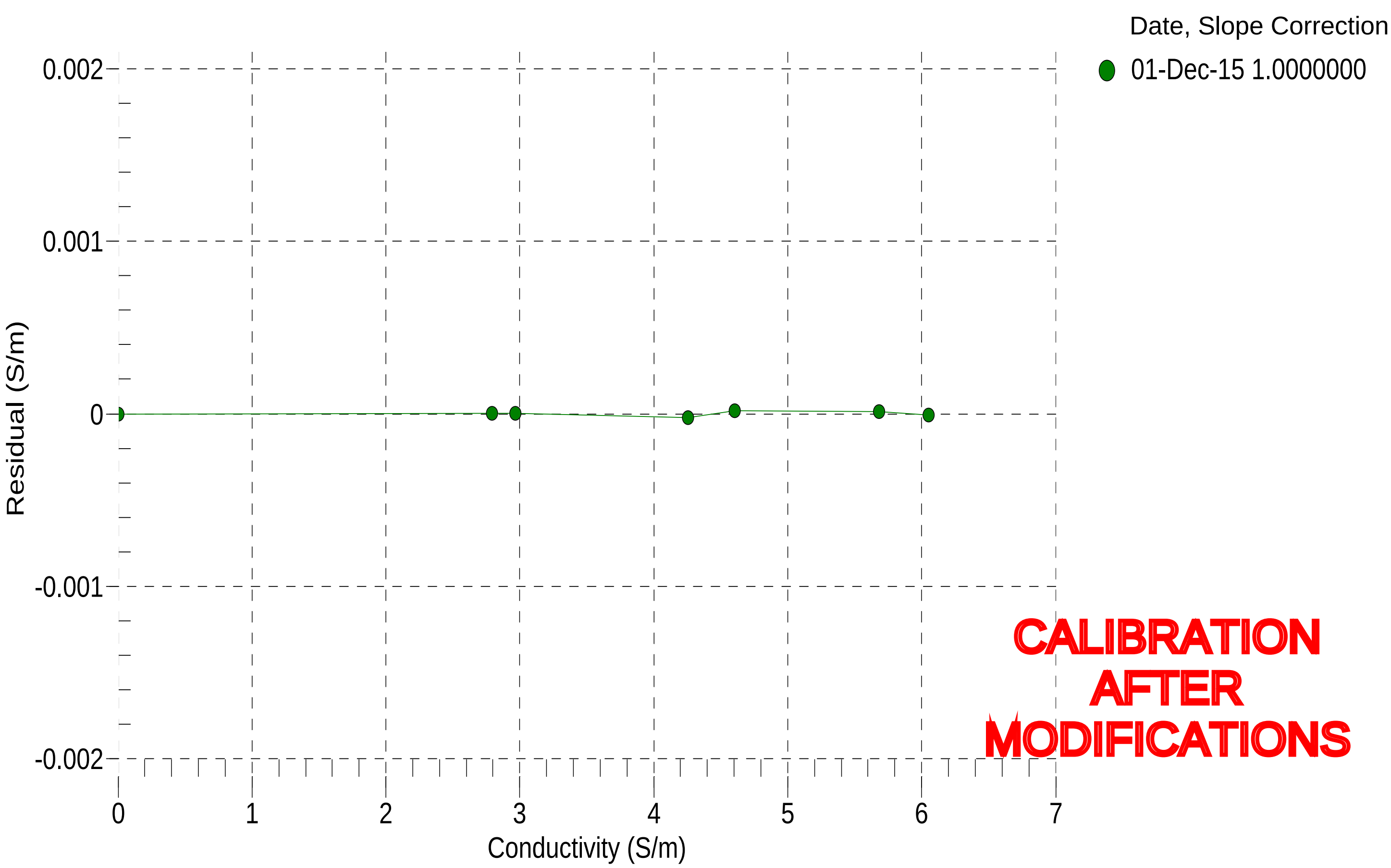
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.63095	0.00000	0.00000
-1.0001	34.6787	2.79451	5.14396	2.79452	0.00000
0.9999	34.6791	2.96534	5.25866	2.96534	0.00000
14.9999	34.6793	4.25657	6.05534	4.25655	-0.00002
18.4999	34.6789	4.60209	6.25125	4.60211	0.00002
28.9999	34.6761	5.68192	6.82702	5.68193	0.00001
32.4999	34.6658	6.05270	7.01373	6.05269	-0.00001

f = Instrument Output (kHz)

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

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / 10 (1 + \delta * t + \varepsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



Sea-Bird Electronics, Inc.

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Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 3207
CALIBRATION DATE: 20-Jan-16

SBE 4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

```
g =  -1.01377568e+001
h =   1.35969549e+000
i =   1.23096178e-004
j =   5.86808354e-005
```

```
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

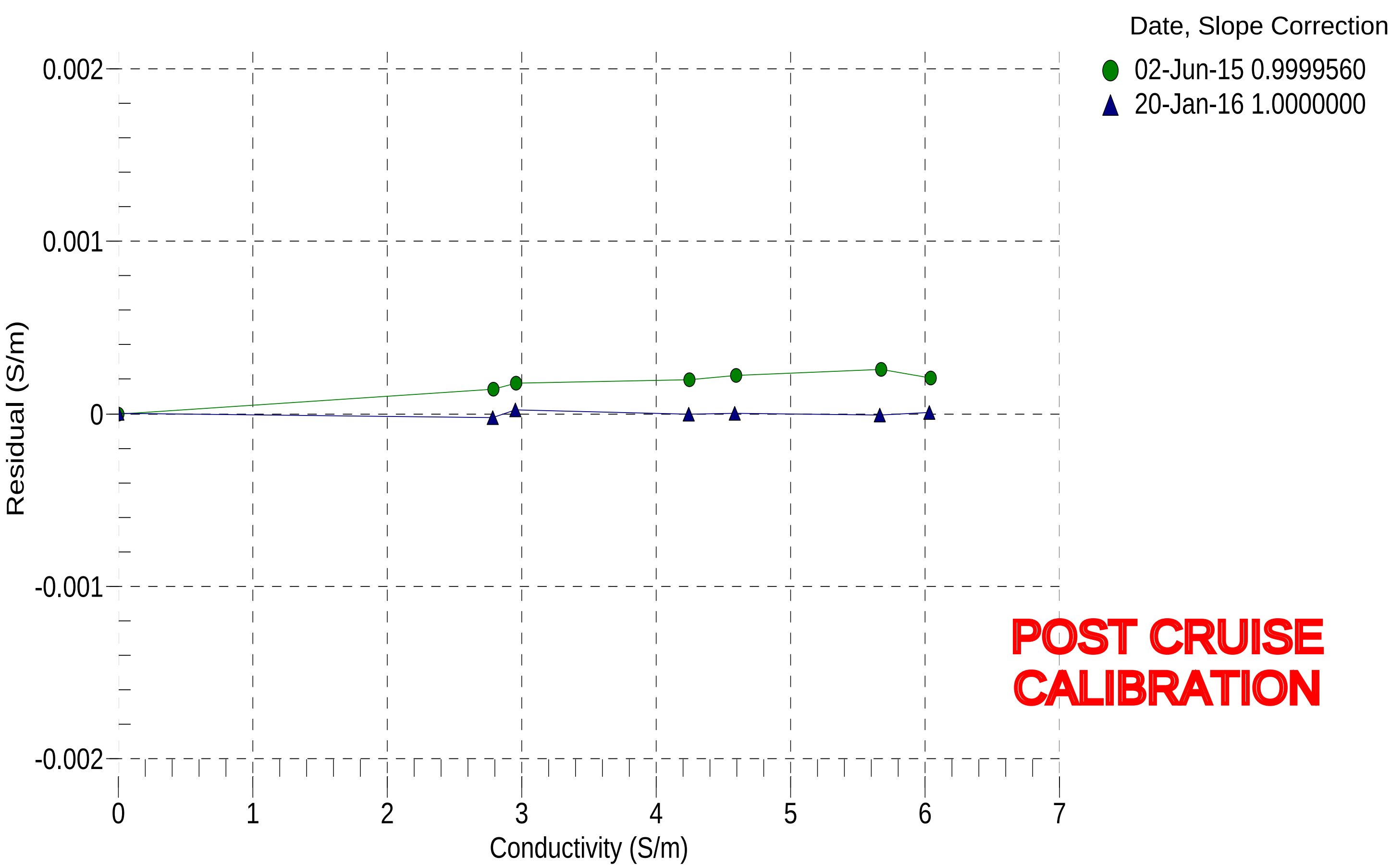
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.72977	0.00000	0.00000
-1.0000	34.5611	2.78593	5.28186	2.78590	-0.00002
1.0000	34.5611	2.95622	5.39880	2.95625	0.00002
15.0000	34.5617	4.24367	6.21143	4.24367	-0.00000
18.5000	34.5613	4.58818	6.41134	4.58818	0.00000
29.0000	34.5592	5.66493	6.99917	5.66492	-0.00001
32.5000	34.5490	6.03463	7.18984	6.03463	0.00001

f = Instrument Output (kHz)

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

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) /10 (1 + \delta * t + \varepsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



POST CRUISE CALIBRATION

Sea-Bird Electronics, Inc.

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

Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 2819
CALIBRATION DATE: 21-Jan-16

SBE 4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

```
g =  -1.03801686e+001
h =   1.46094962e+000
i =  -2.97201593e-003
j =   3.06280201e-004
```

```
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

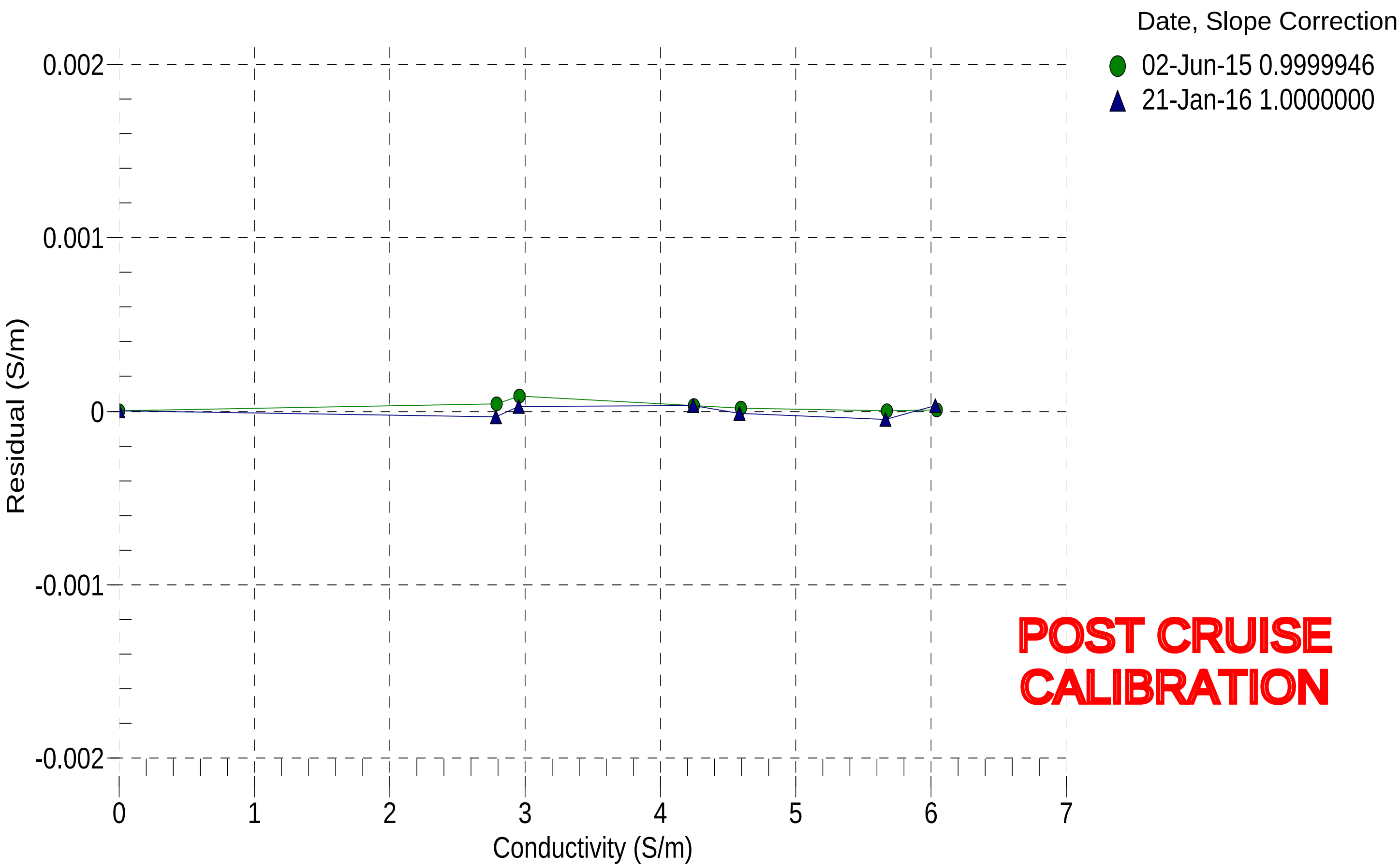
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.67080	0.00000	0.00000
-1.0000	34.5566	2.78560	5.12847	2.78556	-0.00003
1.0000	34.5566	2.95587	5.24143	2.95590	0.00003
15.0000	34.5564	4.24309	6.02651	4.24312	0.00003
18.5000	34.5558	4.58753	6.21961	4.58751	-0.00001
29.0000	34.5548	5.66429	6.78755	5.66424	-0.00005
32.5000	34.5494	6.03469	6.97211	6.03472	0.00003

f = Instrument Output (kHz)

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

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / 10 (1 + \delta * t + \varepsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



POST CRUISE CALIBRATION

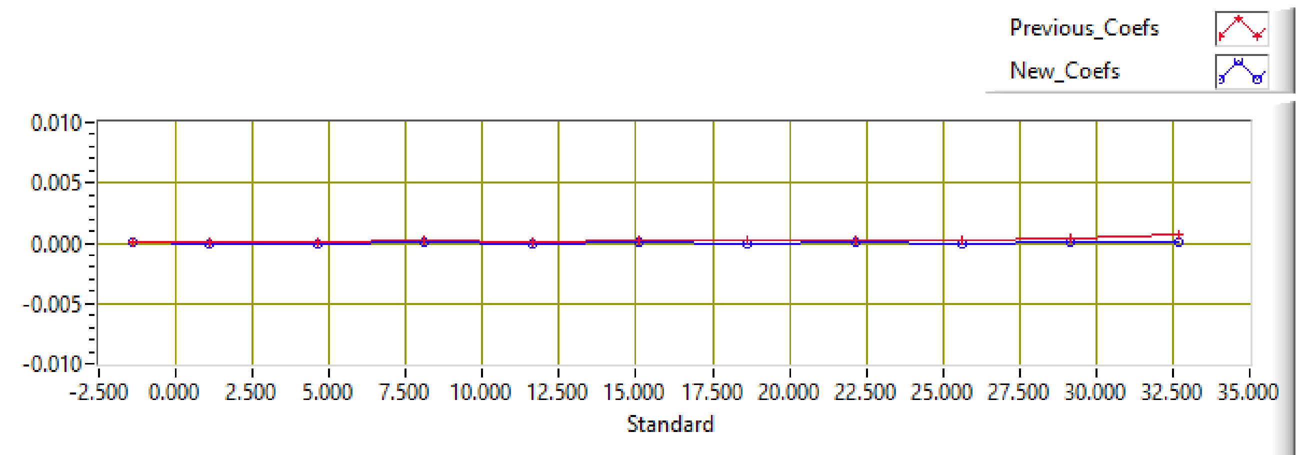
Temperature Calibration Report
STS/ODF Calibration Facility

SENSOR SERIAL NUMBER: 4226
CALIBRATION DATE: 17-Nov-2015
Mfg: SEABIRD   Model: 03
Previous cal: 14-May-15
Calibration Tech: CAL

ITS-90_COEFFICIENTS	IPTS-68_COEFFICIENTS ITS-T90	
g = 4.38217647E-3	a = 4.38238291E-3	
h = 6.47346552E-4	b = 6.47561046E-4	
i = 2.28764202E-5	c = 2.29093466E-5	
j = 1.89272996E-6	d = 1.89426482E-6	
f0 = 1000.0	Slope = 1.0	Offset = 0.0

Calibration Standard: Mfg: Isotech   Model: MicroK100   s/n: 291088-2
Temperature ITS-90 = 1/{g+h[ln(f0/f)]+i[ln2(f0/f)]+j[ln3(f0/f)]} - 273.15 (°C)
Temperature IPTS-68 = 1/{a+b[ln(f0/f)]+c[ln2(f0/f)]+d[ln3(f0/f)]} - 273.15 (°C)
T68 = 1.00024 * T90 (-2 to -35 Deg C)

SBE3 Freq	SPRT ITS-T90	SBE3 ITS-T90	SPRT-SBE3 OLD_Coefs	SPRT-SBE3 NEW_Coefs
3081.2017	-1.4091	-1.4092	0.00007	0.00004
3258.0653	1.0954	1.0954	0.00006	-0.00002
3517.9631	4.6030	4.6031	0.00004	-0.00008
3792.3945	8.1099	8.1099	0.00018	0.00004
4081.9074	11.6176	11.6177	0.00006	-0.00008
4386.1673	15.1184	15.1183	0.00029	0.00014
4707.0602	18.6288	18.6288	0.00016	-0.00002
5043.8662	22.1367	22.1367	0.00027	0.00006
5397.3724	25.6464	25.6465	0.00016	-0.00013
5767.0877	29.1504	29.1504	0.00043	0.00001
6154.7606	32.6615	32.6615	0.00064	0.00003



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SENSOR SERIAL NUMBER: 1919
CALIBRATION DATE: 10-Nov-15

SBE 4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:
g = -3.99264698e+000
h = 5.25774535e-001
i = -1.02610382e-003
j = 8.04692089e-005

CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

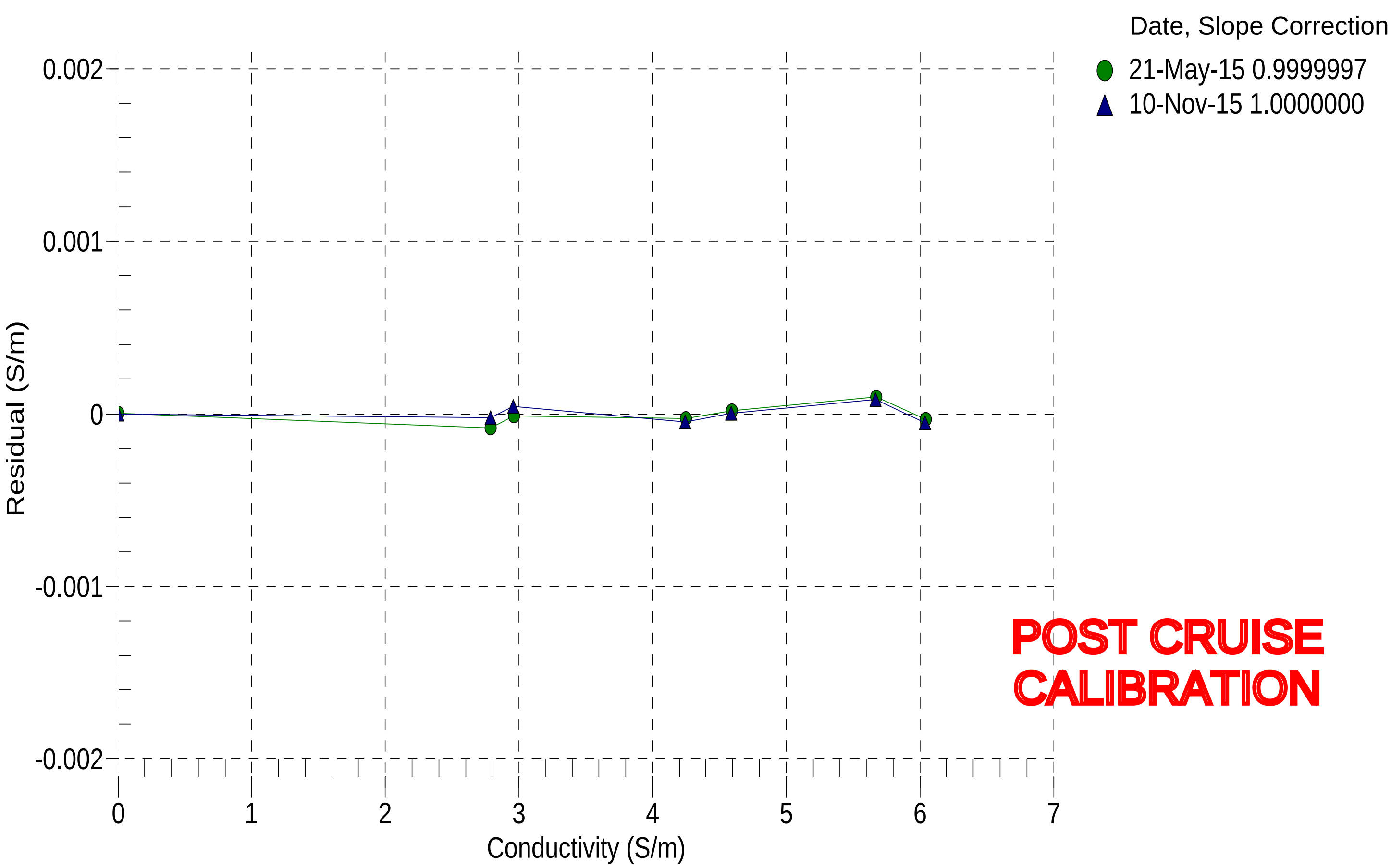
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.76153	0.00000	0.00000
-1.0001	34.5758	2.78699	7.80774	2.78697	-0.00002
0.9999	34.5759	2.95736	8.01347	2.95740	0.00004
14.9999	34.5765	4.24529	9.42160	4.24524	-0.00005
18.4999	34.5762	4.58993	9.76336	4.58993	0.00000
28.9999	34.5750	5.66722	10.75980	5.66730	0.00008
32.4999	34.5684	6.03762	11.08087	6.03757	-0.00005

f = Instrument Output (kHz)

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

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / 10 (1 + \delta * t + \varepsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



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SENSOR SERIAL NUMBER: 3215
CALIBRATION DATE: 21-Jan-16

SBE 4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:
g = -1.01880327e+001
h = 1.54601574e+000
i = -2.45268171e-003
j = 2.72378595e-004

CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

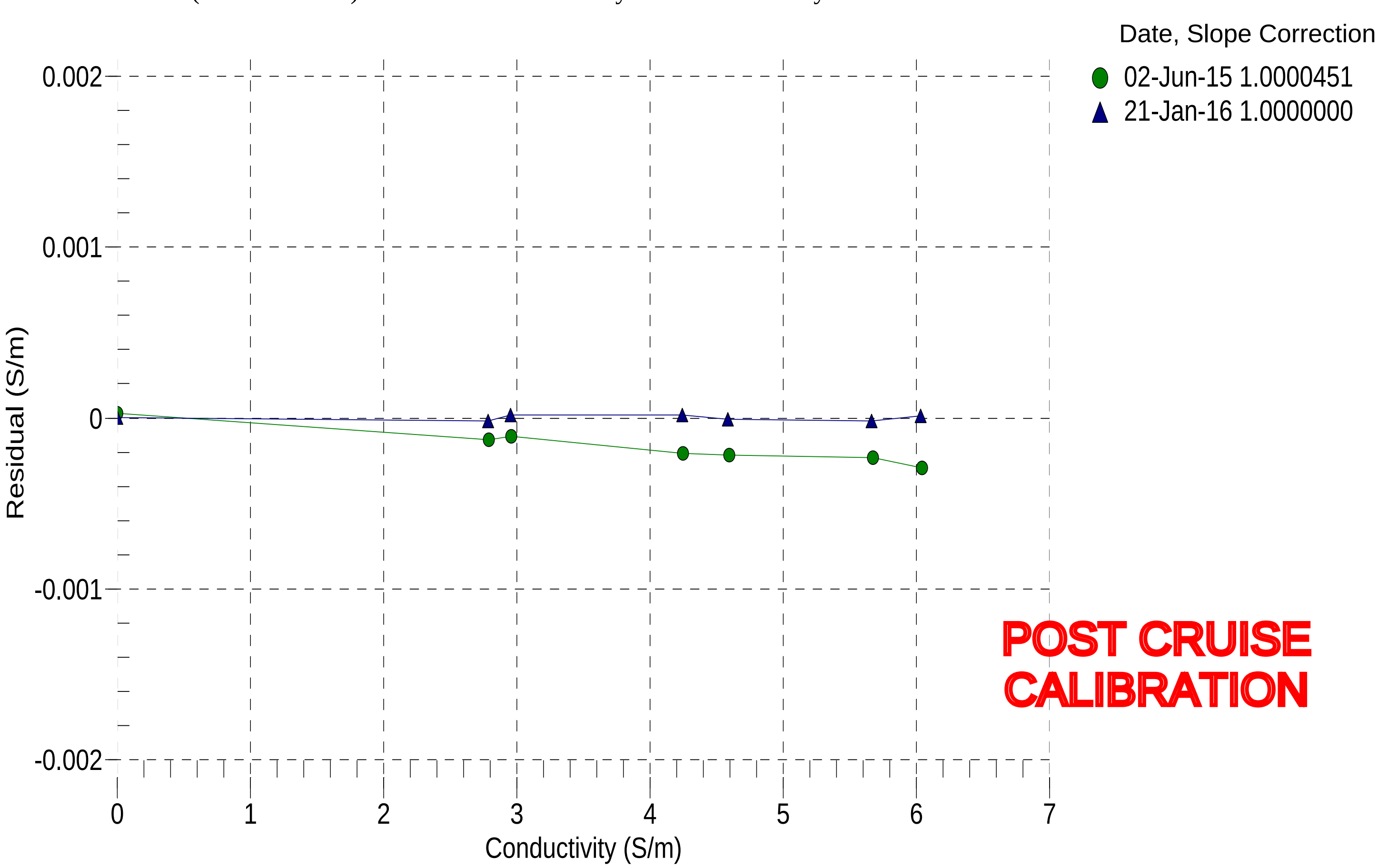
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.57082	0.00000	0.00000
-1.0000	34.5566	2.78560	4.96939	2.78558	-0.00002
1.0000	34.5566	2.95587	5.07937	2.95589	0.00002
15.0000	34.5564	4.24309	5.84361	4.24311	0.00002
18.5000	34.5558	4.58753	6.03156	4.58752	-0.00001
29.0000	34.5548	5.66429	6.58429	5.66427	-0.00002
32.5000	34.5494	6.03469	6.76388	6.03470	0.00001

f = Instrument Output (kHz)

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

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) /10 (1 + \delta * t + \varepsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



PO Box 518
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ECO Chlorophyll Fluorometer Characterization Sheet

Date: 11/24/2015 S/N: FLRTD-2050

Chlorophyll concentration expressed in µg/l can be derived using the equation:

CHL (µg/l) = Scale Factor * (Output - Dark Counts)

	Analog Range 1	Analog Range 2	Analog Range 4 (default)		Digital	
Dark Counts	0.064	0.034	0.019	V	48	counts
Scale Factor (SF)	6	12	24	µg/l/V	0.0074	µg/l/count
Maximum Output	4.98	4.98	4.98	V	16380	counts
Resolution	0.7	0.7	0.7	mV	1.0	counts

Ambient temperature during characterization 22.3 °C

Analog Range: 1 (most sensitive, 0–4,000 counts), 2 (midrange, 0–8,000 counts), 4 (entire range, 0–16,000 counts).

Dark Counts: Signal output of the meter in clean water with black tape over detector.

SF: Determined using the following equation: SF = x ÷ (output - dark counts), where x is the concentration of the solution used during instrument characterization. SF is used to derive instrument output concentration from the raw signal output of the fluorometer.

Maximum Output: Maximum signal output the fluorometer is capable of.

Resolution: Standard deviation of 1 minute of collected data.

The relationship between fluorescence and chlorophyll-a concentrations *in-situ* is highly variable. The scale factor listed on this document was determined using a mono-culture of phytoplankton (*Thalassiosira weissflogii*). The population was assumed to be reasonably healthy and the concentration was determined by using the absorption method. To accurately determine chlorophyll concentration using a fluorometer, you must perform secondary measurements on the populations of interest. This is typically done using extraction-based measurement techniques on discrete samples. For additional information on determining chlorophyll concentration see "Standard Methods for the Examination of Water and Wastewater" part 10200 H, published jointly by the American Public Health Association, American Water Works Association, and the Water Environment Federation.

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SENSOR SERIAL NUMBER: 1138
CALIBRATION DATE: 19-Nov-15

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS:
Soc = 0.4348
Voffset = -0.5124
Tau20 = 1.41

A = -2.3647e-003
B = 1.1539e-004
C = -2.0257e-006
E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS
D1 = 1.92634e-4
D2 = -4.64803e-2

H1 = -3.300000e-2
H2 = 5.00000e+3
H3 = 1.45000e+3

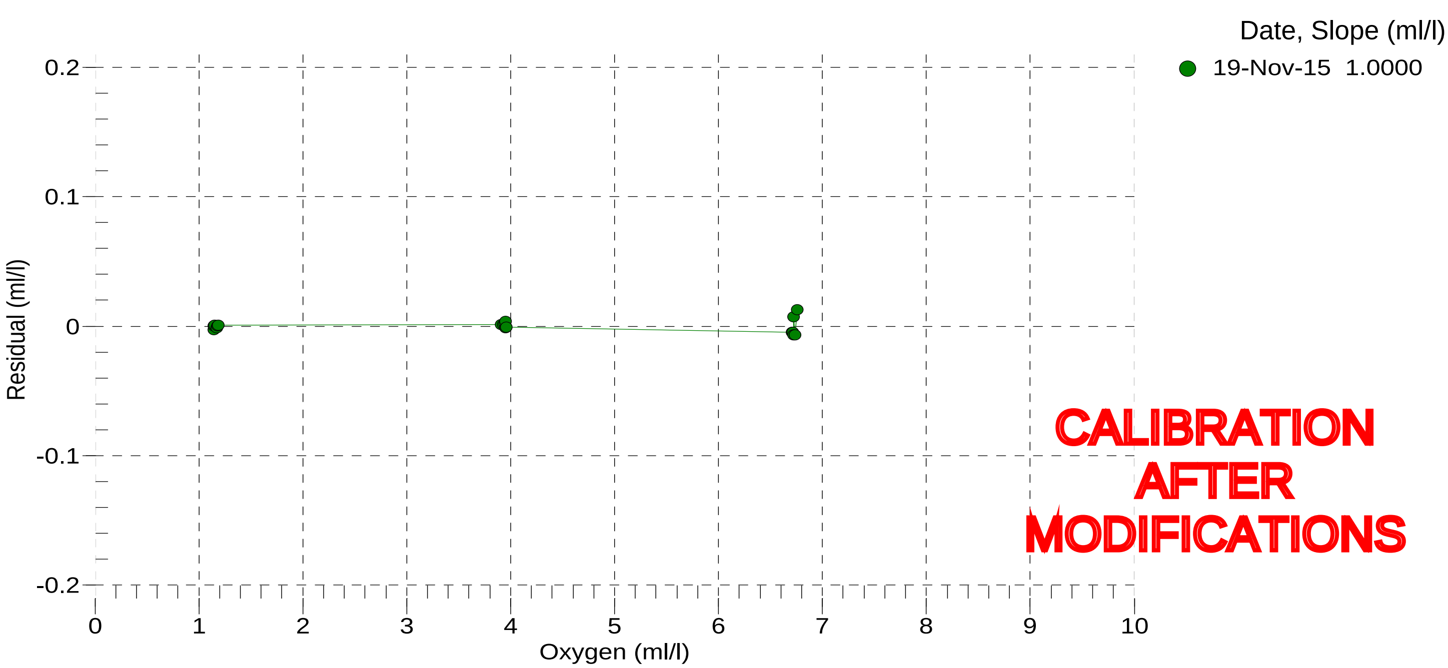
BATH OXYGEN (ml/l)	BATH TEMPERATURE (° C)	BATH SALINITY (PSU)	INSTRUMENT OUTPUT (volts)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.15	2.00	0.00	0.786	1.14	-0.00
1.15	12.00	0.00	0.868	1.15	0.00
1.15	6.00	0.00	0.819	1.15	0.00
1.17	20.00	0.00	0.944	1.17	-0.00
1.18	26.00	0.00	1.000	1.18	0.00
1.19	30.00	0.00	1.041	1.19	0.00
3.91	12.00	0.00	1.724	3.91	0.00
3.93	2.00	0.00	1.451	3.93	0.00
3.94	30.00	0.00	2.266	3.95	0.00
3.95	26.00	0.00	2.142	3.95	-0.00
3.95	6.00	0.00	1.568	3.96	0.00
3.96	20.00	0.00	1.967	3.95	-0.00
6.71	12.00	0.00	2.588	6.70	-0.00
6.71	2.00	0.00	2.113	6.71	-0.00
6.72	30.00	0.00	3.496	6.71	-0.01
6.72	6.00	0.00	2.308	6.73	0.01
6.74	20.00	0.00	2.989	6.73	-0.01
6.76	26.00	0.00	3.308	6.77	0.01

V = instrument output (volts); T = temperature (°C); S = salinity (PSU); K = temperature (°K)

Oxsat(T,S) = oxygen saturation (ml/l); P = pressure (dbar)

$$\text{Oxygen (ml/l)} = Soc * (V + Voffset) * (1.0 + A * T + B * T^2 + C * T^3) * Oxsat(T,S) * \exp(E * P / K)$$

Residual (ml/l) = instrument oxygen - bath oxygen



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SENSOR SERIAL NUMBER: 0848
CALIBRATION DATE: 19-Nov-15

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS:
Soc = 0.4497
Voffset = -0.5207
Tau20 = 1.04

A = -3.5777e-003
B = 1.4405e-004
C = -2.3867e-006
E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS
D1 = 1.92634e-4
D2 = -4.64803e-2

H1 = -3.300000e-2
H2 = 5.00000e+3
H3 = 1.45000e+3

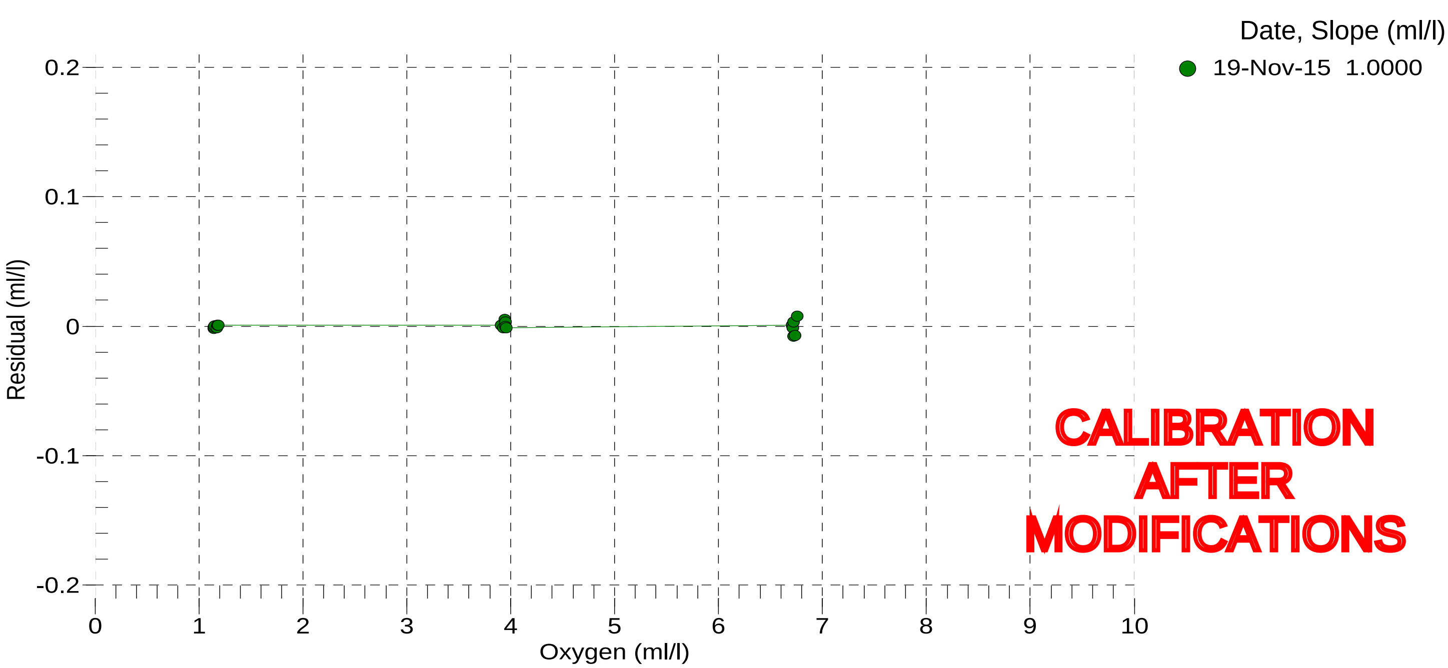
BATH OXYGEN (ml/l)	BATH TEMPERATURE (° C)	BATH SALINITY (PSU)	INSTRUMENT OUTPUT (volts)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.15	2.00	0.00	0.786	1.15	-0.00
1.15	12.00	0.00	0.868	1.15	-0.00
1.15	6.00	0.00	0.819	1.15	0.00
1.17	20.00	0.00	0.944	1.17	-0.00
1.18	26.00	0.00	1.001	1.18	0.00
1.19	30.00	0.00	1.042	1.19	0.00
3.91	12.00	0.00	1.705	3.91	0.00
3.93	2.00	0.00	1.430	3.93	-0.00
3.94	30.00	0.00	2.254	3.95	0.01
3.95	26.00	0.00	2.129	3.95	0.00
3.95	6.00	0.00	1.547	3.95	-0.00
3.96	20.00	0.00	1.950	3.95	-0.00
6.71	12.00	0.00	2.552	6.71	0.00
6.71	2.00	0.00	2.073	6.71	-0.00
6.72	30.00	0.00	3.466	6.71	-0.01
6.72	6.00	0.00	2.267	6.73	0.00
6.74	20.00	0.00	2.954	6.73	-0.01
6.76	26.00	0.00	3.274	6.77	0.01

V = instrument output (volts); T = temperature (°C); S = salinity (PSU); K = temperature (°K)

Oxsat(T,S) = oxygen saturation (ml/l); P = pressure (dbar)

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

Residual (ml/l) = instrument oxygen - bath oxygen



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SENSOR SERIAL NUMBER: 0197
CALIBRATION DATE: 09-Feb-16

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS:		NOMINAL DYNAMIC COEFFICIENTS	
Soc = 0.3709	B = 3.5080e-004	D1 = 1.92634e-4	H1 = -3.300000e-2
Voffset = -0.7133	C = -3.3481e-006	D2 = -4.64803e-2	H2 = 5.00000e+3
Tau20 = 0.90	E nominal = 0.036		H3 = 1.45000e+3
	A = -8.5168e-003		

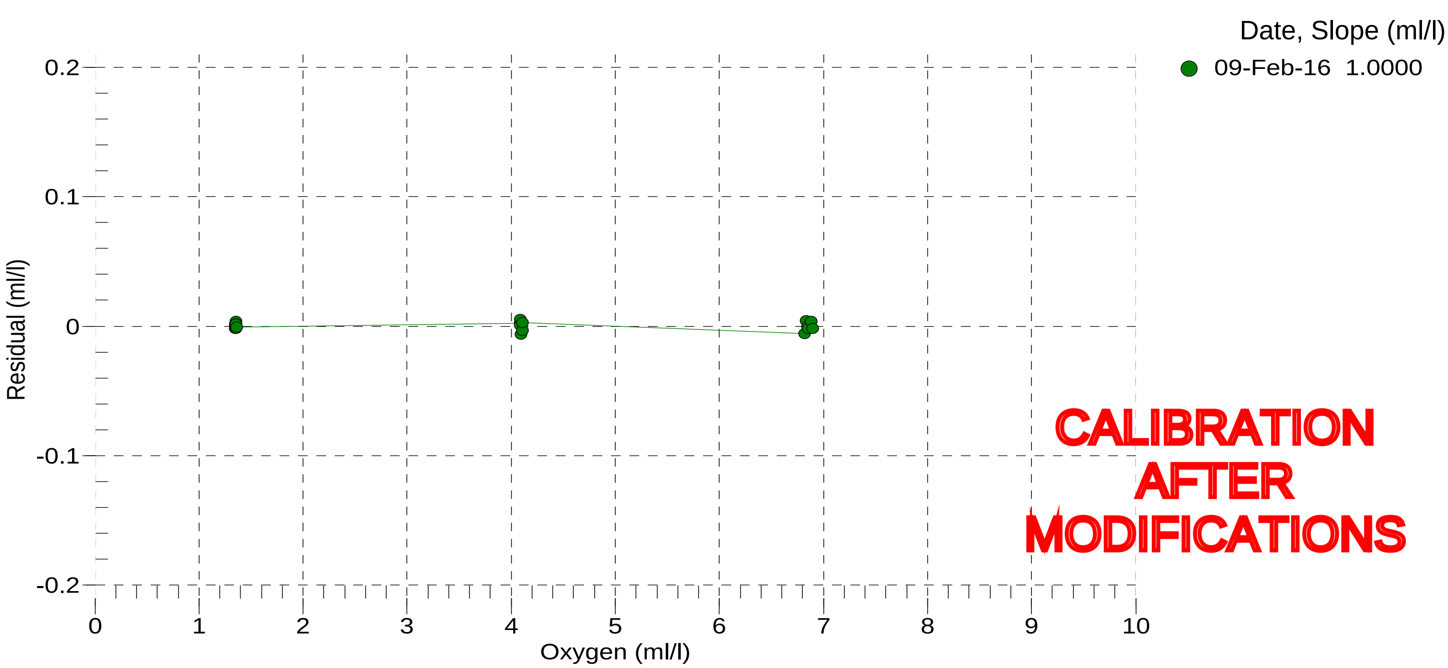
BATH OXYGEN (ml/l)	BATH TEMPERATURE (° C)	BATH SALINITY (PSU)	INSTRUMENT OUTPUT (volts)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.35	2.00	0.00	1.093	1.34	-0.00
1.35	20.00	0.00	1.319	1.35	0.00
1.35	6.00	0.00	1.148	1.35	-0.00
1.35	30.00	0.00	1.426	1.36	0.00
1.36	26.00	0.00	1.388	1.36	0.00
1.36	12.00	0.00	1.229	1.36	-0.00
4.09	30.00	0.00	2.862	4.09	0.00
4.09	26.00	0.00	2.745	4.09	0.01
4.09	12.00	0.00	2.265	4.09	0.00
4.10	20.00	0.00	2.551	4.09	-0.01
4.11	2.00	0.00	1.875	4.11	-0.00
4.11	6.00	0.00	2.038	4.11	0.00
6.82	30.00	0.00	4.294	6.81	-0.01
6.84	26.00	0.00	4.107	6.84	0.00
6.84	2.00	0.00	2.650	6.84	-0.00
6.85	20.00	0.00	3.791	6.85	-0.00
6.88	6.00	0.00	2.932	6.89	0.00
6.89	12.00	0.00	3.328	6.89	-0.00

V = instrument output (volts); T = temperature (°C); S = salinity (PSU); K = temperature (°K)

Oxsol(T,S) = oxygen saturation (ml/l); P = pressure (dbar)

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

Residual (ml/l) = instrument oxygen - bath oxygen



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SENSOR SERIAL NUMBER: 0275

CALIBRATION DATE: 21-Jan-16

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS:
Soc = 0.5378
Voffset = -0.5022
Tau20 = 1.36

A = -3.1385e-003
B = 1.0071e-004
C = -1.2897e-006
E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS
D1 = 1.92634e-4
D2 = -4.64803e-2
H1 = -3.300000e-2
H2 = 5.00000e+3
H3 = 1.45000e+3

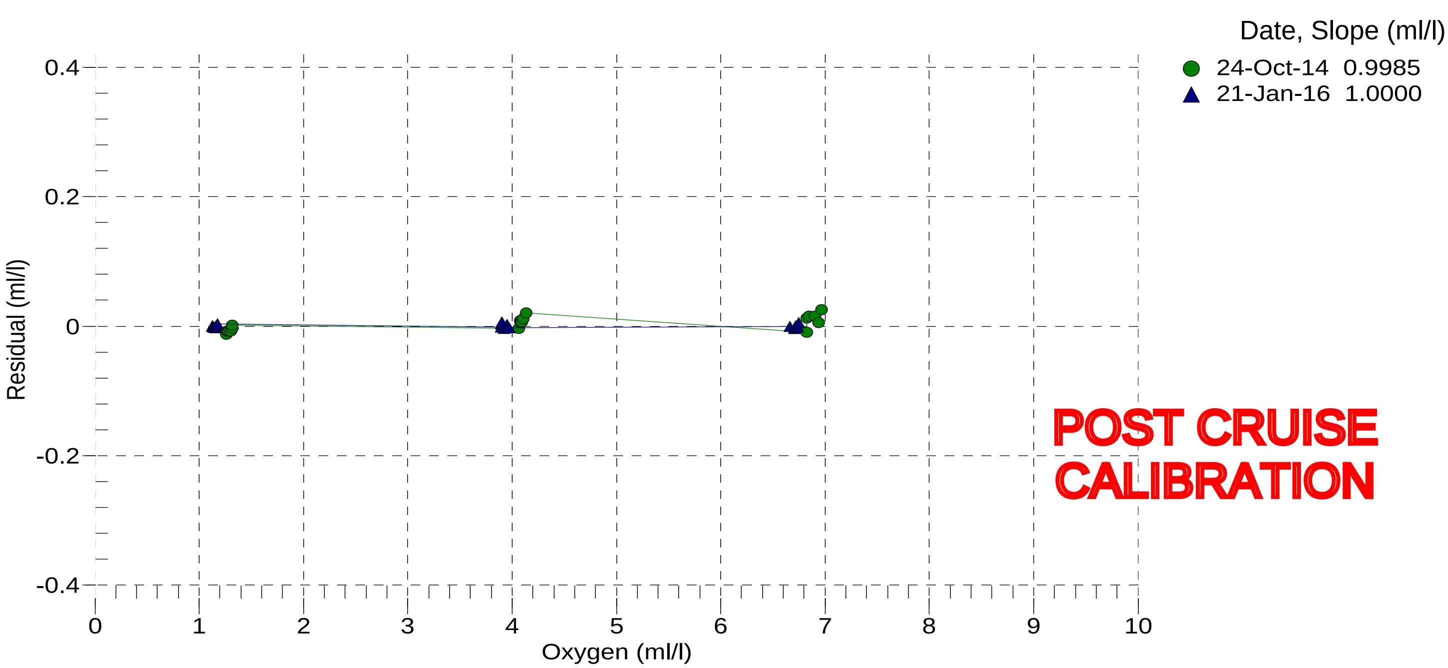
BATH OXYGEN (ml/l)	BATH TEMPERATURE (° C)	BATH SALINITY (PSU)	INSTRUMENT OUTPUT (volts)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.12	6.00	0.00	0.746	1.12	0.00
1.13	12.00	0.00	0.788	1.13	-0.00
1.14	2.00	0.00	0.723	1.14	-0.00
1.16	20.00	0.00	0.851	1.15	-0.00
1.17	26.00	0.00	0.898	1.17	0.00
1.18	30.00	0.00	0.934	1.18	0.00
3.89	2.00	0.00	1.254	3.89	-0.00
3.90	6.00	0.00	1.347	3.90	0.00
3.90	12.00	0.00	1.491	3.91	0.01
3.92	20.00	0.00	1.687	3.92	-0.00
3.95	26.00	0.00	1.846	3.95	0.00
3.98	30.00	0.00	1.954	3.97	-0.00
6.66	2.00	0.00	1.790	6.66	-0.00
6.70	12.00	0.00	2.197	6.70	-0.00
6.71	20.00	0.00	2.530	6.71	-0.00
6.72	6.00	0.00	1.959	6.72	0.00
6.74	30.00	0.00	2.965	6.74	-0.00
6.75	26.00	0.00	2.798	6.76	0.01

V = instrument output (volts); T = temperature (°C); S = salinity (PSU); K = temperature (°K)

Oxsol(T,S) = oxygen saturation (ml/l); P = pressure (dbar)

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

Residual (ml/l) = instrument oxygen - bath oxygen



POST CRUISE CALIBRATION

CCHDO Data Processing Notes

- **File Online** **Carolina Berys**

i09-2016-ctd-data.tar.gz (download) #94f62
Date: 2016-07-19
Current Status: unprocessed

- **File Online** **Carolina Berys**

i09_hy1.csv (download)
#588bc **Date:** 2016-07-19
Current Status: unprocessed

- **File Submission** **Courtney Schatzman**

i09_hy1.csv (download) #588bc
Date: 2016-07-19
Current Status: unprocessed
Notes

```
Updated 115/03, 112/01, 098/01 CTD salinity, oxygen data and flags.
```

- **File Submission** **Courtney Schatzman**

i09-2016-ctd-data.tar.gz (download) #94f62
Date: 2016-07-19
Current Status: unprocessed
Notes

```
Updated 115/03, 112/01, 098/01 CTD salinity, oxygen data and flags.
```

- **File Online** **Carolina Berys**

33RR20160321_hy1.csv (download) #68ca1
Date: 2016-07-11
Current Status: unprocessed

- **File Submission** **Andrew Barna**

33RR20160321_hy1.csv (download) #68ca1
Date: 2016-07-08
Current Status: unprocessed
Notes
`These data are preliminary, updates expected in the next few weeks.`