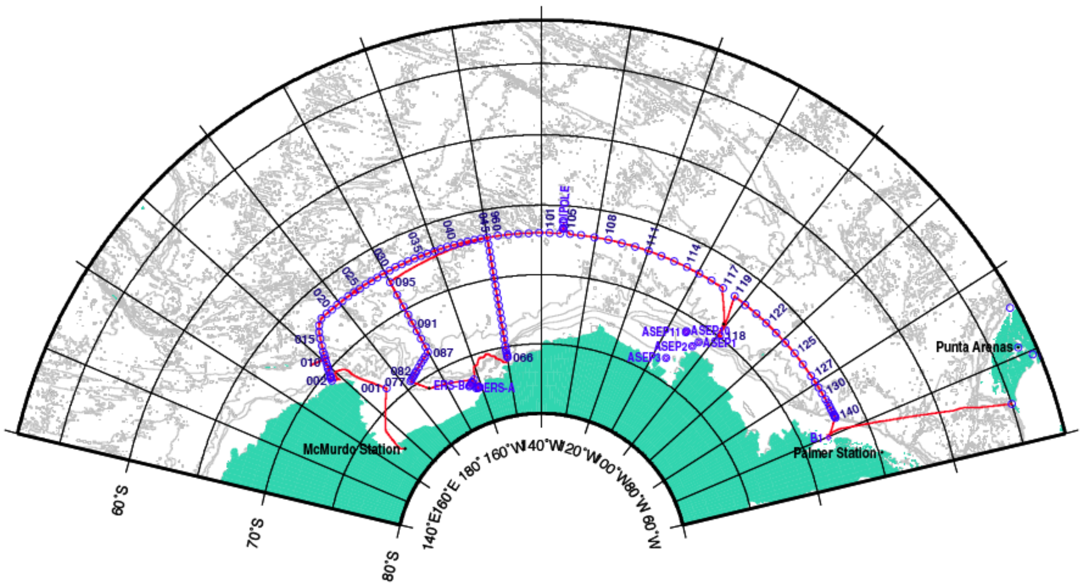
CRUISE REPORT: S04P

(Updated APR 2011)



HIGHLIGHTS

CRUISE SUMMARY INFORMATION

Section Designation	**S04P**
Expedition designation (ExpoCodes)	**320620110219**
Chief Scientist	**Dr. James H. Swift**
Co-Chief Scientist	**Dr. Alejandro Orsi**
Dates	19 FEB 2011 - 23 APR 2011
Ship	*R/V Nathaniel B. Palmer*
Ports of call	McMurdo Station, Ross Island, Antarctica - Punta Arenas, Chile
Geographic Boundaries	66° 12.62' S 168° 37.59' E 72° 54.55' W 77° 20.94' S
Stations	140
Floats and drifters deployed	0
Moorings deployed or recovered	1 mooring deployed; 2 ESR moorings and 1 biophysical mooring recovered

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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

US Global Ocean Carbon and Repeat Hydrography Program Section S04P

Nathaniel B. Palmer Cruise NBP-1102 (RPSC event O-287-N)

19 February 2011 - 23 April 2011 UTC

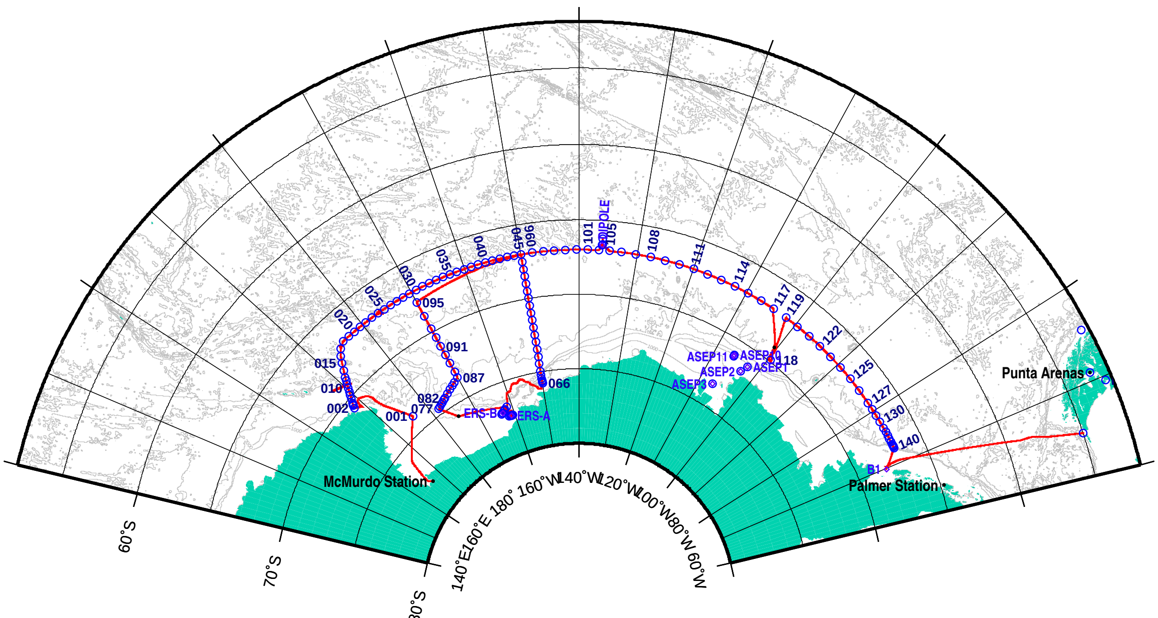
McMurdo Station, Ross Island, Antarctica - Punta Arenas, Chile

Chief Scientist: Dr. James H. Swift

Scripps Institution of Oceanography

Co-Chief Scientist: Dr. Alejandro Orsi

Texas A&M University



Cruise Report

23 April 2011

Narrative

NBP-1102 was scheduled for a 60-70 day voyage, beginning at the US Antarctic Program McMurdo base and ending at Punta Arenas, Chile. The cruise was unique for the US Global Ocean Carbon and Repeat Hydrography Program in that it was carried out on a ship operated by a commercial operator, Edison-Chouest Offshore (ECO) (under charter to the US National Science Foundation), with pre-cruise planning, shipping, logistics, and on-board science support from a second company, Raytheon Polar Services Corporation (RPSC) (via contract with the US National Science Foundation).

The science team assembled in Christchurch, New Zealand, where they attended a pre-ice-flight briefing and cold weather clothing issue on 13 February, and then on 14 February flew to the ice sheet runway near Ross Island via a US Air Force C-17 transport. Although cancelled flights and "boomerangs" (flights turned back by weather or equipment problems) are frequent, this flight went without incident, and ended with an extraordinarily smooth landing. The science team was impressed with the view from the landing site and excited to be in Antarctica. After a ride to the McMurdo base, the team was briefed on McMurdo basics, issued room keys and linens, and told where to eat.

The flight had been scheduled ahead of the Nathaniel B. Palmer's arrival at McMurdo in order to allow for cancelled or "boomeranged" flights, and, after the team was at the McMurdo base, the base operators decided to fuel the ship as soon as it arrived (instead of after loading equipment as is usually done). Thus the science team had more than two days to enjoy the unique amenities, scenery, and recreational opportunities at the base, including a guided tour to Robert F. Scott's 1902 "Discovery Hut" at Hut Point on Ross Island.

During a routine visit on 15 February to the base site where the RPSC McMurdo staff had set most of the S04P cargo it was immediately apparent that RPSC personnel had allowed much of the S04P "do not freeze" cargo to sit outdoors in sub-freezing conditions, despite well-in-advance-of-shipping notice provided to RPSC (Denver) using their guidelines and forms, and despite proper and copious labeling of these cargo items as "do not freeze". The reasons for this incredible blunder remain unknown. In the end, the chief scientific damage was to the Argo float program, which was cancelled with all 17 floats shipped back to the USA. By what appears to be a blind stroke of good fortune, the one "do not freeze" cargo container kept above freezing contained the salinity and carbon seawater standards - with the loss of either the expedition would have been cancelled.

The other primary cargo damage incident was equally inexplicable: During unpacking it was discovered that some of the SIO ODF boxes which had been packed by SIO personnel inside an SIO-owned 20-foot standard cargo container (in excellent condition), had become wet at some point. Some of the contents of those boxes molded, and then froze. Two of the boxes had 4 and 6+ inches of water in them, frozen solid. The chief losses (after thawing and clean-up) were computer manuals, office supplies, a back-up hard drive, and some of the Chief Scientist's sea clothes. There was no evidence of leaks in the van until the steam to port. A pin-hole amount of light was recognized in the container. Inspection on the top of the container revealed that there was in fact a patch which was easily taken off revealing improper repairs to the cargo container's roof, presumably done by SIO personnel at some point prior to shipping - had left a route for water on the container's roof to drain into the container's interior.

The science team was brought to the ship at 1300 on 17 February and after a short safety briefing and ship tour, immediately set to unloading scientific cargo from the 5 20-foot container vans and setting up the CO2 lab van (a trace metal lab van was already at the ship from the previous leg). All RPSC staff on the ship (staff from the previous cruise plus staff from the S04P cruise) plus all ECO personnel were extremely helpful. The basic unloading of container vans was completed before dinner on the 17th, though as usual additional cargo was loaded over the next two days. Lab set-up for science and seas went very well, again with RPSC and ECO personnel efficiently providing assistance.

Because fueling the ship was done before it was possible to set up the labs (which is usually done while fueling), it was necessary to make that up by delaying the ship's departure one day.

RVIB Nathaniel B. Palmer departed McMurdo Base at noon local time on 20 February 2011 in good weather, into Sound waters wider open (more nearly free of sea ice) than at any other time in recent memory. The planned transit to the first station was estimated to be approximately two days. On the 21st the science team held two test/training rosette casts with the large 36-place rosette. The altimeter was not working properly (so was later replaced) and there were a few leaking bottles, easily repaired. The only potentially serious operational problem was that due to specifics of the way that SIO ODF sets up its CTD system, the CTD winch operator was not able to see the CTD pressure information (referred to as "CTD depth" by the ship) on his winch display, as he usually can when RPSC CTD equipment is being used. This problem was rectified in a few days by RPSC and ODF personnel.

The evening of the 21st the trace metal team carried out a trace metal cast of opportunity, making up a station from the previous cruise lost to weather.

During the 22nd, as the ship neared the location of the first S04P station, off Cape Adare, winds rose well past 30 knots during the day, into the low 40s, with a second storm forecast immediately following the first. It was thus necessary to wait until 1000 local time on 23 February to begin the S04P transect stations.

The S04P transect began nearly flawlessly - when the weather permitted stations. Three storms interrupted work, forcing 105 hours in time lost to weather between stations 001 and 024. But after the storm of 03-05 March abated, there was a long stretch of weather mostly suitable for work.

Unusual problems surfaced with the bottle data at two stations: evidence of bottles closing at depths other than the intended level, almost always two at one level with an adjacent skipped level. The most likely culprit was lanyard errors when cocking the rosette (both episodes were traced to the same watch), and so lanyard-carousel positional information was strengthened, as was pre-cast inspection, and this seemed to solve the problem.

One of the two Lowered Acoustic Doppler Current Profiler (LADCP) instruments on the rosette - the downward facing unit - increasingly ceased to function correctly during stations 50-52. It was swapped out with the upward-facing unit (there were no spares).

Work along the S04P line proper stopped at 150°W on 11 March when the ship headed south along 150°W - par t of the original "top priority" cruise plan in order to box in the Ross Sea as well as to complete the Antarctic end of WOCE/CLIVAR line P16 for the first time. This work went very well, with only one minor weather interruption. The 2011 work overlapped with stations from the 2005 P16S cruise from 67-71°S . Comparisons showed some water mass changes, but also general agreement where reasonable, except that the nitrate data were low, before being readjusted to the international reference standards (not available in 2005).

During the work south, email (via INMARSAT) became increasing sporadic. At the south end of P16s, the final five stations were in increasingly heavy ice, with young ice running the gamut from grease ice to new pancakes to larger, consolidated pancakes. There was also some leftover first year ice from the previous season and older ice, plus impressively thick slabs of ice that must have broken off thinning ends of ice sheets. There were also numerous icebergs, some of which were huge. Navigation to the stations was not seriously impeded by ice. The intent then was to head closer to the Continent, where ice maps obtained by the co-chief scientist seemed to show easier going, possibly where ice had been pushed offshore by the winds. Access to new ice maps was hindered by the INMARSAT problems, and so it was not yet known that the latest ice maps showed the area near the continent had closed in. Thankfully this was realized - in effect - by heavy ice conditions which severely slowed progress. Hence the ship turned to the NW to head out of the ice. The ensuing transit around the ice to the site of the "Mooring A" recovery turned into one of the scenic highlights of the voyage, because weather was excellent and there was abundant ice in many forms and wildlife.

As the ship worked near the Mooring A site, weather was deteriorating. Acoustic contact with the release was marginal at first. Via triangulation it was learned that the mooring had moved more than one mile from its February 2010 position. It became too dark to recover the mooring, and so a line of CTD stations, in the ice, was completed overnight. By morning (19 March), conditions had worsened to the point where recovery would not be feasible, and so the ship moved to the Mooring B site in an attempt to located the mooring. Winds in the 50+ knot range and worsening seas made it impossible to contact the mooring. The ship took a "comfort" course until winds subsided. Mooring A was recovered on the morning of March 20th, the only incident being accidental severing of the mooring line by the ship. But both parts had floatation and were recovered along with all instruments. At the Mooring B site it was discovered that the mooring had been moved more than 2 miles from its deployment site. It was recovered without incident. During the lines of CTD stations at each mooring site water at several hundred meters depth was observed that was colder than the freezing point at the sea surface. This can take place when cold water circulates and is cooled under floating, very deep reaching Antarctic ice shelves.

Next was a ca. 300 mile steam to the start of the next line of CTD stations. During this day and a half transit the students and other helpers dropped XBTs every 30 minutes.

As the central Ross Sea cross-shelf section was being carried out, cruise plan adjustments were discussed. On the plus side, the station work had been going well and much less time was spent in the ice than estimated when the cruise was planned. On the minus side, more than 7 days had been lost to bad weather. The cruise to that point had included work of such high scientific priority that it was carried out as planned, without reduction, with the ship waiting out bad weather. To manage time for the remainder of the cruise, it was decided to allot specific amounts of time to each remaining segment of the cruise except for required elements, such as deployment of the Yuan/Sprintall mooring. The Captain worked in a somewhat similarly: within proper maritime limits he allocated fuel in a cruise-segment manner roughly similar to our allocation of time.

It was thus decided to attempt the south-to-north line of stations along 170°W by allocating sufficient time to do 8 stations with average 43-mile spacing (but positioned to hit the deeper channels), and to then complete as much of it as the weather permits. The section across the Ross Sea slope just NW of the major shelf channels had captured cold, fresh, high-oxygen bottom waters of shelf origin on the slope. The 170°W stations would then potentially track this water into the deep interior of the Ross Sea. As it turned out there were no weather delays on the 170°W line, which was completed over 6 hours ahead of the timeline. And, indeed, a broad near-bottom core of the cold, low-salinity, high-oxygen water was sampled via the section. At the final station (095) a group of four Humpback whales swam around the ship at close range for more than two hours.

The ship then steamed eastward to a point on the S04P line (67°S) 40 nautical miles beyond the last station done on the line before turning south on P16S (150°W). Weather was worsening during the transit, and all the time gained on the 170°W line, and then some, was lost. The first station on the resumed line was moved to 45 nautical miles from the previous one, and 45-mile spacing was retained until the mooring site. Another storm blew in meanwhile, causing at least a 9-hour additional delay. Beginning at station 100 (67°S and ca. 140°W), there was a strong shift in water properties to a warmer temperature maximum, deeper and more extreme salinity maximum, and an accompanying significant shift in the isopycnals.

The only significant analytic problem on the cruise arose at station 101: the alkalinity measurements suddenly no longer met quality standards except when run by only one of the two analysts. An exhaustive search for clues and solutions was undertaken without avail. The analysts could alternate samples, with both of them watching carefully every step of the procedure, and, completely inexplicably, the results from only one of them met standards. A third analyst was trained, and that analyst had no success either. Every feasible (and not so feasible) avenue was approached, without success. In the end, it was necessary to continue to limit the number of alkalinity samples analyzed per day to those that could be run by the one analyst. Advice was provided on what samples to skip with least damage to the overall program.

After Station 102, the ship proceeded to the site of a mooring deployment for Xiaojun Yuan (LDEO) and Janet Sprintall (SIO). The specifications called for the top float of the mooring to be 100 meters below the sea surface - in ca. 4500 meters of water - plus the mooring needed to be in an area where the bottom was flat, and had to be deployed in reasonably good weather. The Palmer's multi-beam bathymetric mapping system (managed by Chris Linden, RPSC) was used to map the ocean floor. By the time the bathymetric survey was well in progress, weather was deteriorating. In addition to winds >40 knots, there was considerable mixed swell, such that even after the wind subsided, seas were too high for CTD work, let alone mooring deployment. When winds and seas eased, a CTD cast was completed at the chosen mooring deployment spot to measure the water characteristics and verify the bottom depth. There were also XBT casts and one more CTD cast associated with the mooring science program. The anchor-last deployment itself began the morning of 05 April, and went well, with the anchor ending up only about 130 meters from the desired location. The total time lost to weather during this activity was approximately 24 hours, because in ideal conditions the mooring could have been deployed one full day earlier.

The principal CTD program resumed with station 105, at 45-mile spacing from 102, though spacing was increased to 60 miles, where it stayed for the S04P (67°S) portions of the cruise until the eastern boundary stations.

After Station 117, near 104°W, the Palmer steamed south to the ice edge near the location of the southern end of the P18 (2007) line. Significant sea ice was encountered beginning ca. 69° 30'S. Initially it was possible to make good way through the ice, but increasingly large floes and especially a heavy snow cover greatly slowed progress, and penetration reached to only about 69° 50'S before the ship's officers stopped the ship. [Obviously, it was also impossible to attempt recovery of any of Stan Jacobs' moorings in the area.] (The goal had been the 500-meter isobath near 71°S.) A brief "ice party", i.e., an opportunity for the shipboard party to go out onto the ice, was held in the morning after the ship stopped, and one station was occupied after that. Because that station did not show any promising differences from the nearest P18 (2007) stations - other than what appeared to be the same CTD calibration offset seen in comparing 2007 and 2011 data at 67°S - it was decided to cut losses and head back to the S04P line so that the line could be completed with a small weather allowance.

The completion of the eastern end of the 67°S (S04P) line was remarkable in terms of ambient winds, which were very low the entire time and in fact all but one day to port. The final 8 days of sampling went very smoothly, with only some light to moderate swell and nearly no local waves. At 05:25 local time on Tuesday, 19 April 2011, the rosette from station 140, the easternmost station planned, and the last one on CLIVAR S04P, was brought into the Baltic Room. This completed the over-the-side work for the cruise, though it took a day to analyze the samples that were backlogged as the expedition crossed the eastern boundary of the study area. The ship arrived at the eastern end a little earlier than expected due to the unprecedented (for this cruise) eight day string of days with light winds, plus the equipment worked nearly flawlessly.

An incredible coincidence occurred: five days before the last CTD station was completed, Service Argos reported that a signal had been received from a long-lost mooring - a 400 meter long biophysical mooring for Dr. Richard Limeburner (Woods Hole), deployed in 450 meters of water more than ten years ago by Jim Ryder (the mooring tech on the cruise), but lost in 2001 when it failed to rise to the surface when triggered to do so. The location was only about 8 hours away. So after the final station the ship moved to the last reported location and - voila! - there it was! Jim Ryder, the RPSC marine techs, and the students and other helpers then recovered the entire string of instruments, covered with ten years of marine growth. Everything was cleaned and was stored to be returned to Dr. Limeburner.

The ship then headed to Punta Arenas, Chile. Underway weather was very good except on April 21 when winds to 30-40 knots made for a rough ride. On the way to port, on the evening of the 21st, there was a variety show on the ship, featuring skits and music from the "polliwogs" (those for whom this was their first Antarctic crossing) plus some of the "red noses". There was a traditional induction for the polliwogs the morning of the 22nd, and a cruise video night that evening.

During the long steam to port the analytic rigs, sampling equipment, and other laboratory items were broken down and packed for shipping, and the labs readied for port. The Captain chose speed and course to get the ship in ahead of schedule, arriving Saturday, April 23, 2011, at about 1800 local time instead of the planned Monday, April 25, at 0800. Unloading commenced Monday due to the Easter holiday.

Data quality on this cruise appears to meet very high quality standards. The nutrient data were a challenge in this ocean system of very low variability. They started out at the "very good" level and improved. Away from high gradient portions of the water column, the differences between the bottle salts and oxygens and the CTD values were very small. This requires both top quality bottle salts and oxygens, and skillful, attentive CTDO data processing. Perhaps the Palmer's salinometer room - one of the best set-up salinometer rooms on any research ship - contributed. The F11 and F12 sections show clean contours with little data noise. (The other parameters, including the ocean carbon data analyzed at sea, receive final processing ashore.) The data processing bringing this all together was to high standard from Day 1.

The expedition experienced an extraordinarily small amount of analytic and instrumental problems, the chief exception being the alkalinity data. There were occasional problems with the SF6 analyses, but that is a very sensitive analysis which is not yet regarded as a mainstream measurement in most CFC laboratories. Only a little more than one hour of ship time was lost due to CTD system problems. The chief cause of down time was weather, with 190 hours (8 days) lost to bad weather. At an average of 4.5 hours per station, this is the equivalent of 42 stations lost to weather.

Time lost

hours	from	to	reason
24	1200 02/19	1200 02/20	ship fueled before loading cargo (instead of after loading); science team lost one day of set-up time usually done during fueling and thus needed an extra set-up day in port
14	2000 02/22	1000 02/23	weather, then 3-4 hour transit (in good weather) to first station from sheltered location
55.5	0030 02/25	0800 02/27	weather
0.5	2130 02/27	2200 02/27	failed trace metal cast (electrical problems)
2	1300 02/28	1500 02/28	weather (then found some ice and hid in it to do a cast)
5.5	2230 02/28	0400 03/01	weather (same storm)
42	0730 03/03	0130 03/05	weather
7.5	1700 03/11	0030 03/12	weather
35	1000 03/19	1900 03/20	weather
5.5	1415 03/22	1945 03/22	weather (swell, mostly)
3	2300 03/22	0200 03/23	weather
8	2000 03/29	2200 03/29	weather
9	1800 03/31	0300 04/01	weather
24	1400 04/02	1400 04/03	mooring deployment delayed one day due to weather
3	1230 04/05	1530 04/05	weather
5	1100 04/11	1615 04/11	Chief Scientist error: ship had been asked to go further south the previous night, but Ch. Sci. was unaware the ship had stopped; could have done Station 118 the night before
0.5	1750 04/15	1820 04/15	exhaust hole blockage on main CTD; serviced & was OK

Acknowledgements

This cruise would not have been possible without the continuing advice, encouragement, and support of our NSF and NOAA program managers. The assistance of NSF in scheduling the cruise is especially appreciated. We are also grateful for the Edison Chouest Offshore support at sea from RVIB Nathaniel B. Palmer Captain Maghrabi, his officers, and crew, who contributed a great deal, daily, to the success of the cruise, and to the technicians from Raytheon Polar Services Corporation who worked every station with our science team.

This cruise was supported via these grants and the other listed sources:

NSF OCE-0919454	ODF sea work (CTDO, S, O2, nutrients, data)
NSF OCE-0752970	physical oceanography (incl. LADCP) and students
NSF OCE-0752972	NSF-supported parts of the ocean carbon program
NSF OCE-0752980	CFC and He/Tr programs
NSF OCE-0825163	C14/C13 program
NSF OCE-0962393	trace metal program
NSF OCE-0962158	aerosol program
NSF ANT-0839005	Orsi mooring program
NSF ANT-0632282	Jacobs' mooring and snow counter
NSF ANT-1043669	Yuan mooring program

The NOAA-sponsored portions of the ocean carbon program were supported by the NOAA Climate Program Office, Climate Observation Division.

The TAMU transmissometer program was supported by TAMU Account 51007340000 - Cook Professorship.

The NASA bio-optics program was supported by NASA NNX09AN94G, NASA Ocean Biology and Biogeochemistry (OBB) Calibration and Validation Office (CVO) Director Support.

Hydrographic/CTD Data, Salinity, Oxygen and Nutrients

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

The Southern Ocean S04P repeat hydrographic line was reoccupied for the US Global Ocean Carbon and Repeat Hydrography Program (sometimes referred to as "CLIVAR/CO2") during February-April 2011 from RVIB Nathaniel B. Palmer via a survey consisting of CTD/rosette/LADCP stations, trace-metal stations, and a variety of underway measurements. The ship departed McMurdo, Antarctica, on 19 February 2011 and arrived Punta Arenas, Chile, on 23 April 2011 (UTC dates).

A total of 140 stations were occupied with one CTD/rosette/LADCP cast completed at each. The expedition included in addition to the S04P transect reoccupations of segments of lines P16S and P15S, and one station overlapping with P18S (NBP-1102 stations 46-66, 77-96 and 118, respectively). CTDO profiles were collected with minimal water sampling in the vicinity of three mooring sites (stations 67-76 and 103-104). CTDO data and water samples were collected on each CTD/rosette/LADCP cast, usually to within 10 meters of the bottom. Water samples were measured on board for salinity, dissolved oxygen, nutrients, DIC, pH, total alkalinity, and CFCs. Additional water samples were collected and stored for shore analyses of helium, tritium, O-18, DOC/DON, 13C/14C, chromophoric dissolved organic matter (CDOM), phytoplankton pigments, particulate absorption and image cytoplankton, and density.

A sea-going science team gathered from 12 oceanographic institutions participated on the cruise. The programs and PIs, and the shipboard science team and their responsibilities, are listed below.

Principal Programs of CLIVAR S04P

Program	Affiliation	Principal Investigator	email
CTDO/Rosette, Nutrients, O_2, Salinity, Data Processing	UCSD/SIO	James H. Swift	jswift@ucsd.edu
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CO_2-DIC/Underway pCO_2	NOAA/PMEL	Chris Sabine	chris.sabine@noaa.gov
Total Alkalinity	SIO	Andrew Dickson	adickson@ucsd.edu
Dissolved Organic Carbon / Total Dissolved Nitrogen	UM/RSMAS	Dennis Hansell	dhansell@rsmas.miami.edu
^3He- ^3H ^{18}O	LDEO	Peter Schlosser	schlosser@ldeo.columbia.edu
pH	UM/RSMAS	Frank Millero	fmillero@rsmas.miami.edu
Underway pCO_2 with underway T&S	NOAA/AOML	Rik Wanninkhof	Rik.Wanninkhof@noaa.gov
Underway Discrete pCO_2	LDEO	Taro Takahashi	taka@ldeo.columbia.edu
Carbon/Oxygen Isotopes 13C/14C	WHOI Princeton	Ann McNichol Robert Key	amcnichol@whoi.edu key@Princeton.EDU
Trace Metals	UH FSU	Chris Measures Bill Landing	chrism@soest.hawaii.edu landing@ocean.fsu.edu
Transmissometer	TAMU	Wilf Gardner	wgardner@tamu.edu
Chromographic Dissolved Organic Matter	NASA/GSFC UCSB	Charles R. McClain Norm Nelson	charles.r.mcclain@nasa.gov norm@icess.ucsb.edu
Aerosols	FSU	Bill Landing	landing@ocean.fsu.edu
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Biogeochem, Pigments and Particulate Absorption	NASA/GSFC	Charles R. McClain	charles.r.mcclain@nasa.gov
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Mooring Deployments	LDEO SIO	Xiaojun Yuan Janet Sprintall	xyuan@ldeo.columbia.edu jsprintall@ucsd.edu

Shipboard Scientific Personnel on CLIVAR S04P

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Description of Measurement Techniques

1. CTD/Hydrographic Measurements Program

A total of 140 CTD/rosette/LADCP casts were made at 140 stations. Most casts were lowered to within 10m of the bottom.

Hydrographic measurements consisted of salinity, dissolved oxygen and nutrient water samples taken from each rosette cast. Pressure, temperature, conductivity/salinity, dissolved oxygen, transmissometer and fluorometer data were recorded from CTD profiles. Current velocities were measured by the RDI workhorse ADCP. The distribution of samples are shown in the following figures.

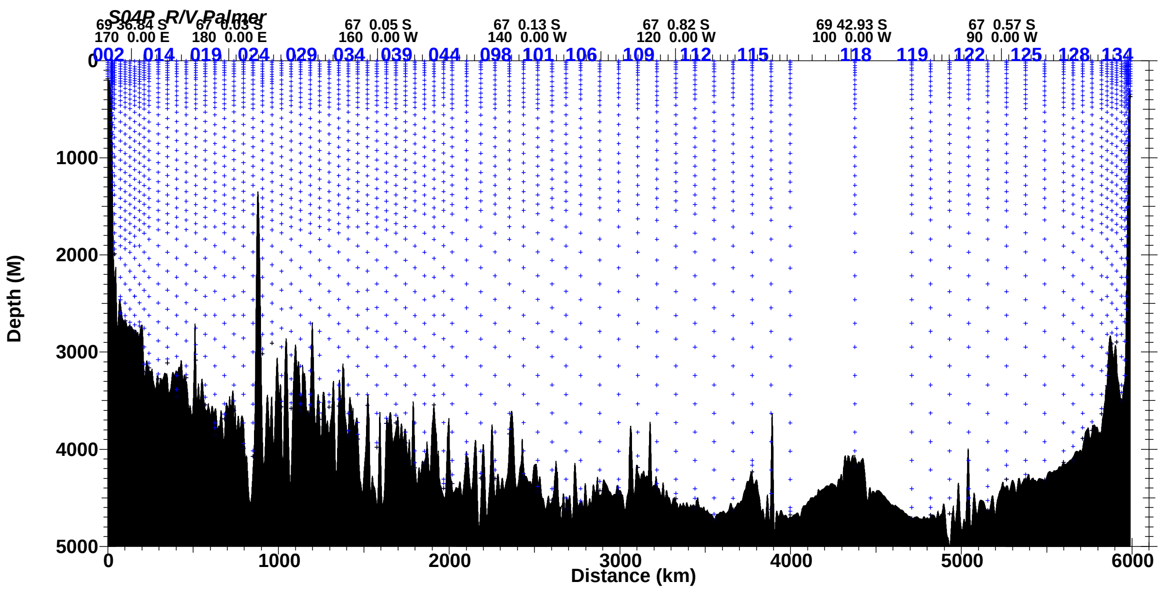

Figure 1.0 S04P Sample distribution, stations 2-45 96-102 105-140 with P18S Station 118.

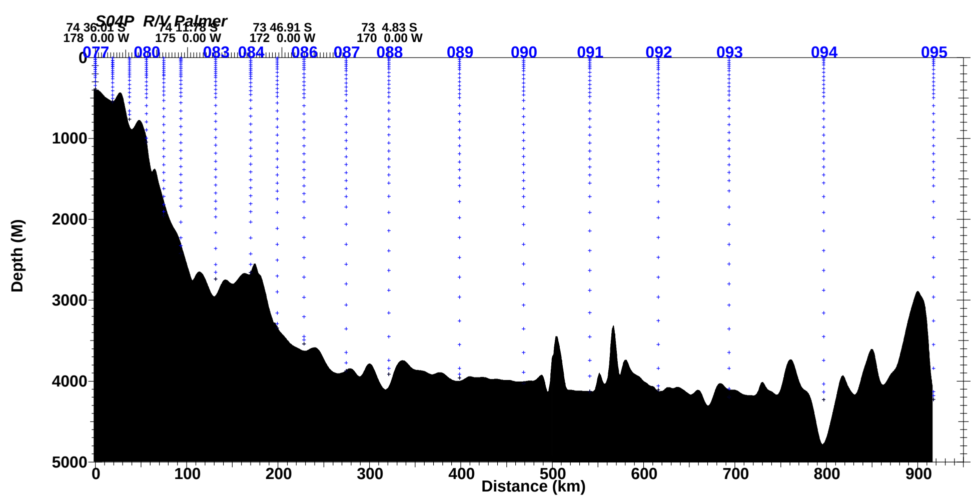

Figure 1.1 S04P Sample distribution on the southern extension of P15s, stations 77-95.

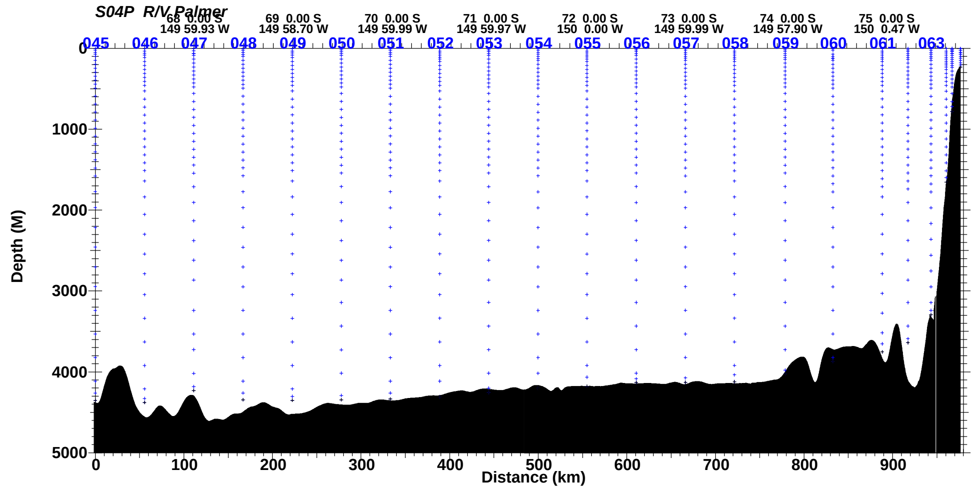

Figure 1.2 S04P Sample distribution on the southern extension of P16S, stations 45-66.

1.1. Water Sampling Package

CTD/rosette/LADCP casts were performed with a package consisting of a 36-bottle rosette frame (SIO/STS), a 36-place carousel (SBE32) and 36 10.0L Bullister bottles (SIO/STS) with an absolute volume of 10.4L. Underwater electronic components consisted of a Sea-Bird Electronics SBE9*plus* CTD with dual pumps (SBE5), dual temperature (SBE3*plus*), reference temperature (SBE35RT) dual conductivity (SBE4C), dissolved oxygen (SBE43), transmissometer (Wetlabs), fluorometer (Wetlabs), altimeter (Benthos) and LADCP (RDI).

The CTD was mounted vertically in an SBE CTD cage attached to the bottom of the rosette frame and located to one side of the carousel. The SBE4C conductivity, SBE3*plus* temperature and SBE43 dissolved oxygen sensors and their respective pumps and tubing were mounted vertically in the CTD cage, as recommended by SBE. Pump exhausts were attached to the CTD cage on the side opposite from the sensors and directed downward. The transmissometer was mounted horizontally, and the fluorometer was mounted vertically near the bottom of the rosette frame. The altimeter was mounted on the inside of the bottom frame ring. The 300 KHz bi-directional Broadband LADCP (RDI) was mounted vertically on the top and bottom sides of the frame. Its battery pack was located opposite the flourometer, also mounted on the bottom of the frame. Table 1.1.0 shows height of the sensors referenced to the bottom of the frame.

Instrument	Height in cm
Temperature/Conductivity Inlet	9
SBE35	9
Altimeter	2
Transmissometer	5
Chlorophyll Fluorometer	15
Pressure Sensor, inlet to capillary tube	17
Inner bottle midline	109
Outer bottle midline	113
ADCP face midline (bottom)	7
ADCP face midline (top):	183
Zero tape	266

Table 1.1.0 Heights referenced to bottom of rosette frame

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 S04P. A electrical retermination was performed during the 2-day run to station 24. A full re-termination (preventatively, electrical and mechanical) was performed after station 95, during the 2-day run to Station 96. The RVIB Nathaniel B. Palmer's DESH-5 winch was used for all casts.

The deck watch prepared the rosette 10-30 minutes prior to each cast. The bottles were cocked and all valves, vents and lanyards were checked for proper orientation. Once stopped on station, the ship's crew and Marine Technician would check the sea state prior to cast and decide if conditions were acceptable for deployment. All decisions and policies on board the NBP were respected, benefiting both parties interests. Overall the deployment and recovery of the CTD rosette on board the RVIB Nathaniel B. Palmer (NBP) went very well and were accomplished without incident. The typical procedure was as follows:

1) Remove securing straps from rosette
2) Open hydraulically locked Baltic Room bulkhead door
3) Pay in wire to pull rosette towards door on sliding track
4) Once rosette is centered under the squirt boom block, the rosette is lifted off the deck
5) Simultaneous extension of squirt boom while paying out wire kept the rosette level and in position to fit through the limited clearance allowed by the width and height of the Baltic Room door. (Approximately 4" on either side of 36 place rosette, and approximately 1' clearance from bottom of door to base of rosette.)
6) Continue to extend boom and level rosette until full extension is reached.
7) Time the lowering of the rosette with the sea conditions.

Due to the confined space and limited scope of wire available to adjust rosette height (approximately 8-16 inches from cable grip to block) the procedure required precise handling of winch controls, especially in the timing of the extension and wire payout. All winch operators were extremely proficient and paid very careful attention to this aspect of CTD operations. Once the boom had reached full extension, the Marine Technician (MT) directed the winch operator in the timing of lowering the rosette into the water, as at this point the winch operator no longer has visual contact with the CTD package.

Most rosette casts were lowered to within 10 meters of the bottom, using the altimeter, winch wire-out, CTD depth and multibeam depth.

For each up-cast, the winch operator was directed to stop the winch at up to 36 predetermined sampling depths. These standard depths were staggered every station using 3 sampling schemes. The CTD console operator waited 30 seconds prior to tripping sample bottles, to ensure package shed wake had dissipated. An additional 10 seconds elapsed before moving to the next consecutive trip depth, which allowed for the SBE35RT to record bottle trip temperature.

Recovering the package at the end of the deployment was essentially the reverse of launching. The RPSC marine technician and winch operator guided the rosette back through the open water tight door and used lines to secure the package to the Baltic Room floor.

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.

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

Specific difficulties encountered when deploying on the NBP included:

1) Slow deployment time due to tight fit of rosette through door, and limited adjustment of wire scope.
2) Risk of taking a wave through the open Baltic Room door and flooding the room, (specific risk to electronic winch controls). Waves can often reach chest height.

3) Wave hitting rosette while passing through doorway or while lowering rosette into water leading to potential shock loading. A high strength bungee system was employed to help counter act shock loading.

1.2. Underwater Electronics

The SBE9*plus* CTD supplied a standard SBE-format data stream at a data rate of 24 frames/second.

Instrument/Sensor	Mfr./Model	Serial Number	A/D Channel	Stations Used
Carousel 36-pl Sampler	Sea-Bird SBE32	3216715-0187		Test,2-140
Reference Temperature	Sea-Bird SBE35	35-0011		Test,2-140
CTD	Sea-Bird SBE9*plus* SIO	831		Test,2-140
Pressure	Paroscientific Digiquartz	99677		Test,2-140
Primary Temperature	Sea-Bird SBE3*plus*	03P-4943		Test,2-10
Primary Temperature	Sea-Bird SBE3*plus*	03P-5046		11-140
Primary Conductivity	Sea-Bird SBE4C	04-3057		Test,2-10
Primary Conductivity	Sea-Bird SBE4C	04-2593		11-140
Dissolved Oxygen	Sea-Bird SBE43	43-1136	Aux4/V6	Test,2-140
Primary Pump	Sea-Bird SBE5T	05-3334		Test,2-140
Secondary Temperature	Sea-Bird SBE3*plus*	03P-5046		Test,2-10
Secondary Temperature	Sea-Bird SBE3*plus*	03P-4943		11-140
Secondary Conductivity	Sea-Bird SBE4C	04-3176		Test
Secondary Conductivity	Sea-Bird SBE4C	04-2593		2-10
Secondary Conductivity	Sea-Bird SBE4C	04-3399		11-140
Secondary Pump	Sea-Bird SBE5T	05-3376		Test,2-140
Transmissometer	WETLabs C-STAR	CST-327DR	Aux3/V4	Test,2-140
Fluorometer	WETLabs	SCF2743	Aux1/V0	Test,2-140
Altimeter (500m)	Simrad 1007	90107	Aux2/V2	Test
Altimeter (100m)	Benthos PSA-916D	45531	Aux2/V2	2-124
Altimeter (100m)	Benthos PSA-916D	47042	Aux2/V2	125-140
LADCP Down	RDI Workhorse 300kHz	12734		Test,2-52
LADCP Up	RDI Workhorse 300kHz	13330		Test,2-52
LADCP Down	RDI Workhorse 300kHz	13330		53-140
Deck Unit	Sea-Bird SBE11	11P47914-0768		Test,2-140

Table 1.2.0 CLIVAR S04P Rosette Underwater Electronics.
Transmissometer provided by TAMU; Altimeter 47042 and Deck-Unit provided by USAP; LADCP provided and operated by UH. All other sensors belong to SIO/STS/ODF.

An SBE35RT reference temperature sensor was connected to the SBE32 carousel and recorded a temperature for each bottle closure. These temperatures were used as additional CTD calibration checks. The SBE35RT was utilized per the manufacturer's specifications and instructions, as described on their website, www.seabirdelectronics.com.

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

1.3. Navigation and Bathymetry Data Acquisition

Navigation data were acquired at 1-second intervals from the ship's Kongsberg Seatex Seapath GPS 200 (receiver "1") by a Linux system beginning 19 February 2011.

Centerbeam bathymetric data from the Kongsberg Simrad EM-120 multibeam echosounder system were fed realtime into the STS acquisition system and merged with navigation data. Depth data displayed by the ship were 7m deeper than the feed to STS; a 7m hull depth offset was added later to STS depth data for all events stored in the hydrographic database.

Bottom depths associated with rosette casts were also recorded on the Console Logs during deployments. The Kongsberg Simrad EM-120 centerbeam depths were typically used. In addition, uncorrected (1500 m/sec) LF/3.5 kHz data from a Knudsen 320 (LF/3.5 kHz) system were also displayed for comparison or as an alternate source for bottom depth when the multibeam signal was out of range or unavailable.

CTD Depth plus Distance Above Bottom (DAB) are reported in STS/ODF bottle and CTD data files for ocean-bottom depth whenever both of these data values were available; otherwise, centerbeam bottom depths are reported. Corrected multibeam center depths are reported for each cast event in the WOCE 90-1 format ".sum" file.

1.4. CTD Data Acquisition and Rosette Operation

The CTD data acquisition system consisted of an SBE-11*plus* (V2) deck unit and three networked generic PC workstations running CentOS-5.5 Linux. Each PC workstation was configured with a color graphics display, keyboard, trackball and DVD+RW drive. One system had a Comtrol Rocketport PCI multiple port serial controller providing 8 additional RS-232 ports. The systems were interconnected through the ship's network. These systems were available for real-time operational and CTD data displays, and provided for CTD and hydrographic data management.

One of the workstations was designated the CTD console and was connected to the CTD deck unit via RS-232. The CTD console provided an interface and operational displays for controlling and monitoring a CTD deployment and closing bottles on the rosette. Another of the workstations was designated the website and database server and maintained the hydrographic database for S04P. Redundant backups were managed automatically.

CTD deployments were initiated by the console watch after the ship had stopped on station. The acquisition program was started and the deck unit turned on at least 3 minutes prior to package deployment. The watch maintained a console operations log containing a description of each deployment, a record of every attempt to close a bottle and any relevant comments. The deployment and acquisition software presented a short dialog instructing the operator to turn on the deck unit, to examine the on-screen CTD data displays and to notify the deck watch that this was accomplished.

Once the deck watch had deployed the rosette, the winch operator lowered it to 10 meters, deeper in heavier seas. The CTD sensor pumps were configured with a 5-second start-up delay after detecting seawater conductivities. The console operator checked the CTD data for proper sensor operation and waited for sensors to stabilize, then instructed the winch operator to bring the package to the surface and descend to a specified target depth, based on CTD pressure available on the winch display. The profiling rate was at most 30m/min to 100m and 60m/min deeper than 100m, depending on sea cable tension and sea state.

The progress of the deployment and CTD data quality were monitored through interactive graphics and operational displays. Bottle trip locations were transcribed onto the console and sample logs. The sample log was used later as an inventory of samples drawn from the bottles. The altimeter channel, CTD depth, winch wire-out and bathymetric depth were all monitored to determine the distance of the package from the bottom, allowing a safe approach to 8-10 meters.

Bottles were closed on the up-cast by operating an on-screen control. The expected CTD pressure was reported to the winch operator for every bottle trip. Bottles were tripped 30-40 seconds after the package stopped to allow the rosette wake to dissipate and the bottles to flush. The winch operator was instructed to proceed to the next bottle stop at least 10 seconds after closing bottles to ensure that stable CTD data were associated with the trip and to allow the SBE35RT temperature sensor to measure bottle trip temperature.

It was necessary at some stations in higher sea states to close shallower bottles (normally only the shallowest bottle) on the fly due to the need to keep tension on the CTD cable. At those closures - always noted on the CTD Console Log Sheet - the SBE35RT temperature is not usable.

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

1.5. CTD Data Processing

Shipboard CTD data processing was performed automatically during and after each deployment using SIO/STS CTD processing software v.5.1.6-1.

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

At the completion of a deployment a sequence of processing steps were performed automatically. The 0.5-second time series data were checked for consistency, clean sensor response and calibration shifts. A 2-decibar pressure series was generated from the down cast data. The pressure-series data were used by the web service for interactive plots, sections and CTD data distribution. Time-series data were also available for distribution through the website.

CTD data were routinely examined for sensor problems, calibration shifts and deployment or operational problems. The primary and secondary temperature sensors (SBE3*plus*) were compared to each other and to the SBE35 temperature sensor. CTD conductivity sensors (SBE4C) were compared to each other, then calibrated by examining differences between CTD and check sample conductivity values. CTD dissolved oxygen sensor data were calibrated to check sample data. Theta-Salinity and theta-O_2 comparisons were made between down and up casts as well as between groups of adjacent deployments.

A total of 140 casts were made using the 36-place CTD/LADCP rosette. Further elaboration of CTD procedures specific to this cruise are found in the next section.

1.6. CTD Acquisition and Data Processing Details

During the run to the Eastern Ross Sea mooring sites, routine Theta-Salinity overlays of deep pressure-series (downcast) data showed that primary sensors were not overlaying the bottle data. Closer examination showed that downcast salinity data were routinely 0.001 to 0.002 PSU lower than upcast salinity data. This was not an issue for the secondary sensors. It was decided to use the secondary sensors for reporting data wherever possible, and only use the primary sensors where the secondary sensors were not usable. This did not seem to have any effect on oxygen data, which was connected into to the primary ducting.

Another problem also surfaced while examining time-series data in more detail on both Theta-Salinity plots and property-property plots near density inversions. The data for both sensors was unusually noisy, more than could be attributed to shiproll. The SBE11 deck unit settings were checked, and both sensors had the standard 0.073-second "advance". Various tests were performed, which showed that both sensor pairs required additional lags to match the TC data for the least noisy salinity data. T1C1 required an 0.06-second lag, and T2C2 required an additional 0.05-second lag.

Various reasons were proposed for this unusual extra lag, directly related to the low water temperatures - rarely outside ±2°C. It is suspected that this either slowed down the pump rates, or the conductivity sensor responses.

All CTD data were re-averaged through station 96 using the additional lags, and noise was greatly reduced for both sensor pairs. The lags were used for initial processing for the remainder of the casts.

Altimeter 90107 (500m range) was replaced by Altimeter 45531 (100m range) after the second Test cast because it was reading 50m too far off the bottom. C2/3176 was replaced by C2/2593 at the same time because it was anywhere from 0.02 to 0.06 mS/cm lower than C1, with a notable drift between its own down and up casts. The deck unit alarm went off when the first test cast went into the water; perhaps this is related to the bad conductivity sensor values.

C1/3057 was replaced by C2/3399 after station 10 due to excessive drift from cast to cast in the first 10 stations. The secondary TC sensors were shifted into the primary ducting, and the previous primary T was shifted into the secondary ducting with the new conductivity sensor. The original secondary TC sensors were used for reporting data for stations 2-10.

The secondary TC sensors were used for all data reported for stations 11-140, except where those sensors were not usable. The following stations used the primary sensors for reporting data:

042/01 spiking/offsets/noise on C2: high late downcast, low all of upcast.

043/02 spiking/offsets (high) on C2 downcast until just above 2900db; upcast still noisy.

076/01 problems with C2 stabilizing at start of cast, T2 also intermittently flaky. lowering to 20-30db did not help. Appeared to clear itself around 40-60db.

077/01 similar problem to station 76: unstable at surface, stabilized deeper in cast.

Secondary pump 05-3376 was replaced with 05-4377 after station 77 and resolved the stabilization problems. A bench test showed no problem with the original pump.

Altimeter 45531 flooded during station 124, and was replaced by Altimeter 47042, with the same make/model/range.

The following table reflects other misc. problems noted during specific casts:

station/ cast	Comment
3/1	inflection at surface in all parameters mirrors upcast - ok.
11/1	blockage in tubing or frozen at top of cast, start pressure-sequencing at 10db
16/1	Conductivity sensors not stable until 14db down, oxygen not stable until much deeper. Probable freezing issue in pump tubes: upcast shows a big mixed layer. Top 28db of raw CTDO data despiked to same value as 28db (after it stabilized), before fitting. Coded CTDO as questionable because so much was extrapolated.
17/1	unusually noisy data: vertically mounted CTD was vibrating significantly within its cage. 3 of the 4 cage mounting bolts were completely loose. They were cranked down with a socket.
22/1	Noisy, possible biological contamination on first descent to 35m; used second yoyo/start-down to start pressure-sequencing
23/2	CTD alarm went off near bottom of cast, 31 "sync" errors during cast. Mechanical retermination done during 2-day run to station 24.
45/1	Stop at 3908m down cast to work on wire.
53/1	Downward-looking ADCP (12734) removed from rosette between stations 52 and 53. Upward-looking ADCP (13330) was moved to the downward-looking ADCP position.
59/2	Prior to deployment, cleaned air bleed hole and rinsed/flushed system with Triton-X.
62/1	first cast attempt aborted after launch due to reported bubbles coming up from rosette when sitting at 10m. No problem found, re-used same cast number.
69/1	carousel froze: No bottles closed.
78/1	Down to 20m for equilibration then up to 15m weather/seas issue. Conductivity response much better this cast.
82/1	Did not bring to surface before downcast: cast begins at 8db.
85/1	offset in all sensors on upcast at ˜1350db. Post cast: found ˜2-inch long weird fish in tube, looked like a combination between a dark brown slug and an earwig, with little fins.
95/1	full preventative re-termination (electrical and mechanical) after sta. 95, during 2-day run to sta.96.
96/1	downcast started at 8db.
98/1	Altimeter did not give a reading (true value) until ˜35m above the bottom, it has ’kicked in’ at ˜70m.
109/1	Start downcast at 20db due to heavy roll (no yoyo back to surface).
126/2	Cast stopped at 100m due to odd CTD data, brought back on deck; visual inspection showed no apparent blockage or loose connectors. Sucked out pumps w/syringe, flushed w/DI slight pooling of water above exhaust hole (primary) cleaned exhaust holes on both tubing section. Flushed with DI, suctioned water w/syringe re-deployed as cast 3.

1.7. CTD Sensor Laboratory Calibrations

Laboratory calibrations of the CTD pressure, temperature, conductivity and dissolved oxygen sensors were performed prior to CLIVAR S04P. The calibration dates are listed in table 1.7.0.

Sensor	S/N	Date	Calib. Facility	Stations Used
Paroscientific Digiquartz Pressure	99677	01 Nov 2010	SIO/STS	Test,2-140
Sea-Bird SBE3*plus* T1 Temperature	03P-4943	09 Nov 2010	SIO/STS	Test,2-10
Sea-Bird SBE3*plus* T1 Temperature	03P-5046	09 Nov 2010	SIO/STS	11-140
Sea-Bird SBE3*plus* T2 Temperature	03P-5046	09 Nov 2010	SIO/STS	Test,2-10
Sea-Bird SBE3*plus* T2 Temperature	03P-4943	09 Nov 2010	SIO/STS	11-140
Sea-Bird SBE4C C1 Conductivity	04-3057	28 Oct 2010	SBE	Test,2-10
Sea-Bird SBE4C C1 Conductivity	04-2593	28 Oct 2010	SBE	11-140
Sea-Bird SBE4C C2 Conductivity	04-3176	20 Aug 2010	SBE	Test
Sea-Bird SBE4C C2 Conductivity	04-2593	28 Oct 2010	SBE	2-10
Sea-Bird SBE4C C2 Conductivity	04-3399	11 Nov 2010	SBE	11-140
Sea-Bird SBE43 Dissolved Oxygen	43-1136	20 Sep 2010	SBE	Test,2-140
Sea-Bird SBE35 Reference Temperature	35-0011	10 Dec 2010	SBE	Test,2-140

Table 1.7.0 CLIVAR S04P CTD sensor laboratory calibrations.

1.8. CTD Shipboard Calibration Procedures

CTD #831 was used for all CTD/rosette/LADCP casts during S04P. The CTD was deployed with all sensors and pumps aligned vertically, as recommended by SBE.

The SBE35RT Digital Reversing Thermometer (S/N 3516590-0011) served as an independent calibration check for T1 and T2. *In situ* salinity and dissolved O_2 check samples collected during each cast were used to calibrate the conductivity and dissolved O_2 sensors.

1.8.1. CTD Pressure

The Paroscientific Digiquartz pressure transducer (S/N 831-99677) was calibrated in November 2010 at the SIO/STS Calibration Facility. The calibration coefficients provided on the report were used to convert frequencies to pressure. The SIO/STS pressure calibration coefficients already incorporate the slope and offset term usually provided by Paroscientific.

Pre- and post-cast on-deck/out-of-water pressure offsets varied from -0.28 to +0.47 dbar before the casts, and -0.26 to +0.43 dbar after the casts. The in/out pressures within a cast were very consistent; most of the variation can be attributed to lows and highs in atmospheric pressure (including a day or two of more than 1020mb, and another period over 1010mb). No adjustments were made to calculated pressures.

1.8.2. CTD Temperature

The same two temperature sensors (03P-4943 and 03P-5046) were used during all S04P casts. 4943 started out in the primary ducting, and 5046 in the secondary. After station 10, the secondary TC pair was physically shifted to the primary circuit, and the original primary T was shifted to the secondary circuit with a new conductivity sensor. For the purposes of this report, T1 will refer to sensor 5046, and T2 to sensor 4943 (referring to where they were ducted for most of the cruise).

Calibration coefficients derived from the pre-cruise calibrations, plus shipboard temperature corrections determined during the cruise, were applied to raw primary and secondary sensor data during each cast.

A single SBE35RT was used as a tertiary temperature check. It was located equidistant between T1 and T2 with the sensing element aligned in a plane with the T1 and T2 sensing elements. The SBE35RT Digital Reversing Thermometer is an internally-recording temperature sensor that operates independently of the CTD. It is triggered by the SBE32 carousel in response to a bottle closure. According to the manufacturer’s specifications, the typical stability is 0.001°C/year.

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

A single temperature correction was required for each sensor during CLIVAR S04P. Both primary and secondary temperature sensors exhibited a linear pressure response compared to the SBE35RT. Offsets for both temperature sensors remained stable through-out the cruise, and did not warrant any adjustment.

The final corrections for temperature data reported on CLIVAR S04P are summarized in Appendix A. All corrections made to CTD temperatures had the form:

$$T_{ITS90} = T + tp_1 P + t_0$$

Residual temperature differences after correction are shown in figures 1.8.2.0 through 1.8.2.8.

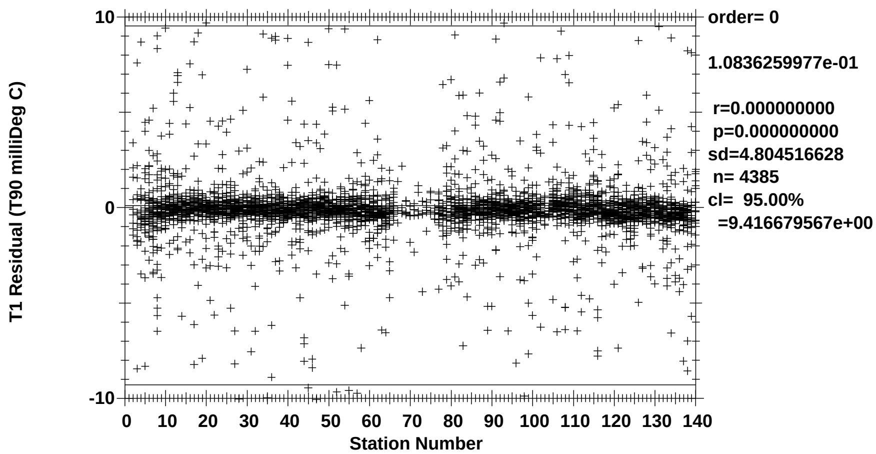

Figure 1.8.2.0 SBE35RT-T1 by station ($-0.01°C \le T1 - T2 \le 0.01°C$).

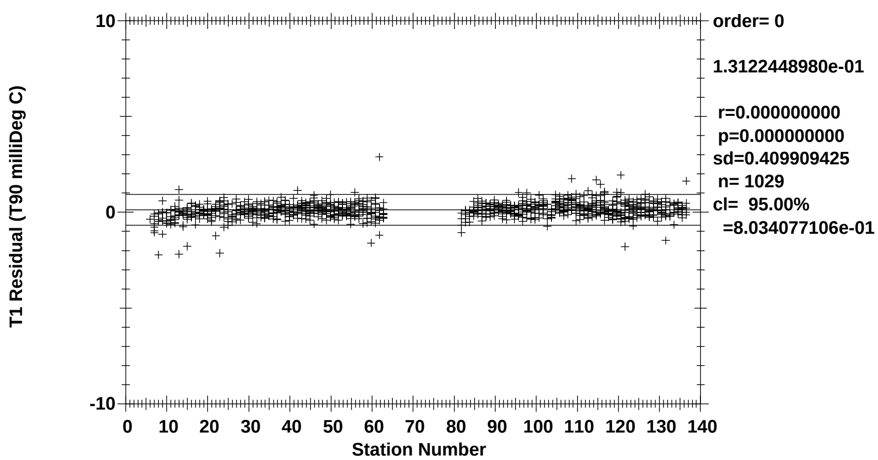

Figure 1.8.2.1 Deep SBE35RT-T1 by station (Pressure >= 2000dbar).

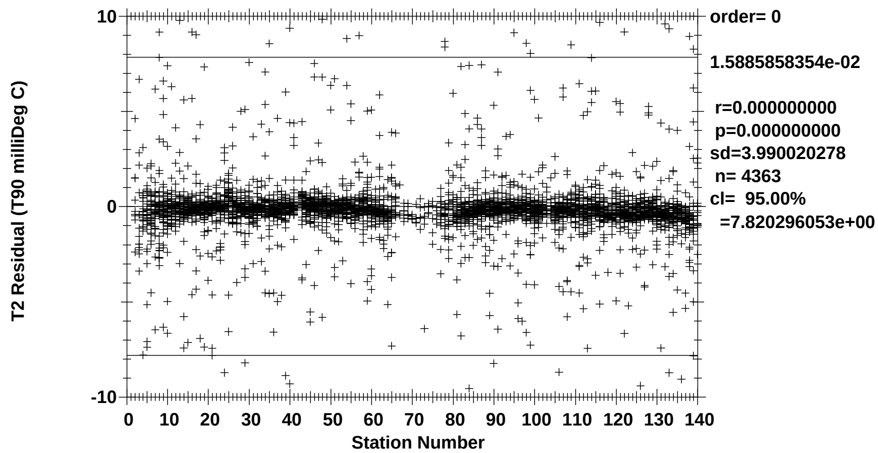

Figure 1.8.2.2 SBE35RT-T2 by station (-0.01°C $\le T1 - T2 \le$ 0.01°C).

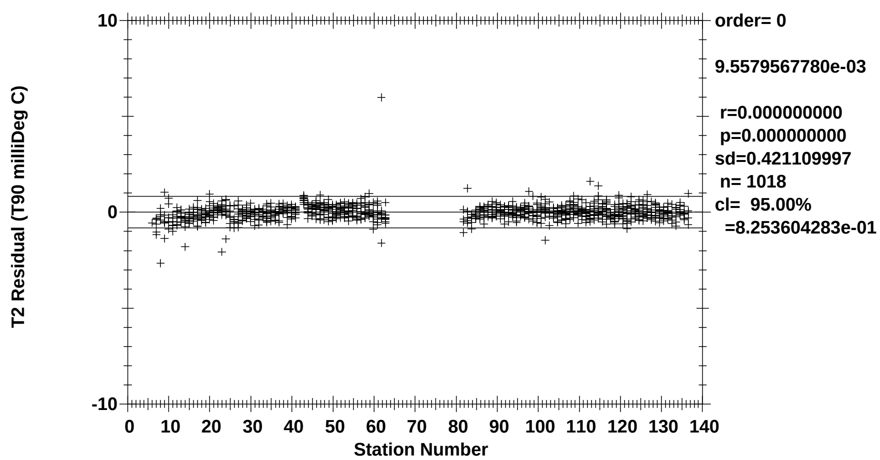

Figure 1.8.2.3 Deep SBE35RT-T2 by station (Pressure >= 2000dbar).

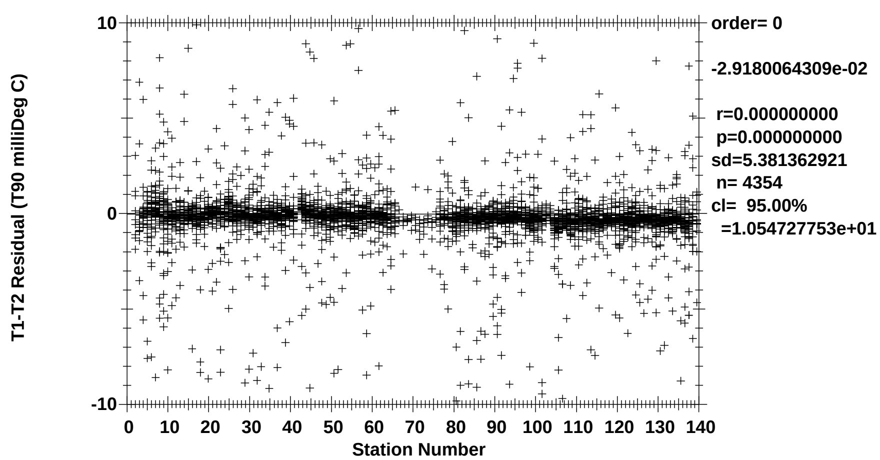

Figure 1.8.2.4 T1-T2 by station (-0.01°C $\le T1 - T2 \le$ 0.01°C).

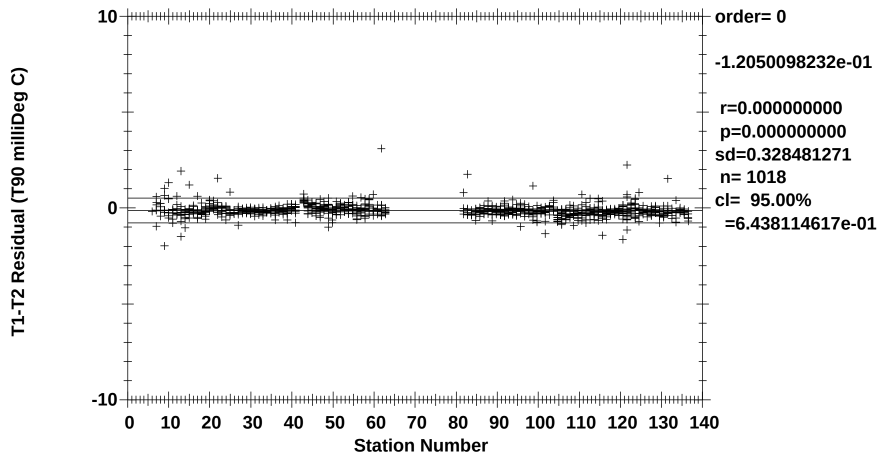

Figure 1.8.2.5 Deep T1-T2 by station (Pressure >= 2000dbar).

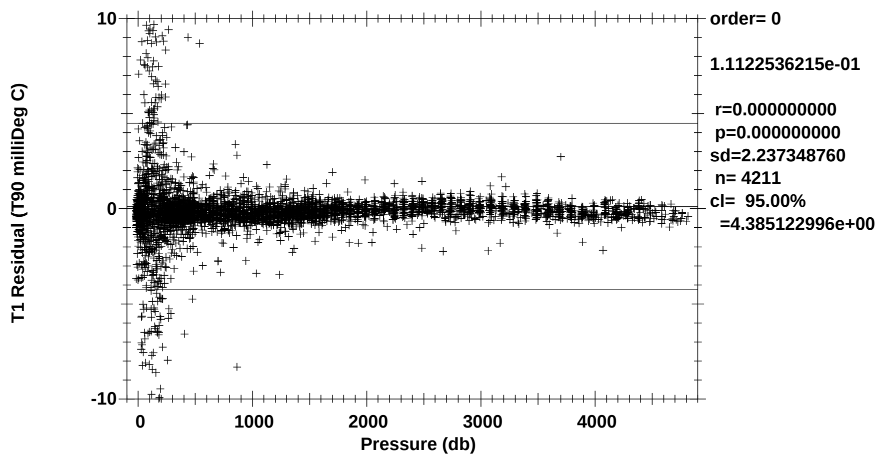

Figure 1.8.2.6 SBE35RT-T1 by pressure (-0.01°C $\leq T1 - T2 \leq$ 0.01°C).

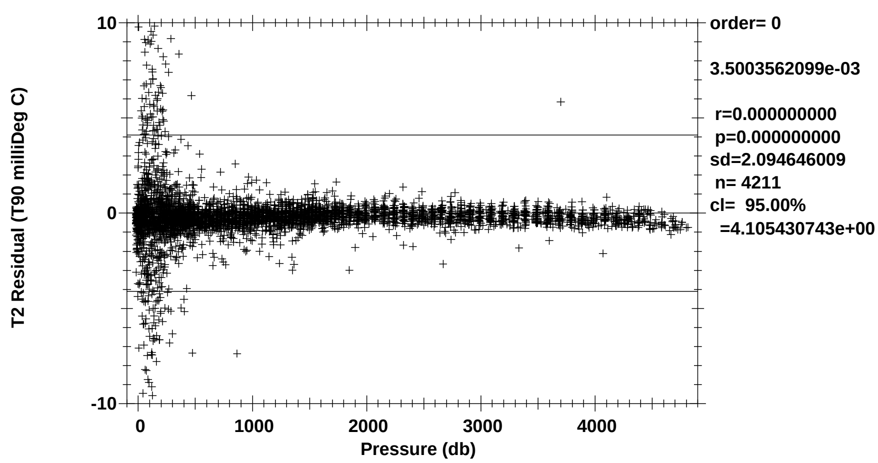

Figure 1.8.2.7 SBE35RT-T2 by pressure (-0.01°C $\leq T1 - T2 \leq$ 0.01°C).

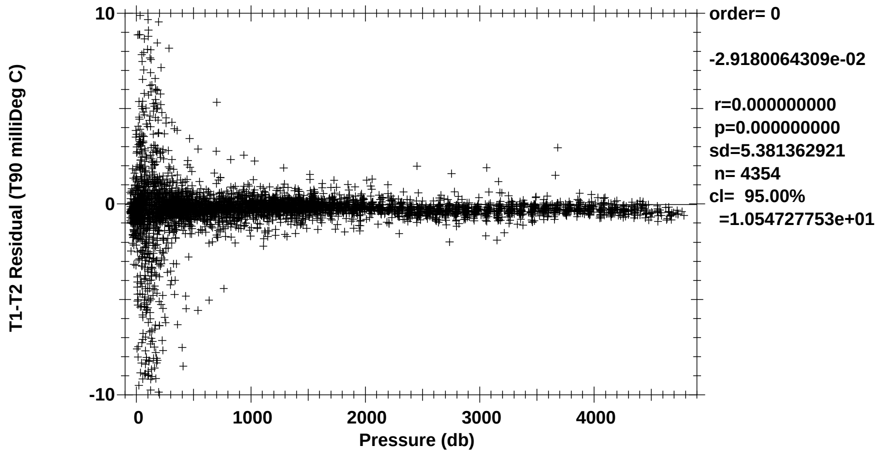

Figure 1.8.2.8 T1-T2 by pressure (-0.01°C $\leq T1-T2 \leq$ 0.01°C).

The 95% confidence limits for the mean low-gradient differences are ±0.00942°C for SBE35R T-T1, ±0.00782°C for SBE35R T-T2 and ±0.01055°C for T1-T2. The 95% confidence limit for deep temperature residuals (where pressure > 2000db) is ±0.00080°C for SBE35R T-T1, ±0.00083°C for SBE35R T-T2 and ±0.00064°C for T1-T2.

1.8.3. CTD Conductivity

Two conductivity sensors were rejected for drift issues: secondary sensor 04-3176 was replaced after the test cast, and primary sensor 04-3057 was replaced after station 10. No data were used from either of these sensors. After station 10, the secondary TC pair was physically shifted to the primary circuit, and the original primary T was shifted to the secondary circuit with the new conductivity sensor.

Secondary sensor 04-2593 was used on stations 2-10, then shifted to primary after station 10. It will be referred to as C1 for the purposes of this report. The new conductivity sensor (04-3399) was placed in the secondary position from station 11 to the end of the cruise, and will be referred to as C2 in this report.

Calibration coefficients derived from the pre-cruise calibrations were applied to convert raw frequencies to conductivity. Shipboard conductivity corrections, determined during the cruise, were applied to primary and secondary conductivity data for each cast.

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

The differences between primary and secondary temperature sensors were used as filtering criteria to reduce the contamination of conductivity comparisons by package wake. The coherence of this relationship is shown in figure 1.8.3.0.

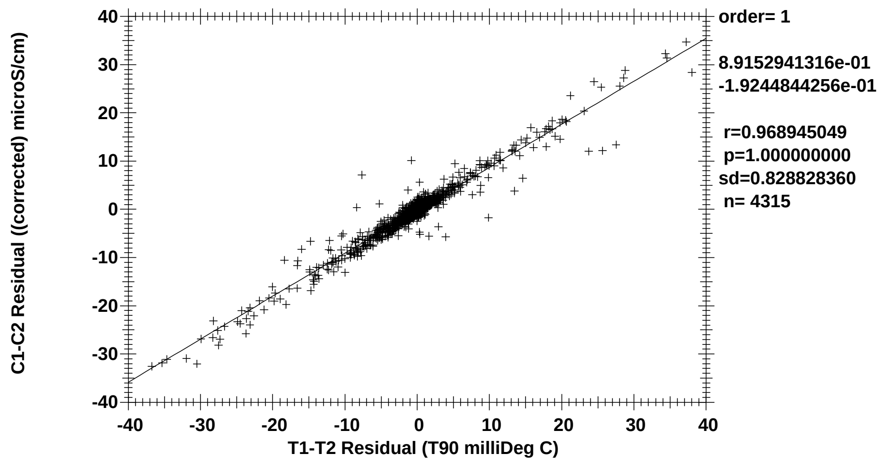

Figure 1.8.3.0 Coherence of conductivity differences as a function of temperature differences.

Uncorrected conductivity comparisons are shown in figures 1.8.3.1 through 1.8.3.3.

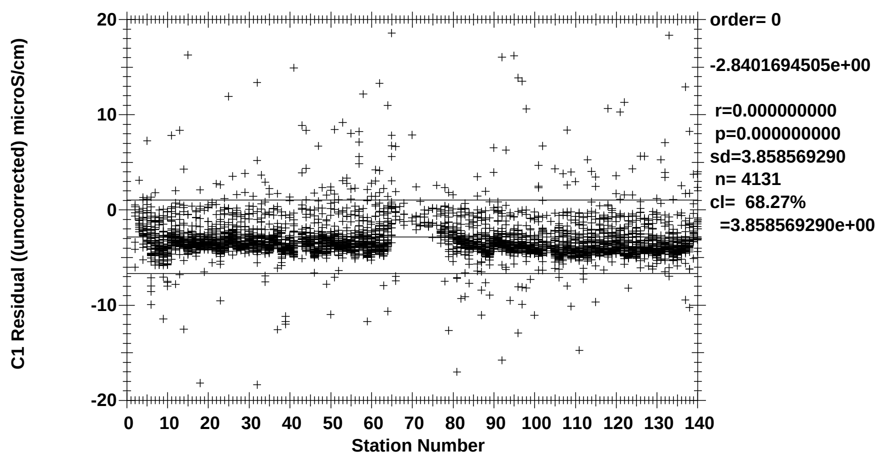

Figure 1.8.3.1 Uncorrected $C_{Bottle} - C1$ by station (-0.01°C $\leq T1 - T2 \leq$ 0.01°C).

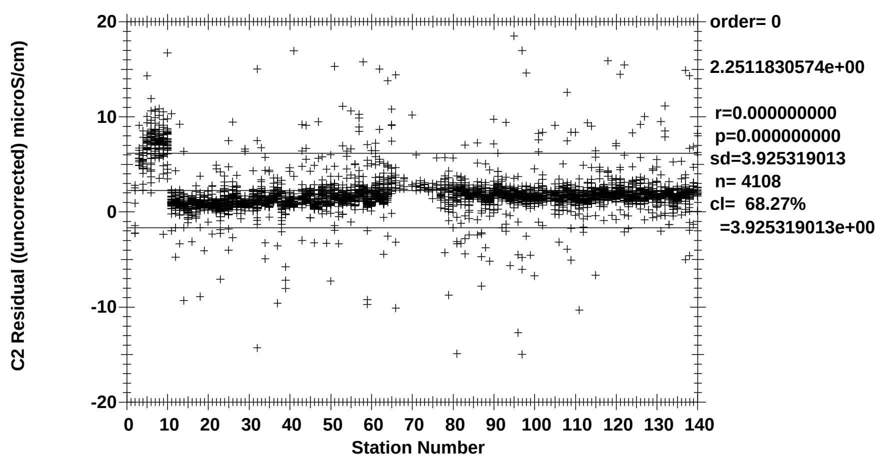

Figure 1.8.3.2 Uncorrected $C_{Bottle} - C2$ by station (-0.01°C $\leq$T1-T2$\leq$0.01°C).

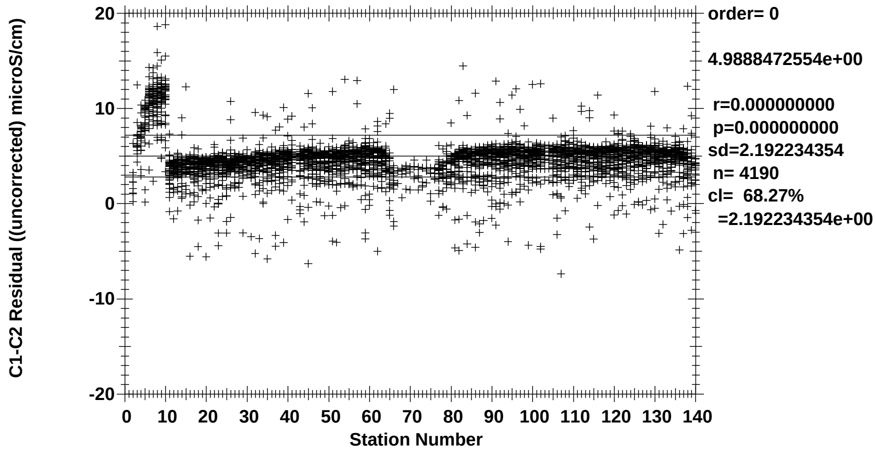

Figure 1.8.3.3 Uncorrected $C1 - C2$ by station (-0.01°C $\leq T1 - T2 \leq$ 0.01°C).

Offsets for each C sensor were determined using $C_{Bottle} - C_{CTD}$ differences in a deeper pressure range (500 or more dbars). C1 generally displayed no drift with time, although offsets were adjusted for stations 2-10, while the conductivity sensor was still acclimating at the start of the cruise. C2 offsets had a steady, slow shift with time; the rate of change flattened about halfway through the cruise. C2 offsets were last evaluated for stations 11-85; then station 85's C2 offset was used for later stations.

After conductivity offsets were applied to all casts, response to pressure and conductivity were examined for each conductivity sensor. The pressure response was not very linear for C1, so residual differences were examined against conductivity first. All differences from stations 2-9 were used to determine a linear correction as a function of conductivity, which held throughout the cruise.

C1 and C2 pressure-dependent corrections were then determined. Only casts deeper than 4000db, and differences deeper than 500db, were used to determine the coefficients for C1, stations 2-76. Excluding shallower values corrected deep conductivity data better without skewing the shallow data. All stations, and all pressure ranges, were used to determine pressure-response coefficients for C2, stations 11-76.

After the pressure dependency was corrected, residual differences were examined against conductivity for C2. A linear correction as a function of conductivity was determined using stations 11-81, including only data where (T1-T2) differences were within ±0.005°C.

Differences were monitored for both sensors during the rest of the cruise. No further adjustment to the pressure- or conductivity-dependent coefficients was warranted. Deep Theta-S overlays showed that deep CTD data overlaid well for the data reported.

The residual conductivity differences after correction are shown in figures 1.8.3.4 through 1.8.3.15.

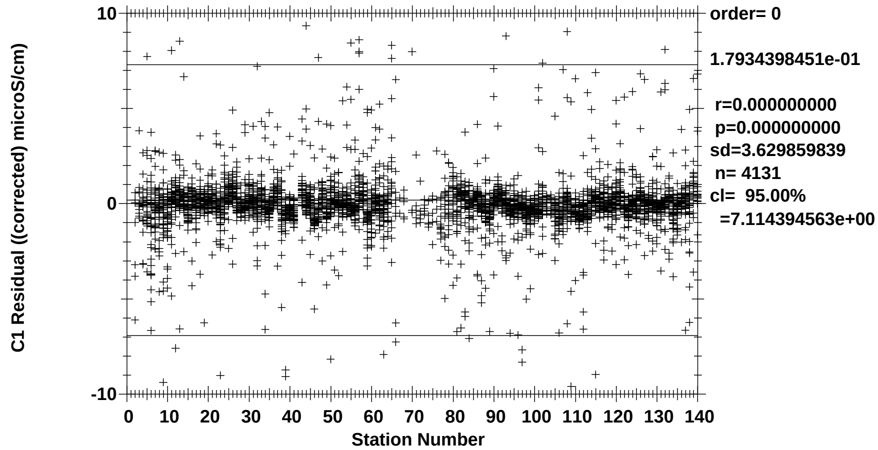

Figure 1.8.3.4 Corrected $C_{Bottle} - C1$ by station (-0.01°C ≤T1-T2≤0.01°C).

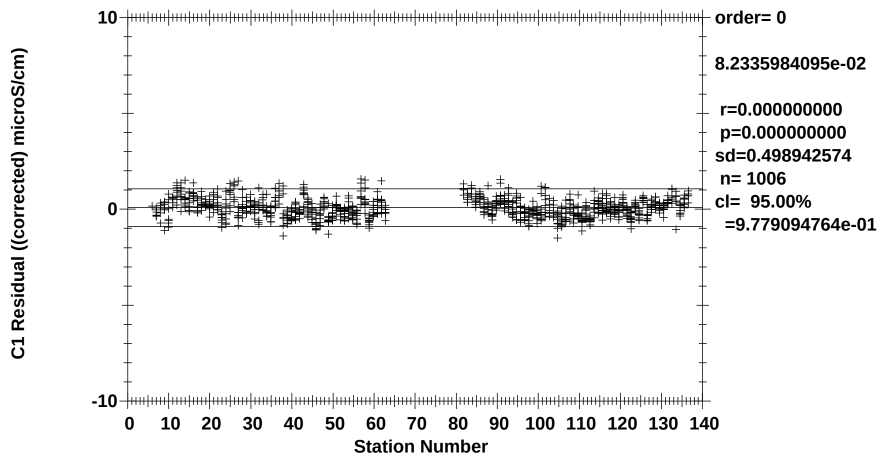

Figure 1.8.3.5 Deep Corrected $C_{Bottle} - C1$ by station (Pressure >= 2000dbar).

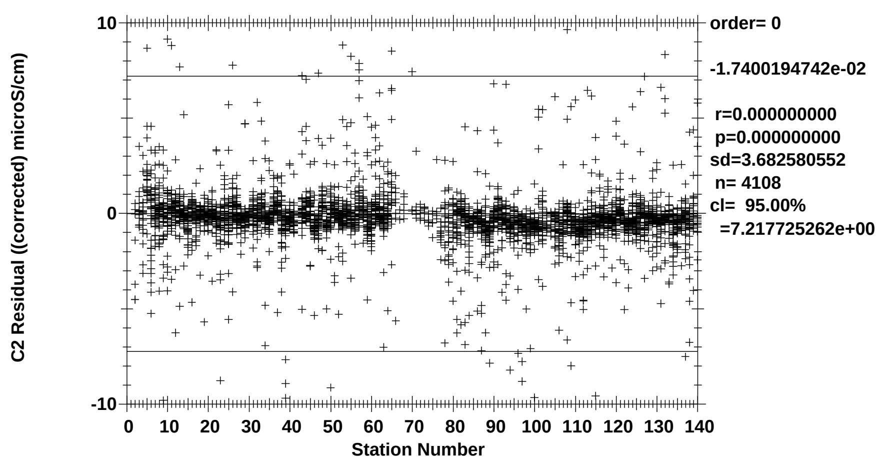

Figure 1.8.3.6 Corrected $C_{Bottle} - C2$ by station (-0.01°C ≤T1-T2≤0.01°C).

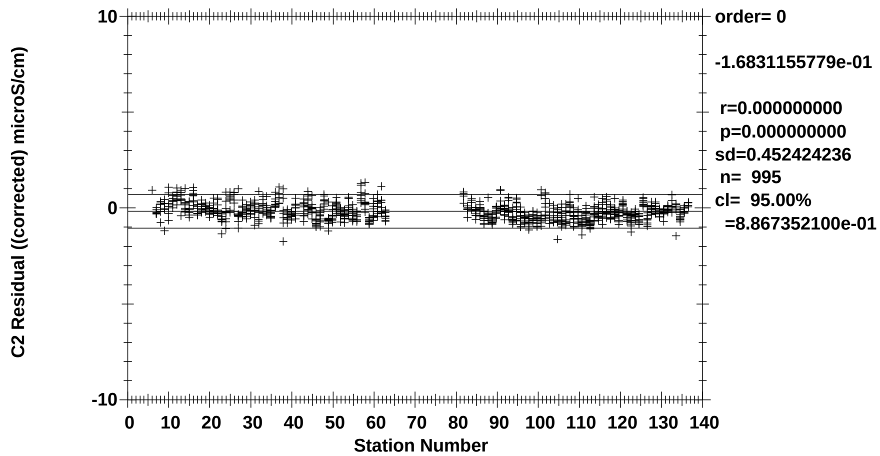

Figure 1.8.3.7 Deep Corrected $C_{Bottle} - C2$ by station (Pressure >= 2000dbar).

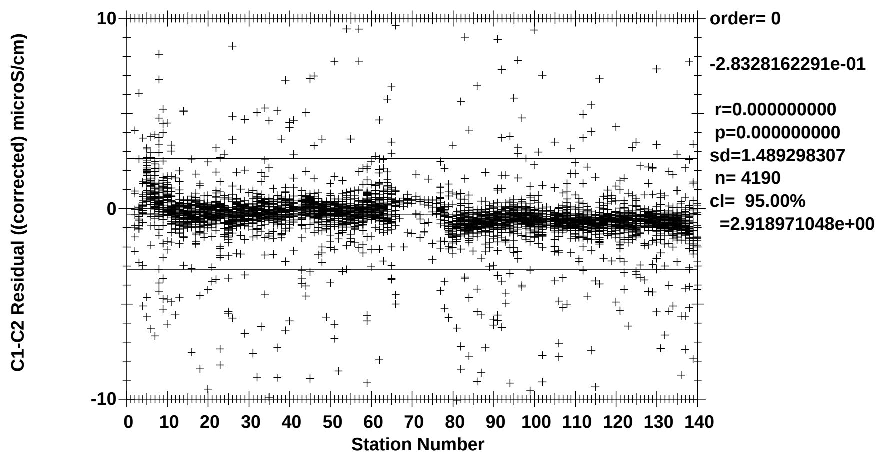

Figure 1.8.3.8 Corrected $C1 - C2$ by station (-0.01°C ≤T1-T2≤0.01°C).

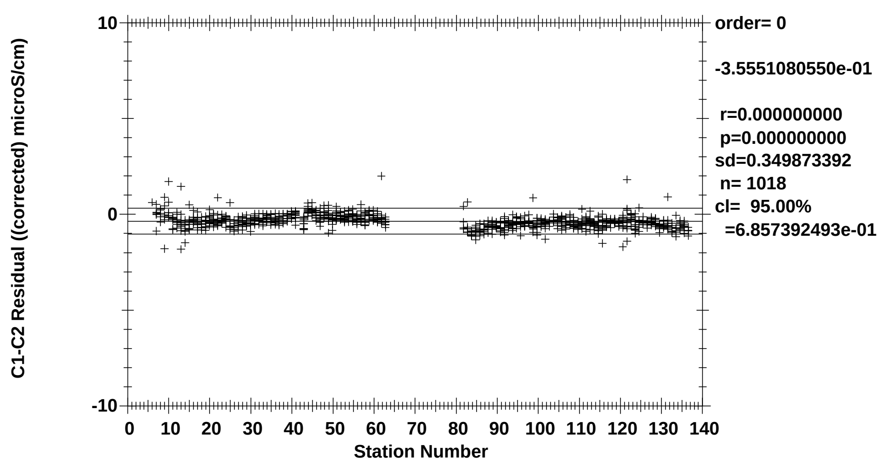

Figure 1.8.3.9 Deep Corrected $C1 - C2$ by station (Pressure >= 2000dbar).

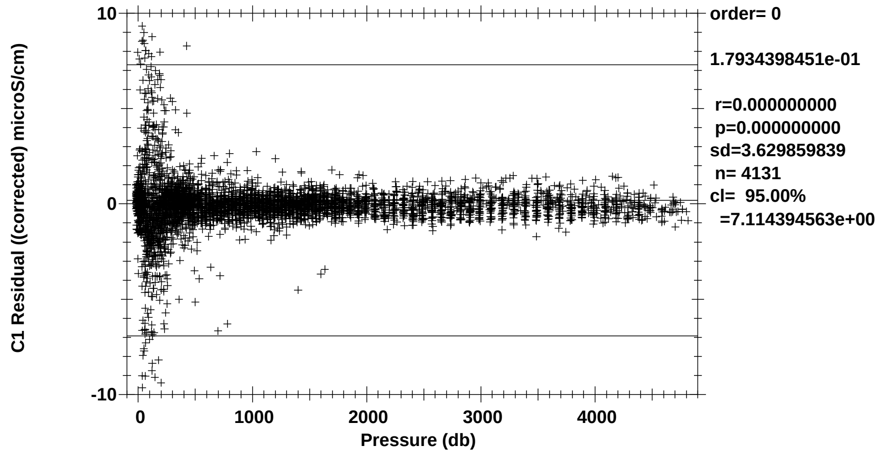

Figure 1.8.3.10 Corrected $C_{Bottle} - C1$ by pressure (-0.01°C ≤T1-T2≤0.01°C).

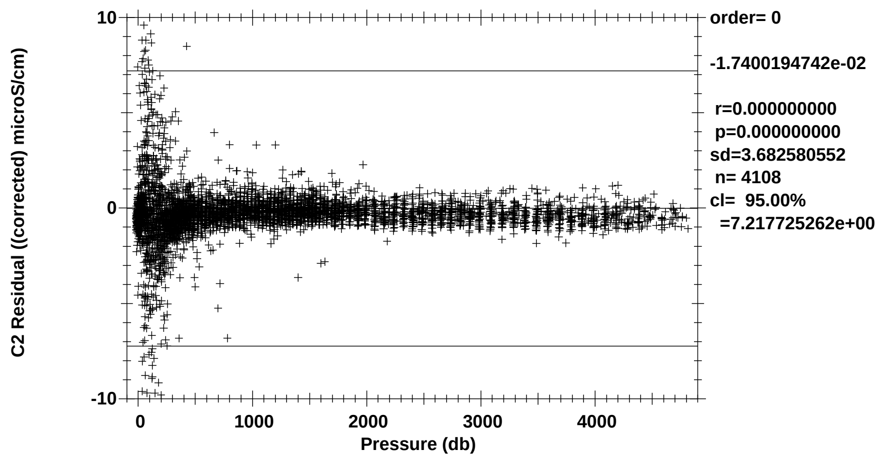

Figure 1.8.3.11 Corrected $C_{Bottle} - C2$ by pressure (-0.01°C ≤T1-T2≤0.01°C).

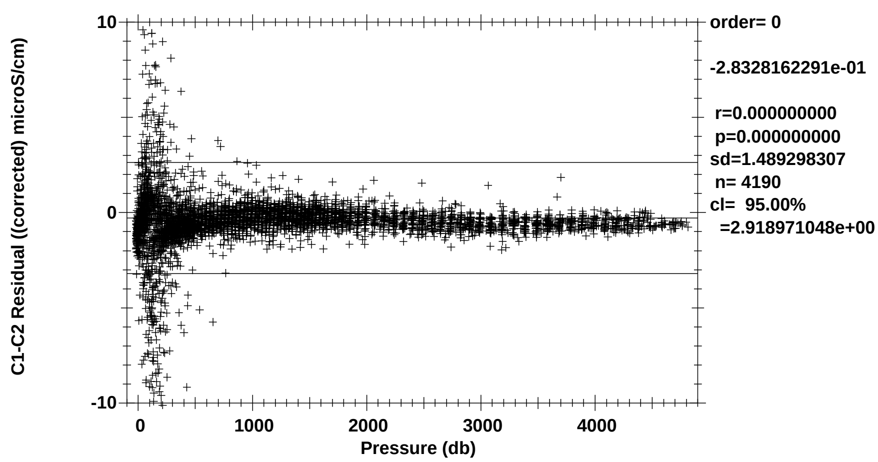

Figure 1.8.3.12 Corrected $C1 - C2$ by pressure (-0.01°C ≤T1-T2≤0.01°C).

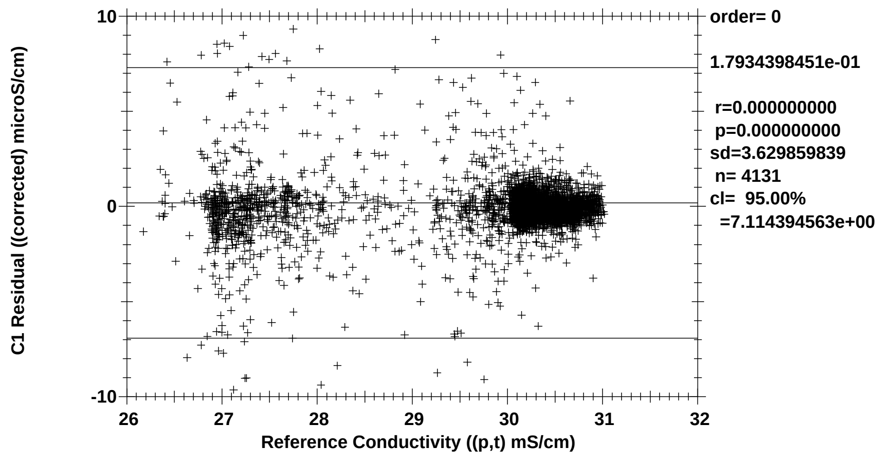

Figure 1.8.3.13 Corrected $C_{Bottle} - C1$ by conductivity (-0.01°C ≤T1-T2≤0.01°C).

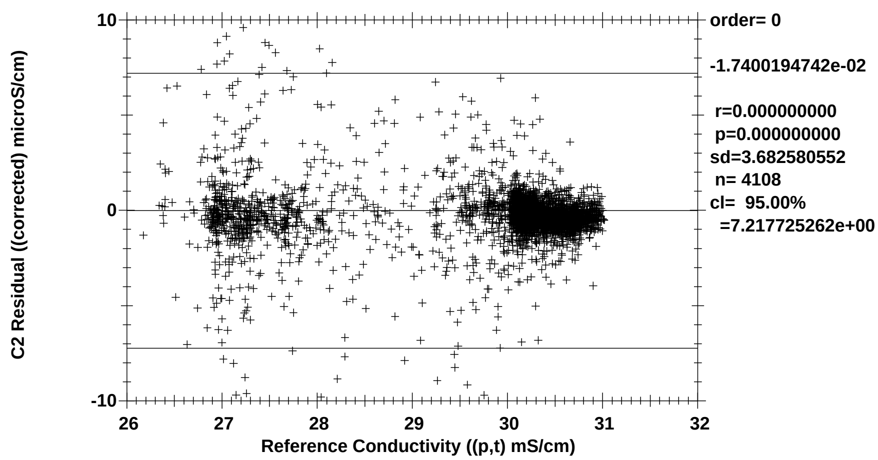

Figure 1.8.3.14 Corrected $C_{Bottle} - C2$ by conductivity (-0.01°C ≤T1-T2≤0.01°C).

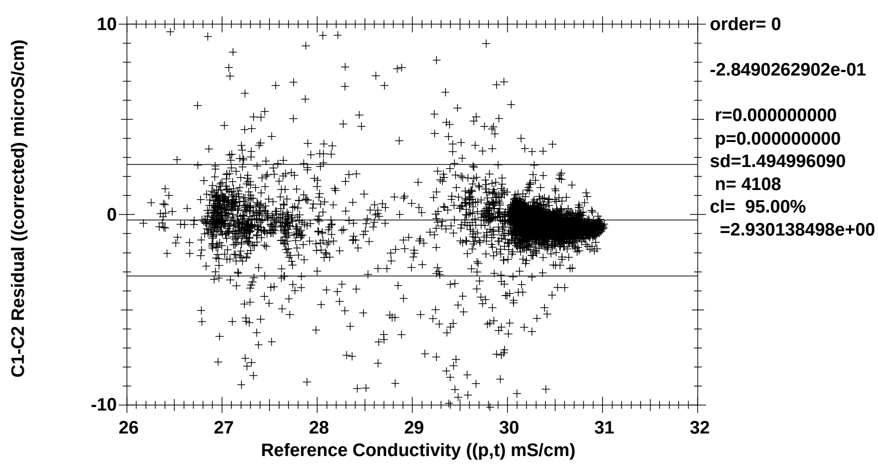

Figure 1.8.3.15 Corrected $C1 - C2$ by conductivity (-0.01°C ≤T1-T2≤0.01°C).

The final corrections for all conductivity sensors used on CLIVAR S04P are summarized in Appendix A. Corrections made to all conductivity sensors had the form:

$$C_{cor} = C + cp_2 P^2 + cp_1 P + c_1 C + c_0$$

Salinity residuals after applying shipboard P/T/C corrections are summarized in figures 1.8.3.16 through 1.8.3.18. Only CTD and bottle salinity data with "acceptable" quality codes are included in the differences.

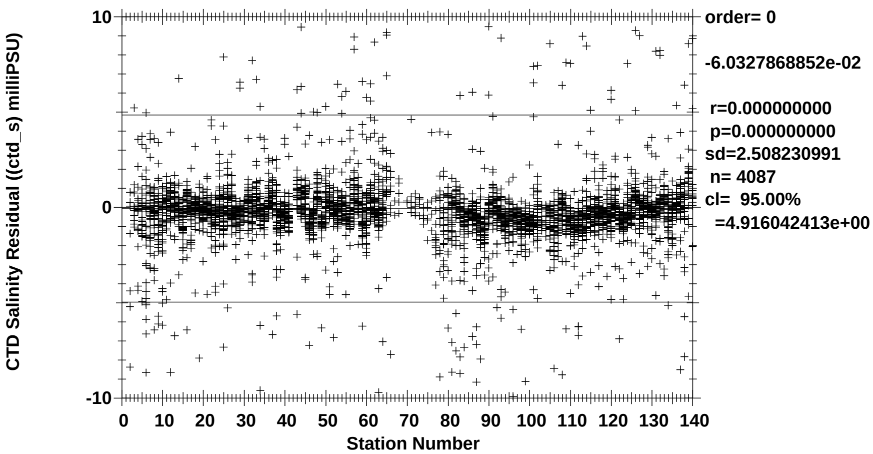

Figure 1.8.3.16 Salinity residuals by station (-0.01°C ≤T1-T2≤0.01°C).

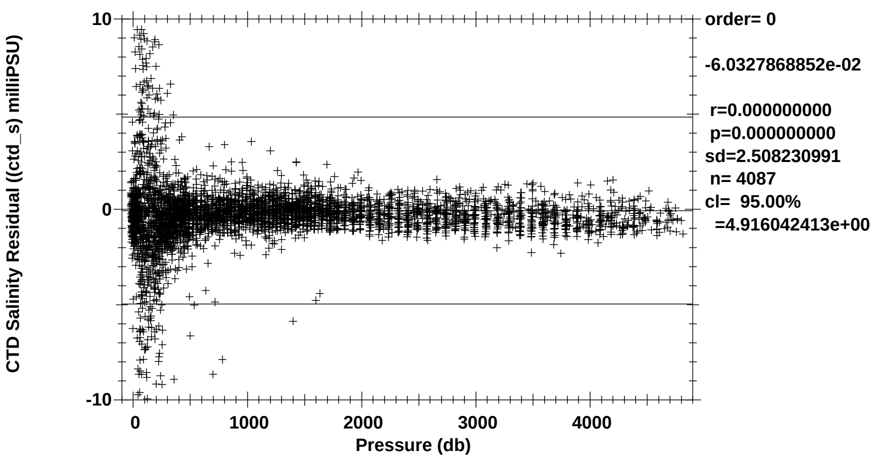

Figure 1.8.3.17 Salinity residuals by pressure (-0.01°C ≤T1-T2≤0.01°C).

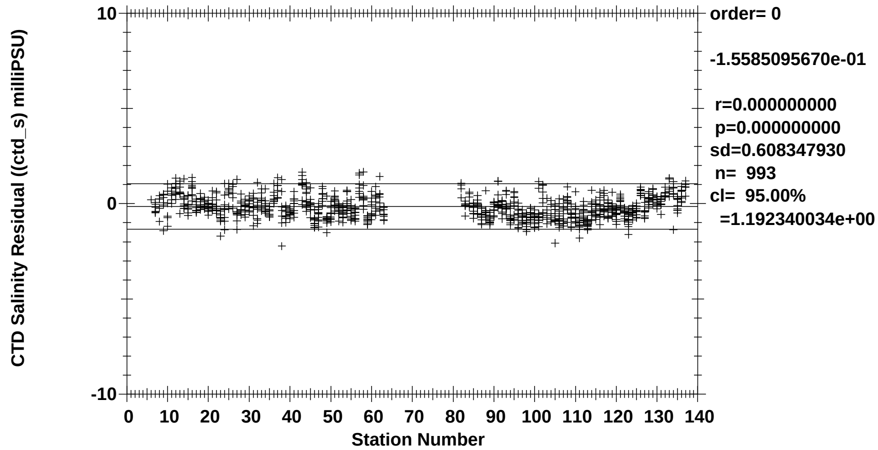

Figure 1.8.3.18 Deep Salinity residuals by station (Pressure >= 2000dbar).

Figures 1.8.3.17 and 1.8.3.18 represent estimates of the salinity accuracy of CLIVAR S04P. The 95% confidence limits are ±0.0012 PSU relative to bottle salinities for deep salinities, and ±0.0049 PSU relative to bottle salinities for all salinities, where T1-T2 is within ±0.01°C.

1.8.4. CTD Dissolved Oxygen

A single SBE43 dissolved O_2 sensor (DO/43-1136) was used during CLIVAR S04P. The sensor was plumbed into the primary T1/C1 pump circuit after C1.

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

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

The small CTDO_2 drop at the surface of most casts seems to be an artifact of a long equilibration time for this particular sensor. The upcast shows no routine drops, nor is any such drop seen in raw Trace Metal CTDO_2 data at the surface on the same stations. On a few stations where a second yoyo was done, it did not appear at the top of the second yoyo. These low data at the surface are marked as questionable in the final reported CTD data files.

Standard and blank values for check sample oxygen titration data were smoothed, and the oxygen values recalculated, after the final fitting of CTD oxygen. However, the changes to bottle oxygen values were small and would have had little effect on the fits.

CTD dissolved O_2 residuals are shown in figures 1.8.4.0-1.8.4.2.

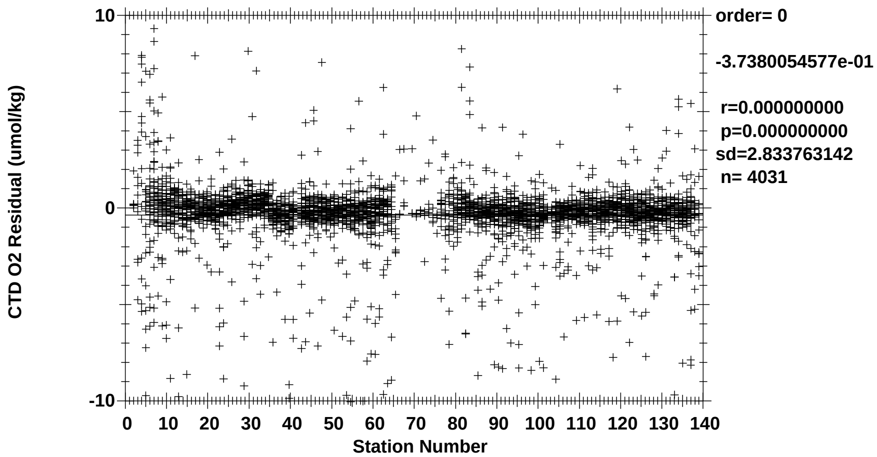

Figure 1.8.4.0 O_2 residuals by station (-0.01°C ≤T1-T2≤0.01°C).

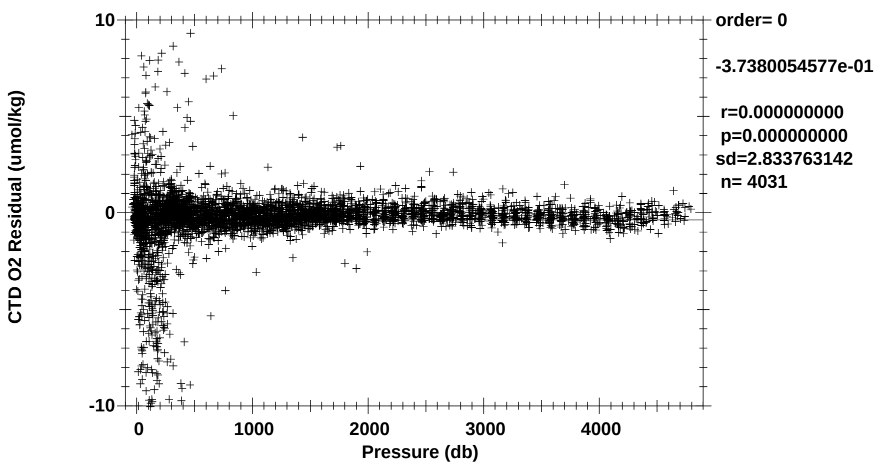

Figure 1.8.4.1 O_2 residuals by pressure (-0.01°C ≤T1-T2≤0.01°C).

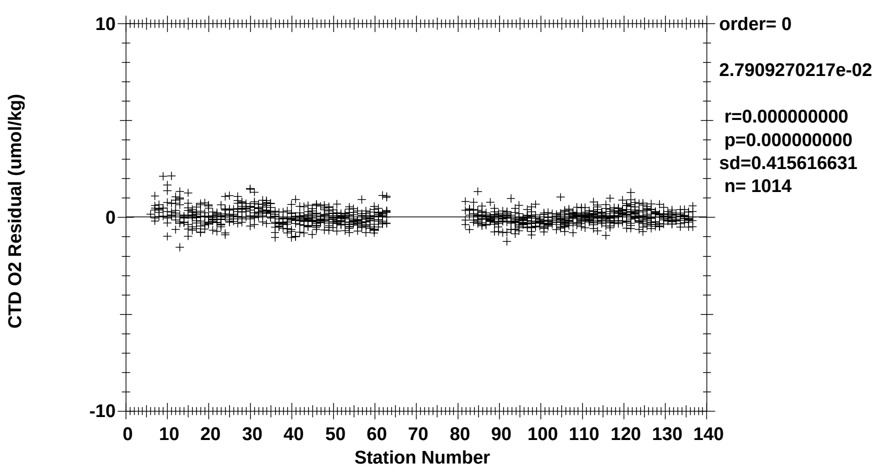

Figure 1.8.4.2 Deep O_2 residuals by station (Pressure >= 2000dbar).

The standard deviations of 2.83 μmol/kg for all oxygens and 0.42 μmol/kg for deep oxygens are only presented as general indicators of goodness of fit. SIO/STS makes no claims regarding the precision or accuracy of CTD dissolved O_2 data.

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

$$O_2ml/l = [C_1V_{DO}e^{(C_2\frac{P_h}{5000})} + C_3] \cdot f_{sat}(T,P) \cdot e^{(C_4T_l + C_5T_s + C_7P_l + C_6\frac{dO_c}{dt} + C_8\frac{dP}{dt} + C_9dT)} \qquad (1.8.4.0)$$

where:

O_2ml/l	Dissolved O_2 concentration in ml/l;
V_{DO}	Raw sensor output;
C_1	Sensor slope
C_2	Hysteresis response coefficient
C_3	Sensor offset
$f_{sat}(T,P)$	O_2 saturation at T,P (ml/l);
T	*in situ* temperature (°C);
P	*in situ* pressure (decibars);
P_h	Low-pass filtered hysteresis pressure (decibars);
T_l	Long-response low-pass filtered temperature (°C);
T_s	Short-response low-pass filtered temperature (°C);
P_l	Low-pass filtered pressure (decibars);
$\frac{dO_c}{dt}$	Sensor current gradient (μamps/sec);
$\frac{dP}{dt}$	Filtered package velocity (db/sec);
dT	low-pass filtered thermal diffusion estimate (T_s - T_l).
$C_4 - C_9$	Response coefficients.

CTD O_2ml/l data are converted to μmol/kg units on demand.

1.9. Bottle Sampling

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

- CFC-11,CFC-12,SF_6
- ^3He
- O_2
- Dissolved Inorganic Carbon (DIC)
- pH
- Total Alkalinity
- ^{13}C and ^{14}C
- Dissolved Organic Carbon (DOC) and Total Dissolved Nitrogen (TDN)
- Tritium
- ^{18}O
- Nutrients
- Chromophoric Dissolved Organic Matter (CDOM)
- Salinity
- Phytoplankton Pigments (Chlorophyll a, Particulate Organic Carbon)
- Particulate Absorption
- Phytoplankton-Cytrometry
- Millero Density

The correspondence between individual sample containers and the rosette bottle position (1-36) from which the sample was drawn was recorded on the sample log for the cast. This log also included any comments or anomalous conditions noted about the rosette and bottles. One member of the sampling team was designated the *sample cop*, whose sole responsibility was to maintain this log and insure that sampling progressed in the proper drawing order.

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

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

1.10. Bottle Data Processing

Water samples collected and properties analyzed shipboard were centrally managed in a relational database (PostgreSQL 8.1.18) running on a Linux system. A web service (OpenACS 5.5.0 and AOLServer 4.5.1) front-end provided ship-wide access to CTD and water sample data. Web-based facilities included on-demand arbitrary property-property plots and vertical sections as well as data uploads and downloads.

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

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

Table 1.10.0 shows the number of samples drawn and the number of times each WHP sample quality flag was assigned for each basic hydrographic property:

Rosette Samples Stations -140								
	Reported levels	WHP Quality Codes 1	2	3	4	5	7	9
Bottle	4413	0	4358	2	40	0	0	12
CTD Salt	4413	0	4350	38	24	0	0	0
CTD Oxy	4356	0	4253	102	0	0	0	57
Salinity	4372	0	4328	25	18	5	0	36
Oxygen	4350	0	4325	8	16	27	0	36
Silicate	4314	0	4310	2	1	1	0	98
Nitrate	4314	0	4307	2	4	1	0	98
Nitrite	4314	0	4294	18	1	1	0	98
Phosphate	4312	0	4279	1	31	3	0	98

Table 1.10.0 Frequency of WHP quality flag assignments.

Additionally, data investigation comments are presented in Appendix C.

Various consistency checks and detailed examination of the data continued throughout the cruise. Chief Scientist, James Swift, reviewed the data and compared it with historical data sets.

1.11. Salinity

Equipment and Techniques

A single Guildline Autosal 8400A salinometer (S/N 57-396) located in the Palmer’s "Thermo Kool" temperature controlled room, was used for all salinity measurements. This salinometer had been modified to include a communication interface for computer-aided measurement, a higher capacity pump and two additional temperature sensors. An external temperature probe was used to measure the air temperature in the room, and an internal probe was used to monitor the water bath temperature. Hand held thermometers were used to monitor the salinity bottle temperature. This was accomplished by inserting the temperature probe outside salinity bottles in the center of the salinity case.

Samples were analyzed after they had been brought to 1 or 2°C below the Autosal’s water bath temperature, usually within 3-12 hours after collection. This was accomplished using a separate water bath, described below. The salinometer was standardized for each group of analyses (usually 1-2 casts, up to ~67 samples) using at one fresh vial of standard seawater before analysis and one fresh vial after, to determine if the standardization had drifted.

Salinometer measurements were aided by a computer with SIO/STS software compiled in LabView. The software maintained a log of each salinometer run which included Autosal settings and air and bath temperatures. The air temperature was displayed and monitored via a 24-hour strip-chart in order to observe changes. The program also guided the operator through the standardization procedure and making sample measurements. The analyst was prompted to change samples and flush the cells between readings.

Special standardization procedures included flushing the cell at least 4 times with a fresh vial of Standard Seawater (SSW), setting the flow rate as low as possible during the last fill, and monitoring the STD dial setting. If the STD dial changed by 10 units or more since the last salinometer run (or during standardization), another vial of SSW was opened and the standardization procedure repeated to verify the setting.

Samples were run using 3 flushes before the final fill. The program user defined configuration determined the stability of a measurement and prompted for additional readings if there appeared to be drift. The operator could annotate the salinometer log, and would routinely add comments about cracked sample bottles, loose thimbles, salt crystals or anything unusual in the amount of sample in the bottle.

Prior to the first salinity run of the cruise, it was determined that due to the low temperature of the sample water (˜-2°C) a scheme other than air equilibration needed to be incor porated. The samples were taking more than 24 hours for the salt cases to reach approximate room temperature. A warm water bath was utilised to bring samples to room temperature. The bottles were only partialy submerged to preventing fresh water from entering the cap/thimble. Once the water bath equilibrated, warm or cold water was added to bring the temperature of the bottles up to 19° and sta y there for approximately 10 minutes. At this point, the box was removed from the water and moved to the controlled temperature room. Analysis began within 15-30 minutes. This process was completed in approximately 1.5 hours.

Standard seawater was stored out of the constant temperature room and brought into the room 3 or 4 cases at a time to ensure that it had enough time to come up to room temperature before being used.

Sampling and Data Processing

A total of 5104 salinity measurements drawn from the CLIVAR STS/ODF rosette and trace metal casts. There were 45 samples from the underway sampling program. Approximately 298 vials of standard seawater (IAPSO SSW) were used.

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

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

Data processing included double checking that the station, sample and box number had been correctly assigned, and reviewing the data and log files for operator comments. The salinity data were compared to CTD salinities and were used for shipboard sensor calibration. Comments the analyst made were gleaned from the program provided file and any anomalous values and investigation and data coding are reported in Appendix C.

Laboratory Temperature

The salinometer water bath temperature was maintained slightly higher than ambient laboratory air temperature at 21°C . The ambient air temperature varied from 19 to 22°C during the cruise.

The constant temperature room was 8’x8’ and temperature was maintained using a Heatcraft TL21AF heating and cooling unit, controlled using a Ranco ETC electronic temperature controller. Room temperature varied sinusoidally about a mean of 20.3°C , with a period of approximately 10 minutes and an amplitude of approximately 1.2°C (standard deviation of temperature recorded at 1 min ute intervals was 1.2°C). The mean temperature, averaged daily, fluctuated randomly due to the ambient temperature of the ship.

Standards

IAPSO Standard Seawater Batche P-152 was used to standardize stations 1-140.

Analytical Problems

There were few analytical problems. There were two stations that appeared to have not been properly equilibrated before analysis. There was also three salinity runs which had unusual standard dial changes. This was attributed to bad standards and appeared in only one box of standard vials.

1.12. Oxygen Analysis

Equipment and Techniques

Dissolved oxygen analyses were performed with an SIO/ODF-designed automated oxygen titrator using photometric end-point detection based on the absorption of 365nm wavelength ultra-violet light. The titration of the samples and the data logging were controlled by ODF PC software compiled in LabView. Thiosulfate was dispensed by a Dosimat 665 buret driver fitted with a 1.0 mL buret. The ODF method used a whole-bottle modified-Winkler titration following the technique of Carpenter [Carp65] with modifications by Culberson *et al.* [Culb91], but with higher concentrations of potassium iodate standard (~0.012N) and thiosulfate solution (~55 gm/l). Standard SIO_3 soluttions prepared ashore were run daily (approximately every 2-4 stations), unless changes were made to the system or reagents. Reagent/distilled water blanks were also determined daily or more often if a change in reagents required it to account for presence of oxidizing or reducing agents.

Sampling and Data Processing

4376 samples were analyzed for oxygen from the main rosette and 44 from the underway sampling program.

Samples were collected for dissolved oxygen analyses soon after the rosette was brought on board. Three different cases of 36 flasks each were rotated by station to minimize flask calibration issues. 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 each time) to assure thorough dispersion of the precipitate, once immediately after drawing, and then again after about 20 minutes.

The samples were analyzed within 1-4 hours of collection, and the data incorporated into the cruise database.

Thiosulfate normalities were calculated from each standardization and corrected to 20°C. The thiosulfate normalities and blanks were monitored for possible drifting or possible problems when new reagents were used. An average blank and thiosulfate normality were used to recalculate oxygen concentrations. The difference between the original and "smoothed" data averaged 0.06% over the course of the cruise.

Bottle oxygen data was reviewed ensuring proper station, cast, bottle number, flask, and draw temperature were entered properly. Comments made during analysis were reviewed. All anomalous actions were investigated and resolved. If an incorrect end point was encountered, the analyst re-examined raw data and program recalculated a correct end point. The occurrences were attributed to debris in the water bath.

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

Volumetric Calibration

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

Standards

Liquid potassium iodate standards were prepared in 6 liter batches and bottled in sterile glass bottles at ODF's chemistry laboratory prior to the expedition. The normality of the liquid standard was determined by calculation from weight. The standard was supplied by Alfa Aesar (lot B05N35) and has a reported purity of 99.4-100.4%. All other reagents were "reagent grade" and were tested for levels of oxidizing and reducing impurities prior to use.

Analytical Problems

The cruise began with a Schott Titronix T100 autoburet outfitted with a glass tip to dispense the thiosulfate solution. During the first week of the expedition there were multiple lost samples due to "freezing" of the PC as well as incorrect endpoints; possibly from the wide glass tip interfering with the light path. After 13 stations, the Titronics unit was switched out for the traditional Dosimat 765 unit. No further program freezing or ligh path problems were noted. ODF chemists will troubleshoot and re-evaluate the Titronics unit on shore.

1.13. Nutrient Analysis

Equipment and Techniques

Nutrient analyses (phosphate, silicate, nitrate plus nitrite and nitrite) were performed on a Seal Analytical continuous-flow AutoAnalyzer 3 (AA3). After each run, the charts were reviewed for any problems and any problems and final concentrations (micromoles per liter) calculated using SEAL Analytical AACE 6.05 software. The analytical methods used are described by Gordon *et al.* [Gord92] Hager *et al.* [Hage68] and Atlas *et al.* [Atla71].

Silicate

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

Reagents

Tartaric Acid (ACS Reagent Grade)

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

Ammonium Molybdate

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

*(Dilute H_2SO_4 = 2.8ml concentrated H_2SO_4 to a liter DW). Added 5 drops 15% ultra pure SDS per liter of solution.

Stannous Chloride (ACS Reagent Grade)

Stock solution:

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

Working solution:

5 ml of stannous chloride stock diluted to 200 ml final volume with 1.2N HCl. Made up daily - refrigerated when not in use in a dark polypropylene bottle.

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

Nitrate plus Nitrite

A modification of the Armstrong *et al.* [Arms67] procedure was used for the analysis of nitrate and nitrite. For the nitrate analysis, the seawater sample was passed through a cadmium reduction column where nitrate was quantitatively reduced to nitrite. Sulfanilamide was introduced to the sample stream followed by N-(1-naphthyl)ethylenediamine dihydrochloride which coupled to form a red azo dye. The stream was then passed through a 15mm flowcell and the absorbance measured at 540nm. The same technique was employed for nitrite analysis, except the cadmium column was not present and a 50mm flowcell was used for measurement.

Reagents

Sulfanilamide (ACS Reagent Grade)

10g sulfanilamide dissolved in 1.2N HCl and brought to 1 liter volume. Added 2 drops of 40% surfynol 465/485 surfactant. Stored at room temperature in a dark polypropylene bottle.

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

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

Imidazole Buffer (ACS Reagent Grade)

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

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

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

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

Prepared solution at least one day before use to stabilize.

Phosphate

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

Reagents

Ammonium Molybdate (ACS Reagent Grade)

H_2SO_4 solution:

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

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

Dihydrazine Sulfate (ACS Reagent Grade)

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

Sampling and Data Processing

4998 nutrient samples from 140 CLIVAR and trace metal stations were analyzed as well as 45 samples from the underway sampling program. The cruise started with new pump tubes and were changed four times, after Stations 14, 49, 66 and 120. Two Beer’s Law calibration checks were run throughout the cruise. Four sets of primary/secondary standards were made up over the course of the cruise. The cadmium column reduction efficiency was checked periodically and ranged between 98%-100%.

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

Carryover was minimized by running the samples from low to high concentration. In addition, percent carryover was calculated and applied using a provision in the AACE software, which involved running one high peak immediately folllowed by two low peaks. A mid-range drift samples was run immediately prior and after each set of samples. A linearly interpolated baseline and instrument drift correction was applied to each run.

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

Standards and Glassware

A 3-point standardization calibration curve was performed at the beginning of each group of analyses. The calibration curve consisted of low, medium and high concentration mixed nutrient standard prepared prior to each run from a secondary standard in a low-nutrient seawater matrix. A group usually consisted on one station.cast (up to 36 samples). The secondard standards were prepared aboard ship by dilution from the pre-weighed primary standards. A set of 7 different standard concentrations (Table 1.13.0) were analyzed twice. This determined the deviation from standard as a function of absorbance for each nutrient (Beer’s Law). All runs and both Beer’s Law were linear for all four parameter (correlation coefficient = 0.9999 - 1.0000). An aliquot from a large volume of stable deep seawater was also run with each set of samples as a substandard and additional check.

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

Table 1.13.0 CLIVAR S04P Concentration of Beer’s Law standards (uM)

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

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

Working standards were made up in low nutrient seawater (LNSW). LNSW was collected off shore of coastal California and treated in the ODF chemistry lab. The water was first filtered through a 0.45 micron filter then re-circulated for ~8 hours through a 0.2 micron filter, an UV lamp and a second 0.2 micron filter. The actual concentration of nutrients in this water was empirically determined during the calculation of the non-linear corrections that were applied to the nutrient concentrations.

The Nitrate (KNO_3 lot# 042263) and phosphate (KH_2PO_4 lot# 991608) primary standards were obtained from Fisher Scientific with reported purites of 100% and 99.8%, respectively. The silicate (Na_2SiF_6 lot# J25E26) and nitrite ($NaNO_2$ lot# K19D12) standards were obtained from Alfa Aesar with reported purities of >98% and 97%.

Quality Control

As is standard ODF practice, a deep calibration "check" sample was run with each set of samples. The cruise-averaged data are tabulated in Table 1.13.1.

Parameter	Concentration (uM)
NO3	32.60 ±0.13
PO4	2.26 ±0.01
SIL	104.49 ±0.56

Table 1.13.1 CLIVAR S04P Deep calibration cruise-averaged data

Reference Material for Nutrients in Seawater (RMNS)

Lot "BE" RMNS samples were run on Stations 14-140 as an unknown check sample (sample "98"). The cruise-averaged data are tabulated in Table 1.13.2.

Parameter	Calculated Concentrations (umol/kg)	Certified Concentration (umol/kg)
NO3	36.65 ±0.13	36.64
PO4	2.66 ±0.01	2.67
SIL	100.00 ±0.57	101.2

Table 1.13.2 CLIVAR S04P RMNS cruise-averaged data

Analytical Problems

The cruise began with an AAI pump, which was replaced by an AAII pump immediately prior to Station 46. Stations 1-66 experienced less of a peak plateau than optimal for the N+N channel only. Data was adjusted by comparing the average calculated RMNS value versus the certified value. Stations 1-66 NO_3 full water column profiles were thus adjusted by multiplying the calculated concentrations by a factor of 1.0177. The peak plateau issue was remiedied after Station 66 by changing out the pump, pump tubes and cadmium column.

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Appendix A

CLIVAR S04P: CTD Temperature and Conductivity Corrections Summary

*NOTE: T2C2 for stations 2-10 are the same physical sensors as T1C1 for stations 11-end

Sta/ Cast	ITS-90 Temperature Coefficients corT = tp_1∗corP + t_0 tp_1	t_0	Conductivity Coefficients corC = cp_2∗corP^2 + cp_1∗corP + c_1∗C + c_0 cp_2	cp_1	c_1	c_0	T *vs* C Lag (secs.)	Sensor Pair Used*
002/01	-2.6480e-07	-0.000803	4.39191e-10	-1.09680e-06	-9.19178e-04	0.025425	0.06	T2C2*
003/01	-2.6480e-07	-0.000803	4.39191e-10	-1.09680e-06	-9.19178e-04	0.024925	0.06	T2C2*
004/01	-2.6480e-07	-0.000803	4.39191e-10	-1.09680e-06	-9.19178e-04	0.024925	0.06	T2C2*
005/01	-2.6480e-07	-0.000803	4.39191e-10	-1.09680e-06	-9.19178e-04	0.024925	0.06	T2C2*
006/02	-2.6480e-07	-0.000803	4.39191e-10	-1.09680e-06	-9.19178e-04	0.024425	0.06	T2C2*
007/01	-2.6480e-07	-0.000803	4.39191e-10	-1.09680e-06	-9.19178e-04	0.023925	0.06	T2C2*
008/01	-2.6480e-07	-0.000803	4.39191e-10	-1.09680e-06	-9.19178e-04	0.023925	0.06	T2C2*
009/01	-2.6480e-07	-0.000803	4.39191e-10	-1.09680e-06	-9.19178e-04	0.023925	0.06	T2C2*
010/02	-2.6480e-07	-0.000803	4.39191e-10	-1.09680e-06	-9.19178e-04	0.023925	0.06	T2C2*
011/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.005542	0.05	T2C2
012/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.005556	0.05	T2C2
013/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.005569	0.05	T2C2
014/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.005586	0.05	T2C2
015/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.005601	0.05	T2C2
016/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.005623	0.05	T2C2
017/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.005659	0.05	T2C2
018/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.005675	0.05	T2C2
019/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.005692	0.05	T2C2
020/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.005713	0.05	T2C2
021/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.005731	0.05	T2C2
022/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.005752	0.05	T2C2
023/02	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.005772	0.05	T2C2
024/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.005902	0.05	T2C2
025/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.005921	0.05	T2C2
026/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.005941	0.05	T2C2
027/02	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.005960	0.05	T2C2
028/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.005976	0.05	T2C2
029/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.005994	0.05	T2C2
030/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006013	0.05	T2C2
031/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006031	0.05	T2C2
032/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006051	0.05	T2C2
033/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006068	0.05	T2C2
034/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006087	0.05	T2C2
035/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006106	0.05	T2C2
036/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006127	0.05	T2C2
037/02	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006147	0.05	T2C2
038/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006165	0.05	T2C2
039/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006183	0.05	T2C2
040/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006206	0.05	T2C2
041/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006225	0.05	T2C2

Sta/ Cast	ITS-90 Temperature Coefficients corT = tp_1*corP + t_0 tp_1	t_0	Conductivity Coefficients corC = cp_2*corP^2 + cp_1*corP + c_1*C + c_0 cp_2	cp_1	c_1	c_0	T *vs* C Lag (secs.)	Sensor Pair Used*
042/01	-2.6480e-07	-0.000803	2.64698e-10	-8.46958e-07	-9.19178e-04	0.024629	0.06	T1C1*
043/02	-2.6480e-07	-0.000803	2.64698e-10	-8.46958e-07	-9.19178e-04	0.024629	0.06	T1C1*
044/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006285	0.05	T2C2
045/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006303	0.05	T2C2
046/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006338	0.05	T2C2
047/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006357	0.05	T2C2
048/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006378	0.05	T2C2
049/02	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006398	0.05	T2C2
050/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006416	0.05	T2C2
051/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006434	0.05	T2C2
052/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006456	0.05	T2C2
053/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006474	0.05	T2C2
054/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006495	0.05	T2C2
055/02	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006515	0.05	T2C2
056/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006533	0.05	T2C2
057/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006550	0.05	T2C2
058/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006572	0.05	T2C2
059/02	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006594	0.05	T2C2
060/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006612	0.05	T2C2
061/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006632	0.05	T2C2
062/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006651	0.05	T2C2
063/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006667	0.05	T2C2
064/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006684	0.05	T2C2
065/02	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006694	0.05	T2C2
066/02	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006702	0.05	T2C2
067/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006840	0.05	T2C2
068/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006843	0.05	T2C2
069/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006847	0.05	T2C2
070/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006851	0.05	T2C2
071/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006855	0.05	T2C2
072/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006957	0.05	T2C2
073/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006962	0.05	T2C2
074/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006971	0.05	T2C2
075/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.006975	0.05	T2C2
076/01	-2.6480e-07	-0.000803	2.64698e-10	-8.46958e-07	-9.19178e-04	0.024629	0.06	T1C1*
077/01	-2.6480e-07	-0.000803	2.64698e-10	-8.46958e-07	-9.19178e-04	0.024629	0.06	T1C1*
078/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007081	0.05	T2C2
079/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007099	0.05	T2C2
080/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007106	0.05	T2C2
081/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007112	0.05	T2C2
082/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007124	0.05	T2C2
083/02	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007139	0.05	T2C2
084/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007152	0.05	T2C2
085/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2

Sta/ Cast	ITS-90 Temperature Coefficients $corT = tp_1{*}corP + t_0$ tp_1	t_0	Conductivity Coefficients $corC = cp_2{*}corP^2 + cp_1{*}corP + c_1{*}C + c_0$ cp_2	cp_1	c_1	c_0	T *vs* C Lag (secs.)	Sensor Pair Used*
086/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
087/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
088/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
089/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
090/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
091/02	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
092/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
093/02	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
094/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
095/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
096/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
097/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
098/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
099/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
100/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
101/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
102/02	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
103/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
104/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
105/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
106/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
107/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
108/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
109/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
110/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
111/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
112/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
113/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
114/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
115/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
116/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
117/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
118/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
119/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
120/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
121/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
122/02	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
123/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
124/02	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
125/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
126/03	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
127/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
128/02	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
129/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2

Sta/ Cast	ITS-90 Temperature Coefficients $corT = tp_1 * corP + t_0$ tp_1	t_0	Conductivity Coefficients $corC = cp_2 * corP^2 + cp_1 * corP + c_1 * C + c_0$ cp_2	cp_1	c_1	c_0	T *vs* C Lag (secs.)	Sensor Pair Used*
130/02	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
131/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
132/02	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
133/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
134/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
135/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
136/02	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
137/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
138/02	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
139/01	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2
140/02	-6.2133e-07	-0.000589	7.14471e-11	-3.65949e-07	-1.48498e-04	0.007163	0.05	T2C2

Appendix B

Summary of CLIVAR S04P CTD Oxygen Time Constants

(time constants in seconds)

Pressure Hysteresis (τ_h)	Temperature Long(τ_{Tl})	Temperature Short(τ_{Ts})	Pressure Gradient (τ_p)	O_2 Gradient (τ_{og})	Velocity (τ_{dP})	Thermal Diffusion (τ_{dT})
100.0	300.0	8.0	0.50	8.00	100.00	300.0

CLIVAR S04P: Conversion Equation Coefficients for CTD Oxygen

(refer to Equation 1.8.4.0)

Sta/ Cast	O_c Slope (c_1)	Offset (c_3)	P_h coeff (c_2)	T_l coeff (c_4)	T_s coeff (c_5)	P_l coeff (c_6)	$\frac{dO_c}{dt}$ coeff (c_7)	$\frac{dP}{dt}$ coeff (c_8)	T_{dT} coeff (c_9)
002/01	4.596e-04	0.451	-2.106	2.136e-01	1.036e-01	-4.124e-04	9.191e-03	0	-0.014307
003/01	3.041e-04	0.235	1.415	8.204e-02	-1.493e-01	-4.699e-04	-8.593e-03	0	0.251290
004/01	5.762e-04	-0.076	-2.440	1.665e-01	-2.959e-02	3.449e-04	9.809e-04	0	-0.203460
005/01	6.356e-04	-0.271	1.137	6.824e-02	8.057e-03	-2.428e-04	-5.869e-03	0	-0.074906
006/02	4.110e-04	0.027	1.013	3.912e-02	-8.443e-02	-1.107e-04	-1.089e-03	0	0.010066
007/01	5.448e-04	-0.185	0.635	7.757e-04	9.468e-04	-3.910e-05	6.634e-03	0	-0.021685
008/01	5.577e-04	-0.221	0.294	9.130e-03	-1.384e-02	5.791e-05	6.092e-03	0	0.008291
009/01	6.244e-04	-0.323	1.132	1.567e-02	-4.737e-03	-1.669e-04	1.056e-03	0	0.023515
010/02	6.163e-04	-0.309	0.575	1.467e-03	1.673e-02	-1.970e-05	-9.390e-04	0	-0.005720
011/01	5.734e-04	-0.240	0.548	-1.796e-04	4.210e-03	-1.401e-05	3.828e-03	0	-0.007968
012/01	8.278e-04	-0.649	0.802	1.131e-02	6.858e-02	-1.094e-04	-3.388e-03	0	0.003361
013/01	9.476e-04	-0.839	0.545	1.571e-02	1.109e-01	-1.697e-05	-1.184e-03	0	-0.006671
014/01	6.313e-04	-0.345	0.003	1.822e-02	4.511e-04	1.710e-04	4.993e-03	0	0.020581
015/01	6.826e-04	-0.423	0.885	7.122e-03	3.822e-02	-1.166e-04	1.007e-03	0	-0.002404
016/01	5.543e-04	-0.206	0.391	1.120e-02	-1.758e-02	2.301e-05	3.898e-03	0	0.007185
017/01	5.967e-04	-0.286	0.068	7.736e-03	-5.486e-04	1.322e-04	4.856e-03	0	0.004261
018/01	5.661e-04	-0.235	-0.014	1.027e-02	-1.599e-02	1.480e-04	4.739e-05	0	0.012345
019/01	5.824e-04	-0.262	-0.031	6.917e-03	-3.536e-03	1.591e-04	5.016e-03	0	0.000457
020/01	5.852e-04	-0.271	-0.032	7.569e-03	-2.259e-03	1.641e-04	4.628e-03	0	0.007626
021/01	6.044e-04	-0.311	-0.069	3.439e-03	1.933e-02	1.939e-04	2.921e-03	0	0.000253
022/01	5.750e-04	-0.254	0.091	9.493e-03	4.957e-03	1.194e-04	-1.702e-03	0	-0.007337
023/02	5.875e-04	-0.273	-0.024	4.698e-03	3.316e-03	1.617e-04	2.788e-03	0	-0.004815
024/01	5.774e-04	-0.253	0.081	2.720e-03	9.630e-03	1.191e-04	8.795e-05	0	-0.019357
025/01	6.121e-04	-0.316	-0.004	3.680e-03	1.518e-02	1.679e-04	1.066e-03	0	-0.000054
026/01	6.114e-04	-0.317	-0.001	1.013e-02	1.234e-02	1.679e-04	8.950e-04	0	0.001920
027/02	6.048e-04	-0.307	-0.025	7.093e-03	1.006e-02	1.736e-04	-1.785e-04	0	0.002566
028/01	6.046e-04	-0.305	-0.043	6.485e-03	7.132e-03	1.790e-04	-7.764e-04	0	0.004621
029/01	6.093e-04	-0.306	0.019	7.284e-03	1.223e-02	1.527e-04	-5.045e-04	0	-0.013355
030/01	7.293e-04	-0.518	0.031	4.949e-03	6.557e-02	2.130e-04	-7.435e-04	0	-0.009033
031/01	6.040e-04	-0.299	0.005	6.097e-03	7.740e-03	1.571e-04	5.655e-03	0	0.001906
032/01	5.676e-04	-0.233	-0.041	4.111e-03	-7.702e-03	1.523e-04	5.387e-03	0	0.000405
033/01	5.839e-04	-0.260	0.047	1.063e-02	-4.805e-03	1.317e-04	3.312e-03	0	0.004150
034/01	5.912e-04	-0.279	-0.061	1.055e-02	-5.939e-04	1.759e-04	9.190e-03	0	0.008061
035/01	6.482e-04	-0.377	-0.013	7.515e-03	2.956e-02	1.886e-04	-5.578e-03	0	0.001913
036/01	4.922e-04	-0.101	-0.078	8.257e-03	-4.895e-02	1.278e-04	1.006e-02	0	0.009796
037/02	6.081e-04	-0.305	-0.012	9.813e-03	7.768e-03	1.654e-04	2.914e-03	0	0.002636

Sta/ Cast	O_c Slope (c_1)	Offset (c_3)	P_h coeff (c_2)	T_l coeff (c_4)	T_s coeff (c_5)	P_l coeff (c_6)	$\frac{dO_c}{dt}$ coeff (c_7)	$\frac{dP}{dt}$ coeff (c_8)	T_{dT} coeff (c_9)
038/01	6.370e-04	-0.362	-0.044	1.007e-02	2.574e-02	1.991e-04	4.212e-03	0	0.009868
039/01	5.843e-04	-0.263	-0.015	7.398e-03	-7.183e-04	1.544e-04	3.736e-03	0	0.000838
040/01	5.903e-04	-0.275	0.009	1.072e-02	1.217e-03	1.499e-04	1.828e-03	0	0.004395
041/01	5.817e-04	-0.256	0.037	4.556e-03	2.132e-03	1.329e-04	5.706e-03	0	-0.011741
042/01	5.932e-04	-0.280	-0.004	8.388e-03	5.080e-03	1.554e-04	3.177e-03	0	-0.005771
043/02	5.843e-04	-0.264	0.035	7.657e-03	6.731e-04	1.390e-04	2.812e-03	0	-0.000475
044/01	5.830e-04	-0.265	-0.030	7.818e-03	1.545e-03	1.614e-04	5.280e-03	0	-0.000941
045/01	6.237e-04	-0.337	-0.032	1.209e-02	1.977e-02	1.867e-04	6.518e-03	0	0.009107
046/01	6.171e-04	-0.321	-0.008	5.938e-03	1.552e-02	1.684e-04	1.051e-02	0	-0.001987
047/01	5.753e-04	-0.245	-0.025	7.729e-03	-8.814e-03	1.513e-04	4.940e-03	0	0.001869
048/01	6.277e-04	-0.342	-0.005	1.398e-02	2.088e-02	1.756e-04	8.157e-03	0	0.003083
049/02	6.101e-04	-0.308	-0.000	6.270e-03	1.162e-02	1.622e-04	2.799e-03	0	-0.000823
050/01	5.950e-04	-0.279	0.002	8.203e-03	1.554e-03	1.518e-04	4.063e-03	0	-0.000999
051/01	5.924e-04	-0.275	-0.009	8.734e-03	2.245e-03	1.554e-04	7.795e-03	0	0.000446
052/01	5.868e-04	-0.267	-0.015	1.852e-03	5.573e-03	1.552e-04	5.727e-03	0	-0.005213
053/01	5.900e-04	-0.268	-0.000	6.581e-03	1.212e-03	1.488e-04	6.102e-03	0	-0.001095
054/01	5.767e-04	-0.245	-0.006	1.558e-03	-2.289e-03	1.454e-04	3.407e-03	0	-0.002214
055/02	5.649e-04	-0.223	0.047	6.756e-03	-7.849e-03	1.214e-04	6.592e-03	0	-0.003745
056/01	5.777e-04	-0.251	-0.048	4.261e-03	-4.180e-03	1.626e-04	2.983e-03	0	0.003465
057/01	5.686e-04	-0.231	-0.006	9.804e-04	-2.876e-03	1.413e-04	6.347e-03	0	-0.006516
058/01	6.680e-04	-0.401	0.024	5.366e-03	2.832e-02	1.782e-04	7.902e-03	0	-0.002192
059/02	5.705e-04	-0.241	0.000	6.270e-03	-5.164e-03	1.448e-04	2.457e-03	0	0.001364
060/01	5.005e-04	-0.127	-0.285	9.703e-04	-3.234e-02	1.947e-04	-4.849e-03	0	0.015703
061/01	5.810e-04	-0.254	0.002	1.999e-03	-1.555e-05	1.457e-04	4.074e-03	0	0.003237
062/01	5.873e-04	-0.265	-0.014	4.411e-03	-1.669e-03	1.535e-04	4.950e-03	0	0.000603
063/01	6.147e-04	-0.304	0.121	2.693e-03	1.026e-02	1.126e-04	6.511e-04	0	-0.009660
064/01	5.714e-04	-0.233	0.166	-3.493e-06	-8.002e-04	9.139e-05	8.576e-03	0	-0.002969
065/02	4.929e-04	-0.133	0.979	-1.569e-02	-2.010e-02	-1.005e-04	4.596e-03	0	0.042484
066/02	6.144e-03	-0.629	1.257	1.588e+00	-1.137e-01	-2.351e-04	1.795e-06	0	-1.314100
067/01	1.166e-03	-0.795	-0.096	3.031e-01	-9.195e-03	2.648e-04	-5.252e-04	0	-0.291010
068/01	1.310e-03	-0.786	0.423	3.330e-01	5.461e-02	9.237e-05	7.702e-04	0	-0.221180
069/01	9.663e-04	-0.480	0.629	2.525e-01	9.758e-03	-4.214e-06	-2.055e-03	0	-0.317590
070/01	6.408e-04	-0.423	-0.019	-3.098e-02	3.438e-03	2.631e-04	1.756e-04	0	0.038206
071/01	5.916e-04	-0.195	0.288	2.022e-02	2.992e-02	4.387e-05	2.091e-03	0	-0.375940
072/01	2.426e-04	0.009	-0.095	-4.346e-01	5.809e-02	-1.085e-04	9.192e-04	0	-0.138680
073/01	9.333e-04	-0.313	0.734	2.369e-01	7.919e-02	-2.838e-05	2.659e-04	0	-0.421030
074/01	1.404e-03	-0.512	1.083	5.318e-01	4.554e-03	-1.282e-04	4.978e-04	0	-0.592220
075/01	1.202e-03	-0.466	0.989	4.210e-01	1.741e-02	-7.616e-05	-9.806e-04	0	-0.356960
076/01	3.035e-04	-0.155	0.347	-4.011e-01	1.160e-02	1.146e-04	-1.033e-03	0	0.601460
077/01	3.551e-04	-0.072	1.936	-2.351e-01	1.610e-02	-2.908e-04	3.659e-03	0	0.169010
078/01	4.792e-04	-0.207	2.283	-9.903e-02	-1.120e-02	-2.609e-04	-8.027e-04	0	0.081094
079/01	9.502e-04	-0.946	1.583	-6.784e-02	1.033e-01	-1.727e-04	-3.907e-03	0	0.064557
080/01	5.555e-04	-0.205	1.360	1.369e-02	-1.748e-02	-2.185e-04	1.623e-03	0	0.018059
081/01	5.797e-04	-0.249	0.072	8.468e-03	-6.519e-03	1.205e-04	3.080e-04	0	0.000530
082/01	5.777e-04	-0.250	0.142	2.417e-03	-5.811e-03	1.053e-04	-3.221e-03	0	0.003479
083/02	7.076e-04	-0.450	0.296	1.209e-02	3.100e-02	6.742e-05	-1.684e-04	0	-0.010935
084/01	5.774e-04	-0.245	0.109	-2.283e-03	4.590e-03	1.076e-04	1.746e-03	0	-0.015206
085/01	6.052e-04	-0.289	0.069	7.433e-03	2.383e-03	1.275e-04	-1.915e-05	0	-0.004422

Sta/ Cast	O_c Slope (c_1)	Offset (c_3)	P_h coeff (c_2)	T_l coeff (c_4)	T_s coeff (c_5)	P_l coeff (c_6)	$\frac{dO_c}{dt}$ coeff (c_7)	$\frac{dP}{dt}$ coeff (c_8)	T_{dT} coeff (c_9)
086/01	6.043e-04	-0.289	0.174	7.534e-03	5.871e-03	9.270e-05	2.265e-04	0	-0.009421
087/01	5.692e-04	-0.238	-0.024	4.486e-03	-8.383e-03	1.503e-04	2.125e-03	0	0.004496
088/01	5.890e-04	-0.267	0.030	9.967e-03	-4.134e-03	1.375e-04	-3.818e-04	0	-0.001455
089/01	6.162e-04	-0.312	0.042	4.795e-03	8.453e-03	1.444e-04	-9.967e-04	0	-0.004816
090/01	6.296e-04	-0.334	0.022	9.721e-03	9.557e-03	1.590e-04	2.162e-03	0	0.006287
091/02	6.235e-04	-0.323	0.015	5.803e-03	6.785e-03	1.575e-04	5.769e-03	0	0.002007
092/01	6.061e-04	-0.291	0.064	7.562e-03	2.831e-03	1.299e-04	-2.638e-03	0	-0.002960
093/02	6.017e-04	-0.291	-0.023	7.310e-03	-1.545e-03	1.646e-04	2.521e-03	0	0.007011
094/01	4.474e-04	-0.031	0.061	5.935e-03	-4.407e-02	8.155e-05	1.959e-03	0	0.004443
095/01	5.065e-04	-0.132	-0.029	5.796e-03	-2.636e-02	1.253e-04	9.737e-03	0	0.004933
096/01	5.809e-04	-0.255	-0.013	7.430e-03	-5.679e-03	1.511e-04	7.774e-03	0	0.003456
097/01	6.124e-04	-0.310	-0.000	6.046e-03	9.832e-03	1.621e-04	3.170e-03	0	0.001289
098/01	5.779e-04	-0.253	-0.025	1.002e-02	-8.823e-03	1.552e-04	6.463e-03	0	0.007444
099/01	5.804e-04	-0.256	-0.024	6.698e-03	-2.234e-03	1.555e-04	3.180e-03	0	-0.000997
100/01	5.908e-04	-0.275	-0.018	5.926e-03	-6.263e-04	1.599e-04	-5.715e-04	0	0.006169
101/01	5.801e-04	-0.252	-0.011	4.984e-03	-3.660e-03	1.484e-04	3.008e-03	0	0.001520
102/02	5.965e-04	-0.285	-0.023	4.372e-03	2.800e-03	1.645e-04	2.622e-03	0	0.004663
103/01	6.829e-04	-0.436	0.044	-1.179e-02	5.349e-02	1.827e-04	-5.207e-04	0	-0.016300
104/01	6.522e-04	-0.381	0.027	-8.620e-03	3.893e-02	1.738e-04	5.665e-03	0	-0.009719
105/01	6.236e-04	-0.328	0.010	7.595e-03	7.496e-03	1.638e-04	1.804e-03	0	0.006730
106/01	5.888e-04	-0.267	-0.015	1.039e-02	-6.489e-03	1.544e-04	1.850e-03	0	0.008257
107/01	4.850e-04	-0.077	0.252	9.208e-03	-4.138e-02	3.964e-05	7.265e-03	0	-0.003507
108/01	5.669e-04	-0.228	-0.026	9.414e-03	-1.423e-02	1.463e-04	3.776e-03	0	0.005682
109/01	5.460e-04	-0.192	-0.027	7.855e-03	-2.049e-02	1.370e-04	6.703e-03	0	0.004953
110/01	5.481e-04	-0.195	-0.042	8.736e-03	-1.959e-02	1.416e-04	7.520e-03	0	0.004338
111/01	6.106e-04	-0.309	-0.006	6.945e-03	3.741e-03	1.663e-04	6.466e-03	0	0.009425
112/01	5.785e-04	-0.248	-0.019	7.245e-03	-6.234e-03	1.499e-04	7.227e-03	0	0.001086
113/01	6.068e-04	-0.301	-0.006	9.158e-03	2.340e-03	1.631e-04	7.167e-03	0	0.004757
114/01	6.068e-04	-0.307	-0.030	1.926e-02	-8.868e-03	1.768e-04	3.960e-03	0	0.025503
115/01	5.768e-04	-0.247	-0.029	5.803e-03	-6.425e-03	1.540e-04	5.126e-03	0	0.005720
116/01	5.618e-04	-0.213	0.125	2.191e-03	-5.487e-03	9.294e-05	5.098e-03	0	-0.017917
117/01	6.158e-04	-0.319	-0.004	1.336e-02	3.926e-04	1.689e-04	3.797e-04	0	0.016364
118/01	5.363e-04	-0.181	-0.035	6.182e-03	-1.487e-02	1.382e-04	8.826e-03	0	0.001067
119/01	5.874e-04	-0.267	0.000	3.296e-03	7.624e-04	1.497e-04	2.560e-04	0	0.000770
120/01	6.107e-04	-0.310	0.007	1.718e-02	-4.145e-03	1.608e-04	8.904e-04	0	0.012026
121/01	5.894e-04	-0.273	-0.005	1.647e-02	-1.082e-02	1.542e-04	5.341e-03	0	0.011252
122/02	6.119e-04	-0.315	-0.049	1.481e-02	-7.171e-03	1.880e-04	6.190e-03	0	0.027507
123/01	5.932e-04	-0.279	-0.003	8.458e-03	-9.684e-04	1.551e-04	4.301e-03	0	0.004999
124/02	6.008e-04	-0.290	-0.007	9.807e-03	-3.281e-05	1.597e-04	2.156e-03	0	0.004677
125/01	5.803e-04	-0.251	0.007	4.281e-03	-2.788e-03	1.421e-04	4.532e-03	0	0.000298
126/03	5.628e-04	-0.218	0.083	-1.366e-04	-1.755e-03	1.079e-04	5.751e-03	0	-0.016284
127/01	5.908e-04	-0.271	-0.033	1.308e-02	-1.133e-02	1.627e-04	8.189e-04	0	0.014632
128/02	5.826e-04	-0.253	0.061	5.632e-03	-8.537e-04	1.233e-04	2.658e-03	0	-0.010092
129/01	6.638e-04	-0.411	0.028	-1.782e-03	4.600e-02	1.884e-04	5.118e-03	0	-0.006654
130/02	6.349e-04	-0.353	0.011	3.419e-03	2.204e-02	1.736e-04	2.266e-03	0	0.004780
131/01	4.945e-04	-0.079	0.252	1.425e-02	-5.495e-02	3.477e-05	3.607e-03	0	-0.000867
132/02	6.044e-04	-0.304	-0.015	4.456e-03	1.348e-02	1.713e-04	-2.167e-03	0	0.002323
133/01	5.843e-04	-0.258	0.008	6.606e-03	4.697e-04	1.437e-04	5.478e-03	0	-0.005303

Sta/ Cast	O_c Slope (c_1)	Offset (c_3)	P_h coeff (c_2)	T_l coeff (c_4)	T_s coeff (c_5)	P_l coeff (c_6)	$\frac{dO_c}{dt}$ coeff (c_7)	$\frac{dP}{dt}$ coeff (c_8)	T_{dT} coeff (c_9)
134/01	5.611e-04	-0.214	0.071	1.239e-02	-2.007e-02	1.127e-04	6.636e-03	0	0.003453
135/01	5.498e-04	-0.196	-0.074	3.502e-03	-1.950e-02	1.517e-04	5.580e-03	0	0.006683
136/02	5.801e-04	-0.251	-0.029	5.390e-03	-5.179e-03	1.545e-04	5.498e-03	0	0.001072
137/01	5.843e-04	-0.254	0.117	6.817e-03	-4.066e-03	1.080e-04	4.149e-03	0	-0.002352
138/02	6.035e-04	-0.295	0.406	1.089e-02	1.667e-02	2.666e-05	1.699e-03	0	-0.002283
139/01	6.144e-04	-0.316	0.014	3.174e-02	2.188e-02	1.162e-04	2.639e-03	0	-0.023959
140/02	5.249e-04	-0.109	-4.697	3.259e-01	-2.797e-02	5.231e-04	5.538e-03	0	-0.205740

Appendix C

CLIVAR S04P: Bottle Quality Comments

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

Station /Cast	Sample No.	Quality Property	Code	Comment
2/1	102	o2	2	O2 value high. Over-titration, could not recover. Processor: "Sample was not over-titrated as analyst thought, used original value resolving oxygen discrepancy."
2/1	103	o2	5	O2 sample lost, possible light interference.
2/1	103	salt	5	Salinity sample kept increasing, lost sample.
2/1	104	o2	5	Oxygen-no endpoint. Sample lost.
2/1	106	salt	3	4 attempts for a good salinity reading. Salinity value very similar to sample 5, cannot recognize that operator had a problem. Code salinity questionable, oxygen and nutrients are acceptable.
2/1	109	o2	5	Oxygen sample lost.
3/1	101	o2	5	Analyst: "sample lost." O2 draw temperature probe had a problem, added +2.5 to the temperatures, should not make a difference in computed kilogram units as all temperatures are less than 5 degrees.
3/1	101	salt	2	4 attempts for a good salinity reading. First reading resulted in a good agreement with the CTD and adjoining stations. Salinity as well as nutrients are acceptable.
3/1	103	no3	2	NO3, possibly PO4 NO3 seems a bit high, maybe by 0.3. Since this is only 1%, probably leave coded as good. Analyst: "Peaks look good, no analytical errors.
3/1	104	salt	2	5 attempts for a good salinity reading. First reading resulted in a good agreement with the CTD and adjoining stations. Salinity as well as oxygen and nutrients are acceptable.
3/1	110	salt	5	Salinity readings kept increasing, could not get a stable reading, value was lost.
3/1	113	salt	2	3 attempts for a good salinity reading. First reading resulted in a good agreement with the CTD and adjoining stations. Salinity as well as oxygen and nutrients are acceptable.
3/1	114	salt	5	Salinity readings kept increasing, could not get a stable reading, value was lost.
4/1	101	o2	5	Analyst: "sample lost. Dosimat stalled."
4/1	101	po4	2	PO4 0.02-0.04 low. Analyst: "Valid peaks, no analytical errors noted."
4/1	102	po4	2	PO4 0.02-0.04 low. Analyst: "Valid peaks, no analytical errors noted."
4/1	103	salt	2	4 attempts for a good salinity reading. First reading resolved slightly high salinity , salinity as well as oxygen and nutrients are acceptable.
4/1	104	salt	2	4 attempts for a good salinity reading. First reading resolved slightly high salinity , salinity as well as oxygen and nutrients are acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
4/1	106	no3	2	There is NO3 chatter at +/- 0.3 level. Since this is only +/- 1%, probably leave coded as good. Analyst: "Peaks look good, no analytical problems noted."
4/1	107	no3	2	There is NO3 chatter at +/- 0.3 level. Since this is only +/- 1%, probably leave coded as good. Analyst: "Peaks look good, no analytical problems noted."
4/1	108	no3	2	There is NO3 chatter at +/- 0.3 level. Since this is only +/- 1%, probably leave coded as good. Analyst: "Peaks look good, no analytical problems noted."
4/1	109	no3	2	There is NO3 chatter at +/- 0.3 level. Since this is only +/- 1%, probably leave coded as good. Analyst: "Peaks look good, no analytical problems noted."
4/1	110	no3	2	There is NO3 chatter at +/- 0.3 level. Since this is only +/- 1%, probably leave coded as good. Analyst: "Peaks look good, no analytical problems noted."
4/1	110	o2	2	Sample was over-titrated then back titrated, appears that first analysis was okay, corrected value and data appears acceptable.
4/1	113	reft	3	SBE35T -0.015/-0.01 vs CTDT1/CTDT2; somewhat unstable SBE35T reading.
4/1	115	o2	2	Sample was over-titrated then back titrated, appears that first analysis was okay, corrected value and data appears acceptable.
4/1	116	salt	2	3 attempts for a good salinity reading. First reading resolved slightly high salinity , salinity as well as oxygen and nutrients are acceptable.
4/1	118	o2	5	Analyst: "sample lost. Dosimat stalled."
4/1	119	o2	4	O2 value low vs CTDO, nearby bottles. No analytical notes. Code bad.
4/1	120	bottle	9	Closed too shallow, possibly partially out of water. Did not use this bottle for sampling, closed bottle 21 at the same depth.
5/1	101	po4	2	PO4 ˜0.02-0.03 low, within accuracy of measurement. Analyst: "Valid peaks, no analytical errors noted."
5/1	102	po4	2	PO4 ˜0.02-0.03 low, within accuracy of measurement. Analyst: "Valid peaks, no analytical errors noted."
5/1	103	o2	5	sample lost.
5/1	103	po4	2	PO4 ˜0.02-0.03 low, within accuracy of measurement. Analyst: "Valid peaks, no analytical errors noted."
5/1	104	po4	2	PO4 ˜0.02-0.03 low, within accuracy of measurement. Analyst: "Valid peaks, no analytical errors noted."
5/1	105	po4	2	PO4 ˜0.02-0.03 low, within accuracy of measurement. Analyst: "Valid peaks, no analytical errors noted."
5/1	105	salt	2	Bottle salinity is low compared with CTD, agrees with adjoining stations as does oxygen and nutrients. There is a spike in the CTD trace, code CTD salinity questionable.
5/1	106	o2	5	Analyst: "OT, no endpoint." O2 value very high vs CTDO and nearby bottles. Oxygen value lost.
5/1	108	o2	2	Low oxygen with corresponding SiO3 and salinity. Data are acceptable.
5/1	115	salt	2	3 attempts for a good salinity reading. Salinity is slightly high and is acceptable.
5/1	121	o2	5	Analyst: "sample lost."
5/1	126	no2	2	NO2 ˜1.7 too high. Analyst: "All peaks look good. TSG sample was analyzed immediately prior to 126 and produced identical results."
6/2	203	no3	3	N:P ratio is low. Analyst: "Peaks look good- no analytical errors. Code questionable."
6/2	206	bottle	2	Nozzles are hard to pull out.
6/2	206	salt	2	Bottle salinity is low compared with CTD, agrees within accuracy of the measurement with adjoining stations. Salinity as well as oxygen and nutrients are acceptable.
6/2	207	bottle	2	Nozzles are hard to pull out.

Station /Cast	Sample No.	Quality Property	Code	Comment
6/2	208	bottle	2	Nozzles are hard to pull out.
6/2	208	salt	2	Bottle salinity is low compared with CTD, agrees within accuracy of the measurement with adjoining stations. Salinity as well as oxygen and nutrients are acceptable.
6/2	210	salt	2	Thimble came off with cap. 4 attempts for a good salinity reading. Salinity as well as oxygen and nutrients are acceptable.
6/2	214	o2	2	O2 low, corresponding high SiO3 feature. Oxygen as well as salinity and nutrients are acceptable.
6/2	215	salt	2	Bottle salinity is low compared with CTD, agrees within accuracy of the measurement with bottle data on adjoining stations. Fine structure seen in the CTD trace. Salinity as well as oxygen and nutrients are acceptable.
6/2	216	salt	2	Thimble came off with cap. 3 attempts for a good salinity reading. Salinity as well as oxygen and nutrients are acceptable.
6/2	218	salt	2	Thimble came off with cap. Salinity as well as oxygen and nutrients are acceptable.
7/1	116	salt	2	3 attempts for a good salinity reading. Salinity as well as oxygen and nutrients are acceptable.
7/1	121	salt	2	Bottle salinity is low compared with CTD, gradient area. Salinity as well as oxygen and nutrients are acceptable.
7/1	135	salt	2	4 attempts for a good salinity reading. Salinity as well as oxygen and nutrients are acceptable.
7/1	136	salt	3	Bottle salinity is 0.04 low compared with CTD, also low compared with adjoining stations, code salinity questionable, oxygen and nutrients acceptable.
8/1	102	no3	2	NO3 0.7 low. Analyst: "All valid peaks. No analytical errors noted."
8/1	110	bottle	2	Full stream on open spigot, valve fully closed. Oxygen as well as salinity and nutrients are acceptable.
8/1	126	salt	2	3 attempts for a good salinity reading. Salinity within accuracy of measurement, oxygen and nutrients are acceptable.
9/1	103	o2	4	Bubble dispensed through burette. O2 high ˜0.2. Code oxygen bad.
9/1	106	o2	3	O2 appears low, 0.1. No analytical problems noted. Code oxygen questionable, salinity and nutrients are acceptable.
9/1	110	salt	3	4 attempts for a good salinity reading. Salt crystal fell in, bad seal on rubber stopper on second read. First reading gives better agreement, still high. Code salinity questionable, oxygen and nutrients are acceptable.
9/1	116	salt	2	3 attempts for a good salinity reading. Second and third readings give better agreement, leave as is. Salinity as well as oxygen and nutrients are acceptable.
9/1	117	o2	2	O2 value high, tried over titration. Analyst thought sample was over-titrated and performed a back-titration. The original value is acceptable.
9/1	121	o2	5	Analyst: "Dosimat stalled, kicked program and tried over titration. Sample lost."
9/1	129	salt	2	3 attempts for a good salinity reading. Second and third readings give better agreement, leave as is. Salinity as well as oxygen and nutrients are acceptable.
9/1	132	ctds	2	Somewhat noisy CTDT/CTDS during soak, but stabilized before trip. Code CTDS acceptable.
9/1	132	salt	3	Salinity +0.035 vs CTDS1/S2; code Salinity questionable. "Bottle salinity high compared with Station 8 as is the CTD.
9/1	134	o2	5	Aborted analysis, sample pickling missed.

Station /Cast	Sample No.	Quality Property	Code	Comment
10/2	205	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	205	o2	2	Interesting sample: bottle O2 possibly a little high (may also be the case to a lesser extent on bottle 06) by ca. 0.08 ml/l, which is edging into questionable (code 3) territory. But NO3 & SiO3 are a little low, and even bottle salt a tiny low, which all are in same oceanographic direction as the high O2. Another interesting possibility - consistent with every ODF property except NO3 (which has been chattering a bit) - is that 05 closed at the same time that 04 closed. Suggest taking a look at CFC data. Processor: "This comment was made prior to bottle reassignment."
10/2	206	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	207	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	208	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	209	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	210	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	210	salt	2	3 attempts for a good salinity reading. Salinity as well as oxygen and nutrients are acceptable.
10/2	211	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	212	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	213	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	214	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.

Station /Cast	Sample No.	Quality Property	Code	Comment
10/2	215	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	216	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	216	salt	4	5 attempts for a good salinity reading. Additional readings did not resolve salinity difference, code salinity bad, oxygen and nutrients are acceptable.
10/2	217	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	218	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	219	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	220	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	221	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	222	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	223	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	224	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	225	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	226	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.

Station /Cast	Sample No.	Quality Property	Code	Comment
10/2	227	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	228	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	229	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	229	reft	3	SBE35T is +0.04/+0.065 vs CTDT1/CTDT2; unstable SBE35T reading.
10/2	230	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	231	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	232	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	233	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	234	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	235	bottle	4	Bottles tripped one level deeper than intended. Suspect that the lanyard for 5 was in the latch position with 4. Trip data was reassigned based on this assessment and salinity, oxygen and nutrients are acceptable unless otherwise individually noted. Code bottle did not trip as scheduled.
10/2	236	bottle	2	Bottle tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
11/1	101	o2	3	Oxygen appears ˜0.1 low compared with CTDO and adjoining stations. No analytical problem noted, except sample was run second, which sometimes means that lines were not properly flushed. Oxygen is questionable, salinity and nutrients are acceptable.
11/1	101	po4	2	The entire station for PO4 & NO3 appear high compared with adjoining stations. Analyst: "Station 11 has noisy peaks for NO3 and especially PO4. There were some autoanalyzer problems for this station. Leave data coded as acceptable except as noted, 10 & 11.
11/1	105	salt	2	4 attempts for a good salinity reading. First reading resolved salinity difference. Salinity as well as oxygen are acceptable. Thimble came off with cap, unstable sample.
11/1	110	bottle	2	Leaking when spigot first tested. Oxygen as well as salinity are acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
11/1	110	no3	4	NO3 & PO4 seems low (by about 0.04?) and NO3 a tiny bit high, leading to an outlier on a NO3/PO4 plot. Might be worth a look at PO4 at this level. Analyst: "Noisy peak, code bad."
11/1	110	po4	4	PO4 possibly a small amount low, though within error limits. Analyst: "Noisy peak, code bad."
11/1	111	no3	4	NO3 & PO4 seems low (by about 0.04?) and NO3 a tiny bit high, leading to an outlier on a NO3/PO4 plot. Might be worth a look at PO4 at this level. Analyst: "Noisy peak, code bad."
11/1	111	po4	4	PO4 possibly a small amount low, though within error limits. Analyst: "Noisy peak, code bad."
11/1	112	o2	2	Analyst: "No peak, sample lost" Analyst thought sample had over-titrated and performed a back-titration. The original readings are acceptable.
11/1	130	salt	2	4 attempts for a good salinity reading. First reading resolved salinity difference. Salinity as well as oxygen are acceptable.
11/1	131	o2	2	Analyst: "Stirrer bar missing on first titration." Back-titration resulted in an acceptable value.
11/1	136	bottle	2	Tripped on the fly due to weather. Oxygen as well as salinity and nutrients are acceptable.
12/1	104	salt	2	4 attempts for a good salinity reading. Thimble came off with cap. First reading resolved salinity difference. Salinity as well as oxygen and nutrients are acceptable.
12/1	106	o2	5	Analyst: "No peak, sample lost."
12/1	121	o2	4	Oxygen high no analytical notes, code oxygen bad.
12/1	124	o2	5	Analyst: "No peak, analysis aborted, sample lost."
12/1	125	salt	2	4 attempts for a good salinity reading. First reading resolved salinity difference. Salinity as well as oxygen and nutrients are acceptable.
12/1	131	reft	3	SBE35T -0.035/-0.025 vs CTDT1/CTDT2; unstable SBE35T reading.
12/1	136	bottle	2	Tripped on the fly due to weather. Oxygen as well as salinity and nutrients are acceptable.
13/1	110	bottle	2	May have slight leak-water comes out of spigot when vent is closed. The spigot was knocked on recovery (by hand). Oxygen as well as salinity and nutrients are acceptable.
13/1	115	salt	2	3 attempts for a good salinity reading. Inner cap not seated well. First reading resolved salinity difference, salinity as well as oxygen and nutrients are acceptable.
13/1	117	salt	4	Bottle salinity +0.01 vs CTDS. Bottle salinity is high compared with CTD and adjoining stations. Inner cap not seated well. Code salinity bad, oxygen and nutrients acceptable.
13/1	129	salt	2	3 attempts for a good salinity reading. First reading resolved salinity difference, salinity as well as oxygen and nutrients are acceptable.
13/1	135	o2	5	Analyst: "Dosimat froze during titration. Sample lost."
13/1	136	bottle	2	Bottle tripped on the fly. Salinity and nutrients are acceptable.
13/1	136	o2	5	Analyst: "Dosimat froze during titration. Sample lost."
14/1	119	salt	4	Bottle salinity is low compared with CTD and adjoining stations. No analytical problems noted. Code salinity bad, oxygen and nutrients are acceptable.
14/1	132	reft	3	SBE35T reading unstable.
14/1	133	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.

Station /Cast	Sample No.	Quality Property	Code	Comment
14/1	133	salt	2	Bottle salinity -0.02 vs CTDS, code CTDS questionable. Gradient, variation in CTD while entrained water is dispersing. Bottle salinity as well as oxygen and nutrients are acceptable. Neither CTD nor bottle is bad, likely 1 meter bottle vs. CTD difference.
15/1	104	sio3	3	SiO3 low 2.1 compared with adjoining stations. PO4 slightly low 0.02, NO3 low 0.09, O2 high 0.03, and Salinity are all within accuracy of the measurements. Analyst: "Valid peak. No analytical error noted." Code SiO3 questionable, salinity, oxygen and other nutrients acceptable.
15/1	105	salt	2	3 attempts for a good salinity reading. First reading gave a better salinity agreement. Salinity as well as oxygen and nutrients are acceptable.
15/1	118	bottle	2	Bottle possibly didn't close properly, clip on lanyard prematurely unclipped, probably ok, suspect occurrence at bottle trip. Oxygen as well as salinity and nutrients are acceptable.
15/1	134	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. Code CTD salinity a questionable, CTD is okay, just does not compare well with bottle salinity.
15/1	134	salt	2	Bottle salinity is low compared with CTD agrees with adjoining stations, variation in CTD, both sensors agree with one another, causing the large difference. Salinity as well as oxygen and nutrients are acceptable.
15/1	136	bottle	2	Bottle tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
16/1	105	salt	2	3 attempts for a good salinity reading. Salinity as well as oxygen and nutrients are acceptable.
16/1	115	o2	2	Possible drawn duplicate of 16. Processor: "Does not appear to have been drawn from 16, leave as is."
16/1	116	o2	2	0.03 difference with CTD not the best but OK to leave as code 2 (acceptable). O2 flasks for 16 and 17 were switched in the box, data file follows Sample Log.
16/1	122	salt	2	3 attempts for a good salinity reading. Salinity as well as oxygen and nutrients are acceptable.
16/1	133	no2	2	NO2 0.5 high compared with adjoining stations. Analyst: "Valid peak; follows trend. No analytical error noted."
16/1	133	salt	2	Bottle salinity is high compared with CTD agrees with adjoining stations, variation in CTD, both sensors agree with one another, causing the large difference. Salinity as well as oxygen and nutrients are acceptable.
16/1	136	bottle	2	Tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
17/1	111	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	112	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	113	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	113	salt	2	Salinity bottles out of order, 13 = bottle 14, 14 = bottle 15, 15 = bottle 13, 16= bottle 16, corrected in text file and salinity is acceptable.
17/1	114	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	115	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	116	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.

Station /Cast	Sample No.	Quality Property	Code	Comment
17/1	117	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	118	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	119	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	120	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	121	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	122	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	123	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	124	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	125	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	126	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	127	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	128	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	129	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	130	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	131	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	132	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	133	bottle	3	Bottle did not close completely, top end cap got stuck on upper LADCP. Oxygen, although a little high, and nutrients appears acceptable.
17/1	133	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	134	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
17/1	134	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	134	salt	2	Bottle salinity is low compared with CTD, agrees with adjoining stations. Large gradient, and large variation in CTD signal, code CTDS as questionable, salinity as well as oxygen and nutrients are acceptable.
17/1	135	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
17/1	136	bottle	2	Tripped on the fly. Oxygen as well as salinity and nutrients agree with adjoining stations.
17/1	136	po4	4	PO4 none of these PO4s look good to me - something happened. Analyst: "AutoAnalyzer error-code bad. The bottom should be OK.
18/1	101	po4	5	PO4 0.05 high on the entire station profile. Analyst: "AutoAnalyzer error PO4 channel only, PO4 lost."

Station /Cast	Sample No.	Quality Property	Code	Comment
18/1	102	po4	5	PO4 0.05 high on the entire station profile. Analyst: "AutoAnalyzer error PO4 channel only, PO4 lost."
18/1	110	bottle	2	Bottle leaking from spigot before vented. Oxygen and salinity are acceptable.
18/1	136	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Oxygen as well as salinity and nutrients are acceptable.
19/1	103	o2	5	Oxygen sample lost.
19/1	107	o2	4	Oxygen 0.2 low, no analytical problems noted. This is the first sample run after a "wake-up" sample which has a tendency to be low. Code oxygen bad, salinity and nutrients are acceptable.
19/1	110	bottle	2	Vent o-ring changed prior to cast.
19/1	112	bottle	2	Minor leak when spigot opened before venting. Oxygen as well as salinity and nutrients are acceptable.
19/1	113	salt	2	3 attempts for a good salinity reading. Salinity as well as oxygen and nutrients are acceptable.
19/1	115	salt	2	Bottle salinity is high compared with CTD and adjoining stations. 5 attempts for a good salinity reading. Thimble came off with cap, bottle not sealed perfectly to bung until after 2nd read, runaway sample. First reading resolved high salinity. Salinity as well as oxygen and nutrients are acceptable.
19/1	116	salt	2	3 attempts for a good salinity reading. First reading resolved high salinity. Salinity as well as oxygen and nutrients are acceptable.
19/1	120	salt	2	3 attempts for a good salinity reading. First reading resolved high salinity. Salinity as well as oxygen and nutrients are acceptable.
19/1	127	salt	2	3 attempts for a good salinity reading. First reading resolved high salinity. Salinity as well as oxygen and nutrients are acceptable.
19/1	132	bottle	2	Slow Spigot leak when vented.
19/1	135	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
19/1	135	salt	2	Bottle salinity is low compared with CTD, large gradient. Salinity as well as oxygen and nutrients are acceptable.
19/1	136	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle.
20/1	121	salt	2	4 attempts for a good salinity reading, inner cap not seated. Salinity as well as oxygen and nutrients are acceptable.
20/1	132	bottle	2	Leaked, vent found open. Oxygen as well as salinity and nutrients are acceptable.
21/1	115	o2	2	Bottle O2 a tiny bit high (by 0.04), but unless there is a reason to mark it questionable, probably leave as code 2 (acceptable).
21/1	118	o2	5	High titration, possible Iodate spillage on titration.
21/1	120	o2	5	Unreasonably high titration, stirrer bar missing.
21/1	130	bottle	2	Pin on spigot is bent. Oxygen as well as salinity and nutrients are acceptable.
21/1	132	bottle	2	Spigot/nozzle is loose. Oxygen as well as salinity and nutrients are acceptable.
21/1	132	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. Code CTD salinity questionable, CTD is okay, just does not compare well with bottle salinity.
21/1	132	reft	3	SBE35T reading unstable.
21/1	133	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. Code CTD salinity questionable, CTD is okay, just does not compare well with bottle salinity.

Station /Cast	Sample No.	Quality Property	Code	Comment
21/1	134	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. Code CTD salinity questionable, CTD is okay, just does not compare well with bottle salinity.
21/1	134	salt	2	Bottle salinity is low compared with CTD, agrees with adjoining stations. Variation in CTD at bottle trip. Salinity as well as oxygen and nutrients are acceptable.
22/1	104	o2	5	O2 pipette not in flask for analysis. Sample lost.
22/1	128	o2	2	SiO3 vs. O2 slightly low, O2 does appear slightly low although within the accuracy of the measurement. Oxygen, nutrients and salinity are acceptable.
22/1	128	sio3	2	SiO3 vs. O2 slightly low, SiO3 does appear slightly low although within the accuracy of the measurement. Nutrients as well as oxygen and salinity are acceptable.
22/1	130	bottle	2	Prior to cast, straightened bent pin on spigot. No leaking complaints during sampling.
22/1	132	bottle	2	Prior to cast, replaced spigot. No leaking complaints during sampling.
22/1	136	bottle	2	Bottle tripped on the fly. Oxygen as well as salinity and oxygen are acceptable. N:P ratio does appear slightly high.
23/2	205	salt	2	3 attempts for a good salinity reading. First reading resolved salinity difference. Salinity as well as oxygen and nutrients are acceptable.
23/2	210	salt	2	3 attempts for a good salinity reading. First reading resolved salinity difference. Salinity as well as oxygen and nutrients are acceptable.
23/2	224	salt	3	Salinity high, no analytical problem noted. Code salinity questionable, oxygen and nutrients are acceptable.
23/2	227	salt	2	3 attempts for a good salinity reading. First reading resolved salinity difference. Salinity as well as oxygen and nutrients are acceptable.
23/2	231	no2	2	NO2 0.04 high compared to adjoining stations. Analyst: "Real peak- no analytical error noted."
23/2	236	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Oxygen as well as salinity and nutrients are acceptable.
24/1	101	sio3	2	SiO3 low, O2, salinity and other nutrients exhibit a feature, but SiO3 vs. O2 relationship is low. Analyst: "Real peak- no analytical error noted."
24/1	102	sio3	2	SiO3 low, O2, salinity and other nutrients exhibit a feature, but SiO3 vs. O2 relationship is low. Analyst: "Real peak- no analytical error noted."
24/1	105	sio3	2	SiO3 appears high, O2, salinity and other nutrients also exhibit a feature. SiO3 vs. O2 relationship is high. Analyst: "Real peak- no analytical error noted."
24/1	123	salt	2	3 attempts for a good salinity reading. Salinity as well as oxygen and nutrients are acceptable.
25/1	110	bottle	2	Leaking, spigot open-vent closed water comes out fast. Vent is unseated and tilted to the side. Oxygen as well as salinity and nutrients are acceptable.
25/1	113	o2	5	O2 Analyst: "Acid not added, Sample lost."
25/1	135	o2	3	Oxygen low, same value as oxygen from bottle 34. Salinity and nutrients are ok, probable mis-draw.
26/1	102	o2	5	Analysis was aborted, oxygen lost.
26/1	110	bottle	2	Prior to cast, bottle was replaced with a new bottle, s/n 37.
26/1	120	o2	5	Sample was over-titrated and then back-titrated and did not give a good value, oxygen lost.
26/1	136	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Oxygen as well as salinity and nutrients are acceptable.
27/2	202	salt	2	3 attempts for a good salinity reading. First reading resolved the small salinity difference.

Station /Cast	Sample No.	Quality Property	Code	Comment
27/2	205	salt	2	3 attempts for a good salinity reading. First reading resolved the small salinity difference. Salinity as well as oxygen and nutrients are acceptable.
27/2	210	salt	2	3 attempts for a good salinity reading. Additional readings are acceptable. Salinity as well as oxygen and nutrients are acceptable.
27/2	231	salt	3	Bottle salinity is low compared with CTD and adjoining stations. No analytical problems noted, code salinity questionable, oxygen and nutrients acceptable.
27/2	232	salt	3	Bottle salinity is low compared with CTD and adjoining stations. No analytical problems noted, code salinity questionable, oxygen and nutrients acceptable.
28/1	132	ctds	3	Small gradient, Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
28/1	132	salt	2	Bottle salinity is high compared with CTD, agrees with adjoining stations. Variation in CTD at bottle trip is causing the difference. Code CTD salinity questionable, bottle salinity, oxygen and nutrients are acceptable.
28/1	134	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
28/1	134	reft	3	SBE35T reading somewhat unstable.
28/1	134	salt	2	Bottle salinity is high compared with CTD, agrees with adjoining stations. Variation in CTD at bottle trip is causing the difference. Code CTD salinity questionable, bottle salinity, oxygen and nutrients are acceptable.
29/1	101	o2	5	Force quit Dosimat stall oxygen sample lost.
29/1	116	salt	2	3 attempts for a good salinity reading. First reading resolved small salinity difference. Salinity, oxygen and nutrients are acceptable.
29/1	125	o2	2	Oxygen, strange curve. Oxygen is slightly high compared with CTD trace, within accuracy of the measurement. Oxygen as well as salinity and nutrients are acceptable.
29/1	136	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Oxygen as well as salinity and nutrients are acceptable.
30/1	103	bottle	2	Possible leak through nozzle (valve not shut all the way?). Oxygen as well as salinity and nutrients are acceptable, bottle acceptable.
30/1	133	reft	3	SBE35T reading unstable.
30/1	136	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Oxygen and salinity are acceptable.
31/1	119	salt	2	3 attempts for a good salinity reading. First reading resolved small salinity difference. Salinity, oxygen and nutrients are acceptable.
31/1	134	ctds	3	Shiproll plus poor mixing in gradient cause CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity code CTD salinity questionable.
31/1	134	salt	2	Bottle salinity is low compared with CTD, okay with adjoining stations. Gradient, salinity as well as oxygen and nutrients are acceptable.
32/1	101	bottle	4	Appears that bottle mis-tripped. Wait until all parameters are measured. Trip level 4 3197 not reported, bottles 2-4 shift 1 level deeper, bottles 5-33 remain the same, bottles 34-36 shift 1 deeper, bottle 1 tripped at the surface. Suspect that lanyards were mis-strung into the carousel.
32/1	101	po4	2	PO4 high, ˜0.1. Analyst: "Good looking run- no analytical errors noted."
32/1	102	bottle	4	Code bottles did not trip as scheduled.
32/1	103	bottle	4	Code bottles did not trip as scheduled.
32/1	104	bottle	4	Code bottles did not trip as scheduled.
32/1	117	no2	5	Inadequate sample volume, sample lost.
32/1	117	no3	5	Inadequate sample volume, sample lost.
32/1	117	po4	5	Inadequate sample volume, sample lost.

Station /Cast	Sample No.	Quality Property	Code	Comment
32/1	117	sio3	5	Inadequate sample volume, sample lost.
32/1	132	reft	3	SBE35T -0.04/-0.055 vs CTDT1/CTDT2; unstable SBE35T reading.
32/1	134	bottle	4	Code bottles did not trip as scheduled.
32/1	135	bottle	4	Code bottles did not trip as scheduled.
32/1	136	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Oxygen as well as salinity and nutrients are acceptable.
33/1	112	o2	4	Bottle oxygen is a little high but only a bit over 0.03 ml/l different. No intrusions seen in CTD trace. Examine bottle and titration records? Processor: "No analytical problems noted. No corresponding feature seen in sio3 or salinity. Code oxygen questionable."
33/1	116	salt	2	4 attempts for a good salinity reading. First reading resolved the salinity difference, salinity as well as oxygen and nutrients are acceptable.
33/1	134	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
33/1	134	salt	2	Bottle salinity is high compared with CTD and low compared with adjoining stations. Gradient, salinity as well as oxygen and nutrients are acceptable.
33/1	136	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Oxygen as well as salinity and nutrients are acceptable.
34/1	101	salt	2	3 attempts for a good salinity reading. Additional readings are acceptable. Salinity as well as oxygen and nutrients are acceptable.
34/1	103	salt	3	Salinity low compared with CTD, station profile and adjoining stations, 2 salinity is also low, but within accuracy of the measurement. Code salinity questionable, oxygen and nutrients are acceptable.
34/1	105	salt	2	3 attempts for a good salinity reading. Additional readings are acceptable. Salinity as well as oxygen and nutrients are acceptable.
34/1	125	o2	2	Bad endpoint. Fixed. O2 is acceptable.
35/1	117	o2	4	Oxygen value high compared to CTDO. jhs: "Bottle oxygen may be code 4 (bad). No intrusions seen in CTD trace. Examine bottle and titration records?" Processor: "No analytical problems noted, code oxygen bad, salinity and nutrients are acceptable.
36/1	104	o2	4	Oxygen value low compared to CTDO. kms: Low compared with adjoining stations, no analytical problems noted. Code oxygen questionable, salinity and nutrients are acceptable. JHS: Bottle oxygen should be code 4 (bad).
36/1	107	salt	3	Bottle salinity is high compared with CTD and adjoining stations. Just outside the precision of the measurement, code salinity questionable, oxygen and nutrients are acceptable.
36/1	122	o2	2	Oxygen flasks were out of order compared with previous runs. Sample number assignment follow the Sample Log sheet. Oxygen appears to be okay.
36/1	123	o2	2	Oxygen flasks were out of order compared with previous runs. Sample number assignment follow the Sample Log sheet. Oxygen appears to be okay.
36/1	132	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
36/1	132	o2	3	Oxygen low compared with CTD and adjoining stations. No analytical problems noted. Code oxygen questionable, salinity and nutrients are acceptable.
36/1	132	salt	2	Bottle salinity is high compared with CTD is comparably high with adjoining stations as is SiO3. Salinity as well as oxygen and nutrients are acceptable.
36/1	134	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.

Station /Cast	Sample No.	Quality Property	Code	Comment
36/1	134	salt	2	Bottle salinity is high compared with CTD is comparably high with adjoining stations as is SiO3. Salinity as well as oxygen and nutrients are acceptable.
36/1	136	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Oxygen as well as salinity and nutrients are acceptable.
37/2	205	salt	3	Bottle salinity high compared with CTD and adjoining stations. 3 attempts for a good salinity reading for bottle 5 first reading results in higher salinity. Analyst could have switched the bottles and read 6 twice which is the 3 readings and disagreement with the first reading. Cannot completely resolve, 5 and 6 are within the accuracy of the measurement, SiO3 is comparably high. Code salinity questionable, oxygen and nutrients are acceptable.
37/2	206	salt	3	Bottle salinity high compared with CTD and adjoining stations. 3 attempts for a good salinity reading for bottle 5 first reading results in higher salinity. Analyst could have switched the bottles and read 6 twice which is the 3 readings and disagreement with the first reading. Cannot completely resolve, 5 and 6 are within the accuracy of the measurement, SiO3 is comparably high. Code salinity questionable, oxygen and nutrients are acceptable.
37/2	207	salt	3	Bottle salinity high compared with CTD and adjoining stations. 3 attempts for a good salinity reading for bottle 5 first reading results in higher salinity. Analyst could have switched the bottles and read 6 twice which is the 3 readings and disagreement with the first reading. Cannot completely resolve, 5 and 6 are within the accuracy of the measurement, SiO3 is comparably high. Code salinity questionable, oxygen and nutrients are acceptable.
37/2	228	salt	2	3 attempts for a good salinity reading. Salinity as well as oxygen and nutrients are acceptable.
38/1	101	salt	3	Bottle salinity is too low, suspect analyst had bottle 2-19 read off one level after the spilled sample. 4 attempts for a good salinity reading. No explanation for the very low salinity. There was an issue with the lab temperature and the standard dial needed to be changed by 5 units. Spilled some of the sample. Suspect that analyst got off, based on the comment on bottle 16 and 19. Suspect that fresher water was run through the salinometer and samples 1, 2 and 3 are low because of this. Code salinity questionable, oxygen and nutrients are acceptable.
38/1	113	o2	4	O2 10 umol/kg high vs. CTDO and adjoining stations, Bad value.
38/1	116	salt	2	3 attempts for a good salinity reading. Suspect the second and third readings are for bottle 17, corrected data files to reflect this. Salinity as well as oxygen and nutrients are acceptable.
38/1	119	salt	2	Noticed on 19 the count was off, count said 18 which is normal, bottle number display should have switched to 20, may have double ran a bottle. Processor: "Comments for 16 confirm this, reorganized data file. Data appears acceptable, witnessed analysis and the progression seemed reasonable.
38/1	134	salt	2	3 attempts for a good salinity reading. Salinity as well as oxygen and nutrients are acceptable.
39/1	133	no2	2	NO2 high, ˜0.1. Analyst: "Real peak. No analytical errors noted."
39/1	134	ctds	3	
39/1	134	reft	3	SBE35T reading unstable.
39/1	134	salt	2	Bottle salinity is low compared with CTD, agrees with adjoining stations. Gradient, salinity as well as oxygen and nutrients are acceptable. Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.

Station /Cast	Sample No.	Quality Property	Code	Comment
39/1	136	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Oxygen as well as salinity and nutrients are acceptable.
40/1	116	po4	2	PO4 low and N:P high compared to adjacent stations. Good run with nice looking peaks. JHS: "PO4s 18-24 are perplexing, especially when accompanied by gradients in SiO3 and at least some variation in NO3. PO4 is acceptable."
40/1	117	po4	2	PO4 low and N:P high compared to adjacent stations. Good run with nice looking peaks. JHS: "PO4s 18-24 are perplexing, especially when accompanied by gradients in SiO3 and at least some variation in NO3. PO4 is acceptable."
40/1	118	po4	2	PO4 low and N:P high compared to adjacent stations. Good run with nice looking peaks. JHS: "PO4s 18-24 are perplexing, especially when accompanied by gradients in SiO3 and at least some variation in NO3. PO4 is acceptable."
40/1	119	po4	2	PO4 low and N:P high compared to adjacent stations. Good run with nice looking peaks. JHS: "PO4s 18-24 are perplexing, especially when accompanied by gradients in SiO3 and at least some variation in NO3. PO4 is acceptable."
40/1	120	po4	2	PO4 low and N:P high compared to adjacent stations. Good run with nice looking peaks. JHS: "PO4s 18-24 are perplexing, especially when accompanied by gradients in SiO3 and at least some variation in NO3. PO4 is acceptable."
40/1	121	po4	2	PO4 low and N:P high compared to adjacent stations. Good run with nice looking peaks. JHS: "PO4s 18-24 are perplexing, especially when accompanied by gradients in SiO3 and at least some variation in NO3. PO4 is acceptable."
40/1	122	po4	2	PO4 low and N:P high compared to adjacent stations. Good run with nice looking peaks. JHS: "PO4s 18-24 are perplexing, especially when accompanied by gradients in SiO3 and at least some variation in NO3. PO4 is acceptable."
40/1	123	po4	2	PO4 low and N:P high compared to adjacent stations. Good run with nice looking peaks. JHS: "PO4s 18-24 are perplexing, especially when accompanied by gradients in SiO3 and at least some variation in NO3. PO4 is acceptable."
40/1	124	po4	2	PO4 low and N:P high compared to adjacent stations. Good run with nice looking peaks. JHS: "PO4s 18-24 are perplexing, especially when accompanied by gradients in SiO3 and at least some variation in NO3. PO4 is acceptable."
41/1	106	sio3	2	SiO3 appears slightly high compared with adjoining stations, within accuracy of the measurement.
42/1	113	o2	2	Oxygen flasks 1729 & 1706 were switched for bottles 13 and 19 respectively. Analyst followed the Sample Log recording and oxygen appears acceptable.
42/1	136	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Oxygen as well as salinity and nutrients are acceptable.
44/1	136	bottle	2	Bottle tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
45/1	101	bottle	2	Styrofoam was put on the rosette in a mesh bag.
45/1	106	sio3	2	SiO3 is low vs. oxygen relationship, ˜3.0. Analyst: "both SIL and o2 profiles look OK compared to neighboring stations. SIL chart is good- no analytical errors."

Station /Cast	Sample No.	Quality Property	Code	Comment
45/1	113	o2	2	Odd curve. Oxygen also did not agree with CTDO and adjoining stations. Flasks were switched in the box, 13=1729 and 19=1706, corrected file then oxygen as well as salinity and nutrients are acceptable.
45/1	116	bottle	2	Bottles tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
45/1	117	bottle	2	Bottles tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
45/1	118	bottle	2	Bottles tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
45/1	119	bottle	2	Bottles tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
45/1	120	bottle	2	Bottles tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
45/1	121	bottle	2	Bottles tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
45/1	122	bottle	2	Bottles tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
45/1	123	bottle	2	Bottles tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
45/1	124	bottle	2	Bottles tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
45/1	125	bottle	2	Bottles tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
45/1	126	bottle	2	Bottles tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
45/1	127	bottle	2	Bottles tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
45/1	128	bottle	2	Bottles tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
45/1	129	bottle	2	Bottles tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
45/1	130	bottle	2	Bottles tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
45/1	131	bottle	2	Bottles tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
45/1	132	bottle	2	Bottles tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
45/1	133	bottle	2	Bottles tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
45/1	134	bottle	2	Bottles tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
45/1	135	bottle	2	Bottles tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
45/1	136	bottle	2	Bottles tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
46/1	132	salt	2	3 attempts for a good salinity reading. First reading results in a higher salinity with better agreement with the CTD. Gradient, salinity as well as oxygen and nutrients are acceptable.
46/1	133	salt	2	3 attempts for a good salinity reading. First reading results in a lower salinity with better agreement with the CTD. Thimble came off with cap. Gradient, salinity as well as oxygen and nutrients are acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
47/1	101	salt	2	Salinity is slightly low compared with CTD and adjoining stations. No analytical problem noted, within accuracy of the measurement. Salinity, oxygen and nutrients are acceptable.
47/1	121	salt	2	3 attempts for a good salinity reading. First reading resolved salinity difference. Salinity, oxygen and nutrients are acceptable.
47/1	134	bottle	4	Bottle was mistakenly tripped with 33 at ˜65m. Changed depth of 35 to 30m to compensate. NO3, PO4 and SiO3 appear low versus adjoining stations, but agree with each other very well. Salinity and oxygen also are lower than adjoining stations.
48/1	103	bottle	9	Bottle failed to close, bottom cap got stuck on adjacent bottle.
48/1	105	salt	2	4 attempts for a good salinity reading. First reading resolved salinity difference. Thimble came off with cap. Salinity as well as oxygen and nutrients are acceptable.
48/1	111	salt	4	Salinity high compared with CTD and adjacent stations. Appears to have been mis-drawn. Code salinity bad, oxygen and nutrients are acceptable.
48/1	112	bottle	2	Leak at vent, o-ring changed after this cast. Oxygen as well as salinity and nutrients are acceptable.
48/1	135	salt	2	3 attempts for a good salinity reading. Additional readings are acceptable. Salinity as well as oxygen and nutrients are acceptable.
49/2	204	o2	4	Oxygen high, ˜0.1, vs. CTD and adjoining stations. O2 analyst thought water dropped into the sample. SiO3 does appear comparably low. Code oxygen bad, salinity and nutrients are acceptable.
49/2	210	salt	2	4 attempts for a good salinity reading. Cap came off in lid. Additional readings produced an acceptable salinity. Salinity as well as oxygen and nutrients are acceptable.
49/2	212	bottle	2	Vent O-ring changed on bottle 12 prior to cast.
49/2	217	salt	2	6 attempts for a good salinity reading. Cap came off in lid. First reading resolved salinity discrepancy. Salinity as well as oxygen and nutrients are acceptable.
49/2	224	salt	2	4 attempts for a good salinity reading. Cap came off in lid. First reading resolved salinity discrepancy. Salinity as well as oxygen and nutrients are acceptable.
49/2	225	salt	2	3 attempts for a good salinity reading. Additional readings produced an acceptable salinity. Additional readings produced an acceptable salinity. Salinity as well as oxygen and nutrients are acceptable.
49/2	227	salt	2	4 attempts for a good salinity reading. Cap came off in lid. Additional reading produced an acceptable salinity. Salinity as well as oxygen and nutrients are acceptable.
49/2	229	o2	2	Oxygen appeared low in relationship to SiO3, both parameters appear reasonable on station comparisons. Oxygen, nutrients and salinity are acceptable.
50/1	108	no3	3	NO3 looks high by ca. 0.5. No extrema in SiO3, PO4, or O2. Analyst: "Peaks and curves look good, no analytical errors." Code NO3 questionable.
50/1	110	salt	2	3 attempts for a good salinity reading. First reading resolved salinity difference. Salinity as well as oxygen and nutrients are acceptable.
50/1	114	salt	2	Analysis was interrupted by fire alarm. 14 had been run, 15 does appear slightly high within accuracy of the measurement. Salinity as well as oxygen and nutrients are acceptable.
50/1	115	bottle	2	Spigot hard to open, changed prior to next station.
50/1	116	salt	2	3 attempts for a good salinity reading. First reading resolved salinity difference. Salinity as well as oxygen and nutrients are acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
51/1	105	salt	2	3 attempts for a good salinity reading. Additional readings produced acceptable salinity. Salinity as well as oxygen and nutrients are acceptable.
51/1	106	bottle	2	Spigot dripping when closed and vent open. bh: "Found that spigot was not pulled all the way out. Replaced collar on spigot."
51/1	108	salt	4	Accidentally read at full flow rate, value look a tad high. Code salinity bad, oxygen and nutrients are acceptable.
51/1	112	bottle	2	Leaks at spigot before venting. Top and bottom end caps o-rings changed after this station.
51/1	114	salt	4	3 attempts for a good salinity reading. Code salinity bad, oxygen and nutrients are acceptable.
51/1	117	bottle	2	Minor leak at spigot before venting. Top and bottom end caps o-rings changed after this station.
51/1	122	salt	2	3 attempts for a good salinity reading. First reading resolved salinity difference. Salinity as well as oxygen and nutrients are acceptable.
51/1	124	o2	5	Flask broke, sample lost. Flask number 1527 replaced with 1735.
51/1	124	salt	2	4 attempts for a good salinity reading. First reading resolved salinity difference. Salinity as well as oxygen and nutrients are acceptable.
51/1	134	ctds	3	
51/1	134	salt	2	Bottle salinity is high compared with CTD agrees with adjoining stations. Gradient, much CTD signal oscillation during bottle stop. Code CTD salinity questionable, bottle salinity, oxygen and nutrients are acceptable.
51/1	136	bottle	2	Bottle tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
52/1	106	bottle	2	Replaced collar on spigot prior to this station."
52/1	108	salt	2	3 attempts for a good salinity reading. Additional readings produced acceptable salinity. Salinity, oxygen and nutrients are acceptable.
52/1	110	salt	2	3 attempts for a good salinity reading. Additional readings produced acceptable salinity. Salinity, oxygen and nutrients are acceptable.
52/1	112	bottle	2	Top and bottom end cap o-rings changed prior to this station.
52/1	117	bottle	2	Top and bottom end cap and vent o-rings changed prior to this station.
53/1	117	bottle	2	Top and bottom end cap and vent o-rings changed prior to this station.
54/1	106	salt	2	3 attempts for a good salinity reading. Additional readings produced an acceptable salinity. Salinity, oxygen and nutrients are acceptable.
54/1	125	salt	2	4 attempts for a good salinity reading. First reading resolved salinity discrepancy. Salinity, oxygen and nutrients are acceptable.
54/1	128	o2	4	Oxygen appears high, looks like it was drawn at bottle 29.
54/1	134	ctds	3	
54/1	134	salt	2	Bottle salinity is high compared with CTD, reasonable with adjoining stations. Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
54/1	136	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Oxygen as well as salinity and nutrients are acceptable.
55/2	201	salt	3	Bottle salinity is high compared with CTD and adjoining stations. SiO3 has a high feature, does not qualify the high salinity. Code salinity questionable, oxygen and nutrients are acceptable.
55/2	206	bottle	2	Leak when spigot open, valve closed. Oxygen as well as salinity and nutrients are acceptable.
55/2	211	salt	4	4 attempts for a good salinity reading. Additional reading did not resolve salinity discrepancy. Code salinity bad, oxygen and nutrients are acceptable.
55/2	212	bottle	2	Leak when spigot open, valve closed. Oxygen as well as salinity and nutrients are acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
55/2	216	bottle	2	Leak when spigot open, valve closed. Oxygen as well as salinity and nutrients are acceptable.
55/2	224	po4	4	AutoAnalyzer error- bad peak. Code PO4 bad, other nutrients and salinity and oxygen are acceptable.
55/2	231	salt	2	3 attempts for a good salinity reading. First reading resulted in better agreement. Salinity as well as oxygen and nutrients are acceptable.
55/2	236	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Oxygen as well as salinity and nutrients are acceptable.
56/1	101	o2	2	Difficulty fitting CTD oxygen until bottom bottle removed from weighting. No analytical problem noted. Oxygen is within accuracy of the measurement. Oxygen as well as salinity and nutrients are acceptable.
56/1	106	o2	2	Reviewed and recalculated with fixed endpoint. Oxygen as well as salinity and nutrients are acceptable.
56/1	116	salt	2	3 attempts for a good salinity reading. Additional readings produced a reasonable salinity. Salinity as well as oxygen and nutrients are acceptable.
56/1	130	bottle	2	Strong flow when nozzle opened with vent closed; reasonably tight, but could be tighter. Oxygen as well as salinity and nutrients are acceptable.
56/1	134	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
56/1	134	salt	2	Bottle salinity is high compared with CTD and adjoining stations. Salinity as well as oxygen and nutrients are acceptable.
57/1	105	salt	2	3 attempts for a good salinity reading. Additional readings produced acceptable salinity. Salinity as well as oxygen and nutrients are acceptable.
57/1	106	salt	4	Bottle salinity is high compared with CTD and adjoining stations. No analytical problems noted. Salinity appears to have been mis-drawn from bottle 8. Code salinity bad, oxygen and nutrients are acceptable.
57/1	107	salt	4	Bottle salinity is high compared with CTD and adjoining stations. No analytical problems noted. Salinity appears to have been mis-drawn from bottle 9. Code salinity bad, oxygen and nutrients are acceptable.
57/1	111	salt	2	3 attempts for a good salinity reading. First reading resolved salinity difference. Salinity as well as oxygen and nutrients are acceptable.
57/1	115	salt	4	Bottle salinity is high compared with CTD and adjoining stations. There seems to be a few mis-draws on this cast. Reviewed salinity analysis and it does not look like that is off by one bottle. Code salinity bad, oxygen and nutrients are acceptable.
57/1	121	salt	2	3 attempts for a good salinity reading. First reading resolved salinity difference. Salinity as well as oxygen and nutrients are acceptable.
57/1	128	salt	2	3 attempts for a good salinity reading. First reading resolved salinity difference. Salinity as well as oxygen and nutrients are acceptable.
57/1	133	po4	3	PO4 high. No analytical error noted. Processor: "Some form of contamination, 1.x high. Feature not seen in any other property."
57/1	136	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Oxygen as well as salinity and nutrients are acceptable.
58/1	109	salt	2	3 attempts for a good salinity reading. First salinity reading resolved small discrepancy. Salinity as well as oxygen and nutrients are acceptable.
58/1	112	bottle	2	Leak at valve? Oxygen as well as salinity and nutrients are acceptable.
58/1	122	po4	4	AutoAnalyzer error- un-recoverable peak. Code PO4 bad.
58/1	134	ctds	3	Shiproll plus poor mixing in gradient cause CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.

Station /Cast	Sample No.	Quality Property	Code	Comment
58/1	134	o2	2	Bottle oxygen appears to have been switched. Physically checked order in the box and could not see that flasks had been switched. Changed the sample numbers and oxygen as well as salinity and nutrients are acceptable.
58/1	135	ctds	3	Shiproll plus poor mixing in gradient cause CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
58/1	135	o2	2	Bottle oxygen appears to have been switched. Physically checked order in the box and could not see that flasks had been switched. Changed the sample numbers and oxygen as well as salinity and nutrients are acceptable.
58/1	135	salt	2	Bottle salinity is high compared with CTD agrees with adjoining stations. Salinity, oxygen and nutrients are acceptable.
59/2	202	salt	2	3 attempts for a good salinity reading. Additional readings resulted in acceptable salinity. Salinity as well as oxygen and nutrients are acceptable.
59/2	226	sio3	3	Unexpected SiO3 minimum. No corresponding feature in other nuts or o2. Good run- no analytical error noted. Code SiO3 questionable.
60/1	101	sio3	2	SiO3 low vs. oxygen, ˜5um/l. Analyst: "Similar feature in pH, DIC, TAlk. No analytical error."
60/1	118	o2	2	Oxygen flasks were switched in the box. Data file agrees with order as written and sampled per Sample Log.
60/1	119	o2	2	Oxygen flasks were switched in the box. Data file agrees with order as written and sampled per Sample Log.
60/1	122	salt	2	3 attempts for a good salinity reading. Additional readings produced acceptable salinity. Salinity, oxygen and nutrients are acceptable.
60/1	130	no2	2	NO2 low 0.06 compared with adjoining stations until plotted with station 58. Analyst: "Not evident on plot with 058-062. No analytical errors noted."
60/1	131	bottle	4	Bottles accidentally tripped at the same/similar pressures.
60/1	132	bottle	4	Bottles accidentally tripped at the same/similar pressures.
61/1	101	sio3	2	SiO3 appears low on station profile and versus oxygen.
61/1	102	salt	2	3 attempts for a good salinity reading. First reading resolved salinity discrepancy, salinity is slightly low but within accuracy of the measurement. Salinity, oxygen and nutrients are acceptable.
61/1	105	salt	2	3 attempts for a good salinity reading. First reading resolved salinity discrepancy, salinity is slightly low but within accuracy of the measurement. Salinity, oxygen and nutrients are acceptable.
61/1	109	salt	4	3 attempts for a good salinity reading. Salinity high with first reading, contamination of the sample. Code salinity bad. Oxygen and nutrients are acceptable.
61/1	111	salt	2	3 attempts for a good salinity reading. First reading resolved salinity discrepancy. Salinity, oxygen and nutrients are acceptable.
61/1	112	bottle	2	Leak from spigot. Oxygen as well as salinity and nutrients are acceptable.
61/1	115	salt	2	3 attempts for a good salinity reading. First reading resolved salinity discrepancy. Salinity, oxygen and nutrients are acceptable.
61/1	136	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Oxygen as well as salinity and nutrients are acceptable.
62/1	104	salt	2	3 attempts for a good salinity reading. Additional reading produced reasonable salinity. Salinity as well as oxygen and nutrients are acceptable.
62/1	105	salt	2	3 attempts for a good salinity reading. First reading resolved salinity discrepancy, although a little low, it is within accuracy of the measurement. Salinity as well as oxygen and nutrients are acceptable.
62/1	108	salt	2	3 attempts for a good salinity reading. Additional readings produced reasonable salinity. Salinity as well as oxygen and nutrients are acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
62/1	119	salt	2	3 attempts for a good salinity reading. First reading resolved salinity discrepancy. Salinity as well as oxygen and nutrients are acceptable.
62/1	121	o2	2	O2 draw temps all the same for bottles 21-31; reset thermometer after bottle 31. Draw temperature used for conversion to mass units, has little or no effect below 5 degrees.
62/1	122	o2	2	O2 draw temps all the same for bottles 21-31; reset thermometer after bottle 31. Draw temperature used for conversion to mass units, has little or no effect below 5 degrees.
62/1	123	o2	2	O2 draw temps all the same for bottles 21-31; reset thermometer after bottle 31. Draw temperature used for conversion to mass units, has little or no effect below 5 degrees.
62/1	124	o2	2	O2 draw temps all the same for bottles 21-31; reset thermometer after bottle 31. Draw temperature used for conversion to mass units, has little or no effect below 5 degrees.
62/1	125	o2	2	O2 draw temps all the same for bottles 21-31; reset thermometer after bottle 31. Draw temperature used for conversion to mass units, has little or no effect below 5 degrees.
62/1	126	o2	2	O2 draw temps all the same for bottles 21-31; reset thermometer after bottle 31. Draw temperature used for conversion to mass units, has little or no effect below 5 degrees.
62/1	127	o2	2	O2 draw temps all the same for bottles 21-31; reset thermometer after bottle 31. Draw temperature used for conversion to mass units, has little or no effect below 5 degrees.
62/1	128	o2	2	O2 draw temps all the same for bottles 21-31; reset thermometer after bottle 31. Draw temperature used for conversion to mass units, has little or no effect below 5 degrees.
62/1	129	o2	2	O2 draw temps all the same for bottles 21-31; reset thermometer after bottle 31. Draw temperature used for conversion to mass units, has little or no effect below 5 degrees.
62/1	130	o2	2	O2 draw temps all the same for bottles 21-31; reset thermometer after bottle 31. Draw temperature used for conversion to mass units, has little or no effect below 5 degrees.
62/1	131	o2	2	O2 draw temps all the same for bottles 21-31; reset thermometer after bottle 31. Draw temperature used for conversion to mass units, has little or no effect below 5 degrees.
63/1	109	salt	3	Salinity high compared with CTD and adjoining stations. Appears it was mis-drawn from 10. Code salinity questionable. Oxygen and nutrients are acceptable.
63/1	114	salt	2	3 attempts for a good salinity reading. First reading resolved salinity difference. Salinity as well as oxygen and nutrients are acceptable.
63/1	116	salt	3	Salinity low compared with CTD and adjoining stations. No analytical problem noted. Code salinity questionable, oxygen and nutrients are acceptable.
63/1	118	salt	2	3 attempts for a good salinity reading. Additional readings produced reasonable salinity. Cap popped. Salinity as well as oxygen and nutrients are acceptable.
63/1	122	salt	2	3 attempts for a good salinity reading. First reading resolved salinity difference. Cap came off in lid. Salinity as well as oxygen and nutrients are acceptable.
63/1	123	salt	2	3 attempts for a good salinity reading. First reading resolved salinity difference. Salinity as well as oxygen and nutrients are acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
63/1	124	salt	2	4 attempts for a good salinity reading. First reading resolved salinity difference. Cap came out in lid. Salinity as well as oxygen and nutrients are acceptable.
63/1	126	salt	2	3 attempts for a good salinity reading. First reading resolved salinity difference. Salinity as well as oxygen and nutrients are acceptable.
63/1	127	salt	2	3 attempts for a good salinity reading. First reading resolved salinity discrepancy, still a little low but within accuracy of the measurement. Salinity as well as oxygen and nutrients are acceptable.
63/1	129	salt	2	3 attempts for a good salinity reading. Additional reading produced reasonable salinity. Salinity as well as oxygen and nutrients are acceptable.
63/1	130	salt	2	3 attempts for a good salinity reading. First reading produced lower salinity, leave as is within accuracy of the measurement. Salinity as well as oxygen and nutrients are acceptable.
63/1	132	salt	2	4 attempts for a good salinity reading. First reading resolved salinity difference. Salinity as well as oxygen and nutrients are acceptable.
64/1	110	o2	3	Oxygen appears high on sio3 vs. o2 plot, adjoining stations and CTDO. No analytical problems noted. Code oxygen questionable, salinity and nutrients acceptable.
64/1	115	salt	2	3 attempts for a good salinity reading. First reading produced a slightly better salinity value. Salinity as well as oxygen and nutrients are acceptable.
64/1	118	o2	2	Bottle o2s are low/high vs CTDO. Bottle flasks appear to be switched: Switched the flask numbers, oxygen data are acceptable.
64/1	119	o2	2	Bottle o2s are low/high vs CTDO. Bottle flasks appear to be switched: Switched the flask numbers, oxygen data are acceptable.
64/1	128	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Oxygen as well as salinity and nutrients are acceptable.
65/2	210	salt	2	3 attempts for a good salinity reading. First reading resolved salinity discrepancy. Salinity as well as oxygen and nutrients are acceptable.
65/2	215	salt	4	4 attempts for a good salinity reading. Additional readings as well as first reading gave discrepancy. Thimble came off with cap. Sample must have been contaminated, code salinity bad, oxygen and nutrients are acceptable.
65/2	216	bottle	2	Heavy leak from spigot after venting.
65/2	217	bottle	2	Duplicate bottle tripped with 18. Sampling for pigments, ODF samples were not drawn.
65/2	219	bottle	2	Duplicate bottle tripped with 20. Sampling for pigments, ODF samples were not drawn.
65/2	221	bottle	2	Duplicate bottle tripped with 22. Sampling for pigments, ODF samples were not drawn.
65/2	223	bottle	2	Duplicate bottle tripped with 24. Sampling for pigments, ODF samples were not drawn.
66/2	207	bottle	2	Duplicate bottle tripped with 8. Sampling for pigments, ODF samples were not drawn.
66/2	209	bottle	2	Duplicate bottle tripped with 10. Sampling for pigments, ODF samples were not drawn.
66/2	211	bottle	2	Duplicate bottle tripped with 12. Sampling for pigments, ODF samples were not drawn.
66/2	213	bottle	2	Duplicate bottle tripped with 14. Sampling for pigments, ODF samples were not drawn.
67/1	101	bottle	2	Mooring cast, 3 bottles, no nutrients.
67/1	101	ctds	3	Gradient caused much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity for calibration purposes.

Station /Cast	Sample No.	Quality Property	Code	Comment
67/1	101	salt	2	Bottle salinity is low compared with CTD. Gradient at the bottom of the cast. Salinity as well as oxygen are acceptable.
68/1	101	bottle	2	Air vent open. Oxygen as well as salinity are acceptable.
68/1	102	bottle	2	Air vent open. Oxygen as well as salinity are acceptable.
68/1	103	bottle	2	Air vent open. Oxygen as well as salinity are acceptable.
69/1	101	bottle	9	No bottles closed due to frozen carousel.
69/1	102	bottle	9	No bottles closed due to frozen carousel.
69/1	103	bottle	9	No bottles closed due to frozen carousel.
69/1	104	bottle	9	No bottles closed due to frozen carousel.
69/1	105	bottle	9	No bottles closed due to frozen carousel.
69/1	106	bottle	9	No bottles closed due to frozen carousel.
70/1	101	bottle	9	Bottle did not trip.
71/1	105	salt	2	3 attempts for a good salinity reading. First reading produced reasonable salinity.
72/1	101	salt	2	4 attempts for a good salinity reading. First reading produced reasonable salinity. Thimble came off with cap.
72/1	102	salt	2	3 attempts for a good salinity reading. First reading produced reasonable salinity.
73/1	102	o2	4	Analyst: "Flask cracked and leaking. Replaced flask." Value low, code bad.
73/1	104	salt	2	4 attempts for a good salinity reading. First reading produces reasonable salinity.
73/1	105	salt	2	3 attempts for a good salinity reading. First reading produces reasonable salinity.
74/1	104	salt	2	4 attempts for a good salinity reading. First reading produced reasonable salinity. Thimble came off with cap.
74/1	105	salt	2	3 attempts for a good salinity reading. First reading produced reasonable salinity.
76/1	101	bottle	9	Bottle 1 did not close, caught on wire of bottle 36.
77/1	101	o2	2	Oxygen was run after wakeup sample, should have been run sixth to the last of run. Oxygen appears acceptable.
77/1	109	bottle	2	Duplicate bottle tripped with 8. Sampling for pigments, ODF samples were not drawn.
77/1	111	bottle	2	Duplicate bottle tripped with 10. Sampling for pigments, ODF samples were not drawn.
77/1	113	bottle	2	Duplicate bottle tripped with 12. Sampling for pigments, ODF samples were not drawn.
77/1	115	bottle	2	Duplicate bottle tripped with 14. Sampling for pigments, ODF samples were not drawn.
77/1	117	bottle	2	Duplicate bottle tripped with 16. Sampling for pigments, ODF samples were not drawn.
77/1	119	bottle	2	Duplicate bottle tripped with 18. Sampling for pigments, ODF samples were not drawn.
77/1	120	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Oxygen as well as salinity and nutrients are acceptable.
78/1	101	no2	3	NO2 0.03-0.05 high, no corresponding fluorometer feature. Analyst: "These are strange, they are showing as real peaks and the RMNS checks out. Perhaps the nutrient tubes got contaminated somehow. The issue does not show in station 83."
78/1	101	salt	2	4 attempts for a good salinity reading. First reading resolved salinity discrepancy. Salinity as well as oxygen and nutrients are acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
78/1	102	no2	3	NO2 0.03-0.05 high, no corresponding fluorometer feature. Analyst: "These are strange, they are showing as real peaks and the RMNS checks out. Perhaps the nutrient tubes got contaminated somehow. The issue does not show in station 83."
78/1	103	no2	3	NO2 0.03-0.05 high, no corresponding fluorometer feature. Analyst: "These are strange, they are showing as real peaks and the RMNS checks out. Perhaps the nutrient tubes got contaminated somehow. The issue does not show in station 83."
78/1	104	no2	3	NO2 0.03-0.05 high, no corresponding fluorometer feature. Analyst: "These are strange, they are showing as real peaks and the RMNS checks out. Perhaps the nutrient tubes got contaminated somehow. The issue does not show in station 83."
78/1	104	o2	2	Flask order switched around. This should be 1764. Files corrected accordingly. Oxygen does appear low with corresponding high SiO3.
78/1	105	no2	3	NO2 0.03-0.05 high, no corresponding fluorometer feature. Analyst: "These are strange, they are showing as real peaks and the RMNS checks out. Perhaps the nutrient tubes got contaminated somehow. The issue does not show in station 83."
78/1	105	o2	3	Flask order switched around. This should be 1760. Processor: "Files produced accordingly. Oxygen does appear high does not have corresponding low SiO3. Oxygen appears ˜0.08 high, code questionable, salinity and nutrients are acceptable."
78/1	105	sio3	2	Oxygen maximum verified by CTDO, no corresponding low SiO3 feature. Analyst: "Nice peak/run- no analytical errors noted. This is indeed an interesting feature. It does not appear to show up in DIC, TALK or pH."
78/1	107	salt	2	5 attempts for a good salinity reading. First reading resolved salinity discrepancy. Thimble came off with cap, runaway sample. Salinity as well as oxygen and nutrients are acceptable.
78/1	108	o2	4	Sample was over-titrated and back-titrated. Original titration is correct, files updated. Processor: "Code oxygen bad, salinity and nutrients acceptable."
78/1	110	salt	2	3 attempts for a good salinity reading. Additional readings produced reasonable salinity. Salinity as well as oxygen and nutrients are acceptable.
78/1	111	salt	2	4 attempts for a good salinity reading. First readings do not resolve salinity discrepancy. Salinity as well as oxygen and nutrients are acceptable.
78/1	113	bottle	2	Duplicate bottle tripped with 14. Sampling for pigments, ODF samples were not drawn.
78/1	115	bottle	2	Duplicate bottle tripped with 16. Sampling for pigments, ODF samples were not drawn.
78/1	117	bottle	2	Duplicate bottle tripped with 18. Sampling for pigments, ODF samples were not drawn.
78/1	119	bottle	2	Duplicate bottle tripped with 20. Sampling for pigments, ODF samples were not drawn.
78/1	120	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Oxygen as well as salinity and nutrients are acceptable.
78/1	121	bottle	2	Out of water, from the spigot, for salinity and nutrients used the dregs. Duplicate DIC samples taken from this surface bottle along with a full suite.
78/1	121	salt	3	Bottle salinity is low compared with CTD agrees with Stations 75, 76, and 79. Suspect technique of drawing from the dregs, may not have rinsed the salinity bottle properly. Code salinity questionable, oxygen and nutrients are acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
79/1	101	no2	3	NO2 0.03-0.05 high, no corresponding fluorometer feature. Analyst: "These are strange, they are showing as real peaks and the RMNS checks out. Perhaps the nutrient tubes got contaminated somehow. The issue does not show in station 83."
79/1	102	no2	3	NO2 0.03-0.05 high, no corresponding fluorometer feature. Analyst: "These are strange, they are showing as real peaks and the RMNS checks out. Perhaps the nutrient tubes got contaminated somehow. The issue does not show in station 83."
79/1	102	salt	2	3 attempts for a good salinity reading. First reading resolves salinity difference. Salinity as well as oxygen and nutrients are acceptable.
79/1	103	no2	3	NO2 0.03-0.05 high, no corresponding fluorometer feature. Analyst: "These are strange, they are showing as real peaks and the RMNS checks out. Perhaps the nutrient tubes got contaminated somehow. The issue does not show in station 83."
79/1	108	salt	2	3 attempts for a good salinity reading. Additional readings produce better salinity than first reading. Salinity as well as oxygen and nutrients are acceptable.
79/1	113	salt	2	3 attempts for a good salinity reading. First reading produced a low salinity than the additional readings. Leave as is. Salinity as well as oxygen and nutrients are acceptable.
79/1	114	salt	2	4 attempts for a good salinity reading. First reading produced a low salinity than the additional readings. Leave as is. Salinity as well as oxygen and nutrients are acceptable.
79/1	117	salt	2	3 attempts for a good salinity reading. First reading produced a reasonable salinity. Salinity as well as oxygen and nutrients are acceptable.
79/1	120	salt	2	3 attempts for a good salinity reading. First reading produced a reasonable salinity. Salinity as well as oxygen and nutrients are acceptable.
80/1	101	bottle	2	22 bottles tripped.
81/1	101	bottle	2	31 bottles tripped.
81/1	101	no2	3	NO2 0.02-0.03 high, no corresponding fluorometer feature. Analyst: "These are strange, they are showing as real peaks and the RMNS checks out. Perhaps the nutrient tubes got contaminated somehow. The issue does not show in station 83."
81/1	102	no2	3	NO2 0.02-0.03 high, no corresponding fluorometer feature. Analyst: "These are strange, they are showing as real peaks and the RMNS checks out. Perhaps the nutrient tubes got contaminated somehow. The issue does not show in station 83."
81/1	103	no2	3	NO2 0.02-0.03 high, no corresponding fluorometer feature. Analyst: "These are strange, they are showing as real peaks and the RMNS checks out. Perhaps the nutrient tubes got contaminated somehow. The issue does not show in station 83."
81/1	104	no2	3	NO2 0.02-0.03 high, no corresponding fluorometer feature. Analyst: "These are strange, they are showing as real peaks and the RMNS checks out. Perhaps the nutrient tubes got contaminated somehow. The issue does not show in station 83."
81/1	105	no2	3	NO2 0.02-0.03 high, no corresponding fluorometer feature. Analyst: "These are strange, they are showing as real peaks and the RMNS checks out. Perhaps the nutrient tubes got contaminated somehow. The issue does not show in station 83."
81/1	120	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.

Station /Cast	Sample No.	Quality Property	Code	Comment
81/1	120	salt	2	Bottle salinity low compared with CTD. Salinity as well as oxygen and nutrients are acceptable.
81/1	122	bottle	2	Winch operator mis-heard console operator, bottle stop and trip and 224 instead of scheme 3, 235. Okay not a data problem.
82/1	101	no2	3	NO2 0.01-0.03 high, no corresponding fluorometer feature. Analyst: "These are strange, they are showing as real peaks and the RMNS checks out. Perhaps the nutrient tubes got contaminated somehow. The issue does not show in station 83."
82/1	102	no2	3	NO2 0.01-0.03 high, no corresponding fluorometer feature. Analyst: "These are strange, they are showing as real peaks and the RMNS checks out. Perhaps the nutrient tubes got contaminated somehow. The issue does not show in station 83."
82/1	103	no2	3	NO2 0.01-0.03 high, no corresponding fluorometer feature. Analyst: "These are strange, they are showing as real peaks and the RMNS checks out. Perhaps the nutrient tubes got contaminated somehow. The issue does not show in station 83."
82/1	104	no2	3	NO2 0.01-0.03 high, no corresponding fluorometer feature. Analyst: "These are strange, they are showing as real peaks and the RMNS checks out. Perhaps the nutrient tubes got contaminated somehow. The issue does not show in station 83."
82/1	105	no2	3	NO2 0.01-0.03 high, no corresponding fluorometer feature. Analyst: "These are strange, they are showing as real peaks and the RMNS checks out. Perhaps the nutrient tubes got contaminated somehow. The issue does not show in station 83."
82/1	113	salt	2	4 attempts for a good salinity reading. First reading resolved salinity discrepancy. Salinity as well as oxygen and nutrients are acceptable.
82/1	133	bottle	2	Duplicate trips with 32, sampling for pigments, ODF samples were not drawn.
82/1	135	bottle	2	Duplicate trips with 34, sampling for pigments, ODF samples were not drawn.
82/1	136	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Oxygen as well as salinity and nutrients are acceptable.
83/2	211	salt	2	Fire alarm went off during sample run, sat on autosal for 5 minutes. Salinity as well as oxygen and nutrients are acceptable.
83/2	219	salt	2	4 attempts for a good salinity reading. First reading produced a better salinity. Salinity as well as oxygen and nutrients are acceptable.
83/2	220	salt	2	3 attempts for a good salinity reading. Additional readings produced reasonable salinity. Salinity as well as oxygen and nutrients are acceptable.
83/2	233	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
83/2	233	salt	2	Bottle salinity is high compared with CTD. 3 attempts for a good salinity reading. Thimble came off with cap. First reading did not resolve salinity discrepancy. Gradient, salinity as well as oxygen and nutrients are acceptable.
83/2	234	salt	2	3 attempts for a good salinity reading. Additional readings produced reasonable salinity. Salinity as well as oxygen and nutrients are acceptable.
83/2	236	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Oxygen as well as salinity and nutrients are acceptable.
84/1	101	bottle	2	35 bottles tripped.
84/1	127	salt	2	3 attempts for a good salinity reading. First reading resolved salinity difference although still a little high within accuracy of the measurement. Salinity, oxygen and nutrients are acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
86/1	120	salt	2	3 attempts for a good salinity reading. First reading resolved the salinity discrepancy. Salinity as well as oxygen and nutrients are acceptable.
86/1	136	bottle	2	Tripped quickly due to waves. Oxygen as well as salinity and nutrients are acceptable.
87/1	103	salt	2	3 attempts for a good salinity reading. First reading resolved salinity difference. Salinity as well as oxygen and nutrients are acceptable.
87/1	104	o2	2	bottle o2 slightly hi (niskin 4) and slightly low (niskin 5). Flask numbers not assigned correctly during analysis. Verified correct flasks/order on sample log, and current order in the sample box. Switched flask numbers in data files, o2 values are ok.
87/1	105	o2	2	bottle o2 slightly hi (niskin 4) and slightly low (niskin 5). Flask numbers not assigned correctly during analysis. Verified correct flasks/order on sample log, and current order in the sample box. Switched flask numbers in data files, o2 values are ok.
87/1	125	o2	5	Analyst: detector volts topped at 1.6V out of 2.5V, resultant h2o discolored brown. Unusually high thio for depth, no obvious analytical errors. Abort end point due to apparent contamination.
87/1	136	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Oxygen as well as salinity and nutrients are acceptable.
88/1	102	salt	2	4 attempts for a good salinity reading. First reading resolved salinity discrepancy. Salinity as well as oxygen and nutrients are acceptable.
88/1	112	salt	2	3 attempts for a good salinity reading. Additional readings produced acceptable salinity. Salinity as well as oxygen and nutrients are acceptable.
88/1	124	salt	2	4 attempts for a good salinity reading. Loose cap. First reading resolved salinity difference. Salinity as well as oxygen and nutrients are acceptable.
88/1	136	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Oxygen as well as salinity and nutrients are acceptable.
89/1	134	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity, code questionable.
89/1	134	salt	2	Bottle salinity is low compared with CTD, agrees with adjoining stations. Gradient, CTD signal oscillation during bottle stop.
90/1	103	salt	2	4 attempts for a good salinity reading. First reading resolved salinity discrepancy. Salinity as well as oxygen and nutrients are acceptable.
90/1	108	o2	4	Oxygen too high, 0.79. No analytical problem noted, draw temperature does not indicate a mis-trip. Nutrients are acceptable.
90/1	112	o2	4	Oxygen too high, 3.6. No analytical problem noted, draw temperature does not indicate a mis-trip. Nutrients are acceptable.
91/2	221	o2	2	Flask 1171 broken during sampling, replaced with 1294. Oxygen as well as salinity and nutrients are acceptable.
91/2	223	salt	2	3 attempts for a good salinity reading. Additional readings produced reasonable salinity. Salinity as well as oxygen and nutrients are acceptable.
91/2	227	salt	2	3 attempts for a good salinity reading. Additional readings produced reasonable salinity. Salinity as well as oxygen and nutrients are acceptable.
91/2	234	ctds	3	Gradient with much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
91/2	234	salt	2	Bottle salinity is high compared with CTD. Gradient, leave bottle salinity as is, oxygen and nutrients are also acceptable.
91/2	236	salt	2	4 attempts for a good salinity reading. First reading resolved salinity discrepancy. Salinity as well as oxygen and nutrients are acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
92/1	102	salt	2	4 attempts for a good salinity reading. First reading resolved salinity discrepancy. Salinity, oxygen and nutrients are acceptable.
92/1	127	salt	2	3 attempts for a good salinity reading. First reading resolved salinity discrepancy. Salinity, oxygen and nutrients are acceptable.
93/2	207	o2	3	Oxygen low, 0.04, compared with CTD and adjoining stations. No analytical problem noted. Code oxygen questionable, salinity and nutrients are acceptable.
93/2	209	o2	4	High titration value attributed to loose valve attached to Thio. Valve was drawing air into the tubing. Fixed valve ran check. Unfixable.
93/2	210	salt	2	3 attempts for a good salinity reading. First reading resolved salinity discrepancy. Salinity as well as oxygen and nutrients are acceptable.
93/2	236	bottle	9	Bottle did not trip. Acquisition recorded carousel confirmation. Lanyard got stuck between bottles, corrected and okay on test and next cast.
94/1	103	salt	2	3 attempts for a good salinity reading. First read was on too high of a flowrate. Additional reading resolved salinity discrepancy. Salinity as well as oxygen and nutrients are acceptable.
94/1	133	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
94/1	133	salt	2	Bottle salinity is high compared with CTD agrees with adjoining stations, Station 91. Salinity as well as oxygen and nutrients are acceptable. Gradient, oscillation in CTD trip data.
95/1	105	salt	4	Bottle salinity is low compared with CTD and adjoining stations. 3 attempts for a good salinity reading. First reading did not resolve salinity discrepancy. Some kind of contamination of the salinity. Code salinity bad, oxygen and nutrients are acceptable.
95/1	109	o2	2	Flask 1413 broken during sampling, replaced with 1117.
95/1	118	salt	2	3 attempts for a good salinity reading. First reading did not resolve salinity discrepancy, within the accuracy of the measurement. Salinity as well as oxygen and nutrients are acceptable.
95/1	136	po4	2	PO4 high, ˜0.1 compared with adjoining stations. Analyst: "Real peak. No analytical error noted. Matches underway sample run."
96/1	130	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
96/1	130	salt	2	Bottle salinity is high compared with CTD. Gradient, salinity as well as oxygen and nutrients are acceptable.
97/1	121	o2	2	Flask 1171 in template box file. Actual flask was 1294. Measurement appears good. Flask 1171 was broken on Station 91, also used on Station 94, assignments were okay.
97/1	130	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
97/1	130	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity as well as oxygen and nutrients are acceptable.
97/1	133	bottle	2	Bottle has a slow flow. Salinity is low compared with CTD, within accuracy of the measurement. Oxygen and nutrients are also acceptable.
98/1	103	salt	2	3 attempts for a good salinity reading. Thimble came off with cap. First reading resolved salinity discrepancy. Salinity as well as oxygen and nutrients are acceptable.
98/1	107	salt	2	3 attempts for a good salinity reading. First reading resolved salinity discrepancy. Salinity as well as oxygen and nutrients are acceptable.
98/1	130	o2	2	Bubbles found under cap prior to running sample. Sample value appears normal.

Station /Cast	Sample No.	Quality Property	Code	Comment
98/1	134	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
98/1	134	salt	2	Bottle salinity is high compared with CTD. Gradient, Salinity as well as oxygen and nutrients are acceptable.
99/1	103	salt	2	3 attempts for a good salinity reading. First reading resolved salinity discrepancy. Thimble came off with cap. Salinity as well as oxygen and nutrients are acceptable.
99/1	134	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
99/1	134	salt	2	Bottle salinity is low compared with CTD. Gradient, salinity as well as oxygen and nutrients are acceptable.
100/1	134	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
100/1	134	salt	2	Bottle salinity is high compared with CTD. Gradient, salinity as well as oxygen and nutrients are acceptable.
101/1	101	salt	2	3 attempts for a good salinity reading. First reading produces lower salinity. Suspect cells were not sufficiently flushed after the higher conductivity standard seawater reading. The lab temperature was also marginally high, ˜0.8 too high and ending ˜1.0 lower than bath. Salinity is within accuracy of the measurement. Oxygen and nutrients are also acceptable.
101/1	108	salt	2	5 attempts for a good salinity reading. First reading produced a reasonable salinity, within accuracy of the measurement. Salinity as well as oxygen and nutrients are acceptable.
101/1	111	salt	2	3 attempts for a good salinity reading. First reading resolved salinity discrepancy. Salinity as well as oxygen and nutrients are acceptable.
101/1	129	salt	2	3 attempts for a good salinity reading. Additional readings produced a reasonable salinity value. Salinity as well as oxygen and nutrients are acceptable.
102/2	203	salt	3	Suspect that salinity was either drawn off one bottle or analyzed off one bottle. Suspect analysis, bottle 3 & 5 had additional readings which could be an indication that the bottle was put in place at the wrong time. Sample drawer is certain that salt bottle number was verified against niskin bottle. Changed data file, suspecting that 5 was actually bottle 5 and 6 and error was caught and order corrected at 20. 3 attempts for a good salinity reading. First reading resolved salinity difference, although a little high within the accuracy of the measurement. Thimble came off with cap. Code salinity questionable, oxygen and nutrients are acceptable.
102/2	204	o2	2	Box template file lists different flask. Verified with sample log, flask is 1764. Bottle value is in line with subsequent samples and agrees with CTDO.
102/2	204	salt	2	CHECK: Suspect that salinity was either drawn off one bottle or analyzed off one bottle. Suspect analysis, bottle 3 had additional readings which could be an indication that the bottle was put in place at the wrong time. Sample drawer is certain that salt bottle number was verified against niskin bottle.
102/2	205	o2	2	Box template file lists different flask. Verified with sample log, flask is 1760. Bottle value is in line with subsequent samples and agrees with CTDO.
102/2	205	salt	2	3 attempts for a good salinity reading. First reading resolved salinity difference. Salinity is slightly high within accuracy of the measurement. Salinity as well as oxygen and nutrients are acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
102/2	206	salt	3	Bottle salinity is high compared with CTD and adjoining stations. Tried to reorganize salinity values, suspect that the actual problem is the bath temperature, it changed by 1.2 degrees during the run. This anomaly is not a tripping issue. Code salinity questionable, oxygen and nutrients are acceptable.
102/2	207	o2	2	Did not run wake-up sample prior to starting run. Bottle value is in line with subsequent samples and agrees with CTDO.
102/2	207	salt	2	Suspect that salinity was either drawn off one bottle or analyzed off one bottle. Suspect analysis, bottle 3 & 5 had additional readings which could be an indication that the bottle was put in place at the wrong time. Sample drawer is certain that salt bottle number was verified against niskin bottle. Changed data file, suspecting that 5 was actually bottle 5 and error was caught and order corrected at 20.
102/2	208	salt	2	Suspect that salinity was either drawn off one bottle or analyzed off one bottle. Suspect analysis, bottle 3 & 5 had additional readings which could be an indication that the bottle was put in place at the wrong time. Sample drawer is certain that salt bottle number was verified against niskin bottle. Changed data file, suspecting that 5 was actually bottle 5 and error was caught and order corrected at 20.
102/2	209	salt	2	Suspect that salinity was either drawn off one bottle or analyzed off one bottle. Suspect analysis, bottle 3 & 5 had additional readings which could be an indication that the bottle was put in place at the wrong time. Sample drawer is certain that salt bottle number was verified against niskin bottle. Changed data file, suspecting that 5 was actually bottle 5 and error was caught and order corrected at 20.
102/2	210	salt	2	Suspect that salinity was either drawn off one bottle or analyzed off one bottle. Suspect analysis, bottle 3 & 5 had additional readings which could be an indication that the bottle was put in place at the wrong time. Sample drawer is certain that salt bottle number was verified against niskin bottle. Changed data file, suspecting that 5 was actually bottle 5 and error was caught and order corrected at 20.
102/2	211	salt	3	Bottle salinity is low compared with CTD and adjoining stations. Tried to reorganize salinity values, suspect that the actual problem is the bath temperature, it changed by 1.2 degrees during the run. This anomaly is not a tripping issue. Code salinity questionable, oxygen and nutrients are acceptable.
102/2	212	salt	3	Bottle salinity is low compared with CTD and adjoining stations. Tried to reorganize salinity values, suspect that the actual problem is the bath temperature, it changed by 1.2 degrees during the run. This anomaly is not a tripping issue. Code salinity questionable, oxygen and nutrients are acceptable.
102/2	213	salt	3	Bottle salinity is low compared with CTD and adjoining stations. Tried to reorganize salinity values, suspect that the actual problem is the bath temperature, it changed by 1.2 degrees during the run. This anomaly is not a tripping issue. Code salinity questionable, oxygen and nutrients are acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
102/2	214	salt	2	Suspect that salinity was either drawn off one bottle or analyzed off one bottle. Suspect analysis, bottle 3 & 5 had additional readings which could be an indication that the bottle was put in place at the wrong time. Sample drawer is certain that salt bottle number was verified against niskin bottle. Changed data file, suspecting that 5 was actually bottle 5 and error was caught and order corrected at 20.
102/2	215	salt	2	Suspect that salinity was either drawn off one bottle or analyzed off one bottle. Suspect analysis, bottle 3 & 5 had additional readings which could be an indication that the bottle was put in place at the wrong time. Sample drawer is certain that salt bottle number was verified against niskin bottle. Changed data file, suspecting that 5 was actually bottle 5 and error was caught and order corrected at 20.
102/2	216	o2	2	Bottle value appears slightly low for subsequent bottle values. PO4 and SIO3 show similar supporting features. Bottle value is valid code good.
102/2	216	salt	2	Suspect that salinity was either drawn off one bottle or analyzed off one bottle. Suspect analysis, bottle 3 & 5 had additional readings which could be an indication that the bottle was put in place at the wrong time. Sample drawer is certain that salt bottle number was verified against niskin bottle. Changed data file, suspecting that 5 was actually bottle 5 and error was caught and order corrected at 20.
102/2	217	o2	2	Oxygen flask 1738 in this position. No note that 1284 was replaced.
102/2	217	salt	2	Suspect that salinity was either drawn off one bottle or analyzed off one bottle. Suspect analysis, bottle 3 & 5 had additional readings which could be an indication that the bottle was put in place at the wrong time. Sample drawer is certain that salt bottle number was verified against niskin bottle. Changed data file, suspecting that 5 was actually bottle 5 and error was caught and order corrected at 20.
102/2	218	salt	2	Suspect that salinity was either drawn off one bottle or analyzed off one bottle. Suspect analysis, bottle 3 & 5 had additional readings which could be an indication that the bottle was put in place at the wrong time. Sample drawer is certain that salt bottle number was verified against niskin bottle. Changed data file, suspecting that 5 was actually bottle 5 and error was caught and order corrected at 20.
102/2	219	salt	2	Suspect that salinity was either drawn off one bottle or analyzed off one bottle. Suspect analysis, bottle 3 & 5 had additional readings which could be an indication that the bottle was put in place at the wrong time. Sample drawer is certain that salt bottle number was verified against niskin bottle. Changed data file, suspecting that 5 was actually bottle 5 and error was caught and order corrected at 20.
103/1	101	bottle	2	Cast for Mooring.
103/1	102	bottle	2	Bottles tripped on the fly. 10 levels. Oxygen and salinity are acceptable.
103/1	103	bottle	2	Bottles tripped on the fly. 10 levels. Oxygen and salinity are acceptable.
103/1	103	salt	2	3 attempts for a good salinity reading. First reading resolves salinity discrepancy. Salinity and oxygen check samples are acceptable.
103/1	104	bottle	2	Bottles tripped on the fly. 10 levels. Oxygen and salinity are acceptable.
103/1	105	bottle	2	Bottles tripped on the fly. 10 levels. Oxygen and salinity are acceptable.
103/1	106	bottle	2	Bottles tripped on the fly. 10 levels. Oxygen and salinity are acceptable.
103/1	107	bottle	2	Bottles tripped on the fly. 10 levels. Oxygen and salinity are acceptable.
103/1	107	salt	2	3 attempts for a good salinity reading. First reading resolves salinity discrepancy. Salinity and oxygen check samples are acceptable.
103/1	108	bottle	2	Bottles tripped on the fly. 10 levels. Oxygen and salinity are acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
103/1	109	bottle	2	Bottles tripped on the fly. 10 levels. Oxygen and salinity are acceptable.
103/1	110	bottle	2	Bottles tripped on the fly. 10 levels. Oxygen and salinity are acceptable.
104/1	101	bottle	2	Cast for Mooring.
104/1	102	bottle	2	Bottles tripped on the fly. 10 levels.
104/1	103	bottle	2	Bottles tripped on the fly. 10 levels.
104/1	104	bottle	2	Bottles tripped on the fly. 10 levels.
104/1	105	bottle	2	Bottles tripped on the fly. 10 levels.
104/1	106	bottle	2	Bottles tripped on the fly. 10 levels.
104/1	107	bottle	2	Bottles tripped on the fly. 10 levels.
104/1	108	bottle	2	Bottles tripped on the fly. 10 levels.
104/1	109	bottle	2	Bottles tripped on the fly. 10 levels.
104/1	110	bottle	2	Bottles tripped on the fly. 10 levels.
105/1	136	bottle	9	Lanyard never released, bottle did not close. No samples taken. Backed out screw on latch that prevented it from firing. Fixed the latch and dismantled the carousel to check all other latches. Everything looked good on a test firing.
106/1	102	salt	2	Salinity is low compared with CTD and adjoining stations. It appears that samples were either misdrawn or analyzed off one bottle with 7 and 8 having exactly the same conductivity ratio. Will leave as is, there is no way to justify where sample 2 came from.
106/1	108	salt	3	Bottle salinity is low compared with CTD and adjoining stations. Lab temperature dropped 2 degrees during run. Suspect salinities from bottle 11 to 1 were effected with 8 being outside of accuracy of the measurement. Code salinity questionable, oxygen and nutrients are acceptable.
107/1	103	salt	3	Bottle salinity is high compared with CTD and adjoining stations. No analytical problem noted. Code salinity questionable, oxygen and nutrients acceptable. Many samples taken with a duplicate for DIC prior to salinity, could have an impact. Code salinity questionable, oxygen and nutrients acceptable.
107/1	112	o2	2	Replaced O2 flask 1700 with 1696, could not remove stopper. Oxygen as well as salinity and nutrients are acceptable.
108/1	106	salt	4	Bottle salinity is low compared with CTD and adjoining stations. 3 attempts for a good salinity reading. Code salinity bad, oxygen and nutrients are acceptable.
108/1	136	bottle	2	Tripped on the fly. Oxygen as well as salinity and nutrients are acceptable.
109/1	121	o2	2	Template flask file mislabeled 1284, actual 1294. O2 bottle value good.
111/1	117	bottle	2	Small leak at spigot, (w/vent may be loose). Oxygen as well as salinity and nutrients are acceptable.
112/1	127	salt	2	3 attempts for a good salinity reading. First reading produced a slightly better salinity, additional readings were within the accuracy of the measurement. Salinity, oxygen and nutrients are acceptable.
112/1	130	bottle	2	Leak, vent loose. Oxygen as well salinity and nutrients are acceptable.
113/1	134	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
113/1	134	salt	2	Bottle salinity is low compared with CTD. Gradient, lots of variation in CTD. Bottle salinity as well as oxygen and nutrients are acceptable.
114/1	103	salt	3	Bottle salinity is low compared with CTD and adjoining stations. No analytical problem noted. Code salinity questionable, oxygen and nutrients are acceptable.

Station /Cast	Sample No.	Quality Property	Code	Comment
114/1	112	salt	2	Bottle salinity is high compared with CTD and adjoining stations. No analytical problem noted. Code salinity questionable, oxygen and nutrients are acceptable.
114/1	115	o2	5	Analyst: O2 rig problem, sample lost.
114/1	116	o2	2	Analyst: Possible O2 rig problem; concomitant feature in silicate present, value ok.
114/1	133	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
114/1	133	salt	2	Bottle salinity is high compared with CTD. Gradient, lots of variation in CTD with lower sampling as though from shallower. Bottle salinity as well as oxygen and nutrients are acceptable.
115/1	115	o2	3	O2 is 0.1ml/l high. Feature not seen in other parameters. No obvious analytical errors.
115/1	117	bottle	3	Appears that bottle leaked. pH also confirms, no DIC or TALK drawn, cfc indicates okay, salinity low. Code bottle 3, salinity, oxygen and nutrients 4.
115/1	117	no2	4	NO3 value is high, No Auto-Analyzer error found, peak looks good.
115/1	117	no3	4	NO3 value is high, No Auto-Analyzer error found, peak looks good.
115/1	117	o2	4	O2 is high, appears that bottle mistripped.
115/1	117	po4	4	PO4 value is high, No Auto-Analyzer error found, peak looks good.
115/1	117	salt	4	Bottle salinity is low compared with CTD and adjoining stations. Bottle leaked, code bottle 3, salinity, oxygen and nutrients 4.
115/1	117	sio3	4	SiO3 value is high, No Auto-Analyzer error found, peak looks good.
116/1	134	ctds	3	Shiproll plus poor mixing in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
116/1	134	salt	2	Bottle salinity is high compared with CTD. Gradient, salinity as well as oxygen and nutrients are acceptable.
118/1	120	salt	2	4 attempts for a good salinity reading. First reading resolved salinity discrepancy. Salinity as well as oxygen and nutrients are acceptable.
118/1	135	ctds	3	Gradient causes CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
118/1	135	salt	2	Bottle salinity is high compared with CTD. Gradient, salinity appears acceptable as does oxygen and nutrients.
119/1	108	o2	2	Oxygen flask 1697 was broken prior to this station during underway sampling, replaced with 1517.
119/1	126	o2	5	Analyst: O2 rig problem, sample lost.
121/1	131	o2	2	Analyst: Red flaky contaminant in sample. Bottle value appears normal, code good.
122/2	234	ctds	3	Gradient, caused CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
122/2	234	salt	2	Bottle salinity is high compared with CTD. Gradient, caused CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
123/1	101	bottle	2	Strong transmissometer minimum at bottom, will this affect SiO3.
123/1	124	salt	2	03 attempts for a good salinity reading. Additional readings produced a reasonable salinity value. Salinity as well as oxygen and nutrients are acceptable.
123/1	128	salt	2	03 attempts for a good salinity reading. Additional readings produced a reasonable salinity value. Salinity as well as oxygen and nutrients are acceptable.
124/2	236	salt	5	Salinity lost, did not save value during run.

Station /Cast	Sample No.	Quality Property	Code	Comment
125/1	128	salt	2	4 attempts for a good salinity reading. Cap was loose and popped. First reading resolved the small salinity discrepancy. Salinity as well as oxygen and nutrients are acceptable.
126/3	301	bottle	2	Cast 2 aborted, there was a blockage in the exhaust hole, had to bring on board to clear.
127/1	101	salt	2	Unusually high standard setting of 463, same results after trying 2 diff standard seawater bottles. Salinity agrees with CTD and adjoining stations. The drift is not unusually high and all salinity are within the accuracy of the measurement. Salinity as well as oxygen and nutrients are acceptable.
127/1	116	bottle	2	Leaked, vent not tight enough. Oxygen as well as salinity and nutrients are acceptable.
127/1	120	bottle	2	Leaked, vent not tight enough. Oxygen as well as salinity and nutrients are acceptable.
127/1	122	salt	2	3 attempts for a good salinity reading. Loose cap, came off in lid. First reading produced a lower, 0.001, salinity value. All readings were within the accuracy of the measurement. Salinity, oxygen and nutrients are acceptable.
127/1	125	salt	4	Bottle salinity is low compared with CTD and adjoining stations. No analytical problems noted. Appears to have been drawn from bottle 27, none of the other samples indicate a mis-trip. Code salinity bad, oxygen and nutrients acceptable.
129/1	121	o2	2	O2 bottle value appears low for column, however supporting feature in po4 and sio3. Value good.
129/1	133	ctds	3	Gradient resulting in CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
129/1	133	salt	2	Bottle salinity is high compared with CTD. Gradient causing CTD signal oscillation. Code CTD salinity questionable, salinity, oxygen and nutrients acceptable.
130/2	201	no3	4	NO3 high, no corresponding feature in any other parameters, some type of contamination.
130/2	211	o2	2	O2 slightly high, 0.025, no analytical problems noted and within the accuracy of the measurement. Oxygen as well as salinity and nutrients are acceptable.
132/2	229	bottle	2	Bottle tripped on the fly. Did not wait 30 seconds, two ship rolls, before tripping the bottle. Changed lanyard on bottom cap prior to this station. This was a preventive maintenance, previous stations are acceptable. Oxygen as well as salinity and nutrients are acceptable.
133/1	103	salt	4	Bottle salinity is high compared with CTD and adjoining stations. No analytical notes, appears to have been drawn from bottle 4, exactly the same conductivity readings. Code salinity bad, oxygen and nutrients are acceptable.
133/1	132	ctds	3	Gradient causes much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.
133/1	132	salt	2	Bottle salinity is high compared with CTD. Gradient, salinity as well as oxygen and nutrients are acceptable.
135/1	127	bottle	2	Ran out of water on salinity which was mistakenly drawn before nutrients. Duplicate CFC samples with other samples resulted in the consumption of water. Salinity sample was taken, but not with a complete fill, nutrients were not drawn.
135/1	127	salt	2	Low sample volume, approximately half bottle. Salinity as well as oxygen and nutrients are acceptable.
135/1	134	ctds	3	Shiproll in gradient cause much CTD signal oscillation during bottle stop. CTD is okay, just does not compare well with bottle salinity.

Station /Cast	Sample No.	Quality Property	Code	Comment
135/1	134	salt	2	Bottle salinity is high compared with CTD. Salinity as well as oxygen and nutrients are acceptable.
137/1	101	bottle	2	35 bottles tripped per sampling schedule.
137/1	101	salt	2	Issues with std not approaching a consistent value. Replaced pick up tube and metal elbow to combat potential leak. Seemed to correct the problem, used 2 stds. Stations 137 and 138 analyzed together, both stations appear reasonable.
138/2	201	salt	2	Bottle salinity is high compared with CTD and adjoining stations. 3 attempts for a good salinity reading. First reading resolved salinity discrepancy. Salinity as well as oxygen and nutrients are acceptable.
138/2	203	salt	4	Bottle salinity is low compared with CTD and adjoining stations. No analytical problems noted. Code salinity bad, oxygen and nutrients are acceptable.
138/2	223	bottle	2	Duplicate bottle tripped with 24. Sampling for pigments, ODF samples were not drawn.
138/2	225	bottle	2	Duplicate bottle tripped with 26. Sampling for pigments, ODF samples were not drawn.
138/2	227	bottle	2	Duplicate bottle tripped with 28. Sampling for pigments, ODF samples were not drawn.
138/2	229	bottle	2	Accidentally opened bottle, mistaken for a duplicate for HPLC, not sampled by CFC, DIC, pH or TALK.
138/2	231	bottle	2	Duplicate bottle tripped with 32. Sampling for pigments, ODF samples were not drawn.
139/1	110	salt	2	3 attempts for a good salinity reading. Analyst ran samples out of order, 9 as 10, 10 as 9, corrected in data file. Checked the data to verify samples were not off up to bottle 12, and they do not. Salinity as well as oxygen and nutrients are acceptable.
139/1	112	salt	5	Sampling error on salinity, sample bottle was turned upside down indicating that it was not drawn, analyst did not attempt to run it. Salinity lost.

Appendix D

CLIVAR S04P: Pre-Cruise Sensor Laboratory Calibrations

CTD 831 Sensors - Table of Contents				
CTD Sensor	Manufacturer and Model No.	Serial Number	Station Number	Appendix D Page (Un-Numbered)
PRESS (Pressure)	Digiquartz 401K-105	99677	Test,2-400	1-3
T1 (Primary Temperature)	Sea-Bird SBE3*plus*	03P-4943	Test,2-10	4
T1 (Primary Temperature)	Sea-Bird SBE3*plus*	03P-5046	11-400	5
C1 (Primary Conductivity)	Sea-Bird SBE4C	04-3057	Test,2-10	6
C1 (Primary Conductivity)	Sea-Bird SBE4C	04-2593	11-400	7
O2 (Dissolved Oxygen)	Sea-Bird SBE43	43-1136	Test,2-400	8
T2 (Secondary Temperature)	Sea-Bird SBE3*plus*	03P-5046	Test,2-10	5
T2 (Secondary Temperature)	Sea-Bird SBE3*plus*	03P-4943	11-400	4
C2 (Secondary Conductivity)	Sea-Bird SBE4C	04-3176	Test	9
C2 (Secondary Conductivity)	Sea-Bird SBE4C	04-2593	2-10	7
C2 (Secondary Conductivity)	Sea-Bird SBE4C	04-3399	11-400	10
TRANS (Transmissometer)	WETLabs C-Star	CST-327DR	Test,2-400	11
FLUOR (Chlorophyll Fluorometer)	Seapoint	SCF2743	Test,2-4	
REFT (Reference Temperature)	Sea-Bird SBE35	3516590-0011	Test,2-400	12

Pressure Calibration Report
STS/ODF Calibration Facility

SENSOR SERIAL NUMBER: 0831
CALIBRATION DATE: 01-NOV-2010
Mfg: SEABIRD Model: 09P CTD Prs s/n: 99677

C1= -4.346032E+4
C2= -4.006928E-1
C3= 1.660343E-2
D1= 3.341599E-2
D2= 0.000000E+0
T1= 3.004630E+1
T2= -4.444244E-4
T3= 4.435306E-6
T4= -4.321959E-9
T5= 0.000000E+0
AD590M= 1.28916E-2
AD590B= -8.23481E+0
Slope = 1.00000000E+0
Offset = 0.00000000E+0

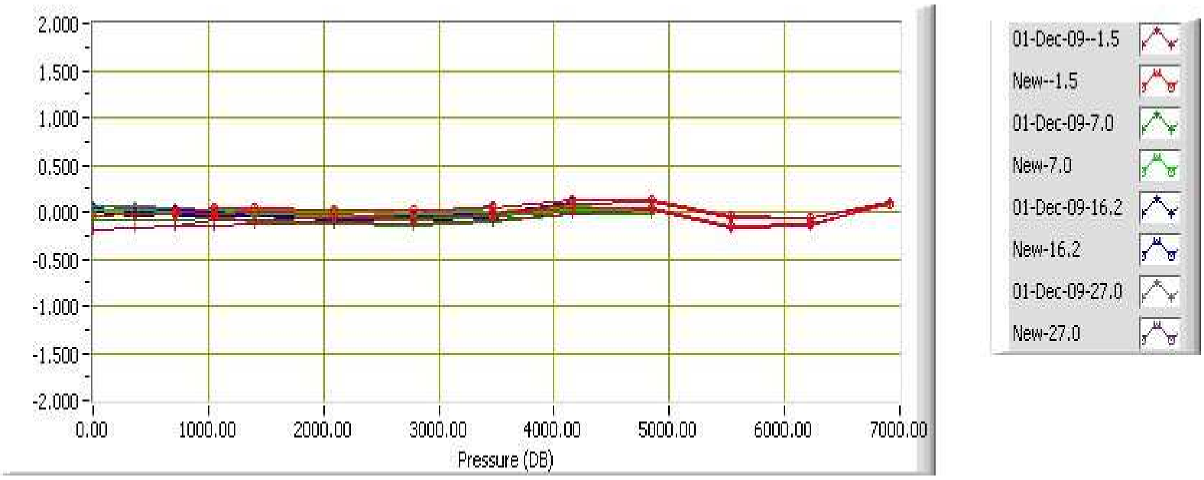
Calibration Standard: Mfg: RUSKA Model: 2400 s/n: 34336
t0=t1+t2*td+t3*td*td+t4*td*td*td
w = 1-t0*t0*f*f
Pressure = (0.6894759*((c1+c2*td+c3*td*td)*w*(1-(d1+d2*td)*w)-14.7)

SBE9 Freq	Ruska	SBE9 New_Coefs	Ruska-SBE9 Prev_Coefs	Ruska-SBE9 New_Coefs	Tprs	Bath_Temp
33287.487	0.18	0.22	-0.20	-0.04	-0.46	-1.464
33489.391	365.06	365.09	-0.17	-0.02	-0.44	-1.464
33678.616	709.32	709.33	-0.15	-0.01	-0.44	-1.464
33866.651	1053.58	1053.54	-0.09	0.03	-0.38	-1.464
34053.516	1397.87	1397.83	-0.08	0.04	-0.38	-1.464
34423.812	2086.48	2086.46	-0.07	0.03	-0.38	-1.463
34789.654	2775.16	2775.14	-0.06	0.02	-0.36	-1.464
35151.152	3463.91	3463.86	-0.02	0.05	-0.36	-1.464
35508.454	4152.72	4152.60	0.08	0.12	-0.33	-1.464
35861.718	4841.60	4841.47	0.10	0.13	-0.33	-1.464
36211.160	5530.54	5530.58	-0.06	-0.04	-0.29	-1.464
36556.684	6219.55	6219.61	-0.06	-0.05	-0.28	-1.464
36898.411	6908.63	6908.54	0.10	0.09	-0.28	-1.464
36556.725	6219.56	6219.69	-0.14	-0.14	-0.28	-1.464
36211.223	5530.55	5530.70	-0.17	-0.15	-0.28	-1.464
35861.789	4841.60	4841.56	0.01	0.05	-0.28	-1.464
35508.541	4152.72	4152.69	-0.02	0.03	-0.25	-1.464
35151.246	3463.91	3463.94	-0.09	-0.03	-0.25	-1.464
34789.750	2775.16	2775.22	-0.14	-0.05	-0.25	-1.464
34423.910	2086.48	2086.50	-0.11	-0.01	-0.23	-1.464
34053.613	1397.87	1397.87	-0.12	0.00	-0.23	-1.464
33866.762	1053.58	1053.61	-0.16	-0.03	-0.23	-1.464
33678.719	709.32	709.33	-0.14	-0.01	-0.23	-1.464
33489.499	365.06	365.07	-0.15	-0.00	-0.20	-1.464
33291.248	0.18	0.17	-0.09	0.01	7.85	6.998
33493.172	365.06	365.05	-0.08	0.01	7.87	6.998
33682.428	709.32	709.31	-0.08	0.01	7.89	6.998

Pressure Calibration Report
STS/ODF Calibration Facility

33870.470	1053.58	1053.56	-0.07	0.02	7.90	6.998
34057.367	1397.87	1397.87	-0.08	-0.00	7.92	6.998
34427.686	2086.48	2086.48	-0.07	0.00	7.94	6.998
34793.555	2775.16	2775.18	-0.08	-0.02	7.96	6.998
35155.086	3463.91	3463.90	-0.05	0.01	7.98	6.998
35512.414	4152.72	4152.66	0.00	0.06	7.99	6.998
35865.745	4841.60	4841.58	-0.03	0.02	8.03	6.998
35512.460	4152.73	4152.70	-0.02	0.03	8.06	6.998
35155.145	3463.91	3463.95	-0.10	-0.04	8.06	6.998
34793.630	2775.16	2775.24	-0.14	-0.07	8.06	6.998
34427.775	2086.48	2086.53	-0.12	-0.05	8.09	6.998
34057.449	1397.87	1397.89	-0.10	-0.02	8.09	6.998
33870.560	1053.58	1053.57	-0.07	0.01	8.11	6.998
33682.524	709.32	709.32	-0.08	0.00	8.12	6.998
33493.282	365.06	365.04	-0.07	0.02	8.14	6.998
33294.531	0.18	0.13	0.01	0.04	16.67	16.211
33496.494	365.06	365.06	-0.03	0.00	16.68	16.211
33685.762	709.32	709.30	-0.02	0.02	16.72	16.211
33873.841	1053.58	1053.58	-0.03	0.00	16.75	16.211
34060.757	1397.87	1397.88	-0.05	-0.01	16.78	16.211
34431.110	2086.48	2086.49	-0.04	-0.00	16.80	16.211
34797.022	2775.16	2775.18	-0.06	-0.02	16.84	16.211
35158.598	3463.91	3463.93	-0.07	-0.02	16.85	16.211
35515.930	4152.73	4152.62	0.06	0.10	16.88	16.211
35158.615	3463.91	3463.93	-0.06	-0.02	16.90	16.211
34797.067	2775.17	2775.21	-0.09	-0.05	16.92	16.211
34431.184	2086.48	2086.54	-0.10	-0.06	16.93	16.211
34060.820	1397.87	1397.88	-0.05	-0.01	16.96	16.211
33873.923	1053.58	1053.59	-0.04	-0.01	16.97	16.211
33685.857	709.32	709.32	-0.03	0.00	16.98	16.211
33496.601	365.06	365.05	-0.03	0.01	17.01	16.211
33297.716	0.18	0.15	0.06	0.03	27.99	27.026
33499.699	365.06	365.03	0.06	0.04	28.05	27.026
33689.015	709.32	709.31	0.03	0.01	28.08	27.026
33877.128	1053.58	1053.58	0.02	0.00	28.12	27.026
34064.061	1397.87	1397.86	0.01	0.01	28.13	27.026
34434.477	2086.48	2086.47	0.01	0.02	28.15	27.026
34800.453	2775.17	2775.18	-0.03	-0.01	28.17	27.026
35162.047	3463.91	3463.84	0.04	0.07	28.17	27.026
34800.463	2775.17	2775.19	-0.04	-0.03	28.18	27.026
34434.525	2086.48	2086.54	-0.06	-0.05	28.19	27.026
34064.097	1397.87	1397.89	-0.01	-0.02	28.22	27.026
33877.170	1053.58	1053.61	-0.02	-0.03	28.22	27.026
33689.070	709.32	709.35	-0.01	-0.03	28.22	27.026
33499.772	365.06	365.08	0.01	-0.02	28.24	27.026
33297.779	0.18	0.16	0.05	0.02	28.25	27.026

Pressure Calibration Report
STS/ODF Calibration Facility



Temperature Calibration Report
STS/ODF Calibration Facility

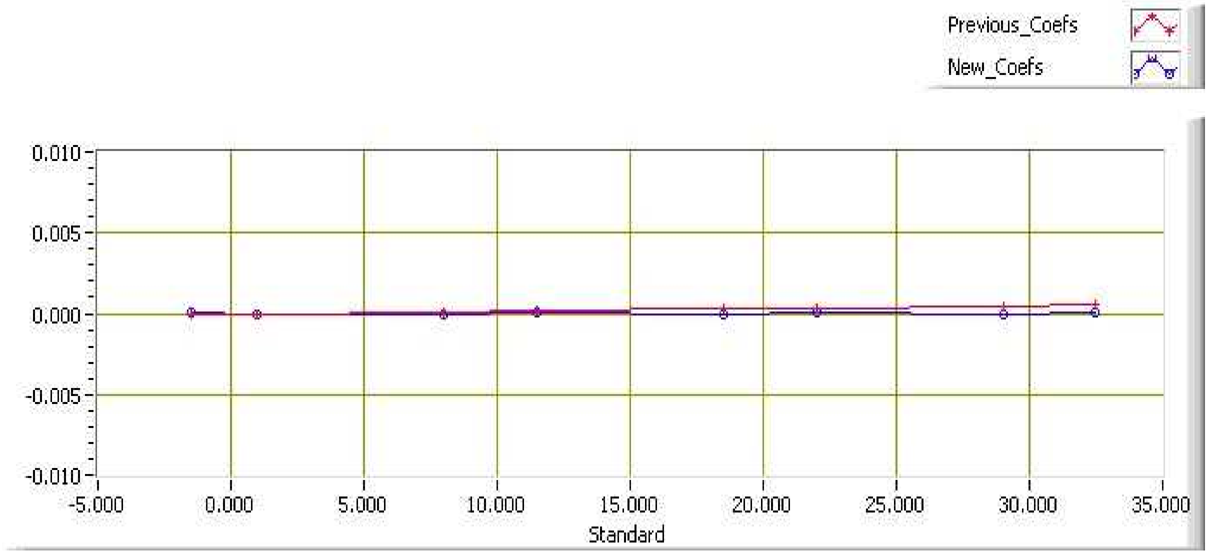
SENSOR SERIAL NUMBER: 4943
CALIBRATION DATE: 10-Nov-2010
Mfg: Seabird   Model: 03
Previous cal: 20-Jul-10
Calibration Tech: CAL

ITS-90_COEFFICIENTS	IPTS-68_COEFFICIENTS
g = 4.37958507E-3	a = 4.37979056E-3
h = 6.41227776E-4	b = 6.41439771E-4
i = 2.26364538E-5	c = 2.26685433E-5
j = 2.13452861E-6	d = 2.13600248E-6

f0 = 1000.0 Slope = 1.0 Offset = 0.0

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

SBE3 Freq	SPRT ITS-90	SBE3 ITS-90	SPRT-SBE3 Old_Coefs	SPRT-SBE3 New_Coefs
3093.1711	-1.5070	-1.5070	-0.00000	0.00004
3272.0007	0.9934	0.9934	-0.00007	-0.00005
3812.4840	7.9962	7.9962	0.00004	-0.00004
4105.4554	11.4984	11.4983	0.00021	0.00007
4738.0302	18.4954	18.4954	0.00025	-0.00003
5078.8528	21.9959	21.9959	0.00037	0.00003
5811.1056	28.9977	28.9977	0.00040	-0.00005
6203.0814	32.4981	32.4981	0.00050	0.00003



Temperature Calibration Report
STS/ODF Calibration Facility

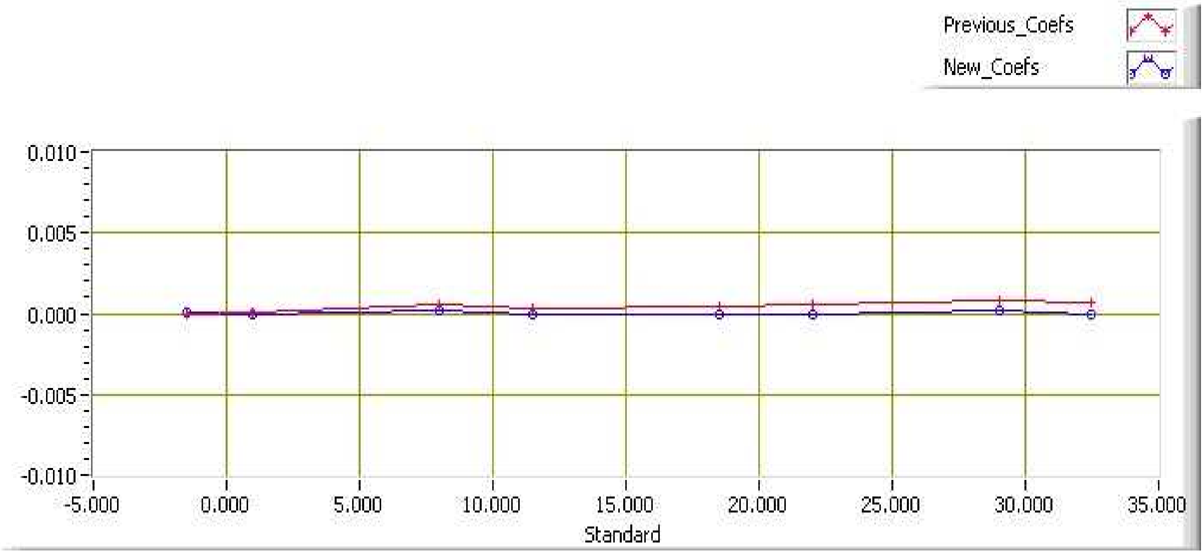
SENSOR SERIAL NUMBER: 5046
CALIBRATION DATE: 09-Nov-2010
Mfg: Seabird   Model: 03
Previous cal: 22-Apr-10
Calibration Tech: CAL

ITS-90_COEFFICIENTS	IPTS-68_COEFFICIENTS
g = 4.41731675E-3	a = 4.41753473E-3
h = 6.45948441E-4	b = 6.46164705E-4
i = 2.37696576E-5	c = 2.38022244E-5
j = 2.31686942E-6	d = 2.31837795E-6

f0 = 1000.0 Slope = 1.0 Offset = 0.0

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

SBE3 Freq	SPRT ITS-90	SBE3 ITS-90	SPRT-SBE3 Old_Coefs	SPRT-SBE3 New_Coefs
3271.2117	-1.5064	-1.5064	-0.00001	0.00001
3459.9695	0.9939	0.9940	0.00006	-0.00005
4030.4221	7.9974	7.9972	0.00050	0.00015
4339.5382	11.4991	11.4992	0.00033	-0.00009
5006.7589	18.4954	18.4955	0.00045	-0.00005
5366.1497	21.9954	21.9954	0.00052	-0.00002
6138.1421	28.9970	28.9969	0.00077	0.00013
6551.5251	32.4990	32.4991	0.00065	-0.00008



SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 3057
CALIBRATION DATE: 28-Oct-10

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

GHIJ COEFFICIENTS

```
g = -1.01998429e+001
h =  1.28503430e+000
i =  3.37575251e-004
j =  3.03944407e-005
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  3.07403474e-004
b =  1.28497046e+000
c = -1.01992051e+001
d = -8.17551825e-005
m =  3.3
CPcor = -9.5700e-008 (nominal)
```

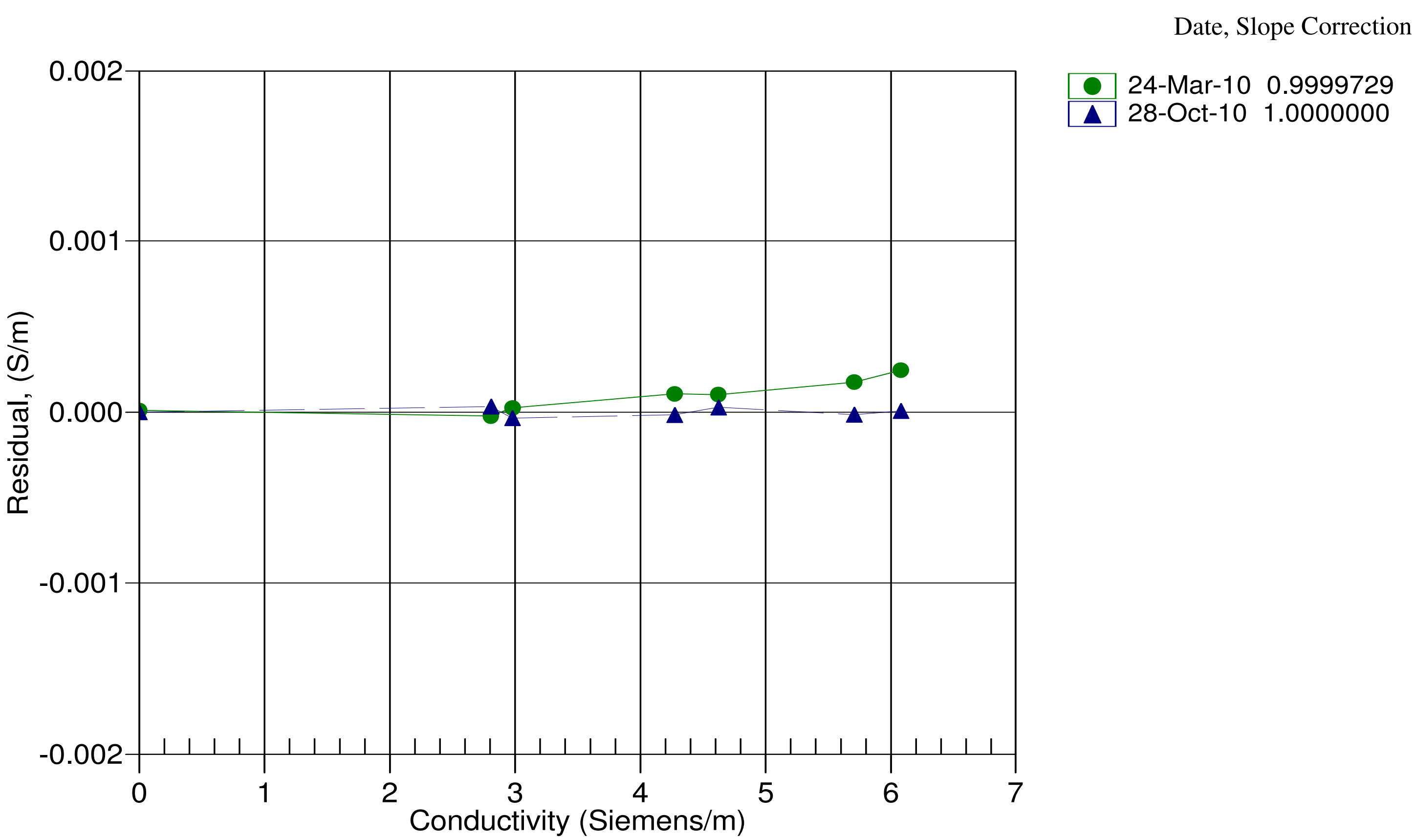
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.81603	0.00000	0.00000
-1.0000	34.8387	2.80621	5.45085	2.80624	0.00003
1.0000	34.8401	2.97781	5.57153	2.97777	-0.00004
15.0000	34.8407	4.27429	6.41029	4.27427	-0.00002
18.5000	34.8401	4.62118	6.61664	4.62121	0.00003
29.0000	34.8384	5.70553	7.22343	5.70552	-0.00001
32.5001	34.8309	6.07826	7.42050	6.07826	0.00001

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

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

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

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



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13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 2593
CALIBRATION DATE: 28-Oct-10

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

GHIJ COEFFICIENTS

g = -9.43305749e+000
h = 1.37053922e+000
i = -1.21141484e-003
j = 1.68892936e-004
CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

ABCDM COEFFICIENTS

a = 4.97227108e-006
b = 1.36765136e+000
c = -9.42787186e+000
d = -8.73763824e-005
m = 5.2
CPcor = -9.5700e-008 (nominal)

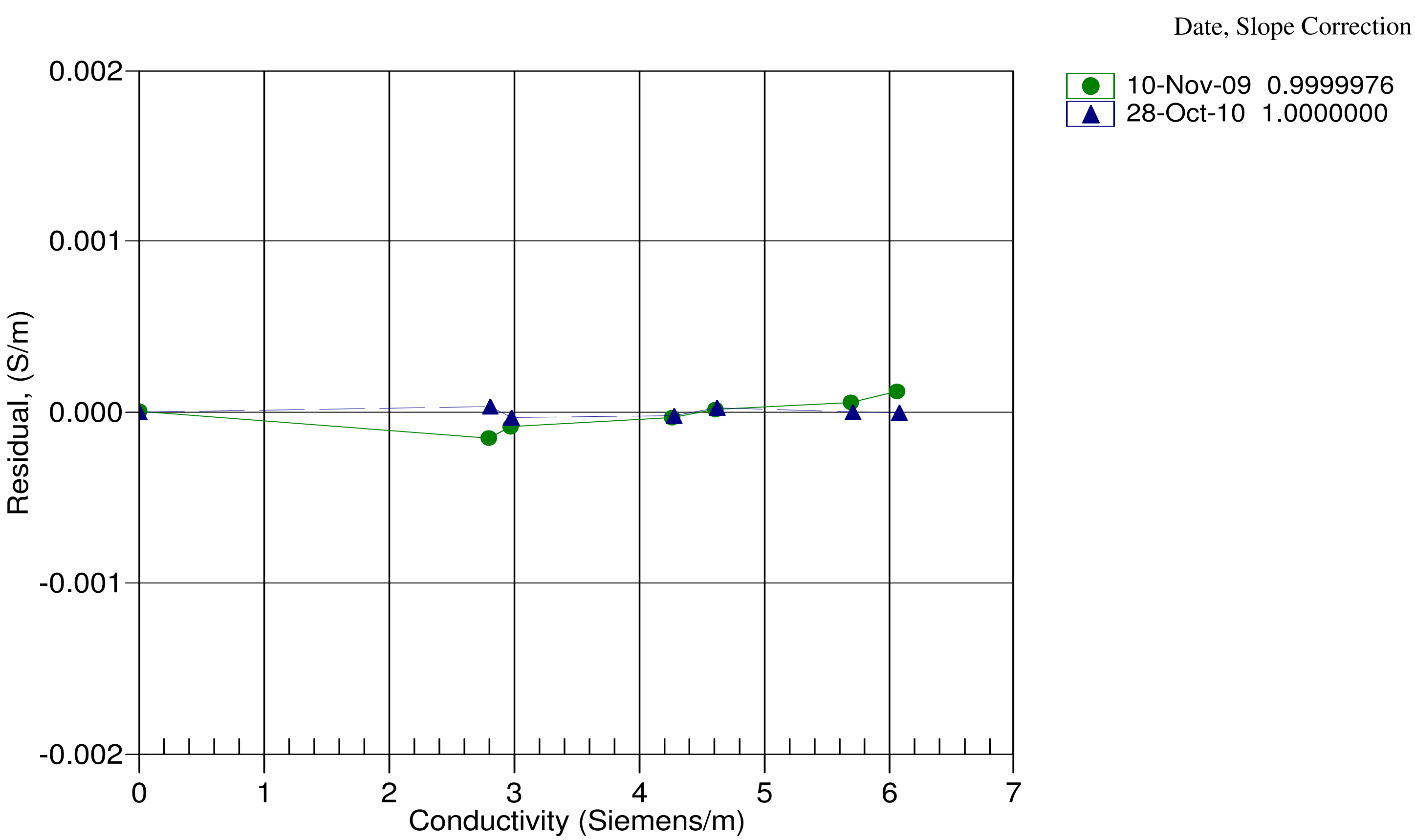
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.62543	0.00000	0.00000
-1.0000	34.8387	2.80621	5.23377	2.80624	0.00003
1.0000	34.8401	2.97781	5.35203	2.97777	-0.00003
15.0000	34.8407	4.27429	6.17252	4.27427	-0.00002
18.5000	34.8401	4.62118	6.37404	4.62121	0.00003
29.0000	34.8384	5.70553	6.96599	5.70553	0.00000
32.5001	34.8309	6.07826	7.15803	6.07826	-0.00000

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

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

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

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



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

SENSOR SERIAL NUMBER: 1136
CALIBRATION DATE: 20-Sep-10p

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS

Soc = 0.4448
Voffset = -0.5227
Tau20 = 1.54

A = -3.1186e-003
B = 1.6645e-004
C = -3.2930e-006
E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS

D1 = 1.92634e-4
D2 = -4.64803e-2

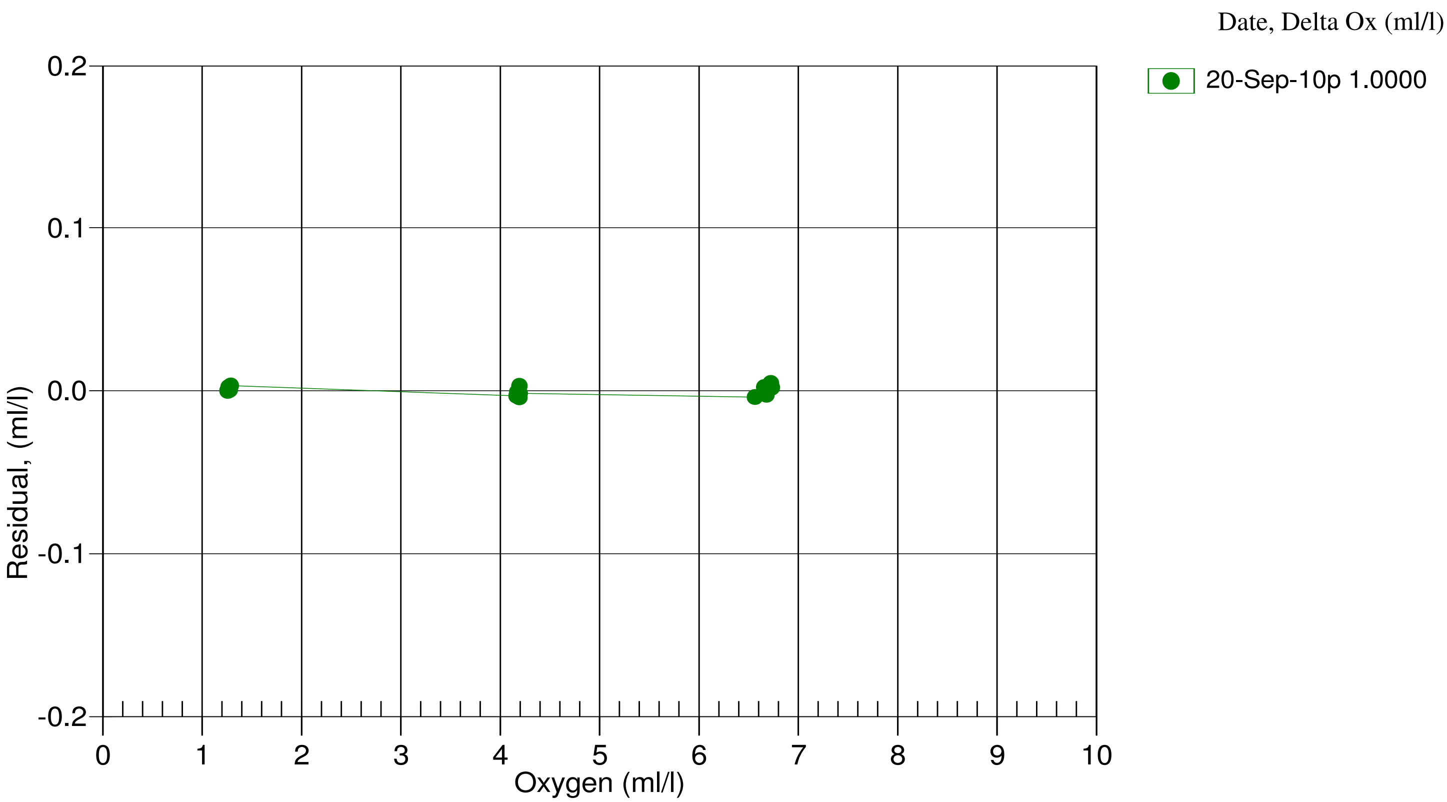
H1 = -3.30000e-2
H2 = 5.00000e+3
H3 = 1.45000e+3

BATH OX (ml/l)	BATH TEMP ITS-90	BATH SAL PSU	INSTRUMENT OUTPUT(VOLTS)	INSTRUMENT OXYGEN(ml/l)	RESIDUAL (ml/l)
1.26	6.00	0.02	0.851	1.26	-0.00
1.26	2.00	0.02	0.816	1.26	0.00
1.26	12.00	0.02	0.907	1.27	0.00
1.28	20.00	0.02	0.985	1.28	0.00
1.28	26.00	0.02	1.045	1.28	0.00
1.29	30.00	0.02	1.090	1.29	0.00
4.16	2.00	0.02	1.495	4.16	-0.00
4.18	12.00	0.02	1.792	4.17	-0.00
4.19	20.00	0.02	2.036	4.19	-0.00
4.19	30.00	0.02	2.366	4.19	0.00
4.19	6.00	0.02	1.619	4.19	-0.00
4.20	26.00	0.02	2.229	4.19	-0.00
6.56	30.00	0.02	3.404	6.56	-0.00
6.65	12.00	0.02	2.546	6.66	0.00
6.68	20.00	0.02	2.935	6.68	-0.00
6.69	6.00	0.02	2.273	6.69	0.00
6.72	26.00	0.02	3.260	6.73	0.00
6.73	2.00	0.02	2.095	6.73	0.00

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

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

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



SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 3176
CALIBRATION DATE: 20-Aug-10

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

GHIJ COEFFICIENTS

g = -9.85456533e+000
h = 1.34309646e+000
i = -1.90224920e-003
j = 2.06940381e-004
CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

ABCDM COEFFICIENTS

a = 7.47119546e-007
b = 1.33782107e+000
c = -9.84258541e+000
d = -8.04511090e-005
m = 6.0
CPcor = -9.5700e-008 (nominal)

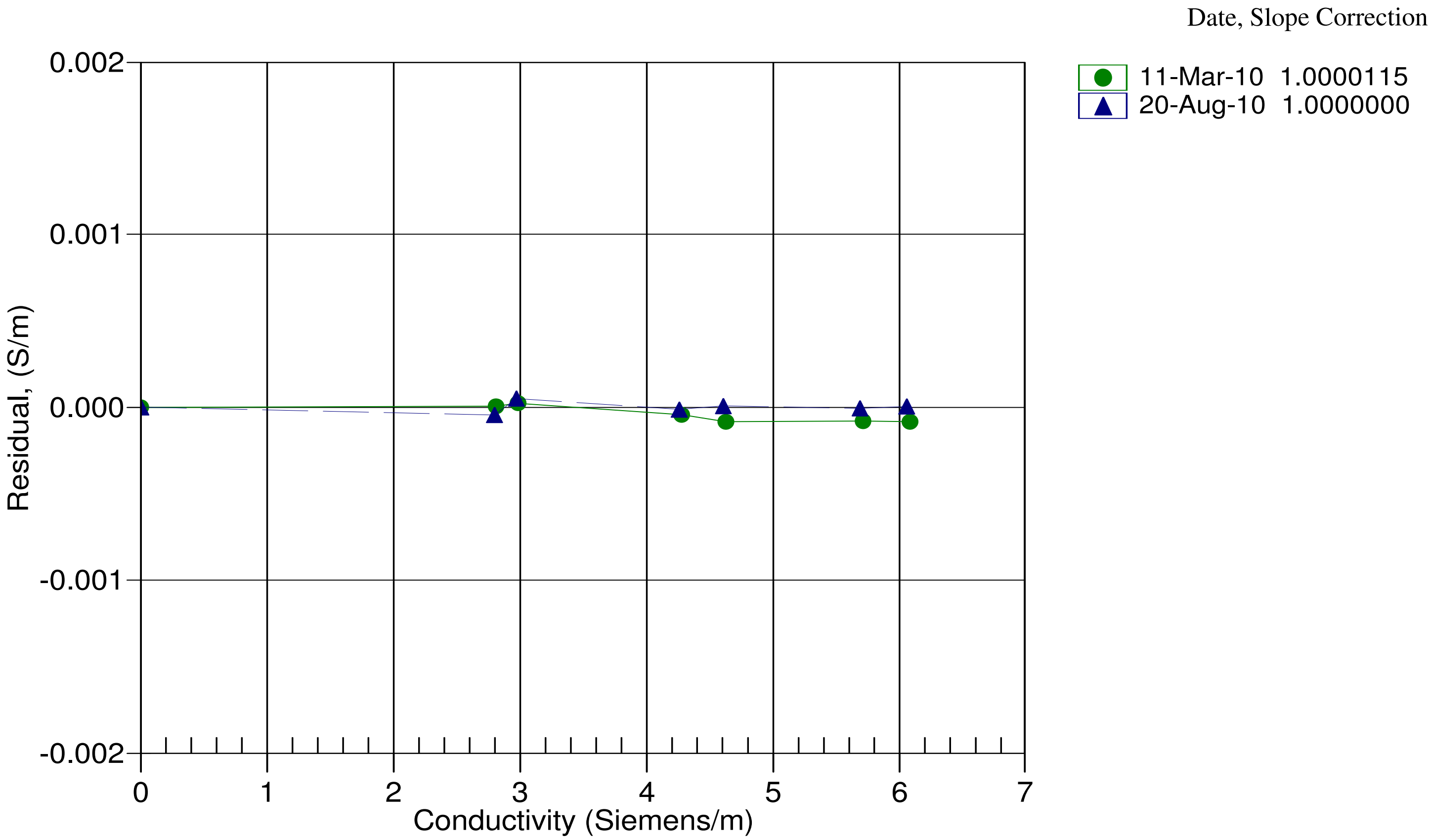
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.71240	0.00000	0.00000
-1.0000	34.6952	2.79573	5.31432	2.79568	-0.00004
0.9999	34.6950	2.96657	5.43306	2.96662	0.00005
15.0000	34.6966	4.25848	6.25747	4.25847	-0.00001
18.4999	34.6963	4.60416	6.46010	4.60416	0.00001
29.0000	34.6945	5.68461	7.05560	5.68460	-0.00001
32.5000	34.6872	6.05602	7.24886	6.05602	0.00000

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

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

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

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



SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 3399
CALIBRATION DATE: 11-Nov-10

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

GHIJ COEFFICIENTS

```
g = -1.01473070e+001
h =  1.53415621e+000
i = -1.96230638e-003
j =  2.34505763e-004
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  1.24862927e-006
b =  1.52916896e+000
c = -1.01376931e+001
d = -8.40350084e-005
m =  5.9
CPcor = -9.5700e-008 (nominal)
```

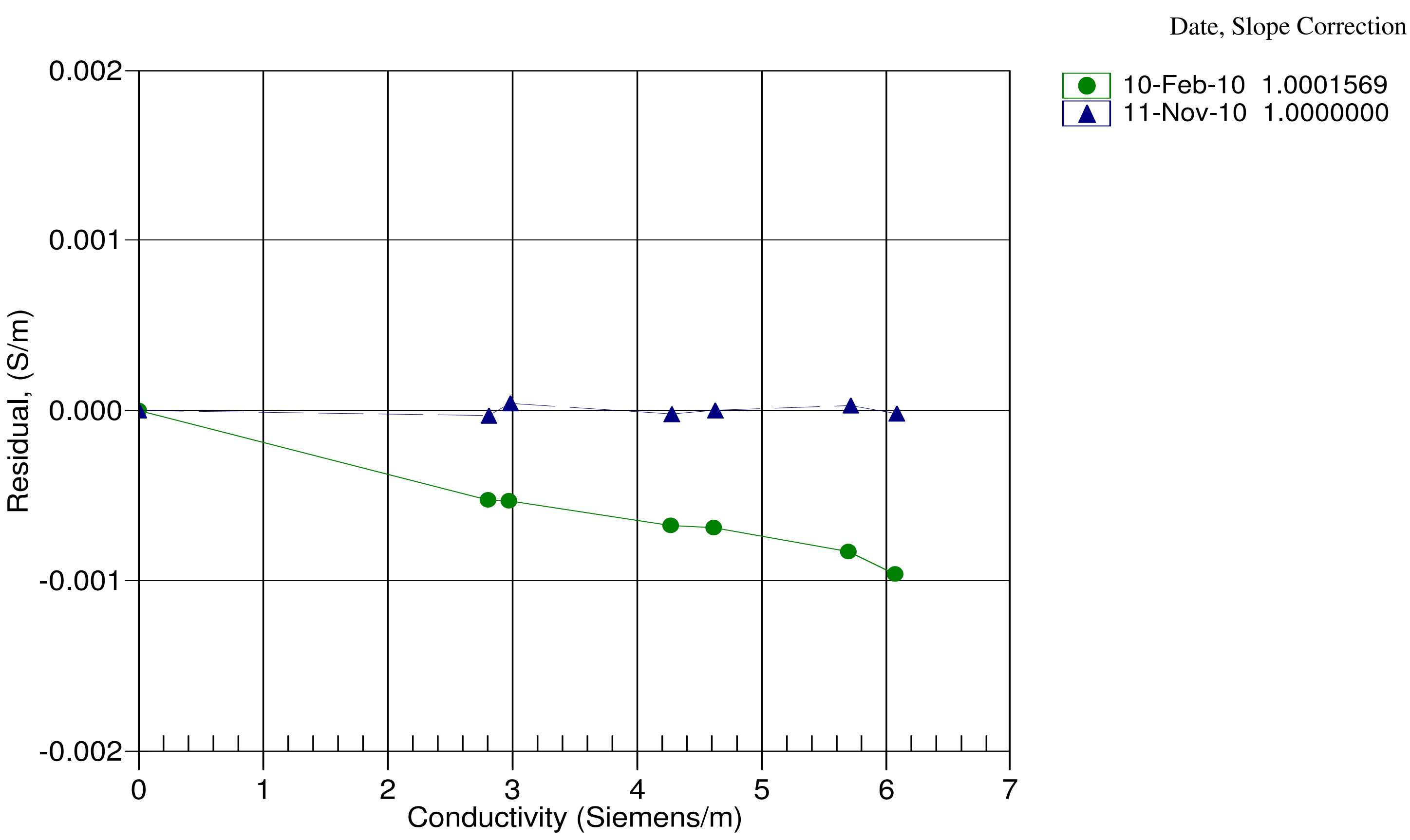
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.57476	0.00000	0.00000
-1.0000	34.8750	2.80886	4.99872	2.80883	-0.00003
1.0000	34.8743	2.98045	5.10963	2.98049	0.00004
15.0000	34.8753	4.27808	5.88034	4.27806	-0.00002
18.5000	34.8747	4.62528	6.06987	4.62528	0.00000
29.0000	34.8729	5.71054	6.62707	5.71057	0.00003
32.5000	34.8664	6.08374	6.80800	6.08372	-0.00002

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

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

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

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



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WET Labs

C-Star Calibration

Date November 30, 2010 S/N# CST-327DR Pathlength 25 cm

	Analog meter
V_d	**0.059 V**
V_{air}	**4.752 V**
V_{ref}	**4.660 V**

Temperature of calibration water	21.3 °C
Ambient temperature during calibration	21.5 °C

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

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

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

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

SEA-BIRD ELECTRONICS, INC.

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

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

SENSOR SERIAL NUMBER: 0011
CALIBRATION DATE: 10-Dec-10p

SBE 35 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

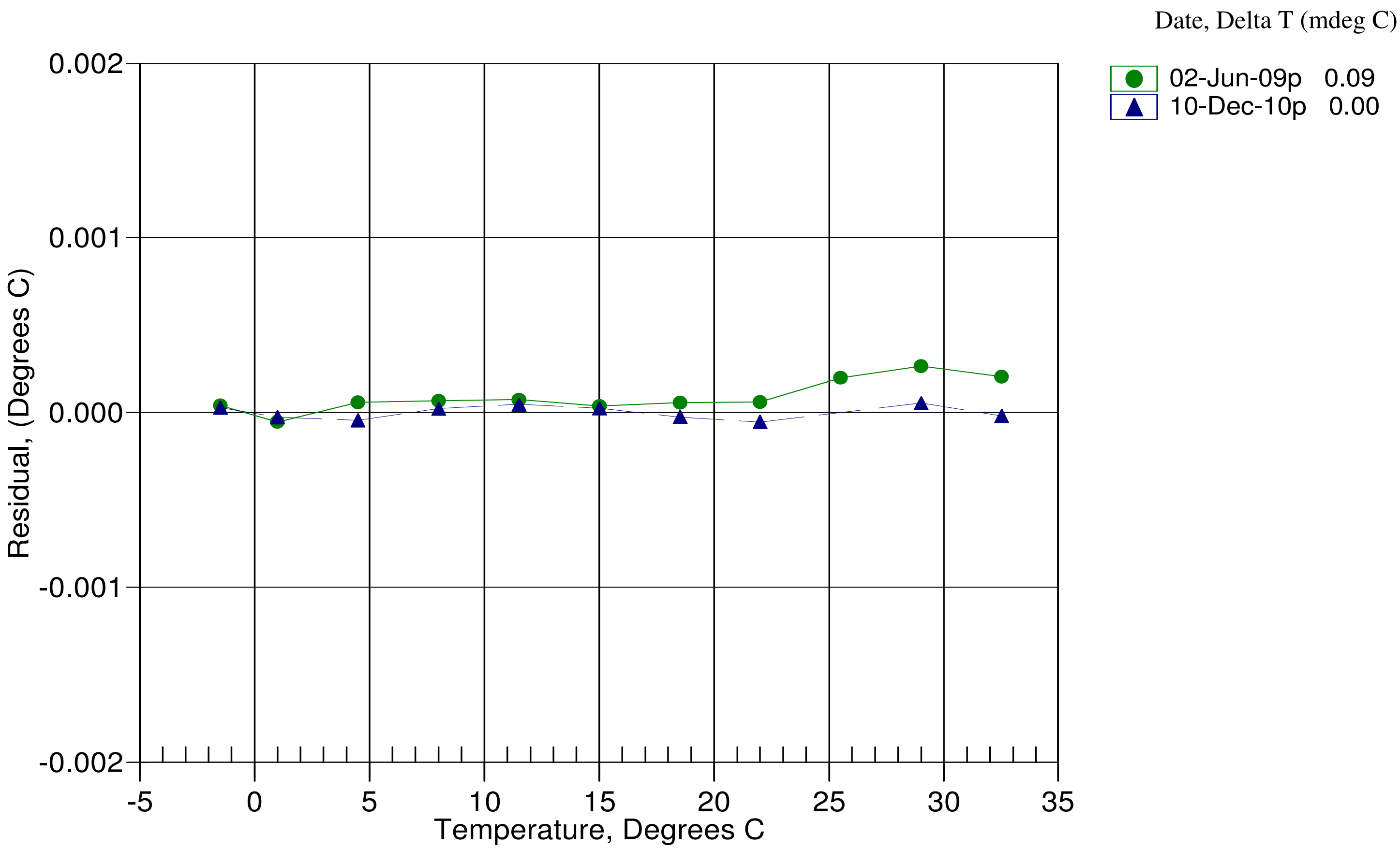
ITS-90 COEFFICIENTS

a0 = 5.07932084e-003
a1 = -1.40241599e-003
a2 = 2.05831106e-004
a3 = -1.13843353e-005
a4 = 2.41071702e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT (n)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.499860	790160.86	-1.499833	0.000027
1.000060	707445.12	1.000033	-0.000027
4.500120	607351.97	4.500075	-0.000045
8.000140	522810.78	8.000162	0.000022
11.500190	451243.15	11.500237	0.000047
15.000220	390515.84	15.000243	0.000023
18.500200	338861.85	18.500173	-0.000027
22.000230	294814.97	22.000176	-0.000054
29.000240	224891.30	29.000294	0.000054
32.500380	197165.70	32.500359	-0.000021

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

Residual = instrument temperature - bath temperature



Lowered Acoustic Doppler Current Profiler Report. Thomas Decloedt
CLIVAR S4P 2011 McMurdo, Antarctica to Punta Arenas, Chile

PI Contact: Eric Firing
University of Hawaii at Manoa
1000 Pope Rd.
Honolulu, HI
96822
efiring@hawaii.edu

Two RD Instruments Work Horse 300-kHz (WH300), Model WHM300-I-UG50, were used throughout the cruise, powered by a DEEPSEA Power & Light 50V SeaBattery. Both ADCPs were installed on the main rosette, one looking up and one looking down. The instruments provide full water column profiles of horizontal velocity currents with a vertical resolution of approximately eight meters.

LADCP downloading and processing were done on a Lenovo S10e laptop running Ubuntu Linux, and using a python gui developed at the University of Hawaii. Data was processed using LDEO software maintained by Andreas Thurnherr, with vertical profiles as well as longitude section plots being produced for general use. CTD time series data, GPS data and shipboard ADCP data, were used to constrain calculations.

At station 50, the downward-looking ADCP started having trouble as evidenced by bogus values when running the UH scanbb program (zmax=10000). At station 51, the LDEO software also warned of a 'broken beam 3' and the downward-looking ADCP (RDI workhorse 300kHZ SN#: 12734) was removed from the rosette between stations 52 and 53. The upward-looking rosette was moved into the downward-looking position. Inspection of the instrument revealed that the ADCP had flooded and was damaged beyond immediate repair. From station 53 onward, the LADCP was a downward-looking system only. While this reduces the accuracy of the measurements, it does not affect vertical resolution.

Figure 1 shows vector plots of the current velocities averaged over 0-100m of depth. The main portion of the S4P cruisetrack is zonal, eastward along 67 degrees south. The first part of the cruise ran from near the Antarctic Continent at 70S30', 168E 21' (station 2) northeastward to 67 S, 175 E 35' (station 18). Figure 2 shows the zonal and meridional velocities inferred by the LADCP. Near the coast, the Antarctic Slope current (ASF) was sampled. Further offshore, two features most likely due to sub-mesoscale eddies were crossed.

Figure 3 shows the meridional and zonal velocities along 67 S. Station spacing was variable due to time constraints. The spacing was 30 nautical miles from stations 18 (169E35') to 45 (150W), then 45 nautical miles from stations 96 (148 W) to 107 (130 W 11') and finally 60 nautical miles from stations 108 (127 W 37') to 127 .

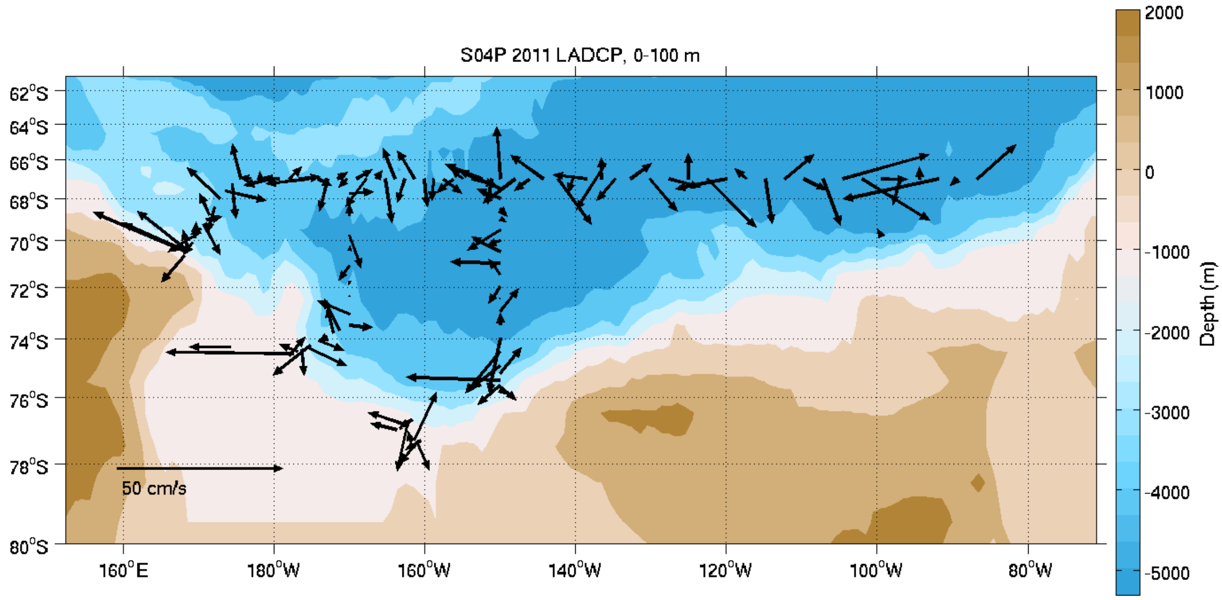


Figure 1: Vector plots of average current for the upper 100 m.

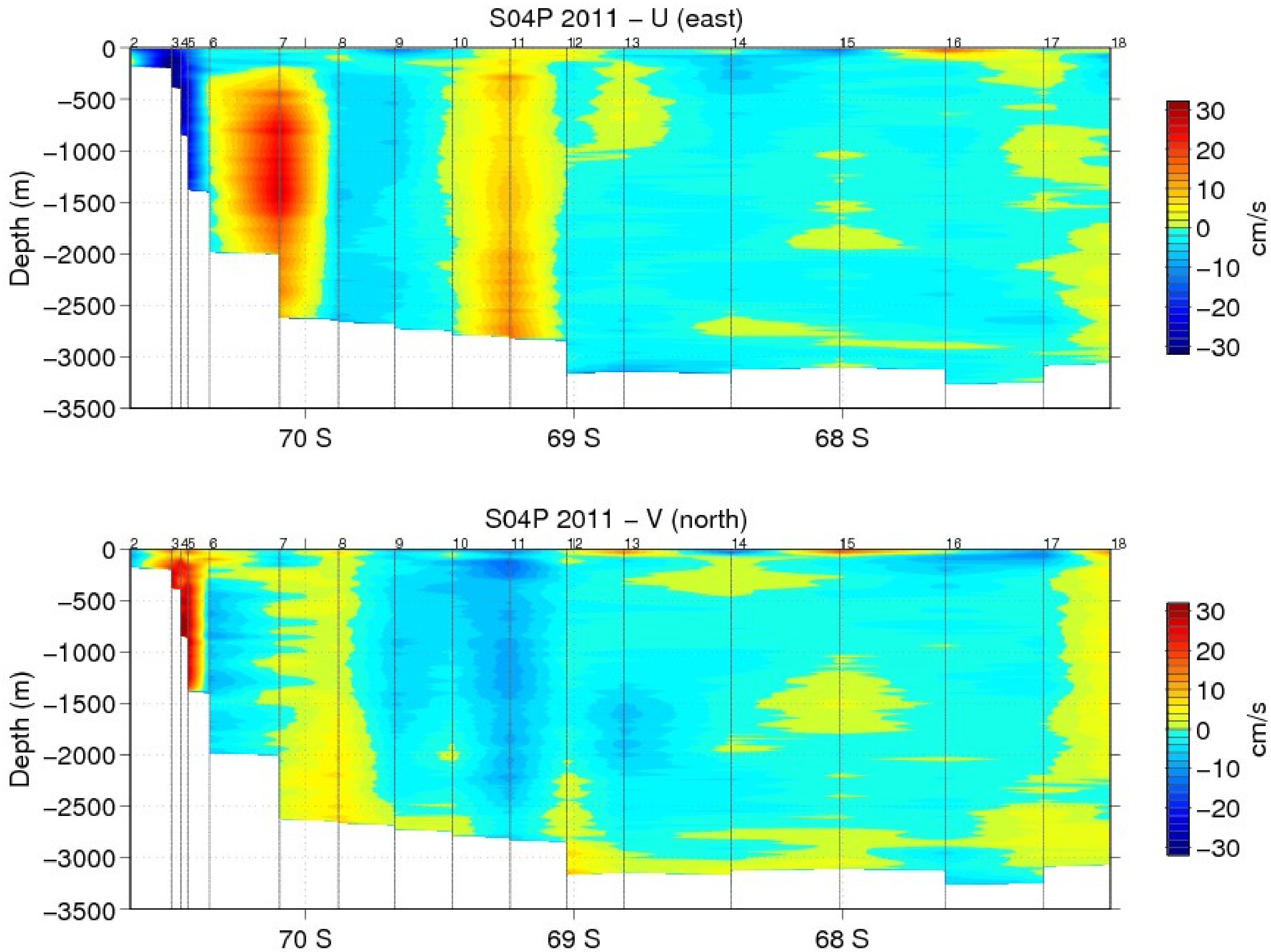


Figure 1: Zonal and meridional LADCP velocities from Cape Adare to 67 degrees south. The westward flowing ASF is evident at stations 3,4 & 5. The features at stations 7 and 11 are most likely due to sub-mesoscale eddies.

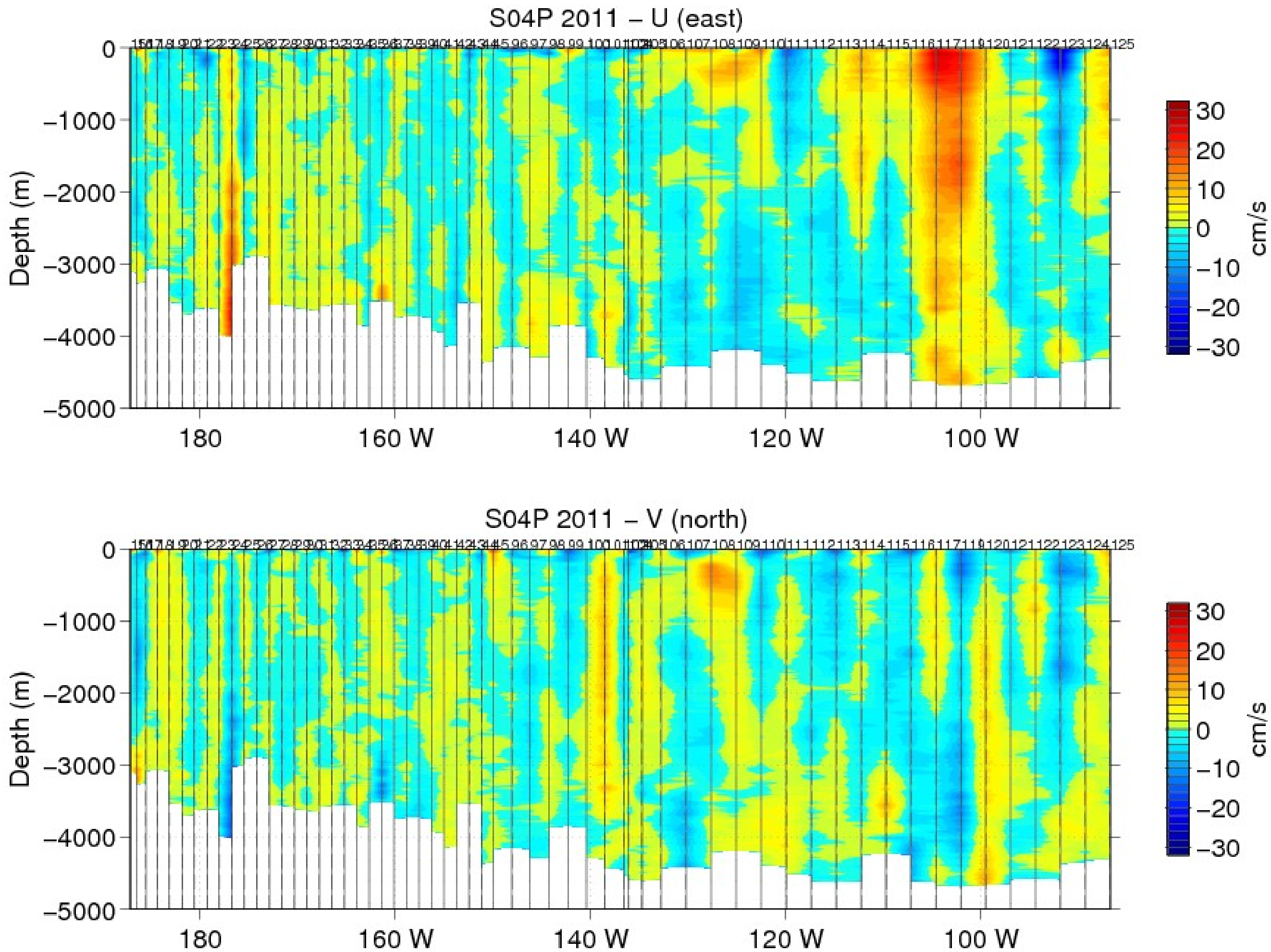


Figure 2: Zonal and meridional velocities along 67 S.

CLIVAR S4P Cruise Report

CFC and SF_6 Measurements

PI: **William Smethie (Lamont-Doherty Earth Observatory, Columbia University)**

Analysts: **Eugene Gorman (Lamont-Doherty Earth Observatory)**
Sarah Eggleston (University of Hawaii at Manoa)
Mingxi Yang (University of Hawaii at Manoa)

Report Prepared by Mingxi Yang
April 15, 2011

Lamont-Doherty Earth Observatory at Columbia University measured discrete waterside and airside concentrations of chlorofluorocarbons (CFC-11, 12, 113) and sulfur hexafluoride (SF_6) using purge-and-trap gas chromatography (GC) with separate electron capturing devices (ECD). With approximately 3000 samples analyzed, the system performed well during the S4P cruise overall.

Water samples for CFCs and SF_6 were the first to be drawn from the main CTD rosette at every cast to minimize interaction between seawater and room air. Except for Station 7, which was skipped due to time constraints, approximately 25 samples were taken from the CTD rosette every station. Water was transferred from niskin bottles to 0.5 L sampling bottles via a Clearflex 60™ PVC tube. Air bubbles were avoided by overfilling the glass sampling bottle as well as a plastic holding container that is ~4 cm taller than the glass sampling bottle, and then capping the sampling bottle underwater. Greater numbers of samples were generally taken near the ocean bottom and surface. The water samples were analyzed after being warmed to ~10 °C in a water bath; warming reduces gas solubility and improve purging efficiency (>99%). Water was transferred from the sampling bottle to a 23 mL sparging column for CFCs and 350 mL sparging column for SF_6; the greater volume for the latter was needed as a result of the three orders of magnitude lower ambient SF_6 concentration. The trace gases were purged out of the water phase at ~ 75 (CFCs) and ~150 mL per minute (SF_6) with purified nitrogen gas for 4 (CFCs) and 5 (SF_6) minutes, which were captured in a Unibeads-2S™ (CFCs) and Carboxen-1000™ (SF_6) traps that were cooled to ~ −80 °C with liquid carbon dioxide. Electronically heating the CFC trap to ~110 °C for one minute and injecting the sample gas into a Porasil-B™ pre-column and then a Carbograph 1AC™ column result in the separation of the CFC peaks. Heating the SF_6 trap to ~165 °C for one minute and injecting the sample gas into a MS-5A™ pre-column and column separate SF_6. The concentrations of trace gases were quantified with a dual ECD Hewlett Packard 6890 GC.

Concentrations from standard gases were measured at least once per cast; these results were used to monitor drift in instrument sensitivity. Calibrations were performed weekly by measuring the concentrations of the standard gases at different known volumes that vary by an order of magnitude. Duplicates were taken on roughly half of the stations, which generally yielded differences of less than 1% for CFC-11 and 12 and ~2% for CFC-113 and SF_6. As expected, greater concentrations of CFCs and SF_6 near the ocean bottom were observed in the Ross Sea as a result of deepwater formation. Deepwater concentrations decline to further the east to near zero by ~130°W along 67°S. Due to a problem with controlling the water level of the SF_6 purging column and high background levels of SF_6 from the GC carrier gas (nitrogen), no SF_6 measurements were made for Stations 18~27, 55~66, and 120.

Triplicates of ambient air samples were taken from the deck everyday with a 200 mL syringe and analyzed for CFCs and SF_6 using the same system as the waterside measurements. Interpolated to times when water samples were taken, airside measurements allowed for calculations of surface saturations. The saturations of these gases were typically higher in open water (~90%) than in regions covered in ice (~80%), and were positively correlated with the surface saturation of oxygen.

Lamont-Doherty Earth Observatory at Columbia University and University of Hawaii (PI: David Ho) also collaborated to measure underway samples for CFCs and SF_6. An underway sample was typically taken within minutes to when the 5-m niskin bottle was tripped and analyzed in the same fashion as niskin samples. Intercomparison between 5-m niskin and underway samples generally yielded good agreement. Duplicates of underway samples taken sequentially also demonstrate excellent precision, which supports the development of continuous underway sampling in the future. In addition to sampling when the ship was stationary, ~hourly underway samples were taken during the periods of March 21~22, March 29~30, and April 12 while the ship was transecting. The variability in measured concentrations was much greater during the first transect in the Ross sea than during the later transects near 67°S and further to the east.

TOTAL DISSOLVED INORGANIC CARBON (DIC)
PI's: Richard Feely, Christopher Sabine, Rick Wanninkhof
Shipboard Technicians: Nancy Williams, Kevin Sullivan

Samples were drawn from the Niskin-type bottles into cleaned, combusted 300 ml borosilicate glass bottles using Tygon tubing with silicone ends. Bottles were rinsed once and filled from the bottom, overflowing half a volume and leaving a 6 ml headspace, taking care not to entrain any bubbles. After 0.125 ml of 50% saturated $HgCl_2$ solution was added as a preservative, the sample bottles were sealed with glass stoppers lightly covered with Apiezon-L grease and stored at room temperature up to a maximum of 8 hours.

Partial profiles (~26 out of 36 Niskins) were sampled for all stations, with replicate samples taken from the surface, 1000m, and bottom bottles. Partial profiles were drawn throughout the water column with focus on the bottom four Niskins and the upper 500m. The replicate samples (N=314) were interspersed throughout the station analysis for quality assurance and integrity of the coulometer cell solutions. No systematic differences between the replicates were observed. Over 3200 samples were analyzed for discrete DIC.

The DIC analytical equipment is set up in a seagoing container modified for use as a shipboard laboratory. The analysis is done by coulometry with two analytical systems (PMEL-1 and PMEL-2) used simultaneously on the cruise. Each system consists of a 5011 coulometer (UIC, Inc.) coupled with a SOMMA (Single Operator Multiparameter Metabolic Analyzer) inlet system developed by Ken Johnson (Johnson et al., 1985,1987,1993; Johnson, 1992) of Brookhaven National Laboratory (BNL). In the coulometric analysis of DIC, all carbonate species are converted to CO_2 (gas) by addition of excess hydrogen to the seawater sample, and the evolved CO_2 gas is carried into the titration cell of the coulometer, where it reacts quantitatively with a proprietary reagent based on ethanolamine to generate hydrogen ions. These are subsequently titrated with coulometrically generated OH-. CO_2 is thus measured by integrating the total change required to achieve this.

The stability of each coulometer cell solution was confirmed three different ways: the Certified Reference Material (CRM), Batch 106 supplied by Dr. Andrew Dickson of SIO, was measured at the beginning, gas loops were run at the beginning and at the end, and the replicate samples interspersed – but typically run at the beginning, middle, and end of each cell solution. The coulometer cell solution was replaced after no more than 28 mg of carbon was titrated, typically after 9–11 hours of continuous use.

The coulometers were each calibrated by injecting aliquots of pure CO_2 (99.995%) by means of an 8-port valve outfitted with two sample loops (Wilke et al., 1993). These calibrations were run at the beginning and end of each cell with a set of the gas loop injections. Calculation of the amount of CO_2 injected was done in accordance with the Guide to best practices for Ocean CO_2 Measurements (PICES 2007).

The instruments each have a salinity sensor, but all DIC values were recalculated to a molar weight (µmol/kg) using density obtained from the CTD's salinity sensor. The DIC values were corrected for dilution by the saturated $HgCl_2$ addition used for sample preservation. The correction factor used for dilution was 1.0004. A correction was also applied for the offset from the CRM. On this cruise, the overall accuracy and precision for the CRMs on both instruments combined was 1.90 µmol/kg (n=201). 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.

References:

Dickson, A.G., Sabine, C.L. and Christian, J.R. (Eds.), (2007): Guide to Best Practices for Ocean CO_2 Measurements. PICES Special Publication 3, 191 pp.

Feely, R.A., R. Wanninkhof, H.B. Milburn, C.E. Cosca, M. Stapp, and P.P. Murphy (1998): A new automated underway system for making high precision pCO_2 measurements aboard research ships. Anal. Chim. Acta, 377, 185–191.

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

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

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

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Lewis, E. and D. W. R. Wallace (1998) Program developed for CO_2 system calculations. Oak Ridge, Oak Ridge National Laboratory. http://cdiac.esd.ornl.gov/oceans/

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

SO4P Alkalinity

(Laura Fantozzi and Emily Bockmon, laboratory of Andrew G. Dickson, Marine Physical Laboratory, Scripps Institution of Oceanography)

Samples were taken at every station, depending on cast depth the number of niskins sampled varied. Bottles were chosen to match what DIC was sampling. After thorough rinsing; samples were collected in 250 ml Pyrex bottles. A headspace of approximately 5mls was removed and 0.06 milliliters of a saturated mercuric chloride solution was added to each sample. The samples were capped with a glass stopper in a Teflon sleeve. All samples were equilibrated to 20 degrees Celsius using a Thermo Scientific water bath.

Beginning on Station 100, samples could only be analyzed between noon and midnight due to an unknown electrical problem. Between Stations 114-117 a third analyst, Wilson Mendoza, tried running samples. Unfortunately this did not alleviate the problem, but he ran approximately 30 samples during this period. Therefore, beginning at Station 121 fewer niskins, usually deep water, were sampled at each station for the remainder of the cruise. If a station was not sampled during this period it was due to the analyst being too far behind due to this unknown electrical problem. During this period of system problems the extra bottles that C14 requested be analyzed for alkalinity were not sampled or analyzed.

Samples of volume 92.085 ± 0.021 ml were prepared using a volumetric pipette and a system of relay valves and air pumps, controlled by a laptop using LabVIEW 2001. The temperature of the samples at time of dispensing was taken automatically by a computer using a Measurement Specialties 4600 thermometer, to convert this volume to mass for analysis.

Samples were analyzed using an open beaker titration procedure using two thermostated beakers; one sample being titrated while the second was being prepared and equilibrating to the system temperature of 20 degrees C. After an initial aliquot of approximately 2.2 mls of standardized hydrochloric acid (~0.1Molar HCl in ~0.6M NaCl solution), the sample was stirred for approximately 5 minutes to remove liberated carbon dioxide. The stir time has been minimized by bubbling air into the sample. After equilibration, 19 aliquots of 0.04 mls were added. The data within the pH range of 3.5 to 3.0 were processed using a non-linear least squares fit from which the alkalinity value of the sample was calculated (Dickson, et.al., 2007). This procedure was performed automatically by a laptop running LabVIEW 10.

Dickson laboratory Certified Reference Materials (CRM) Batch 106 was used to determine the accuracy of the analysis.

Depending on cast depth one, two or three duplicates were analyzed. These duplicates were taken at the surface, intermediate and/or deep water. Throughout the cruise, approximately 289 duplicates were analyzed. The pooled standard deviation was approximately 1.02 μ mol kg^{-1}.

The data should be considered preliminary since the correction for the difference between the CRMs stated and measured values has yet to be finalized and applied. Additionally, the correction for the mercuric chloride addition has yet to be applied. As part of the data evaluation, a determination was made for the possible contribution of the mercuric chloride to the alkalinity. The data indicate no contribution, either positive or negative, from the mercuric chloride.

REFERENCE:

Dickson, Andrew G., Chris Sabine and James R. Christian, editors, "Guide to Best Practices for Ocean CO2 Measurements", Pices Special Publication 3, IOCCP Report No. 8, October 2007, SOP 3b, "Determination of total alkalinity in sea water using an open-cell titration"

S4P DOC/TDN Cruise Summary

PI: Dr. Dennis Hansell, University of Miami, Rosenstiel School of Marine and Atmospheric Science
Ship Technician: Charles T. Farmer

A total of 2591 seawater samples were collected and frozen during the S4P cruise for Dissolved Organic Carbon (DOC) /Total Dissolved Nitrogen (TDN) analysis. The samples were collected by Charles T. Farmer during the cruise and consist of approximately 50 ml of seawater collected directly from the Niskin bottles on the rosette, with samples collected from 250 meters to the surface being filtered through a GF/F filter during sampling. The frozen seawater samples will be returned to the University of Miami, Rosenstiel School of Marine and Atmospheric Science for analysis using High Temperature Catalytic Oxidation (HTCO) with Shimadzu TOC-V_{CSH} instruments. For further information about the analysis or data availability please contact Dr. Dennis Hansell (dhansell@rsmas.miami.edu).

Reference:

Farmer, C. and D.A. Hansell. 2007. Determination of dissolved organic carbon and total dissolved nitrogen in sea water. Dickson, A.G., Sabine, C.L. and Christian, J.R. (Eds.) 2007. *Guide to best practices for ocean CO2 measurements*. PICES Special Publication 3, 191 pp.

CLIVAR S04P Helium Sampling
PI: Peter Schlosser, Lamont-Doherty Earth Observatory
On board technician: Anthony Dachille

690 Helium samples were taken.
Samples were taken roughly every 2.5-3.5 degrees, with 28 stations sampled.

Helium samples were taken in stainless steel sample cylinders. The sample cylinders were leak-checked and Back filled with N_2 prior to the cruise. Samples were drawn using tygon tubing connected to the Niskin bottle at one end and the cylinder at the other. Silicon tubing was used as an adapter to prevent the tygon from touching the Niskin per the request of the CDOM group. Cylinders are thumped vigorously with a bat while being flushed with water from the Niskin to help remove bubbles. After flushing roughly 1 liter of water through them, the plug valves are closed. As the cylinders are sealed by O-ringed plug valves, the samples must be extracted within 24 hours to limit out-gassing.
Eight samples at a time were extracted using our At Sea Extraction line set up in the Biolab. The stainless steel sample cylinders are attached to the vacuum manifold and pumped down to ~2e-7 Torr using a diffusion pump for a minimum of 1 hour to check for leaks. The sections are then isolated from the vacuum manifold and introduced to the reservoir cans which are heated to >90°C for roughly 10 minutes. Glass bulbs are attached to the sections and immersed in an individual ice water bath during the extraction process. After 10 minutes each bulb is flame sealed and packed for shipment back to WHOI. The extraction cans and sections are cleaned with distilled water and isopropanol,and then dried between each extraction.
Helium samples will be analyzed using a mass spectrometer at LDEO.

Tritium / Oxygen-18 Sampling
PI: Peter Schlosser, Lamont-Doherty Earth Observatory
On board technician: Anthony Dachille

556 Tritium and 750 oxygen-18 samples were taken on the same stations as the Helium samples. Each Tritium sample taken corresponded to a Helium sample taken on that station.
Tritium samples were taken using a silicon adapter and tygon tubing to fill 1-qt glass jugs. The jugs were baked in an oven, backfilled with argon, and the caps were taped shut with electrical tape prior to the cruise. While filling, the jugs are place on the deck and filled to about 2 inches from the top of the bottle, being careful not to spill the argon. Caps were replaced and taped shut with electrical tape before being packed for shipment back to WHOI.
Tritium samples will be degassed in the lab at WHOI and stored for a minimum of 6 months before mass spectrometer analysis. Oxygen-18 were sampled in the same manner, without the use of argon.

Discrete pH Analyses
PI: Dr. Andrew Dickson and Dr. Frank Millero
Ship technicians: Ryan Woosley and Wilson Mendoza

Sampling
Samples were collected in 250ml borosilicate glass bottles rinsing a minimum of 3 times, allowing approximately half the volume to overflow, and thermostated to 25°C before analysis. Three duplicates were collected from each station. Samples were collected on the same bottles as total alkalinity or dissolved inorganic carbon in order to completely characterize the carbon system. All data should be considered preliminary.

Analysis
pH (µmol/kg H_2O) on the total scale was measured using an Agilent 8453 spectrophotometer according to the methods outlined by Clayton and Byrne (1993). A RTE17 water bath maintained spectrophotometric cell temperature at 25.0°C. A 10cm flow through cell was filled automatically using a Kloehn 3v syringe pump. The sulfonephthalein indicator m-cresol purple (mCp) was also injected automatically by the kloehn 3v syringe pump into the spectrophotometric cells, and the absorbance of light was measured at two different wavelengths (434 nm, 578 nm). The baseline was subtracted from these wavelengths, determined by averaging the absorbances from 730-735nm. The samples were run with the tungsten lamp unplugged. In order to correct for the increased noise caused by this the spectrum was measured 6 times in rapid succession and then averaged. The ratios of absorbances at the different wavelengths were input and used to calculate pH on the total scales, incorporating temperature and salinity into the equations. Salinity data were obtained from the conductivity sensor on the CTD. These data were later corroborated by shipboard measurements. Temperature of the samples was measured immediately after spectrophotometric measurements using a YSI 4600 thermometer.

Reagents
The mCp indicator dye made to a concentration of 2.0mM in 100ml batches as needed. A total of 4 batches were used during the cruise. The pH of the first two batches were adjusted to ~7.9 (NBS) by the addition of ~0.1N HCl. The last two batches were adjusted to a pH of ~7.6. This was done because of the small pH range of the water column in this area (<0.3) which made it difficult to determine the slope of the perturbation caused by the addition of the indicator.

Standardization
The precision of the data can be accessed from measurements of duplicate samples, and certified reference material (CRM) Batch 106 (Dr. Andrew Dickson, UCSD). CRMs were measured approximately every other. The mean and standard deviation for the CRMs was 7.9168± 0.0031 (n=110).

Data Processing
Addition of the indicator affects the pH of the sample and the degree to which pH is affected is a function of the differences between the pH of the seawater and indicator. Therefore, a correction is applied for each batch of dye. To determine this correction 2 samples from each station where measured twice. Once with a normal amount of indicator and once with double the amount of the indicator. The $\Delta R/\Delta A_{iso}$ versus the average of the ratio (R) is then plotted and fitted with a linear equation; where A_{iso} is the absorbance as the isosbestic point (488nm). From this fitted equation the slope and intercept (b and a repectively) are determined by:

$$\Delta R/\Delta A_{iso} = bR + a \qquad (1)$$

From this the corrected ratio (R') can be determined by:

$$R' = R - A_{iso}(bR + a) \qquad (2)$$

Preliminary quality control of the data are summarized in Table 1.

Table 1. Preliminary Quality Control

Total Number of Samples	3046
Questionable (QC=3)	31

Bad (QC=4)	14
Lost (QC=5)	6
Duplicate (QC=6)	327

Problems

Very few problems occurred during the cruise. During the first 10 stations duplicates were very poor due to bubbles in the cell. This was solved by allowing the cell to soak in surface seawater for over 24hrs to condition the cell. Around stations 20-26 an unusual peak sometimes appeared at <400nm. Although it did not appear to affect the pH (rerunning the sample and getting a spectrum without the peak gave the same pH). The baseline absorbance was also higher than expected, so the spectrophotometer was replaced with a spare. The usual peak no longer appeared after the replacement and background absorbance was normal (<0.001).

References

Clayton, T. D. and Byrne, R. H., "Spectrophotometric seawater pH measurements: Total hydrogen ion concentration scale calibration of m-cresol purple and at-sea results," *Deep-Sea Res.*, 40, pp. 2315-2329 (1993).

Density Samples
PI: Dr. Frank Millero
Ship Technicians: Ryan Woosley and Wilson Mendoza

Density samples were taken at twelve stations during the cruise, sampling the same bottles as the inorganic carbon parameters (Stations 11, 44, 64, 66, 89, 101, 109, 114, 120, 124, 138, 140). The samples were drawn into 150 mL HDPE bottles rinsing three times before filling. These samples will be analyzed for density using an Anton-Parr vibrating densitometer and re-analyzed for salinity (to account for any evaporation) back in Miami.

Discrete Sample Collection from Underway Sea Water System

In support of the autonomous underway pCO2 measurements, discrete samples were collected from the underway sea water system when the spacing between CTD stations was greater than 60 nautical miles. There were four transits to the start of the next line of CTD stations, and forty-four collections were done along these transits. The spacing between CTD stations on a line was never greater than 60 nautical miles. The parameters measured at essentially all of these underway stations were dissolved inorganic carbon, total alkalinity, pH, nutrients, oxygen, and salinity.

Eight of the collections occurred while a CTD cast was being done. The results from the underway discrete samples compared very well with the discrete samples from the CTD Niskin bottles at the two shallowest depths – typically 5 and 25 meters. The inlet for the underway sea water line is at approximately 6 meters depth. The underway seawater line appeared to provide sea water representative of the surface mixed layer.

S4P Carbon14 Cruise Summary

PI: Dr. Ann McNichol, Woods Hole Oceanographic Institution
Dr. Robert Key, Princeton University
Ship Technician: Charles T. Farmer

A total of 527 seawater samples were collected and preserved on the S4P cruise for 14C analysis. The samples were collected by Charles T. Farmer and/or Juan Botella, and consist of approximately 500 ml of seawater collected directly from the rosette. The samples will be returned to Woods Hole Oceanographic Institution for analysis. For more information about the data or analysis please contact Dr. Ann McNichol (amcnichol@whoi.edu) or Dr. Robert Key (key@princeton.edu).

Reference:

McNichol, A., Quay. P. D., Gagnon, A. R., Burton, J. R., "Collection and Measurement of Carbon Isotopes in Seawater DIC", *WHP Operations and Methods-March 2009*.

Trace metal hydrographic casts S4P

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Hydrographic sampling for the trace elements Al, Fe and Mn was conducted during the CLIVAR S4P cruise aboard the R.V. N.B. Palmer. In total (not counting station 1) 56 stations were occupied at approximately 1˚ longitude spacing along each of the sections yielding a total of 671 subsamples. Data generated onboard were submitted to the shipboard data assembly system and each parameter on each subsample was assigned a WOCE quality flag.

Samples were collected using a specially designed rosette system which consists of 12 x12L GO-FLO bottles mounted on a powdercoated rosette frame. The package was equipped with a SeaBird SBE 911 ctd that also had an SBE 43 oxygen sensor and a Wet Labs FL1 flourometer. The package was lowered using a Kevlar conducting cable and bottles were tripped at predetermined depths from the ship using a deck box (Measures et al., 2008b).

The necessity to store the TM rosette outside on the deck resulted in significant problems with the SBE 43 oxygen sensor. On several occasions after particularly cold periods the sensor readings were clearly offset from the expected dissolved oxygen concentrations. The sensor however continued to provide a signal that varied with depth in the water column in an oceanographically reasonable manner. So, even though the sensor was not yielding accurate values of dissolved oxygen on board the ship, the data from the sensor were collected for the duration of the cruise in the expectation that either post cruise calibration of the sensor, or by fitting data from the hydrography rosette the TM sensor values could be made useful at a future date.

Water sub samples were collected from the GO-FLO bottles in the TM van using previously documented procedures (Measures et al., 2008b). Dissolved Al, Fe and Mn were determined on these water samples on board ship using the Flow Injection Analysis methods of Resing and Measures, 1994; Measures et al., 1995; Resing and Mottl, 1992 respectively. In addition samples were collected for shorebased ICPMS determinations of dissolved Mn, Fe, Co, Ni, Cu, Zn, Cd, and Pb using isotope dilution ICPMS (Milne et al., 2010). The suspended matter collected on filters from each GO-FLO bottle will be analyzed at FSU. The samples will be digested in strong acid and analyzed for a suite of trace elements including Al, Ti, Mn, Fe, Co, Ni, Cu, Zn, Cd, and Pb using ICPMS. Unfiltered 4 litre samples were also collected for Aimee Neeley (NASA), for shipboard filtration and shorebased determination of phytoplankton pigments.

In addition to the regular shipboard program additional unfiltered seawater samples were collected from 12 profiles for shore-based analysis of total mercury and methylmercury, in collaboration with Dr. David Krabbenhoft (USGS).

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Measures, C.I., Landing, W.M., Brown, M.T. and Buck, C.S. (2008b). A commercially available rosette system for trace metal clean sampling. Limnol and Oceanography methods, 6, 384-394.

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Summary of Transmissometer Sampling Procedure

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Mary Jo Richardson, Texas A&M Department of Oceanography
Technician: Robert Thombley, Kristin Sanborn, Alex Quintero, Brett Hembrough
SIO/STS

TRANSMISSOMETER:
Instrument: WetLabs C-Star Transmissometer **327DR**

AIR CALIBRATION:

- Calibrated the transmissometer in the lab at beginning and end of the cruise with a pigtail cable attachment to CTD.
- Wash and dried the windows with Kimwipes and distilled water.
- Compare the output voltage with the Factory Calibration data.
- Recorded the final values for unblocked and blocked voltages on the TRANSMISSOMETER CALIBRATION/CAST LOG. In most cases recorded the approximate air temperature as well.

OPERATION:

- With the transmissometer connected to the CTD, cleaned and dried optical windows. Block the light path in the center of the instrument with your fingers or a paper towel and measure the output voltage. Took reading of the output (voltage or counts) through the CTD and record the value on the "TRANSMISSOMETER CALIBRATION/CAST LOG". If the new value is substantially different, wash the windows with slightly soapy water or alcohol and rinsed with fresh water, then wipe dry. Checked output voltage again for stable readings then ceased drying the transmissometer windows; typically employing one or two, wipes with Kimwipes, of each window. This was done before cast, at the beginning and end of the cruise as well as every 20 casts. Temperature disequilibrium and condensation on windows will cause erratic readings.
- Washed the windows before every cast. Rinsed both windows with a distilled water bottle that contains 2-3 drops of liquid soap. This was the last thing before the CTD went in the water.
- Rinse instrument with fresh water at end of cruise.

Date	Blocked Value Vd	Unblocked Value Vair	Air T (°C)	Remarks
11/30/11	0.059	4.752	21.5	
		4.660	21.3	Factory Calibration
2/23/11	0.056	4.707		
3/12/11	0.056	4.673	5.8	
3/22/11	0.056	4.675	6.0	
4/04/11	0.056	4.652	5.8	
4/14/11	0.057	4.666	7.2	
4/19/11	0.059	4.665	8.3	
4/20/11	0.059	4.690	20	

NASA Ocean Ecology Branch
PI:Charles R. McClain
Ship Technician: Aimee Neeley

Summary of the Biogeochemical Sampling Program

The primary objective of the participation of NASA's Ocean Ecology Branch was to collect biogeochemical data for 'ground-truthing' data products obtained from NASA Ocean Color Satellites, both current and future. The following samples were collected from both the uncontaminated seawater system of the Nathaniel B Palmer and/or from the CTD rosette when water was available: phytoplankton pigments, absorption of particulate organic matter (Ap), suspended particulate matter (SPM), particulate organic carbon (POC), chromophoric dissolved organic matter (aCDOM) and dissolved organic carbon (DOC). CDOM samples were collected for a collaborator, Norm Nelson of the University of California, Santa Barbara, who has participated in previous field campaigns within the CLIVAR program. All sample analysis will take place post cruise at the University of California (CDOM) and at NASA Goddard. Detailed protocols of analysis procedures will be provided in the final cruise report

Sample Collection Protocol

CDOM samples were collected from the rosette mid-day using silicone tubing from 17-18 depths. Each sample was filtered in a glass filtration set up through 25mm, 0.2 um polycarbonate filters. The filtrate for each sample was stored in a 40mL amber glass vial and kept in the dark at 4ºC. Phytoplankton pigments were filtered through plastic filter funnels, in duplicate, by gentle vacuum (7psi) onto 25mm Whatman GFF filters. Pigment samples were stored in liquid nitrogen. POC and Ap were filtered as pigments but onto combusted 25mm GFF filters and using glass filter funnels. Ap samples were flash-frozen and stored at -80ºC, while POC samples were stored in liquid nitrogen. SPM samples were filtered through pre-weighed, 47mm polycarbonate filters, also through glass filter funnels and stored at -20ºC. DOC samples were collected at some stations either straight from the underway system (unfiltered) or filtered through a glass filter funnel. These samples were collected in 40mL pre-combusted glass amber vials and stored in the dark at 4ºC. At each station where samples were collected from the underway seawater system, latitude, longitude, time, station number and underway fluorescence were recorded onto a log sheet. Surface water was collected in a 20L carboy. For each parameter a 1L or 4L plastic amber bottle was filled and inverted onto filtration set up. Volumes of filtration were dependent on the chlorophyll fluorescence values. Typically 1- 4L of water, occasionally 6L for pigments, were filtered. When water was collected from the rosette, sampling depths were dependent on the structure and intensity of the fluorescence trace. Water was filtered for pigments as priority and then POC and/or Ap depending upon available volume. Please see the table below for the identification of stations sampled, method of sampling and parameters that were collected. On a few occasions (stations 47, 83, 97, 102, and 111) water was collected from the trace metal rosette.

Station	Surface (Under-way system)	CTD rosette	Depths sampled (from rosette)	Pigments	POC	Ap	SPM	DOC	aCDOM

2	X			X		X	X		
3									X
5		X	3, 20, 40, 65,140	X		X			
9	X			X	X	X	X		X
11			4,20,40,65,177,140	X					
12	X			X	X	X	X		X
15	X			X	X	X			
16		X	3.5,35,60,85,110	X					X
18	X			X	X	X	X	X	X
19	X	X	34,60,84,110	X					
21	X			X	X	X	X	X	X
22	X	X	35,58,85,109	X					
25	X			X	X	X	X		X
26	X	X	20,40,65	X					
28	X	X	35,60,84	X					
29	X			X	X	X	X	X	X
32	X	X	3.8,20,65,90,115	X	X	X	X		X
33	X			X	X	X			
35	X	X	20,40	X	X	X	X	X	X
36	X			X	X	X			
37	X			X					
38	X	X	20,40,65	X	X	X			
39	X			X	X	X	X		X
41	X	X	20,40,65	X	X	X			
42	X			X	X	X	X		X
43	X			X	X	X			
45	X	X	24,50,73,100	X	X	X	X		X
46	X			X	X	X			
47	X	X	20,40,65,90	X	X	X	X	X	X
48	X	X	25,50,75	X	X	X			
50	X	X	20,40,65	X	X	X	X	X	
51	X			X	X	X	X	X	X
52	X			X	X	X			
53	X			X					
54	X			X	X	X	X	X	X
55	X	X	20,40,65	X	X	X			
56	X			X					
57	X			X	X	X	X		X
58	X			X	X	X			
59	X			X					
60	X			X	X	X			X
61	X	X	2.7,35,60	X	X	X			
62	X			X					
64	X			X	X	X			X
65		X	4.5,20,40,65	X	X	X			
66		X	2.2,25,50,75	X					

77	X	X	25,50,75,100 124,150	X	X	X	X	X	X
78	X	X	35,60,85,110	X	X	X			
79	X			X	X	X			
80	X			X					
81	X			X					
82	X	X	20,40	X	X	X	X		X
83	X	X	20,53,75	X	X	X			
84	X			X					
85	X			X					
86	X			X	X	X	X	X	X
87	X	X	33,60,84	X					
88	X	X	20,40,64	X					
89	X			X					
90	X			X	X	X	X	X	X
91	X			X	X				
92	X			X					
93	X			X	X	X	X	X	X
94	X			X	X	X			
95	X	X	25,50	X	X	X	X	X	X
97	X	X	20,41,65	X	X	X			
98	X	X	2.2,25,50,75	X	X	X			
99	X			X					
100	X	X	20,40,66	X	X	X	X	X	X
101	X			X	X				
102	X	X	20,33,60	X	X	X			
105	X			X	X				
106	X			X	X				
107	X			X	X				
108	X			X					
109	X		24,74,99	X	X	X	X	X	
110	X			X					
111	X	X	19,40,55	X	X	X	X		X
112	X			X					
113	X			X	X	X	X	X	X
114	X			X					
115	X			X					
116	X	X	60.5	X	X	X	X	X	
117	X			X					
118	X			X					X
119	X			X	X	X	X		
120	X			X					
121	X			X	X	X	X	X	X
122	X			X					
123	X			X	X	X	X	X	X
124	X			X					
125	X			X					
126	X			X	X	X	X	X	
127	X			X					

128	X	X	50.2	X					X
129	X			X	X	X	X		
130	X			X					
131	X			X	X	X	X		
132	X			X	X	X	X		
133	X			X					
134	X			X					
135	X			X					X
136	X	X	50	X	X	X	X	X	
137	X			X					
139		X	5.6,65,89,99	X	X				
140	X			X					

S4P Cruise Report April 14, 2011
Atmospheric Sampling Program: Aerosols and Precipitation

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1. The role of iron as a limiting plant nutrient in the oceans is widely recognized, but still poorly understood. Atmospheric transport of mineral dust is the major mechanism by which Fe is supplied to the open ocean, and therefore has a major impact on upper ocean biogeochemical cycling of carbon and the major plant nutrients. As a result of industrialization and increased use of fossil fuels (oil and coal), aerosols from urban areas are also reported to carry high concentrations of soluble Fe. There are very few data on the concentrations of total aerosol Fe and the percentage of soluble aerosol Fe over the open ocean. The aerosol sampling/analytical component of the CLIVAR Trace Metals research effort utilizes a 4-channel aerosol sampling system deployed on the forward safety rail on the top of the conning tower of the RVIB NB Palmer. The aerosol sampling system is operational when the wind speed is greater than 2 kts and the wind has been continuously blowing towards the bow of the ship (±75 degrees) for at least 2.5 minutes. If the wind speed drops below this threshold, or moves out of the designated sector, the air flow is immediately shut off using electronically actuated relays and solenoid valves to avoid contamination from stack exhaust. All personnel on board are cautioned not to smoke or conduct any activity forward of the aerosol mast that might generate small particles.

We collect replicate bulk aerosol samples on 47 mm diameter filters. The analyses of these samples is designed to help understand the processes responsible for solubilizing Fe and Al in natural aerosols. One of the bulk aerosol filters is analyzed for total aerosol Fe and Al (and other trace elements). A replicate filter is leached with freshly-collected 0.2 μ m filtered surface seawater to measure seawater-soluble aerosol Fe, Al, Mn, Co, Ni, Cu, Zn, Cd, and Pb. Another replicate filter is leached with ultra-high purity (UHP) deionized water to measure water soluble Fe and a suite of 40-50 other trace elements. UHP water-soluble anions (including excess sulfate and nitrate) and cations (sodium) are also measured on these samples.

Samples were collected (48-hour integrated) from February 23, 2011 (70º 26.395’ S, 168º 28.7'E) through April 20, 2011. A total of 25 sets of 48-hour integrated aerosol samples were collected. Aerosol data are generally available within 12 months of the end of the cruise.

We also made an effort to collect snow samples using three methods. The large polyethylene funnel that is normally used to collect rain samples was deployed on the forward safety rail of the ship's bridge deck, however the snow did not collect efficiently in the funnel. We also deployed three 500mL wide-mouth polyethylene bottles on a PVC pole mounted atop the conning tower. These bottles have threaded openings on each end, and are normally found in use in fast-food outlets to dispense condiments (known as "first in, first out" or FiFo bottles). When the top cap is removed, the openings in the back end caps allow air to pass through the bottles while snow collects inside the bottle. This method worked very well on a few occasions, but it requires very heavy snowfall while the ship is pointed "bow into the wind".

Finally, we took advantage of the opportunity when the ship moored to a large ice floe to leave the ship, walk upwind for 100 meters, and collect snow off the surface of the ice floe.

The collected snow is allowed to melt inside the collection bottles, then transferred to a smaller polyethylene bottle for frozen storage, to be analyzed at FSU.

The atmospheric sampling data will be made available through the Biological and Chemical Oceanography Data Management Office, Department of Marine Chemistry and Geochemistry, Woods Hole Oceanographic Institution. The data will be available at:
http://data.bco-dmo.org/jg/dir/BCO/CLIVAR_AEROSOL/

2. Instruments and Methods:

a. Total aerosol Fe and Al is measured on 47 mm, 0.4 μm polycarbonate track-etched filters following strong acid digestion at FSU.
b. Seawater-soluble aerosol Fe is measured on freshly-collected 47 mm, 0.45 μm Pall/ GN6 (cellulosic esters) aerosol filters. The loaded filter is placed in a clean polycarbonate vacuum filtration rig and 100 mL of 0.2 μm filtered surface seawater (natural pH) is pulled though the filter in 5-10 seconds. Samples are further acidified to pH <2 (0.024M HCl) for storage and analysis of total dissolved Fe at FSU.
c. For the UHP-water aerosol solubility measurements, a replicate loaded aerosol filter is placed in a clean polycarbonate vacuum filtration rig and 100 mL of ultrapure deionized water (UHP; pH 5.4-5.5) is pulled though the filter in 5-10 seconds. These samples are immediately frozen for return to FSU. After thawing and analysis of the soluble anions and cations (section (e) below) the samples are acidified to pH <2 (0.024M HCl) and stored for analysis of total UHP soluble aerosol Fe and Al.
d. Total aerosol Fe and Al, and total soluble, aerosol Fe and Al (and other trace elements) are measured on the digested aerosols and the seawater and UHP-water aerosol leaches using high-resolution Inductively-Coupled Plasma Mass Spectrometry (ICPMS).
e. Soluble aerosol anions and cations are measured on the UHP-water leaches using ion chromatography (for chloride, nitrate, sulfate) and flame Atomic Absorption Spectroscopy (for sodium).
f. Snow samples are analyzed for major ions using the methods listed under (e) above, and for total trace elements using the methods listed under (d) above.

3. Additional Cooperative Sampling

None

Palmer 11-02 Preliminary cruise report
20 April 2011
Peacock/Laney - WHOI

The primary goal of this component was to operate the Imaging FlowCytobot continuously from the ship's flow-through system over the entire cruise track of NBP11-02. This included the S4P line, along 67 S latitude from 170 E to 72 W longitude as well as transects south on 170W, 150W, and 103W, and all transits between transects. This sampling continued during and between fixed stations. The phytoplankton cell images collected with this instrument provide information about the microplankton assemblage composition, for comparison to HPLC proxies for assemblage composition and for direct assessment of algal composition while at sea. In addition, during a majority of fixed stations and longer transits, surface samples from the ship's flow-through system were analyzed by flow cytometry with an Accuri C6 Flow Cytometer. As time and water availability permitted, discrete volumes from CTD bottle samples were also analyzed for images and flow-cytometry to provide similar algal composition information from those samples. Bottle samples were taken down to ~100 meters, depending on the fluorescence profile.

The Imaging FlowCytobot operated continuously throughout the cruise, taking ~2300 5ml samples. Discrete CTD bottle samples were also analyzed from 22 stations.

A total of 224 discrete water samples were analyzed by flow-cytometry. Surface water was analyzed from 84 out of 140 CTD stations occupied during NBP11-02. CTD bottle profiles were analyzed from 23 stations. The remaining 133 were surface samples taken between stations with 60nm spacing or during longer transits.

Post-cruise analysis will involve a detailed examination of algal assemblage structure using these image and flow-cytometry data.

Eastern Ross Sea Mooring Program

The ***Atmosphere-Ice-Ocean Interactions in the Eastern Ross Sea*** study is funded by NSF-OPP (Grant: ANT-0839005; PI: Orsi) to investigate what processes control the flow of warm Circumpolar Deep Water onto the Antarctic continental shelf in the eastern Ross Sea. It is based on 1-yr moored time series of currents, temperature, conductivity and pressure in the interior of the Little America Trough. Also data from high-resolution conductivity/temperature/depth (CTD) and expandable temperature profiling (XBT) measurements are used to characterize the summer regional water mass stratification and circulation, their boundaries and spreading paths, and their interactions with the sea-ice and continental ice.

Two identical moorings were built at the Geochemical and Environmental Research Group of Texas A&M University (TAMU). Each of these moorings had dual Benthos acoustic release, three Sea-Bird SBE-37 Microcats, and two Nortek Aquadopps 3000 (Figure 1).

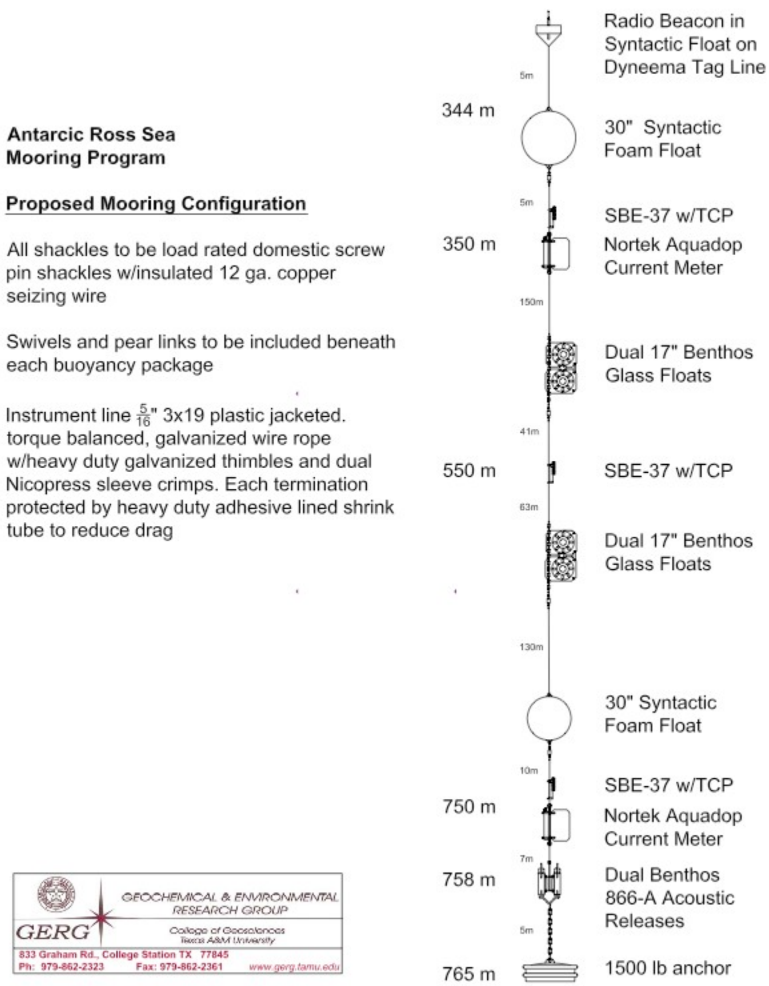


Figure 1: Schematic of mooring design.

During the 09/10 Antarctic field season a team from TAMU sailed on the Swedish Oden icebreaker and deployed the two ERS moorings, one near the mouth of the Little America Trough and the other farther inshore along its eastern flank (Figure 2). The final location of each mooring was established using the ship GPS position when the anchor weight was slipped at the end of the deployment. Because winch failures prevented the occupation of CTD stations, only a handful of XCTD launches were done within a mile of each mooring site.

Buoy expert James Ryder from WHOI met with a team of assistants well ahead of time to go over a detailed procedure to be followed during the mooring recoveries on the N.B. Palmer. Recovery of both ESR moorings took place on 20 March 2011 (Table 1, Figure 2). Prior to that the ship had first arrived at the mooring A location, communication to the acoustic released was established and after a few hours of ranging from different locations the final mooring position was determined to be about a mile off from that determined during its deployment the previous year. After several unsuccessful attempts to range the releases under worsening seas it was decided to cancel operations until the next morning. Five CTD stations (67-71) were occupied along a short section of the eastern flank of the LAT during the night hours, and then the boat proceeded to the second mooring B site. Here again communication with both releases was also established but only to get inconsistent ranges and the exact mooring location was not determined at that time. It was decided to wait until the seas calmed down before attempting any mooring recovery.

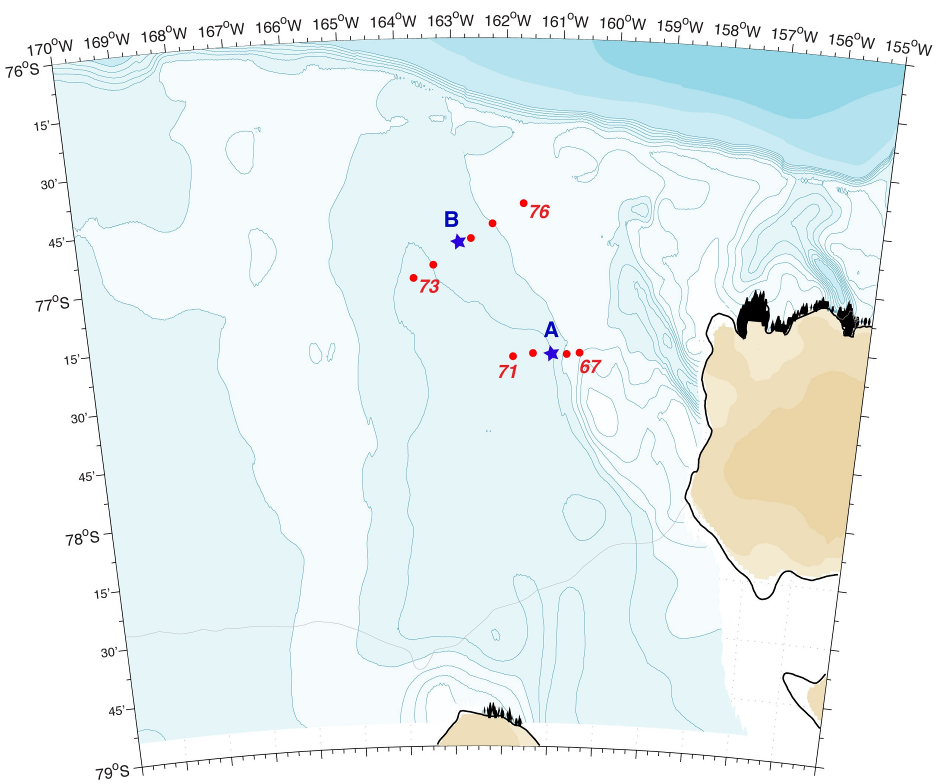


Figure 2: Locations of the two ERS moorings and complementary CTD stations across

the eastern flank of the Little America Trough.

On the morning of March 20, 2011 the ship was once again on location at mooring A. The releases were enabled, interrogated and released without any difficulties. The floats were spotted about twelve minutes later. Seas and ice conditions made the full mooring recovery challenging at times, but it was eventually loaded on the ship about an hour and a half later. All instrumentation was recovered in good conditions, except for two Benthos yellow hard-hat floats that were lost during the handling of a temporary wire entanglement. No appreciable fouling was observed on any of the instruments. About four hours later the ship had located mooring B, enabled and interrogated the releases, and immediately after the releases were triggered. The freed mooring was easily spotted and all of the instruments were brought on board in less than two hours.

With the exception of the top Aquadopp current meter on mooring B whose batteries stopped on 16 September 2010, one hundred percentage of data recovery was achieved from the remaining of the instruments.

Mooring	Location	Location	Longitude	Date	Water Depth
A	Mid Little America Trough	-77.312	-161.067	20 Mar 11	640 m
B	Outer Little America Trough	-76.920	-163.283	20 Mar 11	587 m

Table 1: Mooring locations.

Five CTD stations (72-76) were occupied spanning mooring B, before the ship headed toward the next CLIVAR S4P line along 170°W. A total of sixty nine XBTs were launched along this transit at spacing varying from 5 miles to ten miles. XBT probes were provided by TAMU and RPSC.

Yuan Mooring Program

PI: Xiaojun Yuan of Woods Hole Oceanographic Institution

Janet Sprintall of Scripps Institution Oceanography

Technician: Jim Ryder of WHOI

Deployment Operation

LDEO ADP Profiler Mooring

NSF ANT-1043669

Prior to deployment, the RVIB N.B. Palmer did a set and drift at the desired anchor position. The Palmer was then positioned now 7 n miles to the north of the anchor over position. A general walk through of the deployment procedures took place on the aft deck. The personnel included were: The deck leader, 2 ea ship's MT's, TSE winch operator, stopper line operator, hydraulic tugger operator, A-frame operator, and a mooring log person.

The 45 inch syntactic sphere was positioned under the a-frame. Shackled to the bottom of the sphere was the 0.5 meter shot of chain, microcat, 1.6 meter shot of chain, and the aqua-dopp current meter. The top of the 85.1 meter shot of ¼ inch wire rope was reeved through the Gifford block and shackled to the bottom of the aquadopp cage. The TSE winch paid out roughly 20 meters of wire rope and two SBE-39's were attached to the markings on the wire rope. The hydraulic tugger was shacked to a west coast release. The quick release was attached to the bottom of the stainless bridle of the 45 inch sphere. The hydraulic tugger raised the sphere off the deck while the a-frame boomed out. The instruments below the sphere were lowered by hand over the stern. When the sphere was in the water the quick release was tripped. The a-frame was boomed in and the west coast release was removed. The tugger was shackled to the Gifford block and was raised about 5 feet of the deck. The winch paid out slowly to attach the seven remaining instruments on the 85.1 meter shot. A stopper line was snapped into the 5/8" pear link at the bottom of the 85.1 meter shot. The Gifford block was lowered and removed from the tugger. The 41 inch steel sphere was positioned under the a-frame. The bottom of the 85.1 shot was shackled to the 1 meter ½ inch chain on top of the sphere. The west coast release was shackled back to the hydraulic tugger. The quick release was attached to the bottom of the sphere. The top of the 1008 meter shot was reeved through the Gifford block and shackled to the 1 meter shot of ½ inch chain. The hydraulic tugger took up the slack of the wire and the stopper line was removed. The tugger raised the sphere off the deck while the a-frame boomed out. The TSE winch paid out the wire while the frame was being boomed out. When the sphere was in the water the quick release was tripped. The a-frame was boomed back in and the quick release was removed. The Gifford block was shackled back to the tugger winch and raised off the deck about 5 feet.

The TSE winch paid out the 1008 meter shot and near the end of the 1008 shot the winch stopped paying out. The Gifford block was lowered to the deck. The MMP was attached to the wire. A 150 foot 3/8” slipped line was rigged to the MMP and to the Gifford block. The Gifford block was raised with the tugger winch and the MMP was slipped into the water. The 3/8” vls line was cleared and removed from the Gifford block.

The 500 meter ¼” wire was paid out, at the bottom of that shot the mooring was stopped off to add 8 each Benthos glass balls. The glass balls were slipped out over the stern. With one glass ball still on deck the stopper line was attached to the bottom of the chain and made fast to a deck cleat. The next 500 meter shot was shackled to the bottom of the shot of the ½ inch chain. The TSE winch took up the slack and the stopper line was eased off and removed. The remaining of the mooring was paid out in the same manner until all the wire rope was paid out from the winch. The mooring was stopped off and the Gifford block was removed.

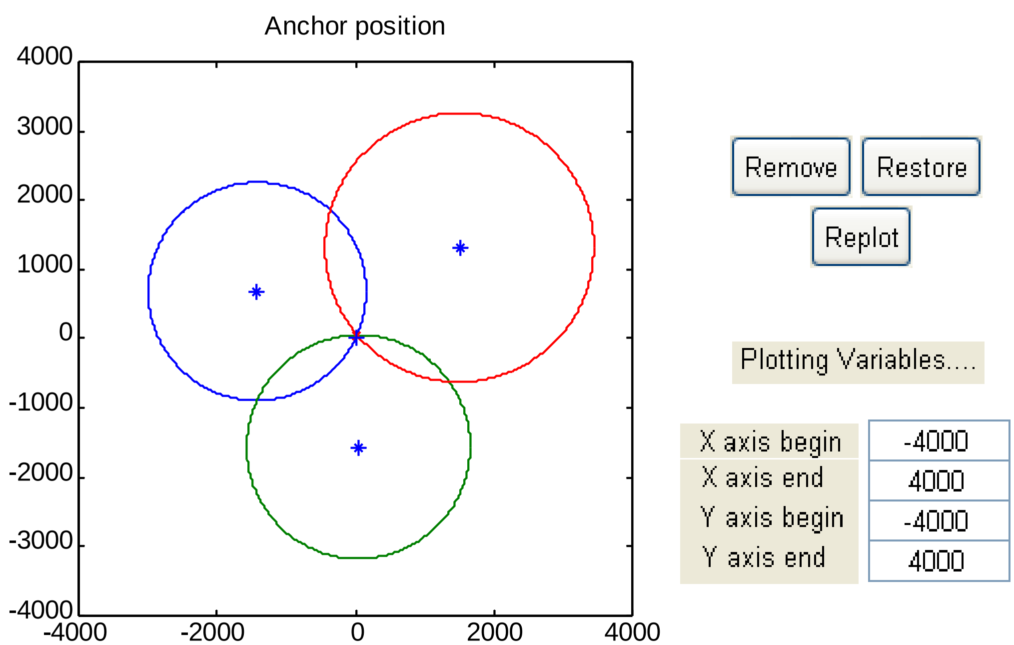
The next step was the deployment of 22 each glass balls. The wire rope was shackled to the top of the ½” chain. A string 8 glass balls were shackled together. The bottom of the shot of chain was connected to the winch leader and took up the slack. The two stopper lines were eased off and cleared. The winch paid out the glass balls slowly. With one glass ball remaining on deck, the winch was stopped and another set of 8 glass balls was shackled together. The stopper line was attached to the bottom of the chain and then took up the slack. The winch leader was eased off and removed. The stopper line eased out the glass balls. This was the procedure for deploying the glass balls. The 5 meter shot of ½” chain was shackled into the last section of glass balls and stopped off with roughly 1 meter of chain remaining on deck.

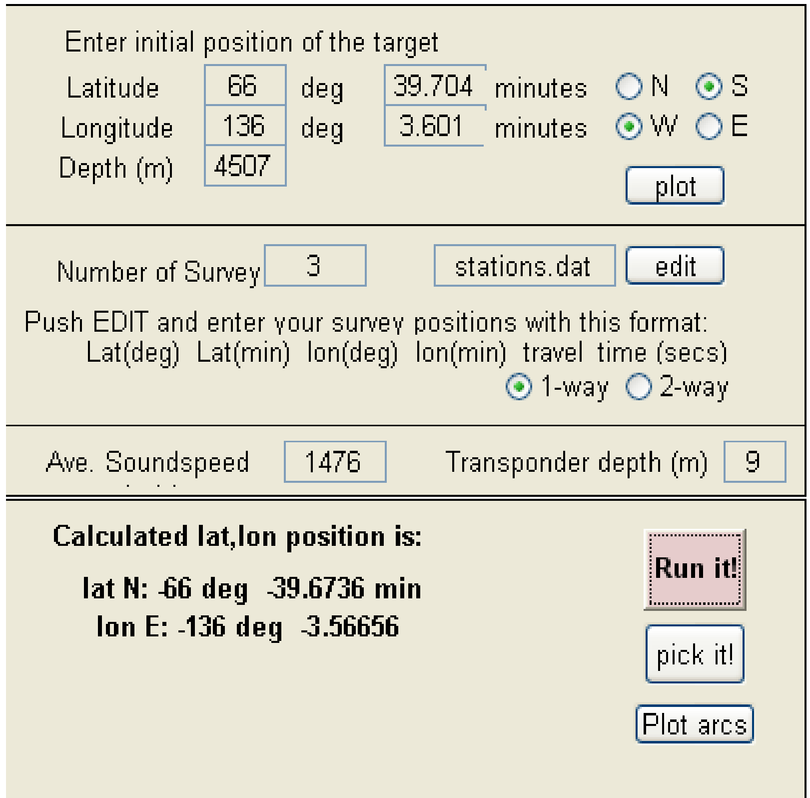
At this point, the ship was still approximately 1.2 nm from the target drop position. The ship towed the mooring toward the drop position in this configuration. Approximately 0.5 nm from the site, the final sections of the mooring were prepared. The tandem-mounted acoustic releases were shackled into the mooring chain at the transom. Another 5-meter shot of chain was attached to the bottom link on the dual release chain. A 70 foot ¾” nystron slip line placed through the 5/8” link which was shackled to the 20 meter shot of 7/8” plaited nylon. The two ends of the slip line were bowline to the winch leader. The slip line and the 20 meter shot of nylon was wound on the winch. The 5 meter ½” chain from the releases was shackled to the 20 meter shot of nylon.

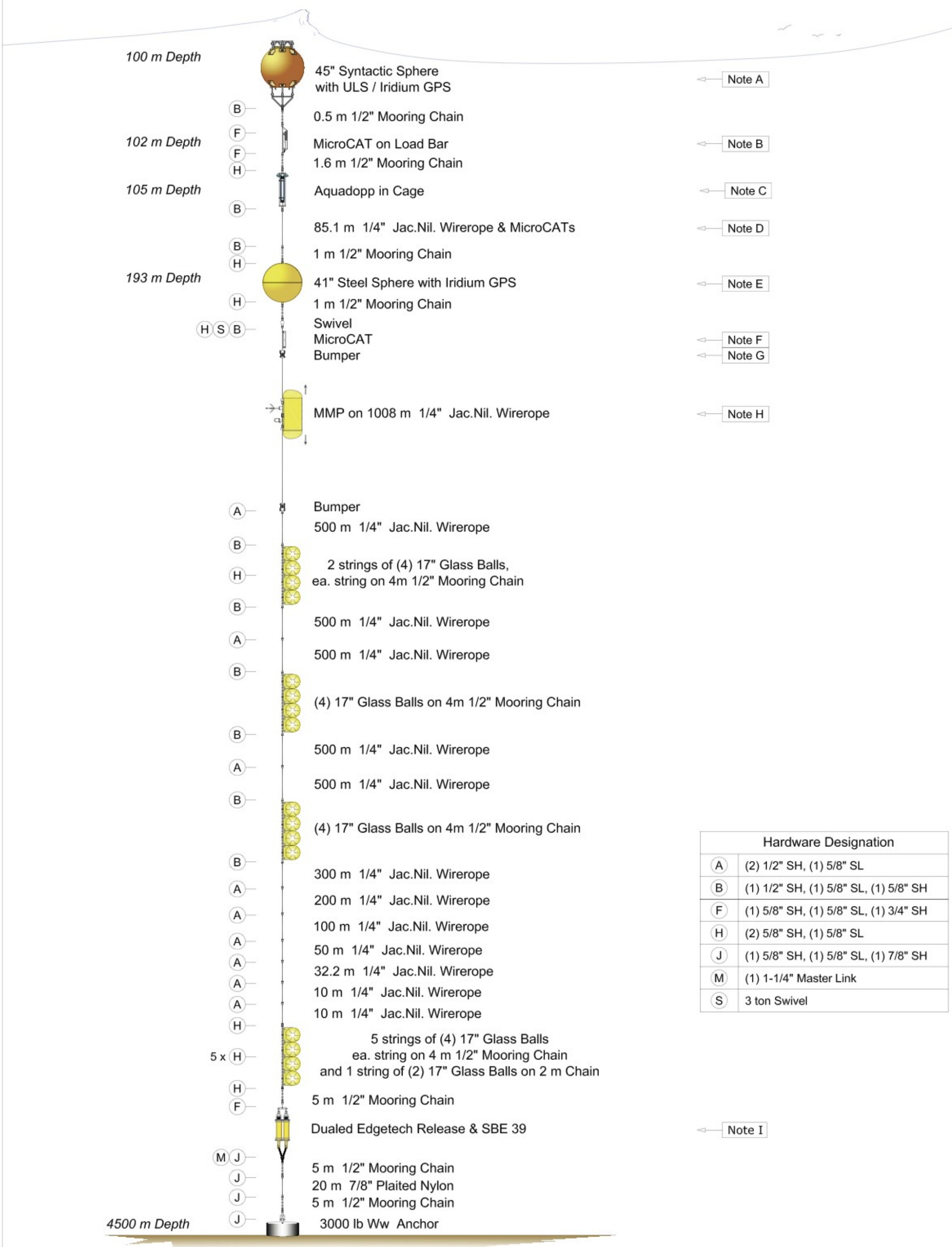
The west coast release was shackled into the hydraulic tugger and hooked into the chain just below the acoustic releases. The tugger was raised lifting the releases off the deck. The tugger paid out and the A-frame was boomed out until the releases were clear of the transom. The working line was lowered and the quick release was tripped. The winch continued to pay out until the end of the 20-meter nylon was near the transom.

The anchor was then positioned center line under the a-frame. The anchor was rigged with a 5-meter shot of ½" chain. The 5 meter shot was shackled to the end of the 20 meter shot of nylon. The quick release now shackled to the ship's trawl winch and hooked into the anchor. With 100 meters to go to the drop site, the trawl winch lifted the anchor off the deck while the a-frame boomed out. Once the anchor was clear of the transom the trawl winch was paid out until the anchor was in the water. Once in position, the line on the quick release was made fast to the deck cleat and the trawl wire paid out tripping the quick release.

The below figures are the anchor survey, anchor position of the mooring, and also the mooring drawing.




Enter initial position of the target
Latitude
66
deg
39.704
minutes
N
S
Longitude
136
deg
3.601
minutes
W
E
Depth (m)
4507
plot
Number of Survey
3
stations.dat
edit
Push EDIT and enter your survey positions with this format:
Lat(deg) Lat(min) lon(deg) lon(min) travel time (secs)
1-way
2-way
Ave. Soundspeed
1476
Transponder depth (m)
9
Calculated lat,lon position is:
lat N: -66 deg -39.6736 min
lon E: -136 deg -3.56656
Run it!
pick it!
Plot arcs



Hardware Designation	
A	(2) 1/2" SH, (1) 5/8" SL
B	(1) 1/2" SH, (1) 5/8" SL, (1) 5/8" SH
F	(1) 5/8" SH, (1) 5/8" SL, (1) 3/4" SH
H	(2) 5/8" SH, (1) 5/8" SL
J	(1) 5/8" SH, (1) 5/8" SL, (1) 7/8" SH
M	(1) 1-1/4" Master Link
S	3 ton Swivel

Lamont Doherty Antarctica Profiler Mooring, Final Version
Sheet 1 of 2

Woods Hole Oceanographic Institution
designed by John Kemp, drawn by Betsey Doherty
file: LDEO Antarctic Prof Final | date: 01/28/11

Report of activities of Juan Botella, PolarTREC teacher, aboard the N.B. Palmer during the CLIVAR & Carbon S4P cruise.

My job during the cruise was to produce outreach materials about the activities that took place on the ship, and help out with the sampling of the rosette.

I kept an online journal in English and Spanish for the general community. PolarTREC assisted by posting the texts and images that I sent through e-mail. I wrote a journal entry for every day save two or three. The topics covered ranged from science, life aboard the ship, and recent events on the expedition. A big component of the journal was devoted to answering questions received from the general audience. I received a lot of questions from students from pre-k to grad school level. The address for the journal is http://www.polartrec.com/expeditions/seawater-property-changes-in-the-southern-ocean

I delivered five live presentations on different forums. Dr. Jim Swift participated in two of the presentations. PolarTREC setup an Internet system in which anyone with an Internet connections could participate in the virtual live presentations, called PolarConnect. I sent the slides to PolarTREC ahead of time and then delivered the presentation through the iridium phone. Two of the presentations where hosted at the Madison Children's Museum; one at the Monona Grove High School, in Monona, WI; one by PolarTREC's CISE course; and one hosted by PolarTREC opened to a general audience.

I created several videos showing important aspects of the scientific activities. Among these videos, there is a description of the procedure for obtaining and partially analyzing hydrographic samples. Another video shows the recovery of oceanographic moorings, and another one describes the CLIVAR trace metals program. I also made video-recordings of interviews to scientists on board and other smaller events.

I have generated a few lesson plans based on the activities on board the Palmer, and are collaborating with another teacher on elaborating another lesson plan.

I also participated on the sampling for Carbon -14 during some of the stations.

I would like to thank Dr. Jim Swift, from Scripps Institution of Oceanography, as well as the PolarTREC program of Arctic Research Consortium of the United States (ARCUS) for selecting me to participate in this project.

Students at Sea

The NSF physical oceanography grant for the US Global Ocean Carbon and Repeat Hydrography Program supports participation of physical oceanography and CFC students on program cruises. Below are statements from the student participants on S04P (NBP-1102).

Jesse Anderson (University of Washington)

When I first told people that I was headed to the Southern Ocean for 60-70 days to participate in my first oceanographic research cruise, many responded that I was "nuts". While the days onboard were, as warned, often monotonous, participating in the CLIVAR S4P cruise has been the highlight of my graduate studies so far. Everyone on the Nathaniel B. Palmer, the science party, Raytheon employees, and ECO crew, has been fantastic to work with and learn from.

My current research examines near-surface processes in the tropical western Pacific from autonomous profiling floats, so the mission of the S4P cruise was a great contrast to my normal area of research. It was nice to finally get out from behind my computer and experience firsthand all of the hard work that goes into collecting such a high-quality data set as well as making sure an ambitious science plan gets completed despite the weather. While unfortunately I was not able to deploy my first "Argo" float, I enjoyed assisting with preparing the rosette for launch, running the CTD console, and collecting water samples for analysis. Through both this hands-on work and impromptu discussions in the dry lab, I greatly enhanced my knowledge of observational oceanography techniques, instrumentation, as well as Southern Ocean processes. This cruise was also a great opportunity to expand my general knowledge of chemical and biological processes. I would strongly recommend that all graduate students go to sea at least once during their studies and I hope I can participate in another cruise soon.

Sam Billheimer (Scripps Institution of Oceanography)

A lot of thought and hard work goes into observing the ocean. It's been great to learn about the water column structure and dynamics of the Southern Ocean by watching real-time profiles, pointing out water masses, and watching these water masses change form with latitude and longitude, but the most revealing part of this sea-going experience has been observing the execution of the necessary planning, and particularly re-planning, that goes into the making of a hydrographic section. Resources (including time) are finite at sea, where one is completely independent and isolated, so a good plan is necessary. With hang-ups like weather looming, it's important to be aware of the scientific priorities and intended use of the hydrographic section in order to redraft the plan in a way that is oceanographically appropriate. Watching the weather eat away at the allotted time for this cruise, it was revealing to listen and contribute to discussions about how to save time by skipping pieces of sections or increasing station spacing. These conversations effectively point out the cruise's scientific goals by explaining what regions are priorities and why. Sea-going also makes it easy to appreciate the amount of work that goes into a section. The method is inherently aggressive, steaming out to the desired positions and physically drawing water samples or leaving behind moored instruments for later recovery. This imparts a better understanding of the true, massive scale of the ocean, and in turn the scale of the work that goes into observing it. Living and working together on a research vessel revolves around getting the job done, but it can also be a lot of fun. The most exciting parts of the cruise were the continental approaches. Powering through the ice provided some excellent wildlife viewing and spectacular scenery. I never knew there were so many forms of sea ice. Also, stomping around in McMurdo was pretty awesome. I'm glad I got the chance to catch a glimpse of what life is like on an Antarctic base.

Eric Mortenson (Florida State University)

I am a second year physical oceanography graduate student, and before this cruise I had never been on an extended oceanographic cruise. I first heard about the CLIVAR-S04P cruise from my advisor Dr. Kevin Speer, who recommended my participation to the chief scientist, Dr. Jim Swift. In total, there were four physical oceanography graduate students who were invited to join. Our jobs were essentially the same, two of us on the noon to midnight shift and the other pair on the midnight to noon shift. We were responsible for manning the CTD station and monitoring the rosette/CTD assembly as it was lowered to within 10 meters of the sea floor and brought back to the surface, all of which could take several hours on an average cast. Once a given cast was back on board, we split the work of extracting salt and nutrient samples and working as 'sample cop', the latter title entailed making sure that all the samples were taken correctly and in the correct order. Occasionally, XBTs were used to obtain higher resolution temperature data without stopping the ship. In addition to these responsibilities, there were random jobs around the ship, for example, helping with mooring deployment and recovery, assisting with other sample collections, or just lending an extra hand when needed. This is a repeat hydrography cruise, and as I mentioned, for me the first extended oceanographic cruise experience, which has given me a chance to see in person how this type of cruise is operated. It has also given me the chance to work with talented oceanographers who have been more than willing to take time to answer any questions I have had concerning the science that this cruise is based on or oceanography in general. I would like to thank both my advisor and the chief scientist for providing me with the chance to participate on this cruise, as well as everyone on board for helping make this a rewarding and enjoyable experience.

Stuart Pierce (Texas A&M University)

As a green physical oceanography student brought along to aid in CTD and sampling operations, the S04P CLIVAR research cruise has presented me with a vast and opportune learning experience for operational oceanography at sea. Regarding myself, I've particularly discovered that I am capable of a longer cruise experience, I find the hours and schedules tolerable, and while not a requirement, it is to my advantage that I don't get sea-sick. My introduction to the logistics of operating a large scale research cruise and collecting large amounts of data have now probably forever spoiled me; since this specific voyage has appeared, from my observations, to have been very successful. The few mishaps that we have encountered have proven to be little to no detriment and only minor inconveniences, owing to superb flexibility and seemingly Zen-like qualities of the ones most affected. I am convinced that I am among some of the best in this field and that this has been the best introduction to operational oceanography that I could have asked for and am glad to have participated.

Most importantly, my oceanography ideals have changed for the better. Previous to this cruise, I was incredulous towards the reported precision of density measurements obtained from captured oceanographic water samples and sensitive electronic sensors and believed that numbers reported were only applicable to general assessments of ocean structure; any fine scale analyses were simply extrapolations. Distinguishing water masses by mere hundredths of a kg/m3 defied, what I believed, were the limits from which information could be extracted with certainty. I easily imagined errors that might arise from human error, lack of confidence in instrumentation or sampling equipment, or from lack of control of environmental variables resulting in noise (electronic or otherwise) preventing confidence to the degree often reported in observations. However, after my participation on this cruise and seeing for myself the care given to data collection along with discussions concerning precisions, accuracy, and confidence of instrumentation, I now believe the solidarity of the measurements that I was previously skeptical of; that alone is worth the 65 days spent at sea.

Mingxi Yang (University of Hawaii)

Even though I had just graduated with a PhD in oceanography prior to the CLIVAR S4P, being able to participate on this cruise has been an invaluable educational experience. I had been a teaching assistant for an introductory oceanography class, where we examined data sets from previous CLIVAR as well as WOCE cruises. On the Ocean Atlas program, each station appeared like a dot and each profile a string of numbers. As the CFC student on this cruise, I sampled approximately half of the casts and analyzed about a third of the samples, which gave me new appreciation for the difficulty and hard worked involved in obtaining quality data in these kinds of repeat hydrography cruises. While sampling and analysis themselves could at times be laborious and repetitive, I was given a side project to intercompare CFC and SF6 measurements between CTD samples and samples taken from the ship's uncontaminated underway seawater line. I also measured atmospheric concentrations of CFCs and SF6 and computed their surface saturation values - a familiar exercise for me because I partly focused on air-sea gas exchange for my PhD. This side project was helpful in maintaining my focus and scientific interest. Overall, I learned a lot of about the physical oceanography in the Southern Ocean. The trace metal chemists and biologists on boarded provided additional insights also in their discipline. Perhaps most importantly, I was very impressed by how the chief scientists improvised cruise plans when weather became unfavorable, and were able to keep different groups together working as a team. These leadership qualities are what I will need to master if I were to lead my own lab one day.

Sarah Eggleston (university of Hawaii)

Sarah was directly supported by the CFC grant. She wrote:

When I was given the opportunity to join the S4P CLIVAR cruise on January 11, 2011, I didn't even know how to decide whether to take the opportunity or not. Knowing what I know now, I'm not sure that I would have taken it, as I've learned that I am somewhat prone to seasickness, and I've also learned just how difficult it is to put life on hold for three months while living at sea. But I know now that I made the right decision, as I have learned infinitely more at sea about science and, at the risk of sounding cliché, about myself, than I ever have during three months on land. The many opportunities to speak with professors, technicians, and other graduate students from around the country gave me a chance to learn about possible career paths and to get advice on writing my master's thesis. I had the chance to learn not only about measuring trace gases at sea by collecting and analyzing samples for CFCs and SF6 every day for over fifty days, but I also got to learn from others about a variety of sampling procedures, from using data from the ADCP to filtering biological samples. The educational aspect of this cruise was incredibly valuable, but even more important to me is that I felt completely at home with the other sixty-five people on the ship, who I now consider to be extended family. The first time I experienced seasickness, six days into a cruise that would last over sixty days, I felt like the cruise would never end. Now, as we prepare to disembark, I wish the cruise would never end.

CCHDO Data Processing Notes

Date	Person	Data Type	Action	Summary
2011-04-25	*Kristin Sandborn*	BTL/CTD/SUM	Submitted	Exchange format; to go online