Hydrographic Properties of the Ross Sea Continental Shelf during November-December, 2006

NBP0608 – CORSACS II

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Controls on Ross Sea Algal Community Structure

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1. Introduction

The Controls on Ross Sea Algal Community Structure (CORSACS) project is an inter-disciplinary study of the interactive effects of Fe, light, and CO_2 on phytoplankton community dynamics in the Ross Sea, Antarctica. The main objective in this proposed research is to investigate the relative importance and potential interactive effects of iron, light, and CO_2 levels in structuring algal assemblages and growth rates in the Ross Sea. The field program is designed to test the hypothesis that the interaction of these three variables largely determines the bottom-up control on two dominant Southern Ocean phytoplankton taxa, diatoms and *Phaeocystis*. Grazing and other loss processes are also important variables controlling the relative dominance of these two taxa; however, the CORSACS project primarily focuses on the bottom-up control mechanisms. It is important to understand such environmentally-driven taxonomic shifts in primary production, since they are expected to impact the fixation and export of carbon and nutrients, and the production of DMS, thus potentially providing both positive and negative feedbacks on climate.

Reported here are Conductivity, Temperature, Depth (CTD), C system, oxygen, and nutrient data from the CORSACS NBP0608 cruise, which were collected aboard the Research Vessel Ice Breaker *(RVIB) Nathaniel B. Palmer* between November 1 and December 15, 2006.

2. Cruise Narrative

The *RVIB Nathaniel B. Palmer* departed Lyttleton, New Zealand at November 1, 2006 and arrived at station #001 on November 8, 2006 at 00:51 UTC. There, a hydrographic cast was conducted to 1000 m to test the integrity of the CTD system and to collect samples from the water column during the beginning of the sea ice sampling transect. No problems were detected during the overall operation of the CTD and bottle firing. The cruise track proceeded into the Ross Sea polynya where a total of 74 hydrographic stations were occupied through December 6, 2006. At various times during the cruise, stations were occupied along 76° 30' S and along the Ross Ice Shelf to provide data for comparison with historical data collected along the same lines. With the exception of those minimal sampling requirements, station locations were selected based on the desire to provide the best possible synoptic survey of the region, consistent with objectives of sampling water with specified levels of Fe and/or CO_2, the prevailing ice conditions, and delays resulting from refueling or resupply requirements from McMurdo. The locations of all the CORSACS hydrographic stations are shown in Figure 1 and listed in Table 1.

3. Sampling

The *RVIB Nathaniel B. Palmer* is equipped with a SeaBird Electronics Model SBE-911*plus* conductivity, temperature, and depth instrument, which is mounted on a SeaBird, epoxy coated 24-bottle rosette sampler. The sampler is equipped with a SeaBird pylon and 10-liter Bullister bottles. Data from dual temperature, dual conductivity, pressure, oxygen, and other instruments as listed in Table 1 were transmitted in real-time to the SBE- 11 deck unit via conducting cable. Onboard, the data were recorded digitally on a Windows computer running SBE Seasave software (version 5.37d).

Prior to the start of each hydrocast, the CTD was lowered to a depth of 10 m to allow time for the CTD pumps to activate and the sensors to equilibrate. During this washing period, the differences between the primary and secondary readings of the temperature and conductivity were monitored as well as dissolved O_2 levels.

TABLE 1. NBP0608 CTD Sensors

Sensor	Description	Serial #	PreCruise Calibration Date	PostCruise Calibration Date	Comments
CTD Fish	SeaBird model SBE 9+	09P7536-0328	04/18/05		Installed 12/12/05
CTD Fish Pressure	Paroscientific model 410K-105 pressure sensor	53980	04/18/05		Installed 12/12/05
CTD Deck Unit	SeaBird model SBE 11+	11P19858-0490	n/a		
Primary T Sensor	SeaBird model 3-02/F	031238	2/27/06	1/25/07	Installed 11/1/06
Secondary T Sensor	SeaBird model 3-02/F	032186	2/27/06	1/25/07	Installed 11/1/06
Primary C Sensor	SeaBird model 4-02/0	040924	3/10/06	1/25/07	Installed 11/1/06
Secondary C Sensor	SeaBird model 4-02/0	041314	3/10/06	1/25/07	Installed 11/1/06
Dissolved O_2 Sensor (Pri)	SeaBird model SBE43	430082	2/17/06	1/25/07	Installed 11/1/06
Dissolved O_2 Sensor (Sec)	SeaBird model SBE43	430139	2/18/06	2/26/07	Installed 11/1/06
PAR Sensor	Biospherical Instruments QSP-2300	4361	1/13/06	1/31/07	Installed 11/1/06
Fluorometer	Wetlabs	AFLT-009	7/12/06	1/30/07	Installed 11/1/06
Transmiss.	WET Labs C-Star	CST-892DR	10/12/05		Installed 11/1/06
CTD Pump (Primary)	SeaBird 5T, PN 90160	051645 3.0K	1/10/04		Installed 11/1/06
CTD Pump (Secondary)	SeaBird 5T, PN 90160	051646 3.0K	1/10/04		Installed 11/1/06
Bottom Cont. Switch	SeaBird	#1	n/a		Installed 11/1/06
Altimeter	OIS 6000 (6000m)	5118	n/a		Installed 11/1/06
Carousel Water Sampler	SeaBird SBE-32	3211265-0066	n/a		Rebuilt: 10/10/06
ISUS	037				Installed 11/1/06
FRRF					Installed 11/1/06

Once stability was achieved, the CTD was brought back to the surface in preparation for the hydrocast. During all hydrocasts, the CTD was lowered at a rate of 30 m min^{-1} through the upper water column (usually 150 m) and then at 50 m min^{-1} at greater depths. The distance between the sensor package and the bottom was determined using a Datasonics pinger. A mechanical safety switch notified the CTD operator when the package had reached a distance of 3 to 5 m from the bottom. We reached the seabed on about half of the hydrocasts conducted during NBP0608. The remaining casts focused on sampling the uppermost, biologically active portion of the water column. Ten-liter Bullister bottles were tripped at selected depths on the upcast to provide in situ sampling of chemical, biological, and physical properties of the water column as well as to provide calibration data for the CTD. Once the CTD was back onboard, the temperature, conductivity, and dissolved oxygen sensors were flushed with deionized water and covered with rubber boots to minimize instrument fouling between casts.

Water samples were drawn in accord with Joint Global Ocean Flux Study (JGOFS) protocols [SCOR, 1994] with gas samples being drawn first, followed by salinity and nutrient samples and samples for biological measurements and experiments. Dissolved oxygen samples were drawn first from the Bullister bottles into calibrated 125 ml Erlenmeyer flasks. Following World Ocean Circulation Experiment (WOCE) guidelines [Culberson, 1991], O_2 flasks were rinsed three times and then slowly filled to overflowing. The samples were pickled immediately by adding 1 ml of $MnCI_2$ and 1 ml of NaOH/NaI. The stoppers were carefully inserted to ensure that no air bubbles were trapped beneath the stopper and the flasks were shaken to mix the reagents throughout the samples. To ensure that the samples were properly preserved, the samples were shaken a second time after 20 to 60 minutes. Samples were held in dark storage at 2°C prior to titration and were normally analyzed within 24 to 36 hours of their collection. Draw temperatures for all samples collected during the CORSACS cruise were in the temperature range -2°C to +2°C. For a nominal draw temperature of 0°C, the DO values reported here (units of ml l^{-1}) can be converted to DO with units of µmol kg^{-1} by using the conversion factor 0.04344 µmol kg^{-1} per ml l^{-1} of DO [Culberson, 1991].

Salinity samples were drawn from the Bullister bottles into 200 ml Borosilicate glass bottles equipped with plastic thimbles and Nalgene caps. The samples were equilibrated to room temperature for 24-72 hours before processing. Nutrient samples were drawn from Bullister bottles and filtered (5µm Acrodisc 32) into 30 ml polycarbonate bottles and were typically analyzed right after the hydrographic cast. Nutrient samples that could not be analyzed immediately were refrigerated in dark storage to minimize their degradation.

ΣCO_2 samples were collected into 250 ml glass BOD bottles with flared necks and ground glass stoppers by rinsing 3 times and then filling slowly to overflowing to avoid bubbling. All samples were poisoned with 50 µl of saturated $HgCl_2$ solution immediately after recovery. Samples were allowed to warm to room temperature before analysis, typically within 6 hours of the hydrocast.

pH samples were taken directly into 30 ml quartz glass 10 cm path length spectrophotometer cells by rinsing three times, then filling slowly to overflowing. These were then immediately capped off and warmed in a water equilibrator bath prior to immediate colorimetric analysis of pH.

Alkalnity was determined by potentiometric tritration during this cruise. 500 ml samples were collected in Borosilicate glass bottle immediately following gas sampling of the rosette. 200 ml aliquots were analyzed using a semi-automated, water-jacketed and T controlled potentiometric tritrator. Detailed methods are written up separately by the Stanford Group.

4. Data Calibration and Processing

4.1 Discrete nutrient, dissolved oxygen, ΣCO_2, and salinity processing

Nutrient samples were analyzed on a Lachat Quickchem FIA+, series 8000, a bench-top instrument for automated analysis of NH_4+ (0.06-2.0 µM range), NO_3^- + NO_2^- (0.16-40 µM), SiO_2 (0.18-125 µM range), and PO_4^{+3}

(0.02-2.5 µM range). Analyses of all nutrients were performed following the chemical procedures as outlined in the WOCE/JGOFS protocols for automated nutrient analysis [Gordon et al., 2001; SCOR, 1994]. The analytical methods were modified for the Lachat Quickchem system. The nutrient measurements are thought to have a precision of ~±1% based on a comparison of identical samples. The accuracy of the nutrient measurements is believed to be of the same order.

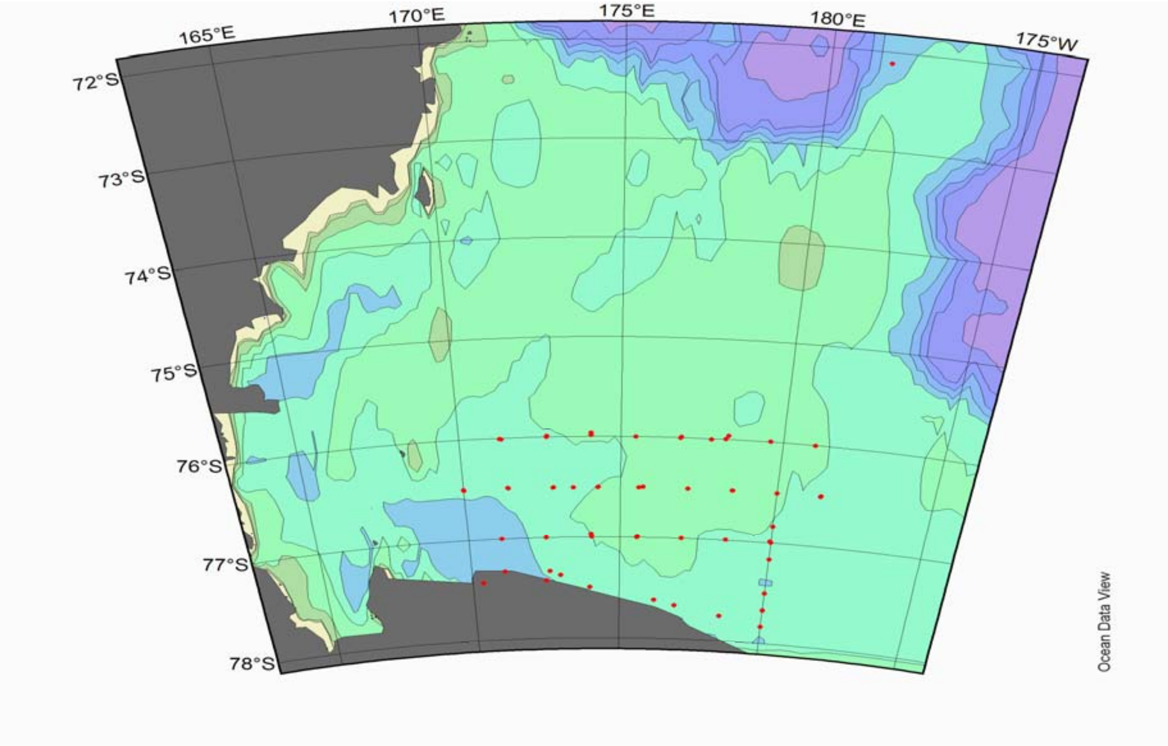

Figure 1. NBP0608 (CORSACS II) Cruise and CTD station map (stations 1-74).

Salinity samples during NBP0608 were analyzed using a Guildline 8400 Autosal four-electrode salinometer (S/N NSF 04504) aboard the RVIB *Nathaniel B. Palmer*. All samples were standardized against IAPSO standard seawater (batches P143 and P144) with a fresh standard bottle opened before and after each salinity run. The Autosal system on the *Nathaniel B Palmer* is housed in a temperature controlled environment kept at 23°C. Analyses were conducted at an instrument temperature of 24°C. The Autosal has an inherent accuracy of ±0.002 psu for 24 hours without restandardization and a maximum resolution of better than 0.0002 psu at 35 psu. The standard deviation of standard seawater is about 0.0004 psu [Mantyla, 1980; Takatsuki et al., 1991], which represents the fundamental limitation of the analysis.

Discrete dissolved oxygen (DO) measurements were made with a Lamont-Doherty Earth Observatory amperometric oxygen titrator titration system [Langdon, 2003; Culberson and Huang, 1987]. Based on standards and replicate samples run during NBP0608, the resulting DO estimates are believed to be accurate to about ±0.02 ml l^{-1}. Precision is operator dependent, but is likely of the same magnitude.

Samples for ΣCO_2 analysis were collected in 250 ml BOD bottles and poisoned with 50 µl saturated $HgCl_2$ solution immediately after drawing, in accordance with JGOFS protocols (Dickson and Goyet 1994). Samples were allowed to warm to room temperature (~20^{o}C) prior to analysis which was typically performed within 3-12 hours of water collection. ΣCO_2 was measured by infrared absorption analysis of CO_2 in a nitrogen carrier gas stream using an automated injection system connected to an infrared gas analyzer (LI-COR LI7000). The injection system consists of a high-precision digital pump, which delivers a precise volume of seawater to a small sparging tube. 0.1 ml of phosphoric acid (3 N) is added by a micro-pump and the sample is bubbled with ultrahigh purity nitrogen with an in-line CO_2 scrubber. This gas stream is passed through a nafion dryer as well as a magnesium perchlorate water trap, and then directed into the LI-COR infrared gas analyzer. Integrating the infrared absorbance signal with respect to time yields the total amount of CO_2 evolved from the sample. ΣCO_2 measurements were calibrated using certified reference materials (CRM's) ob-tained from Andrew Dickson at UCSD-SIO (http://andrew.ucsd.edu/co2qc). CRM's were run periodically as unknowns over the course of a run to constrain instrument drift. All unknowns were run in triplicate. Precision estimated on the basis of triplicate analysis of unknown seawater samples is ±1.2 µmol kg^{-1}.

High precision pH determinations were made following the spectrophotometric method described in SOP7 of Dickson and Goyet (1994). pH samples are drawn directly from the Bullister bottles into 30 ml spectrophotometer cells that are then sealed with rubber caps. The cells are placed in a temperature equilibrator and warmed to 25°C over a period of 30 to 45 minutes immediately following the collection of water samples. The cells are placed in a temperature controlled spectrophotometer 10-cm path length holder (Ocean Optics scanning UV-VIS-IR) and blank values are measured at 730, 578, 434 nm. 50 µl of 2.2 mmol kg^{-1} m-cresol purple dye are then injected into the cell through one of the end caps and the absorbances are remeasured. pH is calculated from the absorbances and a acid dissociation constants as described in Dickson and Goyet (1994). The method is described as having a precision of better than 0.001 pH units (1 std dev.). We found that our working precision, based on replicate analyses of Ross Sea water samples was ±0.002 pH units.

4.2 Temperature sensor calibration

SeaBird temperature sensors #1238 and #2186 were pre-cruise calibrated on 2/27/06. Both temperature sensors were post-cruise calibrated on 1/25/07. The pre- and post-cruise sensor calibration data provided by SeaBird Electronics are listed in Table 2. Sensor #1238 drifted towards recording slightly warmer values between pre- and post-cruise calibrations (by 0.0009°C) whereas sensor #2186 drifted towards recording very slightly cooler values between pre- and post-cruise calibrations (e.g., by -0.0005°C). The pre- and post-cruise calibrations were nearly one year apart and this amount of drift is within factory specification for these sensor heads. Post-cruise corrections will therefore shift the CTD-derived temperatures slightly on both sensors but the corrections are small to negligible (~0.0006°C for the primary sensor and ~0.0003°C for the secondary). The SBE data processing manual states that "SeaBird temperature sensors usually drift by changing offset, typically resulting in higher temperature readings over time for sensors with serial number less than 1050 and lower temperature readings over time for sensors with serial number greater than 1050. SeaBird's data indicates that the drift is smooth and uniform with time; users can make very accurate corrections based only on pre- and post-cruise laboratory calibrations. SeaBird temperature sensors rarely exhibit span errors > ±0.005°C over a range of -5 to +35 °C (0.005°C/(35-[-5])C/year = 0.000125 °C/C/year), even after years of drift. A span error that increases more than ±0.0002 °C/C/year may be a symptom of sensor malfunction." Since the CTD casts on NBP0608 were all accomplished closer to the date of the post-cruise calibration, I have chosen to use these calibration coefficients and an offset correction interpolated back in time from the post-cruise calibration date. The offset correction for sensor #1238 used this way is -0.00016°C for all casts. The offset correction for sensor #2299 used this way is +0.0001°C for all casts. The secondary sensor temperatures are used for the final data release.

The bias between the primary and secondary temperature sensors was estimated using temperature measurements collected at 1 m intervals (as described in the section on *Data Processing)* at water depths between 500 and 750 meters. The choice is somewhat arbitrary but 500 meters was chosen as the upper depth cutoff as it is well below the upper water column zone marked by significant variability in summer T and S. A depth of 750 meters was chosen for the lower depth cutoff as only a few stations from the westernmost Ross Sea had samples from greater depths and thus may have time-biased the comparison. Data used for this comparison came from stations 3 through 74. Based on this approach, the bias between the primary and secondary temperature sensors ($T_{primary}–T_{secondary}$) averages +0.0005°C with a standard deviation of 0.0002°C for 4,266 one-meter binned temperature measurements between 500 and 750 meters. There is no change in bias with time during the cruise. There is slight decrease in bias between the primary and secondary temperature sensors with depth, e.g., the average bias at 500 meters is ~0.00065°C, decreasing to ~0.0005°C at 750 meters. All of these values fall within the accuracy specification for SeaBird temperature sensors (±0.001°C).

4.3 Pressure sensor calibration

No corrections/adjustments were made for pressure parameters in the NBP0608 data set. The SeaBird pressure sensors have typically shown little drift during previous use on the *Nathaniel B Palmer*. In addition, no post-cruise calibration data was supplied for the pressure sensor. RPSC (Raytheon Polar Service Corporation) has adopted a practice of biennial calibration for their SBE Digiquartz pressure sensors. Therefore the next scheduled calibration for the sensor used for both NBP0601 and NBP0608 (Digiquartz SBE #53980) is in April, 2008. In addition to possible sensor drift, we note that the low average atmosphere pressure of the Ross Sea region in summer (~980 mbar) may introduce an offset in estimated pressure depth of up to 0.3 dbar. Again, until evidence of sensor drift is available from the April, 2008, calibration by SeaBird, no corrections for sensor drift or surface atmospheric pressure have been or will be applied to the released CTD data sets. Note that during post processing depth in meters is calculated based on density and pressure data. It is possible to reference all the data back to decibars if the user so desires.

4.4 Conductivity sensor calibration

SeaBird conductivity sensors #924 and #1314 were pre-cruise calibrated on 3/10/06 by SeaBird Electronics. Both sensors were post-cruise calibrated on 1/25/07. Both sensors exhibited changes in slope between the pre-cruise and post-cruise calibrations (321 days). In the case of the primary conductivity sensor (#924) this theoretically resulted in a drift towards recording slightly higher conductivities through the year between calibrations (average drift = 0.000086 S/m). For the secondary conductivity sensor (#1314) the drift between calibrations was towards very slightly lower conductivities (average drift = 0.0000264 S/m). Both of these drift rates are well below the factory specified drift limits of <0.0003 S/m/month for these sensors This kind of drift is typically corrected in post-processing by adjusting the calibration “slope” term rather than an offset value. The slope correction values given by SBE from the pre- and post-cruise calibrations are 1.0000948 for sensor #924 and 1.0000601 for sensor #1314. For post-processing, we initially used the pre-cruise conductivity calibration coefficients and interpolated “islope” values as described in SBE application note #31. The islope values used were 0.999922444 for sensor #924 and 0.99995083 for sensor #1314.

The secondary salinity sensor malfunctioned for short periods (30 to 180 seconds) several times during the first 6 hydrocasts, and rarely thereafter, most likely due to a cable connection issue. These intervals are excluded from further analysis and in fact, we recommend using the processed primary sensor-derived salinity data for all research involving physical and biochemical data from cruise NBP0608.

Initial post-cruise reprocessing of the CTD downcast data into 1 meter bins yielded salinities with a small bias between the primary and secondary conductivity sensors. This bias (given as calculated salinity, $S_{primary}$-$S_{secondary}$) for all bins for all stations (n = 36,887) averages -0.0029 psu with a standard deviation of 0.0056 psu. Most of the variability leading to this moderately high standard deviation is associated with significant haloclines in the uppermost water column at stations in the westernmost Ross Sea. The bias between the two conductivity sensors in downcast samples between 500 and 750 meters is similar, -0.0045 psu, but with a reduced standard deviation of 0.0018 psu (n = 4,264 one meter bins).

Post-processing of the upcast data using the same post-processing sensor corrections and post-processing procedures as used for downcast data was produced a bottle sheet summary that details the properties of the water sampled by each Bullister bottle for each CTD cast. During NBP0608, 635 discrete salinity samples were taken for analysis with the shipboard Guildline Autosal. These values are compared with the CTD bottle sheet salinities as a check on the reliability of the CTD salinity data.

When this was done, we observed that the offsets between the CTD-determined salinities and the Autosal salinities were minimized by using the primary sensor conductivity data processed with the pre-cruise calibration coefficients, *but with no islope correction term*. All subsequent data processing for this final data distribution, e.g., bottle sheets and downcast data was accomplished this way, e.g. using the primary conductivity sensor calibrated with the pre-cruise coefficients and no islope correction.

The clearest indication of how the bottle salinities measured on the shipboard salinometer compare with the CTD measured conductivities/salinities during the upcasts comes from samples collected in the deeper water column. In the uppermost water column, in the presence of significant salinity stratification, significant offsets can and do exist between measured bottle salinities and the CTD salinities. These result from differences in the water sampled by the Bullister bottles and that sampled by the CTD sensors, a function of sensor position on the CTD and the integration of salinities through a depth range sampled by the CTD sensor as well as the equilibration time of the conductivity sensors. In the water column below 200 meters, vertical gradients in salinity are relatively small allowing for a direct comparison of bottle and CTD-derived salinities. Between 200 and 750 meters, the average difference (and standard deviation) between discrete Autosal bottle salinity and CTD salinity (n = 124) for the primary conductivity sensor was 0.0006 psu (stdev = 0.0024 psu) and for the secondary conductivity sensor was 0.0006 psu (stdev = 0.0022 psu). The Autosal salinometer data is part of this data distribution should any user wish to make any further corrections in the future.

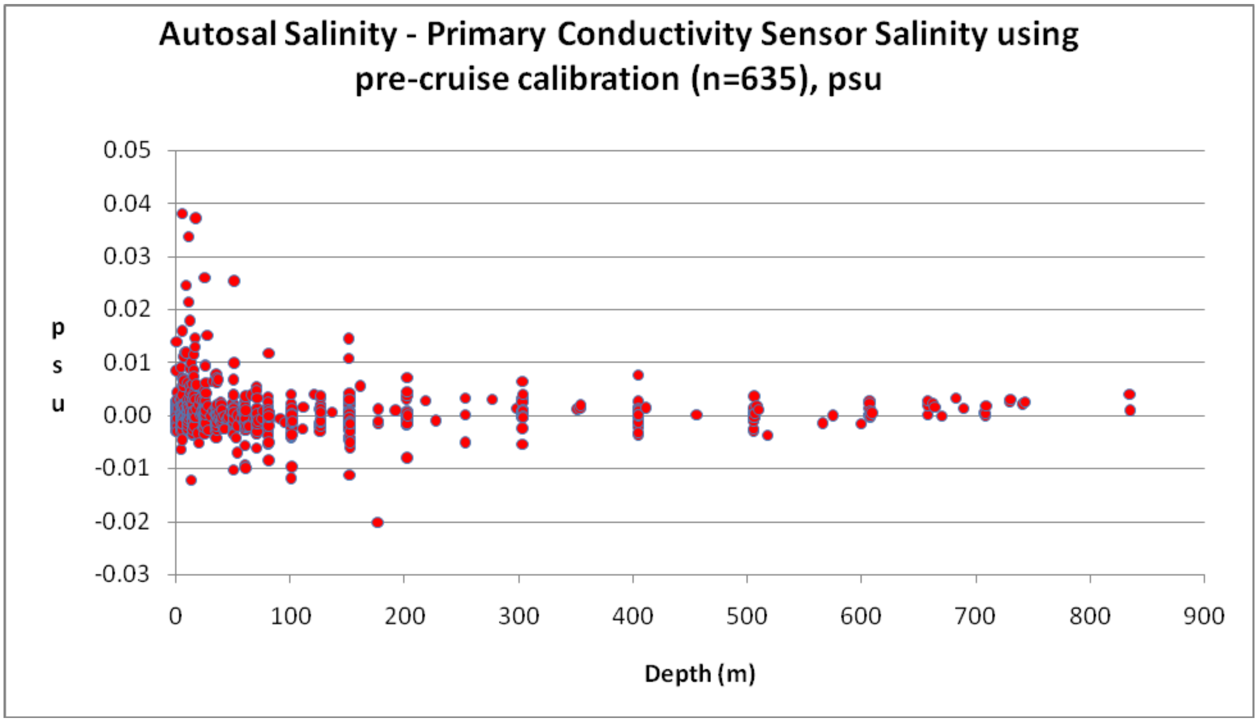

Figure 2. Difference between Autosal-derived salinity measurements and the salinity value determined from the primary CTD conductivity sensor using the precruise calibration factors with no i-slope correction.

The analysis presented here suggests that temperature and conductivity values have been corrected to a level of accuracy consistent with JGOFS standards of ±0.001°C for temperature and ±0.003 for salinity [SCOR, 1994]. The secondary sensor suite is used to derive all subsequent water column parameters. Only secondary sensor values are listed in the final concatenated bottle sheet files. For completeness, both primary and secondary sensor data is listed in the 1-meter downcast CTD data, but the secondary sensor data is considered closest to "true".

4.5 Dissolved oxygen sensor calibration

The primary DO sensor (SBE 43 #430082) was pre-cruise calibrated on 2/17/06 and post-cruise calibrated on 1/30/07 (Table 1). The secondary sensor (SBE 43 #430139) was pre-cruise calibrated on 2/18/06 and post-cruise calibrated on 2/26/07 (Table 1). These sensors are known to drift significantly with time. Moreover, sensor performance is strongly dependent on the direction and rate of flushing; thus, profiled downcast data and samples collected during the stops for water collection are likely to be different. To mitigate these effects, the DO sensor was calibrated *in-situ* using titrated DO measurements from the upcast. Typically, 3 or 4 depths (of the 12 depths typically sampled during each bottle cast) were analyzed for DO by amperometric titration for each cast and compared to the corresponding CTD-derived measurements from the upcast generated bottle sheets.

After initial CTD post-processing, the offset between the titrated Oxygen values and the SBE43-derived values was determined by examining the difference between data from CTD casts 1-74 and below 150 meters. The resulting analysis includes 123 paired titration/SBE dissolved oxygen values. The mean offset (and stdev) is 0.012 (0.057) ml l^{-1} with the SBE reading very slightly high. This corresponds to an offset in terms of percent of total oxygen concentration on the order of 0.25%, a difference that is likely due to the SBE 43 sensor being out of calibration with either the post-cruise or pre-cruise calibration parameters. I followed the protocol established in SBE Application Note 64-2 (2005) to recalibrate the sensor used during our casts with the real-time collected Winkler data. By this method, we consider Amperometric Winkler DO values from 123 Bullister Bottles collected from CTD casts 1-74. We then compare the original SBE 43 output voltages with a parameter defined as Winkler O_2/ϕ (Figure 3).The slope and intercept from a linear regression of these data pairs yields a cruise-specific calibration for the SBE 43 oxygen sensor used on our cruise as follows:

$\phi = e^{(tcor * T)} * O_2sat. * e^{(pcor*P)}$, where T = temperature and P = Pressure from CTD, and

$(DO\ (ml\ l^{-1}))/\phi = Soc * (V + V_{offset}) = M * V + B$, where Soc and V_{offset} are calibration

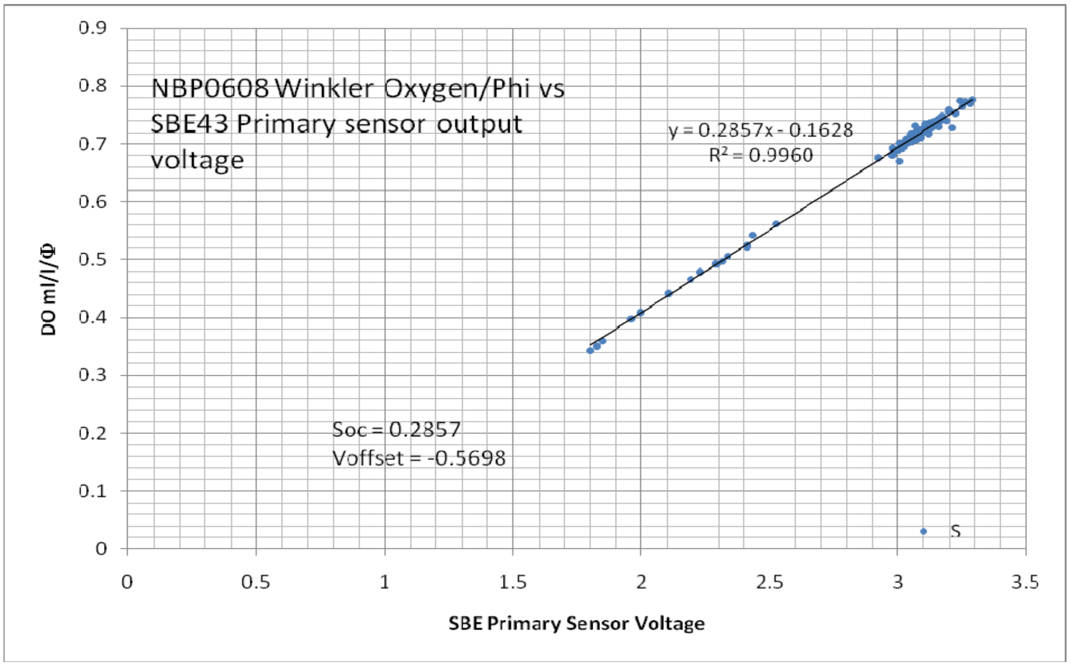

Figure 3. Plot of SBE 43 voltage (sensor #082) versus the ratio of amperometric Winkler DO values to phi (a pressure and temperature oxygen saturation term) used for deriving calibration coefficients for the CTD SBE sensor.

parameters derived from the regression described above. I chose to use Winkler data from all casts below 150 m for this recalibration exercise. By this method, values of Soc = 0.2857 and Voffset = -0.5698 are used for final post-processing of the CTD data for all casts. Data from the primary SBE#43 sensor was used for the final data tabulation. After final post-processing, the mean difference between the titrated and SBE43(primary)-derived oxygen values for 144 bottles sampled for DO below 100 m was 0.01 ml l^{-1} (standard deviation = 0.01 ml l^{-1}).

5. Data Profile Processing

Using the calibration coefficients and the corrections described above, the CTD profile data were processed using the SeaBird Electronics SeaSoft Software Package version 7.14c [SeaBird Electronics, 2004]. The final post-processing followed this sequence of commands: **datacnv, filter, alignctd, wildedit (2,10,12), wildedit (2,10,100), wildedit (2,10,50), celltm, loopedit, derive1** (for O_2), **bin average** (1 meter bins for the downcast and also for the fullcast data conversions), **derive2** (for salinity and density), **bottle summary** (rossummary), **ascii out**. All post-processing was done using a single con (configuration file) that is distributed with this data set: p608postprocessallFINAL.CON. All files derived from this post-processing are available as part of this data distribution. The attached header file shows the processing commands and parameters used for each of the 74 files. In most cases manufacturer recommendations were followed. The latitude and longitude at the beginning of each hydrographic cast were normally inserted into the data file at the start of the hydrographic cast by the CTD data acquisition system. These positions were obtained from the onboard Global Positioning System (GPS) and were recorded to a precision of 0.01 minutes of latitude and longitude.

6. Bottle Data Quality Control

6.1 Dissolved oxygen data

The differences between titrated and CTD-derived DO values were compared against a rejection limit of 2.6σ and differences exceeding this value were flagged for further examination. We selected a rejection threshold of 2.6σ with the knowledge that, on a statistical basis, a maximum of 1% of the good data could be flagged or misidentified as an outliers and inadvertently discarded [Millard and Yang, 1993]. For DO measurements, in some cases, especially in the upper 25 m, the sensor/Winkler difference exceeded 0.2 ml l^{-1}. However, given the slow response time of the DO sensor coupled with relatively steep DO gradients near the ocean surface, such differences are to be expected. In the end, only 1 deep water titrated DO value was removed from the final data release (contained in the final bottle sheet excel file: NBP0608 Final Post-Processed and QCed CTD Bottle Sheets ALL.xls.

6.2 Salinity data

The differences, ΔS, between the Bullister bottle Autosal and CTD-derived secondary salinities were compared against a rejection limit of 2.6σ and differences exceeding this value were flagged for further examination. In most cases the difference between CTD-derived primary and secondary salinities was much smaller than ΔS, suggesting that most of the discrepancies were due to variability in the bottle salinities. Most of the data flagged were in the upper 50 m of the water column where we observed strong S gradients. As a result, some of the observed differences could simply reflect natural variability in the water column. However, the exact source of this uncertainty could not be resolved; therefore, these data were eliminated from the final merged data files (e.g., 10 Autosal salinity values were removed).

7. Contents of the Data Set

The NBP0608 hydrographic data set consists of both discrete bottle samples and continuous downcast profile data, both upcast and fullcast. Normally, users will work with the downcast data but the upcast data may prove useful when checking specific features of water column structure and are thus provided here for completeness. The profile data are provided as individual ASCII (ASC) or TEXT (TXT) files with a single header record describing the parameters in the file. By convention these files are named *CCCCSSSlabel.ASC (or .TXT)*, where *CCCC* is the cruise number (p608), *SSS* is the station number, and label is the descriptor for the file (e.g., DowncastBinAve or FullCastBinAve) and *ASC or TXT* is the extension designating it as a SeaBird Electronics ASCII data file. E.g., p608001DownBinAve.txt is from cruise NBP0608, Cast 001, and consists of bin-averaged 1 m data from the downcast only. An ASCII header file *CCCCSSSlabel.ASC,* which contains information on the raw data and the data processing, is also provided. In additional, the final binary data conversion files (.CNV) used during the post-processing are provided. These allow users to more readily calculate additional derived variables using the SeaSoft data processing package.

We also provide several Excel spreadsheets as part of this data distribution. There is one Excel sheet that contains all the merged 1 meter bins of data from all hydrocasts conducted during NBP0608. In addition, there is a merged bottle sheet file that provides data from the CTD as well as discrete analyses of DO, S, nutrients, and C system parameters. Both CTD downcast and bottle sheet files are also made available as Ocean Data View "collections".

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We also thank Dr. Michael Van Woert for his meticulous reporting of the ROAVERRS CTD data from the Ross Sea in 1996, 1997, and 1998. We have made direct use of his hydrographic report (Van Woert et al., 2000), both prose and style, in the preparation of this document We also followed, where possible, the same data processing protocols performed by Van Woert et al., so as to enhance comparability between the hydrographic data derived from the ROAVERRS and CORSACS programs.

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Cruise	CTD	Latitude	Longitude	TimeJ
NBP0608	1	-65.221	-174.721	312.036
NBP0608	2	-72.110	-178.537	316.010
NBP0608	3	-77.375	173.000	319.136
NBP0608	4	-76.005	171.254	319.933
NBP0608	5	-76.011	171.299	319.995
NBP0608	6	-75.998	172.691	320.361
NBP0608	7	-75.990	172.710	320.418
NBP0608	8	-75.986	174.073	320.793
NBP0608	9	-75.964	174.079	320.849
NBP0608	10	-76.000	175.450	321.013
NBP0608	11	-76.002	176.834	321.177
NBP0608	12	-75.992	176.855	321.224
NBP0608	13	-76.007	177.780	321.345
NBP0608	14	-75.995	178.218	321.790
NBP0608	15	-75.963	178.300	321.842
NBP0608	16	-75.996	179.605	322.184
NBP0608	17	-76.001	-179.004	322.353
NBP0608	18	-76.999	180.000	322.792
NBP0608	19	-76.984	179.965	322.847
NBP0608	20	-76.994	178.496	323.008
NBP0608	21	-76.999	177.031	323.155
NBP0608	22	-76.998	175.558	323.301
NBP0608	23	-76.994	175.568	323.336
NBP0608	24	-76.994	174.068	323.787
NBP0608	25	-76.971	174.044	323.837
NBP0608	26	-77.000	172.573	324.172
NBP0608	27	-76.999	171.098	324.322
NBP0608	28	-77.433	170.362	324.929
NBP0608	29	-77.433	170.362	324.998
NBP0608	30	-77.429	172.523	325.262
NBP0608	31	-77.667	179.997	326.276
NBP0608	32	-77.670	-179.994	326.339
NBP0608	33	-76.502	173.499	326.802
NBP0608	34	-76.502	173.499	326.856
NBP0608	35	-76.502	173.499	326.909
NBP0608	36	-76.499	170.002	327.854
NBP0608	37	-76.493	169.992	327.909
NBP0608	38	-76.496	171.421	328.112
NBP0608	39	-76.492	171.410	328.160
NBP0608	40	-76.500	172.857	328.790
NBP0608	41	-76.499	172.858	328.848
NBP0608	42	-76.502	172.855	328.897
NBP0608	43	-76.500	174.282	329.022
NBP0608	44	-76.495	175.724	329.181
NBP0608	45	-76.502	175.587	329.239
NBP0608	46	-76.500	177.145	329.358
NBP0608	47	-76.500	178.570	329.784
NBP0608	48	-76.500	178.573	329.835
NBP0608	49	-76.499	-179.999	330.042
NBP0608	50	-76.492	-178.595	330.183
NBP0608	51	-76.500	-178.614	330.241
NBP0608	52	-76.836	179.998	330.396
NBP0608	53	-77.167	-179.992	330.791
NBP0608	54	-77.167	-179.992	330.845
NBP0608	55	-77.499	179.997	331.133
NBP0608	56	-77.833	-179.993	331.371
NBP0608	57	-77.833	-179.993	331.432
NBP0608	58	-77.750	178.499	331.790
NBP0608	59	-77.750	178.499	331.852
NBP0608	60	-77.666	176.916	332.228
NBP0608	61	-77.666	176.916	332.273
NBP0608	62	-77.615	176.199	332.397
NBP0608	63	-77.615	176.201	332.495
NBP0608	64	-77.500	173.997	332.790
NBP0608	65	-77.500	173.997	332.851
NBP0608	66	-77.336	172.650	333.045
NBP0608	67	-77.326	171.131	333.245
NBP0608	68	-77.326	171.131	333.303
NBP0608	69	-76.499	174.287	333.829
NBP0608	70	-76.499	174.287	333.887
NBP0608	71	-76.496	171.421	334.219
NBP0608	72	-76.501	-179.998	336.856
NBP0608	73	-70.466	-174.497	339.064
NBP0608	74	-68.185	-173.071	340.085

Note: No bottles were tripped at Station 3 due to CT

Note: No bottles were tripped at Station 13 by desig

Table 2. Pre and Post Cruise CTD calibration coefficients - NBP0608

Primary Temperature Sensor, Model 3-02F, #1238						
pre-cruise calibration date: 27 Feb 06				post-cruise calibration date: 25 Jan 07		
g	4.82484656E-03			4.82486754E-03		
h	6.70977642E-04			6.71057437E-04		
i	2.57750761E-05			2.58300533E-05		
j	2.06165518E-06			2.07332416E-06		
f0	1000.0			1000.0		
offset from 27 Feb 06 = 1.13 mdeg C						

Secondary Temperature Sensor, Model 3-02F, #2186						
pre-cruise calibration date: 27 Feb 06				post-cruise calibration date: 25 Jan 07		
g	4.34028979E-03			4.34029380E-03		
h	6.44873119E-04			6.44734204E-04		
i	2.33799073E-05			2.32915195E-05		
j	2.21759026E-06			2.20150225E-06		
f0	1000.0			1000.0		
offset from 27 Feb 06 = -0.31 mdeg C						

Primary Conductivity Sensor, Model 4-02/0, #0924						
pre-cruise calibration date: 10 Mar 06				post-cruise calibration date: 25 Jan 07		
g	-4.25603312E+00			-4.24522509E+00		
h	5.69614909E-01			5.66783642E-01		
i	-6.23387933E-04			-1.92569409E-05		
j	6.50573839E-05			3.14749324E-05		
CPcor	-9.57E-08			-9.57E-08		
CTcor	3.25E-06			3.25E-06		
Data slope correction from 10 Mar 06: 1.0000948						

Secondary Conductivity Sensor, Model 4C, #1314						
pre-cruise calibration date: 10 Mar 06				post-cruise calibration date: 25 Jan 07		
g	-4.07536260E+00			-4.07451497E+00		
h	4.70981561E-01			4.70881069E-01		
i	-5.52972693E-05			-3.11991178E-05		
j	2.88272015E-05			2.71705647E-05		
CPcor	-9.57E-08			-9.57E-08		
CTcor	3.25E-06			3.25E-06		
Data slope correction from 10 Mar 06: 1.0000601						

Primary Dissolved Oxygen Sensor, Model SBE43, #0082						
pre-cruise calibration date: 17 Feb 06				post-cruise calibration date: 25 Jan 07		
Soc	2.79100000E-01			2.93200000E-01		
Boc	0.00000000E+00			0.00000000E+00		
Voffset	-6.24300000E-01			-6.23700000E-01		
Tcor	1.30000000E-03			1.80000000E-03		
Pcor	1.35E-04			1.35E-04		
Note: significant difference in residual slope						

Secondary Dissolved Oxygen Sensor, Model SBE43, #0139						
pre-cruise calibration date: 18 Feb 06				post-cruise calibration date: 26 Feb 07		
Soc	3.14400000E-01			3.50800000E-01		
Boc	0.00000000E+00			0.00000000E+00		
Voffset	-5.95500000E-01			-6.01800000E-01		
Tcor	1.60000000E-03			1.00000000E-04		
Pcor	1.35E-04			1.35E-04		

PAR Sensor, Model QSP200L4S, #4361						
pre-cruise calibration date: 13 Jan 06				post-cruise calibration date:		31-Jan-07
Dry Cal	5.87E+12	9.74E-06			9.24E+12	1.53E-05
Wet Cal	9.88E+12	1.64E-05			1.56E+13	2.58E-05

Flourometer Sensor, #AFLT-009						
pre-cruise calibration date: 12 Jul 06				post-cruise calibration date: 30 Jan 07		
Dark Counts	0.174 v			0.185 v		
CEV	2.596 v			2.624 v		
SF	10.322			10.25		
FSV	5.45 v			5.45 v		

Table 4. Processing sequence used with final post-processing of NBP0608 CTD data. This is an example header file for the processed and derived data from Station 74.

```
* Sea-Bird SBE 9 Data File:
* FileName = D:\Data\Raw\p608074.dat
* Software Version Seasave Win32 V 5.37d
* Temperature SN = 1238
* Conductivity SN = 0924
* Number of Bytes Per Scan = 37
* Number of Voltage Words = 5
* Number of Scans Averaged by the Deck Unit = 1
* Append System Time to Every Scan
* System UpLoad Time = Dec 06 2006 00:31:17
* NMEA Latitude = 68 11.07 S
* NMEA Longitude = 173 04.27 W
* NMEA UTC (Time) = 00:31:09
* Store Lat/Lon Data = Add to Header Only
** Ship:      Nathaniel B. Palmer
** Cruise:    NBP0608
** Station:  074
** Operator:  Sheldon Blackman
# nquan = 27
# nvalues = 8551
# units = specified
# name 0 = timeJ: Julian Days
# name 1 = latitude: Latitude [deg]
# name 2 = longitude: Longitude [deg]
# name 3 = prDM: Pressure, Digiquartz [db]
# name 4 = t090C: Temperature [ITS-90, deg C]
# name 5 = t190C: Temperature, 2 [ITS-90, deg C]
# name 6 = c0S/m: Conductivity [S/m]
# name 7 = c1S/m: Conductivity, 2 [S/m]
# name 8 = flECO-AFL: Fluorescence, Wetlab ECO-AFL/FL [mg/m^3]
# name 9 = bat: Beam Attenuation, Chelsea/Seatech/Wetlab CStar [1/m]
# name 10 = par: PAR/Irradiance, Biospherical/Licor
# name 11 = spar: SPAR/Surface Irradiance
# name 12 = sbeox0V: Oxygen Voltage, SBE 43
# name 13 = sbeox1V: Oxygen Voltage, SBE 43, 2
# name 14 = sbeox0ML/L: Oxygen, SBE 43 [ml/l], WS = 2
# name 15 = sbeox0Mm/Kg: Oxygen, SBE 43 [umol/Kg], WS = 2
# name 16 = sbeox0PS: Oxygen, SBE 43 [% saturation], WS = 2
# name 17 = sbeox1ML/L: Oxygen, SBE 43, 2 [ml/l], WS = 2
# name 18 = sbeox1Mm/Kg: Oxygen, SBE 43, 2 [umol/Kg], WS = 2
# name 19 = sbeox1PS: Oxygen, SBE 43, 2 [% saturation], WS = 2
# name 20 = sal00: Salinity [PSU]
# name 21 = sal11: Salinity, 2 [PSU]
# name 22 = sigma-é00: Density [sigma-theta, Kg/m^3]
# name 23 = sigma-é11: Density, 2 [sigma-theta, Kg/m^3]
# name 24 = oxsatML/L: Oxygen Saturation [ml/l]
# name 25 = sigma-t11: Density, 2 [sigma-t, Kg/m^3 ]
# name 26 = flag: flag
# span 0 = 340.022055, 340.161884
# span 1 =  -68.18450,  -68.18450
# span 2 = -173.07117, -173.07117
# span 3 =      1.000,   4278.000
# span 4 =    -1.8373,     1.4992
```

```
# span 5 =    -1.8389,     1.4986
# span 6 =   2.691314,   3.067639
# span 7 =   2.690878,   3.068266
# span 8 =     0.1376,     0.3148
# span 9 =     0.0610,     0.1041
# span 10 = 1.0000e-12, 1.0000e-12
# span 11 = 9.3305e+02, 1.8722e+03
# span 12 =     1.8006,     3.1984
# span 13 =     1.6897,     2.9859
# span 14 =    4.04035,    6.38024
# span 15 =    175.564,    277.301
# span 16 =   52.09046,   75.06337
# span 17 =    4.40320,    7.12269
# span 18 =    191.332,    309.570
# span 19 =   56.80873,   83.79813
# span 20 =    34.1933,    34.7244
# span 21 =    34.1892,    34.7304
# span 22 =    27.5256,    27.8596
# span 23 =    27.5223,    27.8667
# span 24 =    7.75072,    8.49990
# span 25 =    27.5223,    27.8505
# span 26 = 0.0000e+00, 0.0000e+00
# interval = decibars: 1
# start_time = Dec 06 2006 00:31:17
# bad_flag = -9.990e-29
# sensor 0 = Frequency  0  temperature, primary, 1238, 25-Jan-07
# sensor 1 = Frequency  1  conductivity, primary, 0924, 25-Jan-07, cpcor = -
9.5700e-08
# sensor 2 = Frequency  2  pressure, 0328, 18-Apr-05
# sensor 3 = Frequency  3  temperature, secondary, 2186, 25-Jan-07
# sensor 4 = Frequency  4  conductivity, secondary, 1314, 25-Jan-07, cpcor =
-9.5700e-08
# sensor 5 = Extrnl Volt  0  userpoly 0, ISUS, 01-Nov-2006
# sensor 6 = Extrnl Volt  1  userpoly 1, ISUS, 01-Nov-2006
# sensor 7 = Extrnl Volt  2  Oxygen, SBE, primary, 0082, 25-Jan-07
# sensor 8 = Extrnl Volt  3  Oxygen, SBE, secondary, 0139, 26-Feb-07
# sensor 9 = Extrnl Volt  4  WET Labs, ECO_AFL
# sensor 10 = Extrnl Volt  5  transmissometer, primary, CST-892DR, 12-OCT-05
# sensor 11 = Extrnl Volt  6  irradiance (PAR), primary, 4361, 13-JAN-06
# sensor 12 = Extrnl Volt  9  surface irradiance (SPAR), degrees = 0.0
# datcnv_date = Aug 23 2007 16:32:18, 7.14c
# datcnv_in = C:\Documents and Settings\owner\Desktop\NBP0608 CTD Data - For
Post Proc\Raw\p608074.dat C:\Documents and Settings\owner\Desktop\NBP0608
Active Post Proc\p608postprocessallFINAL.CON
# datcnv_skipover = 0
# filter_date = Aug 23 2007 16:45:22, 7.14c
# filter_in = C:\Documents and Settings\owner\Desktop\NBP0608 Active Post
Proc\Final PostProc\p608074Final.cnv
# filter_low_pass_tc_A = 0.030
# filter_low_pass_tc_B = 0.150
# filter_low_pass_A_vars = c0S/m c1S/m
# filter_low_pass_B_vars = prDM
# alignctd_date = Aug 23 2007 16:52:34, 7.14c
# alignctd_in = C:\Documents and Settings\owner\Desktop\NBP0608 Active Post
Proc\Final PostProc\p608074Final.cnv
# alignctd_adv = sbeox0V 5.000, sbeox1V 5.000
# wildedit_date = Aug 23 2007 16:59:44, 7.14c
```

```
# wildedit_in = C:\Documents and Settings\owner\Desktop\NBP0608 Active Post
Proc\Final PostProc\p608074Final.cnv
# wildedit_pass1_nstd = 2.0
# wildedit_pass2_nstd = 10.0
# wildedit_pass2_mindelta = 0.000e+000
# wildedit_npoint = 12
# wildedit_vars = latitude longitude prDM t090C t190C c0S/m c1S/m flECO-AFL
bat par spar sbeox0V sbeox1V
# wildedit_excl_bad_scans = yes
# wildedit_date = Aug 23 2007 17:06:29, 7.14c
# wildedit_in = C:\Documents and Settings\owner\Desktop\NBP0608 Active Post
Proc\Final PostProc\p608074Final.cnv
# wildedit_pass1_nstd = 2.0
# wildedit_pass2_nstd = 10.0
# wildedit_pass2_mindelta = 0.000e+000
# wildedit_npoint = 100
# wildedit_vars = latitude longitude prDM t090C t190C c0S/m c1S/m flECO-AFL
bat par spar sbeox0V sbeox1V
# wildedit_excl_bad_scans = yes
# wildedit_date = Aug 23 2007 17:12:24, 7.14c
# wildedit_in = C:\Documents and Settings\owner\Desktop\NBP0608 Active Post
Proc\Final PostProc\p608074Final.cnv
# wildedit_pass1_nstd = 2.0
# wildedit_pass2_nstd = 10.0
# wildedit_pass2_mindelta = 0.000e+000
# wildedit_npoint = 50
# wildedit_vars = latitude longitude prDM t090C t190C c0S/m c1S/m flECO-AFL
bat par spar sbeox0V sbeox1V
# wildedit_excl_bad_scans = yes
# celltm_date = Aug 23 2007 17:18:58, 7.14c
# celltm_in = C:\Documents and Settings\owner\Desktop\NBP0608 Active Post
Proc\Final PostProc\p608074Final.cnv
# celltm_alpha = 0.0300, 0.0300
# celltm_tau = 7.0000, 7.0000
# celltm_temp_sensor_use_for_cond = primary, secondary
# loopedit_date = Aug 23 2007 17:28:16, 7.14c
# loopedit_in = C:\Documents and Settings\owner\Desktop\NBP0608 Active Post
Proc\Final PostProc\p608074Final.cnv
# loopedit_minVelocity = 0.250
# loopedit_surfaceSoak: minDepth = 5.0, maxDepth = 20, useDeckPress = 1
# loopedit_excl_bad_scans = yes
# Derive_date = Aug 23 2007 17:37:52, 7.14c
# Derive_in = C:\Documents and Settings\owner\Desktop\NBP0608 Active Post
Proc\Final PostProc\p608074Final.cnv C:\Documents and
Settings\owner\Desktop\NBP0608 Active Post Proc\p608postprocessallFINAL.CON
# derive_time_window_docdt = seconds: 2
# binavg_date = Aug 23 2007 17:51:55, 7.14c
# binavg_in = C:\Documents and Settings\owner\Desktop\NBP0608 Active Post
Proc\Final PostProc\derive1\p608074Finalderive1.cnv
# binavg_bintype = decibars
# binavg_binsize = 1
# binavg_excl_bad_scans = yes
# binavg_skipover = 0
# binavg_surface_bin = yes, min = 0.000, max = 0.000, value = 0.000
# Derive_date = Aug 23 2007 17:53:54, 7.14c
```

```
# Derive_in = C:\Documents and Settings\owner\Desktop\NBP0608 Active Post
Proc\Final PostProc\p608074Finalderive1FullBinAve.cnv C:\Documents and
Settings\owner\Desktop\NBP0608 Active Post Proc\p608postprocessallFINAL.CON
# file_type = ascii

*END*
```

```
Date: 08/24/2007

Instrument configuration file: C:\Documents and Settings\owner\Desktop\NBP0608
Active Post Proc\p608postprocessallFINAL.CON

Configuration report for SBE 911plus/917plus CTD
------------------------------------------------

Frequency channels suppressed : 0
Voltage words suppressed      : 0
Computer interface            : RS-232C
Scans to average              : 1
Surface PAR voltage added     : Yes
NMEA position data added      : Yes
Scan time added               : Yes

1) Frequency 0, Temperature

   Serial number : 1238
   Calibrated on : 25-Jan-07
   G             : 4.82486754e-003
   H             : 6.71057437e-004
   I             : 2.58300533e-005
   J             : 2.07332416e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : -0.0002

2) Frequency 1, Conductivity

   Serial number : 0924
   Calibrated on : 25-Jan-07
   G             : -4.25603312e+000
   H             : 5.69614909e-001
   I             : -6.23387933e-004
   J             : 6.50573839e-005
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 1.00000000
   Offset        : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

   Serial number : 0328
   Calibrated on : 18-Apr-05
   C1            : -5.847002e+004
   C2            : 6.910390e-001
   C3            : 1.753360e-002
   D1            : 4.241600e-002
   D2            : 0.000000e+000
   T1            : 3.026040e+001
   T2            : -1.938830e-004
   T3            : 4.330190e-006
   T4            : 2.020250e-009
   T5            : 0.000000e+000
   Slope         : 1.00004000
   Offset        : -0.74260
   AD590M        : 1.133000e-002
   AD590B        : -8.475920e+000

4) Frequency 3, Temperature, 2

   Serial number : 2186
```

```
   Calibrated on : 25-Jan-07
   G             : 4.34022938e-003
   H             : 6.44734204e-004
   I             : 2.32915195e-005
   J             : 2.20150225e-006
   F0            : 1000.000
   Slope         : 1.00000000
   Offset        : 0.0001

5) Frequency 4, Conductivity, 2

   Serial number : 1314
   Calibrated on : 25-Jan-07
   G             : -4.07536260e+000
   H             : 4.70981561e-001
   I             : -5.52972693e-005
   J             : 2.88272015e-005
   CTcor         : 3.2500e-006
   CPcor         : -9.57000000e-008
   Slope         : 0.99995083
   Offset        : 0.00000

6) A/D voltage 0, User Polynomial

   Serial number : ISUS
   Calibrated on : 01-Nov-2006
   Sensor name   : ISUS
   A0            : -3.21462010
   A1            : 25.81153400
   A2            : 0.00000000
   A3            : 0.00000000

7) A/D voltage 1, User Polynomial, 2

   Serial number : ISUS
   Calibrated on : 01-Nov-2006
   Sensor name   : ISUS
   A0            : -1.60731000
   A1            : 12.90576700
   A2            : 0.00000000
   A3            : 0.00000000

8) A/D voltage 2, Oxygen, SBE 43

   Serial number : 0082
   Calibrated on : 25-Jan-07
   Equation      : Owens-Millard
   Coefficients for Owens-Millard:
   Soc           : 2.8570e-001
   Boc           : 0.0000
   Offset        : -0.5698
   Tcor          : 0.0015
   Pcor          : 1.35e-004
   Tau           : 0.0
   Coefficients for Murphy-Larson:
   Soc           : 0.00000e+000
   Offset        : 0.00000e+000
   A             : 0.00000e+000
   B             : 0.00000e+000
   C             : 0.00000e+000
   E             : 0.00000e+000
   Tau           : 0.00000e+000
```

```
9) A/D voltage 3, Oxygen, SBE 43, 2

   Serial number : 0139
   Calibrated on : 26-Feb-07
   Equation      : Owens-Millard
   Coefficients for Owens-Millard:
   Soc           : 3.5080e-001
   Boc           : 0.0000
   Offset        : -0.6018
   Tcor          : 0.0001
   Pcor          : 1.35e-004
   Tau           : 0.0
   Coefficients for Murphy-Larson:
   Soc           : 0.00000e+000
   Offset        : 0.00000e+000
   A             : 0.00000e+000
   B             : 0.00000e+000
   C             : 0.00000e+000
   E             : 0.00000e+000
   Tau           : 0.00000e+000

10) A/D voltage 4, Fluorometer, Wetlab ECO-AFL/FL

    Serial number : AFLT-009
    Calibrated on : 12-July-06
    Vblank        : 0.1740
    Scale factor  : 1.03220000e+001

11) A/D voltage 5, Transmissometer, Chelsea/Seatech/Wetlab CStar

    Serial number : CST-892DR
    Calibrated on : 12-OCT-05
    M             : 21.9930
    B             : -1.2210
    Path length   : 0.250

12) A/D voltage 6, PAR/Irradiance, Biospherical/Licor

    Serial number        : 4361
    Calibrated on        : 13-JAN-06
    M                    : 1.00000000
    B                    : 0.00000000
    Calibration constant : 6097560976.00000000
    Multiplier           : 1.00000000
    Offset               : -0.26000000

13) A/D voltage 7, Free

14) SPAR voltage, Unavailable

15) SPAR voltage, SPAR/Surface Irradiance

    Serial number     : 6356
    Calibrated on     : 16-May-05
    Conversion factor : 1595.53220373
    Ratio multiplier  : 1.00000000
```