WHP Cruise Summary Information

WOCE section designation	P19C
Expedition designation (EXPOCODE)	316N138_12
Chief Scientist(s) and their affiliation	Lynne Talley, SIO
Dates	1993.02.22–1993.04.13
Ship	KNORR
Ports of call	Punta Arenas, Chile to Panama City, Panama
Number of stations	221
Geographic boundaries of the stations	9°46.55''N 92°45.59''W 70°51.15''W 54°12.46''S
Floats and drifters deployed	21 floats and 6 drifters
Moorings deployed or recovered	none
Contributing Authors (in order of appearance)	F.M Delahoyde R.T. Williams M.C. Johnson R.M. Key A. Mantyla M. Rosenberg

WHP Cruise and Data Information

Instructions: Click on items below to locate primary reference(s) or use navigation tools above.

Cruise Summary Information	**Hydrographic Measurements**
Description of scientific program	CTD - general
	CTD - pressure
Geographic boundaries of the survey	CTD - temperature
Cruise track (figure)	CTD - conductivity/salinity
Description of stations	CTD - dissolved oxygen
	Salinity
Floats and drifters deployed	Oxygen
Moorings deployed or recovered	Nutrients
Principal Investigators for all measurements	
Cruise Participants	
Problems and goals not achieved	
Other incidents of note	Other parameters: AMS ^{14}C
	Large Volume Samples
Underway Data Information	
Navigation	
Bathymetry	**References**
Acoustic Doppler Current Profiler (ADCP)	
Thermosalinograph and related measurements	**DQE Reports**
XBT and/or XCTD	
Meteorological observations	CTD
Atmospheric chemistry data	S/O2/nutrients
Data Status Notes	

WHP Ref. No.: P19C
Last updated: 3 May 1999

A. Cruise narrative

A.1. Highlights

A.1.a.	WOCE designation:	P19C (R/V Knorr 138-12)
A.1.b.	Expocode	316N138/12
A.1.c.	Chief Scientist	Lynne D. Talley (Scripps Institution of Oceanography)
A.1.d.	Ship	R/V Knorr, Captain C. Swanson
A.1.e.	Ports of Call	Punta Arenas, Chile - Panama City, Panama
A.1.f.	Cruise dates	22 Feb 1993 - 13 April 1993

A.2. Cruise summary

A.2.a Geographic Boundaries

	13.536	
-92.751		-74.923
	-54.00	

A.2.b Stations Occupied

94 CTD/36-bottle rosette stations
94 CTD/33-bottle rosette/LADCP stations
13 Large volume sampling (Gerard barrel) stations
20 200-meter bio-optics stations (JGOFS)

A.2.c Floats and drifters deployed

21 ALACE floats deployed (for Davis)
6 surface drifters deployed (for Niiler)

A.2.d. Moorings deployed or recovered

None

A.3. Principal Investigators

Russ Davis	ALACE floats	SIO	redavis@ucsd.edu
Rana Fine	CFC	RSMAS/U. Miami	rfine@rsmas.miami.edu
Eric Firing	ADCP-LADCP	U.Hawaii	efiring@soest.hawaii.edu
Wilf Gardner	Transmissometer	TAMU	richardson@astra.tamu.edu
Louis Gordon	Nuts support to SIO-ODF	OSU	lgordon@oce.orst.edu
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William Jenkins	Helium-3 & tritium	WHOI	wjj@burford.whoi.edu
Charles Keeling	Carbon Dioxide	SIO	guenther%cdrgmv.span@sds.sdsc.edu
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John Marra	Bio-optics	LDEO	marra@lamont.ldgo.columbia.edu
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Stuart Smith	Bathymetry	SIO	sms@gdcsun1.ucsd.edu
James Swift	CTD-hydrography support	SIO-ODF	jswift@ucsd.edu
Taro Takahashi	Carbon Dioxide	LDEO	taka@lamont.ldgo.columbia.edu
Lynne Talley	CTD-hydrography	SIO	ltalley@ucsd.edu
Mizuki Tsuchiya	CTD-hydrography	SIO	jreid@ucsd.edu
Ray Weiss	underway pCO and pN_2O	SIO	rfweiss@ucsd.edu

LDEO: Lamont-Doherty Earth Observatory, Palisades, NY 10964
LLNL: Lawrence Livermore National Laboratory (Rau address is NASA-Ames, MS239-4 Moffett Field, CA 94035-1000)
NOAA/PMEL: National Oceanic and Atmospheric Administration, Pacific Marine Environmental Laboratory.
OSU: College of Oceanic and Atmospheric Sciences, Oregon State University, Corvallis, OR 97331-5503
Princeton U.: Princeton University, Geology Dept., Guyot Hall, Princeton, NJ 08544
SIO: Scripps Institution of Oceanography, UCSD, La Jolla, CA 92093 USA
SIO/MTG: SIO Marine Technical Group, UCSD, La Jolla, CA 92093-0214 USA
SIO/ODF: SIO Oceanographic Data Facility, UCSD, La Jolla, CA 92093-0214 USA
TAMU: Texas A&M University, College Station, TX 77843
U.C. Santa Cruz:(Rau address is NASA-Ames, MS239-4 Moffett Field, CA 94035-1000)
U. Hawaii: University of Hawaii, 1000 Pope Rd., Honolulu, HI 96822
U. Miami: University of Miami/RSMAS, 4600 Rickenbacker Causeway, Miami, FL 33143
WHOI: Woods Hole Oceanographic Institution, Woods Hole, MA 02543

A.4. Scientific programme and methods

A.4a. Narrative

A complete paper, including vertical sections, was published as Tsuchiya, M. and L. D. Talley, 1998. A Pacific hydrographic section at 88°W: water property distribution. J. Geophys. Res., 103, 12899-12918.

Preliminary results were reported in the International WOCE Newsletter (No. 19, June, 1995).

R/V Knorr departed Punta Arenas, Chile for its twelfth leg of cruise 138 on Feb. 22, 1993. This was the seventh WOCE hydrographic leg on the Knorr in the South Pacific since the beginning of 1992. P19C was supported by the National Science Foundation's Ocean Sciences Division. P19C was the fourth WOCE hydrographic leg on the Knorr with basic technical support from Scripps Institution of Oceanography's Oceanographic Data Facility. Because of the extensive use of the ship for this sort of work prior to our leg, we were fortunate in having very few problems with equipment. We were also fortunate with weather, encountering only two storms, which affected stations 257 and 274.

Stations were numbered consecutively from the beginning of the R/V Knorr 138-9 work on P16S (Reid, chief scientist) starting south of Tahiti in October, 1992. The first station on P19C was numbered 234. On 20 days a separate JGOFS bio-optics station was made within several hours of noon. These stations extended to 200 m.

The original cruise plan was for sampling along 54°S westward out to 88°W and then exclusively along 88°W until about 4°N, where the track jogged westward and then eastward into Central America. Because of clearance questions and also because of rethinking based on the topography between the Galapagos and South America, it was decided to bend the section northeastward to 85°50'W north of 20°S, thereby passing through the deeper part of the equatorial ocean east of the Galapagos.

A.4.b. Interlaboratory comparisons

No interlaboratory comparisons were made per se on P19C, but water sample results were compared with preliminary data acquired on P17E (Swift, chief scientist, R/V Knorr), P6 (Bryden, chief scientist, R/V Knorr), the two old 1968 Scorpio sections at 43°S and 28°S, and final data from the 1989 Moana Wave cruise at 9°30'N. Comparisons of P19C salinity, oxygen, silica, nitrate and phoshate with data from these cruises are shown in Figs. 6-9.

WHP accuracies for deep water values for the Southeastern Pacific are: salinity - .002 if corrected for SSW batch; oxygen - 1% = .03-.04 ml/l; nitrate - 1% = .3-.4 μmol/l; phosphate - 1% = .02-.03 μmol/l; silicate - 1% = 1-2 μmol/l.

P19C and P17E comparison (Fig. 6). The P17E cruise, with chief scientist J. Swift of SIO, immediately preceded P19C on the same vessel. Station 206 from Swift's cruise was in the same location as 256 from our cruise (54°S, 88°W). CTD and salinity/oxygen/nutrient analyses were carried out by SIO's Oceanographic Data Facility (but different analysts) on both cruises. Standard sea water (SSW) batch P120 was used for salinity measurements on both legs, as on all Knorr WOCE legs carried out by SIO/ODF in 1992-1993. There is no offset for any property. These stations occurred within a month and a half of each other and used the same equipment and methods. Comparisons refer to potential temperatures less than 1.2°C.

P17E stations:	204-208	ODF S,O2,nuts/ SSW P120
P19C stations:	254-258	ODF S,O2,nuts/ SSW P120

Salinity: no offset between data sets; scatter of both data sets = .003.
Oxygen: no offset between data sets; scatter of both data sets = .02 ml/l.
Nitrate: no offset between data sets; scatter of P17E data set = .2 μmol/l; scatter of P19C data set = .5 μmol/l; (one outlier station -255- pushes it to 1.0).
Phosphate: no offset between data sets; scatter of both data sets = .02-.04 μmol/l.
Silicate: no offset between data set; scatter of P17E data set = 3 μmol/l; scatter of P19C data set < 1 μmol/l.

P19C and P6 comparison (Fig. 7). Agreement between P19C and P6 results is not as good although both data sets are within WOCE accuracies within themselves; some differences between them are larger than WOCE accuracy requirements. Basic hydrography (T,S,O_2) on P6 was carried out by WHOI and nutrients by Oregon State University. There is no offset in salinity, possibly due to improvement in accuracy of standard sea water. Salinity scatter on P19C was within the WOCE precision and half that of P6. Oxygen on P19C was systematically 0.02 ml/l lower than on P6; this is within the WOCE accuracy. Phosphate on both legs agrees well but is less scattered on P19C. Nitrate and silicate are higher on P19C than on P6, with the offset being larger than the WOCE standard for accuracy. The offset can be removed if the same software is used to process the two data sets; the procedures differ in treatment of the nonlinearity of dependence of concentration on absorbance. We do not know if other factors might have created the offset, but find it encouraging that the P6 nitrate and silicate numbers could be precisely matched with the P19C data when linear response was assumed. Comparisons refer to potential temperatures between 1.3 and 2.5°C.

P6 stations:	33-37	WHOI S,O2 OSU nuts
P19C stations:	297-300	ODF S,O2,nuts/ SSW P120

Salinity: no offset between data sets; scatter of P19C = .002; scatter of P6 = .004.
Oxygen: offset with P19C .02 lower; scatter of P19C = .01; scatter of P6 = .01-.02 with 2 bad outliers.
Nitrate: offset with P19C .3 μmol/l higher - this can be accounted for by the linear/nonlinear calculations; (rerunning ODF/P19C nuts as linear yields excellent agreement with OSU/P6); scatter of P19C = .2 μmol/l; scatter of P6 = .2 μmol/l plus 3 outliers.
Phosphate: no offset between data sets; scatter of P19C = .05 μmol/l (one outlier station, otherwise all agree within .02 μmol/l); scatter of P6 = .07 μmol/l.
Silicate: offset with P19C higher by 1.0 μmol/l; scatter of P19C = 1. μmol/l; scatter of P6 = 1. μmol/l.

P19C and 10°N comparison (Fig. 8). The zonal section at 10°N on R/V Moana Wave, with principal investigator John Toole, used technical support from WHOI for salinity, oxygen and CTD, and from Oregon State University for nutrients. This cruise is considered "pre-WOCE" and of WOCE quality. Nutrients and oxygen all agree quite well between the two cruises at the deepest points, but there are systematic offsets at slightly higher temperatures (see appendix and figure). The scatter of the nutrient data sets is comparable. The P19C salinity and oxygen data are less scattered than the Moana Wave data.

Moana Wave stations:	204-208	WHOI S,O2 OSU nuts
P19C stations:	401-405	ODF S,O2,nuts/ SSW P120

Salinity:	no offset; scatter of P19C = .001-.002; scatter of MW = .005.
Oxygen:	offset with P19C .05-.1 ml/l lower; scatter of P19C = .05 ml/l?; scatter of MW = .1 ml/l?.
Nitrate:	offset with P19C .3 μmol/l higher; scatter of P19C = .3 μmol/l; scatter of MW = .3 μmol/l.
Phosphate:	offset with P19C .03 μmol/l higher?; scatter of P19C = .03 μmol/l; scatter of MW = .03 μmol/l.
Silicate:	offset with P19C 2 μmol/l higher; scatter of P19C = 4 μmol/l; scatter of MW = 2 μmol/l.

P19C and Scorpio comparison (Fig. 9). The Scorpio data at 28°S and 43°S were collected in 1968. Comparisons are included because these are the premier pre-WOCE zonal sections across the South Pacific and a specific decision was made to not repeat them in WOCE. Salinity and oxygen precisions are equivalent to WOCE precisions. The difference in standard sea water between Scorpio (P46) and P19C (P120) is 0.002 psu and accounts for most of the difference at 28°S (Mantyla, personal communication). The Scorpio data were collected prior to the advent of the autoanalyzer method for nutrients so no comparison of nutrient values is shown (silicate appears comparable to WOCE but nitrate and phosphate are much improved in WOCE). All properties are offset and the P19 data are much tighter, especially in nutrients. The broad scatter of all properties in both data sets and examination of both vertical sections suggests that 43°S is a rough boundary between northern and southern water types, so is not a great place for a comparison. Comparisons are for θ of 0.4-1.6°C at 43°S and θ 1.2-2.4°C at 28°S.

Scorpio stations (43S):	65-68	SSW P46
P19C stations:	276-280	ODF S,O2,nuts/ SSW P120

Salinity:	offset with P19C .05-.1psu fresher; scatter of P19C = .05; scatter of Scorpio = .07. LP
Oxygen:	offset with P19C .07-.1 ml/l lower; scatter of P19C = .04; scatter of Scorpio = .1.
Nitrate:	offset with P19C lower probably by 1-1.5 μmol/l; difficult to tell since Scorpio so imprecise; scatter of P19C = .2 μmol/l; scatter of Scorpio = 1-2 μmol/l (very large).
Phosphate:	offset with P19C lower by .06 μmol/l; scatter of P19C = .02-.03 μmol/l; scatter of Scorpio = .06 μmol/l (very large).

Silicate: offset with P19C lower by about 5 μmol/l; scatter of P19C = 2 μmol/l; scatter of Scorpio = about 10 μmol/l (very large).

Scorpio stations (28S): 100-102 SSW P46
P19C stations: 306-310 ODF S, O2, nuts/ SSW P120

Salinity: offset with P19C .003 psu fresher; SSW P46 is .002 high, reducing this offset to .001; scatter of P19C = .003; scatter of Scorpio = .003.
Oxygen: offset with P19C .1 ml/l lower; scatter of P19C = .04; scatter of Scorpio = .07.
Nitrate: offset with P19C 1-2 μmol/l higher; difficult to tell since Scorpio so imprecise; scatter of P19C = .4 μmol/l; scatter of Scorpio = 4.0 μmol/l.
Phosphate: offset with P19C .15-.2 μmol/l lower; difficult since Scorpio so imprecise; scatter of P19C = .02 μmol/l; scatter of Scorpio = .15-.2 μmol/l.
Silicate: offset with P19C 5 lower; scatter of P19C = 1-2 μmol/l; scatter of Scorpio = 3-4 μmol/l.

Summary. Salinity accuracy appears to be within WOCE requirements on recent cruises. There are offsets in oxygen which are larger than the precision required but within the accuracy limits, so indicating no fundamental problems. In nutrients however, there are still serious inter-group differences. In the cruise report from P16C (R/V T. Washington, 1991), a similar cruise-cruise comparison was made with a plea to take seriously discrepancies in results obtained by different groups. It appears that little has been done to correct the differences, and therefore it must be concluded that Pacific WHP nutrient and oxygen measurements as a whole will not fall within the required accuracies, which would have been achievable had there been action to eliminate the known differences in methods between the leading US technical groups.

A.5. Major problems and goals not achieved

There were no problems resulting in major shortfalls in numbers, spacing, or coverage of the stations. There were no major problems with any of the basic WOCE analyses. Major problems arose with the CO_2 analyses about two weeks before the end of the cruise, resulting in sparse sampling north of the equator.

A.5.a. Water sample analyses

A full listing of all data of questionable values, including problems with bottle tripping and leaking, is available from the chief scientist.

A full report on bottle data collection and analyses is given in section C below.

The prototype 36-place General Oceanics pylon and its backup operated very well throughout the cruise. The primary unit was lent to us by John Bullister (NOAA/PMEL) and the backup unit was lent by General Oceanics. Occasional bottle tripping problems were almost always correctly indicated to the CTD operator, who could then attempt to fire the bottle over and over again. When this occurred, we usually tried a total of three times before giving up and moving to the next bottle. Most of the few problems appeared to be with sticky pylon pins, and were corrected with cleaning and lubrication. The backup pylon was used after the deck unit for the first pylon was damaged by when the CTD wire shorted to ground. It was subject to more communications errors than the first pylon but nevertheless performed very well.

Many of the 10-liter bottles suffered from various leaks at the start of the cruise because the best bottles had been placed on the double-ring rosette with two pylons rather than on the rosette with the prototype GO 36-place pylon, since it was not expected that the latter could be used at the beginning of the cruise. Its performance was thoroughly successful throughout the cruise, and the poorer bottles were gradually replaced with the better ones as time permitted. Also because of the new rosette configuration, there was some experimentation with lanyard arrangements, resulting in satisfactory and efficient operation for most stations; station 241 had to be repeated because of lanyard hangups.

A sudden and violent storm which blew in the middle of station 257 resulted in a decision not to collect water samples from the upper 300 meters. Gerard barrel tripping problems were also encountered during the second storm in the same region, station 274, where the 4 bottom bottles did not trip.

A.5.b. CTD

A full report on bottle data collection and analyses is given in section C below. There were no major problems. The full CTD package consisted of pressure, temperature, redundant temperature, oxygen, a transmissometer, and an altimeter. The CTD wire had three conductors but one had shorted on an earlier leg, so only two were used.

Most of the few problems in conductivity resulted from biological fouling of the rosette/CTD during the cast (stas. 271, 344, 355, 383). The transmissometer suffered the most from this fouling, with problems on many more stations. Conductivity offsets occurred during stations 330, 348, 379, but the conductivity came back to near the original calibration during or after the casts.

A.6. Other incidents of note None

A.7. Cruise Participants

Lynne Talley	chief scientist	SIO	ltalley@ucsd.edu
Mizuki Tsuchiya	Co-chief scientist	SIO	jreid@ucsd.edu
Gerry McDonald	Large volume	Princeton U.	gerry@weasel.princeton.edu
Martha Denham	watch stander	SIO	
James Wells	marine tech/WLdr/	SIO/ODF	jwells@ucsd.edu
Gene Pillard	marine tech/WLdr/salts	SIO/MTG	
Leonard Lopez	marine tech/watch/salts	SIO/ODF	leo@odf.ucsd.edu
Barry Nisly	marine tech/oxygen	SIO/ODF	bnisly@ucsd.edu
Loanna Addessi	marine tech/oxygen	SIO/ODF	

Mary Johnson	CTD processing	SIO/ODF	mjohnson@ucsd.edu
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Craig Hutchings	CFC	U.Miami	
Craig Huhta	ADCP/LADCP/watch	U.Hawaii	
Pete Landry	helium/tritium	WHOI	
Ron Greene	helium/tritium	NOAA/PMEL	greene%new@pmel.noaa.gov
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Carol Knudson	biooptics/CO2	LDEO	knudson@lamont.ldgo.columbia.edu
Rebecca Esmay	CO2	LDEO	esmay@lamont.ldgo.columbia.edu
Stephany Rubin	CO2	LDEO	

For abbreviations and addresses, please see the Principal Investigator table.

B. Underway Measurements

B.1. Navigation and bathymetry.

GPS navigation was used throughout P19C. Bathymetry was obtained by manual recording every five minutes from the Knorr's Precision Depth Recorder and merged with the GPS navigation into a single file by ODF.

B.2. Acoustic Doppler Current Profiler (ADCP) (To be supplied by Firing and Hacker).

B.3. Thermosalinograph and underway dissolved oxygen, fluorometer, etc.

The Knorr's "minotaur" system was used throughout the cruise to record surface temperature and conductivity. These values have not been calibrated.

Underway dissolved gases - (text to be supplied by Weiss).

B.4. XBT and XCTD. None.

B.5. Meteorological observations.

Weather data were logged at each station on the bridge and recorded in an ODF weather file. Continuous measurements were made from the IMET system and logged in the Knorr's "minotaur" computer system.

B.6. Atmospheric chemistry. (To be supplied by Weiss).

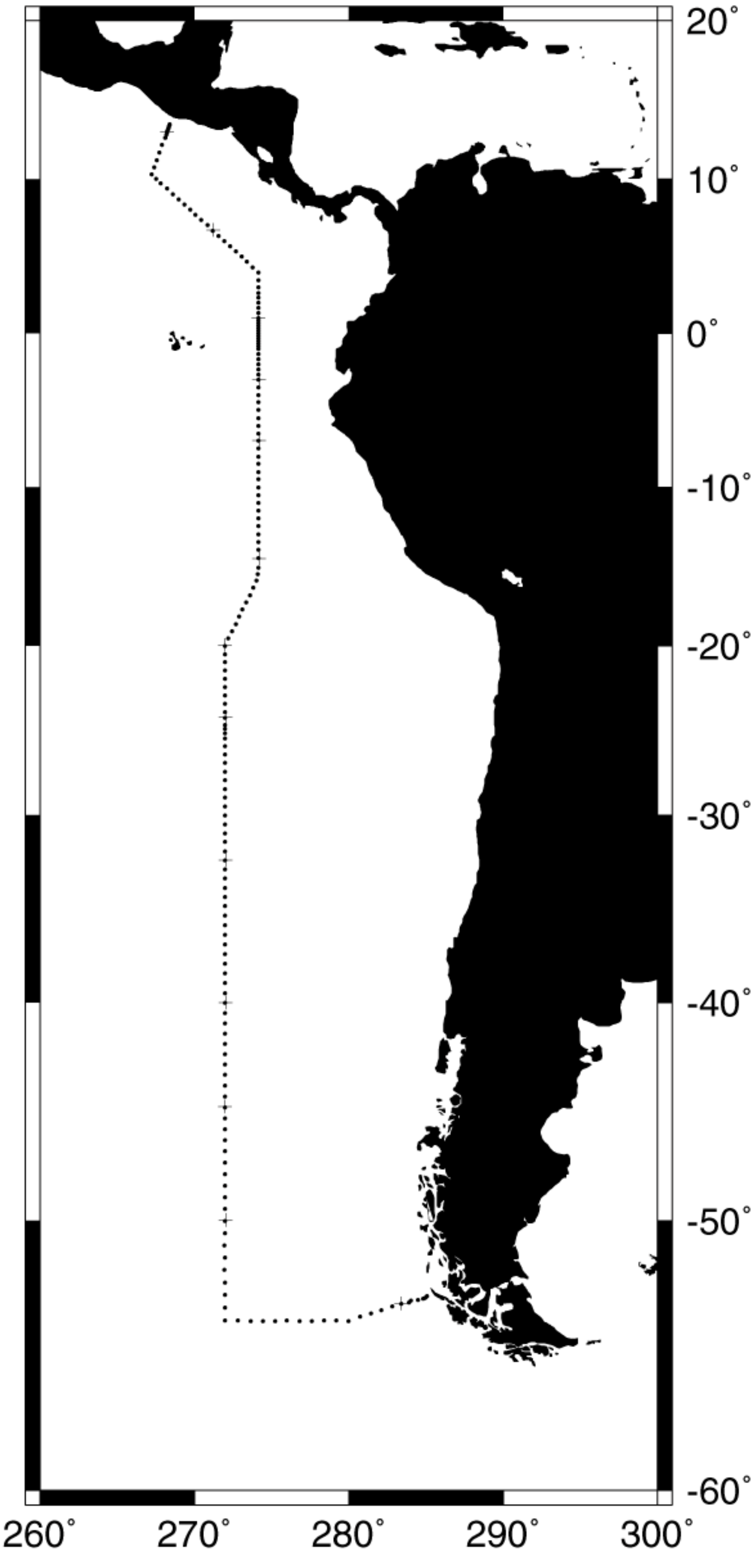


Figure 1. Cruise track for WOCE P19C (R/V Knorr 138-12), 22 Feb 1993 - 13 April 1993. Rosette/CTD stations (circles). Large volume plus rosette/CTD station (crossed circles).

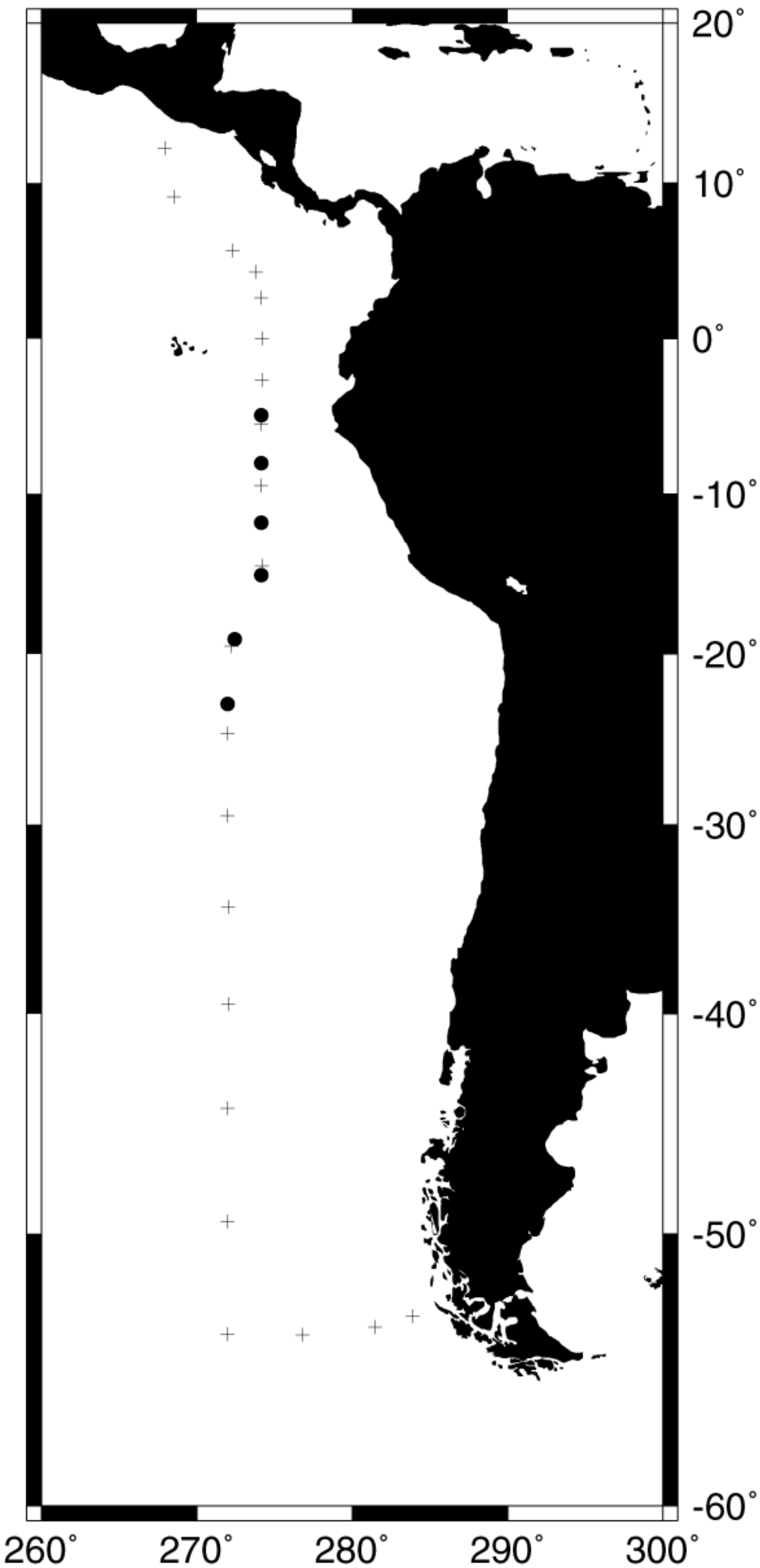


Figure 2. ALACE float (+) and surface drifter (circle) deployments on P19C.

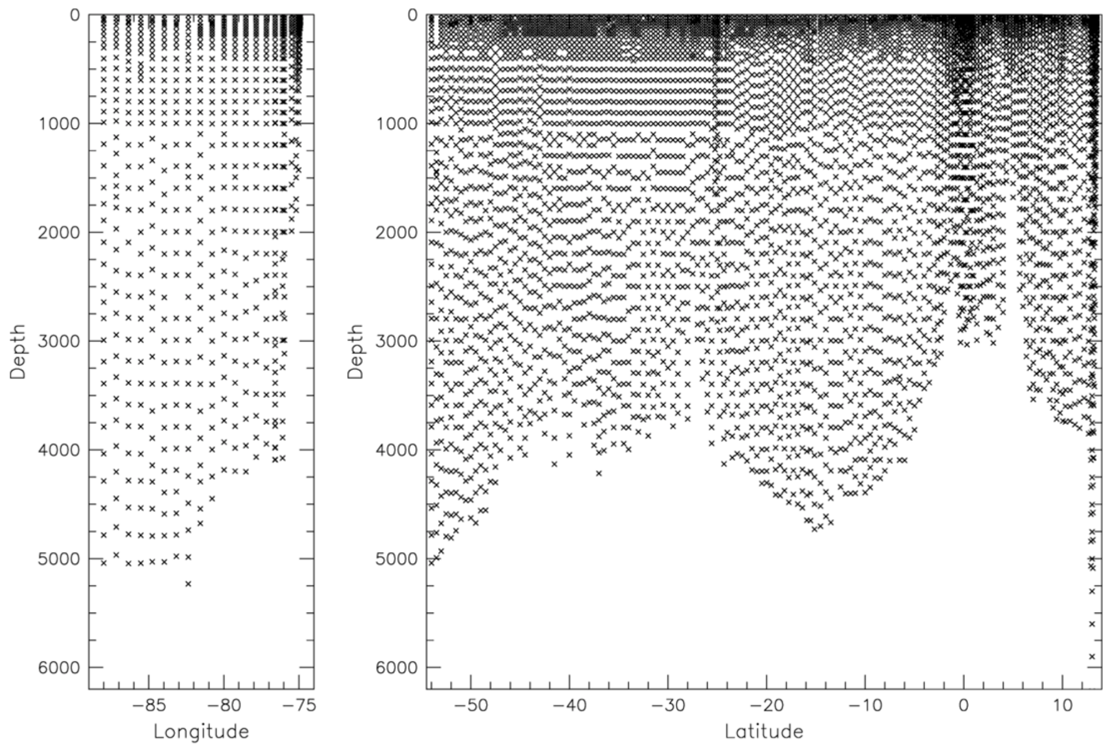


Figure 3. Small volume (10 liter) water samples on P19C.

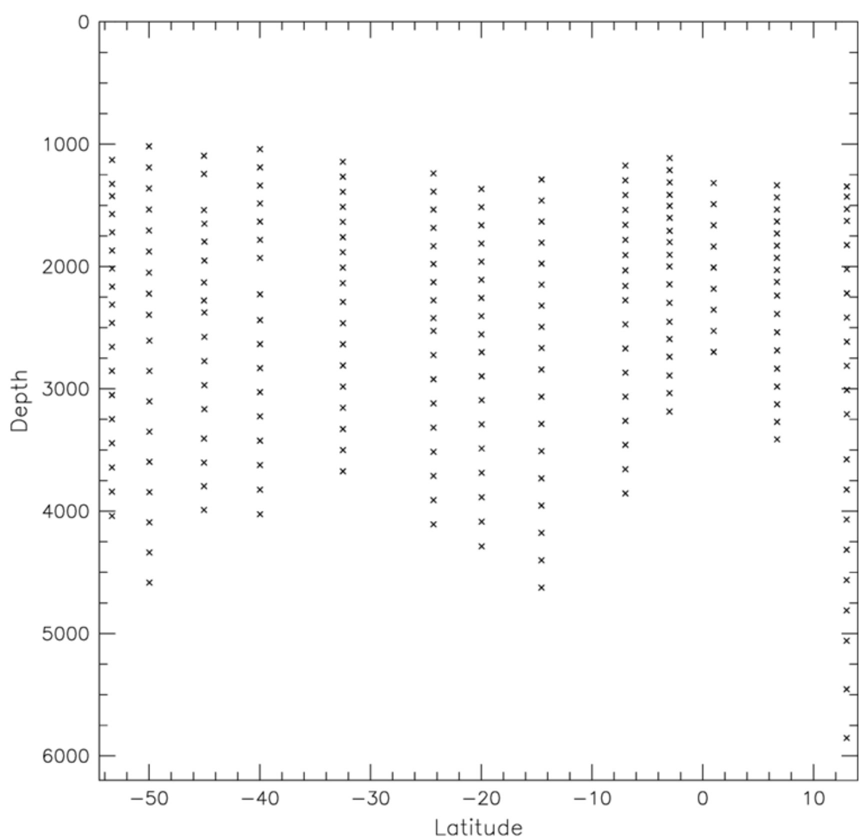
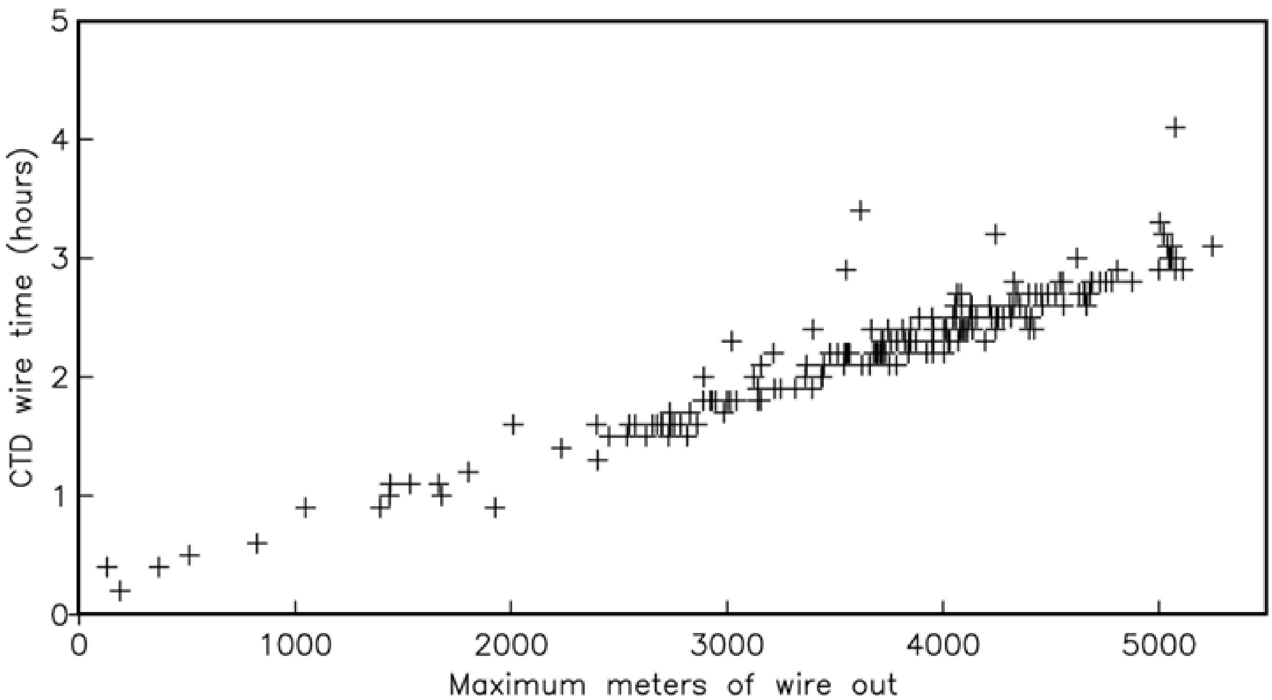


Figure 4. Large volume (Gerard) water samples on P19C.



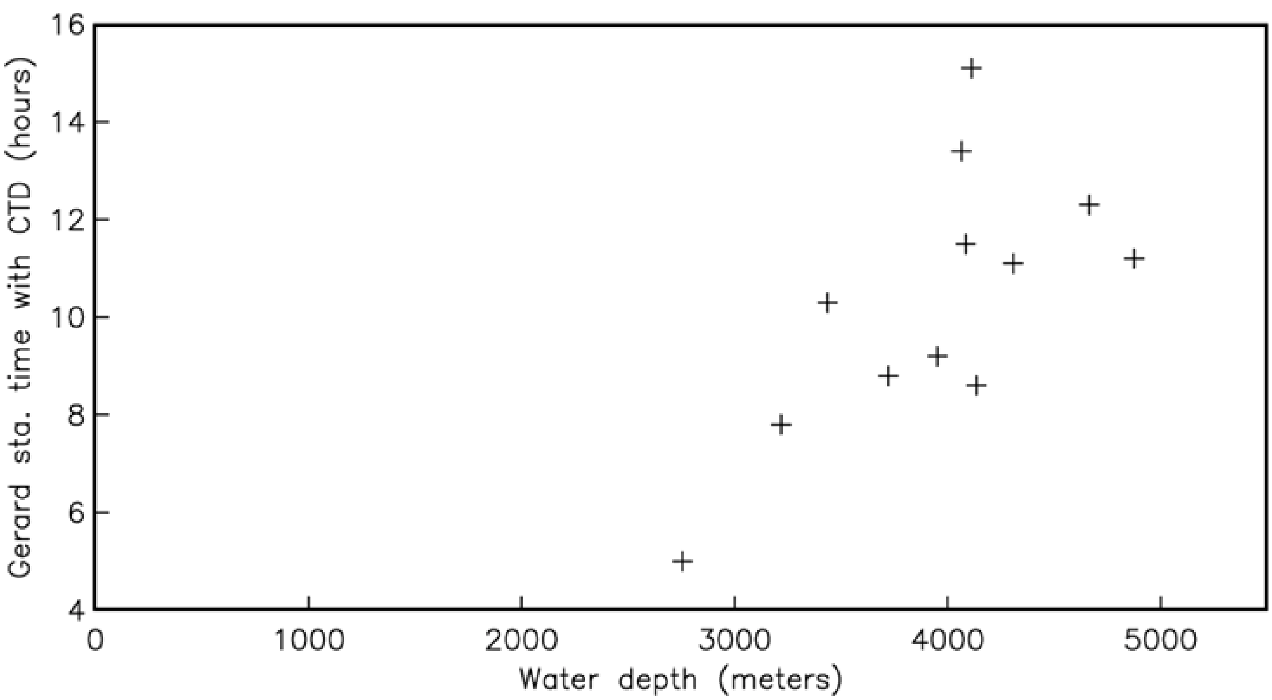


Figure 5. (a) CTD station times (from launch to recovery, not including additional deck time). (b) Gerard station times, from heaving-to to full-ahead, including one or two Gerard barrel casts and a CTD cast.

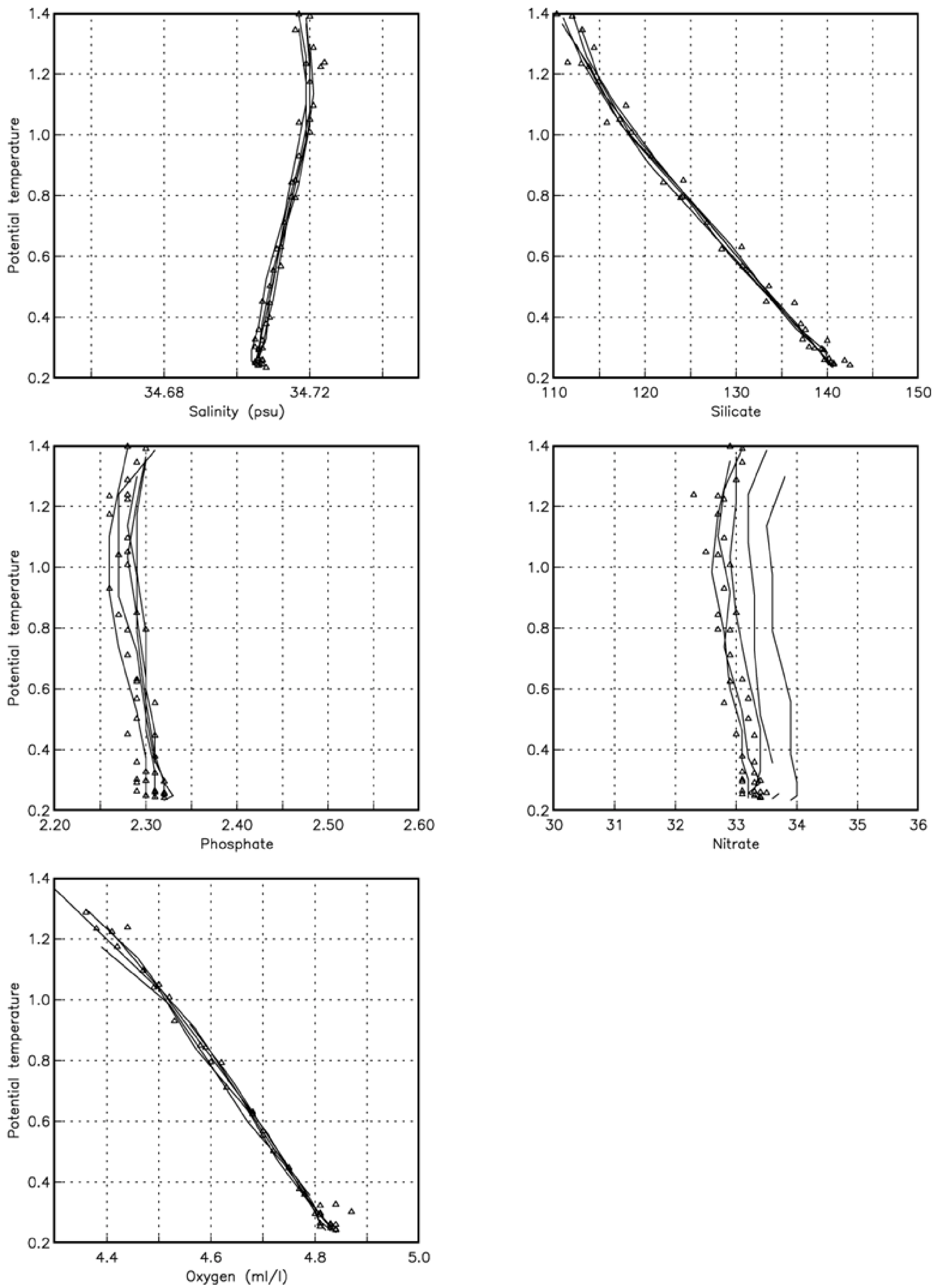


Figure 6. (a) Salinity, (b) phosphate, (c) oxygen, (d) silica, (e) nitrate vs. potential temperature, from P17E stations 204-208 (x) and from P19C stations 254-258 (solid). Both data sets are preliminary.

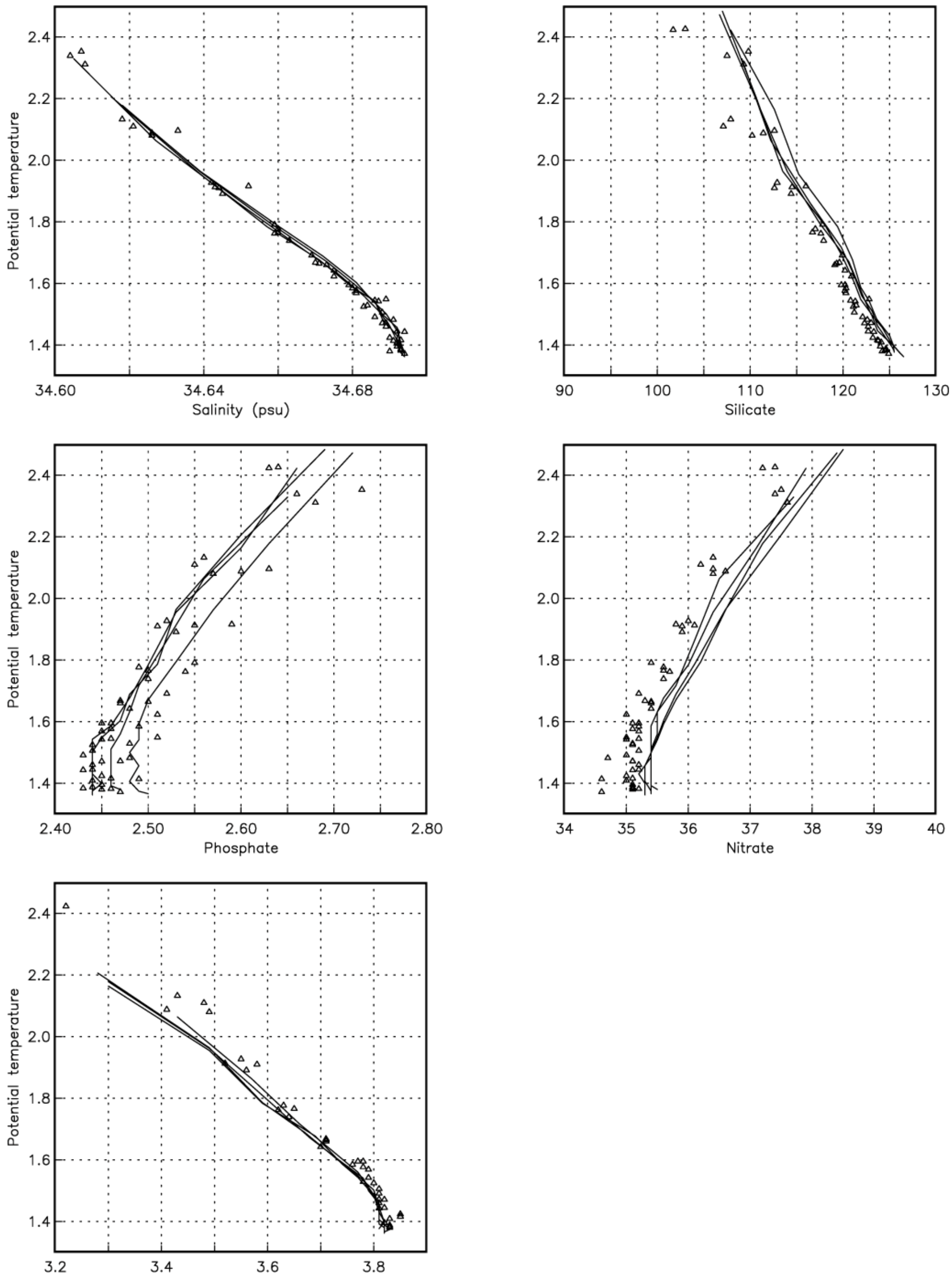


Figure 7. (a) Salinity, (b) phosphate, (c) oxygen, (d) silica, (e) nitrate from P6 stations 33-37 (x) and P19C stations 297-300 (solid), centered at 32°30'S. Both data sets are preliminary.

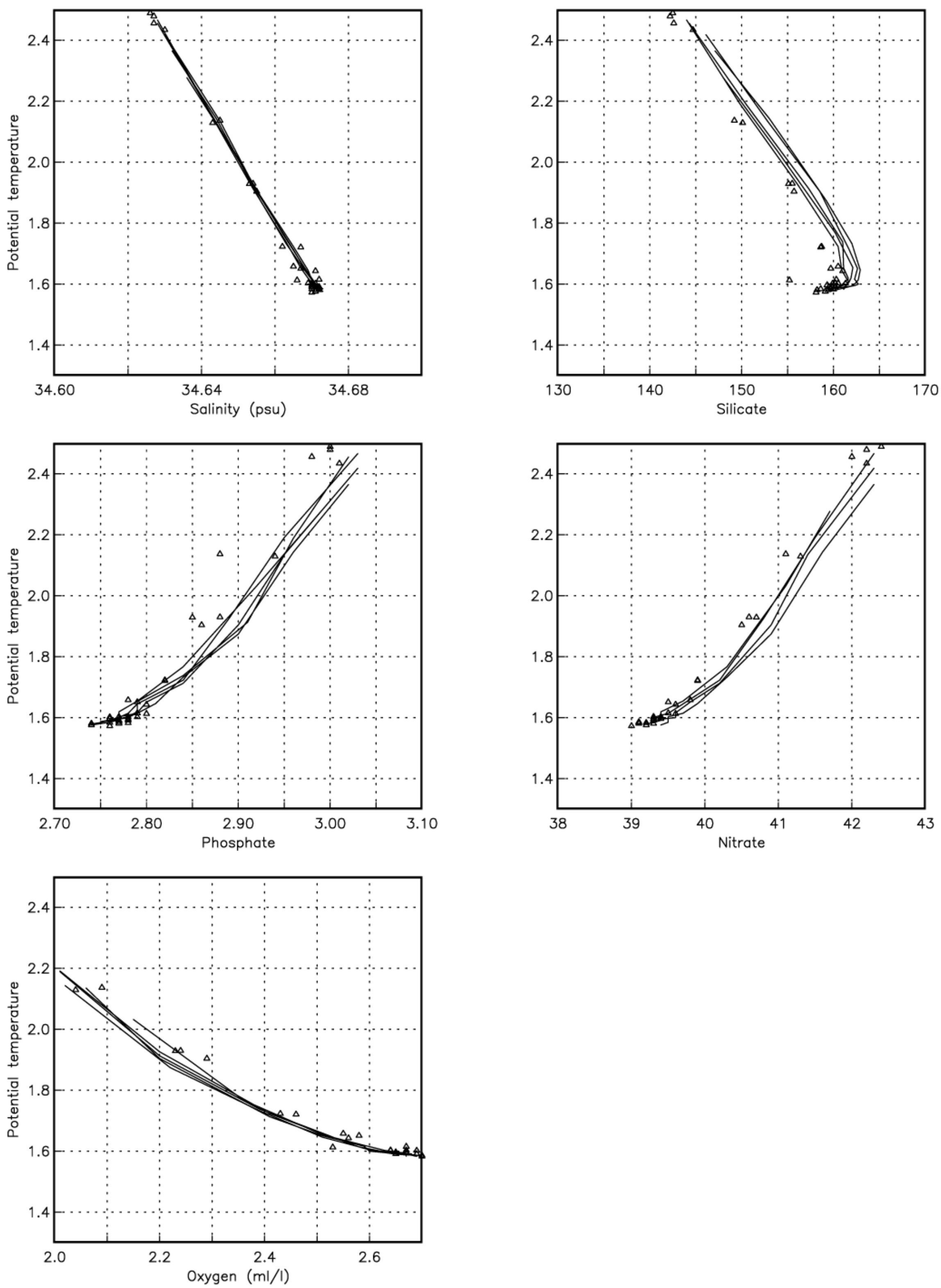


Figure 8. (a) Salinity, (b) phosphate, (c) oxygen, (d) silica, (e) nitrate from Moana Wave (10°N) stations 204-208 (x) and P19C stations 401-405 (solid), centered at 9°30'N. Moana Wave data are final.

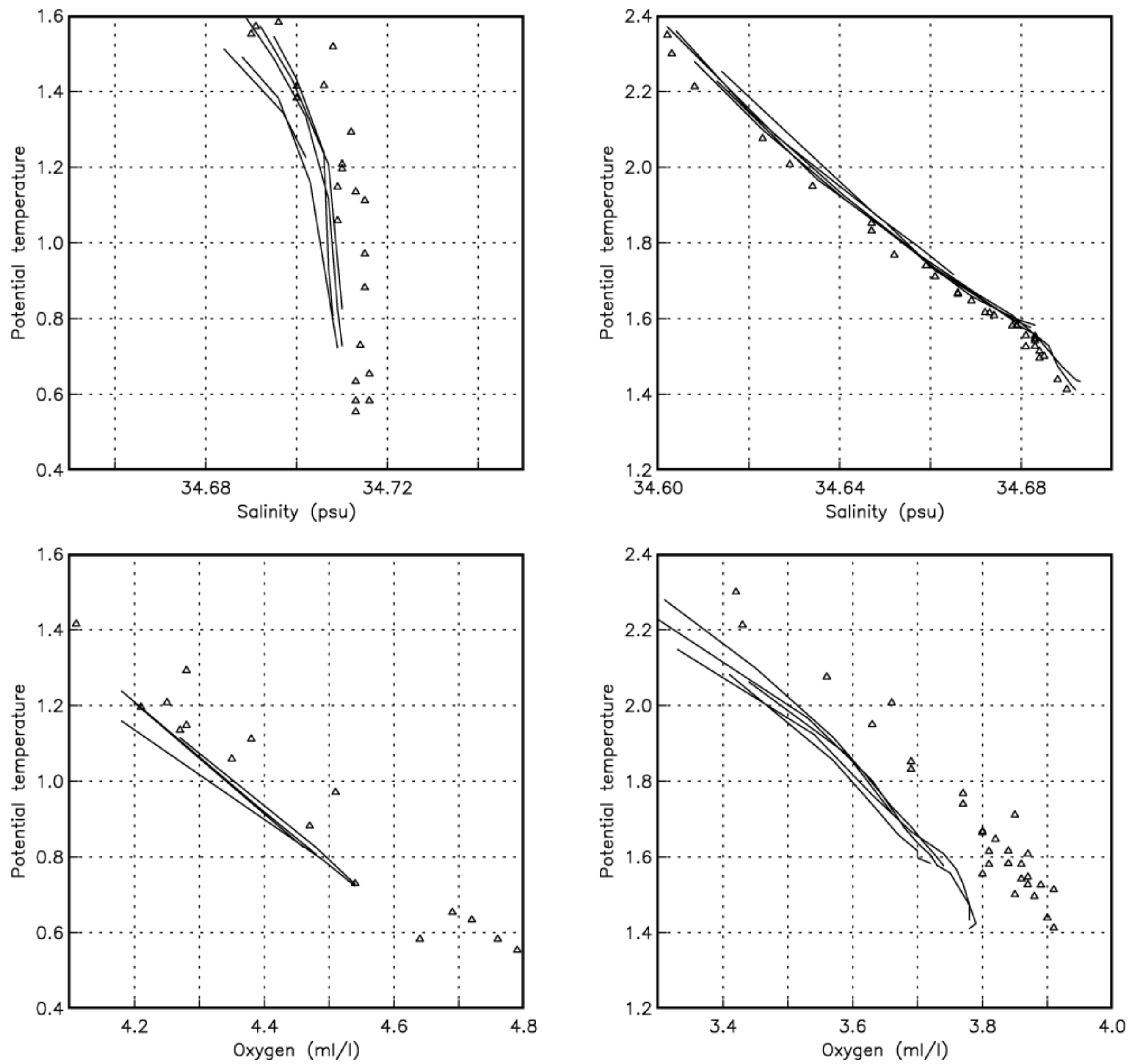


Figure 9. (a) Salinity and (b) oxygen from Scorpio (43°S) stations 65-68 (x) and P19C 276-280 (solid). (c) Salinity and (d) oxygen from Scorpio (28°S) 100-102 (x) and P19C 306-310 (solid).

World Ocean Circulation Experiment (WOCE) P19C
Knorr 138 Leg 12
Expocode: 316N138/12
22 Feb 1993 - 13 April 1993
Punta Arenas, Chile to Balboa, Panama
CHIEF SCIENTIST
Dr. Lynne Talley
Scripps Institution of Oceanography
La Jolla, CA 92093-0230

DATA SUBMITTED BY:
Scripps Institution of Oceanography
11 January 1995

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C. DESCRIPTION OF MEASUREMENT TECHNIQUES AND CALIBRATIONS

ODF CTD/rosette casts were carried out with a 36 bottle rosette sampler of ODF manufacture using General Oceanics pylons. An ODF-modified NBIS Mark 3 CTD, a Benthos altimeter, a SensorMedics oxygen sensor and a SeaTech transmissometer provided by Texas A&M University (TAMU) were mounted on the rosette frame. The 2 CTD temperature channels were compared after each cast to check for drifting or offsets; no problems were noted. The CTD pressure (and temperature) was monitored once daily using a single DSRT; no problems were noted. The DSRT pressures were an average -7 db. compared to the CTD values. Seawater samples were collected in 10-liter PVC ODF bottles mounted on the rosette frame. The frame was a Bullister style 36-place rossette with a GO 36-place pylon. A Benthos pinger was mounted separately on the rosette frame; its signal was displayed on the precision depth recorder (PDR) in the ship's laboratory. The rosette/CTD was suspended from a three-conductor EM cable which provided power to the CTD and relayed the CTD signal to the laboratory.

Each CTD cast extended to within approximately 10 meters of the bottom unless the bottom returns from both the pinger and the altimeter were extremely poor. The bottles were numbered 1 through 36. When one of these 36 bottles needed servicing and repairs could not be accomplished by the next cast, the replacement bottle was given a new number. Subsets of CTD data taken at the time of water sample collection were transmitted to the bottle data files immediately after each cast to provide pressure and temperature at the sampling depth, and to facilitate the examination and quality control of the bottle data as the laboratory analyses were completed. The CTD data and documentation are submitted separately.

After each rosette cast was brought on board, water samples were drawn in the following order: Freon (CFC-11 and CFC-12), Helium-3, Oxygen, ΣCO_2, Alkalinity, and AMS 14C. Tritium, Nutrients (silicate, phosphate, nitrate and nitrite), and Salinity are drawn next and could be sampled in arbitrary order. The identifiers of the sample containers and the numbers of the ODF or Niskin samplers from which the samples were drawn were recorded on the Sample Log sheet. Normal ODF sampling practice is to open the drain valve before opening the air vent to see if water escapes, indicating the presence of a small air leak in the sampler. This observation ("air leak"), and other comments ("lanyard caught in lid", "valve left open", etc.) which may indicate some doubt about the integrity of the water samples were also noted on the Sample Log sheets. These comments are included in this documentation with investigative comments and results.

Tripping problems were experienced at the beginning of the leg until all the lanyards were fine-tuned. The pylons and their deck units reliably indicated bottle tripping problems: the pylon could be repositioned and retried for NO-confirms, and all but one NO-confirmed bottles came up open, as expected. The only other open bottles were a result of lanyard hangups.

Large Volume Sampling (LVS) was also performed on this expedition. These commonly referred to as Gerard casts were carried out with ~270 liter stainless steel Gerard barrels on which were mounted 2-liter Niskin bottles with reversing thermometers. Samples for salinity, silicate and 14C were obtained from the Gerard barrels; samples for salinity and silicate were drawn from the piggyback Niskin bottles. The salinity and silicate samples from the piggyback bottle were used for comparison with the Gerard barrel salinities and silicates to verify the integrity of the Gerard sample.

The discrete hydrographic data were entered into the shipboard data system and processed as the analyses were completed. The bottle data were brought to a usable, though not final, state at sea. ODF data checking procedures included verification that the sample was assigned to the correct depth. This was accomplished by checking the raw data sheets, which included the raw data value and the water sample bottle, versus the sample log sheets. The oxygen and nutrient data were compared by ODF with those from adjacent stations. Any comments regarding the water samples were investigated. The raw data computer files were also checked for entry errors that could have been made on the station number, bottle number and/or flask number (as would be the case for oxygens). The salinity and oxygen values were transmitted from PC's attached to either the salinometer or oxygen titration system. Nutrients were manually entered into the computer; therefore these values were double checked for data entry errors.

Investigation of data included comparison of bottle salinity and oxygen with CTD data, and review of data plots of the station profile alone and compared to nearby stations. In addition, Dr. Mizuki Tsuchiya reviewed the bottle data at sea. He then communicated his concerns to the head ODF chemist on board and appropriate revisions were applied to the data set. If a data value did not either agree satisfactorily with the CTD or with other nearby data, then analysis and sampling notes, plots, and nearby data were reviewed. If any problem was indicated, the data value was flagged. Section E, the Quality Comments, includes comments regarding missing samples and investigative remarks for comments made on the Sample Log sheets, as well as all flagged (WOCE coded) data values other than 2, an acceptable measurement.

The WOCE codes were assigned to the water data using the criteria:

code 1 = Sample for this measurement was drawn from water bottle, but results of analysis not received.
code 2 = Acceptable measurement.
code 3 = Questionable measurement. Does not fit station profile or adjoining station comparisons. No notes from analyst indicating a problem. Datum could be real, but the decision as to whether it is acceptable will be made by a scientist rather than ODF's technicians.
code 4 = Bad measurement. Does not fit station profile and/or adjoining station comparisons. There are analytical notes indicating a problem, but data values are reported. ODF recommends deletion of these data values. Analytical notes for salinity and/or oxygen may include large differences between the water sample and CTD profiles. Sampling errors are also coded 4.
code 9 = Sample for this measurement not drawn.
code P = This code is only used on the LVS pressure. If the Gerard and/or piggyback bottle pre or post-tripped, and a determination was made as to at what pressure the bottles actually tripped within ~50m a P will be assigned to the pressure.

Quality flags assigned to parameter BTLNBR (bottle number) as defined in the WOCE Operations manual are further clarified as follows:

code 4 = If the bottle tripped at a different level than planned, ODF assigned it a code 4. If there is a 4 code on the bottle, and 2 codes on the salinity, oxygen and nutrients then the pressure assignment was probably correct.
code 3 = An air leak large enough to produce an observable effect on a sample is identified by a 3 code on the bottle and 4 code on the oxygen. (Small air leaks may have no observable effect, or may only affect gas samples).

The following table shows the number of ODF samples drawn and the number of times each WOCE sample code was assigned.

Rosette Samples

Stations 234-422												
	Reported levels	Bottle Codes 2	3	4	9	Water Sample Codes 1	2	3	4	5	9
	6344	6250	31	2	61						
Salinity	6258					14	6196	7	41	0	86
Oxygen	6259					4	6219	1	35	0	85
Silicate	6138					15	6094	4	25	0	206
Nitrate	6138					15	6028	71	24	0	206
Nitrite	6138					15	6099	0	24	0	206
Phosphate	6138					15	6080	19	24	0	206

Large Volume Samples

Stations 241, 264, 274, 284, 299, 317, 326, 338, 353, 361, 379, 395, 413													
	Reported levels	Bottle Codes				Water Sample Codes							
		2	3	4	9	1	2	3	4	5	9	P
	456	441	6	8	1							
Salinity	455					0	443	2	10	0	1	
Silicate	455					0	446	1	8	0	1	
Temperature	452					0	454	0	0	0	2	
Pressure	456					0	448	2	0	0	0	6

C.1. Pressure and Temperature

All pressures and temperatures for the bottle data tabulations on the rosette casts were obtained by averaging CTD data for a brief interval at the time the bottle was closed on the rosette.

LVS pressures and temperatures were calculated from deep-sea reversing thermometer (DSRT) readings. Each DSRT rack normally held 2 protected (temperature) thermometers and 1 unprotected (pressure) thermometer. Thermometers were read by two people, each attempting to read a precision equal to one tenth of the thermometer etching interval. Thus, a thermometer etched at 0.05 degree intervals would be read to the nearest 0.005 degrees.

All reported CTD data are calibrated and processed with the methodology described in the documentation accompanying the CTD data submission.

Each temperature value reported on the LVS casts is calculated from the average of four readings provided both protected thermometers function normally. The pressure is verified by comparison with the calculation of pressure determined by wireout. The pressure from the thermometer is fitted by a polynomial equation which incorporates the wireout and wire angle.

Documentation of CTD calibration is included with the CTD data. Calibration of the thermometers are performed in ODF's calibration facility depending on the age of the thermometer and not more than two years of the expedition.

The temperatures are based on the International Temperature Scale of 1990.

C.2. Salinity

A single ODF-modified Guildline Autosal Model 8400A salinometer (Serial Number 57-396), located in a temperature-controlled laboratory, was used to measure salinities. Analyses and data acquisition were controlled by a small computer through an interface board designed by ODF. The salinometer cell was flushed until successive readings met software criteria, then two successive measurements were made and averaged for a final result.

Salinity samples were analyzed for the rosette casts and the Large Volume casts from both the piggyback bottle and the Gerard barrel. Salinity samples were drawn into 200 ml Kimax high alumina borosilicate bottles, after 3 rinses, and were sealed with custom-made plastic insert thimbles and Nalgene screw caps. This assembly provides very low container dissolution and sample evaporation. If loose inserts were found, they were replaced to ensure an airtight seal. Salinity was determined after sample equilibration to laboratory temperature, usually within 8-36 hours of collection. Salinity was calculated according to the equations of the Practical Salinity Scale of 1978 (UNESCO, 1981).

Salinity samples were compared with CTD data and significant differences were investigated. The salinometer was standardized for each cast with IAPSO Standard Seawater (SSW) Batch P-120, using at least one fresh vial per cast.

There were some problems with lab temperature control throughout cruise; the Autosal bath temperature was adjusted accordingly. Salinities were generally considered good for the expedition despite the lab temperature problem.

The estimated accuracy of bottle salinities run at sea is usually better than 0.002 psu relative to the particular Standard Seawater batch used. Although laboratory precision of the Autosal can be as small as 0.0002 psu when running replicate samples under ideal conditions, at sea the expected precision is about 0.001 psu under normal conditions, with a stable lab temperature.

C.3. Oxygen

Dissolved oxygen analyses were performed with an SIO-designed automated oxygen titrator using photometric end-point detection based on the absorption of 365 nm wav elength ultra-violet light. Thiosulfate was dispensed by a Dosimat 665 buret driver fitted with a 1.0 ml buret. ODF uses a whole-bottle Winkler titration following the technique of Carpenter (1965) with modifications by Culberson et al. (1991), but with higher concentrations of potassium iodate standard (approximately 0.012N) and thiosulfate solution (50 gm/l). Standard solutions prepared from pre-weighed potassium iodate crystals were run at the beginning of each session of analyses, which typically included from 1 to 3 stations. Several standards were made up during the cruise and compared to assure that the results were reproducible, and to preclude the possibility of a weighing error. Reagent/distilled water blanks were determined to account for oxidizing or reducing materials in the reagents. The auto-titrator generally performed very well.

Samples were collected for dissolved oxygen analyses soon after the rosette sampler was brought on board and after CFC and helium were drawn. Nominal 125 ml volume-calibrated iodine flasks were rinsed twice with minimal agitation, then filled via a drawing tube, and allowed to overflow for at least 3 flask volumes. The sample temperature was measured with a small platinum resistance thermometer embedded in the drawing tube. Reagents were added to fix the oxygen before stoppering. The flasks were shaken twice; immediately after drawing, and then again after 20 minutes, to assure thorough dispersion of the $MnO(OH)_2$ precipitate. The samples were analyzed within 4-36 hours of collection.

Draw temperatures were very useful in detecting possible bad trips even as samples were being drawn. The data were logged by the PC control software and then transferred to the Sun (the main computer) and calculated.

Blanks, and thiosulfate normalities corrected to 20°C, calculated from each standardization, were plotted versus time, and were reviewed for possible problems. New thiosulfate normalities were recalculated after the blanks had been smoothed. These normalities were then smoothed, and the oxygen data was recalculated.

Oxygens were converted from milliliters per liter to micromoles per kilogram using the in-situ temperature. Ideally, for whole-bottle titrations, the conversion temperature should be the temperature of the water issuing from the Niskin bottle spigot. The sample temperatures were measured at the time the samples were drawn from the bottle, but were not used in the conversion from milliliters per liter to micromoles per kilogram because the software is not available. Aberrant temperatures provided an additional flag indicating that a bottle may not have tripped properly. Measured sample temperatures from mid-deep water samples were about 4-7°C warmer than in-situ temperature. Had the conversion with the measured sample temperature been made, converted oxygen values, would be about 0.08% higher for a 6°C warming (or about 0.2 μmol/kg for a 250 μmol/kg sample).

Oxygen flasks were calibrated gravimetrically with degassed deionized water (DIW) to determine flask volumes at ODF's chemistry laboratory. This is done once before using flasks for the first time and periodically thereafter when a suspect bottle volume is detected. All volumetric glassware used in preparing standards is calibrated as well as the 10ml Dosimat buret used to dispense standard Iodate solution.

Iodate standards are pre-weighed in ODF's chemistry laboratory to a nominal weight of 0.44xx grams and exact normality calculated at sea.

Potassium Iodate (KIO_3) is obtained from Johnson Matthey Chemical Co. and is reported by the suppliers to be > 99.4% pure. All other reagents are "reagent grade" and are tested for high levels of oxidizing and reducing impurities prior to use.

C.4. Nutrients

Nutrient analyses (phosphate, silicate, nitrate and nitrite) were performed on an ODF-modified AutoAnalyzer II, generally within a few hours of the cast, although some samples may have been refrigerated at 2 to 6°C for a maximum of 12 hours. The procedures used are described in Gordon et al. (1992).

Silicate is analyzed using the basic method of Armstrong et al. (1967). Ammonium molybdate is added to a seawater sample to produce silicomolybdic acid which is then reduced to silicomolybdous acid (a blue compound) following the addition of stannous chloride. The sample is passed through a 15mm flowcell and measured at 820nm. This response is known to be non-linear at high silicate concentrations; this non-linearity is included in ODF's software.

A modification of the Armstrong et al. (1967) procedure is used for the analysis of nitrate and nitrite. For nitrate analysis, a seawater sample is passed through a cadmium column where the nitrate is reduced to nitrite. This nitrite is then diazotized with sulfanilamide and coupled with N-(1-naphthyl)-ethylenediamine to form an azo dye. The sample is then passed through a 15mm flowcell and measured at 540nm. A 50mm flowcell is required for nitrite (NO2). The procedure is the same for the nitrite analysis less the cadmium column.

Phosphate is analyzed using a modification of the Bernhardt and Wilhelms (1967) method. Ammonium molybdate is added to a seawater sample to produce phosphomolybdic acid, which is then reduced to phosphomolybdous acid (a blue compound) following the addition of dihydrazine sulfate. The sample is passed through a 50mm flowcell and measured at 820nm.

Besides running rosette cast samples, LVS cast samples for both Gerard barrels and piggyback Niskins were analyzed for silicate as an added check (with salinity) on barrel sample integrity.

Nutrient samples were drawn into 45 ml high density polypropylene, narrow mouth, screw-capped centrifuge tubes which were rinsed three times before filling. Standardizations were performed at the beginning and end of each group of analyses (one cast, usually 36 samples) with a set of an intermediate concentration standard prepared for each run from secondary standards. These secondary standards were in turn prepared aboard ship by dilution from dry, pre-weighed standards. Sets of 4-6 different concentrations of shipboard standards were analyzed periodically to determine the deviation from linearity as a function of concentration for each nutrient.

All peaks were logged manually, and all the runs were re-read to check for possible reading errors.

Temperature regulation problems in the analytical lab did not appear to significantly affect the results, which were generally very good. ODF first attempted to control the temperature in the lab during the previous leg by rigging up a ceramic heater and fan, under the control of a thermistor and in conjunction with the ship's cooling. This worked well on this leg, providing about plus or minus 0.5°C stability, except when outside temperatures were too warm in the tropics, or when it became too cold and the ship's heating system was erratically controlled.

Nutrients, reported in micromoles per kilogram, were converted from micromoles per liter by dividing by sample density calculated at zero pressure, in-situ salinity, and an assumed laboratory temperature of 25°C.

Silicate standard is obtained from Fischer Scientific and is reported by the supplier to be >98% pure. Nitrate, nitrite and phosphate standards are obtained from Johnson Matthey Chemical Co. and the supplier reports a purity of 99.999%, 97%, and 99.999%, respectively.

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E. Quality Comments

Remarks for deleted samples, missing samples, and WOCE codes other than 2 from WOCE P19C. 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 rereading of charts (i.e., nutrients). Comments from the Sample Logs and the results of ODF's investigations are included in this report.

Station 234

176 @ 2db	Sample log: "leaking from top cap." Delta-S is -1.002, oxygen ˜.1 high, no3 and po4 low, no2 high. Not sure where the water is from. Salinity too low to have come from deeper in water water column. Footnote bottle leaking, samples bad.
175 @ 27db	Sample log: "leaking from cap." Data appears to be okay.
171 @ 44db	Only oxygen drawn.
172 @ 46db	Only oxygen drawn.
173 @ 46db	Only oxygen drawn.
174 @ 48db	Sample log: "leaking slightly from bottom." Oxygen values same as duplicate bottles. Only oxygen drawn.
152 @ 53db	Sample log: "open." No samples drawn.
153 @ 54db	Only oxygen drawn.
154 @ 54db	Sample log: "leaking." Oxygen about .01 ml/l high. Only oxygen drawn. Footnote bottle leaking, oxygen bad.
155 @ 56db	Sample log: "open." No samples drawn.
156 @ 57db	Only oxygen drawn.
157 @ 59db	Only oxygen drawn.
158 @ 61db	Only oxygen drawn.
159 @ 63db	Sample log: "slight leak from top." Oxygen agrees with bottles from same depth. Only oxygen drawn.
160 @ 65db	Only oxygen drawn.
161 @ 66db	Only oxygen drawn.
162 @ 67db	Only oxygen drawn.
163 @ 68db	Only oxygen drawn.
164 @ 69db	Only oxygen drawn.
165 @ 70db	Only oxygen drawn.
132 @ 71db	Only oxygen drawn.
166 @ 71db	Sample log: "open." No samples drawn.
133 @ 72db	Only oxygen drawn.
134 @ 72db	Only oxygen drawn.
136 @ 72db	Only oxygen drawn.
167 @ 72db	Sample log: "slightly leaky from top, very warm draw temp." PI: "leaky btl/high oxy/high draw temp; dup.btls/same depth ok salt looks ok despike oxy/leaky bottle, no nuts drawn." Only oxygen drawn, suspect PI was commenting on CTD salinity. ODF recommends deletion of water samples. Footnote bottle leaking, oxygen bad.
135 @ 73db	Only oxygen drawn.

168 @ 73db	Only oxygen drawn.
169 @ 73db	Sample log: "leaking from bottom." Oxygen .01 lower than 4 duplicate trips. ODF recommends deletion of oxygen value. Only oxygen drawn.
131 @ 100db	Sample log: "leaking from stem." Data appears to be okay.

Station 235

152 @ 3db	Sample log: "open." No samples drawn.
131 @ 29db	Sample log indicates salinity and nutrients were drawn; they were not analyzed. Footnote salinity and nutrients lost.
176 @ 53db	Sample log: "leaking from bottom." No samples drawn.
174 @ 78db	Sample log indicates salinity and nutrients were drawn; they were not analyzed. Footnote salinity and nutrients lost.
172 @ 103db	Sample log indicates salinity and nutrients were drawn; they were not analyzed. Footnote salinity and nutrients lost.
170 @ 128db	Sample log indicates salinity and nutrients were drawn; they were not analyzed. Footnote salinity and nutrients lost.
128 @ 152db	Sample log indicates nutrients were drawn; they were not analyzed. Footnote nutrients lost.
168 @ 177db	Sample log indicates salinity and nutrients were drawn; they were not analyzed. Footnote salinity and nutrients lost.
167 @ 203db	Sample log: "dry." No samples drawn.
166 @ 233db	Sample log indicates salinity and nutrients were drawn; they were not analyzed. Footnote salinity and nutrients lost.
159 @ 261db	Sample log: "open." No samples drawn.
161 @ 262db	Sample log indicates nutrients were drawn; they were not analyzed. Footnote nutrients lost.
162 @ 262db	Sample log indicates nutrients were drawn; they were not analyzed. Footnote nutrients lost.
163 @ 262db	Sample log indicates nutrients were drawn; they were not analyzed. Footnote nutrients lost.
164 @ 263db	Sample log indicates salinity and nutrients were drawn; they were not analyzed. Footnote salinity and nutrients lost.
165 @ 263db	Sample log indicates salinity and nutrients were drawn; they were not analyzed. Footnote salinity and nutrients lost.
158 @ 301db	Sample log indicates nutrients were drawn; they were not analyzed. Footnote nutrients lost.
156 @ 351db	Sample log: "open." No samples drawn.
155 @ 401db	Sample log: "leaking from bottom." Data appears to be okay.

Station 236

152 @ 2db	Sample log: "open - lanyard problem." No samples drawn.
131 @ 28db	Sample log: "leak." Data appears to be okay.
174 @ 128db	Sample log: "bad O2 T?." chk sil max = ok: salt/nuts also max here, same structure adjoining stations. Delta-S at 128db is 0.0712, salinity is 34.088.
172 @ 180db	Sample log: "leaker." oxy looks high, no corresp. nuts signal; ctd oxy=same structure

170 @ 253db	Sample log: "leaker." Oxygen not drawn, sample log indicates salinity was drawn. Footnote salinity lost, no analysis was performed. Nutrients plot vs. adjoining stations appears reasonable indicating that leak noted on sample log did not effect water samples, no gas samples were drawn.
168 @ 405db	Oxygen not drawn per sampling schedule.
135 @ 406db	See 167 oxygen comment. This also appears high, suspect same problem as 167. Footnote oxygen bad.
134 @ 455db	Oxygen not drawn per sampling schedule. Footnote salinity lost. No reason noted why samples weren't run.
132 @ 557db	Oxygen not drawn per sampling schedule. Footnote salinity lost. No reason noted why samples weren't run.
162 @ 656db	Oxygen not drawn per sampling schedule. Footnote salinity lost. No reason noted why samples weren't run.
164 @ 606db	Oxygen not drawn per sampling schedule. Footnote salinity lost. No reason noted why samples weren't run.
167 @ 455db	Sample log: "O2 sodium hydroxide possible problem." Footnote oxygen bad.
166 @ 506db	Oxygen not drawn per sampling schedule.
160 @ 706db	nuts/salt from 1-2 lvls deeper - pretrip?; no oxy drawn Footnote samples bad, bottle leaking. ODF recommends deletion of all water samples.
156 @1006db	Sample log: "open - lanyard problem." No samples drawn.

Station 237

151 @ 2db	Sample log: "slight leak at valve." Data appears to be okay.
131 @ 29db	Sample log: "leak from valve." Data appears to be okay.
130 @ 103db	Oxygen not drawn per sampling schedule.
170 @ 205db	Sample log: "small leak." Data appears to be okay.
168 @ 406db	Sample log: "leaks around valve." Data appears to be okay.
134 @ 456db	Sample log: "loose spring tension." Oxygen not drawn per sampling schedule.
132 @ 606db	Oxygen not drawn per sampling schedule.
164 @ 607db	Oxygen not drawn per sampling schedule.
165 @ 607db	Oxygen not drawn per sampling schedule.
166 @ 607db	Oxygen not drawn per sampling schedule.
162 @ 707db	Oxygen not drawn per sampling schedule.

Station 238

152 @ 3db	Sample log: "leaking around bottom cap." Data appears to be okay.
131 @ 38db	Sample log: "leaking around spigot." Data appears to be okay.
176 @ 63db	Sample log: "leaking." Data appears to be okay.
134 @ 380db	Sample log: "leaking." Data appears to be okay.
164 @ 978db	Sample log: "leaking from drain cock." Data appears to be okay.
155 @1782db	Sample log: "slight leak." Data appears to be okay.

Station 239

131 @ 30db	Sample log: "small leak from spigot." Data appears to be okay.
176 @ 81db	Sample log: "leak, bad top end cap." Data appears to be okay.
170 @ 207db	Sample log: "bad leak, bad top end cap." Data appears to be okay.

163 @1213db Sample log: "bottom spigot open." Data appears to be okay.
160 @1822db Sample log: "leak from top end cap." Data appears to be okay.

Station 240
102 @ 81db Sample log: "top didn't set - minor leak." Oxygen appears slightly high, other samples acceptable. Suspect leak affected gas samples. Footnote bottle leaking, oxygen bad.
176 @ 106db Sample log: "leaker." Data appears to be okay.

Station 241
231 @ 56db Sample log: "small leak in valve." Data appears to be OK.
274 @ 156db Sample log: "bottom leak." Data appears to be OK.
451 @ 205db Sample log: "leaking around bottom end cap." looks like pretrip compared to c.2, but in-line on c.4
234 @ 703db Sample log: "leak from bottom end cap." Samples agree with previous station.
215 @1003db Sample log: "open - lanyard too short." No samples drawn.
213 @1408db Sample log: "open - lanyard too short." No samples drawn.
473 @1412db Sample log: "leaking from drain cock." Data appears to be OK.
211 @1813db Sample log: "oxy draw temp high - leaker." oxy too high; other bottle values look ok. Footnote bottle leaking, oxygen bad. ODF recommends deletion of gas samples. Salinity and nutrients were not drawn.
209 @2322db Sample log: "open - lanyard too short." No samples drawn.
207 @2833db Sample log: "open - lanyard too short." No samples drawn.
434 @3032db Sample log: "leaking around bottom end cap." Data appears to be okay.
206 @3087db Sample log: "open - lanyard too short." No samples drawn.
205 @3342db Sample log: "open - lanyard too short." No samples drawn.
204 @3546db Sample log: "spigot ring fell off." Data appears to be OK. sil looks low, no analysis comments; matches sta 243
413 @3644db Sample log: "open, no water." No samples drawn.
203 @3799db Sample log: "Open, new setup for bottle positions and lanyard were too short, no water." No samples drawn.
410 @3847db Sample log: "slow leak from drain cock." Data appears to be OK.
411 @3847db Sample log: "open, no water." No samples drawn.
407 @4049db Sample log: "open, no water." No samples drawn.
403 @4164db Sample log: "open, no water." No samples drawn.
276 @4167db Sample log: "Open, new setup for bottle positions and lanyard were too short, no water." No samples drawn.

Station 242
152 @ 3db Sample log: "bad leak." Comment of a leak does not appear to have affected the samples. NO3 and PO4 agree with previous stations.
131 @ 57db Sample log: "bad leak from bottom." Data appears to be OK.
132 @ 82db Delta-S at 82db is 0.0503, salinity is 33.896. CTD salinity trace has unrealistic spike. Footnote CTD salinity bad.
172 @ 207db Sample log: "slow leak from bottom." Data appears to be OK.
134 @ 710db Sample log: "slow leak." Data appears to be OK.

114 @1214db Sample log: "slow leak (bottom end cap?)." Data appears to be OK.
103 @3552db Sample log: "top end cap open." all properties from shallower water - reject Footnote bottle leaking, samples bad. ODF recommends deletion of all water samples.
176 @4015db Sample log: "leaking from top end cap." Data appears to be OK.

Station 243
151 @ 1db Sample log: "leak at the bottom valve." Data appears to be okay.
131 @ 30db Sample log: "leak at the bottom valve." Data appears to be okay.
174 @ 130db Sample log: "leaker bottom cap." Data appears to be okay.
172 @ 181db Sample log: "leaker bottom cap." Data appears to be okay.
167 @ 704db Sample log: "leaker bottom cap." Data appears to be okay.

Station 244
136 @ 2db Delta-S at 2db is 0.0334, salinity is 33.956. Bottle salinity agrees with adjoining stations, CTD salinity (up trace) has a spike in the data; footnote CTD salinity bad.
151 @ 31db Sample log: "slow leak at the valve." Data appears to be okay.
131 @ 56db Sample log: "slow leak at the valve." Data appears to be okay. Delta-S at 56db is 0.062, salinity is 34.014. Bottle salinity agrees with adjoining stations, CTD salinity (up trace) has a spike in the data; footnote CTD salinity bad.
117 @ 805db Sample log: "possible leak at the top?." Data appears to be okay.
114 @1210db Sample log: "O2 T seems high." Data appears to be okay.
111 @1817db Sample log: "slow leak at the valve." Data appears to be okay.

Station 245
136 @ 3db Surface nuts/salt max looks strange; oxy draw temp low probable pre-trip at 60m. Footnote bottle leaking, samples bad. ODF recommends deletion of all water samples.
134 @ 57db Sample log: "leaking badly." Data appears to be okay.
131 @ 131db Sample log: "spigot loose." Data appears to be okay.
117 @1208db Sample log: "leaking (top end cap?), loose spigot." Data appears to be okay. oxy: check endpoint

Station 246
133 @ 83db Sample log: "vent open." Data appears to be okay.
131 @ 133db Sample log: "slight leak." Data appears to be okay.
128 @ 710db Sample log: "vent not tightly closed." Data appears to be okay.
117 @1109db Sample log: "leaker." Data appears to be okay.

Station 247
136 @ 2db Sample log: "surface btl may have trapped air when triggering." surface oxy min/nuts max doubtful; low oxy draw temp=pretrip Footnote bottle leaking, all samples bad. ODF recommends deletion of all water samples.
131 @ 108db Sample log: "valve leak." Data appears to be okay.
122 @ 611db Sample log: "open." No samples drawn.

116 @1417db Sample log: "open." No samples drawn.
111 @2434db Sample log: "slow valve leak." Data appears to be okay.

Station 248
134 @ 78db Sample log: " major leak - bottom cap." Data appears to be okay.
131 @ 132db Sample log: " small leak lower valve." Data appears to be okay.
172 @ 403db Sample log: " leaky bottom." Data appears to be okay.
121 @ 805db Sample log: " leaky valve when open." Data appears to be okay.
174 @1305db Sample log: " Leaky - bottom cap.." Data appears to be okay.

Station 249
131 @ 248db Sample log: "leaky spigot." Data appears to be okay.
122 @1007db Sample log: "no water, btm end cap didn't shut." No samples drawn.

Station 250
134 @ 68db Sample log: "vent open, and leaking." Data appears to be okay.
124 @ 708db Sample log: "salt bottle 24 broken (salt box A)." Sampler must have gotten another bottle because there is a salinity sample.
117 @1816db Sample log: "leaker." Data appears to be okay.
113 @2426db oxy/nuts/salt vert. sects. bulge btwn 1000-3200db. probably ok. ctd deep theta-salin curve also diverges from nearby stas oxy low compared to ctd btl/ctd salt diff larger than usual no sample log comments, suspect btl problem silicate low/oxy low Delta-S at 2629db is -0.0081, salinity is 34.707. Footnote bottle did not trip as scheduled. Bottles tripped with 14, after correction of pressure all samples acceptable.
101 @5080db Sample log: "leaky bottom collar." Data appears to be okay.

Station 251
131 @ 158db Sample log: "leak lower valve." Data appears to be okay.
121 @1013db Sample log: "slow leak lower valve." Data appears to be okay.
117 @1824db Sample log: "leak from upper cap." Data appears to be okay.
116 @2027db Sample log: "MnCl2 air on oxygen 1178." salt/nuts low, oxy high, oxy draw temp high - leaker/post-trip? Footnote bottle leaking, samples bad. ODF recommends deletion of water samples.
111 @3045db Sample log: "small leak lower valve." Data appears to be okay.
109 @3454db Sample log: "upper vent not closed well." Data appears to be okay.

Station 252
117 @1558db Sample log: "leaks from petcock with air vent closed." Data appears to be okay.

Station 253
131 @ 206db Sample log: "valve dripping." Data appears to be okay.
117 @1617db Sample log: "slow leak." Data appears to be okay.
115 @2024db salt/nuts low, oxy high - leak? No sample log comments. Footnote bottle leaking, samples bad.

Station 254

117 @1613db Sample log: "leaking after drain cock pushed in." Data appears to be okay.

108 @3440db Sample log: "one Niskin popped open on boom during recovery - fresh ding indicates 8." Oxygen: lost smpl: flask label in front of uv beam, missed endpoint. Footnote oxygen lost. No other gas samples drawn.

Station 255

136 @ 4db See 101 NO3 comment; footnote nitrate uncertain.

135 @ 37db See 101 NO3 comment; footnote nitrate uncertain.

168 @ 67db See 101 NO3 comment; footnote nitrate uncertain.

133 @ 103db See 101 NO3 comment; footnote nitrate uncertain.

132 @ 156db See 101 NO3 comment; footnote nitrate uncertain.

131 @ 206db See 101 NO3 comment; footnote nitrate uncertain. Sample log: "leak lower valve when open." Data appears to be okay.

130 @ 256db See 101 NO3 comment; footnote nitrate uncertain.

129 @ 302db See 101 NO3 comment; footnote nitrate uncertain.

128 @ 398db See 101 NO3 comment; footnote nitrate uncertain.

127 @ 497db See 101 NO3 comment; footnote nitrate uncertain.

126 @ 595db See 101 NO3 comment; footnote nitrate uncertain.

125 @ 693db See 101 NO3 comment; footnote nitrate uncertain.

124 @ 791db See 101 NO3 comment; footnote nitrate uncertain.

123 @ 892db See 101 NO3 comment; footnote nitrate uncertain.

122 @ 989db Nutrients appear to have been drawn from btl 24. Footnote nutrients bad. ODF recommends deletion of nutrients.

121 @1138db See 101 NO3 comment; footnote nitrate uncertain. Sample log: "top air vent not fully closed (possible top cap leak)." Data appears to be okay.

120 @1291db See 101 NO3 comment; footnote nitrate uncertain.

119 @1494db See 101 NO3 comment; footnote nitrate uncertain.

118 @1594db See 101 NO3 comment; footnote nitrate uncertain.

117 @1694db See 101 NO3 comment; footnote nitrate uncertain.

116 @1794db See 101 NO3 comment; footnote nitrate uncertain.

115 @1993db See 101 NO3 comment; footnote nitrate uncertain.

114 @2189db See 101 NO3 comment; footnote nitrate uncertain.

113 @2386db See 101 NO3 comment; footnote nitrate uncertain.

112 @2586db See 101 NO3 comment; footnote nitrate uncertain.

111 @2786db See 101 NO3 comment; footnote nitrate uncertain.

110 @2988db See 101 NO3 comment; footnote nitrate uncertain.

109 @3187db See 101 NO3 comment; footnote nitrate uncertain.

108 @3384db See 101 NO3 comment; footnote nitrate uncertain.

107 @3588db See 101 NO3 comment; footnote nitrate uncertain.

106 @3790db See 101 NO3 comment; footnote nitrate uncertain.

105 @4036db See 101 NO3 comment; footnote nitrate uncertain.

104 @4280db See 101 NO3 comment; footnote nitrate uncertain.

103 @4531db See 101 NO3 comment; footnote nitrate uncertain.

102 @4801db See 101 NO3 comment; footnote nitrate uncertain.

101 @5066db NO3: cadmium column changed, analyst thought column was conditioned before running samples, (raw data indicated all was okay). After reviewing final calculations, it is apparent that there is a problem with the data, that it is too high. Station 256 was al-so affected. Footnote nitrate uncertain.

Station 256

136 @ 3db See 101 NO3 comment; footnote nitrate uncertain.
135 @ 37db See 101 NO3 comment; footnote nitrate uncertain.
168 @ 55db Sample log: "salt bottle 34 broken, used 22 instead." Salinity appears to be okay. The note from the Sample Log sheet is for inventory purposes. See 101 NO3 comment; footnote nitrate uncertain.
133 @ 84db See 101 NO3 comment; footnote nitrate uncertain.
132 @ 117db See 101 NO3 comment; footnote nitrate uncertain.
131 @ 157db See 101 NO3 comment; footnote nitrate uncertain.
130 @ 200db See 101 NO3 comment; footnote nitrate uncertain.
129 @ 257db See 101 NO3 comment; footnote nitrate uncertain.
128 @ 307db See 101 NO3 comment; footnote nitrate uncertain.
127 @ 407db See 101 NO3 comment; footnote nitrate uncertain.
126 @ 506db See 101 NO3 comment; footnote nitrate uncertain.
125 @ 602db See 101 NO3 comment; footnote nitrate uncertain.
124 @ 700db See 101 NO3 comment; footnote nitrate uncertain.
123 @ 801db See 101 NO3 comment; footnote nitrate uncertain.
122 @ 901db Sample log: "bottom did not close." No samples drawn.
121 @1000db See 101 NO3 comment; footnote nitrate uncertain.
120 @1202db See 101 NO3 comment; footnote nitrate uncertain.
119 @1405db See 101 NO3 comment; footnote nitrate uncertain.
118 @1608db See 101 NO3 comment; footnote nitrate uncertain.
117 @1761db See 101 NO3 comment; footnote nitrate uncertain.
116 @1915db See 101 NO3 comment; footnote nitrate uncertain.
115 @2119db Sample log: "check lower valve o-ring." Data appears to be okay. See 101 NO3 comment; footnote nitrate uncertain.
114 @2325db See 101 NO3 comment; footnote nitrate uncertain.
113 @2528db See 101 NO3 comment; footnote nitrate uncertain.
112 @2681db See 101 NO3 comment; footnote nitrate uncertain.
111 @2833db See 101 NO3 comment; footnote nitrate uncertain.
110 @3038db See 101 NO3 comment; footnote nitrate uncertain.
109 @3240db See 101 NO3 comment; footnote nitrate uncertain.
108 @3445db See 101 NO3 comment; footnote nitrate uncertain.
107 @3649db See 101 NO3 comment; footnote nitrate uncertain.
106 @3854db See 101 NO3 comment; footnote nitrate uncertain.
105 @4108db See 101 NO3 comment; footnote nitrate uncertain.
104 @4365db See 101 NO3 comment; footnote nitrate uncertain.
103 @4622db Sample log: "lid did not close properly." salt/nuts/oxy look like post-trip; oxy draw temp high asal: salt smpl 3 spilled during bad roll, only 1/3 of original sample remained to run. Footnote bottle leaking, samples bad. ODF

recommends deletion of water samples. See 101 NO3 comment; footnote nitrate uncertain.

102 @4877db Nutrients: "po4 low by .02. Stds up especially at end." PO4 agreement compared with adjoining stations is .01 lower, within WOCE standards. See 101 NO3 comment; footnote nitrate uncertain.

101 @5143db Nutrients: "po4 low by .02. Stds up especially at end." PO4 agreement compared with adjoining stations is .01 lower, within WOCE standards. NO3: cadmium column changed, analyst thought column was conditioned before running samples, (raw data indicated all was okay). After reviewing final calculations, it is apparent that there is a problem with the data, that it is too high. Station 255 was also affected. Footnote nitrate uncertain.

Station 257

130 @ 297db Sample log: "empty, bottle open." No samples drawn. Only 29 bottles were scheduled to trip at Console Ops level. Evidently, bad weather conditions prompted the decision. CTD data was acquired at ˜300db and assigned bottle number 30. There-fore, there were no samples taken from this bottle, because it was purposely not tripped.

116 @1619db Sample log: "leaking from bottom end cap." oxy high, salts/nuts low Footnote bottle leaking, samples bad. ODF recommends deletion of water samples.

111 @2836db Sample log: "slight spigot leak." Data appears to be okay.

Station 258

130 @ 165db Sample log: "did not fire." No samples drawn.

124 @ 583db oxy/oxy draw temp low; sal/nuts high - pretrip? Footnote bottle leaking, samples bad. ODF recommends deletion of water samples.

116 @1752db Sample log: "btm lid did not close." No samples drawn.

112 @2558db sharp oxy/sil max looks phony; sal slightly high; oxy high compared to ctd, o2 draw temp low - pretrip? Footnote bottle leaking, samples bad. ODF recommends deletion of water samples.

108 @3366db Sample log: "leak from lower cap." Data appears to be okay.

Station 259

131 @ 187db Sample log: "leak from valve and bottom cap." Data appears to be okay.

Station 260

136 @ 3db Sample log: "slight leak from bottom." Data appears to be okay.

116 @1873db Sample log: "spring lost, bottle empty." No samples drawn.

Station 261

107 @3654db Sample log: "empty, lanyard hang up." No samples drawn.

Station 262

235 @ 38db Sample log: "pylon hangup - didn’t close." No samples drawn. NO pylon confirm in 3 tries at posn 35/GO-41 errors

214 @2047db Sample log: "leaker from bottom cap - lots." Data appears to be okay.

Station 263
Cast 1 Sample log: "no comments."

Station 264
236 @ 4db Sample log: "leaks a bit from btm lid during sampling." Data appears to be okay.

Station 265
Cast 1 Sample log: "no comments."
117 @1924db Oxy may be too low, also low compared to ctdoxy. Footnote oxygen uncertain.

Station 266
111 @2601db Sample log: "slight leak from spigot." Data appears to be okay.

Station 267
136 @ 2db Sample log: "slight leak from bottom cap." Data appears to be okay.

Station 268
136 @ 4db Sample log: "note temp - maybe therm problem." Data appears to be okay.
135 @ 36db Niskin 35 open - NO pylon confirm/GO-41 on 3 attempts at posn 35 Sample log: "empty." No samples drawn.
168 @ 61db Sample log: "note temp." Data appears to be okay.
126 @ 607db Oxygen: "Sample lost, broke oxy flask 662."
115 @1896db Sample log: "ring off valve." Data appears to be okay.
112 @2361db See 106 nutrients comments. Leave data as is-no footnote.
111 @2510db See 106 nutrients comments. Leave data as is-no footnote. Sample log: "small leak at valve." Data appears to be okay.
110 @2659db See 106 nutrients comments. Leave data as is-no footnote.
109 @2810db See 106 nutrients comments. Leave data as is-no footnote.
108 @2960db See 106 nutrients comments. Leave data as is-no footnote.
107 @3111db See 106 nutrients comments. Leave data as is-no footnote.
106 @3315db Nutrients: "Sil 3.0 high bottles 6-12." No problems that analyst can find. Leave data as is-no footnote.
104 @3720db phosphate slightly too low, nutrient rereads look same Footnote PO4 uncertain.

Station 269
Cast 1 Sample log: "no comments."

Station 270
Cast 1 Sample log: "no comments."

Station 271
Cast 1 Sample log: "no comments."
130 @ 155db oxy: "tiny bubble in sample flask at titration time."

Station 272

Cast 1	Sample log: "no comments."
103 @3805db	sal a little too high/.003; does not match ctd Delta-S at 3805db is 0.0032, salinity is 34.714. Footnote salinity uncertain.

Station 273

168 @ 2db	NO pylon confirm in 3 attempts at posn 34/GO-41 errors; try again at srfc - NO confirm; niskin came up open Sample log: "empty." No samples drawn.

Station 274

235 @ 31db	NO pylon confirm at posn 15/GO-41 error; retry failed Sample log: "open." No samples drawn.
230 @ 154db	NO pylon confirm at posn 15/GO-41 error; retry failed Sample log: "open." No samples drawn.

Station 275

Cast 1	Sample log: "no comments."

Station 276

130 @ 155db	Sample log: "open, no water." No samples drawn.
126 @ 300db	salinity too low compared to ctd; matches btl 28 salt Footnote salinity bad. ODF recommends deletion of salinity.
114 @1680db	Sample log: "valve way too tight." Data appears to be okay.

Station 277

108 @2277db	Sample log: "slight leak from bottom." Data appears to be okay. Nutrients: "sil 2.0 low. Stds, sw response low." Silicates agree with adjoining stations after changes.

Station 278

168 @ 54db	slight max of no3/po4, also oxy: peaks checked/looks ok-LT Leave data as is-no Footnote.
112 @1852db	Sample log: "slow leak bottom cap when open." Data appears to be okay.
101 @3771db	Nutrients: "sil 2.0 low, bottles 1-9." No problems that analyst can find. Leave data as is-no footnote unless DQE decides differently.

Station 279

Cast 1	Sample log: "no comments."

Station 280

123 @ 507db	Sample log: "check/replace stopcock." Data appears to be okay.

Station 281

223 @ 509db	Sample log: "r/r stopcock." Data appears to be okay.
215 @1461db	salinity too low, looks like misdrawn from btl 16 Footnote salinity bad. ODF recommends deletion of salinity.

Station 282
136 @ 3db Sample log: "slow leak from bottom cap when vent open." Data appears to be okay.

Station 283
Cast 1 Sample log: "no comments." niskins tripped 24->1, then 36->25 for freon blank check

Station 284
236 @ 2db Surface salinity high, looks like drawn from bottom btl/201 Footnote salinity bad. ODF recommends deletion of salinity.
235 @ 33db Sample log: "spigot leaks when valve opened." Data appears to be okay.

Station 285
136 @ 3db Sample log: "small leak when open." Data appears to be okay.

Station 286
Cast 1 Sample log: "no comments."

Station 287
126 @ 307db oxy: system crashed during analysis, sample "lost at sea" Footnote oxygen lost.
107 @2671db Sample log: "niskin slid down - valve blocked - fixed by SH & BJN." Data appears to be okay.

Station 288
Cast 1 Sample log: "O2 started sampling at bottle 21.
102 @3396db Bad peaks and/or bubbles for po4 and sil, each could be up to .002 higher but likely ok accounting for reader difference. no3 peaks fine, but definitely higher on btl 1/lower on 2. Footnote silicate and phosphate uncertain.
101 @3619db Nuts slightly high - problem sample 2, see 102 comment. PI indicates data is acceptable.

Station 289
Cast 1 Sample log: "O2 sampled niskins 13-36, then 1-12." Nutrients: "Rising lab T, chief lowered T 4°C around sample 9." Nutrients: "sil noisy. Large lab temp fluctuations. End stds up." Silicate agrees with adjoining stations after standard corrections.
168 @ 57db no3/po4 look too low, is min real? DMM: either 35/36 look hi and 68 looks low, or 68/33/32 all look low: something here looks strange compared to nearby casts. Rereads same. PI indicates leave data as is-no footnote.
123 @ 508db Sample log: "leak from bottom cap when open." Data appears to be okay.
108 @2613db Sample log: "leak from bottom cap when open - does not when cap reseated." Data appears to be okay.

Station 290
Cast 1 Sample log: "no comments."

110 @2823db Nutrients look high/oxy low. Compare w/sta.288. Nuts rereads same. ok. Leave as is-no footnote per PI review.
109 @3026db Nutrients look high/oxy low. Compare w/sta.288. Nuts rereads same. ok. Leave as is-no footnote per PI review.
102 @4091db See 101 NO3 comment, data appears to be okay.
101 @4287db Nutrients: "Bottom no3, samples 1-2, high. Sta 289 stds high by 4." NO3 may be .1 high after correction to standards, but this is within the accuracy of the measurement, therefore, data acceptable.

Station 291
103 @3740db Sample log: "top lid caught lanyard and didn't close." No samples drawn.
102 @3892db Sample log: "bottle is in Davey Jones' locker." No samples drawn.

Station 292
133 @ 73db Sample log: "bottom end cap leaking - spring tension." Data appears to be okay.
172 @3491db Sample log: "r/r stopcock (replace/repair)." Samples appear to be okay, this is the first station this bottle was used on. On previous station, bottle was lost.

Station 293
172 @3852db Sample log: "R/R spigot." Data appears to be okay.

Station 294
232 @ 81db Sample log: "CO2 drew .5 gallon for optics calib. (after salts)." Data appears to be okay.

Station 295
135 @ 32db Sample log: "leaks with vent closed." Data appears to be okay.

Station 296
114 @1460db Sample log: "slight leak from bottom." Data appears to be okay.

Station 297
107 @2527db Sample log: "change battery on O2 thermometer." Data appears to be okay.

Station 298
Cast 1 Nutrients: "po4 high; stds little high." Deep PO4 is .2 higher than adjoining stations, however, this is within the accuracy of the measurement, therefore, data is acceptable. Sample log: "pylon started from position 13 per freon."
135 @ 610db Sample log: "leak bottom cap - check spring tension." Data appears to be okay.
124 @1721db See 113 PO4 comments; footnote PO4 uncertain.
123 @1923db See 113 PO4 comments; footnote PO4 uncertain.
122 @2126db See 113 PO4 comments; footnote PO4 uncertain.
121 @2328db See 113 PO4 comments; footnote PO4 uncertain.
120 @2531db See 113 PO4 comments; footnote PO4 uncertain.
119 @2732db See 113 PO4 comments; footnote PO4 uncertain.
118 @2934db See 113 PO4 comments; footnote PO4 uncertain.

117 @3138db See 113 PO4 comments; footnote PO4 uncertain.
116 @3342db See 113 PO4 comments; footnote PO4 uncertain.
115 @3546db See 113 PO4 comments; footnote PO4 uncertain.
114 @3750db See 113 PO4 comments; footnote PO4 uncertain.
113 @3894db Deep po4 systematically hi, bottles 13-24; stds/DW/SW/calcs/peaks all check ok. LT notes that po4 same on sta 299. PO4 does not agree with adjoining stations ˜.04 high; may not have understood comment made by PI in general comments. Footnote phosphate uncertain.

Station 299
Cast 2 Sample log: "no comments." Deep po4 same as sta 298 (systematically higher than 297) Nutrients: po4 high; sw-dw low by 2 Standard correction has PO4 agree with adjoining stations, that is 300 301 and 297.

Station 300
Cast 1 Sample log: "no comments."
168 @ 56db Delta-S at 56db is -0.0258, salinity is 34.530. Agrees with adjoining stations, okay as is. Footnote CTD salinity bad, has an unrealistic spike.
130 @ 107db slt/oxy low, po4/no3 high; ctd downcast S/Oxy do not match. may be up/down cast diffc? no indication of problem in sample log/co log. ok. Delta-S at 107db is -0.1014, salinity is 34.367.

Station 301
Cast 1 Sample log: "no comments."

Station 302
Cast 2 Sample log: "no comments."
211 @1771db Sample log indicates nutrients were supposed to be drawn, but nutrient analyst indicates that tube was empty. Footnote nutrients lost.

Station 303
Cast 1 Sample log: "no comments."

Station 304
127 @ 156db Sample log: "leaking from bottom end cap." Data appears to be okay.

Station 305
Cast 1 Sample log: "no comments."
110 @2022db Nutrients: "no3 0.40uM low possibly?" Peak OK, calc OK. Footnote nitrate uncertain.

Station 306
Cast 1 15

Sample log: "O2 therm problem - questionable digital readings." Comment regarding O2 thermometer problem does not affect the data. However, station profiles were meticulously reviewed and data appears acceptable, unless otherwise noted.

Station 307

Cast 1	Sample log: "digital thermometer flaky for O2."
118 @ 608db	Salt bad - looks like btl 19 salt. Misdraw? Footnote salinity bad, ODF recommends deletion.

Station 308

Cast 1	Sample log: "O2 using glass thermometer (bucket therm)."
130 @ 106db	Sample log: "didn't trip - no water." No samples drawn. co log: NO pylon confirm at btl 30; 2 retries also failed
101 @3771db	Sample log: "bottle leaking with vent closed." Data appears to be okay.

Station 309

Cast 1	Sample log: "no comments."

Station 310

Cast 1	Sample log: "no comments."

Station 311

Cast 1	Sample log: "no comments." Nutrients: >1000m po4 0.02uM high After correction to standards, PO4 agrees with adjoining stations.

Station 312

127 @ 156db	Sample log: "small leak problems - check caps." Data appears to be okay.
117 @ 910db	Sample log: "vent left partially open." Data appears to be okay.
101 @3704db	Sample log said btl 71; MJ told prior to cast 1 was back on so use bottle 1 here, not 71; sample log/co log updated.

Station 313

130 @ 107db	Sample log: "open, no water." No samples drawn. co log: NO pylon confirm at btl 30; retry also failed
117 @ 911db	Sample log: "spigot open and vent not fully closed." Data appears to be okay.
112 @1820db	Salt .01 low; no comments; doesn't look like misdraw. Delta-S at 1820db is -0.008, salinity is 34.609. Footnote salinity uncertain.

Station 314

Cast 1	Sample log: "no comments."

Station 315

126 @ 154db	Nutrients: "po4 looks low by .05uM, no3 also looks low." Peaks OK, calcs OK. PO4 and NO3 acceptable for shallow water.
114 @1009db	Sample log: "bottom leak." Data appears to be okay.

Station 316

126 @ 205db	Delta-S at 205db is -0.0729, salinity is 34.519. Agrees with adjoining stations, okay as is. Spike in CTD uptrace which is the reason for the large salinity difference. Footnote CTD salinity bad.

122 @ 407db Nutrients: "po4 appears .20uM low." 21=22 all nuts. Possible double draw or trip problem? Peak OK, calc OK Oxygen and salt look ok - no trip problem. Double draw on nutrients. Footnote nutrients bad, ODF recommends deletion.
116 @1010db Sample log: "didn't trip." No samples drawn.

Station 317
211 @2225db Sample log: "slow leak valve." Data appears to be okay.
272 @3955db Sample log: "O2 temp seems high." Data appears to be okay.
201 @4193db Sample log: "O2 temp seems high." Data appears to be okay.

Station 318
Cast 1 Sample log: "no comments."

Station 319
117 @1011db Sample log: "leaking with air vent closed." Data appears to be okay.
115 @1309db Sample log: "open." No samples drawn. co log: NO pylon confirm at btl 15; retry also failed
172 @3932db Sample log: "leak at valve." Data appears to be okay.

Station 320
136 @ 2db Sample log: "drew early to test for nuts contamination." Data appears to be okay.
135 @ 31db Sample log: "bottle open." No samples drawn. co log: NO pylon confirm at btl 35; 2 retries also failed
124 @ 558db Nutrients: "NO3 appears high." Peak OK, calc OK. NO3 agrees with next station.
116 @1510db Sample log: "bottom did not close, lanyard had knot in it." No samples drawn.
115 @1661db Salt, o2, sil low; po4, no3 high. Looks like mistrip. Footnote bottle leaking, samples bad. ODF recommends deletion of water samples.
107 @2982db Sample log: "vent not well closed." Data appears to be okay.

Station 321
128 @ 206db Sample log: "bottle didn't close - lanyard caught on hose clamp." No samples drawn.

Station 322
Cast 1 Sample log: "no comments."

Station 323
136 @ 3db Sample log: "leaking bottom cap." Data appears to be okay.
128 @ 204db Sample log: "leaking from bottom cap when vent open." Data appears to be okay.
117 @1107db Sample log: "leaking spigot - spring tension?." Data appears to be okay.

Station 324
131 @ 137db Sample log: "bottom cap leak - stopped when cap rotated." Data appears to be okay.

151 @1354db Sample log: "didn’t close - "freak lanyard hangup"." No samples drawn.
172 @4115db Sample log: "bottom cap leak - stopped when cap rotated." Data appears to be okay.

Station 325
114 @ 457db Sample log: "small leak bottom cap." Data appears to be okay.

Station 326
Cast 2 Sample log: "started sampling @ 24 (except salts)."
225 @ 534db Sample log: "salt bottle 25 broken and replaced." Data appears to be okay.
216 @1611db Sample log: "open, no water." No samples drawn.

Station 327
Cast 2 Sample log: "no comments."
227 @ 300db po4 might be .08 too high; dmm: calcs ok, peaks ok. Footnote PO4 uncertain.
226 @ 401db po4 looks .2 too high; dmm: calcs ok, peaks ok. Footnote PO4 uncertain.

Station 328
130 @ 188db Sample log: "did not fire (did get confirm on 2nd try)." No samples drawn. co log: NO pylon confirm at btl 30; 2nd try ok
124 @ 635db Salt high, sil high; looks like mistrip. Footnote bottle leaking, samples bad.
122 @ 835db Salt, o2, sil high; po4, no3 low; looks like mistrip. Footnote bottle leaking, samples bad.
117 @1332db Sample log: "bottom didn’t close - lanyard not routed correctly." No samples drawn.
172 @4246db Sample log: "donated to Davy Jones’ locker." No samples drawn.

Station 329
Cast 1 Sample log: "no comments."

Station 330
136 @ 3db See 131 salinity comment; footnote salinity bad, ODF recommends deletion.
135 @ 37db See 131 salinity comment; footnote salinity bad, ODF recommends deletion.
168 @ 57db See 131 salinity comment; footnote salinity bad, ODF recommends deletion.
133 @ 81db See 131 salinity comment; footnote salinity bad, ODF recommends deletion.
132 @ 106db See 131 salinity comment; footnote salinity bad, ODF recommends deletion.
131 @ 146db Sample log: "slight bottom leak." Footnote salinity bad, ODF recommends deletion. High surface salinities. Appears that conductivity ratio incorrect; however, since this is an automated reading system, it is very unlikely.
127 @ 330db Sample log: "slight bottom leak." Data appears to be okay.
114 @1849db Nutrients: "sil appears high." Peak OK, calc OK. Footnote silicate uncertain.
108 @3022db Sample log: "bottom leak." Data appears to be okay.

Station 331
136 @ 2db Sample log: "strange temp - pre-trip?." Salt, o2 low; nuts high. Footnote bottle leaking, samples bad.

131 @ 138db Sample log: "leak from bottom cap when open." Data appears to be okay.
108 @3123db Sample log: "leak from bottom cap when open." Data appears to be okay. Delta-S at 3123db is -0.0038, salinity is 34.680.
170 @4321db Nutrients: "po4 btm values appear .03uM high." Peaks OK, calcs OK. Footnote PO4 uncertain.
171 @4553db Nutrients: "po4 btm values appear .03uM high." Peaks OK, calcs OK. Footnote PO4 uncertain.

Station 332
Cast 1 Sample log: "no comments."

Station 333
Cast 1 Sample log: "no comments." Nutrients: "Sil btm values appear low." After correction to standards, sil is acceptable.

Station 334
Cast 1 Sample log: "no comments." Nutrients: "Bottom sil values appear high by 1.5uM." After correction to standards, bottom silicates are higher than previous station, but agree with next station.

Station 335
228 @ 275db Sample log: "bottom didn't close- lanyard caught on hose clamp." No samples drawn.
210 @2844db Sample log: "slow leak from valve when air vent closed." Data appears to be okay.

Station 336
Cast 1 Sample log: "no comments." Nutrients: "Sil btm values appear high by 1.5uM." After correction to standards silicate is acceptable.
168 @ 67db Nutrients: "Nutrient max real?" Peak OK, calc OK. There is also an oxygen min here. Salinity agreement is reasonable with CTD. NO2 indicates could not have come from deeper or shallower in water column, therefore, suspect this is a real feature.

Station 337
116 @ 330db Sample log: "leaking from bottom cap." Data appears to be okay.
136 @2493db Salt high by ˜.002 - Voltage regulation problem in salt lab. Footnote salinity bad.
135 @2694db Salt high by ˜.002 - Voltage regulation problem in salt lab. Delta-S at 2694db is 0.0036, salinity is 34.677. Footnote salinity bad.
168 @2893db Salt high by ˜.002 - Voltage regulation problem in salt lab. Footnote salinity bad.
133 @3094db Salt high by ˜.002 - Voltage regulation problem in salt lab. Footnote salinity bad.
132 @3298db Salt high by ˜.002 - Voltage regulation problem in salt lab. Footnote salinity bad.
131 @3499db Salt high by ˜.002 - Voltage regulation problem in salt lab. Footnote salinity bad.
130 @3700db Salt high by ˜.002 - Voltage regulation problem in salt lab. Delta-S at 3700db is 0.0035, salinity is 34.689. Footnote salinity bad.

129 @3906db	Nutrients: "Sil bottom values appear low." Peaks OK, calcs OK. NO3 and PO4 are also lower than further up in the water column. Suspect that silicate is acceptable.
128 @4111db	Nutrients: "Sil bottom values appear low." Peaks OK, calcs OK. NO3 and PO4 are also lower than further up in the water column. Suspect that silicate is acceptable.
127 @4313db	Nutrients: "Sil bottom values appear low." Peaks OK, calcs OK. NO3 and PO4 are also lower than further up in the water column. Suspect that silicate is acceptable.
126 @4571db	Nutrients: "Sil bottom values appear low." Peaks OK, calcs OK. NO3 and PO4 are also lower than further up in the water column. Suspect that silicate is acceptable.
125 @4808db	Nutrients: "Sil bottom values appear low." Peaks OK, calcs OK. NO3 and PO4 are also lower than further up in the water column. Suspect that silicate is acceptable.

Station 338

209 @2767db	Sample log: "2 shots Hg2 Cl2 on TCO2 flask 127." Data appears to be okay.
204 @4099db	See 203 silicate comment. Footnote silicate uncertain
203 @4372db	Nutrients: "71, 70, 3 sil appear high at bottom." Peaks OK, calcs OK. Footnote silicate uncertain.

Station 339

Cast 1	Sample log: "O2: NaOH dispensing bubbles." Oxygen data is acceptable.
116 @1557db	Sample log: "very slight bottom leak." Data appears to be okay.

Station 340

114 @2017db	Sample log: "slight bottom leak." Data appears to be okay.
109 @3032db	Salt slightly lower (.002) than CTD salt. Footnote salinity uncertain.

Station 341

Cast 1	Sample log: "O2 sampling back and forth between deep and shallow water bottles."
116 @1502db	Nutrients: "Looks like duplicate draw." Footnote nutrients bad, ODF recommends deletion.
108 @2674db	Sample log: "slow leak from bottom cap." Data appears to be okay.

Station 342

Cast 2	Sample log: "no comments."

Station 343

132 @ 105db	Sample log: "bottom lid stuck open, no water." No samples drawn.
120 @ 995db	Sample log: "vent open." Data appears to be okay.

Station 344

121 @ 835db	Sample log: "slight leak from bottom end cap." Data appears to be okay.
114 @1805db	Sample log: "vent open." Data appears to be okay.

Station 345

Cast 1 Sample log: "no comments."

114 @1902db Nutrients: "no3 appears 0.6uM low." Peak OK, calc OK. Even though no obvious problem could be found with NO3, it is not an acceptable value, therefore it has been footnoted bad.

111 @2514db Oxygen too high by .1 ml/l. Could be misdraw from btl 10 Footnote oxygen bad.

Station 346

127 @ 254db Nutrients: "no3 appears high by 1.0uM although many ups & dns in no3 & po4 traces." Peak OK, calc OK. Not quite sure what PI (MT) is referring to here. Shallow plot pressure vs adjoining stations actually looks clean.

123 @ 500db Sample log: "PCO2 bottle 47 needs new cap." Data appears to be okay.

108 @3024db Sample log: "leak from bottom cap - check spring tension, o-ring." Data appears to be okay.

Station 347

133 @ 102db Nutrients: "Duplicate draw likely with tube 34 sample 68." Footnote nutrients bad, ODF recommends deletion.

114 @1919db Sample log: "didn’t trip @ correct depth?." Data appears to be okay.

Station 348

Cast 1 Sample log: "no comments."

Station 349

123 @ 608db Sample log: "slight leak from bottom cap." Data appears to be okay.

Station 350

328 @ 231db Sample log: "O2 flask 1087 - maybe some little bubbles in sample." Data appears to be okay.

327 @ 271db Sample log: "high O2 draw temps." Data appears to be okay.

326 @ 332db Sample log: "high O2 draw temps." Data appears to be okay.

370 @4148db Nutrients: "Not drawn." Sample log indicates this sample should have been drawn for nutrients. Footnote nutrients lost.

Station 351

Cast 1 Sample log: "sampled 19-36 then 1-18."

117 @1112db Sample log: "upper cap leaking slightly." Oxygen too high (.3). Leaking btl. Salt, nuts look ok. Footnote bottle leaking, oxygen bad.

170 @4031db Sample log: "reversing therm did not fully reverse (lanyard)." Data appears to be okay.

Station 352

117 @1151db Sample log: "spigot pushed in, slight upper cap leak." Oxygen too high (.3). Leaking btl. Salt, nuts look ok. Footnote bottle leaking, oxygen bad.

114 @1600db Sample log: "slight leak." Data appears to be okay.

110 @2404db Sample log: "dripping from spigot." Data appears to be okay.

Station 353

Cast 1 Sample log: "garbage dumped just at last sample."

135 @ 18db Delta-S at 18db is 0.0329, salinity is 35.219. CTD up trace has a unreasonable spike in the data; footnote CTD salinity bad. Bottle salinity agrees with previous station.

168 @ 28db Delta-S at 28db is 0.0561, salinity is 35.311. CTD up trace has a unreasonable spike in the data; footnote CTD salinity bad. Bottle salinity agrees with previous station.

117 @1312db Sample log: "spigot not closed fully, leaks from upper cap." Oxygen too high (.3). Leaking btl. Salt, nuts look ok. Footnote oxygen bad, ODF recommends deletion.

Station 354

135 @ 32db Sample log: "empty." No samples drawn.

127 @ 287db Sample log: "slight bottom leak." Data appears to be okay.

117 @1173db Oxygen too high (.3). Leaking btl. Salt, nuts look ok. Footnote oxygen bad, ODF recommends deletion.

171 @3369db Sample log: "no smpls drawn for o2 - tripped 750m above bottom on down."

Station 355

117 @1092db Sample log: "CO2 drew a krill!!!! ." Data appears to be okay.

Station 356

Cast 1 Sample log: "no comments."

Station 357

Cast 2 Sample log: "no comments."

217 @ 916db Oxygen too high (.3). Leaking btl. Salt, nuts look ok. ODF recommends deletion of gas samples.

Station 358

136 (No Pressure) Sample log: "open, no water." No samples drawn. Console operator must have gotten confused, Console Log seems to indicate that 33 bottles should have been tripped, but only 32 were tripped. Pressure assignment all seems to be corrected properly.

117 @ 859db Sample log: "leaking." Data appears to be okay.

Station 359

121 @ 409db Sample log: "leaks from spigot." Data appears to be okay.

117 @ 810db Sample log: "leaks from spigot - switch bottle out?." Data appears to be okay.

116 @ 911db Salt and nuts in error. Footnote bottle leaking, samples bad. ODF recommends deletion of water samples.

110 @1819db Oxygen too high by .1 ml/l Footnote oxygen bad, ODF recommends deletion.

Station 360

117 @ 927db Sample log: "valve leaks quite a bit when open." Data appears to be okay.

Station 361
Cast 2 Sample log: "no comments."

Station 362
Cast 1 Sample log: "no comments."

Station 363
108 @2095db Sample log: "slight bottom leak." Data appears to be okay.

Station 364
108 @1612db Sample log: "leak from bottom cap when open (again)." Data appears to be okay.

Station 365
Cast 1 Sample log: "no comments."

Station 366
Cast 1 Sample log: "no comments."

Station 367
116 @ 658db Sample log: "slight bottom leak." Data appears to be okay.

Station 368
Cast 1 Sample log: "O2 and salts only."
118 @ 17db Sample log: "leaking." Data appears to be okay.
116 @ 104db Sample log: "slight leak - spring tension?." Data appears to be okay.
114 @ 203db Sample log: "slight bottom leak." Data appears to be okay.

Station 369
Cast 1 Sample log: "no comments."

Station 370
Cast 1 Sample log: "O2 and salts only."
118 @ 15db oxy: bubble Sample log: "leaking." Data appears to be okay.
106 @ 853db Sample log: "empty - bottom lid/lanyard jammed." No samples drawn.

Station 371
Cast 1 Sample log: "no comments."

Station 372
Cast 1 Sample log: "no comments." Nutrients not drawn per sampling schedule.

Station 373
115 @ 809db Sample log: "O2 therm flaky - temp on bottle 15 felt more like ˜8C." Data appears to be okay.

114 @ 909db Sample log: "O2 therm flaky - temp on bottle 15 felt more like ˜8C." Data appears to be okay.

Station 374
Cast 1 Sample log: "no comments." Nutrients not drawn per sampling schedule.

Station 375
Cast 1 Sample log: "no comments."

Station 376
Cast 1 Nutrients not drawn per sampling schedule.
117 @ 90db Sample log: "leaking from spigot." Data appears to be okay.

Station 377
Cast 1 Sample log: "no comments."
117 @ 657db PI: "Salt too low by .03 psu; probably leaking." Shore based analysis: no3, sil and oxy agree with adjoining stations, po4 slightly low and salinity low. No indication of any problem with salinity analysis, and automated system would have revealed a problem if there were one. Not really sure that bottle was leaking from this information, but will leave bottle code as leaking and will footnote po4 uncertain, salinity bad.

Station 378
Cast 1 Nutrients not drawn per sampling schedule.
119 @ 34db Sample log: "slight leak from upper end cap." Data appears to be okay. Delta-S at 34db is -0.0294, salinity is 34.123. Area of complex salinity structure. Data ok.

Station 379
317 @ 607db Sample log: "drips from open spigot with vent closed." Data appears to be okay.

Station 380
Cast 1 Sample log: "no comments."

Station 381
117 @ 802db Sample log: "valve dribbles when vent is closed." Data appears to be okay.

Station 382
132 @ 52db Sample log: "slight bottom leak." Data appears to be okay.
125 @ 206db Sample log: "vent almost blocked - raise bottle?." Data appears to be okay.
108 @1589db Sample log: "leaking from bottom cap." Data appears to be okay.

Station 383
119 @ 573db Sample log: "dripping when spigot pushed in." Data appears to be okay.
105 @2315db Salt too high by .005 psu; no notes in sample log or data sheet. Delta-S at 2315db is 0.0073, salinity is 34.672. Footnote salinity uncertain.

104 @2469db Sample log: "redraw O2." Data appears to be okay.

Station 384

121 @ 405db Sample log: "leaking from the bottom." Data appears to be okay.

Station 385

122 @ 566db Sample log: "pCO2 - throw out bottle Data appears to be okay.

111 @1674db Salt too low by .01 psu; no notes in sample log or data sheet. Delta-S at 1674db is -0.0074, salinity is 34.622. Even though no obvious problem could be found with salinity, it is not an acceptable value, therefore it has been footnoted bad.

110 @1775db Salt too low by .01 psu; no notes in sample log or data sheet. Even though no obvious problem could be found with salinity, it is not an acceptable value, therefore it has been footnoted bad.

Station 386

223 @ 263db Sample log: "spigot needs replacement." Data appears to be okay.

217 @ 728db Sample log: "dripping from spigot." Data appears to be okay.

Station 387

117 @ 780db Sample log: "leaking slightly from spigot." Data appears to be okay.

Station 388

Cast 2 Sample log: "no comments."

204 @1261db Oxy to high by .15 ml/l. Data sheet: bubble in sample before 2nd shake. Footnote oxygen bad.

Station 389

121 @ 2db Sample log: "leak from bottom cap - upper valve not well closed." Data appears to be okay.

117 @ 104db Sample log: "leaking with everything closed (out of valve)." Data appears to be okay. Sample log: "should be swapped -> replaced w/ niskin

Station 390

124 @ 53db Sample log: "serious leak." Data appears to be okay. Delta-S at 53db is -0.0541, salinity is 34.105.

116 @ 314db Sample log: "leaking from bottom cap." Data appears to be okay.

Station 391

110 @ 532db Sample log: "leaking from spigot." Data appears to be okay.

Station 392

114 @ 802db Sample log: "bottom cap leak." Data appears to be okay.

Station 393

Cast 1 Sample log: "no comments."

Station 394
Cast 1 Sample log: "no comments."

Station 395
Cast 2 Sample log: "total CO2 in 500 ml bottles."

Station 396
110 @1921db Sample log: "leaks from valve (open) with vent closed." Data appears to be okay.
106 @2632db Sample log: "valve leaks slowly when closed with vent open." Data appears to be okay.

Station 397
151 @1106db Sample log: "spigot pushed in." Data appears to be okay.
110 @1818db Sample log: "O2 temp done after drawing sample was completed - probably wrong." Data appears to be okay.

Station 398
136 @ 2db No salinity sample analyzed. Sample log says VITA in the box that the salinity bottle number should be. Shore based data processor not certain what this means however, there is no obvious reason that salinity should not have been sampled. It appears that the "Sample cop" was not doing his/her duty properly. Footnote salinity lost.
112 @1532db Salt too low by .017; no notes in sample log or data sheet. Delta-S at 1532db is -0.0155, salinity is 34.605. Footnote salinity uncertain.
109 @1958db Sample log: "vent open." Sil, no3 low; o2 high. Leaker. Footnote oxygen and nutrients bad, bottle leaking, ODF recommends deletion.
106 @2512db Salt too high by .007; no notes in sample log or data sheet. Delta-S at 2512db is 0.0096, salinity is 34.678. Footnote salinity uncertain.

Station 399
116 @ 978db Sample log: "didn't close - lanyard caught on hose clamp." No samples drawn.

Station 400
135 @ 19db co log: NO pylon confirm - 3 tries total Sample log: "did not trip correctly." Freon drawn from this bottle. Data appears to be okay. Appears that correct pressure assignment was made.

Station 401
Cast 1 Sample log: "no comments."

Station 402
130 @ 78db Salt, nuts low; o2 high; leaker? Sample log notes high draw temp (e.g. surface water). Sample log: "O2 draw temp high." Footnote bottle leaking, samples bad.

Station 403
123 @ 327db Sample log: "vent open." Data appears to be okay.

Station 404

268 @ 65db Sample log: "valve has slow leak (with vent open)." Data appears to be okay.
214 @1259db Sample log: "small leak bottom cap." Data appears to be okay.

Station 405

136 @ 1db See 108 Sample Log comment; data appears to be okay.
135 @ 33db See 108 Sample Log comment; data appears to be okay.
168 @ 64db See 108 Sample Log comment; data appears to be okay.
132 @ 95db See 108 Sample Log comment; data appears to be okay.
130 @ 134db See 108 Sample Log comment; data appears to be okay.
128 @ 175db See 108 Sample Log comment; data appears to be okay.
127 @ 225db See 108 Sample Log comment; data appears to be okay.
126 @ 285db See 108 Sample Log comment; data appears to be okay.
125 @ 346db See 108 Sample Log comment; data appears to be okay.
124 @ 406db See 108 Sample Log comment; data appears to be okay.
123 @ 465db See 108 Sample Log comment; data appears to be okay.
122 @ 526db See 108 Sample Log comment; data appears to be okay.
121 @ 586db See 108 Sample Log comment; data appears to be okay.
120 @ 686db See 108 Sample Log comment; data appears to be okay.
119 @ 786db See 108 Sample Log comment; data appears to be okay.
118 @ 886db See 108 Sample Log comment; data appears to be okay.
151 @ 987db See 108 Sample Log comment; data appears to be okay.
116 @1087db See 108 Sample Log comment; data appears to be okay.
115 @1187db See 108 Sample Log comment; data appears to be okay.
114 @1287db See 108 Sample Log comment; data appears to be okay.
113 @1408db See 108 Sample Log comment; data appears to be okay.
112 @1558db See 108 Sample Log comment; data appears to be okay.
111 @1709db See 108 Sample Log comment; data appears to be okay.
110 @1860db See 108 Sample Log comment; data appears to be okay.
109 @2012db See 108 Sample Log comment; data appears to be okay.
108 @2213db Sample log: "O2 may have inaccurate delivery of MnCl2 (pump difficult to operate); samples 8-16, 51,18-28, 30, 32, 68, 35-36." Data appears to be okay.

Station 406

168 @ 3db Sample log: "open, no water." No samples drawn. co log: NO pylon confirm; retry at surface, no confirm 4x more
136 @ 29db Sample log: "@25m, no surface." Data appears to be okay. Delta-S at 29db is 0.0533, salinity is 33.835. Area of complex salinity structure. Data ok.
135 @ 45db Sample log: "@40m instead of 25." Data appears to be okay. Delta-S at 45db is -0.1532, salinity is 33.731. Area of complex salinity structure. Data ok.

Station 407

116 @1035db Oxygen low by .2 umol/l; sil low by 10 umol/l. Footnote oxygen and silicate bad, ODF recommends deletion.
108 @2531db Sample log: "slight bottom leak." Data appears to be okay.

105 @3142db Delta-S at 3142db is 0.0049, salinity is 34.675. Salinity values do not agree with adjoining stations. Footnote salinity bad, ODF recommends deletion.

Station 408

268 @ 64db Sample log: "drips from valve when open." Data appears to be okay.

Station 409

168 @ 39db Sample log: "open (no confirm)." co log: NO pylon confirm 3x; retry 1x more at srfc, stilling No samples drawn.

130 @ 95db Sample log: "open (lanyard hang up)." No samples drawn.

128 @ 145db Sample log: "top did not close well, was ok when top cap shifted slightly." Data appears to be okay.

Station 410

136 @ 2db Sample log: "CO2 sampled late." Data appears to be okay.

Station 411

127 @ 289db Salt high by .03. No notes in sample log or data sheet. Delta-S at 289db is 0.0332, salinity is 34.800. Footnote salinity uncertain.

125 @ 415db Sample log: "vent open." Data appears to be okay.

121 @ 717db Sample log: "leaking." Data appears to be okay.

114 @1625db Salt, nuts, low; oxy high. Sample log: "O2 temp high - mistrip?." Footnote bottle leaking. Footnote oxygen, salinity, and nuts bad, ODF recommends deletion.

Station 412

Cast 1 Sample log: "no comments."

118 @1309db Salinity high by .005. Data sheet: cap lift off and runaway. Footnote salinity bad, ODF recommends deletion.

Station 413

228 @ 511db Sample log: "empty." No samples drawn.

270 @6012db Sample log: "top cap open." Data appears to be okay.

271 @6342db Salt low by .003. Footnote salinity bad, ODF recommends deletion. Sample log: "leaking from bottom cap upon recovery." Other samples look okay. Shore based review: Oxygen does appear slightly low. Based on these two parameters problems, footnote bottle leaking, samples bad.

Station 414

128 @ 306db Sample log: "open, no water." No samples drawn.

Station 415

127 @ 322db Sample log: "leaking from bottom cap on recovery; stopped when cap rotated." Data appears to be okay.

Station 416
123 @ 638db Sample log: "leaking from bottom cap on recovery; stopped when cap rotated." Data appears to be okay.

Station 417
Cast 1 Sample log: "no comments."

Station 418
Cast 1 Sample log: "no comments."

Station 419
151 @ 184db Sample log: "valve opened early." Data appears to be okay.
110 @ 507db Sample log: "valve drips with vent closed." Data appears to be okay.

Station 420
116 @ 52db Sample log: "leaking from bottom cap." Data appears to be okay.

Station 421
Cast 1 Sample log: "no comments."

Station 422
110 @ 2db Sample log: "leaker." Data appears to be okay.

Quality Comments

Remarks for missing samples, and WOCE codes other than 2 from JUNO - WOCE P16A/P17A Large Volume Samples. Investigation of data may include comparison of bottle salinity and silicate data from piggy-back and Gerard with CTD cast data, review of data plots of the station profile and adjoining stations, and rereading of charts (i.e., nutrients). Comments from the Sample Logs and the results of ODF's investigations are included in this report.

Station 241
381 @1141db Sample log: "leaker - upper air valve tight." Salinity and silicate are acceptable; piggy-back (41).
393 @2345db Sample log: "TCO2 70 taken before salts & nuts. TCO2 71 taken after salts & nuts." TCO2 taken after salts & nuts." Comments from Sample Log are for the benefit of TCO2 analyst, this would not effect the Gerard samples. Piggy-back (49).
141 @2496db Delta-S(n-g) at 2496db is -0.047, salinity is 34.672. Salinity and silicate are acceptable, Gerard (81) salinity is high.
181 @2497db Sample log: "top valve open." Salinity is high, silicate is slightly low ˜.7, but reasonable. Footnote salinity bad, piggy-back (41). PI to determine integrity of other Gerard samples.
183 @2898db Sample log: "bubbling on & off during PCO2 & TCO2." Salinity and silicate are acceptable, piggy-back (43) are also acceptable.

144 @3099db Delta-S(n-g) at 3099db is 0.004, salinity is 34.695. Salinity difference is .001 high, but Gerard (84) salinity and silicate are acceptable.
184 @3099db Sample log: "bubbling during PCO2." Salinity and silicate are acceptable, piggy-back (44) is also acceptable.
145 @3300db Delta-S(n-g) at 3300db is -0.537, salinity is 34.164. Footnote bottle leaking, low salinity and low silicate bad; Gerard (85) samples are acceptable.
185 @3301db Sample log: "bubbling during PCO2 & TCO2." Gerard samples are acceptable; piggy-back (45) are bad.
147 @3705db Delta-S(n-g) at 3705db is 0.002, salinity is 34.715. Salinity and silicate are acceptable, Gerard (89) also acceptable.
189 @3705db Sample log: "bubbling during TCO2." Salinity and silicate are acceptable, piggy-back (47) also acceptable.
148 @3908db Delta-S(n-g) at 3908db is 0.003, salinity is 34.713. Salinity and silicate are acceptable; Gerard (90) is also acceptable.
190 @3909db Sample log: "bubbling during PCO2." Salinity and silicate are acceptable; piggy-back (48) are also acceptable.
149 @4112db Delta-S(n-g) at 4112db is 0.003, salinity is 34.711. Salinity and silicate are acceptable; Gerard (93) also acceptable.
193 @4113db Salinity and silicate are acceptable; piggy-back (49).

Station 264
Cast 3 Sample log: "no comments."
185 @3657db Sample log: "top vent closed - bottom valve gushing water - leaky." Salinity and silicate are acceptable; piggy-back (45).
147 @3910db Sample log: "47/46 reversed in rack - suspect on oppos. Gers, confirmed by therm readings." asal: "reverse 47/46 to connect with samplers 6/7." Salinity and silicate slightly low, but within acceptable limits; Gerard (87) samples acceptable. Sample log and thermometer sheet records were changed in an attempt to correct mis-recording at sea. Still appears to be confusion as to what came out of what Gerard or piggy-back. However, can not change sample numbers to "fit" the data.
187 @3911db Salinity and silicate are acceptable; piggy-back (47) also okay.
189 @4164db Sample log: "lid didn’t catch." Salinity and silicate are acceptable; piggy-back (46). PI to determine the integrity of other LV samples.

Station 274
Cast 1 No double ping until 0828z/7 mins before top barrel stop.
146 @1335db See comments on Gerard (87). Delta-S(n-g) at 1335db is -0.002, salinity is 34.546. Footnote bottle did not trip as scheduled, footnote salinity and silicate bad for this pressure, footnote pressure uncertain.
187 @1336db post-trips: last 4 tripped while wire moving up toward 1st barrel. therms not soaked. Gerards 87, 89, 90, and 93 post-tripped, all but 87 appear to have correct reassigned pressures. Salinity and silicate from Gerard and piggy-back agree with one another, but too high compared with rosette cast and station profile; piggy-back (46). Suspect tripped at ˜1500m, if 1500 were used then

ODF would delete the temperature. Footnote bottle did not trip as scheduled, footnote pressure uncertain. Footnote silicate and salinity bad for this pressure.

383 @1557db Delta-S(n-g) at 1556db is -0.002, salinity is 34.554. Salinity and silicate are acceptable. Piggy-back (43)

147 @1669db See post-trip comment on 187. Footnote bottle did not trip as scheduled, pressure post-tripped, samples acceptable at reassigned pressure; Gerard (89).

189 @1669db See post-trip comment on 187. Footnote bottle did not trip as scheduled, pressure post-tripped, samples acceptable at reassigned pressure; piggy-back (47).

148 @1818db See post-trip comment on 187. Footnote bottle did not trip as scheduled, pressure post-tripped, samples acceptable at reassigned pressure; Gerard (90).

190 @1818db See post-trip comment on 187. Footnote bottle did not trip as scheduled, pressure post-tripped, samples acceptable at reassigned pressure; piggy-back (48).

149 @1975db Delta-S(n-g) at 1975db is -0.003, salinity is 34.620. See post-trip comment on 187. Footnote bottle did not trip as scheduled, pressure post-tripped, samples acceptable at reassigned pressure; Gerard (93).

193 @1976db See post-trip comment on 187. Footnote bottle did not trip as scheduled, pressure post-tripped, samples acceptable at reassigned pressure; piggy-back (49).

385 @2308db Sample log: "leaky again." Salinity and silicate are acceptable; piggy-back (45).

185 @3215db Sample log: "leak somewhere - all tight - upper valve - water gushes at lower fitting." Salinity and silicate acceptable; piggy-back (45).

390 @3860db Delta-S(n-g) at 3859db is -0.002, salinity is 34.710. Salinity and silicate are acceptable; piggy-back (48).

393 @4059db Sample log: "possible mix up with nuts draw/maybe not." Appears all okay. Piggy-back (49)

Station 284

Cast 1 Sample log: "everything ok."

384 @1501db Sample log: "a gusher at bottom valve." leaks without venting, main clamp block gone. Salinity and silicate are acceptable; piggy-back (44).

387 @1802db Sample log: "top valve loose/gusher." Salinity and silicate are acceptable; piggy-back (46).

347 @1952db Sample log: "niskin failed, bottom cap open - therms ok." Fails to close due to tie wrap hanging up on release pin. Solution: replaced therm lanyard with correct-length lanyard. Gerard (89)

389 @1953db Sample log: "barrel lid closed but not latched." Salinity and silicate are acceptable; piggy-back (47).

348 @2104db Therm rack 8 fails to reverse because spring lanyard fails. Delta-S(n-g) at 2104db is -0.0083, salinity is 34.628. Footnote salinity and silicate bad, bottle leaking; Gerard (90) samples acceptable. No temperature.

390 @2104db No temperature, problem with piggy-back (48). Salinity and silicate are acceptable.

145 @3274db Delta-S(n-g) at 3274db is -0.0094, salinity is 34.680. Station profile compared with adjoining rosette casts looks reasonable. Rosette data also has a definite "shift" in the data. However, since the salinities and silicates from the Gerard

and piggy-back bottle do not agree with one another, footnote silicate uncertain from the piggy-back and salinity from the Gerard (85).

185 @3274db Footnote salinity uncertain see comments piggy-back (45). PI will have to determine integrity of Gerard samples.

147 @3680db Delta-S(n-g) at 3680db is -0.7731, salinity is 33.928. Footnote salinity and silicate bad bottle leaking, Gerard (89) salinity and silicate are acceptable.

189 @3680db Salinity and silicate are acceptable despite problem with piggy-back (47).

Station 299

344 @1528db Delta-S(n-g) at 1528db is -0.0095, salinity is 34.561. Footnote salinity and silicate uncertain, bottle leaking. Gerard (84) salinity and silicate acceptable.

384 @1528db Sample log: "leaky, pump is sucking air from barrel." Salinity and silicate are acceptable, piggy-back (44)

347 @1904db Delta-S(n-g) at 1905db is -0.0052, salinity is 34.614. Gerard (89) salinity slightly high, silicates agree within .2.

389 @1905db Sample log: "loose pin on barrel." Footnote salinity uncertain, silicates agree within .2. Suspect salinity drawing is a little "sloppy" and not a problem with the barrel; piggy-back (47).

190 @3553db Sample log: "gusher at btm valve." Salinity and silicate are acceptable; piggy-back (48).

Station 317

Cast 1 Sample log:" no comments

383 @1550db Sample log: "gusher/leaky." Salinity and silicate are acceptable; piggy-back (43).

385 @1852db Sample log: "bad vent o-ring/leaky." Salinity and silicate are acceptable; piggy-back (45)

347 @2151db Sample log: "leaky on valve test before sampling (before venting?)." Silicate and salinity are acceptable; Gerard (89).

389 @2152db Silicate and salinity are acceptable; piggy-back (47).

349 @2450db Delta-S(n-g) at 2450db is -0.0078, salinity is 34.661. Gerard (93) salinity is high.

393 @2451db Salinity is slightly high, silicate is acceptable; piggy-back (49). Suspect Gerard samples okay.

Station 326

Cast 3 Sample log: "no comments."

183 @3134db Sample log: "gusher at bottom valve." Salinity and silicate are acceptable; piggy-back (43).

145 @3536db Delta-S(n-g) at 3536db is 0.5725, salinity is 35.259. Footnote bottle leaking, salinity and silicate bad. Gerard (85) appears to be okay.

185 @3537db Salinity and silicate are acceptable; despite piggy-back (45) problems.

147 @3943db Sample log: "top lid not sealing again? leaky." Salinity and silicate are acceptable; Gerard (89).

189 @3944db Salinity and silicate are acceptable; piggy-back (47).

Station 338

342 @1474db Sample log: "leaky on valve test." Salinity and silicate are acceptable as are the Gerard (82) salinity and silicate.

382 @1474db Salinity and silicate are acceptable; piggy-back (42).

347 @2345db Sample log: "too warm for depth?." Delta-S(n-g) at 2345db is 1.17, salinity is 35.830. Footnote bottle leaking, salinity and silicate bad. Gerard (89) salinity and silicate acceptable.

389 @2345db Salinity and silicate acceptable despite piggy-back (47) problems.

193 @4701db Sample log: "gusher at bottom valve, all appears tight; Lid closed - not latched." Salinity and silicate are acceptable; piggy-back (49).

Station 353

381 @1184db Sample log: "gusher again." Salinity and silicate are acceptable; piggy-back (41). PI to determine integrity of other Gerard samples.

342 @1306db Delta-S(n-g) at 1306db is 0.0053, salinity is 34.598. Suspect poor salinity drawing technique, footnote salinity uncertain, it is still usable. Gerard (82) salinity and silicate are acceptable. Gerard (82)

382 @1307db Salinity and silicate are acceptable; piggy-back (42).

281 @2300db Sample log: "gusher." Salinity and silicate are acceptable; piggy-back (41). PI to determine integrity of other Gerard samples.

283 @2702db Sample log: "vent valve stuck, gusher." Salinity and silicate are acceptable; piggy-back (43). PI to determine integrity of other Gerard samples.

284 @2903db Sample log: "no gusher but leak at top valve." Salinity and silicate are acceptable; piggy-back (44). PI to determine integrity of other Gerard samples. Piggy-back (44)

289 @3505db Sample log: "lid slightly open." Salinity and silicate are acceptable; piggy-back (47). PI to determine integrity of other Gerard samples.

Station 361

347 @1724db Sample log: "leaky upon valve test - ok after readj. top lid." Salinity and silicate are acceptable; Gerard (89) also acceptable.

389 @1725db Salinity and silicate are acceptable; piggy-back (47).

181 @2020db Sample log: "gusher." Salinity and silicate are acceptable, piggy-back (41). PI will have to determine integrity of Gerard samples.

147 @2926db Sample log: "leaks on valve test, top cap again?." Delta-S(n-g) at 2926db is -0.0157, salinity is 34.678. Salinity and silicate are acceptable; Gerard (89) salinity is high, but silicate is acceptable.

189 @2927db Footnote salinity bad, see salinity difference comment 147, silicate is acceptable; piggy-back (47).

Station 379

182 @1503db Sample log: "bad O-ring in vent, barrel leaky at vent." Salinity and silicate are acceptable; piggy-back (42).

190 @2554db Sample log: "lower gerard fitting unscrews easily." Salinity and silicate are acceptable; piggy-back (48).

Station 395

341 @1347db Sample log: "not fastened in rack properly/lost a lot of water." Salinity and silicate are acceptable; Gerard (81) also acceptable.

381 @1347db Salinity and silicate are acceptable; piggy-back (41).

382 @1448db Sample log: "bottom valve came out." Salinity and silicate are acceptable; piggy-back (42).

383 @1548db Sample log: "sucking air bubbles - top vent/btm valve ok, chk o-ring." Salinity and silicate are acceptable; piggy-back (43).

182 @2414db therms: "barrel 82 leaks." Sample log: "small gusher, check gerard lid o-ring, may need grease." Salinity and silicate are acceptable; piggy-back (42).

Station 413

Cast 3 Sample log: "perfect cast. (no comment on therm form either)."

488 (No Pressure) Sample log/therms: "leaks from vent - check both O-rings in cap; lower klein clamp needs work and/or grease - check." Sample log: "not sampled."

492 (No Pressure) Sample log: "not sampled."

494 (No Pressure) Sample log: "not sampled."

447 @1357db Delta-S(n-g) at 1357db is -0.0049, salinity is 34.593. Gerard (89)

489 @1357db Sample log: "look fine, no leaks anywhere and all lids latched." Piggy-back (47)

448 @1442db Delta-S(n-g) at 1442db is -0.0031, salinity is 34.602. Salinity and silicate are acceptable, suspect salinity difference is poor drawing. Gerard (90)

490 @1442db Sample log: "look fine, no leaks anywhere and all lids latched." Salinity and silicate are acceptable, suspect salinity difference is poor drawing technique; piggy-back (48).

449 @1544db Delta-S(n-g) at 1544db is -0.002, salinity is 34.611. Gerard (93)

493 @1545db Sample log: "look fine, no leaks anywhere and all lids latched." Piggy-back (49)

190 @5555db Sample log: "valve unscrews needs teflon? otherwise perfect cast." Salinity and silicate are acceptable; piggy-back (48).

Appendix A:

Improving the Measurement of Pressure in the NBIS Mark III CTD

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ABSTRACT

A software model for correcting the dynamic response of the Paine Instruments stainless steel strain-gauge pressure transducer used in the NBIS Mark IIIB CTD is described. Laboratory calibration techniques and the response characteristics of strain-gauge transducers are discussed. Experimental data supporting the model are presented.

August 23, 1994

1. Introduction

The NBIS Mark IIIB CTD uses a stainless steel strain-gauge pressure transducer to measure pressure. The early models contained sensors produced by Standard Controls. Later versions contain sensors from Paine Instruments, with no significant differences in their characteristics. These sensors have proven to be reliable and of adequate sensitivity and stability for oceanographic profiling applications. Their accuracy depends upon careful and frequent calibration, with attention paid to their response characteristics. With an understanding of these characteristics, and applying an appropriate correction model, pressure accuracy of 2 db or better can be consistently attained. This level of pressure accuracy is necessary to insure the accuracy of parameters calculated from pressure; a 4 db error in pressure can result in a 0.002 PSU error in calculated salinity. The manufacturer's specifications are shown in Table 1 and have been found to be generally conservative.

Several response characteristics of strain-gauge transducers can contribute to significant measurement errors in oceanographic applications. These can be loosely grouped into static or steady-state responses and dynamic responses.

Pressure range	0-8850 psi (0-6100 db)
Compensated temperature range	-32 to 151 °C
Thermal zero shift	0.01 %F.S./°F (1.10 db/°C)
Thermal sensitivity shift	0.005% F.S./°F (0.55 db/°C)
Non-linearity and hysteresis	±0.25% F.S. (15.25 db)
Shock, vibration, acceleration	0.01% F.S./G (0.61 db/G)
Repeatability	±0.05 %F.S. (3.05 db)

Table 1.
Specifications of Paine Instruments Model 211-35-090-05 strain-gauge pressure transducer.

Most pressure calibration methods have concentrated on measuring steady-state responses. A dead-weight tester is used to measure non-linearity and hysteresis in the pressure response. Used in conjunction with a temperature-controlled bath, thermal zero and sensitivity shift can be measured . A response characteristic that varies with time before it reaches a steady-state is a dynamic response. For oceanographic applications where both pressure and temperature are changing, dynamic response characteristics become important.

The Mark III CTD Strain-gauge has a thermal response-time several orders of magnitude greater than the pressure response-time, due to the physical location of the sensor. The transducer is threaded into a port drilled through the CTD pressure case end cap, and located on the inside face. Most of the sensor is inside the pressure case, surrounded by a substantial mass of low thermal conductivity stainless steel. The strain-gauge is insulated from the ambient temperature by water filling the port and the material encasing the sensing element. Thermal response-time constants on the order of 400 seconds are not unusual. In the ocean, the sensor can be responding to temperatures differing from the ambient by more than 20°C, depending on profiling velocity and temperature gradients.

Non-linearity and hysteresis are characteristics of the sensor's response to pressure. The amount of hysteresis is dependent upon the maximum pressure applied to the sensor. Typical pressure response-times are less than 40 milli-seconds.

Stability is a measure of how often a sensor must be calibrated to insure some criteria for accuracy. This depends on how frequently the sensor is used, how it is employed, and the required accuracy. Typical stability metrics for 2 db pressure accuracy are on the order of months, and it is usually sufficient to calibrate Mark III pressure sensors immediately before and after 1-2 month expeditions.

A response-correction model for Mark III CTD pressure based on these sensor characteristics must describe the pressure response as functions of pressure, maximum pressure, temperature, and time.

One such model, together with appropriate calibration techniques, was developed by the authors and has been in use for several years. This method interpolates the pressure correction, using the sensor pressure signal and an estimate of the sensor temperature, from tables of calibration values measured at two or more temperatures. The number of calibration temperatures and pressures are selected such that the response of the transducer is adequately defined. In practice, pressure calibrations are performed to low (25% F.S.) and full-scale pressures at each of two widely-spaced temperatures, typically 0 and 25°C. An estimate of the sensor thermal response-time is made by plunging the thermally-equilibrated instrument into an ice-bath, generating a thermal step-change. Corrections are derived by linear interpolation between calibration points selected from the tables using the uncalibrated sensor pressure and a temperature modeled for the thermal response of the sensor.

This technique can be applied to other types of pressure transducers, where non-linear response characteristics make simpler models impractical. It has the advantage of operating directly from the pressure calibration data.

2. Temperature Effects

The response of a Mark III pressure transducer to a step-change in temperature can be modeled as the sum of at least two different responses with different response-times.

The faster thermal response is due to internal strain-gauge temperature compensation. The manufacturer uses a resistive temperature-compensating element in the transducer that ideally would exhibit the same thermal response-time as the strain-gauge, exactly canceling the temperature response. In practice this is not readily achieved, as the compensating element must be exactly matched to an individual sensor. The temperature compensation is adequate to bring the response to within the manufacturer's specifications, but typically introduces a second temperature response due to mismatches of the magnitude and response-time of the compensation. *Figure 1.0 illustrates typical Mark III pressure response to a temperature step-change.

The original Mark III CTD design further complicates the pressure response by an additional attempt at temperature compensation using a thermister attached to the transducer. The response-time of the thermister is grossly mismatched to the transducer, and its placement is such that it does not measure the transducer temperature. The correction techniques discussed in this paper assume that this compensation has been removed.

The pressure signal can be corrected for thermal response by

$$P_{corrected} = P_{raw} + k_1\, T_{lagged1} + k_2\, T_{lagged2} \qquad (1.0)$$

Where:

k_1 is the temperature coefficient (db/°C) associated with the first thermal response;

$T_{lagged1}$ is the lagged temperature associated with the first thermal response;

k_2 is the temperature coefficient (db/°C) associated with the second thermal response; and

$T_{lagged2}$ is the lagged temperature associated with the second thermal response.

The lagged temperatures can be modeled satisfactorily as a simple exponential decay with no initial delay. They are modeled from the in-situ temperature using response-time constants determined experimentally:

$$T_{lagged} = e^{-dt/\tau}\, T_p + (1 - e^{-dt/\tau})\, T \qquad (2.0)$$

Where:

dt is the measurement period in seconds;

τ is the temperature response-time constant in seconds;

Tp is the previous lagged temperature;

T is the in-situ temperature.

*Figure 1.0 illustrates Mark III CTD pressure response to a step change in temperature, together with a 2 term exponential model of the response.

One problem with modeling a sensor temperature from the *in-situ* temperature is the choice of an appropriate initialization value. Using the out-of-water CTD pressure and the pressure calibration, a reasonably-accurate initial temperature can be calculated. Because of the long response-time associated with the thermal response, care should be taken to insure the CTD is reasonably equilibrated with the ambient temperature and does not heat up from exposure to the sun.

3. Pressure Response

Strain-gauge transducers typically exhibit a non-linear pressure response. Correcting the response is complicated by hysteresis. This hysteresis is reproducible, and is dependent on the maximum pressure applied to the sensor. *Figure 2.0 illustrates the pressure correction curves obtained from a Mark III CTD calibrated to several maximum pressures at two different temperatures. To correct for hysteresis, it is necessary to construct an unloading correction curve based on the maximum pressure applied to the sensor.

4. Pressure Hysteresis Correction

A simple method for approximating the unloading curve correction uses the ratio of the observed maximum pressure to the calibration maximum pressure to scale the amount of hysteresis measured in the calibration (see *Figure 3.0):

1 A pressure calibration is performed to some maximum calibration pressure (the "loading" calibration), then back to zero pressure (the "unloading" calibration). Sufficient calibration points are taken to clearly define the response curve. The calibration is then used to correct sensor response.
2 The sensor response is corrected using the temperature correction and the loading calibration correction until the pressure decreases (begins unloading). The corrected maximum loading pressure P_{max} and the maximum calibration pressure P_{cal} are noted.
3 The proportion P_{max}/P_{cal} is calculated. The amount of hysteresis (the difference between loading and unloading calibration curves) at 0 decibars is scaled by P_{max}/P_{cal} to give H_0. The amount of hysteresis at P_{max} gives H_{max}.
4. The slope and intercept of the line between H_0 and H_{max} is calculated.
5 At any pressure less than P_{max}, the difference between this line and the original unloading curve represents the amount of hysteresis at that pressure. This difference, when subtracted from the original loading curve, generates the unloading curve.

Complications to this technique are introduced when repeated raising and lowering of the CTD (a "yo-yo" cast) is necessary. The correction scheme must provide a mechanism for returning along the unloading curve to the loading curve when the original maximum pressure is exceeded, and the construction of a new unloading curve based on the most recent maximum pressure.

5. Correction Interpolation Model

The correction interpolation model for pressure developed by the authors combines the modeled thermal response-correction and unloading curve interpolation techniques previously described with tables of calibration data (Figure 4.0). The calibration data are organized into tables at different calibration temperatures (stored in ascending temperature sequence). The first table contains the calibration pressures for the loading curve, followed by calibration pressures for each of the measured unloading curves (stored from shallowest to deepest maximum pressures). The pressures are stored in ascending sequence for each curve. Subsequent tables, at each calibration temperature, contain the raw pressure measurement corresponding to the calibration pressure at the calibration temperature. Each table has the same number of points as its corresponding calibration pressures table. The number of temperatures and unloading curves are only limited by the amount of calibration information necessary to properly correct the response of a particular sensor to the required degree of accuracy.

```
              ODF Pressure Calibration for Transducer 131910

                      Calibration Date:  5 May 1993
                        Calibrated by:  rp

            Temperature Response Time Constants = 58.2487 426.765
              Temperature Response Coefficients = 0.251782 -0.360534
                    Temperature Response Offset = 0.0
        Lagged Temperature Initialization Range = 1.000000 50.000000
                        Initial Pressure Offset = 0.0
                            Raw Pressure Offset = 0.0
                             Conductivity Limit = 15.0
                   Surface Atmospheric Pressure = 0.0
Minimum Unloading Curve Interpolation Pressure = 50.0
            Unloading State Pressure Threshold = 3.0
                                Sampling Period = 0.5

Calibration Pressures:
        Loading:
    0.00   20.81   89.65  158.48  227.32  296.17  364.98  502.66
  640.34  709.18  846.86 1053.36 1397.62 1741.82 2086.07 2430.27
 2774.53 3118.75 3463.04 4151.57 4840.11 5528.67 6079.51
        Unloading:
    0.00   20.81   89.65  158.48  227.32  296.17  364.98  502.66
  640.34  709.18  846.86 1053.36 1397.62 1741.82 2086.07 2430.27
 2774.53
        Unloading:
    0.00   20.81   89.65  158.48  227.32  296.17  364.98  502.66
  640.34  709.18  846.86 1053.36 1397.62 1741.82 2086.07 2430.27
 2774.53 3118.75 3463.04 4151.57 4840.11 5528.67 6079.51

Calibration Temperature =  0.01
        Loading:
   16.99   37.71  106.33  174.94  243.58  312.29  380.99  518.57
  656.29  725.20  863.10 1069.79 1415.04 1760.28 2105.36 2450.08
 2794.53 3138.57 3482.50 4170.12 4857.54 5544.99 6095.17
        Unloading:
   17.02   37.86  107.19  176.16  245.79  315.14  384.20  522.67
  661.58  730.84  869.26 1076.73 1421.61 1765.70 2109.16 2452.07
 2794.53
        Unloading:
   16.21   37.07  106.33  175.69  245.03  314.38  383.42  522.17
  661.13  730.46  869.06 1076.69 1422.21 1766.93 2111.18 2454.98
 2798.53 3141.86 3485.13 4171.59 4858.27 5545.20 6095.17

Calibration Temperature = 11.74
        Loading:
   17.93   38.77  107.38  176.01  244.69  313.40  382.10  519.86
  657.60  726.54  864.52 1071.17 1416.68 1762.02 2107.18 2451.97
 2796.38 3140.42 3484.36 4171.97 4859.39 5546.85 6097.02
        Unloading:
   17.96   38.93  108.25  177.24  246.91  316.25  385.31  523.96
  662.89  732.18  870.68 1078.12 1423.25 1767.45 2110.99 2453.95
 2796.38
        Unloading:
   17.15   38.14  107.39  176.77  246.14  315.49  384.53  523.46
  662.44  731.80  870.48 1078.07 1423.85 1768.67 2113.00 2456.87
 2800.39 3143.72 3486.98 4173.44 4860.13 5547.06 6097.02

Calibration Temperature = 31.22
        Loading:
   20.80   41.64  110.29  178.95  247.68  316.45  385.23  522.98
  660.90  729.95  868.01 1075.05 1420.40 1765.71 2110.83 2455.59
 2800.04 3144.07 3488.01 4175.63 4863.04 5550.50 6100.67
        Unloading:
   20.99   41.94  111.26  180.32  250.01  319.36  388.60  526.92
  666.04  735.31  873.88 1081.32 1426.48 1770.75 2114.40 2457.41
 2800.04
        Unloading:
   20.03   41.01  110.30  179.70  249.13  318.54  387.65  526.58
  665.74  735.21  873.97 1081.95 1427.57 1772.36 2116.65 2460.49
 2804.04 3147.37 3490.64 4177.10 4863.78 5550.71 6100.67
```

Figure 4.0.
Calibration data for the correction interpolation model.

The model uses the current raw pressure and a sensor temperature modeled from the *in-situ* temperature to look-up the corrected pressures of adjacent calibration points from the calibration tables. The corrected pressure is then calculated by linear interpolation of the adjacent calibration points.

The model is initialized when *in-situ* conductivity exceeds a previously-established "in-water" value. A pressure correction (known pressure minus observed pressure) is interpolated from the calibration data loading curves bracketing the current sensor temperature. An offset is calculated (the correction still required to bring the pressure to 0.0 db after the correction interpolated from the loading curves is applied). This offset is applied to the first loading curve interval. The model is now in the "loading" state.

The model continues in the "loading" state as long as pressure does not decrease. Calibrated pressures are interpolated from four adjacent loading curve points: two higher-pressure points and two lower-pressure points at two adjacent temperatures.

When pressure decreases, the model enters the "unloading" state. Unloading curves are calculated for the two adjacent temperature calibration tables, using the differences between loading and unloading curves. In this model, the possibility of multiple calibration unloading curves permits the construction of an unloading curve from the shallowest calibration curve that originates at a pressure deeper than the maximum observed pressure. Using the sensor temperature, a correction is interpolated from the two calculated unloading curves. If the CTD is again lowered, the calculated unloading curves are followed until the original maximum pressure is reached. The model then reverts to the "loading" state.

The pressure correction is extrapolated if the CTD pressure exceeds the maximum calibration pressure. As the maximum calibration pressure is typically close to full-scale, the practice of exceeding this pressure should be restricted.

The model also extrapolates corrections for temperatures outside the range of available calibration information. This is reasonable behavior for Mark III pressure transducers, which generally exhibit linear temperature response. Certain types of pressure sensors (e.g., piezo-electric quartz transducers) that exhibit nonlinear temperature response would necessarily be calibrated at more temperatures to adequately define the temperature response. Any new or unknown pressure sensor should be calibrated at several temperatures to insure the thermal response is adequately defined. Subsequent recalibrations can be at fewer temperatures if the response is linear.

A graphical representation of the ODF interpolation model is presented in Figure 5.0.

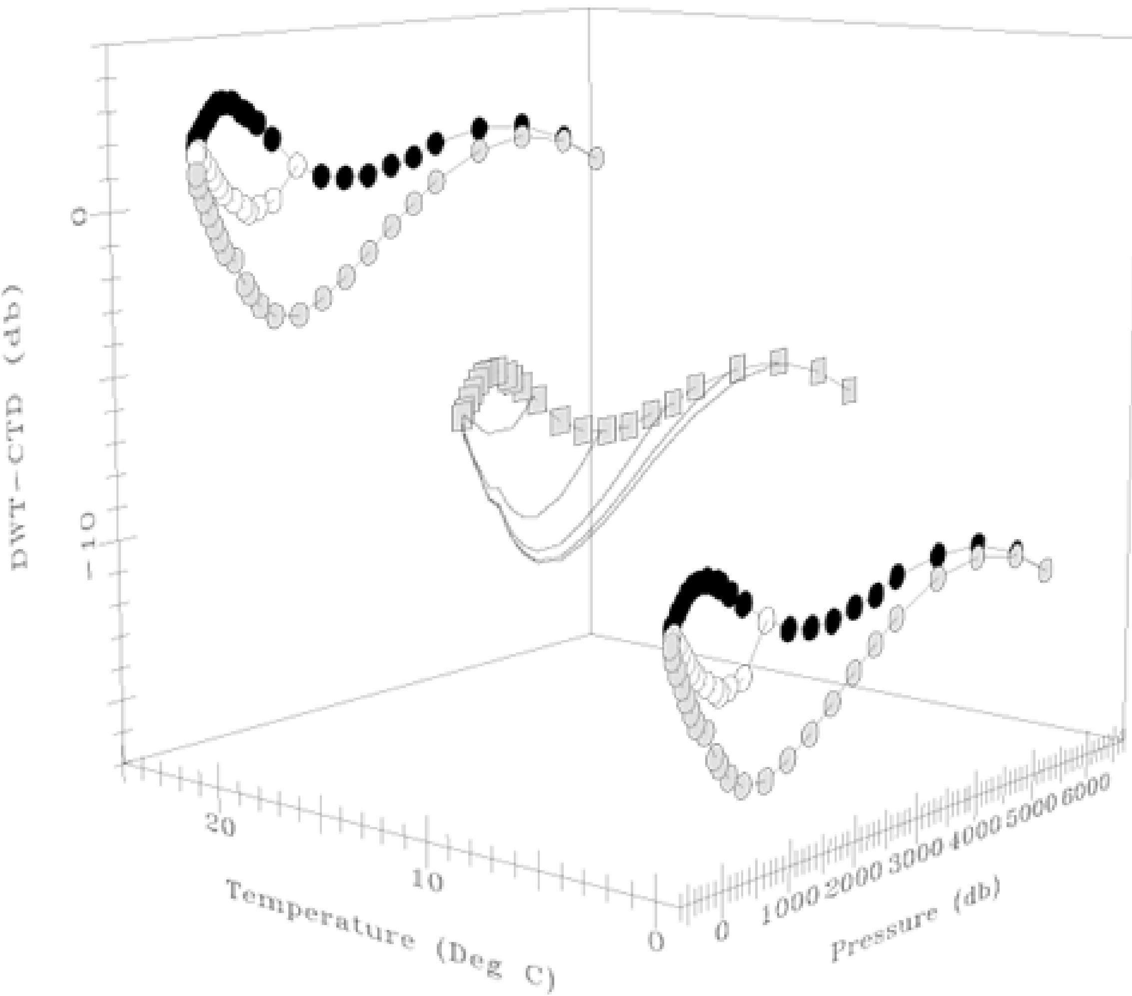

Figure 5.0

A graphic representation of the ODF interpolation method of pressure correction. The left and right hysteresis curves were measured at 22.75°C and 0.9°C, respectively. The black circles are the loading curve points and the grey circles two unloading curves: from 6080db and from 1398db. The center hysteresis curve is interpolated by a computer model at 10.0°C with unloading curves at 1000, 2000, 3000, 4000 and 5000db.

6. Further Information

WOCE participants interested in implementing either model, or who have further questions can contact the authors at the Oceanographic Data Facility.

*Figures 1.0-3.0 not included.

Appendix B:
CTD Dissolved Oxygen Data Processing

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ABSTRACT

This paper describes the techniques used at the Oceanographic Data Facility (ODF) for processing CTD dissolved oxygen data acquired from NBIS Mark III instruments, employing Sensormedics[1] dissolved oxygen sensors. The response characteristics of the sensors are discussed and deployment methods examined. An algorithm for converting the measured oxygen current, pressure, temperature and salinity to dissolved oxygen concentration is presented. The determination of calibration coefficients from Winkler titration check-sample data is discussed. Results from the application of the algorithm to some recently-collected data sets are examined.

August 31, 1993

[1]Formerly Beckman.

1. Introduction

The Oceanographic Data Facility (ODF) at SIO has been making CTD measurements since the early 1970s, primarily using NBIS instrumentation. These instruments employ Sensormedics sensors to effect dissolved O_2 measurement.

Correcting the non-linear response characteristics of these sensors has driven the evolution of a series of sensor models. Early attempts at laboratory calibration had proven futile, due to poor sensor stability and a lack of data on dynamic response characteristics. A practical field calibration technique proved to be fitting sensor model coefficients to differences between modified Winkler titration check-sample data and the sensor measurements. Refinements in this technique has led to a better understanding of the secondary and dynamic responses inherent in these sensors.

The check-sample and sensor data are collected with a 24 or 36-place rosette system containing a CTD. A conducting wire is used to lower and raise the package, transmit check-sample trip signals to the rosette, and transmit CTD data to the ship for real-time analysis. O_2 check-samples are normally drawn from all bottles. At routine profiling velocities of 50-80 m/min, the processed CTD data provide 1-2 meters of vertical resolution in temperature and salinity structure, and 10-15 meters in dissolved O_2 structure.

2. The Sensor and Sensor Interface

The Sensormedics sensor is a membrane-covered polarographic detector consisting of a 0.5 mil thick FEP Teflon membrane covering a layer of KCl gel. A gold cathode is the sensing electrode, and a silver electrode serves as both the anode and the reference. A 0.8 volt potential applied across the two electrodes results in a current proportional to the activity of O_2 diffusing through the membrane and gel, and reducing at the cathode:

$$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$$

The NBIS interface to the Sensormedics sensor employs a current to frequency converter with a sample period of 1.024 seconds. The sensor frequency is resolved to 11-bits, with a full-scale value corresponding to 2.047 µamps. The NBIS interface also provides for an 8-bit digitized O_2 membrane temperature, which is not used by ODF. The interface electronics are contained within the CTD pressure case. The sensor is mounted in an ODF-designed pressure-compensating holder, which is typically attached to the rosette frame in proximity to the CTD end-cap. The sensor assembly plugs into a bulkhead connector in the end-cap through an underwater cable, providing easy servicing and sensor replacement.

3. Deployment and Maintenance

The Teflon membrane is extremely vulnerable to petroleum distillates, such as diesel oil. Care is taken to deploy the package through clean water. Between casts, an air-tight plexiglass cover is fixed over the sensor. The cover contains an absorbent tissue moistened with distilled water. The sensor membrane is periodically examined for any obvious external damage or contamination.

4. Sensor Response Characteristics

4.1. O_2 Response

The O_2 response of the sensor depends upon the O_2 activity at the sensor cathode. The selectivity of the reaction is generally guaranteed by the relatively anodic value for its equilibrium potential [1]. However, a network of reactions can occur at the cathode, depending upon the exact state and ionic species present. H_2O_2 can appear as a stable reaction intermediate and is reduced [2], aliasing the O_2 signal.

The sensitivity of the O_2 response is determined by the O_2 diffusion-rate through the membrane diffusion layer. This is determined by temperature and pressure.

4.2. Temperature Response

The rate of O_2 diffusion through the Teflon membrane is primarily determined by temperature. The diffusion rate can be characterized:

$$Q_d = (P_0/b)\, e^{-(Ep/RT)} \tag{4.2.0}$$

where P_0 is a constant for FEP Teflon, b is the membrane thickness, E_p is the activation energy for permeation, R is the gas constant and T is temperature. Changes in temperature affect the sensitivity of the O_2 response.

Secondary temperature effects include changes in sensor geometry due to thermal expansion or compression (changing membrane tension), and thermal sensitivity of the interface electronics.

4.3. Pressure Response

The crystalline structure of FEP Teflon changes with pressure. This affects the membrane permeability, and sensitivity of the sensor[3].

4.4. Flow-dependence

When the flow rate across the sensor membrane decreases below a certain level, depletion of dissolved O_2 in seawater adjacent to the membrane occurs. The sensor current drops as the membrane diffusion layer thickness is effectively increased. Sensormedics recommends a minimum profiling velocity of 17 m/min.

4.5. Response Time

The time constant for the response of the sensor to an O_2 step-change at 20°C in surface seawater is nominally 2 seconds. This is the optimal case, and is beyond the Nyquist frequency of the sampling electronics. At lower temperatures and higher pressures, the time constant can exceed 15 seconds.

5. Calibration

Repeated exposures to low temperatures and high pressures adversely affects the stability of the sensor, making laboratory calibration unfeasible. Calibration to Winkler titration check-samples insures the prompt detection of sensor malfunctions.

The Winkler titration measures dissolved O_2 concentration. In contrast, the polarographic O_2 sensor measures O_2 activity. It is necessary to correct for salinity, temperature, and pressure effects when calculating concentrations from activity[4,5].

ODF normally collects at least 12 check-samples per cast. The oxygens are generally titrated within 6 hours of the cast. Modeling coefficients and time-constants are then fit to the check-samples.

6. The Model

The general form of the ODF O_2 conversion equation follows WHOI[6,7] and NBIS[8]:

$$O_2 = [c_1 O_c + c_2] \cdot f_{sat}(T, S) \cdot e^{(c3\,P + c4\,Tm)} \qquad (6.0)$$

where:

O_2 is the dissolved O_2 concentration;
O_c is the sensor current, in µamps;
$f_{sat}(S, T, P)$ is the O_2 saturation concentration at T,S in ml/l;
S is the salinity, in PSUs;
T is the temperature, in °C;
P is the pressure at O_2 response-time, in decibars;
T_m is the temperature of the sensor membrane, in °C.

c_1, c_2, c_3 and c_4 are coefficients to be determined through check-sample comparison.

T_m is derived by NBIS from the digitized O_2 temperature. ODF instead models a membrane temperature by low-pass filtering the PRT temperature. *In-situ* pressure and temperature are filtered to match the sensor response. Time-constants for the pressure response τ_p, and two temperature responses τ_{Ts} and τ_{Tf} are fitting parameters. The O_c gradient is approximated by low-pass filtering 1° O_c differences. This term attempts to correct for reduction of species other than O_2 at the cathode. The time-constant for this filter, τ_{og}, is a fitting parameter. Oxygen partial-pressure is then calculated:

$$O_{pp} = [c_1 O_c + c_2] \cdot f_{sat}(S, T, P) \cdot e^{(c3Pl + c4Tf + c5Ts + c6\, dOc/dt)} \qquad (6.1)$$

where:

O_{pp} is the dissolved O_2 partial-pressure in atmo-spheres;
O_c is the sensor current, in µamps;
$f_{sat}(S, T, P)$ is the O_2 saturation partial-pressure at S,T,P in atmospheres;
S is the salinity at O_2 response-time, in PSUs;
T is the temperature at O_2 response-time, in °C;
P is the pressure at O_2 response-time, in decibars;
P_l is the low-pass filtered pressure, in decibars;
T_f is the fast low-pass filtered temperature, in °C;
T_s is the slow low-pass filtered temperature, in °C;
dO_c/d_t is the sensor current gradient.

c_1, c_2, c_3, c_4, c_5 and c_6 are coefficients determined by applying a modified Levenberg-Marquardt non-linear least-squares fitting procedure[2] to differences from the Winkler titration check-sample data.

[2]Procedure *snls*1 from the Stanford SLATEC math library.

CTD O_2 current values used for the fit are normally extracted from the downcast at isopycnals corresponding to the actual up-cast check-sample points. This is done to avoid the flow-dependence problems occurring at bottle stops.

The response time-constants τ_{Ts} and τ_P (slow temperature and pressure) are typically determined once for a cruise. The other two time-constants τ_{og} and τ_{Tf} (O_2 current gradient and fast temperature) show some variability and are determined for each sensor deployment. The remaining modeling coefficients are determined for each sensor deployment.

7. Results

8. Summary

References

[1] Hitchman, M.L., *Measurement of Dissolved Oxygen*, John Wiley & Sons, Inc. and Orbisphere Corp., 1978.

[2] Damjanovic, A., in *Modern Aspects of Electrochemistry*, (J. O'M. Bockris and B.E. Conway, Eds.), No. 5, Butterworths, London, 1969.

[3] Hopfenburg, H.B., Ed., *Permeability of Plastic Films and Coatings to Gases, Vapors and Liquids*, Plenum Press, New York, 1974.

[4] Weiss, R. F., "The solubility of nitrogen, oxygen and argon in water and seawater." *Deep-Sea Research*, **17**, 721 (1970).

[5] Eckert, C.A., "The thermodynamics of gases dissolved at great depths." *Science*, **180**, 426 (1973).

[6] Millard, R.C. Jr., "CTD calibration and data processing techniques at WHOI using the practical salinity scale", *Proc. Int. STD Conference and Workshop*, La Jolla, Mar. Tech. Soc., 19pp. (1982).

[7] Owens, W.B. and Millard, R.C. Jr., "A new algorithm for CTD oxygen calibration", *Journ. of Am. Meteorological Soc.*, **15**, 621 (1985).

[8] Brown, N.L. and Morrison, G.K., "WHOI/Brown conductivity, temperature and depth microprofiler", *Woods Hole Oceanographic Institution Technical Report No. 78-23,* 1978.

Appendix C:

WOCE93-P19C Calibration Figures

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NOTE: some differences fall outside of the plotted limits.
Please refer to the bottle data quality codes.

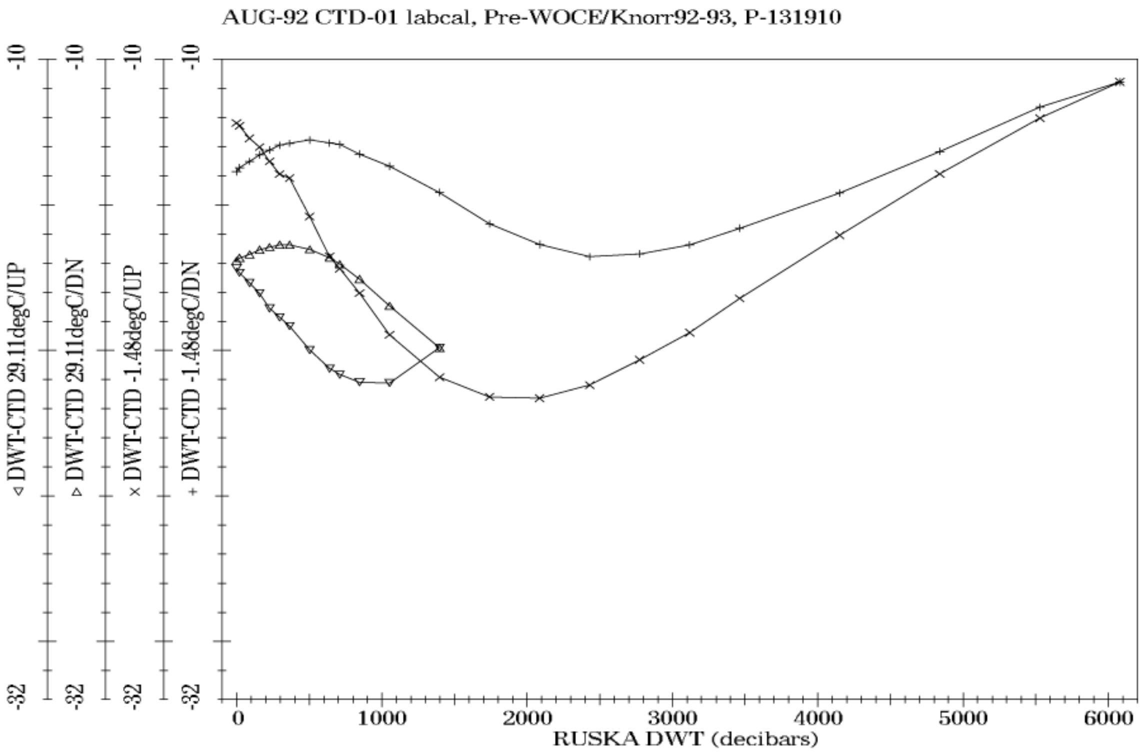

Figure 1a: CTD #1 Pre-cruise Pressure Calibration

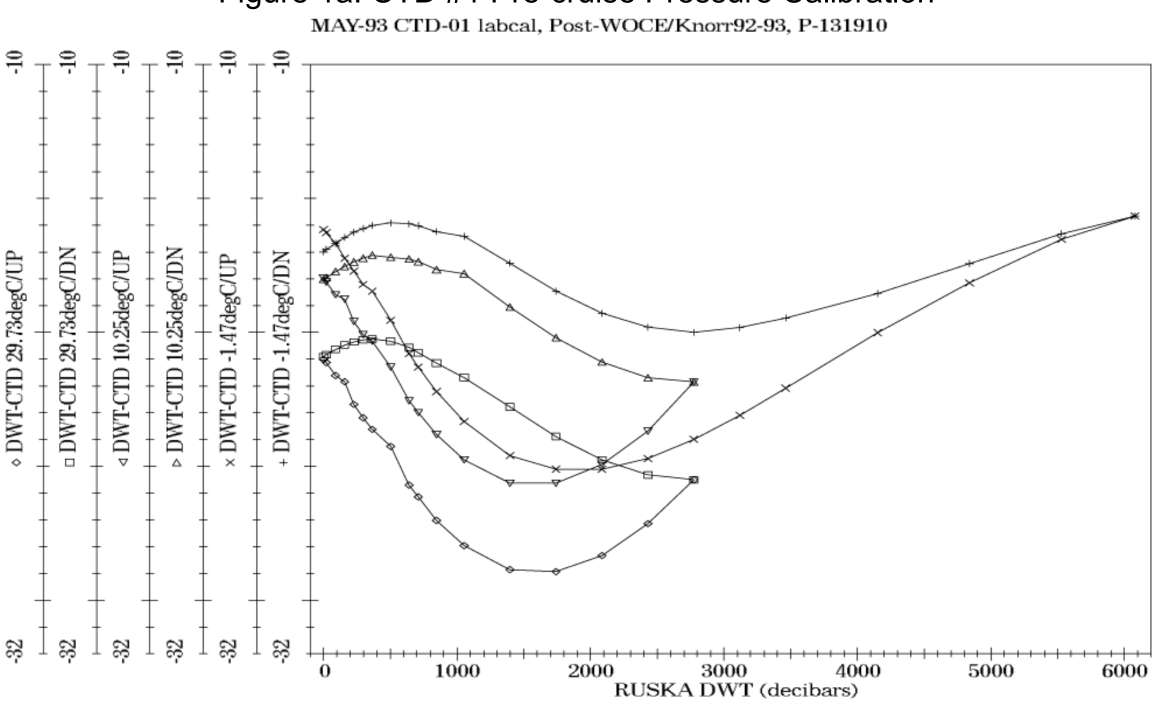

Figure 1b: CTD #1 Post-cruise Pressure Calibration

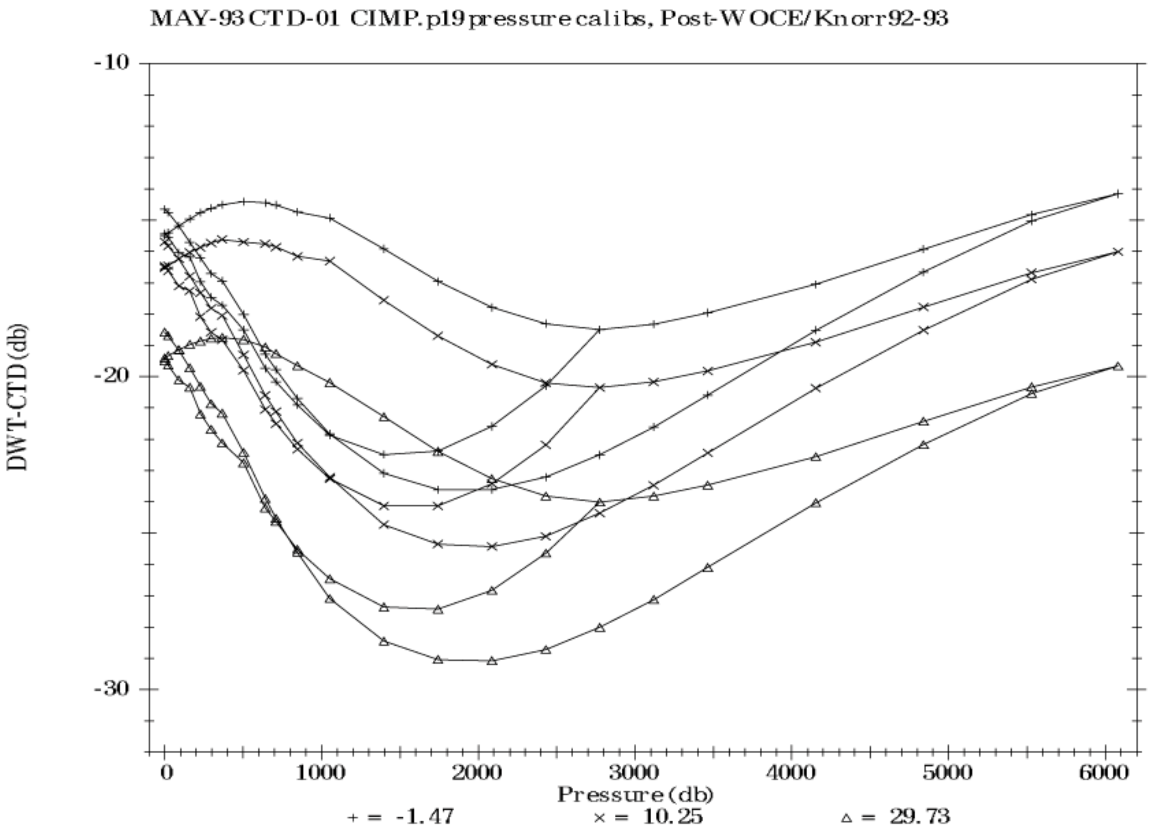

Figure 1c: CTD #1 Post-cruise Pressure Calibration plus Offset used for P19C

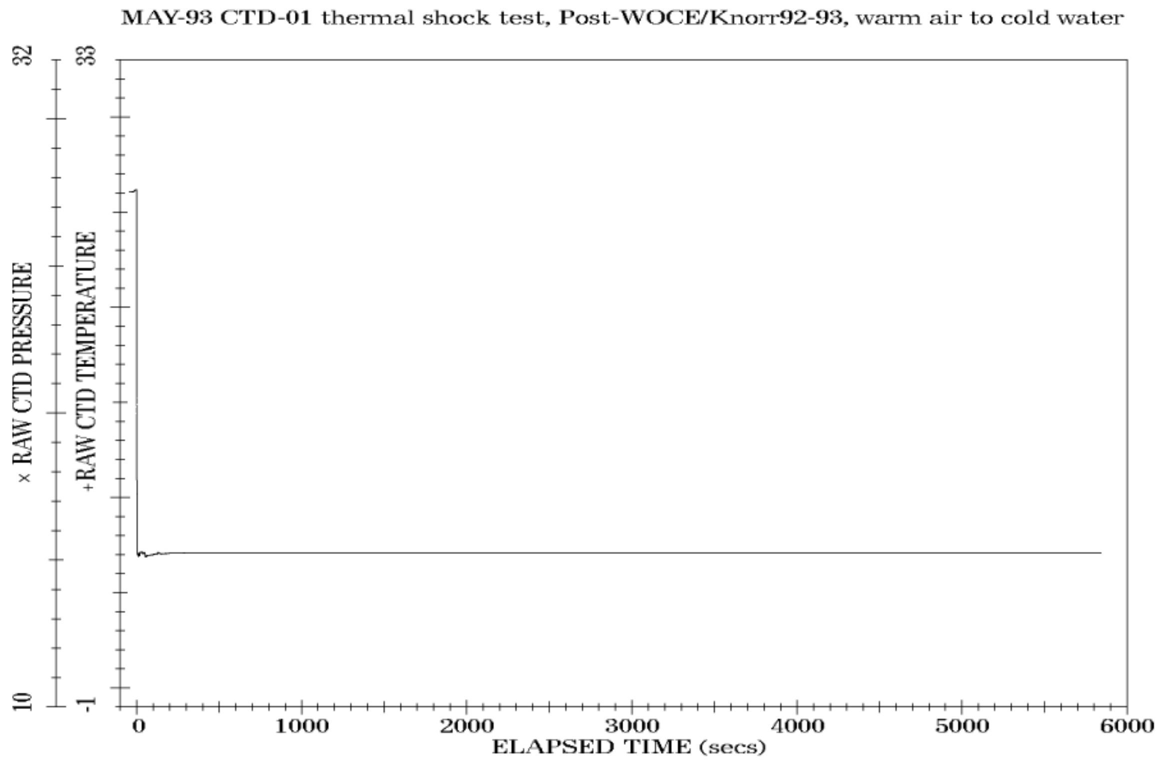

Figure 2a: CTD #1 Warm-to-Cold Thermal Shock Data

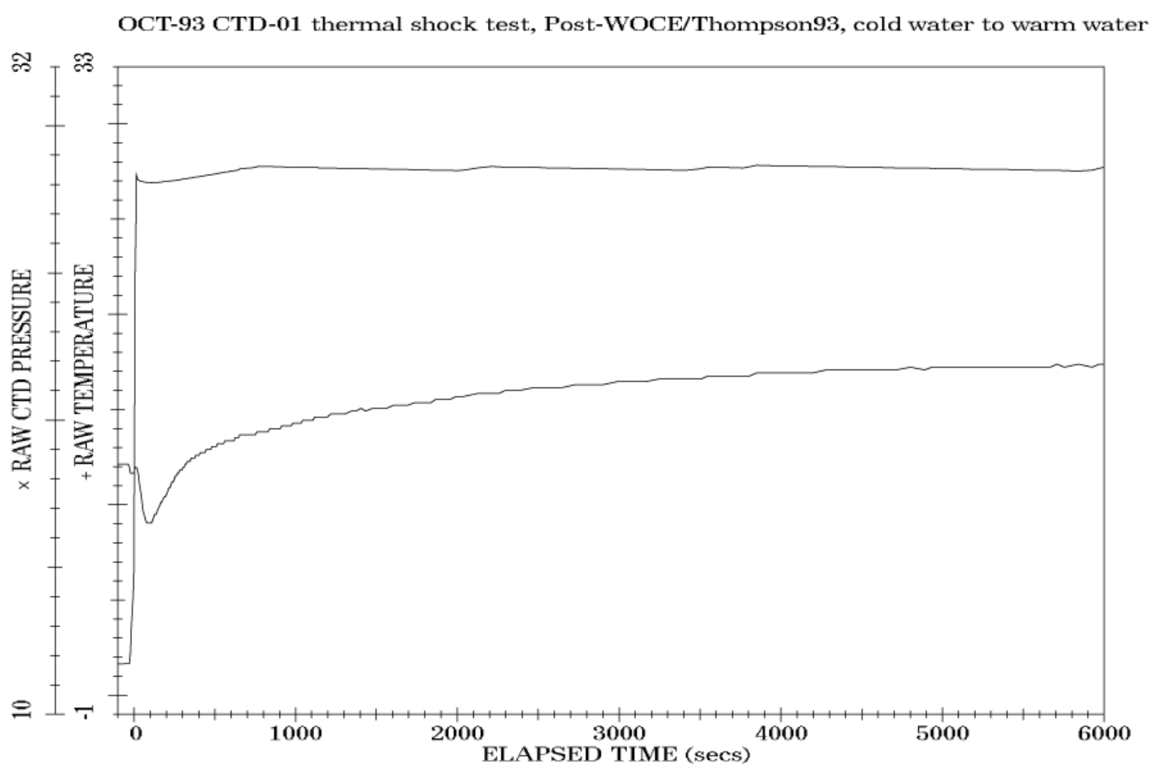

Figure 2b: CTD #1 Cold-to-Warm Thermal Shock Data

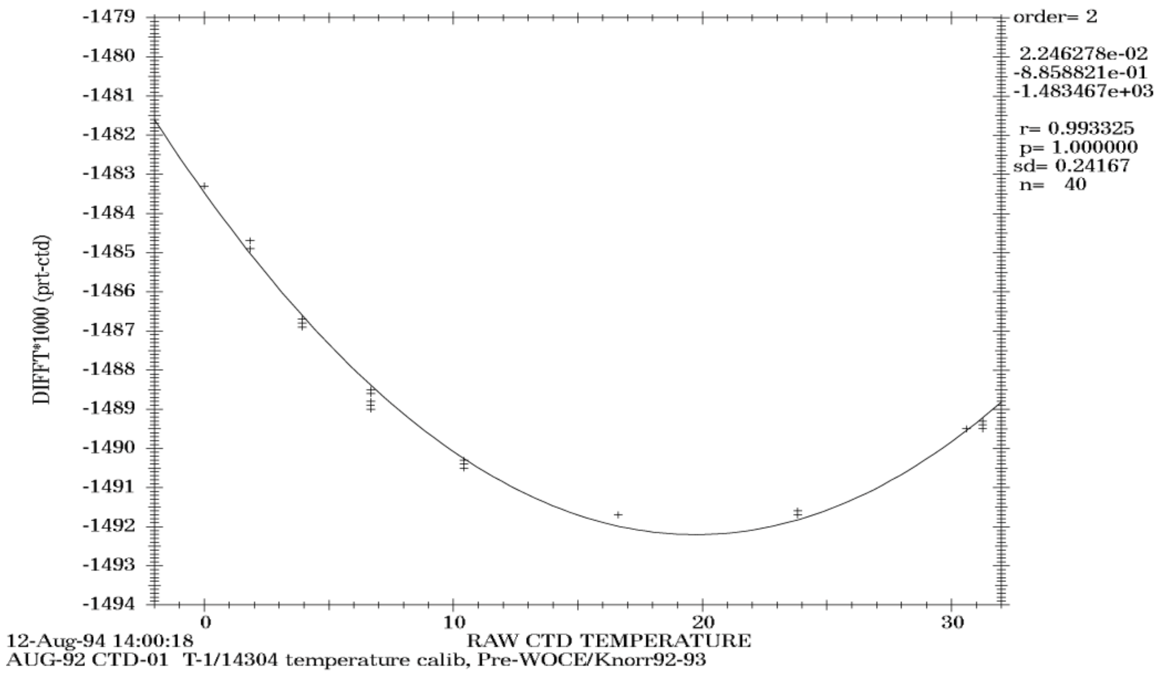

Figure 3a: CTD #1 Pre-cruise PRT-1 Temperature Calibration (ITS-90)

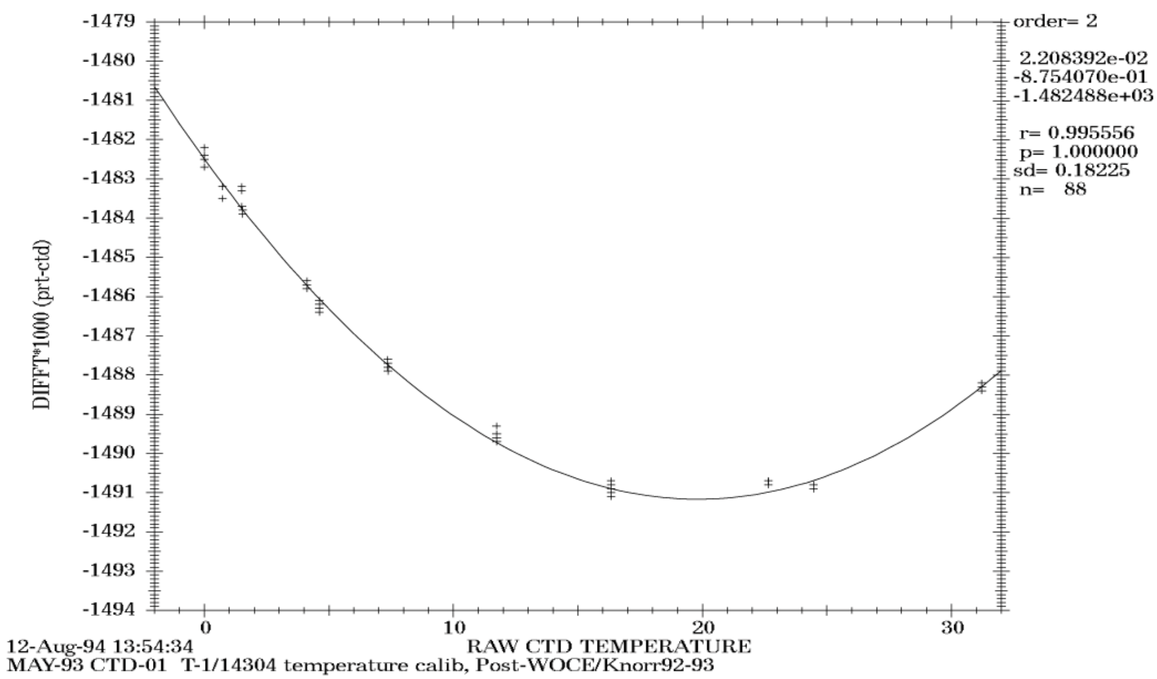

Figure 3b: CTD #1 Post-cruise PRT-1 Temperature Calibration (ITS-90)

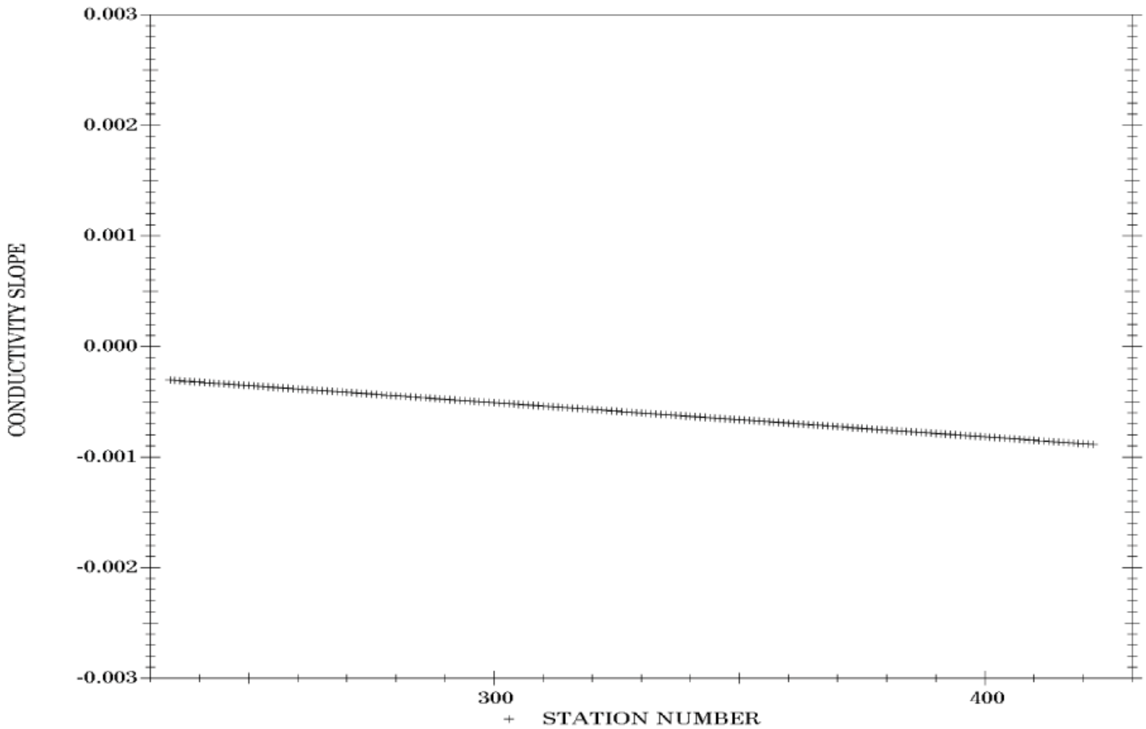

Figure 4a: P19C Conductivity Slopes, Both CTDs

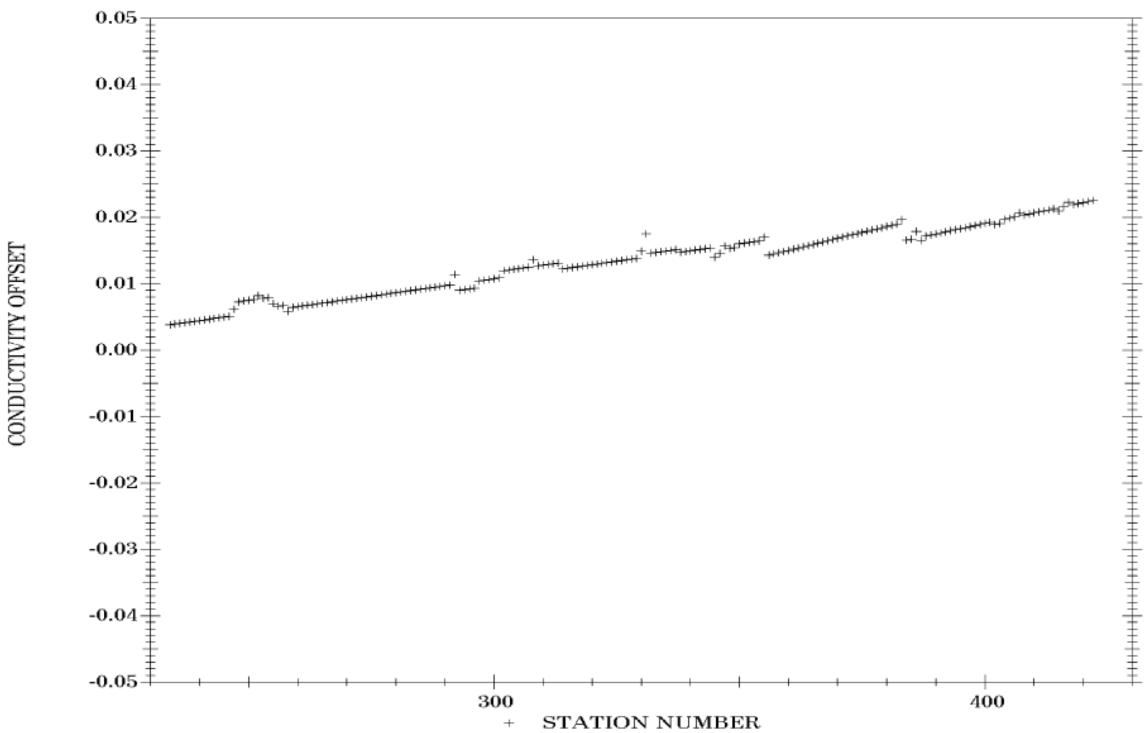

Figure 4b: P19C Conductivity Offsets, Both CTDs

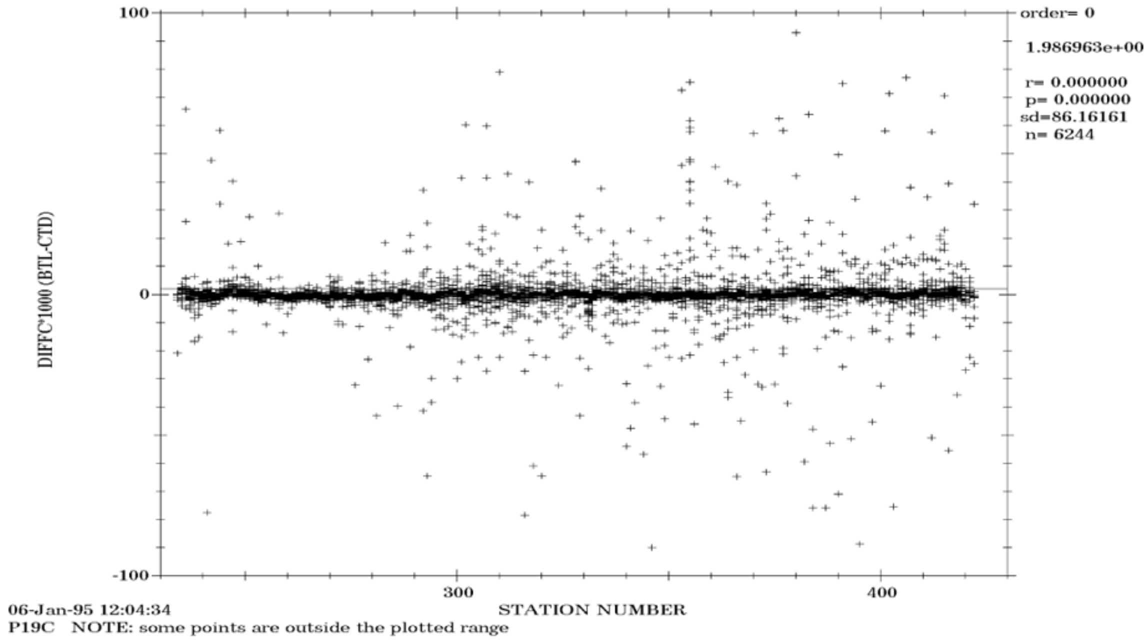

Figure 5a: P19C Residual Conductivity Bottle-CTD Differences - All Pressures

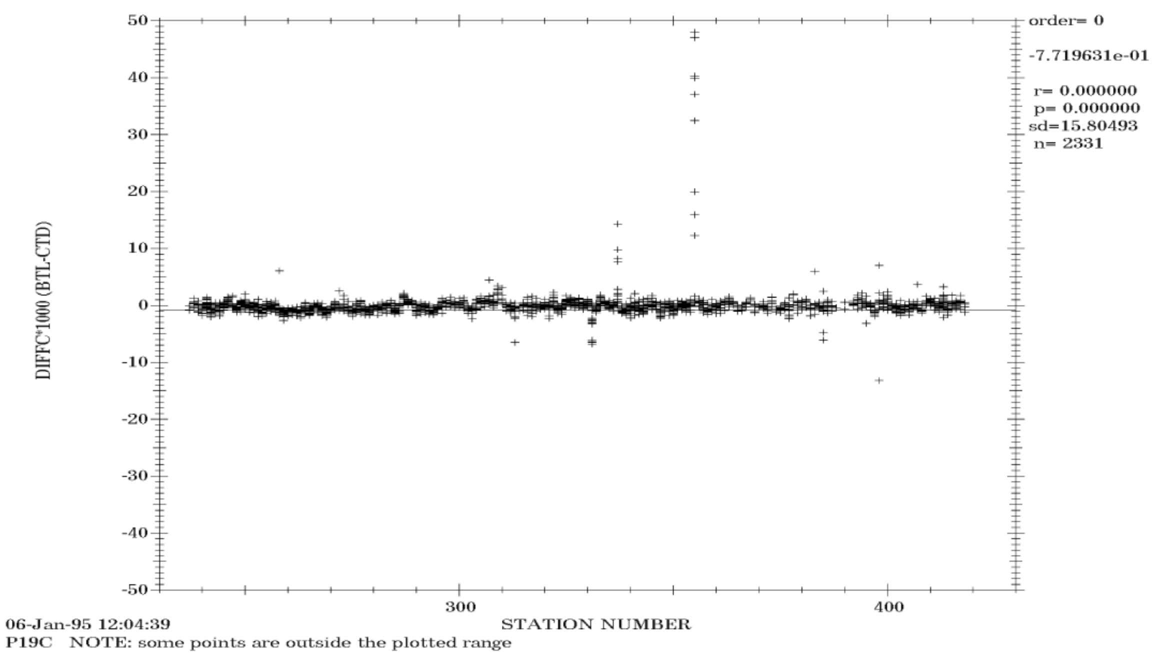

Figure 5b: P19C Residual Conductivity Bottle-CTD Differences - Prs>1500dbar

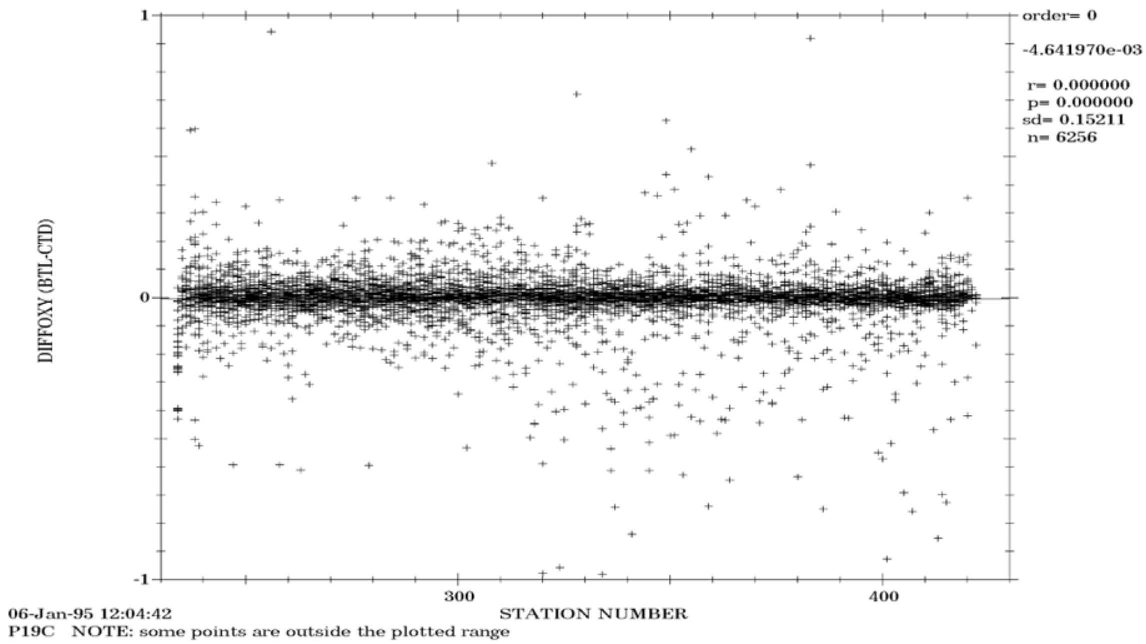

Figure 6a: P19C Residual Diss. Oxygen UpBottle-DownCTD Differences - All Pressures

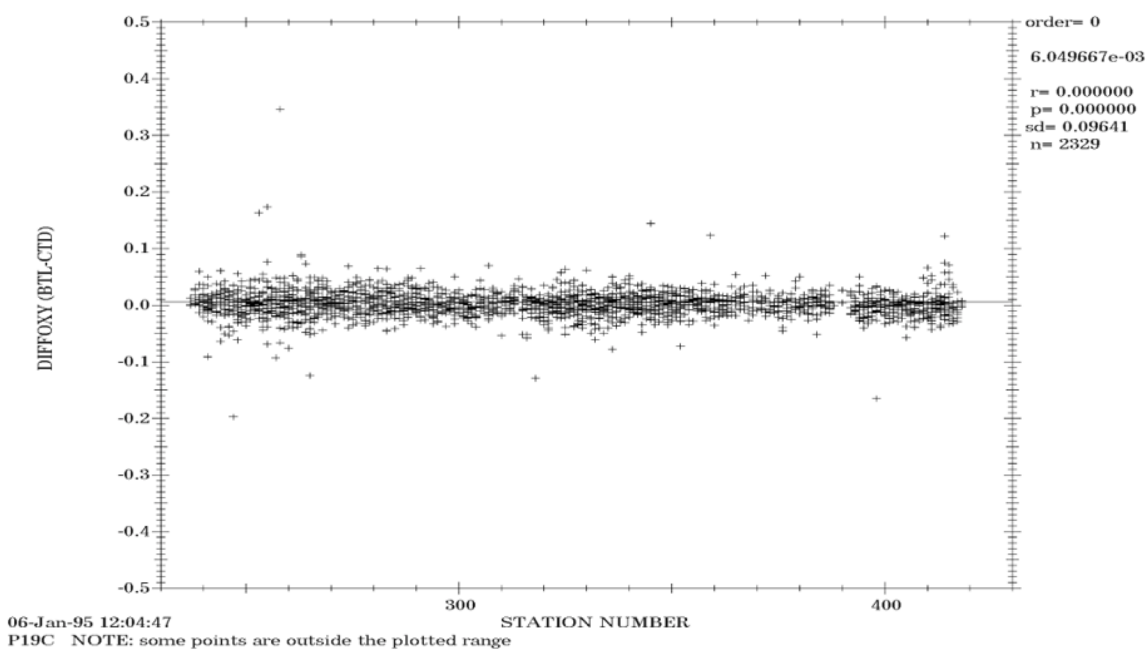

Figure 6b: P19C Residual Diss. Oxygen UpBottle-DownCTD Differences - Prs>1500dbar

Appendix D:

WOCE93-P19C Processing Notes

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WOCE93-P19C CTD Shipboard and Processing Comments

sta/cast	Comments
234/01	new end termination; 4-min. stop/yoyo from 85 db back up to 71 db on down cast before continuing; almost hit as bottom shoaled up during bottle trip; CTD oxygen data would not auto-fit to bottle values, probably because shallow cast with 4-min. stop/yoyo in high gradient area: used coefficients from station 235 cast 1 fit for this cast
235/01	rotate pylon 90 degrees before cast to avoid trip-through at bttm; winch started down at 90 m/min
236/01	
237/01	0 db level extrapolated
238/01	
239/01	
240/01	changed CTD wiring prior to cast: 2 (vs.1) conductors to CTD now: current was stable; some noise caused by change, especially up cast
241/02	back to 1 conductor; some signal noise beginning 2400 db upcast; sparse bottle oxygen data 1000 db to bottom: added cast 4 bottle oxygens to fill in the gaps for CTD oxygen fit
241/04	checked/dried cables/connectors prior to cast; signal noise upcast; this is repeat cast at station due to bottle tripping problems on cast 2; cast delayed 1m minute at 8-12 db down; sparse bottle oxygen data top 1000 db: added cast 2 bottle oxygens to fill in the gaps for CTD oxygen fit
242/01	0 db level extrapolated; found/eliminated one bad conductor in wire prior to cast; down by one conductor for rest of cruise, but signal noise is improved; stopped 2 minutes at cast start (0-6 db) before continuing down
243/01	
244/01	
245/01	0 db level extrapolated; LADCP removed prior to cast; back to 36 bottles
246/01	
247/01	
248/01	acquisition started after ctd in water; pulled package back out before continuing down
249/01	

250/01
251/01 0 db level extrapolated
252/01
253/01 0 db level extrapolated
254/01 GO pylon controller box fault light glowing faintly throughout cast; NO-confirm at btl 13, late confirm for btl 14 at same pressure, next trip ok; signal missing 2586-2421 db upcast: audio ok, replayed.
255/01 glowing GO pylon controller box fault light throughout cast;
256/01 0 db level extrapolated
257/01 0 db level extrapolated; bad weather/shiproll, slower winch speed first 1000m; stop/slow winch multiple times during up cast to turn ship; wire angle increasing beginning 3400m; NO-confirm at 300m trip/btl.30; stopped tripping here and brought package out because of BAD WEATHER: 90-degree wire angle, ship constantly maneuvering in 60-knot winds; perpendicular to swell as package brought out of water; no bottle oxygen data top 300 db: added mostly station 256/some station 258 bottle oxygens to fill in the gap for CTD oxygen fit (station 258 values seemed high for station 257 oxygen shape between 100-300 db)
258/01 new end termination; kinks in wire at end of cast; 3 tries/all NO-confirms at 160m/btl 30, reset to btl 31; last 6 btls confirmed ok
259/01 0 db lev el extrapolated; new end termination; major spiking from 4580 db up to surface, loud noise from deck unit at spikes
260/01 CTD wiring fixed prior to cast = clean signal; cast delayed 1 minute at 4-8 db down; large wire angle near bottom; big transmissometer dropout 2900 db to bottom on down cast
261/01
262/02 0 db level extrapolated; btl 35: 3 tries/all NO-confirms, reset to btl 36 for surface trip = ok; high raw CTD oxygen values - CTD oxygen data questionable from approx. 0 to 60 db; short section of conductivity/ salinity drop 98-102 db, probably organic contamination: despiked/ok now
263/01 high raw CTD oxygen values - CTD oxygen data questionable from approx. 6 to 50 db
264/02 0 db level extrapolated
265/01 0 db level extrapolated
266/01 bottom depth decreased 200m during downcast
267/01
268/01 0 db level extrapolated; btl 35: 3 tries/all NO-confirms; reset to btl 36 for surface trip = ok
269/01
270/01 0 db level extrapolated
271/01 0 db level extrapolated; UP cast: big dropout in conductivity 140-460 db down, probably organic matter contamination of sensor; up cast ok
272/01 0 db level extrapolated; 6-min. winch stop/yoyo at 385 db back up to 359 db on down cast -affected CTD oxygen data; 3-min. stop/yoyo at 679 db back up to 664 db down cast; btl 35: NO-confirm followed by good confirm

273/01	0 db level extrapolated; choppy seas/windy; btl 34: 3 tries/NO-confirm, reset to btl 35; btl 35: NO-confirm followed by good confirm; surface btl 36 tripped on the fly about 5m too deep
274/02	0 db level extrapolated; washed pylon off with fresh water prior to cast; btl 15: NO-confirm followed by good confirm; btl 30: 2 tries/both NO-confirms; btl 35: 2 tries/both NO-confirms
275/01	0 db level extrapolated; cleaned pylon connections before cast; voltmeter added to pylon circuit
276/01	0 db level extrapolated; btl 30: 2 tries/both NO-confirms
277/01	
278/01	
279/01	high raw CTD oxygen values - CTD oxygen data questionable from approx. 8 to 48 db
280/01	0 db level extrapolated; surface btl 36 fired while winch still moving up last meter or so
281/01	0 db level extrapolated; cast ABORTED at 3007 db: forgot to turn on pinger at cast start; brought back to srfc, pinger turned on, restarted as cast 2; reported this cast with final data even though aborted; no btl trips: used cast 2 bottle data for CTD oxygen fit
281/02	0 db level extrapolated
282/01	0 db level extrapolated; two trips at 1212 db - pilot error
283/01	0 db level extrapolated; started pylon tripping at btl 13 for freon blank check; two trips at 2400 db - pilot error
284/02	
285/01	0 db level extrapolated; bio-optics cast over the side mid-CTD cast; winch brake problems during cast - stop 24 mins. at 2062-2068 db up plus 5/3.5 mins. at 2220-2224/2014-2018 db up
286/01	0 db level extrapolated; winch spd VERY slow 90-100m down, stop 15 mins. for brake problems 148-168 db down; stop again 8 mins. at 2484-2508 db down for winch problems/check - visible effect on CTD oxygen data from both high-gradient stops
287/01	0 db level extrapolated
288/01	
289/01	bottom depth uncertain due to side echoes
290/01	stop ctd 30+ mins. near bottom/4242-4257 db to debug/re-initialize GO pylon communications; while debugging, rosette may have touched bottom: brought up to 4211 db w/audio-only running until problem fixed, then back down to near-bottom for bottle trip; delay had offset effect on CTD oxygen data
291/01	10-ft blue marlin swimming under wire lights during cast
292/01	
293/01	0 db level extrapolated
294/02	0 db level extrapolated; LADCP back on this cast
295/01	0 db level extrapolated
296/01	0 db level extrapolated
297/01	0 db level extrapolated; transmissometer noisy 1200m down to end of cast
298/01	0 db level extrapolated; started pylon tripping at btl 13 for freon blank check

299/02	0 db level extrapolated; 1.5-min. delay at 2-4 db before starting down
300/01	0 db level extrapolated
301/01	no transmissometer this cast
302/02	no transmissometer this cast
303/01	0 db level extrapolated; transmissometer reinstalled prior to cast btl 30: NO-confirm followed by good confirm
304/01	0 db level extrapolated; last cast with transmissometer #63D
305/01	0 db level extrapolated; transmissometer #173D installed; pinger died on downcast
306/01	new pinger #1223 installed w/fresh batteries; altimeter moved up on rosette
307/01	
308/01	0 db level extrapolated; btl 30: 3 tries/all NO-confirms; reset to btl 31 and skip 100m trip
309/01	
310/01	
311/01	
312/01	
313/01	0 db level extrapolated; btl 30: 2 tries/both NO-confirms; 100m trip skipped
314/01	shallow bottom; btls 27 thru 36 not fired off
315/01	0 db level extrapolated
316/01	0 db level extrapolated; testing new altimiter = Datasonics #330; no altimeter signal this cast: powered off altimeter only at 800m down, may have induced some CTD signal noise
317/02	winch not set correctly, yoyo back to surface to re-zero/start down after 1-min. delay at 6-8 db; Datasonics altimeter powered on at 100m down, off and on a few times, mostly off during cast; still no good near bottom, left off;
318/01	btl 15: NO-confirm followed by good confirm
319/01	0 db level extrapolated; btl 15: 2 tries/both NO-confirms, reset to btl 16 and skip 1300m trip
320/01	LADCP removed prior to cast; original altimeter back on-line; btl 35: 3 tries/all NO-confirms, reset to btl 36 for surface trip bottom depth nearly 200m less than wire out; CTD probably down in deeper hole just before sta, ship on ledge next to it
321/01	0 db level extrapolated
322/01	0 db level extrapolated; cast start delayed by ship engine problem
323/01	0 db level extrapolated
324/01	
325/01	0 db level extrapolated; started pylon tripping at btl 25 for freon blank check
326/02	
327/02	0 db level extrapolated; pdr bottom reading mid-cast very uncertain, up to 100m-wide area
328/01	0 db level extrapolated; pinger signal died after first 5 mins. of down cast; btl 71: NO-confirm, 1.5-min. delay to re-initialize GO pylon communications, then good confirm; btl 30: NO-confirm followed by good confirm, came up OPEN anyways; btl 72 now in Davey Jones' locker - MIA at rosette recovery
329/01	0 db level extrapolated
330/01	0 db level extrapolated; entire down cast offset from nearby casts, up cast worse: offsets twice mid-cast

331/01 0 db level extrapolated; down cast conductivity is offset low compared to nearby casts; up cast conductivity offsets higher twice, near bottom and halfway up; nothing on sensor after cast, washed with seawater squirt btl anyways

332/01

333/01 0 db level extrapolated

334/01 0 db level extrapolated

335/02

336/01 0 db level extrapolated; transmissometer noisy 140-700 db down, then suspected organic matter probably washed off

337/01 0 db level extrapolated; conductivity sensor not soaking in water prior to this cast; started pylon tripping at btl 25 for freon blank check

338/02 0 db level extrapolated; 4.5-min. delay at 0-6 db before cast started down; big difference between PDR bottom and maximum wire out

339/01

340/01 0 db level extrapolated

341/01

342/02 0 db level extrapolated

343/01 0 db level extrapolated; conductivity dropout 776-784 db down, probably organic matter that washed off: despiked/ok now; stop 1+ min. at 4156-4160 db down to check noisy altimeter rdgs; CTD voltage increased slightly at 3780 db on up cast, dropping several tenths below 25

344/01 0 db level extrapolated; UP cast, conductivity noisy/offset low at 280-1000 db down, up cast ok; probably organic matter contamination of sensor

345/01

346/01 0 db level extrapolated

347/01 0 db level extrapolated

348/01 0 db level extrapolated; UP cast, -.002 psu salinity offset from 2230 db down to bottom, shifts back at bottom: up cast ok

349/01

350/03 CTD cast done while 3 Gerard barrels stuck at 458mwo and trawl winch under repair

351/01

352/01 0 db level extrapolated; CTD found still powered up 3.5 hrs post- cast: turned off

353/01

354/01 0 db level extrapolated; UP cast, 170 db yoyo on down cast; no altimeter signal/side of seamount, tripped btl and started back up before realizing not tripped at bottom; assume first btl 71 contaminated because lowered 750 meters below trip pressure after tripping. 6-min. stop for therm soak at 3874-3878 db up, causes CTD oxygen data to drift high from 3878 to bottom

355/01 0 db level extrapolated; UP cast, LADCP back on rosette, minus 3 niskins; conductivity offsets low approx. 65-400 db down (organic matter probably contaminated the sensor), then down originally offset from up below 400 db; conductivity signal noisy/offsetting on up cast until
approx. 1850+ db, top 1850 db of up cast compares well to nearby stations

355/11 DOWN cast for station 355: major organic matter contamination of conductivity sensor may begin as early as 65 db with slight increase in conductivity; conductivity still drifting back until about 300-400 db down, then offset from up by .02psu from upcast from 400-1800 db and nearby stations to bottom.

356/01 cond. probe cleaned w/fresh water prior to cast; transmissometer spikes below 1000 db

357/02 weights removed from rosette prior to cast for better LADCP balance; CTD wire shorted in pylon conductor prior to cast, took GO pylon deck unit with it; test cast to 300m not numbered or saved: cut 50m off wire, retermination prior to cast; btl 4: NO-confirm, re-initialized GO pylon communications, then good confirm;

358/01 0 db level extrapolated; pinger died just before bottom approach; transmissometer erratic 2800 db down to 3400 db up, spiking at many bottle stops

359/01 0 db level extrapolated; transmissometer offset/noisy surface to 120 db down, ok after that

360/01 0 db level extrapolated

361/02 0 db level extrapolated

362/01 0 db level extrapolated

363/01 0 db level extrapolated

364/01

365/01

366/01

367/01

368/01 unidentifiable foamy/clumpy organic matter, possibly ship refuse, floating on surface at cast launch

369/01

370/01 transmissometer problem 420-510 db down and deeper sections on down cast; some noise on up cast, not as consistent

371/01

372/01 0 db level extrapolated

373/01 transmissometer dropout 495-550 db

374/01 call back cast at 50m down to re-initialize GO pylon communications, restart as if false start never happened

375/01 GO pylon not responding again at cast start; stop just under surface, re-initialize after bringing package out of water, start again as if false start never happened

376/01 0 db level extrapolated

377/01

378/01 transmissometer dropouts from 700 db down to bottom

379/03 0 db level extrapolated; UP cast, down cast conductivity/salinity is offset -.012 psu from up cast until near bottom, up matches nearby casts; no pinger signal, probable operator error

380/01 transmissometer dropouts 285-375 db down and 1370-1250 db up

381/01

382/01

383/01 0 db level extrapolated; UP cast, organic matter contamination on conductivity sensor and transmissometer from 900-1700 db down, up cast ok

384/01 0 db level extrapolated

385/01 0 db level extrapolated; 31-min. stop at 2410-2414 db: lost data acquisition at 1850 db, suspect RS232 port on CTD deck unit, resume after powering off/on fixed deck unit communications; cast replayed from analog backup: no gap, minimal effect on CTD oxygen data

386/01 ABORTED cast, not processed/reported; winch stopped itself at 1102m on down cast; over 2.5 hours to recover package, major winch trouble

386/02 switch to Markey winch, new end termination done during A.Johnson winch repair; yoyo back to surface from 480 db/restart cast after resetting winch - false start section of cast not saved.

387/01 0 db level extrapolated

388/02 0 db level extrapolated; yoyo back to surface from 129mwo after late power-up of GO pylon deck unit: out of water before starting back down; transmissometer dropout 770-900 db up

389/01

390/01 0 db level extrapolated

391/01 0 db level extrapolated; several large transmissometer dropouts up cast

392/01

393/01 0 db level extrapolated; transmissometer dropouts bottom to 800 db on up cast; rosette came up severely slimed with organic matter

394/01 transmissometer cleaned prior to cast; started pylon tripping at btl 13 for freon blank check

395/02 0 db level extrapolated

396/01 0 db level extrapolated; btl 5: NO-confirm, re-initialized GO pylon communications, then good confirm

397/01

398/01

399/01 0 db level extrapolated

400/01 0 db level extrapolated; btl 35: 3 tries/NO-confirm but came up closed; reset to btl 36 for surface trip/ok

401/01 0 db level extrapolated

402/01 stop 6 mins. at 2252-2258 db down cast to check winch noise problem

403/01 btl 35: NO-confirm followed by good confirm; btl 36: NO confirm followed by good confirm

404/02

405/01 0 db level extrapolated

406/01 0 db level extrapolated; btl 68: 5 tries at 2 pressures/all NO-confirms

407/01

408/02 0 db level extrapolated; btl 35: NO-confirm followed by good confirm

409/01 btl 68: 3 tries/all NO-confirms; reset to btl 35: NO-confirm followed by good confirm

410/01 0 db level extrapolated; LADCP removed prior to this cast

411/01

412/01 0 db level extrapolated

413/02 yoyo 18 db back to surface on down to re-zero/reset winch

414/01 0 db level extrapolated; CTD oxygen data difficult to fit to bottle data: quality of approx. 50 to 2000 db CTD oxygen values degraded to fit deep data better

415/01 0 db level extrapolated

416/01 GO pylon deck unit not turned on until about 100m above bottom

417/01

418/01	
419/01	
420/01	CTD oxygen data would not auto-fit to bottle values, probably because cast ends during long section of near-0 oxygen values: used coefficients from station 419 cast 1 fit for this cast
421/01	
422/01	0 db level extrapolated

WOCE93-P19C: CAST STOPS LONGER THAN 1-MINUTE

station /cast	down /up	#minutes stopped	avg.pressure (decibars)	pressure range
234/01	DOWN	3.7	85	(82 - 88)
241/04	DOWN	1.2	10	(8 - 12)
242/01	DOWN	2.2	3	(0 - 6)
260/01	DOWN	1.0	6	(4 - 8)
272/01	DOWN	5.9	385	(382 - 388)
		3.1	679	(678 - 680)
286/01	DOWN	10.1	151	(148 - 154)
		4.5	162	(156 - 168)
		8.3	2496	(2484 - 2508)
290/01	DOWN	9.2	4251	(4244 - 4258)
299/02	DOWN	1.4	3	(2 - 4)
317/02	DOWN	1.1	7	(6 - 8)
328/01	DOWN	1.6	4481	(4480 - 4482)
338/02	DOWN	4.5	3	(0 - 6)
343/01	DOWN	1.3	4158	(4156 - 4160)
354/01	UP	5.7	3876	(3874 - 3878)
383/01	UP	1.0	2009	(2008 - 2010)
		1.2	2618	(2616 - 2620)
385/01	DOWN	30.6	2412	(2410 - 2414)
402/01	DOWN	5.7	2255	(2252 - 2258)

WOCE93-P19C: CTD Temperature and Conductivity Corrections Summary

Sta/ Cast	PRT Response Time (secs)	Temperature Coefficients corT = t2 T 2 +t1 T + t0 t2	t1	t0	Conductivity Coefficients corC = c1 C +c0 c1	c0
234/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.04020e-04	0.00381
235/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.07115e-04	0.00391
236/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.10210e-04	0.00402
237/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.13305e-04	0.00412
238/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.16400e-04	0.00423
239/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.19495e-04	0.00433
240/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.22590e-04	0.00444
241/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.25685e-04	0.00454

Sta/ Cast	PRT Response Time (secs)	Temperature Coefficients corT = t2 T 2 +t1 T + t0 t2	t1	t0	Conductivity Coefficients corC = c1 C +c0 c1	c0
241/04	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.25685e-04	0.00454
242/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.28781e-04	0.00465
243/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.31876e-04	0.00475
244/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.34971e-04	0.00486
245/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.38066e-04	0.00496
246/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.41161e-04	0.00507
247/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.44256e-04	0.00617
248/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.47351e-04	0.00728
249/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.50446e-04	0.00738
250/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.53541e-04	0.00749
251/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.56636e-04	0.00759
252/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.59731e-04	0.00820
253/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.62826e-04	0.00780
254/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.65921e-04	0.00791
255/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.69016e-04	0.00701
256/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.72111e-04	0.00662
257/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.75206e-04	0.00672
258/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.78301e-04	0.00583
259/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.81397e-04	0.00643
260/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.84492e-04	0.00654
261/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.87587e-04	0.00665
262/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.90682e-04	0.00675
263/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.93777e-04	0.00686
264/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.96872e-04	0.00696
265/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-3.99967e-04	0.00707
266/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.03062e-04	0.00717
267/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.06157e-04	0.00728
268/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.09252e-04	0.00738
269/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.12347e-04	0.00749
270/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.15442e-04	0.00759
271/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.18537e-04	0.00770
272/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.21632e-04	0.00780
273/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.24727e-04	0.00791
274/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.27822e-04	0.00801
275/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.30918e-04	0.00812
276/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.34013e-04	0.00822
277/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.37108e-04	0.00833
278/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.40203e-04	0.00843
279/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.43298e-04	0.00854
280/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.46393e-04	0.00864
281/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.49488e-04	0.00875
281/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.49488e-04	0.00875
282/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.52583e-04	0.00885

Sta/ Cast	PRT Response Time (secs)	Temperature Coefficients corT = t2 T 2 +t1 T + t0			Conductivity Coefficients corC = c1 C +c0	
		t2	t1	t0	c1	c0
283/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.55678e-04	0.00896
284/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.58773e-04	0.00906
285/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.61868e-04	0.00917
286/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.64963e-04	0.00927
287/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.68058e-04	0.00938
288/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.71153e-04	0.00948
289/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.74248e-04	0.00959
290/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.77343e-04	0.00970
291/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.80438e-04	0.00980
292/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.83534e-04	0.01141
293/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.86629e-04	0.00901
294/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.89724e-04	0.00912
295/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.92819e-04	0.00922
296/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.95914e-04	0.00933
297/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-4.99009e-04	0.01043
298/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.02104e-04	0.01054
299/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.05199e-04	0.01064
300/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.08294e-04	0.01075
301/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.11389e-04	0.01085
302/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.14484e-04	0.01196
303/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.17579e-04	0.01206
304/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.20674e-04	0.01217
305/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.23769e-04	0.01227
306/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.26864e-04	0.01238
307/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.29959e-04	0.01248
308/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.33054e-04	0.01359
309/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.36150e-04	0.01269
310/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.39245e-04	0.01280
311/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.42340e-04	0.01290
312/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.45435e-04	0.01301
313/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.48530e-04	0.01311
314/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.51625e-04	0.01222
315/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.54720e-04	0.01232
316/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.57815e-04	0.01243
317/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.60910e-04	0.01254
318/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.64005e-04	0.01264
319/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.67100e-04	0.01275
320/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.70195e-04	0.01285
321/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.73290e-04	0.01296
322/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.76385e-04	0.01306
323/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.79480e-04	0.01317
324/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.82575e-04	0.01327
325/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.85671e-04	0.01338

Sta/ Cast	PRT Response Time (secs)	Temperature Coefficients corT = t2 T 2 +t1 T + t0			Conductivity Coefficients corC = c1 C +c0	
		t2	t1	t0	c1	c0
326/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.88766e-04	0.01348
327/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.91861e-04	0.01359
328/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.94956e-04	0.01369
329/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-5.98051e-04	0.01380
330/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.01146e-04	0.01490
331/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.04241e-04	0.01751
332/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.07336e-04	0.01461
333/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.10431e-04	0.01472
334/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.13526e-04	0.01482
335/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.16621e-04	0.01493
336/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.19716e-04	0.01503
337/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.22811e-04	0.01514
338/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.25906e-04	0.01474
339/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.29001e-04	0.01485
340/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.32096e-04	0.01495
341/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.35191e-04	0.01506
342/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.38287e-04	0.01516
343/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.41382e-04	0.01527
344/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.44477e-04	0.01537
345/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.47572e-04	0.01398
346/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.50667e-04	0.01459
347/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.53762e-04	0.01569
348/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.56857e-04	0.01530
349/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.59952e-04	0.01540
350/03	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.63047e-04	0.01601
351/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.66142e-04	0.01611
352/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.69237e-04	0.01622
353/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.72332e-04	0.01632
354/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.75427e-04	0.01643
355/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.78522e-04	0.01700
355/11	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.78522e-04	0.03550
356/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.81617e-04	0.01429
357/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.84712e-04	0.01448
358/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.87808e-04	0.01466
359/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.90903e-04	0.01484
360/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.93998e-04	0.01502
361/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-6.97093e-04	0.01520
362/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.00188e-04	0.01538
363/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.03283e-04	0.01556
364/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.06378e-04	0.01574
365/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.09473e-04	0.01592
366/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.12568e-04	0.01610
367/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.15663e-04	0.01628

Sta/ Cast	PRT Response Time (secs)	Temperature Coefficients corT = t2 T 2 +t1 T + t0			Conductivity Coefficients corC = c1 C +c0	
		t2	t1	t0	c1	c0
368/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.18758e-04	0.01646
369/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.21853e-04	0.01664
370/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.24948e-04	0.01682
371/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.28043e-04	0.01700
372/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.31138e-04	0.01718
373/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.34233e-04	0.01736
374/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.37328e-04	0.01754
375/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.40424e-04	0.01772
376/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.43519e-04	0.01790
377/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.46614e-04	0.01808
378/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.49709e-04	0.01826
379/03	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.52804e-04	0.01844
380/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.55899e-04	0.01862
381/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.58994e-04	0.01880
382/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.62089e-04	0.01898
383/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.65184e-04	0.01966
384/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.68279e-04	0.01656
385/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.71374e-04	0.01671
386/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.74469e-04	0.01787
387/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.77564e-04	0.01653
388/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.80659e-04	0.01719
389/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.83754e-04	0.01734
390/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.86849e-04	0.01750
391/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.89944e-04	0.01766
392/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.93040e-04	0.01782
393/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.96135e-04	0.01798
394/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-7.99230e-04	0.01813
395/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.02325e-04	0.01829
396/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.05420e-04	0.01845
397/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.08515e-04	0.01861
398/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.11610e-04	0.01876
399/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.14705e-04	0.01892
400/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.17800e-04	0.01908
401/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.20895e-04	0.01924
402/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.23990e-04	0.01889
403/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.27085e-04	0.01905
404/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.30180e-04	0.01971
405/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.33275e-04	0.01987
406/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.36370e-04	0.02002
407/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.39465e-04	0.02068
408/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.42560e-04	0.02034
409/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.45656e-04	0.02050
410/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.48751e-04	0.02066

Sta/ Cast	PRT Response Time (secs)	Temperature Coefficients corT = t2 T 2 +t1 T + t0			Conductivity Coefficients corC = c1 C +c0	
		t2	t1	t0	c1	c0
411/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.51846e-04	0.02081
412/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.54941e-04	0.02097
413/02	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.58036e-04	0.02113
414/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.61131e-04	0.02129
415/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.64226e-04	0.02094
416/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.67321e-04	0.02160
417/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.70416e-04	0.02226
418/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.73511e-04	0.02192
419/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.76606e-04	0.02207
420/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.79701e-04	0.02223
421/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.82796e-04	0.02239
422/01	.30	2.22788e-05	-8.80861e-04	-1.48332	-8.85891e-04	0.02255

Summary of WOCE93-P19C CTD Oxygen Time Constants

Temperature		Press.	O2 Grad.
Fast(tauTF)	Slow(tauTS)	(tauP)	(tauOG)
10.0	400.0	16.0	16.0

WOCE93-P19C CTD Oxygen: Levenberg-Marquardt Non-linear Least-Squares-Fit Coefficients
(see Appendix B for the equations these coefficients plug into)

Sta/ Cast	Slope (c1)	Offset (c2)	Pcoeff (c3)	Tfcoeff (c4/fast)	Tscoeff (c5/slow)	OGcoeff (c6)
234/01	7.75352e-04	3.55304e-03	4.66554e-04	-1.55458e-02	1.37148e-02	1.37200e-06
235/01	7.75352e-04	3.55304e-03	4.66554e-04	-1.55458e-02	1.37148e-02	1.37200e-06
236/01	1.33465e-03	1.59708e-02	8.07042e-05	-9.12802e-03	-4.28678e-02	-1.22977e-05
237/01	1.15783e-03	-5.12441e-02	2.44313e-04	-1.72318e-02	-1.65488e-02	-2.22767e-06
238/01	1.37402e-03	-3.35338e-02	1.40493e-04	6.60910e-03	-5.38619e-02	-1.74725e-05
239/01	1.24569e-03	-1.24334e-02	1.51517e-04	-1.37420e-02	-2.70425e-02	1.53732e-05
240/01	1.17559e-03	1.52895e-02	1.40601e-04	-1.22424e-02	-2.39017e-02	-3.11494e-06
241/02	1.31242e-03	2.64981e-04	1.30459e-04	-1.04036e-02	-4.38156e-02	-2.29271e-05
241/04	1.22447e-03	1.01586e-02	1.36176e-04	-7.90643e-03	-3.16191e-02	-1.08954e-05
242/01	1.22373e-03	5.67873e-03	1.39961e-04	-3.17743e-04	-3.66316e-02	-1.27899e-06
243/01	1.35005e-03	-1.47365e-02	1.33144e-04	-2.18148e-02	-3.09893e-02	2.97192e-06
244/01	1.28055e-03	-5.18172e-03	1.40523e-04	-8.02299e-03	-3.87908e-02	3.45118e-06
245/01	1.20828e-03	1.30215e-02	1.37858e-04	-3.64473e-03	-3.30337e-02	-1.48172e-05
246/01	1.31360e-03	-2.90433e-04	1.29336e-04	4.86159e-03	-5.15715e-02	-3.13708e-05
247/01	1.52833e-03	-4.05127e-02	1.22371e-04	-1.01016e-02	-5.91846e-02	-1.12182e-05
248/01	1.62678e-03	-6.89529e-02	1.27537e-04	-2.43837e-02	-5.68011e-02	-1.31304e-05
249/01	1.29330e-03	-6.48183e-03	1.37432e-04	-1.09528e-02	-3.59620e-02	-1.98877e-05
250/01	1.34160e-03	-8.78066e-03	1.32215e-04	-1.21245e-02	-4.22118e-02	-3.21732e-07
251/01	1.28180e-03	1.17562e-03	1.33834e-04	-3.02213e-03	-4.17837e-02	-6.05701e-06
252/01	1.27114e-03	3.68120e-03	1.34314e-04	-9.75255e-03	-3.52634e-02	-2.43072e-06

Sta/ Cast	Slope (c1)	Offset (c2)	Pcoeff (c3)	Tfcoeff (c4/fast)	Tscoeff (c5/slow)	OGcoeff (c6)
253/01	1.32437e-03	-1.75412e-02	1.39691e-04	1.63227e-03	-4.68196e-02	4.40410e-06
254/01	1.44306e-03	-5.18099e-02	1.43702e-04	-5.64415e-03	-5.19225e-02	-2.80786e-05
255/01	1.62273e-03	-9.32757e-02	1.41729e-04	-1.51730e-02	-6.18826e-02	-3.08185e-05
256/01	1.32934e-03	-2.48046e-02	1.42934e-04	-9.89008e-03	-3.96311e-02	-2.58626e-05
257/01	1.29013e-03	-6.96057e-04	1.32655e-04	-8.11755e-04	-4.57550e-02	-2.38334e-05
258/01	1.31078e-03	-1.46364e-02	1.37653e-04	-4.10744e-03	-4.42713e-02	-2.12304e-05
259/01	1.28182e-03	-1.23479e-02	1.41769e-04	-4.27991e-03	-4.07035e-02	-4.85786e-04
260/01	1.37168e-03	-2.99016e-02	1.39860e-04	2.82142e-03	-5.36075e-02	-3.84840e-04
261/01	1.40634e-03	-2.79897e-02	1.32719e-04	3.82277e-03	-5.92769e-02	-2.99344e-03
262/02	1.36785e-03	-2.46122e-02	1.35395e-04	-6.28458e-03	-4.34820e-02	3.96864e-03
263/01	1.25583e-03	9.25171e-03	1.32022e-04	-9.31070e-03	-3.44182e-02	-7.17371e-05
264/02	1.40535e-03	-2.66381e-02	1.33590e-04	-2.10167e-03	-5.50115e-02	-7.18045e-04
265/01	1.40217e-03	-2.94105e-02	1.33854e-04	-4.04382e-03	-4.99672e-02	-1.33862e-03
266/01	1.31805e-03	-1.27158e-02	1.37042e-04	-5.18153e-03	-3.97403e-02	-3.73961e-06
267/01	1.28711e-03	-7.40818e-03	1.37644e-04	-5.17505e-03	-3.85564e-02	-8.68100e-06
268/01	1.33768e-03	-1.64172e-02	1.35307e-04	-2.49373e-03	-4.32231e-02	-3.71288e-06
269/01	1.24454e-03	1.08351e-03	1.39153e-04	-6.77304e-04	-3.73970e-02	-9.84952e-06
270/01	1.20566e-03	6.45115e-03	1.41871e-04	2.46602e-03	-3.59840e-02	-1.52038e-05
271/01	1.13969e-03	2.09149e-02	1.40313e-04	-9.19762e-03	-1.12708e-02	-1.27393e-05
272/01	1.25339e-03	-1.59266e-04	1.38974e-04	6.14067e-04	-4.11059e-02	-1.31840e-05
273/01	1.24391e-03	-6.67888e-03	1.46734e-04	-1.39049e-02	-2.83250e-02	-1.59371e-05
274/02	1.14483e-03	1.42580e-02	1.45766e-04	-4.45936e-03	-2.75860e-02	-8.37811e-06
275/01	1.22541e-03	8.38158e-04	1.40836e-04	-1.20289e-02	-2.88828e-02	-2.51357e-05
276/01	1.26498e-03	-5.04131e-03	1.37364e-04	-8.00100e-04	-3.92202e-02	-1.74437e-05
277/01	1.24923e-03	-6.41713e-03	1.41322e-04	-6.88973e-03	-3.31617e-02	-5.45972e-06
278/01	1.20624e-03	1.00767e-02	1.36242e-04	-4.11571e-03	-3.38851e-02	-8.27337e-06
279/01	1.14811e-03	1.03064e-02	1.47468e-04	-6.74248e-05	-2.89785e-02	2.27496e-03
280/01	1.13048e-03	1.33441e-02	1.47069e-04	3.18961e-03	-2.92645e-02	7.49685e-06
281/01	1.20312e-03	-3.02467e-03	1.51006e-04	-5.32248e-03	-2.89845e-02	-3.25744e-06
281/02	1.16054e-03	8.46244e-03	1.45667e-04	4.68845e-03	-3.10188e-02	-1.25485e-05
282/01	1.33351e-03	-2.03048e-02	1.34244e-04	1.25625e-03	-4.21143e-02	-3.57191e-06
283/01	1.20474e-03	1.37023e-03	1.43309e-04	-2.84721e-03	-2.99125e-02	6.97873e-06
284/02	1.19327e-03	1.01625e-03	1.42646e-04	5.81403e-03	-3.61104e-02	-5.47439e-06
285/01	1.25183e-03	-9.26356e-03	1.41154e-04	-6.19138e-03	-3.20837e-02	2.82626e-06
286/01	1.14420e-03	1.10248e-02	1.45631e-04	7.38812e-03	-3.57504e-02	-1.07213e-05
287/01	1.24694e-03	2.82450e-04	1.40991e-04	-1.05421e-03	-3.28872e-02	-6.73642e-08
288/01	1.19907e-03	7.92431e-03	1.46204e-04	2.46779e-03	-3.14017e-02	1.51681e-06
289/01	1.31578e-03	-3.58961e-03	1.45205e-04	-6.42553e-03	-2.86543e-02	2.38086e-05
290/01	1.26659e-03	1.02109e-02	1.42989e-04	-4.45986e-03	-2.94654e-02	3.28363e-07
291/01	1.42933e-03	-2.31064e-02	1.42709e-04	6.79272e-03	-4.21820e-02	-1.76534e-05
292/01	1.35843e-03	-9.66114e-04	1.39586e-04	1.95570e-03	-3.37095e-02	4.10113e-06
293/01	1.39342e-03	-8.93964e-03	1.45723e-04	-6.14155e-03	-2.99693e-02	-7.71797e-06
294/02	1.47942e-03	-1.29542e-02	1.37461e-04	-5.23746e-04	-3.81007e-02	-1.25477e-05
295/01	1.38856e-03	1.98285e-03	1.40744e-04	1.32147e-03	-3.41683e-02	-7.38983e-06

Sta/ Cast	Slope (c1)	Offset (c2)	Pcoeff (c3)	Tfcoeff (c4/fast)	Tscoeff (c5/slow)	OGcoeff (c6)
296/01	1.36281e-03	6.36291e-03	1.43899e-04	5.57845e-03	-3.42371e-02	-1.17212e-05
297/01	1.47605e-03	-1.50197e-02	1.39819e-04	7.44381e-03	-4.01445e-02	3.34689e-06
298/01	1.42233e-03	-5.23430e-04	1.44801e-04	-6.48933e-03	-2.90093e-02	-6.28144e-06
299/02	1.49919e-03	-1.72302e-03	1.36101e-04	-2.43372e-03	-3.45432e-02	1.90493e-05
300/01	1.46452e-03	-1.06439e-03	1.46851e-04	-2.12791e-03	-3.23197e-02	1.79723e-07
301/01	1.55585e-03	-1.74233e-02	1.43632e-04	-1.00684e-03	-3.49344e-02	5.33584e-06
302/02	1.56033e-03	-9.27531e-03	1.42623e-04	-3.26052e-03	-3.58827e-02	1.56319e-05
303/01	1.57392e-03	-8.72916e-03	1.39695e-04	-4.95132e-04	-3.71699e-02	-9.89115e-06
304/01	1.59887e-03	-6.13551e-03	1.29685e-04	8.80494e-04	-3.84254e-02	6.72129e-06
305/01	1.47869e-03	2.94730e-04	1.45581e-04	-2.54665e-03	-3.06974e-02	-1.58634e-06
306/01	1.48798e-03	7.00448e-03	1.35972e-04	-3.07776e-03	-3.43376e-02	4.97351e-06
307/01	1.53904e-03	3.44496e-03	1.25959e-04	1.39917e-03	-3.72507e-02	3.31312e-06
308/01	1.47941e-03	7.75140e-04	1.42025e-04	-1.74885e-04	-3.35739e-02	-8.54967e-06
309/01	1.61714e-03	-1.23522e-02	1.20160e-04	2.57504e-04	-3.70206e-02	-3.82779e-06
310/01	1.55111e-03	4.15063e-03	1.30329e-04	9.89404e-04	-3.78047e-02	-1.05372e-05
311/01	1.46998e-03	7.70494e-03	1.41996e-04	-8.91142e-03	-2.89695e-02	5.22384e-06
312/01	1.52243e-03	4.34846e-04	1.36697e-04	1.68225e-03	-3.64026e-02	3.61477e-06
313/01	1.38091e-03	3.44072e-02	1.32627e-04	6.58777e-03	-3.62075e-02	-3.59263e-06
314/01	1.80224e-03	-1.68730e-02	6.30523e-05	2.57244e-03	-4.35922e-02	5.32673e-06
315/01	1.56010e-03	9.53376e-04	1.26836e-04	8.82375e-04	-3.68836e-02	-4.63004e-06
316/01	1.53502e-03	6.66787e-03	1.30383e-04	-1.14570e-03	-3.53237e-02	-1.88295e-07
317/02	1.51604e-03	-3.57824e-03	1.47850e-04	-5.57521e-03	-3.15535e-02	1.17955e-05
318/01	1.52733e-03	-1.66701e-03	1.42159e-04	3.24205e-03	-3.77038e-02	4.80745e-07
319/01	1.54577e-03	2.50351e-04	1.38406e-04	-7.06652e-03	-3.33650e-02	5.29189e-06
320/01	1.46121e-03	1.04441e-02	1.40695e-04	-5.09979e-03	-3.10076e-02	5.99810e-06
321/01	1.55639e-03	-9.40892e-04	1.37274e-04	-5.78337e-04	-3.70577e-02	6.85097e-06
322/01	1.46270e-03	1.77236e-02	1.34836e-04	1.46096e-03	-3.57410e-02	-1.57747e-06
323/01	1.51682e-03	4.84044e-03	1.37995e-04	1.19815e-04	-3.59049e-02	3.24703e-07
324/01	1.49669e-03	6.78950e-03	1.40813e-04	-7.45108e-03	-2.98804e-02	4.11839e-06
325/01	1.57006e-03	-4.58283e-03	1.40078e-04	-5.47646e-03	-3.31416e-02	1.39562e-05
326/02	1.54908e-03	-5.53514e-03	1.44785e-04	-3.91221e-03	-3.50316e-02	-6.49402e-06
327/02	1.54926e-03	-1.42075e-03	1.39509e-04	-2.75124e-03	-3.65473e-02	1.08715e-05
328/01	1.59741e-03	-1.82133e-02	1.49444e-04	-1.24048e-02	-2.75995e-02	-9.50024e-06
329/01	1.53679e-03	5.66463e-03	1.37696e-04	-1.21296e-03	-3.45782e-02	8.86121e-06
330/01	1.56426e-03	7.36037e-04	1.38450e-04	-1.56158e-03	-3.50097e-02	-2.87340e-06
331/01	1.46258e-03	1.44385e-02	1.40012e-04	-3.49717e-03	-3.18150e-02	-1.90168e-06
332/01	1.60271e-03	-1.02589e-02	1.41181e-04	-4.81387e-03	-3.29387e-02	1.06907e-06
333/01	1.58836e-03	-6.45337e-03	1.41256e-04	1.78045e-03	-3.93025e-02	-4.32814e-06
334/01	1.61085e-03	-1.11407e-02	1.40491e-04	-1.08693e-02	-2.73688e-02	7.18566e-06
335/02	1.58936e-03	-3.66200e-03	1.37411e-04	8.18649e-04	-3.82174e-02	6.74041e-06
336/01	1.55577e-03	-5.66537e-03	1.42792e-04	-4.32864e-03	-3.14958e-02	7.55191e-07
337/01	1.53702e-03	-1.01296e-03	1.41492e-04	-5.77038e-03	-3.04503e-02	5.56670e-06
338/02	1.58720e-03	-4.96057e-03	1.39296e-04	-6.10604e-04	-3.70031e-02	3.67010e-06
339/01	1.62057e-03	-1.63812e-02	1.42110e-04	-1.45295e-02	-2.46819e-02	1.06797e-06

Sta/ Cast	Slope (c1)	Offset (c2)	Pcoeff (c3)	Tfcoeff (c4/fast)	Tscoeff (c5/slow)	OGcoeff (c6)
340/01	1.56842e-03	-5.60248e-03	1.38964e-04	-1.86065e-03	-3.31656e-02	9.60926e-06
341/01	1.56646e-03	-2.99248e-03	1.35938e-04	-6.48143e-03	-2.99384e-02	1.43557e-05
342/02	1.49361e-03	7.63789e-03	1.39757e-04	-1.19740e-02	-2.38721e-02	7.29042e-06
343/01	1.57718e-03	-1.20404e-02	1.43535e-04	-1.70651e-02	-1.86699e-02	1.45415e-05
344/01	1.46047e-03	-5.05721e-04	1.48227e-04	-2.86127e-02	3.54828e-03	1.13099e-05
345/01	1.44234e-03	4.38243e-03	1.48949e-04	-1.27239e-02	-1.94562e-02	1.20478e-05
346/01	1.53237e-03	1.65694e-03	1.40095e-04	-5.77077e-03	-2.98786e-02	1.40230e-05
347/01	1.61603e-03	-3.74607e-03	1.29966e-04	1.09497e-02	-4.63032e-02	-8.43797e-06
348/01	1.48564e-03	2.22117e-03	1.43433e-04	-1.63009e-02	-9.94466e-03	-2.73275e-05
349/01	1.65880e-03	-3.51365e-03	1.23078e-04	2.07574e-02	-5.75766e-02	-7.37243e-06
350/03	1.45376e-03	5.73821e-03	1.46151e-04	-5.35957e-03	-2.74755e-02	7.18163e-06
351/01	1.62895e-03	-1.60448e-02	1.38012e-04	1.71784e-03	-3.82188e-02	1.00520e-05
352/01	1.59237e-03	-3.78055e-03	1.31543e-04	3.53301e-03	-3.95271e-02	1.08402e-05
353/01	1.55027e-03	-8.25594e-03	1.42665e-04	-6.89856e-03	-2.72649e-02	4.46937e-06
354/01	1.44152e-03	1.27716e-03	1.47365e-04	-1.89031e-02	-4.79165e-03	-2.01977e-05
355/01	1.45868e-03	9.23646e-04	1.42468e-04	-1.25054e-02	-1.09628e-02	-6.10623e-05
355/11	1.58239e-03	-4.33622e-03	1.29458e-04	1.07390e-02	-4.32438e-02	-1.04264e-06
356/01	1.59003e-03	-1.00754e-02	1.35688e-04	4.10406e-03	-3.63776e-02	-3.03747e-06
357/02	1.57747e-03	-4.45453e-03	1.34688e-04	-3.95913e-03	-3.28014e-02	4.74477e-06
313/01	1.38091e-03	3.44072e-02	1.32627e-04	6.58777e-03	-3.62075e-02	-3.59263e-06
314/01	1.80224e-03	-1.68730e-02	6.30523e-05	2.57244e-03	-4.35922e-02	5.32673e-06
315/01	1.56010e-03	9.53376e-04	1.26836e-04	8.82375e-04	-3.68836e-02	-4.63004e-06
316/01	1.53502e-03	6.66787e-03	1.30383e-04	-1.14570e-03	-3.53237e-02	-1.88295e-07
317/02	1.51604e-03	-3.57824e-03	1.47850e-04	-5.57521e-03	-3.15535e-02	1.17955e-05
318/01	1.52733e-03	-1.66701e-03	1.42159e-04	3.24205e-03	-3.77038e-02	4.80745e-07
319/01	1.54577e-03	2.50351e-04	1.38406e-04	-7.06652e-03	-3.33650e-02	5.29189e-06
320/01	1.46121e-03	1.04441e-02	1.40695e-04	-5.09979e-03	-3.10076e-02	5.99810e-06
321/01	1.55639e-03	-9.40892e-04	1.37274e-04	-5.78337e-04	-3.70577e-02	6.85097e-06
322/01	1.46270e-03	1.77236e-02	1.34836e-04	1.46096e-03	-3.57410e-02	-1.57747e-06
323/01	1.51682e-03	4.84044e-03	1.37995e-04	1.19815e-04	-3.59049e-02	3.24703e-07
324/01	1.49669e-03	6.78950e-03	1.40813e-04	-7.45108e-03	-2.98804e-02	4.11839e-06
325/01	1.57006e-03	-4.58283e-03	1.40078e-04	-5.47646e-03	-3.31416e-02	1.39562e-05
326/02	1.54908e-03	-5.53514e-03	1.44785e-04	-3.91221e-03	-3.50316e-02	-6.49402e-06
327/02	1.54926e-03	-1.42075e-03	1.39509e-04	-2.75124e-03	-3.65473e-02	1.08715e-05
328/01	1.59741e-03	-1.82133e-02	1.49444e-04	-1.24048e-02	-2.75995e-02	-9.50024e-06
329/01	1.53679e-03	5.66463e-03	1.37696e-04	-1.21296e-03	-3.45782e-02	8.86121e-06
330/01	1.56426e-03	7.36037e-04	1.38450e-04	-1.56158e-03	-3.50097e-02	-2.87340e-06
331/01	1.46258e-03	1.44385e-02	1.40012e-04	-3.49717e-03	-3.18150e-02	-1.90168e-06
332/01	1.60271e-03	-1.02589e-02	1.41181e-04	-4.81387e-03	-3.29387e-02	1.06907e-06
333/01	1.58836e-03	-6.45337e-03	1.41256e-04	1.78045e-03	-3.93025e-02	-4.32814e-06
334/01	1.61085e-03	-1.11407e-02	1.40491e-04	-1.08693e-02	-2.73688e-02	7.18566e-06
335/02	1.58936e-03	-3.66200e-03	1.37411e-04	8.18649e-04	-3.82174e-02	6.74041e-06
336/01	1.55577e-03	-5.66537e-03	1.42792e-04	-4.32864e-03	-3.14958e-02	7.55191e-07
337/01	1.53702e-03	-1.01296e-03	1.41492e-04	-5.77038e-03	-3.04503e-02	5.56670e-06

Sta/ Cast	Slope (c1)	Offset (c2)	Pcoeff (c3)	Tfcoeff (c4/fast)	Tscoeff (c5/slow)	OGcoeff (c6)
338/02	1.58720e-03	-4.96057e-03	1.39296e-04	-6.10604e-04	-3.70031e-02	3.67010e-06
339/01	1.62057e-03	-1.63812e-02	1.42110e-04	-1.45295e-02	-2.46819e-02	1.06797e-06
340/01	1.56842e-03	-5.60248e-03	1.38964e-04	-1.86065e-03	-3.31656e-02	9.60926e-06
341/01	1.56646e-03	-2.99248e-03	1.35938e-04	-6.48143e-03	-2.99384e-02	1.43557e-05
342/02	1.49361e-03	7.63789e-03	1.39757e-04	-1.19740e-02	-2.38721e-02	7.29042e-06
343/01	1.57718e-03	-1.20404e-02	1.43535e-04	-1.70651e-02	-1.86699e-02	1.45415e-05
344/01	1.46047e-03	-5.05721e-04	1.48227e-04	-2.86127e-02	3.54828e-03	1.13099e-05
345/01	1.44234e-03	4.38243e-03	1.48949e-04	-1.27239e-02	-1.94562e-02	1.20478e-05
346/01	1.53237e-03	1.65694e-03	1.40095e-04	-5.77077e-03	-2.98786e-02	1.40230e-05
347/01	1.61603e-03	-3.74607e-03	1.29966e-04	1.09497e-02	-4.63032e-02	-8.43797e-06
348/01	1.48564e-03	2.22117e-03	1.43433e-04	-1.63009e-02	-9.94466e-03	-2.73275e-05
349/01	1.65880e-03	-3.51365e-03	1.23078e-04	2.07574e-02	-5.75766e-02	-7.37243e-06
350/03	1.45376e-03	5.73821e-03	1.46151e-04	-5.35957e-03	-2.74755e-02	7.18163e-06
351/01	1.62895e-03	-1.60448e-02	1.38012e-04	1.71784e-03	-3.82188e-02	1.00520e-05
352/01	1.59237e-03	-3.78055e-03	1.31543e-04	3.53301e-03	-3.95271e-02	1.08402e-05
353/01	1.55027e-03	-8.25594e-03	1.42665e-04	-6.89856e-03	-2.72649e-02	4.46937e-06
354/01	1.44152e-03	1.27716e-03	1.47365e-04	-1.89031e-02	-4.79165e-03	-2.01977e-05
355/01	1.45868e-03	9.23646e-04	1.42468e-04	-1.25054e-02	-1.09628e-02	-6.10623e-05
355/11	1.58239e-03	-4.33622e-03	1.29458e-04	1.07390e-02	-4.32438e-02	-1.04264e-06
356/01	1.59003e-03	-1.00754e-02	1.35688e-04	4.10406e-03	-3.63776e-02	-3.03747e-06
357/02	1.57747e-03	-4.45453e-03	1.34688e-04	-3.95913e-03	-3.28014e-02	4.74477e-06
358/01	1.55934e-03	-4.14322e-03	1.34794e-04	-6.24229e-04	-3.26510e-02	4.24866e-06
359/01	1.53681e-03	-3.11668e-03	1.37157e-04	-3.11375e-03	-3.00916e-02	7.30831e-06
360/01	1.60198e-03	-6.87871e-03	1.29263e-04	-2.50436e-03	-3.15237e-02	7.84459e-06
361/02	1.64337e-03	-8.90334e-03	1.23168e-04	1.34229e-03	-3.69280e-02	3.73055e-06
362/01	1.65722e-03	-1.30585e-02	1.23288e-04	4.41612e-03	-3.68171e-02	-4.75627e-06
363/01	1.52931e-03	-9.00883e-04	1.33805e-04	2.77012e-03	-3.21128e-02	7.01403e-06
364/01	1.63948e-03	-5.72738e-03	1.18175e-04	5.11034e-03	-3.68236e-02	3.42458e-06
365/01	1.59903e-03	-8.06685e-04	1.13977e-04	-3.06837e-03	-3.07604e-02	8.07452e-06
366/01	1.59041e-03	-5.49369e-03	1.19019e-04	1.65587e-03	-3.44217e-02	-1.13537e-06
367/01	1.65184e-03	-5.94726e-03	1.05528e-04	6.27738e-03	-3.86955e-02	1.39135e-05
368/01	1.62819e-03	-4.26397e-03	1.10790e-04	1.57847e-04	-3.24399e-02	5.05201e-05
369/01	1.50893e-03	-1.30807e-03	1.39795e-04	-3.44761e-03	-2.86157e-02	8.67417e-06
370/01	1.38848e-03	1.31519e-03	1.62141e-04	-2.92186e-03	-2.30093e-02	2.26170e-05
371/01	1.49932e-03	3.72510e-03	1.34806e-04	-7.14270e-04	-3.06054e-02	-6.80468e-06
372/01	1.56900e-03	-2.11829e-03	1.27781e-04	-1.03309e-03	-3.12426e-02	1.00310e-05
373/01	1.47106e-03	6.19374e-03	1.40434e-04	5.72674e-03	-3.49170e-02	1.74343e-05
374/01	1.49895e-03	6.27324e-03	1.32149e-04	2.35790e-03	-3.31526e-02	-1.37618e-06
375/01	1.45964e-03	1.24286e-02	1.28583e-04	-4.49806e-03	-2.94821e-02	1.58058e-05
376/01	1.56705e-03	5.19005e-03	1.11024e-04	9.40670e-03	-4.01970e-02	-5.43522e-06
377/01	1.50944e-03	1.67707e-04	1.43146e-04	-3.22599e-03	-3.03330e-02	6.47492e-06
378/01	1.71025e-03	-9.13654e-03	1.03829e-04	4.90925e-03	-3.72673e-02	6.47864e-06
379/03	1.45785e-03	2.70046e-03	1.38798e-04	-1.85668e-02	-7.03845e-03	-2.00235e-05
380/01	1.53225e-03	-5.16768e-03	1.38262e-04	1.63210e-03	-3.20047e-02	6.92141e-06

Sta/ Cast	Slope (c1)	Offset (c2)	Pcoeff (c3)	Tfcoeff (c4/fast)	Tscoeff (c5/slow)	OGcoeff (c6)
381/01	1.59176e-03	-2.05544e-03	1.19595e-04	4.09759e-03	-3.73142e-02	-6.07401e-06
382/01	1.61502e-03	-2.15186e-04	1.08614e-04	2.03905e-03	-3.69069e-02	2.93371e-06
383/01	1.41099e-03	3.10399e-03	1.48598e-04	-2.02266e-02	-4.36929e-03	-5.37768e-06
384/01	1.48234e-03	3.49670e-03	1.33200e-04	-1.73901e-03	-2.93009e-02	-7.24469e-06
385/01	1.43523e-03	-7.84633e-05	1.51733e-04	-2.23471e-03	-2.90056e-02	9.58248e-06
386/02	1.51857e-03	6.02565e-03	1.24556e-04	-6.39528e-04	-3.11593e-02	1.25276e-05
387/01	1.53496e-03	-1.34990e-03	1.29906e-04	-6.81857e-03	-2.60287e-02	1.19893e-06
388/02	1.71942e-03	1.00279e-02	4.37767e-05	5.85101e-03	-4.12829e-02	5.46158e-06
389/01	2.28339e-03	-9.64600e-03	-9.96188e-05	7.75028e-03	-5.19936e-02	3.40649e-06
390/01	2.03600e-03	-9.77715e-03	1.18237e-06	7.05196e-03	-4.88967e-02	1.00670e-05
391/01	2.01787e-03	-6.18950e-03	-2.20040e-06	3.19772e-03	-4.50124e-02	7.34880e-06
392/01	1.62982e-03	-3.33026e-04	1.02411e-04	5.02818e-03	-3.82902e-02	7.78989e-06
393/01	1.71324e-03	-1.26017e-02	1.04865e-04	6.80001e-03	-4.12664e-02	6.70558e-06
394/01	1.62900e-03	-1.64689e-03	1.23051e-04	-2.88801e-03	-3.35023e-02	2.94251e-06
395/02	1.66512e-03	-7.37788e-03	1.18428e-04	-4.33073e-03	-3.01900e-02	2.29709e-06
396/01	1.63858e-03	-1.22165e-02	1.23601e-04	9.64596e-03	-4.37978e-02	2.45479e-06
397/01	1.56774e-03	2.06346e-03	1.22311e-04	1.67759e-02	-5.14658e-02	-8.73140e-06
398/01	1.52426e-03	1.04980e-04	1.29302e-04	-1.01693e-03	-3.04511e-02	9.58035e-06
399/01	1.53877e-03	-2.26667e-03	1.35374e-04	-1.06104e-02	-2.63372e-02	1.61224e-05
400/01	1.65104e-03	-8.48969e-03	1.16496e-04	7.59609e-03	-4.13892e-02	2.28876e-06
401/01	1.60882e-03	-5.82629e-03	1.26530e-04	-1.67739e-02	-2.30740e-02	2.37789e-05
402/01	1.45945e-03	-3.99954e-03	1.49312e-04	-4.04327e-03	-2.55561e-02	3.32965e-06
403/01	1.50692e-03	-1.18815e-03	1.38757e-04	-4.91172e-03	-2.63025e-02	1.67863e-07
404/02	1.52468e-03	-6.16635e-03	1.41548e-04	-9.23209e-03	-2.66445e-02	6.70728e-06
405/01	1.62054e-03	4.46413e-03	1.11515e-04	2.40066e-02	-5.91655e-02	3.26575e-06
406/01	1.56210e-03	1.39009e-03	1.24948e-04	9.99760e-03	-4.22082e-02	5.70056e-06
407/01	1.62085e-03	-3.33614e-03	1.20371e-04	2.55403e-02	-5.76442e-02	7.07357e-06
408/02	1.52700e-03	-6.33480e-03	1.39808e-04	5.60175e-03	-3.80972e-02	-1.22715e-06
409/01	1.46912e-03	-6.25682e-04	1.44782e-04	-1.40805e-03	-3.13084e-02	1.49193e-06
410/01	1.56623e-03	2.48674e-03	1.21628e-04	2.85820e-02	-6.12733e-02	1.67840e-06
411/01	1.59749e-03	-9.79838e-04	1.20609e-04	3.46869e-02	-6.53846e-02	8.42932e-06
412/01	1.52271e-03	-1.37462e-03	1.32172e-04	2.46078e-02	-5.26770e-02	2.84585e-06
413/02	1.50235e-03	3.69454e-03	1.34045e-04	1.58514e-03	-3.47837e-02	-6.97484e-06
414/01	1.62755e-03	-1.85832e-02	1.37936e-04	4.01637e-02	-7.49309e-02	-6.33250e-06
415/01	1.54496e-03	-6.13903e-03	1.34212e-04	3.54880e-03	-3.35056e-02	-7.89485e-06
416/01	1.56517e-03	-2.33504e-03	1.23689e-04	1.76820e-02	-4.75106e-02	-8.09638e-06
417/01	1.69022e-03	-7.09671e-04	8.82789e-05	1.32192e-02	-4.47324e-02	2.90193e-07
418/01	2.05774e-03	-6.82197e-03	9.06717e-06	2.34076e-02	-6.44391e-02	-7.11790e-06
419/01	4.91018e-03	-1.22319e-02	-4.88910e-04	3.52342e-02	-1.02078e-01	-1.74239e-05
420/01	4.91018e-03	-1.22319e-02	-4.88910e-04	3.52342e-02	-1.02078e-01	-1.74239e-05
421/01	2.03119e-02	-1.37578e-02	-2.64255e-03	1.43830e-02	-1.32537e-01	-6.97251e-06
422/01	5.17937e-04	1.31972e-02	1.09196e-03	2.25231e-02	-1.88006e-02	-1.44454e-06

WOCE93-P19C
(EXPOCODE 316N138/12)
Calibrated Pressure-Series CTD Data
Processing Summary and Comments
January 5, 1995

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1. Introduction

This document describes the CTDO data acquisition, calibration, and other processing techniques used on WOCE93-P19C, also known as Knorr 138/12. This WOCE leg was done on the R/V Knorr from February 22 -April 13, 1993.

2. CTD Acquisition and Processing Summary

190 CTD casts plus two aborted CTD casts were done at 189 P19C stations. The rosette used was an ODF-designed system consisting of a single ring of 36 10-liter bottles with a 36-place General Oceanics Model 1016 intelligent pylon mounted in the center. A CTD, altimeter, pinger and transmissometer were mounted on the bottom of the frame. A University of Hawaii self-contained LADCP was mounted in place of 3 bottles for 93 of the CTD casts. ODF CTD #1, a modified NBIS Mark III-B instrument, was used during the leg.

The ODF CTD acquired data at a rate of 25 Hz. The data consisted of pressure, temperature, conductivity, dissolved oxygen, second temperature, four CTD voltages, trip confirmation, transmissometer, altimeter and elapsed time. LADCP data were not part of the CTD data stream; they were collected and processed separately by University of Hawaii.

An ODF-designed deck unit demodulated the FSK CTD signal to an RS-232 interface. The raw CTD data signal was split into three paths: to be logged in raw digitized form, to be monitored in real time as raw data, and to be processed and plotted. During the P19C expedition, a Sun SPARCstation 2 computer served as the real-time data acquisition processor. Various Sun SPARC computers were used during post-cruise processing as well.

The analog CTD audio signal was recorded on VHS videotape, and all digital binary data were logged on a hard disk and then backed up to cartridge tape. In addition, all intermediate versions of processed data were backed up to cartridge tape.

CTD data processing consists of a sequence of steps; some steps are optional and used only when necessary. Data can be re-processed from any point in this sequence after the data have been acquired and stored. Each CTD cast is assigned a correction file, and while the corrections are usually determined for groups of stations, it is possible to fine tune the parameters for even a single station. The acquisition and processing steps are as follows:

- o Data are acquired from the CTD sea cable and assembled into consecutive .04-second frames containing all data channels. The data are converted to engineering units.
- o The raw pressure, temperature and conductivity data are passed through broad absolute value and gradient filters to eliminate noisy data. The entire frame of raw data is omitted, as opposed to interpolating bad points, if any one of the filters is exceeded. The filters may be adjusted as needed for each cast.

TYPICAL P19C RAW DAT A FILTERS

Raw Data Channel	Minimum	Maximum	Frame-to-Frame Gradient
Pressure	-40	6400	2 decibars
Temperature	-8	32.7	.2 °C
Conductivity	0	64.355	.3 mmho
Oxygen	(no filter was used)		

- o Pressure and conductivity are phase-adjusted to match the temperature response, since the temperature sensor responds more slowly to change. Conductivity data are corrected for ceramic compressibility in accordance with the NBIS Mark III-B Reference Manual.
- o The data are averaged into 0.5-second blocks. During this step, data falling outside four standard deviations from the mean are rejected and the average is recalculated. Then data falling outside two standard deviations from the new mean are rejected, and the data are re-averaged. The resulting averages, minus second temperature and CTD voltages, are reported as the 0.5-second time series. Secondary temperature data are used to verify the stability of the primary temperature channel calibration. Secondary temperature data are only filtered, averaged and reported with the time-series data when they are used in place of the primary temperature data due to a sensor malfunction.
- o Corrections are applied to the data. The pressure data are corrected using laboratory calibration data with the procedure described in Appendix A (Delahoyde/Williams). Temperature corrections, typically a quadratic correction as a function of temperature, are based on laboratory calibrations.

Conductivity and oxygen corrections are derived from water sample data. Conductivity corrections are typically a linear fit as a function of conductivity. Oxygen data are corrected on an individual cast basis using the technique described in Appendix B (Delahoyde). Uncorrected time-series transmissometer data are forwarded to TAMU for final processing and reporting.

The averaged data are recorded on hard disk and sent to the real-time display system, where the data can be reported and plotted during a cast. The averaging system also communicates with the CTD acquisition computer for detection of bottle trips, almost always occurring during the up casts. A 5-second average of the CTD data is stored for each detected bottle trip.

A down-cast pressure-series data set is created from the time series by applying a ship-roll filter to the down-cast time-series data, then averaging the data within 2-dbar pressure intervals centered on the reported pressure. The first few seconds of data for each cast are generally excluded from the averages due to sensor adjustment or bubbles during the in-water transition. Pressure intervals with no time-series data can optionally be filled by double-parabolic interpolation. When the down-cast CTD data have excessive noise, gaps or offsets, the up-cast data are used instead. CTD data from down and up casts are not mixed together in the pressure-series data because they do not represent identical water columns (due to ship movement, internal waves, wire angles, etc.).

The CTD time series is always the primary CTD data record for the pressure, conductivity and temperature channels. The final corrections to the CTD oxygen data are made by correcting pressure-series CTD oxygen data to match the up-cast oxygen water samples at common isopycnals. The final CTDO pressure-series data are the data reported to the principal investigator and to the WHPO.

Subsequent sections of this document discuss the laboratory calibrations, data processing and corrections for the CTD used during P19C.

3. CTD Laboratory Calibrations

3.1. Pressure Transducer Calibration

The CTD #1 pressure transducer was calibrated in a temperature-controlled bath to the ODF Ruska deadweight-tester (DWT) pressure standards. The mechanical hysteresis loading and unloading curves were measured both pre- and post-cruise at cold temperature (-2.0 to -1.4°C bath) to a maximum of 8830 psi, and at warm temperature (29.1 to 30.0°C bath) to a maximum of 2030/4030 psi pre-/post-cruise. The CTD #1 post-cruise testing included an additional calibration to 4030 psi in a 10.3°C bath.

In addition to testing the CTD pressure response to increases in pressure at stable temperatures (mechanical hysteresis), CTD pressure sensor sensitivity to temperature change was checked by thermal shock tests. The CTD was subjected to a step change in temperature from warm air to cold water bath at stable pressure in the laboratory, then the CTD pressure and temperature were measured over a period of at least 1 hour. The thermal shock response was also checked in the opposite direction, cold bath to warm bath; that response was roughly mirror-image to the warm-to-cold response.

Thermal shock tests for CTD #1 were done from warm air to cold water bath, and later from cold bath to warm air, during the post-cruise calibration. Further testing was done in Oct.93 to get a better cold-to-warm response check by going from cold bath to warm bath; the air was too unstable to get a proper check in the May 93 attempt.

CTD #1 pre- and post-cruise pressure calibrations are summarized in Figures 1 and 2.

3.2. PRT Temperature Calibration

Both CTD #1 PRT temperature transducers were calibrated in a temperature-controlled bath. CTD temperatures were compared with temperatures calculated from the resistance of a standard platinum resistance thermometer (SPRT) as measured by a NBIS ATB-1250 resistance bridge. The ultimate temperature standards at ODF are water and diphenyl ether triple-point cells and a gallium cell. Six or more calibration temperatures, spaced across the range of -2.0 to 30.1°C, were measured both pre- and post-cruise.

CTD #1 pre- and post-cruise temperature calibrations, referenced to the ITS-90 standard, are summarized in Figure 3. Calibration coefficients are converted to the IPTS-68 standard: CTD temperature data are corrected to the IPTS-68 standard because calculated parameters, including salinity and density, are currently defined in terms of that standard only. After all data are finalized, IPTS-68 data are converted back to the ITS-90 standard as desired via multiplication by a constant factor.

4. CTD Data Processing

4.1. Pressure, Temperature and Conductivity/Salinity Corrections

A maximum of 36 salinity and oxygen check samples were collected during each CTD cast. DSRT thermometric pressure and temperature data were also measured at 1 level during 36 casts on P19C.

A 5-second average of the CTD time-series data was calculated for each sample. The resulting data were then used to verify the pre- and post-cruise temperature calibrations, and to derive CTD conductivity/salinity and oxygen corrections.

The following chart clarifies which sensors/winches were used for each cast:

P19C CTD/WINCH CONFIGURATION SUMMARY

<table>
<tr><th>Station(s)</th><th>CTD†
ID#</th><th>TAMU</th><th>Oxygen
Sensor</th><th>Winch</th><th>UofH
LADCP</th></tr>
<tr><td>234-244</td><td rowspan="10">1</td><td rowspan="3">63D</td><td rowspan="10">A</td><td rowspan="8">A.Johnson</td><td>Yes</td></tr>
<tr><td>245-293</td><td>No</td></tr>
<tr><td>294-300</td><td rowspan="4">Yes</td></tr>
<tr><td>301-302</td><td>none</td></tr>
<tr><td>303-304</td><td>63D</td></tr>
<tr><td>305-319</td><td rowspan="5">173D</td></tr>
<tr><td>320-354</td><td>No</td></tr>
<tr><td>355-386/01</td><td rowspan="2">Yes</td></tr>
<tr><td>386/02-409</td><td rowspan="2">Markey</td></tr>
<tr><td>410-422</td><td>No</td></tr>
</table>

†ODF CTD #1 sensor serial numbers appear below:

CTD ID#	Pressure	Temperature PRT-1	PRT-2	Conductivity
1	131910	14304	FSI-T1320	5902-F117

4.1.1. CTD #1 Pressure Corrections

Please refer to Appendix A: "Improving the Measurement of Pressure in the NBIS Mark III CTD" (Delahoyde/Williams) for details on the ODF pressure model and its application.

CTD #1 pre- and post-cruise pressure calibrations, Figures 1a and 1b, were compared. The warm/shallow and cold/deep calibration curves both shifted at the surface by about 2.5 to 3 decibars from pre- to post-cruise. The cold/deep pressure calibration curves had similar slopes in the top 2400 decibars, then diverged an additional 2 decibars between 2400 and 6100 decibars. The post-cruise cold/upcast curve was 1 decibar closer to the downcast than pre-cruise. The warm/shallow slope was less steep post-cruise, and the surface points were .5 decibar further from the cold curve than they were during the pre-cruise calibration. The post-cruise downcast pressure calibrations had similar slopes at all 3 temperatures, whereas the pre-cruise warm calibration curve was steeper than the cold.

Because of the pre- and post-cruise slope inconsistencies, laboratory calibrations from Dec.91, May 92 and Oct.93 were also examined for trends over time. The cold/deep correction curve slopes have gone more negative and the warm/cold surface offsets have drifted apart with time. Only the Aug.92/pre-cruise calibration contradicts these trends; the May 93/post-cruise pressure calibrations are much more consistent with the history of the instrument. The post-cruise pressure calibrations were used to correct the CTD #1 station data, with an additional offset applied to account for the shift in the calibration curves over time. No slope change was applied to the May 93 data, since there was less than a 1 decibar in 6000 decibars slope change between May 92 and May 93 laboratory calibrations.

The additional offset to the pressure calibration was determined by examining raw CTD pressure vs temperature data from the laboratory temperature calibrations and comparable shipboard data. Raw CTD pressure vs temperature data from just before the CTD entered the water on each cast were tabulated. The CTD readings were fairly stable, with atmospheric pressures and stable ambient temperatures around the CTD for 30 or more minutes prior to each cast, similar to conditions during the laboratory calibrations. The post-cruise/May 93 pressure calibration curves were shifted by the +1.5-decibar average difference between the laboratory and cast data; the resulting data, Figure 1c, were used to correct P19C CTD #1 pressure data.

Post-cruise warm-to-cold thermal shock data, Figure 2a, were fit to determine the time constants and temperature coefficients which model the pressure response to rapid temperature change. May 91 and May 93/post-cruise data were compared: the results were similar in magnitude and response time. A thermal shock test from cold to warm water baths was done in Oct.93, Figure 2b. The results were similar in magnitude but mirror-image to the warm-to-cold shock tests from May 93. The May 93 time constants and temperature coefficients, listed in the table at the end of this section, were used to correct the P19C CTD #1 pressure data. The thermal response pressure correction applied to upcasts used a modification of the downcast correction to achieve the mirror-image effect seen in the laboratory.

DSRT thermometric pressures were measured at 1 deep point on each of 36 casts. No shift was observed in thermometric/CTD pressure differences during P19C.

The shifted May 93/post-cruise calibration curve, Figure 1c, was used in conjunction with the May 93 thermal shock results, Figure 2a, to correct the pressure for all P19C CTD #1 casts. Any residual offset was compensated for automatically at each station: as the CTD entered the water, the corrected pressure was adjusted to 0.

Thermal Response Coefficients for CTD Pressure†

CTD ID#	Short Time Constant (secs) Tau1	Temp. Coeff. for Tau1 k1	Long Time Constant (secs) Tau2	Temp. Coeff. for Tau2 k2
1	82.1826	+0.306253	384.176	-0.26423

† see Appendix A (Delahoyde/Williams), Section 2

4.1.2. CTD #1 Temperature Corrections

CTD #1 had two temperature sensors: PRT-1, a Rosemount sensor, was calibrated pre- and post-cruise; PRT-2 was an interchangeable FSI sensor.

Different FSI sensors were installed in CTD #1 during the pre- and post-cruise calibrations; both FSI sensors underwent repairs between the calibrations.

PRT-2 was used to monitor any PRT-1 drift during the cruise. PRT-1 versus PRT-2 data showed consistent differences throughout P19C. DSRT thermometric temperatures were measured during 36 casts; they also indicated no PRT-1 shift occurred during the leg.

A comparison of the pre- and post-cruise laboratory CTD #1 PRT-1 temperature transducer calibrations, Figures 3a and 3b, showed two curves with nearly identical slopes and a +.001°C shift in the temperature correction over the range of 0 to 32°C. An average of the two laboratory calibrations was calculated by averaging the coefficients of the pre- and post-cruise temperature correction curve fits. The corrections were converted to the IPTS-68 standard and then applied to the CTD #1 temperature data.

4.1.3. CTD Conductivity Corrections

In order to calibrate CTD conductivity, check-sample conductivities were calculated from the bottle salinities using CTD pressures and temperatures. For each cast, the differences between sample and CTD conductivities at all pressures were fit to CTD conductivity using a linear least-squares fit. Values greater than 2 standard deviations from the fits were rejected. The resulting conductivity correction slopes were plotted as a function of station number. The conductivity slopes were grouped by stations, based on common PRT and conductivity sensor combinations, and then fit as a function of station number to generate smoothed slopes for each group. These smoothed slopes were either averages of the slopes in the station group (0-order) or changing by a fixed amount from station to station (1st-order as a function of station number).

Conductivity differences were then calculated for each cast after applying the preliminary conductivity slope corrections. Residual conductivity offsets were computed for each cast and fit to station number. Smoothed offsets were determined by groups as above, based on common PRT and conductivity sensor combinations. The resulting smoothed offsets were then applied to the data. Conductivity slope as a function of conductivity was re-checked to ensure that no residual slope remained.

4.1.3.1. CTD #1

CTD #1 conductivity slopes were gradually shifting more negative throughout P19C, with some scatter in the first 20 casts. Smoothed first-order conductivity slopes as a function of station number were applied to the P19C casts; the slopes shifted a total of -.00058 over the 189 stations.

Residual CTD #1 conductivity offset values were calculated after applying the conductivity slopes. Conductivity offsets were fit as a function of station number by groups. Smoothed 1st-order offsets were applied to CTD conductivities in three station groups: 234-354, 356-388 and 389-422. The conductivity sensor on station 355 was severely contaminated by organic matter from 75 decibars down to 1900 decibars up and required individual offsets for both down and up casts. The sensor was cleaned with fresh water following that cast. There was a small shift in conductivity between stations 383 and 384 caused by organic matter contamination during station 383 and probable conductivity sensor cleaning afterward.

Some offsets were manually re-adjusted to account for discontinuous shifts in the conductivity transducer response, or to insure a consistent deep T-S relationship from station to station.

Plots of the final/adjusted P19C conductivity slopes and offsets for CTD #1 can be found in Figures 4a and 4b.

4.1.3.2. Bottle vs. CTD Conductivity Statistical Summary

The P19C calibrated bottle-minus-CTD conductivity statistics include salinity values with quality 3 or 4. There is approximately a 1:1 correspondence between conductivity and salinity residual differences. Plots of the differences at all pressures and at pressures below 1500 decibars are shown in Figures 5a and 5b.

The following statistical results were generated from the final bottle data set and the corrected up-cast CTD data:

P19C Final Bottle-CTD Conductivity Statistics

pressure range (decibars)	mean conductivity difference (bottle-CTD mmho)	standard deviation (mmho)	#values in mean
all pressures	0.001987††	0.086162	6244
allp (4,2rej) †	-0.000088	0.003780	6106
press < 1500	0.003630	0.108127	3913
p<1500(4,2rej)†	-0.000109	0.005207	3808
press > 1500	-0.000772††	0.015805	2331
p>1500(4,2rej)†	-0.000191	0.000823	2299

† "4,2rej" means a 4,2 standard-deviation rejection filter was applied to the differences before generating the results.
†† Plots of these differences can be found in Figures 5a and 5b.

4.2. CTD Dissolved Oxygen Data

Please refer to appendix B: "CTD Dissolved Oxygen Data Processing" (Delahoyde) for details on ODF CTD oxygen processing.

4.2.1. CTD Oxygen Corrections

Dissolved oxygen data were acquired using a single Sensormedics dissolved oxygen sensor for the entire leg.

CTD oxygen data are corrected after pressure, temperature and conductivity corrections have been determined. CTD raw oxygen currents were extracted from the pressure-series data at isopycnals corresponding to the up-cast check samples. Most of the pressure-series data were from the down casts, where oxygen data are usually smoother than up-cast data because of the more constant lowering rate, avoiding the flow-dependence problems occurring at up-cast bottle stops. However, the P19C CTD oxygen data were affected with flow-dependence problems, down or up cast, each time a cast was stopped. There can also be flow-dependence problems if a cast is slowed down, as often happens during bottom approaches.

The CTD oxygen correction coefficients were determined by applying a modified Levenberg-Marquardt nonlinear least squares fitting procedure to residual differences between CTD and bottle oxygen values. Bottle oxygen values were weighted as required to optimize the fitting of CTD oxygen to discrete bottle samples. Some bottle levels were omitted from a fit because of large pressure differences between down- and up-cast CTD data at isopycnals. Deep data points were often weighted more heavily than shallower data due to the higher density of shallow sampling on a typical 36-bottle sampling scheme.

The P19C surface oxygen data fitting was adversely affected by the typical going-in-water bubbles/noise, making it difficult to fit CTD oxygens to the bottle data in the surface mixed layer of many casts. Despiking of the raw oxygen current to smooth out the top few decibars helped resolve this problem on many casts. The sharp near-surface gradients combined with extremely low oxygen minima (less than .05 ml/l) that occurred in many tropical stations caused problems in fitting the CTD oxygen signal to bottle samples. The slow 1-second response time of the oxygen sensor, as well as the fact that down-cast data were being fit to up-cast bottles, may have caused these fitting problems. Numerous tropical casts have oxygen spikes at the sub-surface maximum that precedes the sharp thermocline gradients. The value of oxygen data above the second check sample should be very carefully considered.

Several casts had no bottle oxygen data, or sections of missing bottle oxygen data, typically due to equipment failures. These casts were fit by supplementing the data with bottles from other casts at the same station (station 241 casts 2+4 and station 281 cast 1) or bottles from the two adjacent stations' casts (station 257 above 400 decibars). Two casts could not be fit: station 234 cast 1 was very shallow, mostly high-gradient, with numerous replicate bottles/long waits at each stop and a 4-minute stop at 85 decibars down. The oxygen coefficients calculated for station 235 cast 1 were used for station 234 cast 1 to give a very general fit. Station 420 cast 1 also would not fit, for reasons unknown, so the coefficients for station 419 cast 1 were used to give general shape to the calculated oxygen data. Both down and up cast oxygens for station 355 were fit despite major conductivity offsetting problems, noted in the "CTD Shipboard and Processing Comments" section of Appendix D.

4.2.2. Bottle vs. CTD Oxygen Statistical Summary

CTD oxygens were generated by fitting up cast oxygen bottle data to down cast CTD raw oxygen current measurements along isopycnals. Residual oxygen differences from these fits (up cast bottle oxygens vs corrected down cast CTD oxygens), including oxygen values with quality code 3 or 4, are shown in the table below:

P19C Final Bottle-CTD Oxygen Statistics

pressure range (decibars)	mean difference (bottle-CTD ml/l)	oxygen standard deviation (ml/l)	#values in mean
all pressures	-0.00464††	0.15212	6256
allp (4,2rej) †	0.00332	0.04320	5894
press < 1500	-0.01098	0.17677	3927
p<1500(4,2rej)†	0.00298	0.06127	3693
press > 1500	0.00605††	0.09642	2329
p>1500(4,2rej)†	0.00163	0.01717	2243

† "4,2rej" means a 4,2 standard-deviation rejection filter was applied to the differences before generating the results.

†† Plots of these differences can be found in Figures 6a and 6b.

4.3. Additional Processing

A software filter was used on 48 of 192 casts, including both down and up casts of station 355 cast 1, to remove conductivity or temperature spiking problems in 0.033% of the time-series data frames for the leg. Pressure did not require filtering for any P19C cast.

Oxygen spikes were filtered out of 181 casts. The filtered oxygen levels affected approximately .583% of the time-series data frames. 89% of the filtered oxygen data were shallower than 50 dbars and are probably directly related to bubbles trapped during the going-in-water transition.

The remaining density inversions in high-gradient regions cannot be accounted for by a mis-match of pressure, temperature and conductivity sensor response. Detailed examination of the raw data shows significant mixing occurring in these areas because of ship roll. The ship-roll filter resulted in a reduction in the amount and size of density inversions.

After filtering, the down cast (or up cast - see table below) portion of each time-series was pressure-sequenced into 2-decibar pressure intervals. A ship-roll filter was applied to each cast during pressure sequencing to disallow pressure reversals.

5. General Comments/Problems

There is one pressure-sequenced CTD data set, to near the ocean floor, for 192 casts at 189 station locations. In addition to reporting both the down and up casts for station 355, two casts are reported at station 241 (casts 2 and 4) and station 281 (an aborted cast 1 plus cast 2). Station 386 cast 1 was aborted because of winch problems and was neither processed nor reported. Cast 2 was done at the same location immediately after the winch problem was repaired.

The data reported is from down casts, excepting the 7 casts listed below:

P19C UP-CAST PRESSURE-SERIES DAT A

Station(s)	Problem with Down Cast Data
271/01	big conductivity dropout 140-460 db down, probably organic matter contamination of sensor; up cast ok
344/01	conductivity noisy/offset low at 280-1000 db down, up cast ok; probably caused by organic matter contamination on sensor
348/01	-.002 psu salinity offset from 2230 db down to bottom, shifts back at bottom: up cast ok
354/01	170 db yoyo on deep down cast causes problems with CTD oxygen fit, use up
355/01	conductivity offsets low approx. 65-400 db down, probably organic matter contaminated the sensor; then down offset -.02 psu compared to up below 400 db; conductivity signal noisy/offsetting on up cast until approx. 1850+ db, top 1850 db of up cast compares well to nearby stations - reported both down (called cast 11) and up casts, neither cast is acceptable in its entirety
379/03	down cast conductivity/salinity is off-set -.012 psu from up cast until near bottom, up matches nearby casts/ok
383/01	organic matter contamination on conductivity sensor and transmissometer from 900-1700 db down, up cast ok

The 0-decibar level of some casts were extrapolated using a quadratic fit through the next three deeper levels. Recorded surface values were rejected only when it appeared that the drift was caused by sensors adjusting to the in-water transition; if there was any question that the surface values might be real, the original data was reported. Extrapolated surface levels are identified by a count of "1" in the "Number of Raw Frames in Average" reported with each data record in the data files.

Other cast-by-cast shipboard or processing comments are listed in the "CTD Shipboard and Processing Comments" in Appendix D.

The CTD oxygen sensor often requires several seconds in the water before being wet enough to respond properly; this is manifested as low or high CTD oxygen values at the start of some casts. Flow-dependence problems occur when the lowering rate varies, or when the CTD is stopped and/or slowed, as during bottom approaches, at the cast bottom, or at bottle trips, where depletion of oxygen at the sensor causes lower oxygen readings. Significant delays and yoyos during the casts are documented in Appendix D.

P19C

Final Report for Large Volume Samples and $\Delta^{14}C$ Measurements

Robert M. Key

July 10, 1996

1.0 General Information

WOCE cruise P19C was the third of three legs carried out aboard the R/V Knorr in the south central and southeastern Pacific Ocean. The WHPO designation for this leg was 316N138/12 (A.K.A. Juno-3). Lynne Talley of SIO was chief scientist for this leg. This report covers details of data collection and analysis for the large volume Gerard samples. The reader is referred to the Talley's Final Report for general information. The detailed sampling notes from that report regarding Gerard casts are reproduced here as an appendix. The cruise departed Punta Arenas, Chile on February 22, 1993 and ended at Panama City, Panama on April 13, 1993.

Thirteen large volume (LV) stations were occupied on this leg. The planned sampling density was 1 station every 5° of latitude (~300nmi). Each station (except station 379 which had only one cast and station 413 which had 3 casts) included one deep cast (2500db to the bottom), and an intermediate (1000db to 2500db) cast. All LV casts for the Juno cruises were done using the starboard-aft crane and coring cable on the R/V Knorr. This arrangement was far superior to that used on the R/V Thomas Washington for the TUNES cruises. The purpose of these casts was to collect samples for ^{14}C analysis. ^{14}C coverage for the upper water column was done via small volume AMS sampling from the Rosette. Table 1 summarizes the LV sampling and Figure 1 shows the station positions for leg P19C.

Table 1: Station/Cast Summary

Station	Cast	Latitude + => N	West Longitude	# LV Samples
241	1	-53.352	76.609	9
	3	-53.342	76.602	9
264	1	-49.979	87.999	9
	3	-50.012	58.000	9
274	1	-45.000	88.025	9
	3	-45.040	87.998	9
284	1	-39.996	87.987	9
	3	-39.996	87.987	9
299	1	-32.499	87.999	9
	3	-32.500	87.998	9
317	1	-24.322	87.998	9
	3	-24.328	88.011	9
326	1	-19.981	88.008	9
	3	-19.971	88.002	9
338	1	-14.573	85.831	9
	3	-14.562	85.828	9

353	2	-6.994	85.823	9
	3	-6.988	85.814	9
361	1	-3.005	85.831	9
	3	-2.996	85.830	9
379	1	0.998	85.839	9
395	1	6.723	88.762	9
	3	6.712	88.757	9
413	1	13.016	91.777	9
	3	13.023	91.760	9
	4	13.025	91.767	3
13	27	TOTALS		228

Each Gerard barrel was equipped with a piggyback 5 liter Niskin bottle which, in turn, had a full set of high precision reversing thermometers to determine sampling pressure and temperature. Both Gerard and Niskin were sampled for salinity and silicate. Additionally, each Gerard was sampled for radiocarbon. The salinity samples from the piggyback bottle were used for comparison with the Gerard barrel salinities to verify the integrity of the Gerard sample. As samples were collected, information was recorded on a sample log sheet. Normal sampling practice was to open the drain valve before opening the air vent to see if water escapes, indicating the presence of a small air leak in the sampler. This observation ("air leak"), and other comments ("lanyard caught in lid," "valve left open," etc.) which may indicate some doubt about the integrity of the water samples were noted on the sample log sheets. The discrete hydrographic data were entered into the shipboard data system and processed as the analyses were completed. The bottle data were brought to a usable, though not final, state at sea. Data checking procedures included verification that the sample was assigned to the correct depth. The salinity and nutrient data were compared with those from adjacent stations and with the Rosette cast data from the same station. Any comments regarding the water samples were investigated. The raw data computer files were also checked for entry errors that could have been made on the station number, bottle number and/or sample container number.

2.0 Personnel

LV sampling for this cruise was under the direction of the principal investigator, Robert M. Key (Princeton). All LV ^{14}C extractions at sea were done by G. McDonald (Princeton). In addition to McDonald, deck work was done by the SIO CTD group with assistance from the scientific party. J. Wells and G. Pillard (ODF) were responsible for reading thermometers. Salinities and nutrients were analyzed by SIO-ODF with assistance from Andy Ross (Oregon State U.). ^{14}C analyses were performed at Göte Östlund's laboratory (U. Miami, R.S.M.A.S.). Minze Stuiver made the ^{13}C measurements which are necessary to correct the ^{14}C values for fractionation effects. Key collected the data from the originators, merged the files, assigned quality control flags to the ^{14}C, rechecked the flags assigned by ODF and submitted the data files to the WOCE office (7/96).

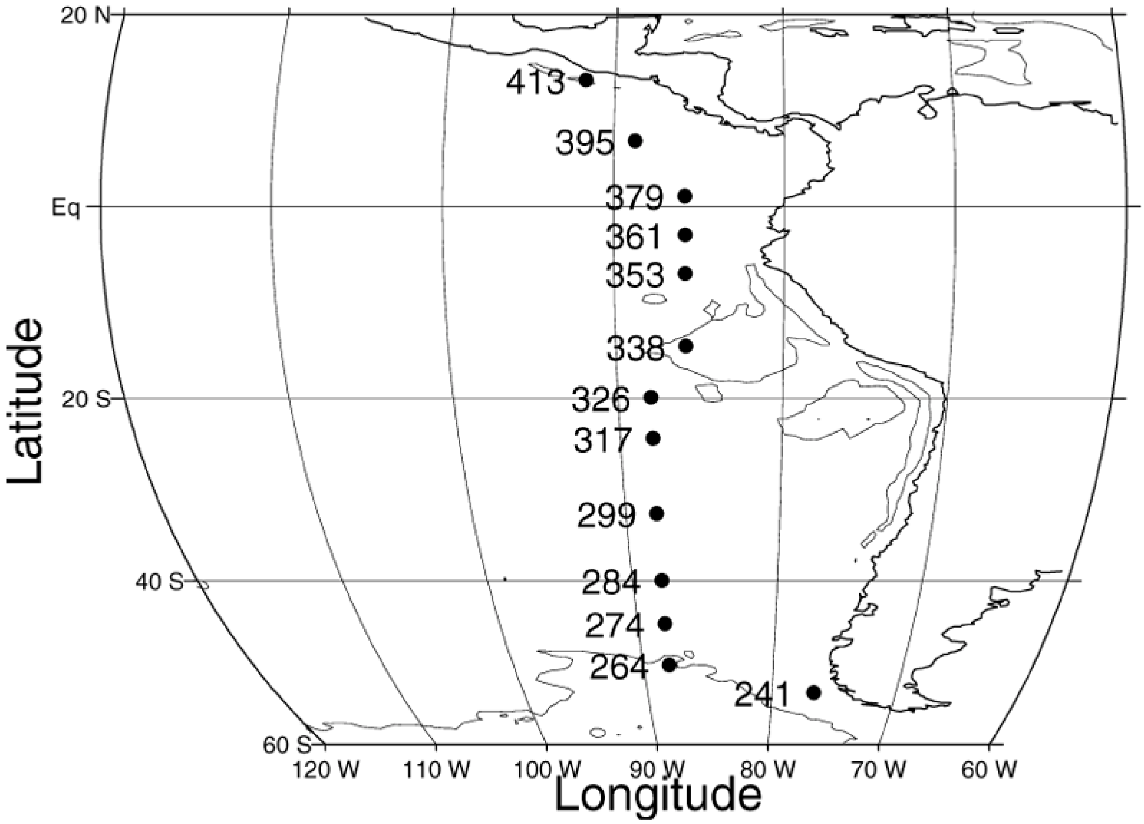

Figure 1: Large volume station locations for WOCE cruise P19C (4500m bathymetry).

3.0 Results

This data set and any changes or additions supersedes any prior release. In this data set Gerard samples can be differentiated from Niskin samples by the bottle number. Niskin bottle numbers are in the range 41-49 while Gerards are in the range 81-93.

3.1 Pressure and Temperature

Pressure and temperature for the LV casts are determined by reversing thermometers mounted on the piggyback Niskin bottle. Each bottle was equipped with the standard set of 2 protected and 1 unprotected thermometer. Each temperature value reported on the LV casts was calculated from the average of four readings, provided both protected thermometers functioned normally. The temperatures are based on the International Temperature Scale of 1990. All thermometers, calibrations and calculations were provided by SIO-ODF. Reported temperatures for samples in the thermocline are believed to be accurate to 0.01°C and for deep samples 0.005°C. Pressures were calculated using standard techniques combining wire out with unprotected thermometer data. In cases where the thermometers failed, pressures were estimated by thermometer data from adjacent bottles combined with wire out data. Because of the inherent error in pressure calculations and the finite flushing time required for the Gerard barrels, the assigned pressures have an uncertainty of approximately 10 dB. The pressures recorded in the data set for each Gerard-Niskin pair generally differ by approximately 0.5 dB with the Gerard pressure being the greater. This is because the Niskin is hung near the upper end of the Gerard. Figure 2 shows potential temperature vs. pressure for the LV casts.

3.2 Salinity

Salinity samples were collected from each Gerard barrel and each piggyback Niskin bottle. Analyses were performed by the same personnel who ran the salt samples collected from the Rosette bottles so the analytical precision should be the same for LV salts and Rosette salt samples. When both Gerard and Niskin trip properly, the difference between the two salt measurements should be within the range 0.000 - 0.003 on the PSU scale. Somewhat larger differences can occur if the sea state is very calm and the cast is not "yoyo'd" once the terminal wire out is reached. This difference is due to the flushing time required for the Gerard barrels and the degree of difference is a function of the salinity gradient where the sample was collected. In addition to providing primary hydrographic data for the LV casts, measured salinity values help confirm that the barrels closed at the desired depth. For the area covered by this leg, deep nutrient values (especially silicate) are as useful for trip confirmation as salt measurements.

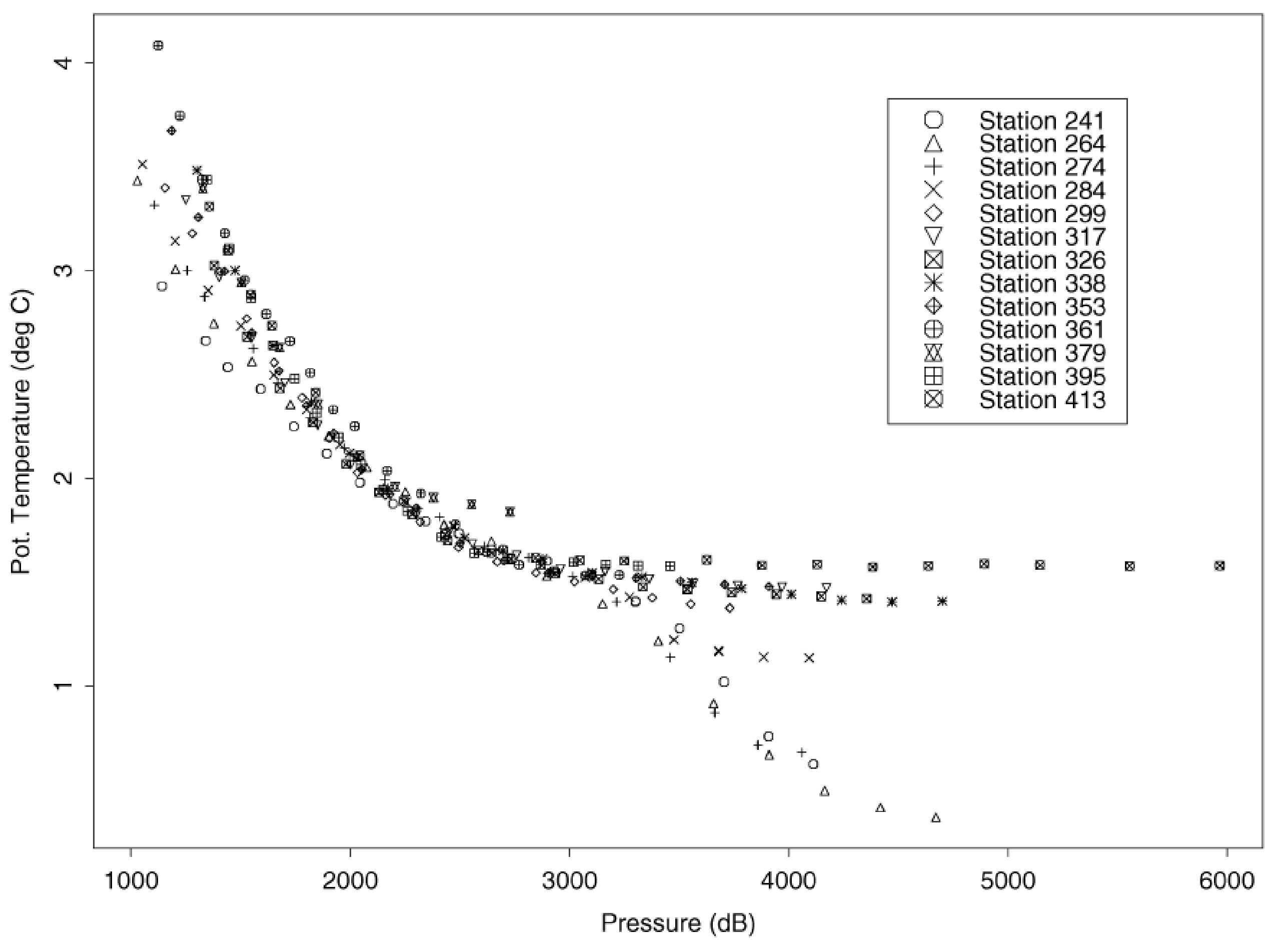

Figure 2: Potential temperature from DSRT on LV casts vs. pressure.

Salinity samples were drawn into 200 ml Kimax high alumina borosilicate bottles after 3 rinses, and were sealed with custom-made plastic insert thimbles and Nalgene screw caps. This assembly provides very low container dissolution and sample evaporation. As loose inserts were found, they were replaced to ensure a continued air-tight seal. Salinity was determined after a box of samples had equilibrated to laboratory temperature, usually within 8-12 hours of collection. The draw time and equilibration time, as well as per-sample analysis time and temperature were logged.

A single Guildline Autosal Model 8400A salinometer located in a temperature controlled laboratory was used to measure salinities. The salinometer was standardized for each cast with IAPSO Standard Seawater (SSW) Batch P-120, using at least one fresh vial per cast. The estimated accuracy of bottle salinities run at sea is usually better than 0.002 PSU relative to the particular Standard Seawater batch used. PSS-78 salinity (UNESCO 1981) was then calculated for each sample from the measured conductivity ratios, and the results merged with the cruise database. There were some problems with lab temperature control throughout cruise; the Autosal bath temperature was adjusted accordingly. Salinities were generally considered good for the expedition despite the lab temperature problem. The quality of the temperature and salinity is demonstrated by Figure 3 which shows data from all of the large volume samples. Each Gerard-Niskin pair is assigned the same temperature which allows direct comparison of many of the paired salinity values on the figure.

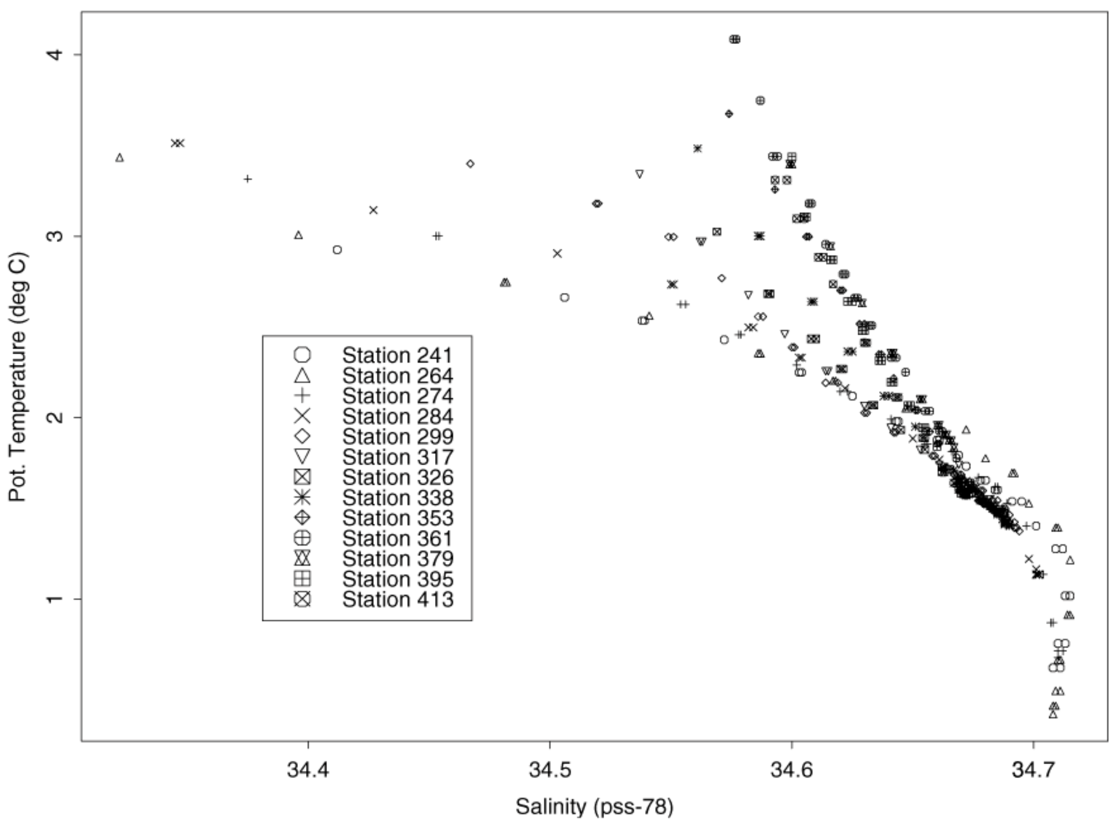

Figure 3: Theta-salinity for all of the large volume cast data with a QC flag of 2 for both temperature and salinity.

3.3 Nutrients

Nutrient samples were collected from Gerard samples. On this leg silicate values were measured on all samples. LV nutrients were measured along with Rosette nutrients so the analytical precision for Gerard samples should be the same as Rosette samples. Nutrients collected from LV casts are frequently subject to systematic offsets from samples taken from Rosette bottles. For this reason it is recommended that these data be viewed primarily as a means of checking sample integrity (*i.e.* trip confirmation). The Rosette- Gerard discrepancy is frequently less for silicate than for other nutrients.

Nutrient samples were drawn into 45 ml high density polypropylene, narrow mouth, screw-capped centrifuge tubes which were rinsed three times before filling. Standardizations were performed with solutions prepared aboard ship from pre-weighed chemicals; these solutions were used as working standards before and after each cast to correct for instrumental drift during analysis. Sets of 4-6 different concentrations of shipboard standards were analyzed periodically to determine the linearity of colorimeter response and the resulting correction factors.

Nutrient analyses were performed on an ODF-modified 4 channel Technicon AutoAnalyzer II, generally within one hour of the cast. Occasionally some samples were re-frigerated at 2 to 6°C for a maximum of 4 hours. The methods used are described by Gordon et al. (1992), Atlas et al. (1971), and Hager et al. (1972). All peaks were logged manually, and all the runs were re-read to check for possible reading errors.

Silicate was analyzed using the technique of Armstrong et al. (1967). ODF"s methodology is known to be non-linear at high silicate concentrations (>120 mM); a correction for this non-linearity was applied. Phosphate was analyzed using a modification of the Bernhardt and Wilhelms (1967) technique.

Na_2SiF_6, the silicate primary standard, was obtained from Fluka Chemical Company and Fischer Scientific and is reported by the suppliers to be >98% pure. Primary standards for phosphate, KH_2PO_4, were obtained from Johnson Matthey Chemical Co. and the supplier reports purity of 99.999%.

Nutrients, reported in micromoles per kilogram, were converted from micromoles per liter by dividing by sample density calculated at zero pressure, *in-situ* salinity, and an assumed laboratory temperature of 25°C. The overall quality of the silicate data for this cruise is demonstrated in Figure 4 which shows both Gerard and piggyback Niskin silicate values as a function of potential temperature. Overlain on the plot (lines) are the Rosette measurements for the same stations and depth ranges.

3.4 ^{14}C

Some of the $\Delta^{14}C$ values reported here have been distributed in data reports produced by Östlund (1994, 1995). Those reports included preliminary hydrographic data and are superseded by this submission.

All Gerard samples deemed to be "OK" on initial inspection at sea were extracted for ^{14}C analysis using the technique described by Key (1991). The extracted $^{14}CO_2$/NaOH samples were returned to the Ocean Tracer Lab at Princeton and subsequently shipped to Östlund's lab in Miami. Both ^{13}C and ^{14}C measurements are performed on the same CO_2 gas extracted from the large volume samples. The standard for the ^{14}C measurements is the NBS oxalic acid standard for radiocarbon dating. R-value is the ratio between the measured specific activity of the sample CO_2 to that of CO_2 prepared from the standard, the latter number corrected to a $\delta^{13}C$ value of -19‰ and age corrected from today to AD1950 all according to the international agreement. $\Delta^{14}C$ is the deviation in ‰ from unity, of the activity ratio, isotope corrected to a sample $\delta^{13}C$ value of -25‰. For further information of these calculations and procedures see Broecker and Olson (1981), Stuiver and Robinson (1974) and Stuiver (1980). Östlund's lab reports a precision of 4‰ for each measurement based on a long term average of counting statistics. Of the 123 Gerard samples collected, ^{14}C has been measured on 102 (83%). This exceeds the rate funded for this work (80%). Prior to this cruise, no ^{14}C data existed for this entire region of the ocean, therefore, no comparisons of that type were possible.

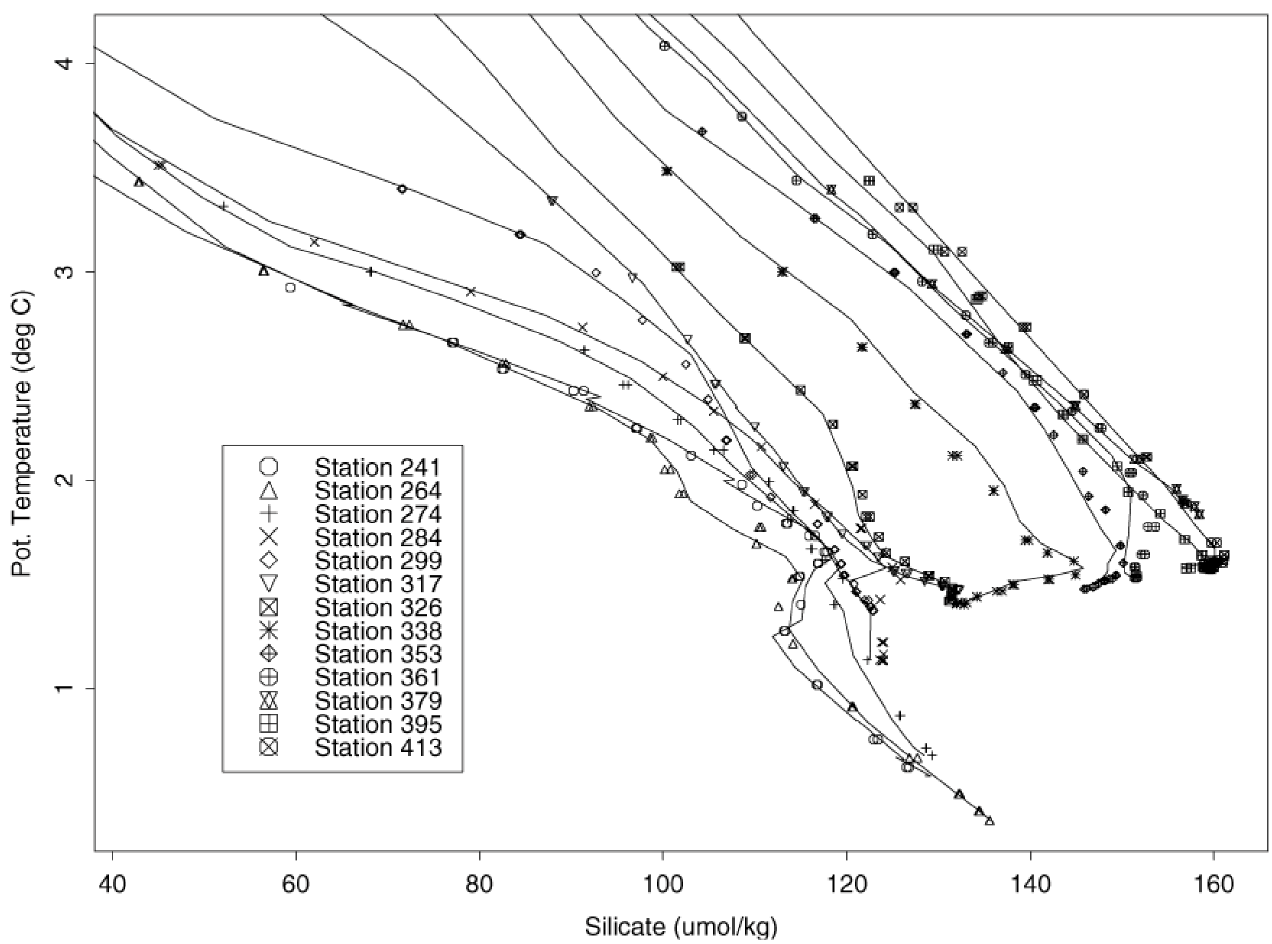

Figure 4: Plot includes silicate data from both Gerard and piggyback Niskin samples. Rosette/CTD data from the same stations and depth ranges are overlain as lines.

4.0 Data Summary

Figures 5 & 6 summarize the large volume ^{14}C data collected on this leg. All $\Delta^{14}C$ measurements with a quality flag value of 2 are included in each figure. Figure 5 shows the $\Delta^{14}C$ values plotted as a function of pressure. One sigma error bars (±4‰) are shown with each datum. The mid-depth minimum which is characteristic of Pacific profiles is present in some of these profiles, however, it is interesting that the minimum is more pronounced at the southern end of the section than at the northern end. Figure 6 shows the $\Delta^{14}C$ values plotted against measured Gerard barrel silicate values. The angled heavy line is the rela-tionship suggested by Broecker *et al*. (1995) to be representative of the mean global pre-bomb $\Delta^{14}C$ - silicate correlation. As was pointed out in that paper, and as is evident with this data set, the relationship does not hold for high latitude southern waters. What is not apparent in this figure, is the fact that the "global" relationship is not even close to correct for any of these data. The southern 3 stations (264, 274, 284) show the "backward J' shape typical of much of the South Pacific. Accepting Broecker's theme with adjustment for this particular area, the data collected north of 30°S, deeper than 1000m (*i.e.* assumed to have no tritium) and shallower than the silicate maximum (taken to be 2500m here) have a linear regression intercept of -148±7 and a slope of -0.55±0.05 with an R^2 value of 0.72 for 47 data values. These values aren't even in the ballpark with the global values of -70 and 1. This rather extreme deviation should provide interesting research material.

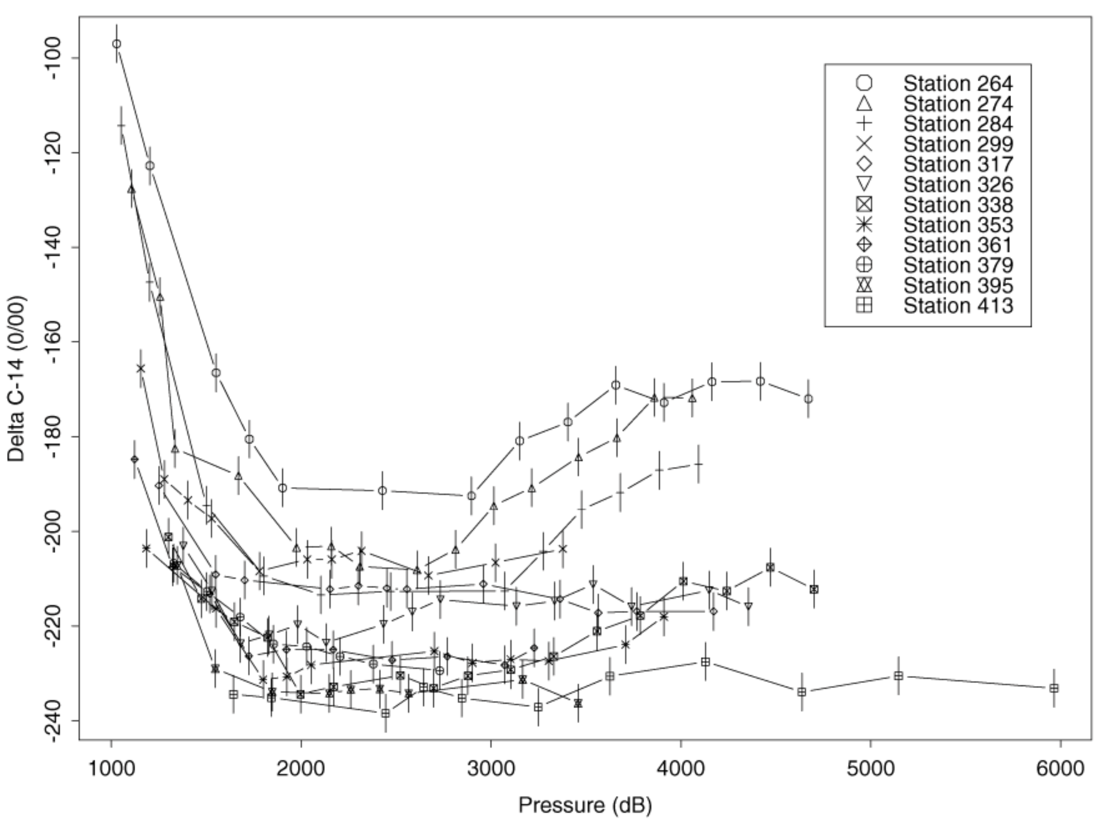

Figure 5: All LV $\Delta^{14}C$ values as a function of pressure. Vertical bars indicate one sigma (4‰) errors.

Figure 7 is a section of the radiocarbon data from P19C large volume samples. The northward flowing Antarctic water is clearly evident near the bottom at the southern end of the section. Lying above is the older water (^{14}C minimum) which presumably came from the North Pacific. The values in the deep basin at the north end of the section are quite uniform ($\Delta^{14}C$ ~ -235‰) throughout most of the deep and bottom waters reflecting the fact that this basin has a sill depth in the vicinity of the minimum.

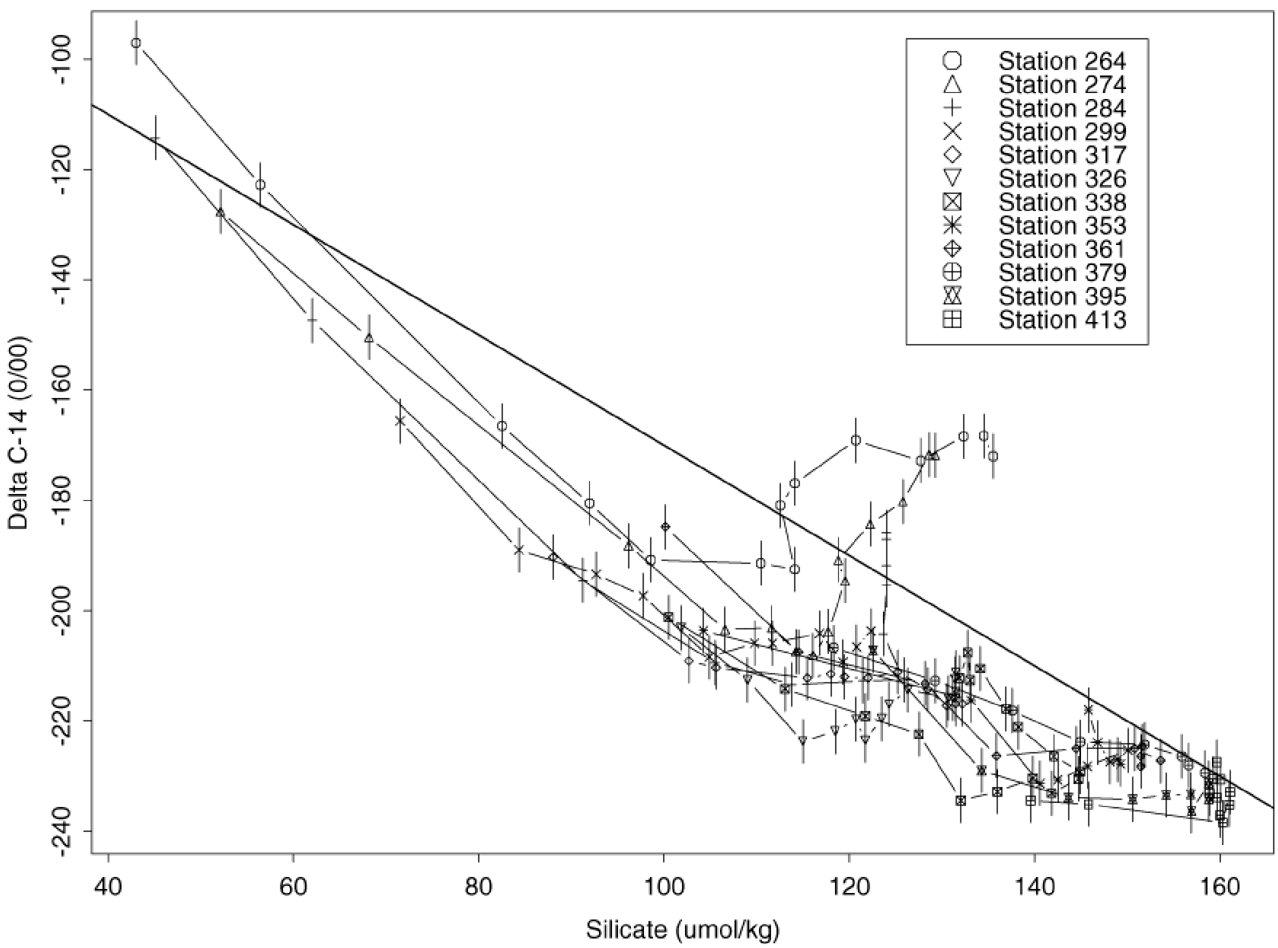

Figure 6: All LV $\Delta^{14}C$ measurements having a quality control flag value of 2 or 6 are plotted. Vertical bars are one sigma errors. The heavy line is that suggested by Broecker, *et al*. (1995) to be representative of the global relationship between pre-bomb ^{14}C and silicate.

5.0 Quality Control Flag Assignment

Quality flag values were assigned to all bottles and all measurements using the code defined in Tables 0.1 and 0.2 of WHP Office Report WHPO 91-1 Rev. 2 sections 4.5.1 and 4.5.2 respectively. In this report the only bottle flag values used were 2, 3, 4 and 9. For the measurement flags values of 2, 3, 4 or 9 were assigned. The interpretation of measurement flag 9 is unambiguous, however the choice between values 2, 3 or 4 is involves some interpretation. For this data set, the salt and nutrient values were checked by plotting them over the same parameters taken from the rosette at the same station.

Points which were clearly outliers were flagged "4." Points which were somewhat outside the envelop of the other points were flagged "3." In cases where the entire cast seemed to be shifted to higher or lower concentrations (in nutrient values), but the values formed a smooth profile, the data was flagged as "2." Once the nutrient and salt data had been flagged, these results were considered in flagging the ^{14}C data. There is no overlap between this data set and any existing ^{14}C data, so that type of comparison was impractical. The lack of other data for comparison led to a more lenient grading on the ^{14}C data. When flagging ^{14}C data, the measurement error was taken into consideration. That is, approximately one-third of the ^{14}C measurements are expected to deviate from the true value by more than the measurement precision of ~4‰. At the time of this writing, Östlund's final report for this cruise was not available. Once that report is out, a few additional ^{14}C values may be added to this data set. At that time flag values 5 and 9 for the ^{14}C data can be adjusted to their final values. At this point, these two flag values have been used synonymously.

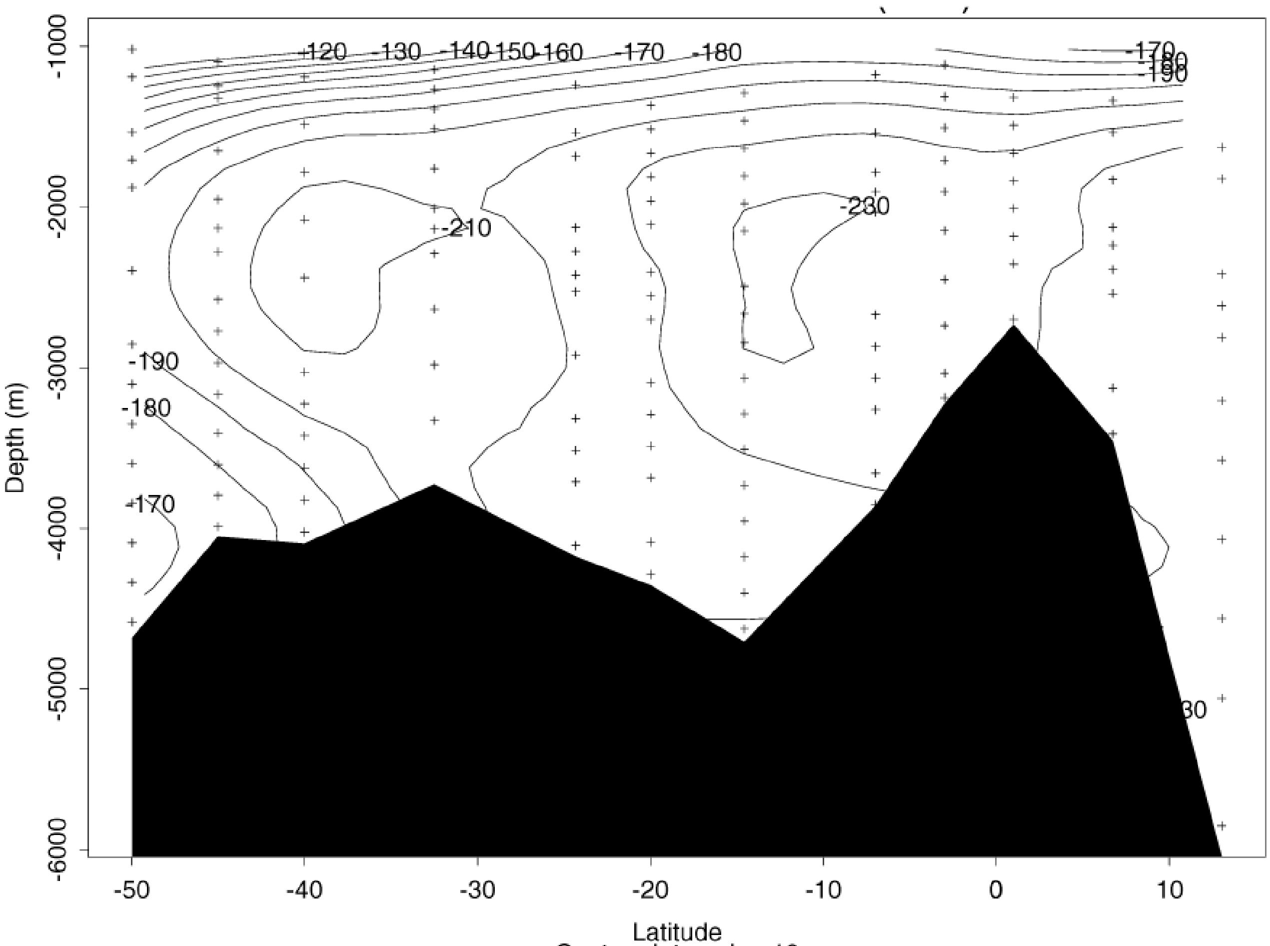

Figure 7: Radiocarbon section along 88°W for deep and bottom waters.Evident in the figure are northward flowing waters of Antarctic origin along the bottom and the older presumably southward flowing deep water around 2500dB.

No measured values have been removed from this data set. When using this data set, it is advised that the nutrient data only be considered as a tool for judging the quality of the ^{14}C data regardless of the quality code value. A summary of all flags is provided in Table 2.

TABLE 2. Quality Code Summary

		WHP Quality Codes								
	Levels	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
BTLNBR	456	0	441	6	8	0	0	0	0	1
SALNTY	456	0	442	3	10	0	0	0	0	1
SILCAT	456	0	446	1	8	0	0	0	0	1
REVPRS	456	0	448	2	0	0	0	6[a]	0	0
REVTMP	456	0	452	1	1	0	0	0	0	2
DELC14[b]	228	0	145	12	1	70	0	0	0	0

a. Pressure assigned by means other than thermometric. Assumed error on these pressure estimates is ±50dB.

b. ^{14}C large volume samples can not be collected from piggyback Niskin bottles

6.0 References and Supporting Documentation

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UNESCO, 1981, Background papers and supporting data on the Practical Salinity Scale, 1978, UNESCO Technical Papers in Marine Science, No. 37, 144 p.

7.0 Appendix

Quality Comments

Remarks for missing samples, and WOCE codes other than 2 from JUNO - WOCE P19C Large Volume Samples. Investigation of data may include comparison of bottle salinity and silicate data from piggy-back and Gerard with CTD cast data, review of data plots of the station profile and adjoining stations, and rereading of charts (*i.e.*, nutrients). Comments from the Sample Logs and the results of ODF's investigations are included in this report.

Station 241

381 @1141db Sample log: "leaker - upper air valve tight." Salinity and silicate are acceptable; piggy-back (41).
393 @2345db Sample log: "TCO2 70 taken before salts & nuts. TCO2 71 taken after salts & nuts." TCO2 taken after salts & nuts." Comments from Sample Log are for the benefit of TCO2 analyst, this would not effect the Gerard samples. Piggy- back (49).
141 @2496db Delta-S(n-g) at 2496db is -0.047, salinity is 34.672. Salinity and silicate are acceptable, Gerard (81) salinity is high.
181 @2497db Sample log: "top valve open." Salinity is high, silicate is slightly low ~.7, but reasonable. Footnote salinity bad, piggy-back (41). PI to determine integrity of other Gerard samples.
183 @2898db Sample log: "bubbling on & off during PCO2 & TCO2." Salinity and silicate are acceptable, piggy-back (43) are also acceptable.
144 @3099db Delta-S(n-g) at 3099db is 0.004, salinity is 34.695. Salinity difference is .001 high, but Gerard (84) salinity and silicate are acceptable.
184 @3099db Sample log: "bubbling during PCO2." Salinity and silicate are acceptable, piggy-back (44) is also acceptable.
145 @3300db Delta-S(n-g) at 3300db is -0.537, salinity is 34.164. Footnote bottle leaking, low salinity and low silicate bad; Gerard (85) samples are acceptable.
185 @3301db Sample log: "bubbling during PCO2 & TCO2." Gerard samples are acceptable; piggy-back (45) are bad.
147 @3705db Delta-S(n-g) at 3705db is 0.002, salinity is 34.715. Salinity and silicate are acceptable, Gerard (89) also acceptable.
189 @3705db Sample log: "bubbling during TCO2." Salinity and silicate are acceptable, piggy-back (47) also acceptable.

148 @3908db Delta-S(n-g) at 3908db is 0.003, salinity is 34.713. Salinity and silicate are acceptable; Gerard (90) is also acceptable.
190 @3909db Sample log: “bubbling during PCO2.” Salinity and silicate are acceptable; piggy-back (48) are also acceptable.
149 @4112db Delta-S(n-g) at 4112db is 0.003, salinity is 34.711. Salinity and silicate are acceptable; Gerard (93) also acceptable.
193 @4113db Salinity and silicate are acceptable; piggy-back (49).

Station 264

Cast 3 Sample log: “no comments.”
185 @3657db Sample log: “top vent closed - bottom valve gushing water - leaky.” Salinity and silicate are acceptable; piggy-back (45).
147 @3910db Sample log: “47/46 reversed in rack - suspect on oppos. Gers, confirmed by therm readings.” asal: “reverse 47/46 to connect with samplers 6/7.” Salinity and silicate slightly low, but within acceptable limits; Gerard (87) samples acceptable. Sample log and thermometer sheet records were changed in an attempt to correct mis-recording at sea. Still appears to be confusion as to what came out of what Gerard or piggy-back. However, can not change sample numbers to “fit” the data.
187 @3911db Salinity and silicate are acceptable; piggy-back (47) also okay.
189 @4164db Sample log: “lid didn’t catch.” Salinity and silicate are acceptable; piggy-back (46). PI to determine the integrity of other LV samples.

Station 274

Cast 1 No double ping until 0828z/7 mins before top barrel stop.
146 @1335db See comments on Gerard (87). Delta-S(n-g) at 1335db is -0.002, salinity is 34.546. Footnote bottle did not trip as scheduled, footnote salinity and silicate bad for this pressure, footnote pressure uncertain.
187 @1336db post-trips: last 4 tripped while wire moving up toward 1st barrel. therms not soaked. Gerards 87, 89, 90, and 93 post- tripped, all but 87 appear to have correct reassigned pressures. Salinity and silicate from Gerard and piggy-back agree with one another, but too high compared with rosette cast and station profile; piggy-back (46). Suspect tripped at ~1500m, if 1500 were used then ODF would delete the temperature. Footnote bottle did not trip as scheduled, footnote pressure uncertain. Footnote silicate and salinity bad for this pressure.
383 @1557db Delta-S(n-g) at 1556db is -0.002, salinity is 34.554. Salinity and silicate are acceptable. Piggy-back (43)
147 @1669db See post-trip comment on 187. Footnote bottle did not trip as scheduled, pressure post-tripped, samples acceptable at reassigned pressure; Gerard (89).
189 @1669db See post-trip comment on 187. Footnote bottle did not trip as scheduled, pressure post-tripped, samples acceptable at reassigned pressure; piggy-back (47).
148 @1818db See post-trip comment on 187. Footnote bottle did not trip as scheduled, pressure post-tripped, samples acceptable at reassigned pressure; Gerard (90).

190 @1818db See post-trip comment on 187. Footnote bottle did not trip as scheduled, pressure post-tripped, samples acceptable at reassigned pressure; piggy-back (48).
149 @1975db Delta-S(n-g) at 1975db is -0.003, salinity is 34.620. See post-trip comment on 187. Footnote bottle did not trip as scheduled, pressure post-tripped, samples acceptable at reassigned pressure; Gerard (93).
193 @1976db See post-trip comment on 187. Footnote bottle did not trip as scheduled, pressure post-tripped, samples acceptable at reassigned pressure; piggy-back (49).
385 @2308db Sample log: “leaky again.” Salinity and silicate are acceptable; piggy-back (45).
185 @3215db Sample log: “leak somewhere - all tight - upper valve - water gushes at lower fitting.” Salinity and silicate acceptable; piggy-back (45).
390 @3860db Delta-S(n-g) at 3859db is -0.002, salinity is 34.710. Salinity and silicate are acceptable; piggy-back (48).
393 @4059db Sample log: “possible mixup with nuts draw/maybe not.” Appears all okay. Piggy-back (49)

Station 284

Cast 1 Sample log: “everything ok.”
384 @1501db Sample log: “a gusher at bottom valve.” leaks without venting, main clamp block gone. Salinity and silicate are acceptable; piggy-back (44).
387 @1802db Sample log: “top valve loose/gusher.” Salinity and silicate are acceptable; piggy-back (46).
347 @1952db Sample log: “niskin failed, bottom cap open - therms ok.” Fails to close due to tie wrap hanging up on release pin. Solution: replaced therm lanyard with correct-length lanyard. Gerard (89)
389 @1953db Sample log: “barrel lid closed but not latched.” Salinity and silicate are acceptable; piggy-back (47).
348 @2104db Therm rack 8 fails to reverse because spring lanyard fails. Delta-S(n-g) at 2104db is -0.0083, salinity is 34.628. Footnote salinity and silicate bad, bottle leaking; Gerard (90) samples acceptable. No temperature.
390 @2104db No temperature, problem with piggy-back (48). Salinity and silicate are acceptable.
145 @3274db Delta-S(n-g) at 3274db is -0.0094, salinity is 34.680. Station profile compared with adjoining rosette casts looks reasonable. Rosette data also has a definite “shift” in the data. However, since the salinities and silicates from the Gerard and piggy-back bottle do not agree with one another, footnote silicate uncertain from the piggy-back and salinity from the Gerard (85).
185 @3274db Footnote salinity uncertain see comments piggy-back (45). PI will have to determine integrity of Gerard samples.
147 @3680db Delta-S(n-g) at 3680db is -0.7731, salinity is 33.928. Footnote salinity and silicate bad bottle leaking, Gerard (89) salinity and silicate are acceptable.
189 @3680db Salinity and silicate are acceptable despite problem with piggy-back (47).

Station 299

344 @1528db Delta-S(n-g) at 1528db is -0.0095, salinity is 34.561. Footnote salinity and silicate uncertain, bottle leaking. Gerard (84) salinity and silicate acceptable.
384 @1528db Sample log: “leaky, pump is sucking air from barrel.” Salinity and silicate are acceptable, piggy-back (44)
347 @1904db Delta-S(n-g) at 1905db is -0.0052, salinity is 34.614. Gerard (89) salinity slightly high, silicates agree within .2.
389 @1905db Sample log: “loose pin on barrel.” Footnote salinity uncertain, silicates agree within .2. Suspect salinity drawing is a little “sloppy” and not a problem with the barrel; piggy-back (47).
190 @3553db Sample log: “gusher at btm valve.” Salinity and silicate are acceptable; piggy-back (48).

Station 317

Cast 1 Sample log:” no comments
383 @1550db Sample log: “gusher/leaky.” Salinity and silicate are acceptable; piggy-back (43).
385 @1852db Sample log: “bad vent o-ring/leaky.” Salinity and silicate are acceptable; piggy-back (45)
347 @2151db Sample log: “leaky on valve test before sampling (before venting?).” Silicate and salinity are acceptable; Gerard (89).
389 @2152db Silicate and salinity are acceptable; piggy-back (47).
349 @2450db Delta-S(n-g) at 2450db is -0.0078, salinity is 34.661. Gerard (93) salinity is high.
393 @2451db Salinity is slightly high, silicate is acceptable; piggy- back (49). Suspect Gerard samples okay.

Station 326

Cast 3 Sample log: “no comments.”
183 @3134db Sample log: “gusher at bottom valve.” Salinity and silicate are acceptable; piggy-back (43).
145 @3536db Delta-S(n-g) at 3536db is 0.5725, salinity is 35.259. Footnote bottle leaking, salinity and silicate bad. Gerard (85) appears to be okay.
185 @3537db Salinity and silicate are acceptable; despite piggy-back (45) problems.
147 @3943db Sample log: “top lid not sealing again? leaky.” Salinity and silicate are acceptable; Gerard (89).
189 @3944db Salinity and silicate are acceptable; piggy-back (47).

Station 338

342 @1474db Sample log: “leaky on valve test.” Salinity and silicate are acceptable as are the Gerard (82) salinity and silicate.
382 @1474db Salinity and silicate are acceptable; piggy-back (42).

347 @2345db Sample log: “too warm for depth?.” Delta-S(n-g) at 2345db is 1.17, salinity is 35.830. Footnote bottle leaking, salinity and silicate bad. Gerard (89) salinity and silicate acceptable.
389 @2345db Salinity and silicate acceptable despite piggy-back (47) problems.
193 @4701db Sample log: “gusher at bottom valve, all appears tight; Lid closed - not latched.” Salinity and silicate are acceptable; piggy-back (49).

Station 353

381 @1184db Sample log: “gusher again.” Salinity and silicate are acceptable; piggy-back (41). PI to determine integrity of other Gerard samples.
342 @1306db Delta-S(n-g) at 1306db is 0.0053, salinity is 34.598. Suspect poor salinity drawing technique, footnote salinity uncertain, it is still usable. Gerard (82) salinity and silicate are acceptable. Gerard (82)
382 @1307db Salinity and silicate are acceptable; piggy-back (42).
281 @2300db Sample log: “gusher.” Salinity and silicate are acceptable; piggy-back (41). PI to determine integrity of other Gerard samples.
283 @2702db Sample log: “vent valve stuck, gusher.” Salinity and silicate are acceptable; piggy-back (43). PI to determine integrity of other Gerard samples.
284 @2903db Sample log: “no gusher but leak at top valve.” Salinity and silicate are acceptable; piggy-back (44). PI to determine integrity of other Gerard samples. Piggy-back (44)
289 @3505db Sample log: “lid slightly open.” Salinity and silicate are acceptable; piggy-back (47). PI to determine integrity of other Gerard samples.

Station 361

347 @1724db Sample log: “leaky upon valve test - ok after readj. top lid.” Salinity and silicate are acceptable; Gerard (89) also acceptable.
389 @1725db Salinity and silicate are acceptable; piggy-back (47).
181 @2020db Sample log: “gusher.” Salinity and silicate are acceptable, piggy-back (41). PI will have to determine integrity of Gerard samples.
147 @2926db Sample log: “leaks on valve test, top cap again?.” Delta- S(n-g) at 2926db is -0.0157, salinity is 34.678. Salinity and silicate are acceptable; Gerard (89) salinity is high, but silicate is acceptable.
189 @2927db Footnote salinity bad, see salinity difference comment 147, silicate is acceptable; piggy-back (47).

Station 379

182 @1503db Sample log: “bad O-ring in vent, barrel leaky at vent.” Salinity and silicate are acceptable; piggy-back (42).
190 @2554db Sample log: “lower gerard fitting unscrews easily.” Salinity and silicate are acceptable; piggy-back (48).

Station 395

341 @1347db Sample log: “not fastened in rack properly/lost a lot of water.” Salinity and silicate are acceptable; Gerard (81) also acceptable.
381 @1347db Salinity and silicate are acceptable; piggy-back (41).
382 @1448db Sample log: “bottom valve came out.” Salinity and silicate are acceptable; piggy-back (42).
383 @1548db Sample log: “sucking air bubbles - top vent/btm valve ok, chk o-ring.” Salinity and silicate are acceptable; piggy- back (43).
182 @2414db therms: “barrel 82 leaks.” Sample log: “small gusher, check gerard lid o-ring, may need grease.” Salinity and silicate are acceptable; piggy-back (42).

Station 413

Cast 3 Sample log: “perfect cast. (no comment on therm form either).”
488 (No Pressure) Sample log/therms: “leaks from vent - check both O-rings in cap; lower klein clamp needs work and/or grease - check.” Sample log: “not sampled.”
492 (No Pressure) Sample log: “not sampled.”
494 (No Pressure) Sample log: “not sampled.”
447 @1357db Delta-S(n-g) at 1357db is -0.0049, salinity is 34.593. Gerard (89)
489 @1357db Sample log: “look fine, no leaks anywhere and all lids latched.” Piggy-back (47)
448 @1442db Delta-S(n-g) at 1442db is -0.0031, salinity is 34.602. Salinity and silicate are acceptable, suspect salinity difference is poor drawing. Gerard (90)
490 @1442db Sample log: “look fine, no leaks anywhere and all lids latched.” Salinity and silicate are acceptable, suspect salinity difference is poor drawing technique; piggy-back (48).
449 @1544db Delta-S(n-g) at 1544db is -0.002, salinity is 34.611. Gerard (93)
493 @1545db Sample log: “look fine, no leaks anywhere and all lids latched.” Piggy-back (49)
190 @5555db Sample log: “valve unscrews needs teflon? otherwise perfect cast.” Salinity and silicate are acceptable; piggy-back (48).

P19C Final Report
for AMS ^{14}C Samples

Robert M. Key
February 24, 1998

1.0 General Information

WOCE cruise P19C was carried out aboard the R/V Knorr in the southeastern Pacific Ocean. The WHPO designation for this cruise was 316N138/12. Lynne Talley was the chief scientist. The cruise departed Punta Arenas, Chile on February 22, 1993 and ended on April 13, 1993 at Panama City, Panama. The cruise made an east to west section along approximately 53°S from Punta Arenas to approximately 88°W. From there the track went approximately northward with minor jogs in the track to avoid the axis of the East Pacific Rise. A total of 191 stations were occupied. The reader is referred to cruise documentation provided by the chief scientists as the primary source for cruise information. This report covers details of the small volume radiocarbon samples. The AMS station locations are summarized in Table 1 and shown in Figure 1. A total of 782 AMS $\Delta^{14}C$ samples were collected at 48 stations. In addition to the AMS samples, large volume Gerard samples were also collected on this cruise. The large volume results were reported previously by Key, 1996(b).

2.0 Personnel

^{14}C sampling for this cruise was carried out by G. McDonald from the Ocean Tracer Lab at Princeton University. Sample extraction, $\delta^{13}C$ analyses and ^{14}C analyses were performed by NOSAMS (National Ocean Sciences AMS Facility at Woods Hole Oceanographic Institution). Salinity, oxygen and nutrients were analyzed by Scripps ODF. R. Key collected the data from the originators, merged the files, assigned quality control flags to the ^{14}C results and submitted the data files to the WOCE office (2/98). R. Key is the PI for the ^{14}C data.

3.0 Results

This ^{14}C data set and any changes or additions supersedes any prior release. The $\Delta^{14}C$ results reported here are, under WOCE guidelines, considered proprietary for two years after publication of the preliminary data report (Dec. 1999) or until publication, whichever comes first.

3.1 Hydrography

Hydrography from this leg has been submitted to the WOCE office by the chief scientist and described in the hydrographic report which is available via the web address (http://diu.cms.udel.edu/woce/data/reports/pacific/p19_c_93_talley.sum).

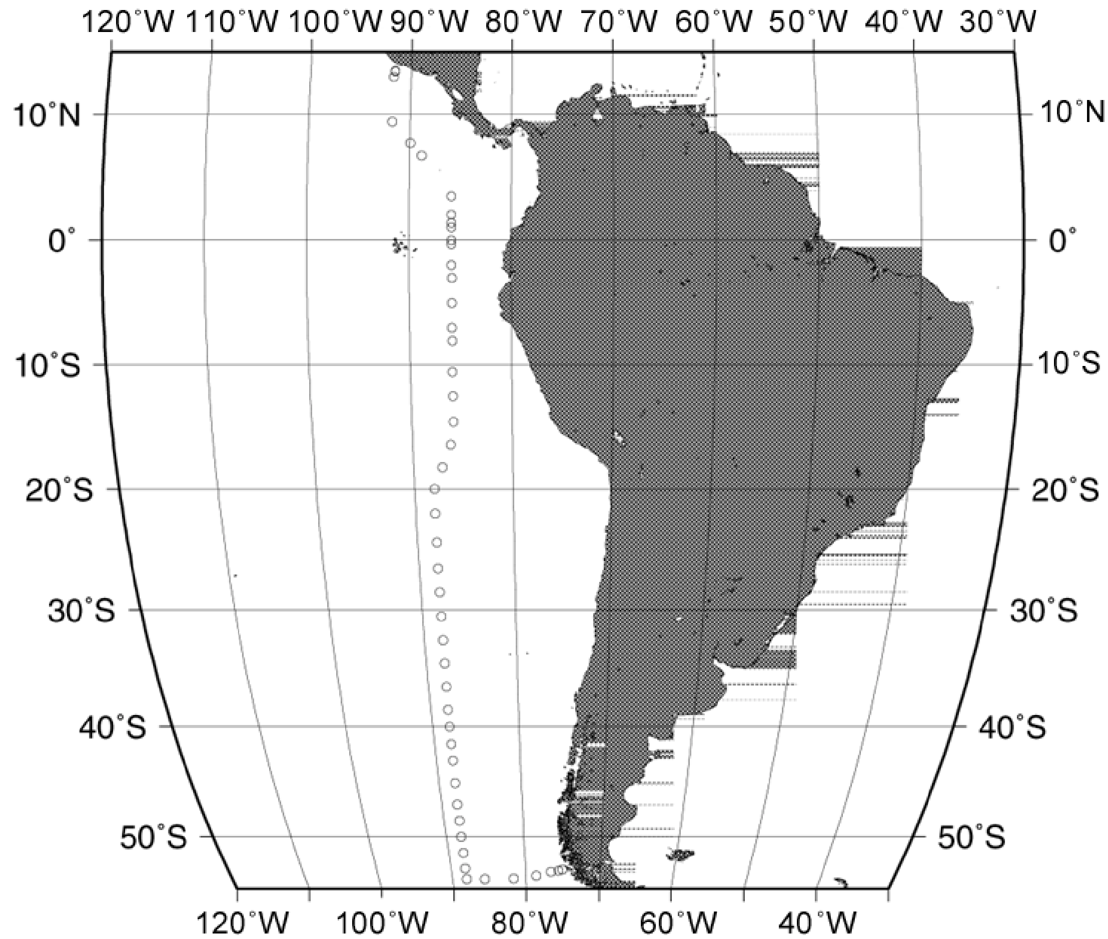


Figure 1: AMS ^{14}C station locations for WOCE P19C (map by GMT, Wessel and Smith, 1991,1995).

TABLE 1. AMS Stations on WOCE Section P19C

Station	Date	Latitude	Longitude	Bottom Depth (m)	Max. Sample Pressure
236	2/23/93	-53.111	-75.024	1437	1462
238	2/24/93	-53.200	-75.494	2011	2032
241	2/25/93	-53.342	-76.584	4105	4182
244	2/25/93	-53.723	-78.536	4253	4295
248	2/26/93	-53.997	-81.580	4683	4784
253	2/28/93	-54.004	-85.544	5045	5161
256	3/1/93	-53.999	-88.008	5045	5159
258	3/1/93	-53.000	-88.016	4940	5046
261	3/2/93	-51.503	-87.994	4750	4852
264	3/3/93	-50.007	-88.007	4625	4731
267	3/4/93	-48.507	-87.991	4565	4658
270	3/5/93	-47.002	-88.008	4025	4090
274	3/6/93	-45.015	-88.003	4020	4070

Station	Date	Latitude	Longitude	Bottom Depth (m)	Max. Sample Pressure
278	3/7/93	-43.007	-88.006	3718	3789
281	3/8/93	-41.516	-88.008	4137	4201
284	3/9/93	-40.008	-88.002	4055	4132
287	3/10/93	-38.502	-88.002	3777	3848
291	3/11/93	-36.504	-88.001	4025	4088
295	3/12/93	-34.499	-87.995	3949	4023
299	3/13/93	-32.503	-87.994	3737	3796
303	3/14/93	-30.499	-87.992	3706	3773
307	3/14/93	-28.499	-88.001	2920	2979
311	3/15/93	-26.504	-88.000	3367	3410
317	3/17/93	-24.330	-88.004	4135	4211
322	3/18/93	-21.991	-88.004	4108	4184
326	3/19/93	-19.996	-88.000	4310	4387
330	3/20/93	-18.198	-87.081	4381	4460
334	3/21/93	-16.376	-86.181	4540	4621
338	3/22/93	-14.537	-85.826	4709	4796
342	3/23/93	-12.489	-85.835	4347	4425
346	3/24/93	-10.493	-85.834	4317	4394
351	3/26/93	- 8.009	-85.836	4188	4272
353	3/26/93	- 7.001	-85.830	3955	4022
357	3/28/93	- 5.004	-85.829	3825	3887
361	3/29/93	- 2.997	-85.829	3227	3273
364	3/29/93	- 1.999	-85.833	2742	2785
371	3/30/93	- 0.334	-85.832	3030	3068
373	3/30/93	0.004	-85.835	2888	2944
379	3/31/93	1.004	-85.836	2792	2832
380	3/31/93	1.340	-85.831	3006	3045
382	4/1/93	2.002	-85.840	2601	2641
386	4/2/93	3.500	-85.842	2910	2928
395	4/4/93	6.715	-88.779	3450	3499
398	4/5/93	7.728	-89.897	3458	3515
403	4/6/93	9.432	-91.754	3717	3786
413	4/9/93	13.029	-91.760	6224	6357
420	4/10/93	13.488	-91.596	830	845
422	4/10/93	13.536	-91.576	200	212

3.2 ^{14}C

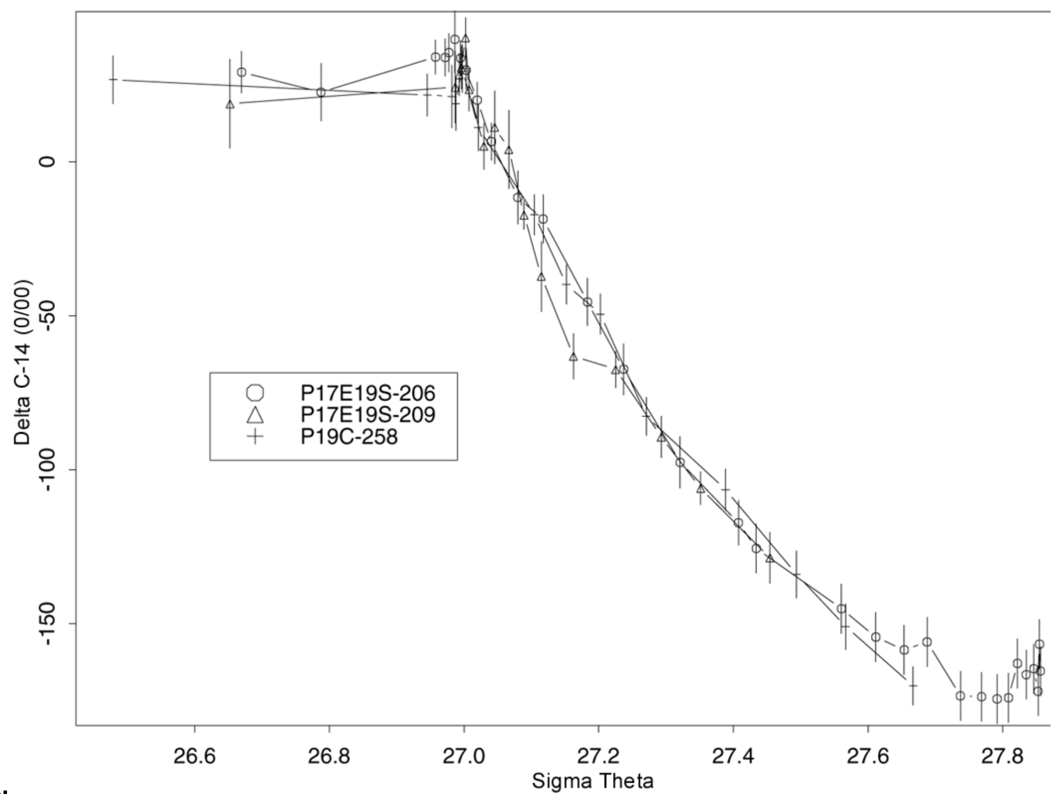
The $\Delta^{14}C$ values reported here were originally distributed in two data reports (NOSAMS, December 13, 1994 and November 21, 1997). Those reports included preliminary results which had not been through the WOCE quality control procedures.

All of the AMS samples from this cruise have been measured. Replicate measurements were made on 13 water samples. These replicate analyses are tabulated in Table 2. The table shows the error weighted mean and uncertainty for each set of replicates. Uncertainty is defined here as the larger of the standard deviation and the error weighted standard deviation of the mean. For these replicates, the simple average of the normal standard deviations for the replicates is 3.0‰ (equal weighting for each replicate set). This precision is typical for the time frame over which these samples were measured (Mar. 1994 - Nov. 1997). Note that the errors given for individual measurements in the final data report (with the exception of the replicates) include only counting errors, and errors due to blanks and backgrounds. The uncertainty obtained for replicate analyses is an estimate of the true error which includes errors due to sample collection, sample degassing, *etc*. For a detailed discussion of this see Key (1996a).

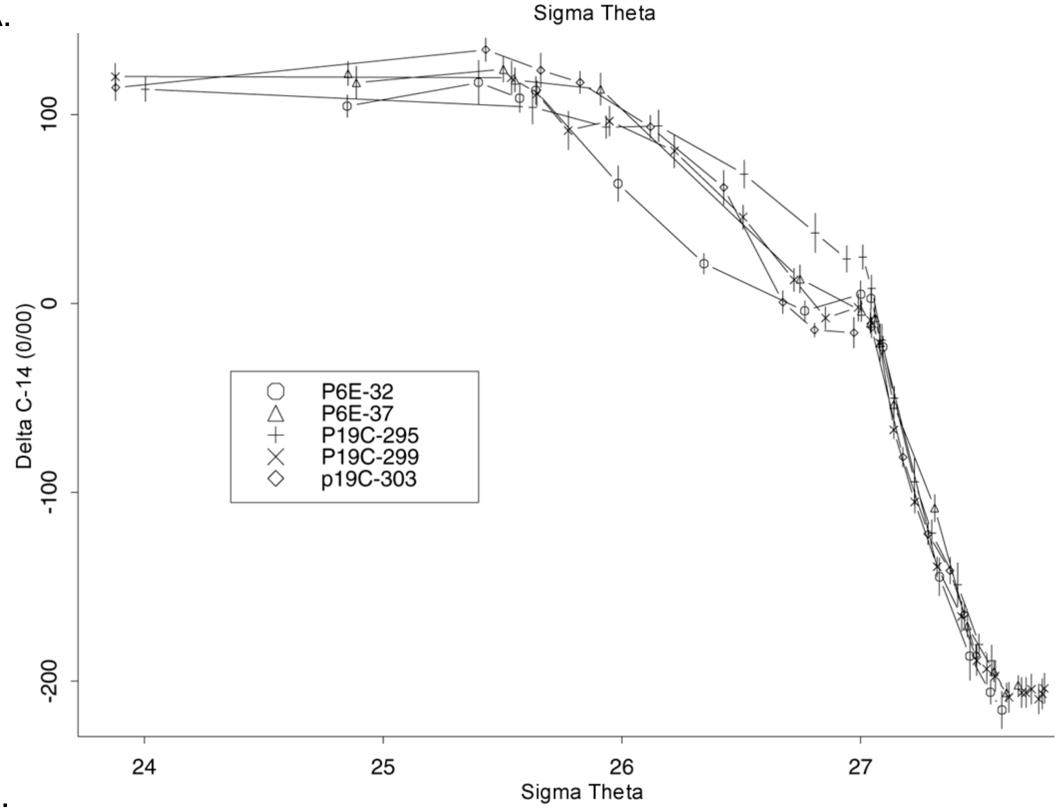
Table 2: Summary of Replicate Analyses

Sta-Cast-Bottle	$\Delta^{14}C$	Err	E.W.Mean[a]	Uncertainty[b]
261-1-19	-151.81	3.01	-151.97	1.87
	-152.07	2.43		
264-2-28	10.85	3.16	11.14	2.62
	11.80	4.71		
299-2-36	118.85	4.01	120.21	3.51
	123.81	6.53		
303-1-22	- 13.47	2.63	- 13.99	1.81
	- 14.45	2.49		
311-1-15	-163.28	3.24	-168.07	5.32
	-170.81	2.45		
317-2-22	-110.91	2.93	-111.06	2.48
	-111.46	4.66		
338-2-19	-151.37	2.53	-154.10	4.23
	-157.35	2.75		
338-2-20	-144.58	2.64	-145.00	2.00
	-145.56	3.06		
338-2-23	-101.18	5.76	-109.80	7.75
	-112.15	3.01		
346-1-22	-117.33	2.67	-118.42	2.62
	-121.03	4.14		
373-1-13	-173.43	3.15	-175.31	6.59
	-182.75	6.27		

A check on the long term reproducibility of the measurements is possible by comparing data from this cruise with previous WOCE cruises in the same area. Figure 2A compares data from P19C with P17E19S (Key, *et al.*, 1996). The comparison is for the section along 88°W near 52°S. Figure 2B compares data from P19C with P6E (Key, *et al.*, 1996). The comparison is for data bounded by the box 30-35°N and 85-90°W (Key, *et al.*, 1996). For the data shown, the comparison is good. The only apparent difference is near the surface where real differences in either $\Delta^{14}C$ concentration or water structure could cause the offset. In each figure the measurements are shown with 2σ error bars.



A.



B.

Figure 2: Data comparison for overlap regions of the cruises indicated. Data are shown with 2σ error bars. Other than near the surface (σ_θ<27) where real differences may exist, the data appear to agree to within the estimated uncertainty.

4.0 Quality Control Flag Assignment

Quality flag values were assigned to all $\Delta^{14}C$ measurements using the code defined in Table 0.2 of WHP Office Report WHPO 91-1 Rev. 2 section 4.5.2. (Joyce, *et al.*, 1994). Measurement flags values of 2, 3, 4, 5 and 6 have been assigned. The choice between values 2 (good), 3 (questionable) or 4 (bad) involves some interpretation.

When using this data set for scientific application, any ^{14}C datum which is flagged with a "3" should be carefully considered. My subjective opinion is that any datum flagged "4" should be disregarded. When flagging ^{14}C data, the measurement error was taken into consideration. That is, approximately one-third of the ^{14}C measurements are expected to deviate from the true value by more than the measurement precision (~3.0‰). No measured values have been removed from this data set, therefore a flag value of 5 implies that the sample was totally lost somewhere between collection and analysis. Table 3 summarizes the quality control flags assigned to this data set. For a detailed description of the flagging procedure see Key, et al. (1996).

Table 3: Summary of Assigned Quality Control Flags

Flag	Number
2	747
3	13
4	0
5	11
6	11

5.0 Data Summary

Figures 3-9 summarize the $\Delta^{14}C$ data collected on this leg. Only $\Delta^{14}C$ measurements with a quality flag value of 2 ("good") or 6 ("replicate") are included in each figure. Figure 3 shows the $\Delta^{14}C$ values with 2σ error bars plotted as a function of pressure. The mid depth $\Delta^{14}C$ minimum which normally occurs around 2200 to 2400 meters in the Pacific is very weak in this data set primarily because the mid-depth water values are high relative to the rest of the Pacific. Measurements in the thermocline region fall into two distinct groups with the higher values being from the southern end of the section and the lower grouping being from the northern end. There is also a very strong gradient with latitude for the deep and bottom waters with the northern waters having significantly lower concentrations.

Figure 4 shows the $\Delta^{14}C$ values plotted against silicate. The straight line shown in the figure is the least squares regression relationship derived by Broecker *et al.* (1995) based on the GEOSECS global data set. According to their analysis, this line ($\Delta^{14}C$ = -70 - Si) represents the relationship between naturally occurring radiocarbon and silicate for most of the ocean. They interpret deviations in $\Delta^{14}C$ above this line to be due to input of bomb-produced radiocarbon, however, they note that the interpretation can be problematic at high latitudes. Samples collected from shallower depths at these stations show an upward trend with decreasing silicate values reflecting the addition of bomb produced ^{14}C. The $\Delta^{14}C$ values for the silicate concentration range 0-50 mmol/kg fall above Broecker's global pre-bomb trend while those with higher silicate values generally fall below the trend. With most of the Pacific data sets, the silicate - $\Delta^{14}C$ trend doubles back on itself with the deep and bottom water values having a somewhat steeper slope than the waters from the thermocline (down to approximately 2500m). This doubling back is absent from the P19C data (Key, 1996b).

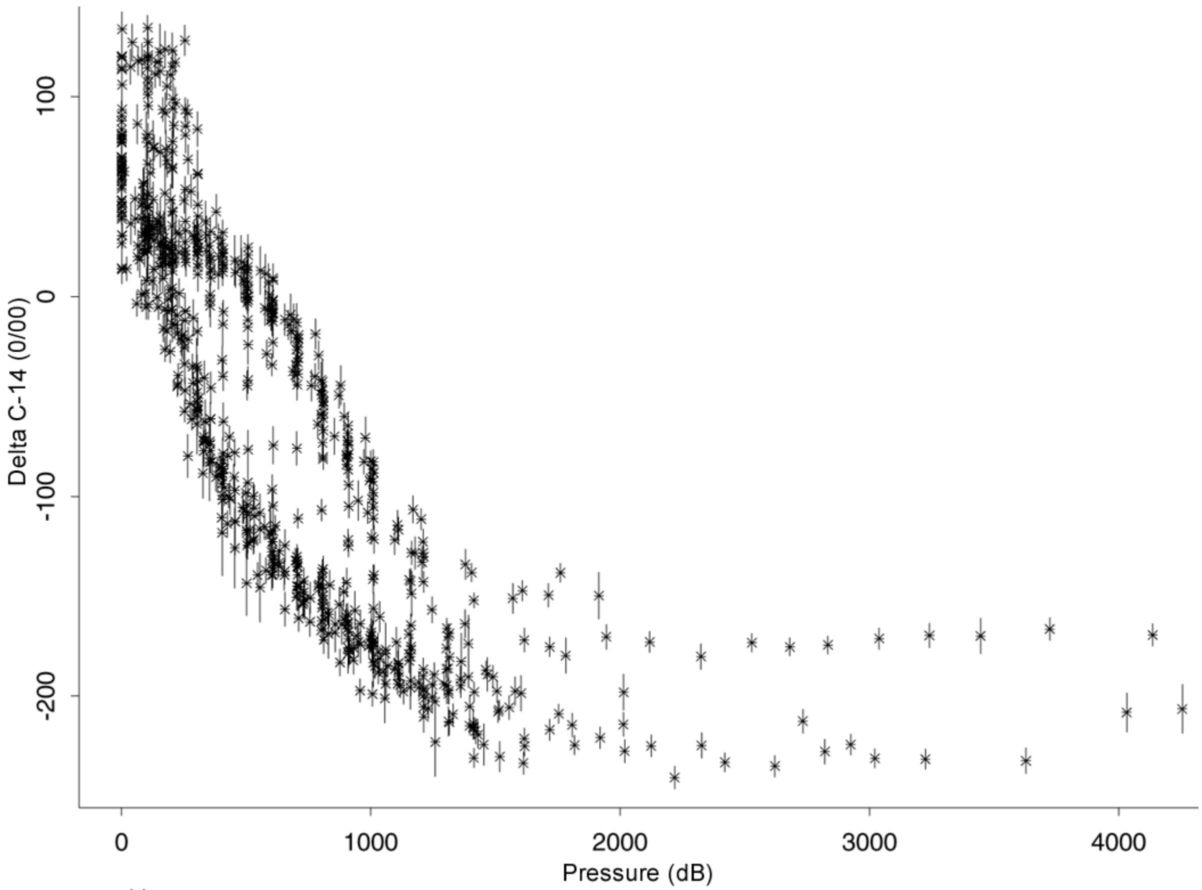


Figure 3: $\Delta^{14}C$ results for P19C stations shown with 2σ error bars. Only those measurements having a quality control flag value of 2 or 6 are plotted.

Another way to visualize the ^{14}C - silicate correlation is as a section. Figure 5 shows $\Delta^{14}C$ as contour lines in silicate - latitude space for samples collected at depths between 500 and 2500 meters. In this space, shallow waters are toward the bottom of the figure. The 500 meter cutoff was selected to eliminate those samples having a very large bomb produced ^{14}C component. The 2500 meter cutoff was selected because this is the approximate depth of the $\Delta^{14}C$ minimum. For reference the 1000 meter depth contour is also shown (heavy line). For this data set, Broecker's hypothesis works reasonably well. The $\Delta^{14}C$ isolines are reasonably horizontal and the spacing of the isolines for contours which fall below the depth of bomb-radiocarbon contamination are more or less equal. The upward curvature of the isolines at the southern end of the section is due to the addition of bomb-produced radiocarbon via ventilation where the isopycnals outcrop in the Southern Ocean.

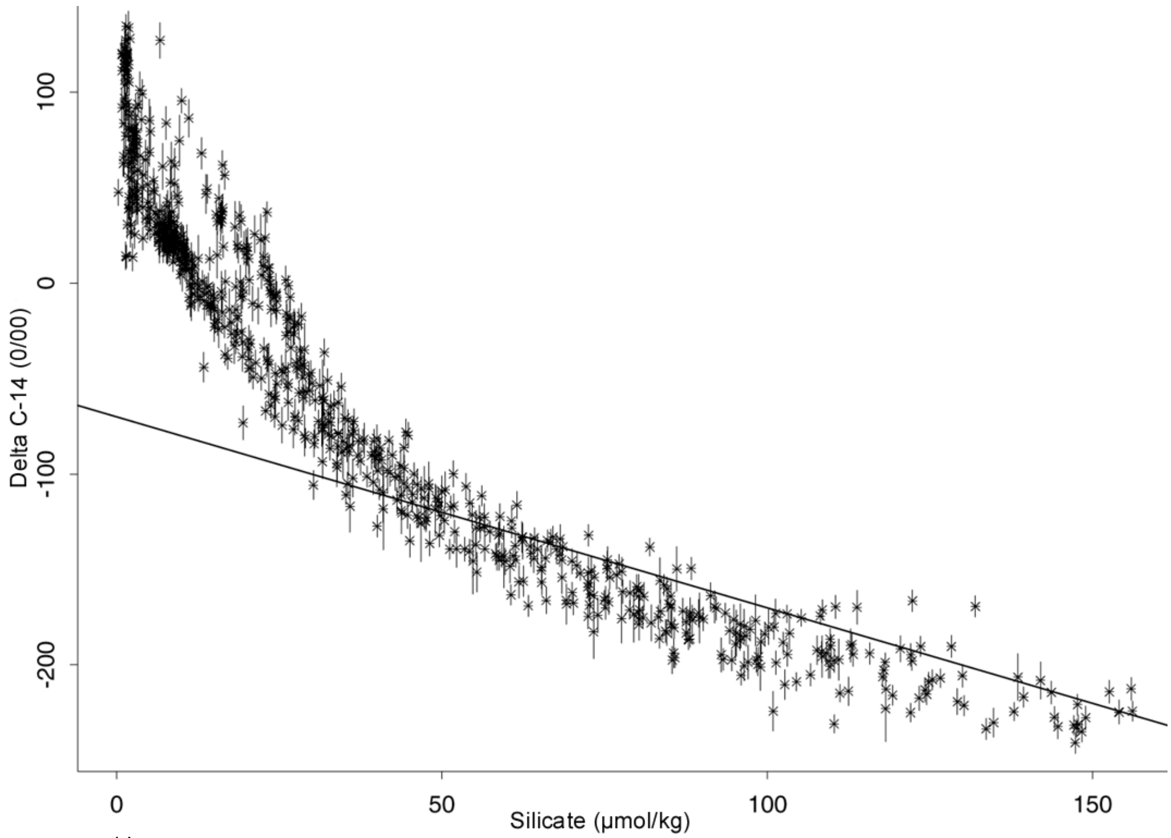


Figure 4: $\Delta^{14}C$ as a function of silicate for P19C AMS samples. The straight line shows the relationship proposed by Broecker, *et al.*, 1995 ($\Delta^{14}C$ = -70 - Si with radiocarbon in ‰ and silicate in µmol/kg).

Figures 6-7 show $\Delta^{14}C$ contoured along the two sections of the cruise track. The "A" portion shows the upper 1.5 kilometers of the section and "B" the remainder of the water column. These figures include both AMS and large volume (Stuiver, et al.1996) results. The data were gridded using the "loess" methods described in Chambers *et al.* (1983), Chambers and Hastie (1991), Cleveland (1979) and Cleveland and Devlin (1988). Figure 8 A-B shows the same data as Figure 6-7A except the sections are plotted in potential density (σ_θ) - latitude space. The top of the N-S section (Figure 8B) was clipped at σ_θ =23.0 to allow a bit more detail for subsurface waters. In the clipped area the $\Delta^{14}C$=50‰ contour continues almost vertically to the surface. The slope of the $\Delta^{14}C$ contours (-50, -100, -150‰) between 40°S and 20°S shown in Figure 7A and Figure 8B marks the region of separation for the two data groupings in the thermocline region of Figure 3. For this region of the Pacific, the maximum $\Delta^{14}C$ concentration was found at the surface near the southern end of the section where the isopycnals outcrop, but subsurface in the main gyre region (35°S - 10°S). The patterns of isolines in Figure 7 and Figure 8B are similar to those found for the WOCE P16 and P17 sections at the same latitude, however the $\Delta^{14}C$ gradient in the deep and bottom waters is stronger on this section (Figure 7B). Also unusual is the blob of water with $\Delta^{14}C$<-220‰ at the northern end of the section (15°S - 5°N). This apparent blob arises because the northernmost station sampled a topographically isolated basin with a sill depth near the $\Delta^{14}C$ minimum and therefore has a near uniform concentration of -235‰.

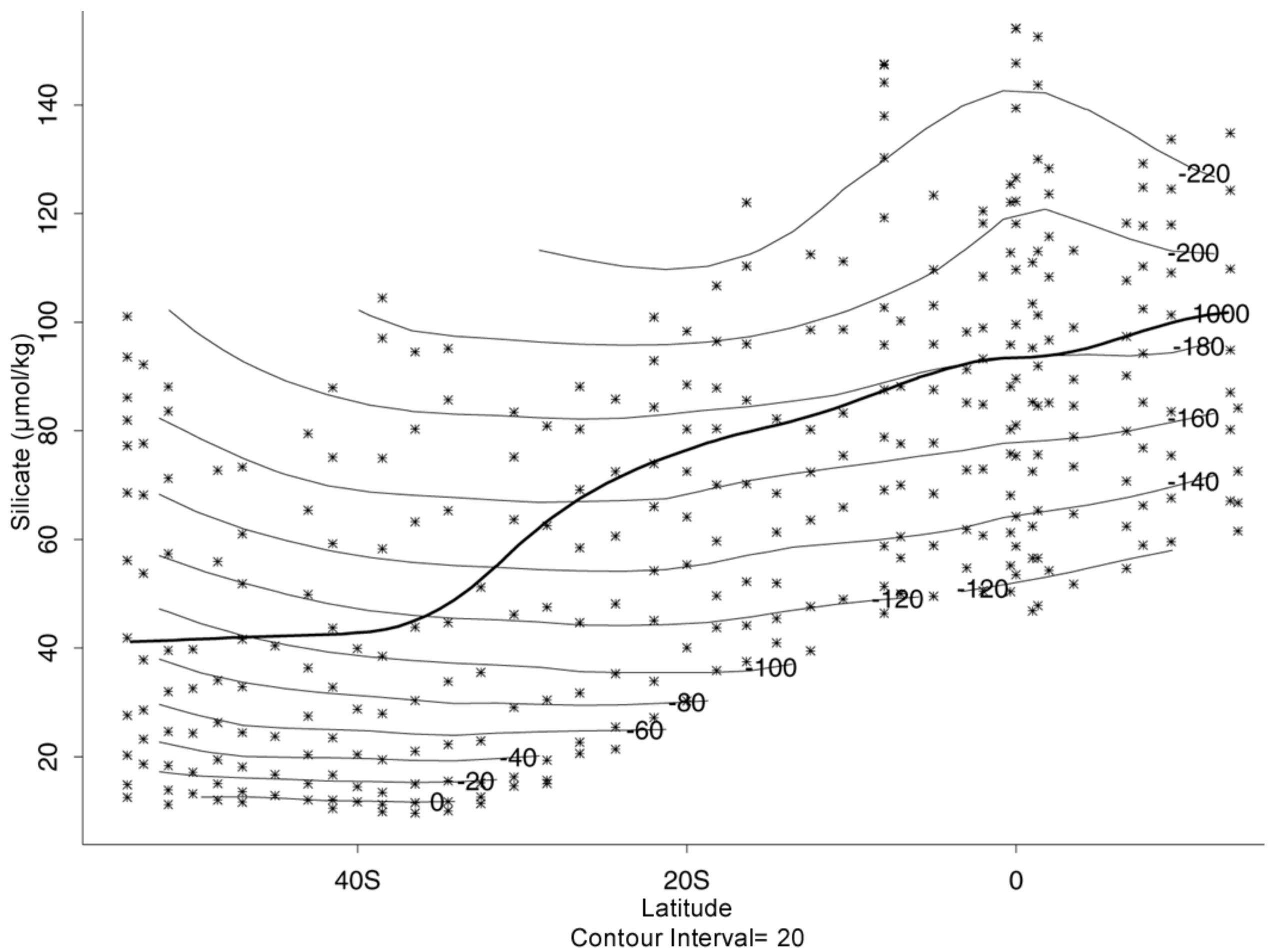


Figure 5: Section of ^{14}C contours along latitude in silicate space for the 500-2500m depth range. Note that for this section, "shallow" is toward the bottom. The 1000m depth contour is added for orientation (heavier line).

Figure 9 shows 3 maps of the $\Delta^{14}C$ distribution using all available data. In Figure 9A the distribution is on the σ_θ = 26.5 surface. This surface outcrops at the southern end of the map (heavy line; Levitus winter data) and reaches a maximum depth of approximately 400m around 20°S. The values in this region increase pole-ward due to the input of bomb-produced radiocarbon at the outcrop region of the isopycnal layer. Confidence in this map will increase significantly with the addition of the data from WOCE section P18 (NOAA line), however the general NW-SE slope of the contours is probably correct. Figure 9B shows the $\Delta^{14}C$ distribution on the 2400m depth surface which is the approximate depth of the $\Delta^{14}C$ minimum. The concentrations clearly increase northward, presumably reflecting the southward return of North Pacific Deep Water. The 2400m bathymetry is also shown on this map. Figure 9C shows the near bottom $\Delta^{14}C$ distribution for stations where the water depth was at least 3500m. The northward flow of Circumpolar Deep Water is clearly evident along the western side of the figure. The contours in the far southeastern portion of the figure might change significantly with the addition of the Meteor data from the Drake Passage.

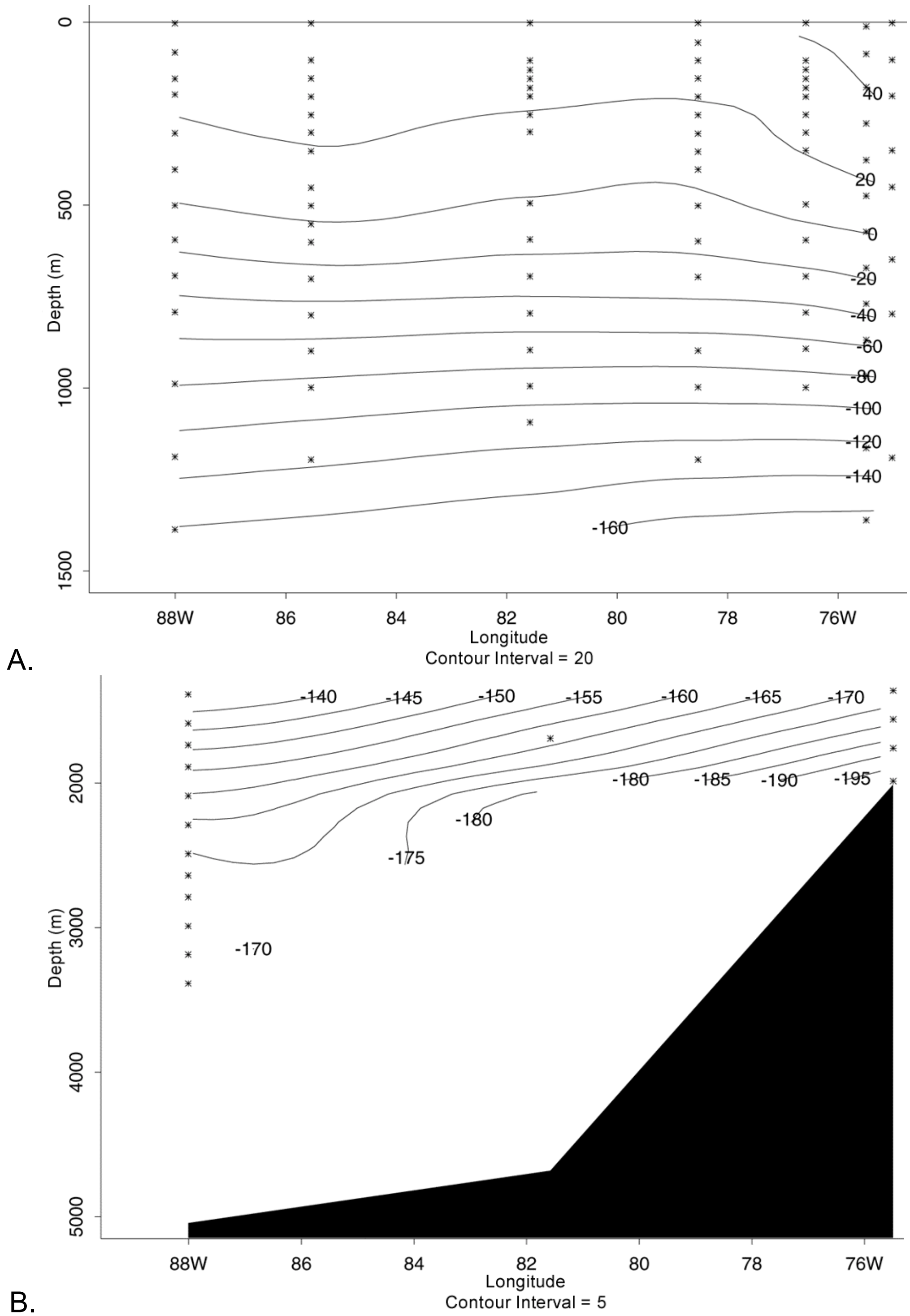


Figure 6: $\Delta^{14}C$ sections for WOCE P19C from Punta Arenas west to approximately 54°Sx88°W. The section in shown in two parts to allow more detail. In B. any existing large volume data is included to maximize the data density. See text for gridding method. The bottom topography in B is taken from cruise data, but only using those stations on which $\Delta^{14}C$ was measured.

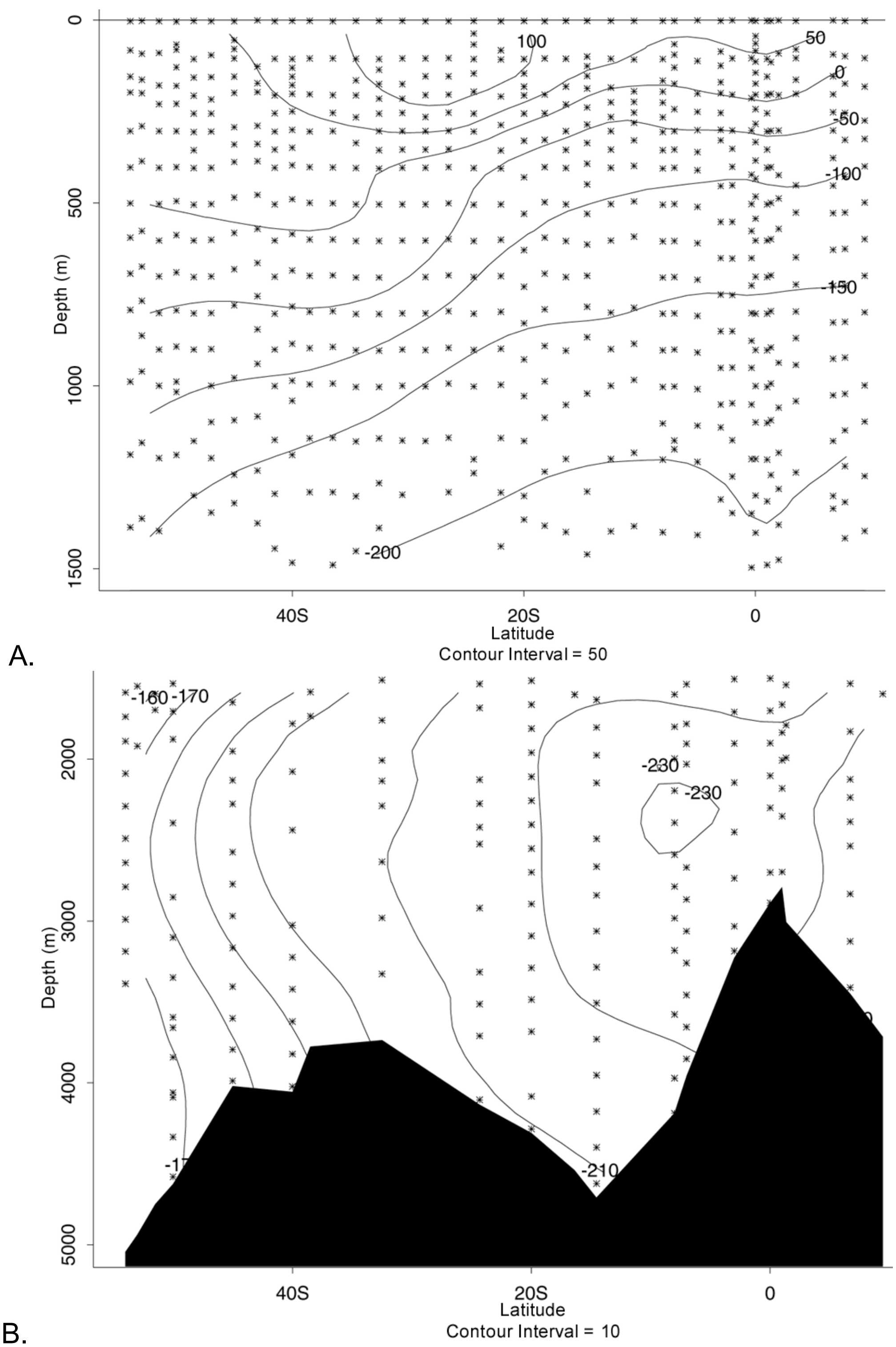


Figure 7: $\Delta^{14}C$ sections for WOCE P19C from 54°Sx88°W north to approximately 13.5°Nx91.5°W. The section in shown in two parts to allow more detail. In B. any existing large volume data is included to maximize the data density. See text for gridding method. The bottom topography in B is taken from cruise data, but only using those stations on which $\Delta^{14}C$ was measured.

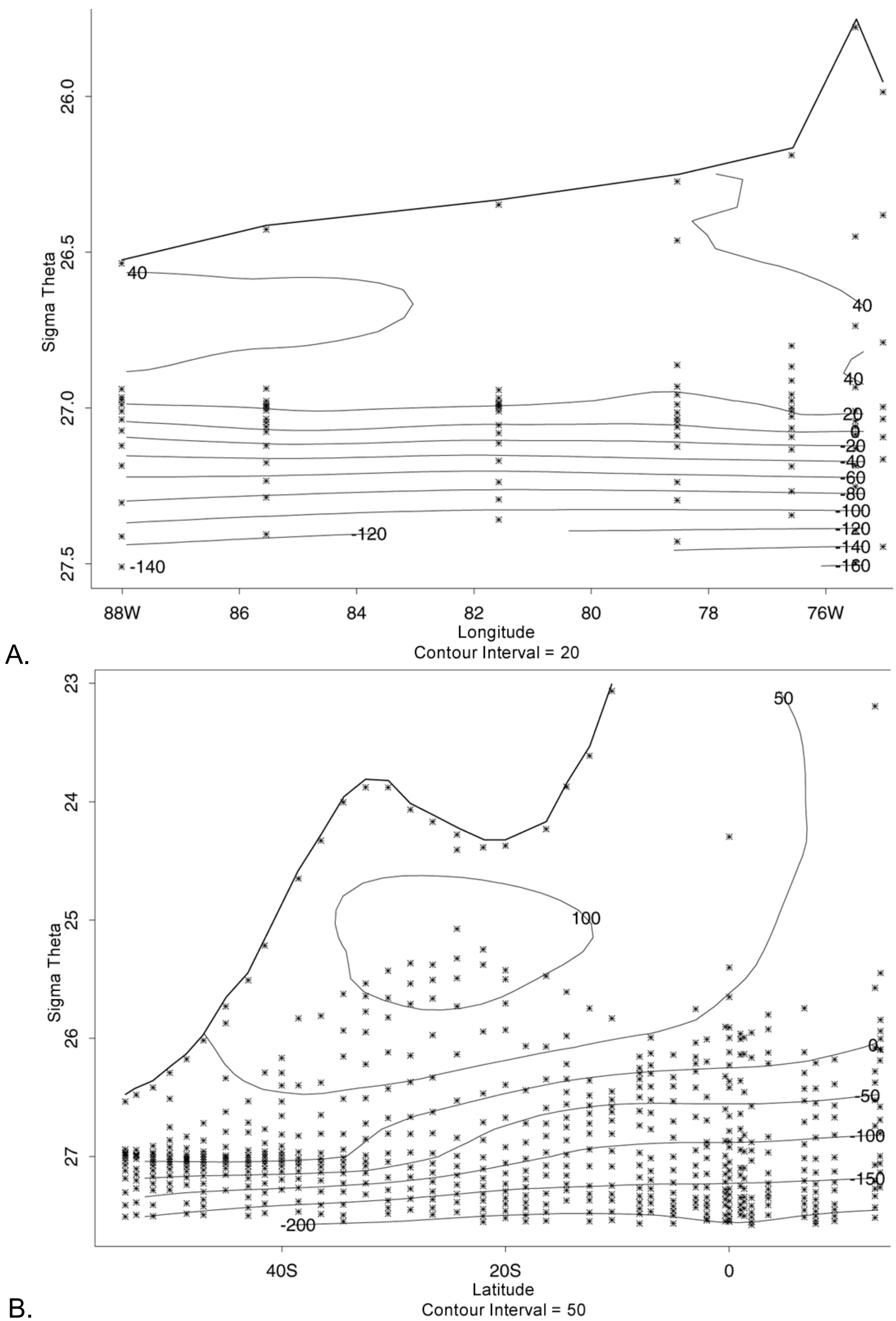


Figure 8: $\Delta^{14}C$ along WOCE section P19C plotted in potential density (σ_θ) - latitude space. The B section was clipped at σ_θ=23 north of ~15S. The data used in these figures is the same as in Figure 6A and Figure 7A.

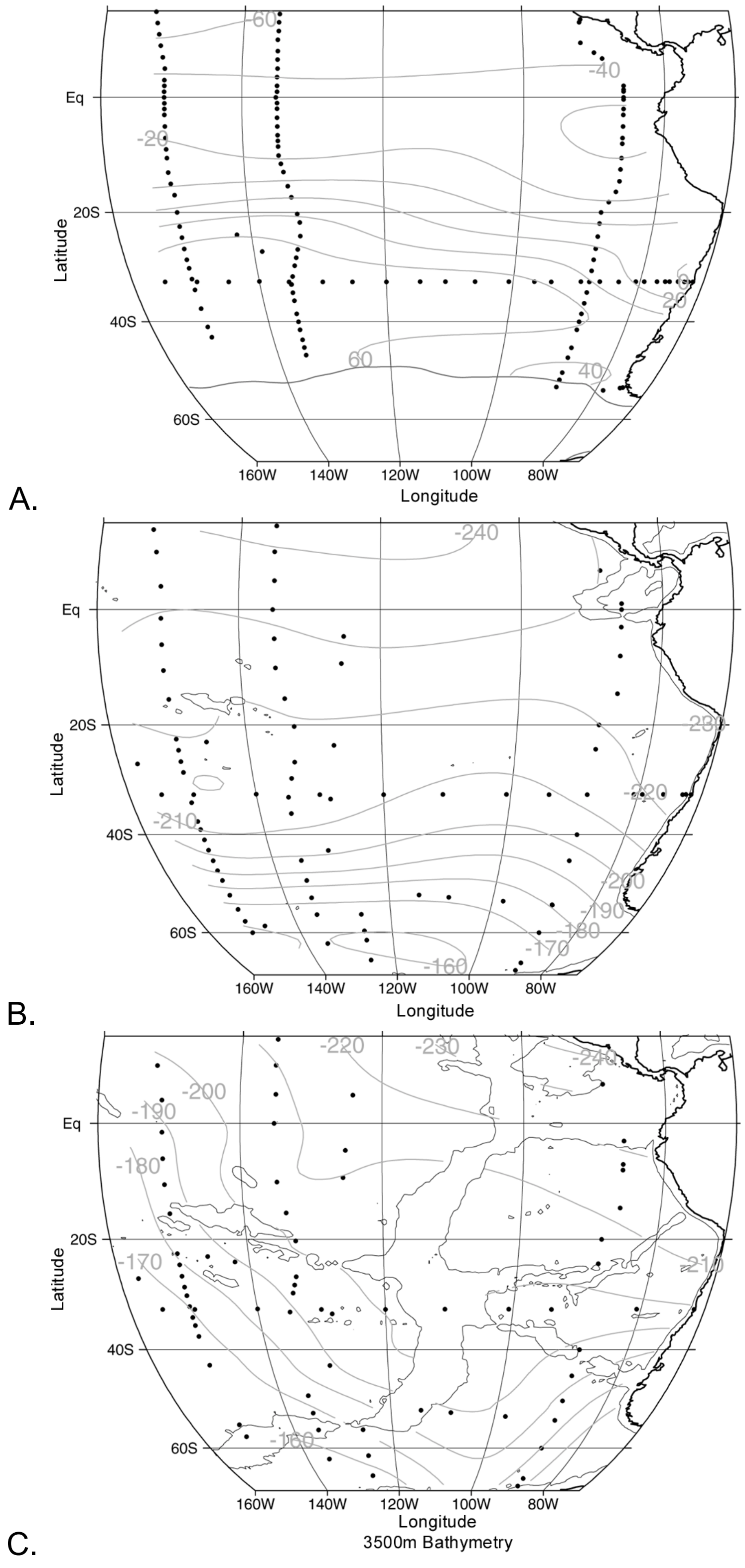


Figure 9: A. $\Delta^{14}C$ distribution on the σ_θ=26.5. B. Distribution on the 2400m surface near the $\Delta^{14}C$ minimum. C. Near-bottom $\Delta^{14}C$ distribution for stations having bottom depth of at least 3500m.

5.1 References and Supporting Documentation

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DQE Evaluation of CTD data for RV Knorr Cruise
along WOCE Section P19C
Expocode 316N138_12

Mark Rosenberg, January 2000

This report contains a data quality evaluation of the CTD data files for the Pacific sector cruise along WOCE section P19C (Figure 1) on the RV Knorr in February to April, 1993. Bottle data are evaluated in a separate report by Arnold Mantyla. 2 dbar CTD data and upcast CTD burst data in the bottle file were examined for all stations. In general, CTD salinity data quality is very good, while CTD oxygen data quality is excellent. CTD data processing methodology is described very well in the cruise report from ODF, and CTD data processing notes are thorough.

Given that this report comes 7 years after the cruise, comments on methodology may no longer be relevant. Please just consider them as ‘historical footnotes’.

STATION SUMMARY FILE (.sum)

The following need fixing in the station summary file:

- o Station 235 maximum pressure reads 5290 dbar - it should be 512 dbar.
- o Station 244 end position is wrong - needs correcting (and confirm that ALACE position is correct).
- o Station 281 dip 1 maximum pressure value is missing - should be 3008 dbar (from CTD file).
- o Station 349 wire out value looks low by ~200 m.
- o Sound speed and transducer depth information for the ship’s sounder were not provided in the documentation. “Corrected depth” (.sum file) was therefore calculated from the CTD at the bottom of the cast i.e. altimeter reading + maximum CTD pressure recalculated in meters (using the method of Saunders and Fofonoff, 1976). For stations with no altimeter reading, no corrected depth was calculated. These corrected depth values are in an ascii file corrdepth.dat, and have not been merged into the .sum file.

SALINITY

In the following discussion on residuals, only CTD and bottle values with a quality flag of 2 are considered (i.e. QUALT1=2 for CTDSAL and SALNTY in the bottle file).

The salinity residual data ΔS (where ΔS = bottle – CTD salinity difference) for all depths is shown in Figure 2 (an additional ~250 data points lie outside the axis limits). Below 500 dbar, scatter of ΔS is greatly reduced (Figure 3). As mentioned in the DQE report for WOCE line P31, increasing the averaging period for CTD burst data at bottle stops to 10 seconds may help decrease residuals, particularly when the ship is rolling.

Standard deviations for ΔS for the whole cruise were calculated from data in the bottle file (Table 1). The salinity standard deviation of 0.0019, calculated using all sampling depths and |ΔS| ≤ 0.008, is a reasonable estimate of the salinity accuracy for the cruise. Overall the calibration is good, and the salinity accuracy is within the WOCE requirement. Closer inspection reveals a small salinity bias (i.e. CTD relative to bottles) remaining for many stations, in some cases for a series of consecutive stations (e.g. station 258 to 263), with a magnitude mostly < 0.002. Deepwater comparisons of θ-S curves (where θ = potential temperature) show that in most cases the bias is due to offset of salinity bottle data. Overall these small bottle inaccuracies do not affect calibration of the CTD salinity, as evidenced by the consistency of deepwater θ-S curves for the CTD data.

Comments on specific stations:

stations 254, 255, 277 - CTD salinity at 0 dbar a bit low, flag as “3”

station 331 - CTD conductivity cell appears to have been fouled on the upcast after the sample at 4320 dbar; the CTD conductivity offset further increases after the sample at 2116 dbar. Flag all CTDSAL values above 4320 dbar in the bottle data file as “4”.

station 355 dip 11 (i.e. downcast) - from looking at θ-S comparison with surrounding stations, the conductivity readings still look offset by the fouling down to ~7^{o}C, so continue the flag “3” for salinity in the CTD file from 400 dbar down to 598 dbar; several small salinity spikes occur below 2200 dbar - flag as “3” the largest of these at 4102 dbar in the CTD file.

station 355 dip 1 (i.e. upcast) - flag as “4” the bottom 11 CTDSAL values in the bottle file to match the bad data in the CTD file (the CTDSAL value for bottle 12 looks okay, despite the equivalent “4” flag at 1880 dbar in the CTD file).

stations 356, 357 - small pressure dependence in the salinity residual which may be due to some fouling remaining on the conductivity cell from station 355. Too small to worry about (i.e. salinity offset < 0.002).

Table 1: Standard deviations for salinity residuals ΔS (using only bottle and CTD data for which the quality flag=2).

data	standard deviation of ΔS
all depths	0.0241
deeper than 500 dbar	0.0029
all depths, |ΔS| ≤ 0.008	0.0019

OXYGEN

CTD oxygen data quality is impressive, and the fit to the oxygen bottle data is excellent.

Given the frequent problems usually encountered with CTD oxygen data sets, the following specific comments normally wouldn't be worth identifying. However against the very high quality of the oxygen data here, these slight irregularities are more noticeable:

station 234 - CTDOXY values in bottle file should be flagged as "3" to match flagging of oxygen data in CTD file (bottom 2 values at 123 and 99 dbar look okay, and can keep their "2" flag).

station 261 - top 70 dbar of CTD oxygen profile looks suspicious; flag 0 to 70 dbar oxygen as "3" in CTD file.

station 264 - top 22 dbar of CTD oxygen profile looks suspicious; flag 0 to 22 dbar oxygen as "3" in CTD file.

station 265 - top 30 dbar of CTD oxygen profile looks suspicious; flag 0 to 30 dbar oxygen as "3" in CTD file.

station 314 - CTD oxygen below 300 dbar low by ~1 _mol/kg compared to bottles, but doesn't warrant flagging.

station 411 - CTD oxygen fit for ~800 to 3300 dbar a little poor, with a maximum residual of ~4 _mol/kg compared to bottles; okay to leave flag as "2" for this cast.

station 414 - CTDOXY values in bottle file for samples from 55 to 1907 dbar should be flagged as "3" to match flagging of oxygen data in CTD file.

Final CTD oxygen calibration coefficient values (from Appendix D in the cruise report) look reasonable, except for the following:

* the P coefficient c3 is negative for stations 389, 391, 419, 420, 421
* the TS coefficient c5 is positive for stations 234, 235, 344

Oxygen data are still acceptable for these stations (except where already flagged).

EXTRAPOLATION

A flag value of 6 has been used for many stations at the 0 dbar level, and the data processors have noted an extrapolation. This extrapolation can occasionally continue to the surface a suspicious gradient between the 4 and 2 dbar levels. Examples are the 0 dbar salinity value for stations 257, 276. I don't believe these data extrapolations are necessary – if there's insufficient data to create a 0 dbar bin, it would be preferable to leave a gap at that bin and flag as 9.

DENSITY INVERSIONS

Locations of unstable vertical density gradients are shown in Figure 4; only gradients more unstable than -0.003 $kg/m^3/dbar$ are shown. Most occur in the top 6 dbar, and may often be due to sensor transient errors/instabilities at the start of casts (further reason not to extrapolate data at the 0 dbar level).

COMPARISONS WITH OTHER CRUISES

Th data processors have put considerable effort into historical comparisons, making the cruise report a much more informative document. To add to this work, a quick comparison is made between P19C data and data from WOCE lines P4 (P.I. H. Bryden on eastern leg) and P21 (P.I. M. McCartney on eastern leg). Deepwater θ-S and θ-oxygen curves for these data sets are compared in figures 5 and 6:

Salinity data - P19C and P4 salinity data agree well (figure 5); P21 salinities are ~0.001 higher than P19C (figure 6), which is within the accuracy of salinity measurements and the scatter of standard seawater batches.

Oxygen data - for both comparisons, oxygen data are scattered over a maximum range of ~5 _mol/kg; P4 oxygens are ~2 _mol/kg higher than P19C below θ=2°C (figure 5); there's no consistent offset between P21 and P19C oxygens (figure 6).

REFERENCES

Saunders, P.M. and Fofonoff, N.P., 1976. Conversion of pressure to depth in the ocean. Deep Sea Research, 23:109-111.

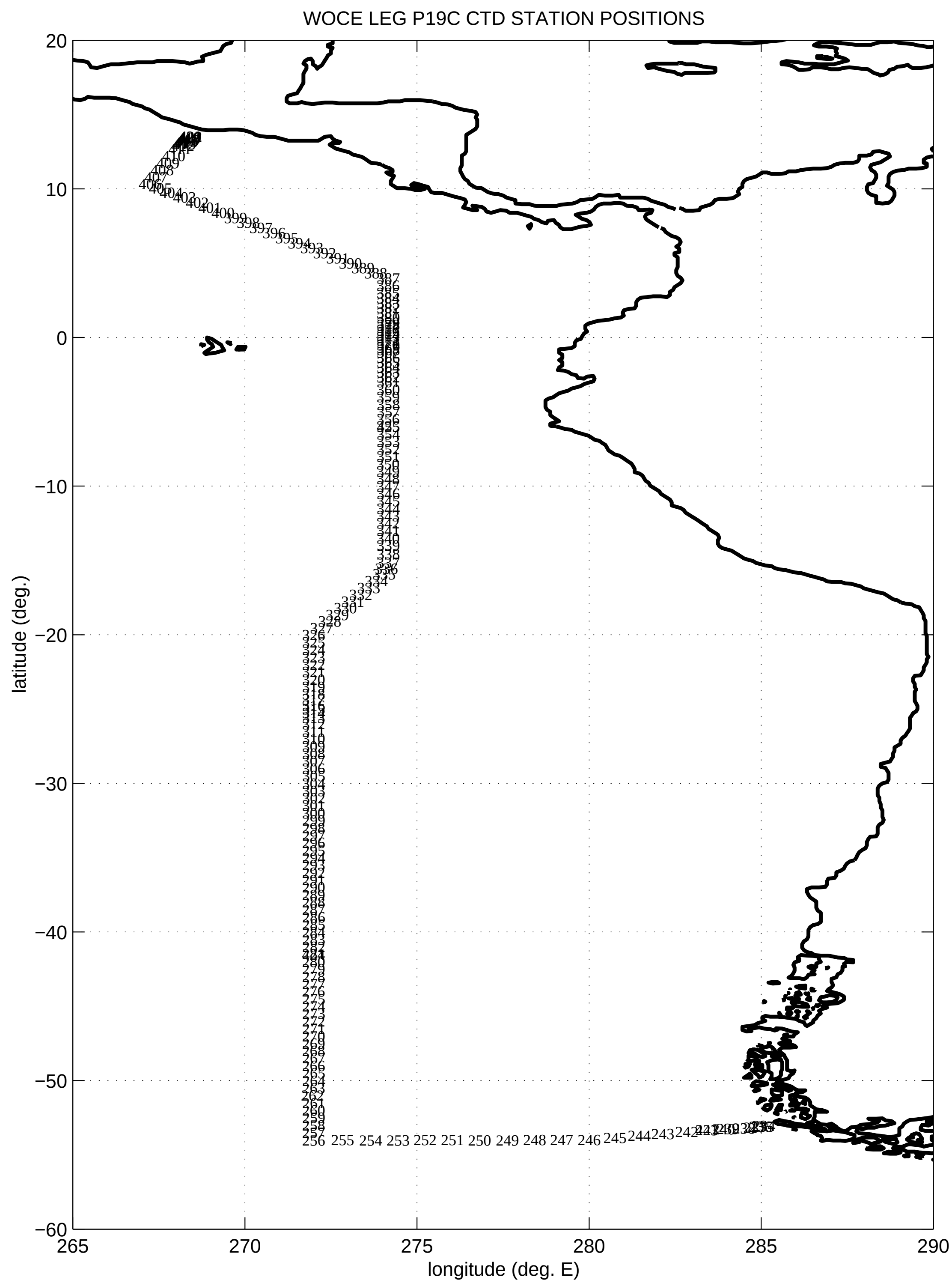
WOCE LEG P19C CTD STATION POSITIONS
latitude (deg.)
longitude (deg. E)
20
10
0
−10
−20
−30
−40
−50
−60
265
270
275
280
285
290
256 255 254 253 252 251 250 249 248 247 246 245 244 243

Figure 1

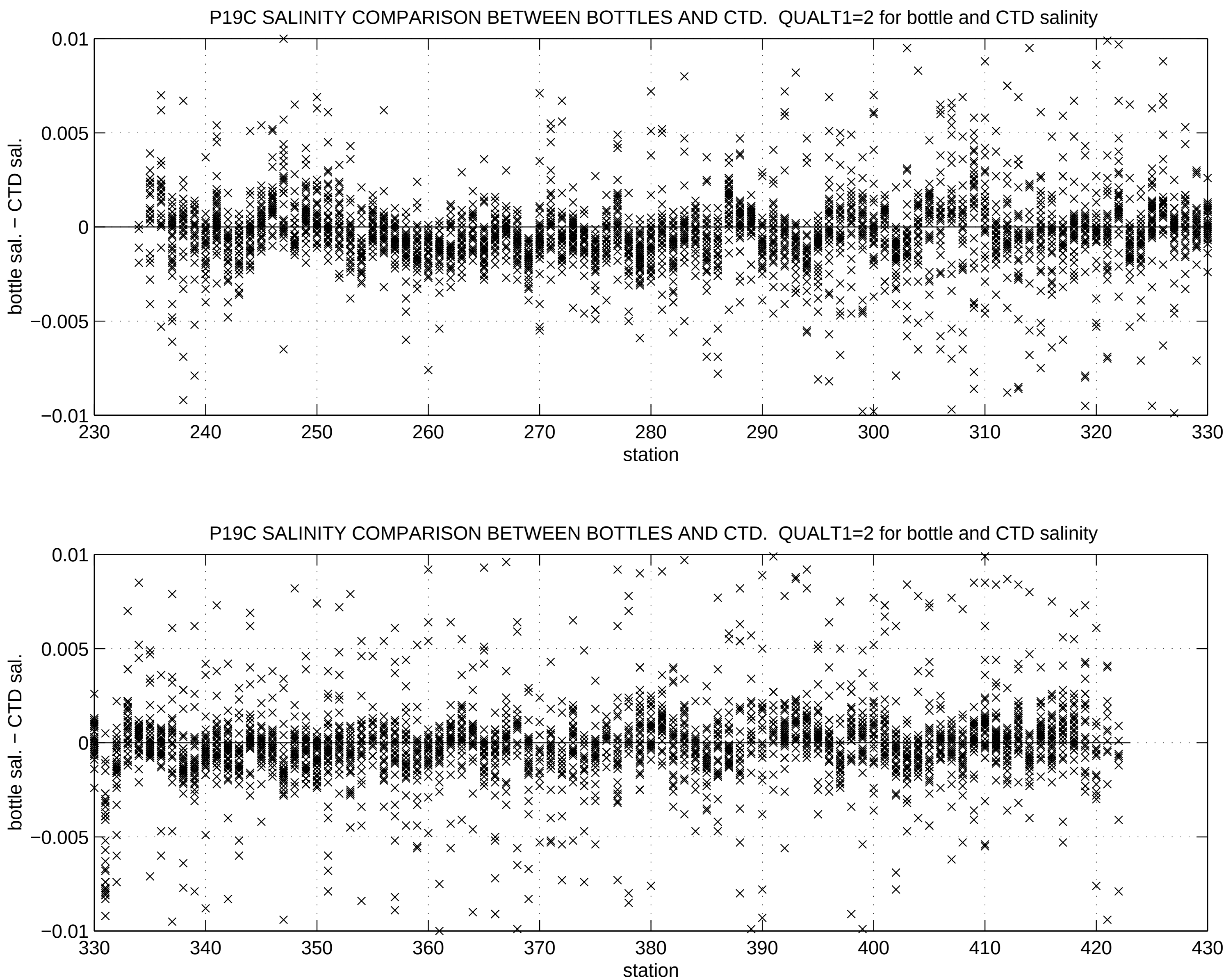

Figure 2: Salinity residuals

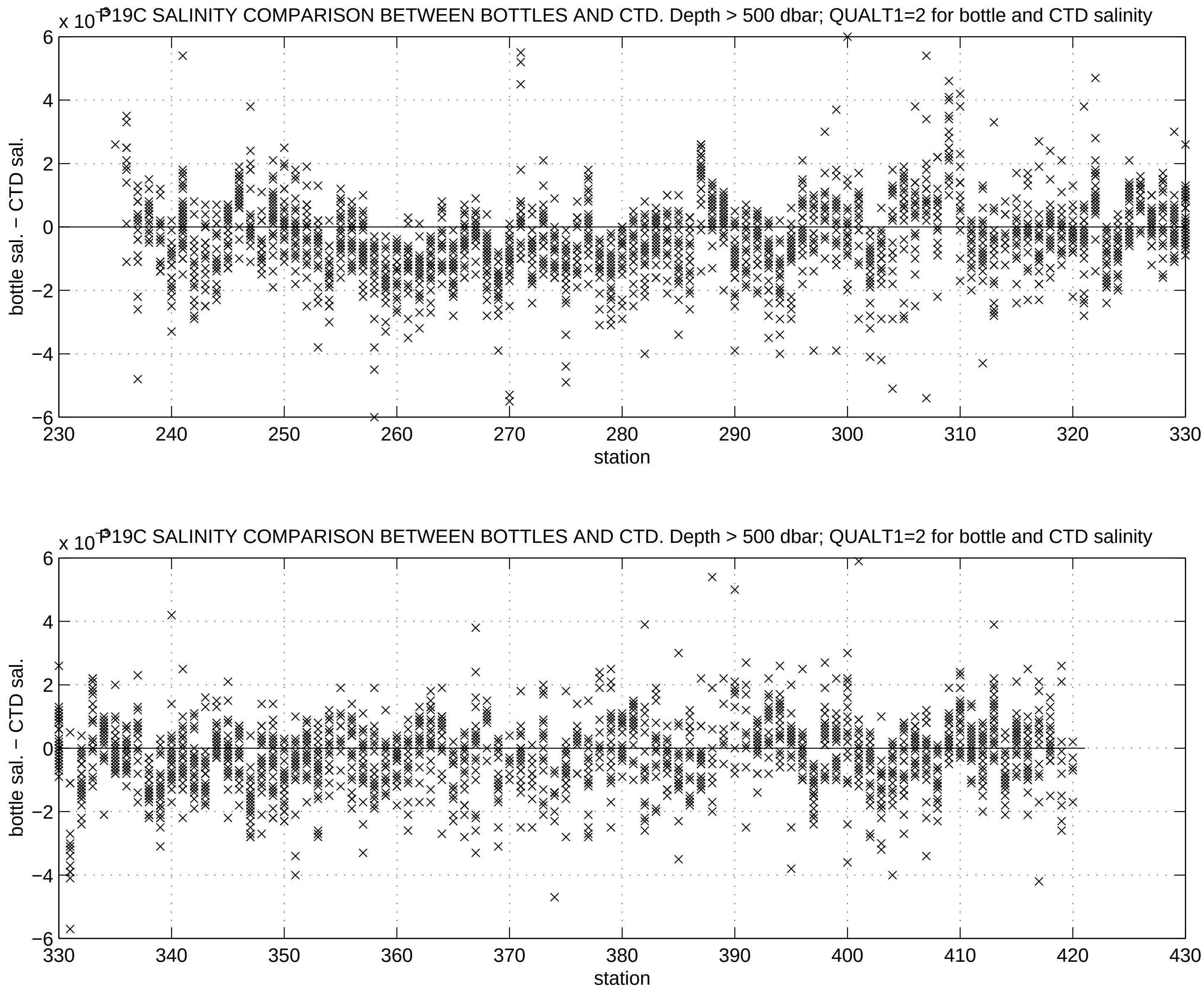

Figure 3: Salinity residuals, data below 500 dbar

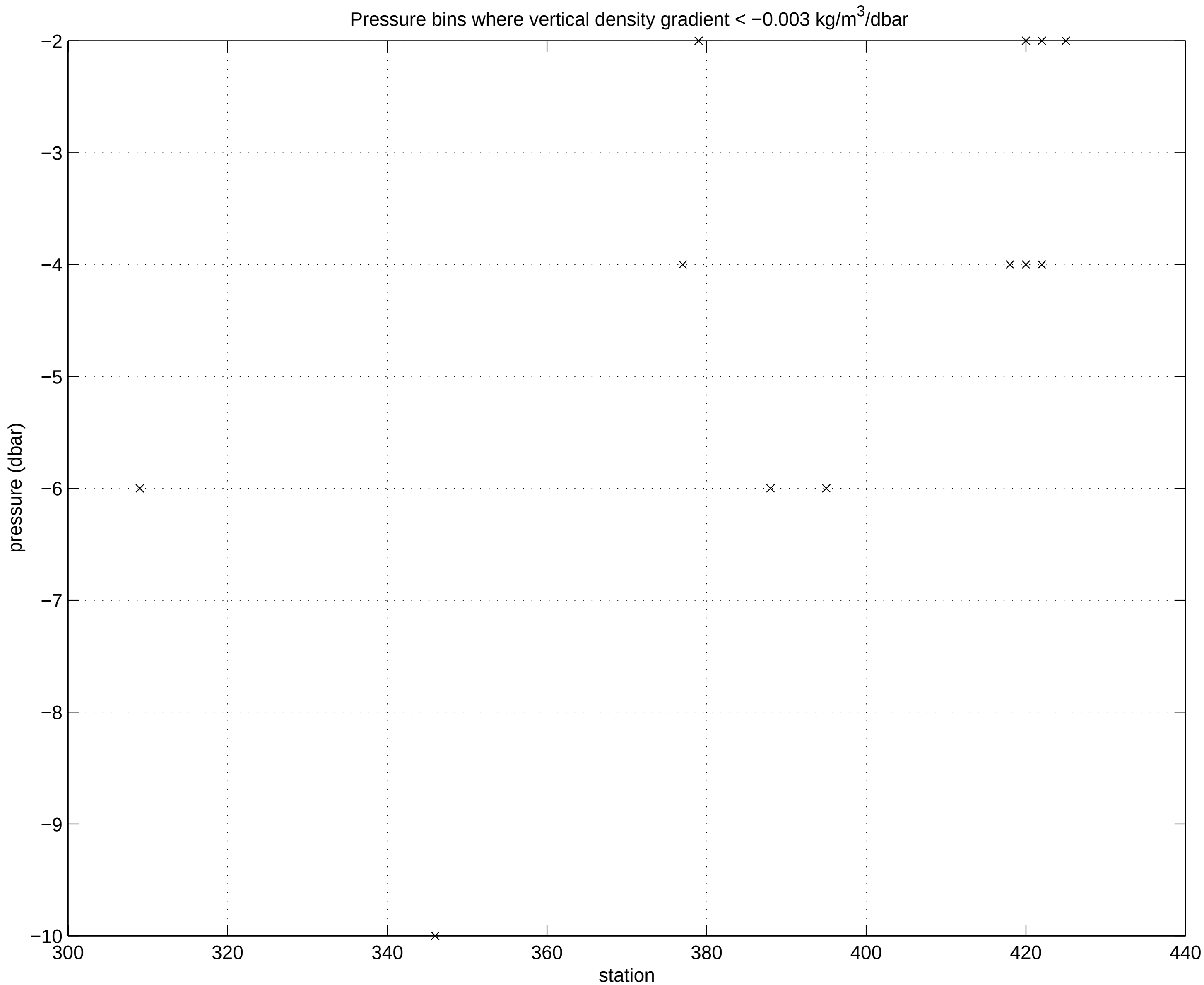

Figure 4: Local density instabilities

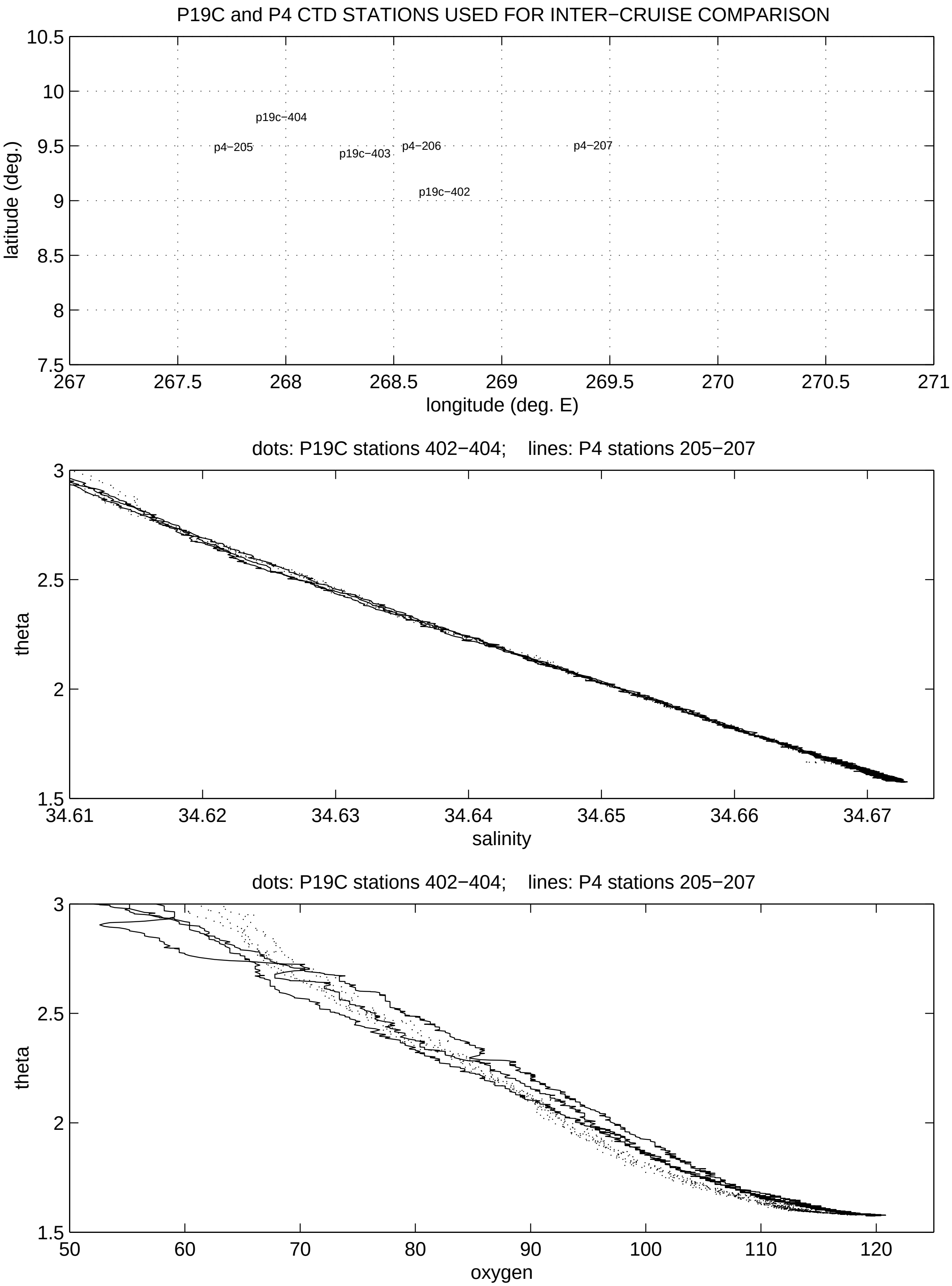

Figure 5a, b and c: (a) Station locations, (b) salinity comparison and (c) oxygen comparison for P19C/P4 comparison.

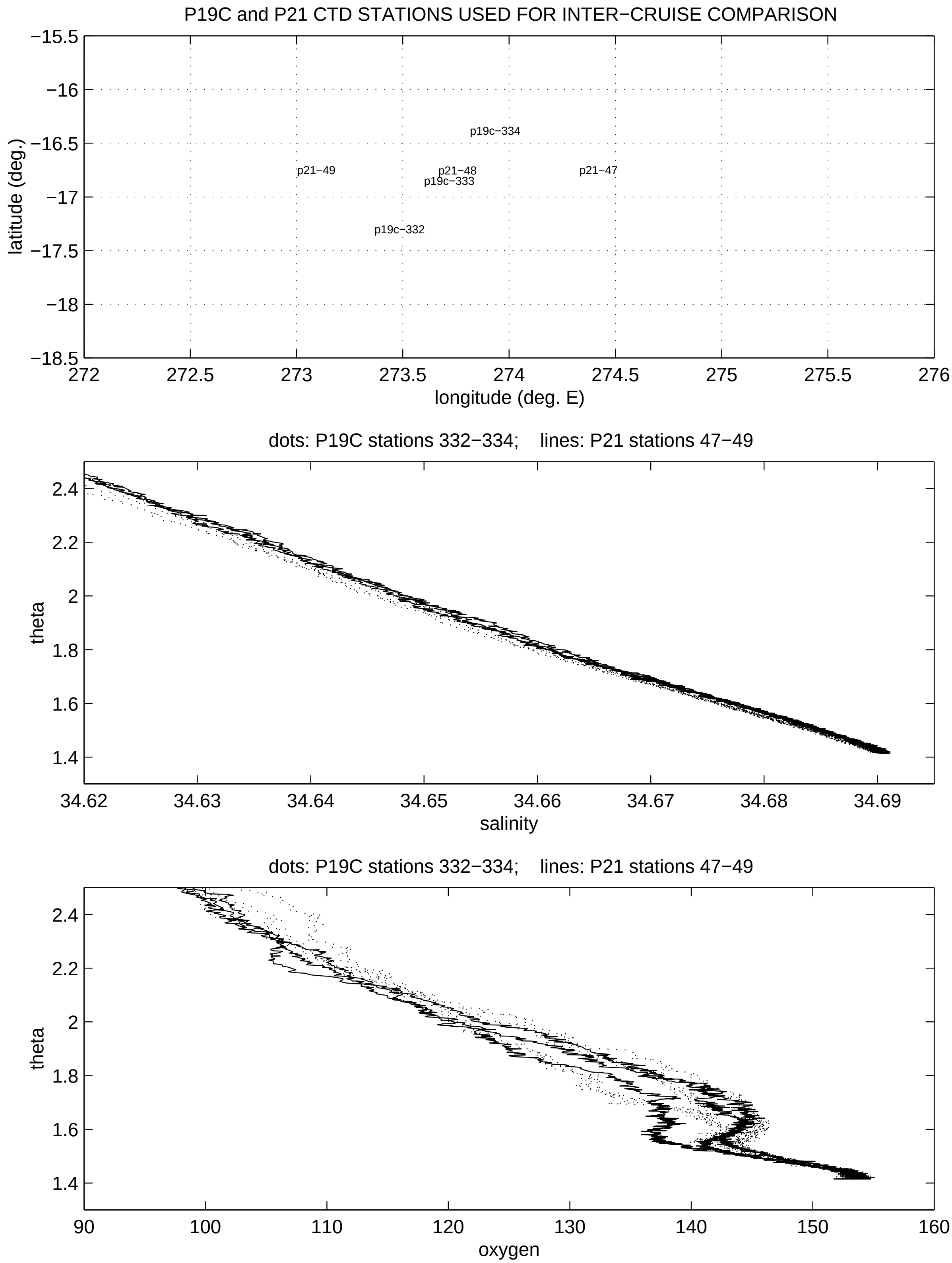

Figure 6a, b and c: (a) Station locations, (b) salinity comparison and (c) oxygen comparison for P19C/P21 comparison.

DQ Evaluation of WOCE P19C hydrographic data

Arnold Mantyla

WOCE P19C mostly ran along 88°W from 54°S to the central American shelf off of Guatemala at 13.5°N. Combined with P19S, this completes an eastern Pacific section to the Antarctic continental slope. A 36 place rosette was used throughout, with the exception of a few additional near-equatorial closely spaced stations. The cruise track crossed WOCE lines P17, P06, P21, and P04; both Scorpio lines, and Piquero Expedition. Data comparisons between the WOCE lines were generally very good, but with the usual OSU/SIO nutrient differences, especially in the silicate data. The older expeditions were noisier than the WOCE data, as expected from the older, less precise analytical techniques then available. The station to station data agreement on this cruise was very, very good, the data originators clearly have done a very thorough job in evaluating the oxygen and nutrient standardizations. Only a couple of stations had uncertain nitrates (due to a new cadmium reduction column, used too soon), but even those were not very far off from the nearby stations and could be used if one wished, with only a small multiplier correction. As for the SIO/OSU long standing silicate differences, it would be possible to resolve those differences if someone were willing to take the time to evaluate the original Beer's Law runs (not many per cruise); both data sets could be improved. I'll write a separate memo on possible solutions.

As on other WOCE cruises, there were too many data points flagged as "bad" data that were only slightly questionable, at times only slight bumps in the profiles that were within the WOCE precision expectations. In the future, I would urge greater caution in using the "bad" flag for data that is merely suspicious. I have not changed very many of the flags; mostly just in flagging poor near surface CTD oxygens uncertain. That data is from the down profile and is known to have problems.

For the salinity analyses, SSW batch P120 was used, 9 to 11 months old at the time of its use. From Bacon, Smith and Yelland's study (J. Atmos. Oceanic Technol., in press) on changes in SSW batches with age, P120 should yield salinities nearly .001 too low at the time of its use on P19C, so the SSW bias is slight for this cruise. Two of the crossing lines had SSW batches with positive errors, but the maximum spread is .0015S, within ±.001 of the combined data.

The following are comments on specific stations that would warrant a second look:

Sta. 241 - There are two full depth profiles 6 hours apart, due to multiple trip failures on the first try. The composite data set isn't appropriate because of real time differences in the separate trys. Cast 2 has good data in the top 905db, and very little for the rest of the water column; while cast 4 has good data below 1000db, and only sparse data shallower. The overlaps are not at the same time and naturally show time differences as property extrema (even in temperature) that do not exist in the individual data sets. Therefore I suggest that the best of the 2 profiles be saved and the rest of the data omitted: 0-903db for cast 2 and 1010db to 4165db for cast 4. That will save future data users from going through this same exercise to identify the useful parts of the 2 data sets.

Sta. 250 - BTL 13 tripped at the same depth as BTL 14 at 2426db, leaving a data gap at about 2625db. Should have left in CTD P, T, S, and O_2 at original level to minimize the data gap. Suggest recover the CTD info, if possible.

Sta. 257 - No data listed for top 296db, apparently 6 bottles did not trip. It would be useful to leave in the CTD P, T, S, and O_2 data at the intended trip levels.

Sta. 287 - Salinities appear to be about .002 high compared to adjacent stations and the CTD. Suggest re-check salinometer calculations, and standard dial settings compared to other stations to see if the data can be corrected.

Sta. 309 - Larger than usual bottle-ctd salt differences, recommend re-check salinometer calculations. Any drift, or apparent drift not real per CTD comparison? One watch on this cruise did seem to be a little more careless in collecting quality salinity samples compared to stations done in other times of the day.

If no problem found, suggest flag all bottle salts uncertain on this station.

Sta. 330 - The top 6 salinities are about 1.985 too high, almost exactly the error that would occur if the suppression dial setting on the salinometer was 0.1 off (2.1 instead of 2.0). Re-check the salinometer calculations to see if the salinities can be salvaged. No sampling error could result in such a large and uniform offset error.

Sta. 331 - CTD salinities appear to be up to .008 high over most of the profile compared to adjacent stations and this station. I've U'd the CTD salts between 228 and 3930db, but the CTD salts should be re-checked.

Sta. 338 - The wrong silicates were flagged as uncertain, per ODF's notes. However, the bottom two are not sufficiently higher than the adjacent stations to flag anyway, so I suggest accept all as ok.

Sta. 355, 2077-4156db - The CTD salinities are very poor, can they be improved? I've U'd the bottom 11 CTD salts. Also, the bottle salts from 3271 to 3683db appear to have been drawn in reverse order. I've U'd 3271db, 3683db could be U'd also.

Sta. 414 - In the Middle America Trench, the deep salinities are about .002 lower than the other two stations (412 and 413) in the trench, while the CTD values are uniform for all 3 stations. However the mean CTD salt agrees with the mean of the bottle salts, so looks like we're at the limit of salinometer salinity, $\pm$.001. It would be a good idea to look at the salinometer run for station 414 to see if the source of the offset can be identified.