

Data Report NBP0506

Maud rise Non-linear Equation of State Study

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United States Antarctic Program

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Table of Contents

INTRODUCTION.....	1
ARCHIVE COMMANDS.....	1
DISTRIBUTION CONTENTS AT A GLANCE.....	2
DISTRIBUTION CONTENTS.....	3
CRUISE INFORMATION.....	3
<i>Cruise Track</i>	3
<i>Satellite Images</i>	3
<i>Bathymetry Plots</i>	3
NBP DATA PRODUCTS.....	3
JGOFS.....	4
MGD77.....	4
SCIENCE OF OPPORTUNITY.....	6
ADCP.....	6
pCO ₂	6
CRUISE SCIENCE.....	6
CTD.....	6
XBT.....	6
RVDAS.....	6
<i>Sensors and Instruments</i>	7
Underway Sensors.....	7
Meteorology and Radiometry.....	7
Geophysics.....	7
Oceanography.....	8
Navigational Instruments.....	8
<i>Raw Data</i>	8
Underway Data.....	9
Sound Velocity Probe (svp1).....	9
Meteorology (met1).....	9
Gravimeter (grv1).....	10
Bathy 2000 (bat1).....	11
Knudsen (knud).....	12
Simrad EM120 (mbdp).....	12
Thermosalinograph (tsg1).....	13
Fluorometer (flr1).....	13
pCO ₂	13
Navigational Data.....	14
Seapath GPS (seap).....	14
Trimble (P-Code) GPS (PCOD).....	17
Gyro Compass (gyr1).....	18
ADCP Course (adcp).....	18
Sound Velocity Probe (svp1).....	18
<i>Processed Data</i>	18
pCO ₂ -merged.....	18
tsgfl.....	19
CALCULATIONS.....	20
TSG.....	20
PAR.....	21
PIR.....	21
PSP.....	21
ACQUISITION PROBLEMS, EVENTS, AND NOTES.....	22
APPENDIX: SENSORS AND CALIBRATIONS.....	23
NBP0506 SENSORS.....	23

<i>Shipboard Sensors</i>	23
<i>NBP0506 CTD Sensors:</i>	24
CALIBRATIONS	24
GRAVITY TIE	25
CTD	26
<i>Pressure Sensor (to Cast 004)</i>	26
<i>Pressure Sensor (Cast 005+)</i>	27
<i>Primary Temperature Sensor</i>	28
<i>Secondary Temperature Sensor</i>	29
<i>Dissolved Oxygen Sensor (1)</i>	30
<i>Dissolved Oxygen Sensor (2)</i>	31
<i>Secondary Conductivity Sensor</i>	35
METEOROLOGY SYSTEM	36
<i>Anemometer (Port, until 8/2/05 - disappeared)</i>	36
<i>Anemometer (Port, installed 8/7/05)</i>	37
<i>Anemometer (Starboard)</i>	38
<i>PIR</i>	39
<i>PSP</i>	40
<i>PAR</i>	41
TSG CALIBRATION FILES	42
<i>Underway Conductivity</i>	42
<i>Underway Temperature Sensor</i>	43
<i>Underway Remote Temperature Sensor</i>	44
<i>Underway Transmissometer</i>	45

Introduction

The NBP data acquisition systems continuously log data from the instruments used during the cruise. This document describes:

- The structure and organization of the data on the distribution media
- The format and contents of the data strings
- Formulas for calculating values
- Information about the specific instruments in use during the cruise
- A log of acquisition problems and events during the cruise that may affect the data
- Scanned calibration sheets for the instruments in use during the cruise.

The data is distributed on a DVD-R written in ISO9660 format. It is readable by virtually every computing platform.

All data has been packaged in Unix tar archive files. Most tar archives have been compressed using gzip to reduce size. Compressed tar files are identified by the extension “tgz”. Tools are available on all platforms for uncompressing and de-archiving these formats:

On Macintosh, use Stuffit Expander with DropStuff.

On Windows, use WinZip or the freeware program 7zip (installer is located in /util/7zip.exe).

tar, gzip, and gunzip are standard tools on all Unix and Unix-like systems.

MultiBeam and BathyW data are distributed separately.

IMPORTANT: Read the last section, “Acquisition Problems and Events,” for important information that may affect the processing of this data.

Archive Commands

All archives were created using the command:

```
tar [z]cvf archive_name files_to_archive
```

With [z] being used to create “.tgz” archives.

To create a list of the files in the archive, use the Unix command:

```
tar [z]tvf archive_name > contents.list
```

where contents.list is the name of the file to create

To extract the files from the archive:

```
tar [z]xvf archive_name file(s)_to_extract
```

Distribution Contents at a Glance

0506data.rtf		process/	0506jgof.tgz
0506data.pdf			0506mgd.tgz
			0506proc.tgz
NBP0506.trk			0506pco2.tgz
NBP0506.mgd			0506qcps.tgz
NBP0506.gmt			
MBplots.tgz			
track.ps		rvdas/nav/	0506adcp.tar
track.jpg			0506gyr.tgz
			0506seap.tgz
			0506sp2a.tgz
			0506PCOD.tgz
adcp/ 0506.tar			
0506a.tar			
		rvdas/uw/	0506eng.tgz
images/ <i>TeraScan satellite</i>			0506flr.tgz
<i>images and Isobar</i>			0506gen5.tgz
<i>plots</i>			0506grv.tgz
			0506knud.tgz
			0506mbdp.tgz
ocean/ 0506ctd.tar			0506met.tgz
0506xbt.tar			0506pco2.tgz
			0506svp.tgz
			0506tsg.tgz
		util/	7zip.exe

Distribution Contents

Cruise Information

Cruise NBP0506, the Maud Rise Non-linear Equation of State Study, departed Punta Arenas, Chile on 21 July 2005. Scientific activities commenced near the Maud Rise, Weddell Sea, Antarctica on 2 August 2005. A CTD survey of the area preceded the establishment of a sea-ice based drift camp. Through-ice science activities included deployment of a “vampire” Vertical Microstructure Profiler, mid- and deep-depth turbulence masts, and a “yoyo” profiling CTD deployed through the NBP moonpool. During the third phase, several mini-draft stations were occupied, with all instruments now operated from the ship.

Cruise Track

The distribution DVD includes a cruise track file (NBP0506.trk). It contains the longitude and latitude at one-minute intervals extracted from the NBP0506.gmt file.

Satellite Images

Satellite images processed during this cruise can be found in the directory /images in three tar files: ice.tar, isobar.tar, and wx.tar (weather). Ice and weather files are named using the convention, IdDDYYA.jpg where:

- Id = image type (ice = ice, wx = weather)
- DDD = year-day
- YY = year
- A = allows for multiple images of one type for one day

Bathymetry Plots

Several Maud Rise bathymetry plots have been placed in /MBplots.tgz. These plots include data collected during the cruise, in some cases superimposed on bathymetry from other sources.

NBP Data Products

Two primary datasets are generated on each cruise: JGOFS and MGD77.

Postscript-format plots of processed data for each day of collection are located in: /process/0506qcps.tgz

The data processing scripts create a number of intermediate files. These files are included on the data distribution media in the file /process/0506proc.tar. They are included to make re-processing easier in the event of an error, but no detail of the formats is included in this document. If you have any questions, please contact Kathleen.Gavahan@usap.gov or itvessel@usap.gov.

JGOFS

The JGOFS data set can be found on the distribution media in the file /process/0506jgof.tgz. The archive contains one file produced for each day named jgDDD.dat, where DDD is the year-day the data was acquired. Each daily file consists of 22 columnar fields in text format as described in the table below. The JGOFS data set is created from calibrated data decimated at one-minute intervals. Several fields are derived measurements from more than a single raw input. For example, Course Made Good (CMG) and Speed Over Ground (SOG) are calculated from gyro and GPS inputs. Daily plots during the cruise are produced from the JGOFS data set. Note: Null, unused, or unknown fields are indicated as "NAN" or 9999 in the JGOFS data.

Field	Data	Units
01	GMT date	dd/mm/yy
02	GMT time	hh:mm:ss
03	NGL latitude (negative is South)	tt.tttt
04	NGL longitude (negative is West)	ggg.gggg
05	Speed over ground	Knots
06	GPS HDOP	-
07	Gyro Heading	Degrees (azimuth)
08	Course made good	Degrees (azimuth)
09	Mast PAR	μ Einsteins/meter ² sec
10	Sea surface temperature	°C
11	Sea surface conductivity	siemens/meter
12	Sea surface salinity	PSU
13	Sea depth (uncorrected, calc. sw sound vel. 1500 m/s)	meters
14	True wind speed (max speed windbird)	meters/sec
15	True wind direction (max speed windbird)	degrees (azimuth)
16	Ambient air temperature	°C
17	Relative humidity	%
18	Barometric pressure	mBars
19	Sea surface fluorometry	volts (0-5 FSO)
20	Not used	-
21	PSP	W/m ²
22	PIR	W/m ²

MGD77

The MGD77 data set is contained in a single file for the entire cruise. It can be found in the top level of the distribution data structure as NBP0506.mgd. The file NBP0506.gmt is created from the MGD77 dataset using the "mgd77togmt" utility. NBP0506.gmt can be used with the GMT plotting package.

The data used to produce the NBP0506.mgd file can be found on the distribution media in the file /process/0506proc.tar. The data files in the archive contain a day's data and follow the naming convention Dddd.fnl.gz, where ddd is the year-day. These files follow a space-delimited columnar format that may be more accessible for some purposes. They contain data at one-second intervals rather than one minute and are individually "gzipped" to save space. Below is a detailed description of the MGD77 data set format. The other files in the archive contain interim processing files and are included to simplify possible reprocessing of the data using the RVDAS NBP processing scripts.

All decimal points are implied. Leading zeros and blanks are equivalent. Unknown or unused fields are filled with 9's. All "corrections", such as time zone, diurnal magnetics, and EOTVOS, are included.

Col	Len	Type	Contents	Description, Possible Values, Notes
1	1	Int	Data record type	Set to "5" for data record
2-9	8	Char	Survey identifier	
10-12	3	int	Time zone correction	Corrects time (in characters 13-27) to GMT when added; 0 = GMT
13-16	4	int	Year	4 digit year
17-18	2	int	Month	2 digit month
19-20	2	int	Day	2 digit day
21-22	2	int	Hour	2 digit hour
23-27	5	real	Minutes x 1000	
28-35	8	real	Latitude x 100000	+ = North - = South. (-9000000 to 9000000)
36-44	9	real	Longitude x 100000	+ = East - = West. (-18000000 to 18000000)
45	1	int	Position type code	1=Observed fix 3=Interpolated 9=Unspecified
46-51	6	real	Bathymetry, 2- way travel time	In 10,000th of seconds. Corrected for transducer depth and other such corrections
52-57	6	real	Bathymetry, corrected depth	In tenths of meters.
58-59	2	int	Bathymetric correction code	This code details the procedure used for determining the sound velocity correction to depth
60	1	int	Bathymetric type code	1 = Observed 3 = Interpolated (Header Seq. 12) 9 = Unspecified
61-66	6	real	Magnetics total field, 1 ST sensor	In tenths of nanoteslas (gammas)
67-72	6	real	Magnetics total field, 2 ND sensor	In tenths of nanoteslas (gammas), for trailing sensor
73-78	6	real	Magnetics residual field	In tenths of nanoteslas (gammas). The reference field used is in Header Seq. 13
79	1	int	Sensor for residual field	1 = 1 st or leading sensor 2 = 2 nd or trailing sensor 9 = Unspecified
80-84	5	real	Magnetics diurnal correction	In tenths of nanoteslas (gammas). (In nanoteslas) if 9-filled (i.e., set to "+9999"), total and residual fields are assumed to be uncorrected; if used, total and residuals are assumed to have been already corrected.
85-90	6	F6.0	Depth or altitude of magnetics sensor	(In meters) + = Below sea level 3 = Above sea level
91-97	7	real	Observed gravity	In 10 th of mgals. Corrected for Eotvos, drift, tares
98-103	6	real	EOTVOS correction	In 10 th of mgals. $E = 7.5 V \cos \phi \sin \alpha + 0.0042 V \cdot V$
104-108	5	real	Free-air anomaly	In 10 th of mgals G = observed G = theoretical
109-113	5	char	Seismic line number	Cross-reference for seismic data
114-119	6	char	Seismic shot number	
120	1	int	Quality code for navigation	5=Suspected, by the originating institution 6=Suspected, by the data center 9=No identifiable problem found

Science of Opportunity

ADCP

The shipboard ADCP system measures currents in a depth range from about 30 to 300 m -- in good weather. In bad weather or in ice, the range is reduced, and sometimes no valid measurements are made. ADCP data collection is the OPP-funded project of Eric Firing (University of Hawaii) and Teri Chereskin (Scripps Institution of Oceanography). Data is collected on both the LMG and the NBP for the benefit of scientists on each cruise, and for the long-term goal of building a profile of current structure in the Southern Ocean.

Matlab “.mat” files containing current contour and vector data have been placed in the files `/adcp/0506.tar` and `/adcp/0506a.tar`. (ADCP data collection was restarted early on in the cruise, and the software identified this restart as “0506a”)

All ADCP data collected during this cruise has been placed on the by-request second volume in the archive `0506adcp.tgz`. This file may be unpackaged using: “tar xvfz 0506adcp.tgz.” For more information on data format, please visit: <http://currents.soest.hawaii.edu>

A data feed is sent from the ADCP system to RVDAS whenever a reference layer is acquired. This feed contains east and north vectors for ship's speed, relative to the reference layer, and ship's heading. Collected files (one per day) are archived in `0506adcp.tar` in the directory `/rvdas/nav`.

pCO₂

The NBP carries a pCO₂ measurement system from Lamont-Doherty Earth Observatory (LDEO). pCO₂ data is recorded by RVDAS and transmitted to LDEO at the end of each cruise. You will find pCO₂ data in a file named `0506pco2.tar` in the `/process` directory, which contains the pCO₂ instrument's data merged with GPS, meteorological and other oceanographic measurements. For more information contact: Colm Sweeney (csweeney@ldeo.columbia.edu).

Cruise Science

CTD

The ctd data have been placed in the tar file `/ocean/0506ctd.tgz`.

XBT

During the cruise, eXpendable BathyThermographs (XBT) were used to obtain water column temperature profiles, providing corrections to the sound velocity profile for the multibeam system. The data files from these launches are included as `0506xbt.tgz` in the `/ocean` directory.

RVDAS

The Research Vessel Data Acquisition System (RVDAS) was developed at Lamont-Doherty Earth Observatory of Columbia University and has been in use on its research ship for many years. It has been extensively adapted for use on the USAP research vessels.

Daily data processing of the RVDAS (Research Vessel Data Acquisition System) data is performed to calibrate and convert values into useable units and as a check of the proper operation of the DAS. Both raw and processed data sets from RVDAS are included in the data distribution. The tables below provide detailed information on the sensors and data. Be sure to read the "Significant Acquisition Events" section for important information about data acquisition during this cruise.

Sensors and Instruments

RVDAS data is divided into two general categories, *underway and navigation*. They can be found on the distribution media as subdirectories under the top level rvdas directory: /rvdas/uw, and /rvdas/nav. Processed oceanographic data is in the top level directory, /process. Each instrument or sensor produces a data file named with its channel ID. Not all data types are collected every day or on every cruise.

The naming convention for data files produced by the sensors and instruments is

NBP[CruiseID][ChannelID].dDDD

Example: NBP0107met1.d317

- The CruiseID is the numeric name of the cruise, in this case, NBP0506.
- The ChannelID is a 4-character code representing the system being logged. An example is "met1," the designation for meteorology.
- DDD is the day of year the data was collected

Underway Sensors

Meteorology and Radiometry

Measurement	Channel ID	Collect. Status	Rate	Instrument
Air Temperature	met1	continuous	1 sec	R. M. Young 41372LC
Relative Humidity	met1	continuous	1 sec	
Wind Speed/Direction	met1	continuous	1 sec	R.M. Young 05106
Barometer	met1	continuous	1 sec	R.M. Young 61201
PIR (LW radiation)	met1	continuous	1 sec	Eppler PIR
PSP (SW radiation)	met1	continuous	1 sec	Eppler PSP
PAR	met1	continuous	1 sec	BSI QSR-240
GUV	guv	not collected	2 sec	BSI GUV-2511
PUV	puv	not collected		BSI PUV-2500

Geophysics

Measurement	Channel ID	Collect. Status	Rate	Instrument
Gravimeter	grv1	continuous	10 sec*	LaCoste & Romberg
Magnetometer	mag1	Not collected	15 sec	EG&G G-866
Bathymetry	bat1	Not collected	Varies	ODEC Bathy 2000
Bathymetry	knu1	Continuous	Varies	Knudsen 320B/R
Bathymetry	sim1	Not collected	Varies	Simrad EK500 Sonar

*Data is output every second but it only changes every 10 seconds.

Oceanography

Measurement	Channel ID	Collect. Status	Rate	Instrument
Conductivity	tsg1	Continuous	6 sec	SeaBird SBE-21
Salinity	tsgfl	Continuous	6 sec	Calc. from pri. temp
Sea Surface Temp	tsg1	Continuous	6 sec	SeaBird 3-01/S
Fluorometry	flr1	Continuous	1 sec	Turner 10-AU-005
Fluorometry	flr1 & tsg1	Continuous	6 sec	
Transmissometry	tsg1	Continuous	6 sec	WET Lab C-Star
pCO ₂	pco2	Continuous	70 sec	(LDEO)
ADCP	adcp	Continuous	varies	RD Instruments

Navigational Instruments

Measurement	Channel ID	Collect. Status	Rate	Instrument
Trimble GPS	PCOD	Continuous	1 sec	Trimble 20636-00SM
Gyro	gyr1	Continuous	0.2 sec	Yokogawa Gyro
SeaPath	seap	Continuous	1 sec	SeaPath 200

Raw Data

Data is received by the RVDAS system via RS-232 serial connections. A time tag is added at the beginning of each line of data in the form,

```
yy+dd:hh:mm:ss.sss [data stream from instrument]
```

where

yy = two-digit year
 ddd = day of year
 hh = 2 digit hour of the day
 mm = 2 digit minute
 ss.sss = seconds

All times are reported in UTC.

The delimiters that separate fields in the raw data files are often spaces and commas but can be other characters such as : = @. Occasionally no delimiter is present. Care should be taken when reprocessing the data that the field's separations are clearly understood.

In the sections below a sample data string is shown, followed by a table that lists the data contained in the string.

Underway Data

Sound Velocity Probe (svp1)

00+348:01:59:52.128 1539.40

Field	Data	Units
1	RVDAS Time tag	
2	Sound velocity in ADCP sonar well	m/s

Meteorology (met1)

01+322:00:03:27.306 04.5 292 010 05.7 294 010 0959.6 000.2 093 -000.1537

0001.0886 0012.8248

Field	Data	Units
1	RVDAS time tag	
2	Port anemometer speed (relative)	m/s
3	Port anemometer direction (relative)	deg
4	Port anemometer standard deviation	deg
5	Starboard anemometer speed (relative)	m/s
6	Starboard anemometer direction (relative)	deg
7	Starboard anemometer standard deviation	deg
8	Barometer	mBar
9	Air temperature	°C
10	Relative humidity	%
11	PSP (short wave radiation)*	mV
12	PIR (long wave radiation)*	mV
13	PAR (photosynthetically available radiation)*	mV

*See page 20 for calculations.

Gravimeter (grv1)

There are now two sets of fields output by the gravity meter. The data record is output once per second, and identified by "\$DAT" in the id field. A summary of sensor environmental data is output every ten seconds, identified by "%ENV" in the id field.

Data record (\$DAT):

05+194:00:00:27.995 \$DAT,2005/ 7/13, 0: 7: 7.36,194, 9050.37, 9050.06, 5410.86, -0.00, -0.01, -0.02, 0.00, 0.00, 0.70, 0.19, -0.12, -0.25, 0.00, -69.45711315, -54.32181487, 0.000, 285.200,

Field	Data	Conversion	Units
1	RVDAS time tag		
2	Text string (id field)	\$DAT for data record	
3	Date	YYYY/MM/DD	
4	Time	HH:MM:SS.SS	
5	Day of Year	DDD	
6	Gravity count	mgal = count x 1.0046 + offset	count
7	Spring Tension		CU
8	Beam Position	Volts x 750,000	
9	VCC		
10	AL		
11	AX		
12	VE		
13	AX2		
14	XACC2		
15	LACC2		
16	CROSS ACCEL		GAL
17	LONG ACCEL		GAL
18	EOTVOS CORR		MGAL
19	LONGITUDE		Degrees
20	LATITUDE		Degrees
21	HEADING		Degrees
22	VELOCITY		Knots

Environmental record (\$ENV)

05+183:19:13:10.945 %ENV,2005/ 7/ 2,19:19:52.16,183,S-036/V1.5, 3.34, 47.19, 20.34,1.111840E-1,-0.57700,-0.10591, 0.40180, 2.55260, 0.43000, 1, 300

Field	Data	Conversion	Units
1	RVDAS time tag		
2	Text string (id field)	\$ENV for environmental record	
3	Date	YYYY/MM/DD	
4	Time	HH:MM:SS.SS	
5	Day of Year	DDD	
6	Meter ID		
7	Meter Pressure		inch-Hg
8	Meter temp		°C
9	Ambient temp		°C
10	K-Factor		
11	VCC Coeff		

Field	Data	Conversion	Units
12	AL Coeff		
13	AX Coeff		
14	VE Coeff		
15	AX2 Coeff		
16	Serial Filter Length		Seconds
17	QC Filter Length		Seconds

Bathy 2000 (bat1)

00+019:23:59:53.901 ;I04485.3ME -23.0, I00000.0,-99.9,0000@01/11/00,
 23:59:52.08 PW2 PF1 SF1 PL3 MO4 SB3 PO0 TX1 TR: GM5 1500 06.7 -72.1

Field	Data	Format / Possible Values	Units
1	RVDAS time tag		
2	Flagged low frequency chn. depth w/ units	;FDDDDD.Dun where F = flag (V for valid, I for invalid), D=depth, un = units	meters
3	Low Frequency echo strength	EEE.EE	dB
4	Flagged high freq. chn. depth	not used	
5	High frequency echo strength	not used	
6	Signed heave data	SHHHH	cm
7	Date	mm/dd/yy	
8	Time	hh:mm:ss	
9	Transmit pulse window type	PW1=Rectangular PW2=Hamming PW3=Cosine PW4=Blackman	
10	Primary transmit frequency	PF1=3.5 kHz PF2=12.0 kHz	kHz
11	Parametric mode secondary frequency	SF1=3.5 kHz SF2=12.0 kHz	kHz
12	Pulse length	PL1=200usec PL2=500usec PL3=1msec PL4=2msec PL5=5msec PL6=10msec PL7=25msec If transmit mode is FM: PL1=25msec PL2=50msec PL3=100msec	
13	Operating mode	MO1=CW parametric MO2=CW MO3=FM parametric MO4=FM	
14	Frequency sweep bandwidth	SB1=1 kHz SB2=2 kHz SB3=5 kHz	kHz
15	Power level	PO1 = 0dB PO2 = -6dB PO3 = -12dB PO4 = -18dB PO5 = -24dB PO6 = -30dB PO6 = -30 dB	

Field	Data	Format / Possible Values	Units
		PO7 = -36dB PO8 = -42dB	
16	Transmit mode	TX1=single ping active TX2=pinger listen TX3=multipinging TR TX4=multipinging TR TX5=multipinging TTRR TX6=multipinging TTTTRRRR TX7=multipinging TTTTTRRRRR	
17	Transmit Rate	TR3 = 4Hz TR4 = 2Hz TR5 = 1Hz TR6 = .5Hz TR7 = .33Hz TR8 = .25Hz TR9 = .20Hz TR: = .10Hz TR; = .05Hz	Hz
18	System gain mode	GM0=hydrographic AGC GM1 to GM9=hydrographic +3db to + 27db manual. GMA to GMD=hydrographic + 30db through + 60db manual GME to GMK=sub-bottom 1 through sub-bottom 7	
19	Speed of sound		m/sec
20	Depth of sonar window below sea-level		meters
21	Background noise level in fixed point reference		dB/V

Knudsen (knud)

99+099:00:18:19.775 HF,305.2,LF,304.3

Field	Data	Units
1	RVDAS time tag	
2	HF = High frequency flag (12 kHz)	
3	High frequency depth	meters
4	LF = Low frequency flag (3.5 kHz)	
5	Low frequency depth	meters

Simrad EM120 (mbdp)

Field	Data	Units
1	LDTDS	
2	\$EMDPT	
3	Depth (corrected)	Meters

Thermosalinograph (tsg1)

00+019:23:59:46.976 15A16CFC163F8C2C100

Field	Data	Units
1	RVDAS time tag	
2	Seabird hex string (see page 20 for conversion to real units)	

Fluorometer (flr1)

00+019:23:59:58.061 0 0818 :: 1/19/00 17:23:17 = 0.983 (RAW) 1.2 (C)

Field	Data	Units
1	RVDAS time tag	
2	Marker 0 to 8	
3	4-digit index	
4	Date	mm/dd/yy
5	Time	hh:mm:ss
6	Signal	
7	signal units of measurement	
8	cell temperature	
9	Temperature units	

pCO₂00+021:23:59:43.190 2000021.9992 2382.4 984.2 30.73 50.8 345.9 334.1 -1.70
-68.046 -144.446 Equil

Field	Data	Units
1	RVDAS time tag	
2	pCO ₂ time tag (decimal is fractional time of day)	yyyyddd.ttt
3	Raw voltage	mV
4	Barometer	mBar
5	Cell temperature	°C
6	Flow rate	ml/min
7	Concentration	ppm
8	pCO ₂ pressure	microAtm
9	Equilibrated temperature	°C
10	Latitude (not collected)	
11	Longitude (not collected)	
12	Flow source (Equil = pCO ₂ measurement)	

Navigational Data

Seapath GPS (seap)

The Seapath GPS outputs six data strings, four in NMEA format and two in proprietary PSXN format:

- GPZDA
- GPGGA
- GPVTG
- GPHDT
- PSXN, 22
- PSXN, 23

GPZDA

02+253:00:00:00.772 \$GPZDA,235947.70,09,09,2002,,*7F

Field	Data	Units
1	RVDAS time tag	
2	\$GPZDA	
3	time	hhmmss.ss
4	Day	dd
5	Month	mm
6	Year	yyyy
7	(empty field)	
8	Checksum	

GPGGA

02+253:00:00:00.938

GPGGA,235947.70,6629.239059,S,06827.668899,W,1,07,1.0,11.81,M,,M,,*6F

Field	Data	Units
1	RVDAS time tag	
2	\$GPGGA	
3	time	hhmmss.ss
4	Latitude	ddmm.mmmmmm
5	N or S for north or south latitude	
6	Longitude	ddmm.mmmmmm
7	E or W for east or west longitude	
8	GPS quality indicator, 0=invalid, 1=GPS SPS, 2=DGPS, 3=PPS, 4=RTK, 5=float RTK, 6=dead reckoning	
9	number of satellites in use (00-99)	
10	HDOP	x.x
9	height above ellipsoid in meters	m.mm
11	M	
12	(empty field)	
13	M	
14	age of DGPS corrections in seconds	s.s
15	DGPS reference station ID (0000-1023)	
16	Checksum	

GPVTG

02+253:00:00:00.940 \$INVTG,19.96,T,,M,4.9,N,,K,A*39

Field	Data	Units
1	RVDAS time tag	
2	\$GPVTG	
3	course over ground, degrees true	d.dd
4	T	
5	,	
6	M	
7	speed over ground in knots	k.k
8	N	
9	,	
10	K	
11	Mode	
12	Checksum	

GPHDT

02+253:00:00:00.941 \$GPHDT,20.62,T*23

Field	Data	Units
1	RVDAS time tag	
2	\$GPHDT	
3	Heading, degrees true	d.dd
4	T	
5	Checksum	

PSXN,22

02+253:00:00:00.942 \$PSXN,22,0.43,0.43*39

Field	Data	Units
1	RVDAS time tag	
2	\$PSXN	
3	22	
4	gyro calibration value since system start-up in degrees	d.dd
5	short term gyro offset in degrees	d.dd
6	Checksum	

PSXN,23

02+253:00:00:02.933 \$PSXN,23,0.47,0.57,20.62,0.03*0C

Field	Data	Units
1	RVDAS time tag	
2	\$PSXN	
3	23	
4	roll in degrees, positive with port side up	d.dd
5	pitch in degrees, positive with bow up	d.dd
6	Heading, degrees true	d.dd
7	heave in meters, positive down	m.mm
8	Checksum	

Measurement data (PBN)

01+324:00:00:00.064 \$PASHR,PBN,172812.00,2129908.6,-1869076.7,-5694992.4,
-063:41.9477,-041:16.0918,00066.2,000.16,002.85,-000.90,08,????,02,01,01,
01*3A

Field	Data	Units
1	RVDAS time tag	
2	\$PASHR	
3	PBN	
4	GPS Time sec. of the week	seconds
5	Station Position: ECEF X	meters
6	Station Position: ECEF Y	meters
7	Station Position: ECEF Z	meters
8	Latitude (- = South)	deg:min
9	Longitude (- = West)	deg:min
10	Altitude	meters
11	Velocity in ECEF X	m/sec
12	Velocity in ECEF Y	m/sec
13	Velocity in ECEF Z	m/sec
14	Number of satellites used	
15	Site name	
16	PDOP	
17	HDOP	
18	VDOP	
19	TDOP	

GPS Position Fix – Geoid/Ellipsoid (GGA)

01+324:00:00:00.323 \$GPGGA,235959.00,6341.9477,S,04116.0918,W,1,08,00.9,
+00066,M,,M,,*77

Field	Data	Units
1	RVDAS time tag	
2	\$GPGGA	
3	UTC time at position	hhmmss.ss
4	Latitude	ddmm.mmm
5	North (N) or South (S)	
6	Longitude	ddmm.mmm
7	East (E) or West (W)	
8	GPS quality: (1 = GPS, 2 = DGPS)	
9	Number of GPS satellites used	
10	HDOP	
11	Antenna height	meters
12	M for Meters	
13	Geoidal height (no data in the sample string)	meters
14	M for meters	
15	Age of diff. GPS data (no data in the sample string)	
16	Differential reference station ID (no data in the sample string)	
17	Checksum (no delimiter before this field)	

Trimble (P-Code) GPS (PCOD)

The Trimble GPS, which formerly output Precise Position (*P-Code*) strings, but now only outputs Standard Position (*Civilian*) strings, outputs three NMEA standard data strings:

- Position fix (GGA)
- Latitude / longitude (GLL),
- Track and ground speed (VTG)

GGA: GPS Position Fix – Geoid/Ellipsoid

```
01+319:00:04:11.193 $GPGGA,000410.312,6227.8068,S,06043.6738,W,1,06,1.0,
031.9,M,-017.4,M,,*49
```

Field	Data	Units
1	RVDAS Time tag	
2	\$GPGGA	
3	UTC time at position	hhmmss.sss
4	Latitude	ddmm.mmm
5	North (N) or South (S)	
6	Longitude	ddmm.mmm
7	East (E) or West (W)	
8	GPS quality: 0 = Fix not available or invalid 1 = GPS, SPS mode, fix valid 2 = DGPS (differential GPS), SPS mode, fix valid 3 = P-CODE PPS mode, fix valid	
9	Number of GPS satellites used	
10	HDOP (horizontal dilution of precision)	
11	Antenna height	meters
12	M for meters	
13	Geoidal height	meters
14	M for meters	
15	Age of differential GPS data (no data in the sample string)	
16	Differential reference station ID (no data in the sample string)	
17	Checksum (no delimiter before this field)	

GLL: GPS Latitude/Longitude

```
01+319:00:04:11.272 $GPGLL,6227.8068,S,06043.6738,W,000410.312,A*32
```

Field	Data	Units
1	RVDAS Time tag	
2	\$GPGLL	
3	Latitude	degrees
4	North or South	
5	Longitude	degrees
6	East or West	
7	UTC of position	hhmmss.sss
8	Status of data (A = valid)	
9	Checksum	

VTG: GPS Track and Ground Speed

```
01+319:00:04:11.273 $GPVTG,138.8,T,126.0,M,000.0,N,000.0,K*49
```

Field	Data	Units
1	RVDAS time tag	

Field	Data	Units
2	\$GPVTG	
3	Heading	degrees
4	Degrees true (T)	
5	Heading	degrees
6	Degrees magnetic (M)	
7	Ship speed	knots
8	N = knots	
9	Speed	km/hr
10	K = km per hour	
11	Checksum	

Gyro Compass (gyr1)

00+019:23:59:59.952 \$HEHRC 25034,-020 *73

Field	Data	Units
1	RVDAS time tag	
2	\$HEHRC	
3	Heading XXXXX = ddd.dd	degrees
4	Rate of change SYYY S = +/-, YYY = r.rr	
5	Checksum	

ADCP Course (adcp)

05+209:15:04:14.575 \$PUHAW,UVH,9.95,-0.98,99.7

Field	Data	Units
1	RVDAS time tag	
2	\$PUHAW	
3	UVH (E-W, N-S, Heading)	
4	Ship Speed relative to reference layer, east vector	knots
5	Ship Speed relative to reference layer, north vector	knots
6	Ship heading	degrees

Sound Velocity Probe (svp1)

00+348:01:59:52.128 1539.40

Field	Data	Units
1	RVDAS Time tag	
2	Sound velocity in ADCP sonar well	m/s

Processed Data

pCO2-merged

00+346:23:58:20.672 2000346.9991 2398.4 1008.4 0.01 45.4 350.3 342.6
 15.77 Equil -43.6826 173.1997 15.51 33.90 0.33 5.28 9.05 1007.57 40.0
 14.87 182.44

Field	Data	Units
1	RVDAS time tag	

Field	Data	Units
2	PCO ₂ time tag (decimal is time of day)	yyydd.ttt
3	Raw voltage	mV
4	Barometer	mB
5	Cell temperature	°C
6	Flow rate	cm ³ /min
7	Concentration	ppm
8	PCO ₂ pressure	microAtm
9	Equilibrated temperature	°C
10	Flow Source (Equil = pCO ₂ measurement)	
11	RVDAS latitude	degrees
12	RVDAS longitude	degrees
13	TSG external temperature	°C
14	TSG salinity	PSU
15	TSG fluorometry	V
16	RVDAS true wind speed	m/s
17	RVDAS true wind direction	degrees
18	Barometric Pressure	mBars
19	Uncontaminated seawater pump flow rate	l/min
20	Speed over ground	knots
21	Course made good	degrees

tsgfl

00+075:00:00:04.467 -01.488 -01.720 02.6783 33.63748 1.002442 0.002442

Field	Data	Units
1	RVDAS time tag	
2	Internal water temperature	°C
3	Sea Surface Temperature	°C
4	Conductivity	μSiemens
5	Salinity	PSU
6	Fluorometry	V
7	Transmissivity	V

Calculations

The file `instcoef.txt` located in the / directory contains the calibration factors for shipboard instruments. This was the file used by the RVDAS processing software.

TSG

Raw TSG data is stored as a 20 byte (character) long hex string

Bytes	Data
1-4	Sensor Temperature
5-8	Conductivity
9-14	Remote Temperature
15-17	Fluorometer voltage
18-20	Transmissometer voltage

The coefficients for temperature and conductivity sensors can be found the `rvdascal.txt` file and on the calibrations sheets in the appendix.

Calculating Temperature – ITS-90

```
T = decimal equivalent of bytes 1-4
Temperature Frequency:  f = T/19 + 2100
Temperature = 1/{g + h[ln(f0/f)] + i[ln2(f0/f)] + j[ln3(f0/f)]} -
273.15 (°C)
```

Calculating Conductivity – ITS-90

```
C = decimal equivalent of bytes 5-8
Conductivity Frequency f = sqrt(C*2100+6250000)
Conductivity = (g + hf2 + if3 + jf4)/[10(1 + δt + εp)]
(siemens/meter)
t = temperature (°C); p = pressure (decibars); δ = Ctcor; ε =
CPcor
```

Calculating Fluorometry Voltage

```
f = decimal equivalent of bytes 15-17
Fluorometry Voltage = f/819
```

Calculating Transmittance

```
Vdark = 0.058 V
Vref = 4.765 V
t = decimal equivalent of bytes 18 - 20
Transmissometer Voltage (Vsignal) = t/819
% Transmittance = (Vsignal - Vdark) / (Vref - Vdark)
```

PAR

raw data = mV
 calibration scale = $6.27 \text{ V}/(\mu\text{Einstiens}/\text{cm}^2\text{sec})$
 offset (V_{dark}) = 0.3 mV
 $(\text{raw mV} - V_{\text{dark}})/\text{scale} \times 10^4 \text{ cm}^2/\text{m}^2 \times 10^{-3} \text{ V/mV} = \mu\text{Einstiens}/\text{m}^2\text{sec}$
 or
 $(\text{data mV} - 0.3 \text{ mV}) \times 1.65 (\mu\text{Einstiens}/\text{m}^2\text{sec})/\text{mV} = \mu\text{Einstiens}/\text{m}^2\text{sec}$

PIR

raw data = mV
 calibration scale = $3.86 \times 10^{-6} \text{ V}/(\text{W}/\text{m}^2)$
 $\text{data mV} / (\text{scale} \times 10^3 \text{ mV/V}) = \text{W}/\text{m}^2$
 or
 $\text{data mV} \times 242.1 (\text{W}/\text{m}^2)/\text{mV} = \text{W}/\text{m}^2$

PSP

raw data = mV
 calibration scale = $8.19 \times 10^{-6} \text{ V}/(\text{W}/\text{m}^2)$
 $\text{data mV} / (\text{scale} \times 10^3 \text{ mV/V}) = \text{W}/\text{m}^2$
 or
 $\text{data mV} \times 120.7 (\text{W}/\text{m}^2)/\text{V} = \text{W}/\text{m}^2$

Acquisition Problems, Events, and Notes

This section lists problems with acquisition noted during this cruise including instrument failures, data acquisition system failures and any other factor affecting this data set. The format is ddd:hh:mm (ddd is year-day, hh is hour, and mm is minute). Times are reported in GMT.

Start	End	Description
205:02:11		Started logging, entering international waters
	206:01:56	Stopped logging, entering S. Georgia I. EEZ
209:15:04		Started logging, entering international waters
	254:01:31	Stopped logging, entering S. Sandwich I. EEZ
258:00:50		Started logging, entering international waters
	258:23:35	Stopped logging, entering Falkland I. EEZ

A serial feed from the acoustic tracker for the University of Washington floats was connected to RVDAS for a portion of the cruise. This data is found in `/rvdas/uw/0506gen5.tgz`

Appendix: Sensors and Calibrations

NBP0506 Sensors

Shipboard Sensors

Sensor	Description	Serial #	Last Calibration Date	Status
Meteorology & Radiometers				
Port Anemometer	RM Young 5106	WM51144	03/25/05	Gone 8/2/05
Port Anemometer	RM Young 5105	WM46262	08/07/05	Installed 08/07/05
Stbd Anemometer	RM Young 5106	WM46263	03/25/05	Collect
Barometer	RM Young 61201	61201	2003	Collect
Air Temp/Rel. Hum.	RM Young 41372LC	06135	04/23/05	Collect
Mast PRR	BSI PRR-610			Not used
UW PRR	BSI PRR-600			Not used
PIR (Pyrgeometer)	Eppley PIR	33023F3	01/20/05	Collect
PSP (Pyranometer)	Eppley PSP	33090F3	11/08/04	Collect
Mast PAR	BSI QSR-240	6356	6/24/03	Collect
GUV				Not used
PUV				Not used
Underway				
TSG	SeaBird SBE-21	3198	02/01/05	Collect
TSG Remote Temp	SeaBird 3-01/S	1267	01/27/05	Collect
Fluorometer	Turner 10-AU-005	5333-FRXX		Collect
Transmissometer	WET Labs C-Star	CST-439DR	09/27/04	Collect
Magnetometer	EG&G G-866			Not used
Gravimeter	LaCoste & Romberg Gravity Meter			Collect
Bathymetry	Simrad EK500	3001	11/1/95	Collect
Bathymetry	Knudsen 320B/R			Collect
Bathymetry	Bathy 2000			Collect

NBP0506 CTD Sensors:

Sensor	Serial #	Last Calibration Date	Status	Comments
CTD Fish	094857-0232	09/29/2003	<i>Collect</i>	Replaced after cast 004
CTD Fish Pressure	43528	09/29/2003	<i>Collect</i>	Failed, Cast 004
CTD Fish	09P7536-0328	4/18/2005	Cast 005+	
CTD Fish Pressure	53980	4/18/2005	Cast 005+	
CTD Deck Unit	11P19858-0490	N/A	Collect	SBE 11-Plus
Temperature (Primary)	03P2308	3/15/2005	Primary	
Temperature (Secondary)	03P2438	1/20/2005	Secondary	
Conductivity (Primary)	042067	8/19/2004	Primary	
Conductivity (Secondary)	041798	8/19/2004	Secondary	
Dissolved Oxygen	430139	2/5/2005	Primary	
Dissolved Oxygen	430155	8/17/2004	Secondary	
Transmissometer	CST-831DR	12/3/2004	<i>Collect</i>	Failed, Cast 005
Transmissometer	CST-533DR	4/5/2005	Cast 007+	Installed 8/03/05 after Cast 006

Calibrations

The following pages are replicas of calibration sheets for the sensors used during this cruise.

Gravity Tie

Gravity Tie Spreadsheet

The fields outlined in BOLD MUST BE FILLED IN for this spreadsheet to operate properly.
The automatically calculated values show up in the shaded fields.

Date: **15-07-05**
 Location: **Punta Arenas, Chile**
 Station: Harbour Admin. Bldg.
 Latitude: 53 09 S
 Longitude: 070 55 W
 Elevation:
 Gravity: 981320.82

Reference Code Numbers:
 Station no. 9337-50
 ISGN no. 51230N

	Value	Time (GMT)
Ship's meter before gravity tie (Digital Gravity)	8970.7	12:50
Ship's meter after gravity tie (Digital Gravity)	8970.7	13:23
Average	8970.7	
Ship Gravimeter's Calibration Constant	1.0046	
Corrected ship's meter (Digital Gravity)	9012.0	

	Value	Time (GMT)
Ship's meter before gravity tie (serial, RVDAS)	8970.7	12:50
Ship's meter after gravity tie (serial, RVDAS)	8970.8	13:23
Average (for comparison check only)	8970.8	

Portable Gravimeter Correction Divisor 1.007937

Station	Value	Time (GMT)	Temp	Date	
Pier measurement 1	4907.26	12:59	53.5	July 15, 2005	OBS mgal, averaged
Pier measurement 2	4907.38	12:59	53.5	July 15, 2005	4868.68
Pier measurement 3	4907.34	12:59	53.5	July 15, 2005	
Average	4907.33				
Station measurement 1	4907.97	13:09	53.5	July 15, 2005	OBS mgal, averaged
Station measurement 2	4907.99	13:09	53.5	July 15, 2005	4869.33
Station measurement 3	4907.97	13:09	53.5	July 15, 2005	
Average	4907.98				
Pier measurement 4	4907.36	13:18	53.5	July 15, 2005	OBS mgal, averaged
Pier measurement 5	4907.33	13:18	53.5	July 15, 2005	4868.70
Pier measurement 6	4907.33	13:18	53.5	July 15, 2005	
Average	4907.34				

Gravity offset from last tie 972307.86
 Drift since last tie 0.51

OBS Differences
 Station to Pier (1, 2, & 3 averaged) -0.64
 Station to Pier (4, 5, & 6 averaged) -0.63
 Averaged Differences -0.64
 Gravity at pier 981320.18
 Elevation of pier above gravimeter, meters 0.5
 Earth differential gravity, mgal/meter 0.3
 Gravity at ship's gravimeter 981320.33
 Gravity Offset 972308.37

Comments
Tie performed by Brent Evers at pier in Punta Arenas. Lots of dock work nearby (cranes, trucks, etc.), lots of wind, only moderately consistent values.

CTD**Pressure Sensor (to Cast 004)****SEA-BIRD ELECTRONICS, INC.**

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

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

SENSOR SERIAL NUMBER: 0232
CALIBRATION DATE: 29-Sep-03SBE9plus PRESSURE CALIBRATION DATA
10000 psia S/N 43528

DIGIQUARTZ COEFFICIENTS:

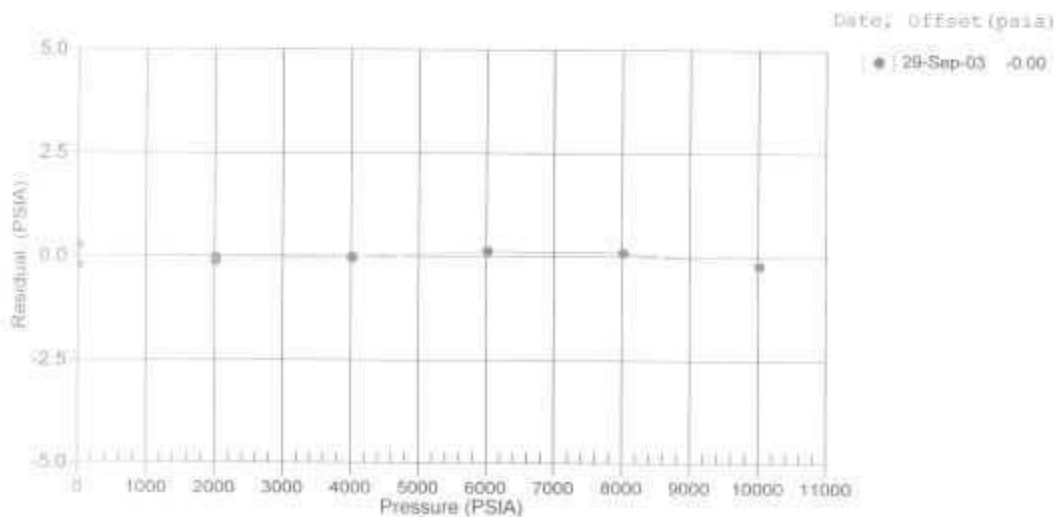
$C1 = -5.102314e+004$
 $C2 = 1.049610e-001$
 $C3 = 1.481220e-002$
 $C4 = 3.642300e-002$
 $C5 = 0.000000e+000$
 $C6 = 3.004970e+001$
 $C7 = -3.354770e-004$
 $C8 = 4.125600e-006$
 $C9 = 1.011600e-009$
 $C10 = 0.000000e+000$

AD590M, AD590B, SLOPE AND OFFSET:

$AD590M = 1.14800e-002$
 $AD590B = 8.78548e+000$
 $Slope = 0.99991$
 $Offset = -0.3993 \text{ (dBar)}$

PRESSURE (PSIA)	INST OUTPUT(Hz)	INST TEMP(C)	INST OUTPUT (PSIA)	CORRECTED INST OUTPUT (PSIA)	RESIDUAL (PSIA)
14.622	33289.33	22.9	15.474	14.895	0.273
2014.892	33934.49	22.9	2015.619	2014.865	-0.027
4015.012	34565.87	23.0	4015.882	4014.952	-0.106
6015.188	35184.26	23.0	6016.407	6015.301	-0.113
8015.405	35790.23	23.1	8016.772	8015.491	0.086
10016.143	36384.54	23.1	10017.369	10015.913	-0.230
8015.392	35790.24	23.1	8016.771	8015.490	0.097
6015.107	35184.26	23.1	6016.337	6015.231	0.124
4014.431	34565.89	23.2	4015.853	4014.923	-0.008
2014.748	33934.45	23.2	2016.371	2014.616	-0.132
14.846	33289.16	23.2	14.789	14.210	-0.236

residual = corrected instrument pressure - reference pressure



Pressure Sensor (Cast 005+)**SEA-BIRD ELECTRONICS, INC.**

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

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

SENSOR SERIAL NUMBER: 0328
CALIBRATION DATE: 18-Apr-05SBE9plus PRESSURE CALIBRATION DATA
10000 psia S/N 53980

DIGIQUARTZ COEFFICIENTS:

C1 = -5.847002e+004
 C2 = 6.910390e-001
 C3 = 1.753360e-002
 D1 = 4.241600e-002
 D2 = 0.000000e+000
 T1 = 3.026040e+001
 T2 = -1.938830e-004
 T3 = 4.330190e-006
 T4 = 2.020250e-009
 T5 = 0.000000e+000

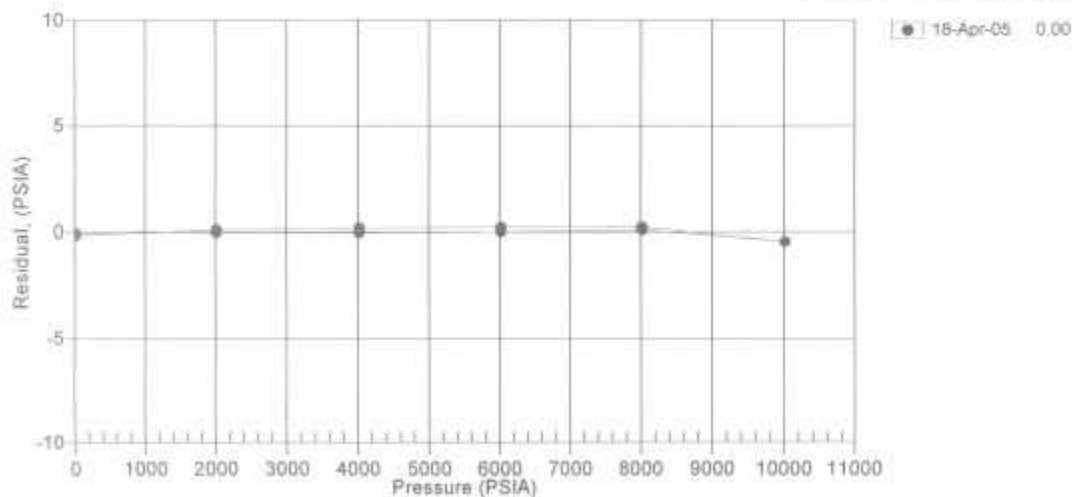
AD590M, AD590B, SLOPE AND OFFSET:

AD590M = 1.13300e-002
 AD590B = -8.47592e+000
 Slope = 1.00004
 Offset = -0.7426 (dbars)

PRESSURE (PSIA)	INST OUTPUT(Hz)	INST TEMP(C)	INST OUTPUT (PSIA)	CORRECTED INST OUTPUT (PSIA)	RESIDUAL (PSIA)
14.762	33053.29	22.0	15.752	14.675	-0.087
2014.939	33613.14	23.1	2015.888	2014.886	-0.053
4014.919	34162.20	23.1	4015.804	4014.878	-0.041
6014.986	34701.06	23.2	6015.837	6014.986	-0.000
8014.992	35230.18	23.2	8015.861	8015.085	0.093
10015.554	35749.99	23.2	10015.800	10015.099	-0.455
8014.880	35230.20	23.3	8015.894	8015.117	0.237
6014.818	34701.08	23.3	6015.881	6015.030	0.212
4014.816	34162.23	23.3	4015.923	4014.996	0.180
2014.828	33613.16	23.3	2015.925	2014.923	0.095
14.761	33053.25	23.4	15.657	14.580	-0.181

Residual = corrected instrument pressure - reference pressure

Date, Avg Offset (psia)



Primary Temperature Sensor**SEA-BIRD ELECTRONICS, INC.**

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

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

SENSOR SERIAL NUMBER: 2308
CALIBRATION DATE: 15-Mar-05SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

$$g = 4.34522770e-003$$

$$h = 6.44581914e-004$$

$$i = 2.34473043e-005$$

$$j = 2.21961589e-006$$

$$f_0 = 1000.0$$

ITS-68 COEFFICIENTS

$$a = 3.68121002e-003$$

$$b = 6.02572778e-004$$

$$c = 1.63739067e-005$$

$$d = 2.22018523e-006$$

$$f_0 = 2906.323$$

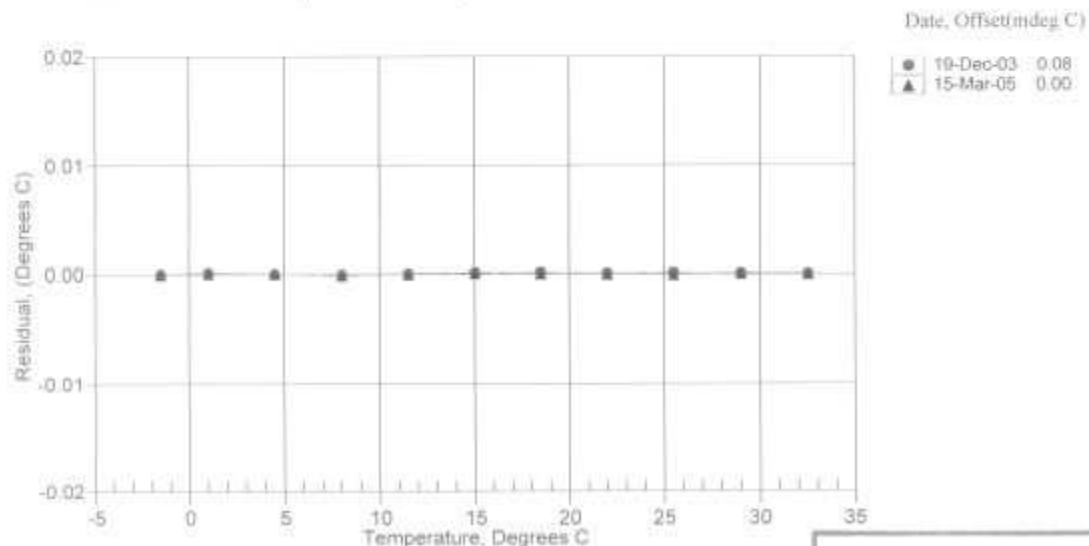
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.4998	2906.323	-1.4998	-0.00003
1.0002	3073.134	1.0003	0.00006
4.5002	3318.152	4.5002	0.00002
8.0002	3576.915	8.0001	-0.00009
11.5002	3849.814	11.5002	-0.00001
15.0002	4137.194	15.0003	0.00007
18.5002	4439.393	18.5002	0.00003
22.0002	4756.757	22.0002	-0.00001
25.5003	5089.619	25.5002	-0.00007
29.0002	5438.281	29.0002	0.00004
32.5003	5803.050	32.5003	-0.00000

$$\text{Temperature ITS-90} = 1 / \{ g + h [\ln(f_0/T)] + i [\ln^2(f_0/T)] + j [\ln^3(f_0/T)] \} - 273.15 \text{ (}^\circ\text{C)}$$

$$\text{Temperature ITS-68} = 1 / \{ a + b [\ln(f_0/T)] + c [\ln^2(f_0/T)] + d [\ln^3(f_0/T)] \} - 273.15 \text{ (}^\circ\text{C)}$$

Following the recommendation of JPOTS: T_{ref} is assumed to be $1.00024 * T_{\text{sp}}$ (-2 to 35 $^\circ\text{C}$).

Residual = instrument temperature - bath temperature

**POST CRUISE
CALIBRATION**

Secondary Temperature Sensor

SEA-BIRD ELECTRONICS, INC.

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

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

SENSOR SERIAL NUMBER: 2438
CALIBRATION DATE: 20-Jan-05

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

$a = 4.31133242e-003$
 $b = 6.41955390e-004$
 $c = 2.30415821e-005$
 $d = 7.18997721e-006$
 $f0 = 1000.0$

ITS-68 COEFFICIENTS

$a = 3.68121048e-003$
 $b = 6.02096073e-004$
 $c = 1.64008298e-005$
 $d = 2.19154271e-006$
 $f0 = 2759.318$

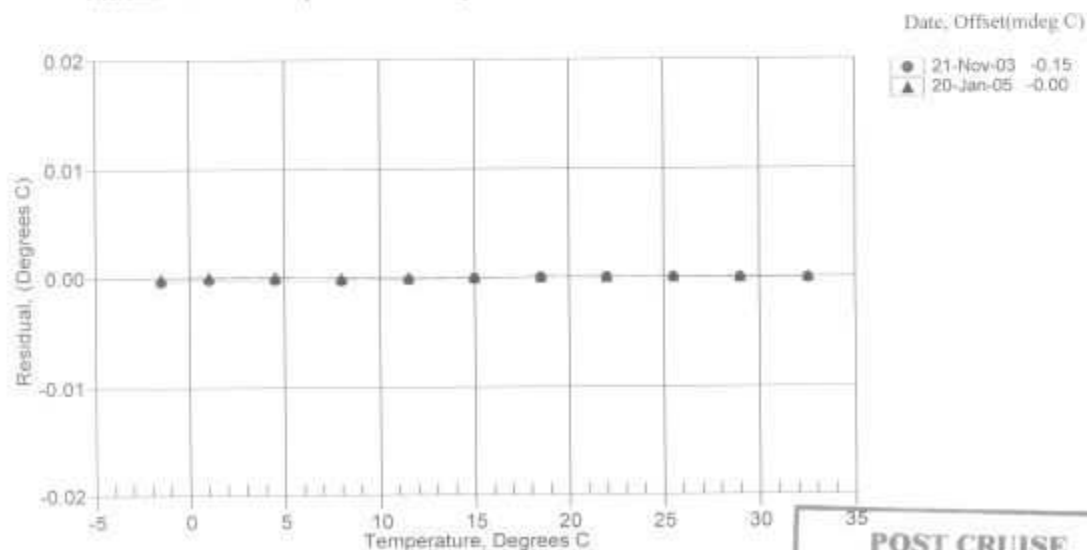
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.4998	2759.318	-1.4999	-0.00006
1.0002	2917.825	1.0003	0.00008
4.5002	3150.658	4.5003	0.00007
8.0002	3396.566	8.0001	-0.00009
11.5001	3655.923	11.5001	-0.00003
15.0002	3929.075	15.0002	-0.00002
18.5002	4216.342	18.5002	0.00004
22.0002	4518.043	22.0002	0.00001
25.5002	4834.499	25.5002	0.00002
29.0002	5166.002	29.0002	-0.00002
32.5002	5512.649	32.5002	-0.00001

Temperature ITS-90 = $1/[g + b[\ln(f_0/T)] + c[\ln^2(f_0/T)] + d[\ln^3(f_0/T)]] - 273.15$ (°C)

Temperature ITS-68 = $1/[a + b[\ln(f_0/T)] + c[\ln^2(f_0/T)] + d[\ln^3(f_0/T)]] - 273.15$ (°C)

Following the recommendation of JPOTS: T_{08} is assumed to be $1.00024 * T_{90}$ (-2 to 35 °C)

Residual = instrument temperature - bath temperature



**POST CRUISE
CALIBRATION**

Dissolved Oxygen Sensor (1)**SEA-BIRD ELECTRONICS, INC.**

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

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

SENSOR SERIAL NUMBER: 0139
CALIBRATION DATE: 16-Aug-04p

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS

Soc = 0.3989

Boc = 0.0000

Voffset = -0.6142

TCor = 0.0019

PCor = 1.350e-04

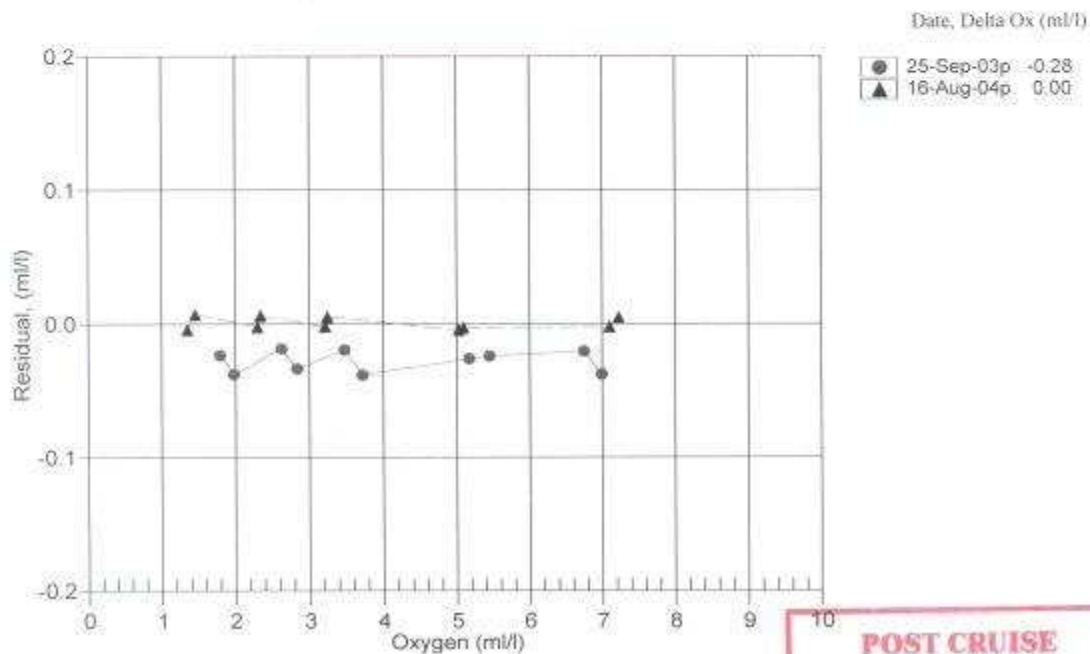
BATH OX (ml/l)	BATH TEMP ITS-90	BATH SAL PSU	INSTRUMENT OUTPUT(VOLTS)	INSTRUMENT OXYGEN(ml/l)	RESIDUAL (ml/l)
1.35	5.00	0.00	0.988	1.34	-0.00
1.46	25.00	0.01	1.220	1.46	0.01
2.30	5.00	0.00	1.253	2.30	-0.00
2.34	25.00	0.01	1.587	2.35	0.01
3.21	5.00	0.00	1.506	3.20	-0.00
3.24	25.00	0.01	1.960	3.25	0.01
5.03	25.00	0.01	2.696	5.02	-0.00
5.09	5.00	0.00	2.030	5.09	-0.00
7.10	25.00	0.01	3.554	7.10	-0.00
7.23	5.00	0.00	2.626	7.23	0.00

oxygen (ml/l) = (Soc * (V + Voffset)) * exp(Tcor * T) * Oxsat(T,S) * exp(PCor * P)

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

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

Residual = instrument oxygen - bath oxygen



Dissolved Oxygen Sensor (2)

SEA-BIRD ELECTRONICS, INC.
 1808 136th Place N.E., Bellevue, Washington, 98005 USA
 Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0155
 CALIBRATION DATE: 17-Aug-04p

SBE 43 OXYGEN CALIBRATION DATA**COEFFICIENTS**

Soc = 0.4809

Pcor = 0.0000

Voffset = -0.4862

TCor = 0.0016

PCor = 1.350e-04

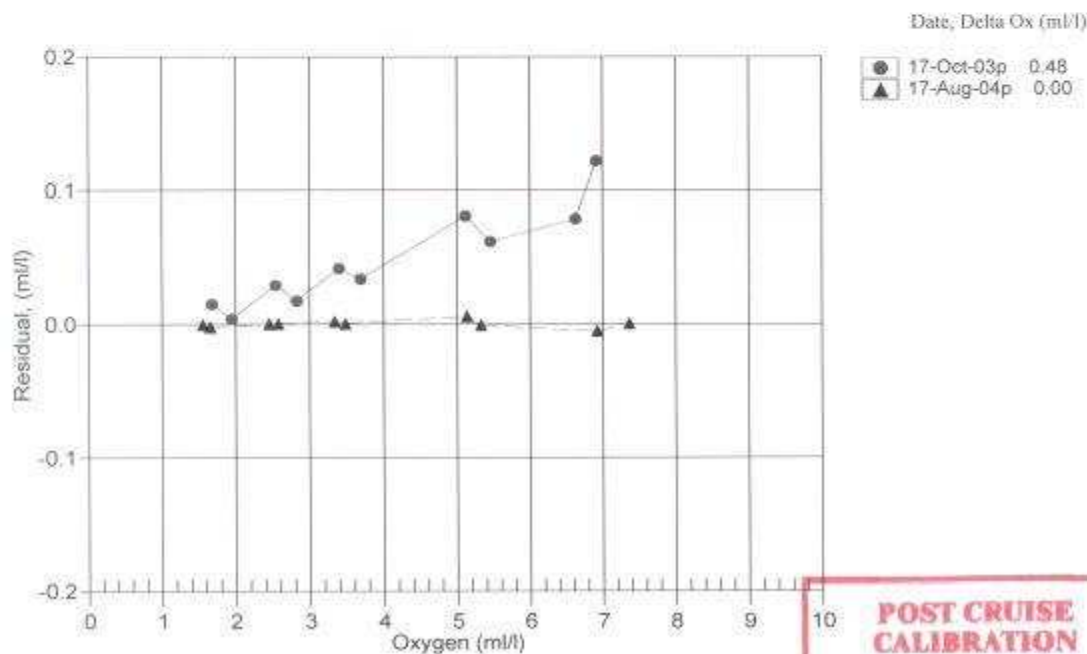
BATH OX (ml/l)	BATH TEMP ITS-90	BATH SAL PSU	INSTRUMENT OUTPUT(VOLTS)	INSTRUMENT OXYGEN(ml/l)	RESIDUAL (ml/l)
1.55	25.00	0.01	1.023	1.55	-0.00
1.66	5.00	0.00	0.868	1.65	-0.00
2.45	25.00	0.01	1.332	2.45	0.00
2.57	5.00	0.00	1.081	2.58	0.00
3.34	25.00	0.01	1.641	3.34	0.00
3.48	5.00	0.00	1.291	3.48	0.00
5.13	25.00	0.01	2.262	5.13	0.01
5.32	5.00	0.00	1.715	5.32	-0.00
6.93	25.00	0.01	2.881	6.92	-0.01
7.37	5.00	0.00	2.188	7.37	0.00

$$\text{oxygen (ml/l)} = (\text{Soc} * (\text{V} + \text{Voffset})) * \exp(\text{TCor} * \text{T}) * \text{Oxsat}(\text{T}, \text{S}) * \exp(\text{Pcor} * \text{P})$$

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

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

Residual = instrument oxygen - bath oxygen



Transmissometer

PO Box 518
620 Applegate St.
Philomath, OR 97370



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

C-Star Calibration

Date	December 24, 2004	Customer	National Science Foundation	Work order	001
Job #	0412005	S/N#	CST-831DR	Pathlength	25 cm

	Analog meter
V_d	0.063 V
V_{air}	4.779 V
V_{ref}	4.665 V

Temperature of calibration water	19.0 °C
Ambient temperature during calibration	23.6 °C

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

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

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

V_d Meter output with the beam blocked. This is the offset.

V_{air} Meter output in air with a clear beam path.

V_{ref} Meter output with clean water in the path.

Temperature of calibration water; temperature of clean water used to obtain V_{ref} .

Ambient temperature; meter temperature in air during the calibration.

V_{sig} Measured signal output of meter.

cstarcalsheet

Revision A

6/23/03

Transmissometer, Chelsea/Seatech/Wetlab	
Serial Number	CST-831DR
Calibration Date	25-07-05
M	21.787
B	-1.242
Path length [m]	0.250
<input type="button" value="OK"/> <input type="button" value="Cancel"/>	

**Instructions: Fill out the Blue parts, print it out.
Fill out the SeaSave form so it looks like this.**

From Calibration Sheet

Serial Number	CST-831DR
Cal Date:	25-07-05
Vd	0.063
Vair	4.779
Vref	4.665
Pathlength (cm)	25

From On-CTD Pre-Cruise Measurements

Voltage in Air	4.697
Voltage Dark	0.057

Primary Conductivity Sensor**SEA-BIRD ELECTRONICS, INC.**

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

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

SENSOR SERIAL NUMBER: 2067
CALIBRATION DATE: 27-Aug-04SBE4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15.0) = 4.2914 Siemens/meter

GHJ COEFFICIENTS

$g = -1.04146860e+001$
 $h = 1.46764981e+000$
 $i = -4.45150339e-003$
 $j = 4.04577174e-004$
 $CPcor = -9.5700e-008$ (nominal)
 $CTcor = 3.2500e-006$ (nominal)

ABCDM COEFFICIENTS

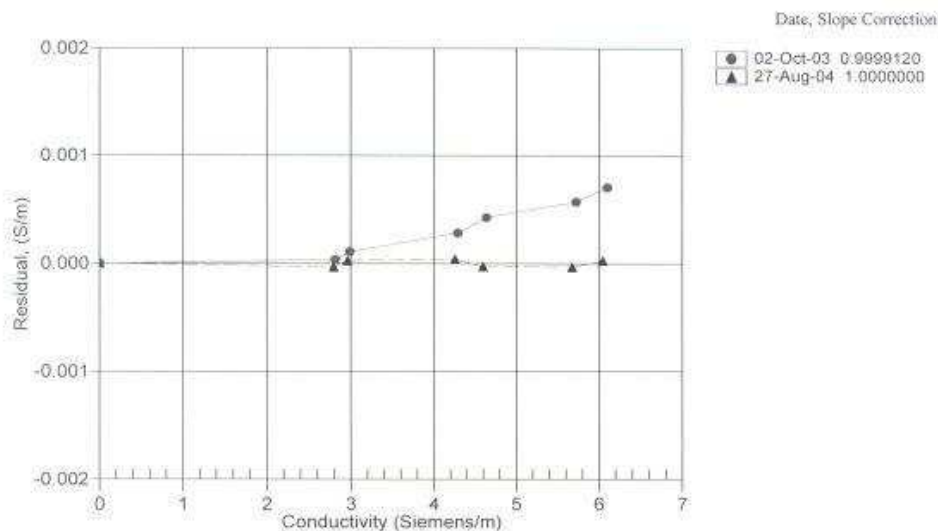
$a = 7.53681811e-009$
 $b = 1.45390546e+000$
 $c = -1.03792989e+001$
 $d = -5.28016520e-005$
 $m = 8.3$
 $CPcor = -9.5700e-008$ (nominal)

BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
8.0000	0.0000	0.00000	2.67208	0.00000	0.00000
-1.0004	34.6379	2.79151	5.13175	2.79147	-0.00003
0.9996	34.6380	2.96214	5.24493	2.96216	0.00003
14.9996	34.6387	4.25209	6.03080	4.25213	0.00004
18.4996	34.6389	4.59733	6.22414	4.59730	-0.00003
28.9997	34.6368	5.67619	6.79255	5.67615	-0.00003
32.4996	34.6279	6.04680	6.97697	6.04683	0.00003

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

$$\text{Conductivity} = (af^m + bf^2 + c + dt) / [10(1 + \epsilon p)] \text{ Siemens/meter}$$
 $t = \text{temperature}[^{\circ}\text{C}]; p = \text{pressure}[\text{decibars}]; \delta = CTcor; \epsilon = CPcor$

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



Secondary Conductivity Sensor

SEA-BIRD ELECTRONICS, INC.

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

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

SENSOR SERIAL NUMBER: 1798
CALIBRATION DATE: 19-Aug-04

SBE4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15.0) = 4.2914 Siemens/meter

GHIJ COEFFICIENTS

g = -4.11976232e+000
h = 4.81248719e-001
i = -4.90610661e-004
j = 4.87383944e-005
CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

ABCDM COEFFICIENTS

a = 9.65331739e-007
b = 4.79625332e-001
c = -4.11487740e+000
d = -1.01696527e-004
m = 5.2
CPcor = -9.5700e-008 (nominal)

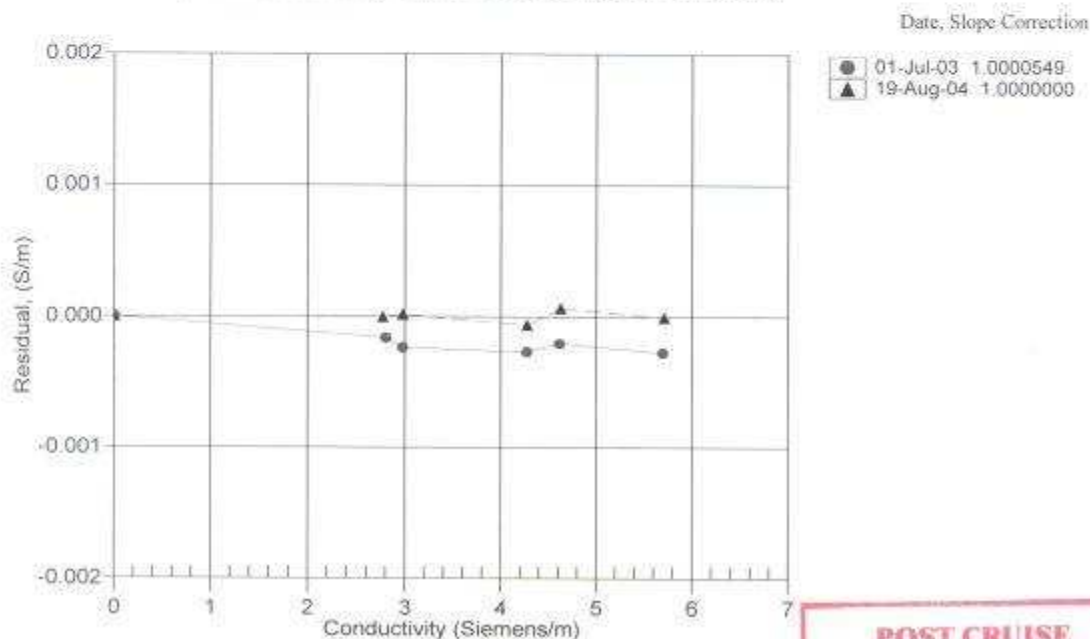
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.92895	0.00000	0.00000
-1.3997	34.8371	2.77228	8.14073	2.77228	-0.00000
1.0002	34.8352	2.97744	8.39823	2.97746	0.00001
15.0003	34.8362	4.27383	9.86863	4.27376	-0.00006
18.5003	34.8361	4.62074	10.22575	4.62080	0.00006
29.0003	34.8357	5.70517	11.26707	5.70516	-0.00001

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

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

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

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



**POST CRUISE
CALIBRATION**

Meteorology System

Anemometer (Port, until 8/2/05 - disappeared)

RM Young Anemometer Calibration, Model 05106

S/N: 51144

Date: 20-Sep-04

Cal'd By: W. Gallagher

Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s	Knots
0	0.00	0.0	0.0	0.0
200	0.98	1.0	0.0	1.9
500	2.45	2.3	0.2	4.8
1000	4.90	4.8	0.1	9.5
1500	7.35	7.3	0.0	14.3
2000	9.80	9.8	0.0	19.0
3000	14.70	14.7	0.0	28.6
4000	19.60	19.6	0.0	38.1
5000	24.50	24.6	-0.1	47.6
6000	29.40	29.4	0.0	57.1
7000	34.30	34.3	0.0	66.6
8000	39.20	39.2	0.0	76.2
9000	44.10	43.9	0.2	85.7
10000	49.00	48.7	0.3	95.2
12000	58.80	58.1	0.7	114.2

Direction	Measured Direction	Delta Direction
0	0	0
30	30	0
60	60	0
90	90	0
120	120	0
150	151	-1
180	182	-2
210	212	-2
240	242	-2
270	272	-2
300	302	-2
330	332	-2
0	0	0

Note: Delta direction should not exceed + or - 3 degrees.

Counter Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s
0	0.00	0.0	0.0
200	0.98	0.9	0.1
500	2.45	2.3	0.2
1000	4.90	4.8	0.1
1500	7.35	7.3	0.0
2000	9.80	9.8	0.0
3000	14.70	14.6	0.1
4000	19.60	19.6	0.0
5000	24.50	24.5	0.0
6000	29.40	29.4	0.0
7000	34.30	34.3	0.0
8000	39.20	39.1	0.1
9000	44.10	43.8	0.3
10000	49.00	48.2	0.8
12000	58.80	57.7	1.1

Caution: Do Not exceed 12000 rpm during Wind Speed test.

Wind Speed Threshold < 2.9 gm?	yes
Wind Direction Threshold < 30 gm?	yes

Additional Comments

Installed new housing assy. and wind direction coupling. Adjusted horizontal nose cone shaft. Good calibration.

Note: Delta Windspeed should not exceed + or - 0.3 m/s for 0 - 5000 rpm

Anemometer (Port, installed 8/7/05)**RM Young Anemometer Calibration, Model 05106**

S/N: 46262

Date: 20-Sep-04

Cal'd By: W. Gallagher

Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s	Knots
0	0.00	0.0	0.0	0.0
200	0.98	0.9	0.1	1.9
500	2.45	2.4	0.0	4.8
1000	4.90	4.9	0.0	9.5
1500	7.35	7.4	-0.1	14.3
2000	9.80	9.8	0.0	19.0
3000	14.70	14.8	-0.1	28.6
4000	19.60	19.8	-0.2	38.1
5000	24.50	24.8	-0.3	47.6
6000	29.40	29.8	-0.4	57.1
7000	34.30	34.8	-0.5	66.6
8000	39.20	39.8	-0.6	76.2
9000	44.10	44.7	-0.6	85.7
10000	49.00	49.7	-0.7	95.2
12000	58.80	59.6	-0.8	114.2

Direction	Measured Direction	Delta Direction
0	0	0
30	30	0
60	58	2
90	89	1
120	119	1
150	149	1
180	179	1
210	208	2
240	238	2
270	269	1
300	299	1
330	330	0
0	0	0

Note: Delta direction should not exceed + or - 3 degrees.

Counter Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s
0	0.00	0.0	0.0
200	0.98	0.9	0.1
500	2.45	2.4	0.0
1000	4.90	4.9	0.0
1500	7.35	7.4	-0.1
2000	9.80	9.8	0.0
3000	14.70	14.8	-0.1
4000	19.60	19.8	-0.2
5000	24.50	24.8	-0.3
6000	29.40	29.8	-0.4
7000	34.30	34.8	-0.5
8000	39.20	39.8	-0.6
9000	44.10	44.8	-0.7
10000	49.00	49.7	-0.7
12000	58.80	59.7	-0.9

Caution: Do Not exceed 12000 rpm during Wind Speed test.

Wind Speed Threshold < 2.9 gm?
 Wind Direction Threshold < 30 gm?

Additional Comments

Installed new housing assy and wind direction coupling. Worn horizontal nose cone shaft. Replaced entire nose cone assembly. Good calibration.

Note: Delta Windspeed should not exceed + or - 0.3 m/s for 0 - 5000 rpm

Anemometer (Starboard)**RM Young Anemometer Calibration, Model 05106**

S/N: 46263

Date: 27-Sep-04

Cal'd By: W. Gallagher

Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s	Knots
0	0.00	0.0	0.0	0.0
200	0.98	0.9	0.1	1.9
500	2.45	2.3	0.2	4.8
1000	4.90	4.8	0.1	9.5
1500	7.35	7.2	0.1	14.3
2000	9.80	9.6	0.2	19.0
3000	14.70	14.4	0.3	28.6
4000	19.60	19.4	0.2	38.1
5000	24.50	24.2	0.3	47.6
6000	29.40	29.0	0.4	57.1
7000	34.30	33.9	0.4	66.6
8000	39.20	38.8	0.4	76.2
9000	44.10	43.6	0.5	85.7
10000	49.00	48.3	0.7	95.2
12000	58.80	56.4	2.4	114.2

Direction	Measured Direction	Delta Direction
0	0	0
30	30	0
60	60	0
90	90	0
120	119	1
150	150	0
180	180	0
210	210	0
240	240	0
270	270	0
300	300	0
330	331	-1
0	0	0

Note: Delta direction should not exceed + or - 3 degrees.

Counter Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s
0	0.00	0.0	0.0
200	0.98	0.9	0.1
500	2.45	2.3	0.2
1000	4.90	4.7	0.2
1500	7.35	7.2	0.1
2000	9.80	9.7	0.1
3000	14.70	14.5	0.2
4000	19.60	19.5	0.1
5000	24.50	24.4	0.1
6000	29.40	29.2	0.2
7000	34.30	33.9	0.4
8000	39.20	38.6	0.6
9000	44.10	43.3	0.8
10000	49.00	48.0	1.0
12000	58.80	57.1	1.7

Caution: Do Not exceed 12000 rpm during Wind Speed test.

Wind Speed Threshold < 2.9 gm?

Wind Direction Threshold < 30 gm?

Additional Comments

Installed new housing assy and wind direction coupling. Good calibration.

Note: Delta Windspeed should not exceed + or - 0.3 m/s for 0 - 5000 rpm

PIR**THE EPPLEY LABORATORY, INC.**

12 Sheffield Ave., P.O. Box 419, Newport, RI 02840 USA

Telephone: 401-847-1020

Fax: 401-847-1031

Email: eplab@mail.bbanet.com

Internet: www.eppleylab.com

Scientific Instruments
for Precision Measurements
Since 1917**STANDARDIZATION OF
EPPLEY PRECISION INFRARED RADIOMETER
Model PIR**

Serial Number: 33023F3

Resistance: 764 Ω at 23 °C

Temperature Compensation Range: -20 to 40 °C

This pyradiometer has been compared with Precision Infrared Radiometer, Serial Number 29326F3 in Eppley's Blackbody Calibration System under radiation intensities of approximately 200 watts meter⁻² and an average ambient temperature of 25 °C.

As a result of a series of comparisons, it has been found to have a sensitivity of:

$$3.86 \times 10^{-6} \text{ volts/watts meter}^{-2}$$

The calculation of this constant is based on the fact that the relationship between radiation intensity and emf is rectilinear to intensities of 700 watts meter⁻². This radiometer is linear to within $\pm 1.0\%$ up to this intensity.

The calibration of this instrument is traceable to the International Practical Temperature Scale (IPTS) through a precision low-temperature blackbody.

Shipped to:
National Science Foundation
Port Hueneme, CA

Date of Test: January 20, 2005

In Charge of Test: *R. G. G. G.*

S.O. Number: 60151
Date: January 24, 2005

Reviewed by: *Thomas J. Hak*

Remarks:

PSP**THE EPPLEY LABORATORY, INC.**

12 Sheffield Ave., P.O. Box 419, Newport, RI 02840 USA

Telephone: 401-847-1020

Fax: 401-847-1031

Email: eplab@mail.bbsnet.com

Internet: www.eppleylab.com

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**STANDARDIZATION
OF
EPPLEY PRECISION SPECTRAL PYRANOMETER
Model PSP**

Serial Number: 33090F3

Resistance: 699 Ω at 23 $^{\circ}\text{C}$ Temperature Compensation Range: -20 to 40 $^{\circ}\text{C}$

This radiometer has been compared with Standard Precision Spectral Pyranometer, Serial Number 21231F3 in Eppley's Integrating Hemisphere under radiation intensities of approximately 700 watts meter⁻² (roughly one-half a solar constant). The adopted calibration temperature is 25 $^{\circ}\text{C}$.

As a result of a series of comparisons, it has been found to have a sensitivity of:

$$8.19 \times 10^{-6} \text{ volts/watts meter}^{-2}$$

The calculation of this constant is based on the fact that the relationship between radiation intensity and emf is rectilinear to intensities of 1400 watts meter⁻². This radiometer is linear to within $\pm 0.5\%$ up to this intensity.

The calibration of this instrument is traceable to standard self-calibrating cavity pyrheliometers in terms of the Systems Internationale des Unites (SI units), which participated in the Ninth International Pyrheliometric Comparisons (IPC IX) at Davos, Switzerland in September-October 2000.

Useful conversion facts: 1 cal cm⁻² min⁻¹ = 697.3 watts meter⁻²
1 BTU/ft²-hr⁻¹ = 3.153 watts meter⁻²

Shipped to:
National Science Foundation
Port Hueneme, CA

Date of Test: November 8, 2004

In Charge of Test: *R.T. Eppley*

S.O. Number: 60076
Date: November 11, 2004

Reviewed by: *Thomas D. Kirk*

Remarks:

PAR**Biospherical Instruments Inc.**

CALIBRATION CERTIFICATE

Calibration Date 5/16/2005
 Model Number QSR-240
 Serial Number 6356
 Operator TPC
 Standard Lamp 99189(4/12/05)
 Probe Excitation Voltage Range: 6 to 18 VDC(+)

Output Polarity: POSITIVE

Probe Conditions at Calibration(in air):

Calibration Voltage: 6 VDC(+)

Probe Current: 1.2 mA

Probe Output Voltage:

Probe Illuminated 86.9 mV

Probe Dark 0.1 mV

Probe Net Response 86.8 mV

Corrected Lamp Output:

Output In Air (same condition as calibration):

8.34E+15 quanta/cm²sec

0.01384 uE/cm²sec

Calibration Factor:

(To calculate irradiance, divide the net voltage reading in Volts by this value.)

Dry: 1.04E-17 V/(quanta/cm²sec)

6.27E+00 V/(uE/cm²sec)

Notes:

1. Annual calibration is recommended.
2. Calibration is performed using a Standard of Spectral Irradiance traceable to the National Institute of Standards and Technology (NIST).
3. The collector should be cleaned frequently with alcohol.
4. Calibration was performed with customer cable, when available.

QSR240R 05/24/95

TSG Calibration Files

*Underway Conductivity***SEA-BIRD ELECTRONICS, INC.**

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

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

SENSOR SERIAL NUMBER: 3198
CALIBRATION DATE: 01-Feb-05SBE21 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15.0) = 4.2914 Siemens/meter

GHJ COEFFICIENTS

$g = -4.26982501e+000$
 $h = 5.04451229e-001$
 $i = -5.14140226e-004$
 $j = 5.01516148e-005$
 $CPcor = -9.5700e-008$ (nominal)
 $CTcor = 3.2500e-006$ (nominal)

ABCDM COEFFICIENTS

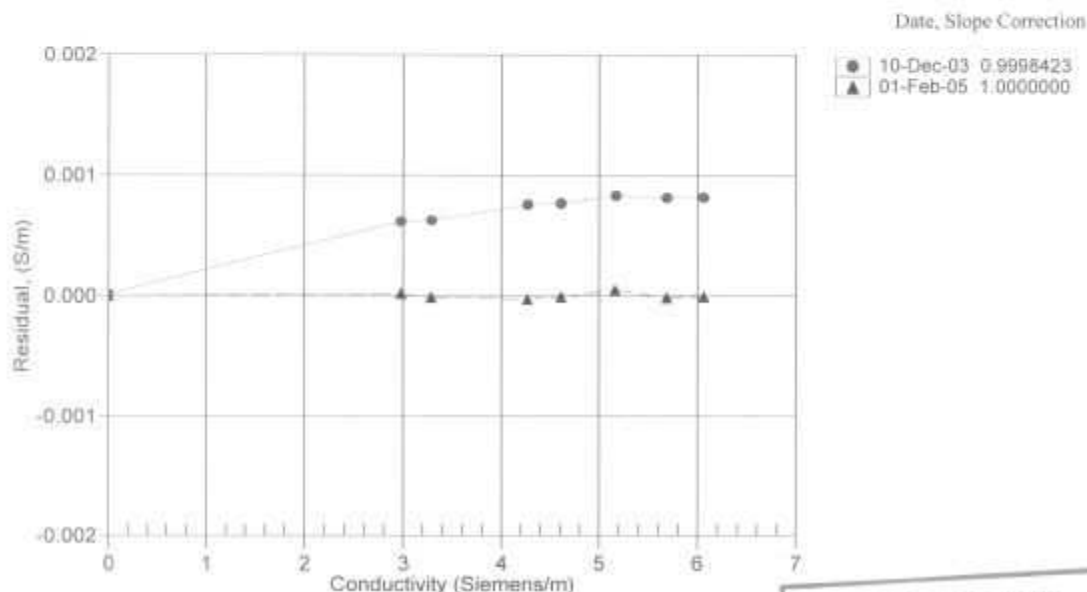
$a = 1.64605226e-006$
 $b = 5.02580692e-001$
 $c = -4.26144824e+000$
 $d = -8.9538292e-005$
 $m = 5.0$
 $CPcor = -9.5700e-008$ (nominal)

BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2.91244	0.00000	0.00000
0.9999	34.7963	2.97441	8.21830	2.97443	0.00002
4.4999	34.7760	3.28129	8.58001	3.28127	-0.00001
15.0000	34.7322	4.26239	9.64456	4.26236	-0.00003
18.5000	34.7227	4.60729	9.99140	4.60728	-0.00001
24.0000	34.7124	5.16487	10.52745	5.16492	0.00005
29.0000	34.7074	5.68649	11.00459	5.68647	-0.00001
32.5001	34.7057	6.05889	11.33265	6.05888	-0.00001

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

$$\text{Conductivity} = (af^m + bf^2 + c + dt) / [10(1 + \epsilon p)] \text{ Siemens/meter}$$
 $t = \text{temperature}[^{\circ}\text{C}]; p = \text{pressure}[\text{decibars}]; \delta = CTcor; \epsilon = CPcor;$

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


**POST CRUISE
CALIBRATION**

Underway Temperature Sensor**SEA-BIRD ELECTRONICS, INC.**

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

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

SENSOR SERIAL NUMBER: 3198
CALIBRATION DATE: 01-Feb-05SBE21 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

 $g = 4.22378538e-003$
 $h = 6.27547484e-004$
 $i = 1.87696196e-005$
 $j = 1.08059211e-006$
 $f0 = 1000.0$

ITS-68 COEFFICIENTS

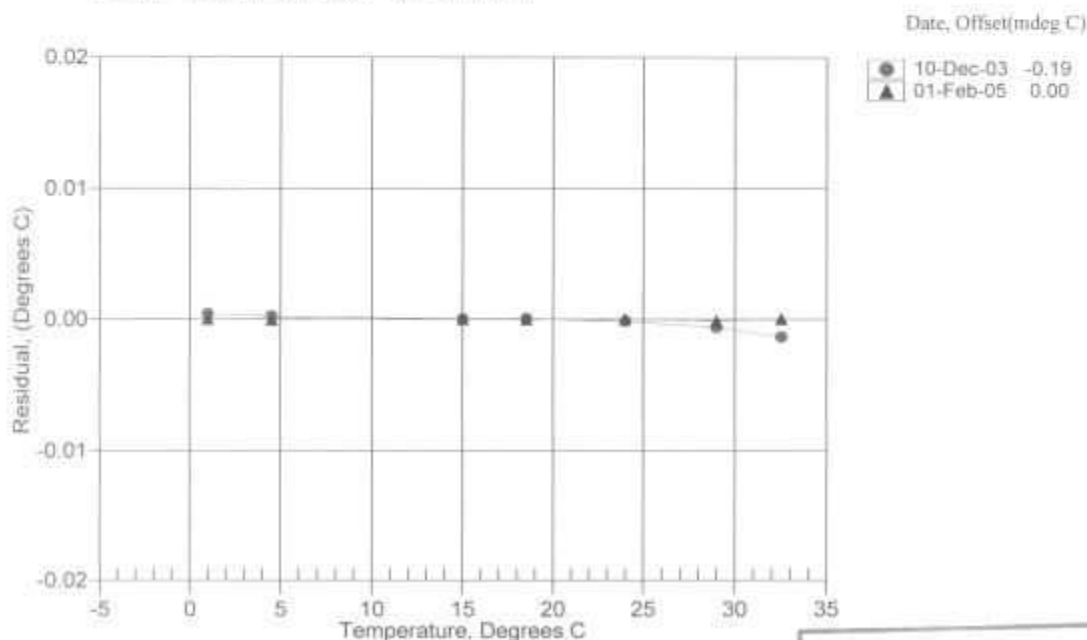
 $a = 3.64763575e-003$
 $b = 5.95164358e-004$
 $c = 1.57386940e-005$
 $d = 1.08194901e-006$
 $f0 = 2568.337$

BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	2568.337	0.9999	0.00002
4.4999	2775.111	4.4998	-0.00004
15.0000	3467.500	15.0000	0.00002
18.5000	3723.427	18.5000	0.00000
24.0000	4152.232	24.0000	0.00004
29.0000	4571.184	29.9999	-0.00009
32.5001	4881.480	32.5001	0.00005

$$\text{Temperature ITS-90} = 1 / \{ g + h[\ln(f_0/T)] + i[\ln^2(f_0/T)] + j[\ln^3(f_0/T)] \} - 273.15 \text{ (}^\circ\text{C)}$$

$$\text{Temperature ITS-68} = 1 / \{ a + b[\ln(f_0/T)] + c[\ln^2(f_0/T)] + d[\ln^3(f_0/T)] \} - 273.15 \text{ (}^\circ\text{C)}$$
Following the recommendation of JPOTS: T_{90} is assumed to be $1.00024 * T_{90}$ (-2 to 35 $^\circ\text{C}$)

Residual = instrument temperature - bath temperature

**POST CRUISE
CALIBRATION**

Underway Remote Temperature Sensor**SEA-BIRD ELECTRONICS, INC.**

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

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

SENSOR SERIAL NUMBER: 1267
CALIBRATION DATE: 27-Jan-05SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

$g = 4.76634262e-003$
 $b = 6.64670506e-004$
 $i = 2.85058534e-005$
 $j = 2.64012684e-006$
 $f0 = 1000.0$

ITS-68 COEFFICIENTS

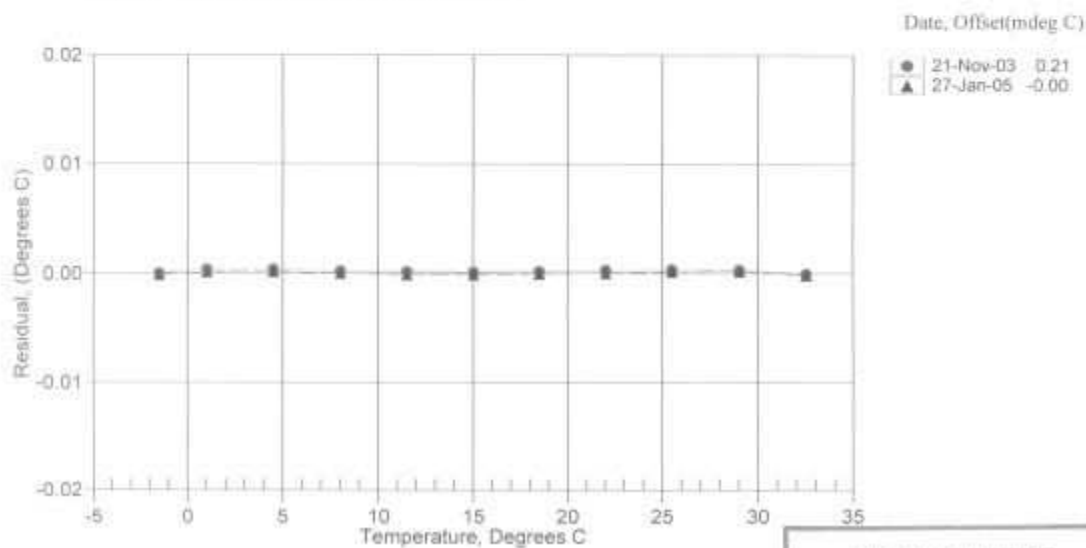
$a = 3.68121281e-003$
 $b = 5.89542737e-004$
 $c = 1.47371122e-005$
 $d = 2.64160048e-006$
 $f0 = 5707.057$

BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.4999	5707.057	-1.5000	-0.00014
1.0002	6042.071	1.0003	0.00011
4.5002	6534.710	4.5004	0.00017
8.0002	7055.658	8.0002	0.00002
11.5002	7605.713	11.5001	-0.00013
15.0002	8185.648	15.0001	-0.00012
18.5002	8796.166	18.5001	-0.00006
22.0002	9437.953	22.0002	0.00001
25.5002	10111.682	25.5003	0.00014
29.0002	10817.954	29.0004	0.00017
32.5002	11557.311	32.5000	-0.00017

$$\text{Temperature ITS-90} = 1/[g + b[\ln(f_0/f)] + i[\ln^2(f_0/f)] + j[\ln^3(f_0/f)]] - 273.15 (^{\circ}\text{C})$$

$$\text{Temperature ITS-68} = 1/[a + b[\ln(f_0/f)] + c[\ln^2(f_0/f)] + d[\ln^3(f_0/f)]] - 273.15 (^{\circ}\text{C})$$
Following the recommendation of JPOTS, T_{68} is assumed to be $1.00024 * T_{90}$ (-2 to 35 $^{\circ}\text{C}$)

Residual = instrument temperature - bath temperature

**POST CRUISE
CALIBRATION**

Underway Transmissometer

P.O. Box 518
620 Applegate St.
Philomath, OR 97370



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

C-Star Calibration

Date	September 27, 2004	Customer	National Science Foundation	Work order	005
Job #	0102007	S/N#	CST-439DR	Pathlength	25 cm

	Analog meter
V_d	0.060 V
V_{air}	4.803 V
V_{ref}	4.694 V

Temperature of calibration water	22.3 °C
Ambient temperature during calibration	22.8 °C

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

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

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

V_d Meter output with the beam blocked. This is the offset.

V_{air} Meter output in air with a clear beam path.

V_{ref} Meter output with clean water in the path.

Temperature of calibration water: temperature of clean water used to obtain V_{ref} .

Ambient temperature: meter temperature in air during the calibration.

V_{sig} Measured signal output of meter.