Data Report NBP0805

Drake Passage

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Dr. Laura Robinson

April 19 – May 25 2008

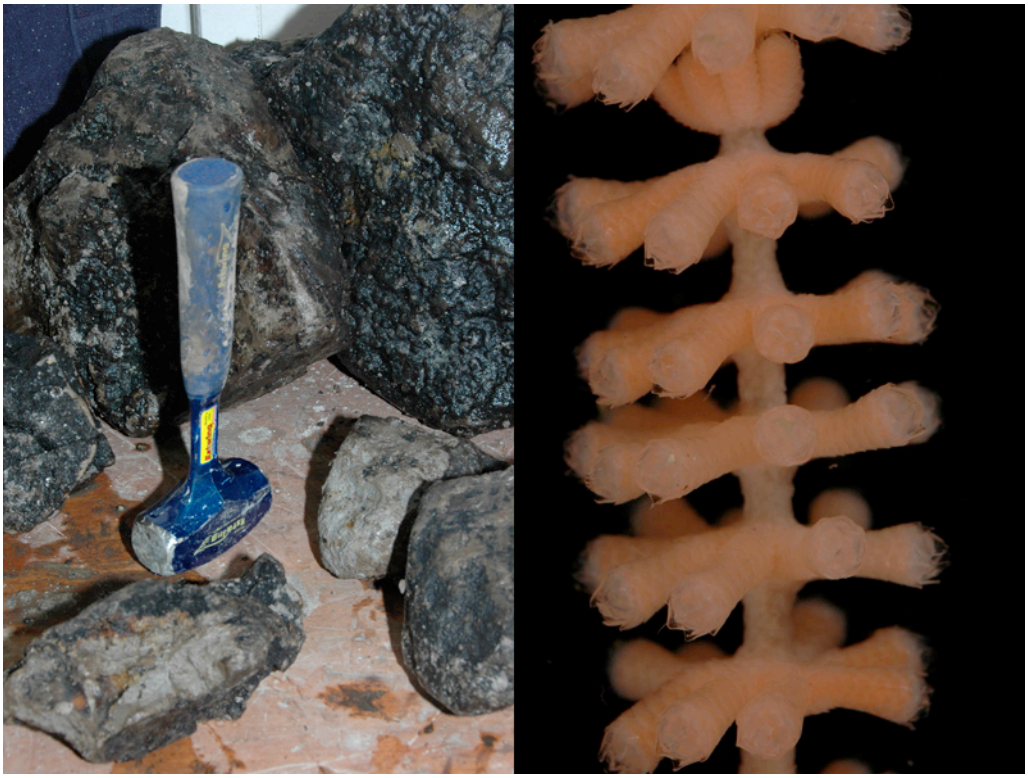

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Table of Contents

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 or CD-ROM written in ISO9660 level-1 format. It is readable by virtually every computing platform.

All the data has been compressed using Unix "gzip," identified by the ".gz" extension. It has been copied to the distribution media in the Unix tar archive format, ".tar" extension. Tools are available on all platforms for uncompressing and de-archiving these formats: On Macintosh, use Stuffit Expander with DropStuff. On Windows operating systems use WinZip.

MultiBeam and BathyW data, if collected, are distributed separately.

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

Distribution Contents at a Glance

Volume 1 of 1: NBP0805

File	Description
/	Root level directory
NBP0805.trk	Text file of cruise track (lat,lon)
NBP0805.mgd	Full Cruise MGD77 data file
NBP0805.gmt	GMT binary file of MGD77 data
INSTCOEF.TXT	Instrument Coefficient File
/process	Geop data
0805jgof.tar	JGOFS fo0rmat data files
0805qc.tar	Daily RVDAS QC postcript plots
0805pco2.tar	Merged pCO2 data files
0805mgd.tar	MGD Data
0805proc.tar	Other processed data
/rvdas/nav	Navigation data
0805gyr1.tar	Gyro raw data
0805PCOD.tar	Trimble P-code raw data
0805seap.tar	Seapath data
0805adcp.tar	ADCP Data Sets
0805gp02	Gp02 Data
/rvdas/uw	Underway data
0805bwnc.tar	Baltic Winch raw data
0805swnc.tar	Starboard Winch raw data
0805uwnc.tar	Upper Waterfall Winch raw data
0805flr1.tar	Fluorometer raw data
0805grv1.tar	Gravimeter raw data
0805met1.tar	Meteorology raw data
0805oyo1.tar	Seismic acquisition data
0805pco2.tar	pCO2 raw data
0805wind.tar	Ultrasonic anemometer raw data
0805tsg1.tar	TSG raw data
0805svp1.tar	Sound velocity probe (in ADCP well)
0805syn1.tar	Syntron data
0805mtsg.tar	Micro TSG data
0805eng1.tar	Engineering Data and PIR
0805hdas.tar	HydroDAS raw data
0805pguv.tar	GUV raw data
0805rtmp.tar	Remote temperature data
0805mbdp.tar	SIMRAD multibeam sonar data
0805knud.tar	Knudsen raw data
0805mag1.tar	Magnetometer raw data
/Imagery	Other Data, Files and Pictures
0805Imag.tar	Satellite imagery
/ocean	
0805ctd.tar	Ctd data
0805xbt.tar	Xbt data

/MultiBeam	
MBmaps.tar	Multi-beam Maps

Extracting Data

The Unix tar command has many options. It is often useful to know exactly how an archive was produced when expanding its contents. All archives were created using the command,

```
tar cvf archive_filename files_to_archive
```

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

```
tar tvf  archive_filename  > contents.list
```

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

To extract the files from the archive:

```
tar xvf  archive_filename file(s)_to_extract
```

G-zipped files will have a ".gz" extension on the filename. These files can be decompressed after de-archiving, using the Unix command,

```
gunzip filename.gz
```

Distribution Contents

Cruise Information

NBP0805 consisted of two independent science projects. Data was collected at various points throughout the Drake Passage. Multiple rock dredges and seismic gun operations were carried out by the geology group, headed by Dr. Ian Dalziel. Trawls, rock dredges and towcam operations were conducted by the biology group, headed by Dr. Laura Robinson. Multi-beam, CTD and XBT data was also collected. There are 3 data distributions, a master, an Argentinean subset, and a British subset. The cruise left Punta Arenas, Chile on April 19, 2008, and returned to Punta Arenas Chile on May 25, 2008.

Cruise Track

The distribution DVD includes a GMT cruise track file (NBP0805.trk). It contains the longitude and latitude at one-minute intervals extracted from the NBP0805.gmt file.

A PostScript cruise track file has been produced and placed in the / directory.

Satellite Images

Satellite Images received for this cruise can be found in the file called 0804Imag.tar Imagery collected and processed on the ship is in two further subdirectories, Ice and WX (weather). Files are named using the convention, ssss_fff_mmddyy_tttt_ww.gif where:

ssss_fff = satellite and flight number
mm = month
dd = day
yy = year
tttt = time in hours and minutes (UTC)
ww = optional field for identifying wavelength, such as vis (visible) or IR (infrared)

Science Reports

Cruise science reports will be found in the directory /scirep.

NBP Data Products

Two datasets are created on each cruise: JGOFS and MGD77.

The data processing scripts used to produce JGOFS and MGD77 data sets create a lot of intermediate files. These files are included on the data distribution media in a file called 0505proc.TAR. They are included to make re-processing easier in the event of an error, but no extensive detail of the formats is included in this document. If you have any questions, please contact itvessel@usap.gov.

JGOFS

The JGOFS data set can be found on the distribution media in the file /process/0805JGOF.tar. The archive contains one file produced for each day named jgDDD.dat.gz, where DDD is the year-day the data was acquired. The ".gz" extension indicates that the individual files are compressed before archiving. 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” as 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	μEinsteins/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 NBP0805.mgd. The file NBP0805.gmt is created from the MGD77 dataset using the “mgd77togmt” utility. NBP0805.gmt can be used with the GMT plotting package.

The data used to produce the NBP0805.mgd file can be found on the distribution media in the file /process/0805proc.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 understood to be added.

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

Col	Len	Type	Contents	Description, Possible Values, Notes
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, 1ST sensor	In tenths of nanoteslas (gammas)
67-72	6	real	Magnetics total field, 2ND 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 = 1st or leading sensor 2 = 2nd 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 10th of mgals. Corrected for Eotvos, drift, tares
98-103	6	real	EOTVOS correction	In 10th of mgals. E = 7.5 V cos phi sin alpha + 0.0042 V*V
104-108	5	real	Free-air anomaly	In 10th of mgals G = observed G = theoretical
109-113	5	char	Seismic line number	Cross-reference for seismic data
114-119	6	char	Seismic shot-point 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 individual cruises, and for the long-term goal of building a profile of current structure in the Southern Ocean.

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 `0805adcp.tar` in the directory `/rvdas/nav`.

pCO_2

The NBP carries a pCO_2 measurement system from Lamont-Doherty Earth Observatory (LDEO). pCO_2 data is recorded by RVDAS and transmitted to LDEO at the end of each cruise. You will find pCO_2 data in a file named `0805pco2.tar` in the `/process` directory, which contains the pCO_2 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 has been placed in the tar file `/ocean/0805ctd.tar`. The archive contains tar files `0805proc.tar`.

Seismic

The seismic data set, located in `/geopdata/seis`, consists of a single file produced each day named mseis.dDDD where DDD is the year day that the data was acquired. The daily file is a merge of navigation, bathymetry and Syntron data based upon shot trigger time.

```
119:20:00:52.113489200   -63.022401   -59.865492 146.899994 4.000000 943.900024
GCS900228     005   469.00001E00/04/29:00:00:161106060000 0000703000 0.020.051
00000000-00101AP1N 00015350000000002AP1N 00016350100100003AP1N
00016549900000004AP1N 000163496-0300005AP1N 00015850200200006AP1N
000157503003000
```

Field	Data	Units
01	RVDAS Time tag	YY+DDD:hh:mm:ss.sss
02	Latitude	tt.tttttt
03	Longitude	ggg.gggggg
04	Heading	degrees
05	Speed	knots
06	Depth	meters
07	Syntron String	

XBT

During the cruise, eXpendable BathyThermographs 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 `0805xbt.tar` 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 data is performed to calibrate and convert values into useable units and as a quality-control on operation of the DAS. 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. Each data file is g-zipped to save space on the distribution media. 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: `NBP0805.met1.d126`

- The CruiseID is the numeric name of the cruise, in this case, NBP0805.
- 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)	eng1	continuous	1 sec	Eppley PIR
PSP (SW radiation)	met1	continuous	1 sec	Eppley PSP
PAR	met1	continuous	1 sec	BSI QSR-240
GUV	pguv	continuous	2 sec	BSI PUV-2511
PUV	pguv	not collected		BSI PUG-2500

Geophysics

Measurement	Channel ID	Collect. Status	Rate	Instrument
Gravimeter	grv1	continuous	10 sec*	LaCoste & Romberg
Magnetometer	mag1	continuous	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	tsg1	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
Transmissometry	hdas	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

Data

Data is received from 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

Each section below describes a type of data file (file name extension in parentheses) followed by a typical line of data in the file. In the table(s) for each section is a description of the fields within each line of data. Note: most data files listed below will be included with each cruise's data distribution, however some types of files may be omitted if the instrument was not operating during the cruise. The available data files can be found in the /rvdas/uw directory on the distribution disc.

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 0959.6 000.2 093.1

-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 21 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	

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

Magnetometer (mag1)

```
99+099:00:00:23.203 %  0  98 235928    0?372453
```

Field	Data	Units
1	RVDAS time tag	
2	% 0 denotes G-866 magnetometer	
3	Year-day	
4	Time	
5	0? Denotes high noise condition	
6	Magnetic data (last digit is 10^{th}'s place)	nT

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 22 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 (if temperature compensation package is installed)	
9	Temperature units (if temperature compensation package is installed)	

pCO_2 (pco2)

```
00+021:23:59:43.190 2000021.99920 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 (IR)	mV
4	Cell temperature	°C
5	Barometer	MBar
6	Concentration	ppm
7	Equilibrated temperature	°C
8	pCO_2 pressure	microAtm
9	Flow rate	ml / min
10	Source ID #	1 or 2 digits
11	Valve position	1 or 2 digits
12	Flow source (Equil = pCO_2 measurement)	text

Engineering (eng1)

```
07+280:06:45:29.359 12.2655 16.29123 134.663 98.51914 83.71822 -
3.354797 45.38742 -0.149594 15.25094 15.08044 NAN
```

Field	Data	Units
1	RVDAS time tag	
2	Power Supply Voltage	
3	Internal Case Temperature	
4	Pump #1 flow rate	L/min
5	Pump #2 flow rate	L/min
6	Seismic air pressure	Lbs/sq-in
7	PIR case resistance	Kohm
8	PIR case ratiometric output	mV
9	Freezer #1 temperature	C
10	Freezer #2 temperature	C
11	Freezer #3 temperature	C

*See page 25 for PIR calculations.

Hydro-DAS (hdas)

```
07+280:00:00:19.352 12.16678 15.94557 244.7432 4432.954 61.5 66.5 80.5
63
```

Field	Data	Units
1	RVDAS time tag	
2	Supply voltage	
3	Panel temperature	

Field	Data	Units
4	Fluorometer	mV
5	Transmissometer	mV
6	Flow meter 1 frequency	Hz
7	Flow meter 2 frequency	Hz
8	Flow meter 3 frequency	Hz
9	Flow meter 4 frequency	Hz

Micro-TSG (mtsg)

```
07+280:00:00:48.058  -1.5017,  2.70111,  33.9692, 1440.723
```

Field	Data	Units
1	RVDAS time tag	
2	Temperature	C
3	Conductivity	s/m
4	Sound velocity	m/s

GUV Data (pguv)

```
07+288:00:00:45.399 101507 000049 .000226 1.627E0 5.253E0 5.831E-1
4.382E-2 6.811E0 1.479E-2 6.719E0 45.707 17.954
```

Field	Data	Units
1	RVDAS time tag	
2	Date	mmddyy
3	Time (UTC)	hhmmss
4	Ed0Gnd	V
5	Ed0320	uW (cm^2 nm)
6	Ed0340	uW (cm^2 nm)
7	Ed0313	uW (cm^2 nm)
8	Ed0305	uW (cm^2 nm)
9	Ed0380	uW (cm^2 nm)
10	Ed0PAR	uW (cm^2 nm)
11	Ed0395	uW (cm^2 nm)

Remote Temperature (rtmp)

```
07+272:00:00:15.960 -1.7870
```

Field	Data	Units
1	RVDAS time tag	
2	Temperature at seawater intake	C

Ultrasonic Anemometer (wind)

```
07+271:00:09:34.240 _A,139,007.55,M,+330.77,-001.52,65,_01
```

Field	Data	Units
1	RVDAS time tag	
2	Code (unit identification)	
3	Wind direction	Degrees
4	Wind speed	m/s
5	Wind speed units (M=M/S)	
6	Sound speed	m/s
7	Temperature (sonic)	C
8	Status (0 = OK, 60 = OK and heated, other code = error state)	
9	Checksum	

Navigational Data

Seapath GPS (seap)

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

- GPZDA
- GPGGA
- GPVTG
- GPHDT
- PSXN, 20
- 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

Field	Data	Units
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,20

```
02+253:00:00:00.942 $PSXN,20,0.43,0.43*39
```

Field	Data	Units
1	RVDAS time tag	
2	$PSXN	
3	20	
4	Horizontal position & velocity quality: 0=normal, 1=reduced performance, 2=invalid data	
5	Height & vertical velocity quality: 0=normal, 1=reduced performance, 2=invalid data	
6	Heading quality: 0=normal, 1=reduced performance, 2=invalid data	
7	Roll & pitch quality: 0=normal, 1=reduced performance, 2=invalid data	
8	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

Field	Data	Units
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	

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)	

Field	Data	Units
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	
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 $HEHDT 25034,-020*73
```

Field	Data	Units
1	RVDAS time tag	
2	$HEHDT	
3	Heading, Degrees True	degrees
5	Checksum	

ADCP Course (adcp)

```
00+019:23:59:59.099 $PUHAW,UVH,-1.48,-0.51,250.6
```

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

Field	Data	Units
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

The processed data sets can be found in the /process directory and subdirectories. Note: many of the subdirectories contain intermediate datasets to facilitate further processing and are not intended to be end-products. Only the final product files and datasets are described below.

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	
2	pCO_2 time tag (decimal is fractional time of day)	yyyyddd.ttt
3	Raw voltage (IR)	mV
4	Cell temperature	°C
5	Barometer	MBar
6	Concentration	ppm
7	Equilibrated temperature	°C
8	pCO_2 pressure	microAtm
9	Flow rate	ml / min
10	Source ID #	1 or 2 digits
11	Valve position	1 or 2 digits
12	Flow source (Equil = pCO_2 measurement)	text
13	RVDAS latitude	degrees
14	RVDAS longitude	degrees
15	TSG external temperature	°C
16	TSG salinity	PSU
17	TSG fluorometry	V
18	RVDAS true wind speed	m/s
19	RVDAS true wind direction	degrees
20	Barometric Pressure	mBars
21	Uncontaminated seawater pump flow rate	l/min
22	Speed over ground	knots
23	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

Field	Data	Units
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. Example:

```
00+019:23:59:46.976 15A16CFC163F8C2C100
```

Bytes	Data
1-4	Sensor Temperature (in wet lab)
5-8	Conductivity
9-14	Remote Temperature (near seawater intake)
15-18	Transmissometer voltage

The coefficients for temperature and conductivity sensors can be found the `instcoef.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 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\} - 273.15$ (°C)

Calculating Conductivity – ITS-90

C = decimal equivalent of bytes 5-8
Conductivity Frequency f = sqrt(C*2100+6250000)
Conductivity = $(g + hf^2 + if^3 + jf^4)/[10(1 + \delta t + \varepsilon p)]$ (siemens/meter)
t = temperature (°C); p = pressure (decibars); δ = Ctcor; ε = CPcor

Calculating Transmittance

V_{dark} = 0.058 V
V_{ref} = 4.765 V
t = decimal equivalent of bytes 18 - 20
Transmissometer Voltage (V_{signal}) = t/819
% Transmittance = $(V_{signal} - V_{dark}) / (V_{ref} - V_{dark})$

PAR

raw data = mV

calibration scale = 6.27 V/(μEinstiens/cm 2sec)

offset (Vdark) = 0.1 mV

(raw mV - Vdark)/scale x 104 cm2/m2 x 10-3 V/mV= μEinstiens/m2sec

or

(data mV – 0.1 mV) x 1.65 (μEinstiens/m2sec)/mV = μEinstiens/m2sec

PSP

```
raw data = mV
calibration scale =  7.92 x 10-6  V/(W/m2)
data mV / (scale x 103 mV/V) = W/m2
or
data mV x 120.7 (W/m2)/V = W/m2
```

PIR

Coefficient pirCoeff for this cruise can be found in the `instcoef.txt` file. Variable PIRr is the PIR case resistance and PIRmv is the radiometric output, as described in the “eng1” file description. Hard-coded “C” coefficients are shown below:

```
C1=0.0010295
C2=0.0002391
C3=0.0000001568
C4=5.6704e-8

Calculations (extracted from the C code):
raw data = mV
calibration scale = 4.16 x 10-6  V/(W/m2)
data mV / (scale x 103 mV/V) = W/m2
or
data mV x 120.7 (W/m2)/V = W/m2
Rr = log(fabs(PIRr * 1000))
T = 1 / ( C1 + (C2 * Rr) + (C3 * Rr * Rr * Rr) )
Rin = ( (PIRmv * 1000) / pirCoeff) + (C4 * T * T * T * T )
```

Acquisition Problems and Events

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
110:11:55		Started Loggers in Argentinean EEZ at 68° West
114:06:50		Exited Argentinean EEZ / Entered Falkland EEZ
114:16:10		Exited Falkland EEZ
116:12:00		Entered South Georgia EEZ
118:23:08		Exited South Georgia EEZ
119:07:58		Entered South Georgia EEZ
119:13:48		Exited South Georgia EEZ
122:00:00		Entered South Georgia EEZ
126:22:59		Exited South Georgia EEZ
127:01:01		Entered South Georgia EEZ
128:08:18		Exited South Georgia EEZ
132:16:47	132:16:53	Data disk storage problems. Data collection interrupted for roughly 6 minutes.
141:09:20		Entered Chilean EEZ without permit. Stopped all loggers.
141:12:02		Received Chilean permit. Started all loggers. Still in Chilean EEZ.
141:14:52		Discrepancies with Chilean permit. Permit not valid. Stopped all loggers again.
141:17:47		Exited Chilean EEZ. Started all loggers.
NOTE		There were discrepancies between what the US and Chile define as the Chilean EEZ. The loggers were stopped because according to the US, we were in Chilean waters. According to Chile, we were never in their EEZ. So any data recorded between the time of the last 4 entries above was actually in international water.
143:22:14		Entered Chilean EEZ. Stopped all loggers.
144:04:55		Exited Chilean EEZ and entered Argentinean EEZ. Started loggers.
146:03:15		Stopped loggers at 68° West at entrance to Straits of Magellan.

Appendix: Sensors and Calibrations

NBP0805 Sensors:

Shipboard Sensors

Sensor	*Serial Number*	*Last Calibration*	*Comments*
Meteorology & Radiometers			
Stbd Anemometer (Gill Ultrasonic)	071739	5/15/2007	Installed 7/19/2007
Stbd Anemometer	WM 46263	6/30/2007	Installed 7/19/2007
Bridge Anemometer	WM 45835	2/28/2007	Bridge (center)
Port Anemometer	WM 73682	6/30/2007	Installed 7/19/2007
Barometer	01706	6/15/2006	Installed 6/27/2007
Humidity/Wet Temp	06135	6/15/2006	Installed 6/27/2007
PIR	32845F3	7/30/2007	Installed 5/30/2007
PSP	32850F3	7/26/2007	Installed 7/20/2007
Mast PAR	6356	8/8/2007	Installed 8/28/2007
GUV (Mast)	25110203113	3/18/2008	Installed 8/28/2007
Underway			
TSG	2131020-3198	5/20/06	Installed 02/07/07
TSG Remote Temp (Primary)	3846730-0352	6/6/2007	Installed 7/15/2007
TSG Remote Temp (Secondary)	031267	4/12/2006	Installed 1/29/07
Micro TSG	4546167-0199	3/21/2007	Installed 6/10/2007
Fluorometer (Primary)	5333-FRXX	Un-calibrated	Installed 4/14/04
Fluorometer (Secondary)	AFL-044	5/31/2006	Installed 6/23/2007
Transmissometer	CST-557DR	2/13/2006	Installed 8/15/07

NBP0805 CTD Sensors:

Sensor	**Serial #**	**Last Calibration Date**	**Comments**
CTD Fish	094857-0232	9/26/2006	
CTD Fish Pressure	43528	9/2/20006	
CTD Deck Unit	11P47914-0768	n/a	
Primary Temperature Sensor	03P2168	6/26/2007	
Secondary Temperature Sensor	03P2367	6/27/2007	

Sensor	Serial #	Last Calibration Date	Comments
Primary Conductivity Sensor	040924	2/9/2007	
Secondary Conductivity Sensor	041799	6/26/2007	
Dissolved Oxygen Sensor (Primary)	0155	1/9/2008	
Dissolved Oxygen Sensor (Secondary)	0158	1/9/2008	
Fluorometer	AFL-016D	10/16/2006	Needed as spare for next cruise
Transmissometer	CST-889DR	7/27/2007	
CTD Pump (Primary)	051265	4/17/2008	In House Cal
CTD Pump (Secondary)	051646	4/17/2008	In House Cal
Altimeter	497	n/a	
Slip Ring Assembly	n/a	n/a	
Carousel Water Sampler	3211265-0066	n/a	

Calibrations

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

Gravity Tie Start (Punta Arenas)

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, April 2008**
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 (Gravity (cu))	8973.4	17:15
Ship's meter after gravity tie (Gravity (cu))	8973.4	18:05
Average	8973.4	
Ship Gravimeter's Calibration Constant	1.0046	
Corrected ship's meter (QC Grav (mgal))	9014.7	

	Value	Time (GMT)
Ship's meter before gravity tie (serial, RVDAS)	8973.3	17:15
Ship's meter after gravity tie (serial, RVDAS)	8973.5	18:07
Average (for comparison check only)	8973.4	

Portable Gravimeter Interval Factor: 1.01007 From Table 1 of Model G #807 Meter

Station	Value	Time (GMT)	Temp	Date	OBS mgal, averaged
Pier measurement 1	4912.93	13:24	54	15, April 2008	
Pier measurement 2	4912.45	13:29	54	15, April 2008	4962.24
Pier measurement 3	4912.92	13:31	54	15, April 2008	
Average	4912.77				
Station measurement 1	4913.53	13:41	54	15, April 2008	OBS mgal, averaged
Station measurement 2	4913.61	13:43	54	15, April 2008	4963.07
Station measurement 3	4913.62	13:45	54	15, April 2008	
Average	4913.59				
Pier measurement 4	4912.86	13:54	54	15, April 2008	OBS mgal, averaged
Pier measurement 5	4912.81	13:57	54	15, April 2008	4962.32
Pier measurement 6	4912.87	14:00	54	15, April 2008	
Average	4912.85				

Gravity offset from last tie 972306.75
Drift since last tie -1.36

OBS Differences	
Station to Pier (1, 2, & 3 averaged)	-0.83
Station to Pier (4, 5, & 6 averaged)	-0.75
Averaged Differences	-0.79
Gravity at pier	981320.03
Elevation of pier above gravimeter, meters	0.1
Earth differential gravity, mgal/meter	0.3
Gravity at ship's gravimeter	981320.07
Gravity Offset (for RVDAS)	972305.39

Comments

Gravity Tie taken at pierside and by admin building in Punta Arenas by Greg Watson and Kevin Pedigo. Pierside measurements were quite stable, however monument readings were very shaky, possible due to construction of new casino.

Meteorology System

Anemometer (Port)

RM Young Anemometer Calibration, Model 05106

S/N: 46263 Date: 30-Jun-07 Cal'd By: George Aukon

Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s	Knots
0	0.00	0.10	-0.10	0.0
200	0.98	0.90	0.08	1.9
500	2.45	2.30	0.15	4.8
1000	4.90	4.80	0.10	9.5
1500	7.35	7.30	0.05	14.3
2000	9.80	9.80	0.00	19.0
3000	14.70	14.70	0.00	28.6
4000	19.60	19.60	0.00	38.1
5000	24.50	24.60	-0.10	47.6
6000	29.40	29.40	0.00	57.1
7000	34.30	34.30	0.00	66.6
8000	39.20	39.40	-0.20	76.2
9000	44.10	44.20	-0.10	85.7
10000	49.00	49.10	-0.10	95.2
12000	58.80	58.90	-0.10	114.2

Direction	Measured Direction	Delta Direction
0	0	0
30	30	0
60	59	1
90	89	1
120	118	2
150	148	2
180	179	1
210	210	0
240	240	0
270	270	0
300	300	0
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	0.10	-0.10
200	0.98	0.80	0.18
500	2.45	2.40	0.05
1000	4.90	4.80	0.10
1500	7.35	7.30	0.05
2000	9.80	9.80	0.00
3000	14.70	14.70	0.00
4000	19.60	19.60	0.00
5000	24.50	24.60	-0.10
6000	29.40	29.50	-0.10
7000	34.30	34.40	-0.10
8000	39.20	39.30	-0.10
9000	44.10	44.30	-0.20
10000	49.00	49.20	-0.20
12000	58.80	58.90	-0.10

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

Wind Speed Threshold < 2.9 gm?	2
Wind Direction Threshold < 30 gm?	15

Additional Comments

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: 73682 Date: 30-Jun-07 Cal'd By: George Aukon

Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s	Knots
0	0.00	0.10	-0.10	0.0
200	0.98	0.80	0.18	1.9
500	2.45	2.40	0.05	4.8
1000	4.90	4.80	0.10	9.5
1500	7.35	7.30	0.05	14.3
2000	9.80	9.80	0.00	19.0
3000	14.70	14.70	0.00	28.6
4000	19.60	19.60	0.00	38.1
5000	24.50	24.60	-0.10	47.6
6000	29.40	29.50	-0.10	57.1
7000	34.30	34.40	-0.10	66.6
8000	39.20	39.30	-0.10	76.2
9000	44.10	44.30	-0.20	85.7
10000	49.00	49.20	-0.20	95.2
12000	58.80	58.90	-0.10	114.2

Direction	Measured Direction	Delta Direction
0	0	0
30	29	1
60	59	1
90	89	1
120	119	1
150	148	2
180	178	2
210	207	3
240	237	3
270	267	3
300	297	3
330	328	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	0.10	-0.10
200	0.98	0.90	0.08
500	2.45	2.30	0.15
1000	4.90	4.80	0.10
1500	7.35	7.30	0.05
2000	9.80	9.80	0.00
3000	14.70	14.70	0.00
4000	19.60	19.60	0.00
5000	24.50	24.60	-0.10
6000	29.40	29.40	0.00
7000	34.30	34.30	0.00
8000	39.20	39.40	-0.20
9000	44.10	44.20	-0.10
10000	49.00	49.10	-0.10
12000	58.80	58.90	-0.10

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

Wind Speed Threshold < 2.9 gm? 2.3
Wind Direction Threshold < 30 gm? 15

Additional Comments

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

Anemometer (Bridge)

RM Young Anemometer Calibration, Model 05106

S/N: 45835 Date: 28-Feb-07 Cal'd By: George Aukon

Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s	Knots
0	0.00	0.00	0.00	0.0
200	0.98	0.90	0.08	1.9
500	2.45	2.40	0.05	4.8
1000	4.90	4.80	0.10	9.5
1500	7.35	7.30	0.05	14.3
2000	9.80	9.80	0.00	19.0
3000	14.70	14.60	0.10	28.6
4000	19.60	19.50	0.10	38.1
5000	24.50	24.30	0.20	47.6
6000	29.40	29.20	0.20	57.1
7000	34.30	34.10	0.20	66.6
8000	39.20	39.00	0.20	76.2
9000	44.10	43.90	0.20	85.7
10000	49.00	48.80	0.20	95.2
12000	58.80	58.60	0.20	114.2

Direction	Measured Direction	Delta Direction
0	359	0
30	29	1
60	59	1
90	89	1
120	119	1
150	148	2
180	179	1
210	210	0
240	240	0
270	270	0
300	301	-1
330	331	-1
0	1	-1

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	0.00	0.00
200	0.98	1.00	-0.02
500	2.45	2.50	-0.05
1000	4.90	4.90	0.00
1500	7.35	7.40	-0.05
2000	9.80	9.80	0.00
3000	14.70	14.80	-0.10
4000	19.60	19.80	-0.20
5000	24.50	24.60	-0.10
6000	29.40	29.50	-0.10
7000	34.30	34.50	-0.20
8000	39.20	39.40	-0.20
9000	44.10	44.40	-0.30
10000	49.00	49.30	-0.30
12000	58.80	59.60	-0.80

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
Potentiometer and potentiometer coupling were replaced , vertical shaft bearings were cleaned and lubricated.

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

Barometer

COPY

R.M. Young Company
2801 Aero Park Drive
Traverse City, Michigan 49686 USA

YOUNG

Barometric Pressure Sensor Calibration Report

Customer: *Raytheon Technical Services Co*

Test Number: 66161 Customer PO: RM25937-50
Test Date: 15 June 2006 Sales Order: 8449

Test Sensor:
Model: 61201 Serial Number: *BP01706*
Description: Barometric Pressure Sensor

Report of calibration comparison of test barometric pressure sensor with National Institute of Standards and Technology traceable standard pressure calibrator at five pressures in the R.M. Young Company controlled pressure facility. Calibration accuracy ± 1.0 hPa.

Reference Pressure (hPa)	Voltage Output (millivolts)	Indicated (1) Pressure (hPa)
800.0	1	800.1
875.0	1251	875.1
950.0	2501	950.1
1025.0	3750	1025.0
1100.0	4998	1099.9

(1) Calculated from voltage output

All reference equipment used in this calibration procedure have been tested by comparison to traceable standards certified by the National Institute of Standards and Technology.

Reference Instrument	Serial #	NIST Test Reference
Druck Pressure Controller Model DPI515	51500497	UKAS Lab 0221
Fluke Multimeter Model 8060A	4865407	234027

Tested By: EChumney

METEOROLOGICAL INSTRUMENTS
Tel: 231-946-3980 Fax: 231-946-4772 Email: met.sales@youngusa.com Website: www.youngusa.com

Humidity Sensor

R.M. Young Company
2801 Aero Park Drive
Traverse City, Michigan 49686 USA

Relative Humidity Sensor Calibration Report

Customer: *Raytheon Technical Services Co*

Test Number: 66900R
Test Date: 15 June 2006
Customer PO: RM25937-50
Sales Order: 8449

Test Sensor:
Model: 41372LC Serial Number: *6135*
Description: Temperature/Relative Humidity Sensor

Report of calibration comparison of test relative humidity sensor with National Institute of Standards and Technology traceable standard relative humidity sensor at five humidity levels in the R.M. Young Company controlled humidity chamber facility. Calibration accuracy ± 2.0 %.

Reference Humidity (%)	Current Output (milliamps)	Indicated (1) Humidity (%)
10.4	6.0	12.3
30.0	8.8	30.1
49.8	12.0	50.2
70.0	15.2	69.7
89.5	17.8	86.5

(1) Calculated from voltage output

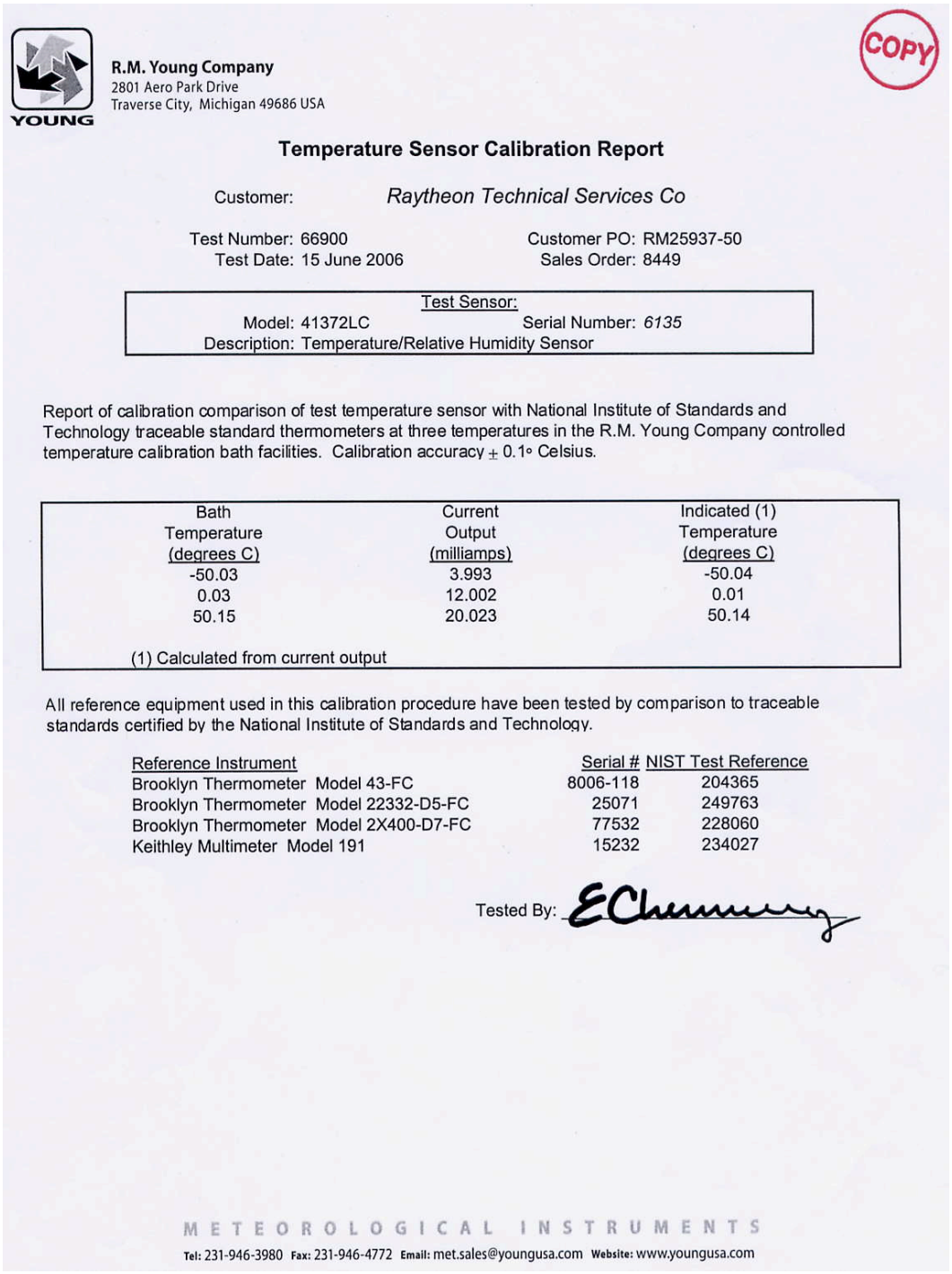
All reference equipment used in this calibration procedure have been tested by comparison to traceable standards certified by the National Institute of Standards and Technology.

Reference Instrument	Serial #	NIST Test Reference
Vaisala Humidity Sensor Model 35AC	N475040	TN 266152
Fluke Multimeter Model 8060A	4865407	234027

Tested By: EChemmey

Tel: 231-946-3980 Fax: 231-946-4772 Email: met.sales@youngusa.com Website: www.youngusa.com

Temperature Sensor



R.M. Young Company
2801 Aero Park Drive
Traverse City, Michigan 49686 USA

COPY

Temperature Sensor Calibration Report

Customer: *Raytheon Technical Services Co*

Test Number: 66900 Customer PO: RM25937-50
Test Date: 15 June 2006 Sales Order: 8449

Test Sensor:
Model: 41372LC Serial Number: *6135*
Description: Temperature/Relative Humidity Sensor

Report of calibration comparison of test temperature sensor with National Institute of Standards and Technology traceable standard thermometers at three temperatures in the R.M. Young Company controlled temperature calibration bath facilities. Calibration accuracy ± 0.1° Celsius.

Bath Temperature (degrees C)	Current Output (milliamps)	Indicated (1) Temperature (degrees C)
-50.03	3.993	-50.04
0.03	12.002	0.01
50.15	20.023	50.14

(1) Calculated from current output

All reference equipment used in this calibration procedure have been tested by comparison to traceable standards certified by the National Institute of Standards and Technology.

Reference Instrument	Serial #	NIST Test Reference
Brooklyn Thermometer Model 43-FC	8006-118	204365
Brooklyn Thermometer Model 22332-D5-FC	25071	249763
Brooklyn Thermometer Model 2X400-D7-FC	77532	228060
Keithley Multimeter Model 191	15232	234027

Tested By: EChemmerling

METEOROLOGICAL INSTRUMENTS
Tel: 231-946-3980 Fax: 231-946-4772 Email: met.sales@youngusa.com Website: www.youngusa.com

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: info@eppleylab.com Internet: www.eppleylab.com

EPLAB
Scientific Instruments
for Precision Measurements
Since 1917

STANDARDIZATION OF EPPLEY PRECISION INFRARED RADIOMETER Model PIR

Serial Number: 32845F3

Resistance: 740 Ω at 23 °C
Temperature Compensation Range: -20 to 40 °C

This pyrgeometer has been compared against Eppley's Blackbody Calibration System under radiation intensities of approximately 200 watts meter^{-2} and an average ambient temperature of °C as measured by Standard Omega Temperature Probe, RTD#1.

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

4.16 x 10^{-6} 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 ±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.

Eppley recommends a minimum calibration cycle of five (5) years but encourages annual calibrations for highest measurement accuracy. Unless otherwise stated in the remarks section below or on the Sales Order, the results are "AS FOUND / AS LEFT".

Shipped to:
National Science Foundation
Port Hueneme, CA

S.O. Number: 61242
Date: August 1, 2007

Remarks:

Date of Test: July 30, 2007

In Charge of Test: R. T. Essen

Reviewed by: Thomas D. Kuh

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: info@eppleylab.com Internet: www.eppleylab.com

EPLAB
Scientific Instruments
for Precision Measurements
Since 1917

STANDARDIZATION OF EPPLEY PRECISION SPECTRAL PYRANOMETER Model PSP

Serial Number: 32850F3

Resistance: 706 Ω at 23 °C
Temperature Compensation Range: -20 to 40 °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 conatant).

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

7.92 x 10^{-6} 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 ± 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 Tenth International Pyrheliometric Comparisons (IPC X) at Davos, Switzerland in September-October 2005.

Eppley recommends a minimum calibration cycle of five (5) years but encourages annual calibrations for highest measurement accuracy. Unless otherwise stated in the remarks section below or on the Sales Order, the results are "AS FOUND / AS LEFT".

Useful conversion facts: 1 cal cm^{-2} min^{-1} = 697.3 watts meter^{-2}
1 BTU/ft^2-hr^{-1} = 3.153 watts meter^{-2}

Shipped to:
National Science Foundation
Port Hueneme, CA

S.O. Number: 61243
Date: August 1, 2007

Date of Test: July 26, 2007

In Charge of Test: P. T. Eppley

Reviewed by: Thomas D. Kirk

Remarks:

GUV

Biospherical Instruments Inc.

GUV-2511 Calibration Certificate

System Serial Number	25110203113	Date of Calibration	3/18/08
Calibration database	25110203113v4.mdb	Date of Certificate	3/18/2008
DASSN	0068	Standard of Spectral Irradiance	91537(10/25/06)
Microprocessor Tag Number	2	Operator	TC

Monochromatic Channels	Address	Wavelength [nm]	Responsivity [Amps per µW/(cm²·nm)]	ScaleSmall [Volts per µW/(cm²·nm)]	ScaleMedium [Volts per µW/(cm²·nm)]	ScaleLarge [Volts per µW/(cm²·nm)]	OffsetSmall [volts]	OffsetMedium [volts]	OffsetLarge [volts]	Measurement Units
Ed0320	2	320	2.7010E-10	2.7551E-05	8.0491E-03	2.8497E+00	6.5000E-05	6.4000E-05	2.2300E-04	µW/(cm²nm)
Ed0340	6	340	2.2027E-10	2.2467E-05	6.5640E-03	2.3144E+00	3.7400E-04	3.7600E-04	1.1590E-03	µW/(cm²nm)
Ed0313	8	313	2.4100E-10	2.4539E-05	7.1692E-03	2.5594E+00	1.0000E-04	1.0000E-04	6.9100E-04	µW/(cm²nm)
Ed0305	10	305	1.6600E-11	1.6943E-06	4.9499E-04	1.5313E-01	4.1300E-04	4.0500E-04	-2.2080E-03	µW/(cm²nm)
Ed0380	12	380	7.0759E-11	7.2174E-06	2.1086E-03	7.0320E-01	1.1140E-03	1.1050E-03	-1.4780E-03	µW/(cm²nm)
Ed0395	18	395	3.4926E-10	3.5624E-05	1.0408E-02	3.3997E+00	1.3100E-04	1.3000E-04	2.2300E-04	µW/(cm²nm)

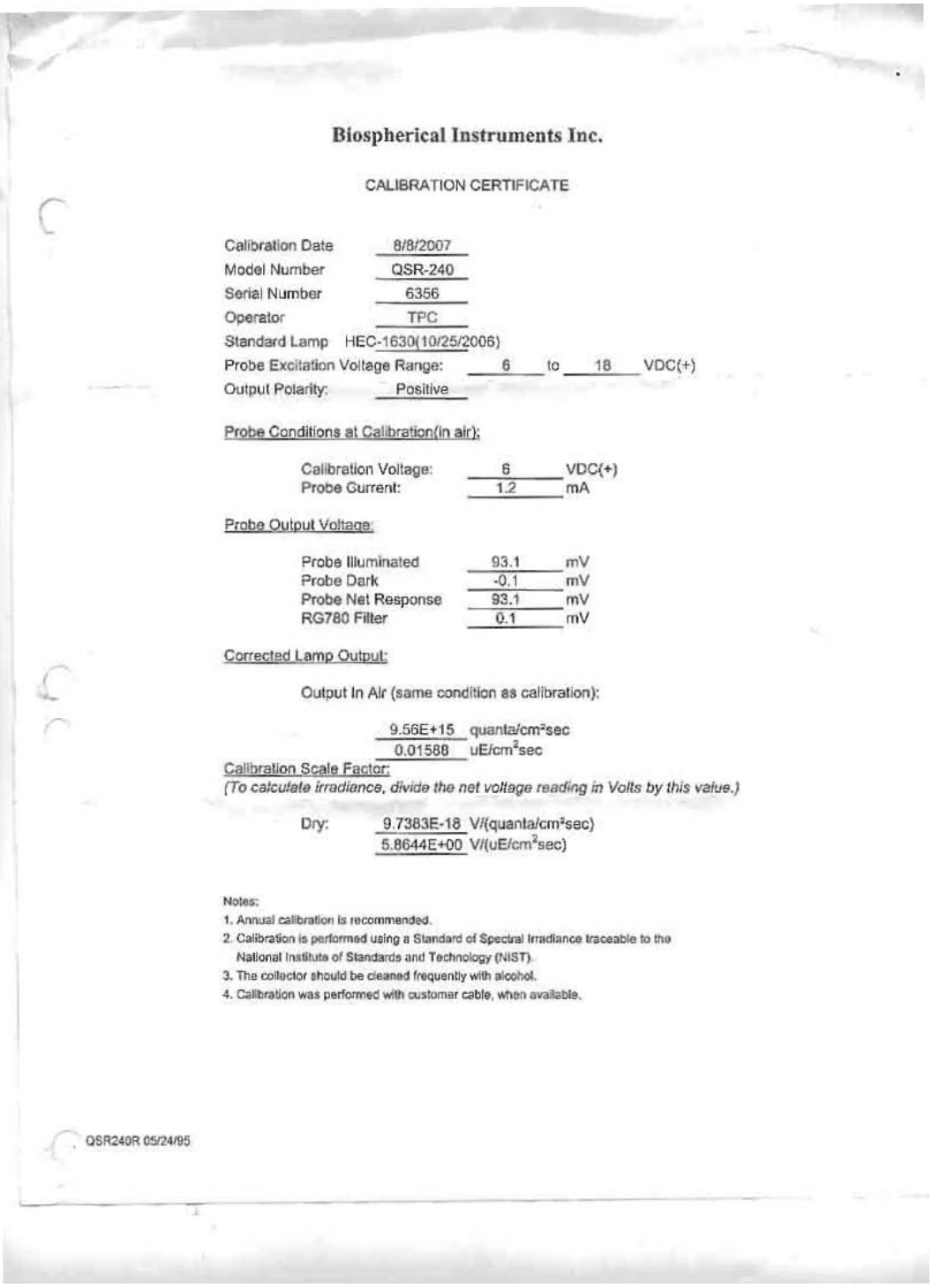
Broadband Channels	Address	Wavelength [nm]	Responsivity [Amps per µE/(cm²·s)]	ScaleSmall [Volts per µE/(cm²·s)]	ScaleMedium [Volts per µE/(cm²·s)]	ScaleLarge [Volts per µE/(cm²·s)]	OffsetSmall [volts]	OffsetMedium [volts]	OffsetLarge [volts]	Measurement Units
Ed0PAR	13	400-700	1.9205E-05	1.9589E+00	5.7230E+02	2.0376E+05	8.8600E-04	8.7700E-04	-1.3030E-03	µE/(cm²sec)

Auxilliary Channels	Address	Wavelength	Responsivity	ScaleS	ScaleM	ScaleL	OffsetS	OffsetM	OffsetL	Measurement Units
Ed0Gnd	0	0	1	1	1	1	0	0	0	V
Ed0Temp	22	0	1	0.01	0.01	0.01	0	0	0	C
Ed0Vin	27	0	1	-0.25	-0.25	-0.25	0	0	0	V

Calibration Data – Do Not Destroy

page 2 of 2

PAR



Biospherical Instruments Inc.

CALIBRATION CERTIFICATE

Calibration Date 8/8/2007
Model Number QSR-240
Serial Number 6356
Operator TPC
Standard Lamp HEC-1630(10/25/2006)
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 93.1 mV
Probe Dark -0.1 mV
Probe Net Response 93.1 mV
RG780 Filter 0.1 mV

Corrected Lamp Output:

Output In Air (same condition as calibration):

9.56E+15 quanta/cm²sec
0.01588 uE/cm²sec

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

Dry: 9.7383E-18 V/(quanta/cm²sec)
5.8644E+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: 20-May-06

SBE21 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS

```
g = -4.27061383e+000
h =  5.04384737e-001
i = -4.53257393e-004
j =  4.72934991e-005
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  2.81077465e-006
b =  5.02715558e-001
c = -4.26259709e+000
d = -8.83813520e-005
m =  4.8
CPcor = -9.5700e-008 (nominal)
```

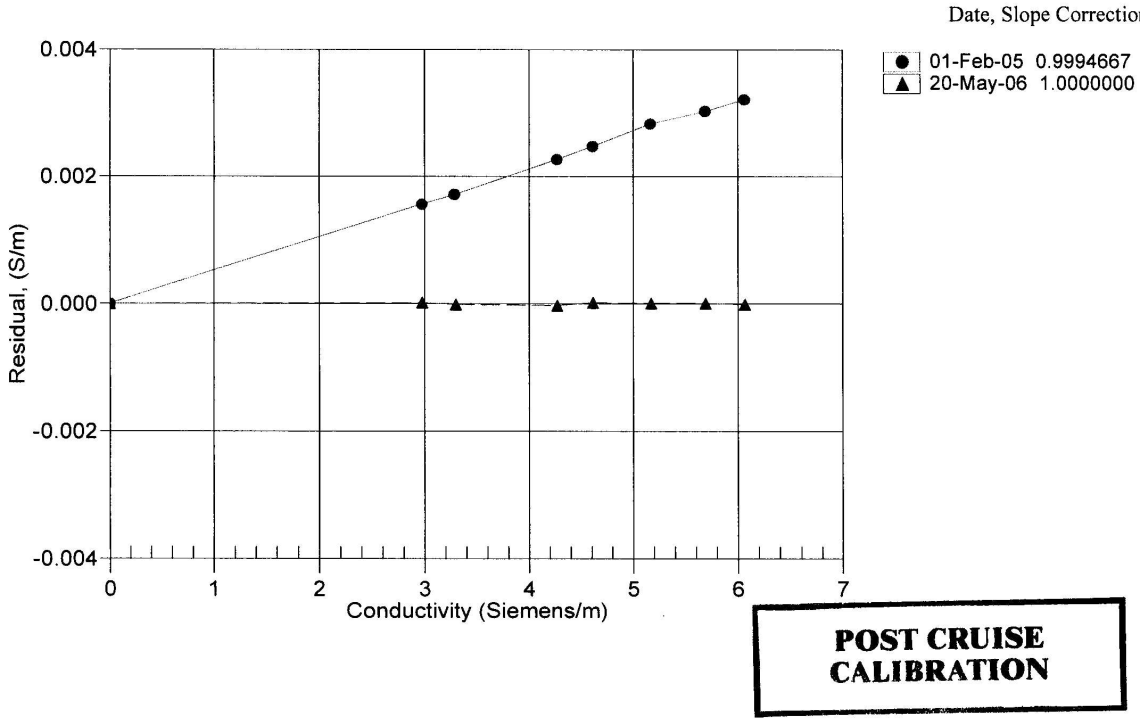
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2.91246	0.00000	0.00000
1.0000	34.8123	2.97566	8.21793	2.97567	0.00002
4.6261	34.7919	3.29397	8.59263	3.29396	-0.00001
15.0000	34.7503	4.26437	9.64425	4.26434	-0.00003
18.4999	34.7417	4.60953	9.99119	4.60955	0.00002
24.0000	34.7323	5.16751	10.52728	5.16752	0.00001
29.0000	34.7279	5.68947	11.00456	5.68948	0.00001
32.4999	34.7263	6.06206	11.33261	6.06205	-0.00001

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

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

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

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



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: 20-May-06

SBE21 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS

g = 4.22473160e-003
h = 6.29770835e-004
i = 2.05272425e-005
j = 1.54706370e-006
f0 = 1000.0

ITS-68 COEFFICIENTS

a = 3.64763347e-003
b = 5.95315785e-004
c = 1.61762223e-005
d = 1.54852177e-006
f0 = 2568.439

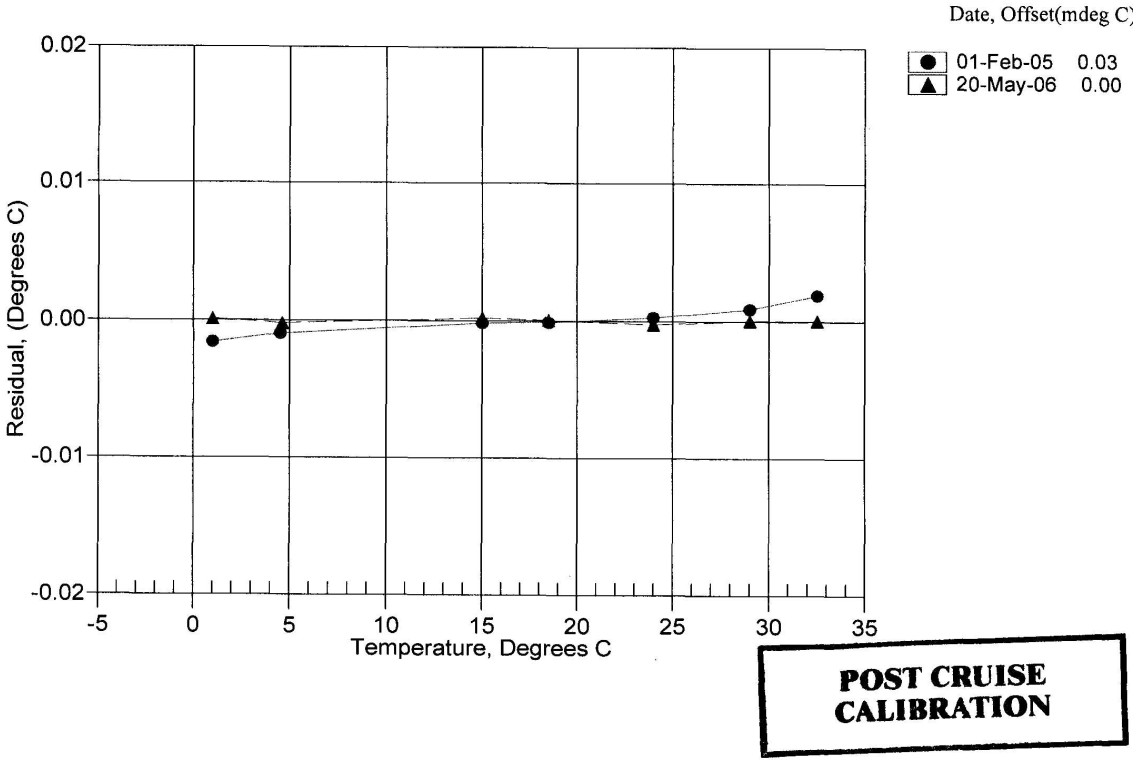
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	2568.439	1.0001	0.00011
4.6261	2782.830	4.6259	-0.00021
15.0000	3467.526	15.0002	0.00020
18.4999	3723.433	18.5000	0.00006
24.0000	4152.193	23.9998	-0.00023
29.0000	4571.111	29.0000	0.00004
32.4999	4881.298	32.4999	0.00004

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

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

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature



POST CRUISE CALIBRATION

Underway Temperature Sensor (Primary Remote)

44

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: 0352
CALIBRATION DATE: 06-Jun-07

SBE 38 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

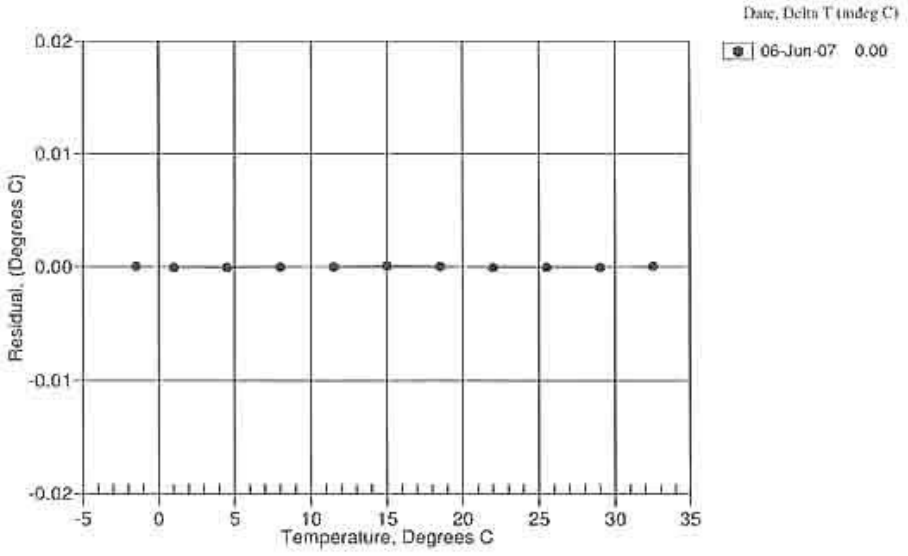
ITS-90 COEFFICIENTS

a0 = -1.791146e-005
a1 = 2.748666e-004
a2 = -2.288718e-006
a3 = 1.522128e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.50010	809858.1	-1.50005	0.00005
0.99990	723216.3	0.99986	-0.00004
4.50000	619038.5	4.49993	-0.00007
7.99990	531605.5	7.99989	-0.00001
11.50000	457969.9	11.50002	0.00002
14.99990	395755.0	15.00000	0.00010
18.49990	343018.4	18.49995	0.00005
22.00000	298175.3	21.99994	-0.00006
25.50000	259928.8	25.49995	-0.00005
29.00000	227212.0	28.99995	-0.00005
32.50000	199144.2	32.50006	0.00006

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

Residual = instrument temperature - bath temperature



Underway Temperature Sensor (Secondary Remote)

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: 12-Apr-06

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS
g = 4.76625066e-003
h = 6.64522185e-004
i = 2.84261863e-005
j = 2.62601374e-006
f0 = 1000.0

ITS-68 COEFFICIENTS
a = 3.68121498e-003
b = 5.89543636e-004
c = 1.47312260e-005
d = 2.62748536e-006
f0 = 5707.029

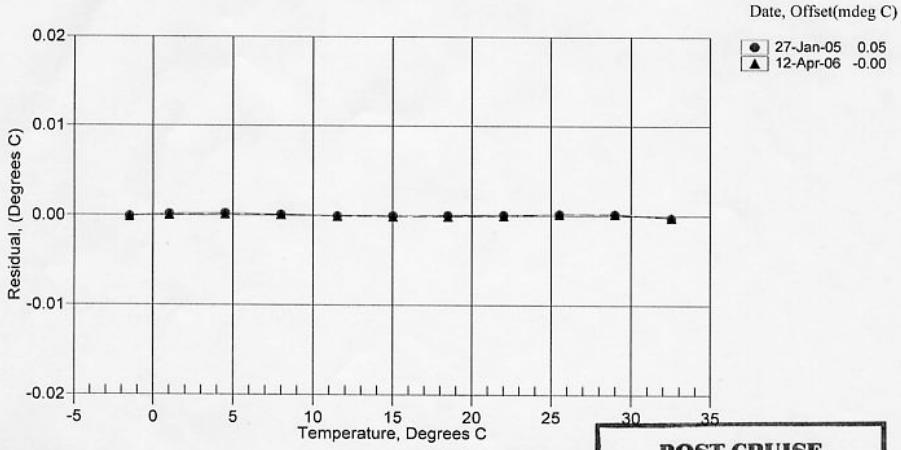
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5001	5707.029	-1.5002	-0.00010
1.0000	6042.027	1.0001	0.00005
4.4999	6534.652	4.5000	0.00014
7.9999	7055.608	8.0000	0.00007
11.4999	7605.659	11.4998	-0.00008
14.9999	8185.578	14.9998	-0.00014
18.4999	8796.088	18.4998	-0.00011
22.0000	9437.895	22.0000	-0.00003
25.4999	10111.624	25.5001	0.00019
28.9999	10817.898	29.0001	0.00019
32.4999	11557.257	32.4997	-0.00019

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

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

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature



POST CRUISE CALIBRATION

Underway Transmissometer

PO Box 518
620 Applegate St.
Philomath, OR 97370

WET Labs
Western Environmental Technology Laboratories Inc.

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

C-Star Calibration and Repairs

Date	12/20/2006	Customer		Raytheon Polar Services	
Job #	021020	S/N#	CST-557DR	Work order	007

Repairs and Modifications:

Replaced bulkhead connector, 38 mm lens and o-rings. Baked to remove moisture. Recalibrated.

Comments:

- Shake-tested unit
- Pressure-tested unit
- Noise test: 1 sample/sec for 60 sec
- Stability test: 1 sample/min for 12 hrs
- Performed water calibration
- Temperature test, 27–2 °C
- Updated unit's calibration sheet

cstarwkbkf1.xls Revision F 6/12/03

Micro-TSG Calibration Files

Temperature Sensor (Micro-TSG)

65

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: 0199
CALIBRATION DATE: 21-Mar-07

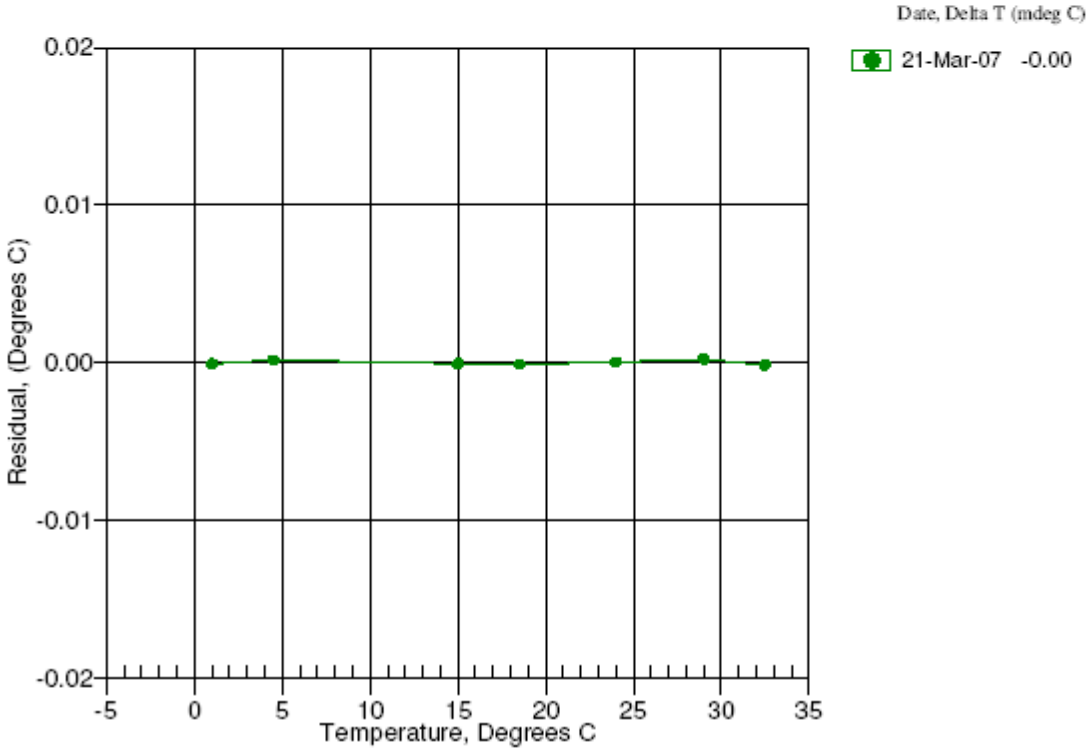
SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
a0 = -1.943659e-005
a1 = 2.808678e-004
a2 = -2.841613e-006
a3 = 1.685518e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	678415.8	0.9999	-0.0001
4.4999	580530.8	4.5001	0.0002
15.0001	370823.7	15.0000	-0.0001
18.5000	321316.6	18.4999	-0.0001
24.0000	258030.0	24.0000	0.0000
29.0000	212647.5	29.0002	0.0002
32.5000	186328.0	32.4999	-0.0001

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

Residual = instrument temperature - bath temperature



Conductivity Sensor (Micro-TSG)

66

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: 0199
CALIBRATION DATE: 21-Mar-07

SBE 45 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -1.000752e+000
h = 1.423709e-001
i = -1.466251e-004
j = 3.326706e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006
WBOTC = -1.0552e-005

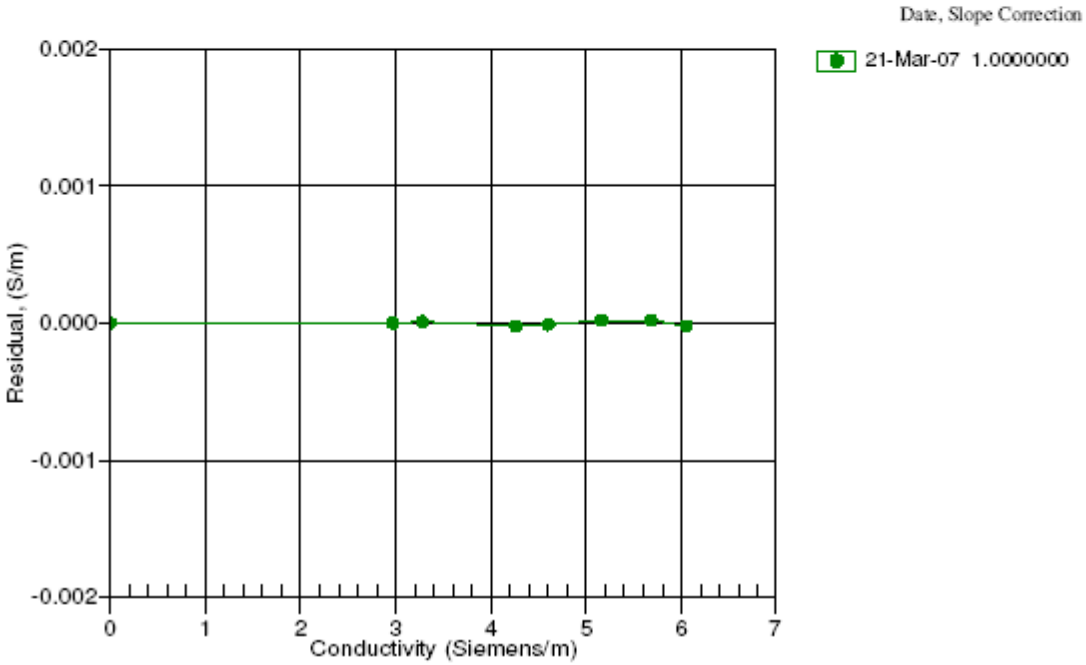
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2653.01	0.00000	0.00000
1.0000	34.7405	2.97010	5278.39	2.97010	0.00000
4.4999	34.7201	3.27653	5477.59	3.27655	0.00001
15.0001	34.6771	4.25635	6070.06	4.25632	-0.00002
18.5000	34.6679	4.60080	6264.80	4.60079	-0.00001
24.0000	34.6577	5.15763	6567.11	5.15765	0.00002
29.0000	34.6517	5.67838	6837.44	5.67841	0.00002
32.5000	34.6477	6.04991	7023.73	6.04989	-0.00002

f = INST FREQ * sqrt(1.0 + WBOTC * t) / 1000.0

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

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

Residual = instrument conductivity - bath conductivity



CTD

Pressure 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: 0232
CALIBRATION DATE: 26-Sep-06

SBE9plus PRESSURE CALIBRATION DATA
10000 psia S/N 43528

DIGIQUARTZ COEFFICIENTS:

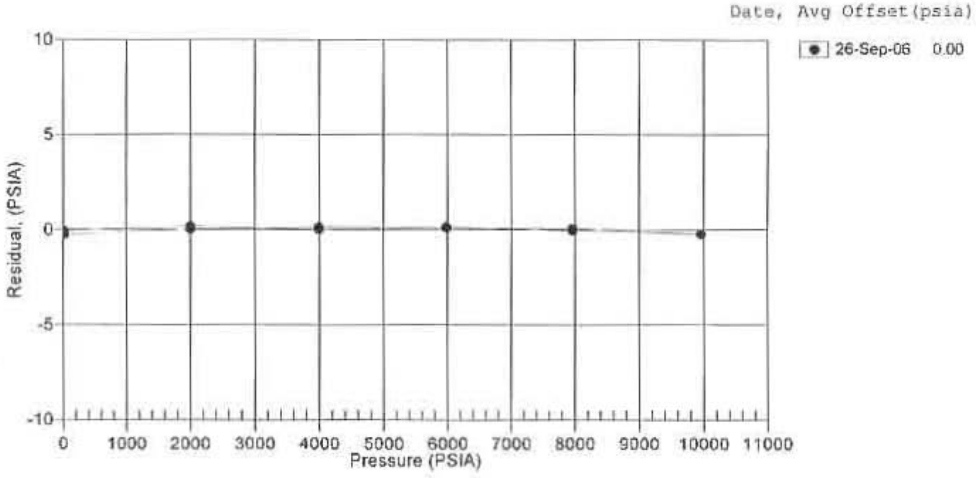
C1 =	-5.103000e+004
C2 =	8.606365e-002
C3 =	1.481220e-002
D1 =	3.642300e-002
D2 =	0.000000e+000
T1 =	3.004925e+001
T2 =	-3.406308e-004
T3 =	4.125600e-006
T4 =	1.811600e-009
T5 =	0.000000e+000

AD590M, AD590B, SLOPE AND OFFSET:

AD590M =	1.13600e-002
AD590B =	-8.42350e+000
Slope =	0.99978
Offset =	0.0319 (dbars)

PRESSURE (PSIA)	INST OUTPUT(Hz)	INST TEMP(C)	INST OUTPUT (PSIA)	CORRECTED INST OUTPUT (PSIA)	RESIDUAL (PSIA)
14.675	33289.50	21.9	14.568	14.615	-0.060
2001.705	33930.70	22.1	2002.284	2001.886	0.181
3988.395	34558.00	22.1	3989.251	3988.409	0.014
5975.164	35172.50	22.2	5976.527	5975.241	0.077
7962.097	35774.80	22.2	7963.884	7962.154	0.057
9949.272	36365.50	22.3	9951.215	9949.041	-0.231
7961.761	35774.70	22.4	7963.436	7961.706	-0.055
5974.924	35172.50	22.5	5976.351	5975.065	0.141
3988.024	34558.00	22.5	3988.996	3988.154	0.130
2001.221	33930.60	22.6	2001.645	2001.247	0.026
14.671	33289.60	22.9	14.346	14.392	-0.279

Residual = corrected instrument pressure - reference pressure



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: 2168
CALIBRATION DATE: 26-Jun-07

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS
g = 4.35084548e-003
h = 6.43833020e-004
i = 2.33730481e-005
j = 2.20267846e-006
f0 = 1000.0

ITS-68 COEFFICIENTS
a = 3.68121193e-003
b = 6.01266288e-004
c = 1.62772369e-005
d = 2.20423515e-006
f0 = 2938.740

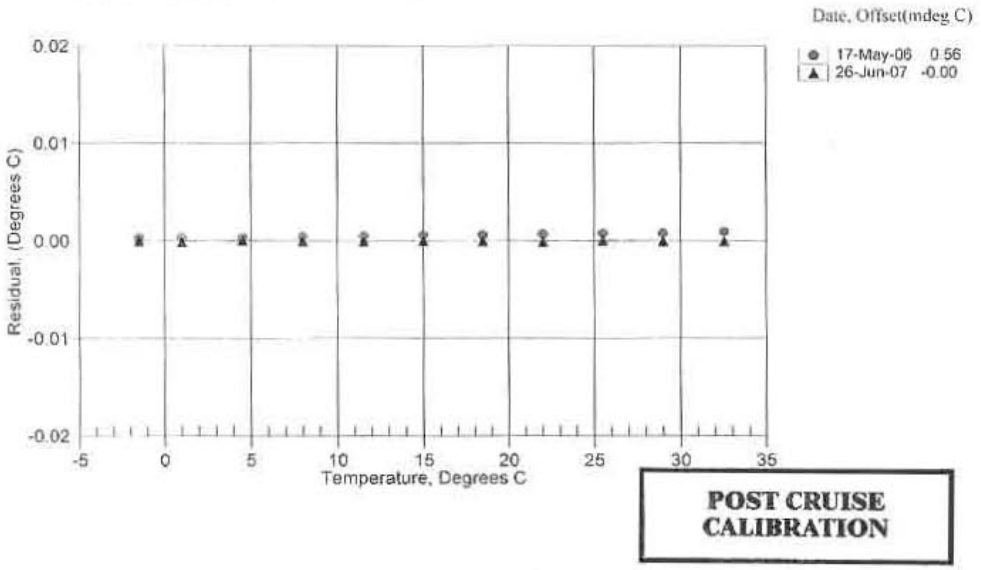
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	2938.740	-1.5000	0.00003
1.0000	3107.775	0.9999	-0.00008
4.5000	3356.126	4.5001	0.00007
8.0000	3618.439	8.0000	-0.00002
11.5000	3895.117	11.5000	-0.00001
15.0000	4186.521	15.0000	0.00002
18.5000	4493.002	18.5000	-0.00001
22.0000	4814.909	22.0000	-0.00005
25.4999	5152.579	25.5000	0.00006
29.0000	5506.331	29.0000	-0.00001
32.5000	5876.467	32.5000	-0.00000

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

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

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °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: 2367
CALIBRATION DATE: 27-Jun-07

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS
g = 4.33460382e-003
h = 6.42900592e-004
i = 2.35863766e-005
j = 2.26388629e-006
f0 = 1000.0

ITS-68 COEFFICIENTS
a = 3.68121222e-003
b = 6.00907833e-004
c = 1.64630707e-005
d = 2.26546453e-006
f0 = 2865.911

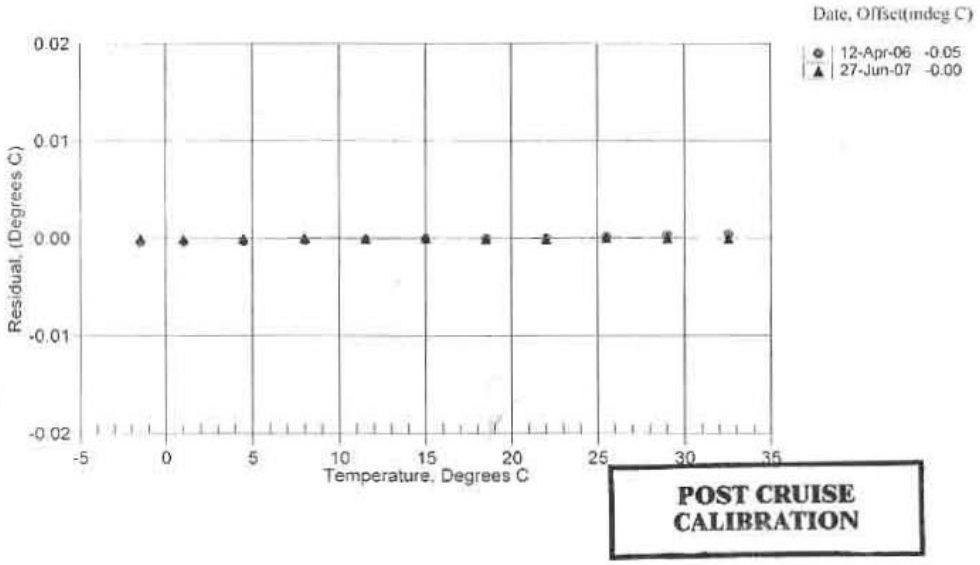
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	2865.911	-1.5000	0.00001
1.0000	3030.867	1.0000	-0.00001
4.5000	3273.226	4.5000	-0.00003
7.9999	3529.253	8.0000	0.00006
11.5000	3799.323	11.5000	0.00000
15.0000	4083.790	15.0000	0.00001
18.5000	4383.002	18.4999	-0.00005
22.0000	4697.307	21.9999	-0.00006
25.4999	5027.031	25.5000	0.00007
29.0000	5372.488	29.0000	0.00004
32.5000	5733.962	32.5000	-0.00004

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

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

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature



POST CRUISE CALIBRATION

Primary Dissolved Oxygen 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: 0155
CALIBRATION DATE: 03-Jan-07p

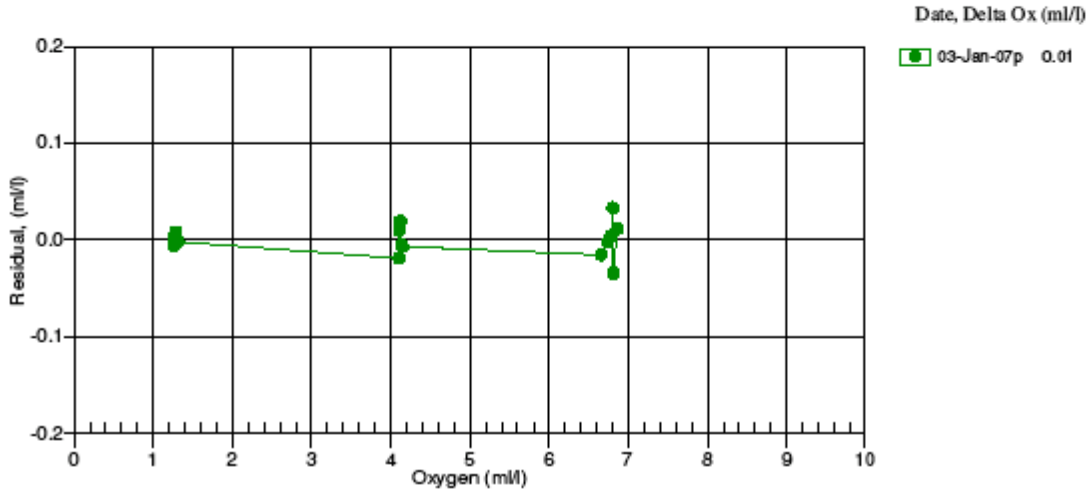
SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS
Soc = 0.3607
Boc = 0.0000
Voffset = -0.4886

TCor = 0.0015
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)
1.26	2.00	0.00	0.847	1.25	-0.01
1.27	6.00	0.00	0.892	1.28	0.00
1.28	12.00	0.01	0.955	1.29	0.01
1.29	20.00	0.01	1.037	1.29	0.00
1.30	26.00	0.01	1.103	1.30	-0.00
1.32	30.00	0.01	1.150	1.32	-0.00
4.10	2.00	0.00	1.656	4.08	-0.02
4.11	20.00	0.01	2.234	4.12	0.01
4.11	6.00	0.00	1.790	4.12	0.01
4.12	12.00	0.01	1.985	4.14	0.02
4.14	26.00	0.01	2.435	4.13	-0.01
4.15	30.00	0.01	2.569	4.14	-0.01
6.66	30.00	0.01	3.829	6.64	-0.02
6.73	26.00	0.01	3.660	6.73	-0.00
6.78	20.00	0.01	3.363	6.78	0.00
6.80	12.00	0.01	2.961	6.84	0.03
6.81	2.00	0.00	2.427	6.78	-0.03
6.86	6.00	0.00	2.657	6.87	0.01

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



Secondary Dissolved Oxygen 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: 0158
CALIBRATION DATE: 09-Jan-08p

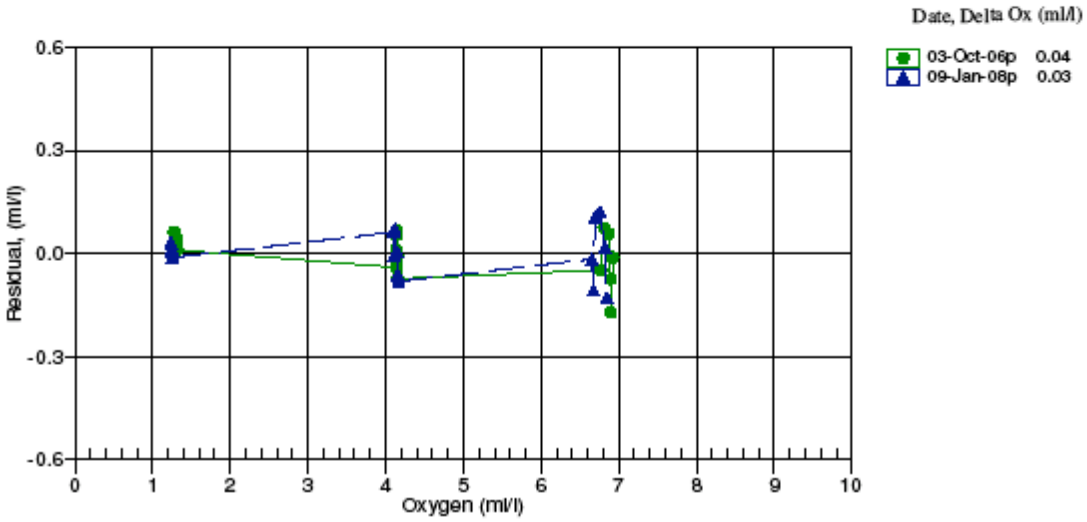
SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS
Soc = 0.4624
Boc = 0.0000
Voffset = -0.5013

TCor = 0.0022
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)
1.23	20.00	0.01	0.912	1.26	0.03
1.24	26.00	0.01	0.950	1.24	0.01
1.24	12.00	0.01	0.856	1.27	0.03
1.24	2.00	0.00	0.774	1.23	-0.01
1.24	6.00	0.00	0.809	1.25	0.01
1.26	30.00	0.02	0.981	1.25	-0.01
4.09	20.00	0.01	1.855	4.16	0.06
4.11	26.00	0.01	1.978	4.10	-0.01
4.12	12.00	0.01	1.672	4.19	0.07
4.14	6.00	0.00	1.519	4.15	0.00
4.15	30.00	0.02	2.068	4.08	-0.06
4.16	2.00	0.00	1.410	4.08	-0.08
6.65	26.00	0.01	2.894	6.64	-0.02
6.67	30.00	0.02	3.019	6.56	-0.11
6.69	20.00	0.01	2.716	6.80	0.11
6.76	12.00	0.01	2.425	6.88	0.12
6.82	6.00	0.00	2.179	6.84	0.02
6.85	2.00	0.00	1.998	6.72	-0.13

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



Fluorometer

3-06

PO Box 518
620 Applegate St.
Philomath OR 97370

WET Labs

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

Chlorophyll Fluorometer Characterization

Date:	**10/16/06**
Serial #:	AFL-016D
Job#:	0102007
Tech:	K.C

Dark Counts	**0.221 volts**
CEV	**2.643 volts**
SF	**10.3220**
FSV	**5.45 volts**
Linearity:	**0.999 R^2 (0–1.5 volts)**
	0.995 R^2 (0– 5.45 volts)

Notes:

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

CEV is the chlorophyll equivalent voltage. This value is the signal output of the fluorometer when using a fluorescent proxy that has been determined to be approximately equivalent to **25 µg/l** of a *Thalassiosira weissflogii* phytoplankton culture.

SF is the scale factor used to derive chlorophyll concentration from the signal voltage output of the fluorometer. The scale factor is determine by using the following equation: SF = (25) / (CEV – dark) e.g.(25 / (2.865 – 0.238) = 9.516)

FSV is the maximum signal voltage output that the fluorometer is capable of.

Chlorophyll concentration expressed in µg/l (mg/m^3) can be derived by using the following equation: (µg/l) = (Vmeasured – dark) * SF

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

Transmissometer

PO Box 518
620 Applegate St.
Philomath, OR 97370

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

WET Labs

C-Star Calibration

Date	July 27, 2007	Customer	National Science Foundation	Work order	002
Job #	0507014	S/N#	CST-889DR	Pathlength	25 cm

	Analog meter
V_d	0.060 V
V_{air}	4.837 V
V_{ref}	4.727 V

Temperature of calibration water	24.8 °C
Ambient temperature during calibration	26.1 °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.

Revision G 3/5/07

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: 0924
CALIBRATION DATE: 08-Feb-08

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

GHIJ COEFFICIENTS

g = -3.99880123e+000
h = 5.35233098e-001
i = -6.08493661e-004
j = 6.02492716e-005
CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

ABCDM COEFFICIENTS

a = 1.52749656e-006
b = 5.33164471e-001
c = -3.99240917e+000
d = -8.24862314e-005
m = 5.1
CPcor = -9.5700e-008 (nominal)

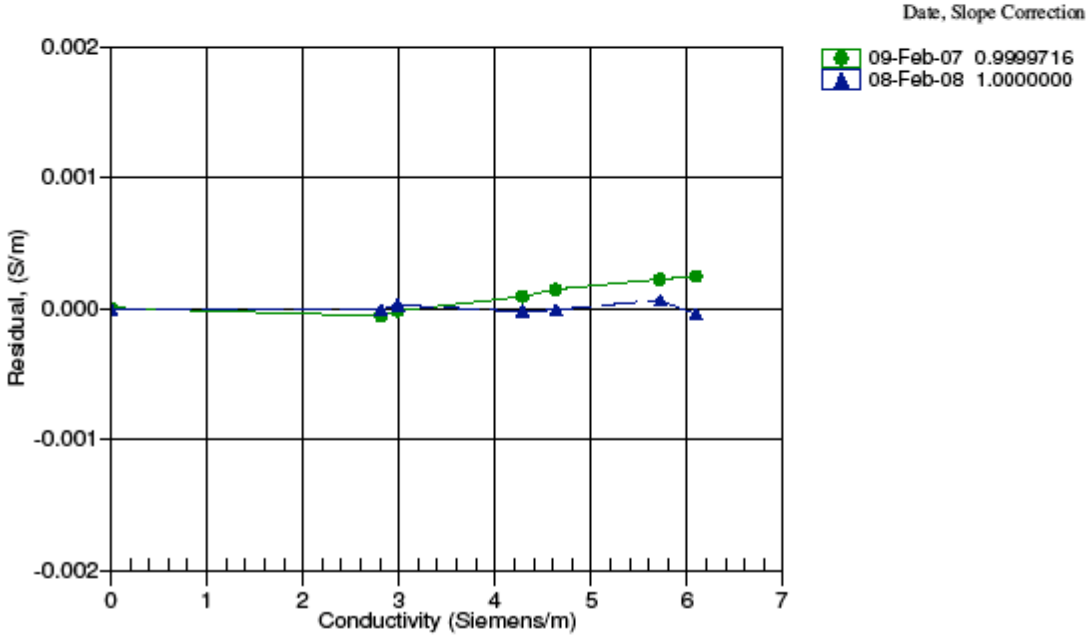
BATH TEMP (ITS-90)	BATH SAL. (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.73644	0.00000	0.00000
-1.0000	34.9363	2.81334	7.75607	2.81333	-0.00001
1.0000	34.9359	2.98521	7.96036	2.98524	0.00003
15.0000	34.9369	4.28484	9.35940	4.28481	-0.00002
18.5000	34.9367	4.63261	9.69899	4.63260	-0.00001
29.0001	34.9319	5.71913	10.68898	5.71919	0.00006
32.5000	34.9226	6.09242	11.00788	6.09238	-0.00004

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

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

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

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



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: 1799
CALIBRATION DATE: 26-Jun-07

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

GHIJ COEFFICIENTS

g = -4.14718079e+000
h = 5.02993735e-001
i = -7.41116121e-004
j = 6.06738981e-005
CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

ABCDM COEFFICIENTS

a = 3.31458743e-007
b = 5.00214174e-001
c = -4.13736503e+000
d = -8.03898748e-005
m = 5.6
CPcor = -9.5700e-008 (nominal)

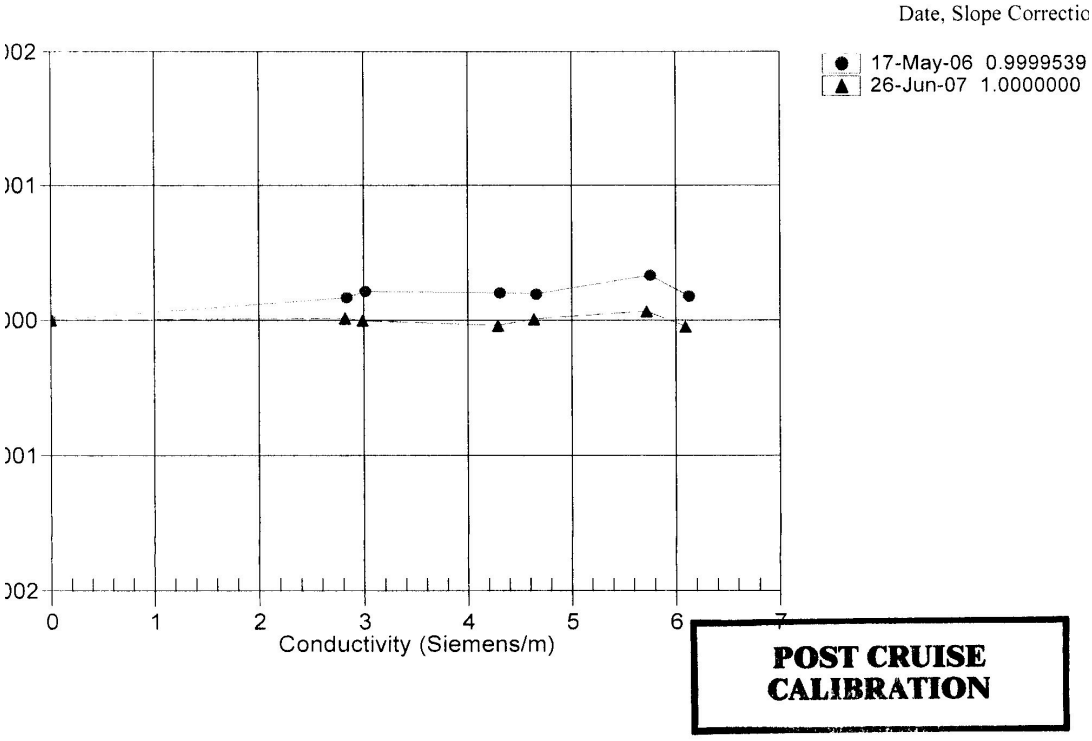
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.87607	0.00000	0.00000
-1.0002	34.9338	2.81314	8.02710	2.81315	0.00001
0.9999	34.9342	2.98507	8.23768	2.98507	-0.00000
14.9999	34.9346	4.28458	9.68025	4.28454	-0.00004
18.4999	34.9334	4.63221	10.03042	4.63222	0.00001
28.9999	34.9290	5.71868	11.05167	5.71875	0.00007
32.4999	34.9217	6.09227	11.38092	6.09223	-0.00005

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

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

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

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



POST CRUISE CALIBRATION