Data Report NBP0602

McMurdo to Punta Arenas Geophysical Transit
3 Feb – 22 Feb, 2006

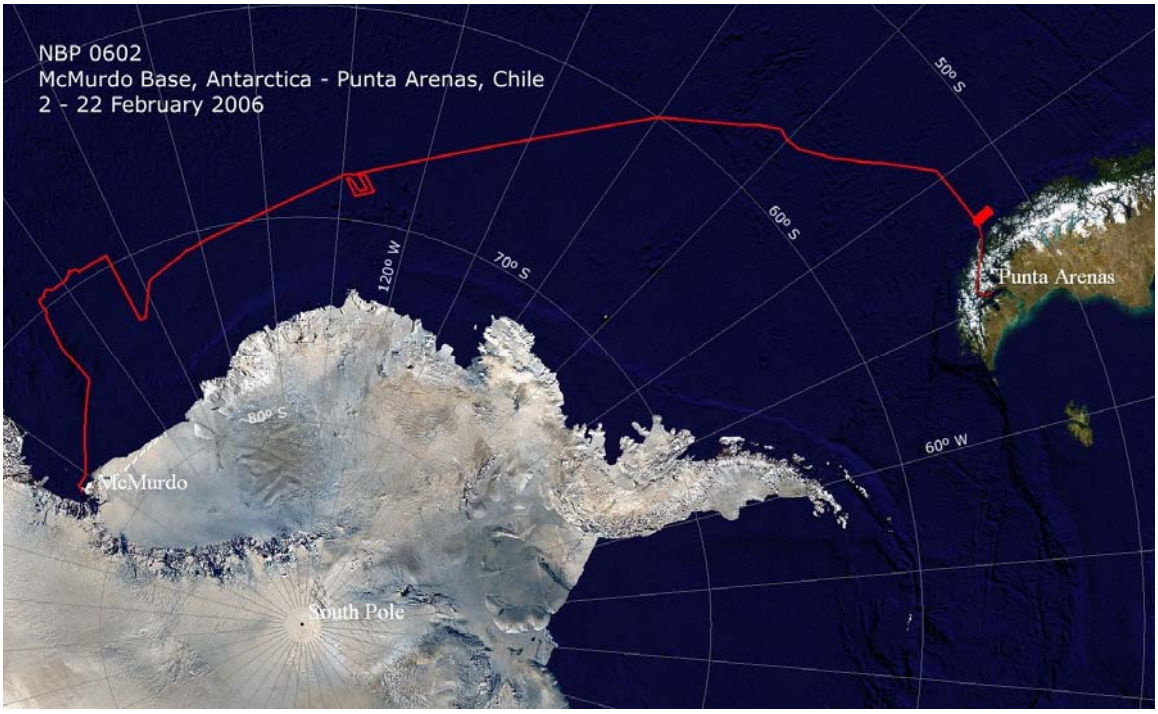

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Table of Contents

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 media 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.

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 file(s) from the archive (on Unix or Mac):

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

To extract the files on Windows, install the included 7-zip program (in /other/7zip.exe).

On Windows, postscript files (.ps) may be viewed using the "ghostview" program (installer in /other/gsview.exe)

Distribution Contents at a Glance

NBP0602.gmt
NBP0602B.gmt
NBP0602.mgd
NBP0602.hdr
NBP0602.trk
0602data.pdf
0602data.doc
602track.jpg
instcoef.txt
scirep.pdf
inst_1.txt

adcp/	adcpproc.tgz
imagery/	images.tar
ocean/	0602xbt.tar
process/	0602JGOF.tar
	0602MGD.tar
	0602PROC.tar
	0602PCO2.tar
	0602QC.tar
sub_btm/	602knud.tar
rvdas/nav/	0602adcp.tar
	0602gp02.tar
	0602gyr1.tar
	0602PCOD.tar
	0602seap.tar
	0602sp2a.tar
	0602trax.tar
rvdas/uw/	0602mag1.tar
	0602eng1.tar
	0602flr1.tar
	0602grv1.tar
	0602knud.tar
	0602mbdp.tar
	0602met1.tar
	0602pco2.tar
	0602pguv.tar
	0602svp1.tar
	0602tsg1.tar

Distribution Contents

Cruise Information

NBP0602 departed McMurdo Antarctica on February 2, 2006.

We had TSG problems on julian day 045 and the sensor was changed. Therefore there are two sets of coefficients in the data distribution and two sets of TSG cal sheets in this document.

Gravity notes

The NBP did not pull up to the McMurdo ice pier at the beginning of the cruise. The gravity tie used for NBP0602 was done at the end of NBP0601 while the NBP was tied up at the ice pier in McMurdo. A chronology of events follows;

Jan 30th NBP0601 finishes, NPB docks at McMurdo. Gravity tie done near ice pier.

Jan 30th – Feb 2nd NBP0601 continued as NBP0601A. Gravity offset was not applied because we did not close out the previous cruise and start a separate cruise for NBP0601A

Feb 2nd NBP0601A ended and a new cruise was started for NBP0602. The gravity offset from Jan 30th was applied at this point. Gravity, navigation and bathymetry from NBP0601A was appended to the start of the NBP0602 data set to correctly start the MGD77 file.

Feb 9th We discovered that the gravity offset that we applied on Feb 2 was incorrect. The correct gravity offset was entered and all gravity data was reprocessed. We also discovered that the gravity offset had been applied incorrectly on the previous 2 cruises (NBP0508 and NBP0601). We will re-process those cruises at the end of 0602.

We lost the magnetometer when it snagged on brash ice on day 036.

Someone on a previous cruise had adjusted the sound speed velocity on the Knudsen to 1452m/s. This instrument is usually run in an uncalibrated mode (1500m/s). We also discovered that the network time daemon on the Knudsen was not functioning and all the time stamps are about 20 minutes off. See the SciRep.pdf file on this disk for more details.

There was a brief event on day 049 where the seawater intake system had problems and we had to shut down the TSG, PCO2 and Flurormeter. The system was repaired by the end of day 049.

There is data on the distribution disk from the last CTD of the previous cruise. This data was used to create our initial Sound Velocity Profile (SVP).

The sub-bottom data from the Knudsen is in the directory /sub_btm/602knud.tar. Software for viewing this data is available from Knudsen.

The file 602_log.xls is a microsoft Xcel spreadsheet of the watch-standers log.

The file inst_1.txt is a copy of the instruments coefficient file used on the first half of the cruise with the original TSG.

Cruise Track

The distribution DVD includes a GMT cruise track file (NBP0602.trk). It contains the longitude and latitude at one-minute intervals extracted from the NBP0602.gmt file.

Satellite Images

Satellite Images processed for this cruise can be found in the directory, /imagery in two files, ice.tar and wx.tar (weather). Files are named using the convention, IdDDDYYA.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

Science Reports

Cruise science reports will be found in the file /scirep.tar

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 0602proc.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 itvessel@usap.gov.

JGOFS

The JGOFS data set can be found on the distribution media in the file /process/0602JGOF.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

Field	Data	Units
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 NBP0602.mgd. The file NBP0602.gmt is created from the MGD77 dataset using the "mgd77togmt" utility. NBP0602.gmt can be used with the GMT plotting package. The file NBP0602B.gmt is the same file as NBP0602.gmt in big endian format.

The file NBP0602.hdr is an MGD77 header file in the standard MGD77 format

The data used to produce the NBP0602.mgd file can be found on the distribution media in the file /process/0602proc.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
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

Col	Len	Type	Contents	Description, Possible Values, Notes
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 up to 1200 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.

The processed ADCP dataset is included on the distribution media under /adcp/adcpproc.tar. Raw files are not included on this media due to size constraints.

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 `0602adcp.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 `0602pco2.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

There were no CTDs done on NBP0602, there is however a single cast of CTD data included on this distribution. That CTD was done on the previous cruise and the data used to make our initial sound velocity profile.

The ctd data has been placed in the tar file /`ocean/0602ctd.tar`. The archive contains tar files `0602proc.tar`.

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. 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: `NBP0107.met1.d317`

- The CruiseID is the numeric name of the cruise, in this case, NBP0602.
- 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	Eppley PIR
PSP (SW radiation)	met1	continuous	1 sec	Eppley PSP
PAR	met1	continuous	1 sec	BSI QSR-240
GUV	guv	continuous	2 sec	BSI PUV-2511
PUV	puv	not collected		BSI PUG-2500

Geophysics

Measurement	Channel ID	Collect. Status	Rate	Instrument
Gravimeter	grv1	continuous	10 sec*	LaCoste & Romberg
Magnetometer	mag1	collected (see cruise notes)	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
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

* This channel is reference layer velocity only – ADCP logging is separate from RVDAS.

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 sent from instruments to 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 0959.6 000.2 093.1

-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	
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	

Field	Data	Format / Possible Values	Units
		PO5 = -24dB PO6 = -30dB PO6 = -30 dB 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

Simrad EK500 (sim1)

```
00+005:00:00:52.388 D1,23583509,1479.6, 17,  1,  0
```

Field	Data	Units
1	RVDAS time tag	
2	Header	
3	Time tag	hhmmss.sss
4	Depth	m
5	Bottom surface backscattering strength	dBar
6	Transducer number (1 = 38 kHz)	
7		

Thermosalinograph (tsg1)

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

Field	Data	Units
1	RVDAS time tag	
2	Seabird hex string (see page 21 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

```
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

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
15	DGPS reference station ID (0000-1023)	

Field	Data	Units
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
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)	
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

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
4	Rate of change SYYY S = +/-, YYY = r.rr	
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
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

Field	Data	Units
1	RVDAS time tag	
2	PCO_2 time tag (decimal is time of day)	yyyddd.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 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\} - 273.15$ (°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 Fluorometry Voltage

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

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 ^{2}sec)
offset (V_{dark}) = 0.1 mV
(*raw* mV - V_{dark})/scale x 10^4 cm^2/m^2 x 10^{-3} V/mV= μEinstiens/m^2sec

PIR

raw data = mV

calibration scale = 4.09 x 10^{-6} V/(W/m^2)
data mV / (scale x 10^3 mV/V) = W/m^2

PSP

raw data = mV
calibration scale = 7.94 x 10^{-6} V/(W/m^2)
data mV / (scale x 10^3 mV/V) = W/m^2

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
033:10:24		NBP0602 Run New_Cruise on fram start NBP0602
033:15:34	033:15:34	Restart RV_TSG had to be restarted in order to use the new TSG coefficients entered in when New_Cruise was run
034:14:05	034:14:37	Uwint problems start. Problem is later determined to be noisy maggy data causing causing uwint to crash.
034:15:01		ET starts working on Maggie to clean up the data.
035:		Maggie problems traced to short in a connection. Maggie fixed
036:02:30		Maggie caught on brash ice. Maggie lost
043:18:27		Power to PcO2 system is lost. Some data lost
045:16:43		Replace TSG
045:	Note	We discovered that on NBP0508 at an undetermined time someone set the sound speed on the Knudsen to be 1452m/sec. Since we claim all Knudsen data to be measured at 1500m/sec this is a problem. We will be sending notices to members of NBP0508 and 0601
048:17:49		Enter Chilean EEZ
049:00:50		GUV The guv started flaking out on day 46 and we finally just turned it off on day 049.
049:18:00	049:23:50	We developed a problem in the seawater intake system. There is a bubble separator down in the hold and it developed a leak. We had to shut down all seawater systems (TSG, Fluorometer and PCO2) until it was fixed.

*Appendix: Sensors and Calibrations

NBP0602 Sensors:

Shipboard Sensors

Sensor	Description	Serial #	Last Calibration Date	Comments
Meteorology & Radiometers				
Port Anemometer	RM Young 5106	WM46262	8/7/05	Port side installed 8/7/05
Stbd Anemometer	RM Young 5106	WM51143	10/22/05	Stbd side installed 10/22/05
Barometer	RM Young 61201	01706	04/23/05	Installed 04/23/05
Humidity/Wet Temp	RM Young 41372LC	06135	4/23/05	Installed 4/23/05
PIR (Pyrgeometer)	Eppley PIR	32845F3	5/31/05	Installed 7/16/05
PSP (Pyranometer)	Eppley PSP	32850F3	6/1/05	Installed 7/16/05
PAR (Mast)	BSI-QSR-240	6356	05/16/05	Installed 7/16/05
GUV (Mast)	BSI GUV-2511	25110203114	09/07/05	Installed 10/23/05
PUV (Underwater)	BSI PUV-2500	25000203114	09/07/05	Installed 11/1/05
PRR (Mast)	BSI PRR-610	9696	01/09/04	Not installed
PRR (Underwater)	BSI PRR-600	9696	01/09/04	Not installed
Underway				
TSG (start of cruise)	SeaBird SBE21	0857	06/15/05	Installed 2/02/06
TSG (installed on jd045)	SeaBird SBE21	1390	03/12/05	Installed 2/14/06
TSG Remote Temp	SeaBird 3-01/S	1497	11/10/05	Installed 2/02/06
Fluorometer	Turner 10-AU-005	5333-FRXX	N/A	Installed 4/14/04
Transmissometer	WET Labs C-Star	CST-557DR	04/07/05	Installed 9/16/05
Magnetometer	EG&G G-877			Lost
Gravimeter	LaCoste & Romberg Gravity Meter	S-36	n/a	Gravity Tie 12/12/05
Bathymetry	Simrad EK500	3001	n/a	Not used
Bathymetry	Knudsen 320B/R	K99394	n/a	Used
Bathymetry	Bathy 2000	2329	n/a	Not used

NBP0601 CTD Sensors (used in initial SVP)

Sensor	Description	Serial #	Last Calibration Date	Comments
CTD Fish	SeaBird model SBE 9+	09P7536-0328	04/18/05	Installed on 10/28/05 on 30L Rosette
CTD Fish Pressure	Paroscientific model 410K-105 pressure sensor	53980	04/18/05	Installed on 10/28/05 on 30L Rosette
CTD Deck Unit	SeaBird model SBE 11+	11P19858-0490	n/a	
Primary Temperature Sensor	SeaBird model 3-02/F	031238	3/18/05	
Secondary Temperature Sensor	SeaBird model 3-02/F	03P299	3/15/05	
Primary Conductivity Sensor	SeaBird model 4-02/0	040924	1/25/05	
Secondary Conductivity Sensor	SeaBird model 4C	041314	1/25/05	
Dissolved Oxygen Sensor	SeaBird model SBE43	430150	2/2/05	Removed after test cast 00
Dissolved Oxygen Sensor	SeaBird model SBE43	430139	12/3/05	Installed after test cast 00
PAR Sensor	Biospherical Instruments QSP-2300	4469	3/18/05	
Transmissometer	WET Labs C-Star	CST-889DR	08/08/05	
CTD Pump (Primary)	SeaBird 5T, PN 90160	051642 3.0K	12/01/04	
CTD Pump (Secondary)	SeaBird 5T, PN 90160	051645 3.0K	01/10/04	
Bottom Contact Switch	SeaBird	#1	n/a	
Altimeter	OIS 6000 (6000m)	5117	n/a	New battery installed 10/30/05
Carousel Water Sampler	SeaBird SBE-32	3214153-0140	n/a	Installed 10/25/05 on 30L Rosette

Calibrations

The following pages are calibration sheets for 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: 1/30/2006
Location: McMurdo Station, Antarctica
Station: Thiel Base Station
Latitude: 77 deg 50' 55.9068" S
Longitude: 166 deg 40' 45.9629" E
Elevation: 46.21 meters
Gravity: 982970.52

Reference Code Numbers:

	Value	Time (GMT)
Ship's meter before gravity tie (Gravity (cu))	10618.9	6:55
Ship's meter after gravity tie (Gravity (cu))	10618.8	8:26
Average	10618.9	
Ship Gravimeter's Calibration Constant	1.0046	
Corrected ship's meter (QC Grav (mgal))	10667.7	

	Value	Time (GMT)
Ship's meter before gravity tie (serial, RVDAS)	10618.9	7:00
Ship's meter after gravity tie (serial, RVDAS)	10618.8	8:27
Average (for comparison check only)	10618.9	

Portable Gravimeter Correction Divisor 1.007937

Station	Value	Time (GMT)	Temp	Date	OBS mgal, averaged
Pier measurement 1	6549.78	7:11	53.5	January 30, 2006	
Pier measurement 2	6549.78	7:13	53.5	January 30, 2006	6498.20
Pier measurement 3	6549.78	7:15	53.5	January 30, 2006	
Average	6549.78				
Station measurement 1	6542.72	7:48	53.5	January 30, 2006	
Station measurement 2	6542.71	7:49	53.5	January 30, 2006	6491.20
Station measurement 3	6542.73	7:51	53.5	January 30, 2006	
Average	6542.72				
Pier measurement 4	6549.88	8:11	53.5	January 30, 2006	
Pier measurement 5	6549.91	8:12	53.5	January 30, 2006	6498.32
Pier measurement 6	6549.89	8:13	53.5	January 30, 2006	
Average	6549.89				

Gravity offset from last tie 972311.94
Drift since last tie -2.06

OBS Differences

Station to Pier (1, 2, & 3 averaged)	7.00
Station to Pier (4, 5, & 6 averaged)	7.12
Averaged Differences	7.06
Gravity at pier	982977.58
Elevation of pier above gravimeter, meters	0.0
Earth differential gravity, mgal/meter	0.3
Gravity at ship's gravimeter	982977.58
Gravity Offset	972309.88

Comments

Gravity tie completed by Sheldon Blackman and Patrick Rowe at Mcmurdo/Theil base station (inside building 149). The pier measurements were taken just across the bridge (on the solid land side) from the McMurdo Ice Pier. The ship was located at the ice pier (approximate distance from ship was 80 m). This was done due to unstable readings on the ice pier itself (next to the ship).

Meteorology System

Anemometer (Port)

RM Young Anemometer Calibration, Model 05106

S/N: 46262 **Date:** 12-Dec-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	4.9	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	34.7	-0.4	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	59.5	-0.7	114.2

Direction	Measured Direction	Delta Direction
0	1	0
30	30	0
60	60	0
90	89	1
120	119	1
150	149	1
180	179	1
210	210	0
240	241	-1
270	272	-2
300	302	-2
330	332	-2
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	0.0	0.0
200	0.98	0.9	0.1
500	2.45	2.3	0.2
1000	4.90	4.9	0.0
1500	7.35	7.3	0.0
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	44.7	-0.6
10000	49.00	49.8	-0.8
12000	58.80	59.7	-0.9

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 BEARINGS AND PROPELLER SHAFT. TESTED OKAY

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: 51143 **Date:** 07-Oct-05 **Cal'd By:** J. Lenorovitz

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	2.35	0.10	4.8
1000	4.90	4.85	0.05	9.5
1500	7.35	7.35	0.00	14.3
2000	9.80	9.80	0.00	19.0
3000	14.70	14.75	-0.05	28.6
4000	19.60	19.75	-0.15	38.1
5000	24.50	24.70	-0.20	47.6
6000	29.40	29.65	-0.25	57.1
7000	34.30	34.65	-0.35	66.6
8000	39.20	39.60	-0.40	76.2
9000	44.10	44.55	-0.45	85.7
10000	49.00	49.50	-0.50	95.2
12000	58.80	59.35	-0.55	114.2

Direction	Measured Direction	Delta Direction
0	0	0
30	30	0
60	60	0
90	90	0
120	120	0
150	150	0
180	180	0
210	208	2
240	239	1
270	269	1
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	0.00	0.00
200	0.98	0.85	0.13
500	2.45	2.35	0.10
1000	4.90	4.85	0.05
1500	7.35	7.35	0.00
2000	9.80	9.75	0.05
3000	14.70	14.75	-0.05
4000	19.60	19.75	-0.15
5000	24.50	24.70	-0.20
6000	29.40	29.65	-0.25
7000	34.30	34.65	-0.35
8000	39.20	39.55	-0.35
9000	44.10	44.55	-0.45
10000	49.00	49.50	-0.50
12000	58.80	59.35	-0.55

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

No repairs or adjustments needed. Unit was spot on from the drawer.

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

PIR

THE EPPLEY LABORATORY, INC.
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STANDARDIZATION OF EPPLEY PRECISION INFRARED RADIOMETER Model PIR

Serial Number: 32845F3

Resistance: 739 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 25 °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:

4.09 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.

Shipped to:
National Science Foundation
Port Hueneme, CA

S.O. Number: 60312
Date: June 13, 2005

Date of Test: May 31, 2005

In Charge of Test: R. T. Eppley

Reviewed by: Thomas D. Kuh

Remarks:

PSP

THE EPPLEY LABORATORY, INC.
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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 constant). The adopted calibration temperature is 25 °C.

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

7.94 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 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/ft^2-hr^{-1} = 3.153 watts meter^{-2}

Shipped to:
National Science Foundation
Port Hueneme, CA

Date of Test: June 1, 2005

In Charge of Test: R. T. Eppley

S.O. Number: 60311
Date: June 13, 2005

Reviewed by: Thomas D. Kuhl

Remarks:

GUV

Biospherical Instruments Inc.

GUV-2511 Calibration Certificate

System Serial Number	2511	Date of Calibration	9-07-05
Calibration database	25110203114v3.mdb	Date of Certificate	9/8/2005
DASSN	0069	Standard of Spectral Irradiance	99188
Microprocessor Tag Number	4	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	2.4952E-10	2.5451E-05	7.4358E-03	2.3469E+00	-1.5175E-04	-1.5535E-04	6.9831E-05	µW/(cm²nm)
Ed0340	6	340	1.9286E-10	1.9671E-05	5.7471E-03	1.9715E+00	1.1280E-04	1.1544E-04	9.0091E-04	µW/(cm²nm)
Ed0313	8	313	2.3926E-10	2.4405E-05	7.1299E-03	2.5028E+00	8.0291E-04	7.8935E-04	-1.4998E-03	µW/(cm²nm)
Ed0305	10	305	1.2875E-11	1.3133E-06	3.8368E-04	1.3188E-01	2.2863E-04	2.3016E-04	8.0871E-04	µW/(cm²nm)
Ed0380	12	380	8.2108E-11	8.3750E-06	2.4468E-03	7.8480E-01	2.1481E-04	2.0369E-04	-2.9957E-04	µW/(cm²nm)
Ed0395	18	400-700	2.9626E-10	3.0218E-05	8.8284E-03	2.7907E+00	2.6231E-04	2.6299E-04	1.1499E-03	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	0	1.7094E-05	1.7436E+00	5.0941E+02	1.8003E+05	4.1797E-04	4.1364E-04	-6.9777E-04	µE/(cm²sec)

Auxilliary Channels	Address	Wavelength	Responsivity	ScaleS	ScaleM	ScaleL	OffsetS	OffsetM	OffsetL	Measurement Units
Ed0Temp	22	0	1.0000E+00	1.0000E-02	1.0000E-02	1.0000E-02	0.0000E+00	0.0000E+00	0.0000E+00	C
Ed0Vin	27	0	1.0000E+00	-2.5000E-01	-2.5000E-01	-2.5000E-01	0.0000E+00	0.0000E+00	0.0000E+00	V

Calibration Data – Do Not Destroy

page 2 of 2

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 (2 Feb to 14 Feb)

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: 0857
CALIBRATION DATE: 15-Jun-05

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

GHIJ COEFFICIENTS

```
g = -3.88827790e+000
h =  4.63839825e-001
i =  1.21272420e-003
j = -3.25957131e-005
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  4.62494433e-002
b =  4.14335811e-001
c = -3.87580303e+000
d = -1.33073281e-004
m =  2.1
CPcor = -9.5700e-008 (nominal)
```

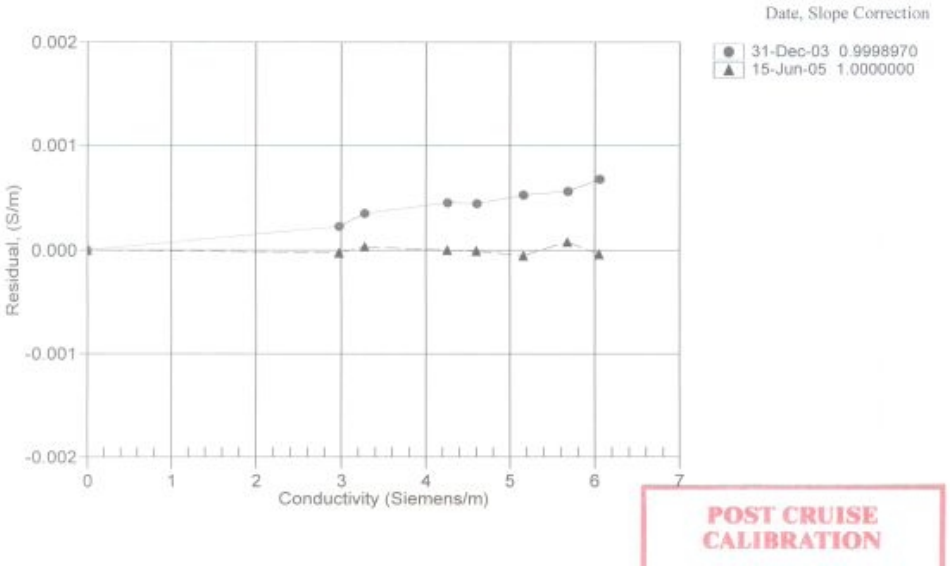
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2.88529	0.00000	0.00000
0.9999	34.7397	2.97003	8.43797	2.97001	-0.00002
4.4999	34.7203	3.27655	8.81242	3.27659	0.00003
15.0000	34.6773	4.25636	9.91374	4.25636	0.00000
18.5000	34.6682	4.60083	10.27264	4.60083	-0.00001
24.0000	34.6581	5.15769	10.82741	5.15763	-0.00005
29.0000	34.6528	5.67854	11.32171	5.67863	0.00008
32.5000	34.6500	6.05026	11.66138	6.05022	-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



POST CRUISE CALIBRATION

Underway Temperature Sensor (2 Feb to 14 Feb)

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: 0857
CALIBRATION DATE: 15-Jun-05

SBE21 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS

g = 4.24087901e-003
h = 5.99013561e-004
i = 4.31107264e-006
j = -1.85065401e-006
f0 = 1000.0

ITS-68 COEFFICIENTS

a = 3.64763853e-003
b = 5.84965792e-004
c = 9.89153582e-006
d = -1.85016963e-006
f0 = 2720.074

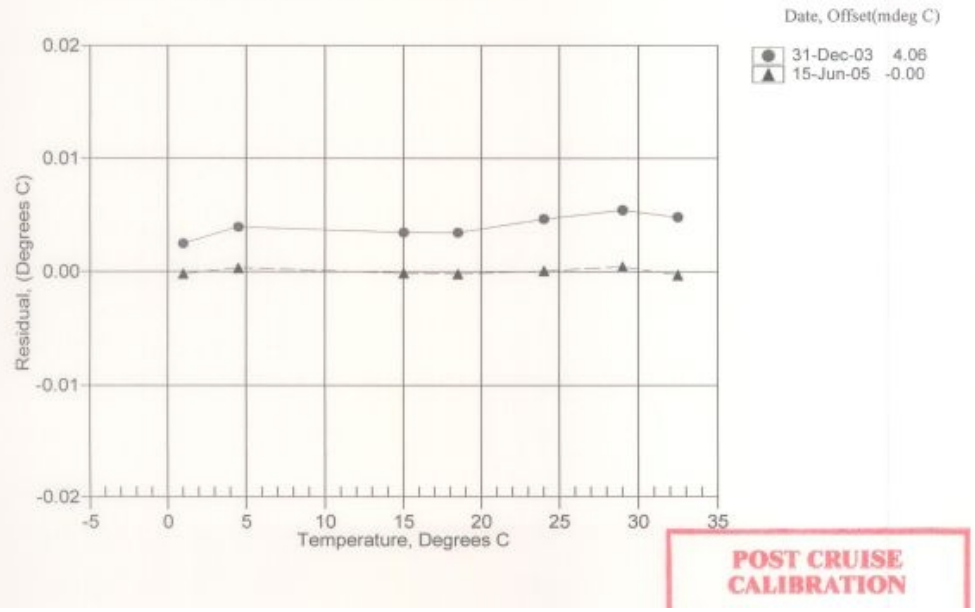
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	2720.074	0.9997	-0.00019
4.4999	2942.916	4.5003	0.00033
15.0000	3688.995	14.9999	-0.00014
18.5000	3964.874	18.4997	-0.00021
24.0000	4427.351	24.0000	0.00006
29.0000	4879.567	29.0004	0.00044
32.5000	5214.642	32.4997	-0.00029

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 Conductivity (14 Feb to end of cruise)

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: 1390
CALIBRATION DATE: 12-Mar-05

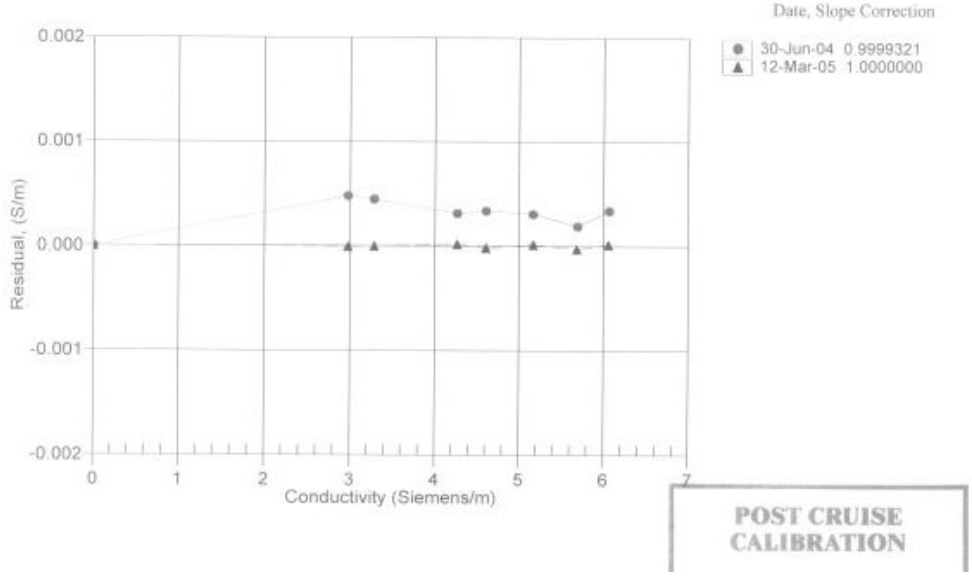
SBE21 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS
g = -3.93226726e+000
h = 4.70569719e-001
i = 6.34631789e-004
j = -9.87772523e-006
CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

ABCDM COEFFICIENTS
a = 4.43616567e-003
b = 4.64684698e-001
c = -3.92316496e+000
d = -8.75063759e-005
m = 2.4
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	2.88539	0.00000	0.00000
0.9999	34.7900	2.97392	8.41759	2.97392	-0.00000
4.5000	34.7690	3.28070	8.79114	3.28070	-0.00000
14.9999	34.7244	4.26152	9.89031	4.26154	0.00002
18.5000	34.7146	4.60633	10.24842	4.60632	-0.00002
24.0000	34.7039	5.16375	10.80209	5.16377	0.00001
29.0000	34.6989	5.68525	11.29521	5.68522	-0.00003
32.5000	34.6969	6.05752	11.63436	6.05754	0.00002

Conductivity = $(g + hf^2 + if^3 + jf^4) / 10(1 + \delta t + \varepsilon p)$ Siemens/meter
Conductivity = $(af^m + bf^2 + c + dt) / [10 (1 + \varepsilon p)$ Siemens/meter
t = temperature[°C)]; p = pressure[decibars]; δ = CTcor; ε = CPcor;
Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



POST CRUISE CALIBRATION

Underway Temperature Sensor (2 Feb to end of cruise)

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: 1390
CALIBRATION DATE: 12-Mar-05

SBE21 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS
g = 4.21050756e-003
h = 5.95355230e-004
i = 4.97876949e-006
j = -1.73798388e-006
f0 = 1000.0

ITS-68 COEFFICIENTS
a = 3.64763867e-003
b = 5.81216773e-004
c = 9.98586302e-006
d = -1.73747972e-006
f0 = 2600.263

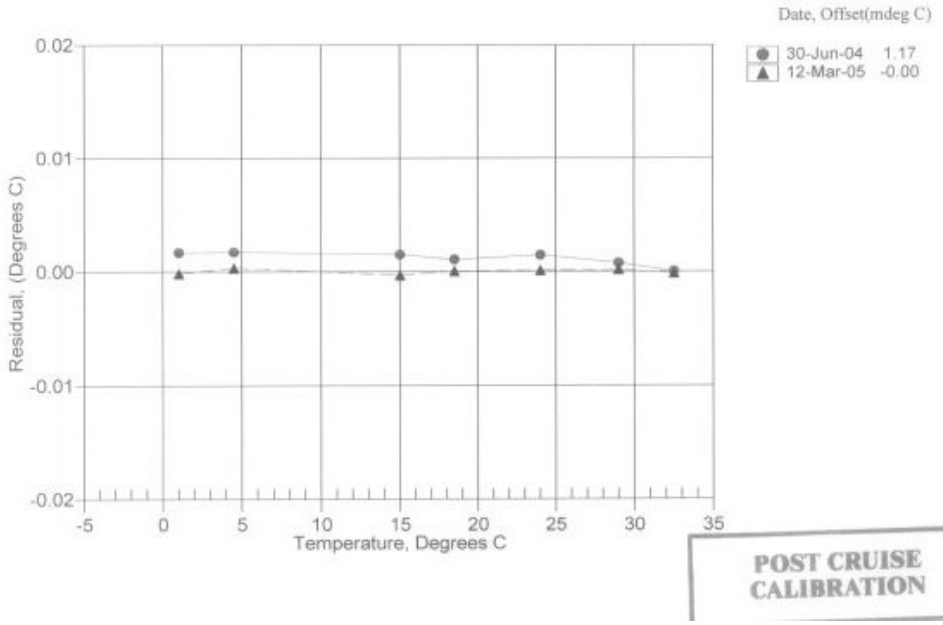
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	2600.263	0.9997	-0.00018
4.5000	2814.731	4.5003	0.00033
14.9999	3533.537	14.9996	-0.00033
18.5000	3799.663	18.5000	0.00004
24.0000	4245.995	24.0001	0.00012
29.0000	4682.732	29.0002	0.00018
32.5000	5006.584	32.4998	-0.00016

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 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: 1497
CALIBRATION DATE: 10-Nov-05

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS

g = 4.73766449e-003
h = 6.68793556e-004
i = 2.84645709e-005
j = 2.61326034e-006
f0 = 1000.0

ITS-68 COEFFICIENTS

a = 3.68121909e-003
b = 5.95381666e-004
c = 1.53096888e-005
d = 2.61478510e-006
f0 = 5372.992

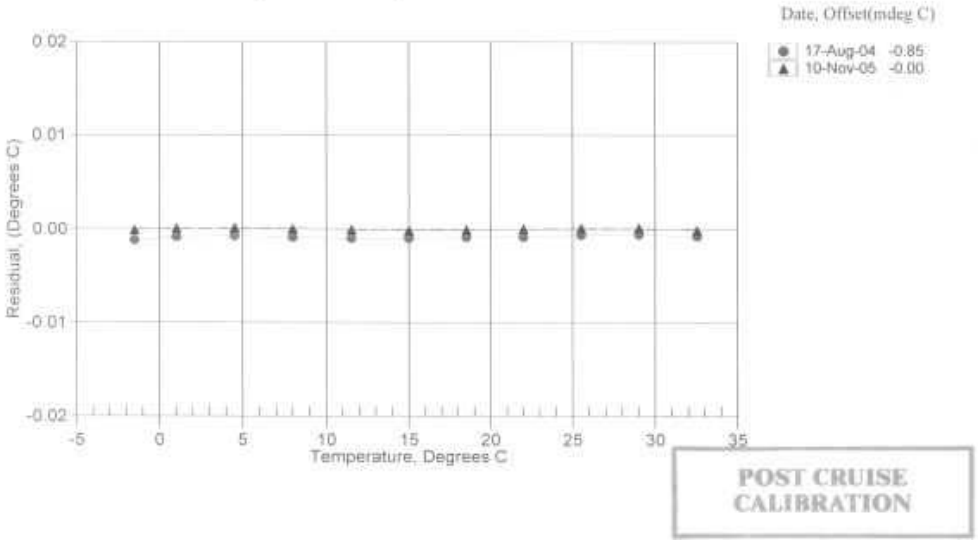
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5004	5372.992	-1.5005	-0.00010
0.9996	5685.203	0.9997	0.00008
4.4996	6144.063	4.4997	0.00010
7.9996	6628.986	7.9996	0.00004
11.4996	7140.671	11.4995	-0.00006
14.9996	7679.800	14.9995	-0.00015
18.4996	8247.050	18.4995	-0.00005
21.9996	8843.015	21.9996	0.00002
25.4996	9468.305	25.4997	0.00013
28.9996	10123.458	28.9997	0.00012
32.4996	10808.995	32.4995	-0.00013

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

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

WET Labs

C-Star Calibration

Date	April 7, 2005	Customer	Raytheon Polar Service Co.	Work order	005
Job #	0201020	S/N#	CST-557DR	Pathlength	25 cm

	Analog meter
V_d	0.060 V
V_{air}	4.851 V
V_{ref}	4.732 V

Temperature of calibration water	20.0 °C
Ambient temperature during calibration	23.4 °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.

cstarwkbkf1.xls Revision F 1/17/05

CTD (used for initial SVP only)

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: 0328
CALIBRATION DATE: 18-Apr-05

SBE9plus PRESSURE CALIBRATION DATA
10000 psia S/N 53980

DIGIQUARTZ COEFFICIENTS:

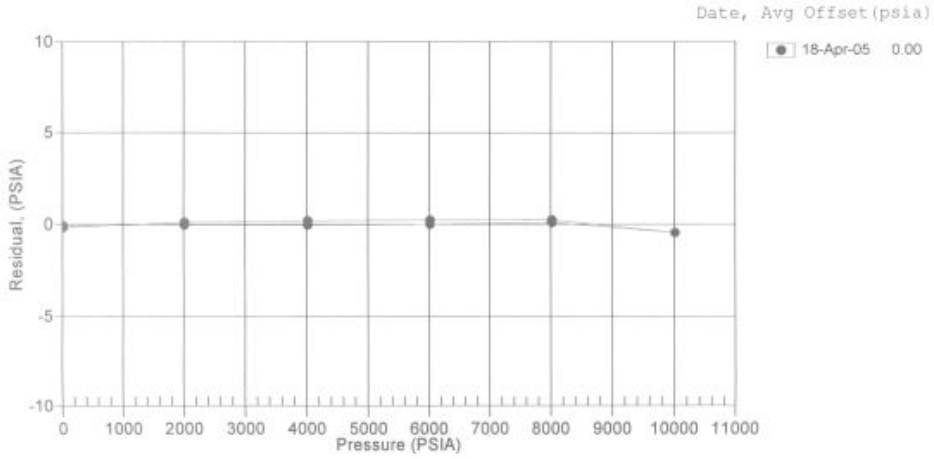
C1 =	-5.847002e+004
C2 =	6.910390e-001
C3 =	1.753360e-002
D1 =	4.241600e-002
D2 =	0.000000e+000
T1 =	3.026040e+001
T2 =	-1.938830e-004
T3 =	4.330190e-006
T4 =	2.020250e-009
T5 =	0.000000e+000

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



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: 1238
CALIBRATION DATE: 17-Mar-05

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS

g = 4.82467117e-003
h = 6.70736079e-004
i = 2.56763932e-005
j = 2.04860441e-006
f0 = 1000.0

ITS-68 COEFFICIENTS

a = 3.68121295e-003
b = 5.97998697e-004
c = 1.45649252e-005
d = 2.05000282e-006
f0 = 6124.788

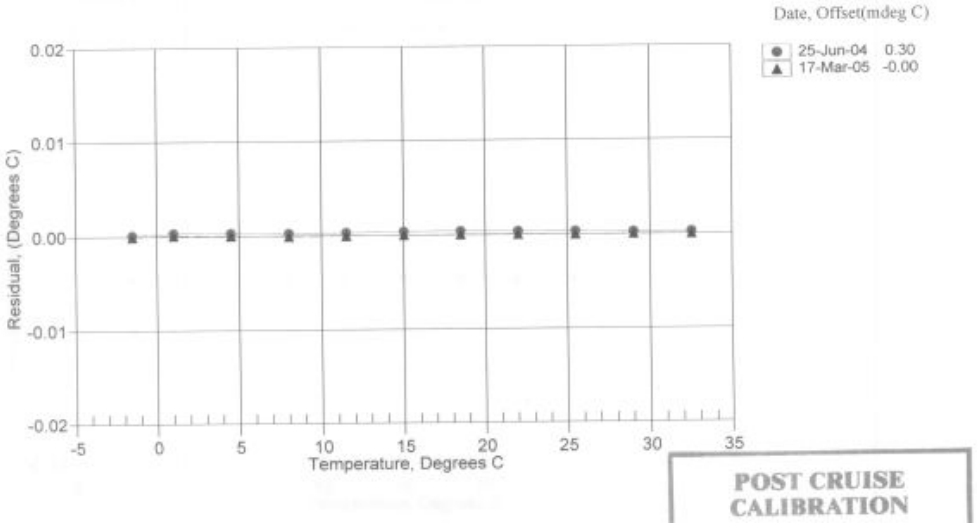
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	6124.788	-1.5000	-0.00005
1.0000	6479.042	1.0001	0.00007
4.5000	6999.449	4.5000	0.00003
8.0000	7549.130	8.0000	-0.00005
11.5000	8128.882	11.5000	-0.00003
15.0000	8739.449	15.0000	0.00001
18.5000	9381.550	18.5000	0.00001
22.0000	10055.895	22.0000	0.00002
25.5000	10763.157	25.5000	-0.00000
29.0000	11503.995	29.0000	0.00001
32.5000	12279.021	32.5000	-0.00001

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



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: 2299
CALIBRATION DATE: 15-Mar-05

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS

g = 4.33175714e-003
h = 6.43377305e-004
i = 2.32961654e-005
j = 2.22652027e-006
f0 = 1000.0

ITS-68 COEFFICIENTS

a = 3.68121019e-003
b = 6.02067823e-004
c = 1.63311774e-005
d = 2.22808596e-006
f0 = 2848.702

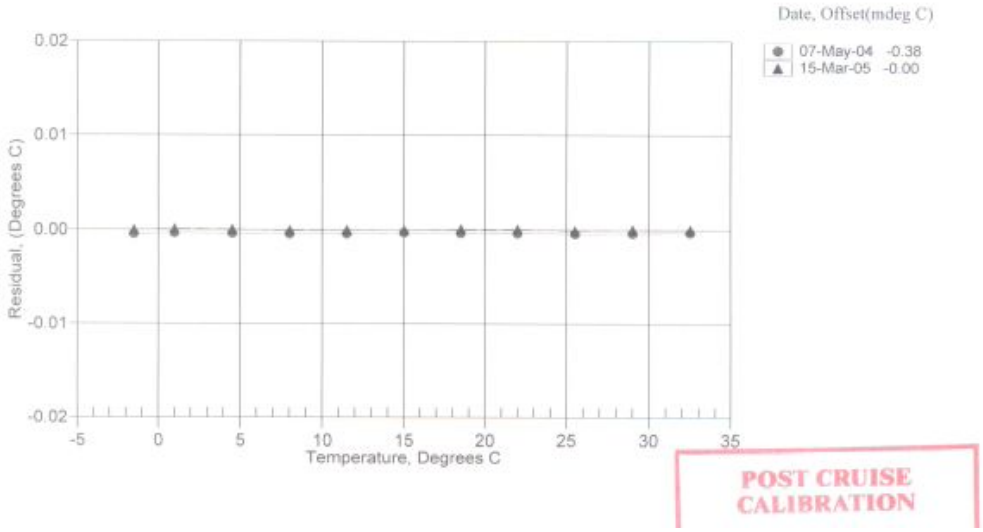
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.4998	2848.702	-1.4998	-0.00004
1.0002	3012.348	1.0003	0.00007
4.5002	3252.728	4.5002	0.00004
8.0002	3506.607	8.0001	-0.00008
11.5002	3774.367	11.5002	-0.00003
15.0002	4056.349	15.0002	-0.00000
18.5002	4352.900	18.5003	0.00007
22.0002	4664.341	22.0003	0.00005
25.5003	4990.995	25.5002	-0.00009
29.0002	5333.176	29.0002	0.00001
32.5003	5691.186	32.5003	0.00001

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

Dissolved Oxygen Sensor (replaced after test cast 00)

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: 0150
CALIBRATION DATE: 05-Feb-05p

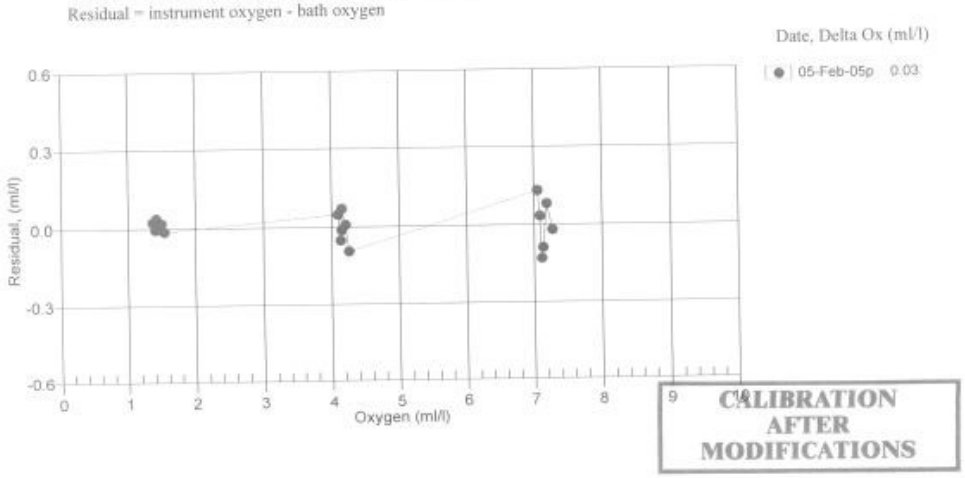
SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS
Soc = 0.4772
Boc = 0.0000
Voffset = -0.4792

TCor = 0.0003
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)
1.37	20.00	0.01	0.935	1.39	0.02
1.41	30.00	0.01	1.031	1.40	-0.01
1.42	12.00	0.01	0.882	1.45	0.04
1.43	26.00	0.01	1.006	1.43	0.00
1.49	6.00	0.00	0.842	1.51	0.02
1.54	2.00	0.00	0.810	1.53	-0.01
4.09	20.00	0.01	1.837	4.14	0.05
4.13	30.00	0.01	2.085	4.08	-0.05
4.14	26.00	0.01	1.996	4.13	-0.01
4.15	12.00	0.01	1.647	4.21	0.07
4.20	6.00	0.00	1.491	4.21	0.01
4.25	2.00	0.00	1.381	4.16	-0.09
7.06	12.00	0.01	2.471	7.19	0.13
7.09	6.00	0.00	2.190	7.12	0.03
7.11	2.00	0.00	1.992	6.98	-0.13
7.13	30.00	0.01	3.251	7.04	-0.09
7.19	20.00	0.01	2.862	7.26	0.08
7.27	26.00	0.01	3.142	7.25	-0.02

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 (installed after test cast 00)

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: 03-Dec-05p

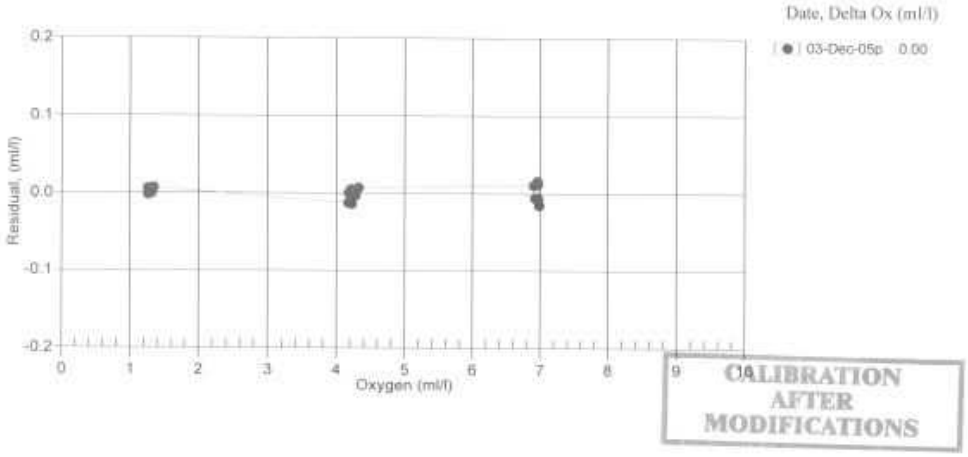
SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS
Soc = 0.3069
Boc = 0.0000
Voffset = -0.5980

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)
1.26	2.01	0.00	1.021	1.26	-0.00
1.26	12.00	0.00	1.135	1.27	0.01
1.26	6.00	0.00	1.067	1.27	0.00
1.30	20.00	0.00	1.244	1.30	-0.00
1.32	26.00	0.00	1.326	1.32	0.00
1.34	30.00	0.00	1.391	1.35	0.01
4.17	2.04	0.00	1.995	4.15	-0.01
4.18	6.00	0.00	2.147	4.18	-0.00
4.21	12.00	0.00	2.385	4.21	0.00
4.22	20.00	0.00	2.686	4.20	-0.01
4.27	26.00	0.00	2.954	4.27	-0.00
4.32	30.00	0.00	3.144	4.33	0.01
6.90	30.00	0.00	4.663	6.91	0.01
6.92	2.05	0.00	2.925	6.92	-0.01
6.96	6.00	0.00	3.183	6.97	0.02
6.97	12.01	0.00	3.561	6.98	0.01
6.93	26.00	0.00	4.441	6.97	-0.01
6.99	20.00	0.00	4.061	6.97	-0.02

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



PAR

Biospherical Instruments Inc

CALIBRATION CERTIFICATE

UNDERWATER PAR SENSOR WITH LOG AMPLIFIER

Calibration Date: 03/18/05 **Job No.:** R8994
Model Number: QSP200L4S
Serial Number: 4469
Operator: TPC
Standard Lamp: 99134 (12/26/03)
Operating Voltage Range: 6 to 15 VDC (+)

Note: The QSP-200L uses a log amplifier to measure the detector signal current with V = log I (Amps) / IRef
To calculate irradiance, use this formula:

Irradiance = Calibration factor * (10^Light Signal Voltage - 10^Dark Voltage)

With the appropriate (solar corrected) Irradiance Calibration Factor:

Dry Calibration Factor:	**8.90E+12**	**quanta/cm²·sec/"amps"**	**1.48E-05**	**µEinsteins/cm²·sec/"amps"**
Wet Calibration Factor:	**1.50E+13**	**quanta/cm²·sec/"amps"**	**2.49E-05**	**µEinsteins/cm²·sec/"amps"**

Sensor Test Data and Results[4)]

Sensor Supply Current (Dark):	64.1	mA			
Supply Voltage:	6	Volts			
Lamp Integrated PAR Irradiance:	8.82E+15	quanta/cm²·sec	0.01465	µEinsteins/cm²sec	
SC3 Immersion Coefficient:	0.594	Scalar Correction:	1	PAR Solar Correction:	1.0000

Nominal Filter OD	Calibrated Trans.	Sensor Voltage	Measured Trans.	Measured Signal (Amps)	Estimated Signal (Amps)	Calc. Output (Volts)	Error (Volts)	Error (%)	Test Irrad. (quanta/ cm²·sec)
No Filter	100.00%	2.997	100.00%	9.92E-08	9.92E-08	2.997	0.001	0.0	8.82E+15
0.3	36.10%	2.556	36.13%	3.58E-08	3.58E-08	2.556	0.000	-0.1	3.19E+15
0.5	27.60%	2.440	27.63%	2.74E-08	2.74E-08	2.440	0.000	-0.1	2.44E+15
1	9.27%	1.968	9.23%	9.16E-09	9.20E-09	1.970	0.002	0.4	8.14E+14
2	1.11%	1.089	1.10%	1.09E-09	1.10E-09	1.093	0.005	1.1	9.69E+13
3	0.05%	0.325	0.07%	7.22E-11	5.30E-11	0.283	-0.041	-26.6	6.42E+12

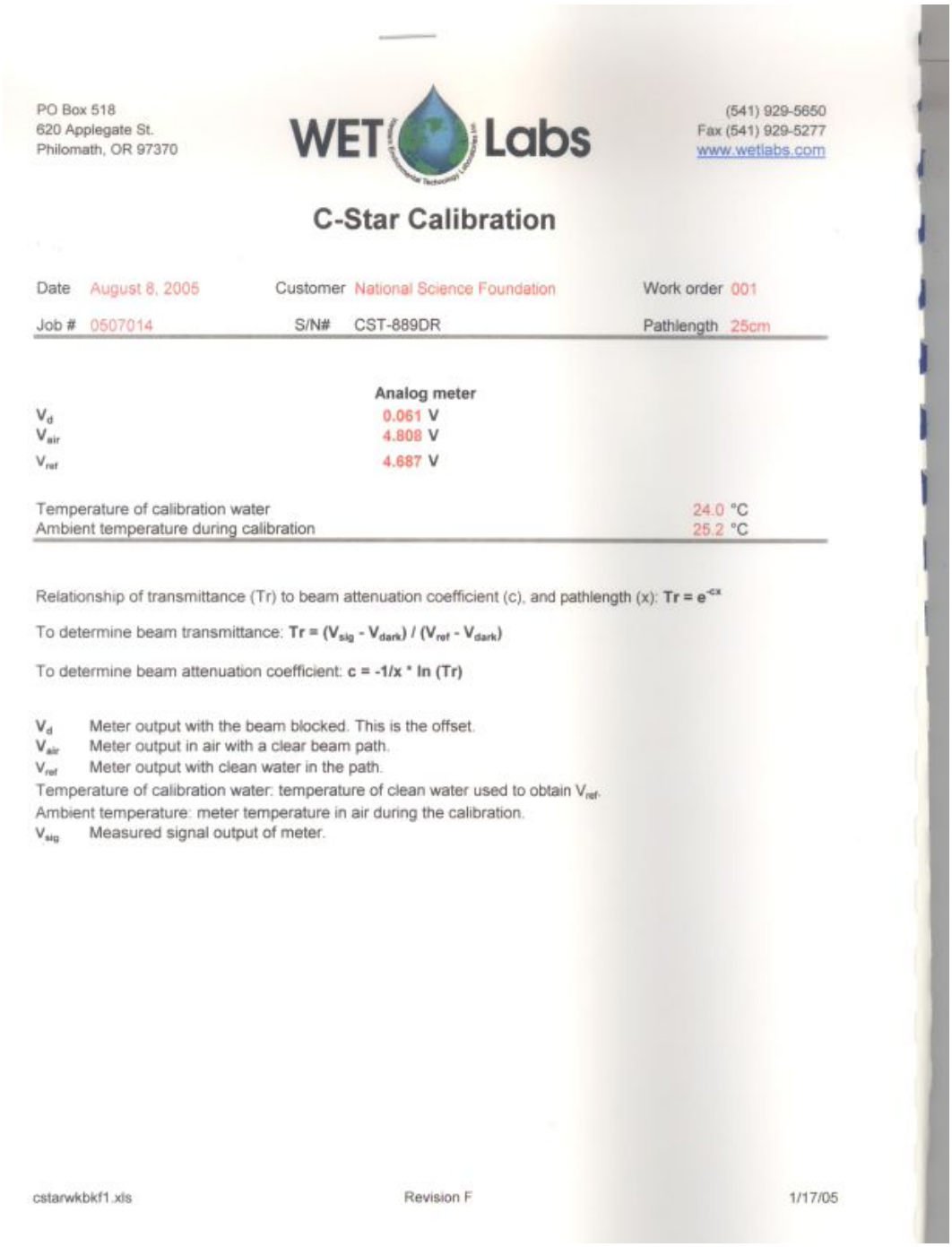
Dark Before: 0.143 Volts
Light - No Filter Hldr.: 2.998 Volts
Dark After - NFH: 0.143 Volts
Average Dark 0.143 Volts

I_{Ref} = 1.00E-10 Amps
I_{Dark} = 1.39E-10 Amps
10^{VLight} = 1.389953 Amps

Notes:
1. Annual calibration is recommended.
2. There is increasing error associated with readings below zero.
3. The collector should be cleaned frequently with alcohol.
4) This section is for internal use and for more advanced analysis.

QSP-200L .xls

Transmissometer



PO Box 518
620 Applegate St.
Philomath, OR 97370

WET Labs

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

C-Star Calibration

Date August 8, 2005 Customer National Science Foundation Work order 001

Job # 0507014 S/N# CST-889DR Pathlength 25cm

	Analog meter
V_d	0.061 V
V_{air}	4.808 V
V_{ref}	4.687 V

Temperature of calibration water	24.0 °C
Ambient temperature during calibration	25.2 °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.

cstarwkbkf1.xls Revision F 1/17/05

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: 25-Jan-05

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

GHIJ COEFFICIENTS
g = -4.25433269e+000
h = 5.69146773e-001
i = -5.27279657e-004
j = 5.95157100e-005
CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

ABCDM COEFFICIENTS
a = 2.87313929e-006
b = 5.67470414e-001
c = -4.24954807e+000
d = -8.51450388e-005
m = 4.9
CPcor = -9.5700e-008 (nominal)

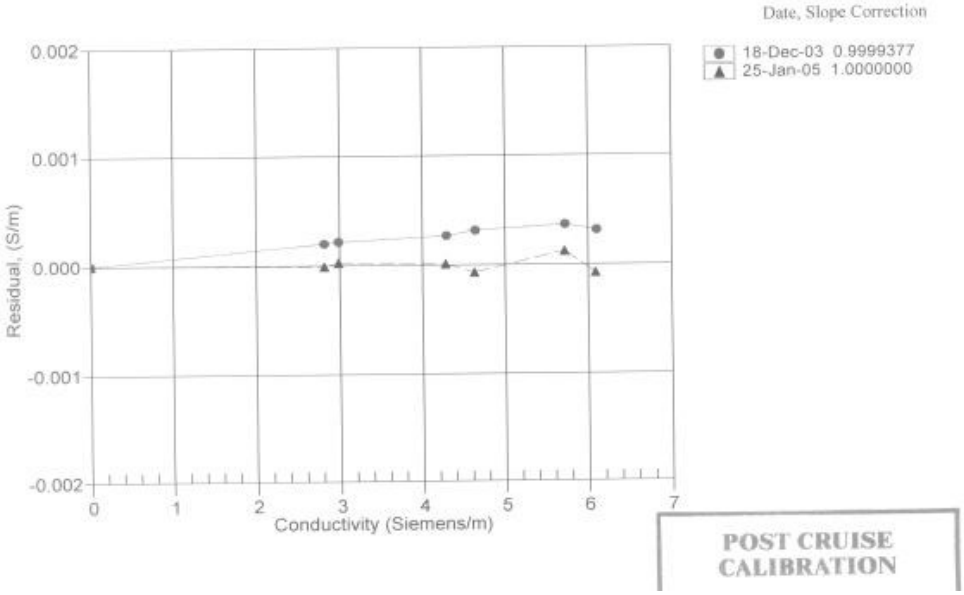
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.73643	0.00000	0.00000
-1.0005	34.9053	2.81103	7.54480	2.81102	-0.00001
0.9995	34.9052	2.98279	7.74196	2.98282	0.00002
14.9995	34.9066	4.28147	9.09321	4.28148	0.00001
18.4995	34.9078	4.62914	9.42148	4.62907	-0.00007
28.9995	34.9059	5.71528	10.37918	5.71541	0.00012
32.4995	34.9027	6.08929	10.68837	6.08922	-0.00008

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

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: 1314
CALIBRATION DATE: 25-Jan-05

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

GHIJ COEFFICIENTS

g = -4.07306392e+000
h = 4.70619624e-001
i = 1.46589188e-005
j = 2.52643431e-005
CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

ABCDM COEFFICIENTS

a = 2.55392337e-005
b = 4.70737289e-001
c = -4.07398884e+000
d = -9.29354023e-005
m = 4.0
CPcor = -9.5700e-008 (nominal)

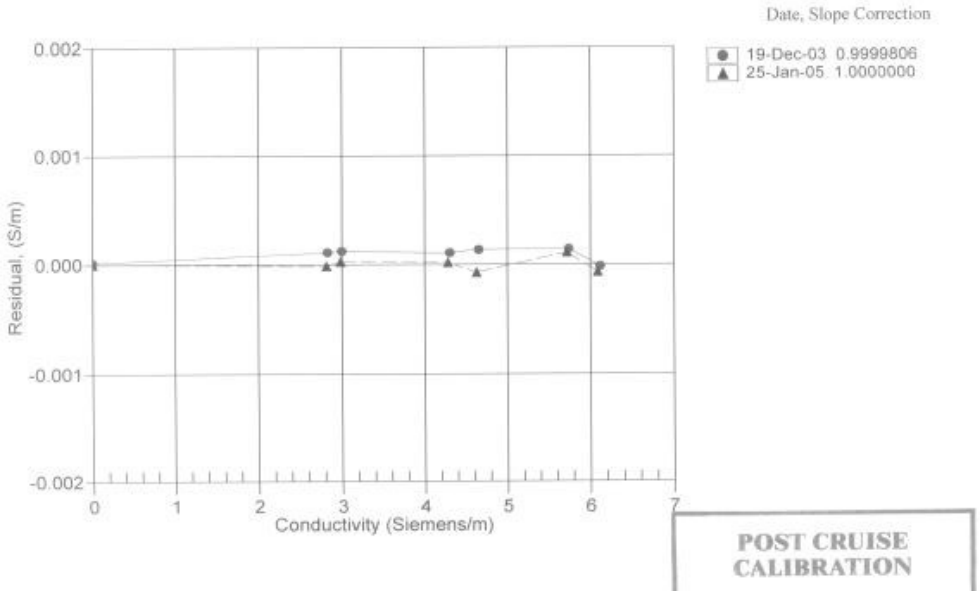
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.94107	0.00000	0.00000
-1.0005	34.9053	2.81103	8.25337	2.81102	-0.00001
0.9995	34.9052	2.98279	8.46997	2.98282	0.00003
14.9995	34.9066	4.28147	9.95374	4.28148	0.00002
18.4995	34.9078	4.62914	10.31408	4.62907	-0.00007
28.9995	34.9059	5.71528	11.36524	5.71539	0.00011
32.4995	34.9027	6.08929	11.70463	6.08923	-0.00007

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