

Data Report NBP1408

NBP1408 - South Georgia Islands, 09/22/2014 – 10/22/2014



United States Antarctic Program

RVIB Nathaniel B. Palmer

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Data Report Prepared by:
Valerie Warner and Joe Tarnow

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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: NBP1408

File	Description
/	Root level directory
NBP1408.trk	Text file of cruise track (lat,lon)
NBP1408.mgd	Full Cruise MGD77 data file
NBP1408.gmt	GMT binary file of MGD77 data
INSTCOEF.TXT	Instrument Coefficient File
1408DATA.doc	Data Report NBP1408 (MS Word)
1408DATA.pdf	Data Report NBP1408 (PDF format)
/plots	Cruise track plots
nbp1408-track.pdf	Cruise track plot (PDF format)
nbp1408-track.jpg	Cruise track plot (JPG format)
nbp1408-track.ps	Cruise track plot (PS format)
/process	Processed data
1408JGOF.tz	JGOFS format data files
1408QC.tz	Daily RVDAS QC postscript plots
1408PCO2.tz	Merged pCO2 data files
1408MGD.tz	MGD Data
1408PROC.tz	Other processed data
/rvdas/nav	Navigation data
1408adcp.tz	ADCP Data Sets
1408gyr1.tz	Gyro raw data
1408PCOD.tz	Trimble P-code raw data
1408seap.tz	Seapath 200 data
1408ais1.tz	AIS data
1408s330.tz	Seapath 330 data
/rvdas/uw	Underway data
1408mag1.tz	Magnetometer data
1408eng1.tz	Engineering data
1408grv1.tz	Gravimeter data
1408hdas.tz	HydroDAS raw data
1408knud.tz	Knudsen raw data
1408mbdp.tz	Multibeam depth data
1408mwx1.tz	Meteorology raw data
1408pco2.tz	pCO2 raw data
1408pguv.tz	GUV raw data
1408rtmp.tz	Remote Temperature data
1408svp1.tz	Sound velocity probe (in ADCP well)
1408tsg1.tz	1 st Micro TSG data
1408tsg2.tz	2 nd Micro TSG data
1408twnc.tz	Trawl winch data
/Imagery	Satellite Imagery
1408Imag.tz	Collection of Imagery Files
/ocean	Ocean data
1408xbt.tz	XBT Data

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

To determine how, when, and where the Antarctic Circumpolar current may have developed during the Oligocene to Miocene and to install GPS receivers on South Georgia Island, Bird Island, and Annenkov Island to quantify plate motion with respect to the South American plate.

NBP14-08 Cruise Dates: 22 September – 22 October, 2014

Cruise Track

The distribution DVD includes a GMT cruise track file NBP1408.trk. It contains the longitude and latitude at one-minute intervals extracted from the NBP1408.gmtfile.

The distribution also includes a JPG, PDF, and PostScript cruise track files placed in the /plots directory. These are standard US Letter sized (8.5" x 11").

Satellite Images

Satellite Images processed for this cruise can be found in the directory, /Imagery in two subdirectories, ice and wx (weather). Files are named using the convention, IdDDYYA.jpg where:

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

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/1408JGOF.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	$\mu\text{Einsteins/meter}^2 \text{ sec}$
10	Sea surface temperature	$^{\circ}\text{C}$
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	$^{\circ}\text{C}$
17	Relative humidity	%
18	Barometric pressure	mBars
19	Sea surface fluorometry	$\mu\text{g/l (mg/m}^3\text{)}$
20	Transmissometry	%
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 NBP1408.mgd. The file NBP1408.gmt is created from the MGD77 dataset using the “mgd77togmt” utility. NBP1408.gmt can be used with the GMT plotting package.

The data used to produce the NBP1408.mgd file can be found on the distribution media in the file /process/1408proc.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
60	1	int	Bathymetric type code	1 = Observed 3 = Interpolated (Header Seq. 12) 9 = Unspecified
61-66	6	real	Magnetics total field, 1 ST sensor	In tenths of nanoteslas (gammas)
67-72	6	real	Magnetics total field, 2 ND sensor	In tenths of nanoteslas (gammas), for trailing sensor
73-78	6	real	Magnetics residual field	In tenths of nanoteslas (gammas). The reference field used is in Header Seq. 13
79	1	int	Sensor for residual field	1 = 1 st or leading sensor 2 = 2 nd or trailing sensor 9 = Unspecified
80-84	5	real	Magnetics diurnal correction	In tenths of nanoteslas (gammas). (In nanoteslas) if 9-filled (i.e., set to “+9999”),

Col	Len	Type	Contents	Description, Possible Values, Notes
				total and residual fields are assumed to be uncorrected; if used, total and residuals are assumed to have been already corrected.
85-90	6	F6.0	Depth or altitude of magnetics sensor	(In meters) + = Below sea level 3 = Above sea level
91-97	7	real	Observed gravity	In 10 th of mgals. Corrected for Eotvos, drift, tares
98-103	6	real	EOTVOS correction	In 10 th of mgals. $E = 7.5 V \cos \phi \sin \alpha + 0.0042 V^2$
104-108	5	real	Free-air anomaly	In 10 th of mgals G = observed G = theoretical
109-113	5	char	Seismic line number	Cross-reference for seismic data
114-119	6	char	Seismic shot-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 `1408adcp.tar` in the directory `/rvdas/nav`.

pCO₂

The NBP carries a pCO₂ measurement system from Lamont-Doherty Earth Observatory (LDEO). pCO₂ data is recorded by RVDAS and transmitted to LDEO at the end of each cruise. You will find pCO₂ data in a file named `1408pco2.tar` in the `/process` directory, which contains the pCO₂ instrument's data merged with GPS, meteorological and other oceanographic measurements. For more information contact Colm Sweeney (csweeney@ldeo.columbia.edu).

Cruise Science

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.ttttt
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 `1408xbt.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: NBP0107.met1.d317

- The CruiseID is the numeric name of the cruise, in this case, NBP1408.
- The ChannelID is a 4-character code representing the system being logged. An example is "met1," the designation for meteorology.
- DDD is the day of year the data was collected

Underway Sensors

Meteorology and Radiometry

Measurement	Channel ID	Collect. Status	Rate	Instrument
Air Temperature	met1	continuous	1 sec	R. M. Young 41372LC
Relative Humidity	met1	continuous	1 sec	
Wind Speed/Direction	met1	continuous	1 sec	R.M. Young 05106
Barometer	met1	continuous	1 sec	R.M. Young 61201
PIR (LW radiation)	met1	continuous	1 sec	Eppler PIR
PSP (SW radiation)	met1	continuous	1 sec	Eppler PSP
PAR	met1	continuous	1 sec	BSI QSR-240
GUV	guv	continuous	2 sec	BSI PUV-2511
PUV	puv	continuous		BSI PUG-2500

Geophysics

Measurement	Channel ID	Collect. Status	Rate	Instrument
Gravimeter	grv1	continuous	1 sec	BGM3/210
Magnetometer	mag1	collected	1 sec	Marine Magnetics SeaSPY Overhauser
Bathymetry	knu1	continuous	Varies	Knudsen Chirp

Oceanography

Measurement	Channel ID	Collect. Status	Rate	Instrument
Conductivity	mtsg	Continuous	6 sec	SeaBird SBE-45
Salinity	mtsg	Continuous	6 sec	Calc. from pri. temp
Sea Surface Temp	mtsg	Continuous	6 sec	SeaBird SBE 38
Fluorometry	flr1	Continuous	1 sec	WetLabs AFLT
Transmissometry	tsg1	Continuous	6 sec	WET Lab C-Star
pCO ₂	pco2	Continuous	70 sec	(LDEO)
ADCP	adcp	Continuous	varies	RD Instruments

Navigational Instruments

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

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

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)

There are 3 different data strings in the mwx1 data file:

MET

08+330:23:59:57.725 MET,12.1,-54,6.64,88.7,111.3374,0.02414567,-
0.4827508,282.9581,281.8823,1003.119

PUS

08+330:23:59:58.546 PUS,A,020,008.53,M,+337.12,+009.00,00,0F

SUS

08+330:23:59:58.779 SUS,A,017,008.76,M,+335.53,+006.35,00,02

MET string

Field	Data	Units
1	RVDAS time tag	
2	MET (string flag)	
3	Power Supply Voltage	V
4	Enclosure Relative Humidity	%
5	Air temperature	°C
6	Air Relative Humidity	%
7	PAR (photosynthetically available radiation)*	mV
8	PSP (short wave radiation)*	mV
9	PIR Thermopile (long wave radiation)*	mV
10	PIR Case Temperature	°Kelvin
11	PIR Dome Temperature	°Kelvin
12	Barometer	mBar

*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

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 EM122 (mbdp)

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

Micro-TSG #1 (tsg1)

08+330:23:59:40.894 5.9322, 3.34685, 34.0550, 1473.281

Field	Data	Units
1	RVDAS time tag	
2	Internal Temperature	°C
3	Conductivity	s/m
4	Salinity	PSU
5	Sound velocity	m/s

Micro-TSG #2 (tsg2)

08+330:23:59:40.894 5.9322, 3.34685, 34.0550, 1473.281

Field	Data	Units
1	RVDAS time tag	
2	Internal Temperature	°C
3	Conductivity	s/m
4	Salinity	PSU
5	Sound velocity	m/s

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)	

pCO₂00+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
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
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 Input Source	degrees -1 stem Thurston; 0 moonpool
24		

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

PAR

Coefficients `parc1` and `parcv` for this cruise can be found in the `instrument.coeff` file as the variable labeled PAR, respectively. Variable `par` is the raw data in mV, as described in the “mw1” file description. The calibration scale and probe offset dark are values taken from the PAR Cal Sheet.

```
par = raw data mV
calibration scale = 5.8644 V/(μEinstiens/cm2sec)
parc1 = 1 / scale = .17
probe offset dark = -.1 mV
parcv = dark x 1000 mV/V = -0.0001 V
((par / 1000 mV/V) - parcv) x parc1 x 10000 cm2/m2 =
μEinstiens/m2sec
```

```
Calculations (extracted from the C code):
/* Convert from mV to V */
par /= 1000;
/* (par V - vdark V) / Calibration Scale Factor V/uE/cm2sec */
parCalc = (par - parcv) * parc1 * 10000;
```

PSP

Coefficient `pspCoeff` for this cruise can be found in the `instrument.coeff` file as the variable labeled PSP1. Variable `psp` is the raw data in mV, as described in the “mw1” file description.

```
psp = raw data mV
calibration scale = pspCoeff x 10^-6 V/(W/m2)
psp / (scale x 1000 mV/V) = W/m2
```

```
Calculations (extracted from the C code):
/* Convert from mV to W/m^2 */
pspCalc = (psp * 1000 / pspCoeff);
```


PIR

Coefficient `pirCoeff` for this cruise can be found in the `instrument.coeff` file as the variable labeled `PIR1`. Variable `pir_thermo` is the raw data in mV, `pir_case` is the PIR case temperature in Kelvins and `pir_dome` is the PIR dome temperature in Kelvins, as described in the “mwx1” file description. Hard-coded “C” coefficients are shown below:

```
Dome constant = 3.5
```

```
Sigma = 5.6704e-8
```

```
pir_thermo = raw data mV
```

```
calibration scale = pirCoeff x 10-6 V/(W/m2)
```

```
pir_thermo / (scale x 1000 mV/V) = W/m2
```

Calculations (extracted from the C code):

```
/* convert mV to W/m^2 */
pirCalc = (pir_thermo * 1000 / pirCoeff)
/* correct for case temperature */
pirCalc += sigma * pow(pir_case,4)
/* correct for dome temperature */
pirCalc -= 3.5 * sigma * (pow(pir_dome, 4) - pow(pir_case,
4))
```


Appendix: Sensors and Calibrations

NBP1408 Sensors:

Shipboard Sensors

Sensor	Description	Serial #	Last Calibration Date	Comments
Meteorology & Radiometers				
Port Anemometer	Gill Instruments 1390-PK-062	924057	11/18/09	Port side installed 03/05/10
Stbd Anemometer	Gill Instruments 1390-PK-062	847014	09/29/10	Stbd side installed 11/17/10
Barometer	RM Young 61201	00872	11/29/12	Installed 01/25/14
Humidity/Wet Temp	RM Young 41372LC	06733	03/07/14	Installed 09/04/14
Humidity/Wet Temp	RM Young 41372LC	06135	06/03/14	Installed 10/13/14
PIR (Pyrgeometer)	Eppler PIR	32845F3	07/18/13	Installed n/a
PSP (Pyranometer)	Eppler PSP	32850F3	08/07/13	Installed n/a
PAR (Mast)	BSI-QSR-240	6356	02/03/14	Installed 08/14/14
GUV (Mast)	BSI GUV-2511	25110203113	02/05/14	Installed 08/14/14
Underway				
Micro-TSG-1	SeaBird SBE 45	4546167-0199	11/02/13	Installed 08/11/14
Micro-TSG-2	SeaBird SBE 45	4549120-0226	06/13/13	Installed 03/15/14
Digital Remote Temp	SeaBird SBE 38	3850449-0389	02/01/13	Installed 06/25/14
Fluorometer	WetLabs AFLT	AFLT-009	03/27/14	Installed 09/17/14
Transmissometer	WET Labs C-Star	CST-557DR	08/28/13	Installed 01/25/14
Magnetometer	Marine Magnetics SeaSPY Overhauser			
Gravimeter	BGM3/210		n/a	Gravity Tie 09/18/14
Bathymetry	Knudsen Chirp		n/a	
Other				
P-Code GPS	Trimble 20636-00 (SM)	0220035116		

Calibrations

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

Gravity Tie

Gravity Tie Spreadsheet

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

Date: 9/18/2014
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 (Filt Counts)	25200.35	17:26
Ship's meter after gravity tie (Filt Counts)	25200.35	18:26
Average	25200.35	
Ship Gravimeter's Calibration Constant	4.99407055	
Corrected ship's meter (QC Grav (mgal))	125852.33	

	Value	Time (GMT)
Ship's meter before gravity tie (serial, RVDAS)	981276.9	17:27
Ship's meter after gravity tie (serial, RVDAS)	981296.8	18:26
Average (for comparison check only)	981286.9	

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

Station	Value	Time (GMT)	Temp	Date	
Pier measurement 1	4918.31	17:39	53	September 18, 2014	OBS mgal, averaged
Pier measurement 2	4918.28	17:40	53	September 18, 2014	4967.82
Pier measurement 3	4918.29	17:42	53	September 18, 2014	
Average	4918.29				
	4919.03	18:02	53	September 18, 2014	OBS mgal, averaged
Station measurement 2	4918.98	18:05	53	September 18, 2014	4968.53
Station measurement 3	4918.98	18:10	53	September 18, 2014	
Average	4919.00				
	4918.51	18:19	53	September 18, 2014	OBS mgal, averaged
Pier measurement 4	4918.49	18:20	53	September 18, 2014	4968.03
Pier measurement 5	4918.49	18:22	53	September 18, 2014	
Pier measurement 6	4918.49	18:22	53	September 18, 2014	
Average	4918.50				

Gravity Bias from last tie 855466.15
Drift since last tie 2.04

OBS Differences	Comments
Station to Pier (1, 2, & 3 averaged)	-0.71
Station to Pier (4, 5, & 6 averaged)	-0.51
Averaged Differences	-0.61
Gravity at pier	981320.21
Elevation of pier above gravimeter, meters	1.0
Earth differential gravity, mgal/meter	0.3
Gravity at ship's gravimeter	981320.51
Gravity Bias (Offset for RVDAS)	855468.19

Note about Elevation of Pier: If pier is below the ship's gravimeter, this value is negative. If above, positive.

Meteorology System**PIR****THE EPPLEY LABORATORY, INC.**

12 Sheffield Avenue, PO Box 419, Newport, Rhode Island USA 02840
Phone: 401.847.1020 Fax: 401.847.1031 Email: info@eppleylab.com

**STANDARDIZATION OF
EPPLEY PRECISION INFRARED RADIOMETER
Model PIR**

Serial Number: 32845F3

Resistance: 712 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 30°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:

$$4.08 \times 10^{-6} \text{ volts/watts meter}^{-2}$$

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

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

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: LMP4 ISGS N.S.F.
Port Hueneme, CA

S.O. Number: 63850

Date: July 18, 2013

Remarks:

Date of Test: July 17, 2013

In Charge of Test: *Olivia L. Blumenthal*

Reviewed by: *Thomas J. Kunk*

PSP**THE EPPLEY LABORATORY, INC.**

12 Sheffield Avenue, PO Box 419, Newport, Rhode Island USA 02840
Phone: 401.847.1020 Fax: 401.847.1031 Email: info@eppleylab.com

Calibration Certificate

Instrument: Precision Spectral Pyranometer, Model PSP, Serial Number 32850F3

Procedure: This pyranometer was compared in Eppley's Integrating Hemisphere according to procedures described in *ISO 9847 Section 5.3.1* and Technical Procedure, TP01 of The Eppley Laboratory, Inc.'s Quality Assurance Manual on Calibrations.

Transfer Standard: Eppley Precision Spectral Pyranometer, Model PSP, Serial Number 21231F3

Results:
Sensitivity: $S = 7.68 \mu V / W m^{-2}$
Uncertainty: $U_{95} = \pm 0.91\%$ (95% confidence level, $k=2$)
Resistance: 706 Ω at 23°C

Date of Test: August 7, 2013

Traceability: This calibration is traceable to the World Radiation Reference (WRR) through comparisons with Eppley's AHF standard self-calibrating cavity pyrheliometers which participated in the Eleventh International Pyrheliometric Comparisons (IPC XI) at Davos, Switzerland in September-October 2010. Unless otherwise stated in the remarks section below or on the Sales Order, the results of this calibration are "AS FOUND / AS LEFT".

Due Date: Eppley recommends a minimum calibration cycle of five (5) years but encourages annual calibrations for highest measurement accuracy.

Customer: LMP4 ISGS
Port Hueneme, CA

Signatures:

D. GIENTY
In Charge of Test:

Thomas D. Kuhl
Reviewed by:

Eppley SO 63884

Date of Certificate August 15, 2013

Remarks:

GUV



Biospherical Instruments Inc.

GUV-2511 Calibration Certificate										
System Serial Number			25110203113			Date of Calibration			2/5/2014	
Calibration database			25110203113v7.mdb			Date of Certificate			2/5/2014	
DASSN			0068			Standard of Spectral Irradiance			V-034(3/7/12)	
Microprocessor Tag Number			2			Operator			TC	
Monochromatic		Wavelength	Responsivity	ScaleSmall	ScaleMedium	ScaleLarge	OffsetSmall	OffsetMedium	OffsetLarge	Measurement
Channels	Address	[nm]	[Amps per $\mu W/(cm^2 \cdot nm)$]	[Volts per $\mu W/(cm^2 \cdot nm)$]	[Volts per $\mu W/(cm^2 \cdot nm)$]	[Volts per $\mu W/(cm^2 \cdot nm)$]	[volts]	[volts]	[volts]	Units
Ed0320	2	320	2.6356E-10	2.6883E-05	7.8542E-03	2.7807E+00	-6.0000E-06	-9.0000E-06	1.7200E-04	$\mu W/(cm^2 \cdot nm)$
Ed0340	6	340	2.1334E-10	2.1761E-05	6.3577E-03	2.2417E+00	3.0500E-04	3.0500E-04	1.1770E-03	$\mu W/(cm^2 \cdot nm)$
Ed0313	8	313	2.5014E-10	2.5515E-05	7.4543E-03	2.6611E+00	6.3000E-05	6.5000E-05	7.6700E-04	$\mu W/(cm^2 \cdot nm)$
Ed0305	10	305	1.6730E-11	1.7064E-06	4.9855E-04	1.5423E-01	3.5000E-04	3.3900E-04	-2.2550E-03	$\mu W/(cm^2 \cdot nm)$
Ed0380	12	380	6.5920E-11	6.7239E-06	1.9644E-03	6.5511E-01	1.0890E-03	1.0750E-03	-1.4790E-03	$\mu W/(cm^2 \cdot nm)$
Ed0395	18	395	3.4630E-10	3.5323E-05	1.0320E-02	3.3709E+00	6.8000E-05	6.3000E-05	2.1600E-04	$\mu W/(cm^2 \cdot nm)$
Broadband		Wavelength	Responsivity	ScaleSmall	ScaleMedium	ScaleLarge	OffsetSmall	OffsetMedium	OffsetLarge	Measurement
Channels	Address	[nm]	[Amps per $\mu E/(cm^2 \cdot s)$]	[Volts per $\mu E/(cm^2 \cdot s)$]	[Volts per $\mu E/(cm^2 \cdot s)$]	[Volts per $\mu E/(cm^2 \cdot s)$]	[volts]	[volts]	[volts]	Units
Ed0PAR	13	400-700	1.8985E-05	1.9365E+00	5.6576E+02	2.0143E+05	8.5300E-04	8.4400E-04	-1.3230E-03	$\mu E/(cm^2 \cdot sec)$
Auxiliary		Wavelength	Responsivity	ScaleS	ScaleM	ScaleL	OffsetS	OffsetM	OffsetL	Measurement
Channels	Address	[nm]								Units
Ed0Gnd	0	0	1	1.00	1.00	1.00	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

© Biospherical Instruments Inc., 5340 Riley Street, San Diego, California 92110 USA. Contact support@biospherical.com for more information.

Calibration Data – Do Not Destroy

page 2 of 2



Biospherical Instruments Inc.

System Calibration Certificate

THE INSTRUMENTS REFERENCED BELOW WERE FACTORY TESTED AND CALIBRATED BY

BIOSPHERICAL INSTRUMENTS INC.

5340 Riley Street

San Diego, California 92110 USA

Instruments: GUV-2511 No 25110203113

Optical Calibrations:

NIST Traceability. For wavelengths longer than 313 nm, the specific instruments cited here were calibrated using a 1000W FEL #V-034 (3/7/12) following procedures and standards traceable to NIST Standard of Spectral Irradiance F-616. Traceability paths and all procedures for all calibrated lamps and associated apparatus (shunts, power supplies, DMMs, etc) are maintained following calibration methodologies per National Bureau of Standards (US) (NBS) Special Publication 250-20 Spectral Irradiance Calibrations (1987) and NBS Publication 594-13 Optical Radiation Measurements: The 1973 Scale of Spectral Irradiance (1977).

Solar Calibrations. Lamp calibrations are problematic for solar UV measurements (wavelengths below 320 nm) because the solar spectrum is radically different from the lamp spectrum and changes greatly as a function of wavelength. Solar calibrations are achieved through direct comparison with measurements of a high resolution scanning spectroradiometer in San Diego (SUV-100), which is part of the National Science Foundation's UV Monitoring Network. The SUV-100 instrument has a bandwidth of 1 nm. Calibrated filter radiometer data therefore report spectral irradiance at the channel's nominal wavelengths with a bandwidth of 1 nm. Solar calibrations are typically accurate to within $\pm 10\%$ for solar zenith angles smaller than 75° . At larger solar zenith angles, UV channels have a greater uncertainty due to the rapid change of the solar UV spectrum.

Note that this certificate contains a subset of the information delivered in the calibration database 25110203113v7.mdb. This database is required for operation of this system using Biospherical Instruments Inc.'s Logger® software.

PAR**Biospherical Instruments Inc.**

CALIBRATION CERTIFICATE

Calibration Date 2/3/2014
 Model Number QSR-240
 Serial Number 6356
 Operator TPC
 Standard Lamp V-032(3/7/12)
 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 99.5 mV
 Probe Dark 0.2 mV
 Probe Net Response 99.3 mV
 RG780 0.3 mV

Corrected Lamp Output:

Output In Air (same condition as calibration):

9.264E+15 quanta/cm²sec
0.01538 uE/cm²sec

Calibration Scale Factor:

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

Dry: 1.0720E-17 V/(quanta/cm²sec)
6.4555E+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

Micro-TSG 1

Sea-Bird Electronics, Inc.

13431 NE 20th Street, Bellevue, WA 98005-2010 USA

Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0199
CALIBRATION DATE: 02-Nov-13

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

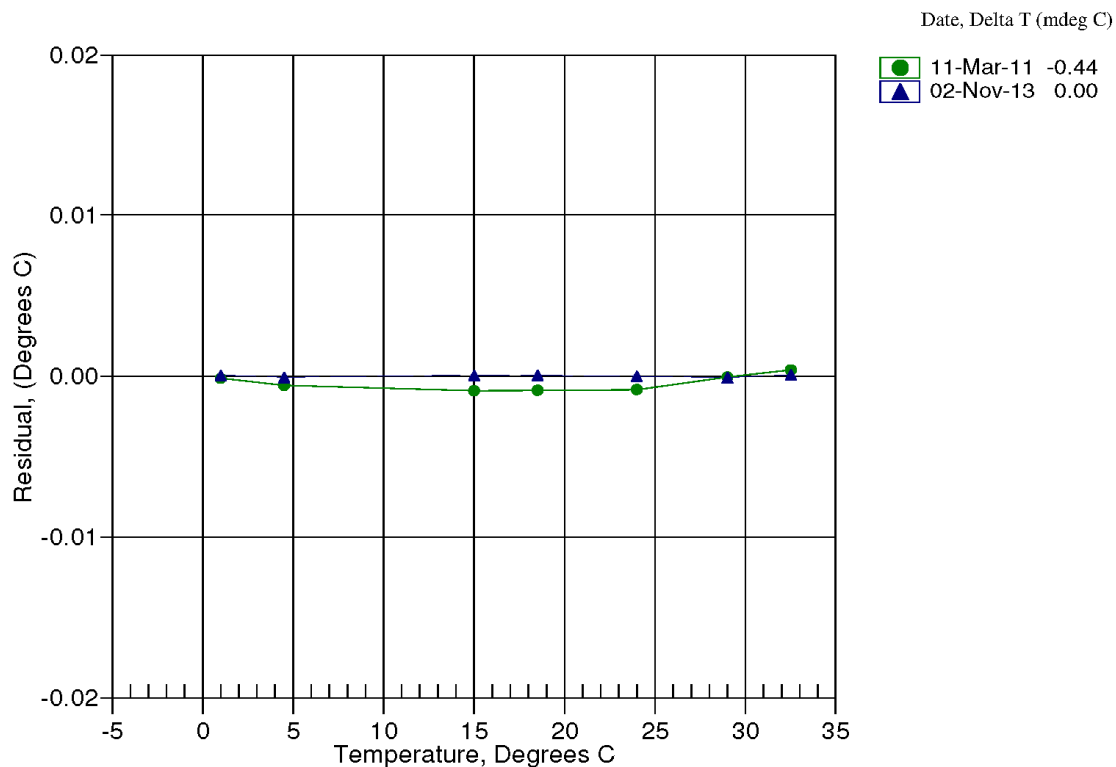
ITS-90 COEFFICIENTS

a0 = 1.853068e-005
a1 = 2.716266e-004
a2 = -2.093146e-006
a3 = 1.483856e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	678395.6	1.0000	0.0000
4.5000	580509.7	4.4999	-0.0001
15.0000	370800.2	15.0001	0.0001
18.5000	321296.5	18.5000	0.0000
24.0000	258018.8	24.0000	-0.0000
29.0000	212643.2	28.9999	-0.0001
32.5000	186322.1	32.5001	0.0001

Temperature ITS-90 = $1/\{a_0 + a_1[\ln(n)] + a_2[\ln^2(n)] + a_3[\ln^3(n)]\} - 273.15$ (°C)

Residual = instrument temperature - bath temperature



Sea-Bird Electronics, Inc.

13431 NE 20th Street, Bellevue, WA 98005-2010 USA

Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0199
CALIBRATION DATE: 02-Nov-13

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

COEFFICIENTS:

g = -1.002257e+000
h = 1.426088e-001
i = -1.618469e-004
j = 3.383846e-005

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

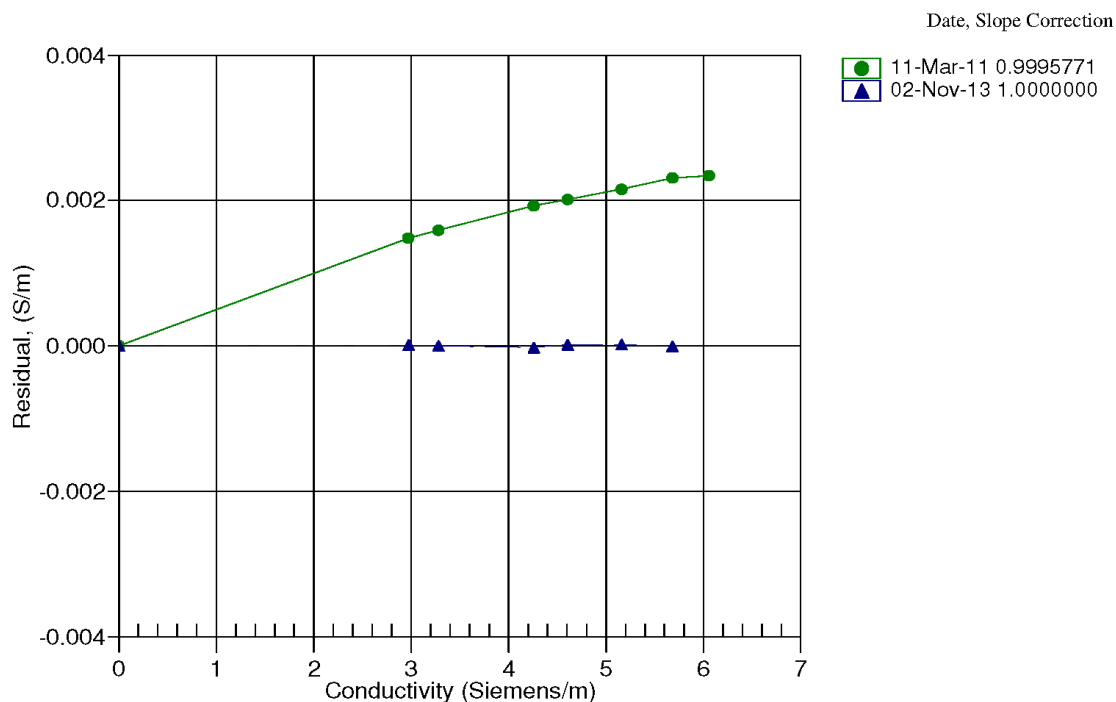
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2653.13	0.00000	0.00000
1.0000	34.7663	2.97210	5277.51	2.97211	0.00001
4.5000	34.7462	3.27876	5476.68	3.27876	-0.00000
15.0000	34.7026	4.25914	6069.01	4.25911	-0.00003
18.5000	34.6921	4.60367	6263.64	4.60368	0.00001
24.0000	34.6804	5.16064	6565.79	5.16066	0.00002
29.0000	34.6720	5.68134	6835.87	5.68133	-0.00001

$$f = \text{INST FREQ} * \sqrt{1.0 + \text{WBOTC} * t} / 1000.0$$

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

$$t = \text{temperature}[^{\circ}\text{C}]; p = \text{pressure}[\text{decibars}]; \delta = \text{CTcor}; \epsilon = \text{CPcor};$$

$$\text{Residual} = \text{instrument conductivity} - \text{bath conductivity}$$



Micro-TSG 2**Sea-Bird Electronics, Inc.**

13431 NE 20th Street, Bellevue, WA 98005-2010 USA

Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0226
CALIBRATION DATE: 13-Jun-13SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

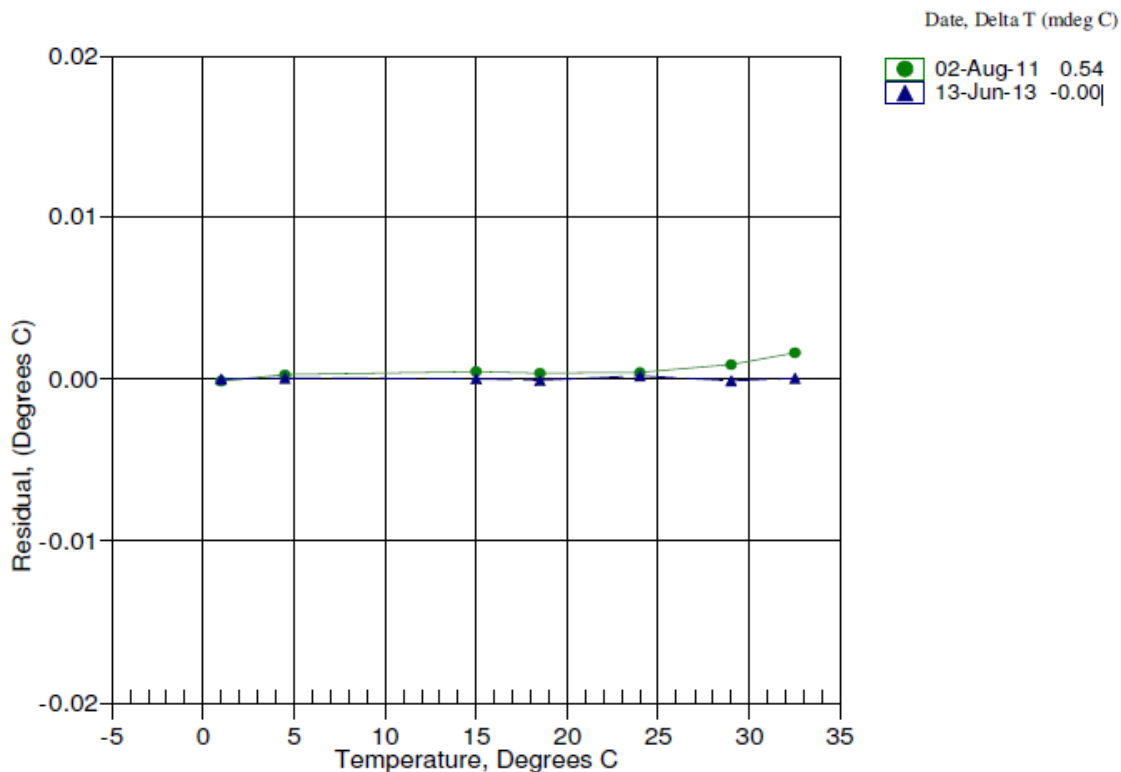
ITS-90 COEFFICIENTS

$a_0 = -1.290681e-004$
 $a_1 = 3.016680e-004$
 $a_2 = -4.417110e-006$
 $a_3 = 2.045426e-007$

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	744329.7	0.9999	-0.0000
4.5000	636489.5	4.5000	0.0000
15.0000	405773.4	15.0000	-0.0000
18.5000	351390.0	18.4999	-0.0001
24.0000	281930.4	24.0002	0.0002
29.0000	232178.4	28.9999	-0.0001
32.5000	203340.8	32.5000	0.0000

$$\text{Temperature ITS-90} = 1/[a_0 + a_1[\ln(n)] + a_2[\ln^2(n)] + a_3[\ln^3(n)]] - 273.15 \text{ (}^\circ\text{C)}$$

Residual = instrument temperature - bath temperature



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SENSOR SERIAL NUMBER: 0226
CALIBRATION DATE: 13-Jun-13

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

COEFFICIENTS:

g = -1.020162e+000
h = 1.581071e-001
i = -6.516728e-004
j = 7.473666e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006
WBOTC = 9.8072e-007

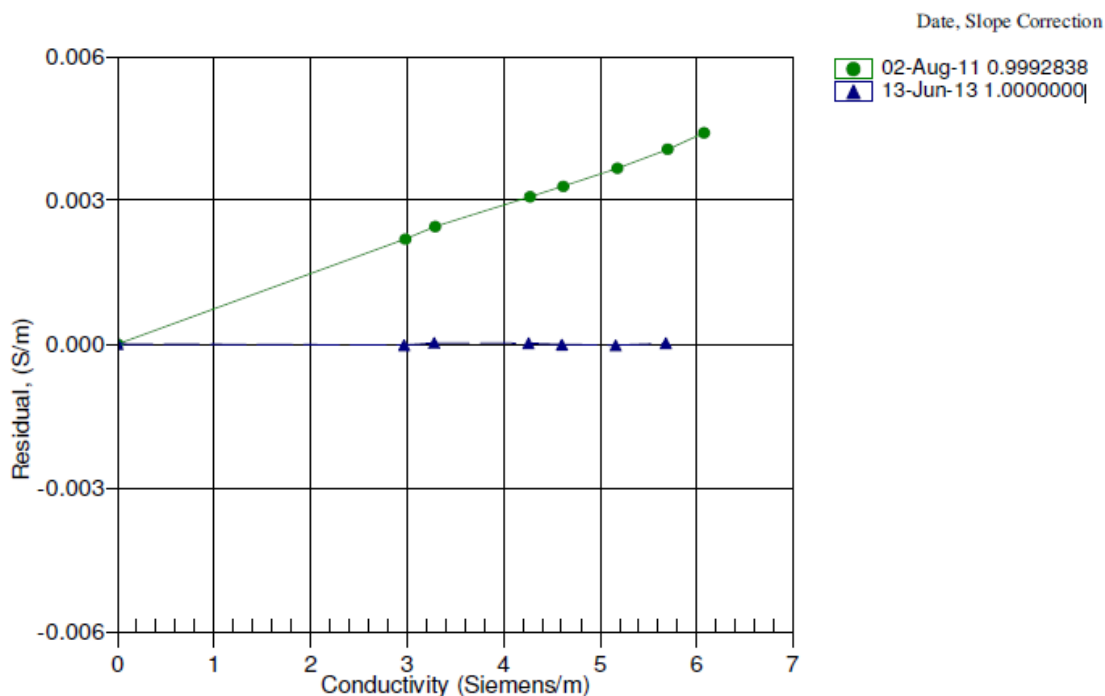
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2549.62	0.00000	0.00000
0.9999	34.7532	2.97108	5046.48	2.97105	-0.00002
4.5000	34.7326	3.27760	5236.35	3.27763	0.00002
15.0000	34.6894	4.25769	5801.01	4.25771	0.00002
18.5000	34.6799	4.60222	5986.56	4.60222	-0.00001
24.0000	34.6695	5.15920	6274.58	5.15917	-0.00003
29.0000	34.6640	5.68017	6532.15	5.68019	0.00002

$$f = \text{INST FREQ} * \text{sqrt}(1.0 + \text{WBOTC} * t) / 1000.0$$

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

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

Residual = instrument conductivity - bath conductivity



Underway Digital Remote Temperature Sensor**Sea-Bird Electronics, Inc.**

13431 NE 20th Street, Bellevue, WA 98005-2010 USA

Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0389
CALIBRATION DATE: 01-Feb-13SBE 38 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

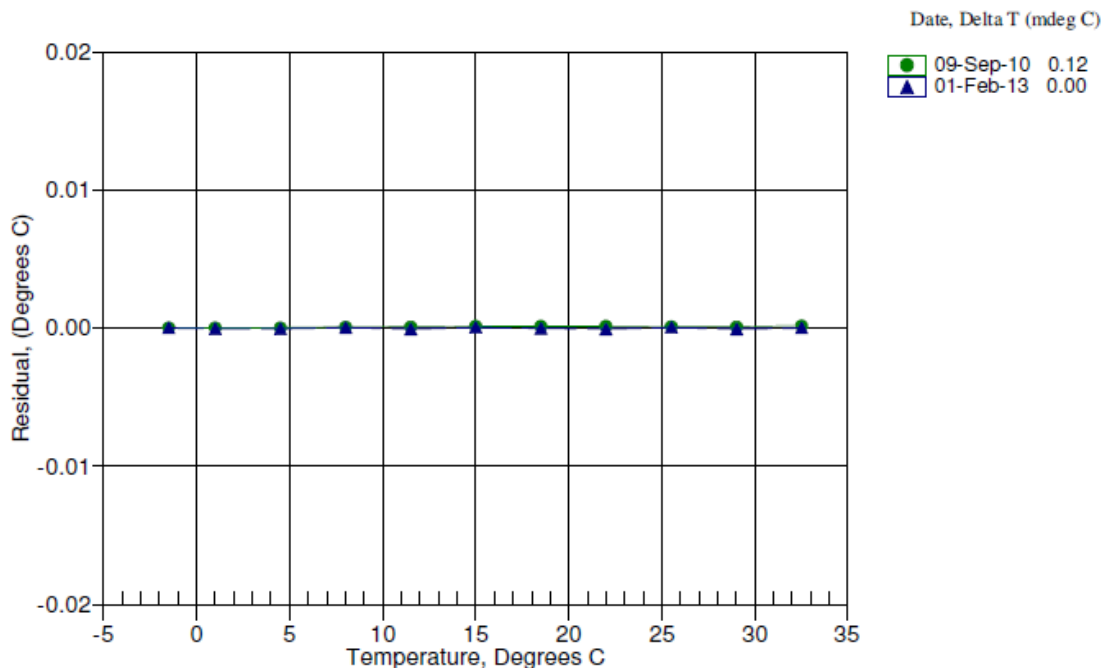
ITS-90 COEFFICIENTS

$a_0 = 5.817069e-005$
 $a_1 = 2.716655e-004$
 $a_2 = -2.274819e-006$
 $a_3 = 1.472026e-007$

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.50000	749667.4	-1.49998	0.00002
1.00000	667858.7	0.99998	-0.00002
4.50000	569779.9	4.49997	-0.00003
7.99990	487736.0	7.99995	0.00005
11.50000	418865.9	11.49995	-0.00005
14.99990	360858.9	14.99996	0.00006
18.49970	311844.4	18.49969	-0.00001
22.00000	270286.5	21.99995	-0.00005
25.49990	234949.3	25.49996	0.00006
29.00000	204808.5	28.99995	-0.00005
32.49990	179024.2	32.49992	0.00002

$$\text{Temperature ITS-90} = 1 / \{ a_0 + a_1[\ln(n)] + a_2[\ln^2(n)] + a_3[\ln^3(n)] \} - 273.15 \text{ (}^\circ\text{C)}$$

Residual = instrument temperature - bath temperature



Fluorometer

PO Box 518
620 Applegate St.
Philomath OR 97370



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

Chlorophyll Fluorometer Characterization, New Proxy .

Date: 03/27/2014
Serial #: AFLT-009
Job#: 006066
Tech: SML

Dark Counts 0.197 volts
CEV 1.076 volts
SF 30.18

FSV 5.37 volts

Linearity: 0.999 R² (0–1.5 volts)
0.995 R² (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 **26.53 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 determined by using the following equation:
 $SF = (26.53) / (CEV - \text{dark})$ e.g. $(26.53) / (1.076 - 0.193) = 30.18$

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

Chlorophyll concentration expressed in µg/l (mg/m³) can be derived by using the following equation: (µg/l) = (V_{measured} - dark) * SF

The relationship between fluorescence and chlorophyll-*a* concentrations in-situ is highly 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.

Underway Transmissometer

PO Box 518
620 Applegate St.
Philomath, OR 97370



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

C-Star Calibration

Date	August 28, 2013	S/N#	CST-557DR	Pathlength	25cm
		Analog output	Digital output		
V_d		0.009 V	0 counts		
V_{air}		4.760 V	15596 counts		
V_{ref}		4.700 V	15399 counts		
Temperature of calibration water				21.2 °C	
Ambient temperature during calibration				21.8 °C	

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

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 L

6/9/09