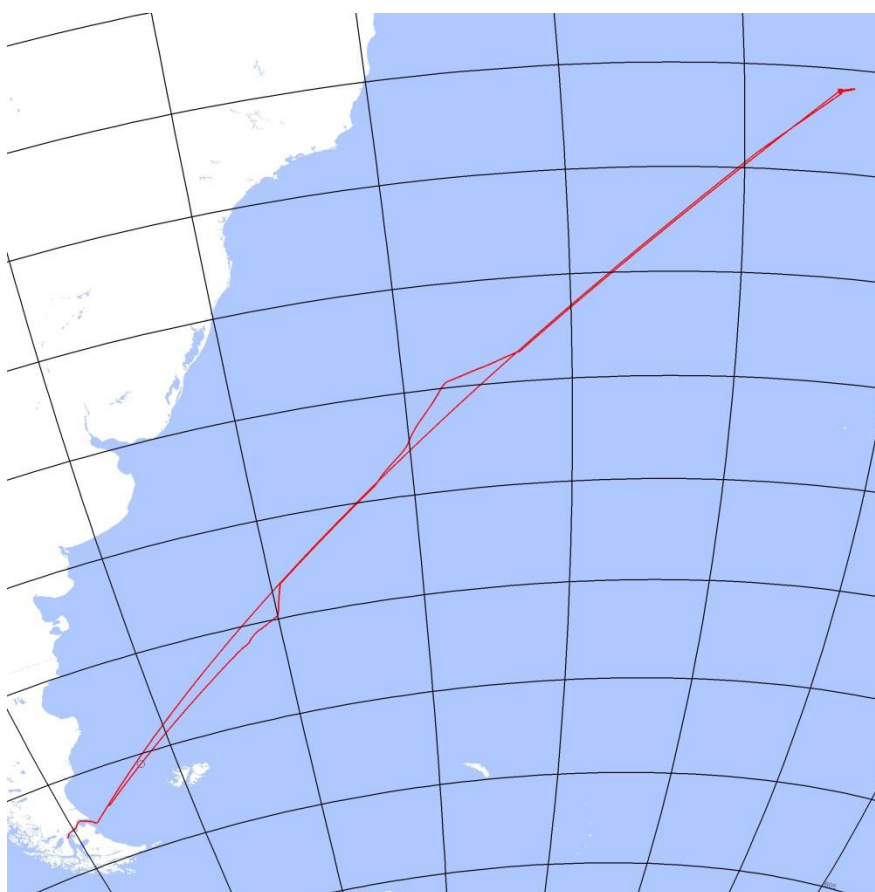


Thurnherr

# Data Report NBP1508

RVIB Nathaniel B. Palmer

September 5th, 2015 – October 23rd, 2015



United States Antarctic Program

Data Report Prepared By:  
Valerie Warner  
Chris Linden

<b>Introduction .....</b>	<b>1</b>
Distribution Contents at a Glance .....	2
Extracting Data .....	3
 <b>Distribution Contents.....</b>	 <b>4</b>
Cruise Track .....	4
Satellite Images .....	4
NBP Data Products .....	4
JGOFS .....	5
<i>MGD77</i> .....	6
 <b>Science of Opportunity .....</b>	 <b>8</b>
ADCP .....	8
pCO <sub>2</sub> .....	8
 <b>Cruise Science .....</b>	 <b>9</b>
CTD .....	9
XBT .....	9
RVDAS.....	9
Sensors and Instruments.....	9
Underway Sensors .....	10
<i>Meteorology and Radiometry</i> .....	10
<i>Geophysics</i> .....	10
<i>Oceanography</i> .....	10
<i>Navigational Instruments</i> .....	10
 <b>Data.....</b>	 <b>11</b>
Underway Data .....	12
<i>Sound Velocity Probe (svp1)</i> .....	12
<i>Meteorology (mwx1)</i> .....	12
<i>Knudsen (knud)</i> .....	13
<i>Gravimeter (grv1)</i> .....	13
<i>pCO<sub>2</sub> (pco2)</i> .....	14
<i>Micro TSG (tsg1,tsg2)</i> .....	14
<i>Remote Temperature (rtmp)</i> .....	14
<i>GUV (pguv)</i> .....	15
<i>Engineering (eng1)</i> .....	15
<i>Hydro DAS (hdas)</i> .....	16
<i>Winch (bwnc, cwnc, twnc)</i> .....	16
<i>Multibeam (mbdp)</i> .....	16
Navigational Data .....	17

<i>Seapath GPS (s330, seap)</i> .....	17
<i>Trimble P-Code GPS (PCOD)</i> .....	21
<i>Gyro Compass (gyr1)</i> .....	23
<i>Processed Data</i> .....	24
<i>pCO<sub>2</sub> – Merged</i> .....	24
<i>Calculations</i> .....	25
<i>PAR</i> .....	25
<i>PSP</i> .....	25
<i>PIR</i> .....	26
<b>Acquisition Problems and Events</b> .....	<b>27</b>
<b>Appendix A: Sensors</b> .....	<b>28</b>
NBP1508 Sensors .....	28
<i>Meteorology and Radiometry</i> .....	28
<i>Underway Seawater Sampling System</i> .....	28
<i>CTD – WHOI 24x4L</i> .....	28
<b>Appendix B: Calibration Sheets</b> .....	<b>29</b>
Gravity .....	29
Meteorology.....	30
<i>Anemometers</i> .....	30
<i>Barometer</i> .....	31
<i>Temperature / Humidity</i> .....	32
<i>PIR</i> .....	34
<i>PSP</i> .....	35
<i>PAR (Mast)</i> .....	36
<i>GUV (Mast)</i> .....	37
Underway Seawater Sampling System .....	39
<i>Micro-TSG 1</i> .....	39
<i>Micro-TSG2</i> .....	41
<i>Digital Remote Temp</i> .....	43
<i>Transmissometer</i> .....	44
<i>Fluorometer</i> .....	45
CTD .....	46
<i>Conductivity</i> .....	46
<i>Conductivity</i> .....	47
<i>Pressure Sensor</i> .....	48
<i>Temperature</i> .....	49
<i>Temperature</i> .....	50

## 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 archived using 'tar' and compressed using 'gzip', identified by the '.tz' extension. Tools are available on all platforms for uncompressing and de-archiving these formats: On Macintosh use the built-in Archive Utility, or tar in the terminal. On Windows operating systems use WinZip or 7Zip.

MultiBeam and Bathymetry 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: NBP1508

File	Description
/	Root level directory
INSTCOEF.TXT	Instrument Coefficient File
NBP1508.gmt	GMT binary file of MGD77 data
NBP1508.mgd	Full Cruise MGD77 data file
NBP1508.trk	Text file of cruise track
1508DATA.docx	Data Report NBP1508 (MS Word)
1508DATA.pdf	Data Report NBP1508 (PDF format)
/process	Processed data
1508JGOF.tz	JGOFS format data files
1508MGD.tz	MGD Data
1508PCO2.tz	Merged pCO <sub>2</sub> data files
1508PROC.tz	Other processed data
1508QC.tz	Daily RVDAS QC postscript plots
/rvdas/nav	Navigation data
1508PCOD.tz	Trimble P-code raw data
1508gyr1.tz	Gyro raw data
1508s330.tz	Seapath 330 data
1508seap.tz	Seapath 200 data
/rvdas/uw	Underway data
1508bwnc.tz	Baltic winch data
1508ctdd.tz	CTD depth data
1508engl.tz	Engineering data
1508flr1.tz	Fluorometer data
1508grv1.tz	Gravimeter data
1508hdas.tz	HydroDAS raw data
1508knud.tz	Multibeam depth profile data
1508mbdp.tz	Knudsen raw data
1508mwx1.tz	Meteorology raw data
1508pco2.tz	pCO <sub>2</sub> raw data
1508pguv.tz	GUV raw data
1508rtmp.tz	Remote Temperature data
1508svp1.tz	Sound velocity probe (ADCP)
1508tsg1.tz	Micro TSG1 data
1508tsg2.tz	Micro TSG2 data
/Imagery	Satellite Imagery
1508Imag.tz	Collection of Imagery Files
/ocean	Ocean data
1508ctd.tz	CTD Data
1508xbt.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 are gzipped tar files and were created using the command,

```
tar -czvf 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 “.tz” extension on the filename. “.tz” stands for tared and gzipped. These files can be decompressed after de-archiving, using the UNIX command,

```
gunzip filename.tz
```

## Distribution Contents

### Cruise Track

The distribution DVD includes a GMT cruise track file (NBP1508.trk). It contains the longitude and latitude at one-minute intervals extracted from the NBP1508.gmt file.

### 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, IdDDDYA.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 1508proc.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](mailto:itvessel@usap.gov).

## JGOFS

The JGOFS data set can be found on the distribution media in the file /process/NBP1508JGOF.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.

03/04/15 00:00:00 -61.5761 131.9662 10.05 0.70 181.39 180.12 255.82 2.258 3.02 33.767 4560 10.39  
277.03 0.82 90.94 975.47 0.92 86.83 46.89 274.17

Field	Data	Units
01	GMT Date	dd/mm/yy
02	GMT Time	hh:mm:ss
03	Seapath Latitude (negative is South)	tt.tttt
04	Seapath 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	μEinstein's/meter <sup>2</sup>
10	Sea Surface Temperature	°C
11	Sea Surface Conductivity	siemens/meter
12	Sea Surface Salinity	PSU
13	Sea Depth (uncorrected, calc. sw sound vel. 1500 m/s)	meters
14	True Wind Speed (max speed windbird)	meters/sec
15	True Wind Direction (max speed windbird)	degrees (azimuth)
16	Ambient Air Temperature	°C
17	Relative Humidity	%
18	Barometric Pressure	mBars
19	Sea Surface Fluorometry	volts (0-5 FSO)
20	Transmissometry	%
21	PSP	W/m <sup>2</sup>
22	PIR	W/m <sup>2</sup>



## 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 NBP1508.mgd. The file NBP1508.gmt is created from the MGD77 dataset using the “mgd77togmt” utility. NBP1508.gmt can be used with the GMT plotting package.

The data used to produce the NBP1508.mgd file can be found on the distribution media in the file /process/1508proc.tar. The data files in the archive contain a day’s data and follow the naming convention Dddd.fnl.tz, 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 chars 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	Positive = North, Negative = South. (-9000000 to 9000000)
36-44	9	real	Longitude x 100000	Positive = East, Negative = 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	Bathymetric, 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 <sup>st</sup> sensor	In tenths of nanoteslas (gammas)
67-72	6	real	Magnetics total field, 2 <sup>nd</sup> 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 <sup>st</sup> or leading sensor, 2 = 2 <sup>nd</sup> 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 residual are assumed to have been already corrected.
85-90	6	F6.0	Depth or altitude of magnetics sensor	(In meters). Positive = Below sea level, 3 = Above sea level
91-97	7	real	Observed gravity	In 10 <sup>th</sup> of mgals. Corrected for Eotvos, drift, tares
98-103	6	real	EOTVOS correction	In 10 <sup>th</sup> of mgals. $E = 7.5 V \cos \phi \sin \alpha + 0.0042 V^2$
104-108	5	real	Free-air anomaly	In 10 <sup>th</sup> 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.

### pCO<sub>2</sub>

The NBP carries a pCO<sub>2</sub> measurement system from Lamont-Doherty Earth Observatory (LDEO). pCO<sub>2</sub> data is recorded by RVDAS and transmitted to LDEO at the end of each cruise. You will find pCO<sub>2</sub> data in a file named 1508pco2.tar in the /process directory, which contains the pCO<sub>2</sub> instrument's data merged with GPS, meteorological and other oceanographic measurements. For more information contact Colm Sweeney ([csweeney@ldeo.columbia.edu](mailto:csweeney@ldeo.columbia.edu)).

## Cruise Science

### CTD

The CTD data has been placed in the tar file /ocean/NBP1508ctd.tar. The archive contains tar files NBP1508proc.tar.

### 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 1508xbt.tar in the /ocean directory. No XBTs were collected on this cruise.

### 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:      NBP1508mwx1.d025

- The CruiseID is the numeric name of the cruise, in this case, NBP1508.
- The ChannelID is a 4-character code representing the system being logged. An example is “mwx1,” the designation for meteorology.
- DDD is the day of year the data was collected

## Underway Sensors

### Meteorology and Radiometry

Measurement	String ID	Collection Status	Rate	Instrument
Air Temperature	mw1 (met)	Continuous	1/sec	RM Young 41372LC
Relative Humidity	mw1 (met)	Continuous	1/sec	RM Young 41372LC
Wind Speed / Direction	mw1 (pus,sus)	Continuous	1/sec	Gill Instruments 1390-PK-062
Barometer	mw1 (met)	Continuous	1/sec	RM Young 61201
PAR	mw1 (met)	Continuous	1/sec	Biospherical Instruments QSR-240
PIR	mw1 (met)	Continuous	1/sec	Eppley PIR
PSP	mw1 (met)	Continuous	1/sec	Eppley PSP
GUV	pguv	Continuous	2/sec	Biospherical Instruments GUV-2511

### Geophysics

Measurement	String ID	Collection Status	Rate	Instrument
Gravimeter	grv1	Continuous	1/sec	BGM3/210
Magnetometer	mag1	Continuous	1/sec	Marine Magnetics – SeaSPY Overhauser
Bathymetry	knud	Continuous	varies	Knudsen Chirp
Bathymetry	mbdp	Continuous	varies	Simrad EM122

### Oceanography

Measurement	String ID	Collection Status	Rate	Instrument
Conductivity	tsg1,tsg2	Continuous	0.5/sec	Sea-Bird SBE 45
Ocean Surface Temperature	rtmp	Continuous	1.2/sec	Sea-Bird SBE 38
Transmissometer	hdas	Continuous	0.5/sec	WetLabs C-Star
Fluorometer	hdas	Continuous	0.5/sec	WetLabs FLRTD
pCO <sub>2</sub>	pco2	Continuous	0.017/sec	LDEO instrumentation
ADCP	adcp	Continuous	1/sec	UHDAS
Bathymetry	sim1	Continuous	varies	Simrad EK60 Sonar

### Navigational Instruments

Measurement	String ID	Collection Status	Rate	Instrument
Heading, Speed, Course, GPS, Heave, Roll and Pitch	s330	Continuous	1/sec	Seapath 330 GPS
Heading, Speed, Course, GPS, Heave, Roll and Pitch	seap	Continuous	1/sec	Seapath 200 GPS
Heading, Speed, Course, GPS	PCOD	Continuous	1/sec	Trimble Centurion GPS
Heading	gyr1	Continuous	0.2/sec	Yokogawa Compass

## 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.

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

**Underway Data** /rvdas/uw**Sound Velocity Probe (svp1)**

15+055:20:27:24.018 1535.43

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Sound Velocity, from ADCP sonar well	xxxx.xx	m/s

**Meteorology (mwx1)****MET**

15+055:20:27:24.636 MET,12.1,-39,-6.07,77.4,178.0729,0.809536,-0.1235019,268.1754,267.9648,970.7878

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	MET Flag		
3	Power Supply Voltage	vv.v	V
4	Enclosure Relative Humidity (not implemented)	xx.x	%
5	Air Temperature, Celsius	xx.x	C
6	Air Relative Humidity	xx.x	%
7	PAR (Photosynthetically Available Radiation)	xxx.xxxx	mV
8	PSP (Shortwave Radiation)	x.xxxxxx	mV
9	PIR Thermopile (Longwave Radiation)	x.xxxxxx	mV
10	PIR Case Temperature	xxx.xxxx	K
11	PIR Dome Temperature	xxx.xxxx	K
12	Barometer	xxx.xxxx	mBar

**PUS**

15+055:21:47:42.452 PUS,A,037,014.36,M,+325.38,-010.29,60,0F

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	PUS Flag		
3	A	x	A
4	Port Wind Relative Direction	xxx	degrees
5	Port Wind Relative Speed	xxx.xx	m/s
6	M = Meters (for previous)	x	M
7	Sound Speed	xxx.xx	m/s
8	Sonic Temperature	xxx.xx	C
9	Unit Status*	xx	numeric
10	Checksum	xx	alphanumeric

**Status**

00 = Good, 60 = Good. Any other value indicates fault

**SUS**

15+055:21:50:48.409 SUS,A,338,012.63,M,+326.15,-009.05,60,0F

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	SUS Flag		
3	A	x	A
4	Starboard Wind Relative Direction	xxx	degrees
5	Starboard Wind Relative Speed	xxx.xx	m/s
6	M = Meters (for previous)	x	M
7	Sound Speed	xxx.xx	m/s
8	Sonic Temperature	xxx.xx	C
9	Unit Status*	xx	numeric
10	Checksum	xx	alphanumeric

**Status**

00 = Good, 60 = Good. Any other value indicates fault

**Knudsen (knud)**

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	3.5kHz = Low frequency in use	x.xxxx	3.5kHz
3	Low Frequency Depth	xxxx.xx	m
4	Valid Flag	x	0
5	12.0kHz = High frequency in use	xx.xxxx	12.0kHz
6	High Frequency Depth	xxxx.xx	m
7	Valid Flag	x	0
8	Sound Speed Velocity	xxxx	m/s
9	Latitude	xx.xxxxxx	degrees
10	Longitude	xx.xxxxxx	degrees

**Gravimeter (grv1)**

15+056:14:21:21.153 01:025268 00

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	01:	xx:	01
3	Gravity Count*	xxxxxx	Flit Count
4	Error Flag	xx	numeric



**pCO<sub>2</sub> (pco2)**

15+056:14:41:10.392 2015056.60236 2608.36 30.14 977.91 48.25 368.76 353.92 -1.18 -1.26 0.00 Equil

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	pCO <sub>2</sub> time tag*	yyyyddd.ttt	UTC
3	Raw Voltage (IR)	xxxx.xx	mV
4	Cell Temperature	xx.xx	C
5	Equilibration Pressure	xxx.xx	mBar
6	Flowrate	xxx.xx	cm <sup>3</sup> /min
7	pCO <sub>2</sub> Pressure	xxx.xx	μAtm
8	VCO <sub>2</sub> Concentration	xx.xx	ppm
9	Equilibrator Temperature, RTD	xx.xx	C
10	Equilibrator Temperature, SBE38	xx.xx	C
11	Valve Position	xx	numeric
12	Flow Source*		text

**pCO<sub>2</sub> time tag**

ttt = fractional time of day

**Flow Source**Equil = pCO<sub>2</sub> Measurement**Micro TSG (tsg1,tsg2)**

15+056:15:06:06.644 -1.1809, 2.73404, 34.0574, 1442.367

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Temperature	xx.xxxx	C
3	Conductivity	xx.xxxx	s/m
4	Salinity	xx.xxxx	PSU
5	Sound Velocity	xxxx.xxx	m/s

**Remote Temperature (rtmp)**

15+056:15:10:38.244 -1.4644

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Temperature, Seawater Intake	xx.xxxx	C

**GUV (pguv)**

15+057:14:51:33.808 022615 065133 .000132 .010878 .047479 .004407 -.002799 .014652 .027558 .094395  
 .417814 -4.466095

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Date	mmddyy	UTC-4
3	Time	hhmmss	UTC-4
4	Ed0GND (sensor ground voltage)	xxxxxx	V
5	Ed0320 (downwelling 320nm irradiance)	xxxxxx	μW
6	Ed0340 (downwelling 340nm irradiance)	xxxxxx	μW
7	Ed0313 (downwelling 313nm irradiance)	xxxxxx	μW
8	Ed0305 (downwelling 305nm irradiance)	xxxxxx	μW
9	Ed0380 (downwelling 380nm irradiance)	xxxxxx	μW
10	Ed0PAR (downwelling 400-700nm irradiance)	xxxxxx	μE
11	Ed0395 (downwelling 395nm irradiance)	xxxxxx	μW
12	Ed0Temp (sensor array temperature)	xxxxxx	C
13	Ed0Vin (input voltage)	x.xxxxxx	V

**Engineering (eng1)**

15+057:16:41:24.536 12.25 23.21 507.8 0.6 162.6 -751.9 0 0 NAN NAN -10.3 7.2

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Supply Voltage	xx.xx	V
3	Case Temperature	xx.xx	C
4	Seawater Flow, Aquarium Room	xxx.x	l / min
5	Seawater Flow, Helo-deck	x.x	l / min
6	Seawater Flow, Hydro-lab	xxx.x	l / min
7	Seismic Air Pressure	xxx.x	lbf/in <sup>2</sup>
8	Not Currently Hooked Up	x	0 or NAN
9	Not Currently Hooked Up	x	0 or NAN
10	Not Currently Hooked Up	x	0 or NAN
11	Not Currently Hooked Up	x	0 or NAN
12	Altimeter for Yo-Yo Camera - <b>Rarely used*</b>	xx.xx	m
13	Transmissometer for Yo-Yo camera - <b>Rarely used*</b>	xxx.x	%

**Altimeter**

This is rarely used, and only provides real data when connected. When not connected, provides a value approx = -10.

**Transmissometer**

This is rarely used, and only provides real data when connected. When not connected, provides a value range of approx = 0 to 10.

**Hydro DAS (hdas)**

15+057:16:07:09.456 12.15038 12.39402 336.5517 4431.724 -1 20.5 64 33.5 43.5

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Supply Voltage	xx.xxxxx	V
3	Case Temperature	xx.xxxxx	C
4	Fluorometer	xxx.xxxx	mV
5	Transmissometer	xxxx.xxx	mV
6	Sea Water Valve*	x	-1 or 0
7	Flow Meter 1 Frequency	xx.x	Hz
8	Flow Meter 2 Frequency	xx.x	Hz
9	Flow Meter 3 Frequency	xx.x	Hz
10	Flow Meter 4 Frequency	xx.x	Hz

**Sea Water Valve**

-1 = Stern Thruster Valve, 0 = Moon Pool Valve

**Winch (bwnc, cwnc, twnc)**

15+057:14:12:24.405 02RD,2015-02-26T14:55:32.051,STBD TRAWL,00000064,-00000.0,-00023.2,3594

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	LAN ID		alphanumeric
3	LCI-90i Date and Time	yyyy-mm-ddThh:mm:ss.sss	
4	Winch Name		alphabetical
5	Tension	xxxxxxxxx	lbs
6	Speed	xxxxx.x	m/min
7	Payout	xxxxx.x	m
8	Checksum	x.xxxx	numeric

**Multibeam (mbdp)**

15+058:22:04:52.826 \$KIDPT,594.68,7.67,12000.0\*43

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	KIDPT	x.x	m
3	Depth at Transducer	x.x	m
4	Distance to Waterline from Transducer	x.x	m
5	Maximum Range in Use	x.x	alphanumeric
6	Checksum	xx	UTC

## Navigational Data */rvdas/nav*

### Seapath GPS (s330, seap)

The Seapath 330 outputs five NMEA standard strings – GPZDA, GPGGA, GPVTG, GPHDT, and GPRMC. The Seapath 200 outputs four NMEA standard strings – GPZDA, GPGGA, GPVTG, and GPHDT. Both GPS's output three PSXN proprietary strings – PSXN 20, PSXN 22, and PSXN 23.

#### GPZDA

15+051:21:02:04.507 \$GPZDA,210204.39,20,02,2015,,\*6F

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$GPZDA		
3	Time	hhmmss.ss	UTC
4	Day	dd	UTC
5	Month	mm	UTC
6	Year	yyyy	UTC
7	(empty field)	x	Blank or 0
8	Checksum	xx	alphanumeric

#### GPGGA

15+051:21:02:02.507 \$GPGGA,210202.38,7712.979244,S,16741.040258,W,1,12,0.7,-5.04,M,-55.90,M,,\*6F

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$GPGGA		
3	Time	hhmmss.ss	UTC
4	Latitude	ddmm.mmmmmm	degrees
5	North or South (for previous)	x	N or S
6	Longitude	ddmm.mmmmmm	degrees
7	East or West (for previous)	x	E or W
8	GPS quality indicator*	x	0,1,2,3,4,5, or 6
9	Number of satellites in use (00-99)	xx	00-99
10	HDOP	x.x	
11	Antenna height	x.xx	m
12	M = Meters (for previous)	x	M
13	Geoidal height	x.xx	m
14	M = Meters (for previous)	x	M
15	Age of DGPS corrections (seconds)	x.x	seconds
16	Station ID of DGPS (if used)	x	numeric
17	Checksum	xx	alphanumeric

#### Quality

0 = invalid, 1 = GPS SPS, 2 = DGPS, 3 = PPS, 4 = RTK, 5 = float RTK, 6 = dead reckoning

**GPVTG**

15+051:16:47:06.625 \$GPVTG,357.84,T,251.99,M,9.5,N,17.7,K,A\*15

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$GPVTG		
3	Heading	x.xx	degrees
4	T = True (for previous)	x	T
5	Heading	x.xx	degrees
6	M = Magnetic (for previous)	x	M
7	Speed over Ground (knots)	x.x	knots
8	N = knots (for previous)	x	N
9	Speed over Ground (kilometers per hour)	x.x	km/h
10	K = km per hour (for previous)	x	K
11	Mode*	X	A,D,E, or N
12	Checksum	xx	alphanumeric

**Modes**

A = GPS used, D = DGPS used, E = Dead reckoning used, N = Invalid position / velocity

**GPRMC**

15+051:21:02:04.741 \$GPRMC,210204.38,A,7712.979182,S,16741.063669,W,9.4,270.82,200215,105.6,E,A\*06

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$GPRMC		
3	Time	hhmmss.sss	UTC
4	Status*	x	A or N
5	Latitude	ddmm.mmmmmm	degrees
6	North or South (for previous)	x	N or S
7	Longitude	ddmm.mmmmmm	degrees
8	East or West (for previous)	x	E or W
9	Speed over Ground, True	x.x	knots
10	Course over Ground True	x.xx	degrees
11	Date	ddmmyy	UTC
12	Magnetic Variation	x.x	degrees
13	East or West (for previous)	x	E or W
14	Mode*	x	alphanumeric
15	Checksum	xx	UTC

***GPHDT***

15+051:21:02:04.741 \$GPHDT,268.87,T\*06

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$GPHDT		
3	Heading, True	x.xx	degrees
4	T = True (for previous)	x	T
5	Checksum	xx	alphanumeric

***PSXN 20***

15+051:22:20:58.740 \$PSXN,20,1,0,0,0\*3A

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$PSXN		
3	20		
4	Horizontal position and velocity quality*	x	0,1,2
5	Height and vertical velocity quality*	x	0,1,2
6	Heading quality*	x	0,1,2
7	Roll and pitch quality*	x	0,1,2
8	Checksum	xx	alphanumeric

**Qualities**

0 = Normal, 1 = Reduced Performance, 2 = Invalid data

***PSXN 22***

15+051:22:20:59.019 \$PSXN,22,0.43,0.50\*3B

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$PSXN		
3	22		
4	Gyro calibration value since system startup	x.xx	degrees
5	Short-term gyro offset	x.xx	degrees
6	Checksum	xx	alphanumeric

**PSXN 23**

15+051:22:20:58.748 \$PSXN,23,-0.20,-0.09,279.85,0.24\*34

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$PSXN		
3	23		
4	Roll, port side up is positive	x.xx	degrees
5	Pitch, bow up is positive	x.xx	degrees
6	Heading, True	x.xx	degrees
7	Heave, positive is down	x.xx	m
8	Checksum	xx	alphanumeric

**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 five NMEA data strings – GPZDA, GPGGA, GPVTG, GPRMC, and GPGLL.

**GPZDA**

15+051:21:02:04.507 \$GPZDA,210204.39,20,02,2015,0,0,\*6F

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$GPZDA		
3	Time	hhmmss.ss	UTC
4	Day	dd	UTC
5	Month	mm	UTC
6	Year	yyyy	UTC
7	(empty field)	x	Blank or 0
8	(empty field)	x	Blank or 0
9	Checksum	xx	alphanumeric

**GPGGA**

15+051:21:02:02.507 \$GPGGA,210202.38,7712.979244,S,16741.040258,W,1,12,0.7,-5.04,M,-55.90,M,0,\*6F

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$GPGGA		
3	Time	hhmmss.ss	UTC
4	Latitude	ddmm.mmmmmm	degrees
5	North or South (for previous)	x	N or S
6	Longitude	ddmm.mmmmmm	degrees
7	North or South (for previous)	x	E or W
8	GPS quality indicator*	x	0,1,2,3,4,5, or 6
9	Number of satellites in use	xx	00-99
10	HDOP	x.x	numeric
11	Antenna height	x.xx	m
12	M = Meters (for previous)	x	M
13	Geoidal height	x.xx	m
14	M = Meters (for previous)	x	M
15	Age of DGPS corrections	x.x	seconds
16	Station ID of DGPS (if used)	x	numeric
17	Checksum	xx	alphanumeric

**Quality**

0 = invalid, 1 = GPS SPS, 2 = DGPS, 3 = PPS, 4 = RTK, 5 = float RTK, 6 = dead reckoning



**GPVTG**

15+051:16:47:06.625 \$GPVTG,357.84,T,251.99,M,9.5,N,17.7,K,\*15

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$GPVTG		
3	Heading	x.xx	degrees
4	T = True (for previous)	x	T
5	Heading	x.xx	degrees
6	M = Magnetic (for pervious)	x	M
7	Speed over Ground	x.x	Knots
8	N = knots (for previous)	x	N
9	Speed over Ground	x.x	km/h
10	K = km per hour (for previous)	x	K
11	Checksum	xx	alphanumeric

**GPRMC**

15+051:21:02:04.741 \$GPRMC,210204.38,A,7712.979182,S,16741.063669,W,9.4,270.82,200215,105.6,E,\*06

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$GPRMC		
3	Time	hhmmss.sss	UTC
4	Status*	x	A or N
5	Latitude	ddmm.mmmmmm	degrees
6	North or South (for previous)	x	N or S
7	Longitude	ddmm.mmmmmm	Degrees
8	East or West (for previous)	x	E or W
9	Speed over Ground, True	x.x	knots
10	Course over Ground, True	x.xx	degrees
11	Date	ddmmyy	UTC
12	Magnetic Variation	x.x	degrees
13	East or West (for previous)	E or W	E or W
14	Checksum	xx	alphanumeric

**Statutes**

A = Valid, N = invalid position

**GPGLL**

15+051:21:02:21.674 \$GPGLL,7712.9783,S,16741.2521,W,210220.627,A\*3C

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$GPGLL		
3	Latitude	ddmm.mmmmmm	degrees
4	North or South (for previous)	x	N or S
5	Longitude	ddmm.mmmmmm	degrees
6	East or West (for previous)	x	E or W
7	Time	hhmmss.sss	UTC
8	Status	x	A or N
9	Checksum	xx	alphanumeric

**Statutes**

A = Valid, N = invalid position

**Gyro Compass (gyr1)**

15+055:20:27:23.653 \$HEHDT,087.31,T\*12

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$HEHDT		
3	Heading	x.xx	degrees
4	T = True (for previous)	x	T
5	Checksum	xx	alphanumeric

*Processed Data /process/***pCO<sub>2</sub> - Merged**

15+055:11:24:43.960 2015055.46596 2534.72 32.41 975.33 48.86 356.94 341.67 -1.20 -1.27 0.00 Equil -  
 75.9209 178.9696 -1.435 33.852 2.26 7.86 137.38 975.34 163.80 9.31 253.75 NaN -1.27 33.84 -1.14 -  
 1.0

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	pCO <sub>2</sub> time tag*	yyyddd.ttt	UTC
3	Raw Voltage (IR)	xxxx.xx	mV
4	Cell Temperature	xx.xx	C
5	Equilibration Pressure	xxx.xx	mBar
6	Flowrate	xxx.xx	cm <sup>3</sup> /min
7	pCO <sub>2</sub> Pressure	xxx.xx	μAtm
8	VCO <sub>2</sub> Concentration	xx.xx	ppm
9	Equilibrator Temperature, RTD	xx.xx	C
10	Equilibrator Temperature, SBE38	xx.xx	C
11	Valve Position	xx	numeric
12	Flow Source*		text
13	Latitude	xx.xxxxx	degrees
14	Longitude	xxx.xxxxx	degrees
15	Sea Water Intake Temperature	xx.xxx	C
16	Sea Surface Salinity	xx.xxx	PSU
17	Sea Surface Fluorometry	x.xxx	mg/m <sup>3</sup>
18	True Wind Speed	x.xx	m/s
19	True Wind Direction	x.xx	degrees
20	Barometric Pressure	xxx.xx	mBar
21	Hydro-Lab H <sub>2</sub> O Flow Rate	xxx.x	l / min
22	Speed over Ground	x.xx	knots
23	Course Made Good	xx.xx	degrees
24	Unused		
25	TSG2 Temperature	x.xx	C
26	TSG2 Salinity	xx.xx	PSU
27	TSG1 Temperature	x.xx	C
28	Sea Water Valve*	x	-1 or 0

**pCO<sub>2</sub> time tag**

ttt = fractional time of day

**Flow Source**

Equil = pCO<sub>2</sub> Measurement

**Sea Water Valve**

-1 = Stern Thruster Valve, 0 = Moon Pool Valve

## Calculations

### 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 “mw1” 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))
```

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.

[illegible]

## Appendix A: Sensors

### NBP1508 Sensors

Sensor	Description	Serial	Last Cal Date	Comments
<b>Meteorology and Radiometry</b>				
Port Anemometer	Gill Instruments 1390-PK-062	924057	11/18/2009	
Stbd Anemometer	Gill Instruments 1390-PK-062	847014	9/29/2010	
Bridge Anemometer	RM Young 5106	WM128975	10/27/2011	ECO Use
Barometer	RM Young 61201	01706	4/10/2014	
Temperature / Humidity	RM Young 41372LC	06134	1/20/2015	
PIR	Eppley PIR	33023F3	6/12/2014	
PSP	Eppley PSP	33090F3	6/11/2014	
PAR (Mast)	Biospherical Instruments QSR-240	6356	2/3/2014	
GUV (Mast)	Biospherical Instruments GUV-2511	25110203114	2/10/2015	

Sensor	Description	Serial	Last Cal Date	Comments
<b>Underway Seawater Sampling System</b>				
Micro-TSG	Sea-Bird SBE 45	4550449-0242	12/20/2014	
Micro-TSG	Sea-Bird SBE 45	4566350-0389	5/29/2014	
Digital Remote Temp	Sea-Bird SBE 38	3846730-0352	11/12/2013	
Transmissometer	WetLabs C-Star	CST-892DR	4/29/2014	
Fluorometer	WetLabs FLRTD	FLRTD-855	3/26/2014	

Sensor	Description	Serial	Last Cal Date	Comments
<b>CTD - WHOI 24x4L</b>				
Altimeter	NA	VA500-47520	NA	
Deck Unit	Sea-Bird SBE 11+	NA	NA	
Conductivity	Sea-Bird SBE 4	0763	6/16/2015	Frequency 1
Conductivity	Sea-Bird SBE 4	1310	3/24/2015	Frequency 2
Pressure	Sea-Bird SBE 9+	1041	1/30/2015	
Temperature	Sea-Bird SBE 3	1085	3/24/2015	Frequency 0
Temperature	Sea-Bird SBE 3	0661	3/24/2015	Frequency 3
Turbidity	NA	LDEO	NA	

## Appendix B: Calibration Sheets

### Gravity

#### 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: 9/1/2015  
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)	25197.81	13:30
Ship's meter after gravity tie (Filt Counts)	25197.79	14:13
Average	25197.80	
Ship Gravimeter's Calibration Constant	4.99407055	
Corrected ship's meter (QC Grav (mgal))	125839.59	

	Value	Time (GMT)
Ship's meter before gravity tie (serial, RVDAS)		
Ship's meter after gravity tie (serial, RVDAS)		
Average (for comparison check only)	#DIV/0!	

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

Station	Value	Time (GMT)	Temp	Date	OBS mgal, averaged
Pier measurement 1	4919.66	13:33	53.5	September 1, 2015	
Pier measurement 2	4919.50	13:37	53.5	September 1, 2015	4969.17
Pier measurement 3	4919.73	13:42	53.5	September 1, 2015	
Average	4919.63				
Station measurement 1	4920.66	13:53	53.5	September 1, 2015	OBS mgal, averaged
Station measurement 2	4920.59	13:56	53.5	September 1, 2015	4970.16
Station measurement 3	4920.58	13:59	53.5	September 1, 2015	
Average	4920.61				
Pier measurement 4	4919.81	14:09	53.5	September 1, 2015	OBS mgal, averaged
Pier measurement 5	4919.96	14:10	53.5	September 1, 2015	4969.46
Pier measurement 6	4919.97	14:11	53.5	September 1, 2015	
Average	4919.91				

Date of last tie	7/2/2015
Gravity Bias from last tie	3/20/4242
Drift since last tie	2.35
Drift RATE since last tie	1.17

OBS Differences	Value	Comments
Station to Pier (1, 2, & 3 averaged)	-0.99	Tie done by Barry Bjork, George Aukon, Maia Theophanis
Station to Pier (4, 5, & 6 averaged)	-0.70	
Averaged Differences	-0.85	
Gravity at pier	981319.97	
Elevation of pier above gravimeter, meters	1.1	
Earth differential gravity, mgal/meter	0.3	
Gravity at ship's gravimeter	981320.30	
Gravity Bias (Offset for RVDAS)	855480.71	

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



## Meteorology

### Anemometers

No Calibration Required

## Barometer



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

### CALIBRATION REPORT Barometric Pressure

Customer: *Lockheed Martin Corp*

Test Number: 4410-02B  
Test Date: 10 April 2014

Customer PO: 4900045904  
Sales Order: 4006

<u>Test Sensor:</u>	
Model: 61201	Serial Number: BP01706
Description: Barometric Pressure Sensor	

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

Reference Pressure (hPa)	Voltage Output (millivolts)	Indicated (1) Pressure (hPa)
800.0	-1	800.0
875.0	1251	875.0
950.0	2501	950.0
1025.0	3750	1025.0
1100.0	4999	1099.9

(1) Calculated from voltage output

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

Reference Instrument  
Druck Pressure Controller Model DPI515  
Fluke Multimeter Model 8060A

Serial # NIST Test Reference  
51500497 UKAS Lab 0221  
4865407 234027

Tested By: \_\_\_\_\_

METEOROLOGICAL INSTRUMENTS  
Tel: 231-946-3980 Fax: 231-946-4772 Email: met.sales@youngusa.com Website: youngusa.com  
ISO 9001:2008 CERTIFIED

## Temperature / Humidity



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

### CALIBRATION REPORT Temperature

Customer: *Lockheed Martin Corp*

Test Number: 5120-07T

Customer PO: 4101741493

Test Date: 20 January 2015

Sales Order: 4554

Test Sensor:

Model: 41372LC

Serial Number: TS06134

Description: Temperature/Relative Humidity Sensor

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

Bath Temperature (degrees C)	Current Output (milliamps)	Indicated (1) Temperature (degrees C)
-49.85	4.029	-49.82
-0.01	11.997	-0.02
49.94	19.990	49.94

(1) Calculated from current output

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

Reference Instrument

Brooklyn Thermometer Model 43-FC  
Brooklyn Thermometer Model 22332-D5-FC  
Brooklyn Thermometer Model 2X400-D7-FC  
Keithley Multimeter Model 191

Serial # NIST Test Reference

3006-118 W204690  
25071 W204691  
77532 W204692  
15232 7124815

Tested By: *R. Thullen*

METEOROLOGICAL INSTRUMENTS  
Tel: 231-946-3980 Fax: 231-946-4772 Email: met.sales@youngusa.com Website: youngusa.com  
ISO 9001:2008 CERTIFIED



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

## CALIBRATION REPORT

### Relative Humidity

Customer: *Lockheed Martin Corp*

Test Number: 5120-07R

Customer PO: 4101741493

Test Date: 20 January 2015

Sales Order: 4554

Test Sensor:

Model: 41372LC      Serial Number: TS06134  
Description: Temperature/Relative Humidity Sensor

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

Reference Humidity (%)	Current Output (milliamps)	Indicated (1) Humidity (%)
10.1	6.0	12.4
30.0	9.0	31.1
50.0	12.4	52.3
70.0	15.4	71.5
90.0	18.2	88.6

(1) Calculated from voltage output

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

Reference Instrument

Vaisala Humidity Sensor Model 35AC  
Agilent Multimeter Model 34405A

Serial # NIST Test Reference

N475040      TN 266152  
MY53020093      7124815

Tested By: \_\_\_\_\_

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: 33023F3

Resistance: 739  $\Omega$  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<sup>-2</sup> and an average ambient temperature of 24°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:

$$3.82 \times 10^{-6} \text{ volts/watts meter}^{-2}$$

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<sup>-2</sup>. 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: NSF/Lockheed Martin  
Port Hueneme, CA

Date of Test: June 11, 2014

S.O. Number: 64124  
Date: June 12, 2014

In Charge of Test: *Debra L. Gentry*  
Reviewed by: *Thomas J. Kutz*

Remarks:

*End of Report*



## 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 33090F3

**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 18851F3

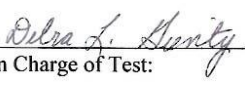
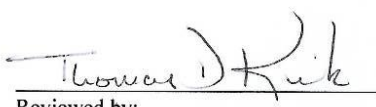
**Results:**  
**Sensitivity:**  $S = 7.90 \mu\text{V} / \text{Wm}^{-2}$   
**Uncertainty:**  $U_{95} = \pm 0.91\%$  (95% confidence level,  $k=2$ )  
**Resistance:**  $700 \Omega$  at  $23^\circ\text{C}$

**Date of Test:** June 23, 2014

**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:** NSF/Lockheed Martin  
Port Hueneme, CA

**Signatures:**  
**In Charge of Test:**   
**Reviewed by:** 

**Eppley SO:** 64130

**Date of Certificate:** June 23, 2014

**Remarks:** Sensitivity before Repainting Element =  $7.86 \mu\text{V} / \text{Wm}^{-2}$

End of Report

## PAR (Mast)

**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/cm<sup>2</sup>sec  
0.01538 uE/cm<sup>2</sup>sec

Calibration Scale Factor:

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

Dry: 1.0720E-17 V/(quanta/cm<sup>2</sup>sec)  
6.4555E+00 V/(uE/cm<sup>2</sup>sec)

## 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

## GUV (Mast)

**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 25110203114**

**Optical Calibrations:**

**NIST Traceability.** For wavelengths longer than 313 nm, the specific instruments cited here were calibrated using a 1000W FEL #V-035(3/7/12) following procedures and standards traceable to NIST Standard of Spectral Irradiance F616. 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  $75^\circ$ . 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 25110203114v8.mdb. This database is required for operation of this system using Biospherical Instruments Inc.'s Logger® software.





Biospherical Instruments Inc.

## GUV-2511 Calibration Certificate

System Serial Number	25110203114	Date of Calibration	2/10/2015
Calibration database	25110203114v8.mdb	Date of Certificate	2/11/2015
DA SSN	0069	Standard of Spectral Irradiance	V-035(3/7/12)
Microprocessor Tag Number	4	Operator	TC

Monochromatic Channels	Address	Wavelength [nm]	Responsivity [Amps per $\mu\text{W}/(\text{cm}^2\cdot\text{nm})$ ]	ScaleSmall [Volts per $\mu\text{W}/(\text{cm}^2\cdot\text{nm})$ ]	ScaleMedium [Volts per $\mu\text{W}/(\text{cm}^2\cdot\text{nm})$ ]	ScaleLarge [Volts per $\mu\text{W}/(\text{cm}^2\cdot\text{nm})$ ]	OffsetSmall [volts]	OffsetMedium [volts]	OffsetLarge [volts]	Measurement Units
Ed0320	2	320	2.3590E-10	2.4062E-05	7.0299E-03	2.2188E+00	3.4492E-05	3.2554E-05	5.6504E-04	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Ed0340	6	340	1.8544E-10	1.8915E-05	5.5262E-03	1.8957E+00	4.2136E-05	4.1875E-05	7.6934E-04	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Ed0313	8	313	2.1863E-10	2.2300E-05	6.5152E-03	2.2871E+00	9.1228E-04	9.0624E-04	-1.2773E-03	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Ed0305	10	305	1.0543E-11	1.0754E-06	3.1419E-04	1.0799E-01	3.5080E-04	3.5087E-04	1.1382E-03	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Ed0380	12	380	8.2468E-11	8.4117E-06	2.4575E-03	7.8824E-01	2.8388E-04	2.7513E-04	-3.8577E-05	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Ed0395	18	395	2.9289E-10	2.9875E-05	8.7282E-03	2.7590E+00	3.8212E-04	3.8356E-04	1.4618E-03	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Broadband Channels	Address	Wavelength [nm]	Responsivity [Amps per $\mu\text{E}/(\text{cm}^2\cdot\text{s})$ ]	ScaleSmall [Volts per $\mu\text{E}/(\text{cm}^2\cdot\text{s})$ ]	ScaleMedium [Volts per $\mu\text{E}/(\text{cm}^2\cdot\text{s})$ ]	ScaleLarge [Volts per $\mu\text{E}/(\text{cm}^2\cdot\text{s})$ ]	OffsetSmall [volts]	OffsetMedium [volts]	OffsetLarge [volts]	Measurement Units
Ed0PAR	13	400-700	1.7184E-05	1.7528E+00	5.1208E+02	1.8098E+05	5.6671E-04	5.6137E-04	-4.7669E-04	$\mu\text{E}/(\text{cm}^2\cdot\text{sec})$
Auxiliary Channels	Address	Wavelength	Responsivity	ScaleS	ScaleM	ScaleL	OffsetS	OffsetM	OffsetL	Measurement Units
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](mailto:support@biospherical.com) for more information.

## Underway Seawater Sampling System

## 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: 0242  
CALIBRATION DATE: 20-Dec-14SBE 45 CONDUCTIVITY CALIBRATION DATA  
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

## COEFFICIENTS:

g = -9.971074e-001  
h = 1.520779e-001  
i = -3.950938e-004  
j = 5.484363e-005CPcor = -9.5700e-008  
CTcor = 3.2500e-006  
WBOTC = -0.0000e+000

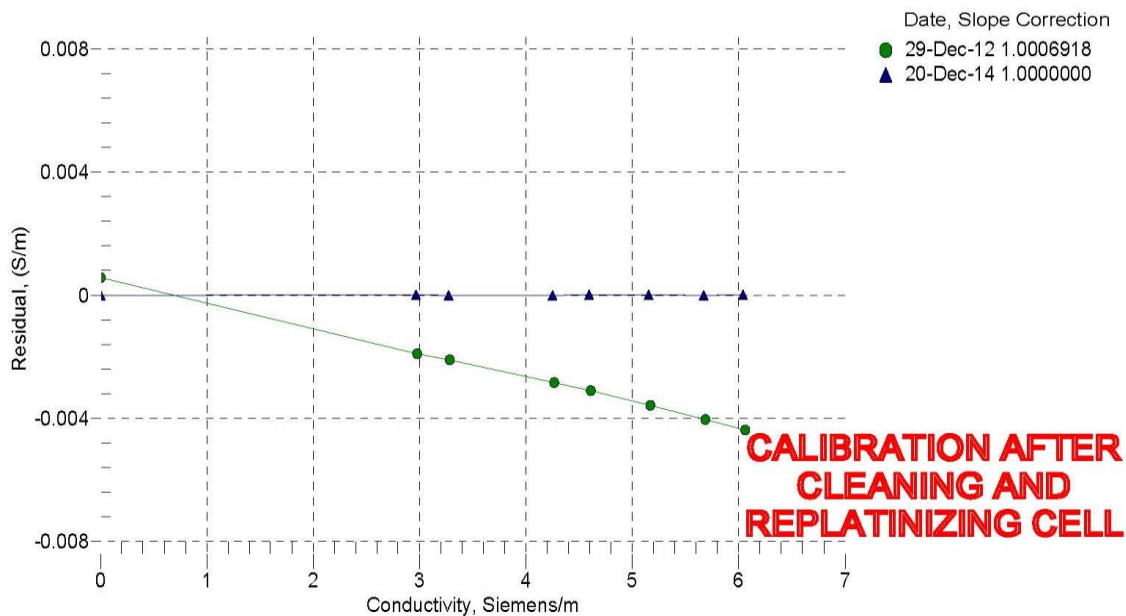
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2566.09	0.00000	0.00000
1.0000	34.6921	2.96636	5114.98	2.96636	0.00000
4.5000	34.6725	3.27249	5308.26	3.27249	-0.00001
15.0000	34.6299	4.25116	5882.92	4.25115	-0.00001
18.5000	34.6209	4.59524	6071.75	4.59525	0.00001
24.0000	34.6113	5.15149	6364.85	5.15149	0.00000
29.0000	34.6062	5.67177	6626.90	5.67176	-0.00000
32.5000	34.6038	6.04311	6807.56	6.04311	0.00000

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

$$\text{Conductivity} = (g + h * f^2 + i * f^3 + j * f^4) / (1 + \delta * t + \epsilon * p) \text{ Siemens / meter}$$

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

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



## 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: 0242  
CALIBRATION DATE: 20-Dec-14SBE 45 TEMPERATURE CALIBRATION DATA  
ITS-90 TEMPERATURE SCALE

## COEFFICIENTS:

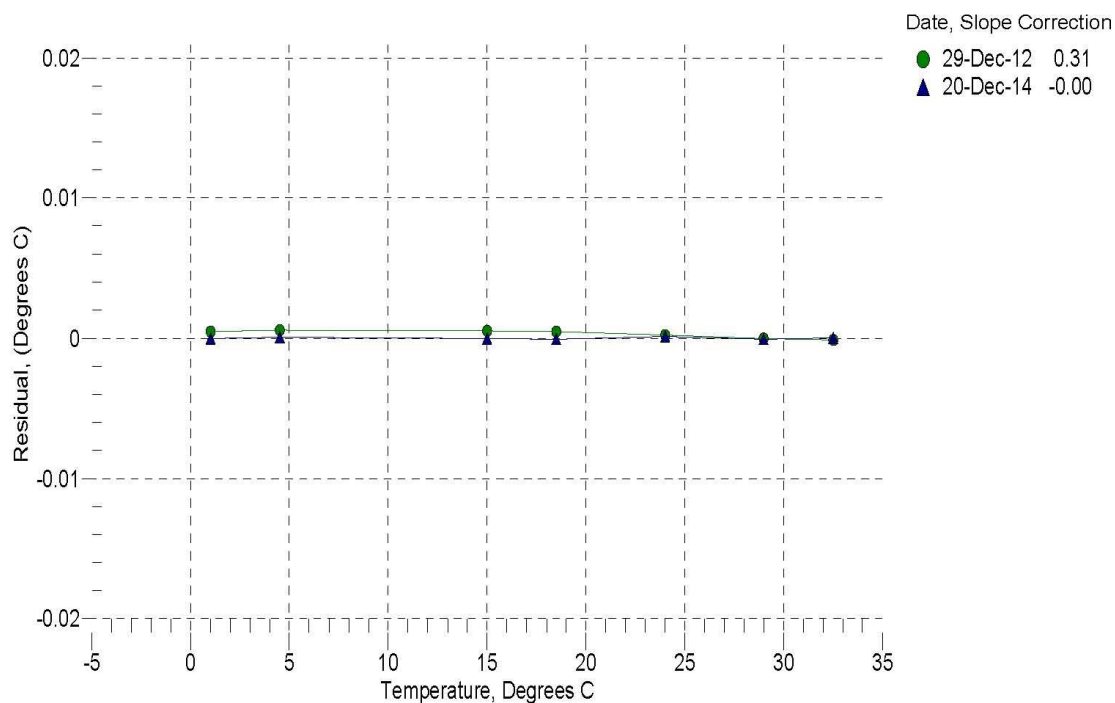
$a_0 = 3.008474e-005$   
 $a_1 = 2.771494e-004$   
 $a_2 = -2.629679e-006$   
 $a_3 = 1.581267e-007$

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	649831.8	1.0000	-0.0000
4.5000	554896.4	4.5001	0.0001
15.0000	352336.2	15.0000	-0.0000
18.5000	304724.2	18.4999	-0.0001
24.0000	244011.9	24.0001	0.0001
29.0000	200602.3	28.9999	-0.0001
32.5000	175478.1	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

n = instrument output



## Micro-TSG2

## 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: 29-May-14SBE 45 CONDUCTIVITY CALIBRATION DATA  
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

## COEFFICIENTS:

$g = -9.972006e-001$   
 $h = 1.453197e-001$   
 $i = -3.532467e-004$   
 $j = 4.851413e-005$

$CPcor = -9.5700e-008$   
 $CTcor = 3.2500e-006$   
 $WBOTC = 1.2700e-007$

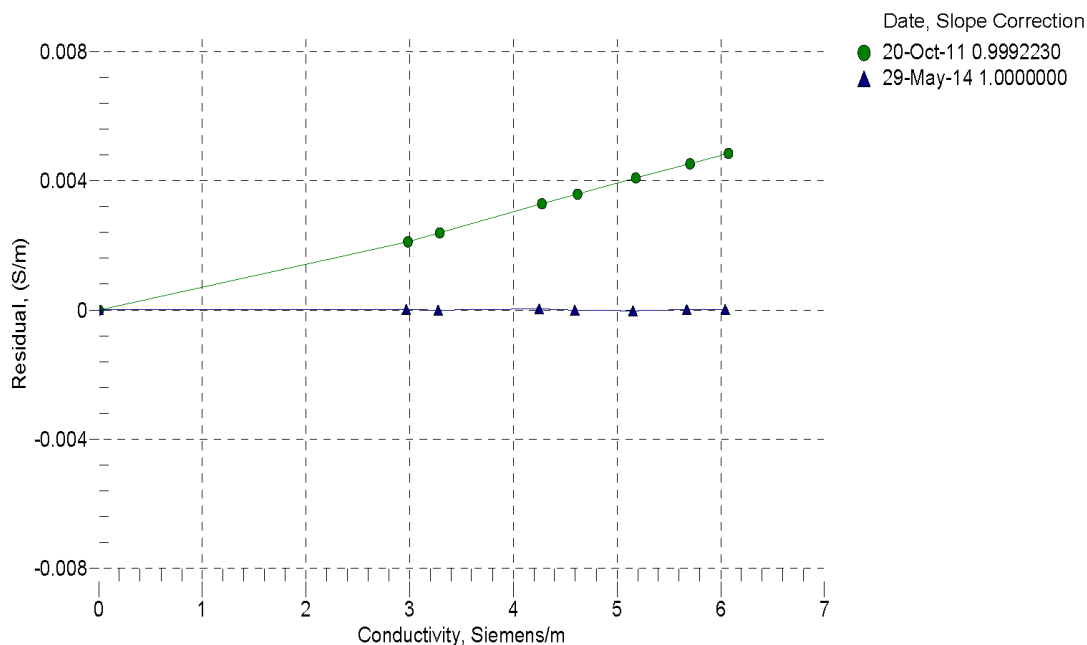
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2624.92	0.00000	0.00000
0.9998	34.6961	2.96665	5232.10	2.96665	0.00000
4.5057	34.6762	3.27332	5430.12	3.27330	-0.00001
15.0000	34.6345	4.25166	6017.72	4.25170	0.00003
18.5010	34.6261	4.59595	6210.96	4.59595	-0.00000
24.0071	34.6168	5.15295	6511.14	5.15292	-0.00003
29.0000	34.6116	5.67255	6778.86	5.67255	0.00000
32.5000	34.6081	6.04378	6963.60	6.04378	0.00001

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

$$\text{Conductivity} = (g + h * f^2 + i * f^3 + j * f^4) / (1 + \delta * t + \epsilon * p) \text{ Siemens / meter}$$

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

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



## 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: 29-May-14SBE 45 TEMPERATURE CALIBRATION DATA  
ITS-90 TEMPERATURE SCALE

## COEFFICIENTS:

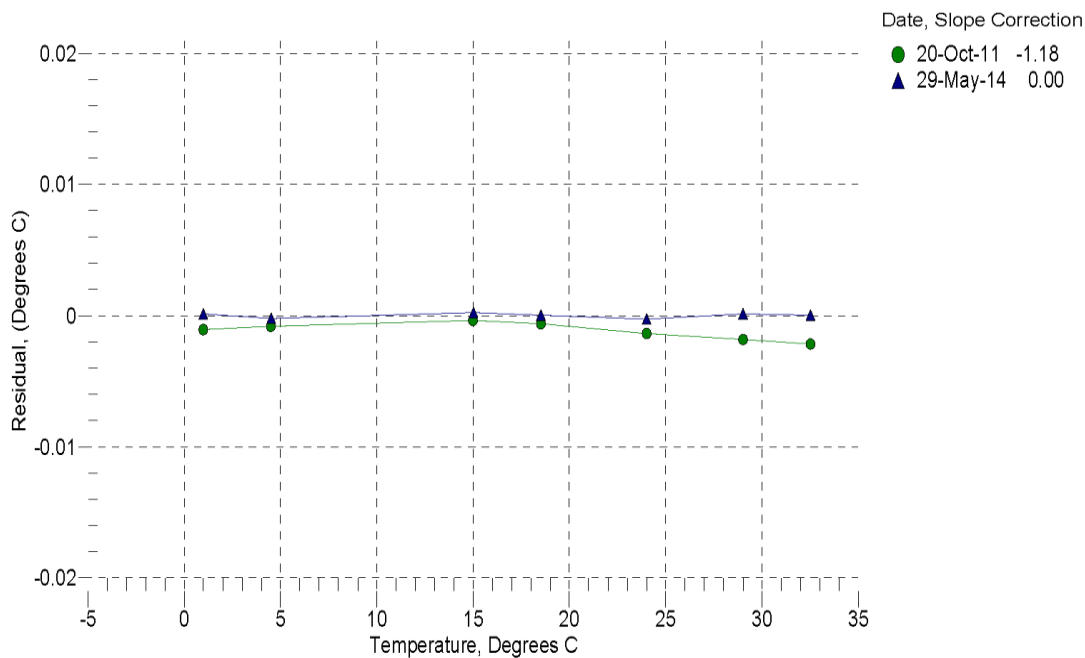
$a_0 = -3.970068e-006$   
 $a_1 = 2.742995e-004$   
 $a_2 = -2.529944e-006$   
 $a_3 = 1.515249e-007$

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9998	828477.2	0.9999	0.0001
4.5057	706509.0	4.5055	-0.0002
15.0000	447322.3	15.0002	0.0002
18.5010	386479.8	18.5010	0.0000
24.0071	308941.3	24.0068	-0.0003
29.0000	253708.3	29.0001	0.0001
32.5000	221731.4	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

n = instrument output



## Digital Remote Temp

**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: 0352  
CALIBRATION DATE: 12-Nov-13SBE 38 TEMPERATURE CALIBRATION DATA  
ITS-90 TEMPERATURE SCALE

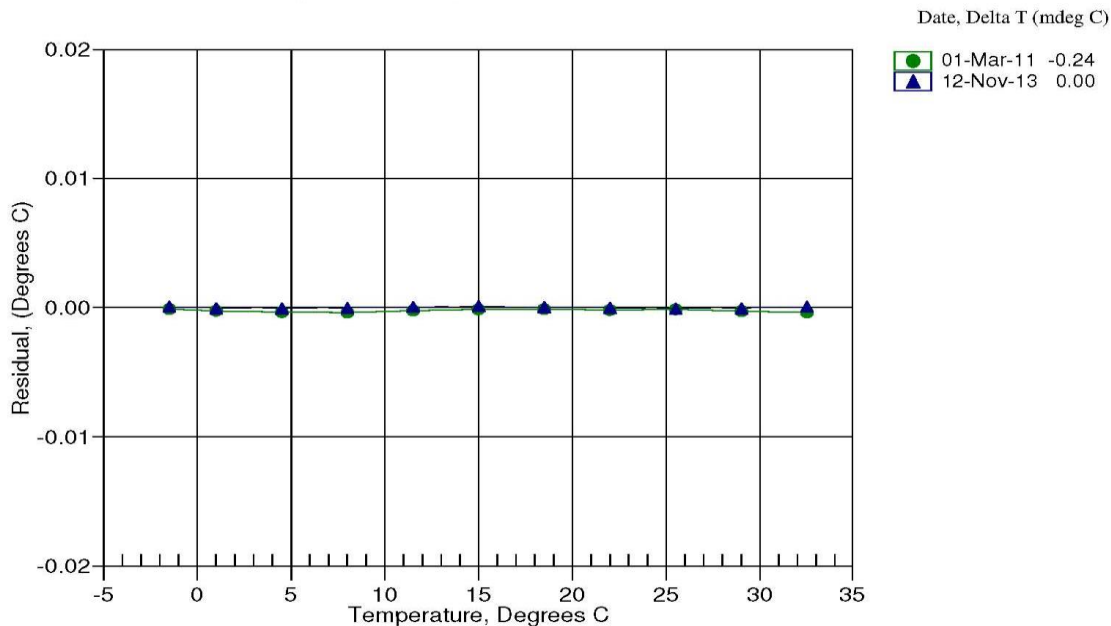
## ITS-90 COEFFICIENTS

$a_0 = 1.511020e-005$   
 $a_1 = 2.671835e-004$   
 $a_2 = -1.693538e-006$   
 $a_3 = 1.368688e-007$

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.50000	809800.6	-1.49994	0.00006
1.00000	723164.1	0.99995	-0.00005
4.50000	618996.5	4.49994	-0.00006
8.00000	531569.6	7.99997	-0.00003
11.50000	457942.4	11.50005	0.00005
15.00000	395732.4	15.00010	0.00010
18.50000	343001.2	18.50002	0.00002
22.00020	298159.9	22.00017	-0.00003
25.50000	259918.4	25.49994	-0.00006
29.00000	227202.8	28.99995	-0.00005
32.50000	199135.3	32.50007	0.00007

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

Residual = instrument temperature - bath temperature



## Transmissometer

PO Box 518  
620 Applegate St.  
Philomath, OR 97370



(541) 929-5850  
Fax (541) 929-5277  
[www.wetlabs.com](http://www.wetlabs.com)

## C-Star Calibration

Date	April 29, 2014	S/N#	CST-892DR	Pathlength	25cm
------	----------------	------	-----------	------------	------

	Analog output
$V_d$	0.059 V
$V_{air}$	4.816 V
$V_{ref}$	4.712 V

Temperature of calibration water	20.4 °C
Ambient temperature during calibration	19.4 °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.



## Fluorometer

PO Box 518  
620 Applegate St.  
Philomath, OR 97370



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

## ECO Chlorophyll Fluorometer Characterization Sheet

Date: 3/26/2014

S/N: FLRTD-855

Chlorophyll concentration expressed in µg/l can be derived using the equation:

$$\text{CHL } (\mu\text{g/l}) = \text{Scale Factor} * (\text{Output} - \text{Dark Counts})$$

	Analog Range 1	Analog Range 2	Analog Range 4 (default)	Digital
Dark Counts	0.116	0.073	0.050 V	71 counts
Scale Factor (SF)	6	13	26 µg/l/V	0.0078 µg/l/count
Maximum Output	4.97	4.97	4.97 V	16326 counts
Resolution	0.8	0.8	0.8 mV	1.0 counts

Ambient temperature during characterization

22.3 °C

**Analog Range:** 1 (most sensitive, 0–4,000 counts), 2 (midrange, 0–8,000 counts), 4 (entire range, 0–16,000 counts).

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

**SF:** Determined using the following equation:  $SF = x + (\text{output} - \text{dark counts})$ , where x is the concentration of the solution used during instrument characterization. SF is used to derive instrument output concentration from the raw signal output of the fluorometer.

**Maximum Output:** Maximum signal output the fluorometer is capable of.

**Resolution:** Standard deviation of 1 minute of collected data.

The relationship between fluorescence and chlorophyll-a concentrations *in-situ* is highly variable. The scale factor listed on this document was determined 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 determining chlorophyll concentration see "Standard Methods for the Examination of Water and Wastewater" part 10200 H, published jointly by the American Public Health Association, American Water Works Association, and the Water Environment Federation.

FLRTD-855

Revision J

3/17/08



## CTD

## Conductivity

## 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: 0763  
CALIBRATION DATE: 16-Jun-15SBE 4 CONDUCTIVITY CALIBRATION DATA  
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

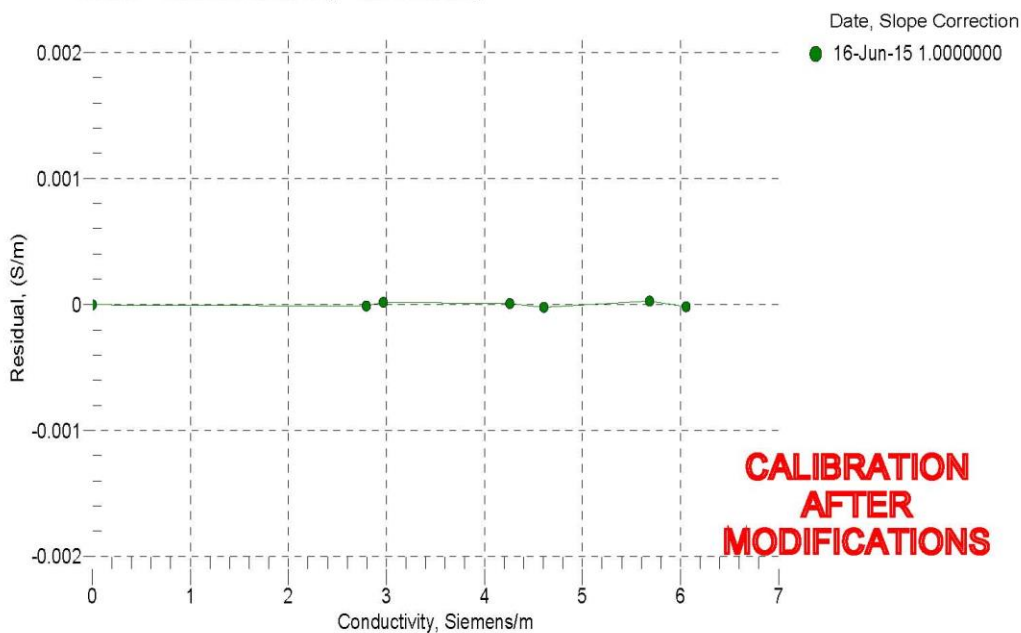
## COEFFICIENTS:

g = -9.91625792e+000  
h = 1.46942808e+000  
i = -2.32623530e-004  
j = 8.13658648e-005CPcor = -9.5700e-008 (nominal)  
CTcor = 3.2500e-006 (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	2.59781	0.00000	0.00000
-1.0000	34.7266	2.79802	5.07678	2.79801	-0.00001
1.0000	34.7269	2.96905	5.18999	2.96907	0.00002
15.0000	34.7285	4.26198	5.97640	4.26199	0.00001
18.5000	34.7286	4.60799	6.16978	4.60797	-0.00002
29.0000	34.7267	5.68929	6.73827	5.68932	0.00003
32.5000	34.7195	6.06102	6.92282	6.06100	-0.00002

 $f = \text{INST FREQ} / 1000.0$  $\text{Conductivity} = (g + h * f^2 + i * f^3 + j * f^4) / (1 + \delta * t + \epsilon * p)$  Siemens / metert = temperature[°C]; p = pressure[decibars];  $\delta = \text{CTcor}$ ;  $\epsilon = \text{CPcor}$ ;

Residual = instrument conductivity - bath conductivity



## Conductivity

## 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: 1310

CALIBRATION DATE: 24-Mar-15

SBE 4 CONDUCTIVITY CALIBRATION DATA

PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

## COEFFICIENTS:

g = -4.05451066e+000

h = 5.11754722e-001

i = -3.92806244e-005

j = 3.05165520e-005

CPcor = -9.5700e-008 (nominal)

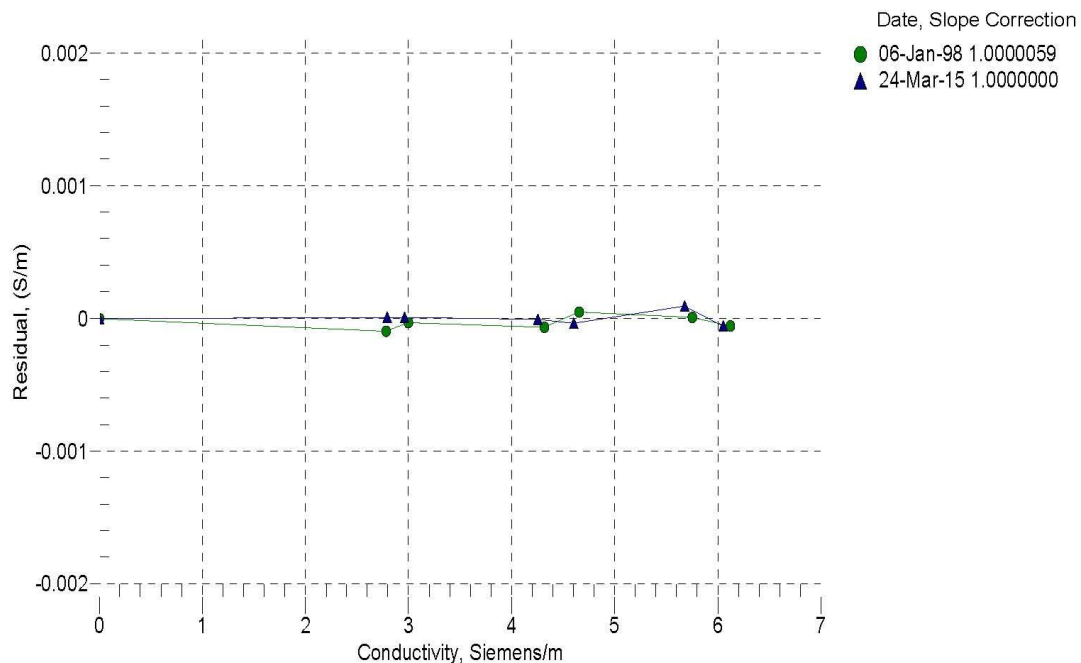
CTcor = 3.2500e-006 (nominal)

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	2.81438	0.00000	0.00000
-1.0000	34.6649	2.79351	7.89404	2.79352	0.00001
1.0000	34.6652	2.96428	8.10128	2.96428	0.00001
15.0000	34.6657	4.25509	9.52103	4.25508	-0.00001
18.5000	34.6662	4.60060	9.86584	4.60056	-0.00004
29.0001	34.6641	5.68020	10.87176	5.68029	0.00009
32.5001	34.6575	6.05143	11.19614	6.05138	-0.00006

f = INST FREQ / 1000.0

Conductivity =  $(g + h * f^2 + i * f^3 + j * f^4) / (1 + \delta * t + \epsilon * p)$  Siemens / metert = temperatur e[°C]; p = pressure[decibars];  $\delta$  = CTcor;  $\epsilon$  = CPcor;

Residual = instrument conductivity - bath conductivity



## Pressure Sensor

## Sea-Bird GmbH

Postfach 1167, 87401 Kempten, Germany

Phone: +49 831 960994 701 Fax: +49 831 960994 709 Email: seabird.eu@seabird.com

SENSOR SERIAL NUMBER: 1041  
CALIBRATION DATE: 30-Jan-15SBE 9plus PRESSURE CALIBRATION DATA  
FSR: 2000 psia S/N 119901

## DIGIQUARTZ COEFFICIENTS:

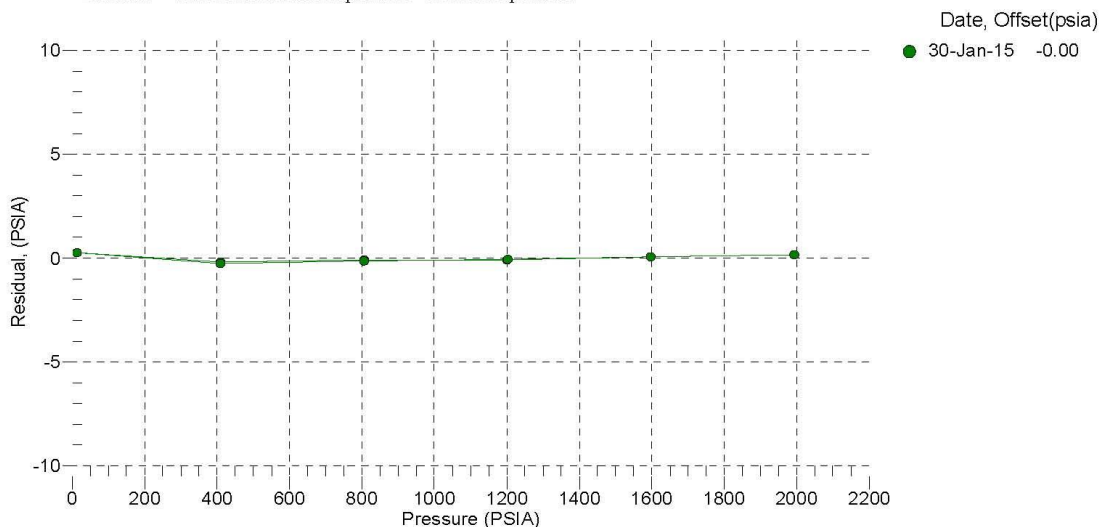
C1 = -1.004661e+004  
 C2 = 6.577280e-002  
 C3 = 2.499710e-003  
 D1 = 5.798700e-002  
 D2 = 0.000000e+000  
 T1 = 3.015686e+001  
 T2 = -5.102570e-005  
 T3 = 3.287630e-006  
 T4 = 1.705840e-009  
 T5 = 0.000000e+000

## AD590M, AD590B, SLOPE AND OFFSET:

AD590M = 1.28200e-002  
 AD590B = -9.28217e+000  
 Slope = 1.00009  
 Offset = 0.1753 (dbars)

PRESSURE (PSIA)	INST OUTPUT (Hz)	INST TEMP (C)	INST OUTPUT (PSIA)	CORRECTED INST OUTPUT (PSIA)	RESIDUAL (PSIA)
13.081	33181.10	21.1	13.084	13.338	0.257
409.630	33826.60	21.1	409.155	409.445	-0.185
805.529	34457.00	21.1	805.114	805.440	-0.089
1201.303	35073.00	21.1	1200.863	1201.226	-0.077
1597.205	35676.10	21.1	1596.876	1597.275	0.070
1992.836	36266.10	21.2	1992.561	1992.995	0.159
1597.620	35676.70	21.2	1597.276	1597.675	0.055
1201.483	35073.30	21.2	1201.062	1201.424	-0.059
805.705	34457.20	21.2	805.247	805.573	-0.132
409.710	33826.60	21.2	409.162	409.453	-0.257
13.094	33181.10	21.3	13.099	13.353	0.259

Residual = corrected instrument pressure - reference pressure



## 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: 1085  
 CALIBRATION DATE: 24-Mar-15

SBE 3 TEMPERATURE CALIBRATION DATA  
 ITS-90 TEMPERATURE SCALE

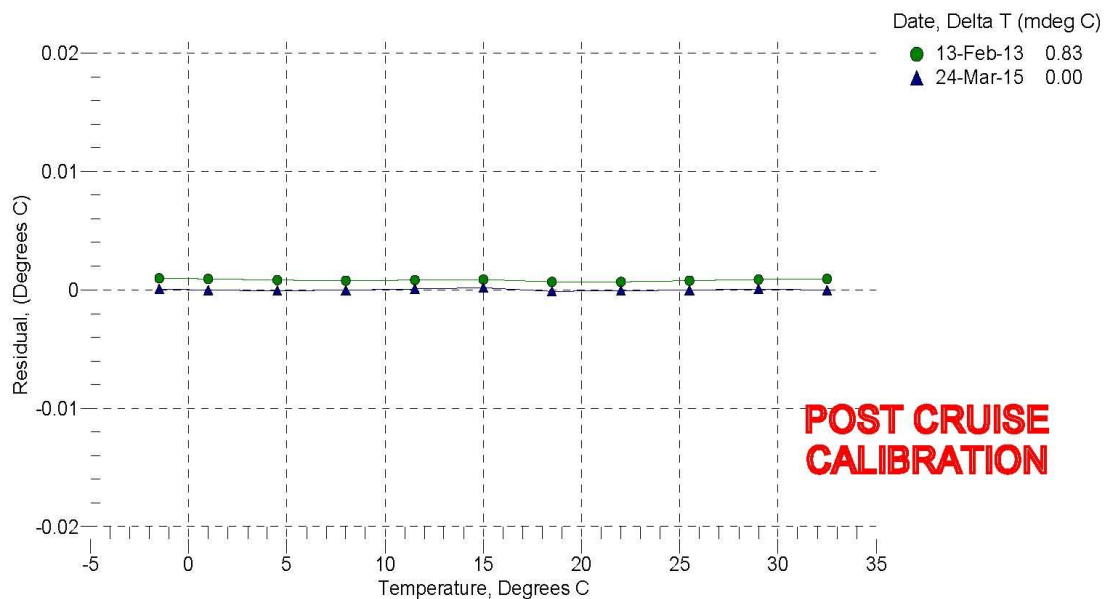
## ITS-90 COEFFICIENTS:

g = 4.85824143e-003  
 h = 6.71702278e-004  
 i = 2.48725436e-005  
 j = 1.87649004e-006  
 f0 = 1000.0

BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	6441.388	-1.4999	0.00006
1.0000	6813.454	1.0000	-0.00005
4.5000	7360.011	4.4999	-0.00007
8.0000	7937.258	8.0000	-0.00003
11.4999	8545.995	11.5000	0.00009
14.9999	9187.024	15.0001	0.00016
18.4999	9861.038	18.4998	-0.00011
21.9999	10568.901	21.9998	-0.00008
25.4999	11311.276	25.4999	-0.00001
28.9999	12088.843	28.9999	0.00005
32.4999	12902.233	32.4999	-0.00000

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

Residual = instrument temperature - bath temperature



## 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: 0661

CALIBRATION DATE: 24-Mar-15

SBE 3 TEMPERATURE CALIBRATION DATA

ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS:

 $g = 4.76930924e-003$  $h = 6.77762472e-004$  $i = 2.99430775e-005$  $j = 2.75925164e-006$  $f_0 = 1000.0$ 

BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	5555.658	-1.5000	-0.00000
1.0000	5876.158	1.0000	0.00002
4.5000	6347.030	4.5000	0.00000
8.0000	6844.417	7.9999	-0.00006
11.4999	7369.021	11.4999	-0.00001
14.9999	7921.523	14.9999	0.00003
18.4999	8502.557	18.5000	0.00007
21.9999	9112.723	21.9999	0.00003
25.4999	9752.623	25.4999	-0.00005
28.9999	10422.829	28.9998	-0.00010
32.4999	11123.915	32.5000	0.00007

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

Residual = instrument temperature - bath temperature

