

19-02 Thwaites Project

Data Report NBP1902

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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All the data has been archived using 'tar' and compressed using 'gzip', identified by the '.tz' extension.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: NBP1902

File	Description
/	Root level directory
NBP1902.gmt	GMT binary file of MGD77 data
NBP1902.mgd	Full Cruise MGD77 data file
NBP1902.trk	Text file of cruise track
1902DATA.docx	Data Report NBP1902 (MS Word)
1902DATA.pdf	Data Report NBP1902 (PDF format)
INSTCOEF.TXT	Instrument Coefficient File
/process	Processed data
1902JGOF.tz	JGOFS format data files
1902MGD.tz	MGD Data
1902PCO2.tz	Merged pCO ₂ data files
1902PROC.tz	Other processed data
1902QC.tz	Daily RVDAS QC postscript plots
/rvdas/nav	Navigation data
1902adcp.tz	ADCP Data Sets
1902gyr1.tz	Gyro raw data
1902s330.tz	Seapath 330 data
1902seap.tz	Seapath 200 data
1902gp02.tz	Furuno Bridge GPS
1902PCOD.tz	Furuno 330B GPS
/rvdas/uw	Underway data
1902bwnc.tz	Baltic winch data
1902cwnc.tz	Waterfall winch
1902twnc.tz	Trawl winch
1902ctdd.tz	CTD depth data
1902engl.tz	Engineering data
1902grv1.tz	Gravimeter data
1902hdas.tz	HydroDAS raw data
1902knud.tz	Knudsen raw data
1902mbdp.tz	Multi-beam depth
1902mwx1.tz	Meteorology raw data
1902ndfl.tz	Digital Fluorometer raw data
1902pco2.tz	pCO ₂ raw data
1902pguv.tz	GUV raw data
1902rtmp.tz	Remote Temperature data
1902tsg1.tz	Micro TSG1 data
1902tsg2.tz	Micro TSG2 data
/Imagery	Cruise Imagery
1902Imag.tz	Collection of Imagery Files
/ocean	Ocean data
1902ctd.tz	CTD Data
1902xbt.tz	XBT Data

Extracting Data

The data files will have a “.tz” extension on the filename. The “.tz” extension is for files whose contents have been archived using the “tar” utility and compressed with the “gzip” utility.

An example of creating a compressed archive file:

```
tar -czvf archive_filename files_to_archive
```

An example of listing the files in an archive:

```
tar -tzvf archive_filename
```

An example redirecting the list output to a file, where `contents.list` is the name of the file to create:

```
tar -tzvf archive_filename > contents.list
```

An example extracting all files from the archive:

```
tar -xzvf archive_filename
```

An example extracting specific files from the archive:

```
tar -xzvf archive_filename list_of_files_to_extract
```

Distribution Contents

Cruise Track

The distribution DVD includes a GMT cruise track file (NBP1902.trk). It contains the longitude and latitude at one-minute intervals extracted from the NBP1902.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 1902proc.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/NBP1902JGOF.tar`. The archive contains one file produced for each day named `jpgDDD.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	UTC Date	dd/mm/yy
02	UTC 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	μ Einstein's/meter ²
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 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 NBP1902.mgd. The file NBP1902.gmt is created from the MGD77 dataset using the “mgd77togmt” utility. NBP1902.gmt can be used with the GMT plotting package.

The data used to produce the NBP1902.mgd file can be found on the distribution media in the file /process/1902proc.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 UTC when added; 0=UTC
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 st sensor	In tenths of nanoteslas (gammas)
67-72	6	real	Magnetics total field, 2 nd sensor	In tenths of nanoteslas (gammas), for trailing sensor
73-78	6	real	Magnetics residual field	In tenths of nanoteslas (gammas). The reference field used is in Header Seq. 13
79	1	int	Sensor for residual field	1 = 1 st or leading sensor, 2 = 2 nd or trailing sensor, 9 = Unspecified
80-84	5	real	Magnetics diurnal correction	In tenths of nanoteslas (gammas). (In nanoteslas) if 9-filled (i.e., set to "+9999"), total and residual fields are assumed to be uncorrected; if used, total and 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 th of mgals. Corrected for Eotvos, drift, tares
98-103	6	real	EOTVOS correction	In 10 th of mgals. $E=7.5 V \cos \phi \sin \alpha + 0.0042 V^*V$
104-108	5	real	Free-air anomaly	In 10 th of mgals, G = observed, G = theoretical
109-113	5	char	Seismic line number	Cross reference for seismic data
114-119	6	char	Seismic shot-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 1902adcp.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 1902pco2.tar in the /process directory, which contains the pCO₂ instrument's data merged with GPS, meteorological and other oceanographic measurements. For more information contact Colm Sweeney (csweeney@ldeo.columbia.edu).

Cruise Science

CTD

The CTD data has been placed in the tar file `/ocean/NBP1902ctd.tar`. The archive contains tar files `NBP1902proc.tar`.

RVDAS

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

Daily data processing of the RVDAS 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: `NBP1902mwx1.d025`

- The CruiseID is the numeric name of the cruise, in this case, NBP1902.
- 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	mwx1 (met)	Continuous	1/sec	RM Young 41372LC
Relative Humidity	mwx1 (met)	Continuous	1/sec	RM Young 41372LC
Wind Speed / Direction	mwx1 (pus,sus)	Continuous	1/sec	Gill Instruments 1390-PK-062
Barometer	mwx1 (met)	Continuous	1/sec	RM Young 61201
PAR	mwx1 (met)	Continuous	1/sec	Biospherical Instruments QSR-240
PIR	mwx1 (met)	Continuous	1/sec	Eppley PIR
PSP	mwx1 (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
Bathymetry	knud	Continuous	varies	Knudsen Chirp
Bathymetry	mbsp	Continuous	varies	Kongsberg 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 AFLT
pCO ₂	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, and GPS	PCOD	Continuous	1/sec	Furuno GP-330B
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 page 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

Error Flag

00 = All well, 01 = CPS malfunction, 02 = Sensor Malfunction, 03 = CPS and sensor Malfunction

A gravity tie is taken at the start of the cruise and applied throughout the cruise. There is no accounting for drift after the pre-cruise gravity time. The post cruise gravity tie is available by requesting it from ethq@usap.gov.

pCO₂ (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 ₂ 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 ³ /min
7	pCO ₂ Pressure	xxx.xx	μAtm
8	VCO ₂ 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

pCO₂ time tag

ttt = fractional time of day

Flow SourceEquil = pCO₂ 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	mmddy	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 ²
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 - Rarely used*	xx.xx	m
13	Transmissometer for Yo-Yo camera - Rarely used*	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	xxxxxxxx	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

Fluorometer (ndfl)

18+121:00:00:21.785 99/99/99 99:99:99 0.71 695 155 559

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Ignore	x.x	n/a
3	Ignore	x.x	n/a
4	Chlorophyll Signal	xx.xx	µg/l
5	Wavelength (Not used)	xxx	nanometers
6	Chlorophyll Counts	xxxx	Counts
7	Internal Thermistor (Not used)	xxx	Therm

Navigational Data */rvdas/nav*

GPS (s330, seap, PCOD)

1. ***Seapath 330***
 - a. NMEA 0183 strings
 - i. GPZDA
 - ii. GPGGA
 - iii. GPVTG
 - iv. GPHDT
 - v. GPRMC
 - b. Proprietary Strings
 - i. PSXN 20
 - ii. PSXN 22
 - iii. PSXN 23
2. ***Seapath 200***
 - a. NMEA 0182 strings
 - i. GPZDA
 - ii. GPGGA
 - iii. GPVTG
 - iv. GPHDT
 - b. Proprietary Strings
 - i. PSXN 20
 - ii. PSXN 22
 - iii. PSXN 23
3. ***Furuno GP-330B***
 - a. NMEA 0183 strings
 - i. GPZDA
 - ii. GPGGA
 - iii. GPVTG
 - iv. GPRMC
 - v. GPGLL
 - vi. GPDTM
4. ***GP02 (Bridge GPS)***
 - a. NMEA 0183 strings
 - i. \$GPZDA
 - ii. \$GPGLL
 - iii. \$GPVTG

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

GPHT

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

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

GPGLL

16+077:00:00:00.725 \$GPGLL,6356.6505,S,05716.0002,W,000000,A,A*4F

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 of Position (not received)	hhmmss.ss	UTC
8	Status*	x	A or V
9	Mode*	x	alphanumeric
10	Checksum	xx	alphanumeric

Status

A = Data Valid, V = Data not valid

Modes

A = GPS used, D = DGPS used, E = Dead reckoning used, M = Manual input mode, S = Simulator Mode, N = Invalid position / velocity

GPDTM

16+077:00:00:02.527 \$GPDTM,W84,,0000.0000,N,00000.0000,E,0.0,W84*5F

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$GPDTM		
3	Local Datum Code*	XXX	alphanumeric
4	Local datum subdivision code	x	numeric
6	Lat offset	x	alphanumeric
7	North or South (for previous)	x	N or S
8	Lon offset	x	alphanumeric
9	East or West (for previous)	x	E or W
10	Altitude offset, meters	x,x	numeric
11	Reference datum code*	xxx	alphanumeric
12	Checksum	xx	alphanumeric

Datum Codes

W84 = WGS84, W72 = WGS72, S85 = SGS85, P90 = PE90, 999 = User defined

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

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

ADCP Course (adcp)

15+049:20:20:57.327 \$PUHAW,UVH,-0.07,-4.59,179.3

Field	Data	Format	Unit
1	RVDAS time tag		
2	\$PUHAW		
3	UVH		
4	Ship Speed relative to reference layer, east vector	x.xx	knots
5	Ship Speed relative to reference layer, north vector	x.xx	knots
6	Ship heading	x.xx	degrees

Processed Data /process**pCO₂ - 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 ₂ 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 ³ /min
7	pCO ₂ Pressure	xxx.xx	μAtm
8	VCO ₂ 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 ³
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 ₂ 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

pCO₂ time tag

ttt = fractional time of day

Flow Source

Equil = pCO₂ 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 “mwx1” 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 “mwx1” 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/m2 */  
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))
```

Acquisition Problems and Events

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

Start	End	Description
19+034:09:02:30		Data collection begins. 55 26.572958 S 078 44.292002 W
		Seapath 200 and the bridge (gp02) GPS's have the wrong date.
		Multiple drops of S330 data during cruise
		Difficulties with Knudsen recording and processing led to MGD77 missing Bathymetry data Some data is in the raw files. Julian days: 044, 045, 059, 064, 065, 066, 071, 072, 073, 074, 075, 076, 077
		Water pump maintenance or failure resulted in loss of some data. Julian days: 036, 037, 039, 052, 053, 062
	19+081:06:34:41	Data collection completes. 59 57.951203 S 069 47.562480 W

Appendix A: Sensors

NBP1902 Sensors

Sensor	Description	Serial	Last Cal Date	Comments
Meteorology and Radiometry				
Port Anemometer	Gill Instruments 1390-PK-062	924057	11/18/2009	<i>ECO BridgeWindbird</i>
Stbd Anemometer	Gill Instruments 1390-PK-062	847014	9/29/2010	<i>Stbd Side (SUS)</i>
Bridge Anemometer	RM Young 5106	WM128975	10/27/2011	<i>Port Side (PUS)</i>
Barometer	Vaisala PTB210B	M2750443	7/13/2016	
Wet temp / Humidity	RM Young 41372LC	06135	7/31/2017	Secondary (RMY)
Humidity/Temp/Dew Pt	Rotronic	0020198912	8/18/2017	Primary (Rotronic)
PIR	Eppley PIR	32845F3	11/7/2017	
PSP	Eppley PSP	32850F3	11/7/2017	
PAR (Mast)	Biospherical Instruments QSR-2200	20546	3/8/2017	
GUV (Mast)	Biospherical Instruments GUV-2511	25110203114	12/6/2017	
GUV Deckbox	Biospherical Instruments GUV-2511	SPARE - 1126	N/A	

Sensor	Description	Serial	Last Cal Date	Comments
Underway Seawater Sampling System				
Micro-TSG	Sea-Bird SBE 45	4550449-0242	4/2/2017	Primary
Micro-TSG	Sea-Bird SBE 45	4566350-0389	4/25/2018	Secondary
Digital Remote Temp	Sea-Bird SBE 38	3849120-0178	2/7/2017	

Sensor	Description	Serial	Last Cal Date	Comments
CTD				
Altimeter	Valeport VA-500	51520	7/10/2015	

Carousel Water Sampler	Sea-Bird SBE 32	3214153-0140	NA	
SBE 11+ Deck Unit	Sea-Bird SBE 11+	11P47914-0768	NA	Deck Unit
Conductivity	Sea-Bird 4 - 02/O	040924	7/12/2016	
Conductivity	Sea-Bird 4 - 02/O	040926	7/12/2016	
Conductivity	Sea-Bird 4 - 02/O	041431	11/22/2016	Pri. Cond.
Conductivity	Sea-Bird 4C 6800m	041852	2/14/2017	Sec. Cond.
CTD Fish	Sea-Bird SBE 9+	09P70675-1130	4/23/2018	Fish
CTD Pressure Sensor	Sea-Bird SBE 9+	120089	4/23/2018	
Dissolved Oxygen	Sea-Bird SBE 43	0080	11/21/2017	Pri. DO
Dissolved Oxygen	Sea-Bird SBE 43	0150	4/11/2018	Sec. DO
CTD Pump	Sea-Bird 5T, PN 90160	051626 3.0K	8/8/2017	Pri. Pump
CTD Pump	Sea-Bird 5T, PN 90543	051627 3.0K	8/8/2017	Sec. Pump
Fluorometer	WetLabs FLRTD	FLRTD-397	4/20/2017	
Fluorometer	WetLabs FLRTD	FLRTD-855	5/16/2018	
PAR	Biospherical Instruments QSP-200L4S	70555	12/12/2016	
Temperature	QSR-2200	03P2438	11/29/2016	Pri. Temp
Temperature	Sea-Bird 3plus 6800m	035185	2/7/2017	Sec. Temp
Transmissometer	WetLabs C-Star	CST-439DR	7/29/2016	<i>UW System</i>
Transmissometer	WetLabs C-Star	CST-892DR	11/10/2016	Transmiss.
Micro-TSG	Sea-Bird SBE 45	4550449-0242	4/2/2017	<i>Primary</i>
Micro-TSG	Sea-Bird SBE 45	4566350-0389	4/25/2018	<i>Secondary</i>
Digital Remote Temp	Sea-Bird SBE 38	3849120-0178	2/7/2017	

Appendix B: Calibration Sheets

Gravity

BGM3 ship-to-shore gravity tie report

Barry Bjork, Sheldon Blackman, vessel: R/V Palmer

Release Date: 2019/01/28 18:24:11 UTC

Sensor: S210

Software version: 1.2

Port/Pier/Berth: Pratt Pier

Gravity station number	9337-50 (3)
Station name	Harbour Admin Bldg
mGal at pier	981320.82
Tie start time UTC	2019/01/28 17:23:53.388
Samples used	3600
Land tie used	Yes
Water height to pier 1	12 ft 0 in
Water height to pier 2	11 ft 6 in
Water height to pier 3	11 ft 0 in
Average of filtered counts	25190.318653028
Filter length	361
Scale factor	4.994070552
NEW BIAS	855519.67

Table 1: Gravity tie information

BGM3 land tie report

Barry Bjork, Sheldon Blackman, vessel: R/V Palmer

Release Date: 2019/01/28 17:18:32 UTC

Sensor: S210

Land meter: G-807

Land meter temperature: 53.6

Software version: 1.2

Reference station: B

Reference station name: Harbour Admin Bldg

Reference station number: 9337-50 (3)

Reference mGal: 981320.82

Reference latitude: -53.15

Reference longitude: -70.9166667

New station: A

New station mGal: 981320.11472005

New station latitude: -53.17

New station longitude: -70.9

Notes:

Meteorology

Anemometers

Cal sheet not required

Barometer



1 (1)
Certificate report no. H44-16280021

CALIBRATION CERTIFICATE

Instrument PTB210B Digital Barometer
Serial number M2750443
Manufacturer Vaisala Oyj, Finland
Calibration date 13th July 2016

The above instrument was calibrated by comparing the readings of the instrument to the factory working standard of Vaisala.

The pressure readings of the factory working standard have been calibrated at an ISO/IEC 17025 accredited calibration laboratory (FINAS), Vaisala Measurement Standards Laboratory (MSL), by using MSL working standards traceable to NIST.

Calibration results

Reference hPa	Observed hPa	Correction* hPa	Acceptance limit hPa
510.0	510.0	0.0	± 0.2
610.0	610.0	0.0	± 0.2
700.0	700.0	0.0	± 0.2
810.0	810.0	0.0	± 0.2
910.0	910.0	0.0	± 0.2
950.0	950.0	0.0	± 0.2
1000.0	1000.0	0.0	± 0.2
1098.0	1098.0	0.0	± 0.2

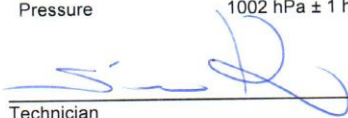
*To obtain the true pressure, add the correction to the barometer reading.
 Interpolated corrections may be used at intermediate readings of the scale of the barometer.

Equipment used in calibration

Type	Serial number	Calibration date	Certificate number
PPC4	670	2015-08-21	K008-Y01989

Uncertainty (95 % confidence level, k=2)
 Pressure ± 0.15 hPa

Ambient Conditions
 Humidity 39 %RH ± 5 %RH
 Temperature 21 °C ± 1 °C
 Pressure 1002 hPa ± 1 hPa


 Technician

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doc223087-B

Temperature / Humidity



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

CALIBRATION REPORT
Temperature & Humidity

Customer: *Leidos Innovations Corp*

Test Number: 7731-01T
 Test Date: 31 July 2017

Customer PO: 21800
 Sales Order: 6363

Instrument Under Test (IUT)

Model: 41372LC
 Description: Temp / Humidity Sensor

Serial Number: TS06135

Temperature: Report of calibration comparison with National Institute of Standards and Technology traceable standard thermometer(s) at three temperatures in the R.M. Young Company controlled temperature calibration facility. The following data describe the relationship between actual temperature, as determined by the NIST calibrated thermometer, and test sensor temperature, as determined by its output.

Reference Temperature Celcius	IUT Output mA	Indicated (1) Temperature Celcius
-49.85	4.0	-49.93
-0.01	12.0	0.07
50.03	20.0	50.01

(1) Calculate from IUT voltage output. Calibration accuracy $\pm 0.1^\circ$ Celcius.

Humidity: Report of calibration comparison with National Institute of Standards and Technology traceable standard humidity sensor at five humidity levels in the R.M. Young Company controlled humidity chamber. The following data describe the relationship between actual humidity, as determined by the NIST calibrated humidity sensor, and test sensor humidity, as determined by its output.

Reference Humidity %	IUT Output mA	Indicated (1) Humidity %
10.0	6	11.9
30.0	9	31.4
50.0	12	51.8
70.0	15	71.2
90.0	18	88.3

(1) Calculate from IUT voltage output. Calibration accuracy $\pm 2.0\%$.

National Institute of Standards and Technology Reference	Serial No.	Reference No.
Brooklyn Thermometer Model 43-FC	8006-118	W204690
Brooklyn Thermometer Model 22332-D5-FC	25071	W204691
Brooklyn Thermometer Model 2X400-D7-FC	77532	W204692
Keithley Multimeter Model 191	15232	8604897
Vaisala Humidity Sensor Model 35AC	N475040	TN 266152
Fluke Multimeter Model 8060A	4865407	8604897

Tested By *S. Sage*

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

Humidity/Temp/Dew

CERTIFICATE**rotronic**

LEADING IN HUMIDITY MEASUREMENT

Device type	HC2A-S3
Serialnumber	0020198912
RPC-number	9-0312721260

ROTRONIC AG certifies that this instrument meets the published specifications. It has been calibrated using standards and instruments as stated below and corresponds to the process requirements of ISO 9001:2008. The references are traceable to national standards. The calibrated values are only valid at the time of measurement and are referenced to the indicated references and working standards.

FACTORY CALIBRATION*Adjustment*

Temperature	23.56°C
Humidity 1	16.46%rH (@23.57°C)
Humidity 2	35.53%rH (@23.57°C)
Humidity 3	74.74%rH (@23.65°C)

Calibration

	Device	Reference
Temperature	23.53°C	23.57°C
Humidity	49.86%rH	49.92%rH

Date of calibration: 13.08.2017

Reference System

HC2-S (SCS certified)

FUNCTION TEST

Firmware	V1.2
Analog Output	Out1: Humi 0..100%rH (0..1V) Set: 40.00%rH, measured 40.03%rH (0.400V)
	Out2: Temp -40..60°C (0..1V) Set: 20.00°C, measured 20.04°C (0.600V)
Printnumber	66.1085.0301

Final test passed – 04.09.2017 – quality engineer: M. Ferreira
Control number: 148



ROTRONIC AG, Grindelstrasse 6, CH - 8303 Bassersdorf
www.rotronic.com

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

Calibration Certificate

Instrument: Precision Infrared Radiometer, Model PIR, Serial Number 32845F3

Procedure: This pyrgeometer was compared against Eppley's Blackbody Calibration System under radiation intensities of approximately 350 Wm^{-2} with an average ambient temperature of 21°C according to procedures described in Technical Procedure, TP05 of The Eppley Laboratory, Inc.'s Quality Assurance Manual on Calibrations.

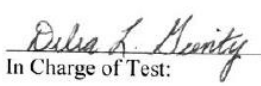
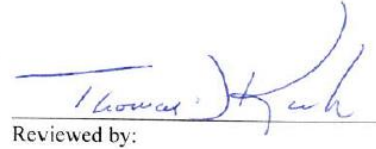
Transfer Standard: Eppley Precision Infrared Radiometer, Model PIR, Serial Number 32227F3

Results:
Sensitivity: $S = 4.16 \mu\text{V} / \text{Wm}^{-2}$
Uncertainty: $U_{95} = \pm 1.7\%$ (95% confidence level, $k=2$)
Resistance: 712Ω at 23°C
Date of Test: November 7, 2017

Traceability: This calibration is traceable to the International Practical Temperature Scale (IPTS). Additionally, transfer standard PIR #32227F3 provides traceability to the World Infrared Standard Group (WISG) of pyrgeometers housed at the Infrared Radiometry Section of the World Radiation Centre (WRC-IRS). 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/LEIDOS
 Port Hueneme, CA

Signatures:
 In Charge of Test: 
 Reviewed by: 

Eppley SO: 65087

Date of Certificate: November 8, 2017

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 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 Standard Precision Pyranometer, Model SPP, Serial Number 37501F3

Results: **Sensitivity:** $S = 6.89 \mu\text{V} / \text{Wm}^{-2}$
 Uncertainty: $U_{95} = \pm 0.91\%$ (95% confidence level, $k=2$)
 Resistance: 706 Ω at 23°C

Date of Test: November 7, 2017

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 Twelfth International Pyrheliometric Comparisons (IPC XII) at Davos, Switzerland in September-October 2015. 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/LEIDOS
 Port Hueneme, CA

Signatures: *Debra A. Gentry* In Charge of Test: *Thomas J. Kuhl* Reviewed by:

Eppley SO: 65088

Date of Certificate November 8, 2017

Remarks:

PAR (Mast)

Biospherical Instruments Inc.

CALIBRATION CERTIFICATE

Calibration Date	<u>3/8/2017</u>
Model Number	<u>QSR2200</u>
Serial Number	<u>20546</u>
Operator	<u>TPC</u>
Standard Lamp	<u>91453(7/20/16)</u>
Probe Excitation Voltage Range:	<u>6</u> to <u>18</u> VDC(+)
Output Polarity:	<u>POSITIVE</u>

Probe Conditions at Calibration(in air):

Calibration Voltage:	<u>6</u> VDC(+)
Probe Current:	<u>4.0</u> mA

Probe Output Voltage:

Probe Illuminated	<u>88.8</u> mV
Probe Dark	<u>1.0</u> mV
Probe Net Response	<u>87.8</u> mV
RG780	<u>1.1</u> mV

Corrected Lamp Output:

Output In Air (same condition as calibration):

<u>8.379E+15</u>	quanta/cm ² sec
<u>0.013914</u>	uE/cm ² sec

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

Dry:	<u>1.0481E-17</u> V/(quanta/cm ² sec)
	<u>6.3114E+00</u> V/(uE/cm ² 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.

GUV (Mast)

**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 25110203114**Optical Calibrations:**

NIST Traceability. For wavelengths longer than 313 nm, the specific instruments cited here were calibrated using a 1000W FEL #V-041(7/21/16) 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° . 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 25110203114v10_12-2017.mdb. This database is required for operation of this system using Biospherical Instruments Inc.'s Logger® software.



GUV-2511 Calibration Certificate

System Serial Number	25110203114	Date of Calibration	12/6/2017
Calibration database	25110203114v10_12-2017.mdb	Date of Certificate	12/6/2017
DASSN	0069	Standard of Spectral Irradiance	V-041(7/21/16)
Microprocessor Tag Number	4	Operator	TC

Monochromatic Channels		Wavelength [nm]	Responsivity [Amps per $\mu\text{W}/(\text{cm}^2\text{-nm})$]	ScaleSmall [Volts per $\mu\text{W}/(\text{cm}^2\text{-nm})$]	ScaleMedium [Volts per $\mu\text{W}/(\text{cm}^2\text{-nm})$]	ScaleLarge [Volts per $\mu\text{W}/(\text{cm}^2\text{-nm})$]	OffsetSmall [volts]	OffsetMedium [volts]	OffsetLarge [volts]	Measurement Units
Ed0320	2	320	2.3842E-10	2.4319E-05	7.1051E-03	2.2425E+00	3.4492E-05	3.2554E-05	5.6504E-04	$\mu\text{W}/(\text{cm}^2\text{-nm})$
Ed0340	6	340	1.8676E-10	1.9050E-05	5.5656E-03	1.9092E+00	4.2136E-05	4.1875E-05	7.6934E-04	$\mu\text{W}/(\text{cm}^2\text{-nm})$
Ed0313	8	313	2.2846E-10	2.3303E-05	6.8081E-03	2.3899E+00	9.1228E-04	9.0624E-04	-1.2773E-03	$\mu\text{W}/(\text{cm}^2\text{-nm})$
Ed0305	10	305	1.1615E-11	1.1847E-06	3.4613E-04	1.1897E-01	3.5080E-04	3.5087E-04	1.1382E-03	$\mu\text{W}/(\text{cm}^2\text{-nm})$
Ed0380	12	380	8.3114E-11	8.4776E-06	2.4768E-03	7.9442E-01	2.8388E-04	2.7513E-04	-3.8577E-05	$\mu\text{W}/(\text{cm}^2\text{-nm})$
Ed0395	18	395	2.9356E-10	2.9944E-05	8.7482E-03	2.7653E+00	3.8212E-04	3.8356E-04	1.4618E-03	$\mu\text{W}/(\text{cm}^2\text{-nm})$

Broadband Channels		Wavelength [nm]	Responsivity [Amps per $\mu\text{E}/(\text{cm}^2\text{-s})$]	ScaleSmall [Volts per $\mu\text{E}/(\text{cm}^2\text{-s})$]	ScaleMedium [Volts per $\mu\text{E}/(\text{cm}^2\text{-s})$]	ScaleLarge [Volts per $\mu\text{E}/(\text{cm}^2\text{-s})$]	OffsetSmall [volts]	OffsetMedium [volts]	OffsetLarge [volts]	Measurement Units
Ed0PAR	13	400-700	1.7122E-05	1.7465E+00	5.1025E+02	1.8033E+05	5.6671E-04	5.6137E-04	-4.7669E-04	$\mu\text{E}/(\text{cm}^2\text{-sec})$

Auxiliary Channels		Wavelength [nm]	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 for more information.

GUV (Deckbox)

Cal sheet not required

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: 02-Apr-17

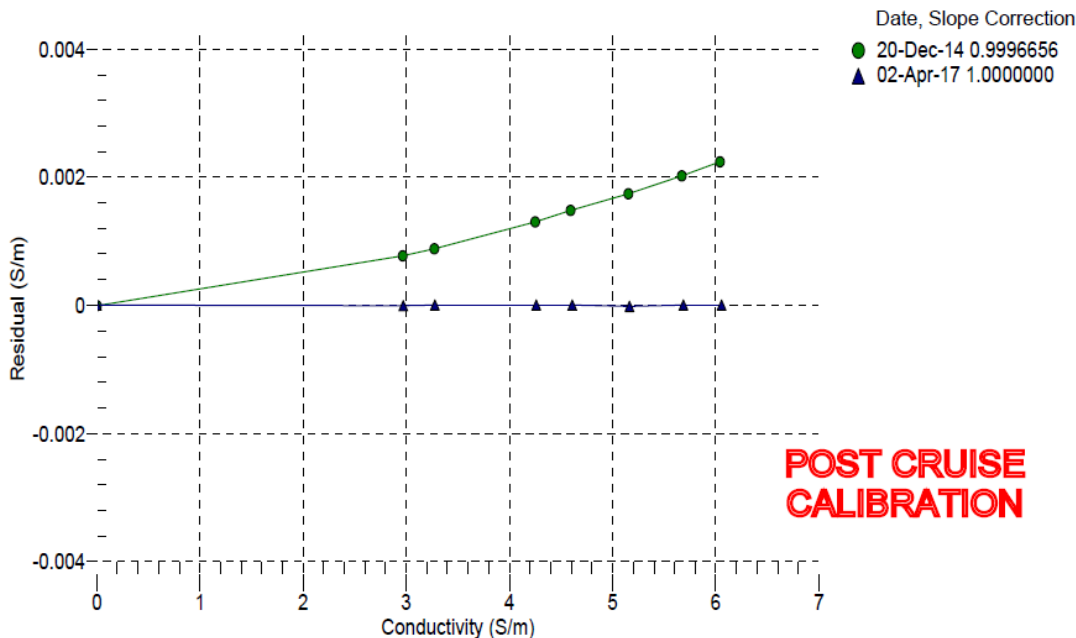
SBE 45 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -9.982038e-001	CPcor = -9.5700e-008
h = 1.522508e-001	CTcor = 3.2500e-006
i = -4.303026e-004	WBOTC = -0.0000e+000
j = 5.783952e-005	

BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2566.64	0.00000	0.00000
1.0000	34.7888	2.97384	5119.28	2.97383	-0.00001
4.5000	34.7689	3.28069	5312.80	3.28070	0.00001
15.0000	34.7272	4.26184	5888.15	4.26184	0.00000
18.5000	34.7186	4.60681	6077.20	4.60681	0.00000
24.0000	34.7094	5.16448	6370.62	5.16447	-0.00001
29.0000	34.7049	5.68612	6632.98	5.68612	0.00000
32.5000	34.7030	6.05846	6813.84	6.05847	0.00000

f = Instrument Output(Hz) * sqrt(1.0 + WBOTC * t) / 1000.0
 t = temperature (°C); p = pressure (decibars); δ = CTcor; ε = CPcor;
 Conductivity (S/m) = (g + h * f² + i * f³ + j * f⁴) / 10 (1 + δ * t + ε * p)
 Residual (Siemens/meter) = instrument conductivity - 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: 02-Apr-17

SBE 45 TEMPERATURE CALIBRATION DATA
 ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

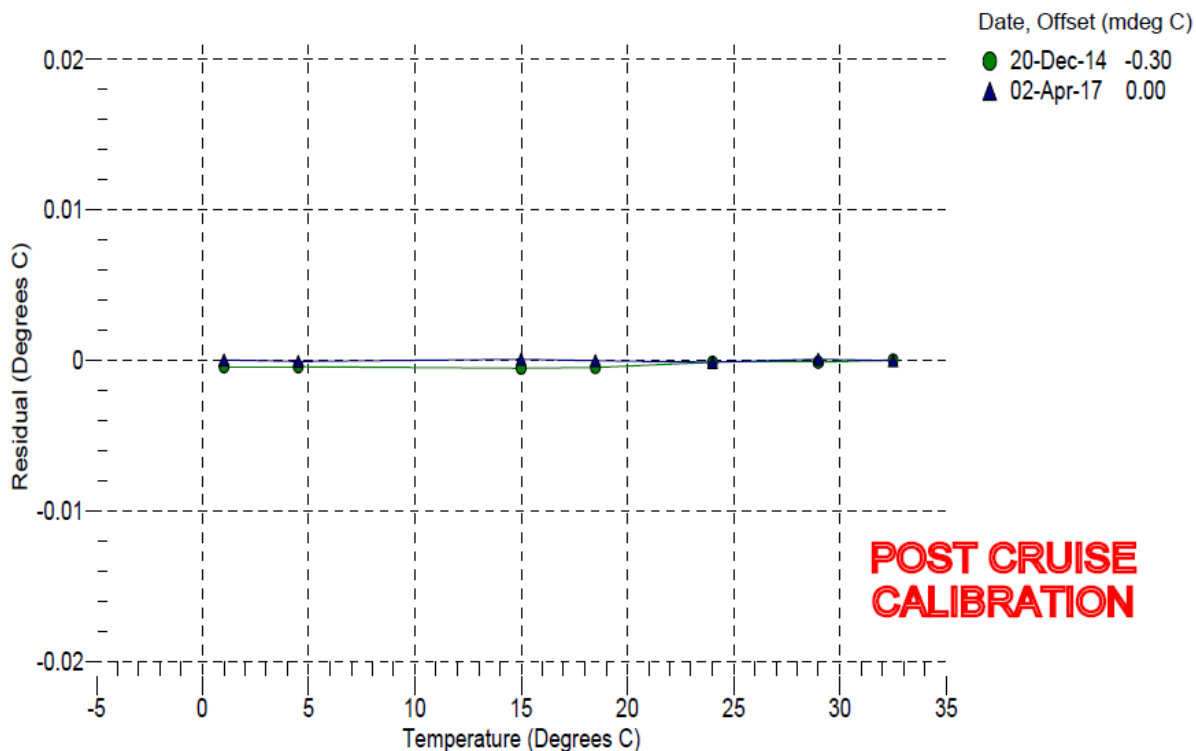
a0 = 3.676223e-005
 a1 = 2.754692e-004
 a2 = -2.489671e-006
 a3 = 1.542625e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	649818.7	1.0000	0.0000
4.5000	554887.7	4.4999	-0.0001
15.0000	352327.2	15.0001	0.0001
18.5000	304718.5	18.5000	-0.0000
24.0000	244011.5	23.9999	-0.0001
29.0000	200600.4	29.0001	0.0001
32.5000	175478.5	32.5000	-0.0000

n = Instrument Output (counts)

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

$$\text{Residual (°C)} = \text{instrument temperature} - \text{bath temperature}$$



Micro-TSG2



Sea-Bird Scientific
13431 NE 20th Street
Bellevue, WA 98005
USA

+1 425-643-9866
seabird@seabird.com
www.seabird.com

SENSOR SERIAL NUMBER: 0389
CALIBRATION DATE: 25-Apr-18

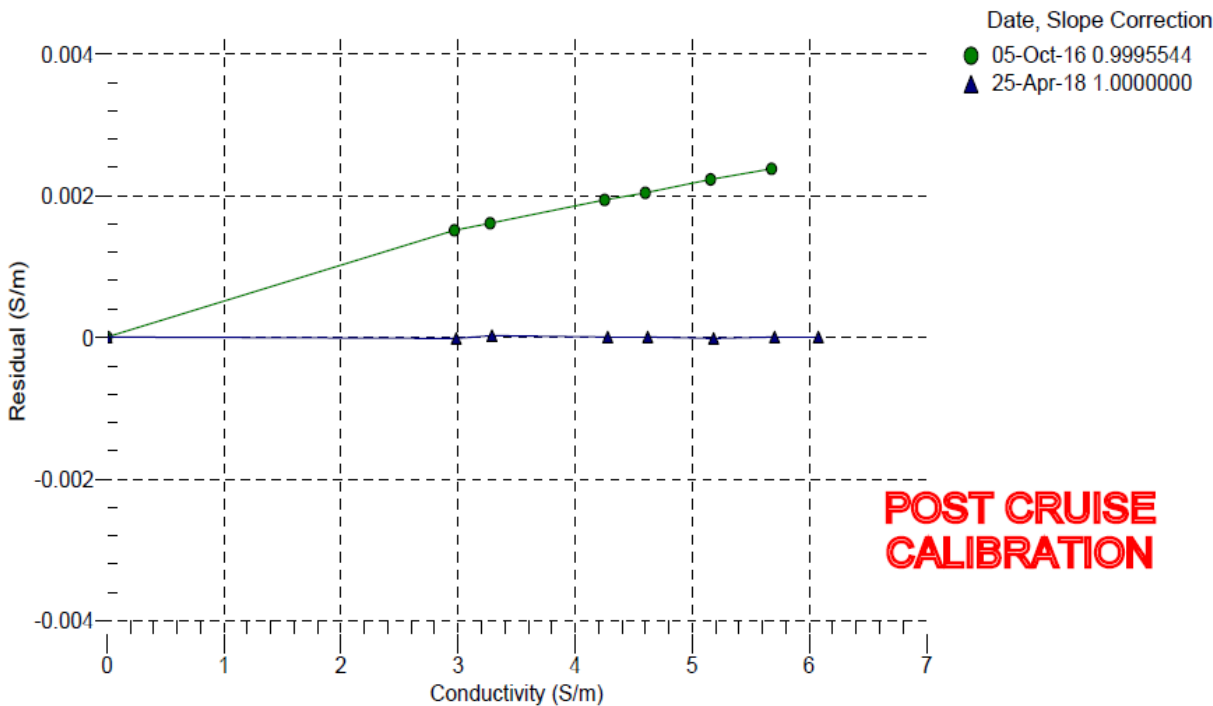
SBE 45 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -9.985799e-001 CPcor = -9.5700e-008
h = 1.455792e-001 CTcor = 3.2500e-006
i = -3.660237e-004 WBOTC = 1.2700e-007
j = 4.864142e-005

BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2624.68	0.00000	0.00000
1.0000	34.9196	2.98395	5240.82	2.98393	-0.00002
4.5000	34.8990	3.29176	5439.06	3.29178	0.00002
15.0000	34.8558	4.27595	6028.45	4.27595	0.00000
18.5000	34.8464	4.62193	6222.11	4.62194	0.00001
24.0000	34.8356	5.18118	6522.65	5.18116	-0.00002
29.0001	34.8286	5.70412	6791.31	5.70412	0.00000
32.5000	34.8234	6.07709	6976.39	6.07709	0.00000

f = Instrument Output(Hz) * sqrt(1.0 + WBOTC * t) / 1000.0
t = temperature (°C); p = pressure (decibars); δ = CTcor; ε = CPcor;
Conductivity (S/m) = (g + h * f² + i * f³ + j * f⁴) / (1 + δ * t + ε * p)
Residual (Siemens/meter) = instrument conductivity - bath conductivity





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 www.seabird.com

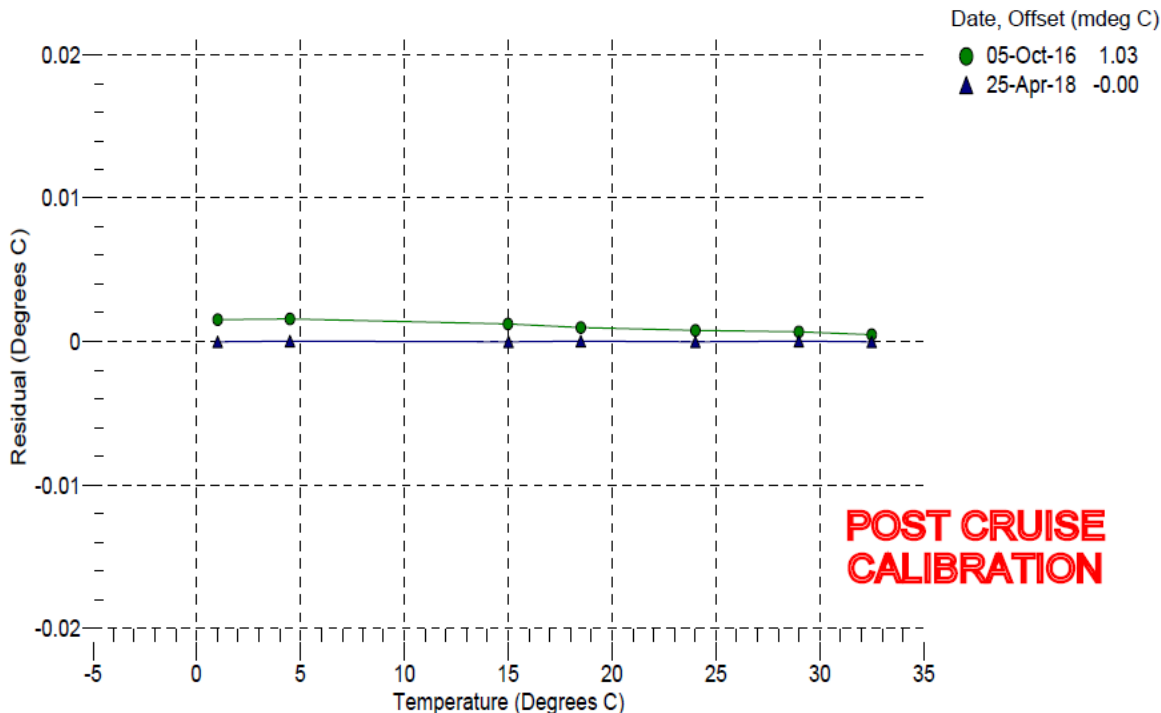
SENSOR SERIAL NUMBER: 0389
 CALIBRATION DATE: 25-Apr-18

SBE 45 TEMPERATURE CALIBRATION DATA
 ITS-90 TEMPERATURE SCALE

COEFFICIENTS:
 a0 = 7.863170e-006
 a1 = 2.711897e-004
 a2 = -2.263006e-006
 a3 = 1.440061e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	828476.9	1.0000	-0.0000
4.5000	706678.1	4.5000	0.0000
15.0000	447327.3	15.0000	-0.0000
18.5000	386500.1	18.5000	0.0000
24.0000	309037.1	24.0000	-0.0000
29.0001	253723.7	29.0001	0.0000
32.5000	221749.9	32.5000	-0.0000

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



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: 0178
 CALIBRATION DATE: 07-Feb-17

SBE 38 TEMPERATURE CALIBRATION DATA
 ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

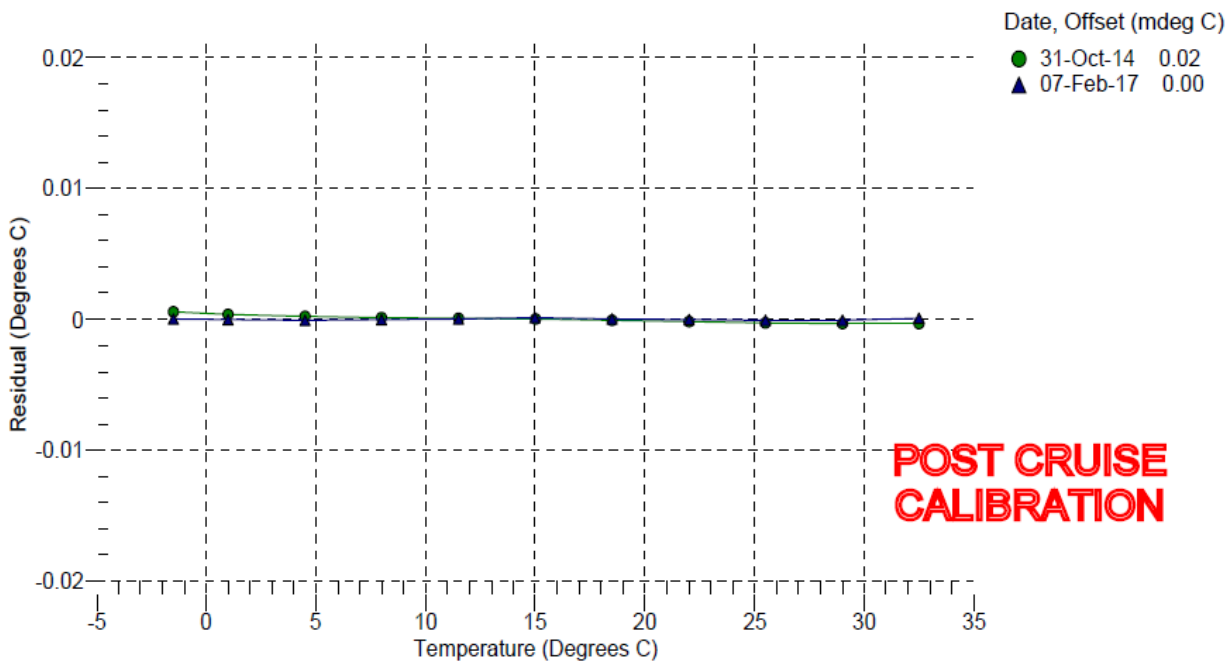
a0 = -3.943075e-005
 a1 = 2.802070e-004
 a2 = -2.606506e-006
 a3 = 1.642771e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
-1.5000	750884.0	-1.5000	0.0000
1.0000	671251.6	1.0000	-0.0000
4.5000	575382.9	4.4999	-0.0001
8.0000	494800.5	8.0000	-0.0000
11.5000	426841.3	11.5000	0.0000
14.9999	369340.5	15.0000	0.0001
18.5000	320533.9	18.5000	0.0000
22.0000	278978.8	22.0000	-0.0000
25.5000	243492.0	25.4999	-0.0001
29.0000	213097.4	28.9999	-0.0001
32.5000	186990.2	32.5001	0.0001

n = Instrument Output (counts)

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

Residual (°C) = instrument temperature - bath temperature



CTD

Altimeter



This document certifies that the instrument detailed below has been calibrated according to Valeport Limited's Standard Procedures, using equipment with calibrations traceable to UKAS or National Standards.

Calibration Certificate Number: 49383

Instrument Type: Altimeter

Instrument Serial Number: 51520

Calibrated By: J.Harper

Date: 07/10/2015

Signed: 

Full details of the results from the calibration procedure applied to each fitted sensor are available, on request, via email. This summary certificate should be kept with the instrument.



Valeport Ltd | St Peter's Quay | Totnes | Devon | TQ9 5EW | UK
T: +44 (0) 1803 869292 | F: +44 (0) 1803 869293

Instrument Serial Number	51520
Sensor Type	500kHz Neptune
Altimeter Range (m)	100m
Certificate Number	49383

Stage 1

Test the assembled altimeter in a body of water to ensure a signal is recieved at the minimum range. Taking direct readings from the unit immerse the head till it is roughly 0.1m from the bottom, readings should come through - if not then the signal is being saturated and there is a problem

To inhibit spurious readings set using: #226;40

	Pass/Fail
Bench Test Min Range <0.1m	Pass

Stage 2

Using a mini SVS or similar, measure the average sound velocity for the water in the tow tank and input the value in the cell below.

Enter the SOS	1484.355
---------------	----------

Input SOS value to the altimeter using: #830;1484.3550

Stage 3

Fit the altimeter into the calibration fixture and lower the assembly into the tank till it is about 0.5m down facing the far end of the tow tank and clamp in place. Using the distance markers on the wall align the front edge of the trolley with the datum line to set the front of the altimeter at stated distance from the wall.

To determine the Range Offset		
Distance m	Measured Range m	Measured Offset m
1	1.025	-0.025

Stage 4: Enter the Offset Correction
#828;-0.0250

Stage 5 - Range Check after Offset Correction			
Distance m	Measured Range m	Measured Offset m	Pass/Fail
1	0.997	0.003	Pass
5	5.003	-0.003	Pass

Stage 6: Reset the SOS
#830;1500

Stage 7: Reset maximum range to 105m	Stage 8: Reset spurious range
#823;105 (500kHz units)	#226;0

Calibrated by:	J,Harper	Date:	07/10/2015
----------------	----------	-------	------------

Bottom Contact Switch

Cal sheet not required

Carousel Water Sampler



SEA-BIRD
SCIENTIFIC

Sea-Bird Scientific
13431 NE 20th Street
Bellevue, WA 98005
USA

+1 425-643-9866
seabird@seabird.com
www.seabird.com

Pressure Test Certificate

Test Date: **2017-05-12**

Description: **SBE-32 Carousel**

Sensor Information:

Model Number: **SBE-32**

Serial Number: **32-0140**

Replaced the main piston "O"-Rings.

Replaced 6-pin connector.

Replaced main housing.

* Due to the dimensions of the CAROUSEL we are unable to perform a high pressure test at this time.

Pressure Test Protocol:

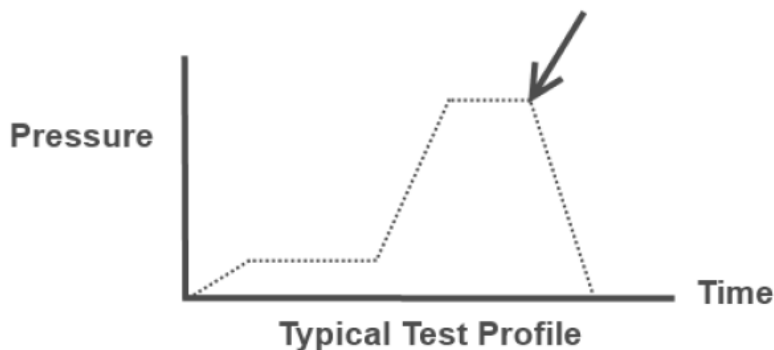
Low Pressure Test: **50** PSI Held For: **60** Minutes

High Pressure Test: **50** PSI Held For: **60** Minutes

Passed Test: **True**

Tested By: **BLT**

High pressure is generally equal to the maximum depth rating of the instrument



SBE 11+ Deck Unit

Cal sheet not required

Conductivity (primary)

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: 0924
 CALIBRATION DATE: 12-Jul-16

SBE 4 CONDUCTIVITY CALIBRATION DATA
 PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -3.98953205e+000
 h = 5.33996727e-001
 i = -6.17748041e-004
 j = 6.07241578e-005

CPcor = -9.5700e-008 (nominal)
 CTcor = 3.2500e-006 (nominal)

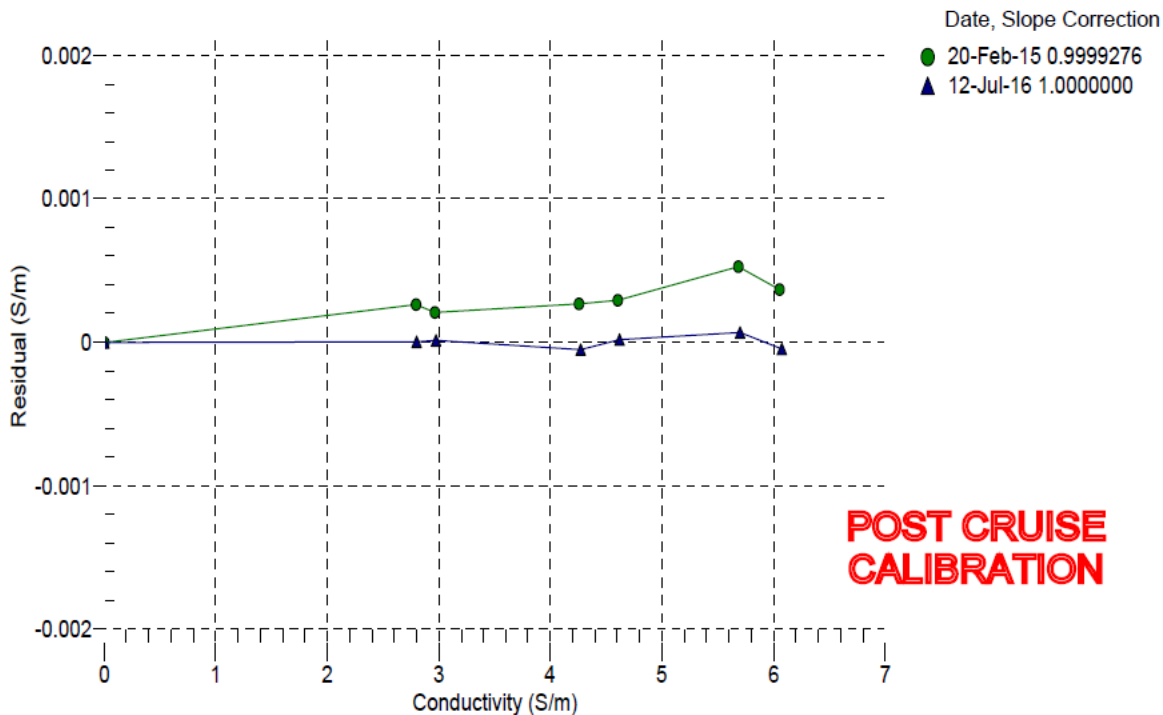
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.73649	0.00000	0.00000
-0.9999	34.8078	2.80396	7.75295	2.80397	0.00000
1.0000	34.8082	2.97534	7.95718	2.97535	0.00001
15.0001	34.8101	4.27094	9.35579	4.27089	-0.00005
18.5001	34.8100	4.61763	9.69532	4.61765	0.00002
29.0001	34.8089	5.70125	10.68537	5.70132	0.00007
32.5001	34.8016	6.07373	11.00441	6.07368	-0.00005

f = Instrument Output (kHz)

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

Conductivity (S/m) = (g + h * f² + i * f³ + j * f⁴) / 10 (1 + δ * t + ε * p)

Residual (Siemens/meter) = instrument conductivity - bath conductivity



Conductivity (secondary)

Sea-Bird Electronics, Inc.

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

SENSOR SERIAL NUMBER: 0926
 CALIBRATION DATE: 12-Jul-16

SBE 4 CONDUCTIVITY CALIBRATION DATA
 PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -3.91309829e+000
 h = 5.12414297e-001
 i = -5.20191483e-004
 j = 5.45810431e-005

CPcor = -9.5700e-008 (nominal)
 CTcor = 3.2500e-006 (nominal)

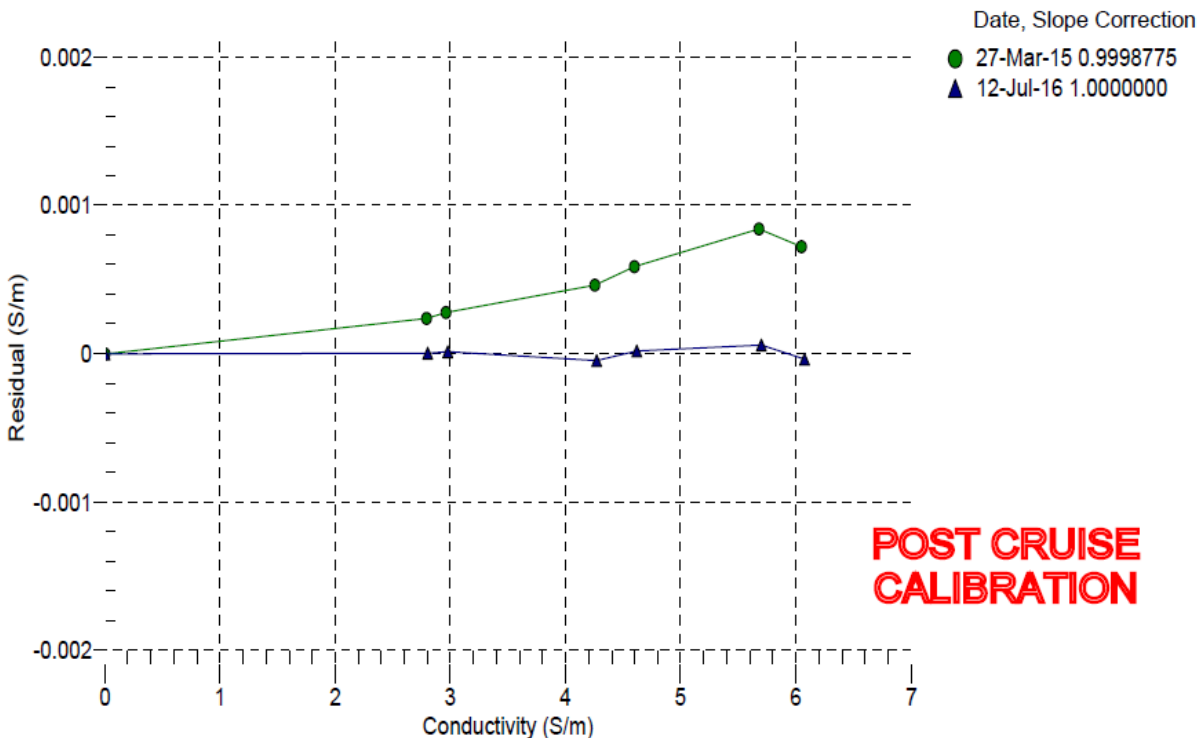
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.76619	0.00000	0.00000
-0.9999	34.8078	2.80396	7.90207	2.80397	0.00000
1.0000	34.8082	2.97534	8.11066	2.97535	0.00001
15.0001	34.8101	4.27094	9.53878	4.27090	-0.00005
18.5001	34.8100	4.61763	9.88540	4.61765	0.00002
29.0001	34.8089	5.70125	10.89599	5.70131	0.00006
32.5001	34.8016	6.07373	11.22165	6.07369	-0.00004

f = Instrument Output (kHz)

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

Conductivity (S/m) = (g + h * f² + i * f³ + j * f⁴) / 10 (1 + δ * t + ε * p)

Residual (Siemens/meter) = instrument conductivity - bath conductivity



Conductivity

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SENSOR SERIAL NUMBER: 1431
 CALIBRATION DATE: 22-Nov-16

SBE 4 CONDUCTIVITY CALIBRATION DATA
 PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -4.10386848e+000
 h = 5.32924476e-001
 i = -2.82561902e-004
 j = 4.25075718e-005

CPcor = -9.5700e-008 (nominal)
 CTcor = 3.2500e-006 (nominal)

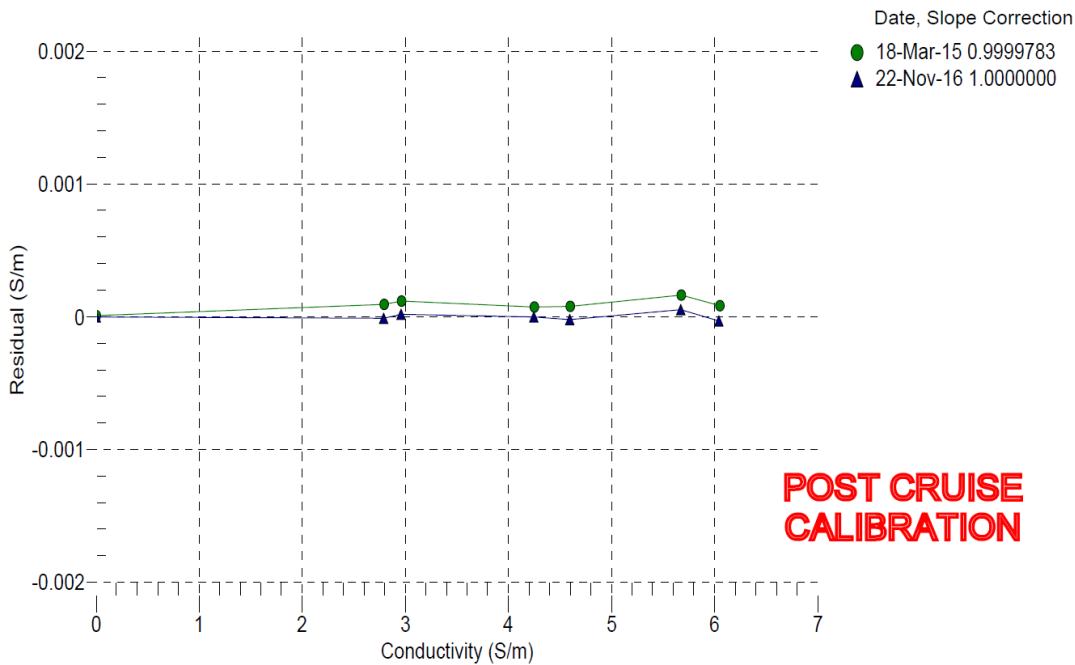
BATH TEMP (°C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.77620	0.00000	0.00000
-1.0000	34.6022	2.78893	7.74546	2.78892	-0.00001
1.0000	34.6026	2.95943	7.94865	2.95945	0.00002
15.0000	34.6021	4.24811	9.34037	4.24811	-0.00000
18.5000	34.6016	4.59295	9.67833	4.59293	-0.00002
29.0000	34.5994	5.67078	10.66450	5.67083	0.00005
32.5001	34.5947	6.04171	10.98285	6.04168	-0.00003

f = Instrument Output (kHz)

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

Conductivity (S/m) = (g + h * f² + i * f³ + j * f⁴) / 10 (1 + δ * t + ε * p)

Residual (Siemens/meter) = instrument conductivity - bath conductivity



Conductivity

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

SENSOR SERIAL NUMBER: 1852
 CALIBRATION DATE: 14-Feb-17

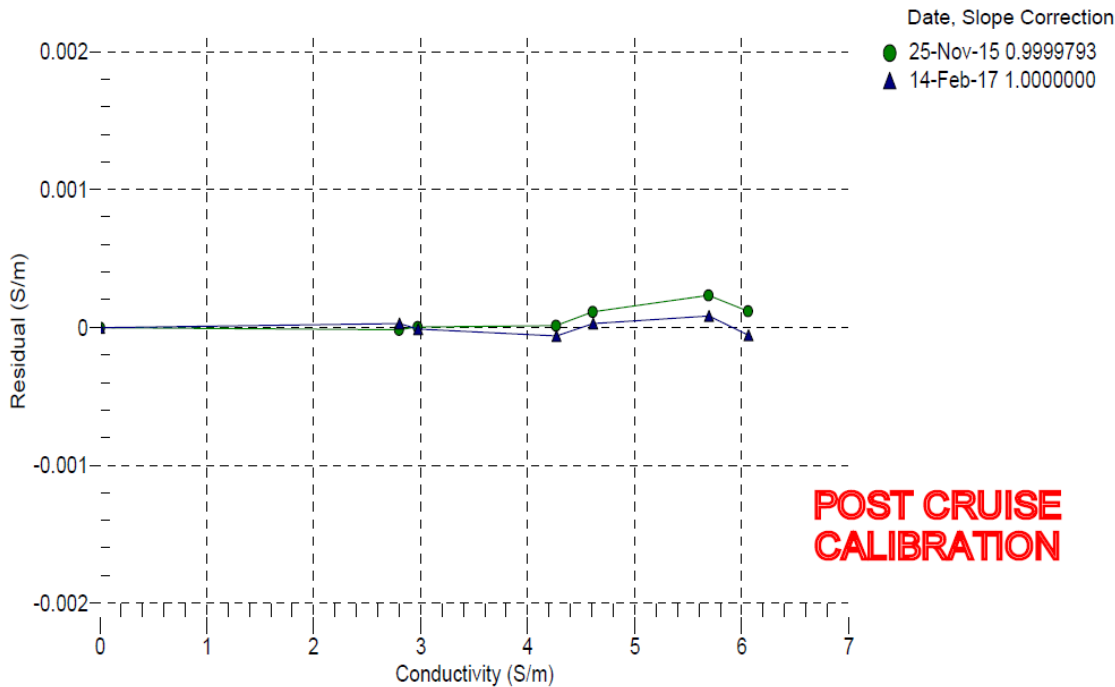
SBE 4 CONDUCTIVITY CALIBRATION DATA
 PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -3.96181319e+000 CPcor = -9.5700e-008 (nominal)
 h = 5.06072991e-001 CTcor = 3.2500e-006 (nominal)
 i = -6.18116622e-004
 j = 5.77417256e-005

BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.80149	0.00000	0.00000
-1.0000	34.7698	2.80118	7.95853	2.80121	0.00003
1.0000	34.7699	2.97238	8.16825	2.97236	-0.00001
15.0000	34.7686	4.26638	9.60449	4.26632	-0.00006
18.5000	34.7663	4.61245	9.95295	4.61248	0.00003
29.0000	34.7555	5.69348	10.96833	5.69356	0.00008
32.5000	34.7372	6.06376	11.29438	6.06370	-0.00006

f = Instrument Output (kHz)
 t = temperature (°C); p = pressure (decibars); δ = CTcor; ϵ = CPcor;
 Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / 10 (1 + \delta * t + \epsilon * p)$
 Residual (Siemens/meter) = instrument conductivity - bath conductivity



CTD Fish



SEA-BIRD
SCIENTIFIC

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SENSOR SERIAL NUMBER: 1130
CALIBRATION DATE: 23-Apr-18

SBE 9plus PRESSURE CALIBRATION DATA
10000 psia S/N 120089

DIGIQUARTZ COEFFICIENTS:

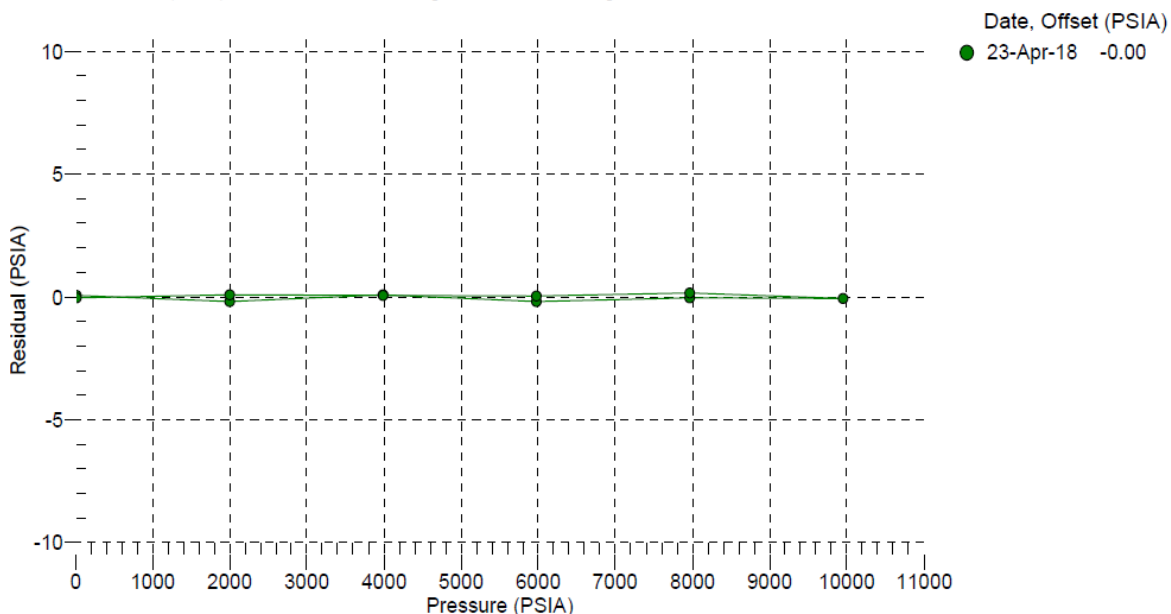
C1 = -4.230776e+004
C2 = 1.490078e-001
C3 = 1.507500e-002
D1 = 3.473000e-002
D2 = 0.000000e+000
T1 = 3.002251e+001
T2 = -2.774200e-004
T3 = 4.796030e-006
T4 = 1.754420e-009
T5 = 0.000000e+000

AD590M, AD590B, SLOPE AND OFFSET:

AD590M = 1.28100e-002
AD590B = -8.83931e+000
Slope = 1.00002
Offset = 0.0671 (dbars)

PRESSURE (PSIA)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT TEMPERATURE (°C)	INSTRUMENT PRESSURE (PSIA)	CORRECTED PRESSURE (PSIA)	RESIDUAL (PSIA)
14.773	33318.30	21.8	14.731	14.828	0.055
2001.291	34090.10	21.8	2000.973	2001.116	-0.175
3988.404	34842.80	21.9	3988.299	3988.486	0.082
5975.389	35577.00	21.9	5974.980	5975.212	-0.177
7962.053	36294.10	21.9	7961.729	7962.007	-0.046
9950.019	36995.50	22.0	9949.640	9949.963	-0.056
7962.381	36294.30	22.0	7962.271	7962.548	0.167
5975.403	35577.10	22.0	5975.213	5975.446	0.043
3988.370	34842.80	22.0	3988.249	3988.437	0.067
2001.246	34090.20	22.1	2001.179	2001.322	0.076
14.766	33318.30	22.3	14.632	14.730	-0.036

Residual (PSIA) = corrected instrument pressure - reference pressure



CTD Pressure Sensor

Dissolved Oxygen



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SENSOR SERIAL NUMBER: 0080
CALIBRATION DATE: 21-Nov-17

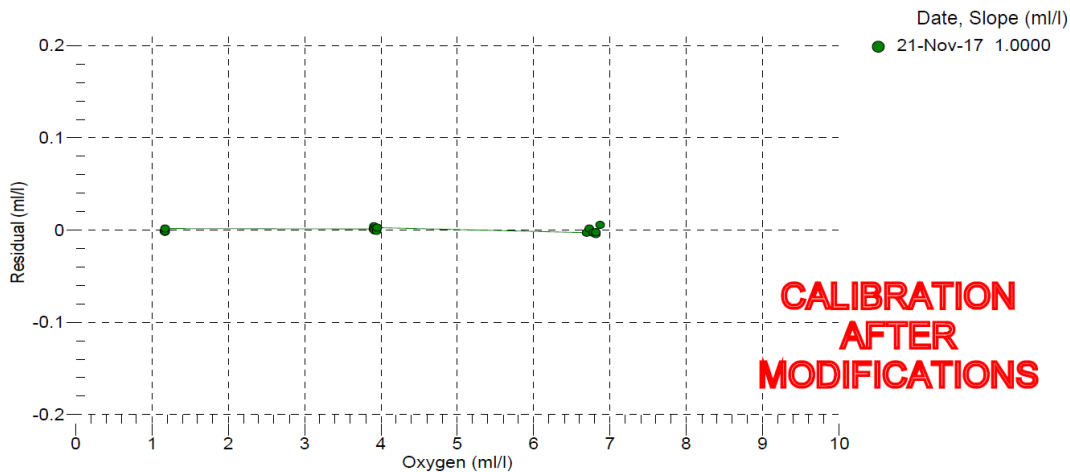
SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS: A = -3.4000e-003
Soc = 0.5115 B = 1.3686e-004
Voffset = -0.5002 C = -2.0534e-006
Tau20 = 1.56 E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS
D1 = 1.92634e-4 H1 = -3.300000e-2
D2 = -4.64803e-2 H2 = 5.00000e+3
H3 = 1.45000e+3

BATH OXYGEN (ml/l)	BATH TEMPERATURE (°C)	BATH SALINITY (PSU)	INSTRUMENT OUTPUT (volts)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.16	6.00	0.00	0.766	1.16	-0.00
1.17	12.00	0.00	0.810	1.16	-0.00
1.17	20.00	0.00	0.870	1.17	-0.00
1.17	2.00	0.00	0.738	1.17	-0.00
1.17	26.00	0.00	0.916	1.17	-0.00
1.18	30.00	0.00	0.951	1.18	0.00
3.90	2.00	0.00	1.294	3.90	0.00
3.91	6.00	0.00	1.392	3.91	0.00
3.91	12.00	0.00	1.540	3.91	0.00
3.92	20.00	0.00	1.741	3.92	-0.00
3.94	26.00	0.00	1.903	3.94	-0.00
3.95	30.00	0.00	2.014	3.96	0.00
6.70	2.00	0.00	1.861	6.69	-0.00
6.73	6.00	0.00	2.036	6.73	0.00
6.78	12.01	0.00	2.301	6.77	-0.00
6.81	30.00	0.00	3.105	6.81	-0.00
6.81	20.00	0.00	2.657	6.81	-0.00
6.87	26.00	0.00	2.945	6.87	0.01

V = instrument output (volts); T = temperature (°C); S = salinity (PSU); K = temperature (°K)
 Oxsol(T,S) = oxygen saturation (ml/l); P = pressure (dbar)
 $Oxygen (ml/l) = Soc * (V + Voffset) * (1.0 + A * T + B * T^2 + C * T^3) * Oxsol(T,S) * exp(E * P / K)$
 Residual (ml/l) = instrument oxygen - bath oxygen



Dissolved Oxygen



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SENSOR SERIAL NUMBER: 0150
CALIBRATION DATE: 11-Apr-18

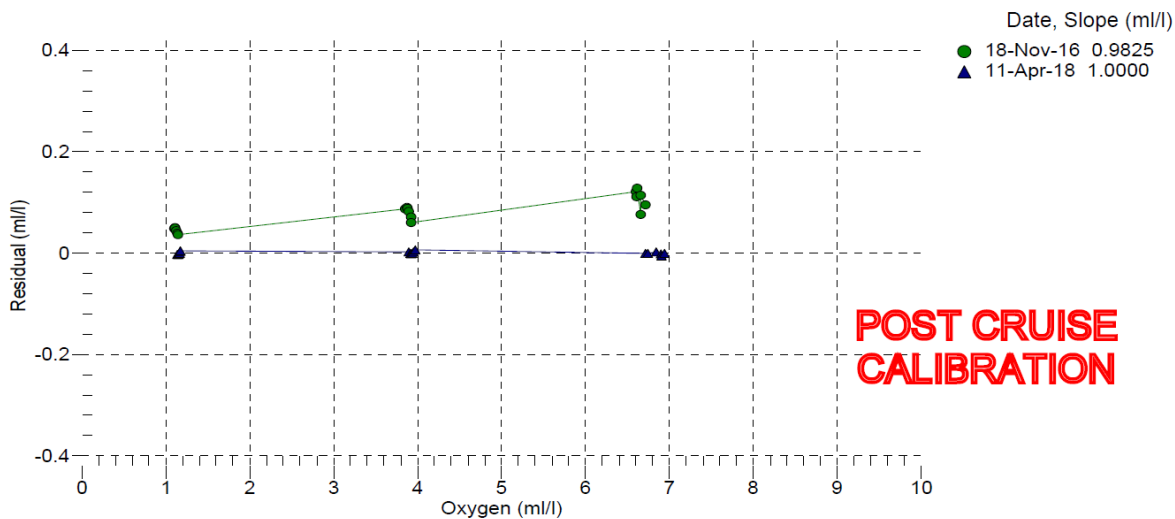
SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS: A = -4.2999e-003
Soc = 0.4635 B = 2.3799e-004
Voffset = -0.4894 C = -3.3472e-006
Tau20 = 1.29 E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS
D1 = 1.92634e-4 H1 = -3.300000e-2
D2 = -4.64803e-2 H2 = 5.00000e+3
H3 = 1.45000e+3

BATH OXYGEN (ml/l)	BATH TEMPERATURE (° C)	BATH SALINITY (PSU)	INSTRUMENT OUTPUT (volts)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.14	2.03	0.00	0.745	1.14	-0.00
1.14	6.00	0.00	0.777	1.14	-0.00
1.15	12.00	0.00	0.826	1.15	-0.00
1.16	20.00	0.00	0.891	1.16	-0.00
1.18	26.00	0.00	0.942	1.18	0.00
1.18	30.00	0.00	0.973	1.18	0.00
3.90	2.05	0.00	1.366	3.90	0.00
3.91	6.00	0.00	1.476	3.91	-0.00
3.92	12.00	0.00	1.638	3.92	-0.00
3.94	20.00	0.00	1.849	3.94	-0.00
3.95	26.00	0.00	2.008	3.96	0.00
3.98	30.00	0.00	2.122	3.98	0.01
6.72	2.05	0.00	2.001	6.72	-0.00
6.74	6.00	0.00	2.191	6.74	-0.00
6.84	12.00	0.00	2.495	6.85	0.00
6.90	20.00	0.00	2.869	6.89	-0.00
6.91	30.00	0.00	3.320	6.90	-0.01
6.94	26.00	0.00	3.152	6.94	-0.00

V = instrument output (volts); T = temperature (°C); S = salinity (PSU); K = temperature (°K)
 Oxsol(T,S) = oxygen saturation (ml/l); P = pressure (dbar)
 Oxygen (ml/l) = Soc * (V + Voffset) * (1.0 + A * T + B * T² + C * T³) * Oxsol(T,S) * exp(E * P / K)
 Residual (ml/l) = instrument oxygen - bath oxygen



CTD Pump (primary)



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Pressure Test Certificate

Test Date: **2017-08-02**

Description: **SBE-5T Submersible Pump**

Sensor Information:

Replaced the main piston "O"-Rings.

Model Number: **SBE-5T**

Serial Number: **05T-1626**

Pressure Test Protocol:

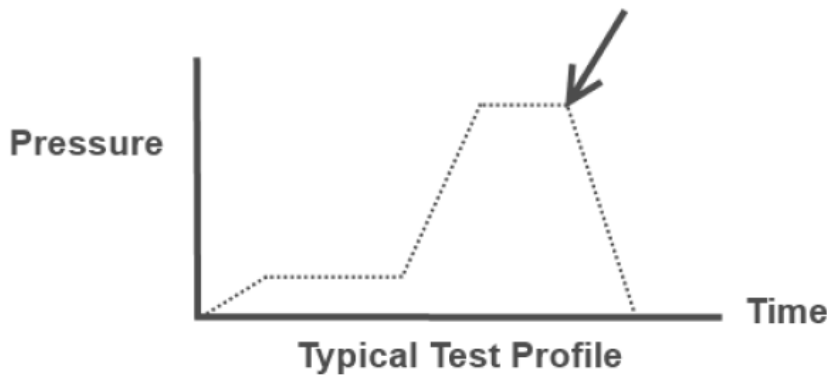
Low Pressure Test: **50** PSI Held For: **15** Minutes

High Pressure Test: **10000** PSI Held For: **30** Minutes

Passed Test: **True**

Tested By: **BLT**

High pressure is generally equal to the maximum depth rating of the instrument



CTD Pump (secondary)



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Pressure Test Certificate

Test Date: **2017-08-02**

Description: **SBE-5T Submersible Pump**

Sensor Information:

Replaced the main piston "O"-Rings.

Model Number: **SBE-5T**

Serial Number: **05T-1627**

Pressure Test Protocol:

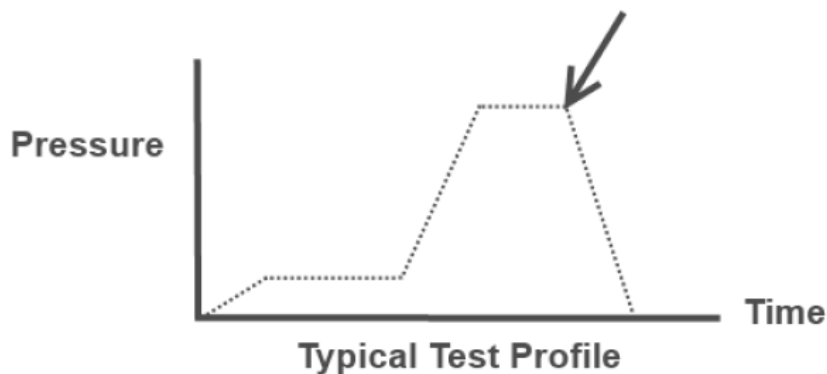
Low Pressure Test: **50** PSI Held For: **15** Minutes

High Pressure Test: **10000** PSI Held For: **30** Minutes

Passed Test: **True**

Tested By: **BLT**

High pressure is generally equal to the maximum depth rating of the instrument



Fluorometer

PO Box 518
620 Applegate St.
Philomath, OR 97370



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www.wetlabs.com

ECO Chlorophyll Fluorometer Characterization Sheet

Date: 4/20/2017

S/N: FLRTD-397

Chlorophyll concentration expressed in $\mu\text{g/l}$ 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	0.102	0.063	0.043 V	63 counts
Scale Factor (SF)	6	13	25 $\mu\text{g/l/V}$	0.0077 $\mu\text{g/l/count}$
Maximum Output	4.98	4.98	4.98 V	16330 counts
Resolution	0.8	0.8	0.8 mV	1.0 counts

Ambient temperature during characterization

22.0 °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: $\text{SF} = x \div (\text{output} - \text{dark counts})$, 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-397

Revision J

3/17/08

Fluorometer

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Philomath, OR 97370



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www.wetlabs.com

ECO Chlorophyll Fluorometer Characterization Sheet

Date: 5/16/2018

S/N: FLRTD-855

Chlorophyll concentration expressed in $\mu\text{g/l}$ 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	0.113	0.070	0.049 V	71 counts
Scale Factor (SF)	7	14	29 $\mu\text{g/l/V}$	0.0079 $\mu\text{g/l/count}$
Maximum Output	4.98	4.98	4.98 V	16326 counts
Resolution	0.6	0.6	0.6 mV	1.0 counts

Ambient temperature during characterization

22.0 °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: $\text{SF} = x \div (\text{output} - \text{dark counts})$, 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

PAR

Calibration Date: 12/12/16
Model Number: QSP2350
Serial Number: 70555
Operator: TPC
Standard Lamp: 91453(7/20/16)
Operating Voltage Range: 6 to 15 VDC (+)

Job No.: R12817

Note: The QSP2350 output is a voltage that is proportional to the log of the incident irradiance. To calculate irradiance, use this formula:

$$\text{Irradiance} = \text{Calibration factor} * (10^{\wedge}\text{Light Signal Voltage} - 10^{\wedge}\text{Dark Voltage})$$

Dry Calibration Factor: 2.72E+12 quanta/cm²·sec per volt 4.52E-06 μEinsteins/cm²·sec per volt
Wet Calibration Factor: 4.81E+12 quanta/cm²·sec per volt 7.99E-06 μEinsteins/cm²·sec per volt

Sensor Test Data and Results²⁾

Sensor Supply Current (Dark): 3.4 mA
Supply Voltage: 6 Volts
Lamp Integrated PAR Irradiance: 8.38E+15 quanta/cm²·sec 0.01391 μEinsteins/cm²·sec
Immersion Coefficient: 0.566

Nominal Filter OD	Expected Transmission	Calibrated Trans.	Sensor Voltage	Expected Voltage	Error %	Measured Trans.	Transmission Error (%)	Test Irrad. (quanta/cm ² ·sec)
No Filter	100%	100.00%	3.488	3.488	0%	100.00%	0.0	8.38E+15
0.3	50%	36.10%	3.046	3.046	0%	36.11%	0.0	3.03E+15
0.5	32%	27.60%	2.933	2.929	0%	27.86%	-0.9	2.33E+15
1	10%	9.27%	2.465	2.455	0%	9.45%	-1.9	7.92E+14
2	1%	1.11%	1.551	1.533	1%	1.12%	-1.2	9.42E+13
3	0.10%	0.05%	0.396	0.216	46%	0.05%	12.3	4.06E+12
RG780	0.00%	0.00%	0.011	0.011	-3%	0.00%	-100.0	6.99E+10

Dark Before: 0.011 Volts
Light - No Filter Hldr.: 3.488 Volts
Dark After - NFH: 0.012 Volts
Average Dark: 0.0114 Volts

1. Annual calibration is recommended.
 2) This section is for internal use and for more advanced analysis.

Temperature (primary)

Sea-Bird Electronics, Inc.

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

SENSOR SERIAL NUMBER: 2438
 CALIBRATION DATE: 29-Nov-16

SBE 3 TEMPERATURE CALIBRATION DATA
 ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

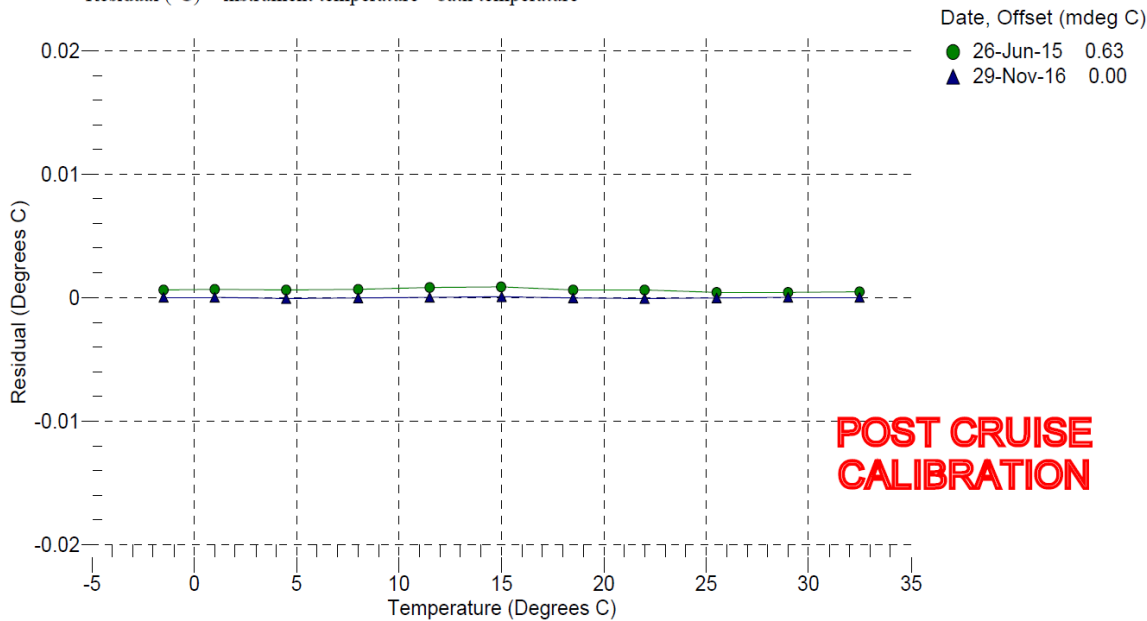
g = 4.31133990e-003
 h = 6.41922897e-004
 i = 2.30163393e-005
 j = 2.18396589e-006
 f0 = 1000.0

BATH TEMP (° C)	INSTRUMENT OUTPUT (Hz)	INST TEMP (° C)	RESIDUAL (° C)
-1.5000	2759.406	-1.5000	0.00002
1.0000	2917.908	1.0000	0.00001
4.5000	3150.743	4.4999	-0.00007
8.0000	3396.674	8.0000	-0.00001
11.5000	3656.045	11.5000	0.00004
15.0000	3929.201	15.0001	0.00008
18.5000	4216.464	18.5000	-0.00000
22.0000	4518.170	21.9999	-0.00006
25.5000	4834.638	25.5000	-0.00002
29.0000	5166.156	29.0000	0.00000
32.5000	5513.014	32.5000	0.00002

f = Instrument Output (Hz)

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

Residual (°C) = instrument temperature - bath temperature



Temperature (Secondary)

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: 5185
 CALIBRATION DATE: 07-Feb-17

SBE 3 TEMPERATURE CALIBRATION DATA
 ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

g = 4.35781623e-003
 h = 6.35001056e-004
 i = 2.14104779e-005
 j = 1.94043187e-006
 f0 = 1000.0

BATH TEMP (° C)	INSTRUMENT OUTPUT (Hz)	INST TEMP (° C)	RESIDUAL (° C)
-1.5000	3011.406	-1.5000	0.00003
1.0000	3186.481	1.0000	-0.00002
4.5000	3443.813	4.5000	-0.00004
8.0000	3715.782	8.0000	-0.00002
11.5000	4002.790	11.5000	0.00003
15.0000	4305.233	15.0001	0.00014
18.5000	4623.458	18.4999	-0.00007
22.0000	4957.878	21.9999	-0.00010
25.5000	5308.850	25.5000	0.00003
29.0000	5676.692	29.0000	0.00004
32.5000	6061.738	32.5000	-0.00001

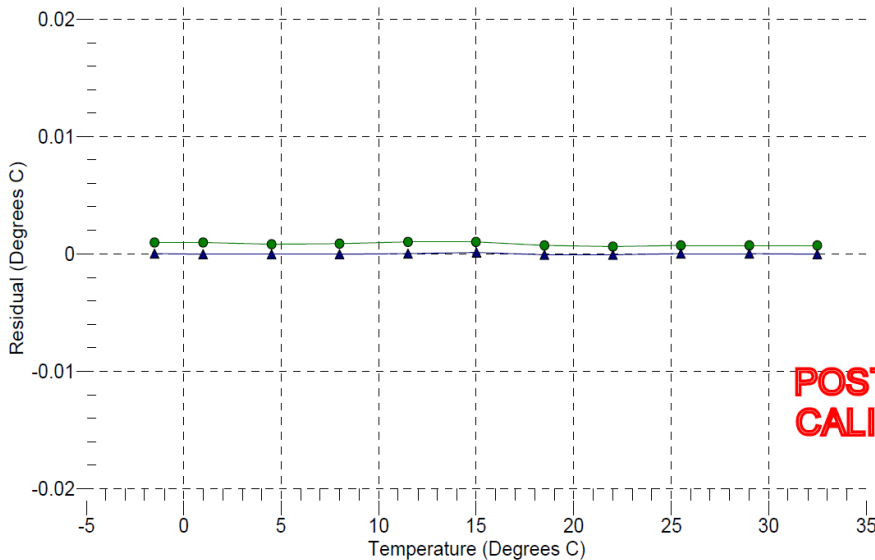
f = Instrument Output (Hz)

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

Residual (°C) = instrument temperature - bath temperature

Date, Offset (mdeg C)

- 30-Jun-15 0.85
- ▲ 07-Feb-17 0.00



Transmissometer

PO Box 518
620 Applegate St.
Philomath, OR 97370



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

C-Star Calibration

Date **7.29.16** S/N# **CST-439DR** Pathlength **25 cm**

Analog output

V_d	0.057 V
V_{air}	4.752 V
V_{ref}	4.659 V
Temperature of calibration water	23.7 °C
Ambient temperature during calibration	22.8 °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.

Transmissometer

PO Box 518
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Philomath, OR 97370



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Fax (541) 929-5277
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C-Star Calibration

Date **11.10.16** S/N# **CST-892DR** Pathlength **25 cm**

	Analog output
V_d	0.058 V
V_{air}	4.761 V
V_{ref}	4.662 V

Temperature of calibration water	23.5 °C
Ambient temperature during calibration	24.7 °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.

Micro-TSG

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: 02-Apr-17

SBE 45 CONDUCTIVITY CALIBRATION DATA

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

COEFFICIENTS:

g = -9.982038e-001

h = 1.522508e-001

i = -4.303026e-004

j = 5.783952e-005

CPcor = -9.5700e-008

CTcor = 3.2500e-006

WBOTC = -0.0000e+000

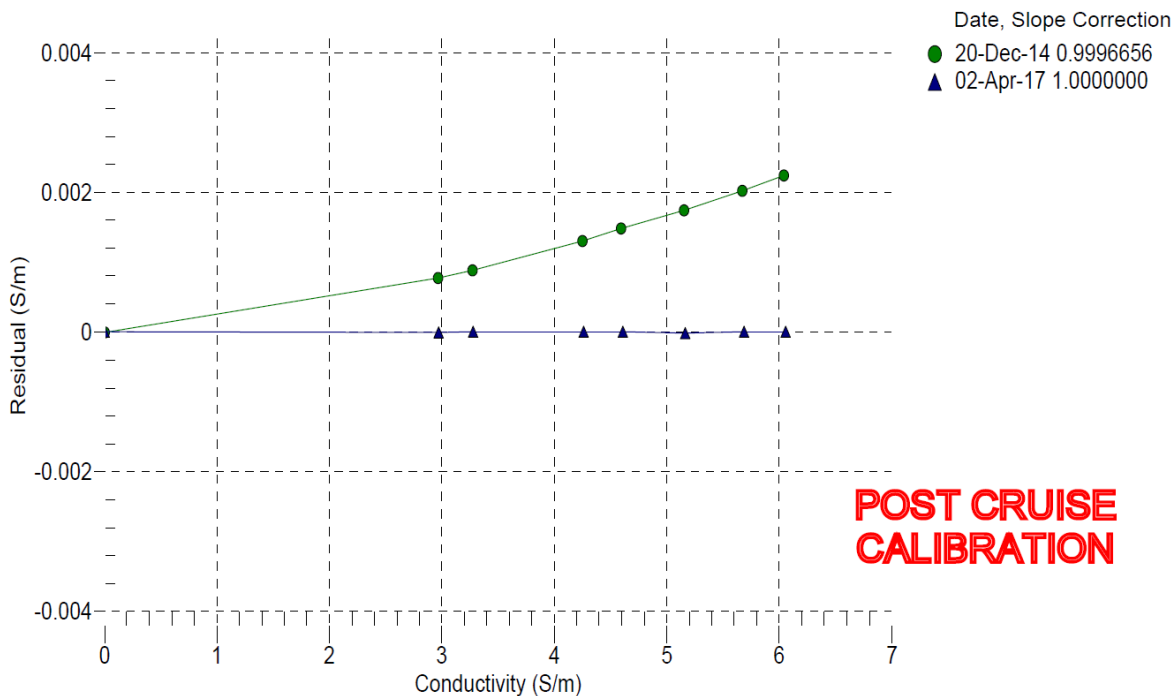
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2566.64	0.00000	0.00000
1.0000	34.7888	2.97384	5119.28	2.97383	-0.00001
4.5000	34.7689	3.28069	5312.80	3.28070	0.00001
15.0000	34.7272	4.26184	5888.15	4.26184	0.00000
18.5000	34.7186	4.60681	6077.20	4.60681	0.00000
24.0000	34.7094	5.16448	6370.62	5.16447	-0.00001
29.0000	34.7049	5.68612	6632.98	5.68612	0.00000
32.5000	34.7030	6.05846	6813.84	6.05847	0.00000

$$f = \text{Instrument Output(Hz)} * \text{sqrt}(1.0 + \text{WBOTC} * t) / 1000.0$$

t = temperature (°C); p = pressure (decibars); $\delta = \text{CTcor}$; $\epsilon = \text{CPcor}$;

$$\text{Conductivity (S/m)} = (g + h * f^2 + i * f^3 + j * f^4) / 10 (1 + \delta * t + \epsilon * p)$$

$$\text{Residual (Siemens/meter)} = \text{instrument conductivity} - \text{bath conductivity}$$



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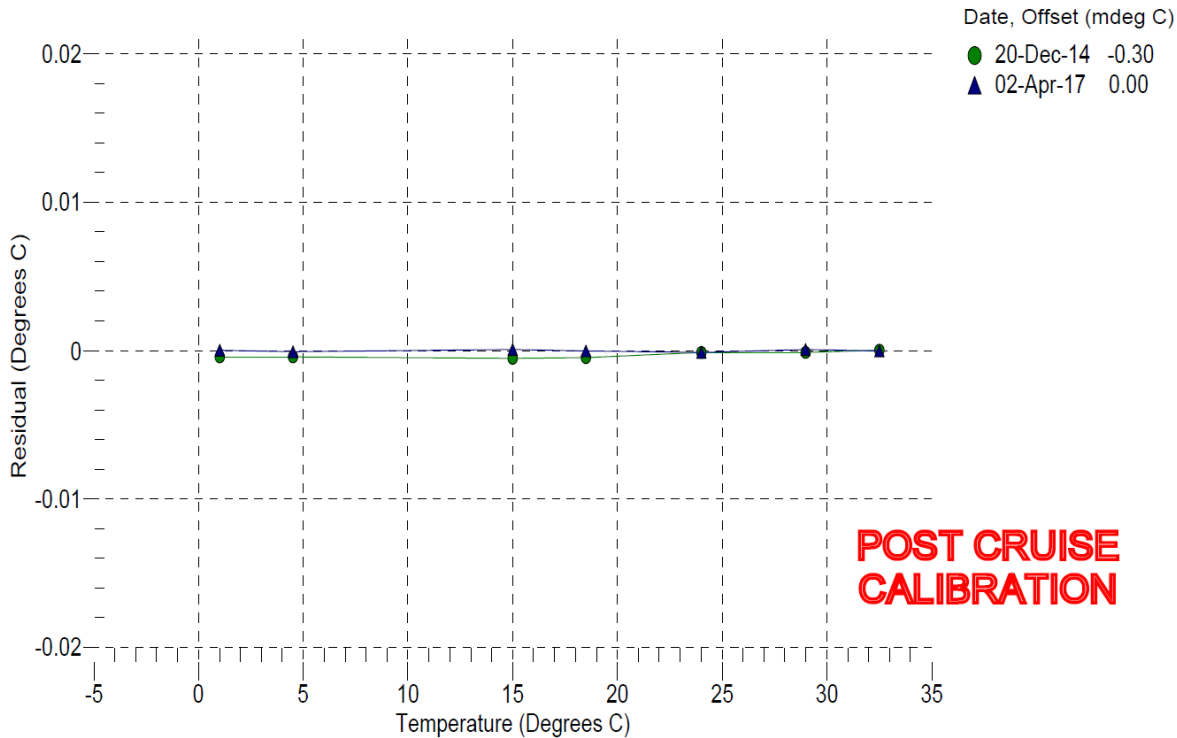
SENSOR SERIAL NUMBER: 0242
 CALIBRATION DATE: 02-Apr-17

SBE 45 TEMPERATURE CALIBRATION DATA
 ITS-90 TEMPERATURE SCALE

COEFFICIENTS:
 a0 = 3.676223e-005
 a1 = 2.754692e-004
 a2 = -2.489671e-006
 a3 = 1.542625e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	649818.7	1.0000	0.0000
4.5000	554887.7	4.4999	-0.0001
15.0000	352327.2	15.0001	0.0001
18.5000	304718.5	18.5000	-0.0000
24.0000	244011.5	23.9999	-0.0001
29.0000	200600.4	29.0001	0.0001
32.5000	175478.5	32.5000	-0.0000

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



Micro-TSG



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SENSOR SERIAL NUMBER: 0389
CALIBRATION DATE: 25-Apr-18

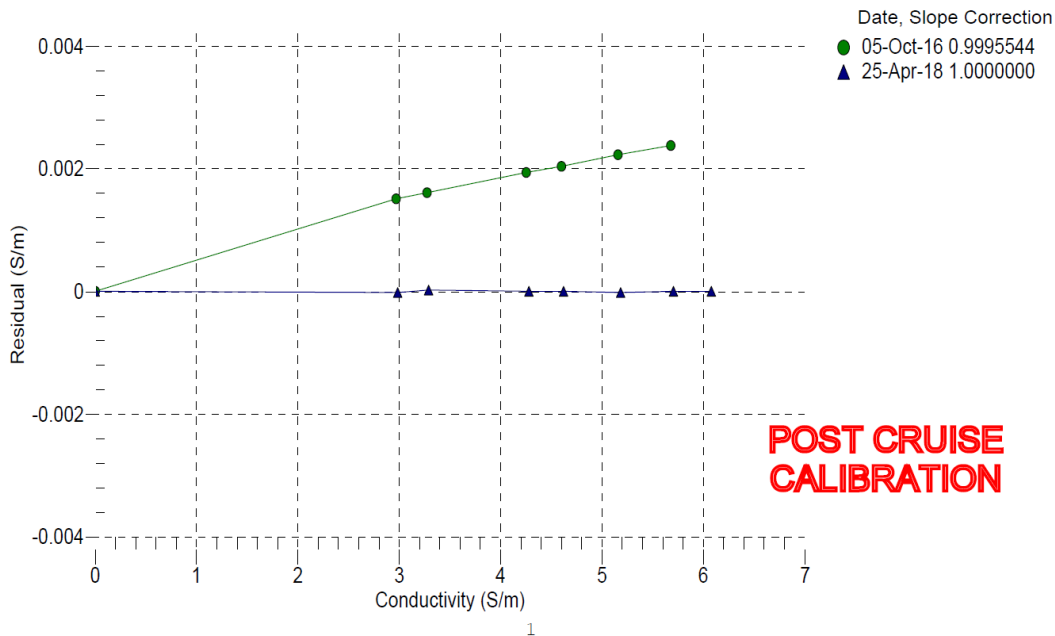
SBE 45 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -9.985799e-001 CPcor = -9.5700e-008
h = 1.455792e-001 CTcor = 3.2500e-006
i = -3.660237e-004 WBOTC = 1.2700e-007
j = 4.864142e-005

BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2624.68	0.00000	0.00000
1.0000	34.9196	2.98395	5240.82	2.98393	-0.00002
4.5000	34.8990	3.29176	5439.06	3.29178	0.00002
15.0000	34.8558	4.27595	6028.45	4.27595	0.00000
18.5000	34.8464	4.62193	6222.11	4.62194	0.00001
24.0000	34.8356	5.18118	6522.65	5.18116	-0.00002
29.0001	34.8286	5.70412	6791.31	5.70412	0.00000
32.5000	34.8234	6.07709	6976.39	6.07709	0.00000

f = Instrument Output(Hz) * sqrt(1.0 + WBOTC * t) / 1000.0
t = temperature (°C); p = pressure (decibars); δ = CTcor; ε = CPcor;
Conductivity (S/m) = (g + h * f + i * f² + j * f⁴) / (1 + δ * t + ε * p)
Residual (Siemens/meter) = instrument conductivity - bath conductivity





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SENSOR SERIAL NUMBER: 0389
 CALIBRATION DATE: 25-Apr-18

SBE 45 TEMPERATURE CALIBRATION DATA
 ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

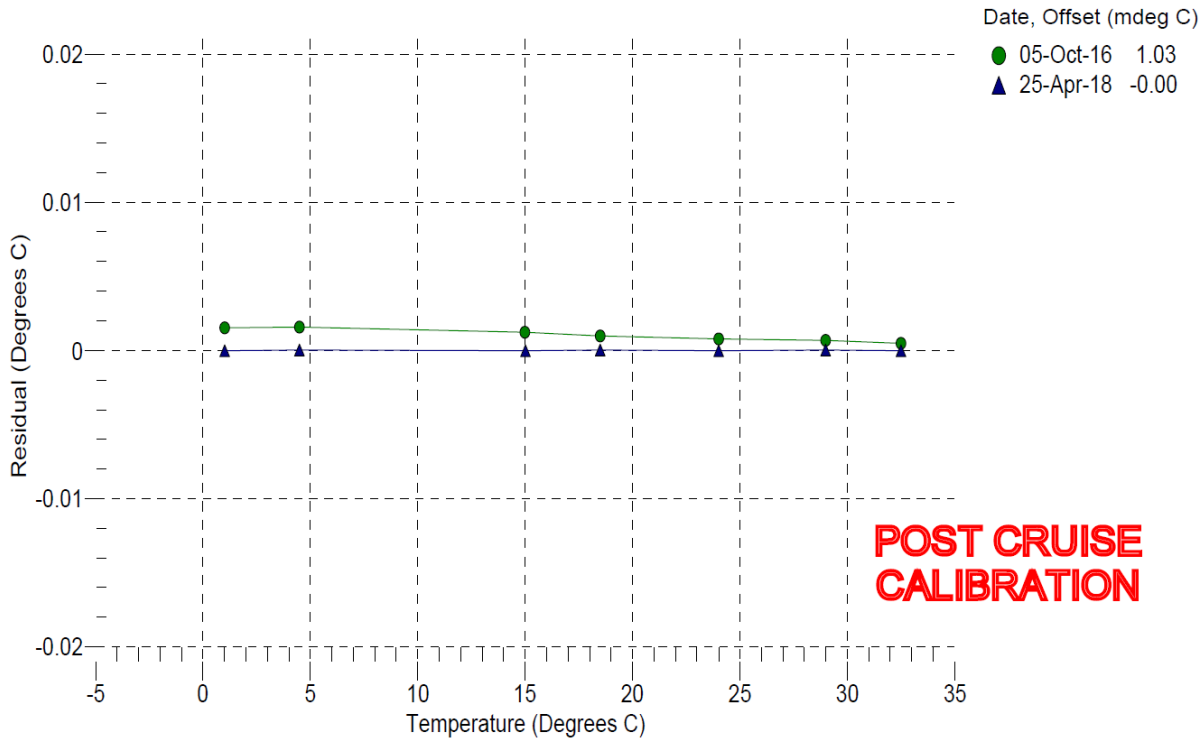
a0 = 7.863170e-006
 a1 = 2.711897e-004
 a2 = -2.263006e-006
 a3 = 1.440061e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	828476.9	1.0000	-0.0000
4.5000	706678.1	4.5000	0.0000
15.0000	447327.3	15.0000	-0.0000
18.5000	386500.1	18.5000	0.0000
24.0000	309037.1	24.0000	-0.0000
29.0001	253723.7	29.0001	0.0000
32.5000	221749.9	32.5000	-0.0000

n = Instrument Output (counts)

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

Residual (°C) = instrument temperature - bath temperature



Digital Remote Temp

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SENSOR SERIAL NUMBER: 0178
 CALIBRATION DATE: 07-Feb-17

SBE 38 TEMPERATURE CALIBRATION DATA
 ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

a0 = -3.943075e-005
 a1 = 2.802070e-004
 a2 = -2.606506e-006
 a3 = 1.642771e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
-1.5000	750884.0	-1.5000	0.0000
1.0000	671251.6	1.0000	-0.0000
4.5000	575382.9	4.4999	-0.0001
8.0000	494800.5	8.0000	-0.0000
11.5000	426841.3	11.5000	0.0000
14.9999	369340.5	15.0000	0.0001
18.5000	320533.9	18.5000	0.0000
22.0000	278978.8	22.0000	-0.0000
25.5000	243492.0	25.4999	-0.0001
29.0000	213097.4	28.9999	-0.0001
32.5000	186990.2	32.5001	0.0001

n = Instrument Output (counts)

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

Residual (°C) = instrument temperature - bath temperature

