LMG 1804

Cruise Data Report

13 April 2018 – 15 May 2018

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Introduction

The LMG data acquisition systems continuously log data from a suite of instrumentation throughout 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.

All the data has been archived using 'tar' and compressed using 'gzip', identified by the '.gz' extension.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

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

Archive Data Extraction

It is often useful to know exactly how an archive was produced when expanding its contents. Tar files were created using the following commands:

```
tar cvf archive-file files-to-be-archived
```

To create a list of the files in the archive:

```
tar tvf  archive-file  > contents.list
```

To extract the files from the archive:

```
tar xvf  archive-file file(s)-to-extract
```

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

```
gunzip filename.gz
```

Distribution Contents

ADCP data (/ADCP)

This directory contains a tar file of the ADCP system's "proc" directory, which is generated by the well-known ADCP system UHDAS, and contains averaged ping data, files used in processing the data, and daily graphs of the currents. For more information contact Teri Chereskin at tchereskin@ucsd.edu .

Data collection parameters (/CAL)

Refer to the InstCoef.txt file along with the specific instrument calibration sheets in this report for information on how the RVDAS data was collected and processed.

Imagery (/Imagery)

This directory contains things such as ice imagery, isobar charts, sat imagery, wave and wind images, and weather reports.

Automatically processed data (/process)

Contains automatically processed datasets and QC graphs produced by the RVDAS system

QC Plots (/process/QC.tar)

Postscript files of data stored each day on RVDAS for quality control analysis during the cruise. There are 3 types of files, named metXXX.ps, navXXX.ps, and oceanXXX.ps, where XXX is represents the Julian day. Met files are a summary of the data from the meteorological instruments, Nav files are a summary of navigational data, and Ocean files are a summary of the underway seawater and bathymetry data. Some files have a PNG (Portable Network Graphics) format copy generated.

Reports (/Report)

Copies of this report in MS Word and pdf formats, and scanned copies of logsheets provided by various science groups.

Additional Data (/Science)

Instrument data (/rvdas)

Contains data collected by the suite of standard instruments on the LMG. This data is detailed later in the report

Utility programs (/Utility)

Contains utility programs to access the data on the distribution.

JGOFS Data Set

/Process/JGOF/

The JGOFS data set consists of a single file produced each day named jg<julian_day>.dat.gz where <julian_day> is the day the data was acquired. The ".gz" extension indicates that the individual files are compressed before archiving. The daily file consists of 22 separate columnar fields in text format, which are described below. The JGOFS data set is obtained primarily by applying calibrations to raw data and decimating to whole minute intervals. However, several fields are derived measurements from more than a single raw input. *Note: Null, unused, or unknown fields are filled with 9's in the JGOFS data.*

Additionally, 3 separate QC plots are generated daily by the ET using the JGOFS data set. These plots include TSG and Bathymetry data, meteorological data, and navigation data. The files are called ocean<julian_day>.ps, met<julian_day>.ps, and nav<julian_day>.ps respectively.

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/meter2
10	Sea Surface Temperature	°C
11	Sea Surface Conductivity	siemens/meter
12	Sea Surface Salinity	PSU
13	Sea Depth (uncorrected, calc. sw soud 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	µg/l
20	Transmissometer Voltage[2]	V
21	PSP	W/m2
22	PIR	W/m2

[1]For raw depth please refer to the Knudsen logger file (lknu) for sea depth

[2]Calibration factors to calculate % transmission can be found in the calibration sheet section and in instrument.coeff

pCO2-merged Data Set

/Process/PCO2/

```
23:59:00 00+346:23:58:20.672 2000346.9991 2398.4 1008.4 0.01 45.4 350.3 342.6 15.77 Equil -
43.6826 173.1997 15.51 33.90 0.33 5.28 9.05 1007.57 40.0 14.87 182.44 -1
```

Field	Data	Format	Unit
1	Elapsed time	hh:mm:ss	min
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	pCO_2 system internal Barometer	xxx.xx	mBar
6	Flowrate	xxx.xx	cm^3/min
7	VCO_2 Concentration	xxx.xx	µAtm
8	pCO_2 Pressure	xx.xx	ppm
9	Equilibrator Temperature, RTD	xx.xx	°C
10	Equilibrator Temperature, SBE38	xx.xx	°C
11	Valve Position	xx	numeric
12	Gas Flow Source (Equil = pCO_2 measurement)		text
13	Latitude	xx.x	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_2O Flow Rate	xxx.x	Raw counts
22	Speed over Ground	x.xx	knots
23	Course Made Good	xx.xx	degrees
24	Oxygen	xxx.xx	µm/kg
25	TSG2 Internal Temperature	x.xx	°C
26	TSG2 Salinity	xx.xx	PSU
27	TSG1 Internal Temperature	x.xx	°C

RVDAS

/RVDAS/

RVDAS (Research Vessel Data Acquisition System) was originally developed at Lamont-Doherty Earth Observatory of Columbia University and was used on the R/V Maurice Ewing for many years. It was modified extensively for use on the Nathaniel B. Palmer and her sister ship, the R/V Laurence M. Gould.

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

We divide RVDAS data into two general categories, *underway and navigation*. The raw data can be found on the distribution media as subdirectories under the top-level rvdas directory: /rvdas/uw, and /rvdas/nav. Processed 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

```
LMG[CruiseID][ChannelID].dDDD
```

Example: `LMG1804lmwx.d112`

- The CruiseID is the numeric name of the cruise, in this case.
- 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

Meteorological Data

Measurement	String ID	Collection Status	Rate	Instrument
Air Temperature	lmwx (met)	Continuous	1/sec	Rotronic HC2-S3
Relative Humidity	lmwx (met)	Continuous	1/sec	Rotronic HC2-S3
Wind Speed / Direction	lmwx (pus,sus)	Continuous	1/sec	Gill Instruments 1390-PK-062
Barometer	lmwx (met)	Continuous	1/sec	Vaisala PTB210B
PAR	lmwx (met)	Continuous	1/sec	Biospherical Instruments QSR-240
PIR	lmwx (met)	Continuous	1/sec	Eppley PIR
PSP	lmwx (met)	Continuous	1/sec	Eppley PSP
GUV	lguv	Continuous	2/sec	Biospherical Instruments GUV-2511
Oxygen	lgo2	Continuous	1/min	UCAR Oxygen system

Navigational Data

Measurement	String ID	Collection Status	Rate	Instrument
Gyroscope	lgyr	Continuous	5/sec	Meridian Bridgemate Gyro
Seapath GPS	lsep	Continuous	1/sec	Seapath 330
Garmin GPS	lgar	Continuous	1/sec	Garmin 19
AIS	lais	Continuous	var	Standard Horizon GX2150

Geophysical Data

Measurement	String ID	Collection Status	Rate	Instrument
Bathymetry	lknu	Variable	Varies	Knudsen Chirp 3260
Dush-11 Winch	lwn1	Variable	20/sec	Markey DUSH-11
Dush-5 Winch	lwn1	Variable	20/sec	Markey DUSH-5
Dush-4 Winch	lwn1	Variable	20/sec	Markey DUSH-4

Oceanographic Data

Measurement	String ID	Collection Status	Rate	Instrument
Salinity	utsg	Continuous	3 sec	Seabird-45
Salinity (secondary)	tsg2	Continuous	3 sec	Seabird-45
Sea Surface Temperature	lrtm	Continuous	1 sec	Seabird-38
Fluorometry	ldfl	Continuous	1 sec	WetLabs ECO
ADCP, Speed Log	ladc	Continuous	1 sec	RD Instruments Workhorse 150
Dissolved Oxygen	loxy	Continuous	1 sec	Anderaa Optode
pCO_2	lpco2	Continuous	2.5 min	PCO2 System

Data File Names and Structures

RVDAS data is divided into two broad categories, ***Underway*** and ***Navigation***. The groups are abbreviated "uw" and "nav". Thus, these two tar files, lmguw.tar and lmgnav.tar exist under the top-level rvdas directory. The instruments are broken down as shown. Each data file is g-zipped to save space on the distribution. Not all data types are collected every day or on every cruise.

RVDAS data files are named following the convention: LMG[FileID].dDDD.

- The FileID is a 4-character code representing the system being logged, for example: lmet (for meteorology)
- DDD is the Julian day of the data collection

Underway Data	File ID	Navigation Data	File ID
Meteorological	lmwx	Gyro Compass	lgyr
Knudsen	lknu	Garmin GPS	lgar
microTSG	utsg	Seapath GPS	lsep
Sea Surface Temperature	lrtm	AIS	lais
Fluorometer	ldfl		
ADCP	ldfl		
Sound Velocity Probe	lsvp		
GUV & PUV	lguv		
PCO2 system	lpco		
Dissolved Oxygen	loxy		
Sea Water Wall	lsea		
Winches	lwn1		

Data is received by the RVDAS system via RS-232 serial connections. The data files that comprise the rvdas data set are described below. A time tag is added to each line of data received and the data is written to disk.

```
YY+DDD:HH:MM:SS.SSS [data stream from instrument]
```

Where, YY: two-digit year, DDD: Julian Day, HH: 2 digit hours, MM: 2 digit minutes SS.SSS: seconds. All times are UTC.

The delimiters used to separate fields in the raw data files are usually spaces and commas, but other delimiters are used (::, =, @) and occasionally there is no delimiter. Care should be taken when reprocessing the data that the field separations are clearly understood. Example data strings of the loggers follow.

lknu – Knudsen Chirp 3260 Sonar

```
14+002:19:07:04.648 3.5kHz,4000.92,1,12.0kHz,4001.12,1,1500,-57.343073,-63.750720
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	3.5kHz = Low frequency in use	text	3.5kHz
3	Low Frequency Depth	xxxx.xx	m
4	Valid Flag	x	0 or 1
5	12.0kHz = High frequency in use	text	12.0kHz
6	High Frequency Depth	xxxx.xx	m
7	Valid Flag	x	0 or 1
8	Empty Field	0.00	NA
9	Latitude	xx.xxxxxx	degrees
10	Longitude	xx.xxxxxx	degrees

lwn1 - Winches

```
16+093:16:55:49.561 -01RD,2016-04-02T12:38:50.854,DUSH11,-0000233,00000000,000000.0,3275
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Record Identifier, RD=Remote Data		alphanumeric
3	LCI-90i Date and Time	yyyy-mm-ddThh:mm:ss	
4	Winch Indentifier		text
5	Winch Name		alphabetical
6	Tension	xxxxxxxx	lbs
7	Speed	xxxxx.x	m/min
8	Payout	xxxxx.x	m
9	Checksum	x.xxxx	numeric

lmwx – Campbell Meteorological DAS

```
17+050:00:00:00.258 MET,12.5,58,-0.25,90.6,14.16584,0.0273877,-0.02605171,272.1153,
272.0825,993.81
```

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	%
5	Air Temperature, Celsius	xx.xx	°C
6	Air Relative Humidity	xx.x	%
7	PAR (Photosynthetically Available Radiation)	xxx.xxxxx	mV
8	PSP (Shortwave Radiation)	x.xxxxxxxx	mV
9	PIR Thermopile (Longwave Radiation)	x.xxxxxxxx	mV
10	PIR Case Temperature	xxx.xxxx	°K
11	PIR Dome Temperature	xxx.xxxx	°K
12	Barometer	xxx.xxxx	mBar

```
08+034:13:52:14.216 PUS,A,356,002.15,M,+332.28,+000.97,60,08
08+034:13:52:14.216 SUS,A,356,002.15,M,+332.28,+000.97,60,08
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Identifier (PUS = port, SUS = stbd)	xxx	Text
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	ºC
9	Unit Status	xx	numeric
10	Checksum	xx	alphanumeric

lguv – Biospherical GUV

```
08+037:14:17:59.211 020608 141758 -.000099 1.307E0 7.24E0 1.316E1 2.609E1 3.285E1 3.505E1
8.075E-2 38.993 17.985
```

Field	Data	Units
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss
2	GUV Computer date	mmddyy
3	GUV Computer Time	hhmmss
4	Ed0Gnd	Volts
5	Ed0305	$\mu W/cm^2nm$
6	Ed0313	$\mu W/cm^2nm$
7	Ed0320	$\mu W/cm^2nm$
8	Ed0340	$\mu W/cm^2nm$
9	Ed0380	$\mu W/cm^2nm$
10	Ed0395	$\mu W/cm^2nm$
11	Ed0PAR	$\mu E/cm^2sec$
12	Ed0Temp	°C
13	Ed0Vin	Volts

lsea – wet wall flows, transmissometer

```
12+004:12:01:04.438 WetLab_1,14.1,XMISS,3.098,V,0.000,0.000,0.000,-928.535,-
220.566,0.000,0.000,T,NAN,NAN,NAN,NAN,P,0,0,F,47.91811,0,6.815308,0,0,0,0,0,I,1,1,1,1
```

Field	Data	Unit
1	RVDAS time tag	UTC
2	WetLab_1	Text
3	Internal Temperature	ºC
4	XMISS	Text
5	Transmissometer Reading	volts
6	V	Text
7	High precision voltage #1 (not used)	mV
8	High precision voltage #2 (not used)	mV
9	High precision voltage #3 (not used)	mV
10	Standard precision voltage #1 (not used)	mV
11	Standard precision voltage #2 (not used)	mV
12	Standard precision voltage #3 (not used)	mV
13	Standard precision voltage #4 (not used)	mV
14	T	Text
15	Temperature Probe 1 (not used)	°C
16	Temperature Probe 2 (not used)	°C
17	Temperature Probe 3 (not used)	°C
18	Temperature Probe 4 (not used)	°C
19	P	Text
20	Pulse Counter 1 (not used)	counts
21	Pulse Counter 2 (not used)	counts
22	F	Text
23	Flow Counter #1	counts
24	Flow Counter #2 (not used)	counts
25	Flow Counter #3	counts
26	Flow Counter #4 (not used)	counts
27	Flow Counter #5 (not used)	counts
28	Flow Counter #6 (not used)	counts
29	Flow Counter #7 (not used)	counts
30	Flow Counter #8 (not used)	counts
31	I	Text
32	Digital Input #1 (not used)	1 or 0
33	Digital Input #2 (not used)	1 or 0
34	Digital Input #3 (not used)	1 or 0
35	Digital Input #4 (not used)	1 or 0

utsg – microTSG, Thermosalinograph

For further information on this data, check www.seabird.com for SBE 45 MicroTSG Thermosalinograph

```
08+037:13:45:57.596   2.6470,  3.03853,  33.8129, 1475.332
```

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

[1]This field usually not logged. Detailed for reference only.

lrtm – digital Remote Temperature

For further information on this data, check on www.seabird.com on SBE38 Digital Thermometer

```
08+037:13:47:17.841  2.2527
```

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

ldfl – Fluorometer, Wetlab ECO

```
08+037:13:55:08.434 99/99/99    99:99:99        0.00    2585    73      543
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Fluorometer Date	mm/dd/yy	text
3	Fluorometer Time	hh:mm:ss	text
4	Chlorophyl Signal	x.xx	µg/l
5	Reference	xxxx	λq
6	Counts – Chlorophyll Signal	xx	counts
7	Thermistor Counts	xxxx	counts

lgo2 – Oxygen System

For further information on this data, please contact Britt Stephens at stephens@ucar.edu

NOTE: Oxygen System was offline for repairs. There was no O2 data for this entire cruise.

```
12+301:22:35:30.558 81300.8 16.0 32.0 000.0 005.0 1.2589631 1.2379622 744.549 111.853 131.642
-2.089 -2.448 723.594 002.50 086.43 099.74 002.77 000.97 050.65 0.000 001.19 065.59 039.48
1966.097 01.345 37.0171 37.8433 000.0 000.0 20.66 20.41 -92.0 28.66 37.44 42.33 37.80 47.95
0.0 01.88 0.0001711 0.0001712 0.0000747 0.0000725 02.657 02.678 -1 0.0000895 -043.94
```

Field	Data
01	RVDAS Time Tag
02	jsecoday - Seconds since midnight
03	jselflag - 8 bit decimal value indicated selected gases
04	jprgflag - 8 bit decimal value indicated purged gases
05	jmfcflag - 8 bit decimal value indicated mass-flow controller states
06	jgenflag - 8 bit decimal value indicated other parameters
07	jfcv1 - voltage on Fuel Cell #1
08	jfcv2 - voltage on Fuel Cell #2
09	jpfcell - pressure in torr at fuel cells
10	jlico2a - CO2 in ppm in Li7000 Cell A
11	jlico2b - CO2 in ppm in Li7000 Cell B [CO2 MEASUREMENT]
12	jlih2oa - H2O in ppt in Li7000 Cell A
13	jlih2ob - H2O in ppt in Li7000 Cell B
14	jlipb - pressure in torr at Li7000 Cell B
15	flmfcset - mass-flow controller set voltage
16	jfll1 - flow in sccm on Inlet Line #1
17	jfll2 - flow in sccm on Inlet Line #2
18	jfllt - flow in sccm on Long-Term reference cylinder
19	jflcal - flow in sccm on selected Calibration cylinder
20	jflwta - flow in sccm on selected Working Tank Cylinder
21	jvsoset - purge line voltage-sensitive orifice set voltage
22	jflpurge - flow in sccm on purge line
23	jflwtb - flow in sccm on Working Tank line through sensors
24	jflsp - flow in sccm on Span line through sensors
25	jpfridge - pressure in torr inside fridge trap
26	jtfridge - temperature in C inside fridge trap
27	jtmpt - fuel-cell control temperature (thermistor) in C for MPT10000
28	jtfcell - fuel-cell thermistor temperature in C
29	jtach1 - rmp of fan inside Line #1 Inlet
30	jtach2 - rmp of fan inside Line #2 Inlet
31	jtcyl1 - temperature in C from cylinder box RTD #1
32	jtcyl2 - temperature in C from cylinder box RTD #2
33	jtchill - temperature in C from chiller RTD
34	jtamb - temperature in C RTD near Analyzer Box electronics
35	jtomega - Analyzer Box control temperature (RTD) for Omega CNi2332
36	jtu4ch - temperature in C inside USB4CH 24-bit A/D box

37	jtfcrtd - fuel-cell RTD temperature in C
38	jtirga - temperature in C inside Li7000
39	jliflags - Li7000 status flag
40	jlirhsrc - Li7000 source/detector relative humidity
41	jsdfcv1 - standard deviation of 1-Hz Fuel Cell #1 voltage
42	jsdfcv2 - standard deviation of 1-Hz Fuel Cell #2 voltage
43	jslfcv1 - slope of 1-Hz Fuel Cell #1 voltage
44	jslfcv2 - slope of 1-Hz Fuel Cell #2 voltage
45	jsdco2a - standard deviation of 1-Hz Li7000 Cell A CO2 in ppm
46	jsdco2b - standard deviation of 1-Hz Li7000 Cell B CO2 in ppm
47	posneg - flag indicating position of fuel-cell changeover valve
48	jogdeltadiff - amplitude of 3-jog O2 difference-signal [O2 MEASUREMENT]
49	O2 concentration in uAtm

loxy – Oxygen (Part of PCO2 system, separate from Oxygen System)

For further information on this data, contact Tim Newberger at ***tim.newberger@noaa.gov***

```
04+117:23:57:23.504 MEASUREMENT         3830     380  Oxygen:           309.95      Saturation:
83.48   Temperature:        -1.35      DPhase:             33.41      BPhase:             32.22      RPhase:
              0.00      BAmp:      262.09      BPot:      163.00      RAmp:        0.00      RawTem.:
694.92
```

Field	Data	Unit
1	RVDAS time tag	UTC
2 - 4	Measurement ID, Model Number, Serial Number	text
5	Oxygen (literal text heading)	text
6	Oxygen reading	Numeric (raw)
7	Saturation (literal text heading)	text
8	Saturation reading	Numeric (raw)
9	Temperature (literal text heading)	text
10	Water Temperature	ºC
11	Dphase (literal text heading)	text
12	D-phase	Numeric (raw)
13	BPhase (literal text heading)	text
14	B-phase	Numeric (raw)
15	RPhase (literal text heading)	V
16	R-phase	Numeric (raw)
17	Bamp (literal textheading)	text
18	B-amplitude	Numeric (raw)
19	Bpot (literal text heading)	text
20	Bpot	Numeric (raw)
21	Ramp (literal text heading)	text
22	R-amplitude	Numeric (raw)
23	RawTem (literal text heading)	Text
24	Raw Temperature	Numeric (raw)

lpco – PCO2 system

For further information on this data, contact Tim Newberger at ***tim.newberger@noaa.gov***

```
02+319:23:59:13.748 2002319.99851    7154.27     26.49    1033.6     325.79      6.74     329.3   53.76
0   Equil
```

Field	Data	Unit
1	RVDAS time tag	UTC
2	Julian date file string	Julian date
3	IR voltage reading	mV
4	Cell temperature	°C
5	Barometer	millibar
6	Gas flow	ml/min
7	VCO2 dry value	PPM
8	PCO2 wet/Delta value	PPM
9	Equilibrator temperature from RTD	°C
10	Equilibrator temperature from SBE-38	°C
11	Solenoid position ID	number
12	Measured gas	text

lsvp - Sound Velocity Probe in ADCP Transducer Well

NOTE: This value does not represent or reflect the sound speed in the ocean, and is for internal use by the ADCP.

```
00+348:01:59:52.128  1536.45
```

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Sound Speed	xxxx.xx	m/s

ladc – ADCP Speed Log

```
00+019:23:59:59.099 $PUHAW,UVH,-1.48,-0.51,250.6
00+019:23:59:59.099 $VDVBW,10.30,0.32,A,,,*2C
```

Field	Data	Unit
1	RVDAS time tag	UTC
2	$PUHAW (used when speedlog derived from the NB150)	text
3	UVH (E-W, N-S, Heading)	text
4	Ship speed over water relative to reference[1] layer velocity[2], East vector	knots
5	Ship speed over water relative to reference[1] layer velocity[2], North vector	knots
6	Ship heading	Degrees (true)

Field	Data	Unit
1	RVDAS time tag	UTC
2	$VDVBW (used when speedlog derived from the OS38)	text
3	Longitudinal water speed (negative means astern)	knots
4	Transverse water speed (negative means to port)	knots
5	Status	A = Data Valid
6	Longitudinal ground speed[3]	knots
7	Transverse ground speed[3]	knots
8	Status[3]	A = Data Valid
9	Checksum	ASCII Hex

[1]The reference layer is an average velocity measured in a number of depth "bins". On the LMG, the bins are typically eight meters deep and bins 3-10 define the reference layer. Hence, the reference layer is the water column from 16-80 meters beneath the ship.

[2]The speed ouput is water velocity relative to the ship's hull and is therefore opposite of the actual movement of the ship. For example, if the ship's heading is due north, the North/South reference layer velocity is likely to be negative (southerly).

[3] The ADCP system only supplies speed over water. These fields are experimental calculations

lgyr - Gyrocompass

02+315:23:59:58.616 $HEHDT,287.7,T*25

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

lsep – Seapath 330 GPS

INZDA: Time and Date Data

10+351:23:59:58.142 $INZDA,235958.08,17,12,2010,,*78

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	$INZDA		
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

INGGA: Global Positioning Fix Data

10+351:23:59:58.142 $INGGA,235958.07,6118.168460,S,06008.089527,W,1,12,0.7,22.57,M,17.79,M,,*46

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	$INGGA		
3	Time	hhmmss.ss	UTC
4	Latitude in degrees with decimal minutes	ddmm.mmmmmm	degrees
5	North or South (for previous)	x	N or S
6	Longitude in degrees with decimal minutes	ddmm.mmmmmm	ddmm.mmmmmm
7	East or West (for previous)	x	E or W
8	GPS quality indicator	x	0 – 6
9	Number of satellites in use (00-99)	xx	00-99
10	Horizontal dilution of precision (HDOP)	x.x	
11	Antenna height	x.xx	meters
12	M = meters (for previous)	X	M
13	Geoidal separation	x.xx	meters
14	M = meters (for previous)	X	M
15	Age of DGPS corrections (null with no DGPS)	x.x	seconds
16	If used, ID of DGPS reference station	Xxxx	0000 - 1023

INRMC: Recommended Minimum Specific GNSS Data

10+351:23:59:58.200 $INRMC,235958.07,A,6118.168460,S,06008.089527,W,12.8,331.22,171210,11.3,E,A*1C

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	$INRMC		
3	Time	hhmmss.sss	UTC
4	Status A=valid data, N=receiver warning	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

INVTG: Speed Over Ground, Course Over Ground

14+025:23:59:59.100 $INVTG,32.69,T,,M,10.6,N,19.6,K,A*1A

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

PSXN,20: Data Quality

10+351:23:59:58.200 $PSXN,20,1,2,0,0*38

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

Quality flags: 0 = normal, 1 = reduced performance, 2 = invalid data

PSXN,23: Roll, Pitch, Heading and Heave

10+351:23:59:58.213 $PSXN,23,0.02,-0.76,330.56,*0B

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

lgar - Garmin GPS

RMC: Recommended Minimum for Navigation

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

GGA: Global Positioning Fix Data

08+034:12:26:06.131 $GPGGA,122607,6446.4733,S,06403.4455,W,1,11,0.9,-193.4,M,9.7,M,,*5A

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	$GPGGA		
3	Time	hhmmss.ss	UTC
4	Latitude in degrees with decimal minutes	ddmm.mmmmmm	degrees
5	North or South (for previous)	x	N or S
6	Longitude in degrees with decimal minutes	ddmm.mmmmmm	ddmm.mmmmmm
7	East or West (for previous)	x	E or W
8	GPS quality indicator	x	0 – 6
9	Number of satellites in use (00-99)	xx	00-99
10	Horizontal dilution of precision (HDOP)	x.x	
11	Antenna height	x.xx	meters
12	M = meters (for previous)	X	M
13	Geoidal separation	x.xx	meters
14	M = meters (for previous)	X	M
15	Age of DGPS corrections (null with no DGPS)	x.x	seconds
16	If used, ID of DGPS reference station	Xxxx	0000 - 1023

VTG: Track Made Good and Speed over Ground

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

GNS: Global Positioning Fix Data

16+148:00:00:01.835 $GPGNS,000001,6451.3766,S,06352.1432,W,AA,21,0.5,33.0,M,12.7,M,,*50

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	$GPGNS		
3	Time	hhmmss.ss	UTC
4	Latitude in degrees with decimal minutes	ddmm.mmmmmm	degrees
5	North or South (for previous)	x	N or S
6	Longitude in degrees with decimal minutes	ddmm.mmmmmm	ddmm.mmmmmm
7	East or West (for previous)	x	E or W
8	Mode indicator*	x[x]	N, A, D, P
9	Number of satellites in use (00-99)	xx	00-99
10	Horizontal dilution of precision (HDOP)	x.x	
11	Antenna height	x.xx	meters
12	M = meters (for previous)	X	M
13	Geoidal separation	x.xx	meters
14	M = meters (for previous)	X	M
15	Age of DGPS corrections (null with no DGPS)	x.x	seconds
16	If used, ID of DGPS reference station	xxxx	0000 - 1023
17	Checksum	xx	alphanumeric

*** Mode Indicator:** One character indicator per constellation tracked. First character for GPS, second (optional) for GLONASS

A = Autonomous, N = No fix, D = Differential, P = Precise

lais – AIS receiver

AIVDM: AIS Data

14+070:00:02:38.575 !AIVDM,1,1,,B,15O5G4000oKPfggK2F2RQj7>0@FU,0*04

Field	Data	Format
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss
2	!AIVDM	text
3	Total number of sentences needed to transfer message	(1-9)
4	Message sentence number	(1-9)
5	Sequential identifier to link multiple messages	(0-9 or null)
6	AIS channel	A or B
7	Encapsulated Binary Coded Data[1]	ASCII text
8	Number of fill bits	(0-5)
9	*Checksum	hexadecimal

[1]Data is encoded as described in ITU-R M.1371

LMG Sensors

Shipboard Sensors

Sensor	Description	Serial #	Cal. Date	Status
Port Anemometer	Gill Ultrasonic Wind Observer II	1246001-WC45	N/A	Collected
Starboard Anemometer	Gill Ultrasonic Wind Observer II	1246002-WC45	N/A	Collected
Barometer	Vaisala PTB210B	K284002	10-July-2014	Collected
Humidity/Wet Temp	Rotronic HygroClip HC2-S3	20090149	09-Aug-2016	Collected
PAR for Mast	Biosph. Inst. QSR-240P	6393	5-June-2017	Collected
PIR	Eppley PIR	28903F3	14-Dec-2016	Collected
PSP	Eppley PSP	28933F3	16-Dec-2016	Collected
GUV (Mast)	Biosph. Inst. GUV-2511	25110805127	15-Feb-2017	Collected
Transmissometer	WET Labs C-Star 25 cm deep	CST-406DR	09-Dec-2016	Collected
MicroTSG (Primary)	Sea-Bird 45	390	22-Jul-2017	Collected except d108
MicroTSG (Primary)	Sea-Bird 45	243	28-Dec-2016	Collected d108
MicroTSG (Secondary)	Sea-Bird 45	200	17-Dec-2016	Collected
Digital Remote Temp	Sea-Bird 38	324	15-Jul-2016	Collected
Fluorometer	WET Labs ECO-FL	FLRTD-1735	16-May-2017	Collected

Underway Calibration Sheets

Anemometer- Port

WindObserver II™
Product Test Report

Product Tested: WindObserver II
Part Number: 1390-70-B-322
Serial Number: 1246001 - WC45
Test Data: 15/11/2012
Location: Gill Instruments Ltd

GILL ensures that quality is inherent in all aspects of the activities and ensures that compliance with BS EN ISO9001: 2008 is maintained.

This report certifies that the above instrument has been tested in accordance with Gill internal procedures

Results

Test	Limits	Passed
Still Air Test (Zero Wind Speed)	< 0.02m/s	Pass
Wind Tunnel Test (12 m/s nominal)	Pass/Fail	Pass

Generic calibration is traceable to the University of Southampton wind tunnel and instrumentation is maintained in accordance with UKAS.

All tests have been successfully completed

On behalf of Gill Instruments Ltd

Tony Raine
Quality Control

2002-0395 Issue 1

Gill Instruments Ltd
Solent Park
57 Gosport Street
Lymington
Hampshire
SO41 9BG, UK

www.gill.co.uk

ISO 9001 Registered

Anemometer-Starboard

WindObserver II™

Product Test Report

Product Tested: WindObserver II
Part Number: 1390-70-B-322
Serial Number: 1246002 - WC45
Test Date: 15/11/2012
Location: Gill Instruments Ltd

GILL ensures that quality is inherent in all aspects of the activities and ensures that compliance with BS EN ISO9001: 2008 is maintained.

This report certifies that the above instrument has been tested in accordance with Gill internal procedures

Results

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All tests have been successfully completed

On behalf of Gill Instruments Ltd

Tony Raine
Quality Control

2002-0395 Issue 1

Gill Instruments Ltd
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F: +44 (0) 1590 613 565
E: [illegible]
www.gill.co.uk

ISO 9001 Registered

Barometer

VAISALA

1 (1)
Certificate report no. H44-14280027

CALIBRATION CERTIFICATE

Instrument	PTB210B Digital Barometer
Serial number	K2840002
Manufacturer	Vaisala Oyj, Finland
Calibration date	10th July 2014

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
1090.0	1090.0	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	476	2014-05-27	K008-X01113

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

Ambient Conditions

Humidity	34 %RH ± 5 %RH
Temperature	23 °C ± 1 °C
Pressure	1019 hPa ± 1 hPa

Technician

Vaisala Oyj | PO Box 26, FI-00421 Helsinki, Finland
Phone +358 9 894 91 | Fax +358 9 8949 2227
Email firstname.surname@vaisala.com | www.vaisala.com
Domicile Vantaa, Finland | VAT FI01244.52 | Business ID 0122416-2

Air Temperature / Relative Humidity

rotronic
LEADING IN HUMIDITY MEASUREMENT

Certificate of Conformance

Rotronic Instrument Corp certifies that the following product(s) meet their published specifications. Calibrations are carried out using instruments and standards traceable to the National Institute of Standards and Technology (NIST).

Traceable Standards:

Humidity reference: RH Systems / MBW, model number 973, s/n 06-0808

Temperature reference: Hart Thermometer, model number 1529-R, s/n A38490 PRT Model 5614, s/n 640981

Download Product Manuals From:
http://www.rotronic-usa.com/

By: Gary Boney Date: 9/8/2016

Product Name	Serial Number	TAG	Your P.O.	WO Nbr	Processed Date
HC2-S3 Pbe	20090149	0000000	4102683190	83031	9/8/2016
HC2-S3 Pbe	20090287	0000000	4102683190	83031	9/8/2016

Item Total: 2

NOTE:
This document lists only the serialized items included in this shipment
See the packing list for a complete list of shipped items
Please retain this document in your records for warranty purposes

PAR for mast

Biospherical Instruments Inc.

CALIBRATION CERTIFICATE

Calibration Date	6/5/2017			
Model Number	QSR240			
Serial Number	6393			
Operator	TPC			
Standard Lamp	91453(7/20/16)			
Probe Excitation Voltage Range:		6	to 18	VDC(+)
Output Polarity:	POSITIVE			

Probe Conditions at Calibration (in air):

Calibration Voltage:	6	VDC(+)
Probe Current	1.3	mA

Probe Output Voltage:

Probe Illuminated	85.2	mV
Probe Dark	0.3	mV
Probe Net Response	84.9	mV
RG780	0.4	mV

Corrected Lamp Output:

Output In Air (same condition as calibration):

8.379E+15	quanta/cm²sec
0.013914	uE/cm²sec

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

Dry:	1.0132E-17	V/(quanta/cm²sec)
	6.1014E+00	V/(uE/cm²sec)

Notes:
1. Annual calibration is recommended.
2. Calibration is performed using a Standard of Spectral Irradiance traceable to the National Institute of Standards and Technology (NIST).
3. The collector should be cleaned frequently with alcohol.
4. Calibration was performed with customer cable, when available.

QSR240R 05/24/95

PIR

EPLAB

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 28903F3
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 22°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: $S = 3.58\ \mu V / Wm^{-2}$** Uncertainty: $U_{95} = \pm 1.7\%$ (95% confidence level, k=2) Resistance: 675 Ω at 23°C
	Date of Test: December 14, 2016
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:	Leidos / NSF Port Hueneme, CA
Signatures:	In Charge of Test: Reviewed by:
Eppley SO	64857
Date of Certificate	December 16, 2016
Remarks:	

End of Report

PSP

EPLAB

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 28933F3
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 = 7.48 µV / Wm^{-2}** Uncertainty: U_{95} = ±0.91% (95% confidence level, k=2) Resistance: 686 Ω at 23°C
	Date of Test: December 16, 2016
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:	Leidos Innovations Corp / NSF Port Hueneme, CA
Signatures:	In Charge of Test: Reviewed by:
Eppley SO:	64856
Date of Certificate	December 16, 2016
Remarks:	Instrument Sensing Element repainted. "As Found" calibration was 8.09 µV/Wm^{-2}.

End of Report

GUV

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 25110805127

Optical Calibrations:

NIST Traceability. For wavelengths longer than 313 nm, the specific instruments cited here were calibrated using a 1000W FEL #V-039 (7/20/16) 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 ±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 **25110805127v8.mdb**. This database is required for operation of this system using Biospherical Instruments Inc.'s Logger® software.

Transmissometer

PO Box 518
620 Applegate St.
Philomath, OR 97370

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

C-Star Calibration

Date 12.19.16 S/N# CST-406DR Pathlength 25 cm

	Analog output
V_d	0.058 V
V_{air}	4.779 V
V_{ref}	4.677 V

Temperature of calibration water	21.3 °C
Ambient temperature during calibration	21.5 °C

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

To determine beam transmittance: $Tr = (V_{sig} - V_{dark}) / (V_{ref} - V_{dark})$

To determine beam attenuation coefficient: $c = -1/x * \ln (Tr)$

V_d Meter output with the beam blocked. This is the offset.
V_{air} Meter output in air with a clear beam path.
V_{ref} Meter output with clean water in the path.
Temperature of calibration water: temperature of clean water used to obtain V_{ref}.
Ambient temperature: meter temperature in air during the calibration.
V_{sig} Measured signal output of meter.

Revision M 7/26/11

Thermosalinograph (Temperature) – Primary (except d108)

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

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

SENSOR SERIAL NUMBER: 0390
CALIBRATION DATE: 22-Jul-17

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

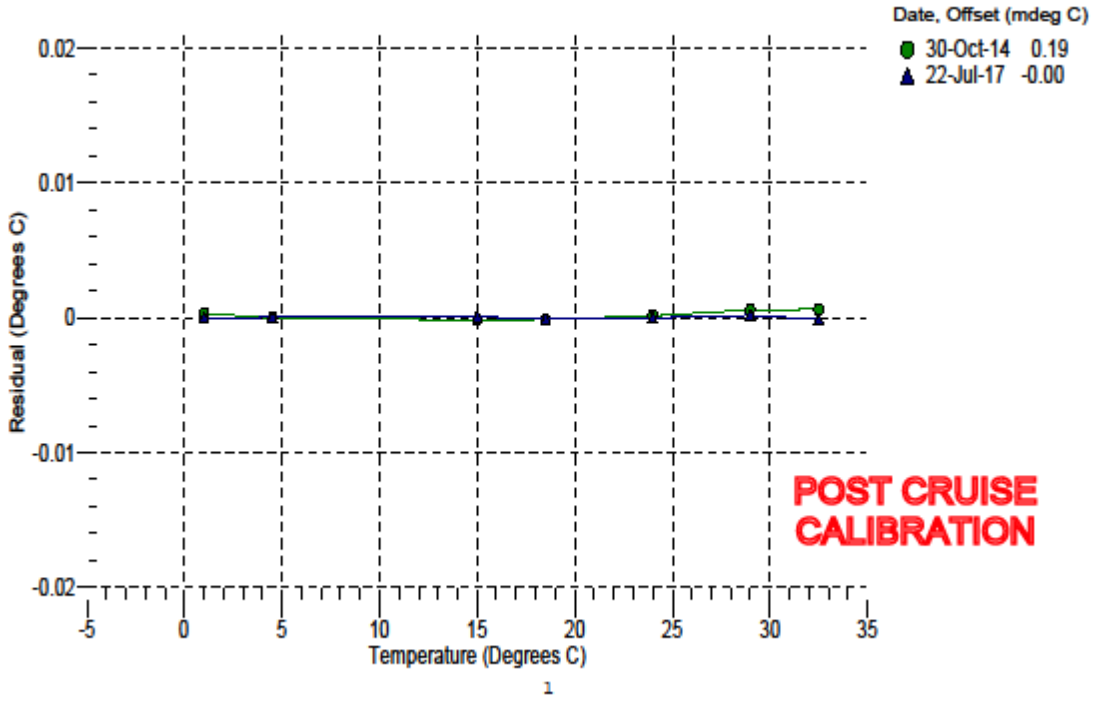
a0 = 3.694979e-005
a1 = 2.756447e-004
a2 = -2.529366e-006
a3 = 1.538609e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	662316.8	1.0000	-0.0000
4.5000	565261.0	4.5000	0.0000
15.0000	358386.1	15.0001	0.0001
18.5000	309815.9	18.4999	-0.0001
23.9999	247918.0	23.9999	-0.0000
29.0000	203686.4	29.0002	0.0002
32.4998	178106.7	32.4997	-0.0001

n = Instrument Output (counts)

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

Residual (°C) = instrument temperature - bath temperature



1

Thermosalinograph (Conductivity) – Primary (except d108)

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

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

SENSOR SERIAL NUMBER: 0390
CALIBRATION DATE: 22-Jul-17

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

COEFFICIENTS:

```
g = -9.865104e-001
h =  1.453645e-001
i = -4.020137e-004
j =  5.158129e-005

CPcor = -9.5700e-008
CTcor =  3.2500e-006
WBOTC =  2.8724e-007
```

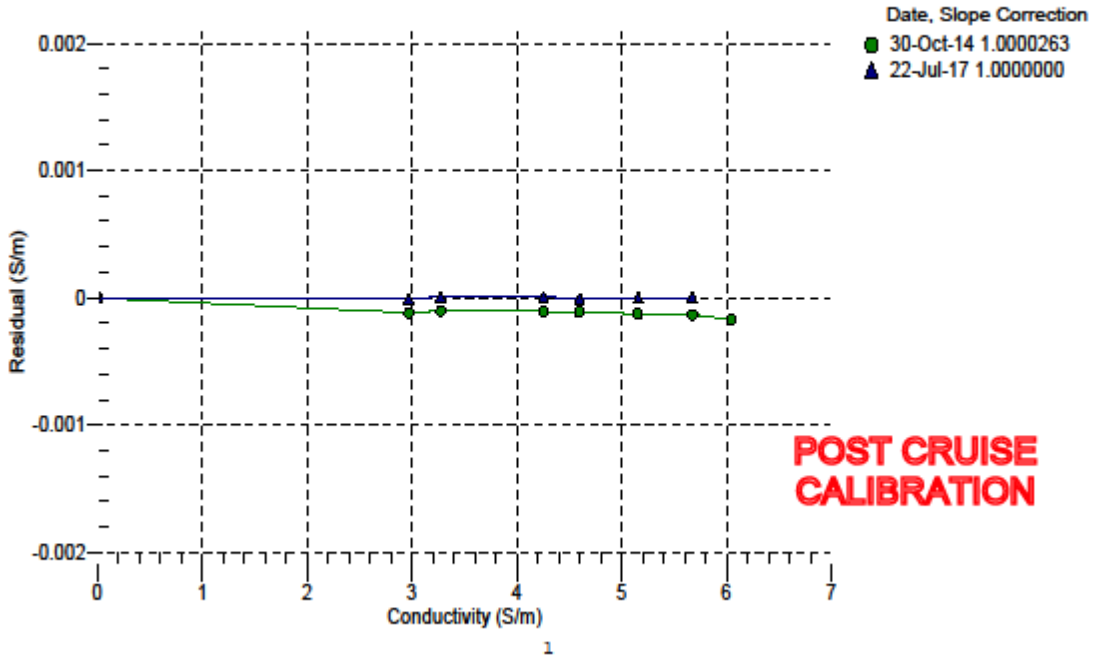
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2611.35	0.00000	0.00000
1.0000	34.7103	2.96777	5228.06	2.96776	-0.00001
4.5000	34.6910	3.27407	5426.25	3.27407	0.00001
15.0000	34.6491	4.25327	6015.35	4.25327	0.00001
18.5000	34.6403	4.59753	6208.89	4.59753	-0.00001
23.9999	34.6306	5.15404	6509.27	5.15403	-0.00000
29.0000	34.6248	5.67447	6777.77	5.67448	0.00000
32.4998	34.6147	6.04478	6962.34	6.04487	0.00010

f = Instrument Output(Hz) * sqrt(1.0 + WBOTC * t) / 1000.0

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

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

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



1

Thermosalinograph (Conductivity) – Primary (d108)

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

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

SENSOR SERIAL NUMBER: 0243
CALIBRATION DATE: 17-Sep-17

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

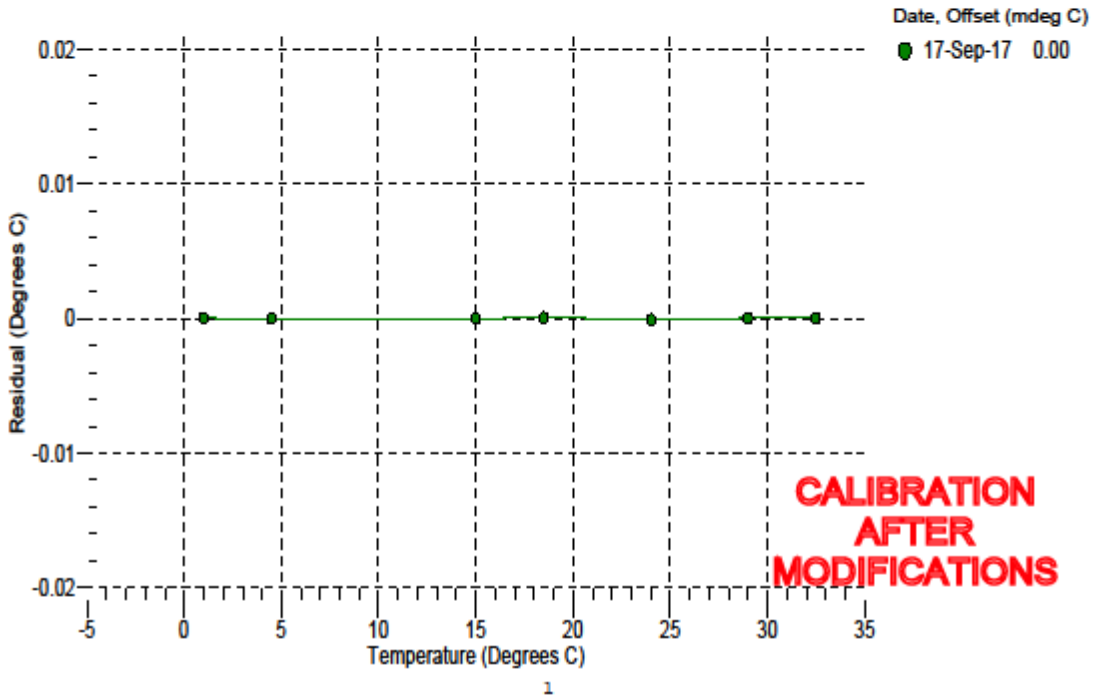
a0 = -4.571030e-005
a1 = 2.798142e-004
a2 = -2.692756e-006
a3 = 1.596861e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	764201.6	1.0000	0.0000
4.5000	653623.5	4.5000	-0.0000
15.0000	416964.5	15.0000	-0.0000
18.5000	361155.9	18.5001	0.0001
24.0000	289864.9	23.9999	-0.0001
29.0000	238774.4	29.0000	0.0000
32.5000	209156.3	32.5000	0.0000

n = Instrument Output (counts)

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

Residual (°C) = instrument temperature - bath temperature



1

Thermosalinograph (Conductivity) – Primary (d108)

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

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

SENSOR SERIAL NUMBER: 0243
CALIBRATION DATE: 17-Sep-17

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

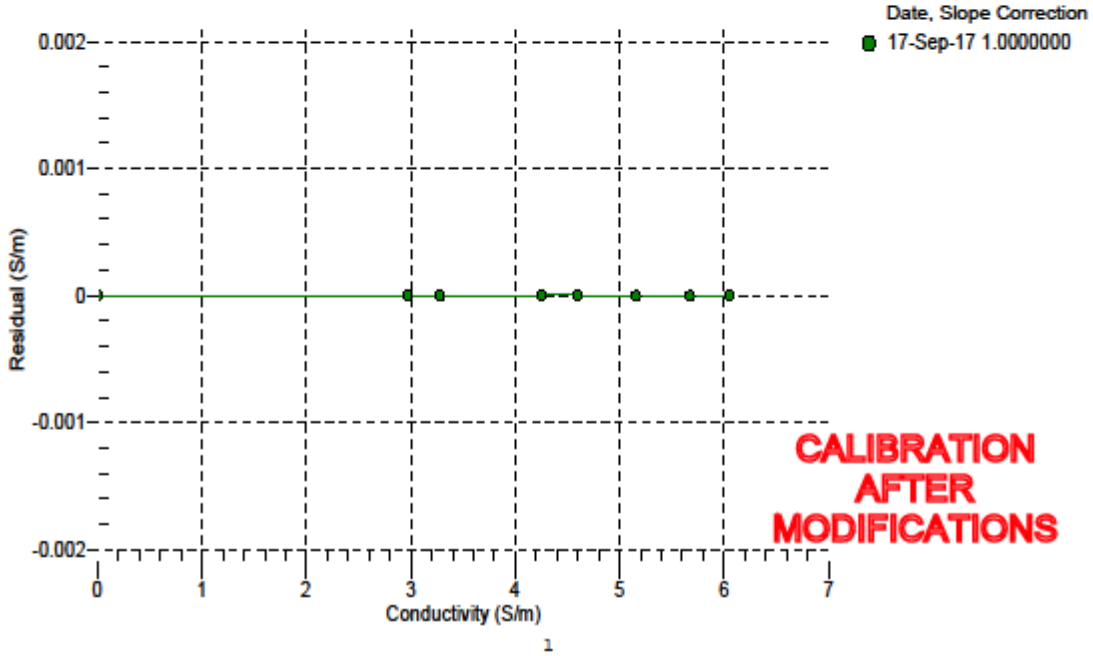
COEFFICIENTS:

```
g = -1.013036e+000
h =  1.582180e-001
i = -4.131859e-004
j =  5.965159e-005

CPcor = -9.5700e-008
CTcor =  3.2500e-006
WBOTC =  1.1173e-006
```

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	2535.67	0.00000	0.00000
1.0000	34.7102	2.96776	5025.06	2.96776	0.00000
4.5000	34.6909	3.27406	5214.19	3.27405	-0.00000
15.0000	34.6495	4.25331	5776.65	4.25331	0.00000
18.5000	34.6409	4.59761	5961.51	4.59761	0.00000
24.0000	34.6316	5.15418	6248.45	5.15418	-0.00000
29.0000	34.6267	5.67475	6505.01	5.67475	-0.00000
32.5000	34.6243	6.04628	6681.89	6.04629	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) = $(g + h * f^2 + i * f^3 + j * f^4) / (1 + \delta * t + \varepsilon * p)$
Residual (Siemens/meter) = instrument conductivity - bath conductivity



1

Thermosalinograph (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: 0200
CALIBRATION DATE: 17-Dec-16

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

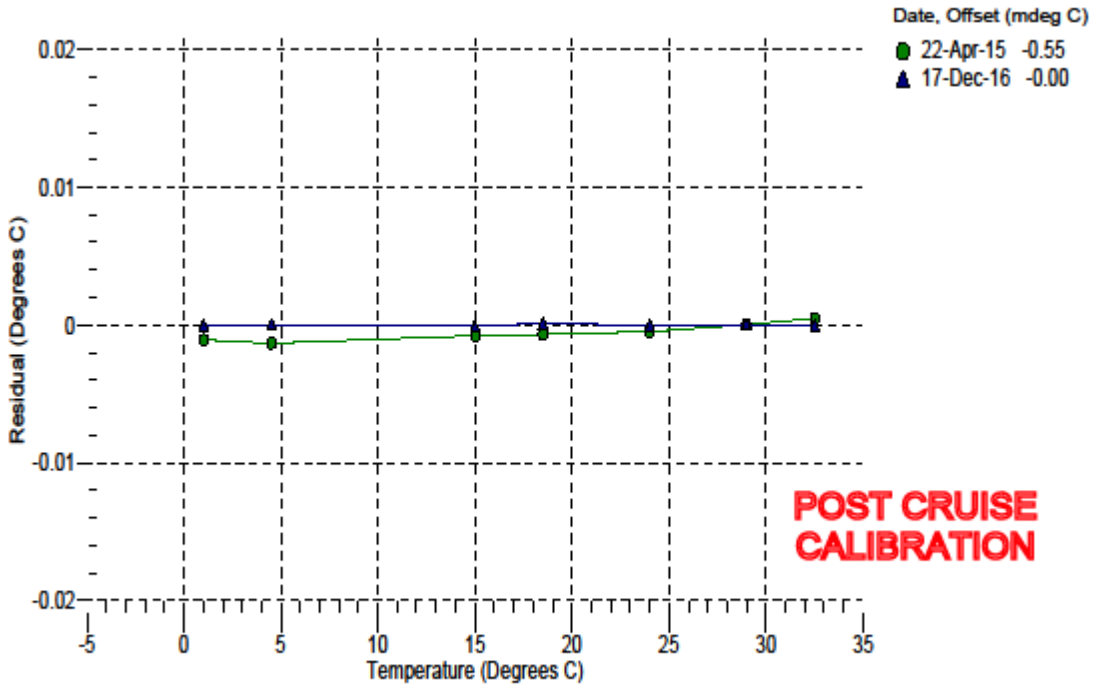
a0 = -2.129663e-005
a1 = 2.777475e-004
a2 = -2.541932e-006
a3 = 1.613532e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	694961.7	1.0000	-0.0000
4.5000	595076.2	4.5000	0.0000
15.0000	380820.7	14.9999	-0.0001
18.5000	330170.2	18.5001	0.0001
24.0000	265382.7	24.0000	-0.0000
29.0000	218881.8	29.0000	0.0000
32.5000	191891.6	32.5000	-0.0000

n = Instrument Output (counts)

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

Residual (°C) = instrument temperature - bath temperature



Thermosalinograph (Conductivity) – 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: 0200
CALIBRATION DATE: 17-Dec-16

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

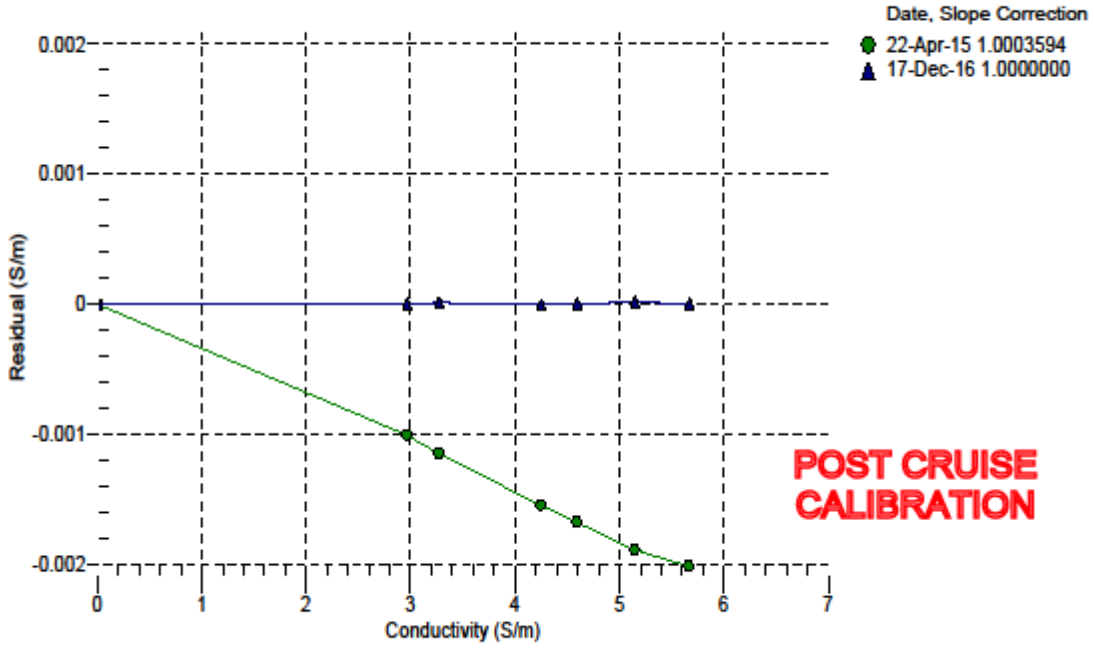
COEFFICIENTS:

g = -1.018756e+000
h = 1.333639e-001
i = -1.281211e-004
j = 2.752051e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006
WBOTC = -1.0877e-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	2765.68	0.00000	0.00000
1.0000	34.6838	2.96572	5463.51	2.96571	-0.00000
4.5000	34.6637	3.27174	5668.80	3.27175	0.00001
15.0000	34.6217	4.25026	6279.61	4.25025	-0.00001
18.5000	34.6127	4.59427	6480.44	4.59426	-0.00000
24.0000	34.6029	5.15038	6792.27	5.15039	0.00001
29.0000	34.5975	5.67050	7071.18	5.67050	-0.00000
32.5000	34.5940	6.04159	7263.43	6.04154	-0.00006

f = Instrument Output(Hz) * sqrt(1.0 + WBOTC * t) / 1000.0
t = temperature (°C); p = pressure (decibars); δ = CTcor; ε = CPcor;
Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / 10 (1 + \delta * t + \varepsilon * p)$
Residual (Siemens/meter) = instrument conductivity - bath conductivity



Digital Remote 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: 0324
CALIBRATION DATE: 15-Jul-16

SBE 38 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

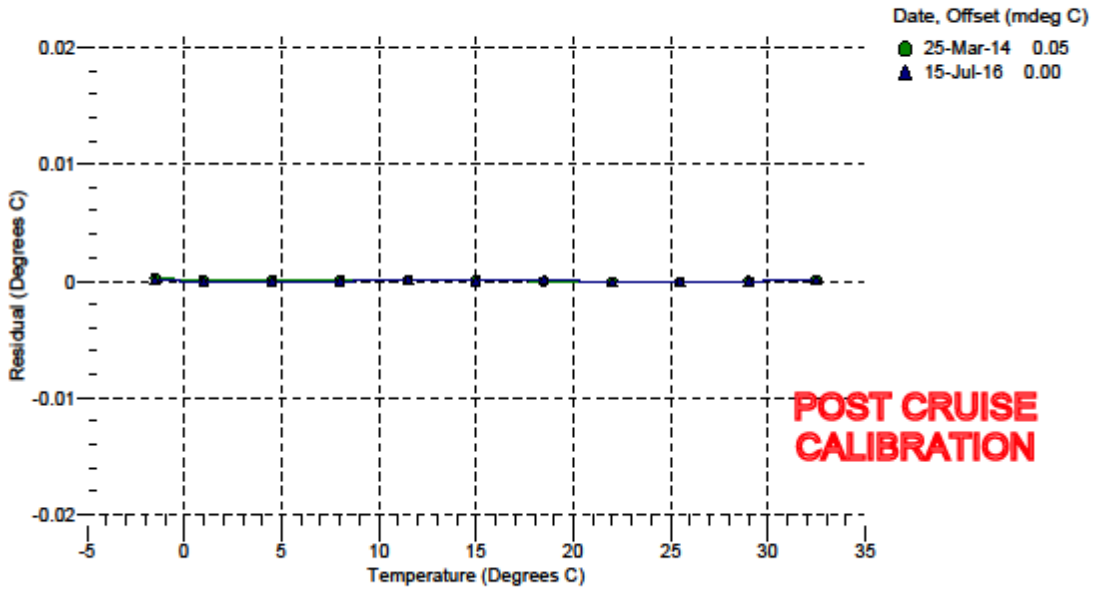
a0 = -3.124125e-005
a1 = 2.779406e-004
a2 = -2.664781e-006
a3 = 1.568583e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
-1.5001	895410.9	-1.5000	0.0001
1.0000	798437.2	0.9999	-0.0001
4.5000	682047.6	4.4999	-0.0001
8.0000	584561.4	8.0000	-0.0000
11.4999	502627.6	11.5000	0.0001
15.0000	433532.9	15.0000	0.0000
18.4999	375078.0	18.5000	0.0001
22.0000	325465.9	21.9999	-0.0001
25.5000	283228.4	25.4999	-0.0001
29.0000	247161.7	29.0000	-0.0000
32.5000	216274.4	32.5001	0.0001

n = Instrument Output (counts)

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

Residual (°C) = instrument temperature - bath temperature



Fluorometer

PO Box 518
620 Applegate St.
Philomath, OR 97370

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

ECO Chlorophyll Fluorometer Characterization Sheet

Date: 5/16/2017 S/N: FLRTD-1735

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

CHL (µg/l) = Scale Factor * (Output - Dark Counts)

	Analog Range 1	Analog Range 2	Analog Range 4 (default)		Digital
Dark Counts	0.055	0.025	0.010	V	49 counts
Scale Factor (SF)	6	12	24	µg/l/V	0.0073 µg/l/count
Maximum Output	4.99	4.99	4.99	V	16380 counts
Resolution	0.4	0.4	0.4	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 ÷ (output - 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-1735 Revision J 3/17/08

Acquisition and Processing Information

Errors and Events

Day Of Year	Time (GMT)	Event	Location
104	0139	RVDAS ON	68W
		O2 system not working	
104	0150	Restart Sound Velocity Probe	
104	2018	ADCP Bottom Tracking Off	Leaving continental shelf
105	1639	Deploy Drifter Buoy	59S
106	1224	ADCP Bottom Tracking On	Arriving at Antarctic shelf
107	1604	Underway systems off	Arriving at Palmer Station
108		Removed TSG s/n 390, replaced with TSG s/n 243	
108		Cleaned transmissometer	
108	1429	Underway systems on	Leaving Palmer Station
109	1204	Underway systems off	Arriving at Palmer Station
109		Removed TSG s/n 243, replaced with TSG s/n 390	
109	1912	Underway systems on	Leaving Palmer Station
110	0231	ADCP failed	
110	0740	Knudsen lost comms	
110	1105	Knudsen up	
110	1308	ADCP up, logging as cruise LMG1804b	
112	1204	Underway systems off	Arriving at Palmer Station
113		Cleaned transmissometer, fluorometer, TSGs	
117	1224	Underway systems on	Leaving Palmer Station
118	0121	Knudsen lost comms	
118	0254	Restart Knudsen logging	
118	0427	ADCP starts having comms issues, data is intermittent	
118	0900	Knudsen lost comms	
118	0945	Restart Knudsen logging	
118	2013	Switch to backup ADCP computer, logging as cruise LMG1804c	
119		ADCP up	
120	1213	Seawater pump off	Arriving Palmer Station Area
120	1250	Seawater pump on	Leaving Palmer Station Area
121	1215	Knudsen off for troubleshooting	
121	1953	Knudsen on	
122	1212	Underway systems off	Arriving at Palmer Station
122	1325	GUV off	
122	1345	GUV on	
124	1326	Underway systems on	Leaving Palmer Station
124	1802	Switched ADCP to primary computer, logging as LMG1804d	
127	1827	Seawater pump off	Arriving Palmer Station Area
127	1842	Seawater pump on	Leaving Palmer Station Area
128	0438	SVP off	
128	0757	Restarted SVP	
128	1137	Underway systems off	Arriving at Palmer Station
129	1325	Underway systems on	Leaving Palmer Station

130	1923	ADCP Bottom Tracking off	Leaving Antarctic Shelf
131	0739	Drifter Northbound	60S
131	1329	Air Sample Northbound	59S
132	1112	ADCP Bottom Tracking on	Arriving continental shelf
133	1700	DAS to in port mode. Data collection stopped. PCO2, ADCP, Knudsen Off.	68W

Note that the O2 system was off for the duration of the cruise