LMG 1504

Cruise Data Report

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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 format of that data and its location on the distribution CDs or DVDs. It also contains important information that may affect how this data is processed such as instrument failures or other known problems with acquisition.

All of the data has been archived with the Unix "tar" command and/or compressed using Unix "gzip" compression. Tar files have a ".tar" extension and Gzipped files have a ".gz" extension. Tools are available on all platforms for uncompressing and de-archiving these formats. On Macintosh, Stuffit Expander with DropStuff will open a tar archive and uncompress gzipped and Unix compressed files. For Windows, WinZip, a shareware utility included on this CD (remember, it is shareware) will open these files.

In some cases to adhere to the ISO9660 format the .tar extension was removed. When we tarred the files then gzip the tar archive the name of the file became *File*.tgz. This name does not follow the 8.3 naming convention of the ISO9660 format. On Windows and Mac Platforms Winzip and Stuffit Expander handles this just fine. When they expand the *File*.gz the expanded file becomes *File*.tar, which both software packages can handle. On Unix platforms gunzip expands *File*.tgz but it does not append the .tar extension. So you may not recognize the file as a tar archive, but OS does recognize it as a tar archive. If you use the file command it will return saying it is a tar file. The below tar command will un-archive the file just fine.

IMPORTANT: Read the last section in this document, 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

/ADCP/

This directory contains a tar file of gentoo's proc directory, which contains a database of the averaged ping data, Matlab m-files used in processing the data, and daily graphs of the currents. For more information contact Teri Chereskin at tchereskin@ucsd.edu .

Calibration

/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.

Logsheets

/logsheet/

This directory contains scanned paper log sheets in PDF format for various science of opportunity or projects or cruise related science, including such things as XBT's, XCTD's, air sample log sheets, oxygen system maintenance logs, etc.

Maps

/Maps/

This directory maps and mapping data generated by the ship's MCIS and automated scripts, usually in JPEG or PostScript format, plus any maps provided for this purpose by the on-board science party.

Ocean (CTD, XBT and XCTD)

/Ocean/XBT

Contains a zip archive of XBT data generated for the Drake Transect by NOAA standard "AMVERSEAS" software. Non-Drake transect data may also be included, which will a combination of binary and ascii files generated by standard Sippican MK-21 software.

/Ocean/XCTD

Expendable Conductivity, Temperature, and Depth (XCTD) digital probes were used to obtain water column temperature and Salinity profiles. The two files were created for each drop .RDF files contain the raw data, and the .EDF contain the exported ascii data.

/Ocean/CTD

This directory contains the directory structure copied over from the CTD computer, and includes subdirectories for graphs, software configuration files, processing scripts, calibration files, raw data, and processed data.

Data and Science Report

/Report/

Copies of this report in MS Word and pdf formats.

Science

/Science/

This directory, if populated, contains data specified by the on-board science party.

WAYPOINTS

/waypoint/

Contains the waypoint file used for the cruise; this is read by the DAS system and the selected waypoint is displayed on the CCTV system.

QC Plots

/process/QC_PLOTS/

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.

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	PCOD latitude (negative is South)	Ddd.dddd
04	PCOD longitude (negative is West)	Ddd.dddd
05	Ships speed	Knots
06	GPS HDOP	-
07	Gyro Heading	Degrees (azimuth)
08	Course over ground	Degrees (azimuth)
09	Mast PAR	μEinsteins/meters^2 sec
10	Sea surface temperature	°C
11	Not used	-
12	Sea surface salinity	PSU
13	Sea depth (uncorrected, calc. sw sound vel. 1500 m/s)	meters
14	True wind speed (port windbird)	meters/sec
15	True wind direction (port windbird)	degrees (azimuth)
16	Ambient air temperature	°C
17	Relative humidity	%
18	Barometric pressure	mBars
19	Sea surface fluorometry	μg/l
20	Transmissometer	Volts (0-5)
21	PSP	W/m^2
22	PIR	W/m^2

pCO2-merged Data Set

/Process/PCO2/

```
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	Units
1	RVDAS time tag	
2	pCO_2 time tag (decimal is fractional time of day)	yyyyddd.ttt
3	Raw voltage (IR)	mV
4	Cell temperature	°C
5	Barometer	MBar
6	Flow rate	ml / min
7	Concentration	ppm
8	pCO_2 pressure	microAtm
9	Equilibrated temperature	°C
10	Sea Water Temp	1 or 2 digits
11	Valve position	°C
12	Flow source (Equil = pCO_2 measurement)	text
13	RVDAS latitude	degrees
14	RVDAS longitude	degrees
15	TSG external temperature	°C
16	TSG 1 salinity	PSU
17	Fluorometer	V
18	RVDAS true wind speed	m/s
19	RVDAS true wind direction	degrees
20	Barometric Pressure	mBars
21	Uncontaminated seawater pump flow rate	l/min
22	Speed over ground	knots
23	Course made good	degrees
24	Oxygen	µM
25	TSG 2 internal temperature	°C
26	TSG 2 salinity	PSU
27	TSG 1 internal temperature	°C
28	H2O Input Source	-1 stern thrustor 0 moonpool

RVDAS

/RVDAS/

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

Below you will find detailed information on the data included. Be sure to read the "Significant Acquisition Events" section below for important information about data acquisition during this cruise.

Meteorological Data

Measurement	File ID	Collect. Status	Rate	Instrument
Air Temperature	lmwx	continuous	1 sec	R. M. young 41372VC
Relative Humidity	lmwx	continuous	1 sec	R. M. young 41372VC
Wind Speed/Direction	lmwx	continuous	1 sec	Gill Ultrasonic
PAR, (Photosynthetically-Available Radiation)	lmwx	continuous	1 sec	BSI QSR-240
Barometer	lmwx	continuous	1 sec	R. M. young 61201
Port Ultrasonic Wind Speed/Direction	lmwx	continuous	1 sec	Gill Wind Observer II
PIR (LW radiation)	lmwx	continuous	1 sec	Eppley PIR
PSP (SW radiation)	lmwx	continuous	1 sec	Eppley PSP
Oxygen	lgo2	continuous	1 min	UCAR Oxygen system

Navigational Data

Measurement	File ID	Collect. Status	Rate	Instrument
Gyro	lgyr	continuous	0.2 sec	Meridian Bridgemate Gyro
Garmin GPS	lgar	continuous	1 sec	Garmin 17
Seapath GPS	lsep	Continuous	1 sec	Seapath 330

Geophysical Data

Measurement	File ID	Collect. Status	Rate	Instrument
Bathymetry	lknu	variable	Varies	Knudsen Chirp 3260
DUSH 11 Winch	lwn1	variable	varies	Markey DUSH 11
DUSH 5 Winch	lwn1	variable	varies	Markey DUSH 5
DUSH 4 Winch	lwn1	variable	varies	Markey DUSH 4
COM10 Winch	lwn1	variable	varies	Markey COM10

Oceanographic Data

Measurement	File ID	Collect. Status	Rate	Instrument
Salinity	utsg	continuous	3 sec	SeaBird 45
Salinity	tsg2	continuous	3 sec	SeaBird 45
Sea Surface Temperature	lrtm	continuous	1 sec	SeaBird 38
Fluorometry (digital)	ldfl	continuous	1 sec	Wetlab ECO
ADCP, Speed Log	ladc	continuous	1 sec	RD Instruments
Oxygen	loxy	continuous	1 sec	
PCO2	lpco2	continuous	2.5 min	

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 everyday 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**
Meteorological - Cambell	lmwx
Knudsen	lknu
microTSG	utsg
Digital Remote Temperature	lrtm
Fluorometer – Wetlab ECO	ldfl
ADCP	ladc
Sound Velocity Probe	lsvp
GUV & PUV	lguv
PCO2 System	lpco
Oxygen	loxy
Wet Wall Flows	lsea
Winches: Dush4,5,&11	lwn1
Net Depth Sensor	lnds

Navigation Data	**File ID**
Gyro Compass	lgyr
Garmin 17 GPS	lgar
Seapath 330 GPS	lsep
AIS	lais

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. An example data

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	Units
1	RVDAS Time Tag	
2	3.5kHz – low frequency header	
3	LF - depth to surface	meters
4	LF – Depth Valid Flag	
5	12.0kHz – high frequency header	
6	HF - depth to surface	meters
7	HF – Depth Valid Flag	
8	Sound speed velocity	m/s
9	Latitude	Dec degrees
10	Longitude	Dec degrees

lwn1 - Winches

```
08+033:11:27:50.673 RD,DUSH-5,00111.63,00000000,-0000012,1938
```

Field	Data	Units
1	RVDAS Time Tag	
2	Record Identifier, RD=Remote Data	
3	Winch Indentifier, DUSH-X where X is 4, 5, or 11	
4	Tension	lbs
5	Speed	Meters/minute
6	Payout	meters
7	Checksum	

lmwx – Campbell Meteorological DAS

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

Field	Data	Units
1	RVDAS Time Tag	
2	PUS tag – Port UltraSonic Anemometer	
3	Unit Identification, A-Z	
4	Port Wind Direction, degrees relative to Bow	deg
5	Port Wind Speed	m/s
6	Units, M=meters per second	
7	Sound Speed	m/s
8	Sonic Temperature	°C
9	Status, 0=ok, 60=Heating Enabled & ok, Other value mean a fault	
10	Check Sum	

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

Field	Data	Units
1	RVDAS Time Tag	
2	SUS tag – Starboard UltraSonic Anemometer	
3	Unit Identification, A-Z	
4	Port Wind Direction, degrees relative to Bow	deg
5	Port Wind Speed	m/s
6	Units, M=meters per second	
7	Sound Speed	m/s
8	Sonic Temperature	°C
9	Status, 0=ok, 60=Heating Enabled & ok, Other value mean a fault	
10	Check Sum	

```
08+034:13:52:14.454 MET,12.22322,44.25706,-75,-25,-363.6365,2.332982,-0.08215196,278.6845,
279.2192,854.6198
```

Field	Data	Units
1	RVDAS Time Tag	
2	MET tag	
3	Power Supply Voltage	Volts
4	Enclosure Relative Humidity	%
5	Air Temp	ºC
6	Air Relative Humidity	%
7	PAR	mVolts
8	PSP Thermopile	mVolts
9	PIR Thermopile	mVolts
10	PIR Case Temperature	°K
11	PIR Dome Temperature	°K
12	Barometer	mBars

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	Units
01	RVDAS Time Tag	
02	WetLab_1	Text
03	Internal Temperature	°C
04	XMISS	Text
05	Transmissometer	V
06	V	Text
07	Double Ended Voltage 1	V
08	Double Ended Voltage 2	V
09	Double Ended Voltage 3	V
10	Voltage 1	V
11	Voltage 2	V
12	Voltage 3	V
13	Voltage 4	V
14	T	Text
15	Temperature 1	°C
16	Temperature 2	°C
17	Temperature 3	°C
18	Temperature 4	°C
19	P	Text
20	Pulse Counter 1	Number
21	Pulse Counter 2	Number
22	F	Text
23	Flow Counter 1	Number
24	Flow Counter 2	Number
25	Flow Counter 3	Number
26	Flow Counter 4	Number
27	Flow Counter 5	Number
28	Flow Counter 6	Number
29	Flow Counter 7	Number
30	Flow Counter 8	Number
31	I	Text
32	Digital Input 1	Number
33	Digital Input 2	Number
34	Digital Input 3	Number
35	Digital Input 4	Number

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, 1459.351
```

Field	Data	Units
1	RVDAS Time Tag	
2	Internal water temperature	°C
3	Conductivity	S/m
4	Salinity	psu
5	Sound Velocity	m/s

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	Units
1	RVDAS Time Tag	
2	External water temperature	°C

ldfl – Fluorometer, Wetlab ECO

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

Field	Data	Units
1	RVDAS Time Tag	
2	Fluorometer Date	mm/dd/yy
3	Fluorometer Time	hh:mm:ss
4	Chlorophyll Signal	µg/l
5	Reference	λq
6	Counts – Chlorophyll Signal	Count
7	Thermistor	

lgo2 – Oxygen System

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

```
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	Units
1	RVDAS Time Tag	
2	jsecoday - Seconds since midnight	
3	jselflag - 8 bit decimal value indicated selected gases	
4	jprgflag - 8 bit decimal value indicated purged gases	
5	jmfcflag - 8 bit decimal value indicated mass-flow controller states	
6	jgenflag - 8 bit decimal value indicated other parameters	
7	jfcv1 - voltage on Fuel Cell #1	
8	jfcv2 - voltage on Fuel Cell #2	
9	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]	

Ioxy – 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	Units
1	RVDAS Time Tag	
2-4	Measurement ID, Model Number, Serial Number	alphanumeric
5	Oxygen heading	text
6	Oxygen Reading	Raw numeric
7	Saturation heading	text
8	Saturation Reading	Raw numeric
9	Temperature heading	text
10	Water Temperature	ºC
11	Dphase heading	text
12	Dphase	Raw numeric
13	Bphase heading	text
14	BPhase	Raw numeric
15	Rphase heading	text
16	Rphase	Raw numeric
17	Bamp heading	text
18	Bamp	Raw numeric
19	Bpot heading	text
20	Bpot	Raw numeric
21	Ramp heading	text
22	Ramp	Raw numeric
23	RawTem heading	text
24	RawTemp	Raw numeric

Ipco – 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	Units
1	RVDAS Time Tag	
2	Julian date file string	Julian
3	IR voltage reading	mV
4	Cell temperature	°C
5	Barometer	millibars
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	name

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  177204
```

Field	Data	Units
1	RVDAS Time Tag	
2	Raw data counts	N /A

ladc – ADCP Speed Log

```
00+019:23:59:59.099 $PUHAW,UVH,-1.48,-0.51,250.6
```

Field	Data	Units
1	RVDAS Time Tag	
2	$PUHAW	
3	UVH (E-W, N-S, Heading)	
4	Ship Speed relative to reference layer[1] velocity[2], East vector	knots
5	Ship Speed relative to reference layer[1] velocity[2], North vector	knots
6	Ship heading	degrees

[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).

lgyr - Gyro

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

HDT: True Heading

```
01+083:00:00:02.893 $HEHDT,246.3,T*2C
```

Field	Data	Units
1	RVDAS Time Tag $HEHDT	
2	Heading XXXXX = ddd.d	degrees
3	T flag for true heading, checksum	

lsep – Seapath 330 GPS

INZDA: Time and Date Data

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

Field	Data	Units
1	RVDAS Time Tag	
2	$INZDA Tag	
3	time	hhmmss.ss
3	day	dd
4	month	mm
5	year	yyyy
6	(blank)	
7	Check sum	hexadecimal

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	Units
1	RVDAS Time Tag	
2	$INGGA Tag	
3	Time (UTC)	hhmmss.ss
3	Latitude in degrees with decimal minutes	ddmm.mmm
4	{N|S} (latitude is north or south)	
5	Longitude in degrees with decimal minutes	ddmm.mmm
6	{E|W} (longitude is east of west)	
7	GPS quality indicator: 0 = invalid position, 1 = GPS SPS used, 2 = DGPS used, 3 = GPS PPS used, 4 = GPS RTK used, 5 = GPS float RTK used, 6 = dead reckoning	
8	Number of Satellites in use (00-99)	
9	HDOP	
10	Height above ellipsoid in meters	m.mm
11	M	
12	Age of DGPS corrections in seconds	ss.ss
13	M	
14	(blank)	
15	*Check sum	hexadecimal

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	Units
1	RVDAS Time Tag	
2	$INRMC Tag	
3	UTC of position	hhmmss.ss
4	Status A = Data Valid, V = Navigation Receiver Warning	
5	Latitude in degrees with decimal minutes	ddmm.mmm
6	North (N) or South (S)	
7	Longitude in degrees with decimal minutes	ddmm.mmm
8	East (E) or West (W)	
9	Speed Over Ground, knots	knots
10	Course Over Ground, degrees True	degrees
11	Date	ddmmyy
12	Magnetic Variation, degrees E/W	degrees
13	Mode Indicator E= Estimated Mode	
14	*Check sum	

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	Units
1	RVDAS Time Tag	
2	$INVTG Tag	
3	Course over ground, degrees true	d.dd
4	T	
5	,	
6	M	
7	Speed over ground in Knots	k.k
8	N	
9	,	
10	K	
11	Mode	
12	Checksum	

PSXN,20: Data Quality

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

Field	Data	Units
1	RVDAS Time Tag	
2	$PSXN Tag	
3	20 (PSXN identifier)	
3	Horizontal position and velocity quality: 0 = normal, 1 = reduced performance, 2 = invalid data	
4	Height and vertical velocity quality: 0 = normal, 1 = reduced performance, 2 = invalid data	
5	Heading quality: 0 = normal, 1 = reduced performance, 2 = invalid data	
6	Roll and pitch quality: 0 = normal, 1 = reduced performance, 2 = invalid data	
7	*Check sum	hexadecimal

PSXN,23: Roll, Pitch, Heading and Heave

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

Field	Data	Units
1	RVDAS Time Tag	
2	$PSXN Tag	
3	23 (PSXN identifier)	
3	Roll in degrees. Positive with port side up.	d.dd
4	Pitch in degrees. Positive with bow up.	d.dd
5	Heading in degrees true	d.dd
6	Heave in meters. Positive is down	m.mm
7	*Check sum	hexadecimal

lgar - Garmin GPS

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	Units
1	RVDAS Time Tag	
2	$GPGGA Tag	
3	UTC of position	hhmmss.ss
4	Latitude in degrees with decimal minutes	ddmm.mmm
5	North (N) or South (S)	
6	Longitude in degrees with decimal minutes	ddmm.mmm

Field	Data	Units
7	East (E) or West (W)	
8	GPS quality (1=GPS 2=DGPS)	
9	Number of GPS satellites used	
10	Horizontal dilution of precision (HDOP)	
11	Antenna height above/below mean-sea-level (geoid)	meters
12	Units for antenna height (M = Meters)	
13	Geoidal Separation[1]	
14	Units for Geoidal Separation (M = Meters)	meters
15	Age of differential GPS data, number of seconds since last SC104 Type 1 or 9	
16	Differential reference station ID	

[1]Geoidal Separation: the difference between the WGS-84 earth ellipsoid and mean-sea-level (geoid). A negative value represents mean-sea-level below ellipsoid.

GLL: Geographic Position – Latitude/Longitude

```
08+034:12:26:06.211 $GPGLL,6446.4733,S,06403.4455,W,122607,A
```

Field	Data	Units
1	RVDAS Time Tag	
2	$GPGLL Tag	
3	Latitude	ddmm.mmm
4	North (N) or South (S)	
5	Longitude	ddmm.mmm
6	East (E) or West (W)	
7	UTC of position	hhmmss.ss
8	Status: A = Data Valid, V =Data Not Valid	

VTG: Track Made Good and Speed over Ground

```
08+034:12:26:06.211 $GPVTG,167,T,151,M,000.0,N,0000.0,K
```

Field	Data	Units
1	RVDAS Time Tag	
2	$GPVTG Tag	
3	Track, degrees true	degrees
3	T flag for True	
4	Track, degrees magnetic	degrees
5	M flag for Magnetic	
6	Speed over Ground	knots
7	N flag for Knots	
8	Speed over Ground	kmhr
9	K flag for km/hr	

lais – AIS receiver

AIVDM: AIS Data

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

Field	Data	Units
1	RVDAS Time Tag	
2	!AIVDM	
3	Total number of sentences needed to transfer the 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)
15	*Check sum	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	R.M. Young 61201	BP00873	12-Jun-2014	Collected
Humidity/Wet Temp	RM Young 41372LC	06133	07-Dec-2012	Collected
PAR for Mast	Biosph. Inst. QSR-240P	6719	1-Oct-2012	Collected
PIR	Eppley PIR	32031F3	14-Dec-2012	Collected
PSP	Eppley PSP	31701F3	20-Dec-2012	Collected
GUV (Mast)	Biosph. Inst. GUV-2511	Off for recal.	28-Jan-2013	Collected
Transmissometer	WET Labs C-Star 25 cm deep	CST-407DR	01-Oct-2012	Collected
MicroTSG (Primary)	Sea-Bird 45	243	05-Jan-2013	Collected
MicroTSG (Secondary)	Sea-Bird 45	227	09-Apr-2013	Collected
Digital Remote Temp	Sea-Bird 38	351	15-Nov-2012	Collected
Fluorometer	WET Labs ECO-FL	FLRTD-1735	23-Aug-12	Collected

CTD Sensors

Sensor	Description	Serial #	Cal. Date	Status
CTD Fish	SBE-9Plus	0328	21-May-2014	Collected
Primary Temperature	SBE-3	2205	23-May-2014	Collected
Secondary Temperature	SBE-3	2470	02-Apr-2014	Collected
Primary Conductivity	SBE-4	2065	11-Apr-2014	Collected
Secondary Conductivity	SBE-4	2293	04-Apr-2014	Collected
Secondary Conductivity	SBE-4	2048	06-May-2014	Collected
Primary Oxygen	SBE-43	0161	11-Jul-2014	Collected
Secondary Oxygen	SBE-43	0200	08-Apr-2014	Collected
Transmissometer	WET Labs C-Star 25 cm deep	CST-553DR	08-Aug-2014	Collected
Fluorometer	Wetlabs ECO FLRTD	FLRTD-399	14-Apr-2014	Collected
PAR	Biospherical QSP200L	4714	08-Aug-2014	Collected

Underway Calibration Sheets

Anemometer

WindObserver II™
Product Test Report

Product Tested: WindObserver II
Part Number: 1390-70-B-322
Serial Number: 1246001 - 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

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
Saltmarsh Park
67 Gosport Street
Lymington
Hampshire
SO41 9EG, UK

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E: anem@gill.co.uk

www.gill.co.uk

ISO 9001 Registered

Gill Instruments Ltd
Reg No. 3154453 Registered Office: The George Business Centre, Christchurch Road, New Milton, BH25 6QJ

Barometer

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

COPY

CALIBRATION REPORT

Barometric Pressure

Customer: *Lockheed Martin Corp*

Test Number: 4612-03B
Test Date: 12 June 2014

Customer PO: 4900049769
Sales Order: 4131

Test Sensor:
Model: 61201 Serial Number: *BP000873*
Description: Barometric Pressure Sensor

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

Reference Pressure (hPa)	Voltage Output (millivolts)	Indicated (1) Pressure (hPa)
800.0	-2	799.9
875.0	1250	875.0
950.0	2501	950.0
1025.0	3750	1025.0
1100.0	4998	1099.9

(1) Calculated from voltage output

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

Reference Instrument	Serial #	NIST Test Reference
Druck Pressure Controller Model DPI515	51500497	UKAS Lab 0221
Fluke Multimeter Model 8060A	4865407	234027

Tested By: RBurley

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

Air Temperature / Relative Humidity

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

CALIBRATION REPORT

Temperature

Customer: *Lockheed Martin*

Test Number: 3911-12T
Test Date: 21 October 2013

Customer PO: 4100966256
Sales Order: 3569

Test Sensor:
Model: 41372LC Serial Number: *TS06719*
Description: Temperature/Relative Humidity Sensor

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

Bath Temperature (degrees C)	Current Output (milliamps)	Indicated (1) Temperature (degrees C)
-49.95	4.010	-49.94
0.00	12.001	0.01
49.93	19.988	49.93

(1) Calculated from current output

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

Reference Instrument	Serial #	NIST Test Reference
Brooklyn Thermometer Model 43-FC	3006-118	W204690
Brooklyn Thermometer Model 22332-D5-FC	25071	W204691
Brooklyn Thermometer Model 2X400-D7-FC	77532	W204692
Keithley Multimeter Model 191	15232	4200646497

Tested By: _______________

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

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

CALIBRATION REPORT
Relative Humidity

Customer: *Lockheed Martin*

Test Number: 3911-12R
Test Date: 21 October 2013

Customer PO: 4100966256
Sales Order: 3569

Test Sensor:
Model: 41372LC Serial Number: *TS06719*
Description: Temperature/Relative Humidity Sensor

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

Reference Humidity (%)	Current Output (milliamps)	Indicated (1) Humidity (%)
10.0	6.0	12.3
30.0	8.9	30.8
50.0	12.3	51.9
70.0	15.2	70.3
90.0	18.1	87.9

(1) Calculated from voltage output

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

Reference Instrument	Serial #	NIST Test Reference
Vaisala Humidity Sensor Model 35AC	N475040	TN 266152
Agilent Multimeter Model 34405A	MY53020093	4200646497

Tested By: R Phillips

M E T E O R O L O G I C A L I N S T R U M E N T S
Tel: 231-946-3980 Fax: 231-946-4772 Email: met.sales@youngusa.com Website: youngusa.com
ISO 9001:2008 CERTIFIED

PAR (mast)

Biospherical Instruments Inc.

CALIBRATION CERTIFICATE

Calibration Date	5/20/2013
Model Number	QSR-240
Serial Number	6394
Operator	TPC
Standard Lamp	V-031(3/7/12)
Probe Excitation Voltage Range:	6 to 18 VDC(+)
Output Polarity:	Positive

Probe Conditions at Calibration(in air):

Calibration Voltage:	6	VDC(+)
Probe Current:	4.0	mA

Probe Output Voltage:

Probe Illuminated	107.0	mV
Probe Dark	0.3	mV
Probe Net Response	106.7	mV
RG780	0.3	mV

Corrected Lamp Output:

Output In Air (same condition as calibration):

1.044E+16	quanta/cm²sec
0.01733	uE/cm²sec

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

Dry:	1.0225E-17	V/(quanta/cm²sec)
	6.1572E+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.

PAR for mast

Biospherical Instruments Inc.

CALIBRATION CERTIFICATE

Calibration Date	5/20/2013
Model Number	QSR-240
Serial Number	6394
Operator	TPC
Standard Lamp	V-031(3/7/12)
Probe Excitation Voltage Range:	6 to 18 VDC(+)
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Probe Conditions at Calibration(in air):

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Probe Output Voltage:

Probe Illuminated	107.0	mV
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Probe Net Response	106.7	mV
RG780	0.3	mV

Corrected Lamp Output:

Output In Air (same condition as calibration):

1.044E+16 quanta/cm²sec

0.01733 uE/cm^2sec

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

Dry:	1.0225E-17	V/(quanta/cm²sec)
	6.1572E+00	$V/(uE/cm^2sec)$

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

THE EPPLEY LABORATORY, INC.

EPLAB

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

STANDARDIZATION OF EPPLEY PRECISION INFRARED RADIOMETER Model PIR

Serial Number: 32031F3

Resistance: 709 Ω at 23°C
Temperature Compensation Range: -20° to +40°C

This pyrgeometer has been compared against Eppley's Blackbody Calibration System under radiation intensities of approximately 200 watts meter^{-2} and an average ambient temperature of 25°C as measured by Standard Omega Temperature Probe, RTD#1.

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

$$3.80 \times 10^{-6} \text{ volts/watts meter}^{-2}$$

The calculation of this constant is based on the fact that the relationship between radiation intensity and emf is rectilinear to intensities of 700 watts meter^{-2}. This radiometer is linear to within ±1.0% up to this intensity.

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

Eppley recommends a minimum calibration cycle of five (5) years but encourages annual calibrations for highest measurement accuracy. Unless otherwise stated in the remarks section below or on the Sales Order, the results are "AS FOUND / AS LEFT".

Shipped to: LMP4 ISGS (NSF)
Port Hueneme, CA

S.O. Number: 63900
Date: September 5, 2013

Remarks:

Date of Test: September 4, 2013

In Charge of Test: Debra L. Gentz

Reviewed by: Thomas D Kirk

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 31701F3

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

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

Results:

Sensitivity: **$S = 8.14\ \mu V / Wm^{-2}$**
Uncertainty: $U_{95} = \pm 0.91\%$ (95% confidence level, k=2)
Resistance: 674 Ω at 23°C

Date of Test: September 3, 2013

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

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

Customer: LMP4 ISGS (NSF)
Port Hueneme, CA

Signatures: In Charge of Test: Debra L. Ginty Reviewed by: Thomas D. Kirk

Eppley SO 63900

Date of Certificate September 5, 2013

Remarks:

Transmissometer

PO Box 518
620 Applegate St.
Philomath, OR 97370

WET Labs

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

C-Star Calibration

Date April 1, 2013 S/N# CST-407DR Pathlength 25 cm

	Analog output
V_d	0.060 V
V_{air}	4.750 V
V_{ref}	4.663 V

Temperature of calibration water	20.1 °C
Ambient temperature during calibration	21.1 °C

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

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

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

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

Revision L 6/9/09

Thermosalinograph (temp) – 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

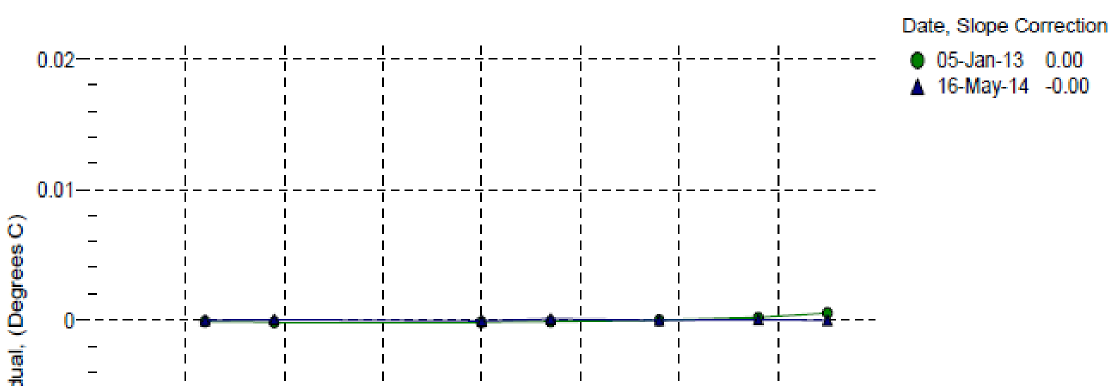
SENSOR SERIAL NUMBER: 0243
CALIBRATION DATE: 16-May-14

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:
a0 = 1.417246e-005
a1 = 2.749041e-004
a2 = -2.553507e-006
a3 = 1.527836e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	759568.9	1.0000	-0.0000
4.5000	647915.0	4.5000	0.0000
15.0000	410152.8	14.9999	-0.0001
18.5000	354383.2	18.5001	0.0001
24.0000	283362.0	24.0000	-0.0000
29.0000	232648.2	29.0000	0.0000
32.5000	203331.4	32.5000	-0.0000

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



Thermosalinograph (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: 0243
CALIBRATION DATE: 16-May-14

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

COEFFICIENTS:

g = -1.008861e+000
h = 1.574112e-001
i = -3.646901e-004
j = 5.431565e-005

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

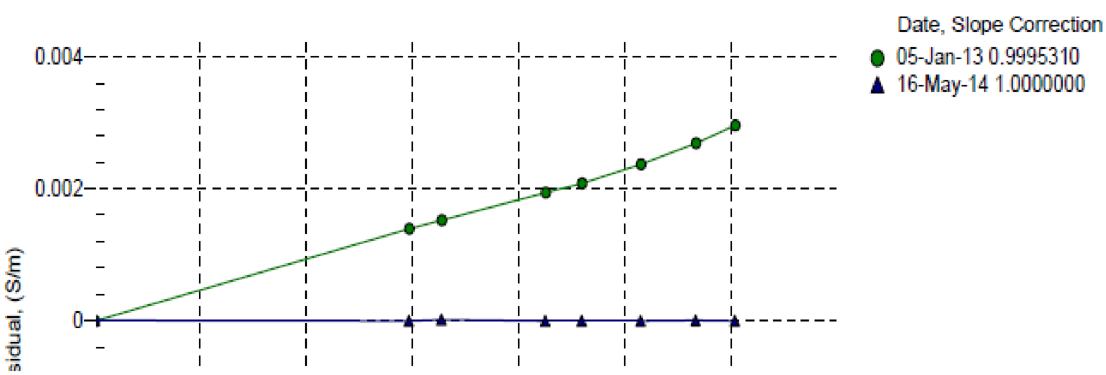
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2536.23	0.00000	0.00000
1.0000	34.6704	2.96468	5031.60	2.96467	-0.00001
4.5000	34.6504	3.27061	5221.13	3.27062	0.00001
15.0000	34.6078	4.24873	5784.74	4.24873	-0.00000
18.5000	34.5989	4.59263	5969.99	4.59263	-0.00000
24.0000	34.5892	5.14857	6257.55	5.14856	-0.00000
29.0000	34.5834	5.66845	6514.65	5.66846	0.00001
32.5000	34.5796	6.03937	6691.83	6.03936	-0.00000

f = INST FREQ * sqrt(1.0 + WBOTC * t) / 1000.0

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

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

Residual = instrument conductivity - bath conductivity



Thermosalinograph (Temp) – 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: 0227
CALIBRATION DATE: 25-Aug-13

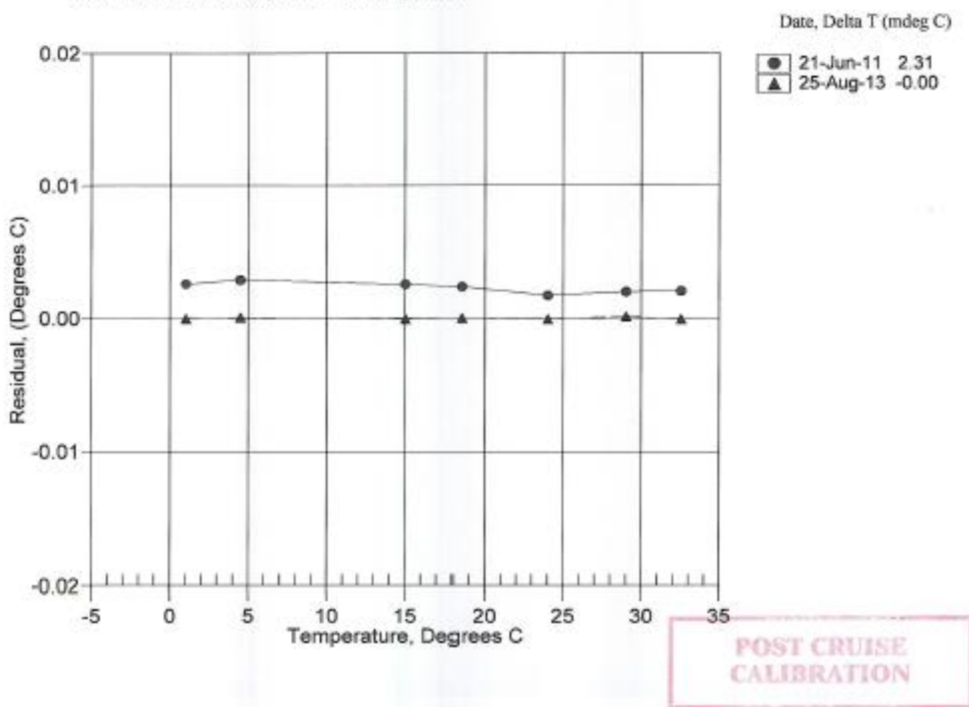
SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
a0 = -5.724362e-005
a1 = 2.934054e-004
a2 = -3.824766e-006
a3 = 1.903347e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	664656.6	0.9999	-0.0000
4.4999	568086.2	4.5000	0.0001
15.0000	361665.6	15.0000	-0.0000
18.5000	313054.3	18.5000	0.0000
24.0000	251007.2	23.9999	-0.0001
29.0000	206585.1	29.0001	0.0001
32.5000	180854.7	32.4999	-0.0001

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

Residual = 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: 0227
CALIBRATION DATE: 25-Aug-13

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

COEFFICIENTS:
g = -1.020049e+000
h = 1.581270e-001
i = -4.833232e-004
j = 6.326134e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006
WBOTC = 1.0472e-006

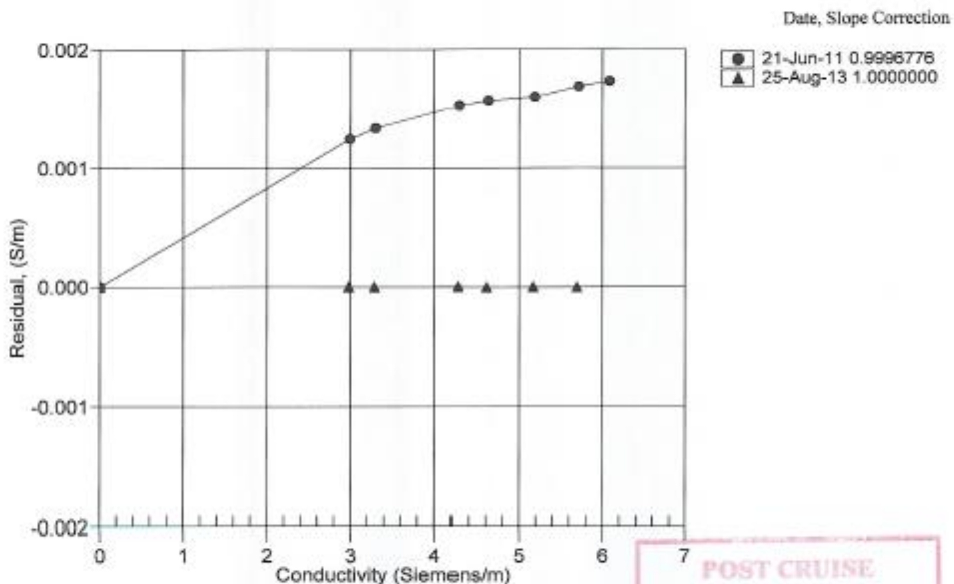
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2546.43	0.00000	0.00000
0.9999	34.8073	2.97526	5039.81	2.97526	0.00000
4.4999	34.7873	3.28225	5229.34	3.28225	-0.00000
15.0000	34.7443	4.26371	5793.02	4.26372	0.00000
18.5000	34.7355	4.60881	5978.31	4.60880	-0.00000
24.0000	34.7260	5.16668	6265.93	5.16668	0.00000
29.0000	34.7212	5.68849	6523.12	5.68849	-0.00000

f = INST FREQ * sqrt(1.0 + WBOTC * t) / 1000.0

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

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

Residual = instrument conductivity - bath conductivity



POST CRUISE CALIBRATION

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: 0351
CALIBRATION DATE: 28-Dec-13

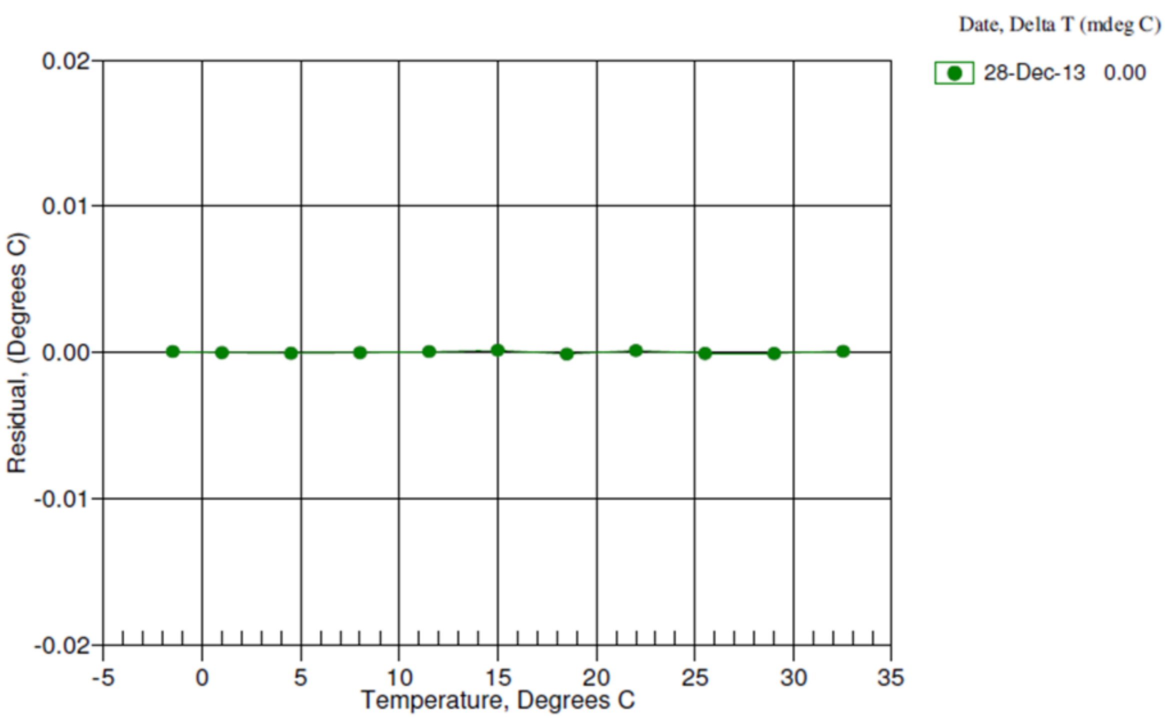
SBE 38 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
a0 = 6.847307e-005
a1 = 2.737587e-004
a2 = -2.376425e-006
a3 = 1.515438e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.50000	674751.5	-1.49996	0.00004
1.00000	601342.4	0.99997	-0.00003
4.50020	513289.0	4.50015	-0.00005
8.00000	439602.0	7.99997	-0.00003
11.50000	377712.0	11.50004	0.00004
14.99990	325560.5	15.00003	0.00013
18.50020	281469.0	18.50008	-0.00012
22.00000	244073.8	22.00011	0.00011
25.50000	212261.3	25.49992	-0.00008
29.00010	185112.4	29.00003	-0.00007
32.50010	161877.4	32.50017	0.00007

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

Residual = instrument temperature - bath temperature



Fluorometer

PO Box 518
620 Applegate St.
Philomath, OR 97370

WET Labs

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

ECO Chlorophyll Fluorometer Characterization Sheet

Date: 4/19/2013 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	0.058	0.027	0.010	V	50 counts
Scale Factor (SF)	6	12	25	µg/l/V	0.0076 µg/l/count
Maximum Output	4.98	4.98	4.98	V	16380 counts
Resolution	0.7	0.7	0.7	mV	0.9 counts

Ambient temperature during characterization 23.7 °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.xls Revision J 3/17/08

CTD Sensor Calibration Sheets

CTD Fish

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: 0328
CALIBRATION DATE: 21-May-14

SBE 9plus PRESSURE CALIBRATION DATA
FSR: 10000 psia S/N 53980

DIGIQUARTZ COEFFICIENTS:

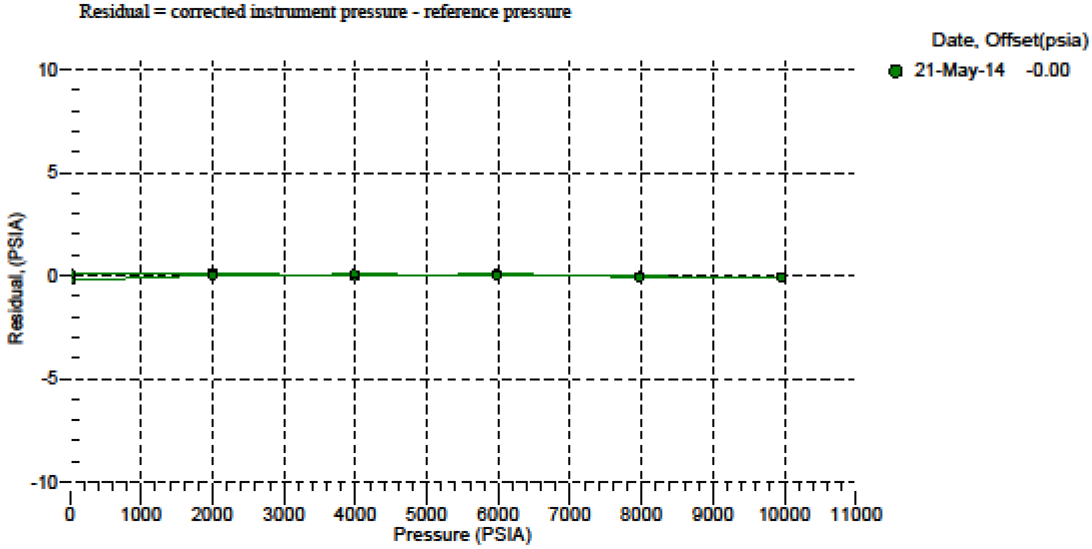
C1 = -5.847002e+004
C2 = 6.910390e-001
C3 = 1.753360e-002
D1 = 4.241600e-002
D2 = 0.000000e+000
T1 = 3.026040e+001
T2 = -1.938830e-004
T3 = 4.330190e-006
T4 = 2.020250e-009
T5 = 0.000000e+000

AD590M, AD590B, SLOPE AND OFFSET:

AD590M = 1.13300e-002
AD590B = -8.47592e+000
Slope = 0.99999
Offset = -0.9481 (dbars)

PRESSURE (PSIA)	INST OUTPUT (Hz)	INST TEMP (C)	INST OUTPUT (PSIA)	CORRECTED INST OUTPUT (PSIA)	RESIDUAL (PSIA)
14.692	33053.40	22.9	16.156	14.781	0.089
2001.219	33609.50	23.1	2002.739	2001.350	0.131
3987.972	34155.00	23.1	3989.337	3987.934	-0.038
5975.145	34690.60	23.1	5976.655	5975.239	0.094
7962.287	35216.50	23.1	7963.691	7962.261	-0.026
9949.671	35733.30	23.2	9951.062	9949.617	-0.054
7962.311	35216.50	23.2	7963.685	7962.255	-0.056
5975.184	34690.60	23.2	5976.646	5975.229	0.045
3988.230	34155.10	23.2	3989.696	3988.293	0.063
2001.346	33609.50	23.2	2002.737	2001.348	0.002
14.695	33053.30	23.4	15.821	14.446	-0.249

Residual = corrected instrument pressure - reference pressure



Primary 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: 2205
CALIBRATION DATE: 23-May-13

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
g = 4.34881187e-003
h = 6.47917325e-004
i = 2.33788065e-005
j = 2.17158813e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS
a = 3.68121187e-003
b = 6.05576961e-004
c = 1.64527132e-005
d = 2.17316390e-006
f0 = 2907.874

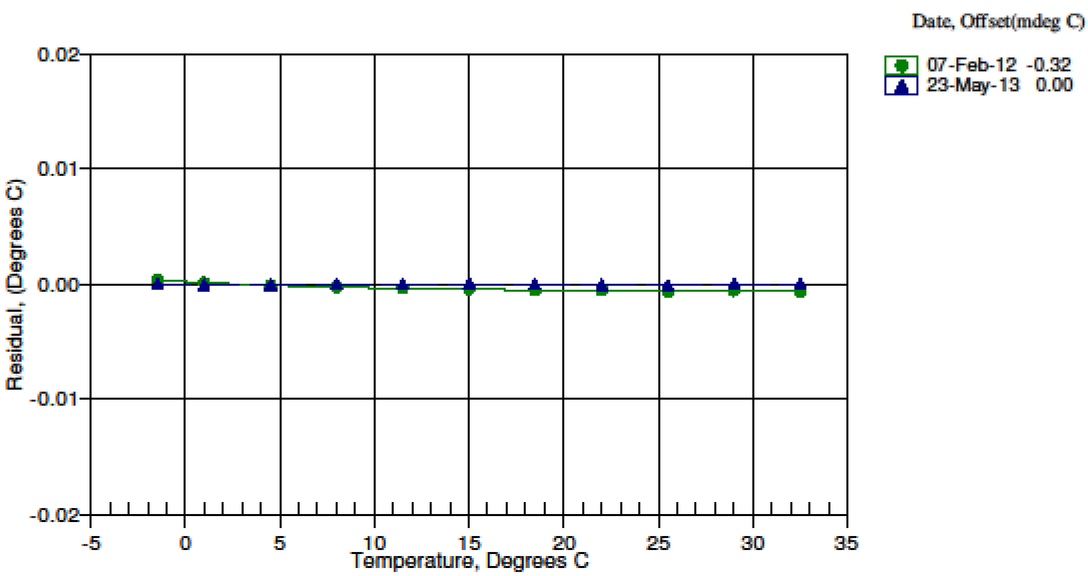
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	2907.874	-1.5000	0.00003
1.0000	3073.912	1.0000	-0.00002
4.5000	3317.724	4.4999	-0.00006
7.9999	3575.120	7.9999	0.00003
11.5000	3846.466	11.5000	0.00000
15.0000	4132.102	15.0000	0.00004
18.5000	4432.365	18.5000	0.00002
22.0000	4747.587	22.0000	-0.00000
25.5000	5078.078	25.4999	-0.00009
28.9999	5424.157	28.9999	0.00003
32.5000	5786.114	32.5000	0.00002

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

Temperature IPTS-68 = $1/\{a + b[ln(f_0/f)] + c[ln^2(f_0/f)] + d[ln^3(f_0/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature



Secondary Temperature

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: 2470
CALIBRATION DATE: 02-Apr-14

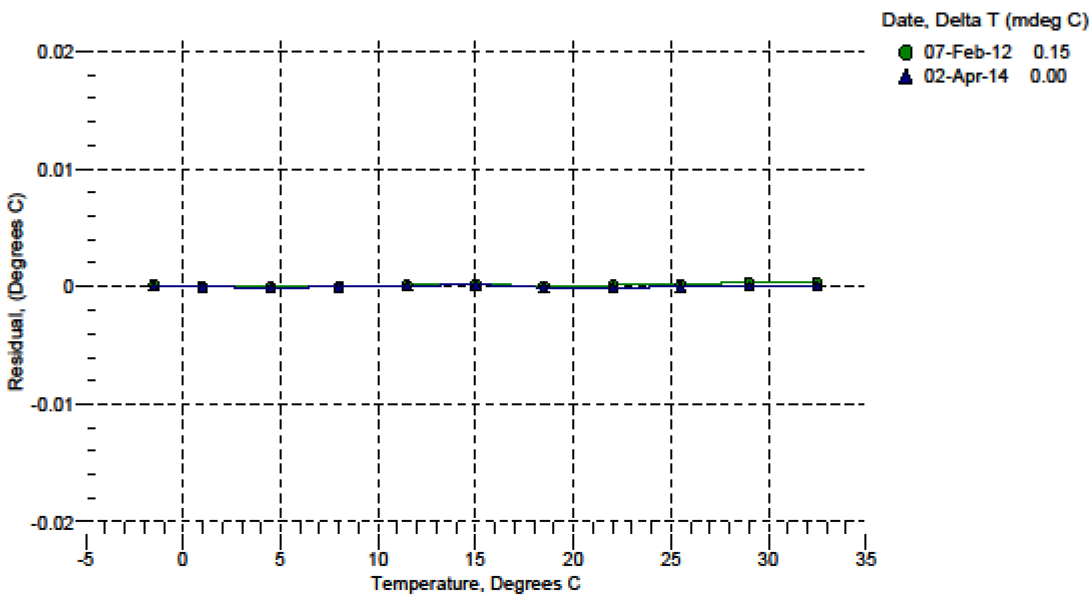
SBE 3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS:
g = 4.31685951e-003
h = 6.54789836e-004
i = 2.44358894e-005
j = 2.30987382e-006
f0 = 1000.0

BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	2731.573	-1.5000	0.00004
1.0000	2885.657	1.0000	-0.00002
4.5000	3111.772	4.4999	-0.00007
8.0000	3350.317	8.0000	-0.00005
11.5000	3601.617	11.5001	0.00007
15.0000	3865.976	15.0002	0.00015
18.5000	4143.673	18.4999	-0.00006
22.0000	4435.041	21.9999	-0.00006
25.5000	4740.347	25.5000	-0.00003
29.0000	5059.858	29.0000	0.00001
32.5000	5393.828	32.5000	0.00002

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

Residual = instrument temperature - bath temperature



Primary 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: 2065
CALIBRATION DATE: 02-Apr-14

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

COEFFICIENTS:

```
g = -1.01845994e+001
h =  1.41063974e+000
i = -3.52393734e-003
j =  3.25451485e-004
```

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

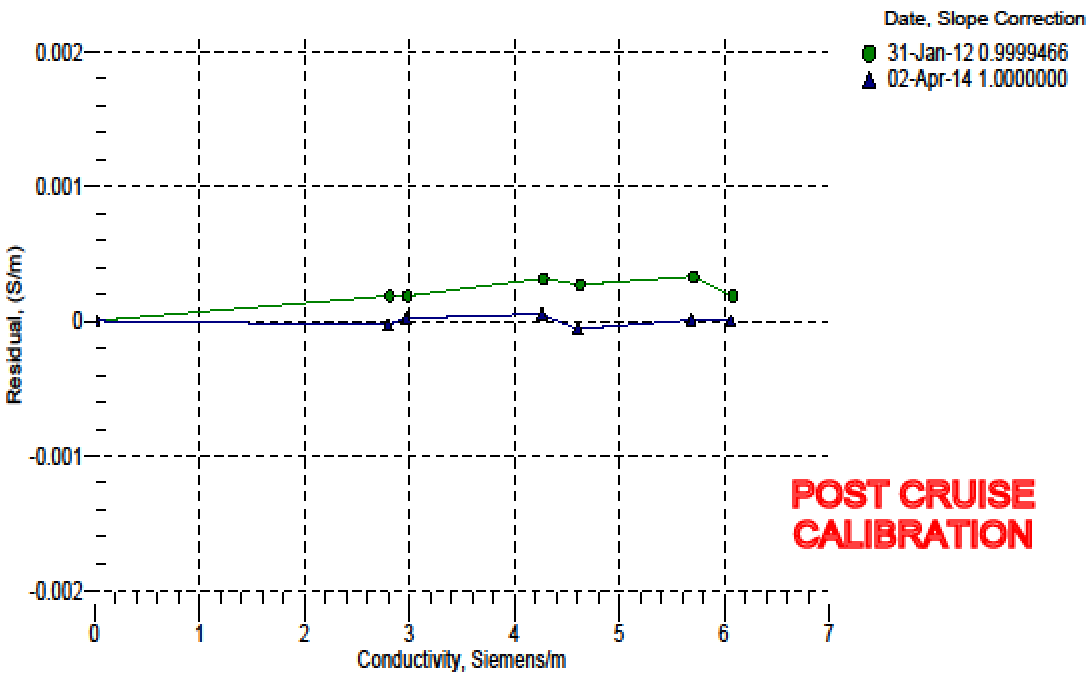
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.69380	0.00000	0.00000
-1.0000	34.7162	2.79726	5.21855	2.79724	-0.00003
1.0000	34.7160	2.96821	5.33423	2.96823	0.00002
15.0000	34.7159	4.26060	6.13801	4.26065	0.00005
18.5000	34.7162	4.60652	6.33566	4.60647	-0.00006
29.0001	34.7142	5.68749	6.91670	5.68749	0.00001
32.5001	34.7071	6.05911	7.10531	6.05911	0.00000

f = INST FREQ / 1000.0

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

t = temperatur e[°C)]; p = pressure[decibars]; δ = CTcor; ε = CPcor;

Residual = instrument conductivity - bath conductivity



Secondary Conductivity (cast 00, 01)

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: 2293
CALIBRATION DATE: 01-Apr-14

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

COEFFICIENTS:
g = -1.07116183e+001
h = 1.48028171e+000
i = -2.30888001e-003
j = 2.44799847e-004

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

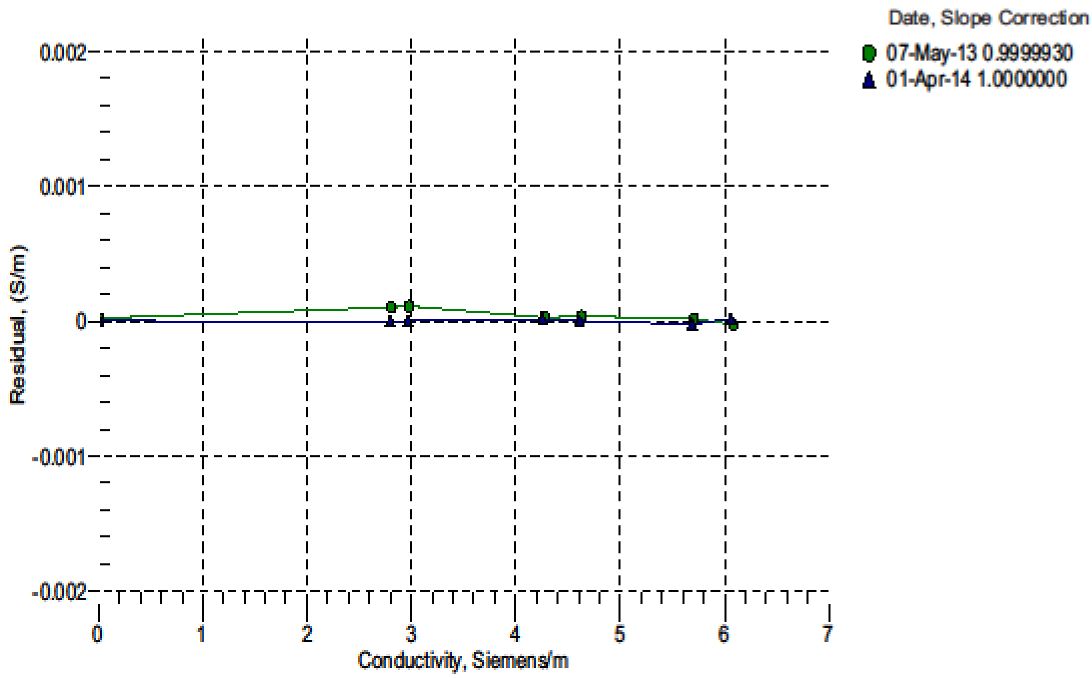
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.69407	0.00000	0.00000
-1.0000	34.7195	2.79750	5.12155	2.79750	-0.00000
1.0000	34.7199	2.96851	5.23349	2.96851	0.00000
15.0000	34.7191	4.26095	6.01210	4.26096	0.00001
18.5000	34.7182	4.60676	6.20374	4.60676	0.00000
29.0000	34.7153	5.68764	6.76749	5.68761	-0.00002
32.5001	34.7064	6.05900	6.95053	6.05902	0.00002

f = INST FREQ / 1000.0

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

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

Residual = instrument conductivity - bath conductivity



Secondary Conductivity (cast 02 –)

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: 2048
CALIBRATION DATE: 06-May-14

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

COEFFICIENTS:

```
g = -1.02998431e+001
h =  1.43089329e+000
i = -4.86502571e-003
j =  5.61716856e-004

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

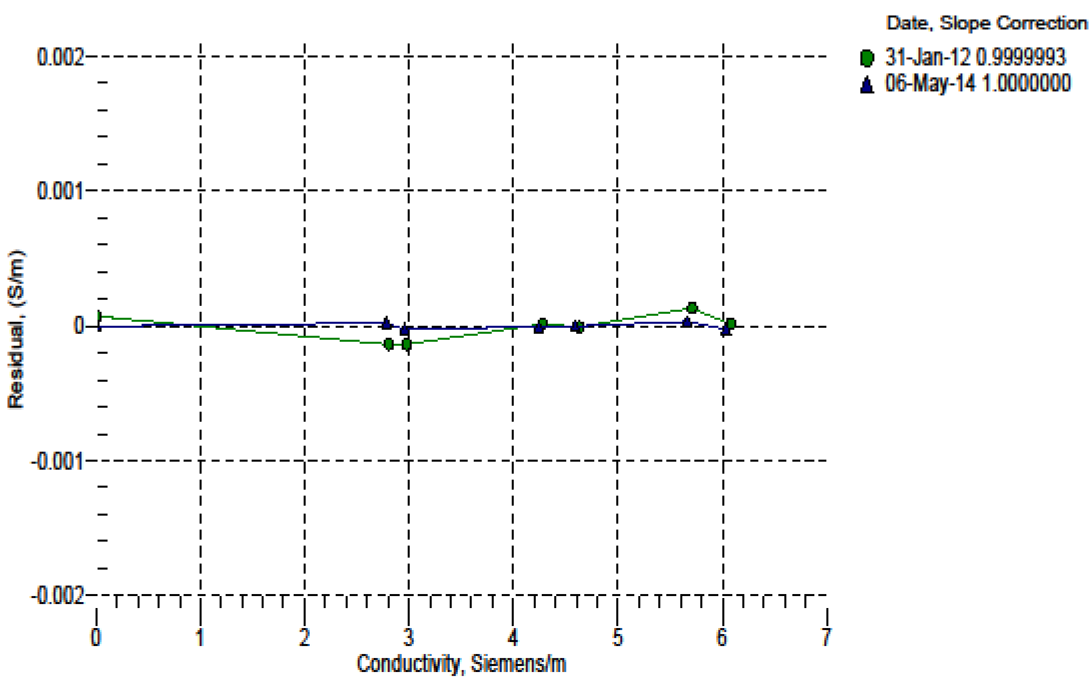
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.69145	0.00000	0.00000
-1.0000	34.5447	2.78473	5.18168	2.78475	0.00002
1.0000	34.5456	2.95502	5.29584	2.95500	-0.00002
15.0000	34.5459	4.24194	6.08875	4.24193	-0.00001
18.5000	34.5452	4.58627	6.28358	4.58627	-0.00000
29.0000	34.5434	5.66263	6.85599	5.66266	0.00003
32.5000	34.5376	6.03286	7.04173	6.03284	-0.00002

f = INST FREQ / 1000.0

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

t = temperatur e[°C)]; p = pressure[decibars]; δ = CTcor; ε = CPcor;

Residual = instrument conductivity - bath conductivity



Primary Oxygen

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: 0161
CALIBRATION DATE: 11-Jul-14

SBE 43 OXYGEN CALIBRATION DATA

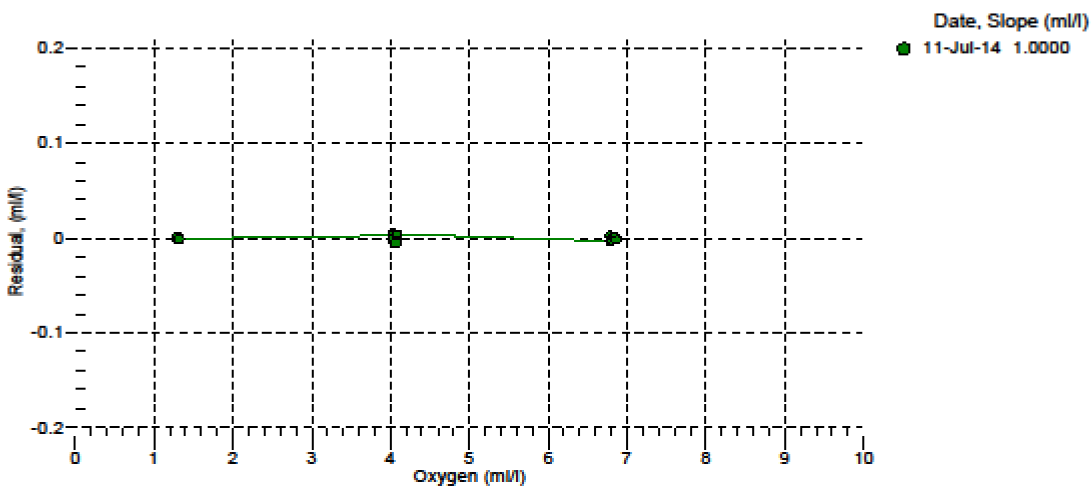
COEFFICIENTS:
Soc = 0.5245
Voffset = -0.5178
Tau20 = 1.09

A = -3.7765e-003
B = 1.5619e-004
C = -2.3847e-006
E nominal = 0.036

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

BATH OX (ml/l)	BATH TEMP (ITS-90)	BATH SAL (PSU)	INSTRUMENT OUTPUT (VOLTS)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.30	6.00	0.00	0.807	1.30	-0.00
1.30	12.00	0.00	0.855	1.30	-0.00
1.30	20.00	0.00	0.920	1.30	-0.00
1.30	2.00	0.00	0.776	1.30	0.00
1.32	26.00	0.00	0.975	1.31	-0.00
1.32	30.00	0.00	1.012	1.32	-0.00
4.03	6.00	0.00	1.417	4.03	0.00
4.04	12.00	0.00	1.566	4.03	-0.00
4.04	2.00	0.00	1.320	4.05	0.00
4.04	20.00	0.00	1.769	4.04	-0.00
4.07	26.00	0.00	1.932	4.06	-0.01
4.08	30.00	0.00	2.045	4.08	0.00
6.78	6.00	0.00	2.028	6.78	-0.00
6.79	12.00	0.00	2.282	6.79	0.00
6.80	2.00	0.00	1.867	6.80	-0.00
6.83	20.00	0.00	2.632	6.83	0.00
6.84	26.00	0.00	2.899	6.85	0.00
6.86	30.00	0.00	3.086	6.86	-0.00

Oxygen (ml/l) = Soc * (V + Voffset) * $(1.0 + A * T + B * T^2 + C * T^3)$ * OxSol(T,S) * exp(E * P / K)
V = voltage output from SBE43, T = temperature [deg C], S = salinity [PSU], K = temperature [deg K]
OxSol(T,S) = oxygen saturation [ml/l], P = pressure [dbar]
Residual = instrument oxygen - bath oxygen



Secondary Oxygen

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: 08-Apr-14

SBE 43 OXYGEN CALIBRATION DATA

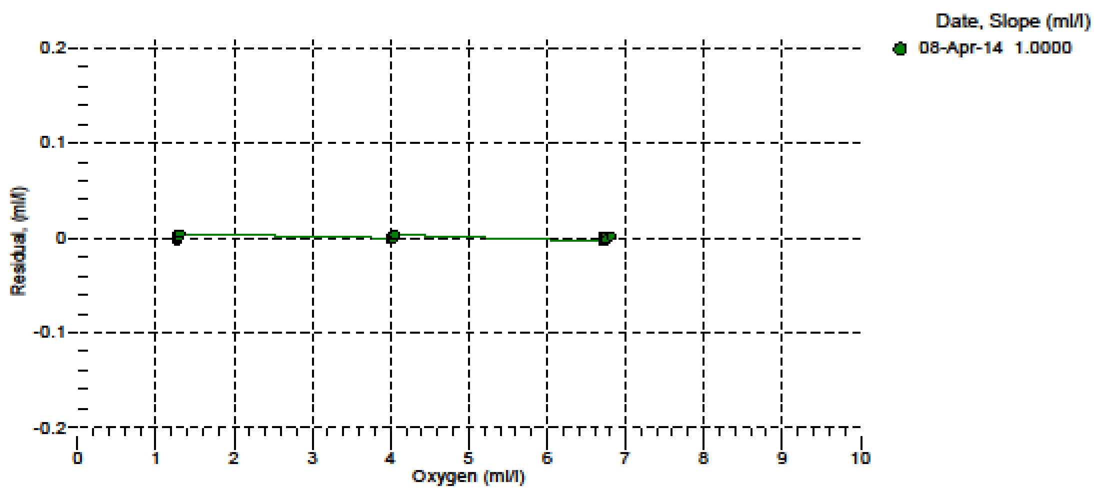
COEFFICIENTS:
Soc = 0.4796
Voffset = -0.5032
Tau20 = 1.41

A = -4.3511e-003
B = 2.4469e-004
C = -3.6897e-006
E nominal = 0.036

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

BATH OX (ml/l)	BATH TEMP (ITS-90)	BATH SAL (PSU)	INSTRUMENT OUTPUT (VOLTS)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.27	2.00	0.00	0.777	1.26	-0.00
1.27	6.00	0.00	0.813	1.27	-0.00
1.27	12.00	0.00	0.863	1.27	-0.00
1.29	20.00	0.00	0.934	1.29	0.00
1.29	26.00	0.00	0.985	1.29	0.00
1.31	30.00	0.00	1.027	1.32	0.00
4.00	26.00	0.00	1.992	4.00	-0.00
4.01	20.00	0.00	1.843	4.01	-0.00
4.01	6.00	0.00	1.482	4.01	-0.00
4.03	12.00	0.00	1.643	4.03	-0.00
4.04	2.00	0.00	1.381	4.04	0.00
4.04	30.00	0.00	2.115	4.05	0.00
6.72	30.00	0.00	3.177	6.71	-0.00
6.72	26.00	0.00	3.006	6.73	0.00
6.74	12.00	0.00	2.411	6.74	0.00
6.75	20.00	0.00	2.756	6.74	-0.00
6.76	2.00	0.00	1.971	6.76	-0.00
6.82	6.00	0.00	2.165	6.82	0.00

Oxygen (ml/l) = Soc * (V + Voffset) * (1.0 + A * T + B * T^2 + C * T^3) * OxSol(T,S) * exp(E * P / K)
V = voltage output from SBE43, T = temperature [deg C], S = salinity [PSU], K = temperature [deg K]
OxSol(T,S) = oxygen saturation [ml/l], P = pressure [dbar]
Residual = instrument oxygen - bath oxygen



Fluorometer

PO Box 518
620 Applegate St.
Philomath, OR 97370

WET Labs

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

ECO Chlorophyll Fluorometer Characterization Sheet

Date: 4/14/2014 S/N: FLRTD-399

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	0.098	0.056	0.033 V	70 counts
Scale Factor (SF)	6	13	26 µg/l/V	0.0079 µg/l/count
Maximum Output	4.98	4.98	4.98 V	16330 counts
Resolution	0.5	0.5	0.5 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-399.xls Revision J 3/17/08

Transmissometer

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Philomath, OR 97370

(541) 929-5650
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WET Labs

C-Star Calibration

Date 8.8.14 S/N# CST-553DR Pathlength 25cm

	Analog output
V_d	0.057 V
V_{air}	4.787 V
V_{ref}	4.682 V

Temperature of calibration water	23.4 °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

PAR

Biospherical Instruments Inc

CALIBRATION CERTIFICATE

UNDERWATER PAR SENSOR WITH LOG AMPLIFIER

Calibration Date: 08/08/14 **Job No.:** R11986
Model Number: QSP200L
Serial Number: 4714
Operator: TPC
Standard Lamp: V-033(2/7/12)
Operating Voltage Range: 6 to 15 VDC (+)

Note: The QSP200L uses a log amplifier to measure the detector signal current with V = log I (Amps) / IRef
To calculate irradiance, use this formula:

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

With the appropriate (solar corrected) Irradiance Calibration Factor.

Dry Calibration Factor:	**2.64E+13**	**quanta/cm²·sec/"amps"**	**4.39E-05**	**µEinsteins/cm²·sec/"amps"**
Wet Calibration Factor:	**4.67E+13**	**quanta/cm²·sec/"amps"**	**7.76E-05**	**µEinsteins/cm²·sec/"amps"**

Sensor Test Data and Results[4]

Sensor Supply Current (Dark):	82.5	mA		
Supply Voltage:	6	Volts		
Lamp Integrated PAR Irradiance:	9.34E+15	quanta/cm²·sec	0.01561	µEinsteins/cm²sec
SC3 Immersion Coefficient:	0.5664	Scalar Correction: 1	PAR Solar Correction:	1.0000

Nominal Filter OD	Calibrated Trans.	Sensor Voltage	Measured Trans.	Measured Signal (Amps)	Estimated Signal (Amps)	Calc. Output (Volts)	Error (Volts)	Error (%)	Test Irrad. (quanta/cm²·sec)
No Filter	100.00%	2.550	100.00%	3.55E-08	3.55E-08	2.552	0.002	0.0	9.34E+15
0.3	36.10%	2.114	36.37%	1.29E-08	1.28E-08	2.113	-0.001	-0.7	3.40E+15
0.5	27.60%	1.999	27.81%	9.87E-09	9.79E-09	1.998	-0.001	-0.8	2.60E+15
1	9.27%	1.547	9.54%	3.39E-09	3.29E-09	1.537	-0.010	-2.8	8.91E+14
2	1.11%	0.750	1.16%	4.13E-10	3.94E-10	0.736	-0.014	-4.6	1.09E+14
3	0.05%	0.254	0.08%	2.84E-11	1.89E-11	0.231	-0.023	-33.3	7.48E+12

Dark Before: 0.179 Volts
Light - No Filter Hldr.: 2.550 Volts
Dark After - NFH: 0.180 Volts
Average Dark: 0.180 Volts

I_{Ref} = 1.00E-10 Amps
I_{Dark} = 1.51E-10 Amps
10^{VDark} = 1.51182 Amps

RG780 **0.197**

Notes:
1. Annual calibration is recommended.
2. The collector should be cleaned frequently with alcohol.
4) This section is for internal use and for more advanced analysis.

QSP200L-QSP2300 (4-2013-).xls

Acquisition and Processing Information

Processing Specifics

Refer to the InstCoef.txt file along with the specific instrument calibration sheets, both located in the Cal/ directory of the data distribution, for information on how the RVDAS data was collected and processed.

Significant Notes

Errors and Events

This section lists all significant events and known problems with acquisition during this cruise including instrument failures, data acquisition system failures, and other factors affecting this data set.
(i.e, The PCO2 system was turned off for the troubleshooting and repairs of the equilibrator pump.)

Day Of Year	Time (GMT)	Event	Location
098	06:47	Begin Data Collection	@68W
099	00:11	ADCP Bottom Tracking off	Off the shelf
101	11:30	ADCP Bottom Tracking on	On Shelf
101	16:28	O2 weekly maintenance	
102	13:22	Suspend Seawater and Sonar	Arrive Palmer Station
104	12:11	Resume Seawater and Sonar	Depart Palmer Station
108	12:42	Suspend Seawater and Sonar	Arrive Palmer Station
109	12:41	Resume Seawater and Sonar	Depart Palmer Station
109	12:48	O2 weekly maintenance	
110	16:05	ADCP Bottom Tracking off	
115	13:55	O2 weekly maintenance	
116	16:35	Suspend Seawater and Sonar	Arrive Palmer Station
120	12:20	Resume Seawater and Sonar	Depart Palmer Station
124	12:27	Suspend Seawater and Sonar	Arrive Palmer Station
127	12:27	Resume Seawater and Sonar	Depart Palmer Station
129	15:33	O2 weekly maintenance	
130	12:41	ADCP Bottom Tracking On	Patagonian shelf
131	01:53	End data collection	@68W