LMG 1601 LTER

Cruise Data Report

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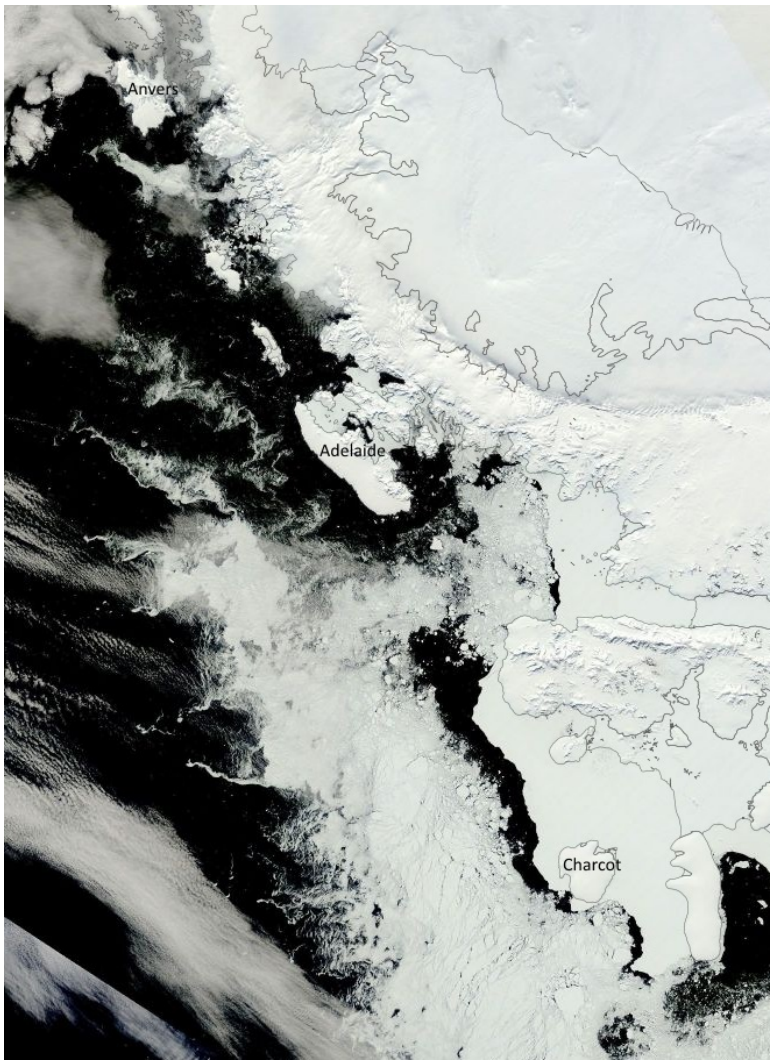

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Introduction

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All of the data has been archived with the Unix “tar” command and/or compressed using Unix “gzip” compression.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

/Logsheets/

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. It also contains a GPX trackline file for the cruise.

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.

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	GPS latitude (negative is South)	Ddd.dddd
04	GPS 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/cm^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 41372LC
Relative Humidity	lmwx	continuous	1 sec	R. M. young 41372LC
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
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 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**
Meteorological - Campbell	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. 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	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+034:13:52:14.454 MET,12.22322,44.25706,-75,-25,-363.6365,2.332982,-0.08215196,278.6845,
279.2192,854.6198,854.6184
```

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

Field	Data	Units
12	Barometer	mBars
13	Second Barometer (experimental)	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 (often used for YoYo xmiss)	V
11	Voltage 2 (often used for YoYo altimeter)	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]	

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	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

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	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
4	T	
5	,	
6	M	
7	Speed over ground	Knots
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. Positive with port side up.	degrees
4	Pitch. Positive with bow up.	degrees
5	Heading	Degrees true
6	Heave. Positive is down	meters
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	km/hr
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	BP01150	10-Apr-2014	Collected
Humidity/Wet Temp	RM Young 41372LC	6133	14-Aug-2014	Collected
PAR for Mast	Biosph. Inst. QSR-240P	6393	31-Mar-2015	Collected
PIR	Eppley PIR	28903F3	3-Feb-2015	Collected
PSP	Eppley PSP	28933F3	3-Feb-2015	Collected
GUV (Mast)	Biosph. Inst. GUV-2511	25110805127	15-Jun-2015	Collected
Transmissometer	WET Labs C-Star 25 cm deep	CST-830DR	22-Jul-2014	Collected
MicroTSG (Primary)	Sea-Bird 45	243	16-May-2014	Collected
MicroTSG (Secondary)	Sea-Bird 45	390	30-Oct-2014	Collected
Digital Remote Temp	Sea-Bird 38	351	28-Dec-2013	Collected
Fluorometer	WET Labs ECO-FL	FLRTD-380	24-Oct-2014	Collected

CTD Sensors

Sensor	Description	Serial #	Cal. Date	Status
CTD Fish	Seabird SBE9Plus	0232	20-Feb-2015	Collected
Primary Temperature	Seabird SBE3	2205	23-Jun-2015	Collected
Secondary Temperature	Seabird SBE3	5034	22-Apr-2015	Collected
Primary Conductivity	Seabird SBE4	0350	03-Mar-2015	Collected
Secondary Conductivity	Seabird SBE4	1223	9-Dec-2014	Collected
Fluorometer	Wet Labs ECO	FLRTD-399	14-Apr-2014	Collected
Transmissometer	Wet Labs C-Star	CST-553DR	08-Aug-2014	Collected
Primary Oxygen	Seabird 43	0190	22-Apr-2015	Collected
Secondary Oxygen	Seabird 43	0196	22-Apr-2015	Collected
PAR	Biospherical Instruments Inc.	4722	17-Feb-2015	Collected
Altimeter	Teledyne Benthos PSA-916	54648	n/a	Collected

Trace Metal Clean CTD Sensors

Sensor	Description	Serial #	Cal. Date	Status
CTD Fish	Seabird SBE9Plus	1242	30-Jul-2015	Collected
Primary Temperature	Seabird SBE3	5786	29-Jul-2015	Collected
Secondary Temperature	Seabird SBE3	5851	29-Jul-2015	Collected
Primary Conductivity	Seabird SBE4	4380	29-Jul-2015	Collected
Secondary Conductivity	Seabird SBE4	4422	29-Jul-2015	Collected

Fluorometer	Wet Labs ECO	FLRTD-3928	24-Feb-2015	Collected
Transmissometer	Wet Labs C-Star	CST-1721	6-May-2015	Collected
Primary Oxygen	Seabird 43	3170	29-Jul-2015	Collected
Secondary Oxygen	Seabird 43	3178	25-Jul-2015	Collected
PAR	Biospherical Instruments Inc.	70558	13-May-2014	Collected
Altimeter	Valeport VA500	50580	n/a	Collected

MOCNESS Sensors

Sensor	Description	Serial #	Cal. Date	Status
Pressure Sensor	MOCNESS Depth Sensor	186	18-Nov-2010	Collected
Primary Temperature	Seabird SBE3S	2686	18-Jun-2008	Collected
Primary Conductivity	Seabird SBE4C	2047	23-Apr-2015	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 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
Solent Park
47 Gosport Street
Lymington
Hampshire
SO41 9EG, UK

T: +44 (0) 1590 613 500
F: +44 (0) 1590 613 501
E: orders@gill.co.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

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 Business Park
Whiteley
Hampshire
SO32 3GH, UK

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E: sales@gill.co.uk

www.gill.co.uk

ISO 9001 Registered

Barometer

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

CALIBRATION REPORT

Barometric Pressure

Customer: *Lockhood Martin Corp*

Test Number: 4410-01B
Test Date: 10 April 2014
Customer PO: 4800045952
Sales Order: 3886

Test Sensor:
Model: 61201
Serial Number: BP01150
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	2500	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:

METEOROLOGICAL INSTRUMENTS
Tel 231-946-3980 Fax 231-946-4772 Email: metsales@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 Corp*

Test Number: 4814-08T
Test Date: 14 August 2014
Customer PO: 4900051188
Sales Order: 4250

Test Sensor:
Model: 41372LC
Serial Number: *TS06133*
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)
-50.00	4.001	-49.99
-0.01	11.997	0.02
49.94	19.989	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 Instrumen:	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	4200646197

Tested By: _____

METEOROLOGICAL INSTRUMENTS
Tel 231-946 3980 Fax 231-946-4772 E-mail rmcsales@youngusa.com Website: Yourguse.com
ISO 9001:2008 CERTIFIED

PAR for mast

Biospherical Instruments Inc.

CALIBRATION CERTIFICATE

Calibration Date	3/31/2015			
Model Number	QSR240			
Serial Number	6393			
Operator	TPC			
Standard Lamp	V-033(3/3/15)			
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	97.9	mV
Probe Dark	0.4	mV
Probe Net Response	97.5	mV
RG780	0.4	mV

Corrected Lamp Output:

Output In Air (same condition as calibration):

9.391E+15	quanta/cm^{2}sec
155.94603	uE/m^{2}sec

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

Dry:	1.0379E-17	V/(quanta/cm^{2}sec)
	6.2504E-04	V/(uE/m^{2}sec)

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

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

STANDARDIZATION OF EPPLEY PRECISION INFRARED RADIOMETER Model PIR

Serial Number: 28903F3

Resistance: 675 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:

3.57×10^{-6} 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: 64325
Date: February 3, 2015

Date of Test: February 3, 2015

In Charge of Test: Julia L. Hunter

Reviewed by: Thomas J. Kirk

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 Precision Spectral Pyranometer, Model PSP, Serial Number 21231F3
Results:	**Sensitivity: $S = 8.13\ \mu V / Wm^{-2}$** Uncertainty: $U_{95} = \pm 0.91\%$ (95% confidence level, k=2) Resistance: 686 Ω at 23°C
	Date of Test: February 3, 2015
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: Reviewed by:
Eppley SO:	64325
Date of Certificate:	February 3, 2015
Remarks:	

End of Report

GUV

Biospherical Instruments Inc.

GUV-2511 Calibration Certificate

System Serial Number	25110805127	Date of Calibration	6/15/2015
Calibration database	25110805127v7.mdb	Date of Certificate	6/15/2015
DASSN	0111	Standard of Spectral Irradiance	V-033 (3/3/15)
Microprocessor Tag Number	2	Operator	TC

Monochromatic Channels	Address	Wavelength [nm]	Responsivity [Amps per µW/(cm²-nm)]	ScaleSmall [Volts per µW/(cm²-nm)]	ScaleMedium [Volts per µW/(cm²-nm)]	ScaleLarge [Volts per µW/(cm²-nm)]	OffsetSmall [volts]	OffsetMedium [volts]	OffsetLarge [volts]	Measurement Units
Ed0305	2	305	4.3412E-11	4.4645E-06	1.3124E-03	4.0159E-01	-4.4209E-04	-4.4843E-04	-5.4940E-04	µW/(cm²nm)
Ed0313	6	313	1.7792E-10	1.8120E-05	5.3084E-03	1.8643E+00	1.3446E-04	1.4032E-04	1.2464E-03	µW/(cm²nm)
Ed0320	8	320	2.5802E-10	2.6271E-05	7.7145E-03	2.5278E+00	-1.8351E-04	-1.8546E-04	6.7677E-05	µW/(cm²nm)
Ed0340	10	340	1.9800E-10	2.0210E-05	5.9050E-03	2.1161E+00	1.0116E-04	9.5762E-05	1.2388E-03	µW/(cm²nm)
Ed0380	12	380	7.0722E-11	7.2188E-06	2.1141E-03	7.2645E-01	-2.7743E-04	-2.8172E-04	-1.4003E-04	µW/(cm²nm)
Ed0395	13	395	2.7486E-10	2.8166E-05	8.2305E-03	2.8018E+00	-2.2586E-04	-2.2546E-04	-4.9964E-04	µW/(cm²nm)

Broadband Channels	Address	Wavelength [nm]	Responsivity [Amps per µE/(cm²-s)]	ScaleSmall [Volts per µE/(cm²-s)]	ScaleMedium [Volts per µE/(cm²-s)]	ScaleLarge [Volts per µE/(cm²-s)]	OffsetSmall [volts]	OffsetMedium [volts]	OffsetLarge [volts]	Measurement Units
Ed0PAR	18	400-700	1.6871E-05	1.6983E+00	4.9737E+02	1.6394E+05	-1.0804E-04	-1.0693E-04	6.2169E-04	µE/(cm²sec)

Auxiliary Channels	Address	Wavelength	Responsivity	ScaleS	ScaleM	ScaleL	OffsetS	OffsetM	OffsetL	Measurement Units
Ed0Temp	22	0	1	0.01	0.01	0.01	0	0	0	°C
Ed0Vin	27	0	1	-0.25	-0.25	-0.25	0	0	0	V

Calibration Data – Do Not Destroy page 2 of 2

Transmissometer

PO Box 518
620 Applegate St.
Philomath, OR 97370

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

C-Star Calibration

Date July 22, 2014 S/N# CST-830DR Pathlength 25cm

	Analog output
V_d	0.059 V
V_{air}	4.713 V
V_{ref}	4.622 V

Temperature of calibration water	22.4 °C
Ambient temperature during calibration	21.8 °C

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

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

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

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

Revision M 7/26/11

Thermosalinograph (Temperature) – 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

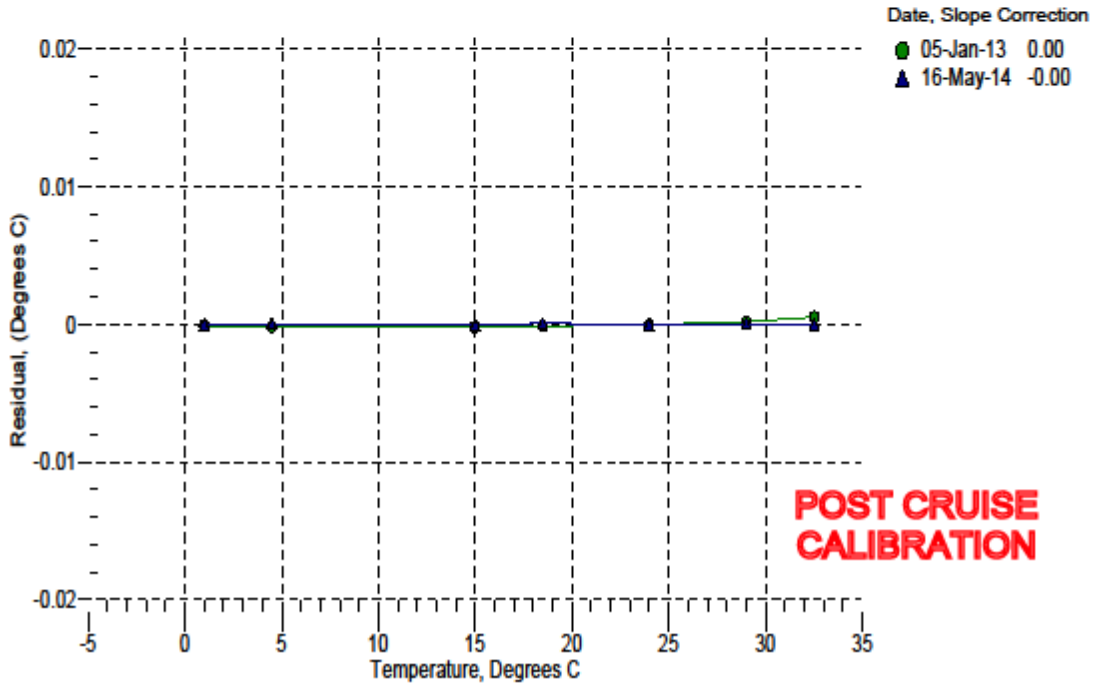
SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

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

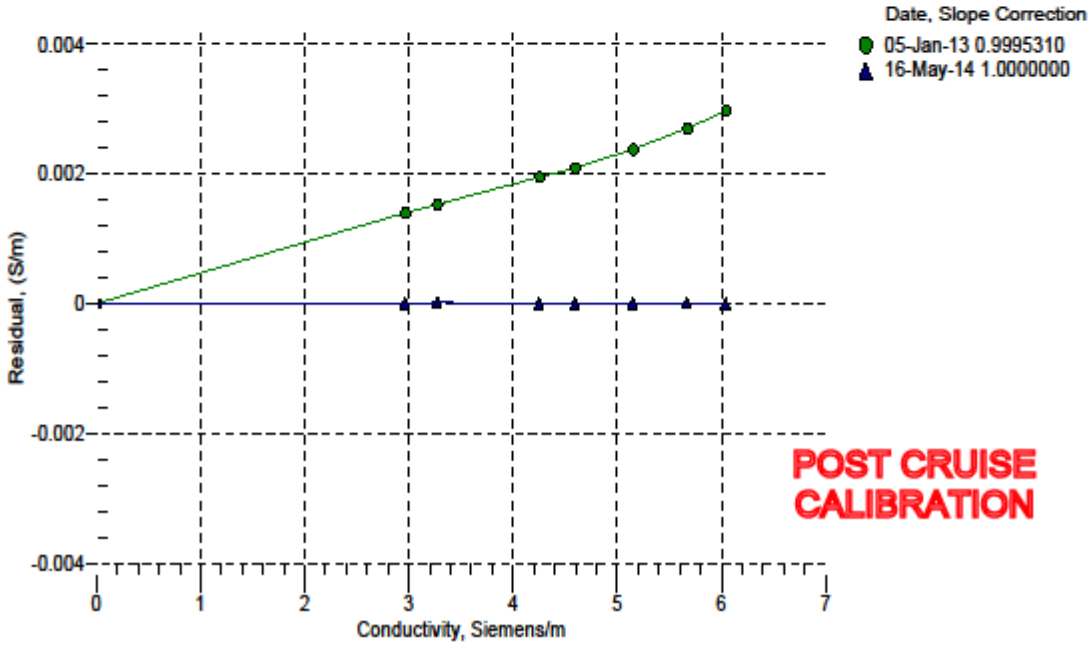
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2536.23	0.00000	0.00000
1.0000	34.6704	2.96468	5031.60	2.96467	-0.00001
4.5000	34.6504	3.27061	5221.13	3.27062	0.00001
15.0000	34.6078	4.24873	5784.74	4.24873	-0.00000
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

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

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

Residual = instrument conductivity - bath conductivity



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: 0390
CALIBRATION DATE: 30-Oct-14

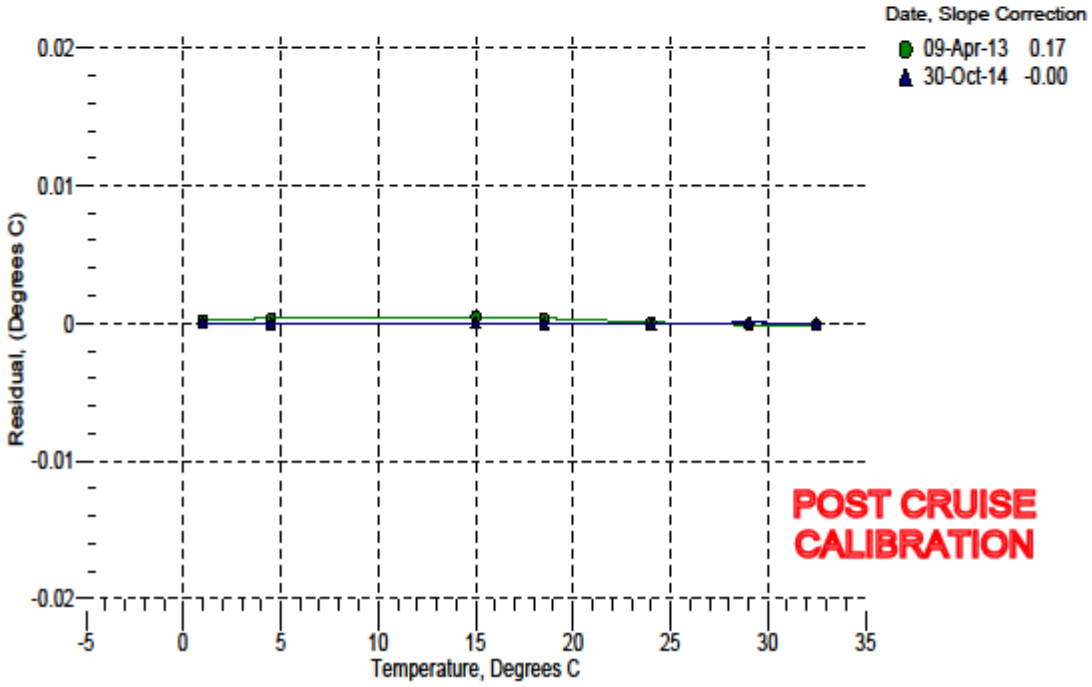
SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

a0 = 8.496577e-006
a1 = 2.825921e-004
a2 = -3.093430e-006
a3 = 1.690910e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	662306.1	1.0000	0.0000
4.5000	565262.5	4.5000	-0.0000
15.0000	358389.6	15.0000	0.0000
18.5000	309815.7	18.5000	-0.0000
24.0000	247915.6	23.9999	-0.0001
29.0000	203683.3	29.0001	0.0001
32.5000	178100.4	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) – 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: 0390
CALIBRATION DATE: 30-Oct-14

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

COEFFICIENTS:

g = -9.863328e-001	CPcor = -9.5700e-008
h = 1.453844e-001	CTcor = 3.2500e-006
i = -4.104173e-004	WBOTC = 2.8724e-007
j = 5.237151e-005	

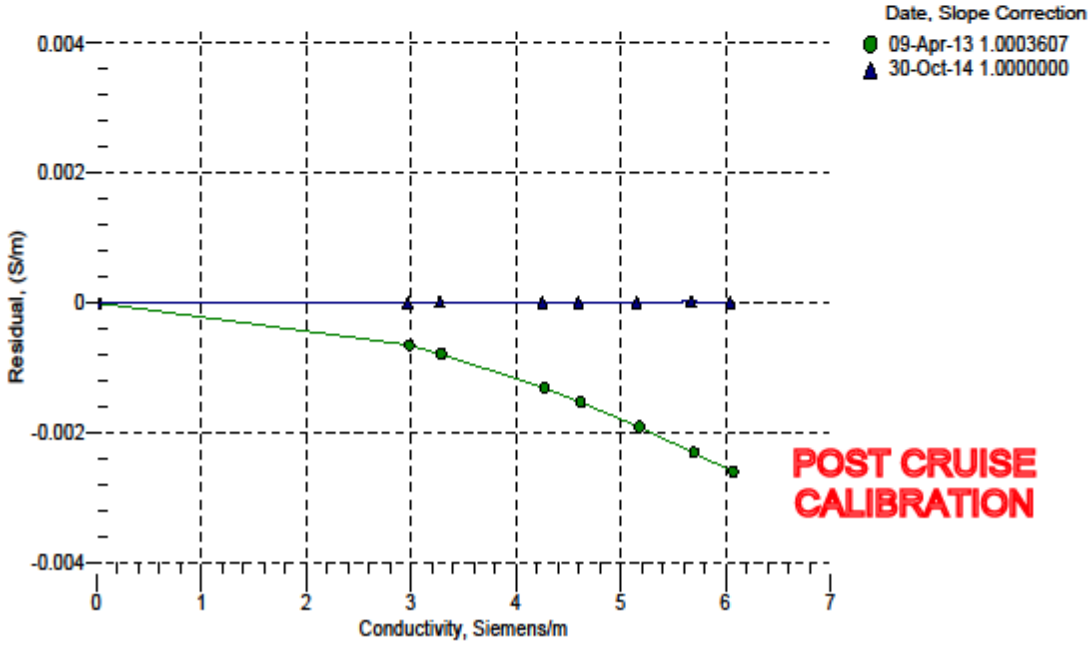
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2611.09	0.00000	0.00000
1.0000	34.6932	2.96644	5227.11	2.96644	-0.00000
4.5000	34.6730	3.27253	5425.21	3.27254	0.00001
15.0000	34.6287	4.25103	6014.01	4.25103	-0.00000
18.5000	34.6182	4.59492	6207.39	4.59491	-0.00000
24.0000	34.6058	5.15076	6507.48	5.15076	-0.00000
29.0000	34.5974	5.67049	6775.69	5.67050	0.00001
32.5000	34.5926	6.04138	6960.54	6.04137	-0.00001

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

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

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

Residual = instrument conductivity - bath conductivity



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

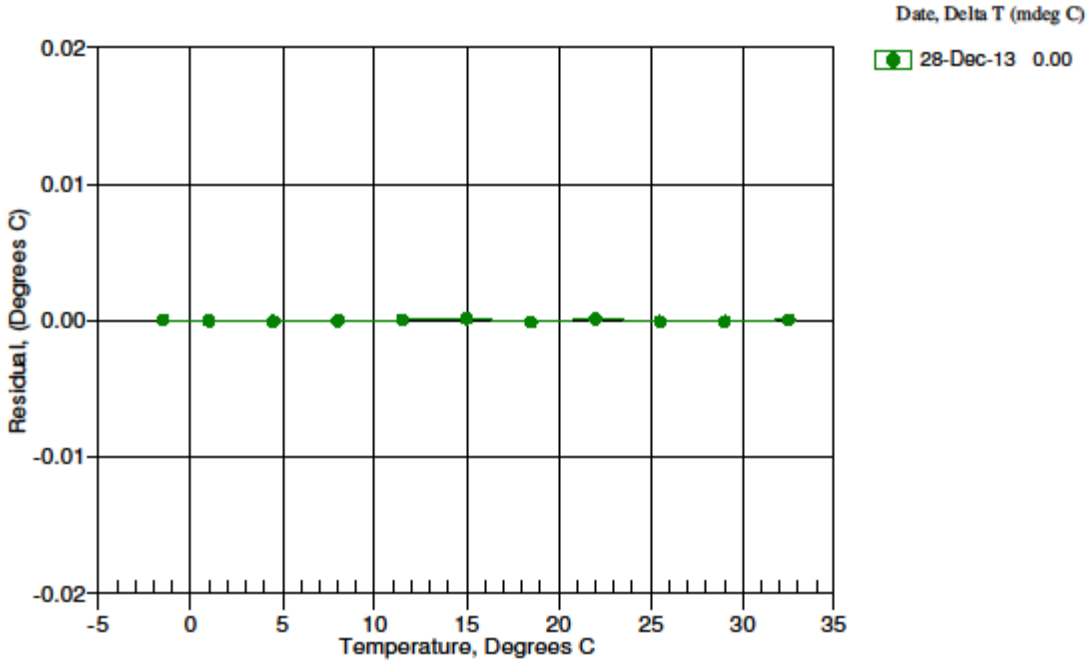
ITS-90 COEFFICIENTS

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

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

ECO Chlorophyll Fluorometer Characterization Sheet

Date: 10/24/2014 S/N: FLRTD-380

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	0.109	0.062	0.040 V	75 counts
Scale Factor (SF)	7	14	28 µg/l/V	0.0084 µg/l/count
Maximum Output	4.97	4.97	4.97 V	16326 counts
Resolution	0.6	0.6	0.6 mV	0.7 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.

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CTD Calibration Sheets

CTD Fish (Pressure Sensor)

Sea-Bird Electronics, Inc.
13431 NE 20th Street, Bellevue, WA 98005-2010 USA
Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0232
CALIBRATION DATE: 20-Feb-15

SBE 9plus PRESSURE CALIBRATION DATA
FSR: 10000 psia S/N 43528

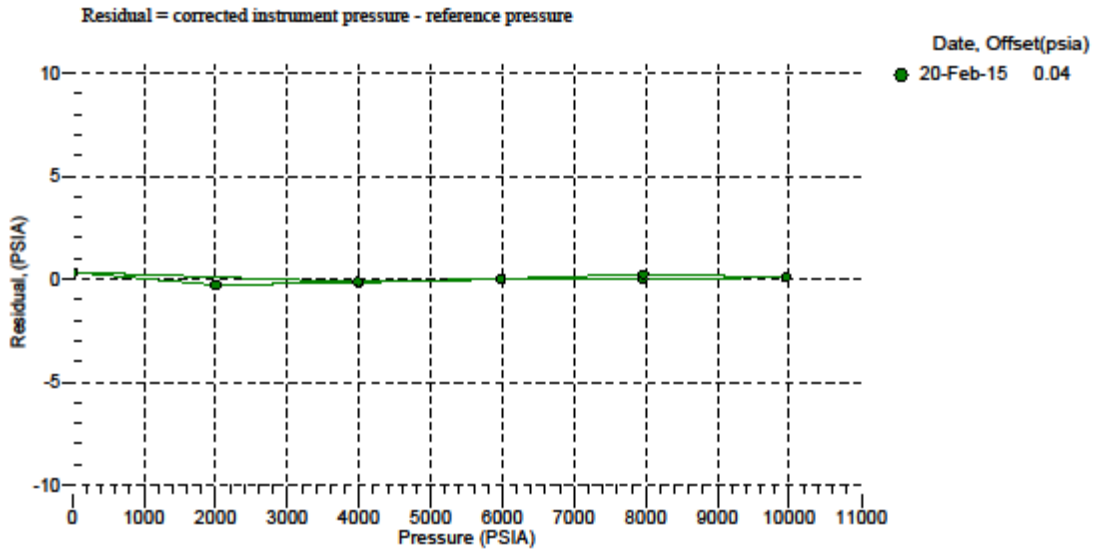
DIGIQUARTZ COEFFICIENTS:

C1 =	-5.103000e+004
C2 =	8.606365e-002
C3 =	1.481220e-002
D1 =	3.642300e-002
D2 =	0.000000e+000
T1 =	3.004925e+001
T2 =	-3.406308e-004
T3 =	4.125600e-006
T4 =	1.811600e-009
T5 =	0.000000e+000

AD590M, AD590B, SLOPE AND OFFSET:

AD590M =	1.13600e-002
AD590B =	-8.42350e+000
Slope =	0.99991
Offset =	1.8905 (dbars)

PRESSURE (PSIA)	INST OUTPUT (Hz)	INST TEMP (C)	INST OUTPUT (PSIA)	CORRECTED INST OUTPUT (PSIA)	RESIDUAL (PSIA)
14.750	33288.70	21.5	12.337	15.079	0.329
2001.642	33929.50	21.6	1998.788	2001.360	-0.282
3988.590	34556.90	21.6	3986.035	3988.437	-0.153
5975.530	35171.40	21.7	5973.284	5975.516	-0.014
7962.665	35773.70	21.7	7960.587	7962.649	-0.016
9950.060	36364.50	21.8	9948.248	9950.140	0.080
7962.700	35773.80	21.8	7960.870	7962.932	0.232
5975.713	35171.50	21.9	5973.494	5975.726	0.013
3988.746	34557.00	21.9	3986.197	3988.599	-0.147
2001.853	33929.60	21.9	1998.909	2001.481	-0.372
14.748	33288.80	22.0	12.339	15.081	0.333



Temperature (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: 2205
CALIBRATION DATE: 23-Jun-15

SBE 3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

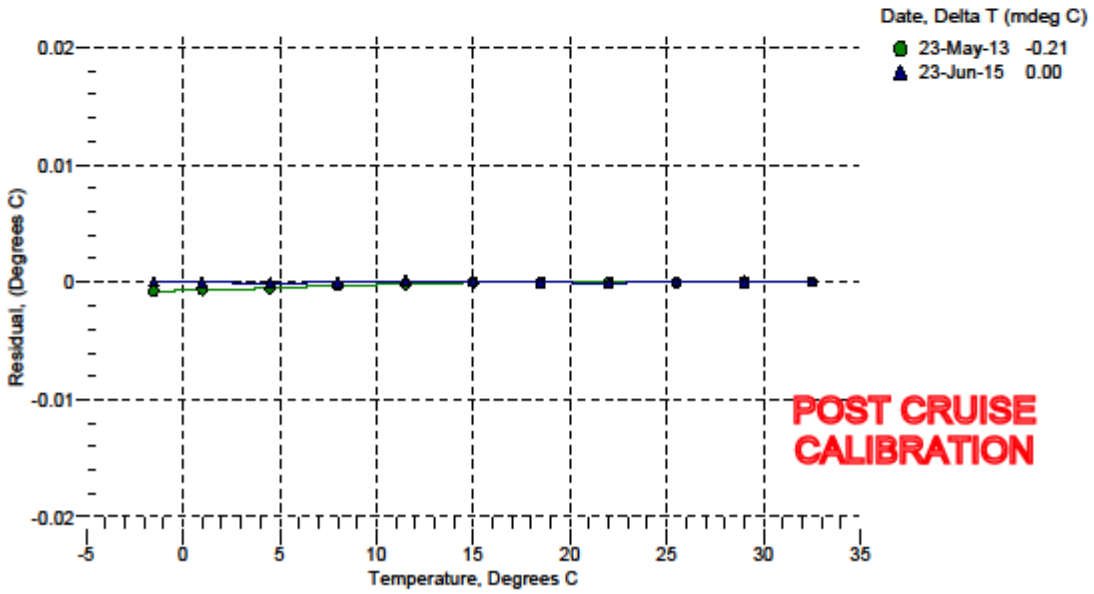
ITS-90 COEFFICIENTS:

g = 4.34892263e-003
h = 6.48065456e-004
i = 2.34340729e-005
j = 2.17544063e-006
f0 = 1000.0

BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	2907.927	-1.5000	0.00004
0.9999	3073.950	0.9999	-0.00001
4.5000	3317.754	4.4999	-0.00010
7.9999	3575.139	7.9999	-0.00002
11.4999	3846.479	11.5000	0.00010
14.9999	4132.103	15.0000	0.00008
18.5000	4432.359	18.5000	-0.00005
21.9999	4747.568	21.9998	-0.00007
25.4999	5078.074	25.4999	0.00002
28.9999	5424.148	28.9999	-0.00003
32.4999	5786.107	32.4999	0.00003

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



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: 5034
CALIBRATION DATE: 22-Apr-15

SBE 3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

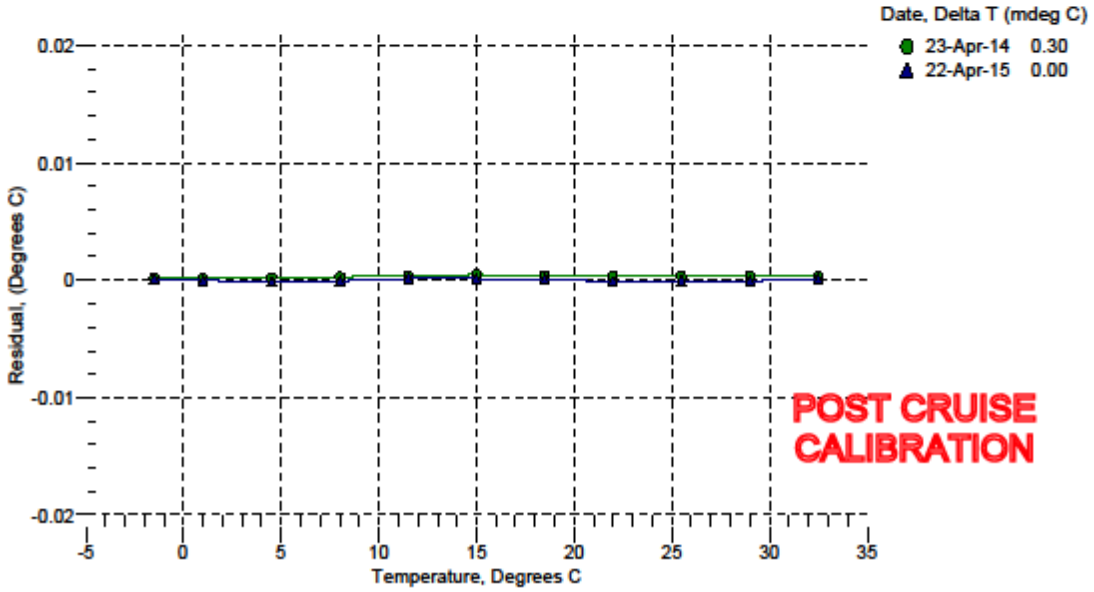
ITS-90 COEFFICIENTS:

g = 4.33949004e-003
h = 6.35934233e-004
i = 2.12493401e-005
j = 1.91460518e-006
f0 = 1000.0

BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5001	2914.478	-1.5000	0.00006
0.9999	3083.281	0.9999	-0.00001
4.5000	3331.338	4.4999	-0.00011
8.0000	3593.431	7.9999	-0.00009
11.4999	3869.949	11.5000	0.00012
14.9999	4161.250	15.0000	0.00013
18.4999	4467.696	18.5000	0.00006
22.0000	4789.644	21.9999	-0.00011
25.5000	5127.445	25.4999	-0.00008
29.0000	5481.414	28.9999	-0.00005
32.4999	5851.868	32.5000	0.00009

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



Conductivity (Primary)

SEA-BIRD ELECTRONICS, INC.
13431 NE 20th Street Bellevue, Washington 98005 USA
Phone: (425) 643-9866 Fax: (425) 643-9954 www.seabird.com

Conductivity Calibration Report

Customer:	Lockheed Martin Antarctic Support		
Job Number:	82646	**Date of Report:**	3/3/2015
Model Number	SBE 04-01/0	**Serial Number:**	040350

Conductivity sensors are normally calibrated 'as received', without cleaning or adjustments, allowing a determination of sensor drift. If the calibration identifies a problem or indicates cell cleaning is necessary, then a second calibration is performed after work is completed. The 'as received' calibration is not performed if the sensor is damaged or non-functional, or by customer request.

An 'as received' calibration certificate is provided, listing the coefficients used to convert sensor frequency to conductivity. Users must choose whether the 'as received' calibration or the previous calibration better represents the sensor condition during deployment. In SEASOFT enter the chosen coefficients. The coefficient 'slope' allows small corrections for drift between calibrations (consult the SEASOFT manual). Calibration coefficients obtained after a repair or cleaning apply only to subsequent data.

'AS RECEIVED CALIBRATION' ☑ Performed ☐ Not Performed

Date: 2/20/2015 **Drift since last cal:** 0.0000 **PSU/month**

Comments:

'FINAL CALIBRATION' ☑ Performed ☐ Not Performed

Date: 3/3/2015 **Drift since 11 Sep 12** 0.0000 **PSU/month**

Comments:
The connector was upgraded to wet-pluggable type.

**Measured at 3.0 S/m*

Cell cleaning and electrode replatinizing tend to 'reset' the conductivity sensor to its original condition. Lack of drift in post-cleaning-calibration indicates geometric stability of the cell and electrical stability of the sensor circuit.

Conductivity (Secondary)

SEA-BIRD ELECTRONICS, INC.
13431 NE 20th Street Bellevue, Washington 98005 USA
Phone: (425) 643-9866 Fax: (425) 643-9954 www.seabird.com

Conductivity Calibration Report

Customer:	Lockheed Martin Antarctic Support		
Job Number:	78996	**Date of Report:**	12/9/2014
Model Number	SBE 04-02/0	**Serial Number:**	041223

Conductivity sensors are normally calibrated 'as received', without cleaning or adjustments, allowing a determination of sensor drift. If the calibration identifies a problem or indicates cell cleaning is necessary, then a second calibration is performed after work is completed. The 'as received' calibration is not performed if the sensor is damaged or non-functional, or by customer request.

An 'as received' calibration certificate is provided, listing the coefficients used to convert sensor frequency to conductivity. Users must choose whether the 'as received' calibration or the previous calibration better represents the sensor condition during deployment. In SEASOFT enter the chosen coefficients. The coefficient 'slope' allows small corrections for drift between calibrations (consult the SEASOFT manual). Calibration coefficients obtained after a repair or cleaning apply only to subsequent data.

'AS RECEIVED CALIBRATION' ☑ Performed ☐ Not Performed

Date: 12/3/2014 **Drift since last cal:** 0.0000 **PSU/month**

Comments:

'FINAL CALIBRATION' ☑ Performed ☐ Not Performed

Date: 12/9/2014 **Drift since 04 Apr 13** -0.00010 **PSU/month**

Comments:
The connector was upgraded.

**Measured at 3.0 S/m*

Cell cleaning and electrode replatinizing tend to 'reset' the conductivity sensor to its original condition. Lack of drift in post-cleaning-calibration indicates geometric stability of the cell and electrical stability of the sensor circuit.

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

PO Box 518
620 Applegate St.
Philomath, OR 97370

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

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

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: 0190
CALIBRATION DATE: 22-Apr-15

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS:
Soc = 0.5305
Voffset = -0.5193
Tau20 = 1.16
A = -4.4841e-003
B = 2.0670e-004
C = -2.8403e-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

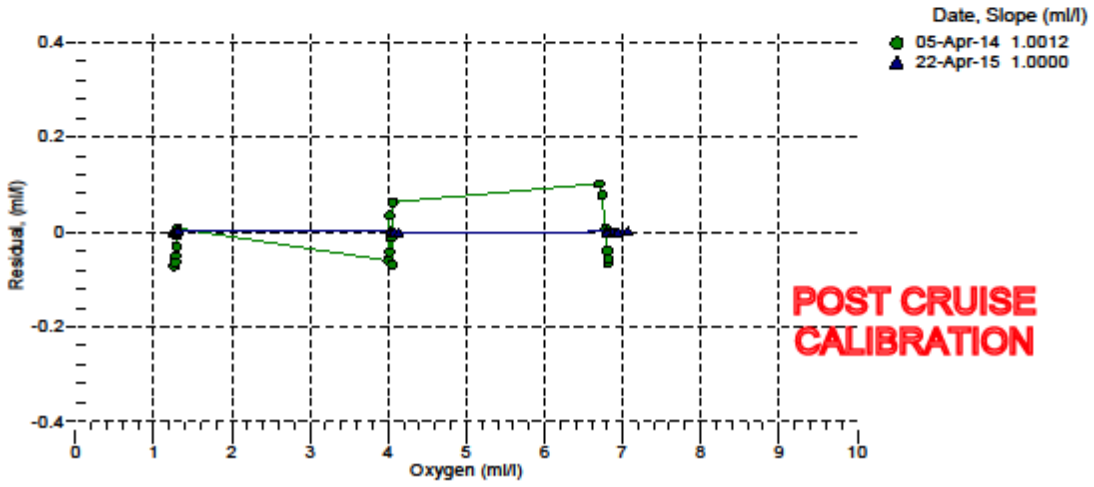
BATH OX (ml/l)	BATH TEMP (ITS-90)	BATH SAL (PSU)	INSTRUMENT OUTPUT (VOLTS)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.24	2.00	0.00	0.763	1.24	-0.00
1.26	6.00	0.00	0.797	1.26	-0.00
1.27	12.00	0.00	0.845	1.27	-0.00
1.30	26.00	0.00	0.963	1.30	0.00
1.30	20.00	0.00	0.918	1.30	0.00
1.31	30.00	0.00	0.999	1.31	0.00
4.02	12.00	0.00	1.555	4.02	0.00
4.02	2.00	0.00	1.309	4.02	-0.00
4.02	6.00	0.00	1.408	4.02	-0.00
4.06	20.00	0.00	1.760	4.06	-0.00
4.09	26.00	0.00	1.913	4.08	-0.00
4.13	30.00	0.00	2.029	4.13	-0.00
6.79	2.00	0.00	1.853	6.79	0.00
6.80	6.00	0.00	2.021	6.80	0.00
6.80	12.00	0.00	2.270	6.80	-0.00
6.88	20.00	0.00	2.620	6.88	0.00
6.94	26.00	0.00	2.886	6.94	-0.00
7.07	30.00	0.00	3.105	7.07	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: 0196
CALIBRATION DATE: 22-Apr-15

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS:
Soc = 0.4866
Voffset = -0.5243
Tau20 = 1.55

A = -4.7188e-003
B = 2.5087e-004
C = -3.6024e-006
E nominal = 0.036

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

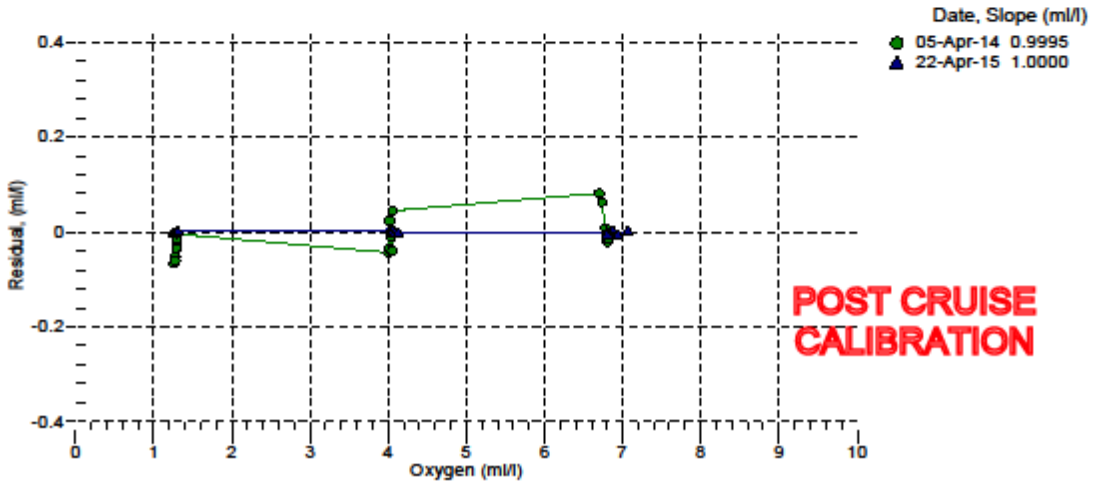
BATH OX (ml/l)	BATH TEMP (ITS-90)	BATH SAL (PSU)	INSTRUMENT OUTPUT (VOLTS)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.24	2.00	0.00	0.791	1.24	-0.00
1.26	6.00	0.00	0.827	1.26	-0.00
1.27	12.00	0.00	0.879	1.27	-0.00
1.30	26.00	0.00	1.002	1.30	0.00
1.30	20.00	0.00	0.955	1.30	0.00
1.31	30.00	0.00	1.040	1.31	0.00
4.02	12.00	0.00	1.652	4.03	0.00
4.02	2.00	0.00	1.386	4.03	0.00
4.02	6.00	0.00	1.493	4.02	-0.00
4.06	20.00	0.00	1.869	4.07	0.00
4.09	26.00	0.00	2.027	4.08	-0.00
4.13	30.00	0.00	2.151	4.13	-0.00
6.79	2.00	0.00	1.979	6.79	-0.00
6.80	6.00	0.00	2.161	6.80	0.00
6.80	12.00	0.00	2.428	6.80	-0.00
6.88	20.00	0.00	2.800	6.88	0.00
6.94	26.00	0.00	3.076	6.93	-0.01
7.07	30.00	0.00	3.309	7.07	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



PAR

Biospherical Instruments Inc

CALIBRATION CERTIFICATE

UNDERWATER PAR SENSOR WITH LOG AMPLIFIER

Calibration Date: 02/17/15 **Job No.:** R12167
Model Number: QSP2300
Serial Number: 4722
Operator: TPC
Standard Lamp: V-033(3/7/12)
Operating Voltage Range: 6 to 15 VDC (+)

Note: The QSP2300 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:	**2.50E+13**	**quanta/cm²·sec/"amps"**	**4.15E-05**	**µEinsteins/cm²·sec/"amps"**
Wet Calibration Factor:	**4.41E+13**	**quanta/cm²·sec/"amps"**	**7.32E-05**	**µEinsteins/cm²·sec/"amps"**

Sensor Test Data and Results[4)]

Sensor Supply Current (Dark):	85.4	mA			
Supply Voltage:	6	Volts			
Lamp Integrated PAR Irradiance:	9.34E+15	quanta/cm²·sec	0.01551	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)	Est mated Signal (Amps)	Ca.c. Output (Volts)	Error (Volts)	Error (%)	Test Irrad. (quanta/ cm²·sec)
No Filter	100.00%	2.575	100.00%	3.76E-08	3.76E-08	2.577	0.002	0.0	9.34E+15
0.3	36.10%	2.138	36.27%	1.36E-08	1.36E-08	2.137	0.000	-0.5	3.39E+15
0.5	27.60%	2.023	27.77%	1.04E-08	1.04E-08	2.022	-0.001	-0.6	2.59E+15
1	9.27%	1.564	9.37%	3.52E-09	3.48E-09	1.561	-0.003	-1.1	8.76E+14
2	1.11%	0.762	1.12%	4.22E-10	4.17E-10	0.760	-0.002	-1.2	1.05E+14
3	0.05%	0.270	0.07%	2.81E-11	2.01E-11	0.251	-0.019	-28.7	6.99E+12

Dark Before:	0.199	Volts				
Light - No Filter Hldr.:	2.575	Volts	I_{Ref} =	1.00E-10 Amps		
Dark After - NFH:	0.199	Volts	I_{Dark} =	1.58E-10 Amps	RG780	0.2196
Average Dark	0.199	Volts	$10^{V_{Dark}}$ =	1.581248 Amps		

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

Trace Metal Clean CTD Calibration Sheets

CTD Fish (Pressure Sensor)

SEA-BIRD ELECTRONICS, INC.
13431 NE 20th St, Bellevue Washington 98005 USA
Phone: (425) 643-9866 Fax: (425) 643-9954 Email: seabird@seabird.com

Digiquartz Pressure Calibration dP/dT Corrected Coefficients
(Changed coefficients are posted in italics)

Pressure Transducer Serial Number: 134250
Original Calibration Date: 30-Jul-15
Date of Correction: 2015-08-06
Installed in: SBE 9Plus S/N 1242

PRESSURE COEFFICIENTS

C1	*-41778.7*	*psia*
C2	*-0.8067902*	*psia/deg C*
C3	1.306520e-002	psia/deg C^2
D1	3.716100e-002	
D2	0.000000e+000	
T1	*30.07602*	*µsec*
T2	*-5.29399e-04*	*µsec/deg C*
T3	4.018760e-006	µsec/deg C^2
T4	2.640250e-009	µsec/deg C^3
T5	0.000000e+000	

Slope = 1.0
Offset = 0.0

Corrected at Sea-Bird Electronics as per Paroscientific Calibration and Sea-Bird Electronics dP/dT tests. The original calibration from Paroscientific assumes an operating temperature range of 0 to 125 degrees C. dP/dT correction adjusts this operating range to a nominal range of 0 to 22 degrees C. This increases the accuracy of the transducer in this temperature range.

NOTE: Original coefficients from Paroscientific are attached to this form for informational purposes and should not be used.

Temperature (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: 5786
CALIBRATION DATE: 29-Jul-15

SBE 3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

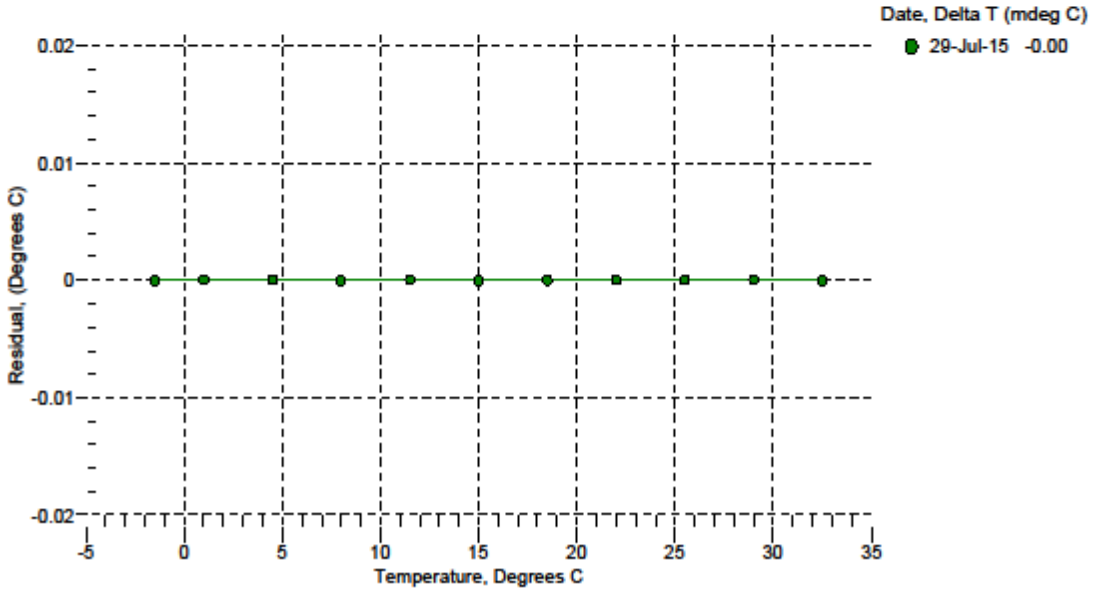
ITS-90 COEFFICIENTS:

g = 4.36742000e-003
h = 6.41014428e-004
i = 2.26822855e-005
j = 2.09417815e-006
f0 = 1000.0

BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	3033.187	-1.5000	-0.00003
1.0000	3208.472	1.0000	0.00004
4.5000	3466.031	4.5000	0.00003
8.0000	3738.148	8.0000	-0.00004
11.5000	4025.234	11.5000	0.00001
15.0000	4327.659	15.0000	-0.00001
18.5000	4645.806	18.5000	-0.00002
22.0000	4980.041	22.0000	0.00002
25.5000	5330.705	25.5000	0.00001
29.0000	5698.141	29.0000	0.00002
32.5000	6082.667	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



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: 5851
CALIBRATION DATE: 29-Jul-15

SBE 3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

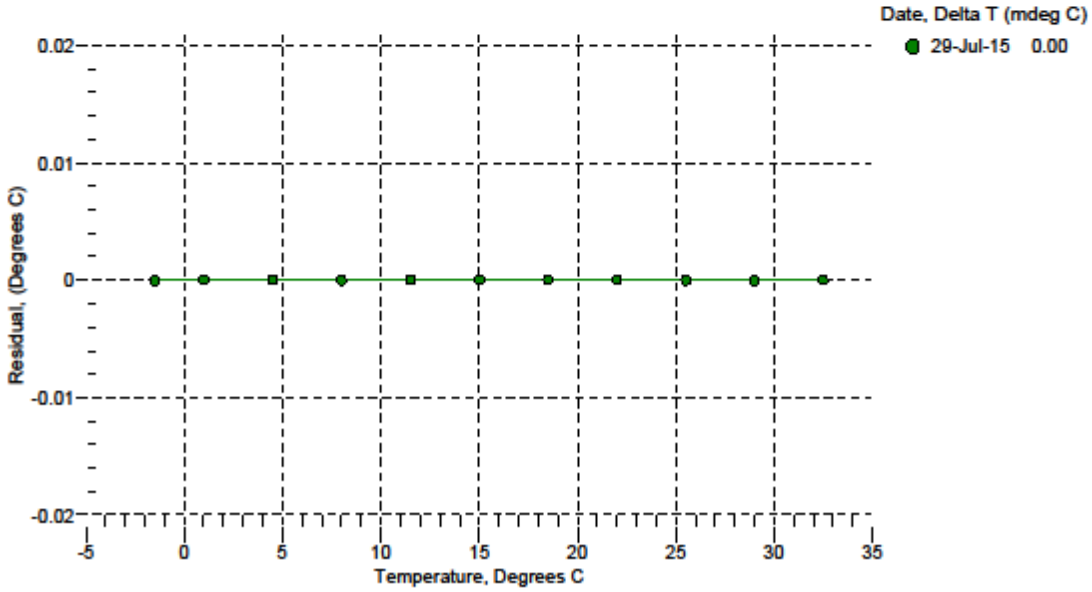
ITS-90 COEFFICIENTS:

g = 4.37306454e-003
h = 6.40139994e-004
i = 2.26788412e-005
j = 2.14922155e-006
f0 = 1000.0

BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	3066.542	-1.5000	-0.00002
1.0000	3244.056	1.0000	0.00004
4.5000	3504.905	4.5000	0.00000
8.0000	3780.518	8.0000	-0.00005
11.5000	4071.305	11.5000	0.00001
15.0000	4377.644	15.0000	0.00001
18.5000	4699.917	18.5000	0.00002
22.0000	5038.489	22.0000	0.00002
25.5000	5393.708	25.5000	-0.00001
29.0000	5765.916	29.0000	-0.00005
32.5000	6155.450	32.5000	0.00003

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



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: 4380
CALIBRATION DATE: 29-Jul-15

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

COEFFICIENTS:

```
g =  -9.92565304e+000
h =   1.37955589e+000
i =  -7.72858999e-004
j =   1.21390671e-004

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

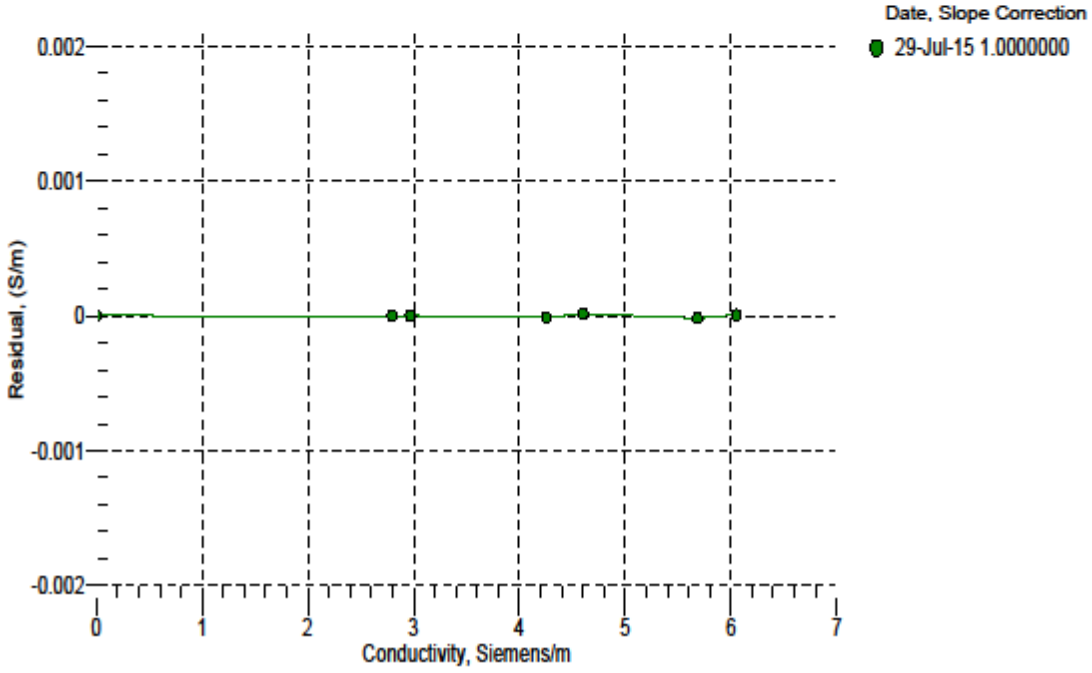
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.68348	0.00000	0.00000
-1.0001	34.6557	2.79283	5.23960	2.79283	-0.00000
0.9999	34.6601	2.96387	5.35657	2.96388	0.00000
14.9999	34.6673	4.25526	6.16810	4.25524	-0.00001
18.4999	34.6721	4.60129	6.36792	4.60131	0.00002
28.9999	34.6781	5.68221	6.95485	5.68220	-0.00002
32.5000	34.6779	6.05458	7.14580	6.05459	0.00001

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



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: 4422
CALIBRATION DATE: 29-Jul-15

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

COEFFICIENTS:

```
g =  -9.82326842e+000
h =   1.70759288e+000
i =  -1.10989412e-003
j =   1.85202702e-004

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

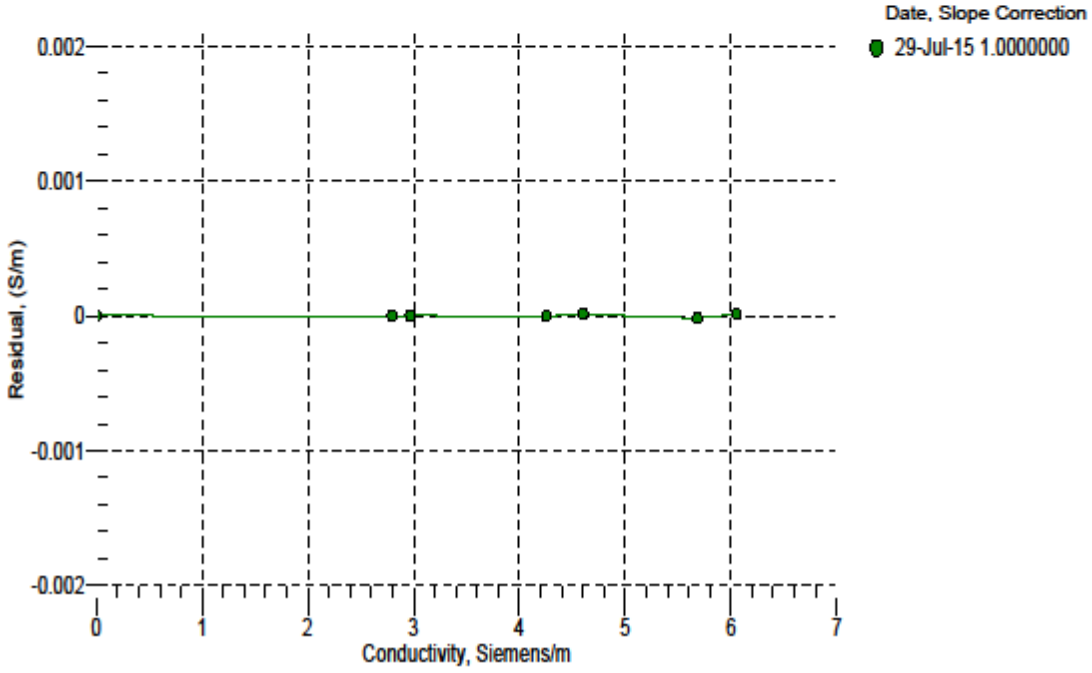
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.39960	0.00000	0.00000
-1.0001	34.6557	2.79283	4.70346	2.79283	-0.00000
0.9999	34.6601	2.96387	4.80875	2.96388	0.00000
14.9999	34.6673	4.25526	5.53912	4.25525	-0.00000
18.4999	34.6721	4.60129	5.71892	4.60130	0.00001
28.9999	34.6781	5.68221	6.24701	5.68220	-0.00002
32.5000	34.6779	6.05458	6.41881	6.05459	0.00001

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



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: 2/24/2015 S/N: FLRTD-3928

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	0.070	0.040	0.026 V	49 counts
Scale Factor (SF)	6	13	25 µg/l/V	0.0076 µg/l/count
Maximum Output	4.96	4.96	4.96 V	16380 counts
Resolution	1.0	1.0	1.0 mV	1.0 counts

Ambient temperature during characterization 21.0 °C

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

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

SF: Determined using the following equation: 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-3928.xls Revision J 3/17/08

Transmissometer

PO Box 518
620 Applegate St.
Philomath, OR 97370

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

WET Labs

C-Star Calibration

Date 5.6.15 S/N# CST-1721DR Pathlength 25cm

	Analog output	Digital output
V_d	0.007 V	0 counts
V_{air}	4.824 V	15804 counts
V_{ref}	4.703 V	15406 counts

Temperature of calibration water	21.7 °C
Ambient temperature during calibration	21.2 °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

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: 3170
CALIBRATION DATE: 29-Jul-15

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS:	A = -3.9345e-003	NOMINAL DYNAMIC COEFFICIENTS	
Soc = 0.3646	B = 2.4005e-004	D1 = 1.92634e-4	H1 = -3.300000e-2
Voffset = -0.4895	C = -3.5486e-006	D2 = -4.64803e-2	H2 = 5.00000e+3
Tau20 = 1.42	E nominal = 0.036		H3 = 1.45000e+3

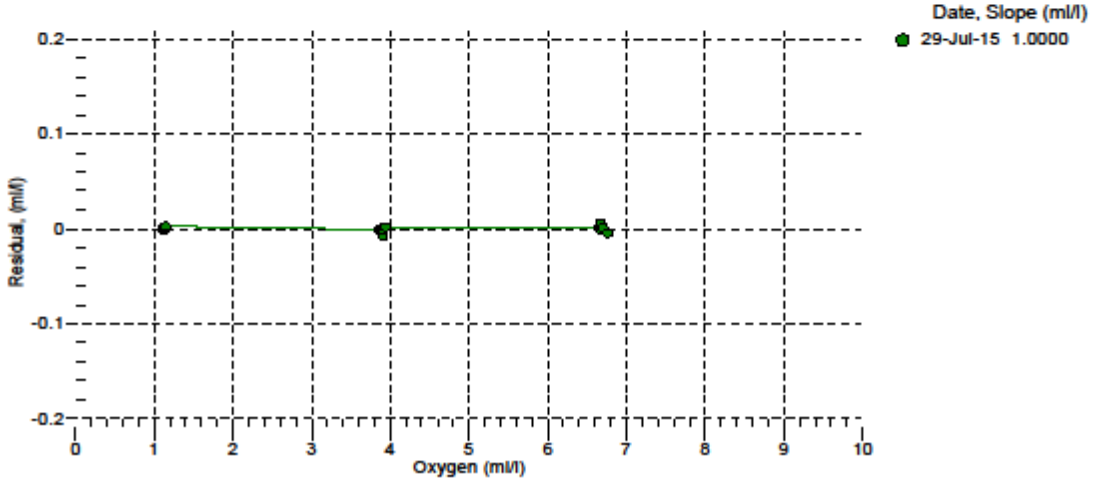
BATH OX (ml/l)	BATH TEMP (ITS-90)	BATH SAL (PSU)	INSTRUMENT OUTPUT (VOLTS)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.10	2.00	0.00	0.805	1.10	-0.00
1.14	5.82	0.00	0.852	1.14	0.00
1.14	26.00	0.00	1.041	1.14	0.00
1.14	12.00	0.00	0.914	1.14	-0.00
1.15	30.00	0.00	1.083	1.15	0.00
1.15	20.00	0.00	0.991	1.15	0.00
3.86	2.00	0.00	1.591	3.86	-0.00
3.88	5.92	0.00	1.729	3.88	-0.00
3.91	30.00	0.00	2.508	3.90	-0.01
3.91	12.00	0.00	1.939	3.91	-0.00
3.91	20.00	0.00	2.196	3.91	0.00
3.94	26.00	0.00	2.398	3.94	0.00
6.65	12.00	0.00	2.955	6.65	0.00
6.66	6.00	0.00	2.621	6.66	-0.00
6.68	2.00	0.00	2.395	6.68	0.00
6.68	30.00	0.00	3.947	6.68	0.01
6.70	20.00	0.00	3.411	6.70	0.00
6.76	26.00	0.00	3.760	6.75	-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: 3178
CALIBRATION DATE: 25-Jul-15

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS:
Soc = 0.3979
Voffset = -0.7065
Tau20 = 2.17
A = -3.7722e-003
B = 1.6610e-004
C = -2.7127e-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

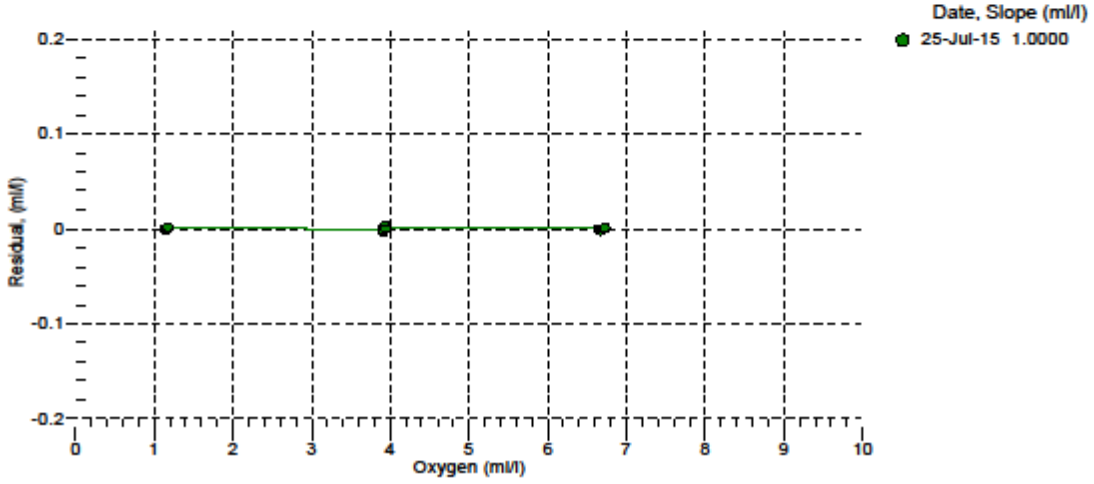
BATH OX (ml/l)	BATH TEMP (ITS-90)	BATH SAL (PSU)	INSTRUMENT OUTPUT (VOLTS)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.13	2.00	0.00	1.002	1.13	0.00
1.14	5.81	0.00	1.040	1.14	0.00
1.15	12.00	0.00	1.099	1.15	-0.00
1.15	26.00	0.00	1.234	1.15	-0.00
1.16	20.00	0.00	1.181	1.16	-0.00
1.17	30.00	0.00	1.285	1.17	0.00
3.90	2.00	0.00	1.726	3.90	-0.00
3.91	5.93	0.00	1.852	3.91	0.00
3.91	26.00	0.00	2.498	3.91	-0.00
3.92	12.00	0.00	2.046	3.91	-0.00
3.93	30.00	0.00	2.648	3.94	0.00
3.94	20.00	0.00	2.312	3.94	0.00
6.65	12.00	0.00	2.982	6.65	0.00
6.66	6.00	0.00	2.663	6.66	-0.00
6.68	2.00	0.00	2.452	6.68	0.00
6.68	30.00	0.00	4.000	6.68	-0.00
6.70	20.00	0.00	3.436	6.70	0.00
6.73	26.00	0.00	3.789	6.73	0.00

$Oxygen\ (ml/l) = Soc * (V + Voffset) * (1.0 + A * T + B * T^2 + C * T^3) * OxSol(T,S) * \exp(E * P / K)$

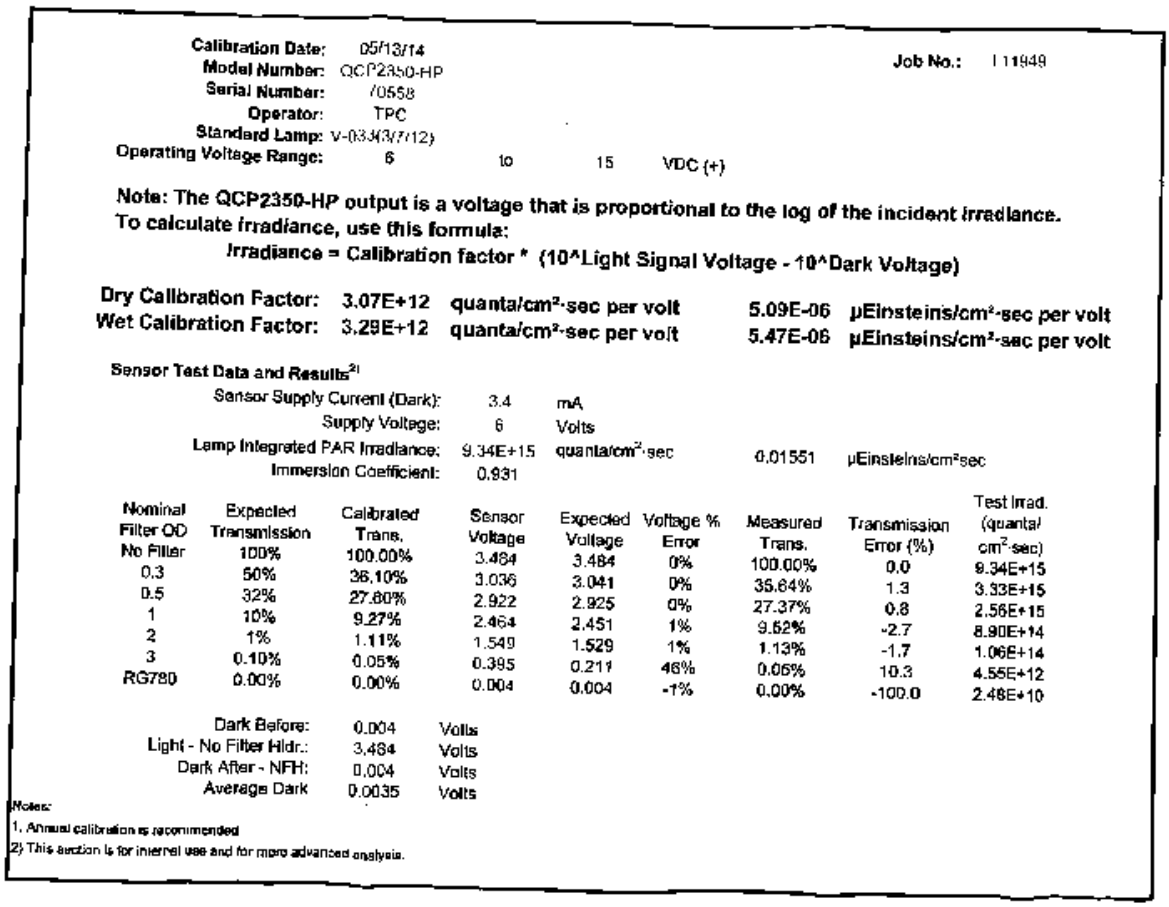
V = voltage output from SBE43, T = temperature [deg C], S = salinity [PSU], K = temperature [deg K]

OxSol(T,S) = oxygen saturation [ml/l], P = pressure [dbar]

Residual = instrument oxygen - bath oxygen



PAR



Calibration Date: 05/13/14
Model Number: QCP2350-HP
Serial Number: 70558
Operator: TPC
Standard Lamp: V-0334(3/712)
Operating Voltage Range: 6 to 15 VDC (+)

Job No.: 111949

Note: The QCP2350-HP output is a voltage that is proportional to the log of the incident irradiance.
To calculate irradiance, use this formula:
Irradiance = Calibration factor * (10^Light Signal Voltage - 10^Dark Voltage)

Dry Calibration Factor: 3.07E+12 quanta/cm²·sec per volt 5.09E-06 µEinsteins/cm²·sec per volt
Wet Calibration Factor: 3.29E+12 quanta/cm²·sec per volt 5.47E-06 µEinsteins/cm²·sec per volt

Sensor Test Data and Results[2]

Sensor Supply Current (Dark): 3.4 mA
Supply Voltage: 6 Volts
Lamp Integrated PAR Irradiance: 9.34E+15 quanta/cm²·sec 0.01551 µEinsteins/cm²sec
Immersion Coefficient: 0.931

Nominal Filter OD	Expected Transmission	Calibrated Trans.	Sensor Voltage	Expected Voltage	Voltage % Error	Measured Trans.	Transmission Error (%)	Test Irrad. (quanta/ cm²·sec)
No Filter	100%	100.00%	3.484	3.484	0%	100.00%	0.0	9.34E+15
0.3	50%	36.10%	3.036	3.041	0%	35.64%	1.3	3.33E+15
0.5	32%	27.60%	2.922	2.925	0%	27.37%	0.8	2.56E+15
1	10%	9.27%	2.464	2.451	1%	9.52%	-2.7	8.90E+14
2	1%	1.11%	1.549	1.529	1%	1.13%	-1.7	1.06E+14
3	0.10%	0.05%	0.395	0.211	46%	0.06%	10.3	4.55E+12
RG780	0.00%	0.00%	0.004	0.004	-1%	0.00%	-100.0	2.48E+10

Dark Before: 0.004 Volts
Light - No Filter Hldr.: 3.484 Volts
Dark After - NFH: 0.004 Volts
Average Dark 0.0035 Volts

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

Sea-Bird Electronics, Inc.
13431 NE 20th Street, Bellevue, WA 98005
Website: http://www.seabird.com

FAX: (425) 643-9954
Tel: (425) 643-9866
Email: seabird@seabird.com

SEASOFT COEFFICIENTS
FOR THE BIOSPHERICAL PAR LIGHT SENSOR
S/N 70558

Your Sea-Bird Instrument has been configured to record light data from a BIOSPHERICAL Quantum sensor. The 0 – 5 volt output of this sensor corresponds on a logarithmic scale to light measurement over the measurement range.

Make the following entries in SEASOFT

M = 1
B = 0

From the Biospherical calibration sheet obtain:

C_w = Calibration Factor (µEinsteins/cm^2 * sec per volt)
= 5.47E-06

V = Average Dark Voltage (Volts)
= 0.0035

Calculate the following coefficients:

Calibration Constant = Seasoft Calibration Coefficient
= 10^5 / Cw
= 1.8282E+10

Offset = $-(10^4 * C_w * 10^V)$ (V is the dark voltage)
= -0.055142611

Multiplier = 1

Set multiplier to 1 for output in µEinsteins/m^2sec. See Application Note 11 General for information on output in units other than µEinsteins/m^2sec. See Application Note 11QSP-L for information regarding this calibration sheet.

MOCNESS Sensors

Pressure Sensor

DEPTH SENSOR CALIBRATION
S/N 186 XI-18-2010

The pressure sensor used in the MOCNESS is a titanium strain gauge with an internal temperature sensor. The temperature of the sensor is measured and used to correct for the thermal offsets in the measurement of pressure. The MOCNESS measures the voltage across the pressure and temperature bridges of the sensor and reports these values in its output data stream. The MOCNESS pressure sensor is calibrated at several pressure points and at two temperatures. There are no adjustments in the MOCNESS hardware and all calibration is done in software in the surface control computer. The values sent up the wire in the MOCNESS data stream (the bridge voltages) are scaled to be sent as integers in the range of 0-99999 for pressure and 0-9999 for temperature. The calibration data is fit by the following equation-

Z=(C1*Vt+C0)*Vp^2+(B1*Vt+B0)*Vp+(A1*Vt+A0)

where-
Z=pressure in decibars (1 decibar is approx 1m of water)
Vp=voltage reading in data stream from pressure sensor
Vt=voltage reading in data stream from temperature sensor

The following constants are for your MOCNESS underwater unit.

serial_number =
186
C1 =
-1.398519166559790e-12
C0 =
3.028998129747348e-08
B1 =
4.213305800724209e-08
B0 =
0.10317176619001
A1 =
-0.00413109498238
A0 =
-1.622556199612343e+02

Temperature

SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

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

SENSOR SERIAL NUMBER: 2686
CALIBRATION DATE: 18-Jun-08

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.33921790e-003
h = 6.32051355e-004
i = 2.13939843e-005
j = 1.73857485e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS

a = 3.68121477e-003
b = 5.92165834e-004
c = 1.58039646e-005
d = 1.74001372e-006
f0 = 2935.523

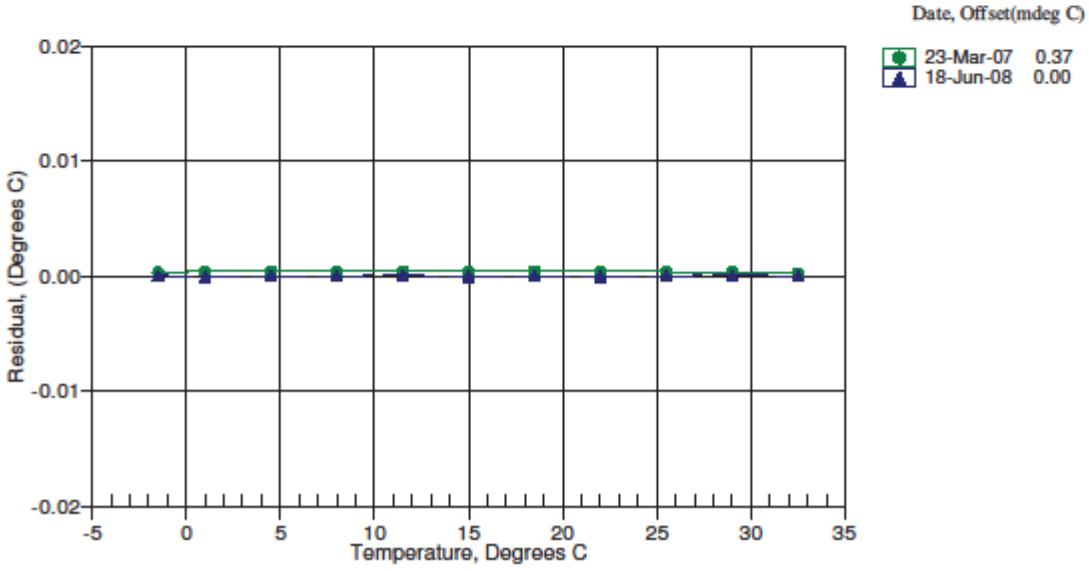
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5002	2935.523	-1.5002	0.00002
0.9998	3107.047	0.9998	-0.00003
4.4998	3359.304	4.4998	-0.00000
7.9998	3626.084	7.9998	0.00001
11.4998	3907.807	11.4998	0.00002
14.9998	4204.882	14.9998	-0.00001
18.4998	4517.717	18.4998	-0.00000
21.9998	4846.699	21.9998	-0.00001
25.4998	5192.212	25.4998	-0.00001
28.9998	5554.626	28.9998	0.00002
32.4998	5934.290	32.4998	-0.00001

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



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: 2047
CALIBRATION DATE: 23-Apr-15

SBE4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS
g = -1.06169808e+001
h = 1.45334125e+000
i = -5.17240656e-003
j = 5.84314376e-004
CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

ABCDM COEFFICIENTS
a = 2.35466703e-006
b = 1.43942676e+000
c = -1.05867511e+001
d = -7.96086907e-005
m = 6.0
CPcor = -9.5700e-008 (nominal)

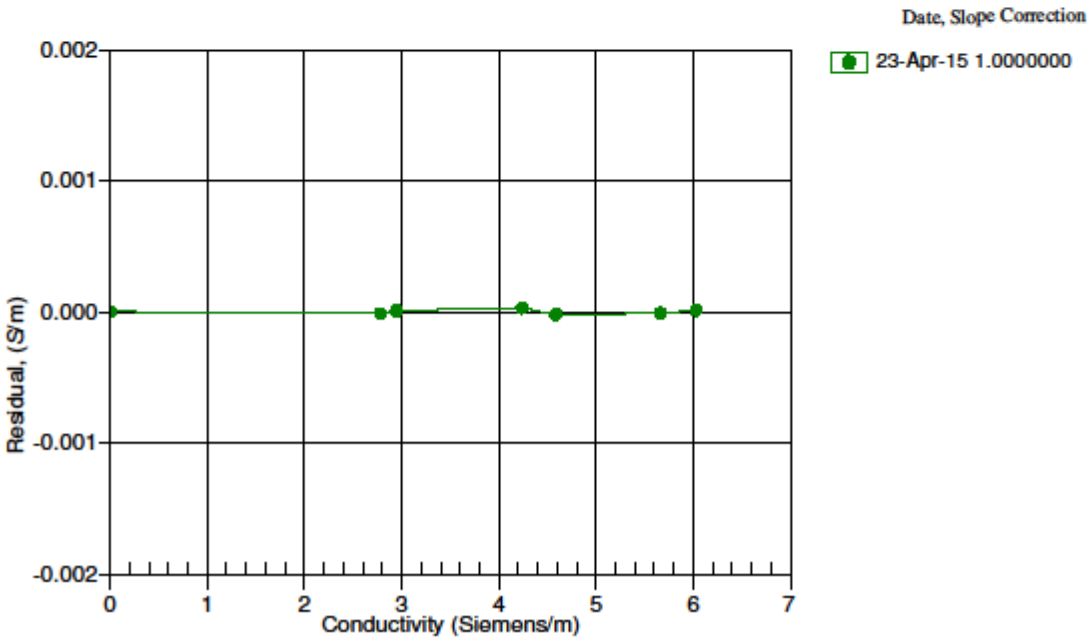
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.71191	0.00000	0.00000
-1.0000	34.4896	2.78070	5.16161	2.78069	-0.00001
1.0000	34.4900	2.95072	5.27441	2.95073	0.00001
15.0000	34.4906	4.23586	6.05824	4.23589	0.00003
18.5000	34.4910	4.57985	6.25099	4.57982	-0.00002
29.0000	34.4883	5.65461	6.81731	5.65460	-0.00001
32.5001	34.4797	6.02391	7.00098	6.02392	0.00001

Conductivity = $(g + hf^2 + if^3 + jf^4)/10(1 + \delta t + \varepsilon p)$ Siemens/meter

Conductivity = $(af^m + bf^2 + c + dt)/[10(1 + \varepsilon p)$ Siemens/meter

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

Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



Acquisition and Processing Information

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.

Day Of Year	Time (GMT)	Event	Location
004	11:30	Begin logging	@68W
004	21:24	GUV feed repaired and brought online	
005	04:56	ADCP Bottom Tracking Off	Leaving Patagonian shelf
004	11:05	ADCP Bottom Tracking On	Arrive Antarctic shelf
008	11:04	Suspend logging of seawater and sonar	Arrive Palmer Station
010	12:29	Resume logging of seawater and sonar	Depart Palmer Station
010	12:50	O2 system weekly maintenance	
014	15:03	ADCP Bottom Tracking Off	
015	16:10	PCO2 N2 tank changed to 180942	
019-020		Heavy sea ice caused seawater system flow to be interrupted several times	300 line
021	1750	GUV computer stopped receiving data	
022	0330	GUV back online	
025	0515	O2 system weekly maintenance	
030	05:15	GUV restarted. Previous 2 days of data are suspect and should be discarded	
030	1335	O2 system weekly maintenance	
032	09:30-18:00	Knudsen Off	Mooring
033	03:43-03:55	Seawater system off for maintenance	
034	10:15-11:40	Knudsen off	Mooring
035	03:10-03:13	Seawater system off for maintenance	
037	11:33	O2 system weekly maintenance	
043	11:44	Suspend logging of seawater and sonar	Arrive Palmer Station
044	13:30	Resume logging of seawater and sonar	Depart Palmer Station
045	10:10	ADCP Bottom Tracking Off	Leaving Antarctic shelf
047	00:48	ADCP Bottom Tracking On	Arrive Patagonian shelf
047	21:05	Stop data acquisition	@68W