LMG 1301

LTER

Cruise Data Report

By Mike Coons and Tony D'Aoust

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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. It also contains important information that may affect how this data is processed such as instrument failures or other known problems with acquisition.

The data collected during this cruise is distributed on a CD-ROM written in ISO9660 level-1 format. This data format has very strict requirements on filenames and organization. However, it is readable by virtually every computing platform.

All of the data has been archived with the Unix "tar" command and/or compressed using Unix "gzip" compression.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

CD Directory Structure

Disc 1 ADCP: ADCP.tar Cal: InstCoef.txt UW\\ CTD\\ Mocness\\ Imagery: Imag.tar Logs: Air.pdf H2O.pdf XCTD.pdf XBT.pdf Maps: LMG1301.jpg Ocean: Ctd.tar Xbt.tar Xctd.tar Process: JGOF.tar PCO2.tar PROC.tar QC.tar Report: Report.doc Report.pdf RVDAS: nav/ uw/ Salinity: LMG13-01 Southbound.xls Science: elog/ FIRe/ Mocness/ Moorings/ PUV/ Sedtrap/ Utility: Acrobat/ Winzip/ Waypoint: Waypoint.txt		

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, both located in this directory, 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 logsheets for XBT, XCTD, salts, air samples and TCO2 data. For further information on this data (TCO2), contact Tim Newberger at ***tnewberg@ldeo.columbia.edu*****.**

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/CTD

The ctd data was collected and processed on a computer running Windows XP, using Seasave Win32 – Version 7.20 and SBE Data Processing – Version 7.21

For more information and software visit the web site at www.seabird.com.

/Ocean/CTD/Configs/

This directory contains the Seabird .xmlcon config file. This file contains information of which sensors where used and what freq or volt the where connected to.

/Ocean/CTD/Scripts/

This directory contains the batch file and psa files that we used for post processing the data. The data was processed with the standard seabird processing method. This is just a preliminary processing which was done to verify that the sensors were functioning properly during the cruise. The raw data should be re-processed using the pre and post cruise sensor calibrations.

/Ocean/CTD/Raw

This directory contains the raw file collected at each CTD cast, which is represented by a set of four files containing a bottle-firing file (.bl), a configuration file (.xmlcon), a data file (.hex) and a header file (.hdr). Casts are named with the following g501CCC.ext, where g is for the LMG, 501 is the cruise 05-01, CCC is the cast number. For example; the raw files associated with the Cast 1are: g501001.bl, g501001.con, g501001.dat, g501001.hdr. The raw data files(*.hex) are binary files.

/Ocean/CTD/Graphs

This directory contains graphical plots of each CTD cast.

/Ocean/CTD/Process

This directory contains the processed data files for each CTD cast, the processing method used is briefly described in the above section *CTD/Scripts/.* Also see the above section *CTD/Data/raw* for a description of the file naming convention used. Each processed cast is represented here by a set of ten files:

GXXXCCC.xmlcon	A copy of the configuration file for the cast.
GXXXCCC.cnv	The converted file for the whole cast.
GXXXCCC.ros	The rosette file that contains the scan lines for each bottle trip.
GXXXCCC.btl	The bottle file that contains the avg, standard deviation, min, and max for a select set of variables for each bottled fired during the upcast.
dGXXXCCC.cnv	The converted file for the down cast.
dGXXXCCC.asc	An ASCII formatted file for the down cast without a header.
dGXXXCCC.hdr	The header for the down cast.
uGXXXCCC.cnv	The converted file for the up cast.
uGXXXCCC.asc	An ASCII formatted file for the up cast without a header.
uGXXXCCC.hdr	The header for the up cast.

/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. The dataset includes the following files:

dat.zip	The probe drop schedule and other configuration files.
efiles.zip	The edited data files.
log.zip	The log files for drop and GPS positioning.
nav.zip	The navigation files.
sfiles.zip	The raw data files.
*.pdf	Scanned images of the paper log sheets.

/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.

Data and Science Report

/Report/

Copies of this report in MS Word, HTML, and text formats.

Salts

/Salinity/

This directory contains the log sheet for the Salt sample take during the Drake Transect Sampling, also a spreadsheet containing the Salt sample and TSG comparison. These samples were analyzed with the onboard AutoSal by the MST.

Science

/Science/

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

WAYPOINTS

/WAYPTS/

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 and Light 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
GUV	lguv	continuous	1 sec	GUV2511
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
Trimble GPS	tgps	civilian mode	1 sec	Trimble 20636-00SM
Gyro	lgyr	continuous	0.2 sec	Anschutz 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 320B/R
Net Depth Sensor	lnds	variable	~1/3 sec	Omega PX-605
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

Oceanographic Data

Measurement	File ID	Collect. Status	Rate	Instrument
Salinity	utsg	continuous	1 sec	SeaBird 45
Sea Surface Temperature	Lrtm	continuous	1 sec	SeaBird 38
Fluorometry (digital)	lflr	continuous	1 sec	Turner 10-AU-005
Fluorometry (digital)	ldflr	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
P-CODE GPS	tgps
Garmin 17 GPS	lgar
Seapath 330 GPS	lsep

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 fields separations are clearly understood. An example data

lknu – Knudsen Sonar

```
08+024:07:36:36.245 HF,00.00, 000,0,LF,448.9,-026,1
```

Field	**Data**	**Units**
1	RVDAS Time Tag	
2	HF – high frequency header (12 kHz)	
3	HF - depth to surface	meters
4	HF - Echo Strength	
5	HF – Depth Valid Flag	
6	LF – low frequency header (3.5 kHz)	
7	LF - depth to surface	meters
8	LF - Echo Strength	
9	LF – Depth Valid Flag	

lnds – Net Depth Sensor

```
99+099:00:18:19.775 V01 00199.8
```

Field	Data	Units
1	RVDAS Time Tag	
2	V01 – Sensor 1	label
3	Depth	meters

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

Field	Data	Units
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 ***tnewberg@ldeo.columbia.edu***

```
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 ***tnewberg@ldeo.columbia.edu***

```
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

Lguv – Biospherical GUV

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

GUV only

Field	Data	Units
1	RVDAS Time Tag	
2	GUV Computer Date	mmddyy
3	GUV Computer Time	hhmmss
4	Ed0Gnd - GUV	Volts
5	Ed0305 - GUV	$\mu W/cm^2nm$
6	Ed0313 - GUV	$\mu W/cm^2nm$
7	Ed0320 - GUV	$\mu W/cm^2nm$
8	Ed0340 - GUV	$\mu W/cm^2nm$
9	Ed0380 - GUV	$\mu W/cm^2nm$
10	Ed0395 - GUV	$\mu W/cm^2nm$
11	Ed0PAR - GUV	$\mu E/cm^2sec$
12	Ed0Temp - GUV	℃
13	Ed0VIn	Volts

GUV and PUV

Field	Data	Units
1	RVDAS Time Tag	
2	GUV Computer Date	mmddyy
3	GUV Computer Time	hhmmss
4	EdZGnd -PUV	Volts
5	EdZ305 -PUV	$\mu W/cm^2nm$
6	EdZ313 -PUV	$\mu W/cm^2nm$
7	EdZ320 -PUV	$\mu W/cm^2nm$
8	EdZ395 -PUV	$\mu W/cm^2nm$
9	EdZ340 -PUV	$\mu W/cm^2nm$
10	EdZPAR -PUV	$\mu E/cm^2sec$
11	LuZChl -PUV	$\mu E/srm^2sec$
12	EdZ380 -PUV	$\mu W/cm^2nm$
13	WTemp -PUV	℃
14	Depth -PUV	m
15	EdZTemp -PUV	℃
16	LuZTemp -PUV	℃
17	Tilt -PUV	Degrees
18	Roll -PUV	Degrees
19	Ed0Gnd - GUV	Volts
20	Ed0305 - GUV	$\mu W/cm^2nm$
21	Ed0313 - GUV	$\mu W/cm^2nm$
22	Ed0320 - GUV	$\mu W/cm^2nm$
23	Ed0340 - GUV	$\mu W/cm^2nm$
24	Ed0380 - GUV	$\mu W/cm^2nm$
25	Ed0395 - GUV	$\mu W/cm^2nm$
26	Ed0PAR - GUV	$\mu E/cm^2sec$
27	Ed0Temp - GUV	℃
28	Ed0VIn	Volts

lsvp - Sound Velocity Probe in ADCP Transducer Well

```
00+348:01:59:52.128  1539.40
```

Field	Data	Units
1	RVDAS Time Tag	
2	Sound velocity	m/s

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 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+315:23:59:58.194 $PASVW,00.1,A*1D
02+315:23:59:58.414 $IIVHW,287.7,T,,M,,N,,K*71
02+315:23:59:58.616 $HEHDT,287.7,T*25
02+315:23:59:58.821 $HEROT,001.6,A*2C
02+315:23:59:58.984 $HCHDT,,T*07
```

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	

ROT: Rate of Turn

```
01+083:00:00:03.093 $HEROT,-006.3,A*03
```

Field	Data	Units
1	RVDAS Time Tag $HEROT	
2	Rate of turn	degrees/min
3	Status: A = data valid, 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	

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
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	

tgps – Trimble Centurion 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
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	

RMC: Recommended Minimum Specific GNSS Data

08+034:13:17:26.627 $GPRMC,131726.605,A,6446.4820,S,06403.3075,W,000.0,094.4,030208,16.3,E

Field	Data	Units
1	RVDAS Time Tag	
2	$GPRMC 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	

LMG Sensors

Shipboard Sensors

Sensor	Description	Serial #	Cal. Date	Status
Port Anemometer	Gill Ultrasonic Wind Observer II	71739	N/A	Collected
Starboard Anemometer	Gill Ultrasonic Wind Observer II	71738	N/A	Collected
Barometer	R.M. Young 61201	BP01150	03-Jun-2011	Collected
Humidity/Wet Temp	RM Young 41372LC	6719	26-Aug-2011	Collected
PAR for Mast	Biosph. Inst. QSR-240P	6393	1-Oct-2012	Collected
PIR	Eppley PIR	32031F3	16-Jul-2012	Collected
PSP	Eppley PSP	31701F3	13-Jul-2012	Collected
GUV (Mast)	Biosph. Inst. GUV-2511	5127	7-Sep-2012	Collected
Transmissometer	WET Labs C-Star 25 cm deep	CST-830DR	04-Nov-2011	Collected
MicroTSG (Primary)	Sea-Bird 45	390	20-Oct-2011	Collected
MicroTSG (Secondary)	Sea-Bird 45	227	21-Jun-2011	Collected
Digital Remote Temp	Sea-Bird 38	324	07-Nov-2012	Collected
Fluorometer	WET Labs ECO-FL	FLRTD-398	07-Sep-11	Collected

CTD Sensors

Sensor	Description	Serial #	Cal. Date	Status
CTD Fish	Seabird SBE9Plus	232	30-Oct-2012	Collected
Primary Temperature	Seabird SBE3	2637	8-Apr-2011	Collected
Secondary Temperature	Seabird SBE3	5025	7-Nov-2012	Collected
Primary Conductivity	Seabird SBE4	3519	10-Aug-2011	Collected
Secondary Conductivity	Seabird SBE4	2047	7-Nov-2012	Collected
Primary Dissolved Oxygen	Seabird SBE43	181	7-Nov-2012	Collected
Secondary Dissolved Oxygen	Seabird SBE43	182	7-Nov-2012	Collected
Fluorometer	Wet Labs ECO	FLRTD-867	22-Aug-2012	Collected
PAR	Biosph. Inst. QSP-2300	4722	9-Feb-2012	Collected
Transmissometer	Wet Labs C-Star	CST-407DR	1-Feb-2012	Collected
Transmissometer	Wet Labs C-Star	CST-248DR	12-Sep-2012	Collected

Mocness Sensors

Sensor	Description	Serial #	Cal. Date	Status
Pressure Sensor	Mocness depth sensor	156		Collected
Temperature	Seabird SBE3	2205	7-Feb-2012	Collected
Conductivity	Seabird SBE4	2293	31-Jan-2012	Collected
Fluorometer	Wet Labs ECO-FL	1735	22-Aug-2012	Collected
Transmissometer	Wet Labs C-Star	CST-553DR	12-Sep-2012	Collected

Underway Calibration Sheets

Note: Embedded pdf files can be opened with a right-click, Acrobat Document Object, Open

Thermosalinograph (temp) – Primary

7

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: [illegible]
CALIBRATION DATE: 20-Oct-11

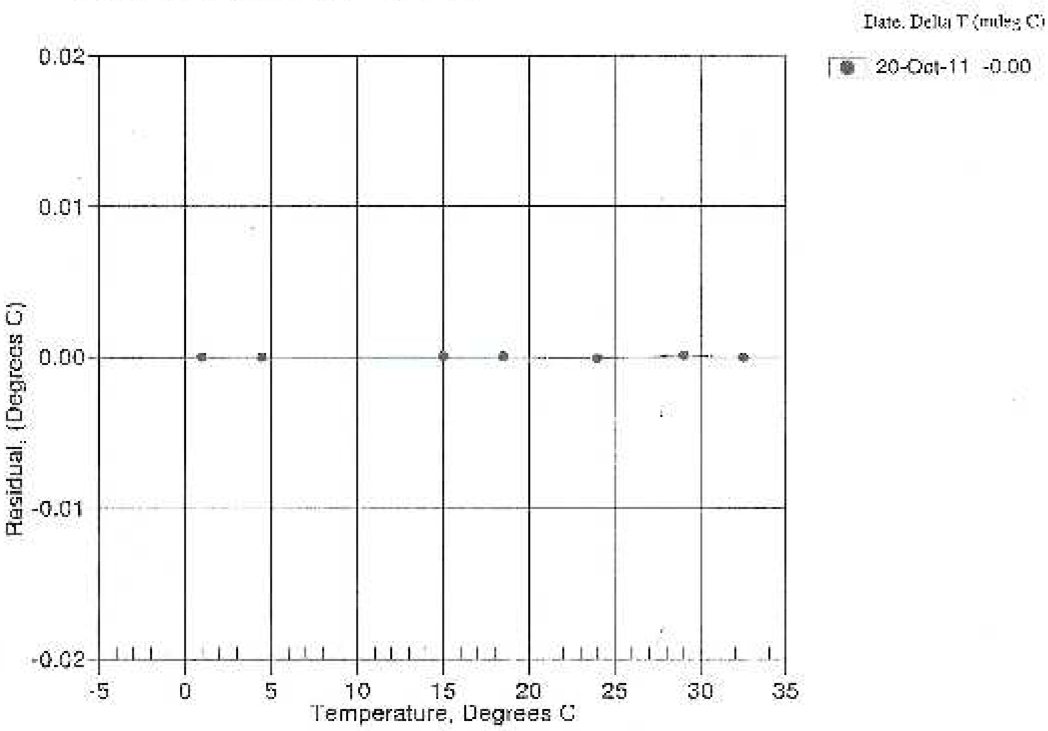
SBE45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
a0 = [illegible]e-006
a1 = 2.[illegible]e-004
a2 = -[illegible]e-006
a3 = 1.[illegible]e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	[illegible]	[illegible].0000	0.0000
4.5000	[illegible]	4.5000	-0.0000
14.9999	[illegible]	14.9999	0.0000
18.4999	303307.3	18.4999	0.0000
24.0000	[illegible]	23.9999	-0.0001
29.0000	[illegible]	29.0001	0.0001
32.5000	[illegible]	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



Thermosalinograph (conductivity) - Primary

8

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: 20-Oct-11

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

COEFFICIENTS:

g = -9.852963e-001
h = 1.472444e-001
i = -4.051034e-004
j = 5.237106e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006
WBOTC = 2.5724e-007

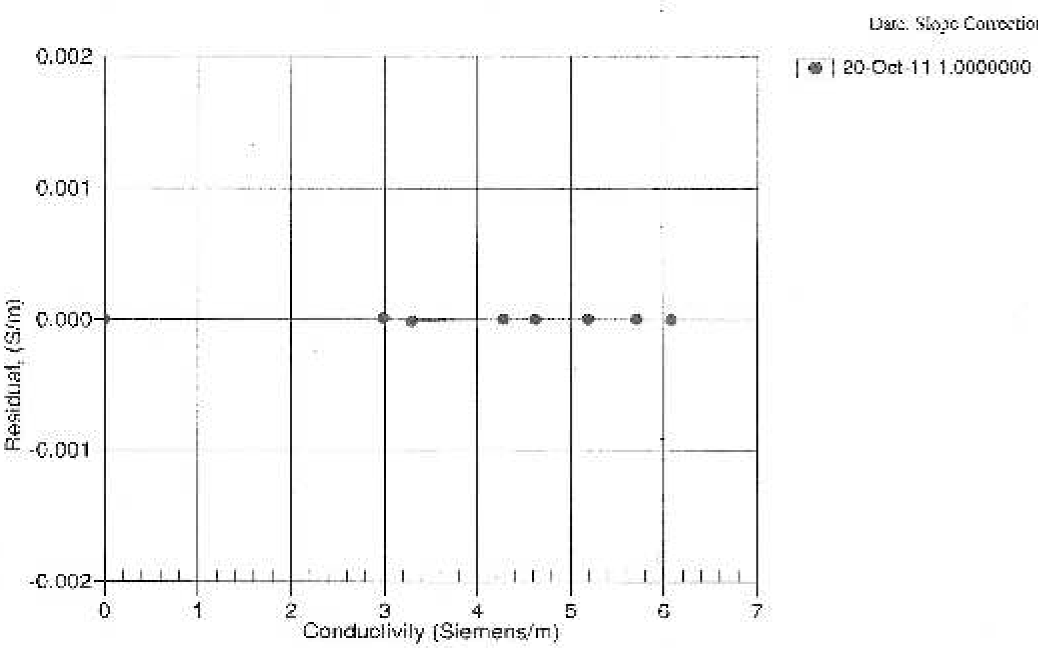
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2610.61	0.00000	0.00000
1.0000	34.7210	2.98406	5239.98	2.98407	0.00001
4.5000	34.5005	3.29188	5438.78	3.29187	-0.00001
14.9999	34.6064	4.27600	6009.77	4.27600	0.00000
18.4999	34.6467	4.62196	6221.63	4.62196	0.00000
24.0000	34.6354	5.18115	6525.11	5.18115	0.00000
28.0000	34.8277	5.70397	6794.28	5.70396	0.00000
32.5000	34.8211	6.07673	6979.63	6.07673	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



Thermosalinograph (Temp) – Secondary

SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0227
CALIBRATION DATE: 21-Jun-11

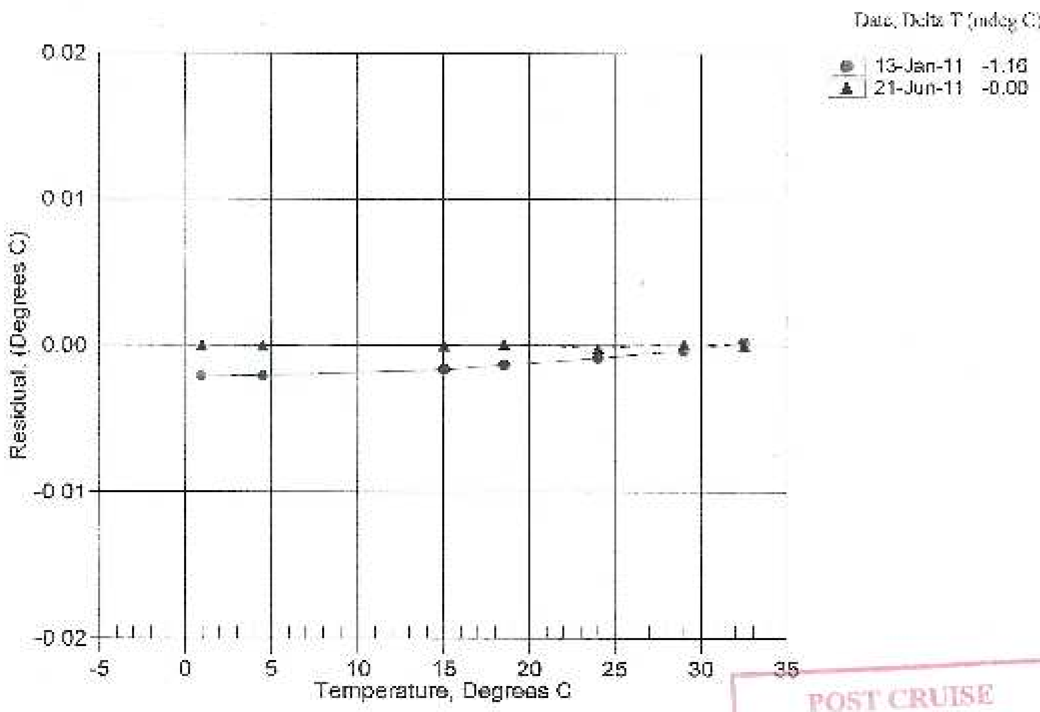
SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
a0 = 4.383651e-005
a1 = 2.696211e-004
a2 = -1.946313e-006
a3 = 1.411508e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	664575.1	1.0000	0.0000
4.5000	568018.5	4.5000	0.0000
15.0000	361626.2	15.0000	-0.0000
18.5000	313024.1	18.5001	0.0001
24.0000	250909.5	23.9998	-0.0002
29.0000	205570.3	29.0001	0.0001
32.5000	180840.5	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



POST CRUISE CALIBRATION

Thermosalinograph (Conductivity) – Secondary

SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street. Bellevue, Washington, 98005-2010 USA

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

SENSOR SERIAL NUMBER: 0227
CALIBRATION DATE: 21-Jun-11

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

COEFFICIENTS:

g = -1.015545e+000
h = 1.[illegible]e-001
i = -4.3[illegible]031e-004
j = 6.026765e-005

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

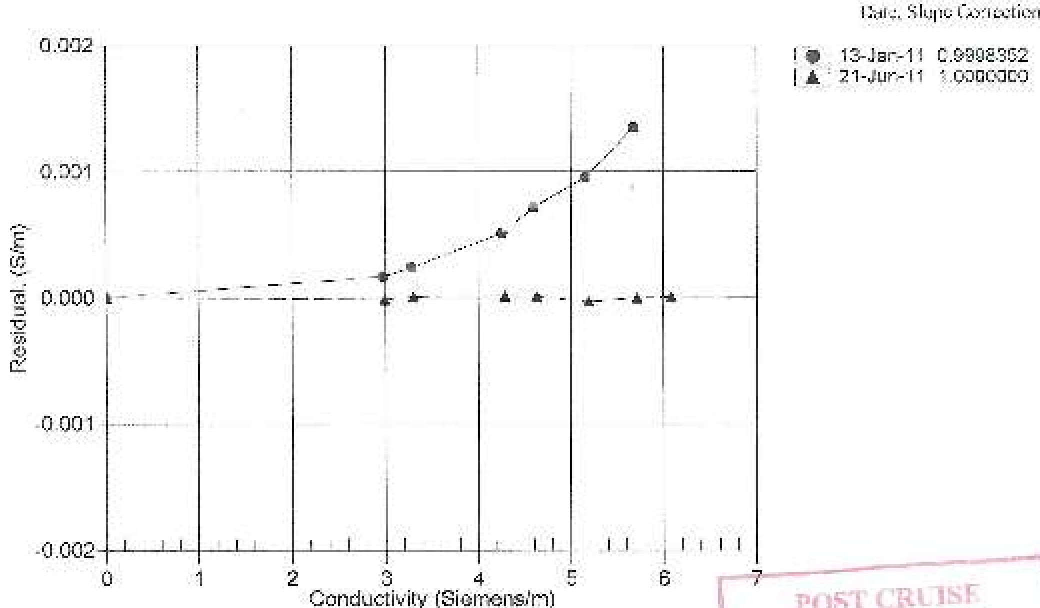
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	3546.37	0.00000	0.00000
1.0000	34.9659	2.98753	5018.30	2.98752	-0.00001
4.5000	34.9455	3.29571	5238.29	3.29572	0.00001
15.0000	34.9015	4.28096	5805.26	4.28097	0.00002
18.5000	34.8917	4.62729	5988.89	4.62730	0.00001
24.0000	34.8758	5.18703	6276.96	5.18700	-0.00003
29.0000	34.8717	5.71037	6534.19	5.71037	-0.00000
32.5000	34.8648	6.08349	6711.84	6.08350	0.00001

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

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 November 4, 2011 S/N# CST-830DR Pathlength 25 cm

	Analog output
V_d	0.059 V
V_{air}	4.868 V
V_{ref}	4.713 V

Temperature of calibration water	23.5 °C
Ambient temperature during calibration	21.6 °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

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: 9/7/2011 S/N: FLRTD-398

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	0.097	0.053	0.031 V	70 counts
Scale Factor (SF)	6	13	25 µg/l/V	0.0076 µg/l/count
Maximum Output	4.96	4.96	4.96 V	16328 counts
Resolution	1.0	1.0	1.0 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-398.xls Revision J 3/17/08

Temperature/Relative Humidity

YOUNG

CERTIFICATE OF CALIBRATION AND TESTING

CUSTOMER:	RAYTHEON TECHNICAL SERVICES CO LLC
P.O. NUMBER:	RR59937-01
MODEL:	41372LC
SERIAL NUMBER:	TS06719

R. M. Young Company certifies that the above equipment was inspected and calibrated prior to shipment in accordance with established manufacturing and testing procedures. Standards established by R.M. Young Company for calibrating the measuring and test equipment used in controlling product quality are traceable to the National Institute of Standards and Technology.

To maintain these specifications, regular maintenance intervals are essential.

Date of Certification: 26 August 2011

R.M. Young Company

Ryan Phillips

R.M. YOUNG COMPANY 2801 Aero Park Drive, Traverse City Michigan 49686-9171 USA
TEL: (231) 946-3980 FAX: (231) 946-4772 Email: met.sales@youngusa.com
ISO 9001:2008 CERTIFIED

Barometer

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

YOUNG

CALIBRATION REPORT

Barometric Pressure Sensor

Customer: *Raytheon Technical Services Company LLC*

Test Number: 1603-01B
Test Date: 3 June 2011

Customer PO: RR58987-01
Sales Order: 1959

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	0	800.0
875.0	1251	875.1
950.0	2501	950.1
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: E Chenny

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

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: 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 28°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:

3.79×10^{-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: Lockheed Martin (NSF)
Port Hueneme, CA

S.O. Number: 63509
Date: July 18, 2012

Date of Test: July 16, 2012

In Charge of Test: Debra L. Heintz

Reviewed by: Thomas D. Kirk

Remarks:

PSP

THE EPPLEY LABORATORY, INC.

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

STANDARDIZATION OF EPPLEY PRECISION SPECTRAL PYRANOMETER Model PSP

Serial Number: 31701F3

Resistance: 674 Ω at 23°C
Temperature Compensation Range: -20° to +40°C

This radiometer has been compared with Standard Precision Spectral Pyranometer, Serial Number 21231F3 in Eppley's Integrating Hemisphere under radiation intensities of approximately 700 watts meter^{-2} (roughly one half a solar constant).

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

$$8.21 \times 10^{-6} \text{ volts/watts meter}^{-2}$$

The calculation of this constant is based on the fact that the relationship between radiation intensity and emf is rectilinear to intensities of 1400 watts meter^{-2}. This radiometer is linear to within ± 0.5% up to this intensity.

The calibration of this instrument is traceable to standard self-calibrating cavity pyrheliometers in terms of the Systems Internationale des Unites (SI units), which participated in the Eleventh International Pyrheliometric Comparisons (IPC XI) at Davos, Switzerland in September-October 2010.

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".

Useful conversion facts: 1 cal cm^{-2} min^{-1} = 697.3 watts meter^{-2}
1 BTU/ft^{2}-hr^{-1} = 3.153 watts meter^{-2}

Shipped to: Lockheed Martin (NSF)
Port Hueneme, CA

S.O. Number: 63509
Date: July 18, 2012

Date of Test: July 13, 2012

In Charge of Test:

Reviewed by:

Remarks: Replaced Shield

Digital Remote Temperature

SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0389
CALIBRATION DATE: 09-Sep-10

SBE 38 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

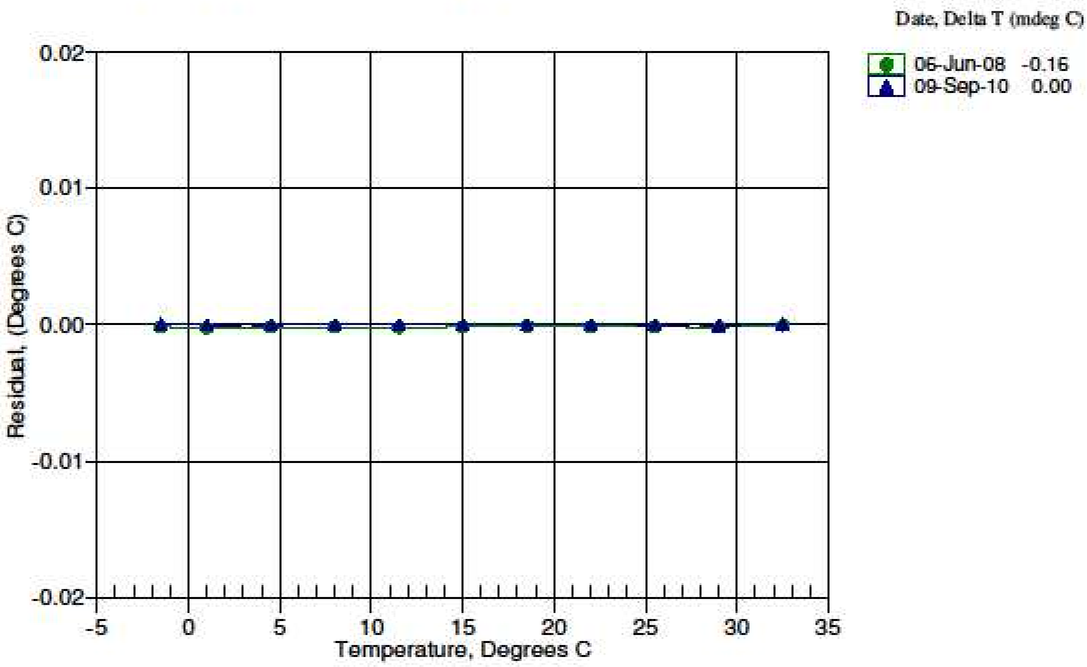
ITS-90 COEFFICIENTS

a0 = 5.882900e-005
a1 = 2.715026e-004
a2 = -2.261327e-006
a3 = 1.468299e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.50000	749666.3	-1.49998	0.00002
1.00000	667856.9	0.99999	-0.00001
4.50000	569777.7	4.49997	-0.00003
8.00000	487732.7	8.00000	0.00000
11.50000	418862.9	11.50000	0.00000
15.00000	360856.1	15.00002	0.00002
18.50000	311838.4	18.50002	0.00002
22.00000	270284.2	22.00001	0.00001
25.50000	234947.7	25.49997	-0.00003
29.00000	204807.1	28.99996	-0.00004
32.50000	179022.3	32.50003	0.00003

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

Residual = instrument temperature - bath temperature



PAR (mast)

Biospherical Instruments Inc.

CALIBRATION CERTIFICATE

Calibration Date	10/3/2012			
Model Number	QSR-240			
Serial Number	5393			
Operator	TPC			
Standard Lamp	V-030(3/7/12)			
Probe Excitation Voltage Range:	6	to	18	VDC(+)
Output Polarity:	Positive			

Probe Conditions at Calibration(in air):

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

Probe Output Voltage:

Probe Illuminated	103.6	mV
Probe Dark	0.4	mV
Probe Net Response	103.2	mV
RG780	0.4	mV

Corrected Lamp Output:

Output in Air (same condition as calibration):

9.826E+15	quanta/cm²sec
0.01632	uE/cm²sec

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

Dry:	1.0503E-17	V/(quanta/cm²sec)
	6.3246E+00	V/(uE/cm²sec)

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

QSR240R 05/24/95

GUV

Biospherical Instruments Inc.

GUV-2511 Calibration Certificate

System Serial Number	25110805127	Date of Calibration	9/7/2012
Calibration database	25110805127v5.mdb	Date of Certificate	9/10/2012
DASSN	0111	Standard of Spectral Irradiance	V-030 (3/7/12)
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	1.3700E-11	4.4922E-06	1.3205E-03	4.0408E-01	-4.0955E-04	-4.1177E-04	-6.7727E-04	µW/(cm²nm)
Ed0313	6	313	1.7900E-10	1.8175E-05	5.3244E-03	1.4809E+00	1.6768E-04	1.7127E-04	6.3906E-04	µW/(cm²nm)
Ed0320	8	320	2.4954E-10	2.5411E-05	7.4620E-03	2.4490E+00	-1.7180E-04	-1.7065E-04	2.0532E-05	µW/(cm²nm)
Ed0340	10	340	1.9061E-10	1.8490E-05	5.6947E-03	2.0107E+00	1.4062E-04	1.3973E-04	1.1637E-03	µW/(cm²nm)
Ed0380	12	380	7.0485E-11	7.1946E-06	2.1073E-03	7.2402E-01	-2.3676E-04	-2.4152E-04	-1.0790E-04	µW/(cm²nm)
Ed0395	13	395	2.8722E-10	2.9433E-05	8.6007E-03	2.9279E+00	-1.7243E-04	-1.7335E-04	-3.9703E-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	15	400-700	1.6596E-05	1.6920E+00	4.9661E+02	1.6333E+05	-8.3616E-05	-8.2950E-05	5.2453E-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

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Calibration Data Do Not Destroy page 2 of 2

CTD 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: 0232
CALIBRATION DATE: 30-Oct-12

SBE9plus PRESSURE CALIBRATION DATA
10000 psia S/N 43528

DIGIQUARTZ COEFFICIENTS:

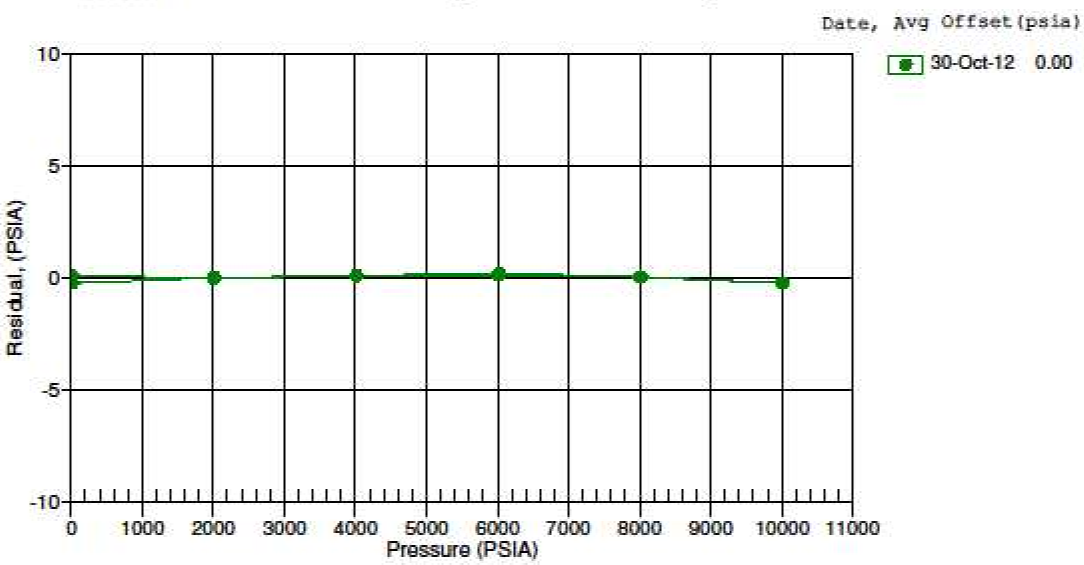
C1 = -5.103000e+004
C2 = 8.606365e-002
C3 = 1.481220e-002
D1 = 3.642300e-002
D2 = 0.000000e+000
T1 = 3.004925e+001
T2 = -3.406308e-004
T3 = 4.125600e-006
T4 = 1.811600e-009
T5 = 0.000000e+000

AD590M, AD590B, SLOPE AND OFFSET:

AD590M = 1.13600e-002
AD590B = -8.42350e+000
Slope = 0.99979
Offset = 0.4107 (dbars)

PRESSURE (PSIA)	INST OUTPUT(Hz)	INST TEMP(C)	INST OUTPUT (PSIA)	CORRECTED INST OUTPUT (PSIA)	RESIDUAL (PSIA)
14.539	33289.36	22.1	14.028	14.624	0.085
2014.765	33934.64	22.2	2014.549	2014.730	-0.035
4014.592	34566.04	22.2	4014.912	4014.677	0.085
6014.545	35184.40	22.3	6015.362	6014.712	0.167
8014.593	35790.36	22.3	8015.700	8014.635	0.042
10014.826	36384.58	22.3	10016.051	10014.571	-0.255
8014.613	35790.36	22.3	8015.697	8014.632	0.019
6014.608	35184.41	22.3	6015.347	6014.697	0.089
4014.600	34566.07	22.4	4014.905	4014.671	0.070
2014.689	33934.66	22.4	2014.499	2014.680	-0.010
14.541	33289.31	22.5	13.689	14.285	-0.256

Residual = corrected instrument pressure - reference pressure



Primary Temperature

SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 2637
CALIBRATION DATE: 08-Apr-11

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
g = 4.33542684e-003
h = 6.40147639e-004
i = 2.34440629e-005
j = 2.37995756e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS
a = 3.68121155e-003
b = 5.98657801e-004
c = 1.59129120e-005
d = 2.38150463e-006
f0 = 2882.375

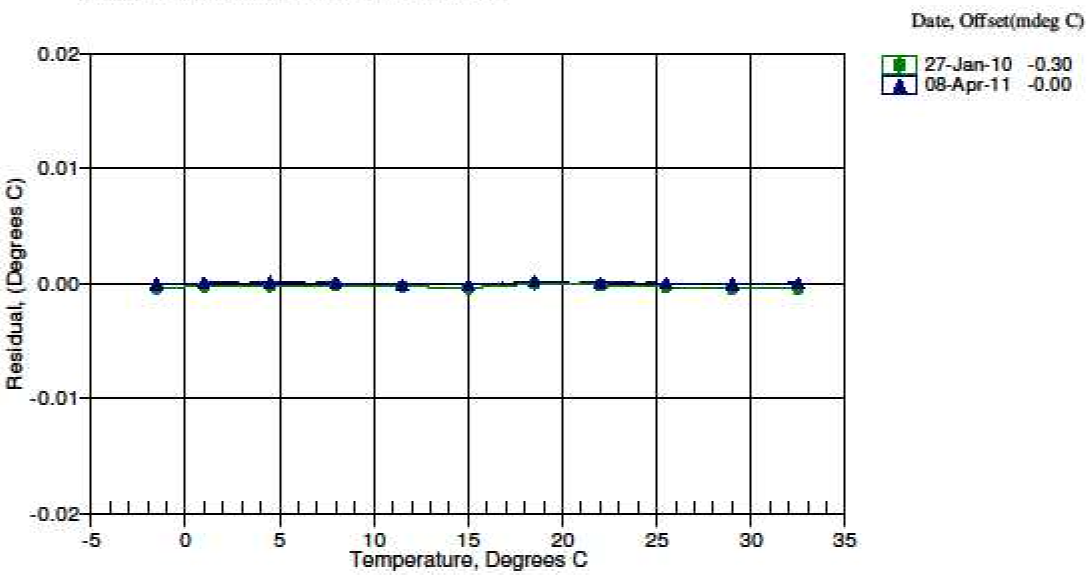
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.4999	2882.375	-1.4999	-0.00004
1.0002	3048.925	1.0002	0.00002
4.5002	3293.651	4.5003	0.00011
8.0002	3552.202	8.0002	0.00001
11.5002	3824.960	11.5001	-0.00012
15.0001	4112.290	15.0000	-0.00015
18.5001	4414.582	18.5003	0.00017
22.0002	4732.106	22.0002	0.00005
25.5001	5065.205	25.5001	0.00000
29.0002	5414.219	29.0001	-0.00007
32.5002	5779.436	32.5002	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: 5025
CALIBRATION DATE: 11-Sep-12

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
g = 4.37609867e-003
h = 6.37268343e-004
i = 2.13680977e-005
j = 1.85140386e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS
a = 3.68121177e-003
b = 5.96244034e-004
c = 1.51243712e-005
d = 1.85281529e-006
f0 = 3092.501

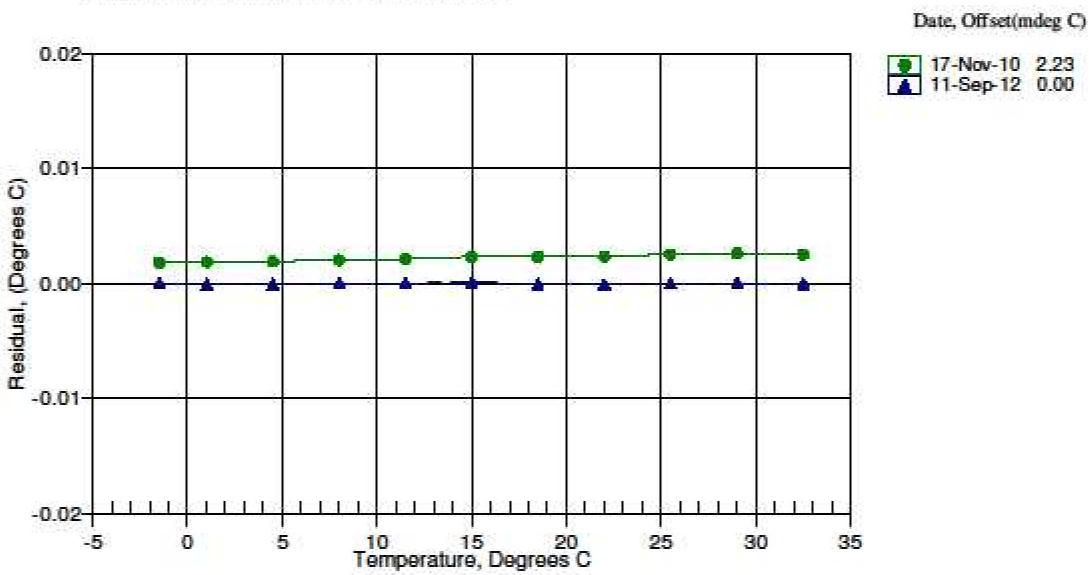
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	3092.501	-1.5000	0.00004
1.0000	3271.907	0.9999	-0.00005
4.5000	3535.580	4.5000	-0.00002
8.0000	3814.210	8.0000	0.00000
11.5000	4108.208	11.5000	0.00002
14.9999	4417.972	15.0000	0.00009
18.5000	4743.894	18.4999	-0.00005
22.0000	5086.357	21.9999	-0.00008
25.5000	5445.737	25.5000	0.00002
29.0000	5822.367	29.0000	0.00003
32.5000	6216.589	32.5000	-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



Primary Conductivity

SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 3519
CALIBRATION DATE: 10-Aug-11

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

GHIJ COEFFICIENTS

```
g = -9.91083346e+000
h =  1.23085722e+000
i = -1.40435452e-003
j =  1.52687506e-004
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  8.45003164e-007
b =  1.22689847e+000
c = -9.90138937e+000
d = -8.28842436e-005
m =  5.8
CPcor = -9.5700e-008 (nominal)
```

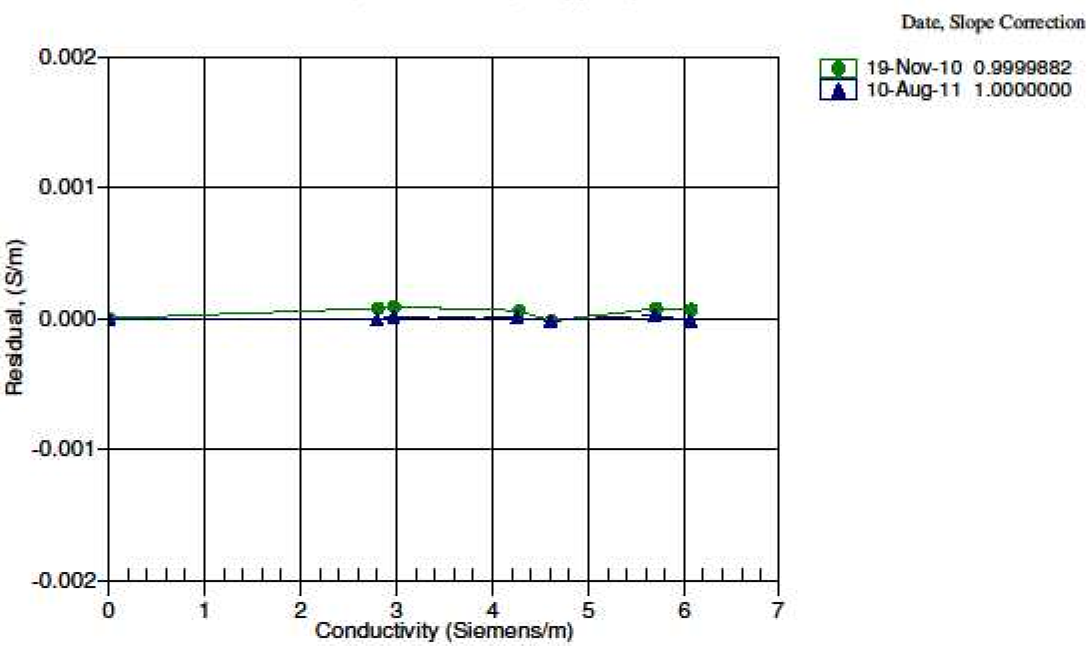
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.84078	0.00000	0.00000
-1.0000	34.7055	2.79648	5.55419	2.79647	-0.00001
1.0000	34.7065	2.96747	5.67812	2.96748	0.00001
15.0000	34.7077	4.25970	6.53862	4.25970	0.00000
18.5000	34.7079	4.60554	6.75017	4.60552	-0.00002
29.0000	34.7059	5.68627	7.37190	5.68629	0.00003
32.5001	34.6974	6.05761	7.57358	6.05759	-0.00002

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

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

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

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



Secondary 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: 11-Sep-12

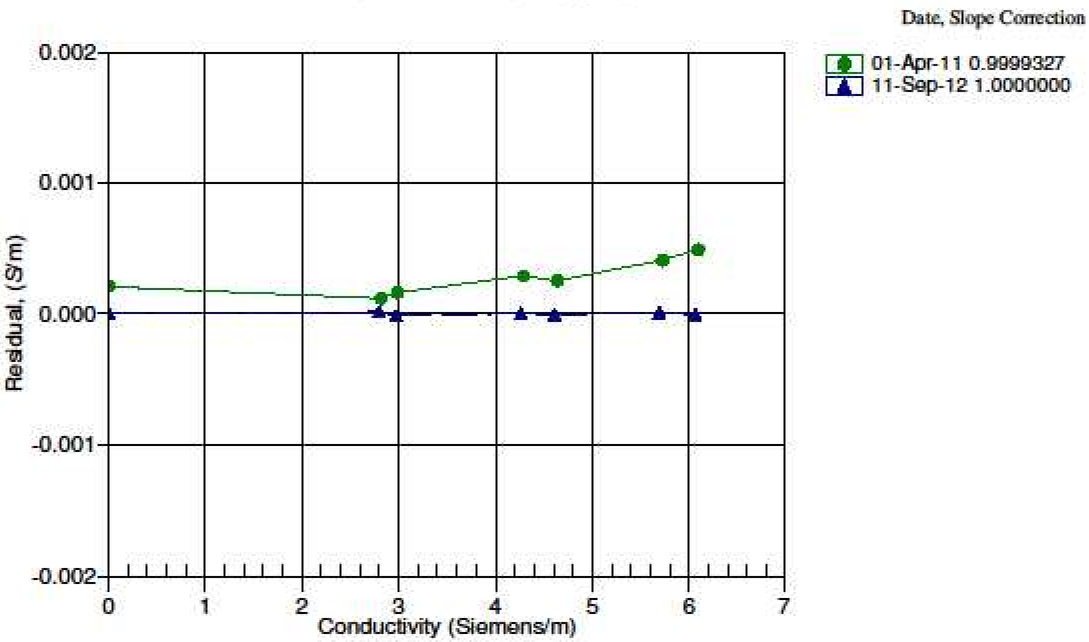
SBE4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS
g = -1.06168602e+001
h = 1.45366259e+000
i = -5.30872445e-003
j = 5.95198302e-004
CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

ABCDM COEFFICIENTS
a = 2.36316800e-006
b = 1.43927151e+000
c = -1.05851356e+001
d = -7.59354518e-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	2.71187	0.00000	0.00000
-1.0000	34.7322	2.79843	5.17367	2.79845	0.00001
1.0000	34.7334	2.96955	5.28690	2.96954	-0.00002
15.0000	34.7346	4.26265	6.07368	4.26265	0.00000
18.5000	34.7346	4.60870	6.26711	4.60869	-0.00001
29.0001	34.7303	5.68983	6.83528	5.68984	0.00001
32.5001	34.7194	6.06101	7.01938	6.06100	-0.00001

Conductivity = $(g + hf^2 + if^3 + jf^4) / 10(1 + \delta t + \epsilon p)$ Siemens/meter
Conductivity = $(af^m + bf^2 + c + dt) / [10 (1 + \epsilon p)$ Siemens/meter
t = temperature[°C)]; p = pressure[decibars]; δ = CTcor; ϵ = CPcor;
Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



Primary Dissolved 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: 0181
CALIBRATION DATE: 30-Aug-12

SBE 43 OXYGEN CALIBRATION DATA

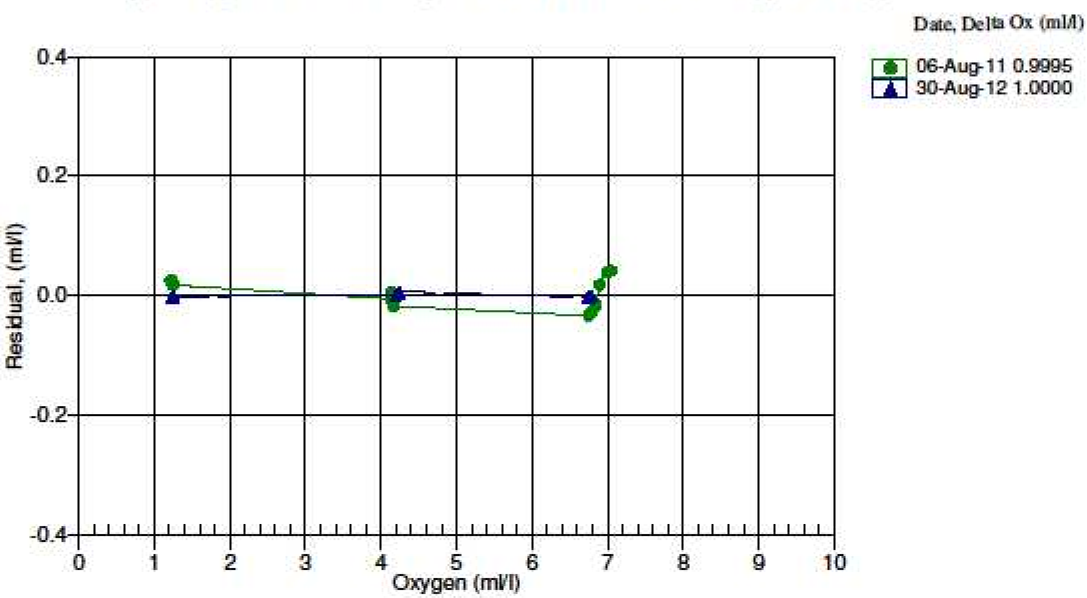
COEFFICIENTS
Soc = 0.5567
Voffset = -0.5037
Tau20 = 1.81

A = -2.4737e-003
B = 6.7259e-005
C = -1.4561e-006
E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS
D1 = 1.92634e-4 H1 = -3.30000e-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	0.05	0.734	1.24	-0.00
1.24	6.00	0.05	0.763	1.24	-0.00
1.24	30.00	0.04	0.950	1.24	-0.00
1.25	12.00	0.05	0.807	1.24	-0.00
1.25	26.00	0.04	0.917	1.25	0.00
1.25	20.00	0.04	0.868	1.25	-0.00
4.20	30.00	0.04	2.009	4.20	0.00
4.21	26.00	0.04	1.897	4.21	0.00
4.23	20.00	0.04	1.741	4.23	0.01
4.24	12.00	0.05	1.538	4.24	0.00
4.24	6.00	0.05	1.391	4.25	0.01
4.24	2.00	0.05	1.296	4.25	0.01
6.74	12.00	0.05	2.147	6.74	-0.00
6.75	2.00	0.05	1.761	6.74	-0.00
6.75	20.00	0.04	2.476	6.75	-0.00
6.75	6.00	0.05	1.914	6.75	-0.00
6.76	30.00	0.04	2.929	6.76	-0.00
6.78	26.00	0.05	2.750	6.78	-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 [Kelvin]
OxSol(T,S) = oxygen saturation [ml/l], P = pressure [dbar], Residual = instrument oxygen - bath oxygen



Secondary Dissolved 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: 0182
CALIBRATION DATE: 19-Oct-12

SBE 43 OXYGEN CALIBRATION DATA

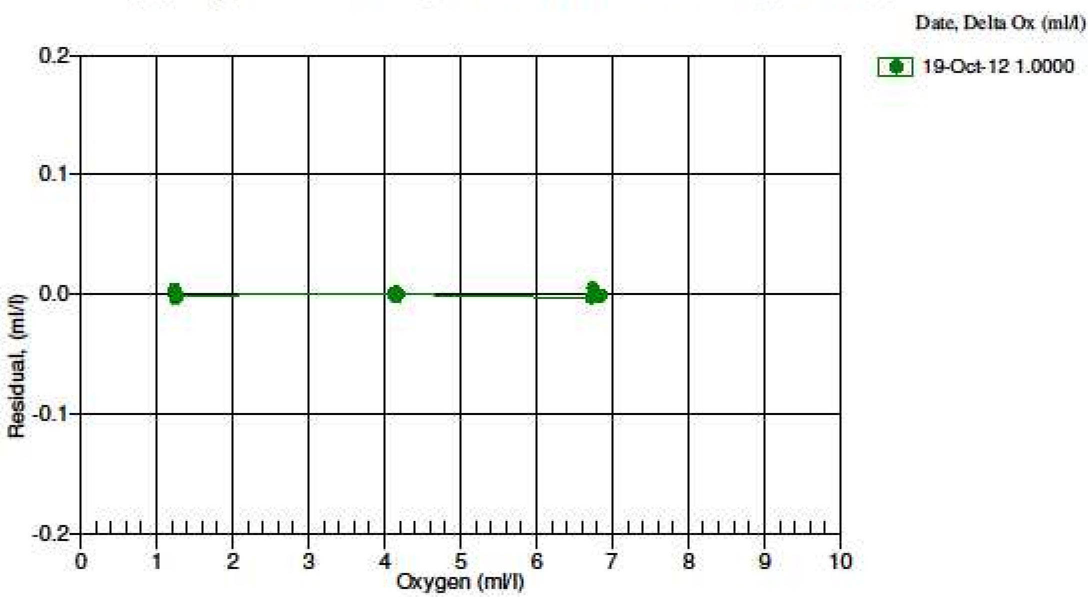
COEFFICIENTS
Soc = 0.4732
Voffset = -0.7426
Tau20 = 1.64

A = 6.6373e-004
B = 1.6162e-004
C = -1.1384e-006
E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS
D1 = 1.92634e-4 H1 = -3.30000e-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)
1.23	2.00	0.01	1.012	1.24	0.00
1.24	6.00	0.01	1.040	1.24	0.00
1.24	12.00	0.01	1.079	1.24	-0.00
1.26	20.00	0.01	1.132	1.25	-0.00
1.27	26.00	0.01	1.168	1.27	-0.00
1.27	30.00	0.01	1.190	1.27	-0.00
4.12	2.00	0.01	1.641	4.12	0.00
4.13	6.00	0.01	1.734	4.13	-0.00
4.14	12.00	0.01	1.871	4.14	0.00
4.14	20.00	0.01	2.029	4.14	-0.00
4.15	26.00	0.01	2.140	4.16	0.00
4.19	30.00	0.01	2.217	4.19	-0.00
6.72	20.00	0.01	2.829	6.71	-0.00
6.74	26.00	0.01	3.012	6.75	0.01
6.76	12.00	0.01	2.583	6.76	0.00
6.81	6.00	0.01	2.379	6.81	-0.00
6.83	30.00	0.01	3.147	6.83	-0.00
6.85	2.00	0.01	2.236	6.85	-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 [Kelvin]
OxSol(T,S) = oxygen saturation [ml/l], P = pressure [dbar], Residual = instrument oxygen - bath oxygen



PAR Sensor

Biospherical Instruments Inc

CALIBRATION CERTIFICATE

UNDERWATER PAR SENSOR WITH LOG AMPLIFIER

Calibration Date: 02/09/12 Job No.: R11719
Model Number: QSP200L
Serial Number: 4722
Operator: TPC
Standard Lamp: S0573(10/19/11)
Operating Voltage Range: 6 to 15 VDC (+)

Note: The QSP-200 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:	2.59E+13	quanta/cm²-sec/"amps"	4.30E-05	µEinsteins/cm²-sec/"amps"
Wet Calibration Factor:	4.58E+13	quanta/cm²-sec/"amps"	7.60E-05	µEinsteins/cm²-sec/"amps"

Sensor Test Data and Results[4)]

Sensor Supply Current (Dark):	88.2	mA		
Supply Voltage:	6	Volts		
Lamp Integrated PAR Irradiance:	9.79E+15	quanta/cm²-sec	0.01626	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%	2.579	100.00%	3.79E-08	3.79E-08	2.581	0.002	0.0	9.79E+15
0.3	36.10%	2.140	36.12%	1.37E-08	1.37E-08	2.142	0.002	-0.1	3.54E+15
0.5	27.60%	2.028	27.83%	1.06E-08	1.05E-08	2.026	-0.002	-0.8	2.72E+15
1	9.27%	1.570	9.41%	3.57E-09	3.52E-09	1.565	-0.004	-1.4	9.21E+14
2	1.11%	0.767	1.13%	4.27E-10	4.21E-10	0.764	0.003	-1.5	1.10E+14
3	0.05%	0.273	0.08%	2.85E-11	2.03E-11	0.254	-0.019	-28.9	7.35E+12

Dark Before: 0.202 Volts
Light - No Filter Hldr.: 2.579 Volts I_{Ref} = 1.00E-10 Amps
Dark After - NFH: 0.202 Volts I_{Dark} = 1.59E-10 Amps RG780 0.2215
Average Dark 0.202 Volts $10^{V_{Dark}}$ = 1.591476 Amps

Notes:
1. Annual calibration is recommended.
2. There is increasing error associated with readings below zero.
3. The collector should be cleaned frequently with alcohol.
4) This section is for internal use and for more advanced analysis.

QSP-200L.QSP2300(2005-)

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: 8/22/2012 S/N: FLRTD-867

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	0.093	0.057	0.040 V	56 counts
Scale Factor (SF)	7	13	26 µg/l/V	0.0078 µg/l/count
Maximum Output	4.94	4.94	4.94 V	16326 counts
Resolution	0.6	0.6	0.6 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-867.xls Revision J 3/17/08

Transmissometer (casts 1 through 25)

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 February 1, 2012 S/N# CST-407DR Pathlength 25

	Analog output
V_d	0.060 V
V_{air}	4.778 V
V_{ref}	4.678 V

Temperature of calibration water	22.1 °C
Ambient temperature during calibration	20.9 °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

Transmissometer (casts 26 through 70)

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 September 17, 2012 S/N# CST-248DR Pathlength 25cm

	Analog output
V_d	0.059 V
V_{air}	4.744 V
V_{ref}	4.631 V

Temperature of calibration water	20.1 °C
Ambient temperature during calibration	20.8 °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

Mocness Calibration Sheets

Pressure Housing

DEPTH SENSOR CALIBRATION
S/N 156 XII-16-2009

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 =
156
C1 =
1.906887085529089e-11
C0 =
-1.786165831421366e-08
B1 =
-3.681685468843880e-07
B0 =
0.10481555322975
A1 =
0.00198004969432
A0 =
-2.097971989891269e+02

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: 07-Feb-12

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
g = 4.34907876e-003
h = 6.48424617e-004
i = 2.36943674e-005
j = 2.23737057e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS
a = 3.68121202e-003
b = 6.05635188e-004
c = 1.65575950e-005
d = 2.23896340e-006
f0 = 2907.897

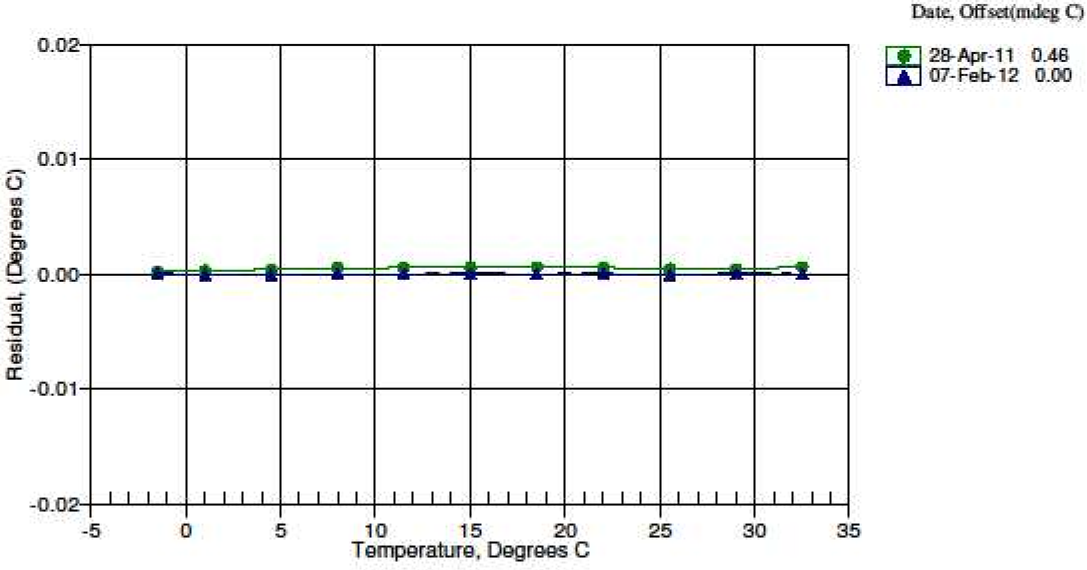
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	2907.897	-1.5000	0.00002
1.0000	3073.922	1.0000	-0.00003
4.5000	3317.721	4.5000	-0.00002
8.0000	3575.107	8.0000	0.00001
11.5000	3846.436	11.5000	0.00000
15.0000	4132.062	15.0000	0.00002
18.5000	4432.318	18.5000	-0.00000
22.0000	4747.539	22.0000	0.00002
25.5000	5078.023	25.4999	-0.00008
29.0063	5424.745	29.0063	0.00005
32.5000	5786.042	32.5000	-0.00000

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: 2293
CALIBRATION DATE: 31-Jan-12

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

GHIJ COEFFICIENTS
g = -1.07166224e+001
h = 1.48197133e+000
i = -2.80448373e-003
j = 2.83271240e-004
CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

ABCDM COEFFICIENTS
a = 7.08567283e-008
b = 1.47403096e+000
c = -1.06988150e+001
d = -8.18826439e-005
m = 7.2
CPcor = -9.5700e-008 (nominal)

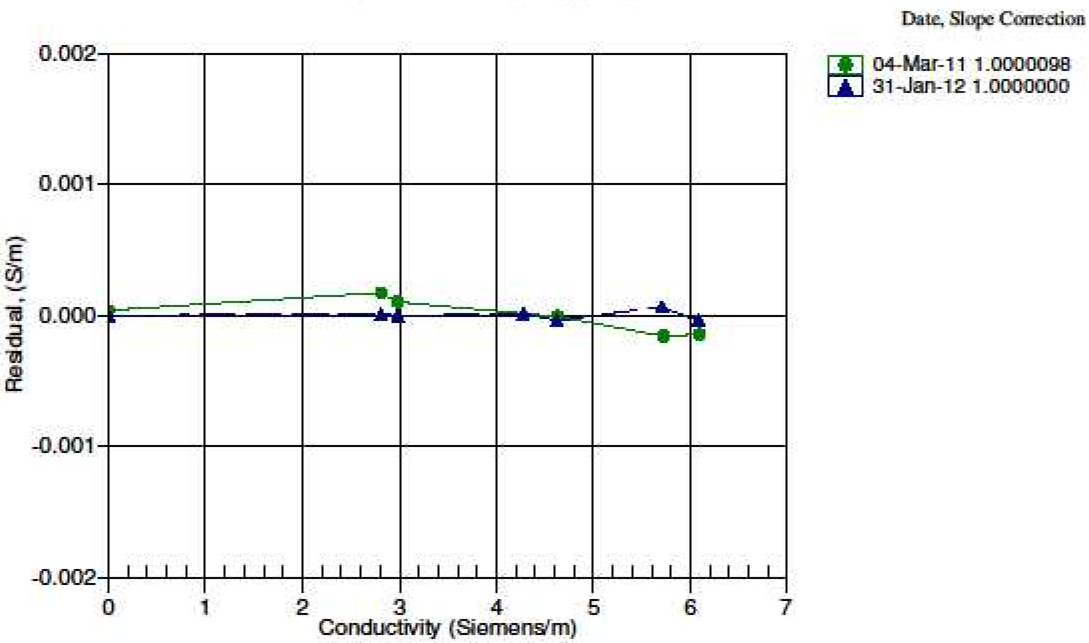
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.69412	0.00000	0.00000
-0.9999	34.8715	2.80862	5.12896	2.80862	0.00001
1.0001	34.8719	2.98027	5.24116	2.98027	-0.00000
15.0001	34.8711	4.27763	6.02156	4.27764	0.00001
18.5001	34.8708	4.62483	6.21364	4.62479	-0.00004
29.0001	34.8688	5.70996	6.77870	5.71002	0.00006
32.5001	34.8634	6.08328	6.96229	6.08324	-0.00004

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



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: 8/22/2012 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	0.057	0.025	0.010 V	49 counts
Scale Factor (SF)	6	13	26 µg/l/V	0.0078 µg/l/count
Maximum Output	4.97	4.97	4.97 V	16380 counts
Resolution	0.4	0.4	0.4 mV	1.0 counts

Ambient temperature during characterization 22.3 °C

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

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

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

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

Resolution: Standard deviation of 1 minute of collected data.

The relationship between fluorescence and chlorophyll-a concentrations *in-situ* is highly variable. The scale factor listed on this document was determined using a mono-culture of phytoplankton (*Thalassiosira weissflogii*). The population was assumed to be reasonably healthy and the concentration was determined by using the absorption method. To accurately determine chlorophyll concentration using a fluorometer, you must perform secondary measurements on the populations of interest. This is typically done using extraction-based measurement techniques on discrete samples. For additional information on determining chlorophyll concentration see "Standard Methods for the Examination of Water and Wastewater" part 10200 H, published jointly by the American Public Health Association, American Water Works Association, and the Water Environment Federation.

FLRTD-1735.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 October 1, 2012 S/N# CST-553DR Pathlength 25cm

	Analog output
V_d	0.060 V
V_{air}	4.797 V
V_{ref}	4.705 V

Temperature of calibration water	20.0 °C
Ambient temperature during calibration	21.6 °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

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
366	00:49	Data logging ON	@68°West
003	10:19	Data logging OFF	@ PAL
005	11:47	Data logging ON	Leaving PAL
012	07:30	Transmissometer on CTD was giving erratic data. Removed trans. 407DR and replaced with 248DR	
019	17:43	Data logging OFF	@ Rothera
020	10:23	Data logging ON	Leaving Rothera
033	10:44	Data logging OFF	@ PAL
034	16:15	Data logging ON	Leaving PAL
037	20:20	Data logging OFF	@68°West