LMG 1201

LTER

Cruise Data Report

By Mike Coons and Tony Daoust

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All of the data has been archived with the Unix "tar" command and/or compressed using Unix "gzip" compression.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

ADCP:
ADCP.tar

Cal:
InstCoef.txt
CTD/
UW/
Mocness/
PRR-PUV/

Imagery:
Imag.tar

Logsheet:
Air.pdf
TCO2.pdf
XBT_Log.pdf
XCTD_Log.pdf

Maps:
LMG1201.jpg
LMG1201.ps
LMG1201.track

Mocness:
Mocness.tar.gz

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:
LMG1201.xls

Science:
Eventlog_1201.xls
B-019/
B-021/
B-045/

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.

MOCNESS

1-meter and 10-meter

Mocness/

The MOCNESS data resides in the MOC1.gz and MOC10.gz archive for the 1-meter and 10-meter respectively. The data set from each cast is made up of three files. The filenames consist of the station number and an extension: .pro .raw or .tab. The type of data in each file is listed below.

.pro	processed data in space delimited tabular format
.raw	raw cast data in ASCII text format
.tab	statistical summary in space-delimited tabular format

Processed filename *.pro

This file contains the processed data for each tow, written in ASCII to disk in a simple configuration, which consists of:

Rows 1-5	header information about sensors and the tow
Row 6	the column headings (discussed below): time pres echo temp theta sal sigma angle flow hzvel vtvel vol net fluor ptran oxycurrent oxytemp oxygen lat lon
Succeeding rows	data for each column heading with each value separated by 2 spaces.

time	Julian day, hours and minutes expressed as decimal
pres	depth (m)
temp	temperature degrees C
theta	potential temperature, formulae from Fofonoff and Millard 1983
sal	salinity ppt
sigma	potential density, formulae from Fofonoff and Millard 1983
angle	angle 0-90
flow	flow counts 0000-9999
hzvel	horizontal velocity (knots)
vtvel	vertical velocity (m/min)
vol	seawater volume filtered (m3)
net	net number
fluor	fluorescence (0-5 volts)
ptran	extinction coefficient (0-5 volts)
oxycurrent	0-5 volts
oxytemp	0-5 volts internal to the probe
oxygen	dissolved oxygen (ml/l)
lat	latitude decimal degrees
lon	longitude decimal degrees

Raw filename *.raw

This file contains the raw data from the underwater unit. These “*.raw” files can be used in the playback mode to re-process the data (see page 33 MOCNESS instructions), and also serve as the backup in case there are problems with the processed data file.

For each tow, data is written (as it appears in the acquisition window) in ASCII to disk in a simple configuration, which consists of:

Rows 1-5	header information about sensors and the tow
Succeeding rows	raw data string formatted thusly: #MN- N1 N2 AA FFFF PPPPP PTPT TTTTTT CCCCCC BBB $GPGLL

The fields are as follows and are discussed individually below.

N1	net count, counts of left response switch, 00-99
N2	net count, counts of right response switch, 00-99
AA	net angle in degrees, 00-99
FFFF	flow counts, 0000-9999. Reset to 0000 with every net response or increment net # button command
PPPPP	pressure value, converted to decibars by the deck computer
PTPT	a decimal number derived from the temperature sensor in the pressure sensor which is used to improve the pressure calibration
TTTTTT	averaged SeaBird temperature period. The frequency from the SeaBird temperature sensor is measured and processed in the NCU to generate the value TTTTTT, a 6-digit decimal number. This number is scaled as follows: (frequency of the temp. sensor)=K/(TTTTTT) where K=1,258,291,200. Software in the deck computer uses this frequency value along with the individual sensor's calibration file to calculate temperature.
CCCCCC	averaged SeaBird conductivity period, handled exactly like the temperature frequency and the same scaling factor should be used
BBB	battery voltage (divide value by 10)
$GPGLL	latitude and longitude in decimal degrees

Tab filename *.tab

The statistical summary for a given *.pro file. For each net, the following parameters are included:

pmin,pmax,pavg	minimum, maximum and average depth of net
tmin,tmax,tavg	minimum, maximum and average temperature of net
smin,smax,savg	minimum, maximum and average salinity of net
amin,amax,aavg	minimum, maximum and average angle of net
spmin,spmax,spavg	minimum, maximum and average horizontal velocity (kt) of net
armin,armax,aravg	minimum, maximum and average vertical velocity (m/sec) of net
#obs	total number of observations while net was open
vol	total seawater volume filtered for net

Captured screens, filenames *.bmp

This file is bitmap image of the acquisition software captured at any point during a MOCNESS "flight". The files on this CD reflect the acquisition window at the end of each "flight", immediately prior to ending acquisition.

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

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
PIR (LW radiation)	lmwx	continuous	1 sec	Eppley PIR
PSP (SW radiation)	lmwx	continuous	1 sec	Eppley PSP
Port Ultrasonic Wind Speed/Direction	lmwx	continuous	1 sec	Gill Wind Observer II

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

ldflr – 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	

loxy - Oxygen

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

lpco – 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	VCO2	mL
7	Equilibrator temperature	°C
8	PCO2	millibars
9	Gas flow	mL/min
10	Solenoid position ID	number
11	Valve 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	μW/cm^{2}nm
6	Ed0313 - GUV	μW/cm^{2}nm
7	Ed0320 - GUV	μW/cm^{2}nm
8	Ed0340 - GUV	μW/cm^{2}nm
9	Ed0380 - GUV	μW/cm^{2}nm
10	Ed0395 - GUV	μW/cm^{2}nm
11	Ed0PAR - GUV	μE/cm^{2}sec
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	μW/cm^{2}nm
6	EdZ313 -PUV	μW/cm^{2}nm
7	EdZ320 -PUV	μW/cm^{2}nm
8	EdZ395 -PUV	μW/cm^{2}nm
9	EdZ340 -PUV	μW/cm^{2}nm
10	EdZPAR -PUV	μE/cm^{2}sec
11	LuZChl -PUV	μE/srm^{2}sec
12	EdZ380 -PUV	μW/cm^{2}nm
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	μW/cm^{2}nm
21	Ed0313 - GUV	μW/cm^{2}nm
22	Ed0320 - GUV	μW/cm^{2}nm
23	Ed0340 - GUV	μW/cm^{2}nm
24	Ed0380 - GUV	μW/cm^{2}nm
25	Ed0395 - GUV	μW/cm^{2}nm
26	Ed0PAR - GUV	μE/cm^{2}sec
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 – Latitiude/Logitude

`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	Logitude	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 – Latitiude/Logitude

```
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	Logitude	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	840019	N/A	Collected
Starboard Anemometer	Gill Ultrasonic Wind Observer II	71738	N/A	Collected
Barometer	R.M. Young 61201	BP0873	28-Jul-2010	Collected
Humidity/Wet Temp	RM Young 41372LC	06133	03-Dec-2010	Collected
PAR for Mast	Biosph. Inst. QSR-240P	6393	31-Aug-2010	Collected
PIR	Eppley PIR	28903F3	13-Oct-2010	Collected
PSP	Eppley PSP	28933F3	9-Sept-2010	Collected
GUV (Mast)	Biosph. Inst. GUV-2511	25110805126	18-May-2011	Collected
Transmissometer	WET Labs C-Star 25 cm deep	CST-248DR	09-Mar-2010	Collected
MicroTSG (Primary)	Sea-Bird 45	390	20-Oct-2012	Collected
MicroTSG (Secondary)	Sea-Bird 45	243	21-Jul-2010	Collected
Digital Remote Temp	Sea-Bird 38	262	22-Jul-2010	Collected
Fluorometer	WET Labs ECO-FL	FLRTD-398	07-Sep-11	Collected

CTD Sensors

Sensor	Description	Serial #	Cal. Date	Status
CTD Fish	Seabird SBE9Plus	0328	19-Aug-11	Collected
Primary Temperature	Seabird SBE3	5025	17-Nov-10	Collected
Secondary Temperature	Seabird SBE3	5034	10-Aug-11	Collected
Primary Conductivity	Seabird SBE4	0350	15-Mar-11	Collected
Secondary Conductivity	Seabird SBE4	2247	19-Nov-10	Collected
Primary Dissolved Oxygen	Seabird SBE43	0181	06-Aug-11	Collected
Secondary Dissolved Oxygen	Seabird SBE43	0196	06-Aug-11	Collected
Fluorometer	Wet Labs ECO	AFLD-001	19-Apr-10	Collected
PAR	Biosph. Inst. QSP-2300	4561	14-Apr-11	Collected
Transmissometer	Wet Labs C-Star	CST-406DR	21-Dec-10	Collected

Mocness Sensors

Sensor	Description	Serial #	Cal. Date	Status
Pressure Sensor	Mocness depth sensor	178	19-Nov-10	Collected
Temperature	Seabird SBE3	2658	03-Mar-11	Collected
Conductivity	Seabird SBE4	2047	01-Apr-11	Collected
Fluorometer	Wet Labs ECO-FL	380	27-Apr-11	Collected
Transmissometer	Wet Labs C-Star	CST-892DR	28-Jun-10	Collected

Underway Calibration Sheets

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

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: 0262
CALIBRATION DATE: 22-Jul-10

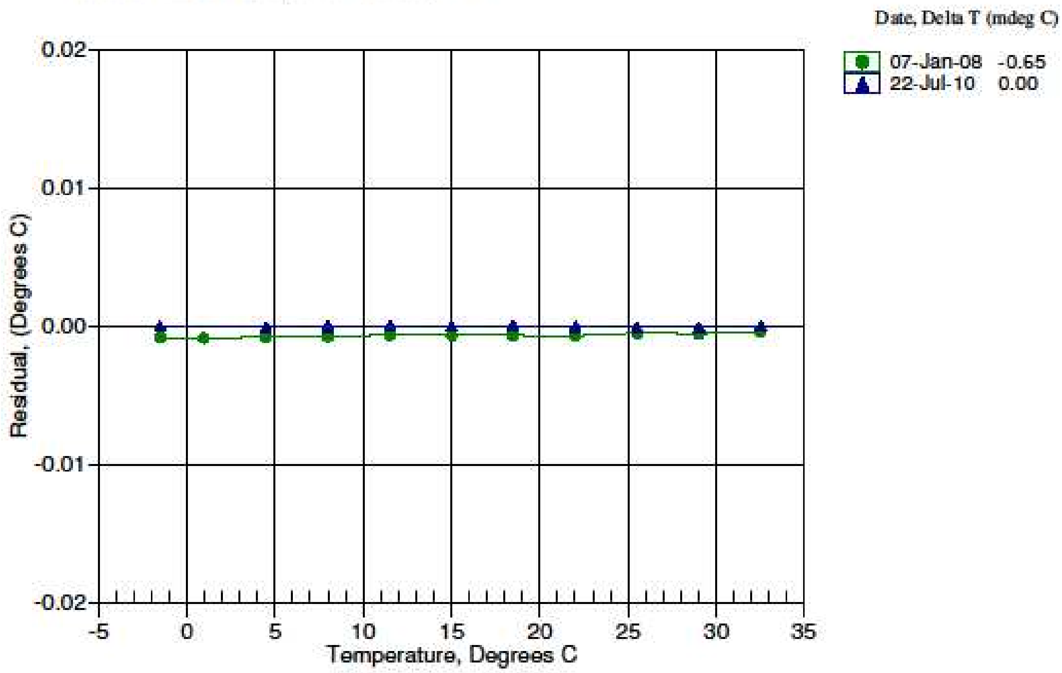
SBE 38 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
a0 = -3.222115e-005
a1 = 2.825818e-004
a2 = -2.780818e-006
a3 = 1.692821e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.50000	702866.8	-1.49998	0.00002
4.50000	538524.7	4.49996	-0.00004
8.00000	463074.9	7.99997	-0.00003
11.50000	399447.6	11.50003	0.00003
15.00000	345616.6	15.00002	0.00002
18.50000	299927.6	18.50005	0.00005
22.00000	261030.3	22.00001	0.00001
25.50000	227815.0	25.49995	-0.00005
29.00000	199368.1	28.99994	-0.00006
32.50000	174935.4	32.50005	0.00005

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 (temp) – Primary

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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: 1390
CALIBRATION DATE: 20-Oct-11

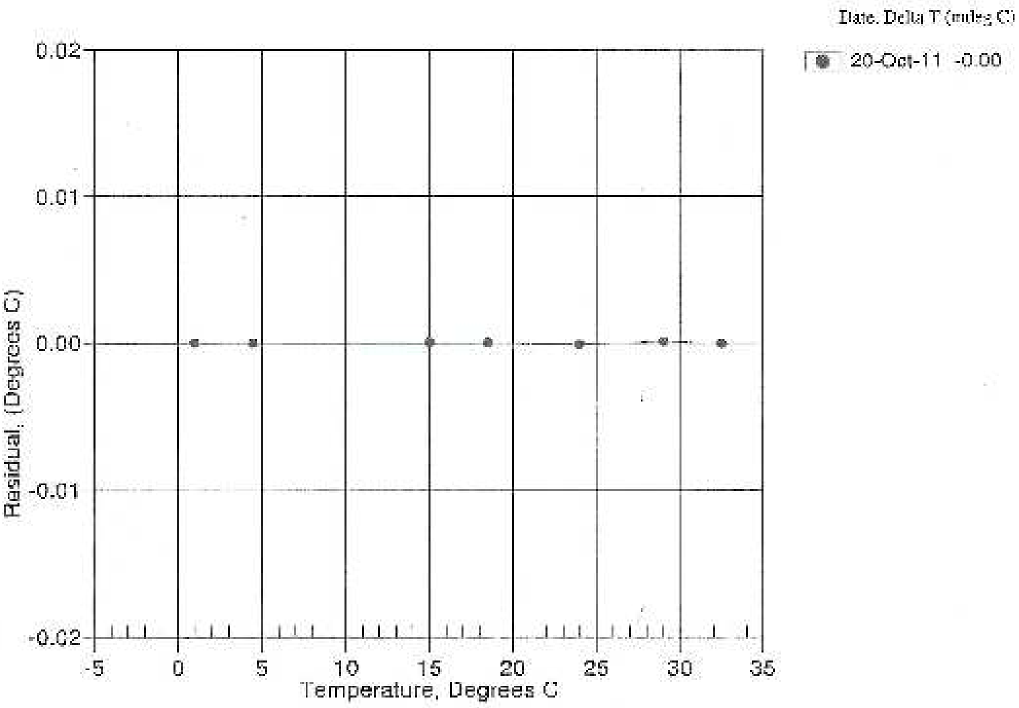
SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
a0 = 3.467593e-006
a1 = 2.937730e-004
a2 = -3.[illegible]78238e-006
a3 = 1.722408e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	652265.1	1.0000	0.0000
4.5000	55323[illegible].6	4.5000	-0.0000
14.9999	358378.3	14.9999	0.0000
18.4999	303307.3	18.4999	0.0000
24.0000	24[illegible]	23.9999	-0.0001
29.0000	20369[illegible].3	29.0001	0.0001
32.5000	[illegible]79[illegible]00.9	32.5000	-0.0000

Temperature ITS-90 = 1/{a0 + a1[ln(n)] + a2[ln²(n)] + a3[ln³(n)]} - 273.15 (°C)

Residual = instrument temperature - bath temperature



Thermosalinograph (conductivity) - Primary

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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 = -9.852968e-001
h = 1.472444e-001
i = -4.051034e-004
j = 5.337 06e-005

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

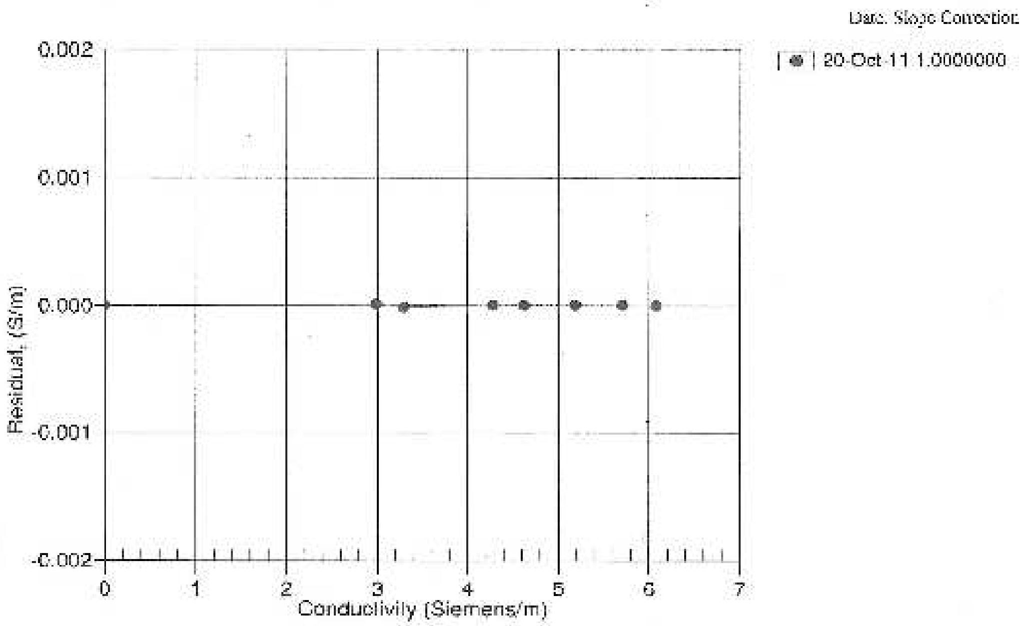
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2610.64	0.00000	0.00000
1.0000	34.7210	2.98436	5239.98	2.98407	0.00001
4.5000	34.8005	3.29188	5438.78	3.29187	-0.00001
14.9999	34.8564	4.27600	6029.77	4.27600	0.00000
18.4999	34.8467	4.62196	6221.68	4.62196	0.00000
24.0000	34.8354	5.18115	6525.11	5.18115	0.00000
29.0000	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: 0243
CALIBRATION DATE: 21-Jul-10

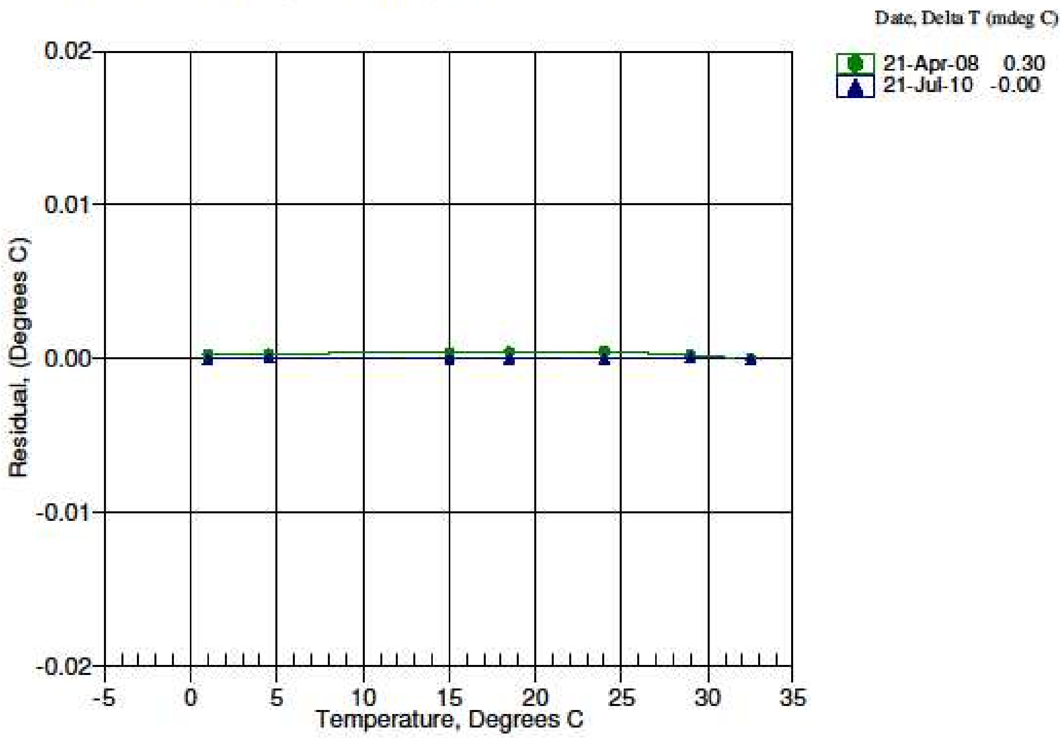
SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
a0 = 3.707259e-005
a1 = 2.694215e-004
a2 = -2.115219e-006
a3 = 1.410851e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	759624.8	1.0000	-0.0000
4.4999	647951.1	4.4999	0.0000
15.0000	410156.6	15.0000	-0.0000
18.5000	354385.3	18.5000	0.0000
23.9999	283361.9	23.9999	-0.0000
29.0000	232645.5	29.0001	0.0001
32.5000	203328.3	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) – 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: 0243
CALIBRATION DATE: 21-Jul-10

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

COEFFICIENTS:

g = -1.008835e+000
h = 1.573683e-001
i = -3.239483e-004
j = 5.119501e-005

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

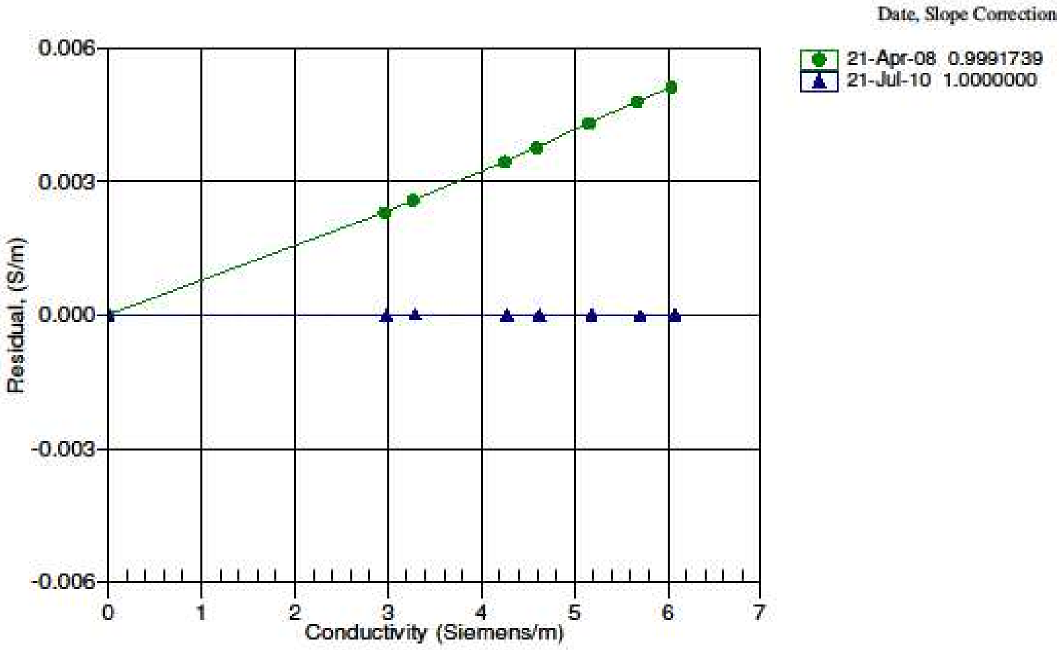
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2535.87	0.00000	0.00000
1.0000	34.9328	2.98497	5043.04	2.98496	-0.00001
4.4999	34.9132	3.29295	5233.27	3.29297	0.00001
15.0000	34.8700	4.27750	5798.83	4.27750	-0.00000
18.5000	34.8603	4.62357	5984.66	4.62357	-0.00000
23.9999	34.8493	5.18298	6273.11	5.18299	0.00001
29.0000	34.8428	5.70617	6531.01	5.70615	-0.00002
32.5000	34.8381	6.07936	6708.74	6.07937	0.00001

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

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

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

Residual = instrument conductivity - bath conductivity



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 March 9, 2010 S/N# CST-248DR Pathlength 25 cm

	Analog meter
V_d	0.059 V
V_{air}	4.742 V
V_{ref}	4.625 V

Temperature of calibration water	21.5 °C
Ambient temperature during calibration	23.0 °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

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

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

STANDARDIZATION OF EPPLEY PRECISION SPECTRAL PYRANOMETER Model PSP

Serial Number: 28933F3
Resistance: 686 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:

8.01×10^{-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 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 Tenth International Pyrheliometric Comparisons (IPC X) at Davos, Switzerland in September-October 2005.

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: Raytheon Polar Services
National Science Foundation
Port Hueneme, CA

Date of Test: September 9, 2010

In Charge of Test: Sidan L. Bunty

S.O. Number: 62700
Date: September 20, 2010

Reviewed by: Thomas D. Kirk

Remarks:

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: 674 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 23°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:

3.60×10^{-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: Raytheon Polar Services
Port Hueneme, CA

S.O. Number: 62716
Date: October 13, 2010

Date of Test: October 13, 2010

In Charge of Test:

Reviewed by:

Remarks: Instrument has new dome and element repainted. No "AS FOUND" data available.

PAR

Biospherical Instruments Inc.

CALIBRATION CERTIFICATE

Calibration Date	8/31/2010
Model Number	QSR240
Serial Number	6393
Operator	TPC
Standard Lamp	GS 1024(8/26/08)
Probe Excitation Voltage Range:	6 to 10 VDC(+)
Output Polarity:	Positive

Probe Conditions at Calibration(in air):

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

Probe Output Voltage:

Probe Illuminated	95.9	mV
Probe Dark	0.3	mV
Probe Net Response	95.6	mV
RG780	0.4	mV

Corrected Lamp Output:

Output In Air (same condition as calibration):

9.271E+15 quanta/cm²sec
0.01540 uE/cm²sec

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

Dry: 1.0310E-17 V/(quanta/cm²sec)
6.2087E+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 09/24/95

Temperature/Relative Humidity

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

COPY

CALIBRATION REPORT
Temperature Sensor

Customer: *Raytheon Technical Services Company LLC*

Test Number: 00641
Test Date: 3 December 2010

Customer P: RR53870-01
Sales Ord: 1597

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)
-50.04	3.990	-50.06
0.04	12.008	0.05
50.00	20.000	50.00

(1) Calculated from current output

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

Reference Instrument	Serial #	NIST Test Reference
Brooklyn Thermometer Model 43-FC	8006-B	204365
Brooklyn Thermometer Model 22332-D5-FC	2571	249763
Brooklyn Thermometer Model 2X400-D7-FC	7732	228060
Keithley Multimeter Model 191	1532	234027

Tested By: [signature]

METEOROLOGICAL INSTRUMENTS
Tel: 231-946-3980 Fax: 231-946-4772 Email: met.sales@youngusa.com Web: youngusa.com

Barometer

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

COPY

CALIBRATION REPORT
Barometric Pressure Sensor

Customer: *Raytheon Technical Services Company LLC*

Test Number: 07261
Test Date: 28 July 2010

Customer ID: RR52837-01
Sales Ord: 1325

Test Sensor:
Model: 61201 Serial Num: *BP00873*
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	4997	1099.8

(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	5150047	UKAS Lab 0221
Fluke Multimeter Model 8060A	486547	234027

Tested By: E. Chenny

METEOROLOGICAL INSTRUMENTS
Tel: 231-946-3980 Fax: 231-946-4772 Email: met.sales@youngusa.com Web: youngusa.com

GUV

Biospherical Instruments Inc.

GUV-2511 Calibration Certificate

System Serial Number	25110805126	Date of Calibration	5/18/2011
Calibration database	25110805126v5.mdb	Date of Certificate	5/18/2011
DASSN	0109	Standard of Spectral Irradiance	GS-1024(8/28/08)
Microprocessor Tag Number	2	Operator	TC

Monochromatic Channels	Address	Wavelength [nm]	Responsivity [Amps per µW/(cm²nm)]	ScaleSmall [Volts per µW/(cm²nm)]	ScaleMedium [Volts per µW/(cm²nm)]	ScaleLarge [Volts per µW/(cm²nm)]	OffsetSmall [volts]	OffsetMedium [volts]	OffsetLarge [volts]	Measurement Units
Ed0305	2	305	4.6890E-11	4.8236E-06	1.4095E-03	4.2917E-01	-6.9000E-05	-5.7000E-05	1.2390E-03	µW/(cm²nm)
Ed0313	6	313	2.3710E-10	2.4176E-05	7.0677E-03	2.4874E+00	-1.1400E-04	-1.1000E-04	1.1370E-03	µW/(cm²nm)
Ed0320	8	320	2.6470E-10	2.6942E-05	7.9183E-03	2.7409E+00	-2.9100E-04	-2.9500E-04	4.6900E-04	µW/(cm²nm)
Ed0340	10	340	1.9970E-10	2.0334E-05	5.9605E-03	2.1066E+00	-1.0600E-04	-1.0700E-04	1.1780E-03	µW/(cm²nm)
Ed0380	12	380	7.3830E-11	7.5232E-06	2.1953E-03	7.7065E-01	-3.8400E-04	-3.8500E-04	3.6900E-04	µW/(cm²nm)
Ed0395	13	395	3.0960E-10	3.1661E-05	9.2971E-03	3.2340E+00	5.4000E-05	5.2000E-05	1.5050E-03	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	1.6920E-05	1.7232E+00	5.0493E+02	1.7674E+05	-1.7000E-05	-1.9000E-05	1.4330E-03	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

CTD Sensors

CTD Fish

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: 0328
CALIBRATION DATE: 19-Aug-11

SBE9plus PRESSURE CALIBRATION DATA
10000 psia S/N 53980

DIGIQUARTZ COEFFICIENTS:

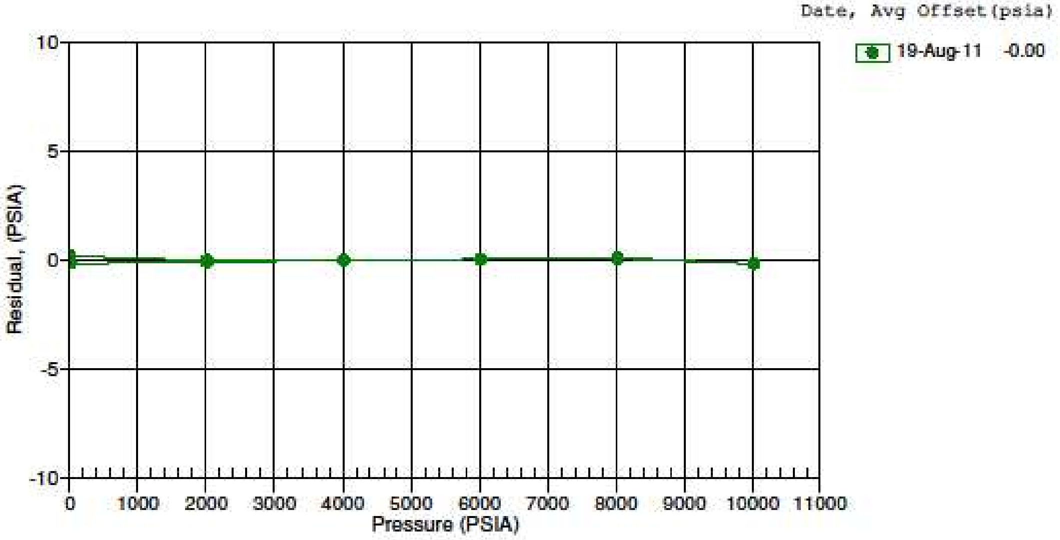
```
C1 =  -5.847002e+004
C2 =   6.910390e-001
C3 =   1.753360e-002
D1 =   4.241600e-002
D2 =   0.000000e+000
T1 =   3.026040e+001
T2 =  -1.938830e-004
T3 =   4.330190e-006
T4 =   2.020250e-009
T5 =   0.000000e+000
```

AD590M, AD590B, SLOPE AND OFFSET:

```
AD590M =    1.13300e-002
AD590B =   -8.47592e+000
Slope =     0.99998
Offset =   -0.8777 (dbars)
```

PRESSURE (PSIA)	INST OUTPUT(Hz)	INST TEMP(C)	INST OUTPUT (PSIA)	CORRECTED INST OUTPUT (PSIA)	RESIDUAL (PSIA)
14.646	33053.38	23.5	16.091	14.818	0.172
2015.118	33613.29	23.6	2016.419	2015.104	-0.014
4015.087	34162.38	23.6	4016.439	4015.082	-0.005
6015.115	34701.27	23.7	6016.559	6015.161	0.046
8015.276	35230.45	23.7	8016.782	8015.342	0.066
10015.529	35750.28	23.7	10016.841	10015.359	-0.169
8015.286	35230.46	23.7	8016.833	8015.393	0.108
6015.178	34701.29	23.8	6016.622	6015.224	0.046
4015.109	34162.39	23.8	4016.460	4015.104	-0.005
2015.058	33613.25	23.8	2016.279	2014.965	-0.093
14.643	33053.28	23.8	15.764	14.491	-0.152

Residual = corrected instrument pressure - reference pressure



Primary Temperature

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

SENSOR SERIAL NUMBER: 5025
CALIBRATION DATE: 17-Nov-10

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.37625317e-003
h = 6.37556383e-004
i = 2.15762687e-005
j = 1.89988436e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS

a = 3.68121102e-003
b = 5.96246109e-004
c = 1.51681048e-005
d = 1.90130549e-006
f0 = 3092.634

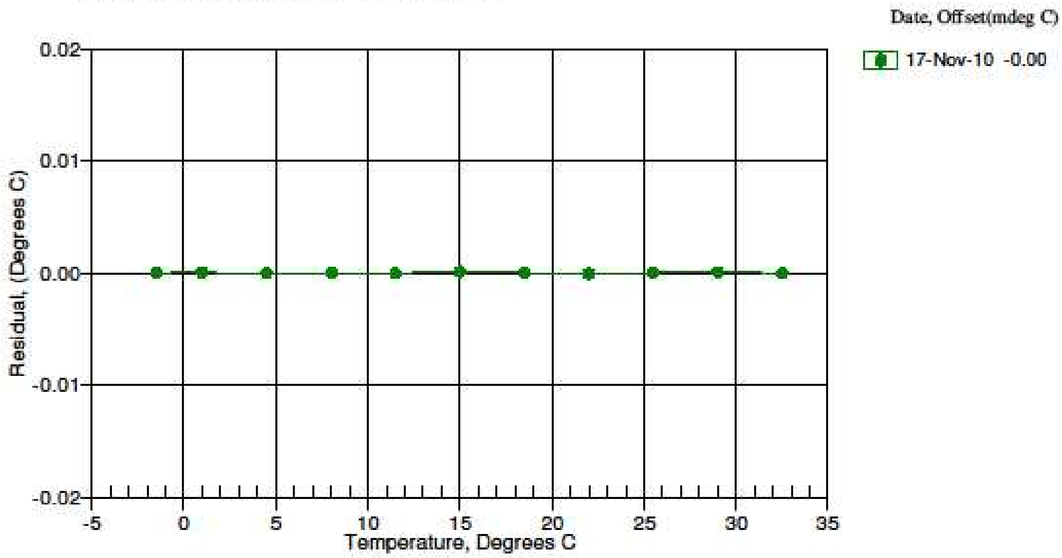
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.4999	3092.634	-1.4999	-0.00000
1.0000	3272.049	1.0000	0.00002
4.5001	3535.737	4.5001	-0.00003
8.0000	3814.376	8.0000	0.00000
11.5001	4108.397	11.5001	-0.00002
15.0000	4418.184	15.0001	0.00008
18.5001	4744.133	18.5001	-0.00001
22.0002	5086.621	22.0001	-0.00009
25.5001	5446.012	25.5001	0.00001
29.0001	5822.663	29.0002	0.00006
32.5001	6216.894	32.5001	-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)

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, Washington, 98005-2010 USA

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

SENSOR SERIAL NUMBER: 5034
CALIBRATION DATE: 10-Aug-11

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS	IPTS-68 COEFFICIENTS
g = 4.33939563e-003	a = 3.68121069e-003
h = 6.35747673e-004	b = 5.97166683e-004
i = 2.11367255e-005	c = 1.50926875e-005
j = 1.89179562e-006	d = 1.89321217e-006
f0 = 1000.0	f0 = 2914.509

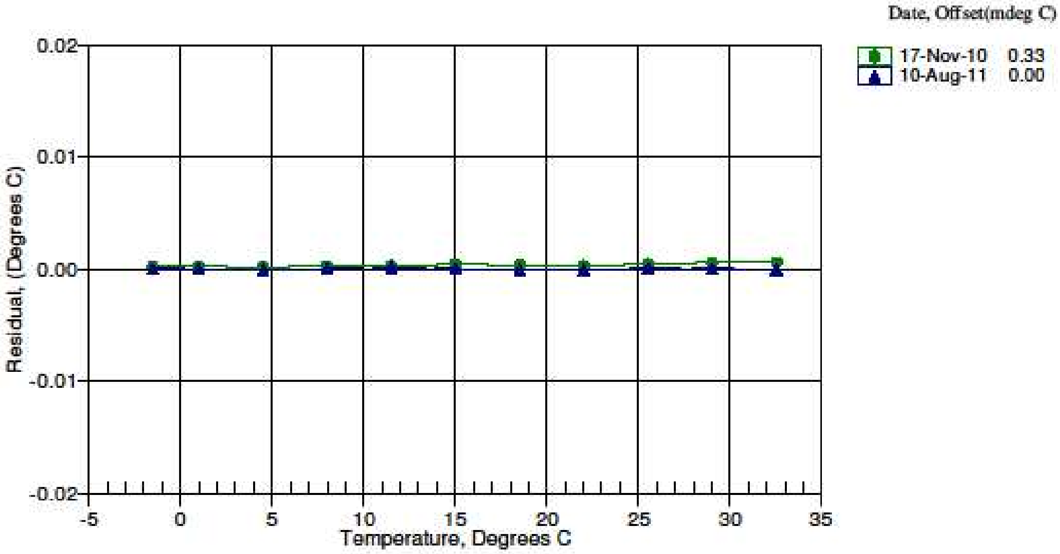
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.4999	2914.509	-1.4999	0.00002
1.0000	3083.317	1.0000	-0.00000
4.5001	3331.386	4.5000	-0.00008
8.0000	3593.486	8.0000	0.00001
11.5000	3870.010	11.5001	0.00010
15.0001	4161.318	15.0001	0.00000
18.5001	4467.774	18.5001	-0.00003
22.0001	4789.732	22.0000	-0.00008
25.5001	5127.548	25.5001	0.00004
29.0001	5481.522	29.0001	0.00004
32.5001	5851.974	32.5001	-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



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: 0350
CALIBRATION DATE: 15-Mar-11

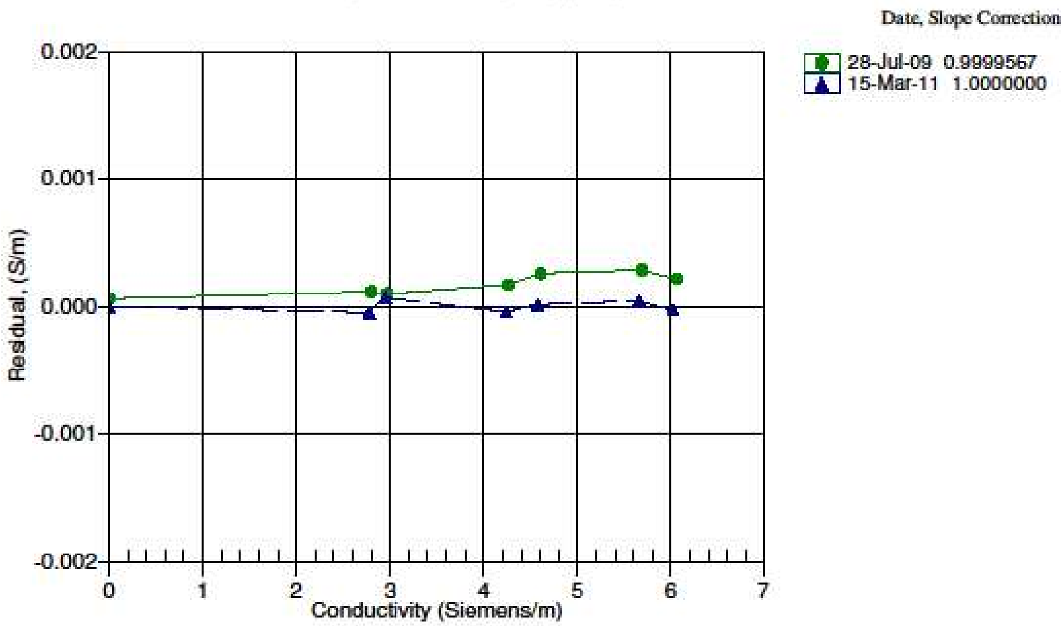
SBE4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS
g = -4.23044581e+000
h = 4.99585199e-001
i = -1.82843165e-004
j = 3.49852078e-005
CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

ABCDM COEFFICIENTS
a = 1.11100279e-005
b = 4.99006430e-001
c = -4.22852385e+000
d = -8.12086617e-005
m = 4.3
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	2.91066	0.00000	0.00000
-1.0000	34.4621	2.77869	7.99920	2.77864	-0.00005
1.0000	34.4610	2.94847	8.20807	2.94854	0.00007
14.9999	34.4628	4.23280	9.63954	4.23276	-0.00004
18.4999	34.4617	4.57636	9.98723	4.57638	0.00001
29.0000	34.4582	5.65023	11.00178	5.65027	0.00004
32.5000	34.4493	6.01919	11.32883	6.01916	-0.00003

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, Washington, 98005-2010 USA
Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 2247
CALIBRATION DATE: 19-Nov-10

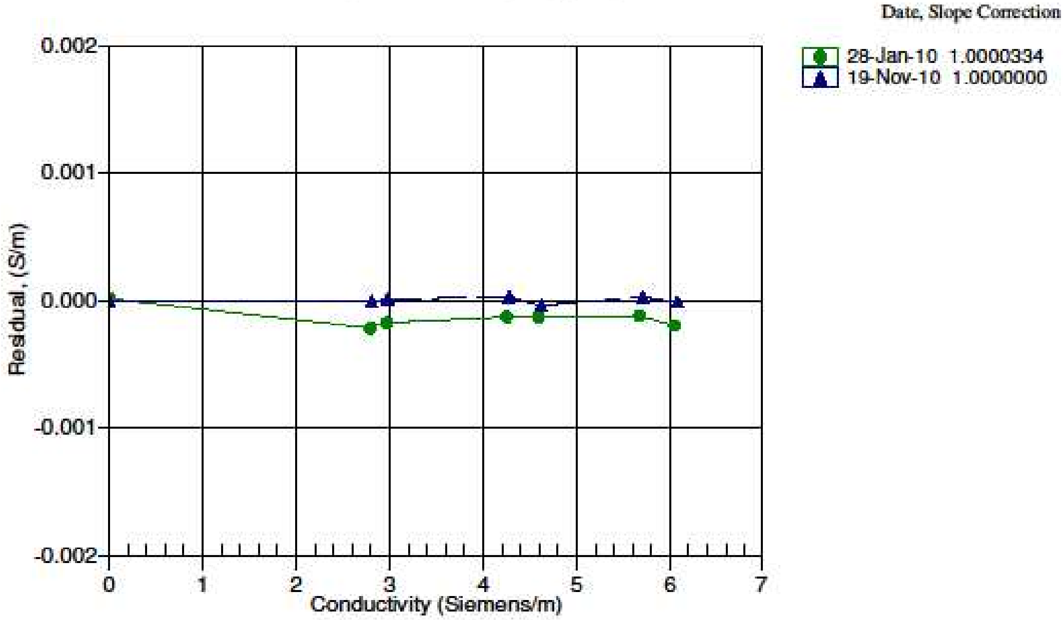
SBE4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Seimens/meter

GHIJ COEFFICIENTS
g = -1.03544955e+001
h = 1.37256514e+000
i = -1.83550046e-003
j = 2.01100103e-004
CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

ABCDM COEFFICIENTS
a = 5.94436022e-007
b = 1.36754951e+000
c = -1.03434546e+001
d = -8.44758212e-005
m = 6.1
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	2.75015	0.00000	0.00000
-1.0000	34.8484	2.80692	5.29881	2.80691	-0.00001
1.0000	34.8486	2.97846	5.41575	2.97847	0.00001
15.0000	34.8489	4.27519	6.22862	4.27522	0.00003
18.4999	34.8487	4.62219	6.42855	4.62215	-0.00004
29.0000	34.8449	5.70647	7.01642	5.70650	0.00002
32.5000	34.8372	6.07922	7.20727	6.07921	-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



Primary Dissolved Oxygen

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: 0181
CALIBRATION DATE: 06-Aug-11p

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS
Soc = 0.5570
Voffset = -0.5081
Tau20 = 1.32

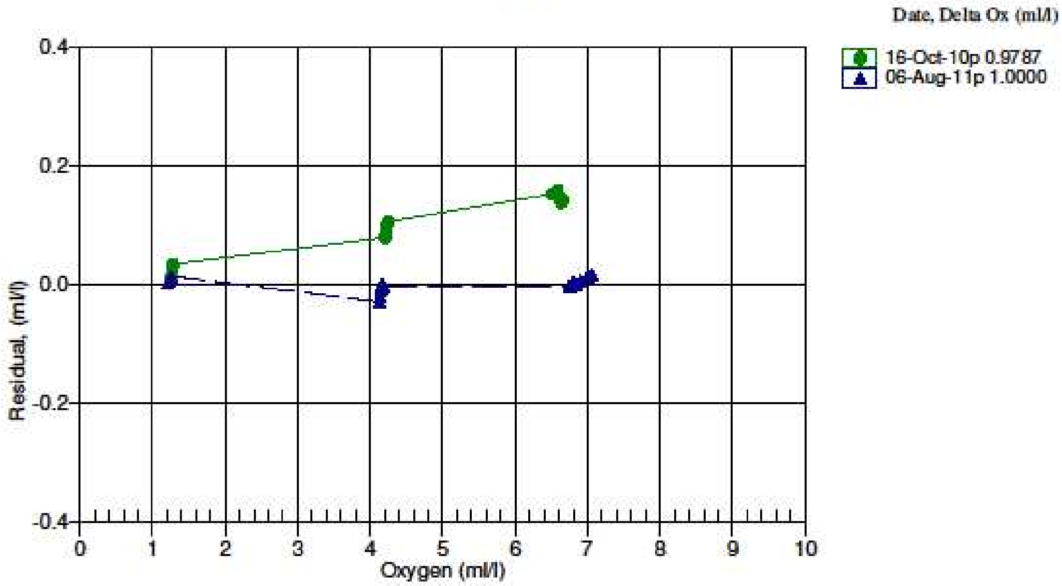
A = -2.9158e-003
B = 1.1921e-004
C = -2.4852e-006
E nominal = 0.036

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)
1.22	2.00	0.07	0.735	1.22	0.00
1.22	6.00	0.07	0.764	1.23	0.00
1.23	12.00	0.06	0.810	1.24	0.01
1.24	20.00	0.06	0.872	1.25	0.01
1.25	26.00	0.05	0.925	1.27	0.01
1.26	30.00	0.05	0.961	1.27	0.01
4.13	2.00	0.07	1.274	4.10	-0.03
4.13	6.00	0.07	1.368	4.11	-0.02
4.14	12.00	0.06	1.515	4.13	-0.01
4.15	20.00	0.06	1.716	4.15	-0.01
4.16	26.00	0.05	1.879	4.17	0.00
4.18	30.00	0.05	1.996	4.17	-0.00
6.75	30.00	0.05	2.913	6.75	-0.00
6.80	26.00	0.05	2.747	6.80	0.00
6.84	20.00	0.05	2.501	6.84	-0.00
6.89	12.00	0.06	2.189	6.90	0.01
6.99	6.00	0.07	1.973	7.01	0.01
7.05	2.00	0.07	1.827	7.07	0.02

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

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 Dissolved Oxygen

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: 0196
CALIBRATION DATE: 06-Aug-11p

SBE 43 OXYGEN CALIBRATION DATA

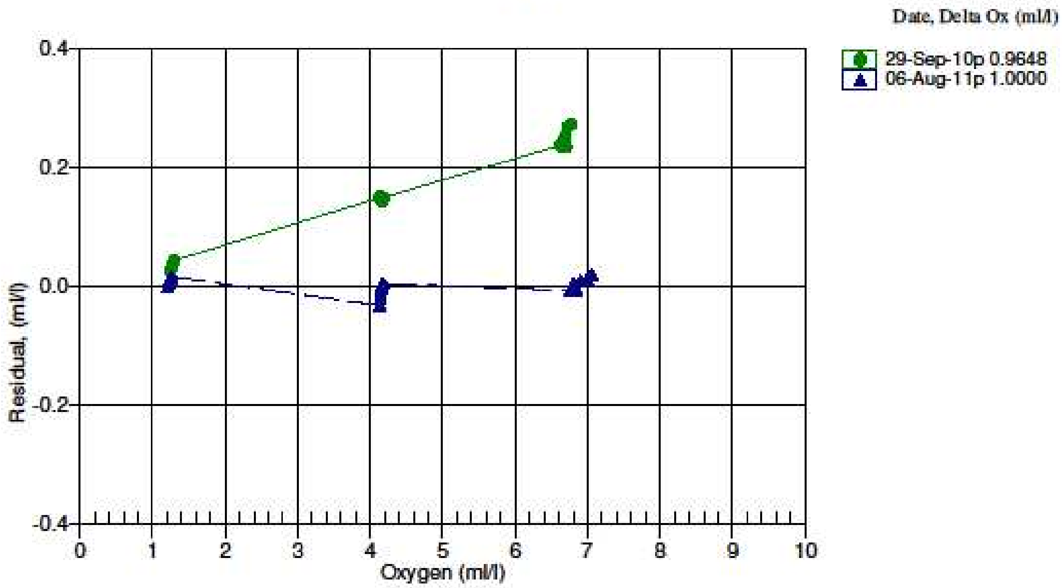
COEFFICIENTS
Soc = 0.5401
Voffset = -0.5075
Tau20 = 1.03

A = -6.5213e-003
B = 3.7152e-004
C = -4.3125e-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)
1.22	2.00	0.07	0.743	1.22	-0.00
1.22	6.00	0.07	0.775	1.23	0.00
1.23	12.00	0.06	0.822	1.24	0.01
1.24	20.00	0.06	0.877	1.25	0.01
1.25	26.00	0.05	0.918	1.27	0.01
1.26	30.00	0.05	0.944	1.27	0.02
4.13	2.00	0.07	1.301	4.10	-0.03
4.13	6.00	0.07	1.407	4.11	-0.02
4.14	12.00	0.06	1.556	4.13	-0.01
4.15	20.00	0.06	1.737	4.15	-0.00
4.16	26.00	0.05	1.857	4.16	-0.00
4.18	30.00	0.05	1.940	4.18	0.00
6.75	30.00	0.05	2.817	6.74	-0.01
6.80	26.00	0.05	2.714	6.80	0.00
6.84	20.00	0.05	2.531	6.84	-0.01
6.89	12.00	0.06	2.260	6.90	0.01
6.99	6.00	0.07	2.038	7.01	0.01
7.05	2.00	0.07	1.877	7.07	0.02

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



Fluorometer

PO Box 518
620 Applegate St.
Philomath OR 97370

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

Chlorophyll Fluometer Characterization

Date: 04/1/10
Serial #: AFD-001
Tech: DCI

Dark Counts	**0.1841 volts**
CEV	**2.431 volts**
SF	**9.835**
FSV	**4.70 volts**
Linearity:	**0.999 R^2 (0–1.5 volts)**
	0.995 R^2 (0– 5.45 volts)

Notes:

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

CEV is the chloropyll equivalent voltage. This value is the signal output of the fluorometer when ung a fluorescent proxy that has been determined to be approximately equivalent to **22.1** g/l of a *Thalassiosira weissflogii* phytoplanktum culture.

SF is the scale fact used to derive chlorophyll concentration from the signal voltage output of the fluometer. The scale factor is determinc by using the following equation: SF = (22.1) / (CEV- dark).

FSV is the maximu signal voltage output that the fluorometer is capable of.

Chlorophyll concentran expressed in µg/l (mg/m^3) can be derived by using the following equation: (µg/l) = (Vmeasured -dark) SF

The relationship betwen fluorescence and chlorophyll-*a* concentrations in-situ is high variable. The scale factor listed on this doment was determined by using a mono-culture of phytoplankton (*Thalassiosira weissflogii*). The popution was assumed to be reasonably healthy and the concentration was determined by using the absorptiomethod. To accurately determine chlorophyll concentration using a fluorometer you must perform secdary measurements on the populations of interest. This is typically done using extraction based measament techniques on discrete samples. For additional information on determination of chlorophyll concentiion see [Standard Methods For The Examination Of Water And Wastewater] part 10200 H published joiny by: American Public Health Association, American Water Works Association and Water Environme Federation.

PAR

Biospherical Instruments Inc

CALIBRATION CERTIFICATE

UNDERWATER PAR SENSOR WITH LOG AMPLIFIER

Calibration Date: 04/14/11 **Job No.:** R10913
Model Number: QSP200L
Serial Number: 4561
Operator: TPC
Standard Lamp: GS1024(6/28/08)
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:	1.30E+13	quanta/cm²·sec/"amps"	2.16E-05	μEinsteins/cm²·sec/"amps"
Wet Calibration Factor:	2.19E+13	quanta/cm²·sec/"amps"	3.64E-05	μEinsteins/cm²·sec/"amps"

Sensor Test Data and Results[4]

Sensor Supply Current (Dark):	58.8	mA			
Supply Voltage:	6	Volts			
Lamp Integrated PAR Irradiance:	9.27E+15	quanta/cm²·sec	0.01540	μEinsteins/cm²·sec	
SC3 Immersion Coefficient:	0.594	Scalar Correction:	✓	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%	2.553	100.00%	7.13E-08	7.13E-08	2.854	0.001	0.0	9.27E+15
0.3	36.10%	2.412	36.10%	2.57E-08	2.57E-08	2.413	0.001	0.0	3.35E+15
0.5	27.80%	2.299	27.78%	1.98E-08	1.97E-08	2.297	-0.002	-0.7	2.58E+15
1	9.27%	1.836	9.43%	6.72E-09	6.61E-09	1.829	-0.007	-1.7	8.75E+14
2	1.11%	0.980	1.14%	8.11E-10	7.91E-10	0.971	-0.009	-2.4	1.05E+14
3	0.05%	0.300	0.08%	5.47E-11	3.81E-11	0.262	-0.038	-30.4	7.11E+12

Dark Before:	0.152	Volts				
Light - No Filter Hldr.:	2.853	Volts	I_{ref} =	1.00E-10	Amps	
Dark After - NFH:	0.181	Volts	I_{dark} =	1.45E-10	Amps	RG780 0.261
Average Dark:	0.161	Volts	$10^{V_{dark}}$ =	1.449606	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(2006).xls

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 December 21, 2010 S/N# CST-406DR Pathlength 25 cm

	Analog meter
V_d	0.059 V
V_{air}	4.854 V
V_{ref}	4.751 V

Temperature of calibration water	22.8 °C
Ambient temperature during calibration	21.7 °C

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

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

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

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

Revision L 6/9/09

Mocness Sensors

Mocness Pressure Sensor

DEPTH SENSOR CALIBRATION
SERIAL #178 XI-18-2010

The pressure sensor used in MOCNESS is a titanium strain gauge with an internal temperature sensor. The temperature of the sensor is measured and used to correct for thermal effects. The MOCNESS measures the voltage across the temperature and pressure bridges of the sensor and reports these values in its output data stream. The MOCNESS pressure sensor is calibrated at several pressure points and two temperatures. There are no adjustments in the MOCNESS hardware and all the calibration is done with 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 temperature. The calibration data is fit in 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 from pressure sensor
VT = voltage reading from strain gauge temperature sensor

Serial number = 178

C1= -4.905836339649276e-12

C0= 3.913477086547072e-08

B1= 1.144591303033090e-07

B0= 0.10333754008354

A1= -0.00410050111951

A0= -1.521207434502750e+02

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: 2658
CALIBRATION DATE: 03-Mar-11

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS
g = 4.31185927e-003
h = 6.39520807e-004
i = 2.21994418e-005
j = 2.01447123e-006
f0 = 1000.0

IPTS-68 COEFFICIENTS
a = 3.68121106e-003
b = 6.00704593e-004
c = 1.60696391e-005
d = 2.01598531e-006
f0 = 2769.966

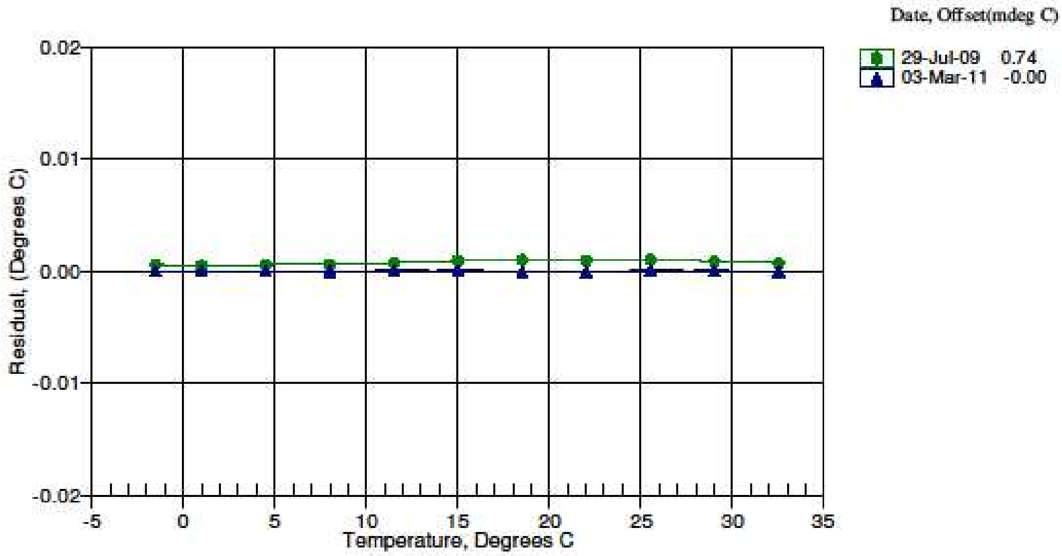
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.4999	2769.966	-1.4999	-0.00001
1.0001	2929.452	1.0001	0.00002
4.5001	3163.757	4.5001	-0.00000
8.0002	3411.266	8.0002	-0.00005
11.5002	3672.337	11.5002	0.00005
15.0002	3947.311	15.0003	0.00006
18.5002	4236.523	18.5001	-0.00007
22.0002	4540.324	22.0001	-0.00008
25.5001	4859.030	25.5002	0.00008
29.0002	5192.942	29.0002	0.00003
32.5001	5542.333	32.5001	-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)

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, Washington, 98005-2010 USA

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

SENSOR SERIAL NUMBER: 2047
CALIBRATION DATE: 01-Apr-11

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

GHIJ COEFFICIENTS

```
g = -1.06210369e+001
h =  1.45418660e+000
i = -5.40301219e-003
j =  5.97778332e-004
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  1.51676579e-006
b =  1.43957446e+000
c = -1.05895066e+001
d = -8.46206392e-005
m =  6.2
CPcor = -9.5700e-008 (nominal)
```

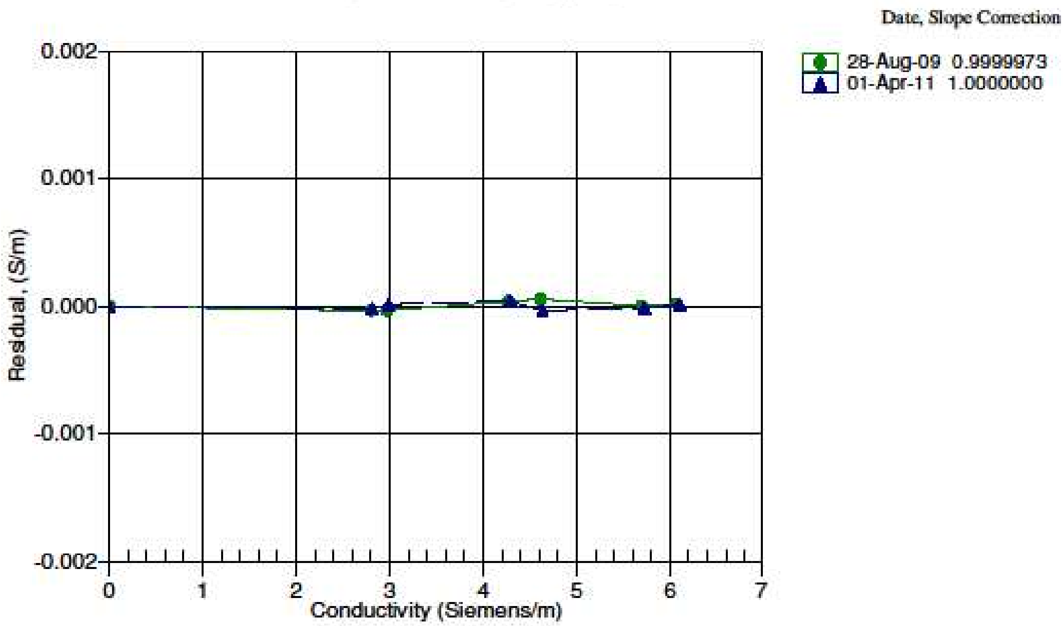
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.71213	0.00000	0.00000
-1.0000	34.9711	2.81588	5.18540	2.81586	-0.00002
0.9999	34.9714	2.98795	5.29904	2.98796	0.00001
15.0000	34.9716	4.28864	6.08859	4.28868	0.00004
18.5000	34.9716	4.63674	6.28266	4.63671	-0.00003
28.9999	34.9674	5.72426	6.85277	5.72425	-0.00001
32.5000	34.9563	6.09763	7.03751	6.09765	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



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: 4/27/2011 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	0.104	0.060	0.037 V	73 counts
Scale Factor (SF)	6	13	26 µg/l/V	0.0077 µg/l/count
Maximum Output	4.91	4.91	4.91 V	16326 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-380.xls Revision J 3/17/08

Transmissometer

PO Box 518
520 Applegate St.
Philomath, OR 97370

WET Labs

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

C-Star Calibration

Date June 28, 2010 S/N# CST-892DR Pathlength 25 cm

	Analog meter
V_d	0.068 V
V_{air}	4.823 V
V_{ref}	4.716 V

Temperature of calibration water	22.4 °C
Ambient temperature during calibration	22.3 °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

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.

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.

The PCO2 system was turned off when it was discovered that there was no regulator onboard for the Chilean replacement Nitrogen tank. Palmer Station supplied the LMG with an appropriate tank for running the PCO2 system during the Northbound Drake passage.

Date (Julian)	Time (GMT)	Event	Location
364	04:54	Started data collection	@68W
002	16:04	Data logging turned OFF	Arrive Palmer Station
002		Swapped fluorometer on wet wall from s/n 399 to s/n 398	@ Palmer Station
003	23:35	Started new cruise on ADCP called lmg1201a after changes were made to ADCP server by Jules Hummons	
004	11:34	Data logging turned ON	Depart Palmer Station
021	10:06	Started new cruise on ADCP called lmg1201_RTHA. A collaborating scientist at Rothera needed only the ADCP data from that day.	@ Rothera Station
021	17:23	Data logging turned OFF	Arrive Rothera Station
022	10:10	Data logging turned ON	Depart Rothera Station
022	10:14	Started new cruise on ADCP called lmg1201b after we left Rothera.	@ Rothera Station
026	~7:50	Sea water intake clogged while we were in the ice, causing pressure to increase and pumps to shut down. They were cycled on but kept cutting out for about an hour. Wet wall data from this time may be inaccurate.	
032	10:02	Data logging turned OFF	Arrive Palmer Station
033	12:50	Data logging turned ON	Depart Palmer Station
037	08:27	Data logging turned OFF	@68W