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# LMG 1111

**LTER Site Review**

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## **Cruise Data Report**

**By Mike Coons and Bruce Felix**



**5 Dec 2011 – 19 Dec 2011**

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All of the data has been archived with the Unix “tar” command and/or compressed using Unix “gzip” compression.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

<p>ADCP: ADCP.tar</p> <p>Cal: InstCoef.txt</p> <p>Imagery: Imag.tar</p> <p>Logsheet: Air.pdf</p> <p>Maps: LMG1111.jpg LMG1111.ps LMG1111.track</p> <p>Ocean: Ctd.tar</p> <p>Process: JGOF.tar PCO2.tar PROC.tar QC.tar</p> <p>Report: Report.doc Report.pdf</p> <p>RVDAS: nav/ uw/</p> <p>Utility: Acrobat Winzip</p>		
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## 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](mailto: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.

### CTD

CTD/

The ctd data was collected and processed on a computer running Windows XP, using Seasave Win32 – Version 7.2 and SBE Data Processing – Version 7.21

For more information and software visit the web site at [www.seabird.com](http://www.seabird.com).

CTD/Setup/

In the Setup directory there is a Config file in html, excel, and text form which contain information of which sensors were used and what freq or volt the were connected to. The file also contains a table with the vertical distance in meters from the pressure port that each sensor was mount. The distances are positive as pressure increases.

CTD/Scripts/

This directory contains the batch file and psu 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.

CTD/Data/raw

The raw.tgz file is a tar archive file that has been compressed with gzip, for more information on this see the above *Introduction* section. This archive contains the raw file collect at each CTD cast, which is represented by a set of four files containing a bottle-firing file (.bl), a configuration file (.con), a data file (.dat) 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 1 on this cruise are: g501001.bl, g501001.con, g501001.dat, g501001.hdr. The raw data files(\*.dat) are binary files.

CTD/Data/process

The process.gz file is a tar archive file that has been compressed with gzip. For more information on this see the above *Introduction* section. This archive 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.con	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.

## Imagery

/Imagery/

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

## Data and Science Report

/Report/

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

## XBT

/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 be a combination of binary and ascii files generated by standard Sippican MK-21 software.

## XCTD

/XCTD/

Contains binary and ascii data files as generated by standard Sippican MK-21 software.

## Logsheets

/logsheet/

This directory contains logsheets for XBT, XCTD, air samples and TCO<sub>2</sub> data. For further information on this data (TCO<sub>2</sub>), contact Tim Newberger at [tnewberg@ldeo.columbia.edu](mailto:tnewberg@ldeo.columbia.edu).

## **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.

## **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.

## **QC Plots**

/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

/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	$\mu\text{Einsteins/meters}^2 \text{ sec}$
10	Sea surface temperature	$^{\circ}\text{C}$
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	$^{\circ}\text{C}$
17	Relative humidity	%
18	Barometric pressure	mBars
19	Sea surface fluorometry	volts (0-5 FSO)
20	Not used	-
21	PSP	$\text{W/m}^2$
22	PIR	$\text{W/m}^2$

## TSG Data files

/TSG/tsgfl

RVDAS processes the ltsg.d### file, using the Seabird calibration. It produces a daily tsgfl.d### file with the below fields.

04+321:00:01:23.978 -00.070 -00.089 02.8042 33.75690 0.471306 4.341880

Field	Data	Units
1	RVDAS Time Tag	
2	Internal water temperature	$^{\circ}\text{C}$
3	External water temperature	$^{\circ}\text{C}$
4	Conductivity	S/cm
5	Salinity	PSU

Field	Data	Units
6	Transmissometer signal	Volts

## 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	Eppler PIR
PSP (SW radiation)	lmwx	continuous	1 sec	Eppler 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
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)	lfir	continuous	1 sec	Turner 10-AU-005
Fluorometry (digital)	ldfir	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	Navigation Data	File ID
Meteorological - Cambell	lmwx	Gyro Compass	lgyr
Knudsen	lknu	P-CODE GPS	tgps
microTSG	utsg	Garmin 17 GPS	lgar
Digital Remote Temperature	lrtm	Seapath 330 GPS	lsep
Fluorometer – Wetlab ECO	ldfl		
ADCP	ladc		
Sound Velocity Probe	lsvp		
GUV & PUV	lguv		
PCO2 System	lpcu		
Oxygen	loxy		
Wet Wall Flows	lsea		
Winches: Dush4,5,&11	lwn1		
Net Depth Sensor	lnds		

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	

**Inds – 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

**Iwn1 - 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 Identifier, DUSH-X where X is 4, 5, or 11	
4	Tension	lbs
5	Speed	Meters/minute
6	Payout	meters
7	Checksum	

**Imwx - 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	°C
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

### utsg – microTSG, Thermosalinograph

For further information on this data, check [www.seabird.com](http://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

### Irtm – digital Remote Temperature

For further information on this data, check on [www.seabird.com](http://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

### Idflr – 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](mailto: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	°C
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](mailto: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	$\mu\text{W}/\text{cm}^2\text{nm}$
6	Ed0313 - GUV	$\mu\text{W}/\text{cm}^2\text{nm}$
7	Ed0320 - GUV	$\mu\text{W}/\text{cm}^2\text{nm}$
8	Ed0340 - GUV	$\mu\text{W}/\text{cm}^2\text{nm}$
9	Ed0380 - GUV	$\mu\text{W}/\text{cm}^2\text{nm}$
10	Ed0395 - GUV	$\mu\text{W}/\text{cm}^2\text{nm}$
11	Ed0PAR - GUV	$\mu\text{E}/\text{cm}^2\text{sec}$
12	Ed0Temp - GUV	°C
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	$\mu\text{W}/\text{cm}^2\text{nm}$
6	EdZ313 -PUV	$\mu\text{W}/\text{cm}^2\text{nm}$
7	EdZ320 -PUV	$\mu\text{W}/\text{cm}^2\text{nm}$
8	EdZ395 -PUV	$\mu\text{W}/\text{cm}^2\text{nm}$
9	EdZ340 -PUV	$\mu\text{W}/\text{cm}^2\text{nm}$
10	EdZPAR -PUV	$\mu\text{E}/\text{cm}^2\text{sec}$
11	LuZChl -PUV	$\mu\text{E}/\text{srm}^2\text{sec}$
12	EdZ380 -PUV	$\mu\text{W}/\text{cm}^2\text{nm}$
13	WTemp -PUV	°C
14	Depth -PUV	m
15	EdZTemp -PUV	°C
16	LuZTemp -PUV	°C
17	Tilt -PUV	Degrees
18	Roll -PUV	Degrees
19	Ed0Gnd - GUV	Volts
20	Ed0305 - GUV	$\mu\text{W}/\text{cm}^2\text{nm}$
21	Ed0313 - GUV	$\mu\text{W}/\text{cm}^2\text{nm}$
22	Ed0320 - GUV	$\mu\text{W}/\text{cm}^2\text{nm}$
23	Ed0340 - GUV	$\mu\text{W}/\text{cm}^2\text{nm}$
24	Ed0380 - GUV	$\mu\text{W}/\text{cm}^2\text{nm}$
25	Ed0395 - GUV	$\mu\text{W}/\text{cm}^2\text{nm}$
26	Ed0PAR - GUV	$\mu\text{E}/\text{cm}^2\text{sec}$
27	Ed0Temp - GUV	°C
28	Ed0VIn	Volts

**Isvp - 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

**Iadc – 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 <sup>1</sup> velocity <sup>2</sup> , East vector	knots
5	Ship Speed relative to reference layer <sup>1</sup> velocity <sup>2</sup> , North vector	knots
6	Ship heading	degrees

<sup>1</sup>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.

<sup>2</sup>The speed output 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).

**Igyr - 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	

**Isep – 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	{NIS} (latitude is north or south)	
5	Longitude in degrees with decimal minutes	ddmm.mmm
6	{EIW} (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

Field	Data	Units
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

## Igar - 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 <sup>1</sup>	
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	

<sup>1</sup>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 <sup>1</sup>	
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	

<sup>1</sup>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	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	25110805127	17-May-2010	Collected
Transmissometer	WET Labs C-Star 25 cm deep	CST-553DR	26-Aug-2010	Collected
MicroTSG	Sea-Bird 45	243	21-Jul-2010	Collected
Digital Remote Temp	Sea-Bird 38	324	26-Jan-2010	Collected
Fluorometer	WET Labs ECO-FL	FLRTD-399	15-Sep-09	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

## 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: 0324  
CALIBRATION DATE: 26-Jan-10

SBE 38 TEMPERATURE CALIBRATION DATA  
ITS-90 TEMPERATURE SCALE

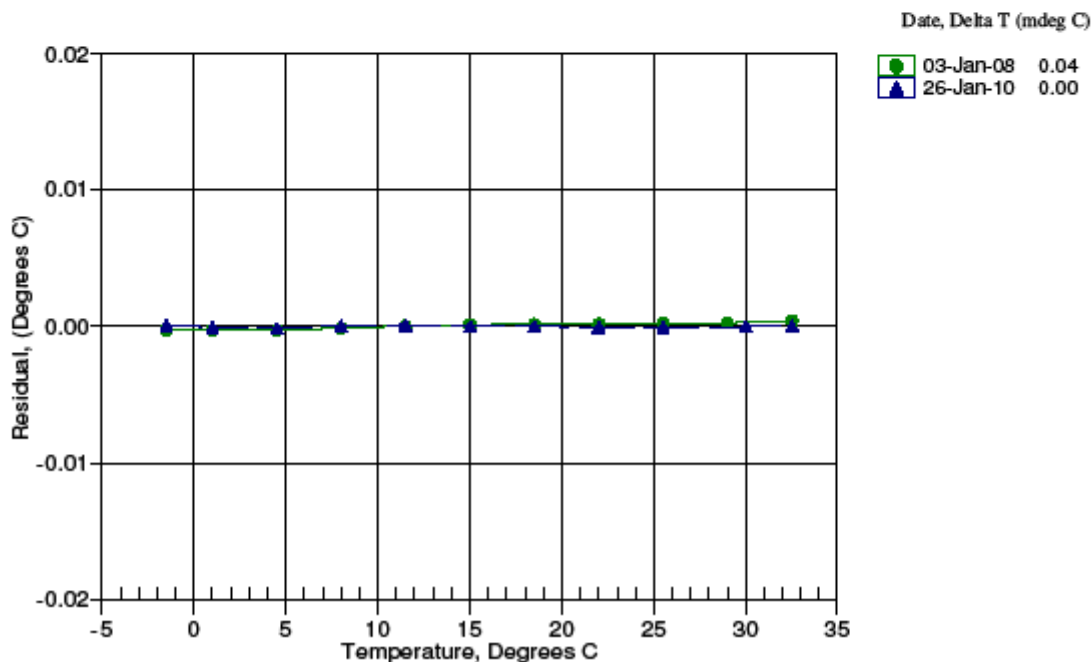
##### ITS-90 COEFFICIENTS

a0 = -2.126219e-005  
a1 = 2.756564e-004  
a2 = -2.490794e-006  
a3 = 1.524467e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.50010	895419.1	-1.50002	0.00008
0.99990	798448.4	0.99984	-0.00006
4.50000	682058.1	4.49983	-0.00017
7.99990	584568.4	7.99997	0.00007
11.49990	502633.3	11.50003	0.00013
15.00000	433539.8	15.00002	0.00002
18.50000	375083.6	18.50001	0.00001
22.00000	325471.2	21.99994	-0.00006
25.50000	283232.8	25.49995	-0.00005
30.00000	237850.6	29.99998	-0.00002
32.50000	216277.2	32.50005	0.00005

Temperature ITS-90 =  $1/[a_0 + a_1[\ln(n)] + a_2[\ln^2(n)] + a_3[\ln^3(n)]] - 273.15$  (°C)

Residual = instrument temperature - bath temperature



## Thermosalinograph

### 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

CPcor = -9.5700e-008

h = 1.573683e-001

CTcor = 3.2500e-006

i = -3.239483e-004

WBOTC = 1.1173e-006

j = 5.119501e-005

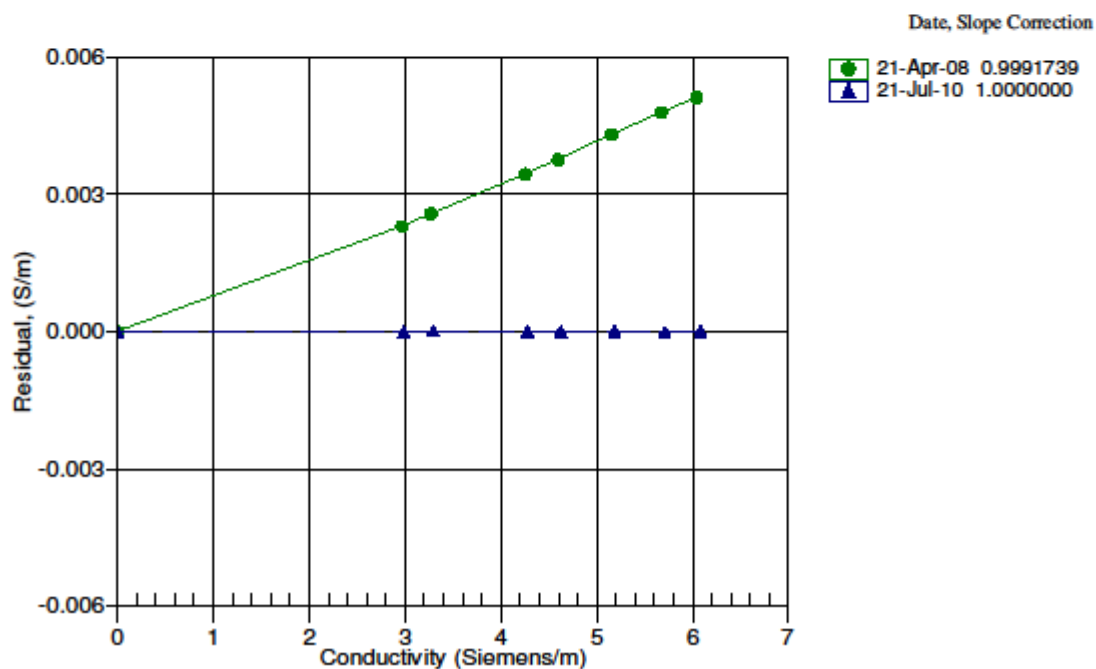
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2535.87	0.00000	0.00000
1.0000	34.9328	2.98497	5043.04	2.98496	-0.00001
4.4999	34.9132	3.29295	5233.27	3.29297	0.00001
15.0000	34.8700	4.27750	5798.83	4.27750	-0.00000
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

$$f = \text{INST FREQ} * \sqrt{1.0 + \text{WBOTC} * t} / 1000.0$$

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

$$t = \text{temperature}[^{\circ}\text{C}]; p = \text{pressure}[\text{decibars}]; \delta = \text{CTcor}; \epsilon = \text{CPcor};$$

Residual = instrument conductivity - bath conductivity



## Transmissometer

PO Box 518  
620 Applegate St.  
Philomath, OR 97370



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

### C-Star Calibration

Date	August 26, 2010	S/N#	CST-553DR	Pathlength	25 cm
<hr/>					
			Analog meter		
V <sub>d</sub>			0.058 V		
V <sub>air</sub>			4.782 V		
V <sub>ref</sub>			4.687 V		
Temperature of calibration water				24.9 °C	
Ambient temperature during calibration				23.6 °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 L

6/9/09

## Fluorometer

PO Box 518  
620 Applegate St.  
Philomath, OR 97370



(541) 929-5850  
Fax: (541) 929-5277  
[www.wetlabs.com](http://www.wetlabs.com)

### ECO Chlorophyll Fluorometer Characterization Sheet

Date: 9/15/2009

S/N: FLRTD-399

Chlorophyll concentration expressed in  $\mu\text{g/l}$  can be derived using the equation:

$$\text{CHL } (\mu\text{g/l}) = \text{Scale Factor} * (\text{Output} - \text{Dark Counts})$$

	Analog Range 1	Analog Range 2	Analog Range 4 (default)	Digital
Dark Counts	0.097	0.054	0.033 V	68 counts
Scale Factor (SF)	6	12	24 $\mu\text{g/l/V}$	0.0074 $\mu\text{g/l/count}$
Maximum Output	4.96	4.96	4.96 V	16330 counts
Resolution	0.7	0.7	0.7 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:  $\text{SF} = x + (\text{output} - \text{dark counts})$ , where  $x$  is the concentration of the solution used during instrument characterization. SF is used to derive instrument output concentration from the raw signal output of the fluorometer.

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

**Resolution:** Standard deviation of 1 minute of collected data.

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

FLRTD-399\_workbookj1.xls

Revision J

3/17/08

**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: 28933F3

Resistance: 686  $\Omega$  at 23°C

Temperature Compensation Range: -20° to + 40°C

This radiometer has been compared with Standard Precision Spectral Pyranometer, Serial Number 2133F3 in Eppley's Integrating Hemisphere under radiation intensities of approximately 700 watts meter<sup>-2</sup> (roughly one half a solar constant).

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

$$8.01 \times 10^{-5} \text{ volts/watts meter}^{-2}$$

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<sup>-2</sup>. 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 Pyheliometric 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<sup>-2</sup> min<sup>-1</sup> = 697.3 watts meter<sup>-2</sup>  
1 BTU/ft<sup>2</sup>-hr<sup>-1</sup> = 3.153 watts meter<sup>-2</sup>

Shipped to: Raytheon Polar Services  
National Science Foundation  
Port Hueneme, CA

Date of Test: September 9, 2010

In Charge of Test:

*Julius L. Huntz*

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

Reviewed by:

*Thomas J. Kuh*

Remarks:

**PIR****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  $\Omega$  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<sup>-2</sup> 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:

$$3.60 \times 10^{-6} \text{ volts/watts meter}^{-2}$$

The calculation of this constant is based on the fact that the relationship between radiation intensity and emf is rectilinear to intensities of 700 watts meter<sup>-2</sup>. This radiometer is linear to within  $\pm 1.0\%$  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: *Debra L. Gentry*

Reviewed by: *Thomas D. Kuhn*

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

**PAR****Biospherical Instruments Inc.****CALIBRATION CERTIFICATE**

Calibration Date: 8/31/2013  
 Model Number: QSR240  
 Serial Number: 6393  
 Operator: TPC  
 Standard Lamp: SS-1024(8/25/08)  
 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/cm<sup>2</sup>sec  
0.01540 μE/cm<sup>2</sup>sec

Calibration Scale Factor:

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

Dry: 1.0310E-17 V/(quanta/cm<sup>2</sup>sec)  
6.2037E+00 V/(μE/cm<sup>2</sup>sec)

Notes:

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

QSR240R 03/24/95



## Temperature/Relative Humidity



R.M. Young Company  
2801 Aero Park Drive  
Livonia, Michigan 48150 USA



### CALIBRATION REPORT Temperature Sensor

Customer: *Raytheon Technical Services Company LLC*

Test Number: 00641

Customer ID: RR53870-01

Test Date: 3 December 2010

Sales Off: 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  $\pm 0.1^\circ$  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	8005-B	204365
Brooklyn Thermometer Model 22332-D5-FC	2671	249763
Brooklyn Thermometer Model 2X400-D7-FC	7712	228060
Keithley Multimeter Model 191	1512	234027

Tested By:

METEOROLOGICAL INSTRUMENTS  
Tel: 231-518-3950 Fax: 231-545-4772 Email: [rmc@youngus.com](mailto:rmc@youngus.com) Web: [youngus.com](http://youngus.com)

**Barometer**

**R.M. Young Company**  
2901 Aero Park Drive  
Traverse City, Michigan 49686 USA



**CALIBRATION REPORT**  
**Barometric Pressure Sensor**

Customer: *Raytheon Technical Services Company LLC*

Test Number: 07261  
Test Date: 28 July 2010

Customer ID: RR52837-01  
Sales Order: 1325

<u>Test Sensor:</u>	
Model: 81201	Serial Number: 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  $\pm 1.0$  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  
Druck Pressure Controller Model DPI515  
Fluke Multimeter Model 8080A

Serial NIST Test Reference  
5150041 UKAS Lab 0221  
486540 234027

Tested By: *E. Chennery*

**METEOROLOGICAL INSTRUMENTS**  
Tel: 231-046-3990 Fax: 231-046-4772 Email: rnielesales@youngusa.com Web: youngusa.com

## GUV



Biospherical Instruments Inc.

## GUV-2511 Calibration Certificate

System Serial Number		25110005127		Date of Calibration		5/17/2010					
Calibration database		25110005127.v4.mdb		Date of Certificate		5/17/2010					
DASSEN		0111		Standard of Spectral Irradiance		G8101818/28108					
Microprocessor Tag Number		2		Operator		TC					
Monochromatic Channels	Wavelength	Responsivity	Scale:small	Scale:medium	Scale:large	Offset:small	Offset:medium	Offset:large	Measurement Units		
	Address	[amps per $\mu\text{W}/(\text{cm}^2\cdot\text{nm})$ ]	[Volts per $\mu\text{W}/(\text{cm}^2\cdot\text{nm})$ ]	[Volts per $\mu\text{W}/(\text{cm}^2\cdot\text{nm})$ ]	[Volts per $\mu\text{W}/(\text{cm}^2\cdot\text{nm})$ ]	[offset]	[offset]	[offset]			
	Ed0306	2	305	3.5700E-14	4.0785E-06	1.1899E-03	3.6985E-01	-3.8201E-04	-5.3300E-04	-5.7100E-04	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
	Ed0310	6	313	1.7000E-10	1.7535E-05	5.0755E-03	1.7535E-00	2.2800E-04	2.4900E-04	1.5870E-03	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
	Ed0320	8	320	2.5444E-10	2.8603E-05	7.6075E-03	2.4607E-00	-1.1000E-04	-1.3900E-04	1.4100E-04	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
	Ed0340	10	340	1.0947E-10	1.3747E-05	5.7656E-03	2.0677E-00	1.9000E-04	2.0800E-04	1.6130E-03	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
	Ed0350	12	350	7.2288E-11	7.8784E-06	2.1911E-03	7.4361E-01	-7.6900E-04	-1.5500E-04	4.1000E-05	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
	Ed0356	13	365	3.0030E-10	3.0030E-06	8.0561E-03	3.0030E-00	-3.5901E-04	-1.3500E-04	-3.5100E-04	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
	Broadband Channels	Wavelength	Responsivity	Scale:small	Scale:medium	Scale:large	Offset:small	Offset:medium	Offset:large	Measurement Units	
		Address	[amps per $\mu\text{W}/(\text{cm}^2\cdot\text{s})$ ]	[Volts per $\mu\text{W}/(\text{cm}^2\cdot\text{s})$ ]	[Volts per $\mu\text{W}/(\text{cm}^2\cdot\text{s})$ ]	[Volts per $\mu\text{W}/(\text{cm}^2\cdot\text{s})$ ]	[offset]	[offset]	[offset]		
Ed03PAR	18	400-700	1.6747E-05	1.7075E+01	5.0000E+02	1.8492E+05	-8.3000E-05	-5.1000E-05	1.7470E-03	$\mu\text{W}/(\text{cm}^2\cdot\text{s})$	
Auxiliary Channels	Wavelength	Responsivity	Scale:small	Scale:medium	Scale:large	Offset:small	Offset:medium	Offset:large	Measurement Units		
	Address	[amps per $\mu\text{W}/(\text{cm}^2\cdot\text{s})$ ]	[Volts per $\mu\text{W}/(\text{cm}^2\cdot\text{s})$ ]	[amps per $\mu\text{W}/(\text{cm}^2\cdot\text{s})$ ]	[Volts per $\mu\text{W}/(\text{cm}^2\cdot\text{s})$ ]	[offset]	[offset]	[offset]			
Ed0TEMP	22	C	1.0000E+00	1.0000E-02	1.0000E-02	1.0000E-02	0.0000E+00	0.0000E+00	0.0000E+00	$^{\circ}\text{C}$	
Ed0VOLT	27	C	1.0000E+00	-2.5000E-01	-2.5000E-01	-2.5000E-01	0.0000E+00	0.0000E+00	0.0000E+00	V	

\* Biospherical Instruments Inc., 5340 Riley Street, San Diego, California 92119 USA. Contact [support@biospherical.com](mailto:support@biospherical.com) for more information.

Calibration Data Do Not Destroy

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## 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:

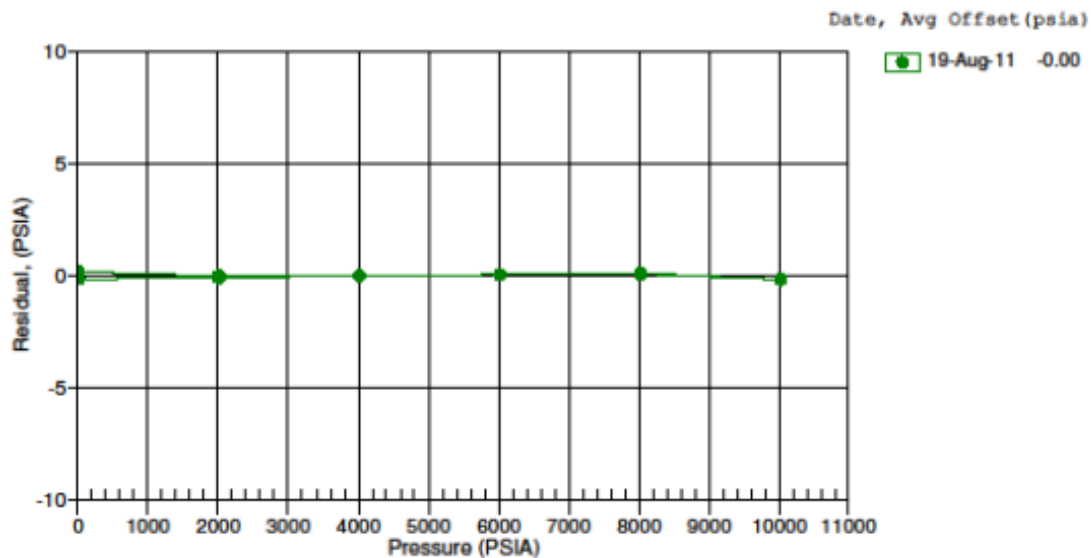
C1 = -5.847002e+004  
C2 = 6.910390e-001  
C3 = 1.753360e-002  
D1 = 4.241600e-002  
D2 = 0.000000e+000  
T1 = 3.026040e+001  
T2 = -1.938830e-004  
T3 = 4.330190e-006  
T4 = 2.020250e-009  
T5 = 0.000000e+000

##### 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

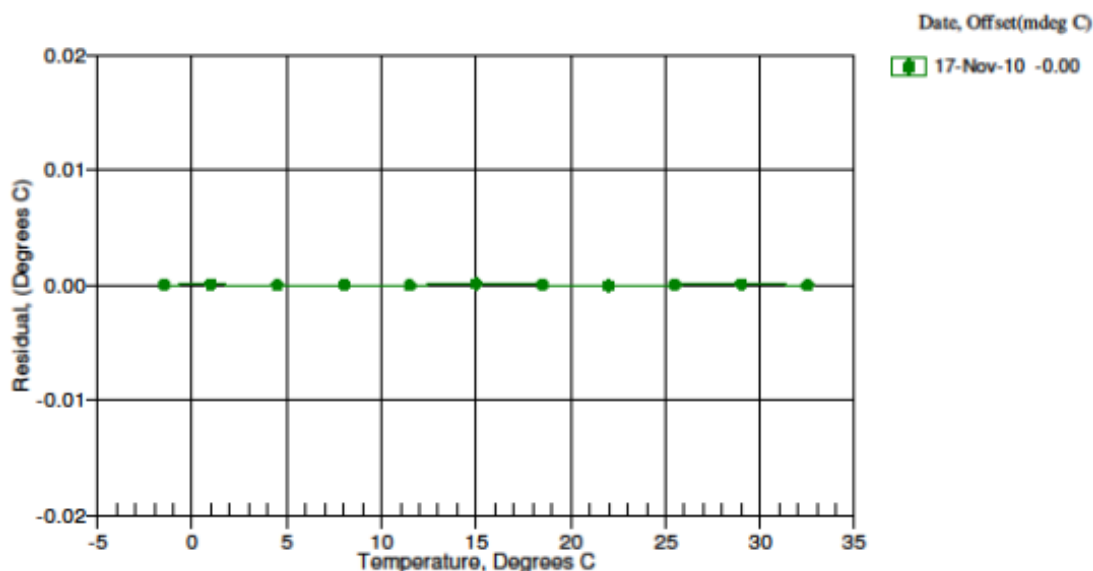
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.4999	3092.634	-1.4999	-0.00000
1.0000	3272.049	1.0000	0.00002
4.5001	3535.737	4.5001	-0.00003
8.0000	3814.376	8.0000	0.00000
11.5001	4108.397	11.5001	-0.00002
15.0000	4418.184	15.0001	0.00008
18.5001	4744.133	18.5001	-0.00001
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:  $T_{90}$  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

g = 4.33939563e-003  
h = 6.35747673e-004  
i = 2.11367255e-005  
j = 1.89179562e-006  
f0 = 1000.0

## IPTS-68 COEFFICIENTS

a = 3.68121069e-003  
b = 5.97166683e-004  
c = 1.50926875e-005  
d = 1.89321217e-006  
f0 = 2914.509

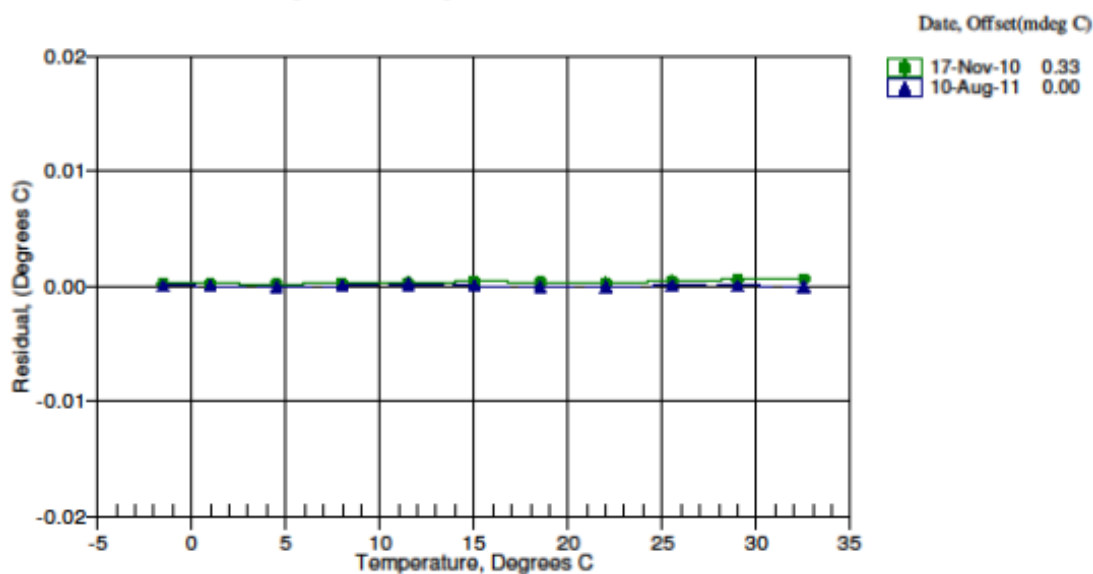
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.4999	2914.509	-1.4999	0.00002
1.0000	3083.317	1.0000	-0.00000
4.5001	3331.386	4.5000	-0.00008
8.0000	3593.486	8.0000	0.00001
11.5000	3870.010	11.5001	0.00010
15.0001	4161.318	15.0001	0.00000
18.5001	4467.774	18.5001	-0.00003
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:  $T_{90}$  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 Siemens/meter

## GHJ 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)

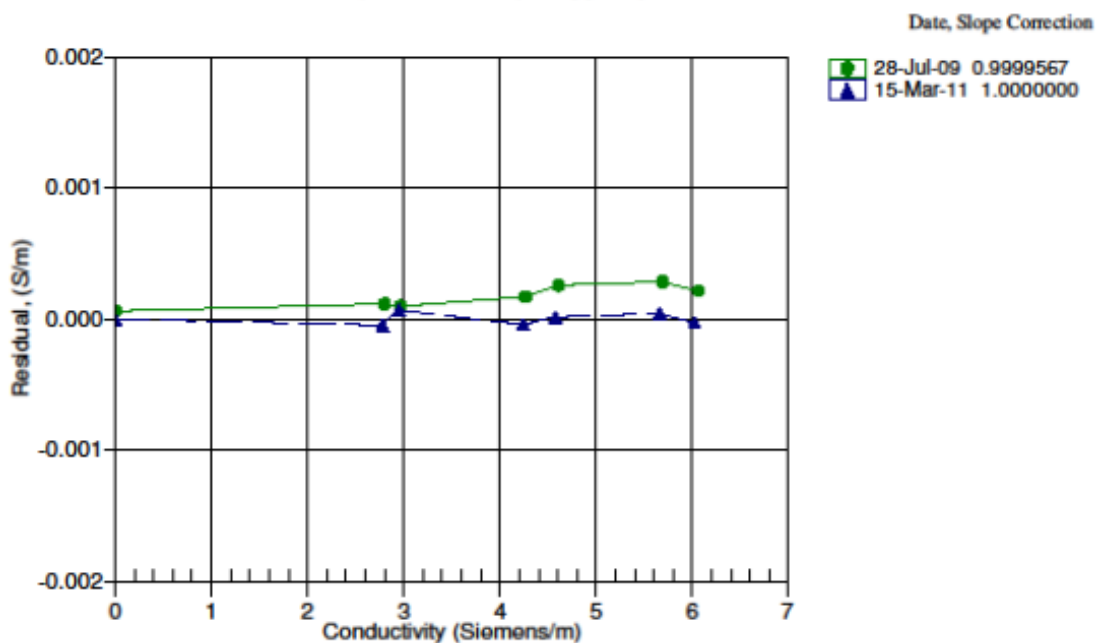
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.91066	0.00000	0.00000
-1.0000	34.4621	2.77869	7.99920	2.77864	-0.00005
1.0000	34.4610	2.94847	8.20807	2.94854	0.00007
14.9999	34.4628	4.23280	9.63954	4.23276	-0.00004
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);  $\delta$  = CTcor;  $\epsilon$  = 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 Siemens/meter

## GHJ 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

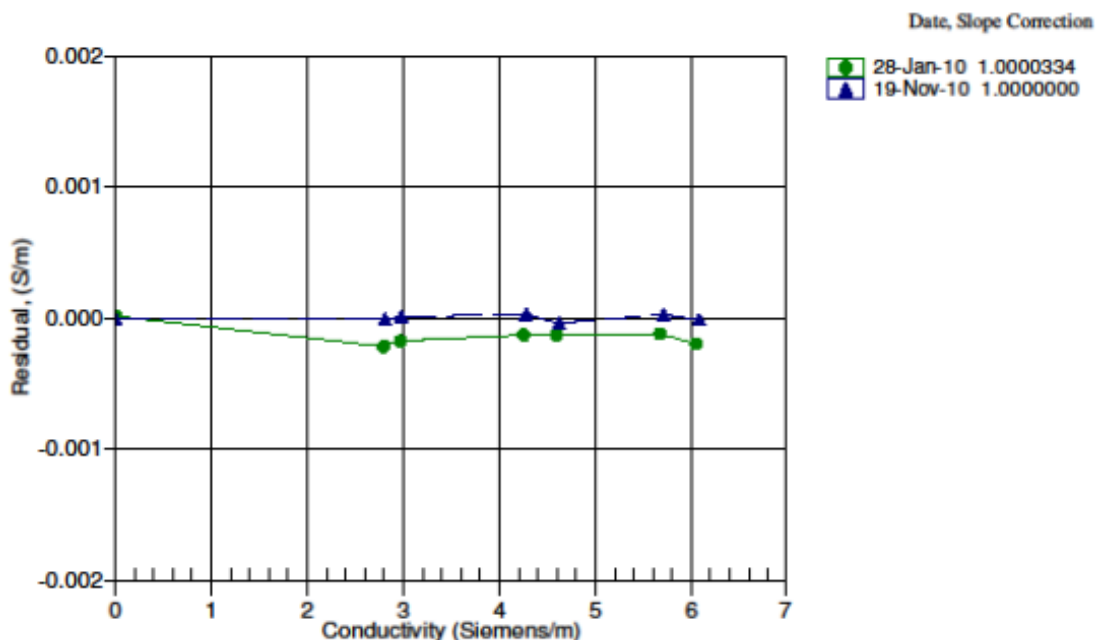
a = 5.94436022e-007  
b = 1.36754951e+000  
c = -1.03434546e+001  
d = -8.44758212e-005  
m = 6.1  
CPcor = -9.5700e-008 (nominal)

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

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

$$\text{Conductivity} = (af^m + bf^2 + c + dt) / [10(1 + \epsilon p)] \text{ Siemens/meter}$$
t = temperature[°C]; p = pressure[decibars];  $\delta$  = CTcor;  $\epsilon$  = 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

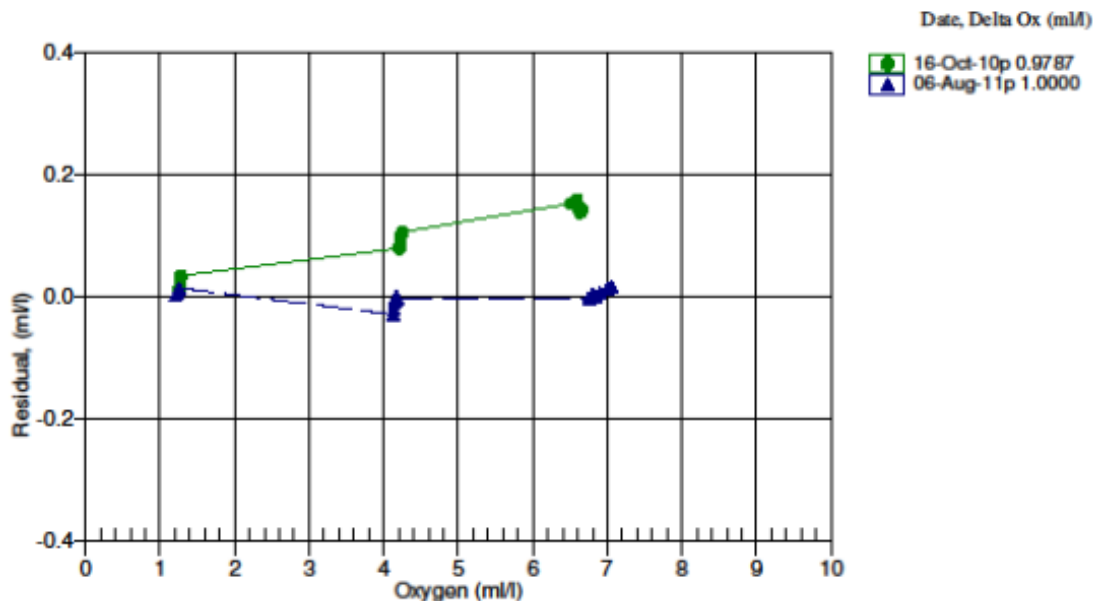
H3 = 1.45000e+3

BATH OX (m/l)	BATH TEMP ITS-90	BATH SAL PSU	INSTRUMENT OUTPUT (VOLTS)	INSTRUMENT OXYGEN (m/l)	RESIDUAL (m/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

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

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

OxSol(T,S) = oxygen saturation [m/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

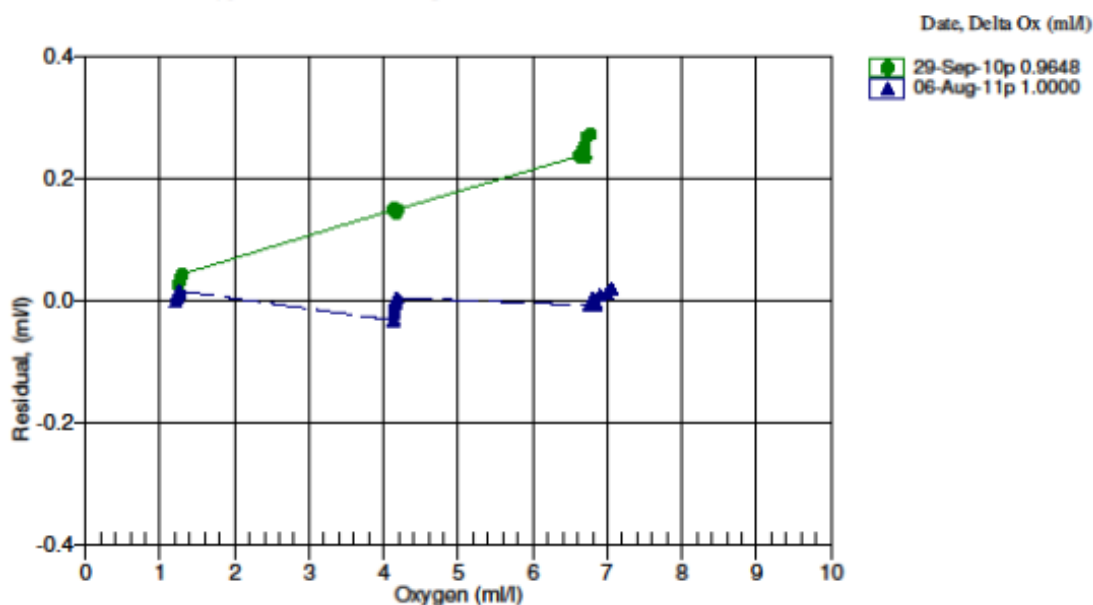
H3 = 1.45000e+3

BATH OX (m/l)	BATH TEMP ITS-90	BATH SAL PSU	INSTRUMENT OUTPUT (VOLTS)	INSTRUMENT OXYGEN (m/l)	RESIDUAL (m/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

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

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

OxSol(T,S) = oxygen saturation [m/l], P = pressure [dbar], Residual = instrument oxygen - bath oxygen



## Fluorometer

PO Box 518  
620 Applegate St.  
Philomath OR 97370



(541) 829-5850  
Fax: (541) 929-5277  
<http://www.wetlabs.com>

### Chlorophyll Fluorometer Characterization

Date: 04/0/10  
Serial #: AFD-001  
Tech: DCJ

Dark Counts	0.1841 volts
CEV	2.431 volts
SF	9.835
FSV	4.70 volts
Linearity:	0.999 R <sup>2</sup> (0-1.5 volts) 0.995 R <sup>2</sup> (0-5.45 volts)

#### Notes:

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

**CEV** is the chlorophyll equivalent voltage. This value is the signal output of the fluorometer when using a fluorescent proxy that has been determined to be approximately equivalent to 22.1 µg/l of a *Thalassiosira weissflogii* phytoplankton culture.

**SF** is the scale factor used to derive chlorophyll concentration from the signal voltage output of the fluorometer. The scale factor is determined by using the following equation:  

$$SF = (22.1) / (CEV - \text{dark})$$

**FSV** is the maximum signal voltage output that the fluorometer is capable of.

Chlorophyll concentration expressed in µg/l (mg/m<sup>3</sup>) can be derived by using the following equation: (µg/l) = (V<sub>measured</sub> - dark) \* SF

The relationship between fluorescence and chlorophyll-a concentrations in-situ is highly variable. The scale factor listed on this document was determined by 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 determination of chlorophyll concentration see [Standard Methods For The Examination Of Water And Wastewater] part 10200 H published jointly by: American Public Health Association, American Water Works Association and Water Environment 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: 4501  
 Operator: TPC  
 Standard Lamp: GS1024/6/28W  
 Operating Voltage Range: 8 to 15 VDC (+)  
 Note: The QSP-200 uses a log amplifier to measure the detector signal current with  $V = \log I (\text{Amps}) / I R_e$   
 To calculate irradiance, use this formula:  
**Irradiance = Calibration factor \* ( $10^{\Delta \text{Light Signal Voltage} - 10^{\Delta \text{Dark Voltage}}$ )**  
 With the appropriate (solar corrected) Irradiance Calibration Factor:  
 Dry Calibration Factor: 1.30E+13 quanta/cm<sup>2</sup>·sec/amps" 2.16E-05 μEinstein/cm<sup>2</sup>·sec/amps"  
 Wet Calibration Factor: 2.19E+13 quanta/cm<sup>2</sup>·sec/amps" 3.84E-05 μEinstein/cm<sup>2</sup>·sec/amps"  
**Sensor Test Data and Results<sup>4)</sup>**  

Sensor Supply Current (Dark):	<u>68.8</u>	mA
Supply Voltage:	<u>8</u>	Volt
Long Integrated PAR Irradiance:	<u>9.27E+15</u>	quanta/cm <sup>2</sup> ·sec
SC3 Immersion Coefficient:	<u>0.584</u>	Scalar Correction:
		PAR Solar Correction:
		<u>1.0000</u>

Nominal Filter OD	Calibrated Trans.	Sensor Voltage	Measured Trans.	Measured Signal (Amps)	Estimated Signal (Amps)	Calc. Output (Volts)	Error (Volts)	Error (%)	Total Trans (quanta/cm <sup>2</sup> ·sec)
No Filter	100.00%	2.953	100.00%	7.13E-08	7.13E-08	2.804	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	27.00%	2.239	27.78%	1.90E-08	1.97E-08	2.297	-0.002	-0.7	2.58E+15
1	9.27%	1.836	9.43%	8.72E-09	8.81E-09	1.829	-0.007	-1.7	8.75E+14
2	1.11%	0.980	1.14%	8.11E-10	7.01E-10	0.971	-0.008	-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 Hdr.: 2.853 Volts  
 Dark After - NFH: 0.151 Volts  
 Average Dark: 0.151 Volts

$I_{\text{dark}} = 1.30E-10$  Amps  
 $I_{\text{dark}} = 1.45E-10$  Amps  
 $10^{\Delta \text{dark}} = 1.449606$  Amps

RG780 0.281

Notes:  
 1) Manual calibration is recommended.  
 2) There is increasing error associated with readings below zero.  
 3) The collector should be cleaned frequently with a wad of cotton.  
 4) This section is for internal use and for more advanced analyses.

QSP-200L, QSP2300(2006) .xls

## Transmissometer

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[www.wetlabs.com](http://www.wetlabs.com)

### C-Star Calibration

Date	December 21, 2010	S/N#	CST-406DR	Pathlength	25 cm
<b>Analog meter</b>					
$V_d$	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

## 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
340	00:41	Started data collection	@68W
343	21:25	Data logging turned OFF	Arrive Palmer Station
344	12:39	Data logging turned ON	Depart Palmer Station
344	12:46	Started new cruise on ADCP called lmg1111_a. The ADCP wouldn't start, so I ended cruise lmg1111 and tried making a new one. Turns out it was just an unplugged serial cable, but we left it running on lmg1111_a.	
344	20:23	Data logging turned OFF	Arrive Palmer Station
347	00:06	Data logging turned ON	Depart Palmer Station
352	18:34	Data logging turned OFF	@68W