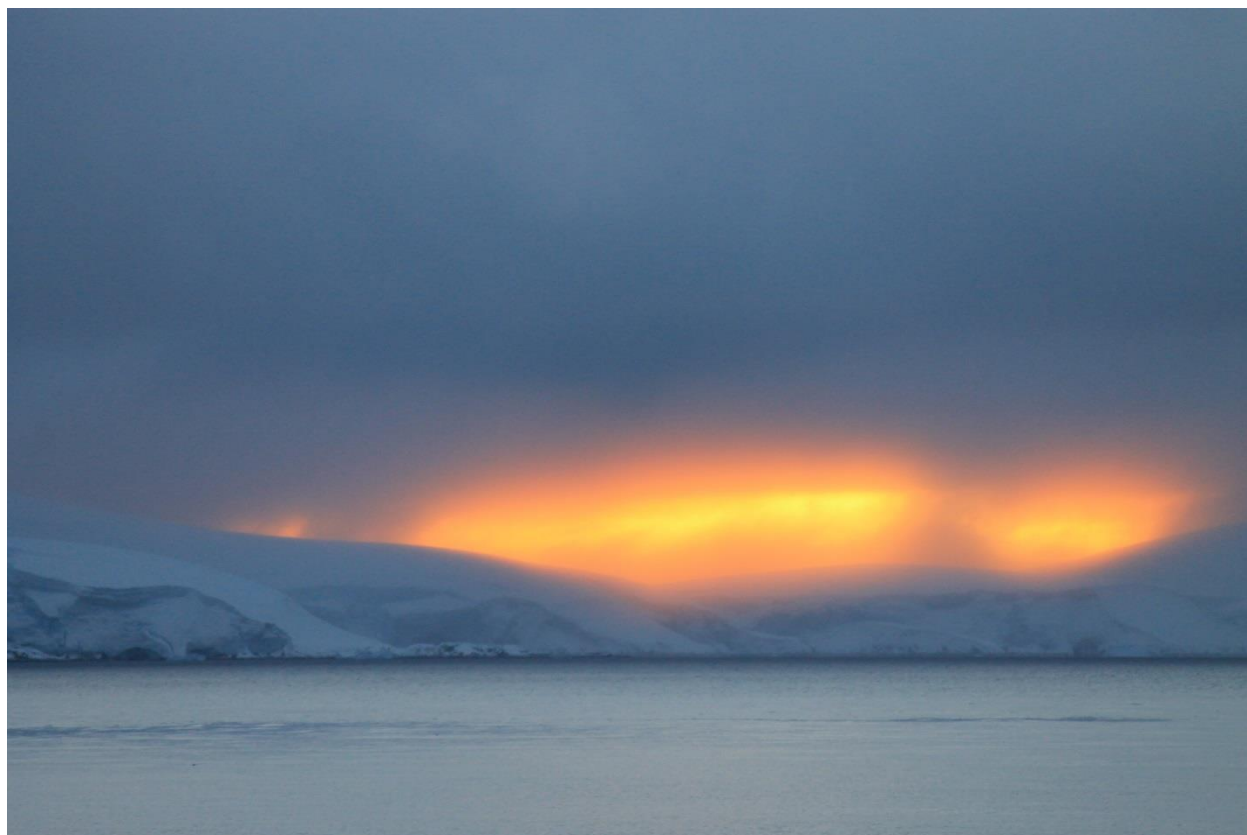

LMG 1310



Cruise Data Report

By W. Kevin Pedigo

04 Oct, 2013 – 22 Oct, 2013

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All of the data has been archived with the Unix "tar" command and/or compressed using Unix "gzip" compression.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

DVD Directory Structure

Disc 1 ADCP: ADCP.tar Cal: InstCoef.txt UW\ Imagery: Imag.tar LogSheets: Air Sample Logs.pdf O2Weekly*.pdf Maps: Process: JGOF.tar PCO2.tar PROC.tar QC.tar Report: Report.doc Report.pdf rvdas: nav/ uw/ 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 scanned paper log sheets in PDF format for various science of opportunity or projects or cruise related science, including such things as XBT's, XCTD's, air sample log sheets, oxygen system maintenance logs, etc.

Maps

/Maps/

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

Data and Science Report

/Report/

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

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 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	$\mu\text{Einsteins/meters}^2 \text{ sec}$
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	$\mu\text{g/l}$
20	Transmissometer	Volts (0-5)
21	PSP	W/m^2
22	PIR	W/m^2

pCO₂-merged Data Set

/Process/PCO2/

00+346:23:58:20.672 2000346.9991 2398.4 1008.4 0.01 45.4 350.3 342.6 15.77 Equil -43.6826
 173.1997 15.51 33.90 0.33 5.28 9.05 1007.57 40.0 14.87 182.44 -1

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

RVDAS

/RVDAS/

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

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

Meteorological and Light Data

Measurement	File ID	Collect. Status	Rate	Instrument
Air Temperature	lmwx	continuous	1 sec	R. M. young 41372VC
Relative Humidity	lmwx	continuous	1 sec	R. M. young 41372VC
Wind Speed/Direction	lmwx	continuous	1 sec	Gill Ultrasonic
PAR, (Photosynthetically-Available Radiation)	lmwx	continuous	1 sec	BSI QSR-240
Barometer	lmwx	continuous	1 sec	R. M. young 61201
GUV	lguv	continuous	1 sec	GUV2511
Port Ultrasonic Wind Speed/Direction	lmwx	continuous	1 sec	Gill Wind Observer II
PIR (LW radiation)	lmwx	continuous	1 sec	Eppley PIR
PSP (SW radiation)	lmwx	continuous	1 sec	Eppley PSP
Oxygen	lgo2	continuous	1 min	UCAR Oxygen system

Navigational Data

Measurement	File ID	Collect. Status	Rate	Instrument
Trimble GPS	tgps	civilian mode	1 sec	Trimble 20636-00SM
Gyro	lgyr	continuous	0.2 sec	Meridian Bridgemate Gyro
Garmin GPS	lgar	continuous	1 sec	Garmin 17
Seapath GPS	Lsep	Continuous	1 sec	Seapath 330

Geophysical Data

Measurement	File ID	Collect. Status	Rate	Instrument
Bathymetry	lknu	variable	Varies	Knudsen 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)	lfir	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, *Imguw.tar* and *Imgnav.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

Lsea – wet wall flows, transmissometer

12+004:12:01:04.438 WetLab_1,14.1,XMISS,3.098,V,0.000,0.000,0.000,-928.535,-220.566,0.000,0.000,T,NAN,NAN,NAN,NAN,P,0,0,F,47.91811,0,6.815308,0,0,0,0,0,I,1,1,1,1

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

Field	Data	Units
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

Irtm – 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

Idfl – 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	λg
6	Counts – Chlorophyll Signal	Count
7	Thermistor	

Igo2 – Oxygen System

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

12+301:22:35:30.558 81300.8 16.0 32.0 000.0 005.0 1.2589631 1.2379622 744.549 111.853 131.642 -
2.089 -2.448 723.594 002.50 086.43 099.74 002.77 000.97 050.65 0.000 001.19 065.59 039.48
1966.097 01.345 37.0171 37.8433 000.0 000.0 20.66 20.41 -92.0 28.66 37.44 42.33 37.80 47.95 0.0
01.88 0.0001711 0.0001712 0.0000747 0.0000725 02.657 02.678 -1 0.0000895 -043.94

Field	Data	Units
1	RVDAS Time Tag	
2	jsecoday - Seconds since midnight	
3	jselflag - 8 bit decimal value indicated selected gases	
4	jprgflag - 8 bit decimal value indicated purged gases	
5	jmfclflag - 8 bit decimal value indicated mass-flow controller states	
6	jgenflag - 8 bit decimal value indicated other parameters	
7	jfcv1 - voltage on Fuel Cell #1	
8	jfcv2 - voltage on Fuel Cell #2	
9	jpfcell - pressure in torr at fuel cells	

10	jlico2a - CO2 in ppm in Li7000 Cell A	
11	jlico2b - CO2 in ppm in Li7000 Cell B [CO2 MEASUREMENT]	
12	jlih2oa - H2O in ppt in Li7000 Cell A	
13	jlih2ob - H2O in ppt in Li7000 Cell B	
14	jlipb - pressure in torr at Li7000 Cell B	
15	flmfcset - mass-flow controller set voltage	
16	jfl1 - flow in sccm on Inlet Line #1	
17	jfl2 - flow in sccm on Inlet Line #2	
18	jfl1t - flow in sccm on Long-Term reference cylinder	
19	jflcal - flow in sccm on selected Calibration cylinder	
20	jflwta - flow in sccm on selected Working Tank Cylinder	
21	jvsoset - purge line voltage-sensitive orifice set voltage	
22	jflpurge - flow in sccm on purge line	
23	jflwtb - flow in sccm on Working Tank line through sensors	
24	jflsp - flow in sccm on Span line through sensors	
25	jpfridge - pressure in torr inside fridge trap	
26	jtfridge - temperature in C inside fridge trap	
27	jtmpt - fuel-cell control temperature (thermistor) in C for MPT10000	
28	jtfcell - fuel-cell thermistor temperature in C	
29	jtach1 - rmp of fan inside Line #1 Inlet	
30	jtach2 - rmp of fan inside Line #2 Inlet	
31	jtcyl1 - temperature in C from cylinder box RTD #1	
32	jtcyl2 - temperature in C from cylinder box RTD #2	
33	jtechill - temperature in C from chiller RTD	
34	jtamb - temperature in C RTD near Analyzer Box electronics	
35	jtomega - Analyzer Box control temperature (RTD) for Omega CNI2332	
36	jtu4ch - temperature in C inside USB4CH 24-bit A/D box	
37	jtfcrtd - fuel-cell RTD temperature in C	
38	jtirga - temperature in C inside Li7000	
39	jliflags - Li7000 status flag	
40	jlirsrc - Li7000 source/detector relative humidity	
41	jsdfcv1 - standard deviation of 1-Hz Fuel Cell #1 voltage	
42	jsdfcv2 - standard deviation of 1-Hz Fuel Cell #2 voltage	
43	jslfcv1 - slope of 1-Hz Fuel Cell #1 voltage	
44	jslfcv2 - slope of 1-Hz Fuel Cell #2 voltage	
45	jsdco2a - standard deviation of 1-Hz Li7000 Cell A CO2 in ppm	
46	jsdco2b - standard deviation of 1-Hz Li7000 Cell B CO2 in ppm	
47	posneg - flag indicating position of fuel-cell changeover valve	
48	jogdeltadiff - amplitude of 3-jog O2 difference-signal [O2 MEASUREMENT]	

loxy – Oxygen (Part of PCO2 system, separate from Oxygen System)

For further information on this data, contact Tim Newberger at tim.newberger@noaa.gov

```
04+117:23:57:23.504 MEASUREMENT      3830      380 Oxygen:      309.95      Saturation:
83.48 Temperature:      -1.35      DPhase:      33.41      BPhase:      32.22
      RPhase:      0.00      BAmp:      262.09      BPot:      163.00      Ramp:
0.00 RawTem.:      694.92
```

Field	Data	Units
1	RVDAS Time Tag	
2-4	Measurement ID, Model Number, Serial Number	alphanumeric
5	Oxygen heading	text
6	Oxygen Reading	Raw numeric
7	Saturation heading	text
8	Saturation Reading	Raw numeric
9	Temperature heading	text
10	Water Temperature	°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 tim.newberger@noaa.gov

```
02+319:23:59:13.748 2002319.99851      7154.27      26.49      1033.6      325.79      6.74      329.3
53.76      0      Equil
```

Field	Data	Units
1	RVDAS Time Tag	
2	Julian date file string	Julian
3	IR voltage reading	mV
4	Cell temperature	°C
5	Barometer	millibars
6	Gas flow	mL/min
7	VCO2 dry value	PPM
8	PCO2 wet/Delta value	PPM
9	Equilibrator Temperature from RTD	°C
10	Equilibrator Temperature from SBE-38	°C
11	Solenoid position ID	number
12	Measured gas	name

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

NOTE: This value does not represent or reflect the sound speed in the ocean, and is for internal use by the ADCP.

00+348:01:59:52.128 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 ¹ velocity ² , East vector	knots
5	Ship Speed relative to reference layer ¹ velocity ² , North vector	knots
6	Ship heading	degrees

¹The reference layer is an average velocity measured in a number of depth “bins”. On the LMG, the bins are typically eight meters deep and bins 3-10 define the reference layer. Hence, the reference layer is the water column from 16-80 meters beneath the ship.

²The 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+315:23:59:58.616 \$HEHDT,287.7,T*25

HDT: True Heading

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

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

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	{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

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 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	

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

GLL: Geographic Position – Latitude/Longitude

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

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

VTG: Track Made Good and Speed over Ground

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

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

tgps – Trimble Centurion GPS**GGA: Global Positioning Fix Data**

08+034:12:26:06.131 \$GPGGA,122607,6446.4733,S,06403.4455,W,1,11,0.9,-193.4,M,9.7,M,,*5A

Field	Data	Units
1	RVDAS Time Tag	
2	\$GPGGA Tag	
3	UTC of position	hhmmss.ss
4	Latitude in degrees with decimal minutes	ddmm.mmm
5	North (N) or South (S)	
6	Longitude in degrees with decimal minutes	ddmm.mmm
7	East (E) or West (W)	
8	GPS quality (1=GPS 2=DGPS)	
9	Number of GPS satellites used	
10	Horizontal dilution of precision (HDOP)	
11	Antenna height above/below mean-sea-level (geoid)	meters
12	Units for antenna height (M = Meters)	
13	Geoidal Separation ¹	
14	Units for Geoidal Separation (M = Meters)	meters
15	Age of differential GPS data, number of seconds since last SC104 Type 1 or 9	
16	Differential reference station ID	

¹Geoidal 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	1246001-WC45	N/A	Collected
Starboard Anemometer	Gill Ultrasonic Wind Observer II	1246002-WC45	N/A	Collected
Barometer	R.M. Young 61201	BP00873	24-Oct-2012	Collected
Humidity/Wet Temp	RM Young 41372LC	06133	07-Dec-2012	Collected
PAR for Mast	Biosph. Inst. QSR-240P	6393	1-Oct-2012	Collected
PIR	Eppley PIR	NOT INSTALLED		Not Collected
PSP	Eppley PSP	NOT INSTALLED		Not Collected
GUV (Mast)	Biosph. Inst. GUV-2511	5127	7-Sep-2012	Collected
Transmissometer	WET Labs C-Star 25 cm deep	CST-553DR	01-Oct-2012	Collected
MicroTSG (Primary)	Sea-Bird 45	243	05-Jan-2013	Collected
MicroTSG (Secondary)	Sea-Bird 45	390	09-Apr-2013	Collected
Digital Remote Temp	Sea-Bird 38	324	12-Sept-2012	Collected
Fluorometer	WET Labs ECO-FL	FLRTD-380	23-Aug-11	Collected

Underway Calibration Sheets

Note: Embedded pdf files can be opened by double-clicking.

Thermosalinograph (temp) – Primary

Sea-Bird Electronics, Inc.

13431 NE 20th Street, Bellevue, WA 98005-2010 USA

Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0390
CALIBRATION DATE: 09-Apr-13

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

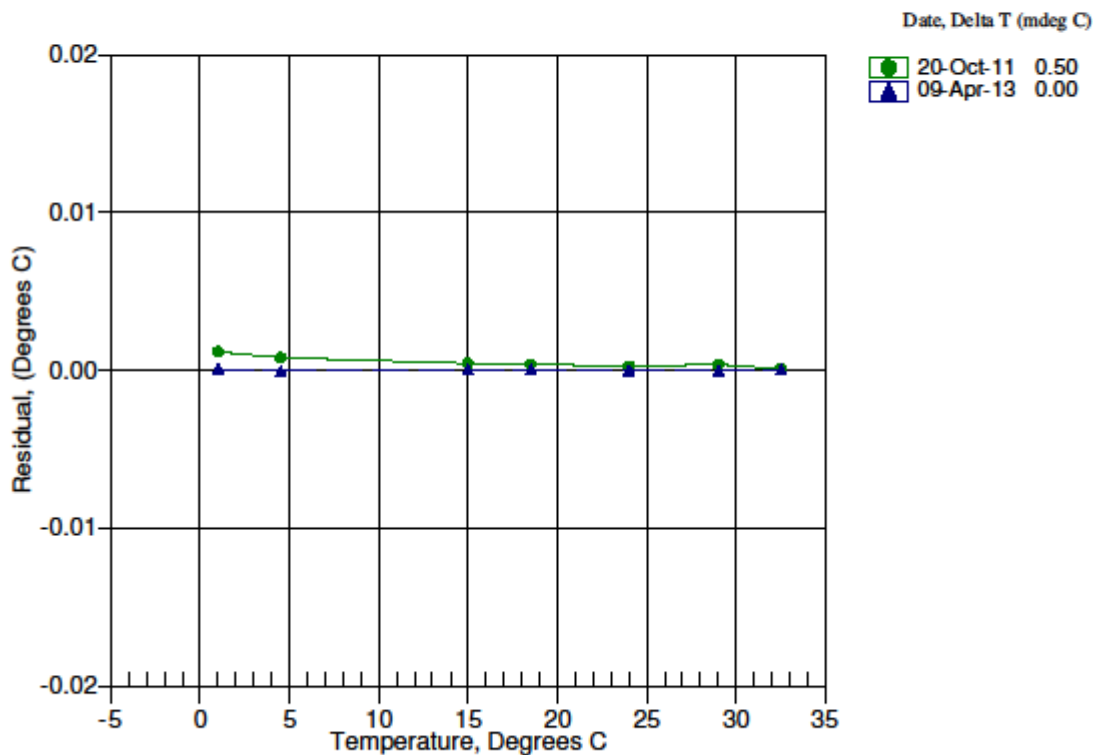
ITS-90 COEFFICIENTS

a0 = 3.920979e-005
a1 = 2.752051e-004
a2 = -2.502164e-006
a3 = 1.533429e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	662299.5	1.0000	0.0000
4.5000	565253.2	4.4999	-0.0001
15.0000	358382.9	15.0000	0.0000
18.5000	309810.8	18.5000	0.0000
24.0000	247914.2	24.0000	-0.0000
29.0000	203685.2	28.9999	-0.0001
32.5000	178101.0	32.5000	0.0000

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 (conductivity) - Primary

Sea-Bird Electronics, Inc.

13431 NE 20th Street, Bellevue, WA 98005-2010 USA

Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0390
CALIBRATION DATE: 09-Apr-13SBE 45 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -9.858436e-001

CPcor = -9.5700e-008

h = 1.452874e-001

CTcor = 3.2500e-006

i = -3.922347e-004

WBOTC = 2.8724e-007

j = 5.265154e-005

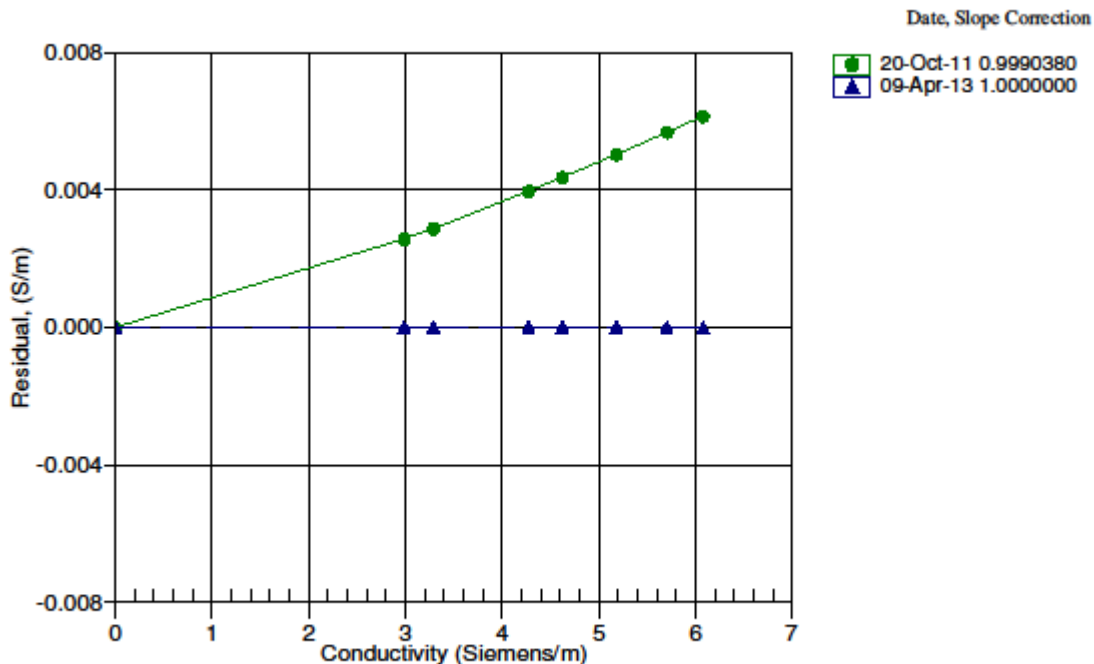
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2610.87	0.00000	0.00000
1.0000	34.9022	2.98261	5237.34	2.98261	0.00000
4.5000	34.8785	3.29001	5435.79	3.29001	-0.00000
15.0000	34.8306	4.27318	6025.91	4.27318	0.00000
18.5000	34.8211	4.61894	6219.82	4.61894	-0.00000
24.0000	34.8109	5.17791	6520.77	5.17792	0.00001
29.0000	34.8054	5.70073	6789.79	5.70072	-0.00001
32.5000	34.8011	6.07364	6975.11	6.07364	0.00000

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

Conductivity = (g + hf² + if³ + jf⁴) / (1 + δt + εp) 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 - 8866 Fax (425) 643 - 8954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0227
CALIBRATION DATE: 21-Jun-11SBE-45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

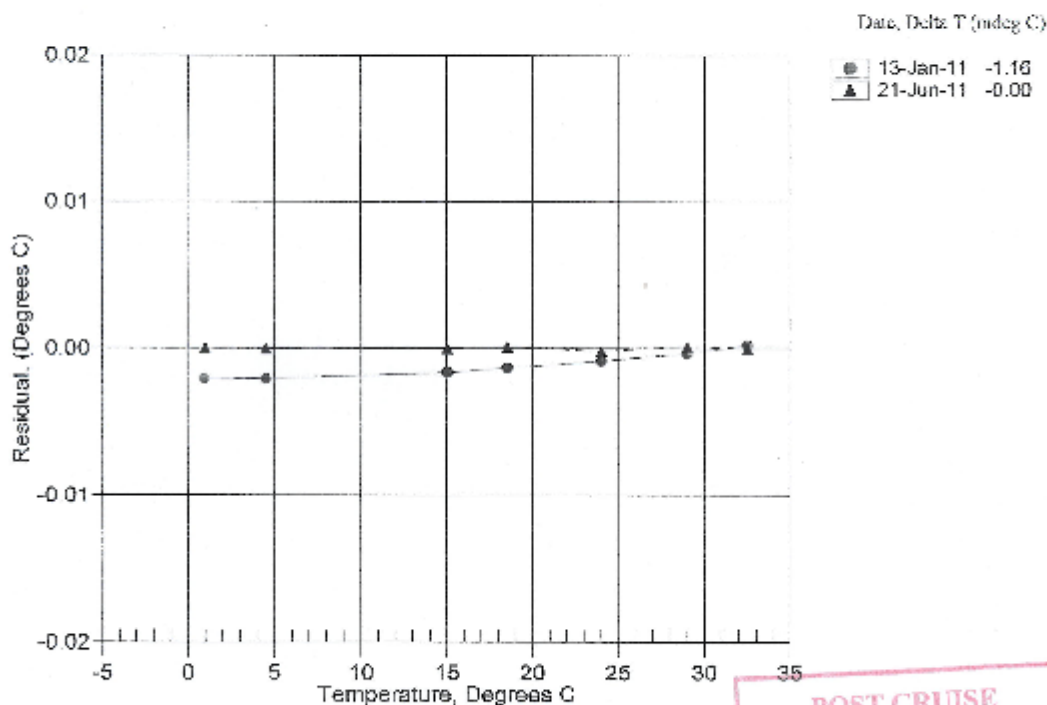
ITS-90 COEFFICIENTS

$a_0 = 4.389651e-005$
 $a_1 = 2.486211e-004$
 $a_2 = -1.946313e-006$
 $a_3 = 1.411606e-007$

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	564575.1	1.0000	0.0000
4.0000	568012.3	4.0000	-0.0000
15.0000	561626.2	15.0000	-0.0000
19.5000	553024.1	19.5001	0.0001
24.0000	550909.5	23.9998	-0.0002
29.0000	506570.3	29.0001	0.0001
32.5000	480840.3	32.4999	-0.0001

$$\text{Temperature ITS-90} = 1/[a_0 + a_1[t_0(n)] + a_2[t_0^2(n)] + a_3[t_0^3(n)]] - 273.15 \text{ (}^\circ\text{C)}$$

Residual = instrument temperature - bath temperature

POST CRUISE
CALIBRATION

Thermosalinograph (Conductivity) – Secondary

SEA-BIRD ELECTRONICS, INC.

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

Phone: (425) 643 - 9686 Fax: (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0227
CALIBRATION DATE: 21-Jun-11SBE 45 CONDUCTIVITY CALIBRATION DATA
PSS 1978, C(35, 5, 0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -1.5188680e+000

h = 1.8788020e-001

i = -4.340031e-004

j = 6.026783e-005

CPcor = -9.5700e-008

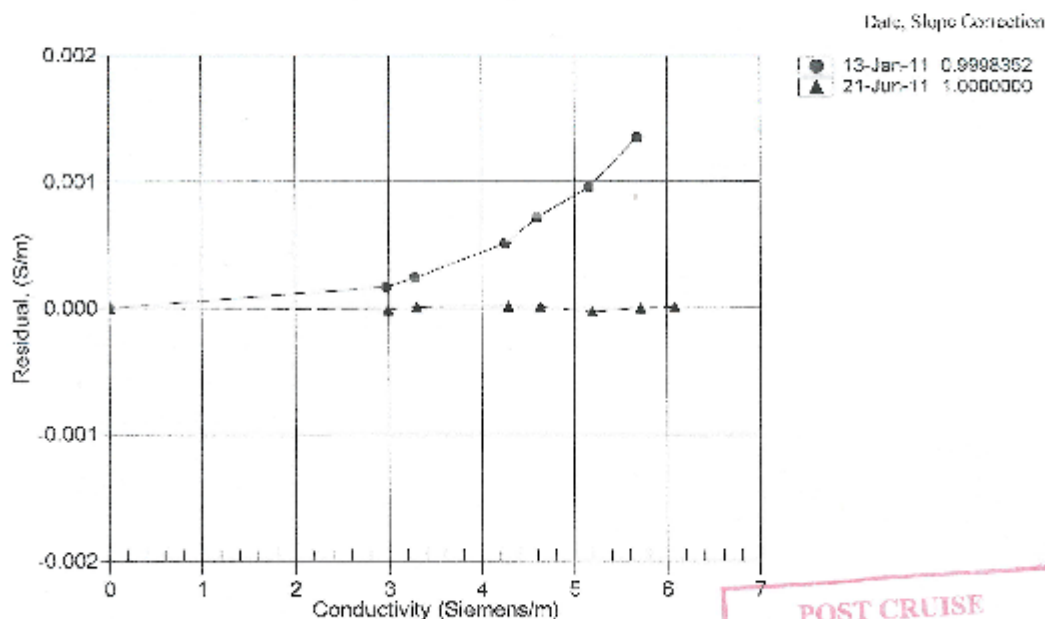
CTcor = 3.2500e-006

WBTC = 1.0472e-006

BATH TEMP (°C-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	34.0000	0.00000	3546.31	0.00000	0.00000
23.0000	34.9059	2.50753	5010.10	2.98752	-0.00001
24.0000	34.9465	3.29671	5238.29	3.29572	0.00001
25.0000	34.9015	4.08096	5803.26	4.28097	0.00002
26.5000	34.8017	4.62729	5988.89	4.62730	0.00001
24.0000	34.0758	5.18703	6376.06	5.18700	0.00003
29.0000	34.8717	5.71037	6534.19	5.71037	-0.00000
32.5000	34.8648	6.08349	6711.84	6.08350	0.00001

 $f = \text{INST FREQ} * \sqrt{(1.0 + \text{WBTC} * t) / 1000.0}$ Conductivity = $(g + hf^2 + if^3 - jf^4) / (- + 34 - ps)$ Siemens/metert = temperature[°C]; p = pressure[decibars]; δ = CTcor; ϵ = CPcor;

Residual = instrument conductivity - bath conductivity

POST CRUISE
CALIBRATION

Transmissometer

PO Box 518
620 Applegate St.
Philomath, OR 97370



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

C-Star Calibration

Date	October 1, 2012	S/N#	CST-553DR	Pathlength	25cm
<hr/>					
Analog output					
V_d	0.060 V				
V_{air}	4.797 V				
V_{ref}	4.705 V				
<hr/>					
Temperature of calibration water				20.0	°C
Ambient temperature during calibration				21.6	°C
<hr/>					

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

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

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

V_d Meter output with the beam blocked. This is the offset.

V_{air} Meter output in air with a clear beam path.

V_{ref} Meter output with clean water in the path.

Temperature of calibration water: temperature of clean water used to obtain V_{ref} .

Ambient temperature: meter temperature in air during the calibration.

V_{sig} Measured signal output of meter.

Revision M

7/26/11

Fluorometer

PO Box 518
620 Applegate St.
Philomath, OR 97370



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

ECO Chlorophyll Fluorometer Characterization Sheet

Date: 8/23/2012

S/N: FLRTD-380

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	0.110	0.063	0.039 V	76 counts
Scale Factor (SF)	7	13	26 $\mu\text{g/l/V}$	0.0077 $\mu\text{g/l/count}$
Maximum Output	4.97	4.97	4.97 V	16326 counts
Resolution	0.8	0.8	0.8 mV	0.9 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: $\text{SF} = x \div (\text{output} - \text{dark counts})$, 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-380.xls

Revision J

3/17/08

Temperature/Relative Humidity

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

**CALIBRATION REPORT****Temperature**

Customer: *Lockheed Martin Maritime Systems & Sensors*

Test Number: 2068-09T

Customer PO: 4900028658

Test Date: 7 December 2012

Sales Order: 3025

Test Sensor:

Model: 41372LC Serial Number: 7506133
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)
-19.81	4.033	-19.79
0.03	12.004	0.02
50.02	20.003	50.02

(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

Brooklyn Thermometer Model 43-FC
Brooklyn Thermometer Model 22332 D5 FC
Brooklyn Thermometer Model 2X400 D7-FC
Keithley Multimeter Model 191

Serial # NIST Test Reference

8006-110 204365
25071 249763
77532 228080
15232 234027

Tested By: *E. Chennery*

METEOROLOGICAL INSTRUMENTS

Tel: 231-946-3565 Fax: 231-946-4772 E-mail: metlsales@youngusa.com Website: youngusa.com
ISO 9001:2008 CERTIFIED

Barometer



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

CALIBRATION REPORT**Barometric Pressure**

Customer: *Lockheed Martin Maritime Systems & Sensors*

Test Number: 2024-C1P

Customer PO: 4900022820

Test Date: 24 October 2012

Sales Order: 2829

<u>Test Sensor</u>	
Model: 61201	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 ± 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 8060A

Serial # NIST Test Reference

51500497 UKAS Lab 0221
4865407 234027

Tested By:

E. Chennery

METEOROLOGICAL INSTRUMENTS
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ISO 9001:2008 CERTIFIED

Digital Remote Temperature

Sea-Bird Electronics, Inc.

13431 NE 20th Street, Bellevue, WA 98005-2010 USA

Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0324
CALIBRATION DATE: 12-Sep-12SBE 38 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

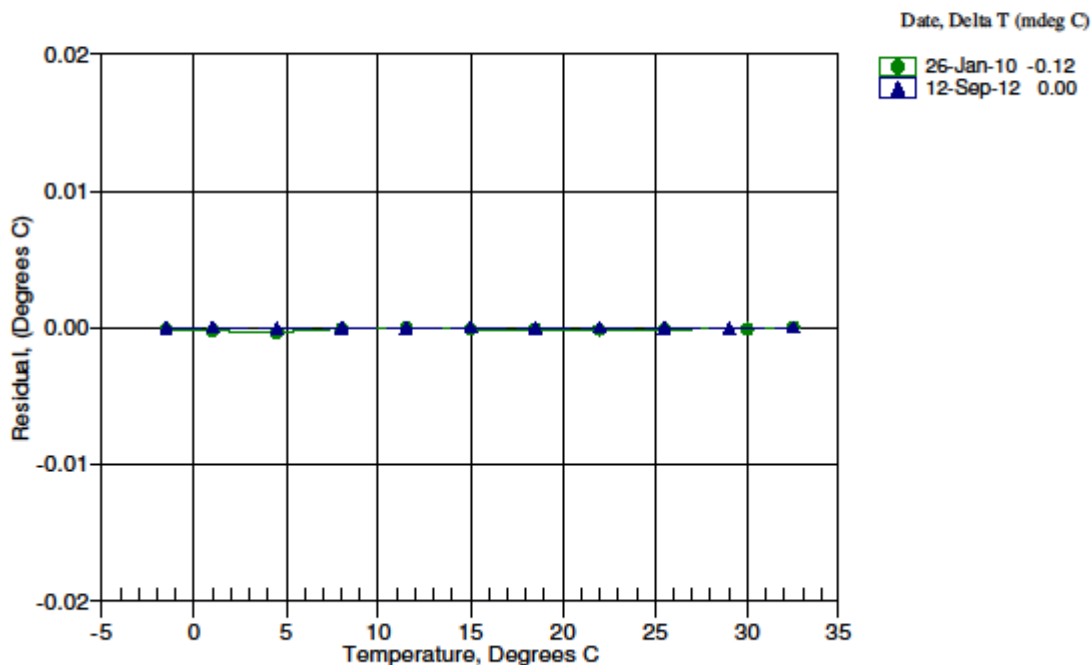
ITS-90 COEFFICIENTS

$a_0 = -2.504284e-005$
 $a_1 = 2.765241e-004$
 $a_2 = -2.557210e-006$
 $a_3 = 1.541428e-007$

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.50000	895410.5	-1.50000	0.00000
0.99990	798438.5	0.99994	0.00004
4.50000	682050.9	4.49991	-0.00009
7.99990	584566.0	7.99992	0.00002
11.50000	502630.7	11.50002	0.00002
15.00000	433537.4	15.00002	0.00002
18.50000	375081.7	18.50001	0.00001
21.99990	325470.0	21.99992	0.00002
25.50000	283231.7	25.49996	-0.00004
29.00000	247165.1	28.99995	-0.00005
32.50000	216277.1	32.50004	0.00004

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

Residual = instrument temperature - bath temperature



PAR (mast)**Biospherical Instruments Inc.****CALIBRATION CERTIFICATE**

Calibration Date: 10/12/2012
 Model Number: QSR-240
 Serial Number: 3393
 Operator: TPC
 Standard Lamp: V-0301277121
 Probe Excitation Voltage Range: 0 to 16 VDC(+)

Output Polarity: Positive

Probe Conditions at Calibration (in air):

Calibration Voltage: 6 VDC(+)

Probe Current: 1.3 mA

Probe Output Voltage:

Probe Illuminated: 103.6 mV
 Probe Dark: 0.4 mV
 Probe Net Response: 103.2 mV
 RG/80: 0.4 mV

Corrected Lamp Output:

Output in Air (same condition as calibration):

9.826E+15 quanta/cm²sec
0.01832 uE/cm²sec

Calibration Scale Factor:

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

Dry: 1.0503E-17 V/(quanta/cm²sec)
6.3248E+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 minimum noise, when available.

QSR240R 05/24/05

GUV



GUV-2511 Calibration Certificate

System Serial Number 25110805127 Date of Calibration 9/7/2012
 Calibration database 25110805127v5.mdb Date of Certificate 9/10/2012
 DASSM 0111 Standard of Spectral Irradiance V-030 (37712)
 Microprocessor Tag Number 2 Operator TC

Monochromatic Channels	Address	Wavelength [nm]	Responsivity [Amps per $\mu\text{W}/(\text{cm}^2 \cdot \text{nm})$]	ScaleSmall [Volts per $\mu\text{W}/(\text{cm}^2 \cdot \text{nm})$]	ScaleMedium [Volts per $\mu\text{W}/(\text{cm}^2 \cdot \text{nm})$]	ScaleLarge [Volts per $\mu\text{W}/(\text{cm}^2 \cdot \text{nm})$]	OffsetSmall [Volts]	OffsetMedium [m [Volts]	OffsetLarge [Volts]	Measurement Units
E0300	2	305	$2.3700\text{E}-11$	$4.4922\text{E}-06$	$1.3205\text{E}-03$	$4.0400\text{E}-01$	$4.0400\text{E}-04$	$-8.1771\text{E}-04$	$-8.7777\text{E}-04$	$\mu\text{W}/(\text{cm}^2 \cdot \text{nm})$
E0313	6	313	$1.7300\text{E}-10$	$1.0175\text{E}-05$	$3.2244\text{E}-03$	$7.4808\text{E}-01$	$1.0768\text{E}-04$	$1.7127\text{E}-04$	$6.9303\text{E}-04$	$\mu\text{W}/(\text{cm}^2 \cdot \text{nm})$
E0320	0	320	$2.4764\text{E}-10$	$2.9411\text{E}-05$	$7.4020\text{E}-03$	$2.4790\text{E}-01$	$-1.7160\text{E}-04$	$-7.7066\text{E}-04$	$2.0332\text{E}-03$	$\mu\text{W}/(\text{cm}^2 \cdot \text{nm})$
E0340	70	340	$1.8761\text{E}-10$	$1.8190\text{E}-05$	$5.6977\text{E}-03$	$2.0707\text{E}-01$	$1.4032\text{E}-04$	$1.3970\text{E}-04$	$1.1687\text{E}-03$	$\mu\text{W}/(\text{cm}^2 \cdot \text{nm})$
E0380	72	380	$7.0485\text{E}-11$	$7.7946\text{E}-06$	$2.7071\text{E}-03$	$7.2402\text{E}-01$	$-2.3670\text{E}-04$	$-2.4710\text{E}-04$	$-7.0791\text{E}-04$	$\mu\text{W}/(\text{cm}^2 \cdot \text{nm})$
E0395	73	395	$2.8722\text{E}-10$	$2.8433\text{E}-05$	$8.8607\text{E}-03$	$2.6979\text{E}-01$	$-1.7245\text{E}-04$	$-7.7335\text{E}-04$	$-8.9703\text{E}-04$	$\mu\text{W}/(\text{cm}^2 \cdot \text{nm})$
Brandband Channels	Address	Wavelength [nm]	Responsivity [Amps per $\mu\text{E}/(\text{cm}^2 \cdot \text{nm})$]	ScaleSmall [Volts per $\mu\text{E}/(\text{cm}^2 \cdot \text{nm})$]	ScaleMedium [Volts per $\mu\text{E}/(\text{cm}^2 \cdot \text{nm})$]	ScaleLarge [Volts per $\mu\text{E}/(\text{cm}^2 \cdot \text{nm})$]	OffsetSmall [Volts]	OffsetMedium [m [Volts]	OffsetLarge [Volts]	Measurement Units
E00PAR	16	400-700	$1.6536\text{E}-05$	$1.6520\text{E}-05$	$4.8657\text{E}-02$	$1.6533\text{E}-05$	$-8.3676\text{E}-05$	$-8.2860\text{E}-05$	$5.2458\text{E}-04$	$\mu\text{E}/(\text{cm}^2 \cdot \text{nm})$
Auxiliary Channels	Address	Wavelength [nm]	Responsivity	ScaleS	ScaleM	ScaleL	OffsetS	OffsetM	OffsetL	Measurement Units
E00Temp	29	0	1	3.0°	3.0°	0.01	0	0	0	$^{\circ}\text{C}$
E00Vol	27	0	1	0.25	0.25	-0.25	0	0	0	V

* Biospherical Instruments Inc., 5340 Riley Street, San Diego, California 92110 USA. Contact support@biospherical.com for more information.

Calibration Data Do Not Destroy

page 2 of 2

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: 675 Ω at 23°C

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

This pyrometer 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:

$$3.55 \times 10^{-6} \text{ volts/watts meter}^{-2}$$

The calculation of this constant is based on the fact that the relationship between radiation intensity and emf is rectilinear to intensities of 700 watts meter⁻². This radiometer is linear to within $\pm 1.0\%$ 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: LMP4 ISGS (NSF)
Port Hueneme, CA

S.O. Number: 63658
Date: January 7, 2013

Remarks:

Date of Test: December 14, 2012

In Charge of Test:

Reviewed by:

Dale L. Hinz
Thomas D. Hinz

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 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:

$$8.27 \times 10^{-6} \text{ volts/watts meter}^{-2}$$

The calculation of this constant is based on the fact that the relationship between radiation intensity and emf is rectilinear to intensities of 1400 watts meter⁻². This radiometer is linear to within $\pm 0.5\%$ up to this intensity.

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

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

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

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

Date of Test: December 20, 2012

S.O. Number: 63658
Date: January 7, 2013

In Charge of Test:

Reviewed by:

Remarks: Sensitivity before repainting element = 7.81×10^{-6} volts/watts meter⁻²

Acquisition and Processing Information

Processing Specifics

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

Significant Notes

Icing impacted collection of seawater data during first several hours after departure from Palmer Station on day 265. Data end users are encouraged to visually evaluate the data prior to use.

Errors and Events

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

Day Of Year	Time (GMT)	Event	Location
XXX	XX:XX	Start data collection LMG1310	@68W
279	12:35	ADCP Bottom Tracking off	Leaving shelf
280	21:45	ADCP Bottom Tracking on	Antarctic Shelf
281	20:12	Suspended data collection on sonars and seawater systems	Arrive Palmer Station
285	13:06	O2 Weekly	
291	13:32	Resume data collection on sonars and seawater systems	Leave Palmer Station
291	~1400Z- ~2100Z	Icing prevented seawater collection	
292	14:04	O2 Weekly	
292	19:04	ADCP Bottom Tracking off	Leaving Antarctic Shelf
294	10:14	ADCP Bottom Tracking On	Arrive Patagonian shelf
295	00:53	End Data Collection	@68W