Data Report NBP1302

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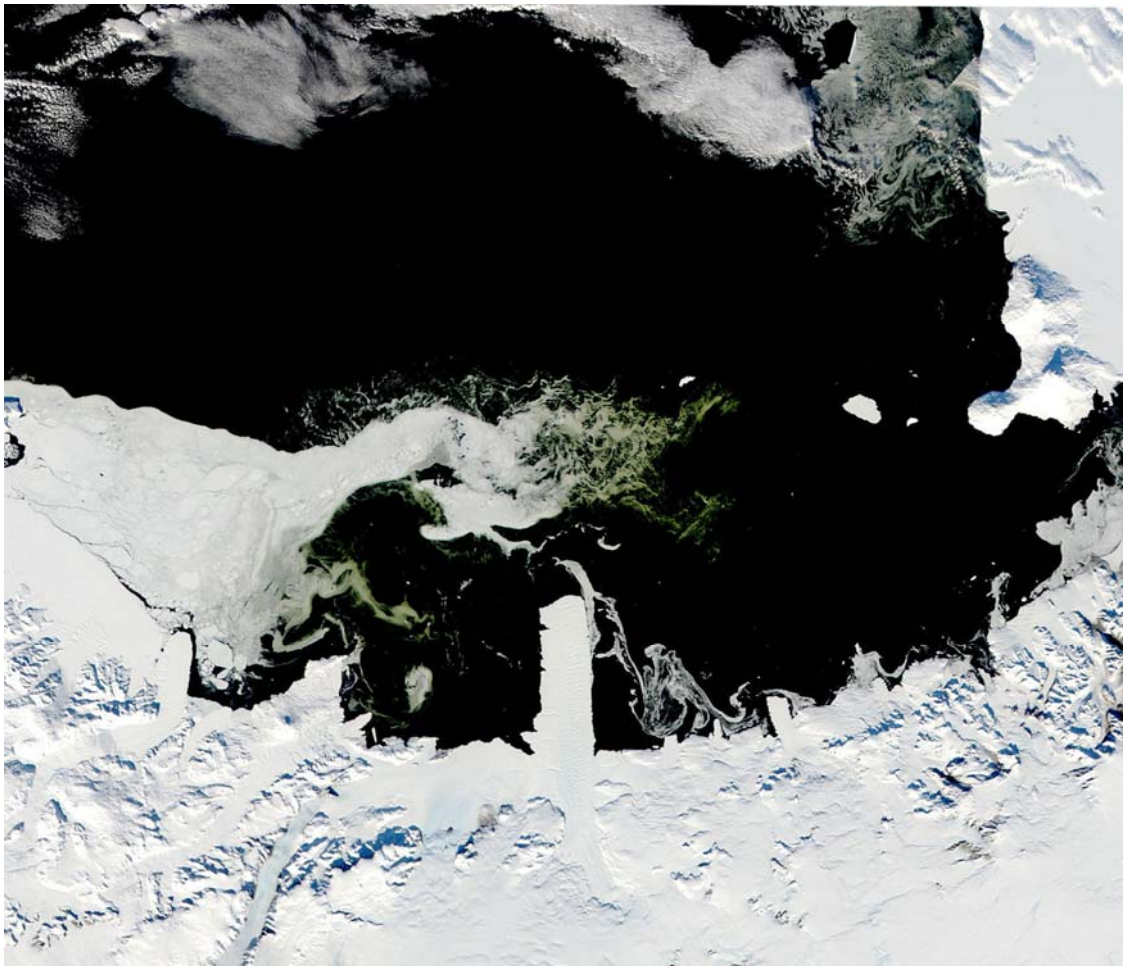

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Introduction

The NBP data acquisition systems continuously log data from the instruments used during the cruise. This document describes:

- The structure and organization of the data on the distribution media
- The format and contents of the data strings
- Formulas for calculating values
- Information about the specific instruments in use during the cruise
- A log of acquisition problems and events during the cruise that may affect the data
- Scanned calibration sheets for the instruments in use during the cruise.

The data is distributed on a DVD-R written in written in UDF format. It is readable by most modern computer platforms.

All the data has been compressed using Unix “gzip,” identified by the “.gz” extension. It has been copied to the distribution media in the Unix tar archive format, “.tar” extension. Tools are available on all platforms for uncompressing and de-archiving these formats: On Macintosh, one can use Stuffit Expander with DropStuff. On Windows operating systems, one can use WinZip.

MultiBeam and raw ADCP data are distributed separately.

IMPORTANT: Read the last section, “Acquisition Problems and Events,” for important information that may affect the processing of this data.

Distribution Contents at a Glance

Volume 1 of 1: NBP1302

File		Description
/		Root level directory
	NBP1302.trk	Text file of cruise track (lat,lon)
	NBP1302.mgd	Full Cruise MGD77 data file
	NBP1302.gmt	GMT binary file of MGD77 data
	INSTCOEF.TXT	Instrument Coefficient File
	1302DATA.doc	Data Report NBP1302 (MS Word)
	1302DATA.pdf	Data Report NBP1302 (PDF format)
/cal-sheets		Cruise track plots
	NBP1302-Sensors.doc	Sensor Calibration Sheet Reference
	NBP1302-CalSheets.tar.gz	Sensor Calibration Sheet files
/plots		Cruise track plots
	NBP1302-track.jpg	Cruise track plot (JPEG format)
	NBP1302-track.pdf	Cruise track plot (PDF format)
/process		Processed data
	1302JGOF.tar	JGOFS format data files
	1302QC.tar	Daily RVDAS QC postcript plots
	1302PCO2.tar	Merged pCO2 data files
	1302MGD.tar	MGD Data
	1302PROC.tar	Other processed data
/rvdas/nav		Navigation data
	1302adcp.tar	ADCP Data Sets
	1302gyr1.tar	Gyro raw data
	1302PCOD.tar	Trimble P-code raw data
	1302seap.tar	Seapath data
/rvdas/uw		Underway data
	1302bwnc.tar	Baltic Winch data
	1302ctdd.tar	CTD Depth data
	1302cwnc.tar	Waterfall Winch data
	1302eng1.tar	Engineering data
	1302grv1.tar	Gravimeter raw data
	1302hdas.tar	HydroDAS raw data
	1302knud.tar	Knudsen raw data
	1302mbdp.tar	Multibeam depth data
	1302mwx1.tar	Meteorology raw data
	1302oxyg.tar	Oxygen sensor
	1302pco2.tar	pCO2 raw data
	1302pguv.tar	GUV raw data
	1302rtmp.tar	Remote temperature data
	1302svp1.tar	Sound velocity probe (in ADCP well)
	1302tsg1.tar	Micro TSG data
	1302tsg2.tar	2nd Micro TSG data
	1302twnc.tar	Winch data
/Imagery		Satellite Imagery
	1302Imagery.tar	Collection of Imagery Files
/ocean		Ocean data
	1302ctd.tar	CTD Data
	1302xbt.tar	XBT Data

Extracting Data

The Unix tar command has many options. It is often useful to know exactly how an archive was produced when expanding its contents. All archives were created using the command,

```
tar -cvf archive_filename files_to_archive
```

To create a list of the files in the archive, use the Unix command,

```
tar -tvf  archive_filename  > contents.list
```

where `contents.list` is the name of the file to create

To extract the files from the archive:

```
tar -xvf  archive_filename file(s)_to_extract
```

G-zipped files will have a ".gz" extension on the filename. These files can be decompressed after de-archiving, using the Unix command,

```
gunzip filename.gz
```

Distribution Contents

Cruise Information

NBP1302 departed McMurdo Station, Antarctica on February 12, 2013

Data logging was started at 11:37:30 GMT on February 12, 2013

Data logging was stopped at 06:09 GMT on April 3, 2013

Cruise Track

The distribution DVD includes a GMT cruise track file (NBP1302.trk). It contains the longitude and latitude of the ship's position at one-minute intervals extracted from the NBP1302.gmt file.

JPEG and PDF cruise track files have been produced and placed in the /plots directory.

Satellite Images

Satellite Images received for this cruise can be found in the file called /Imagery/1302Imagery.tar. Each type of image is contained in a .tar.gz file within that file.

NBP Data Products

The IT staff on the NBP creates two processed data products for every cruise: JGOFS and MGD77.

The data processing scripts used to produce JGOFS and MGD77 data sets create a lot of intermediate files. These files are included on the data distribution media in a file called /process/1302proc.tar. These files are not intended to be end-products. They are included to make re-processing easier in the event of an error, but no extensive detail of the formats is included in this document. If you have any questions, please contact itvessel@usap.gov.

JGOFS

The JGOFS data set can be found on the distribution media in the file /process/1302jgof.tar. The archive contains one file produced for each day named jgDDD.dat.gz, where DDD is the year-day the data was acquired. The ".gz" extension indicates that the individual files are compressed before archiving. Each daily file consists of 22 columnar fields in text format as described in the table below. The JGOFS data set is created from calibrated data decimated at one-minute intervals. Several fields are derived measurements from more than a single raw input. For example, Course Made Good (CMG) and Speed Over Ground (SOG) are calculated from gyro and GPS inputs. Daily plots during the cruise are produced from the JGOFS data set. Note: Null, unused, or unknown fields are indicated as "NAN" 9999 in the JGOFS data.

Field	Data	Units
01	GMT date	dd/mm/yy
02	GMT time	hh:mm:ss
03	SEAPATH latitude (negative is South)	tt.tttt
04	SEAPATH longitude (negative is West)	ggg.gggg
05	Speed over ground	Knots
06	GPS HDOP	-
07	Gyro Heading	Degrees (azimuth)
08	Course made good	Degrees (azimuth)
09	Mast PAR	μEinsteins/meter^2 sec
10	Sea surface temperature (remote)	°C
11	Sea surface conductivity (TSG1)	siemens/meter
12	Sea surface salinity (TSG1)	PSU
13	Sea depth (uncorrected, calc. sw sound vel. 1500 m/s)	meters
14	True wind speed (max speed windbird)	meters/sec
15	True wind direction (max speed windbird)	degrees (azimuth)
16	Ambient air temperature	°C
17	Relative humidity	%
18	Barometric pressure	mBars
19	Sea surface fluorometry	μg/l (mg/m^3)
20	Transmissometer	%
21	PSP	W/m^2
22	PIR	W/m^2

MGD77

The MGD77 data set is contained in a single file for the entire cruise. It can be found in the top level of the distribution data structure as NBP1302.mgd. The file NBP1302.gmt is created from the MGD77 dataset using the “mgd77togmt” utility. NBP1302.gmt can be used with the GMT plotting package.

The data used to produce the NBP1302.mgd file can be found on the distribution media in the file /process/1302proc.tar. The data files in the archive contain a day’s data and follow the naming convention Dddd.fnl.gz, where ddd is the year-day. These files follow a space-delimited columnar format that may be more accessible for some purposes. They contain data at one-second intervals rather than one minute and are individually “gzipped” to save space. Below is a detailed description of the MGD77 data set format. The other files in the archive contain interim processing files and are included to simplify possible reprocessing of the data using the RVDAS NBP processing scripts.

All decimal points are implied. Leading zeros and blanks are equivalent. Unknown or unused fields are filled with 9’s. All “corrections”, such as time zone, diurnal magnetics, and EOTVOS, are understood to be added.

Col	Len	Type	Contents	Description, Possible Values, Notes
1	1	Int	Data record type	Set to “5” for data record
2-9	8	Char	Survey identifier	
10-12	3	int	Time zone correction	Corrects time (in characters 13-27) to GMT when added; 0 = GMT
13-16	4	int	Year	4 digit year
17-18	2	int	Month	2 digit month
19-20	2	int	Day	2 digit day
21-22	2	int	Hour	2 digit hour
23-27	5	real	Minutes x 1000	
28-35	8	real	Latitude x 100000	+ = North - = South. (–9000000 to 9000000)
36-44	9	real	Longitude x 100000	+ = East - = West. (–18000000 to 18000000)
45	1	int	Position type code	1=Observed fix 3=Interpolated 9=Unspecified
46-51	6	real	Bathymetry, 2- way travel time	In 10,000th of seconds. Corrected for transducer depth and other such corrections
52-57	6	real	Bathymetry, corrected depth	In tenths of meters.
58-59	2	int	Bathymetric correction code	This code details the procedure used for determining the sound velocity correction to depth
60	1	int	Bathymetric type code	1 = Observed 3 = Interpolated (Header Seq. 12) 9 = Unspecified
61-66	6	real	Magnetics total field, 1ST sensor	In tenths of nanoteslas (gammas)
67-72	6	real	Magnetics total field, 2ND sensor	In tenths of nanoteslas (gammas), for trailing sensor
73-78	6	real	Magnetics residual field	In tenths of nanoteslas (gammas). The reference field used is in Header Seq. 13
79	1	int	Sensor for residual field	1 = 1st or leading sensor 2 = 2nd or trailing sensor 9 = Unspecified

Col	Len	Type	Contents	Description, Possible Values, Notes
80-84	5	real	Magnetics diurnal correction	In tenths of nanoteslas (gammas). (In nanoteslas) if 9-filled (i.e., set to "+9999"), total and residual fields are assumed to be uncorrected; if used, total and residuals are assumed to have been already corrected.
85-90	6	F6.0	Depth or altitude of magnetics sensor	(In meters) + = Below sea level 3 = Above sea level
91-97	7	real	Observed gravity	In 10th of mgals. Corrected for Eotvos, drift, tares
98-103	6	real	EOTVOS correction	In 10th of mgals. E = 7.5 V cos phi sin alpha + 0.0042 V*V
104-108	5	real	Free-air anomaly	In 10th of mgals G = observed G = theoretical
109-113	5	char	Seismic line number	Cross-reference for seismic data
114-119	6	char	Seismic shot-point number	
120	1	int	Quality code for navigation	5=Suspected, by the originating institution 6=Suspected, by the data center 9=No identifiable problem found

Science of Opportunity

ADCP

The shipboard ADCP system measures currents in a depth range from about 30 to 300 m -- in good weather. In bad weather or in ice, the range is reduced, and sometimes no valid measurements are made. ADCP data collection is the OPP-funded project of Eric Firing (University of Hawaii) and Teri Chereskin (Scripps Institution of Oceanography). Data is collected on both the LMG and the NBP for the benefit of scientists on individual cruises, and for the long-term goal of building a profile of current structure in the Southern Ocean.

A data feed is sent from the ADCP system to RVDAS whenever a reference layer is acquired. This feed contains east and north vectors for ship's speed, relative to the reference layer, and ship's heading. Collected files (one per day) are archived in 1302adcp.tar in the directory /rvdas/nav.

pCO_2

The NBP carries a pCO2 measurement system from Lamont-Doherty Earth Observatory (LDEO). pCO2 data is recorded by RVDAS and transmitted to LDEO at the end of each cruise. You will find pCO2 data in a file named 1302pco2.tar in the /process directory, which contains the pCO2 instrument's data merged with GPS, meteorological and other oceanographic measurements. For more information contact Colm Sweeney (csweeney@ldeo.columbia.edu).

Cruise Science

XBT

During the cruise, eXpendable BathyThermographs were used to obtain water column temperature profiles, providing corrections to the sound velocity profile for the multibeam system. The data files from these launches are included as 1302xbt.tar in the /ocean directory.

RVDAS

The Research Vessel Data Acquisition System (RVDAS) was developed at Lamont-Doherty Earth Observatory of Columbia University and has been in use on its research ship for many years. It has been extensively adapted for use on the USAP research vessels.

Daily data processing of the RVDAS data is performed to calibrate and convert values into useable units and as a quality-control on operation of the DAS. Raw and processed data sets from RVDAS are included in the data distribution. The tables below provide detailed information on the sensors and data. Be sure to read the “Significant Acquisition Events” section for important information about data acquisition during this cruise.

Sensors and Instruments

RVDAS data is divided into two general categories, *underway and navigation*. They can be found on the distribution media as subdirectories under the top level rvdas directory: /rvdas/uw, and /rvdas/nav. Processed oceanographic data is in the top level directory, /process. Each instrument or sensor produces a data file named with its channel ID. Each data file is g-zipped to save space on the distribution media. Not all data types are collected every day or on every cruise.

The naming convention for data files produced by the sensors and instruments is

NBP[CruiseID][ChannelID].dDDD

Example: `NBP1302mwx1.d025`

- The CruiseID is the numeric name of the cruise, in this case, NBP1302.
- The ChannelID is a 4-character code representing the system being logged. An example is “mwx1,” the designation for meteorology.
- DDD is the day of year the data was collected

Underway Sensors

Meteorology and Radiometry

Measurement	Channel ID	Collect. Status	Rate	Instrument
Air Temperature	mwx1	continuous	1 sec	R.M. Young 41372LC
Relative Humidity	mwx1	continuous	1 sec	R.M. Young 41372LC
Wind Speed/Direction	mwx1	continuous	1 sec	Gill 1390-PK-062/R
Barometer	mwx1	continuous	1 sec	R.M. Young 61201
PIR (LW radiation)	mwx1	continuous	1 sec	Eppley PIR
PSP (SW radiation)	mwx1	continuous	1 sec	Eppley PSP
PAR	mwx1	continuous	1 sec	BSI QSR-240
GUV	pguv	continuous	2 sec	BSI PUV-2511
PUV	pguv	not collected		BSI PUG-2500

Geophysics

Measurement	Channel ID	Collect. Status	Rate	Instrument
Gravimeter	grv1	continuous	10 sec*	LaCoste & Romberg
Magnetometer	mag1	not collected	15 sec	EG&G G-866
Bathymetry	knud	continuous	Varies	Knudsen 320B/R

*Data is output every second but it only changes every 10 seconds.

Oceanography

Measurement	Channel ID	Collect. Status	Rate	Instrument
Conductivity	mtsg	Continuous	6 sec	SeaBird SBE-45
Salinity	mtsg	Continuous	6 sec	Calc. from pri. temp
Sea Surface Temp	mtsg	Continuous	6 sec	SeaBird SBE 38
Fluorometry	hdas	Continuous	2 sec	WET Lab AFL
Transmissometry	hdas	Continuous	2 sec	WET Lab C-Star
pCO_2	pco2	Continuous	70 sec	(LDEO)
ADCP	adcp	Continuous	varies	RD Instruments
Oxygen	oxyg	Continuous	10 sec	Oxygen Optode 3835

Navigational Instruments

Measurement	Channel ID	Collect. Status	Rate	Instrument
Trimble GPS	PCOD	Continuous	1 sec	Trimble 20636-00SM
Gyro	gyr1	Continuous	0.2 sec	Yokogawa Gyro
SeaPath	seap	Continuous	1 sec	SeaPath 200

Data

Data is received from the RVDAS system via RS-232 serial connections. A time tag is added at the beginning of each line of data in the form,

```
yy+dd:hh:mm:ss.sss [data stream from instrument]
```

where

yy = two-digit year
ddd = day of year
hh = 2 digit hour of the day
mm = 2 digit minute
ss.sss = seconds

All times are reported in UTC.

The delimiters that separate fields in the raw data files are often spaces and commas but can be other characters such as : = @. Occasionally no delimiter is present. Care should be taken when reprocessing the data that the field's separations are clearly understood.

In the sections below a sample data string is shown, followed by a table that lists the data contained in the string.

Underway Data /rvdas/uw

Each section below describes a type of data file (file name extension in parentheses) followed by a typical line of data in the file. In the table(s) for each section is a description of the fields within each line of data. Note: most data files listed below will be included with each cruise's data distribution; however some types of files may be omitted if the instrument was not operating during the cruise. The available data files can be found in the /rvdas/uw directory on the distribution disc.

Sound Velocity Probe (svp1)

```
08+330:00:00:49.011  1519.35
```

Field	Data	Units
1	RVDAS Time tag	
2	Sound velocity in ADCP sonar well	m/s

Meteorology (mwx1)

```
There are 3 different data strings in the mwx1 data file:

MET

08+330:23:59:57.725 MET,12.1,-54,6.64,88.7,111.3374,0.02414567,-
0.4827508,282.9581,281.8823,1005.119

PUS

08+330:23:59:58.546 PUS,A,020,008.53,M,+337.12,+009.00,00,0F

SUS

08+330:23:59:58.779 SUS,A,017,008.76,M,+335.53,+006.35,00,02
```

MET string

Field	Data	Units
1	RVDAS time tag	
2	MET (string flag)	
3	Power Supply Voltage	V
4	Enclosure Relative Humidity (not currently implemented)	%
5	Air temperature	°C
6	Air Relative Humidity	%
7	PAR (photosynthetically available radiation)*	mV
8	PSP (short wave radiation)*	mV
9	PIR Thermopile (long wave radiation)*	mV
10	PIR Case Temperature	°Kelvin
11	PIR Dome Temperature	°Kelvin
12	Barometer	mBar

*See page 21 for calculations.

PUS string

Field	Data	Units
1	RVDAS time tag	
2	PUS (string flag)	
3	A (unit identification)	
4	Port Wind direction relative	deg
5	Port Wind speed relative	m/s
6	Units	
7	Sound Speed	m/s
8	Sonic Temperature	°C
9	Unit Status (00 or 60 are good, any other value indicates fault)	
10	Check Sum	

SUS string

Field	Data	Units
1	RVDAS time tag	
2	SUS (string flag)	
3	A (unit identification)	
4	Starboard Wind direction relative	deg
5	Starboard Wind speed relative	m/s
6	Units	
7	Sound Speed	m/s
8	Sonic Temperature	°C
9	Unit Status (00 or 60 are good, any other value indicates fault)	
10	Check Sum	

Knudsen (knud)

```
99+099:00:18:19.775 HF,305.2,LF,304.3
```

Field	Data	Units
1	RVDAS time tag	
2	HF = High frequency flag (12 kHz)	
3	High frequency depth	meters
4	LF = Low frequency flag (3.5 kHz)	
5	Low frequency depth	meters

Fluorometer (flr1)

This Fluorometer is not in use. The current Fluorometer goes to the hdas string.

```
00+019:23:59:58.061 0  0818 ::  1/19/00 17:23:17 = 0.983  (RAW)   1.2 (C)
```

Field	Data	Units
1	RVDAS time tag	
2	Marker 0 to 8	
3	4-digit index	
4	Date	mm/dd/yy
5	Time	hh:mm:ss
6	Signal	
7	Signal units of measurement	
8	Cell temperature (if temperature compensation package is installed)	
9	Temperature units (if temperature compensation package is installed)	

pCO_2 (pco2)

```
00+021:23:59:43.190 2000021.99920 2382.4 984.2 30.73 50.8 345.9 334.1 -1.70
-68.046 -144.446 Equil
```

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	Concentration	ppm
7	Equilibrated temperature	°C
8	pCO_2 pressure	microAtm
9	Flow rate	ml / min
10	Source ID #	1 or 2 digits
11	Valve position	1 or 2 digits
12	Flow source (Equil = pCO_2 measurement)	text

Micro-TSG (tsg1)

```
08+330:23:59:40.894   5.9322,  3.34685,  34.0550, 1473.281
```

Field	Data	Units
1	RVDAS time tag	
2	Internal Temperature	°C
3	Conductivity	s/m
4	Salinity	PSU
5	Sound velocity	m/s

Micro-TSG #2 (tsg2)

```
08+330:23:59:40.894   5.9322,  3.34685,  34.0550, 1473.281
```

Field	Data	Units
1	RVDAS time tag	
2	Internal Temperature	°C
3	Conductivity	s/m
4	Salinity	PSU
5	Sound velocity	m/s

Gravimeter (grv1)

There are now two sets of fields output by the gravity meter. The data record is output once per second, and identified by “$DAT” in the id field. A summary of sensor environmental data is output every ten seconds, identified by “%ENV” in the id field.

Data record ($DAT):

05+194:00:00:27.995 $DAT,2005/ 7/13, 0: 7: 7.36,194, 9050.37, 9050.06, 5410.86, -0.00, -0.01, -0.02, 0.00, 0.00, 0.70, 0.19, -0.12, -0.25, 0.00, -69.45711315, -54.32181487, 0.000, 285.200,

Field	Data	Conversion	Units
1	RVDAS time tag		
2	Text string (id field)	$DAT for data record	
3	Date	YYYY/MM/DD	
4	Time	HH:MM:SS.SS	
5	Day of Year	DDD	
6	Gravity count	mgal = count x 1.0046 + offset	count
7	Spring Tension		CU
8	Beam Position	Volts x 750,000	
9	VCC		
10	AL		
11	AX		
12	VE		
13	AX2		
14	XACC2		
15	LACC2		
16	CROSS ACCEL		GAL
17	LONG ACCEL		GAL
18	EOTVOS CORR		MGAL
19	LONGITUDE		Degrees
20	LATITUDE		Degrees
21	HEADING		Degrees
22	VELOCITY		Knots

Environmental record ($ENV)

```
05+183:19:13:10.945 %ENV,2005/ 7/ 2,19:19:52.16,183,S-036/V1.5,    3.34,
47.19,   20.34,1.111840E-1,-0.57700,-0.10591, 0.40180, 2.55260, 0.43000,   1,
300
```

Field	Data	Conversion	Units
1	RVDAS time tag		
2	Text string (id field)	$ENV for environmental record	
3	Date	YYYY/MM/DD	
4	Time	HH:MM:SS.SS	
5	Day of Year	DDD	
6	Meter ID		
7	Meter Pressure		inch-Hg
8	Meter temp		°C
9	Ambient temp		°C
10	K-Factor		
11	VCC Coeff		
12	AL Coeff		
13	AX Coeff		
14	VE Coeff		
15	AX2 Coeff		
16	Serial Filter Length		Seconds
17	QC Filter Length		Seconds

Engineering (eng1)

```
13+079:10:22:16.035 12.26 19.68 507.4  0.3 173.3 -751.9 0 0 NAN NAN
43.2 85.7
```

Field	Data	Units
1	RVDAS time tag	
2	Power Supply Voltage	V
3	Internal Case Temperature	°C
4	Pump #1 flow rate (aquarium room)	L/min
5	Pump #2 flow rate (helo deck)	L/min
6	Pump #3 flow rate (hydro-lab)	L/min
7	Seismic air pressure	Lbs/sq-in
8	PIR case resistance (not currently hooked up, data is irrelevant)	Kohm
9	PIR case ratiometric output (not currently hooked up, data is irrelevant)	mV
10	Freezer #1 temperature	°C
11	Freezer #2 temperature	°C
12	Altimeter, OIS benthic (yoyo) camera; distance from the seafloor	m
13	Transmissometer, OIS benthic (yoyo) camera	%

*See page 24 for PIR calculations.

Hydro-DAS (hdas)

```
08+330:23:59:41.877 12.15836 14.22853 368.9655 4060.69 -1 65.5 65.5 80
57
```

Field	Data	Units
1	RVDAS time tag	
2	Supply voltage	V
3	Panel temperature	°C
4	Fluorometer	mV
5	Transmissometer	mV
6	Sea Water Valve (-1 = stern thruster valve, 0 = moon pool valve)	
7	Flow meter 1 frequency	Hz
8	Flow meter 2 frequency	Hz
9	Flow meter 3 frequency	Hz
10	Flow meter 4 frequency	Hz

GUV Data (pguv)

```
08+330:23:59:40.328 112508 235940 .000197 1.856E-1 1.116E0 4.987E-2 -
1.959E-4 1.637E0 4.153E-3 1.76E0 42.296 17.844
```

Field	Data	Units
1	RVDAS time tag	
2	Date	mmddyy
3	Time (UTC)	hhmmss
4	Ed0Gnd	V
5	Ed0320	uW (cm^2 nm)
6	Ed0340	uW (cm^2 nm)
7	Ed0313	uW (cm^2 nm)
8	Ed0305	uW (cm^2 nm)
9	Ed0380	uW (cm^2 nm)
10	Ed0PAR	uE (cm^2 nm)
11	Ed0395	uW (cm^2 nm)
12	Ed0Temp	°C
13	Ed0Vin	V

Remote Temperature (rtmp)

```
07+272:00:00:15.960 -1.7870
```

Field	Data	Units
1	RVDAS time tag	
2	Temperature at seawater intake	°C

Oxygen Data (oxyg)

Internal reference salinity is set to 34 ppt. For further information on this data, contact Sharon Stammerjohn, sstammer@ucsc.edu.

11+011:00:21:48.109 MEASUREMENT 3835 1424 Oxygen: 334.01
Saturation: 90.71 Temperature: -0.78 DPhase: 37.65
BPhase: 35.95 RPhase: 0.00 BAmp: 212.13 BPot:
30.00 RAmp: 0.00 RawTem.: 788.05

Field	Data	Units
1	RVDAS time tag	
2-4	Measurement ID, Model Number, Serial Number	alphanumeric
5	Oxygen heading	text
6	Oxygen Reading	µM
7	Saturation heading	text
8	Saturation Reading	%
9	Temperature heading	text
10	Water Temperature	°C
11	Dphase heading	text
12	Dphase	Raw numeric
13	Rphase heading	Text
14	Rphase	Raw numeric
15	Bamp heading	Text
16	Bamp	Raw numeric
17	Bpot heading	Text
18	Bpot	Raw numeric
19	Ramp heading	Text
20	Ramp	Raw numeric
21	RawTem heading	Text
22	RawTemp	V

Navigational Data /rvdas/nav

Seapath GPS (seap)

The Seapath GPS outputs the following data strings, four in NMEA format and two in proprietary PSXN format:

- GPZDA
- GPGGA
- GPVTG
- GPHDT
- PSXN, 20
- PSXN, 22
- PSXN, 23

GPZDA

```
02+253:00:00:00.772 $GPZDA,235947.70,09,09,2002,,*7F
```

Field	Data	Units
1	RVDAS time tag	
2	$GPZDA	
3	time	hhmmss.ss
4	Day	dd
5	Month	mm
6	Year	yyyy
7	(empty field)	
8	Checksum	

GPGGA

```
02+253:00:00:00.938
GPGGA,235947.70,6629.239059,S,06827.668899,W,1,07,1.0,11.81,M,,M,,*6F
```

Field	Data	Units
1	RVDAS time tag	
2	$GPGGA	
3	time	hhmmss.ss
4	Latitude	ddmm.mmmmmm
5	N or S for north or south latitude	
6	Longitude	ddmm.mmmmmm
7	E or W for east or west longitude	
8	GPS quality indicator, 0=invalid, 1=GPS SPS, 2=DGPS, 3=PPS, 4=RTK, 5=float RTK, 6=dead reckoning	
9	number of satellites in use (00-99)	
10	HDOP	x.x
9	height above ellipsoid in meters	m.mm
11	M	
12	(empty field)	
13	M	
14	age of DGPS corrections in seconds	s.s
15	DGPS reference station ID (0000-1023)	
16	Checksum	

GPVTG

```
02+253:00:00:00.940 $INVTG,19.96,T,,M,4.9,N,,K,A*39
```

Field	Data	Units
1	RVDAS time tag	
2	$GPVTG	
3	course over ground, degrees true	d.dd
4	T	
5	,	
6	M	
7	speed over ground in knots	k.k
8	N	
9	,	
10	K	
11	Mode	
12	Checksum	

GPHDT

```
02+253:00:00:00.941 $GPHDT,20.62,T*23
```

Field	Data	Units
1	RVDAS time tag	
2	$GPHDT	
3	Heading, degrees true	d.dd
4	T	
5	Checksum	

PSXN,20

```
02+253:00:00:00.942 $PSXN,20,0.43,0.43*39
```

Field	Data	Units
1	RVDAS time tag	
2	$PSXN	
3	20	
4	Horizontal position & velocity quality: 0=normal, 1=reduced performance, 2=invalid data	
5	Height & vertical velocity quality: 0=normal, 1=reduced performance, 2=invalid data	
6	Heading quality: 0=normal, 1=reduced performance, 2=invalid data	
7	Roll & pitch quality: 0=normal, 1=reduced performance, 2=invalid data	
8	Checksum	

PSXN,22

```
02+253:00:00:00.942 $PSXN,22,0.43,0.43*39
```

Field	Data	Units
1	RVDAS time tag	
2	$PSXN	
3	22	
4	gyro calibration value since system start-up in degrees	d.dd
5	short term gyro offset in degrees	d.dd
6	Checksum	

PSXN,23

```
02+253:00:00:02.933 $PSXN,23,0.47,0.57,20.62,0.03*0C
```

Field	Data	Units
1	RVDAS time tag	
2	$PSXN	
3	23	
4	roll in degrees, positive with port side up	d.dd
5	pitch in degrees, positive with bow up	d.dd
6	Heading, degrees true	d.dd
7	heave in meters, positive down	m.mm
8	Checksum	

Trimble (P-Code) GPS (PCOD)

The Trimble GPS, which formerly output Precise Position (*P-Code*) strings, but now only outputs Standard Position (*Civilian*) strings, outputs three NMEA standard data strings:

- Position fix (GGA)
- Latitude / longitude (GLL),
- Track and ground speed (VTG)

GGA: GPS Position Fix – Geoid/Ellipsoid

```
01+319:00:04:11.193 $GPGGA,000410.312,6227.8068,S,06043.6738,W,1,06,1.0,
031.9,M,-017.4,M,,*49
```

Field	Data	Units
1	RVDAS Time tag	
2	$GPGGA	
3	UTC time at position	hhmmss.sss
4	Latitude	ddmm.mmm
5	North (N) or South (S)	
6	Longitude	ddmm.mmm
7	East (E) or West (W)	
8	GPS quality: 0 = Fix not available or invalid 1 = GPS, SPS mode, fix valid 2 = DGPS (differential GPS), SPS mode, fix valid 3 = P-CODE PPS mode, fix valid	
9	Number of GPS satellites used	
10	HDOP (horizontal dilution of precision)	
11	Antenna height	meters
12	M for meters	
13	Geoidal height	meters
14	M for meters	
15	Age of differential GPS data (no data in the sample string)	
16	Differential reference station ID (no data in the sample string)	
17	Checksum (no delimiter before this field)	

GLL: GPS Latitude/Longitude

```
01+319:00:04:11.272 $GPGLL,6227.8068,S,06043.6738,W,000410.312,A*32
```

Field	Data	Units
1	RVDAS Time tag	
2	$GPGLL	
3	Latitude	degrees
4	North or South	
5	Longitude	degrees
6	East or West	
7	UTC of position	hhmmss.sss
8	Status of data (A = valid)	
9	Checksum	

VTG: GPS Track and Ground Speed

```
01+319:00:04:11.273 $GPVTG,138.8,T,126.0,M,000.0,N,000.0,K*49
```

Field	Data	Units
1	RVDAS time tag	
2	$GPVTG	
3	Heading	degrees
4	Degrees true (T)	
5	Heading	degrees
6	Degrees magnetic (M)	
7	Ship speed	knots
8	N = knots	
9	Speed	km/hr
10	K = km per hour	
11	Checksum	

Gyro Compass (gyr1)

```
00+019:23:59:59.952 $HEHDT 25034,-020*73
```

Field	Data	Units
1	RVDAS time tag	
2	$HEHDT	
3	Heading, Degrees True	degrees
5	Checksum	

ADCP Course (adcp)

```
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, east vector	knots
5	Ship Speed relative to reference layer, north vector	knots
6	Ship heading	degrees

Processed Data /process/

pCO2-merged

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

Field	Data	Units
1	RVDAS time tag	
2	pCO_2 time tag (decimal is fractional time of day)	yyyyddd.ttt
3	Raw voltage (IR)	mV
4	Cell temperature	°C
5	Barometer	MBar
6	Flow rate	ml / min
7	Concentration	ppm
8	pCO_2 pressure	microAtm
9	Equilibrated temperature	°C
10	Sea Water Temp	1 or 2 digits
11	Valve position	°C
12	Flow source (Equil = pCO_2 measurement)	text
13	RVDAS latitude	degrees
14	RVDAS longitude	degrees
15	TSG external temperature	°C
16	TSG 1 salinity	PSU
17	Fluorometer	V
18	RVDAS true wind speed	m/s
19	RVDAS true wind direction	degrees
20	Barometric Pressure	mBars
21	Uncontaminated seawater pump flow rate	l/min
22	Speed over ground	knots
23	Course made good	degrees
24	Oxygen	µM
25	TSG 2 internal temperature	°C
26	TSG 2 salinity	PSU
27	TSG 1 internal temperature	°C
28	H2O Input Source	-1 stern thrustor 0 moonpool

Calculations

The file `instrument.coeff` located in the `/` directory contains the calibration factors for shipboard instruments. This was the file used by the RVDAS processing software.

PAR

Coefficients parc1 and parcv for this cruise can be found in the `instrument.coeff` file as the variable labeled PAR, respectively. Variable par is the raw data in mV, as described in the "mwx1" file description. The calibration scale and probe offset dark are values taken from the PAR Cal Sheet.

```
par = raw data mV
calibration scale = 5.8644 V/(µEinstiens/cm2sec)
parc1 = 1 / scale = .17
probe offset dark = -.1 mV
parcv = dark x 1000 mV/V = -0.0001 V
((par / 1000 mV/V) – parcv) x parc1 x 10000 cm2/m2 = µEinstiens/m2sec

Calculations (extracted from the C code):
/* Convert from mV to V */
par /= 1000;
/* (par V - vdark V) / Calibration Scale Factor V/uE/cm2sec */
parCalc = (par - parcv) * parc1 * 10000;
```

PSP

Coefficient pspCoeff for this cruise can be found in the `instrument.coeff` file as the variable labeled PSP1. Variable psp is the raw data in mV, as described in the "mwx1" file description.

```
psp = raw data mV
calibration scale =  pspCoeff x 10^-6  V/(W/m2)
psp / (scale x 1000 mV/V) = W/m2

Calculations (extracted from the C code):
     /* Convert from mV to W/m^2  */
     pspCalc = (psp * 1000 / pspCoeff);
```

PIR

Coefficient pirCoeff for this cruise can be found in the `instrument.coeff` file as the variable labeled PIR1. Variable pir_thermo is the raw data in mV, pir_case is the PIR case temperature in Kelvins and pir_dome is the PIR dome temperature in Kelvins, as described in the “mwx1” file description. Hard-coded “C” coefficients are shown below:

```
Dome constant = 3.5
Sigma = 5.6704e-8

pir_thermo = raw data mV
calibration scale = pirCoeff x 10^-6  V/(W/m2)
pir_thermo / (scale x 1000 mV/V) = W/m2

Calculations (extracted from the C code):
      /* convert mV to W/m^2 */
     pirCalc = (pir_thermo * 1000 / pirCoeff)
     /* correct for case temperature */
     pirCalc += sigma * pow(pir_case,4)
     /* correct for dome temperature */
     pirCalc -= 3.5 * sigma * (pow(pir_dome, 4) - pow(pir_case, 4))
```

Acquisition Problems and Events

This section lists problems with acquisition noted during this cruise including instrument failures, data acquisition system failures and any other factor affecting this data set. The format is ddd:hh:mm (ddd is year-day, hh is hour, and mm is minute). Times are reported in GMT.

Start	End	Description
12 Feb, 2013		Gravity meter is giving incorrect values. No gravity tie was provided from McMurdo.
11:37 12 Feb, 2013		Departed McMurdo Station and started logging.
14:40 12 Feb, 2013		Transmissometer was cleaned affecting data collection for transmissometer, O2 sensor and TSG-2
08:12 13 Feb, 2013	08:18 13 Feb, 2013	Flourometer flow was impacted due to cell cleaning.
20:01 18 Feb, 2013		NB-150 (ADCP) bottom tracking turned off per Jules and Bruce Huber
11:42 24 Feb, 2013	13:21 24 Feb, 2013	Cleaning of TSG1; bypassing limited effects on fluorometer transmissometer and O2 sensor
13:27 24 Feb, 2013	15:00 24 Feb, 2013	Cleaning of TSG2; bypassing limited effects on fluorometer transmissometer and O2 sensor
01 March 2013		The gravity computer Spring Tension was corrected to match the meter Spring Tension.
20:50 01 March 2013	20:55 01 March 2013	Transmissometer cleaning for approximately 5 minutes
16:48 04 March 2013	17:20 04 March 2013	Water flow to pCO2 system shut-off for inspection
17:50 04 March 2013	17:55 04 March 2013	TSG-1 was shutdown and swapped for another unit.
21:00 04 March 2013	21:07 4 March 2013	pCO2 water flow shut-off
21:14 4 March 2013	21:07 4 March 2013	pCO2 logging stopped; repaired clog; krill in sprayer; adjusted flows
18:45 6 March 2013		Sea water flow was clogged due ice for a short period of time. Engineering back flushed the system.
09:26 6 March 2013	20:15 6 March 2013	The Seapath GPS has had the wrong heading
20:15 6 March 2013	20:23 6 March 2013	Seapath GPS rebooted to correct heading error
07:03 7 March 2013	07:06 7 March 2013	ADCP stopped and restarted for configuration changes.
02:00 8 March 2013	05:00 8 March 2013	ENGDAS data stream interrupted for

		software update.
01:32 13 March 2013	19:55 13 March 2013	pCO2 system not recording due to power failure
01:30 13 March 2013	02:00 13 March 2013	Main ship power failure. Some sensor feeds interrupted.
08:50 20 March 2013	09:17 20 March 2012	Hydrolab seawater flow clogged by ice
22:15 22 March 2013	23:45 22 March 2013	Power interruption to main deck labs due to fire alarm event. Some sensor feeds interrupted.
05:56:00 23 March 2013	05:56:10 23 March 2013	Gyro converter switched to UPS power. Ten seconds of data loss.
	06:09 April 3, 2013	Stopped Logging at the Chilean EEZ boundry

Appendix: Sensors and Calibrations

Sensor	*Serial Number*	*Last Cal.*	*Comments*
Meteorology & Radiometers			
Stbd Anemometer (Gill US)	847014	9/29/2010	Installed 11/17/2010
Port Anemometer (Gill US)	924057	11/18/09	Installed 3/5/2010
Barometer	01705	5/10/2011	Installed 07/30/2012
Humidity/Wet Temp	06134	6/23/2011	Installed 7/30/2012
PIR	32845F3	4/12/2011	Installed 6/17/2011
PSP	32850F3	4/11/2011	Installed 6/17/2011
Mast PAR	6356	8/4/2011	Installed 7/30/2012
GUV (Mast)	25110203113	7/29/2011	Installed 7/31/2012
Underway			
Micro-TSG #1 (until 3/4/13)	4549120-0226	8/2/2011	Installled 9/7/2012, removed 3/4/13
Micro-TSG #1	4546167-0199	3/11/2011	Installled 3/4/2013
Micro-TSG #2	4566350-0389	10/20/2011	Installled 9/7/2012
Digital Remote Temp (Primary)	3846730-0323	5/18/2010	Installed 11/16/2011
Oxygen Optode	3835-1424	10/21/2010	Installed12/30/2010
Fluorometer	AFLT-009	9/12/2011	Installed 12/24/2012
Transmissometer	CST-889DR	4/21/2011	Installed 4/21/2011
CTD			
CTD Fish	91480	12/18/2012	Installed 2/11/2013
CTD Fish Pressure	53952	12/18/2012	Installed 2/11/2013
CTD Deck Unit	11P19858-0768	N/A	Installed11/8/2007
Slip-Ring Assembly	1.406	N/A	Installed 3/27/04
Carousel Water Sampler	3214153-0140	N/A	Installed 2/11/2013
Pump (primary)	051626 3.0K	12/23/2012	Installed 2/11/2013
Pump (secondary)	051627 3.0K	12/23/2012	Installed 2/11/2013
Temperature (primary)	03P2299	8/22/2012	Installed 2/11/2013, removed 2/16
Temperature (primary)	03P5090	6/21/2011	Installed 2/16/2013
Temperature (secondary)	03P2308	7/25/2012	Installed 2/11/2013, removed 2/14
Temperature (secondary)	031649	8/22/2012	Installed 2/14/2013, removed 2/16
Temperature (secondary)	03P5097	6/18/2011	Installed 2/16/2013
Conductivity (primary)	040926	7/25/2012	Installed 2/11/2013
Conductivity (secondary)	042513	7/20/2011	Installed 2/11/2013
Dissolved Oxygen (primary)	430161	8/18/2012	Installed 2/11/2013
Dissolved Oxygen (secondary)	432267	12/14/2012	Installed 2/11/2013
Fluorometer	FLRTD-1482	8/7/2012	Installed 2/11/2013
Transmissometer	CST-439DR	8/17/2012	Installed 2/11/2013
PAR	4361	10/26/2012	Installed 2/11/2013
Altimeter	49432	N/A	Installed 2/11/2013
Bottom Contact Switch	#4	N/A	Installed 2/21/2013

Gravity Tie

Gravity Tie Spreadsheet

The fields outlined in BOLD MUST BE FILLED IN for this spreadsheet to operate properly. The automatically calculated values show up in the shaded fields.

Date: 3/7/2012
Location: **Punta Arenas, Chile**
Station: Harbour Admin. Bldg.
Latitude: 53 09 S
Longitude: 070 55 W
Elevation:
Gravity: 981320.82

Reference Code Numbers:
Station no. 9337-50
ISGN no. 51230N

	Value	Time (GMT)
Ship's meter before gravity tie (Gravity (cu))	8974.9	17:01
Ship's meter after gravity tie (Gravity (cu))	8974.9	18:01
Average	8974.9	
Ship Gravimeter's Calibration Constant	1.0046	
Corrected ship's meter (QC Grav (mgal))	9016.2	

	Value	Time (GMT)
Ship's meter before gravity tie (serial, RVDAS)	8974.9	17:03
Ship's meter after gravity tie (serial, RVDAS)	8974.9	18:02
Average (for comparison check only)	8974.9	

Portable Gravimeter Interval Factor 1.01007 From Table 1 of Model G #807 Meter

Station	Value	Time (GMT)	Temp	Date	OBS mgal, averaged
Pier measurement 1	4917.64	17:23	54	March 7, 2012	
Pier measurement 2	4917.62	17:24	54	March 7, 2012	4962.15
Pier measurement 3	4917.63	17:25	54	March 7, 2012	
Average	4917.63				
Station measurement 1	4918.43	17:36	54	March 7, 2012	
Station measurement 2	4918.41	17:37	54	March 7, 2012	4962.94
Station measurement 3	4918.39	17:38	54	March 7, 2012	
Average	4918.41				
Pier measurement 4	4917.70	17:36	54	March 7, 2012	
Pier measurement 5	4917.63	17:52	54	March 7, 2012	4962.19
Pier measurement 6	4917.67	17:55	54	March 7, 2012	
Average	4917.67				

Gravity offset from last tie 972302.62
Drift since last tie 1.23

OBS Differences	
Station to Pier (1, 2, & 3 averaged)	0.79
Station to Pier (4, 5, & 6 averaged)	0.75
Averaged Differences	0.77
Gravity at pier	981320.05
Elevation of pier above gravimeter, meters	0.0
Earth differential gravity, mgal/meter	0.3
Gravity at ship's gravimeter	981320.05
Gravity Offset (for RVDAS)	972303.82

Comments

Tie done by Sheldon Blackman prior to NBP1203. Very stable conditions on pier. Pier elevation exactly even with ship's gravimeter.

Note about Elevation of Pier: *If pier is below the ship's gravimeter, this value is negative. If above, positive.*

Bridge Anemometer

RM Young Anemometer Calibration, Model 05106

S/N: 45835 **Date:** 27-Sep-04 **Cal'd By:** W. Gallagher

Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s	Knots
0	0.00	0.0	0.0	0.0
200	0.98	0.9	0.1	1.9
500	2.45	2.3	0.2	4.8
1000	4.90	4.8	0.1	9.5
1500	7.35	7.3	0.0	14.3
2000	9.80	9.7	0.1	19.0
3000	14.70	14.7	0.0	28.6
4000	19.60	19.7	-0.1	38.1
5000	24.50	24.6	-0.1	47.6
6000	29.40	29.7	-0.3	57.1
7000	34.30	34.7	-0.4	66.6
8000	39.20	39.7	-0.5	76.2
9000	44.10	44.7	-0.6	85.7
10000	49.00	49.6	-0.6	95.2
12000	58.80	59.6	-0.8	114.2

Direction	Measured Direction	Delta Direction
0	0	0
30	28	2
60	59	1
90	89	1
120	119	1
150	150	0
180	180	0
210	210	0
240	240	0
270	270	0
300	300	0
330	330	0
0	0	0

Note: Delta direction should not exceed + or - 3 degrees.

Counter Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s
0	0.00	0.0	0.0
200	0.98	0.9	0.1
500	2.45	2.3	0.2
1000	4.90	4.9	0.0
1500	7.35	7.3	0.0
2000	9.80	9.8	0.0
3000	14.70	14.7	0.0
4000	19.60	19.8	-0.2
5000	24.50	24.7	-0.2
6000	29.40	29.8	-0.4
7000	34.30	34.7	-0.4
8000	39.20	39.7	-0.5
9000	44.10	44.7	-0.6
10000	49.00	49.7	-0.7
12000	58.80	59.6	-0.8

Caution: Do Not exceed 12000 rpm during Wind Speed test.

Wind Speed Threshold < 2.9 gm?	yes
Wind Direction Threshold < 30 gm?	yes

Additional Comments
Installed new housing assy.and wind direction coupling. Adjusted clearence on wind direction potentiometer thumbwheel.

Note: Delta Windspeed should not exceed + or - 0.3 m/s for 0 - 5000 rpm

Mast Barometer

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

COPY

CALIBRATION REPORT
Barometric Pressure Sensor

Customer: *Raytheon Technical Services Company LLC*

Test Number: 1510-01B
Test Date: 10 May 2011

Customer PO: RR57542-01
Sales Order: 1906

Test Sensor:
Model: 61201
Serial Number: *BP01705*
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	3749	1024.9
1100.0	4997	1099.8

(1) Calculated from voltage output

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

Reference Instrument:	Serial #	NIST Test Reference
Druck Pressure Controller Model DPI515	51500497	UKAS Lab 0221
Fluke Multimeter Model 8060A	4865407	234027

Tested By: E Chenuing

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

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

CALIBRATION REPORT
Relative Humidity Sensor

Customer: *Raytheon Technical Services Company LLC*

Test Number: 1623-01R
Test Date: 23 June 2011
Customer PO: RR59338-01
Sales Order: 1983

Test Sensor:
Model: 41372LC
Serial Number: *TS06134*
Description: Temperature/Relative Humidity Sensor

Report of calibration comparison of test relative humidity sensor with National Institute of Standards and Technology traceable standard relative humidity sensor at five humidity levels in the R.M. Young Company controlled humidity chamber facility. Calibration accuracy ± 2.0 %.

Reference Humidity (%)	Current Output (milliamps)	Indicated (1) Humidity (%)
10.4	5.9	11.9
30.3	8.9	30.4
50.3	12.2	51.3
70.4	15.3	70.4
89.6	17.9	86.9

(1) Calculated from voltage output

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

Reference Instrument	Serial #	NIST Test Reference
Vaisala Humidity Sensor Model 35AC	N475040	TN 266152
Fluke Multimeter Model 8060A	4865407	234027

Tested By: E Chenuney

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

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

CALIBRATION REPORT
Temperature Sensor

Customer: *Raytheon Technical Services Company LLC*

Test Number: 1623-01T
Test Date: 23 June 2011
Customer PO: RR59338-01
Sales Order: 1983

Test Sensor:
Model: 41372LC
Serial Number: *TS06134*
Description: Temperature/Relative Humidity Sensor

Report of calibration comparison of test temperature sensor with National Institute of Standards and Technology traceable standard thermometers at three temperatures in the R.M. Young Company controlled temperature calibration bath facilities. Calibration accuracy ± 0.1° Celsius.

Bath Temperature (degrees C)	Current Output (milliamps)	Indicated (1) Temperature (degrees C)
-49.81	4.031	-49.81
0.03	12.003	0.02
50.29	20.046	50.29

(1) Calculated from current output

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

Reference Instrument	Serial #	NIST Test Reference
Brooklyn Thermometer Model 43-FC	8006-118	204365
Brooklyn Thermometer Model 22332-D5-FC	25071	249763
Brooklyn Thermometer Model 2X400-D7-FC	77532	228060
Keithley Multimeter Model 191	15232	234027

Tested By: E Chenuney

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

EPLAB

THE EPPLEY LABORATORY, INC.

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

STANDARDIZATION OF EPPLEY PRECISION INFRARED RADIOMETER Model PIR

Serial Number: 32845F3

Resistance: 713 Ω at 23°C
Temperature Compensation Range: -20° to + 40°C

This pyrgeometer has been compared against Eppley's Blackbody Calibration System under radiation intensities of approximately 200 watts meter^{-2} and an average ambient temperature of 22°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:

4.11×10^{-6} volts/watts meter^{-2}

The calculation of this constant is based on the fact that the relationship between radiation intensity and emf is rectilinear to intensities of 700 watts meter^{-2}. This radiometer is linear to within ±1.0% up to this intensity.

The calibration of this instrument is traceable to the International Practical Temperature Scale (IPTS) through a precision low-temperature blackbody.

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

Shipped to: Raytheon Polar Services NSF
Port Hueneme, CA

Date of Test: April 12, 2011

In Charge of Test: Giles L. Gentry

S.O. Number: 62959
Date: April 14, 2011

Reviewed by: Thomas DeKoch

Remarks:

EPLAB

THE EPPLEY LABORATORY, INC.

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

STANDARDIZATION OF EPPLEY PRECISION SPECTRAL PYRANOMETER Model PSP

Serial Number: 32850F3

Resistance: 706 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:

$$7.87 \times 10^{-5} \text{ volts/watts meter}^{-2}$$

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^{-2}. This radiometer is linear to within ± 0.5% up to this intensity.

The calibration of this instrument is traceable to standard self-calibrating cavity pyrheliometers in terms of the Systems Internationale des Unites (SI units), which participated in the Tenth International Pyrheliometric Comparisons (IPC X) at Davos, Switzerland in September-October 2005.

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

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

Shipped to: Raytheon Polar Services NSF
Port Hueneme, CA

Date of Test: April 11, 2011

In Charge of Test: Debra L. Beverly

S.O. Number: 62958
Date: April 14, 2011

Reviewed by: Thomas D. Kirk

Remarks:

Mast PAR

PAR for Mast

Biospherical Instruments Inc.

CALIBRATION CERTIFICATE

Calibration Date	8/4/2011
Model Number	QSR-240
Serial Number	6356
Operator	TPC
Standard Lamp	GS-1024(7/22/11)
Probe Excitation Voltage Range:	6 to 18 VDC(+)
Output Polarity:	Positive

Probe Conditions at Calibration(in air):

Calibration Voltage:	6	VDC(+)
Probe Current:	1.2	mA

Probe Output Voltage:

Probe Illuminated	97.2	mV
Probe Dark	0.1	mV
Probe Net Response	97.0	mV
RG780	0.3	mV

Corrected Lamp Output:

Output In Air (same condition as calibration):

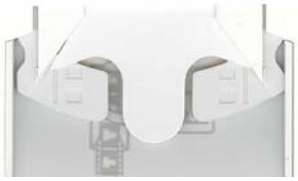
9.298E+15	quanta/cm²sec
0.01544	uE/cm²sec

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

Dry:	1.0436E-17	V/(quanta/cm²sec)
	6.2847E+00	V/(uE/cm²sec)

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

QSR240R 05/24/95



Biospherical Instruments Inc.

System Calibration Certificate

THE INSTRUMENTS REFERENCED BELOW WERE FACTORY TESTED AND CALIBRATED BY

BIOSPHERICAL INSTRUMENTS INC.
5340 Riley Street
San Diego, California 92110 USA

Instruments: GUV-2511 No 25110203113

Optical Calibrations:

NIST Traceability. For wavelengths longer than 313 nm, the specific instruments cited here were calibrated using a 1000W FEL **#GS-1024 (7/22/11)** following procedures and standards traceable to NIST Standard of Spectral Irradiance **F473**. Traceability paths and all procedures for all calibrated lamps and associated apparatus (shunts, power supplies, DMMs, etc) are maintained following calibration methodologies per National Bureau of Standards (US) (NBS) Special Publication 250-20 Spectral Irradiance Calibrations (1987) and NBS Publication 594–13 Optical Radiation Measurements: The 1973 Scale of Spectral Irradiance (1977).

Solar Calibrations. Lamp calibrations are problematic for solar UV measurements (wavelengths below 320 nm) because the solar spectrum is radically different from the lamp spectrum and changes greatly as a function of wavelength. Solar calibrations are achieved through direct comparison with measurements of a high resolution scanning spectroradiometer in San Diego (SUV-100), which is part of the National Science Foundation's UV Monitoring Network. The SUV-100 instrument has a bandwidth of 1 nm. Calibrated filter radiometer data therefore report spectral irradiance at the channel's nominal wavelengths with a bandwidth of 1 nm. Solar calibrations are typically accurate to within ±10% for solar zenith angles smaller than 75°. At larger solar zenith angles, UV channels have a greater uncertainty due to the rapid change of the solar UV spectrum.

Note that this certificate contains a subset of the information delivered in the calibration database **25110203113v6.mdb**. This database is required for operation of this system using Biospherical Instruments Inc.'s Logger® software.

Biospherical Instruments Inc.

GUV-2511 Calibration Certificate

System Serial Number	25110203113	Date of Calibration	7/29/2011
Calibration database	25110203113.mdb	Date of Certificate	8/1/2011
DASSN	0068	Standard of Spectral Irradiance	GS1024(7/22/11)
Microprocessor Tag Number	2	Operator	TC

Monochromatic Channels	Address	Wavelength [nm]	Responsivity [Amps per µW/(cm²-nm)]	ScaleSmall [Volts per µW/(cm²-nm)]	ScaleMedium [Volts per µW/(cm²-nm)]	ScaleLarge [Volts per µW/(cm²-nm)]	OffsetSmall [volts]	OffsetMedium [volts]	OffsetLarge [volts]	Measurement Units
Ed0320	2	320	2.5711E-10	2.6225E-05	7.6619E-03	2.7126E+00	-5.8115E-06	-9.1758E-06	1.7218E-04	µW/(cm²nm)
Ed0340	6	340	2.0927E-10	2.1346E-05	6.2363E-03	2.1989E+00	3.0451E-04	3.0474E-04	1.1770E-03	µW/(cm²nm)
Ed0313	8	313	2.1800E-10	2.2286E-05	6.5111E-03	2.3245E+00	6.3074E-05	6.4994E-05	7.6713E-04	µW/(cm²nm)
Ed0305	10	305	1.6400E-11	1.6687E-06	4.8753E-04	1.5082E-01	3.4984E-04	3.3908E-04	-2.2555E-03	µW/(cm²nm)
Ed0380	12	380	6.6055E-11	6.7376E-06	1.9684E-03	6.5646E-01	1.0888E-03	1.0755E-03	-1.4791E-03	µW/(cm²nm)
Ed0PAR	13	0	1.8677E-05	1.9051E+00	5.5658E+02	1.9817E+05	8.5258E-04	8.4359E-04	-1.3226E-03	µE/(cm²sec)

Broadband Channels	Address	Wavelength [nm]	Responsivity [Amps per µE/(cm²-s)]	ScaleSmall [Volts per µE/(cm²-s)]	ScaleMedium [Volts per µE/(cm²-s)]	ScaleLarge [Volts per µE/(cm²-s)]	OffsetSmall [volts]	OffsetMedium [volts]	OffsetLarge [volts]	Measurement Units
Ed0395	18	400-700	3.3639E-10	3.4312E-05	1.0024E-02	3.2744E+00	6.7600E-05	6.2557E-05	2.1591E-04	µW/(cm²nm)

Auxiliary Channels	Address	Wavelength	Responsivity	ScaleS	ScaleM	ScaleL	OffsetS	OffsetM	OffsetL	Measurement Units
Ed0Gnd	0	0	1	1.00	1.00	1.00	0	0	0	V
Ed0Temp	22	0	1	0.01	0.01	0.01	0	0	0	C
Ed0Vin	27	0	1	-0.25000	-0.25000	-0.25000	0.0000	0.0000	0.0000	V

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Calibration Data – Do Not Destroy

page 2 of 2

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: 1480
CALIBRATION DATE: 18-Dec-12

SBE9plus PRESSURE CALIBRATION DATA
10000 psia S/N 53952

DIGIQUARTZ COEFFICIENTS:

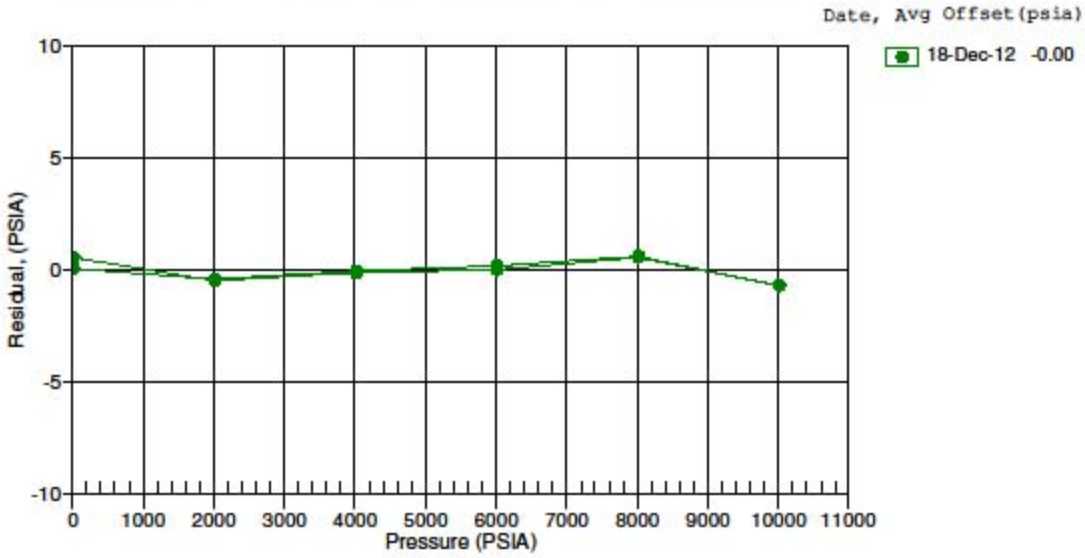
C1 =	-5.561704e+004
C2 =	4.302402e-001
C3 =	1.582810e-002
D1 =	4.708200e-002
D2 =	0.000000e+000
T1 =	3.029296e+001
T2 =	-2.122954e-004
T3 =	4.352450e-006
T4 =	2.626550e-009
T5 =	0.000000e+000

AD590M, AD590B, SLOPE AND OFFSET:

AD590M =	1.16300e-002
AD590B =	-8.63457e+000
Slope =	0.99999
Offset =	-3.0213 (dbars)

PRESSURE (PSIA)	INST OUTPUT(Hz)	INST TEMP(C)	INST OUTPUT (PSIA)	CORRECTED INST OUTPUT (PSIA)	RESIDUAL (PSIA)
14.547	33019.50	21.4	19.466	15.084	0.537
2014.689	33606.67	21.7	2018.592	2014.196	-0.493
4014.621	34182.17	21.8	4018.885	4014.476	-0.145
6014.640	34746.23	21.9	6019.053	6014.631	-0.009
8014.742	35299.59	21.9	8019.715	8015.280	0.537
10014.990	35842.18	22.0	10018.718	10014.268	-0.722
8014.780	35299.62	22.1	8019.806	8015.370	0.590
6014.719	34746.31	22.2	6019.301	6014.878	0.159
4014.689	34182.23	22.2	4019.027	4014.618	-0.070
2014.710	33606.71	22.3	2018.677	2014.281	-0.429
14.555	33019.38	22.4	18.981	14.598	0.043

Residual = corrected instrument pressure - reference pressure



CTD 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: 0926
CALIBRATION DATE: 25-Jul-12

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

GHIJ COEFFICIENTS

```
g = -4.06369846e+000
h =  5.32012297e-001
i = -4.89944689e-004
j =  5.31403540e-005
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  2.47482851e-006
b =  5.30391610e-001
c = -4.05874325e+000
d = -8.30754798e-005
m =  4.9
CPcor = -9.5700e-008 (nominal)
```

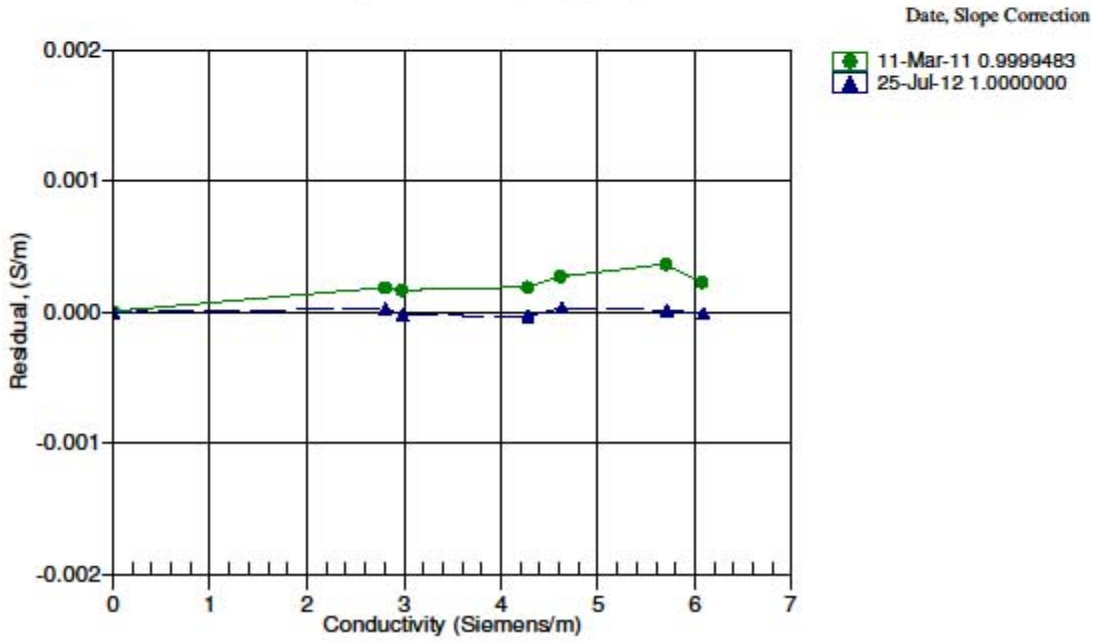
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.76622	0.00000	0.00000
-0.9999	34.8839	2.80952	7.77919	2.80955	0.00003
1.0001	34.8850	2.98129	7.98366	2.98126	-0.00002
15.0001	34.8864	4.27931	9.38426	4.27927	-0.00004
18.5001	34.8861	4.62664	9.72434	4.62667	0.00003
29.0000	34.8855	5.71237	10.71624	5.71239	0.00001
32.5000	34.8790	6.08568	11.03613	6.08567	-0.00001

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

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

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

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



CTD Conductivity (Secondary)

SEA-BIRD ELECTRONICS, INC.

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

SENSOR SERIAL NUMBER: 2513
CALIBRATION DATE: 20-Jul-11

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

GHIJ COEFFICIENTS

```
g = -1.05838778e+001
h =  1.63290195e+000
i = -1.66593103e-003
j =  2.42286512e-004
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS

```
a =  6.09811958e-006
b =  1.62916049e+000
c = -1.05779038e+001
d = -8.84680310e-005
m =  5.3
CPcor = -9.5700e-008 (nominal)
```

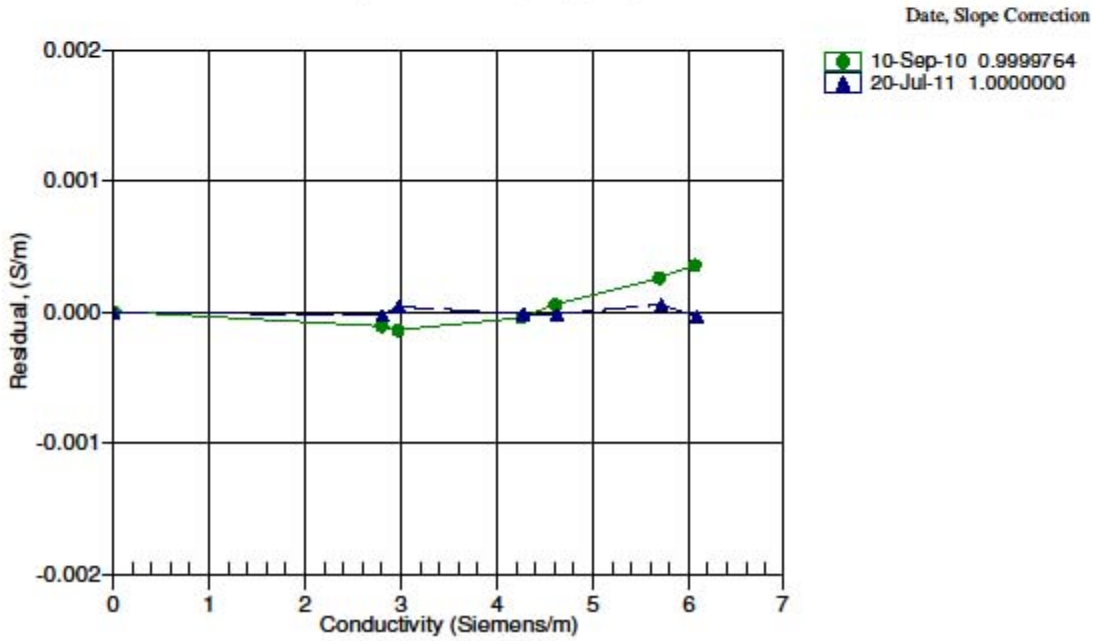
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.54799	0.00000	0.00000
-1.0000	34.8738	2.80878	4.87000	2.80875	-0.00003
1.0000	34.8742	2.98044	4.97686	2.98048	0.00004
15.0000	34.8746	4.27801	5.71959	4.27799	-0.00002
18.5000	34.8743	4.62523	5.90239	4.62521	-0.00002
29.0000	34.8724	5.71047	6.44002	5.71053	0.00006
32.5000	34.8670	6.08383	6.61471	6.08379	-0.00003

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

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

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

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



CTD Temperature (Primary)

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

SENSOR SERIAL NUMBER: 2299
CALIBRATION DATE: 22-Aug-12

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

```
g =  4.33176171e-003
h =  6.43414330e-004
i =  2.33281281e-005
j =  2.23506074e-006
f0 = 1000.0
```

IPTS-68 COEFFICIENTS

```
a =  3.68121201e-003
b =  6.02066590e-004
c =  1.63364398e-005
d =  2.23662896e-006
f0 = 2848.651
```

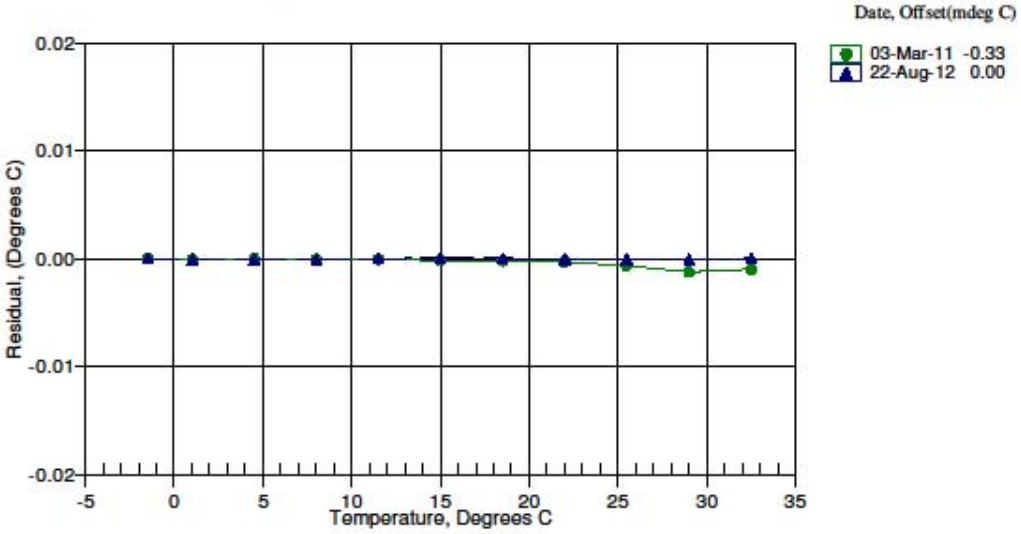
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	2848.651	-1.5000	0.00002
1.0000	3012.285	1.0000	-0.00001
4.5000	3252.664	4.5000	-0.00000
8.0000	3506.543	7.9999	-0.00007
11.5000	3774.302	11.5000	0.00001
14.9999	4056.275	15.0000	0.00007
18.4999	4352.815	18.5000	0.00006
22.0000	4664.254	22.0000	-0.00002
25.5000	4990.903	25.4999	-0.00006
29.0000	5333.077	28.9999	-0.00006
32.5000	5691.081	32.5001	0.00006

Temperature ITS-90 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\}$ - 273.15 (°C)

Temperature IPTS-68 = $1/\{a + b[ln(f_0/f)] + c[ln^2(f_0/f)] + d[ln^3(f_0/f)]\}$ - 273.15 (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature



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: 5090
CALIBRATION DATE: 21-Jun-11

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

```
g =  4.39937967e-003
h =  6.43983900e-004
i =  2.30774139e-005
j =  2.18283148e-006
f0 = 1000.0
```

IPTS-68 COEFFICIENTS

```
a =  3.68120924e-003
b =  5.99463400e-004
c =  1.55214771e-005
d =  2.18432470e-006
f0 = 3183.551
```

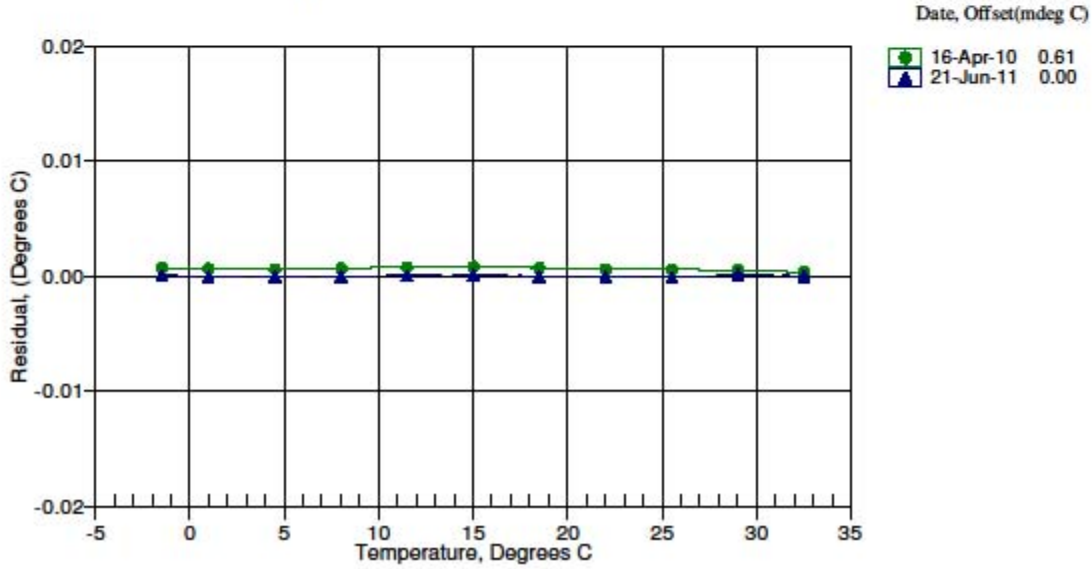
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.4998	3183.551	-1.4998	0.00003
1.0002	3367.226	1.0002	-0.00002
4.5002	3637.080	4.5002	-0.00003
8.0002	3922.134	8.0002	-0.00003
11.5002	4222.803	11.5002	0.00004
15.0002	4539.472	15.0003	0.00008
18.5002	4872.516	18.5002	-0.00001
22.0002	5222.323	22.0002	-0.00004
25.5002	5589.239	25.5001	-0.00010
29.0002	5973.640	29.0003	0.00010
32.5002	6375.788	32.5002	-0.00002

Temperature ITS-90 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\} - 273.15$ (°C)

Temperature IPTS-68 = $1/\{a + b[ln(f_0/f)] + c[ln^2(f_0/f)] + d[ln^3(f_0/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature



CTD Temperature (Secondary)

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

SENSOR SERIAL NUMBER: 2308
CALIBRATION DATE: 25-Jul-12

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

```
g =  4.34511630e-003
h =  6.44659687e-004
i =  2.32771907e-005
j =  2.17764963e-006
f0 = 1000.0
```

IPTS-68 COEFFICIENTS

```
a =  3.68121214e-003
b =  6.02574747e-004
c =  1.63351253e-005
d =  2.17921037e-006
f0 = 2906.225
```

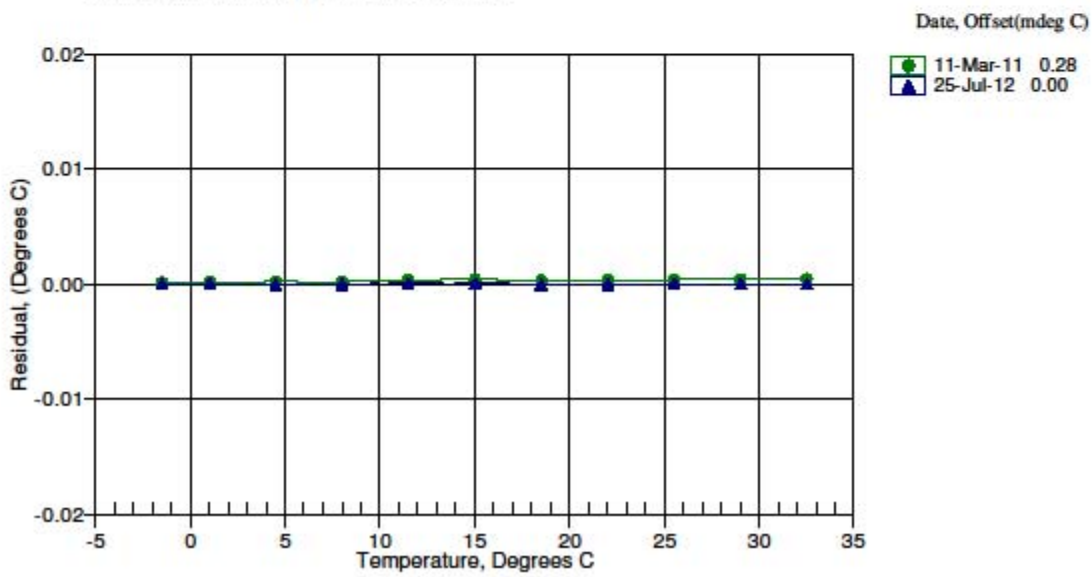
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	2906.225	-1.5000	0.00001
1.0000	3073.023	1.0000	0.00001
4.5000	3318.028	4.5000	-0.00005
8.0000	3576.787	8.0000	-0.00002
11.5000	3849.669	11.5000	0.00005
15.0000	4137.026	15.0001	0.00006
18.5000	4439.201	18.5000	-0.00003
22.0000	4756.547	21.9999	-0.00005
25.5000	5089.392	25.5000	0.00001
29.0000	5438.034	29.0000	0.00000
32.5000	5802.781	32.5000	0.00001

Temperature ITS-90 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\} - 273.15$ (°C)

Temperature IPTS-68 = $1/\{a + b[ln(f_0/f)] + c[ln^2(f_0/f)] + d[ln^3(f_0/f)]\} - 273.15$ (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be $1.00024 * T_{90}$ (-2 to 35 °C)

Residual = instrument temperature - bath temperature



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: 1649
CALIBRATION DATE: 22-Aug-12

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

```
g =  4.80598749e-003
h =  6.63478355e-004
i =  2.10878027e-005
j =  1.35866055e-006
f0 = 1000.0
```

IPTS-68 COEFFICIENTS

```
a =  3.68120564e-003
b =  6.01330471e-004
c =  1.38395628e-005
d =  1.35992443e-006
f0 = 5958.996
```

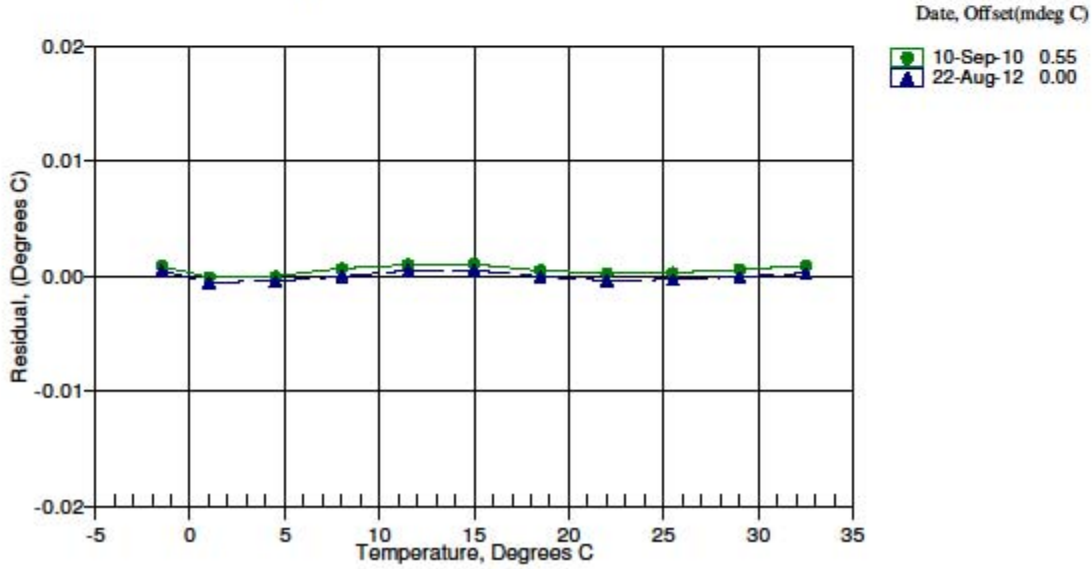
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	5958.996	-1.4995	0.00049
1.0000	6301.509	0.9995	-0.00053
4.5000	6804.636	4.4996	-0.00043
8.0000	7335.800	8.0000	-0.00002
11.5000	7895.712	11.5005	0.00048
14.9999	8484.982	15.0004	0.00051
18.4999	9104.313	18.4999	-0.00003
22.0000	9754.515	21.9996	-0.00039
25.5000	10436.269	25.4997	-0.00029
29.0000	11150.168	28.9999	-0.00007
32.5000	11896.827	32.5003	0.00026

Temperature ITS-90 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\}$ - 273.15 (°C)

Temperature IPTS-68 = $1/\{a + b[ln(f_0/f)] + c[ln^2(f_0/f)] + d[ln^3(f_0/f)]\}$ - 273.15 (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature



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: 5097
CALIBRATION DATE: 18-Jun-11

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

```
g =  4.39463414e-003
h =  6.45758686e-004
i =  2.33370030e-005
j =  2.20361088e-006
f0 = 1000.0
```

IPTS-68 COEFFICIENTS

```
a =  3.68120946e-003
b =  6.01060301e-004
c =  1.57804310e-005
d =  2.20512996e-006
f0 = 3149.369
```

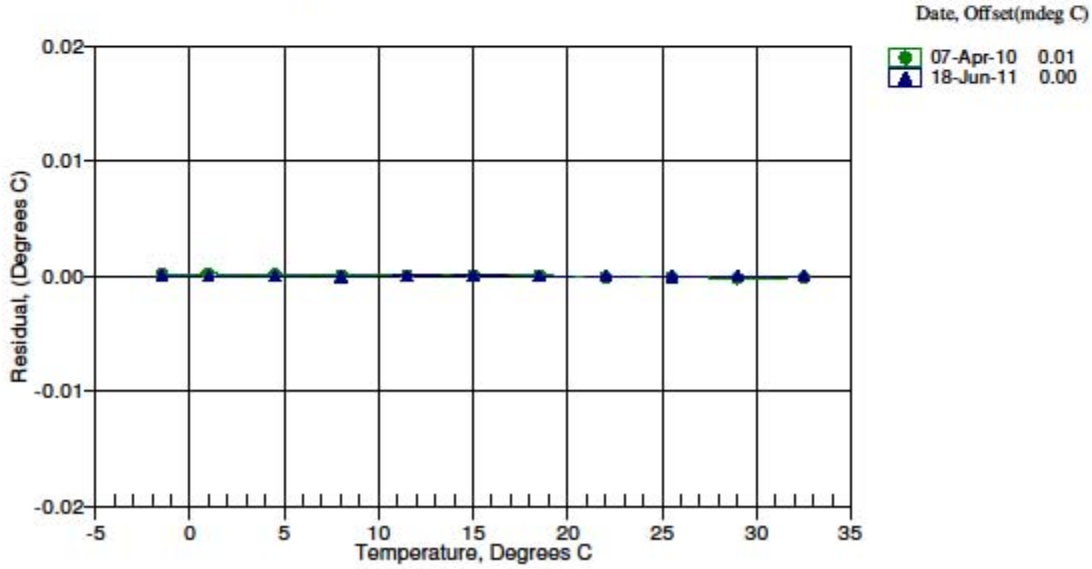
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.4998	3149.369	-1.4998	0.00001
1.0002	3330.581	1.0002	-0.00000
4.5002	3596.777	4.5002	-0.00001
8.0002	3877.923	8.0002	-0.00003
11.5002	4174.426	11.5002	0.00002
15.0002	4486.663	15.0002	0.00002
18.5002	4815.014	18.5002	0.00002
22.0002	5159.841	22.0002	0.00000
25.5002	5521.491	25.5002	-0.00004
29.0002	5900.311	29.0002	-0.00000
32.5002	6296.612	32.5002	0.00002

Temperature ITS-90 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\}$ - 273.15 (°C)

Temperature IPTS-68 = $1/\{a + b[ln(f_0/f)] + c[ln^2(f_0/f)] + d[ln^3(f_0/f)]\}$ - 273.15 (°C)

Following the recommendation of JPOTS: T_{68} is assumed to be 1.00024 * T_{90} (-2 to 35 °C)

Residual = instrument temperature - bath temperature



PO Box 518
620 Applegate St.
Philomath, OR 97370

WET Labs

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

ECO Chlorophyll Fluorometer Characterization Sheet

Date: 8/7/2012 S/N: FLRTD-1482

Chlorophyll concentration expressed in µg/l can be derived using the equation:

CHL (µg/l) = Scale Factor * (Output - Dark Counts)

	Analog Range 1	Analog Range 2	Analog Range 4 (default)	Digital
Dark Counts	0.066	0.035	0.020 V	49 counts
Scale Factor (SF)	6	13	26 µg/l/V	0.0078 µg/l/count
Maximum Output	4.99	4.99	4.99 V	16380 counts
Resolution	0.6	0.6	0.6 mV	0.8 counts

Ambient temperature during characterization 22.7 °C

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

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

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

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

Resolution: Standard deviation of 1 minute of collected data.

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

FLRTD-1482.xls Revision J 3/17/08

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620 Applegate St.
Philomath, OR 97370

WET Labs

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

C-Star Calibration

Date August 17, 2012 S/N# CST-439DR Pathlength 25 cm

	Analog output
V_d	0.058 V
V_{air}	4.751 V
V_{ref}	4.652 V

Temperature of calibration water	24.5 °C
Ambient temperature during calibration	21.8 °C

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

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

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

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

Revision M 7/26/11

CTD Dissolved Oxygen Sensor (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: 0161
CALIBRATION DATE: 18-Aug-12

SBE 43 OXYGEN CALIBRATION DATA

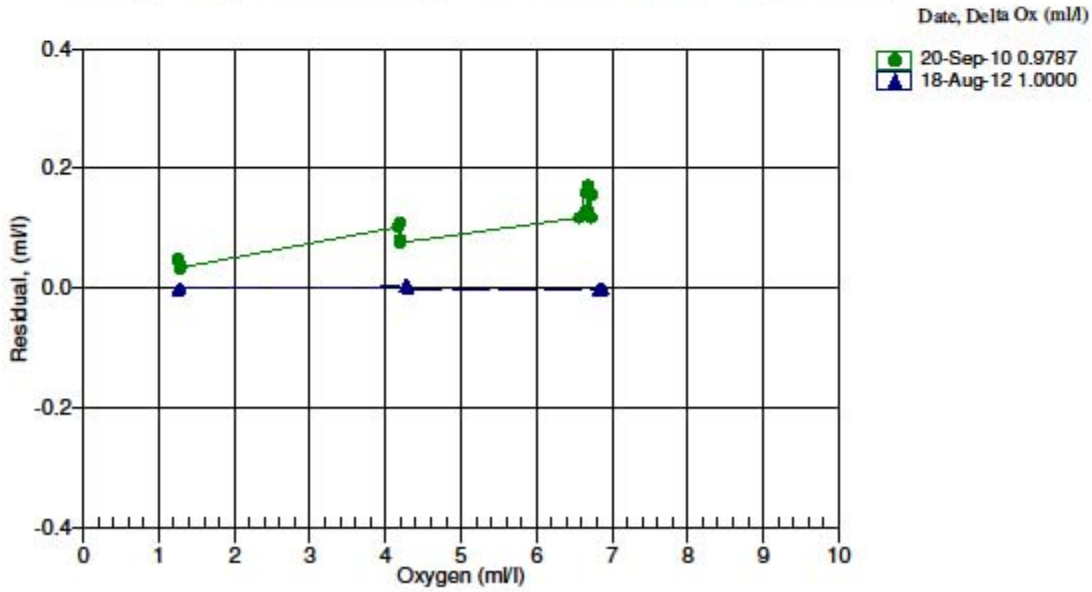
COEFFICIENTS
Soc = 0.4831
Voffset = -0.5087
Tau20 = 1.18

A = -1.5845e-003
B = 4.4133e-005
C = -9.8171e-007
E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS
D1 = 1.92634e-4 H1 = -3.30000e-2
D2 = -4.64803e-2 H2 = 5.00000e+3
H3 = 1.45000e+3

BATH OX (ml/l)	BATH TEMP ITS-90	BATH SAL PSU	INSTRUMENT OUTPUT(VOLTS)	INSTRUMENT OXYGEN(ml/l)	RESIDUAL (ml/l)
1.25	2.00	0.05	0.776	1.25	-0.00
1.26	6.00	0.04	0.810	1.26	-0.00
1.26	12.00	0.04	0.861	1.26	-0.00
1.27	20.00	0.04	0.932	1.27	-0.00
1.28	26.00	0.04	0.990	1.28	-0.00
1.28	30.00	0.05	1.029	1.28	0.00
4.26	6.00	0.04	1.530	4.26	0.00
4.26	2.00	0.05	1.424	4.27	0.00
4.28	12.00	0.04	1.702	4.28	0.01
4.29	26.00	0.04	2.119	4.29	0.00
4.29	20.00	0.04	1.937	4.29	0.01
4.29	30.00	0.05	2.248	4.29	-0.00
6.82	6.00	0.04	2.144	6.82	-0.00
6.82	12.00	0.04	2.409	6.82	-0.00
6.84	2.00	0.05	1.977	6.84	-0.00
6.85	20.00	0.04	2.788	6.85	-0.00
6.86	30.01	0.05	3.291	6.86	0.00
6.88	26.00	0.04	3.092	6.88	-0.00

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



CTD Dissolved Oxygen Sensor (Secondary)

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

SENSOR SERIAL NUMBER: 2267
CALIBRATION DATE: 14-Dec-12

SBE 43 OXYGEN CALIBRATION DATA

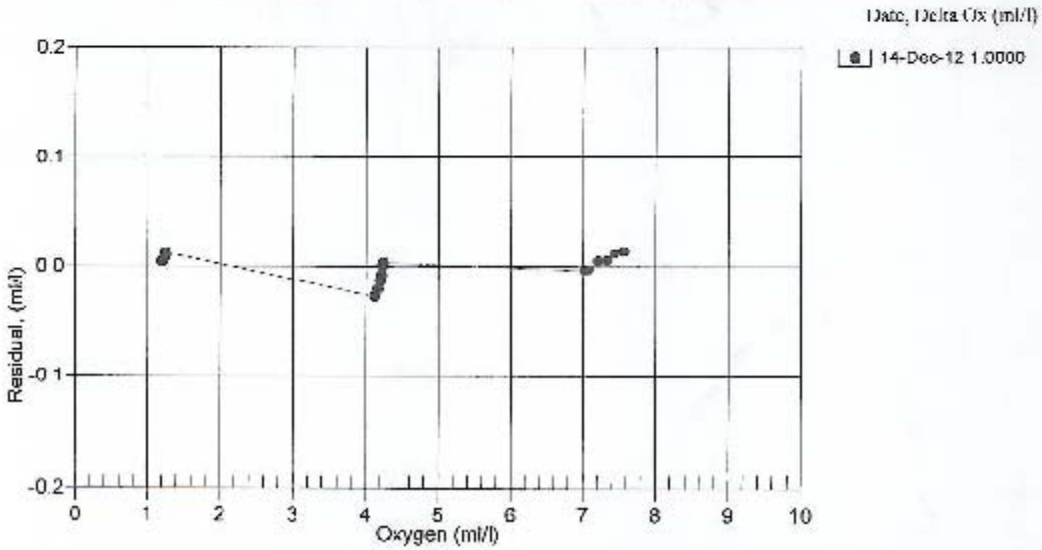
COEFFICIENTS
Soc = 0.4853
Voffset = -0.5185
Tau20 = 1.24

A = 2.4558e-004
B = -3.3948e-005
C = 8.0575e-007
E (nominal) = 0.036

NOMINAL DYNAMIC COEFFICIENTS
D1 = 1.92634e-4 B1 = -3.30000e-2
D2 = -4.64803e-2 H2 = 5.00000e+3
H3 = 1.45000e+3

BATH OX (ml/l)	BATH TEMP ITS-90	BATH SAL PSU	INSTRUMENT OUTPUT(VOLTS)	INSTRUMENT OXYGEN(ml/l)	RESIDUAL (ml/l)
1.20	2.00	0.00	0.775	1.20	0.00
1.22	6.00	0.00	0.830	1.22	0.00
1.24	12.00	0.00	0.881	1.24	0.01
1.25	26.00	0.00	0.988	1.26	0.01
1.25	30.00	0.00	0.936	1.26	0.01
1.25	36.00	0.00	1.029	1.27	0.01
4.13	2.00	0.00	1.392	4.10	-0.03
4.17	6.00	0.00	.503	4.15	0.02
4.20	12.00	0.00	1.672	4.18	-0.01
4.21	20.00	0.00	1.808	4.21	-0.01
4.22	26.00	0.00	1.897	4.22	-0.00
4.24	30.00	0.00	1.951	4.25	0.00
7.32	30.00	0.00	3.360	7.32	-0.00
7.38	36.00	0.00	3.164	7.38	-0.00
7.21	30.00	0.00	2.902	7.21	0.00
7.33	12.00	0.00	2.54	7.33	0.01
7.43	6.00	0.00	2.265	7.42	0.01
7.50	2.00	0.00	2.134	7.50	0.01

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



Biospherical Instruments Inc

CALIBRATION CERTIFICATE

UNDERWATER PAR SENSOR WITH LOG AMPLIFIER

Calibration Date: 10/26/12 **Job No.:** R11457
Model Number: OSP2300
Serial Number: 4301
Operator: TPC
Standard Lamp: V-030(3/7/12)
Operating Voltage Range: 6 to 15 VDC (+)

Note: The OSP-200 uses a log amplifier to measure the detector signal current with V = log I (Amps) / IRef
To calculate irradiance, use this formula:

Irradiance = Calibration factor * (10^Light Signal Voltage - 10^Dark Voltage)

With the appropriate (solar corrected) Irradiance Calibration Factor:

Dry Calibration Factor:	**1.06E+13**	**quanta/cm² sec/"amps"**	**1.79E-05**	**µEinsteins/cm²-sec/"amps"**
Wet Calibration Factor:	**1.91E+13**	**quanta/cm²-sec/"amps"**	**3.16E-05**	**µEinsteins/cm²-sec/"amps"**

Sensor Test Data and Results[4]

Sensor Supply Current (Dark):	75.8	mA	current dithers		
Supply Voltage:	6	Volts			
Lamp Integrated PAR Irradiance:	9.80E+15	quanta/cm²-sec	0.01632	µEinsteins/cm²sec	
SC3 Immersion Coefficient:	0.5664	Scalar Correction:	1	PAR Solar Correction:	1.0000

Nominal Filter OD	Calibrated Trans	Sensor Voltage	Measured Trans.	Measured Signal (Amps)	Estimated Signal (Amps)	Calc. Output (Volts)	Error (Volts)	Error (%)	Test Irrad. (quanta/cm²-sec)
No Filter	100.00%	2.960	100.00%	9.12E-08	9.12E-08	2.961	0.001	0.0	9.83E+15
0.3	36.10%	2.518	35.85%	3.27E-08	3.29E-08	2.519	0.004	0.7	3.52E+15
0.5	27.60%	2.402	27.54%	2.51E-08	2.52E-08	2.403	0.002	0.2	2.71E+15
1	9.27%	1.931	9.20%	8.39E-09	8.45E-09	1.935	0.004	0.7	9.04E+14
2	1.11%	1.053	1.08%	9.82E-10	1.01E-09	1.065	0.012	3.1	1.06E+14
3	0.05%	0.329	0.07%	8.44E-11	4.87E-11	0.296	-0.033	-24.3	6.93E+12

Dark Before:	0.173	Volts				
Light - No Filter Hdr:	2.960	Volts	I_{ref} =	1.00E-10	Amps	
Dark After - NFH:	0.174	Volts	I_{Dark} =	1.49E-10	Amps	RG780 0.212
Average Dark	0.173	Volts	10^{VDark} =	1.490562	Amps	

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

OSP-200L/OSP2300(2006-)

AANDERAA DATA INSTRUMENTS

CALIBRATION CERTIFICATE

Form No. 622, Dec 2005
Page 1 of 2

Sensing Foil Batch No: 5009
Certificate No:

Product: Oxygen Optode 3835
Serial No: 1424
Calibration Date: 21 October 2010

This is to certify that this product has been calibrated using the following instruments:

Calibration Bath model FNT	321-1-40
ASL Digital Thermometer model F250	Serial: 6792/06

Parameter: Internal Temperature:

Calibration points and readings:

Temperature (°C)	1.17	12.12	24.11	36.08
Reading (mV)	730.09	383.95	-11.29	-379.10

Giving these coefficients

Index	0	1	2	3
TempCoef	2.37613E01	-3.08128E-02	2.84735E-06	-4.15311E-09

Parameter: Oxygen:

	O2 Concentration	Air Saturation
Range:	0-500 µM [1]	0 - 120%
Accuracy [1]:	< ±8µM or ±5% (whichever is greater)	±5%
Resolution:	< 1 µM	< 0.4%
Settling Time (63%):	< 25 seconds	

Calibration points and readings[2]:

	Air Saturated Water	Zero Solution (Na_2SO_3)
Phase reading (°)	3.27669E+01	6.65595E+01
Temperature reading (°C)	9.90918E+00	2.04774E+01
Air Pressure (hPa)	9.76884E+02	

Giving these coefficients

Index	0	1	2	3
PhaseCoef	-4.44928E00	1.17131E00	0.00000E00	0.00000E00

[1] Valid for 0 to 2000m (6562ft) depth, salinity 33 - 37ppt
[2] The calibration is performed in fresh water and the salinity setting is set to: 0

AANDERAA DATA INSTRUMENTS AS

5851 BERGEN, NORWAY Tel. +47 55 60 48 00 Fax. +47 55 60 48 01 E-mail: info@aadi.no Web: http://www.aadi.no

AANDERAA DATA INSTRUMENTS

CALIBRATION CERTIFICATE

Form No. 622, Dec 2005
Page 2 of 2

Sensing Foil Batch No: 5009
Certificate No:

Product: Oxygen Optode 3835
Serial No: 1424
Calibration Date: 21 October 2010

SR10 Scaling Coefficients:

At the SR10 output the Oxygen Optode 3830 can give either absolute oxygen concentration in µM or air saturation in %. The setting of the internal property "Output" [3], controls the selection of the unit. The coefficients for converting SR10 raw data to engineering units are fixed.

Output = -1	Output = -2
A = 0	A = 0
B = 4.883E-01	B = 1.465E-01
C = 0	C = 0
D = 0	D = 0
Oxygen (µM) = A + BN + CN2 + DN3	Oxygen (%)= A + BN + CN2 + DN3

[3] The default output setting is set to -1

Date: 22 October 2010

Sign:

Tor Ove Kvalvåg

Tor Ove Kvalvåg, Calibration Engineer

AANDERAA DATA INSTRUMENTS AS

5851 BERGEN, NORWAY Tel. +47 55 60 48 00 Fax. +47 55 60 48 01 E-mail: info@aadi.no Web: http://www.aadi.no

Underway Micro-TSG number 1

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: 0226
CALIBRATION DATE: 02-Aug-11

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

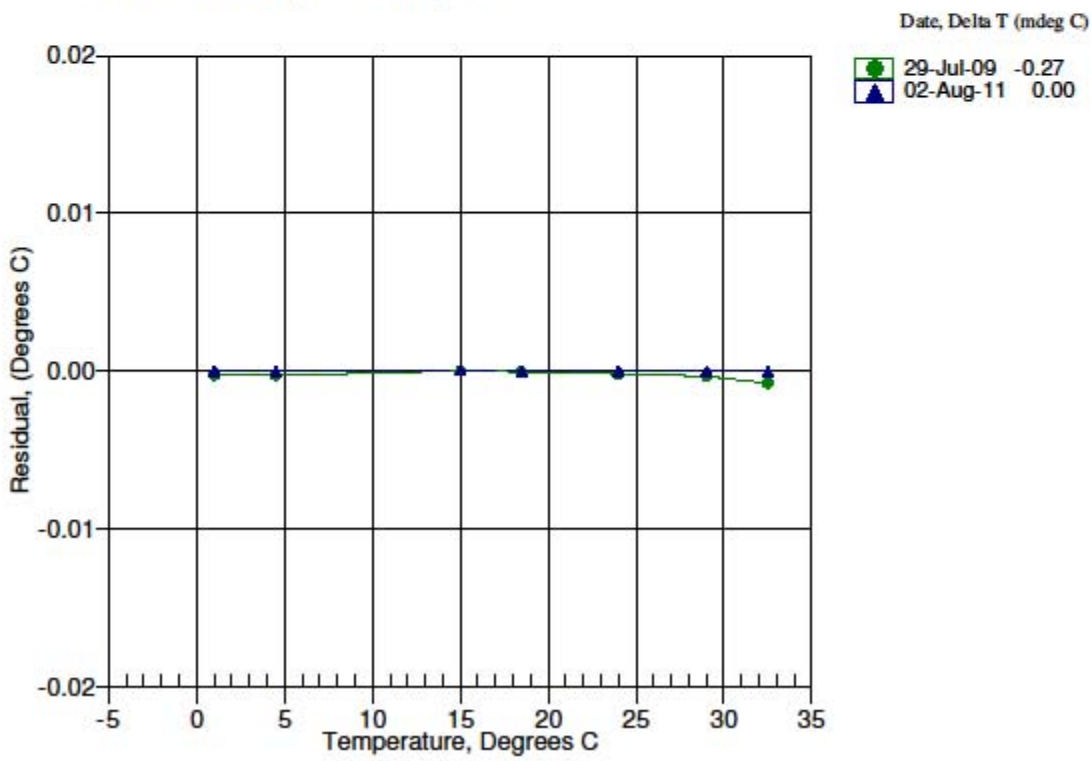
ITS-90 COEFFICIENTS

```
a0 = -1.379033e-005
a1 =  2.748706e-004
a2 = -2.341217e-006
a3 =  1.509549e-007
```

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	744330.2	1.0000	0.0000
4.4999	636486.3	4.4999	-0.0000
15.0000	405765.8	15.0000	0.0000
18.5000	351383.6	18.5000	0.0000
24.0000	281928.0	24.0000	-0.0000
29.0000	232169.4	29.0000	-0.0000
32.5000	203328.8	32.5000	0.0000

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

Residual = instrument temperature - bath temperature



Error! Objects cannot be created from editing field codes.

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: 0199
CALIBRATION DATE: 11-Mar-11

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

COEFFICIENTS:

```
g = -1.001606e+000
h =  1.425083e-001
i = -1.604369e-004
j =  3.444263e-005

CPcor = -9.5700e-008
CTcor =  3.2500e-006
WBOTC = -1.0552e-005
```

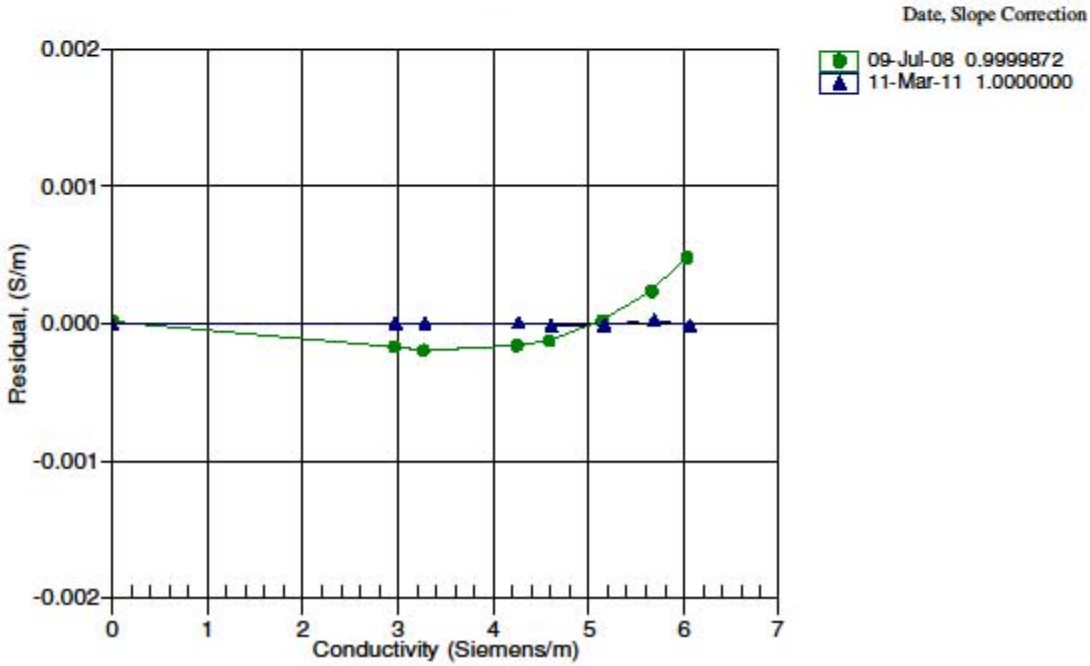
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2653.13	0.00000	0.00000
0.9999	34.7611	2.97169	5278.21	2.97169	0.00000
4.5000	34.7410	3.27832	5477.41	3.27832	-0.00000
15.0000	34.6983	4.25867	6069.85	4.25867	0.00001
18.4999	34.6896	4.60336	6264.58	4.60335	-0.00001
24.0000	34.6801	5.16060	6566.90	5.16059	-0.00001
28.9999	34.6753	5.68181	6837.29	5.68183	0.00003
32.5000	34.6728	6.05379	7023.68	6.05378	-0.00001

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

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

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

Residual = instrument conductivity - bath conductivity



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

SENSOR SERIAL NUMBER: 0199
CALIBRATION DATE: 11-Mar-11

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

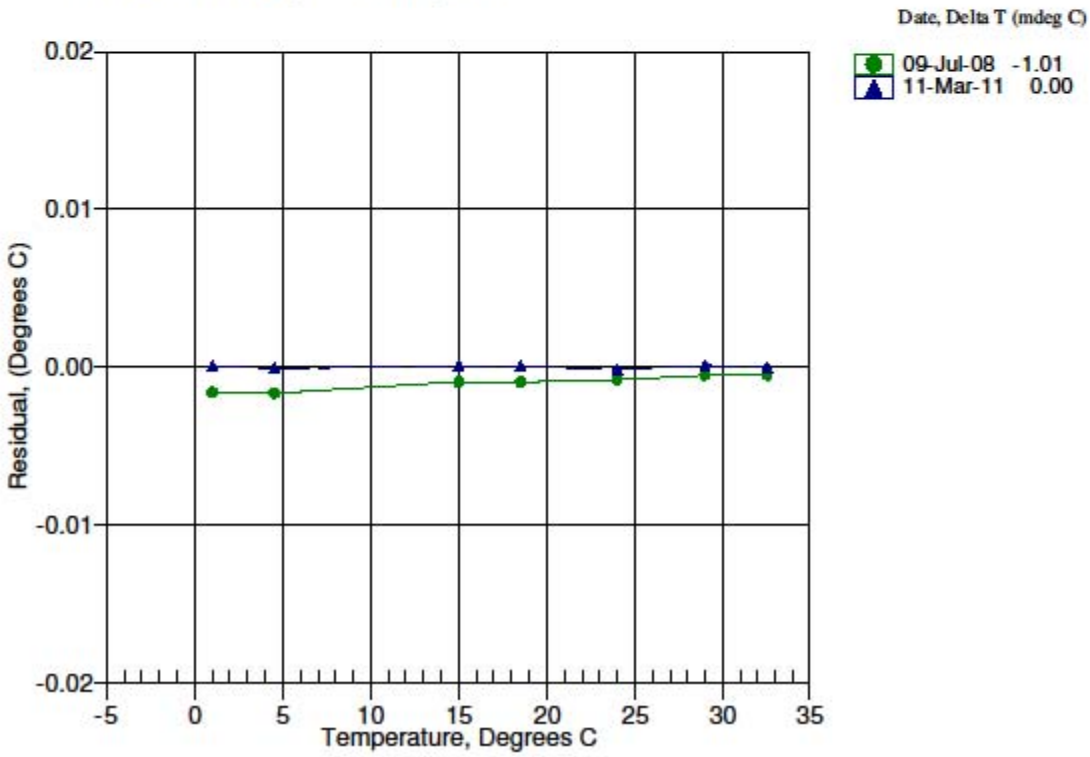
ITS-90 COEFFICIENTS

```
a0 =  3.975667e-005
a1 =  2.670294e-004
a2 = -1.763637e-006
a3 =  1.405751e-007
```

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	678404.7	0.9999	0.0000
4.5000	580522.4	4.4999	-0.0001
15.0000	370815.0	15.0001	0.0001
18.4999	321309.9	18.5000	0.0001
24.0000	258027.3	23.9998	-0.0002
28.9999	212643.8	29.0000	0.0001
32.5000	186319.9	32.5000	-0.0000

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

Residual = instrument temperature - bath temperature



Underway Micro-TSG number 2

8

Sea-Bird Electronics, Inc.

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

Micro TSG

SENSOR SERIAL NUMBER: 0389
CALIBRATION DATE: 20-Oct-11

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

COEFFICIENTS:

g = -9.860211e-001
h = 1.453855e-001
i = 4.322911e-004
j = 5.188313e-005

CPcor = 9.5700e-008
CTcor = 3.2500e-006
WBOTC = 1.2700e-007

BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.3000	0.0000	0.00000	2824.51	0.00000	0.00000
1.3000	34.9210	2.98406	5244.92	2.98406	0.00000
4.5000	34.9005	3.29188	5443.39	3.29188	-0.00000
14.3999	34.8864	4.27003	6066.44	4.27001	0.00001
18.4999	34.8867	4.62149	6277.28	4.62149	-0.00000
24.3000	34.8804	5.18113	6628.11	5.18113	-0.00000
29.3000	34.8273	5.70357	6951.07	5.70357	-0.00000
32.5000	34.8211	6.07673	6962.11	6.07673	0.00000

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

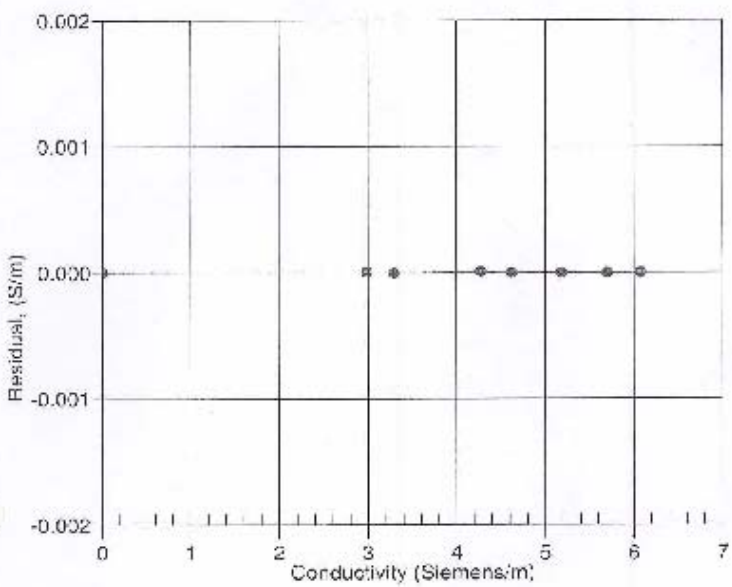
Conductivity = (g + hf^2 + if^3 + jf^4) / (1 + δt + εp) Siemens/meter

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

Residual = instrument conductivity - bath conductivity

Date, Slope Correction

20-Oct-11 1.0000000



Sea-Bird Electronics, Inc.

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

Micro TSG

SENSOR SERIAL NUMBER: 0589
CALIBRATION DATE: 20 Oct. 11

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

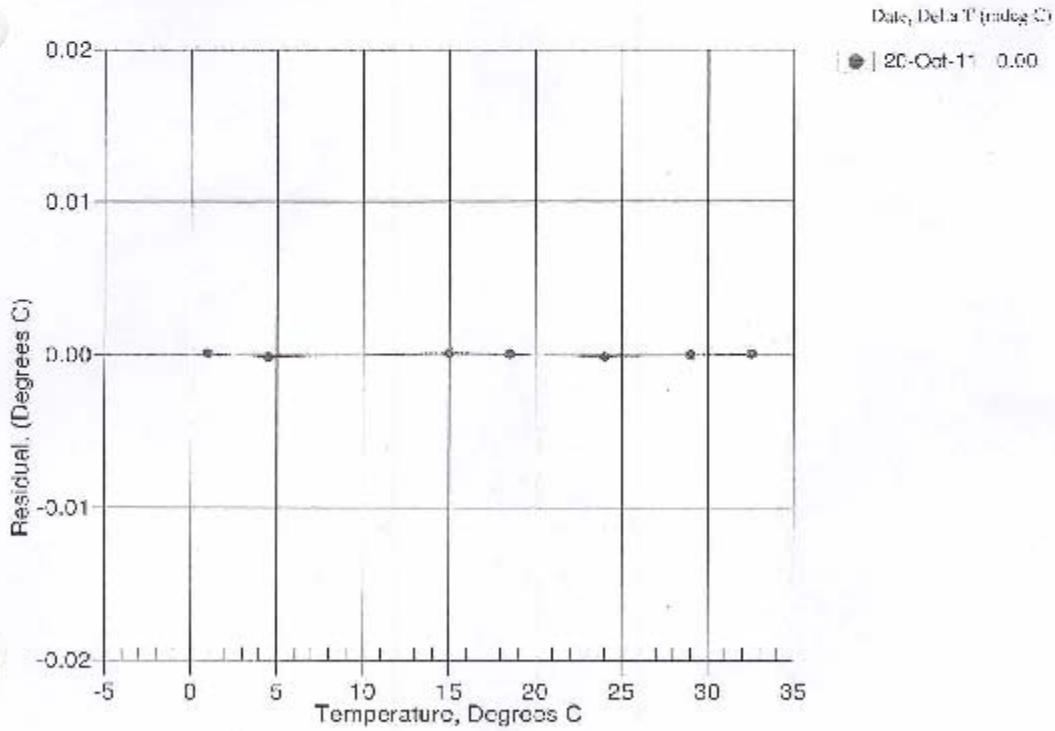
ITS-90 COEFFICIENTS

a0 = 3.1[illegible]3853e-[illegible]
a1 = 2.8561[illegible]e-[illegible]
a2 = -1.828627e-[illegible]
a3 = [illegible].097174e-[illegible]

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	828514.5	[illegible].0001	0.0001
4.0000	706709.4	4.4990	-0.0002
14.9999	447335.5	15.0000	0.0001
18.4999	386307.8	18.5000	0.0001
24.0000	305342.6	23.9999	-0.0001
26.0000	253727.3	29.0000	-0.0000
32.0000	221749.5	32.0000	0.0000

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

Residual = instrument temperature - bath temperature



SEA-BIRD ELECTRONICS, INC.

13431 NE 20th Street, Bellevue, Washington, 98005-2010 USA
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SENSOR SERIAL NUMBER: 0323
CALIBRATION DATE: 18-May-10

SBE 38 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

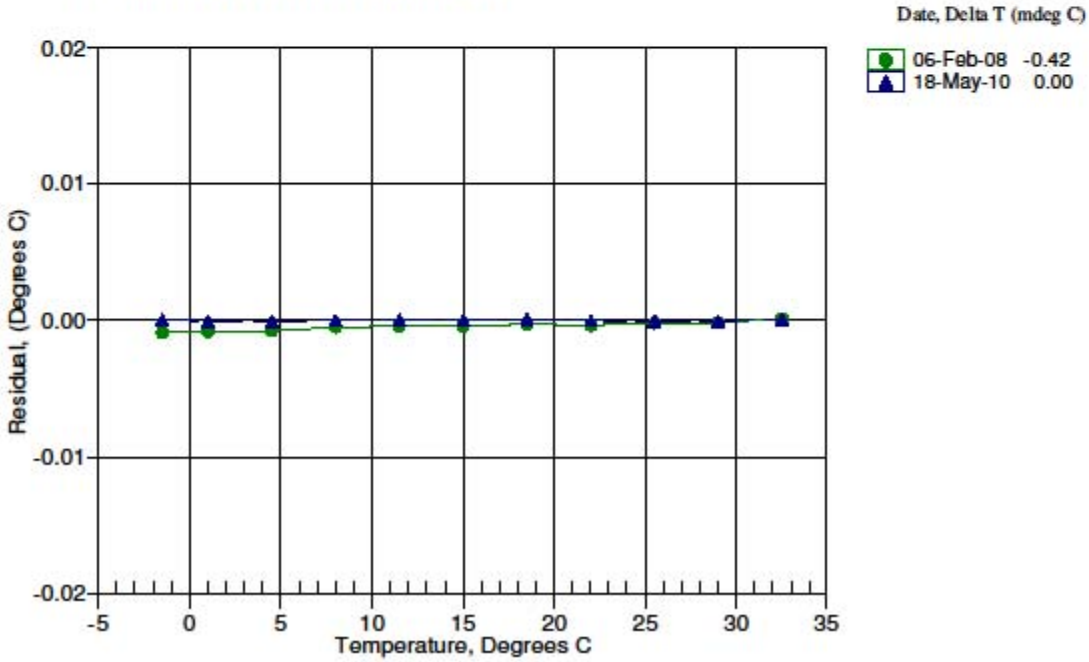
ITS-90 COEFFICIENTS

```
a0 = -7.978660e-006
a1 =  2.802838e-004
a2 = -2.734104e-006
a3 =  1.671396e-007
```

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.50010	711080.8	-1.50004	0.00006
0.99990	635133.7	0.99984	-0.00006
4.49990	543787.8	4.49985	-0.00005
7.99990	467095.3	7.99991	0.00001
11.49990	402489.0	11.49995	0.00005
14.99990	347886.3	14.99991	0.00001
18.49990	301588.8	18.49993	0.00003
21.99990	262212.4	21.99990	-0.00000
25.49990	228620.9	25.49984	-0.00006
28.99990	199879.3	28.99986	-0.00004
32.49990	175217.1	32.49995	0.00005

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

Residual = instrument temperature - bath temperature



PO Box 518
620 Applegate St.
Philomath OR 97370

WET Labs

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

Chlorophyll Fluorometer Characterization, New Proxy .

Date:	**09/12/2011**
Serial #:	AFLT-009
Job#:	006066
Tech:	SML

Dark Counts	**0.193 volts**
CEV	**1.429 volts**
SF	**19.29**
FSV	**5.36 volts**
Linearity:	**0.999 R^2 (0–1.5 volts)**
	0.995 R^2 (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 **24.63 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 determine by using the following equation: SF = (24.63) / (CEV – dark) e.g.(24.63 / (1.429 – 0.193) = 19.29)

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

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

The relationship between fluorescence and chlorophyll-*a* concentrations in-situ is high 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.

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WET Labs

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Chlorophyll Fluorometer Pre-Characterization, Old Proxy .

Date:	**09/12/2011**
Serial #:	AFLT-009
Job#:	006066
Tech:	SML

Dark Counts	**0.193 volts**
CEV	**2.372 volts**
SF	**10.142**
FSV	**5.36 volts**
Linearity:	**0.999 R^2 (0–1.5 volts)**
	0.995 R^2 (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 determine by using the following equation: SF = (22.1) / (CEV – dark) e.g.(22.1 / (2.372 – 0.193) = 9.516)

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

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

The relationship between fluorescence and chlorophyll-*a* concentrations in-situ is high 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.

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WET Labs

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Date: 9/12/11 **Customer: National Science Foundation/ Suzy Williams**

S/N# AFLT-009 **Technician: SML**

Repairs and Modifications: Characterized instrument using old proxy. Replaced case seals, tested, and characterized instrument using new proxy. The instrument's tuning was not changed.

Comments: New Characterization sheet, old proxy Characterization sheet, and Chl Customer Alert included on the CD. Please see Customer Alert for more information on the differences between proxies.

620 Applegate St. PO Box 518 • Philomath, OR 97370 • 541-929-5650 • fax 541-929-5277

July 2011 Customer Alert:

Chlorophyll-a Scale Factors Shift

Affected instruments:
- ✓ All *ECO* chl-a fluorometers built or characterized before January 2011.
- ✓ All WETStar chl-a fluorometers built or characterized before July 2011.

WET Labs characterization testing has revealed that the chlorophyll-*a* (chl-a) solid proxy used to characterize our *ECO* and WETStar fluorometers allows a large amount of instrument-to-instrument variability. There are also differences in scaling between WETStar chl-a fluorometers and *ECO* chl-a fluorometers because of differences in the solid proxy used to characterize these instruments. A new methodology using a liquid proxy has been implemented to assure stable characterizations between instruments and to match up the *ECO* and WETStar fluorometers' corrected data outputs.

WET Labs' Actions

New Instruments:
WET Labs has instituted a new characterization standard solution preparation methodology. All new *ECO* and WETStar chl-a fluorometers delivered from this date forward will have range characteristics as per current specifications and scale factors.

Instruments returned for service and characterization:
Instruments returned for service and characterization will be characterized using the new methodology. All instruments returned for servicing will be tuned to the new liquid proxy to decrease instrument-to-instrument variability.

In some cases, we will not be able to achieve the previously stated range of an instrument. In these cases, we will strive for the highest resolution with the highest signal-to-noise ratio possible.

WET Labs service technicians will incorporate these improvements during service when practical. WET Labs' term for this service is "retuning." Accordingly, a serviced instrument may well perform better after retuning than when it was first built. For instruments that are retuned and benefit from either improved resolution or signal-to-noise ratio, WET Labs can provide pre-characterization data to allow you to link your data sets prior to service with your data sets after the instrument is returned to you.

Recommended Customer Actions:

- If you characterize your instruments, you do not need to take any action. Continue to use your characterization.
- If you report scaled or raw data, you should adjust your reported values.
- For instruments returned for service, you will use the ratio between the previous scale factor and pre-service scale factor. This ratio will cover both the change in the methodology and any change in your instrument between the previous characterization and current service.
- Use the post-service scale factor going forward.

Chl-a Scale Factor Change Customer Alert July 2011

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Philomath, OR 97370

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WET Labs

C-Star Calibration

Date April 21, 2011 S/N# CST-889DR Pathlength 25 cm

	Analog meter
V_d	0.058 V
V_{air}	4.823 V
V_{ref}	4.709 V

Temperature of calibration water	20.7 °C
Ambient temperature during calibration	22.8 °C

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

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

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

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

Revision L 6/9/09