

Data Report NBP0905A

Pacific Ocean - Shakedown Cruise

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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 or CD-ROM written in ISO9660 level-1 format. It is readable by virtually every computing platform.

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, use Stuffit Expander with DropStuff. On Windows operating systems use WinZip.

MultiBeam, BathyW data, 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: NBP0905A

File	Description
/	Root level directory
NBP0905A.trk	Text file of cruise track (lat,lon)
NBP0905A.mgd	Full Cruise MGD77 data file
NBP0905A.gmt	GMT binary file of MGD77 data
INSTCOEF.TXT	Instrument Coefficient File
0905ADATA.doc	Data Report NBP0905A (MS Word)
0905ADATA.pdf	Data Report NBP0905A (pdf)
0905AOPS.doc	Report on Operations (MS Word)
0905AMBRReport.doc	Multibeam Report (MS Word)
/plots	Cruise track plots
0905A_trak.ps	Cruise track plot (PostScript format)
0905A_trak.jpg	Cruise track plot (JPEG format)
/MB	Multibeam data
Raw.tar	Raw data
process.tar	Processed and edited data
/process	Processed data
0905Ajgof.tar	JGOFS format data files
0905Aqc.tar	Daily RVDAS QC postscript plots
0905Apco2.tar	Merged pCO2 data files
0905Amgd.tar	MGD Data
0905Aproc.tar	Other processed data
/rvdas/nav	Navigation data
0905Agyr1.tar	Gyro raw data
0905Aseap.tar	Seapath data
0905Aadcp.tar	ADCP Data Sets
/rvdas/uw	Underway data
0905Aeng1.tar	Engineering Data
0905Agrv1.tar	Gravimeter raw data
0905Ahdas.tar	HydroDAS raw data
0905Aknud.tar	Knudsen raw data
0905Amtsg.tar	Micro TSG data
0905Amwx1.tar	Meteorology raw data
0905Apco2.tar	pCO2 raw data
0905Apguv.tar	GUV raw data
0905Artmp.tar	Remote temperature data
0905Asvp1.tar	Sound velocity probe (in ADCP well)
/Imagery	Other data, files and pictures
0905AImag.tar	Satellite imagery
/ocean	Expendable Bathythermograph data
0905Axbt.tar	XBT data
/ek500	Echolog 500 data
0905AEK500.tar	EK500 data

Volume 1 of 1: NBP0905A Continued

File		Description
/ss0905A	0905ASS.tar	Side Scan sonar data
/adcp	0905Aadcp.tar	ADCP data ADCP 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

NBP0905A departed Talcahuano, Chile on October 7, 2009 and spent approximately 5 days west of the coastline. The aim of the cruise was to test and calibrate several onboard data acquisition systems (notably, the Multi-Beam and SideScanner). We returned to Chile via Puerto Montt on October 12, 2009.

Cruise Track

The distribution DVD includes a GMT cruise track file (NBP0905A.trk). It contains the longitude and latitude of the ship's position at one-minute intervals extracted from the NBP0905A.gmt file.

JPEG and PostScript 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/0905Imag.tar collected and processed on the ship is in two further subdirectories, Ice and WX (weather). Files are named using the convention, ssss_fff_mmddyy_tttt_ww.gif where:

ssss_fff	= satellite and flight number
mm	= month
dd	= day
yy	= year
tttt	= time in hours and minutes (UTC)
ww	= optional field for identifying wavelength, such as vis (visible) or IR (infrared)

NBP Data Products

Two datasets are created on each 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/0905proc.tar. 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/0905jgof.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” as 9999 in the JGOFS data.

Field	Data	Units
01	GMT date	dd/mm/yy
02	GMT time	hh:mm:ss
03	NGL latitude (negative is South)	tt.tttt
04	NGL 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	$\mu\text{Einsteins/meter}^2 \text{ sec}$
10	Sea surface temperature	$^{\circ}\text{C}$
11	Sea surface conductivity	siemens/meter
12	Sea surface salinity	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	$^{\circ}\text{C}$
17	Relative humidity	%
18	Barometric pressure	mBars
19	Sea surface fluorometry	$\mu\text{g/l (mg/m}^3\text{)}$
20	Transmissometry	%
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 NBP0905A.mgd. The file NBP0905A.gmt is created from the MGD77 dataset using the “mgd77togmt” utility. NBP0905A.gmt can be used with the GMT plotting package.

The data used to produce the NBP0905A.mgd file can be found on the distribution media in the file /process/0905proc.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, 1 ST sensor	In tenths of nanoteslas (gammas)
67-72	6	real	Magnetics total field, 2 ND 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	1 = 1 st or leading sensor

Col	Len	Type	Contents	Description, Possible Values, Notes
			field	2 = 2 nd or trailing sensor 9 = Unspecified
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 10 th of mgals. Corrected for Eotvos, drift, tares
98-103	6	real	EOTVOS correction	In 10 th of mgals. $E = 7.5 V \cos \phi \sin \alpha + 0.0042 V^*V$
104-108	5	real	Free-air anomaly	In 10 th 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 0905adcp.tar in the directory /rvdas/nav.

pCO₂

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 0905pco2.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

Data acquired from expendable bathymetric temperature probes has been placed in the tar file /ocean/0905xibt.tar. The tar archive contains “.gz” files of the output files from the probe in the format

T7_000XX.EDF

where the first two digits indicate the probe type, the string after the underscore indicates the cast number, and the extension indicates the data format.

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: NBP0905A.mwx1.d330

- The CruiseID is the numeric name of the cruise, in this case, NBP0905A.
- 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-007
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	bat1	continuous**	Varies	ODEC Bathy 2000
Bathymetry	knud	continuous	Varies	Knudsen 320B/R
Bathymetry	sim1	not collected	Varies	Simrad EK500 Sonar

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

**Primary underway bathymetry was switched from Knudsen to Bathy 2000 at 016:16:33.

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 3-01/S
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

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

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,-
0.4827508,282.9581,281.8823,1003.119

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	%
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	

Bathy 2000 (bat1)

00+019:23:59:53.901 ;I04485.3ME -23.0, I00000.0,-99.9,0000@01/11/00,
 23:59:52.08 PW2 PF1 SF1 PL3 MO4 SB3 PO0 TX1 TR: GM5 1500 06.7 -72.1

Field	Data	Format / Possible Values	Units
1	RVDAS time tag		
2	Flagged low frequency chn. depth w/ units	;FDDDDD.Dun where F = flag (V for valid, I for invalid), D=depth, un = units	meters
3	Low Frequency echo strength	EEE.EE	dB
4	Flagged high freq. chn. depth	not used	
5	High frequency echo strength	not used	
6	Signed heave data	SHHHH	cm
7	Date	mm/dd/yy	
8	Time	hh:mm:ss	
9	Transmit pulse window type	PW1=Rectangular PW2=Hamming PW3=Cosine PW4=Blackman	
10	Primary transmit frequency	PF1=3.5 kHz	kHz

Field	Data	Format / Possible Values	Units
		PF2=12.0 kHz	
11	Parametric mode secondary frequency	SF1=3.5 kHz SF2=12.0 kHz	kHz
12	Pulse length	PL1=200usec PL2=500usec PL3=1msec PL4=2msec PL5=5msec PL6=10msec PL7=25msec If transmit mode is FM: PL1=25msec PL2=50msec PL3=100msec	
13	Operating mode	MO1=CW parametric MO2=CW MO3=FM parametric MO4=FM	
14	Frequency sweep bandwidth	SB1=1 kHz SB2=2 kHz SB3=5 kHz	kHz
15	Power level	PO1 = 0dB PO2 = -6dB PO3 = -12dB PO4 = -18dB PO5 = -24dB PO6 = -30dB PO6 = -30 dB PO7 = -36dB PO8 = -42dB	
16	Transmit mode	TX1=single ping active TX2=pinger listen TX3=multipinging TR TX4=multipinging TR TX5=multipinging TTRR TX6=multipinging TTTTRRRR TX7=multipinging TTTTTRRRRR	
17	Transmit Rate	TR3 = 4Hz TR4 = 2Hz TR5 = 1Hz TR6 = .5Hz TR7 = .33Hz TR8 = .25Hz TR9 = .20Hz TR: = .10Hz TR; = .05Hz	Hz
18	System gain mode	GM0=hydrographic AGC GM1 to GM9=hydrographic +3db to + 27db manual. GMA to GMD=hydrographic + 30db through + 60db manual GME to GMK=sub-bottom 1 through sub-bottom 7	
19	Speed of sound		m/sec
20	Depth of sonar window below sea-		meters

Field	Data	Format / Possible Values	Units
	level		
21	Background noise level in fixed point reference		dB/V

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. 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)	

pCO₂ (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

Simrad EM120 (mbdp)

09+282:10:53:38.318 \$KGDPT,3945.60,7.29,1;12000.0*7c

Field	Data	Units
1	RVDAS time tag	
2	EM120 (string flag)	
3	Depth below keel	Meters
4	Keel depth	Meters
5		

Micro-TSG (mtsg)

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

Field	Data	Conversion	Units
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)

08+330:23:59:50.899 12.25684 23.89813 0.4029922 0.2541656 233.4218 -
 751.9 -8145.28 -1.386184 23.37653 23.37653 NAN

Field	Data	Units
1	RVDAS time tag	
2	Power Supply Voltage	V
3	Internal Case Temperature	°C
4	Pump #1 flow rate	L/min
5	Pump #2 flow rate	L/min
6	Pump #3 flow rate	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	Freezer #3 temperature	°C

*See page 25 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	

Field	Data	Units
2	Temperature at seawater intake	°C

Navigational Data

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

The processed data sets can be found in the /process directory and subdirectories. Note: many of the subdirectories contain intermediate datasets to facilitate further processing and are not intended to be end-products. Only the final product files and datasets are described below.

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)	yyyymmdd.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
13	RVDAS latitude	degrees
14	RVDAS longitude	degrees
15	TSG external temperature	°C
16	TSG salinity	PSU
17	TSG fluorometry	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	Input Source	-1 stem Thurston; 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 “mw1” 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 “mw1” 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 “`mw1`” 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.

Please refer to the included event log.

Appendix: Sensors and Calibrations

NBP0905A Shipboard Sensors

Sensor	Serial Number	Last Calibration Date	Comments
Meteorology & Radiometers			
Port Anemometer (Gill Ultrasonic)	836076	5/15/2007	Installed 11/17/2008
Stbd Anemometer (Gill Ultrasonic)	836077	5/15/2007	Installed 11/17/2008
Bridge Anemometer	WM 45835	2/28/2007	Bridge (center)
Barometer	01706	7/31/2008	Installed 10/6/2009
Humidity/Wet Temp	06135	7/31/2008	Installed 10/6/2009
PIR	33023F3	6/20/2008	Installed 7/9/2008
PSP	33090F3	6/11/2008	Installed 7/9/2008
Mast PAR	6356	8/8/2007	Installed 8/28/2007
GUV (Mast)	25110203113	3/18/2008	Installed 3/18/2008
PRR-800/810 System	8000803115	6/20/2007	Installed at beginning of cruise
Underway			
Micro TSG	4550449-0242	1/12/2008	Installed 3/31/2009
Remote Temp (primary)	3849120-0178	1/12/2008	Installed 7/1/2008
Fluorometer	AFLD-011	10/29/2008	Installed 1/1/2009
Transmissometer	CST-439DR	11/14/2007	Installed 12/13/008

Calibrations

The following pages are replicas of current calibration sheets for the sensors used during this cruise.

Gravity Tie Start (Punta Arenas)

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:	1/3/2009	Reference Code Numbers:			
Location:	Punta Arenas, Chile	Station no.	9337-50		
Station:	Harbour Admin. Bldg.	ISGN no.	51230N		
Latitude:	53 09 S				
Longitude:	070 55 W				
Elevation:					
Gravity:	981320.82				
	Value	Time (GMT)			
Ship's meter before gravity tie (Gravity (cu))	8974.4	17:37			
Ship's meter after gravity tie (Gravity (cu))	8974.6	18:38			
Average	8974.5				
Ship Gravimeter's Calibration Constant	1.0046				
Corrected ship's meter (QC Grav (mgal))	9015.8				
	Value	Time (GMT)			
Ship's meter before gravity tie (serial, RVDAS)	8974.5	17:37			
Ship's meter after gravity tie (serial, RVDAS)	8974.6	18:38			
Average (for comparison check only)	8974.6				
Portable Gravimeter Interval Factor	1.01007	From Table 1 of Model G #807 Meter			
Station	Value	Time (GMT)	Temp	Date	
Pier measurement 1	4913.36	17:51	53	January 3, 2009	OBS mgal, averaged
Pier measurement 2	4913.33	17:53	53	January 3, 2009	4962.82
Pier measurement 3	4913.35	17:54	53	January 3, 2009	
Average	4913.35				
Station measurement 1	4914.18	17:51	53	January 3, 2009	OBS mgal, averaged
Station measurement 2	4914.14	17:53	53	January 3, 2009	4963.64
Station measurement 3	4914.14	17:53	53	January 3, 2009	
Average	4914.15				
Pier measurement 4	4913.40	18:30	53	January 3, 2009	OBS mgal, averaged
Pier measurement 5	4913.45	18:31	53	January 3, 2009	4962.91
Pier measurement 6	4913.45	18:31	53	January 3, 2009	
Average	4913.43				
			Gravity offset from last tie	972304.81	
			Drift since last tie	0.50	
OBS Differences			Comments		
Station to Pier (1, 2, & 3 averaged)	-0.81	Gravity Tie performed by Greg Watson at pier in Punta Arenas and at port admin building.			
Station to Pier (4, 5, & 6 averaged)	-0.73				
Averaged Differences	-0.77				
Gravity at pier	981320.05				
Elevation of pier above gravimeter, meters	0.1				
Earth differential gravity, mgal/meter	0.3				
Gravity at ship's gravimeter	981320.09				
Gravity Offset (for RVDAS)	972304.31				

Anemometer (Bridge)**RM Young Anemometer Calibration, Model 05106**

S/N: 45835

Date: 28-Feb-07

Cal'd By: George Aukon

Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s	Knots
0	0.00	0.00	0.00	0.0
200	0.98	0.90	0.08	1.9
500	2.45	2.40	0.05	4.8
1000	4.90	4.80	0.10	9.5
1500	7.35	7.30	0.05	14.3
2000	9.80	9.80	0.00	19.0
3000	14.70	14.60	0.10	28.6
4000	19.60	19.50	0.10	38.1
5000	24.50	24.30	0.20	47.6
6000	29.40	29.20	0.20	57.1
7000	34.30	34.10	0.20	66.6
8000	39.20	39.00	0.20	76.2
9000	44.10	43.90	0.20	85.7
10000	49.00	48.80	0.20	95.2
12000	58.80	58.60	0.20	114.2

Direction	Measured Direction	Delta Direction
0	359	0
30	29	1
60	59	1
90	89	1
120	119	1
150	148	2
180	179	1
210	210	0
240	240	0
270	270	0
300	301	-1
330	331	-1
0	1	-1

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	0.00	0.00
200	0.98	1.00	-0.02
500	2.45	2.50	-0.05
1000	4.90	4.90	0.00
1500	7.35	7.40	-0.05
2000	9.80	9.80	0.00
3000	14.70	14.80	-0.10
4000	19.60	19.80	-0.20
5000	24.50	24.60	-0.10
6000	29.40	29.50	-0.10
7000	34.30	34.50	-0.20
8000	39.20	39.40	-0.20
9000	44.10	44.40	-0.30
10000	49.00	49.30	-0.30
12000	58.80	59.60	-0.80

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

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

Additional Comments

Potentiometer and potentiometer coupling
were replaced, vertical shaft bearings were
cleaned and lubricated.

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

Barometer

R.M. Young Company
2601 Aero Park Drive
Traverse City, Michigan 49686 USA

CALIBRATION REPORT **Barometric Pressure Sensor**

Customer: *Raytheon Technical Services Co LLC*

Test Number: 87311
Test Date: 31 July 2008

Customer PO: RR41221-01
Sales Order: 9867

Test Sensor:

Model: 61201 Serial Number: BP01706
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	-2	799.9
875.0	1249	874.9
950.0	2500	950.0
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
Druck Pressure Controller Model DPI515
Fluke Multimeter Model 8060A

Serial # NIST Test Reference
51500497 UKAS Lab 0221
4885407 234027

Tested By:

E. Channing

METEOROLOGICAL INSTRUMENTS

Tel: 231-946-3580 Fax: 231-946-4772 Email: met.sales@youngusa.com Website: www.youngusa.com

Humidity Sensor

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

CALIBRATION REPORT Relative Humidity Sensor

Customer: *Raytheon Technical Services Co LLC*

Test Number: 87910R
Test Date: 31 July 2008

Customer PO: RR41221-01
Sales Order: 9867

Test Sensor:

Model: 41372LC Serial Number: 6135
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 (%)
10.0	5.9	11.6
30.0	8.8	30.0
50.0	12.1	50.7
70	15.1	69.6
90	18.0	87.2

(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

Vaisala Humidity Sensor Model 35AC
Fluke Multimeter Model 8060A

Serial # NIST Test Reference

N475040 TN 266152
4865407 234027

Tested By: *E. Channing*

METEOROLOGICAL INSTRUMENTS
Tel: 231-946-3930 Fax: 231-946-4772 Email: met.sales@youngusa.com Website: www.youngusa.com

Temperature Sensor

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

CALIBRATION REPORT **Temperature Sensor**

Customer: *Raytheon Technical Services Co LLC*

Test Number: 87910

Test Date: 30 July 2008

Customer PO: RR41221-01

Sales Order: 9867

Test Sensor:

Model: 41372LC

Serial Number: 6135

Description: Temperature/Relative Humidity Sensor

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

Bath Temperature (degrees C)	Current Output (milliamps)	Indicated (1) Temperature (degrees C)
-49.93	4.009	-49.94
0.03	12.006	0.04
49.92	19.986	49.91

(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.

<u>Reference Instrument</u>	<u>Serial #</u>	<u>NIST Test Reference</u>
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. Channing*

METEOROLOGICAL INSTRUMENTS

Tel: 231-946-3990 Fax: 231-946-4777 Email: met.sales@youngusa.com Website: www.youngusa.com

PIR

THE EPPLEY LABORATORY, INC.

12 Sheffield Ave., P.O. Box 419, Newport, RI 02840 USA

Telephone: 401-847-1020

Fax: 401-847-1031

Email: info@eppleylab.com

Internet: www.eppleylab.com



Scientific Instruments
for Precision Measurements
Since 1917

**STANDARDIZATION OF
EPPLEY PRECISION INFRARED RADIOMETER
Model PIR**

Serial Number: 32845F3

Resistance: 713 Ω at 23 $^{\circ}\text{C}$ Temperature Compensation Range: -20 to +40 $^{\circ}\text{C}$

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 24 $^{\circ}\text{C}$ 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:

$$4.15 \times 10^{-6} \text{ volts/watts meter}^{-2}$$

The calculation of this constant is based on the fact that the relationship between radiation intensity and emf is rectilinear to intensities of 700 watts meter⁻². This radiometer is linear to within $\pm 1.0\%$ up to this intensity.

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

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

Shipped to: National Science Foundation Date of Test: Sept. 30, 2008
Port Huemac, CA

S.O. Number: 61816

Date: October 14, 2008

In Charge of Test: *N. B. Palmer*Reviewed by: *[Signature]*

Remarks:

PSP**THE EPPLEY LABORATORY, INC.**

12 Sheffield Ave., P.O. Box 419, Newport, RI 02840 USA

Telephone: 401-847-1020

Fax: 401-847-1031

Email: info@eppleylab.com

Internet: www.eppleylab.com

Scientific Instruments
for Precision Measurements
Since 1917**STANDARDIZATION OF
EPPLEY PRECISION SPECTRAL PYRANOMETER
Model PSP**

Serial Number: 32850F3

Resistance: 706 Ω at 23 $^{\circ}\text{C}$ Temperature Compensation Range: -20 to +40 $^{\circ}\text{C}$

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:

$$7.89 \times 10^{-6} \text{ volts/watts meter}^{-2}$$

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

The calibration of this instrument is traceable to standard self-calibrating cavity pyrheliometers in terms of the Systems Internationale des Unites (SI units), which participated in the 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/ft²-hr⁻¹ = 3.153 watts meter⁻²

Shipped to: National Science Foundation Date of Test: Sept. 24, 2008
Port Hueneme, CA

S.O. Number: 61817

Date: Oct. 14, 2008

In Charge of Test: *R. Eggeman*Reviewed by: *Thomas D. Kuh*

Remarks:

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

Calibration Date: 2/7/2008
 Model Number: QSR-240
 Serial Number: 6357
 Operator: TPO
 Standard Lamp: Q1537(10/25/2008)
 Probe Excitation Voltage Range: 6 to 18 VDC(+)

Output Polarity: Positive

Probe Conditions at Calibration(in air):

Calibration Voltage: 6 VDC(+)
 Probe Current: 7.2 mA

Probe Output Voltage:

Probe Illuminated: 84.5 mV
 Probe Dark: 2.0 mV
 Probe Net Response: 82.5 mV
 RG780: 4.2 mV

Corrected Lamp Output:

Output in Air (same condition as calibration):

8.83E+15 quanta/cm²sec
0.01467 μ E/cm²sec

Calibration Scale Factor:

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

Dry: 9.3380E-18 V/(quanta/cm²sec)
5.6234E+00 V/(μ E/cm²sec)

Notes:

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

QSR240R 05/24/95

GUV



Biospherical Instruments Inc.

GUV-2511 Calibration Certificate										
System Serial Number			25110203113			Date of Calibration			3/18/08	
Calibration database			25110203113v4.mdb			Date of Certificate			3/18/2008	
DASSN			0068			Standard of Spectral Irradiance			91537(10/25/06)	
Microprocessor Tag Number			2			Operator			TC	
Monochromatic Channels	Address	Wavelength [nm]	Responsivity [Amps per $\mu\text{W}/(\text{cm}^2\cdot\text{nm})$]	ScaleSmall [Volts per $\mu\text{W}/(\text{cm}^2\cdot\text{nm})$]	ScaleMedium [Volts per $\mu\text{W}/(\text{cm}^2\cdot\text{nm})$]	ScaleLarge [Volts per $\mu\text{W}/(\text{cm}^2\cdot\text{nm})$]	OffsetSmall [volts]	OffsetMedium [volts]	OffsetLarge [volts]	Measurement Units
Ed0320	2	320	2.7010E-10	2.7551E-05	8.0491E-03	2.8497E+00	6.5000E-05	6.4000E-05	2.2300E-04	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Ed0340	6	340	2.2027E-10	2.2467E-05	6.5640E-03	2.3144E+00	3.7400E-04	3.7600E-04	1.1590E-03	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Ed0313	8	313	2.4100E-10	2.4539E-05	7.1692E-03	2.5594E+00	1.0000E-04	1.0000E-04	6.9100E-04	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Ed0305	10	305	1.6600E-11	1.6943E-06	4.9499E-04	1.5313E-01	4.1300E-04	4.0500E-04	-2.2080E-03	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Ed0380	12	380	7.0759E-11	7.2174E-06	2.1086E-03	7.0320E-01	1.1140E-03	1.1050E-03	-1.4780E-03	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Ed0395	16	395	3.4926E-10	3.5624E-05	1.0408E-02	3.3997E+00	1.3100E-04	1.3000E-04	2.2300E-04	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Broadband Channels	Address	Wavelength [nm]	Responsivity [$\mu\text{E}/(\text{cm}^2\cdot\text{s})$]	ScaleSmall [$\mu\text{E}/(\text{cm}^2\cdot\text{s})$]	ScaleMedium [$\mu\text{E}/(\text{cm}^2\cdot\text{s})$]	ScaleLarge [$\mu\text{E}/(\text{cm}^2\cdot\text{s})$]	OffsetSmall [volts]	OffsetMedium [volts]	OffsetLarge [volts]	Measurement Units
Ed0PAR	13	400-700	1.9205E-05	1.9589E+00	5.7230E+02	2.0376E+05	8.8600E-04	8.7700E-04	-1.3030E-03	$\mu\text{E}/(\text{cm}^2\cdot\text{sec})$
Auxilliary Channels	Address	Wavelength	Responsivity	ScaleS	ScaleM	ScaleL	OffsetS	OffsetM	OffsetL	Measurement Units
Ed0Gnd	0	0	1	1	1	1	0	0	0	V
Ed0Temp	22	0	1	0.01	0.01	0.01	0	0	0	C
Ed0Vin	27	0	1	-0.25	-0.25	-0.25	0	0	0	V

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Micro-TSG Calibration Files

Temperature Sensor (Micro-TSG) #0242

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SEA-BIRD ELECTRONICS, INC.

1808 136th Place N.E., Bellevue, Washington, 98005 USA

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

SENSOR SERIAL NUMBER: 0242
 CALIBRATION DATE: 31-Mar-08

SBE 45 TEMPERATURE CALIBRATION DATA
 ITS-90 TEMPERATURE SCALE

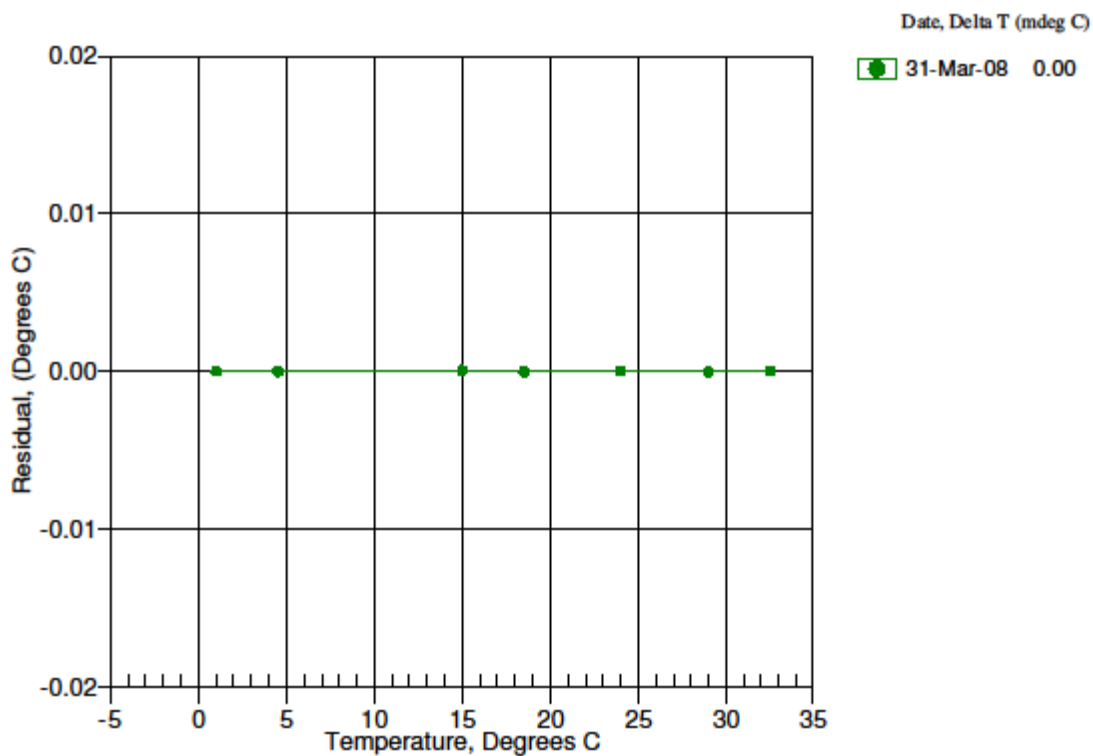
ITS-90 COEFFICIENTS

a0 = -3.912618e-006
 a1 = 2.847375e-004
 a2 = -3.193105e-006
 a3 = 1.720429e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	649832.1	1.0000	0.0000
4.5000	554895.8	4.5000	-0.0000
15.0000	352330.7	15.0000	0.0000
18.5000	304721.7	18.5000	-0.0000
24.0000	244015.9	24.0000	0.0000
29.0000	200610.7	29.0000	-0.0000
32.5000	175490.5	32.5000	0.0000

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

Residual = instrument temperature - bath temperature



Conductivity Sensor (Micro-TSG) #0242

64

SEA-BIRD ELECTRONICS, INC.
 1808 136th Place N.E., Bellevue, Washington, 98005 USA
 Phone: (425) 643-9866 Fax (425) 643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0242
 CALIBRATION DATE: 31-Mar-08

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

COEFFICIENTS:

g = -9.980367e-001
 h = 1.523293e-001
 i = -4.438334e-004
 j = 5.882995e-005

CPcor = -9.5700e-008
 CTcor = 3.2500e-006
 WBOTC = 0.0000e+000

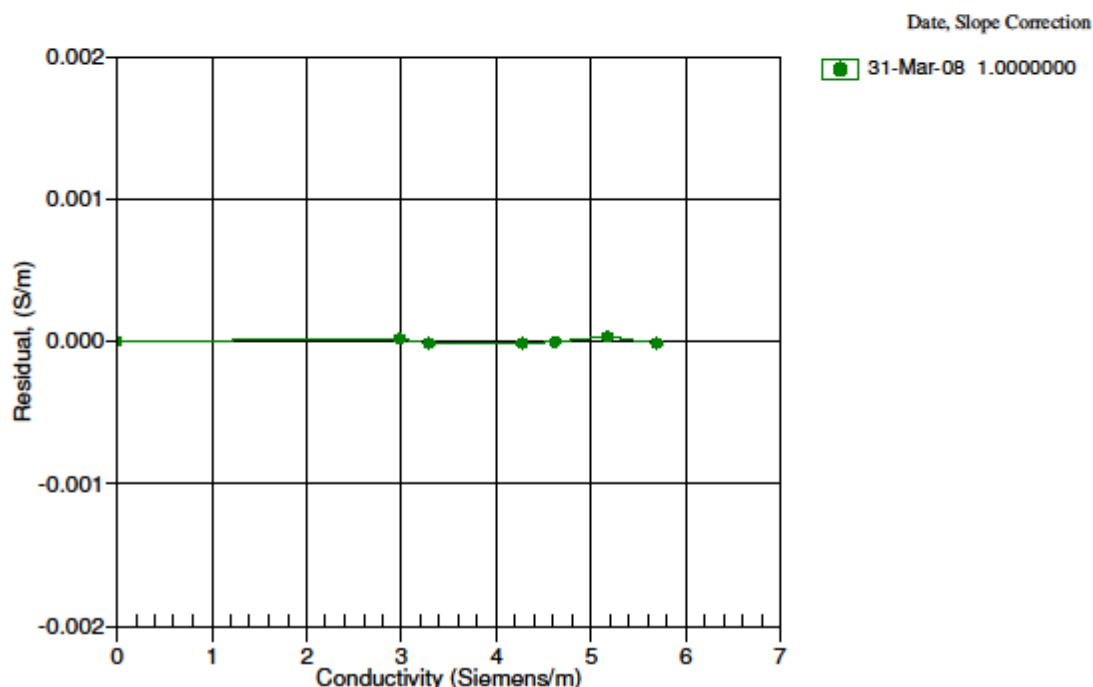
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (Hz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2565.99	0.00000	0.00000
1.0000	34.8739	2.98042	5122.83	2.98043	0.00002
4.5000	34.8542	3.28795	5316.56	3.28793	-0.00001
15.0000	34.8112	4.27105	5892.53	4.27104	-0.00001
18.5000	34.8020	4.61668	6081.77	4.61667	-0.00001
24.0000	34.7913	5.17532	6375.44	5.17535	0.00003
29.0000	34.7843	5.69767	6637.87	5.69765	-0.00002

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

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

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

$$\text{Residual} = \text{instrument conductivity} - \text{bath conductivity}$$



Underway Temperature Sensor (Primary Remote)

SEA-BIRD ELECTRONICS, INC.
 1808 136th Place N.E., Bellevue, Washington, 98005 USA
 Phone: (425) 643 - 9866 Fax (425) 643 - 9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0178
 CALIBRATION DATE: 07-Jan-08

SBE 38 TEMPERATURE CALIBRATION DATA
 ITS-90 TEMPERATURE SCALE

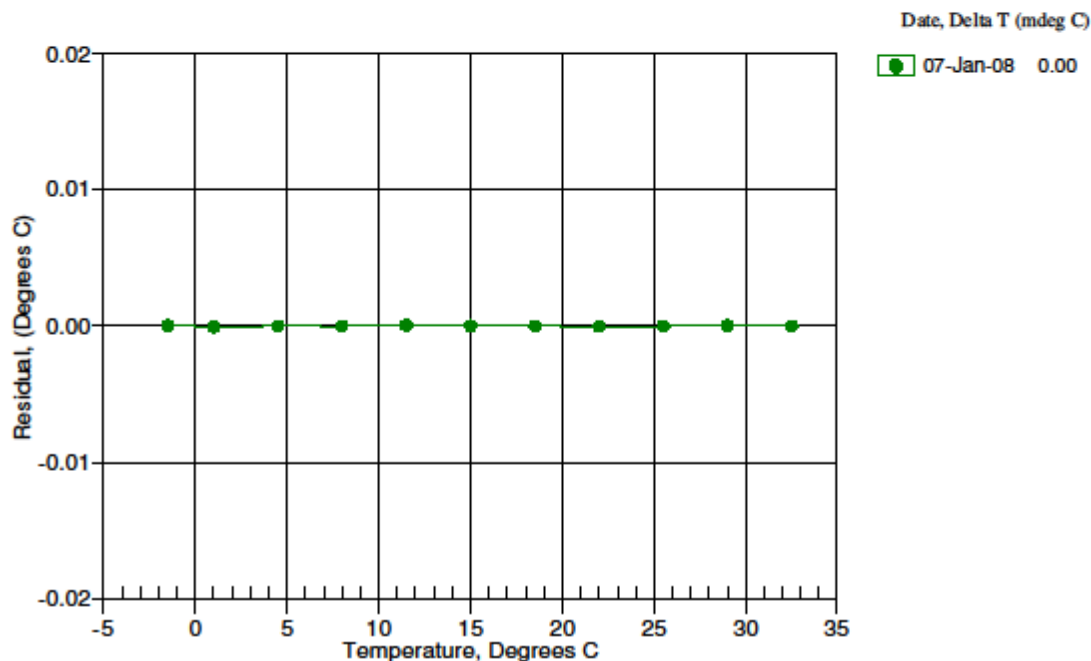
ITS-90 COEFFICIENTS

a0 = -4.331693e-005
 a1 = 2.811171e-004
 a2 = -2.677535e-006
 a3 = 1.661218e-007

BATH TEMP (ITS-90)	INSTRUMENT OUTPUT	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.50010	750904.5	-1.50006	0.00004
0.99990	671271.1	0.99984	-0.00006
4.49990	575397.3	4.49989	-0.00001
7.99990	494813.7	7.99989	-0.00001
11.49990	426851.8	11.49995	0.00005
14.99990	369349.8	14.99992	0.00002
18.50000	320540.5	18.50001	0.00001
22.00000	278985.0	21.99995	-0.00005
25.49990	243497.2	25.49989	-0.00001
28.99990	213101.8	28.99992	0.00002
32.49990	186995.1	32.49990	0.00000

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 Temperature Sensor (Secondary Remote)**SEA-BIRD ELECTRONICS, INC.**

1808 136th Place N.E., Bellevue, Washington, 98005 USA

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

SENSOR SERIAL NUMBER: 1267
CALIBRATION DATE: 12-Apr-06SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS

$g = 4.76625066e-003$
 $h = 6.64522185e-004$
 $i = 2.84261863e-005$
 $j = 2.62601374e-006$
 $f_0 = 1000.0$

ITS-68 COEFFICIENTS

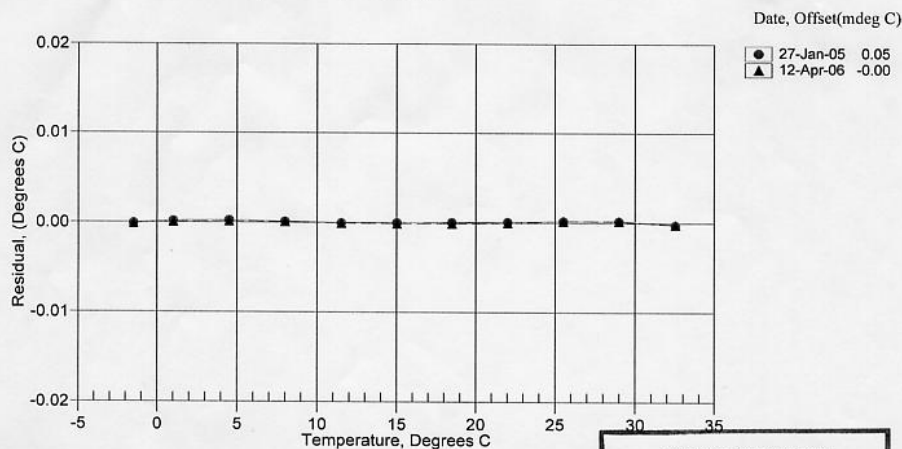
$a = 3.68121498e-003$
 $b = 5.89543636e-004$
 $c = 1.47312260e-005$
 $d = 2.62748536e-006$
 $f_0 = 5707.029$

BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5001	5707.029	-1.5002	-0.00010
1.0000	6042.027	1.0001	0.00005
4.4999	6534.652	4.5000	0.00014
7.9999	7055.608	8.0000	0.00007
11.4999	7605.659	11.4998	-0.00008
14.9999	8185.578	14.9998	-0.00014
18.4999	8796.088	18.4998	-0.00011
22.0000	9437.895	22.0000	-0.00003
25.4999	10111.624	25.5001	0.00019
28.9999	10817.898	29.0001	0.00019
32.4999	11557.257	32.4997	-0.00019

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

$$\text{Temperature ITS-68} = 1/\{a + b[\ln(f_0/f)] + c[\ln^2(f_0/f)] + d[\ln^3(f_0/f)]\} - 273.15 \text{ (}^\circ\text{C)}$$
Following the recommendation of JPOTS: T_{68} is assumed to be $1.00024 * T_{90}$ (-2 to 35 $^\circ\text{C}$)

Residual = instrument temperature - bath temperature

**POST CRUISE
CALIBRATION**

Underway fluorometer (Primary)

PO Box 518
620 Applegate St.
Philomath OR 97370



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

Chlorophyll Fluorometer Characterization .

Date: 10/29/08
Serial #: AFLD-011
Job#: 0011007
Tech: K.C

Dark Counts 0.183 volts
CEV 2.902 volts
SF 8.6598

FSV 5.36 volts

Linearity: 0.999 R² (0–1.5 volts)
0.995 R² (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 25 µg/l of a *Thalassiosira weissflogii* phytoplankton culture.

SF is the scale factor used to derive chlorophyll concentration from the signal voltage output of the fluorometer. The scale factor is determined by using the following equation:
SF = (25) / (CEV – dark) e.g. (25 / (2.865 – 0.238) = 9.516)

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

Chlorophyll concentration expressed in µg/l (mg/m³) can be derived by using the following equation: (µg/l) = (V_{measured} - dark) * SF

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

Underway Transmissometer

PO Box 518
620 Applegate St.
Philomath, OR 97370



(511) 929-5650
Fax (541) 929-5277
www.wetlabs.com

C-Star Calibration

Date	November 14, 2007	S/N#	CST-438DR	Pathlength	25 cm
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	Analog meter
V_d	0.060 V
V_{air}	4.794 V
V_{ref}	4.663 V

Temperature of calibration water	23.2 °C
Ambient temperature during calibration	25.9 °C

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

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 H

10/3/07