

# Data Report NBP0505

**Anderson/Hallet, Chilean Fjords, 23 Jun – 15 Jul 2005**



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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 and BathyW data, if collected, 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

/	0505data.doc		
	instcoef.txt	scirep/	week1.doc
	NBP0505.trk		week2.doc
	NBP0505.mgd		week1.htm
	NBP0505.gmt		week2.htm
	0505_BE.gmt		
	watchlog.xls	rvdas/nav/	0505adcp.tar
	mrnlitrk.jpg		0505seap.tar
	mrnlitrk.ps (Marinelli track)		0505sp2a.tar
	pngntrk.jpg		0505gp02.tar
	pngntrk.ps (Penguin track)		0505PCOD.tar
	snrfltrk.jpg		0505gyr.tar
	snrfltrk.ps (SanRafael track)		
adcp/	adcp0505.tgz	rvdas/uw/	0505flr.tar
			0505bat.tar
images/	coverart.jpg		0505grv.tar
			0505knud.tar
ocean/xbt/	0505xbt.tar		0505mbdp.tar
			0505met.tar
process/	0505jgof.tar		0505pco2.tar
	0505mgd.tar		0505oyo.tar
	0505pco2.tar		0505svp.tar
	0505proc.tar		0505tsg.tar
	0505qcps.tar		0505sim.tar
	0505tsg.tar		0505svp.tar
			0505syn.tar
			0505eng.tar

## 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

NBP0505 was the first of two Anderson/Hallet cruises to glacier terminus fjords in Chilean Patagonia (and next year to the Antarctic Peninsula). It departed Punta Arenas, Chile on 23 June 2005 for the San Rafael and Penguin/Europa glacier systems in Southern Chile, and the Europa glacier area on the island of Tierra del Fuego. Please note that data collection and data plots will have several lengthy time gaps. These gaps reflect transit periods between study sites, during which data was not logged due to permit considerations.

### Cruise Track

The distribution DVD includes a GMT cruise track file (NBP0505.trk). It contains the longitude and latitude at one-minute intervals extracted from the NBP0505.gmt file.

There are two GMT cruise track files on the DVD, the NBP0505.gmt file is in a Linux format (little endian) and the 0505\_BE.gmt file is in a Sun/Unix format (big endian).

There are also postscript and gif files in the root directory on the data distribution that have a basic plot of the cruise track (mrnlitrk, pngntrk, and snrfltrk .gif and .ps, the Marinelli, Penguin/Europa, and San Rafael tracks respectively).

### Science Report

The weekly science reports are stored in the directory /scirep.

### NBP Data Products

Two datasets are created on each cruise: JGOFS and MGD77.

The data processing scripts on board the NBP that are used to produce the JGOFS and MGD77 data sets produce a lot of temp files. As of March 2005 we have started including those temp files on the data distribution in a file called 0505proc.TAR. These files are not described in any detail in this document, nor will they be. They are included to make re-processing easier in the event of an error. If you have any questions please contact [Kathleen.Gavahan@usap.gov](mailto:Kathleen.Gavahan@usap.gov).

## JGOFS

The JGOFS data set can be found on the distribution media in the file /process/0505jgof.tar. The archive contains a single file produced 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. The daily file consists of 22 columnar fields in text format described in the table below. The JGOFS data set is obtained primarily by applying calibrations to raw data and decimating to whole 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. During the cruise, the JGOFS data set produces the daily data plots. 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 (port windbird)	meters/sec
15	True wind direction (port windbird)	degrees (azimuth)
16	Ambient air temperature	$^{\circ}\text{C}$
17	Relative humidity	%
18	Barometric pressure	mBars
19	Sea surface fluorometry	volts (0-5 FSO)
20	Not used	-
21	PSP	$\text{W/m}^2$
22	PIR	$\text{W/m}^2$

## 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 NBP0505.mgd. Also at the root level, NBP0505.gmt is the output of the mgd77togmt utility using NBP0505.mgd as input. The NBP0505.gmt file can be used by GMT plotting software.

The data used to produce the NBP0505.mgd file can be found on the distribution media in the file /process/0505mgd.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 <sup>ST</sup> sensor	In tenths of nanoteslas (gammas)
67-72	6	real	Magnetics total field, 2 <sup>ND</sup> 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 = 1 <sup>st</sup> or leading sensor 2 = 2 <sup>nd</sup> 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 <sup>th</sup> of mgals. Corrected for Eotvos, drift, tares
98-103	6	real	EOTVOS correction	In 10 <sup>th</sup> of mgals. $E = 7.5 V \cos \phi \sin \alpha + 0.0042 V^2$
104-108	5	real	Free-air anomaly	In 10 <sup>th</sup> 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



Col	Len	Type	Contents	Description, Possible Values, Notes
				9=No identifiable problem found

## Science of Opportunity

### ADCP

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

The ADCP data set collected during this cruise has been placed on the distribution media in the archive `/adcp/0505adcp.tgz`. This file may be unpackaged using: `# tar xvzf 0505adcp.tgz`. For more information on data format, visit <http://currents.soest.hawaii.edu>

Some ADCP data is also transmitted to RVDAS. East and north vectors for ship's speed relative to the reference layer and ship's heading are archived as `0505adcp.tar` in the directory `/rvdas/nav`.

### pCO<sub>2</sub>

The NBP carries Lamont-Doherty Earth Observatory's (LDEO) pCO<sub>2</sub> system and RPSC staff maintains it. Data is sent to LDEO at the end of each cruise. The pCO<sub>2</sub> data is transmitted and archived on RVDAS. You will find it in a file named `0505pco2.tar` in the `/process` directory, which contains the pCO<sub>2</sub> instrument's data merged with GPS, meteorological and other oceanographic measurements. For more information contact Colm Sweeney ([csweeney@ldeo.columbia.edu](mailto:csweeney@ldeo.columbia.edu)).

## Cruise Science

### XBT

During the cruise Expendable Bathythermographs were used to obtain water column temperature profiles. These were used to adjust the sound velocity profile for the multibeam system. The data files from these launches are included as `0505xbt.tar` in the `/ocean/xbt` 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 (Research Vessel Data Acquisition System) data is performed to convert values into useable units and as a check of the proper operation of the DAS. Both raw and processed data sets from RVDAS are included in the data distribution. The tables below provide detailed information on the 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 tar archive /process/0505full.tar. 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: NBP0505met1.d317

- The CruiseID is the numeric name of the cruise, in this case, NBP0505.
- The ChannelID is a 4-character code representing the system being logged. An example is "met1," 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	met1	Continuous	1 sec	R. M. Young 41372LC
Relative Humidity	met1	Continuous	1 sec	
Wind Speed/Direction	met1	Continuous	1 sec	R.M. Young 05106
Barometer	met1	Continuous	1 sec	R.M. Young 61201
PIR (LW radiation)	met1	Continuous	1 sec	Eppler PIR
PSP (SW radiation)	met1	Continuous	1 sec	Eppler PSP
PAR	met1	Continuous	1 sec	BSI QSR-240
GUV	guv	Not used		BSI GUV-2511

## Geophysics

Measurement	Channel ID	Collect. Status	Rate	Instrument
Gravimeter	grv1	Continuous	10 sec*	LaCoste & Romberg
Magnetometer	mag1	Not used	15 sec	EG&G G-877
Bathymetry	bat1	Continuous	Varies	ODEC Bathy 2000
Bathymetry	knu1	Continuous	Varies	Knudsen 320B/R
Bathymetry	sim1	depth < 2500 m	Varies	Simrad EK500 Sonar

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

## Oceanography

Measurement	Channel ID	Collect. Status	Rate	Instrument
Conductivity	tsg1	Continuous	6 sec	SeaBird 21
Salinity	tsgfl	Continuous	6 sec	Calc. from pri. temp
Sea Surface Temp	tsg1	Continuous	6 sec	SeaBird 3-01/S
Fluorometry	flr1	Continuous	1 sec	Turner 10-AU-005
Fluorometry	flr1 & tsg1	Continuous	6 sec	

Measurement	Channel ID	Collect. Status	Rate	Instrument
Transmissometry	tsg1	Continuous	6 sec	WET Lab C-Star
pCO <sub>2</sub>	pco2	Continuous	70 sec	(LDEO)
ADCP	adcp	Continuous	varies	RD Instruments

## Navigational Instruments

Measurement	Channel ID	Collect. Status	Rate	Instrument
Attitude GPS	seap	Continuous	1 sec	SeaPath 200
Trimble GPS	PCOD	Not collected	1 sec	Trimble 20636-00SM
Gyro	gyr1	Continuous	0.2 sec	Yokogawa Gyro
SeaPath	Seap	Continuous	1 sec	SeaPath 200
SeaPath2*	Sp2a	Continuous	1 sec	SeaPath 200

\*The NBP has 2 SeaPath GPS units. Seapath2 is a backup navigation unit for the primary SeaPath unit. For a description of Sea2 data, see Seap.

## 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

### Sound Velocity Probe (svp1)

```
00+348:01:59:52.128 1539.40
```

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

### Meteorology (met1)

01+322:00:03:27.306 04.5 292 010 05.7 294 010 0959.6 000.2 093 -000.1537  
 0001.0886 0012.8248

Field	Data	Units
1	RVDAS time tag	
2	Port anemometer speed (relative)	m/s
3	Port anemometer direction (relative)	deg
4	Port anemometer standard deviation	deg
5	Starboard anemometer speed (relative)	m/s
6	Starboard anemometer direction (relative)	deg
7	Starboard anemometer standard deviation	deg
8	Barometer	mBar
9	Air temperature	°C
10	Relative humidity	%
11	PSP (short wave radiation)*	mV
12	PIR (long wave radiation)*	mV
13	PAR (photosynthetically available radiation)*	mV

\*See page 19 for calculations.

### 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, and 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

## Magnetometer (mag1)

05+031:22:51:10.559 = 63270.84 614 17.63

Field	Data	Units
1	RVDAS time tag	
2	= (field separator, part of output string)	
3	Magnetic field strength	nT
4	Signal strength	
5	Depth	meters

## 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	

Field	Data	Format / Possible Values	Units
10	Primary transmit frequency	PF1=3.5 kHz PF2=12.0 kHz	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-level		meters

Field	Data	Format / Possible Values	Units
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

### Simrad EM120 (mbdp)

05+039:00:00:15.846 \$EMDPT,2865.72,0.0

Field	Data	Units
1	LDTDS	
2	\$EMDPT	
3	Depth (corrected)	Meters

### Simrad EK500 (sim1)

00+005:00:00:52.388 D1,23583509,1479.6, 17, 1, 0

Field	Data	Units
1	RVDAS time tag	
2	Header	
3	Time tag	hhmmss.sss
4	Depth	m
5	Bottom surface backscattering strength	dBar
6	Transducer number ( 1 = 38 kHz )	
7		

### Thermosalinograph (tsg1)

00+019:23:59:46.976 15A16CFC163F8C2C100

Field	Data	Units
1	RVDAS time tag	
2	Seabird hex string (see page 19 for conversion to real units)	

**Fluorometer (flr1)**

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	
9	Temperature units	

**pCO<sub>2</sub>**00+021:23:59:43.190 2000021.9992 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 <sub>2</sub> time tag (decimal is fractional time of day)	yyyyddd.ttt
3	Raw voltage	mV
4	Barometer	mBar
5	Cell temperature	°C
6	Flow rate	ml/min
7	Concentration	ppm
8	pCO <sub>2</sub> pressure	microAtm
9	Equilibrated temperature	°C
10	Latitude (not collected)	
11	Longitude (not collected)	
12	Flow source (Equil = pCO <sub>2</sub> measurement)	



## Navigational Data

### Seapath GPS (seap and sp2a)

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

- GPZDA
- GPGGA
- GPVTG
- GPHDT
- 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,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
-------	------	-------

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 \$HEHRC 25034,-020 \*73

Field	Data	Units
1	RVDAS time tag	
2	\$HEHRC	
3	Heading XXXXX = ddd.dd	degrees
4	Rate of change SYYY S = +/-, YYY = r.rr	
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

### Sound Velocity Probe (svp1)

00+348:01:59:52.128 1539.40

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

### Trak Systems GPS Station Clock (trax)

The Trak GPS clock combines a GPS receiver with a precision time signal generator. The Trak receiver outputs time and frequency signals synchronized to within one microsecond of GPS/UTC time received from satellites. When no satellites are seen it uses a rubidium crystal with an output drift of less than 40 nanoseconds per hour. The trak is set to a one second pulse rate. The last 5 digits are not used.

05+105:16:07:11.049 10516071100000

Field	Data	Units
1	RVDAS Time tag	
2	Trax time	dddhmmss

**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

Field	Data	Units
1	RVDAS time tag	
2	PCO <sub>2</sub> time tag (decimal is time of day)	yyyddd.ttt
3	Raw voltage	mV
4	Barometer	mB
5	Cell temperature	°C
6	Flow rate	cm <sup>3</sup> /min
7	Concentration	ppm
8	PCO <sub>2</sub> pressure	microAtm
9	Equilibrated temperature	°C
10	Flow Source (Equil = pCO <sub>2</sub> measurement)	
11	RVDAS latitude	degrees
12	RVDAS longitude	degrees
13	TSG external temperature	°C
14	TSG salinity	PSU
15	TSG fluorometry	V
16	RVDAS true wind speed	m/s
17	RVDAS true wind direction	degrees
18	Barometric Pressure	mBars
19	Uncontaminated seawater pump flow rate	l/min
20	Speed over ground	knots
21	Course made good	degrees

**tsgfl**

00+075:00:00:04.467 -01.488 -01.720 02.6783 33.63748 1.002442 0.002442

Field	Data	Units
1	RVDAS time tag	
2	Internal water temperature	°C
3	Sea Surface Temperature	°C
4	Conductivity	μSiemens
5	Salinity	PSU
6	Fluorometry	V
7	Transmissivity	V

## Calculations

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

### TSG

Raw TSG data is stored as a 20 byte (character) long hex string

Bytes	Data
1-4	Sensor Temperature
5-8	Conductivity
9-14	Remote Temperature
15-17	Fluorometer voltage
18-20	Transmissometer voltage

The coefficients for temperature and conductivity sensors can be found the `instcoef.txt` file and on the calibrations sheets in the appendix.

#### Calculating Temperature – ITS-90

```
T = decimal equivalent of bytes 1-4
Temperature Frequency:  f = T/19 + 2100
Temperature = 1/{g + h[ln(f0/f)] + i[ln2(f0/f)] + j[ln3(f0/f)]} -
273.15 (°C)
```

#### Calculating Conductivity – ITS-90

```
C = decimal equivalent of bytes 5-8
Conductivity Frequency f = sqrt(C*2100+6250000)
Conductivity = (g + hf2 + if3 + jf4)/[10(1 + δt + εp)]
(siemens/meter)
t = temperature (°C); p = pressure (decibars); δ = Ctcor; ε =
CPcor
```

#### Calculating Fluorometry Voltage

```
f = decimal equivalent of bytes 15-17
Fluorometry Voltage = f/819
```

#### Calculating Transmittance

```
Vdark = 0.058 V
Vref = 4.765 V
t = decimal equivalent of bytes 18 - 20
Transmissometer Voltage (Vsignal) = t/819
% Transmittance = (Vsignal - Vdark) / (Vref - Vdark)
```

**PAR**

raw data = mV  
 calibration scale =  $6.10 \text{ V}/(\mu\text{Einstiens}/\text{cm}^2\text{sec})$   
 offset ( $V_{\text{dark}}$ ) = 0.3 mV  
 $(\text{raw mV} - V_{\text{dark}})/\text{scale} \times 10^4 \text{ cm}^2/\text{m}^2 \times 10^{-3} \text{ V/mV} = \mu\text{Einstiens}/\text{m}^2\text{sec}$   
 or  
 $(\text{data mV} - 0.3 \text{ mV}) \times 1.65 (\mu\text{Einstiens}/\text{m}^2\text{sec})/\text{mV} = \mu\text{Einstiens}/\text{m}^2\text{sec}$

**PIR**

raw data = mV  
 calibration scale =  $4.13 \times 10^{-6} \text{ V}/(\text{W}/\text{m}^2)$   
 $\text{data mV} / (\text{scale} \times 10^3 \text{ mV/V}) = \text{W}/\text{m}^2$   
 or  
 $\text{data mV} \times 242.1 (\text{W}/\text{m}^2)/\text{mV} = \text{W}/\text{m}^2$

**PSP**

raw data = mV  
 calibration scale =  $8.05 \times 10^{-6} \text{ V}/(\text{W}/\text{m}^2)$   
 $\text{data mV} / (\text{scale} \times 10^3 \text{ mV/V}) = \text{W}/\text{m}^2$   
 or  
 $\text{data mV} \times 120.7 (\text{W}/\text{m}^2)/\text{V} = \text{W}/\text{m}^2$

## 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	Description
177:02:30	Begin logging for cruise NBP0505.
177:05:07	Started GPS on bathy – reconnected to Seapath GPS.
092:21:38	Started PUV/GUV.
182:09:45	Stopped all data logging for transit between permit sites.
183:15:45	Started logging
188:09:25	Stopped all data logging for transit to PA (then on to Marinelli)
190:11:46	Started logging
195:1540	Stopped logging for NBP0505, end of cruise.



## Appendix: Sensors and Calibrations

### NBP0505 Sensors:

#### *Shipboard Sensors*

Sensor	Description	Serial #	Last Calibration Date	Status
<b>Meteorology &amp; Radiometers</b>				
Bridge Anemometer	RM Young 5106	WM45835	12/08/04	Not used
Port Anemometer	RM Young 5106	WM51144	09/27/04	Collect
Stbd Anemometer	RM Young 5106	WM46263	03/25/05	Collect
Barometer	RM Young 61201	00872	05/13/04	Collect
Air Temp/Rel. Hum.	RM Young 41372LC	06733	08/07/04	
Mast PRR	BSI PRR-610			Not used
UW PRR	BSI PRR-600			Not used
PIR (Pyrgeometer)	Eppler PIR	32845F3	06/28/04	Collect
PSP (Pyranometer)	Eppler PSP	32850F3	06/22/04	Collect
Mast PAR	BSI QSR-240	6357	6/24/03	Collect
GUV	Ed0 GUV-2511	25110203114	08/26/04	Collect
PUV				Not used
<b>Underway</b>				
TSG	SeaBird SBE21	2131020-3198	02/01/05	Collect
TSG Remote Temp (#3)	SeaBird 3S 3400m	032593	05/07/04	Collect
TSG Remote Temp (#5)	SeaBird 3-01/S	034080	06/30/04	Collect
Fluorometer	Turner 10-AU-005	5333-FRXX	04/14/04	Collect
Transmissometer	WET Labs C-Star	CST-439DR	09/27/04	Collect
Magnetometer	EG&G G-877			Used
Gravimeter	LaCoste & Romberg Gravity Meter			Collect
Bathymetry	Simrad EK500	3001	11/1/95	Collect
Bathymetry	Knudsen 320B/R			Collect
Bathymetry	Bathy 2000			Collect

### Calibrations

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

**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: **6/22/2005**  
 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 (Digital Gravity)	8971.0	17:06
Ship's meter after gravity tie (Digital Gravity)	8971.0	17:05
Average	8971.0	
Ship Gravimeter's Calibration Constant	1.0046	
Corrected ship's meter (Digital Gravity)	9012.3	

	Value	Time (GMT)
Ship's meter before gravity tie (serial, RVDAS)	8970.9	17:08
Ship's meter after gravity tie (serial, RVDAS)	8971.0	17:45
Average (for comparison check only)	8971.0	

Portable Gravimeter Correction Divisor 1.007937

Station	Value	Time (GMT)	Temp	Date	
Pier measurement 1	4907.33	17:14	53.5	June 22, 2005	OBS mgal, averaged
Pier measurement 2	4907.33	17:15	53.5	June 22, 2005	4868.69
Pier measurement 3	4907.33	17:16	53.5	June 22, 2005	
Average	4907.33				
Station measurement 1	4908.06	17:24	53.5	June 22, 2005	OBS mgal, averaged
Station measurement 2	4908.05	17:25	53.5	June 22, 2005	4869.40
Station measurement 3	4908.03	17:27	53.5	June 22, 2005	
Average	4908.05				
Pier measurement 4	4907.36	17:35	53.5	June 22, 2005	OBS mgal, averaged
Pier measurement 5	4907.35	17:36	53.5	June 22, 2005	4868.72
Pier measurement 6	4907.37	17:37	53.5	June 22, 2005	
Average	4907.36				

Gravity offset from last tie 972307.059  
 Drift since last tie 0.80

**OBS Differences**  
 Station to Pier (1, 2, & 3 averaged) -0.71  
 Station to Pier (4, 5, & 6 averaged) -0.68  
 Averaged Differences -0.70  
 Gravity at pier 981320.12  
 Elevation of pier above gravimeter, meters 0.0  
 Earth differential gravity, mgal/meter 0.3  
 Gravity at ship's gravimeter 981320.12  
 Gravity Offset 972307.86

Comments
Tie performed by Brent Evers at pier in Punta Arenas. Lots of dock work nearby (cranes, trucks, etc.), but consistent values.

**Meteorology System****Anemometer (Port)****RM Young Anemometer Calibration, Model 05106**

S/N: 46262

Date: 20-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	2.4	0.0	4.8
1000	4.90	4.9	0.0	9.5
1500	7.35	7.4	-0.1	14.3
2000	9.80	9.8	0.0	19.0
3000	14.70	14.8	-0.1	28.6
4000	19.60	19.8	-0.2	38.1
5000	24.50	24.8	-0.3	47.6
6000	29.40	29.8	-0.4	57.1
7000	34.30	34.8	-0.5	66.6
8000	39.20	39.8	-0.6	76.2
9000	44.10	44.7	-0.6	85.7
10000	49.00	49.7	-0.7	95.2
12000	58.80	59.6	-0.8	114.2

Direction	Measured Direction	Delta Direction
0	0	0
30	30	0
60	58	2
90	89	1
120	119	1
150	149	1
180	179	1
210	208	2
240	238	2
270	269	1
300	299	1
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	2.4	0.0
1000	4.90	4.9	0.0
1500	7.35	7.4	-0.1
2000	9.80	9.8	0.0
3000	14.70	14.8	-0.1
4000	19.60	19.8	-0.2
5000	24.50	24.8	-0.3
6000	29.40	29.8	-0.4
7000	34.30	34.8	-0.5
8000	39.20	39.8	-0.6
9000	44.10	44.8	-0.7
10000	49.00	49.7	-0.7
12000	58.80	59.7	-0.9

**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. Worn horizontal nose cone shaft. Replaced entire nose cone assembly. Good calibration.

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

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

S/N: 51144

Date: 20-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	1.0	0.0	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	9.8	0.0	19.0
3000	14.70	14.7	0.0	28.6
4000	19.60	19.6	0.0	38.1
5000	24.50	24.6	-0.1	47.6
6000	29.40	29.4	0.0	57.1
7000	34.30	34.3	0.0	66.6
8000	39.20	39.2	0.0	76.2
9000	44.10	43.9	0.2	85.7
10000	49.00	48.7	0.3	95.2
12000	58.80	58.1	0.7	114.2

Direction	Measured Direction	Delta Direction
0	0	0
30	30	0
60	60	0
90	90	0
120	120	0
150	151	-1
180	182	-2
210	212	-2
240	242	-2
270	272	-2
300	302	-2
330	332	-2
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	4.8	0.1
1500	7.35	7.3	0.0
2000	9.80	9.8	0.0
3000	14.70	14.6	0.1
4000	19.60	19.6	0.0
5000	24.50	24.5	0.0
6000	29.40	29.4	0.0
7000	34.30	34.3	0.0
8000	39.20	39.1	0.1
9000	44.10	43.8	0.3
10000	49.00	48.2	0.8
12000	58.80	57.7	1.1

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

Wind Speed Threshold < 2.9 gm?

Wind Direction Threshold < 30 gm?

**Additional Comments**

Installed new housing assy. and wind direction coupling. Adjusted horizontal nose cone shaft. Good calibration.

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

## Temperature



Meteorological Instruments

### Temperature Sensor Calibration Report

Customer: *Raytheon Tech Services*Test Number: 45062  
Test Date: 6 May 2004Customer PO: RM11141-50  
Sales Order: 7175

Model: 41372LC	<u>Test Sensor:</u>	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)
-50.03	4.000	-50.00
0.03	12.006	0.04
50.12	20.018	50.11

(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. Chumney*

R.M. YOUNG COMPANY 2801 Aero Park Drive, Traverse City, Michigan 49686 USA  
Tel: 231-946-3980 Fax: 231-946-4772 Email: met.sales@youngusa.com

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for Precision Measurements  
Since 1917**STANDARDIZATION OF  
EPPLEY PRECISION INFRARED RADIOMETER  
Model PIR**

Serial Number: 33023F3

Resistance: 764  $\Omega$  at 23  $^{\circ}\text{C}$   
Temperature Compensation Range: -20 to 40  $^{\circ}\text{C}$ 

This pyrgeometer has been compared with Precision Infrared Radiometer, Serial Number 29326F3 in Eppley's Blackbody Calibration System under radiation intensities of approximately 200 watts meter<sup>-2</sup> and an average ambient temperature of 25  $^{\circ}\text{C}$ .

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

$$3.86 \times 10^{-6} \text{ volts/watts meter}^{-2}$$

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

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

Shipped to:  
National Science Foundation  
Port Hueneme, CA

S.O. Number: 60151  
Date: January 24, 2005

Date of Test: January 20, 2005

In Charge of Test: *R. Egan*Reviewed by: *Thomas D. Hak*

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: eplab@mail.bbsnet.com

Internet: www.eppleylab.com



Scientific Instruments  
for Precision Measurements  
Since 1917

**STANDARDIZATION  
OF  
EPPLEY PRECISION SPECTRAL PYRANOMETER  
Model PSP**

Serial Number: 33090F3

Resistance: 699  $\Omega$  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<sup>-2</sup> (roughly one-half a solar constant). The adopted calibration temperature is 25 °C.

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

8.19  $\times 10^{-6}$  volts/watts meter<sup>-2</sup>

The calculation of this constant is based on the fact that the relationship between radiation intensity and emf is rectilinear to intensities of 1400 watts meter<sup>-2</sup>. This radiometer is linear to within  $\pm 0.5\%$  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 Ninth International Pyrheliometric Comparisons (IPC IX) at Davos, Switzerland in September-October 2000.

Useful conversion facts: 1 cal cm<sup>-2</sup> min<sup>-1</sup> = 697.3 watts meter<sup>-2</sup>  
1 BTU/ft<sup>2</sup>-hr<sup>-1</sup> = 3.153 watts meter<sup>-2</sup>

Shipped to:  
National Science Foundation  
Port Hueneme, CA

Date of Test: November 8, 2004

In Charge of Test: *R.T. Egan*

S.O. Number: 60076  
Date: November 11, 2004

Reviewed by: *Thomas D. Kirk*

Remarks:

**MAST PAR**

installed 11/2/03 03:03 GMT

**Biospherical Instruments Inc.**

## CALIBRATION CERTIFICATE

Calibration Date 6/24/03  
 Model Number QSR-240  
 Serial Number 6357  
 Operator TPC  
 Standard Lamp 98700(5/19/01)  
 Probe Excitation Voltage Range: 5 to 18 VDC(+)

Output Polarity: Positive

Probe Conditions at Calibration(in air):

Calibration Voltage: 6 VDC(+)

Probe Current: 7.1 mA

Probe Output Voltage:

Probe Illuminated 94.7 mV

Probe Dark 2.1 mV

Probe Net Response 92.6 mV

Corrected Lamp Output:

Output In Air (same condition as calibration):

9.14E+15 quanta/cm<sup>2</sup>sec  
0.015 uE/cm<sup>2</sup>sec

Calibration Factor:

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

Dry: 1.01E-17 V/(quanta/cm<sup>2</sup>sec)  
6.10E+00 V/(uE/cm<sup>2</sup>sec)

## Notes:

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

QSR240R 05/24/95



## TSG Calibration Files

### Underway Conductivity

#### 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: 3198  
CALIBRATION DATE: 01-Feb-05

SBE21 CONDUCTIVITY CALIBRATION DATA  
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

## GHJ COEFFICIENTS

g = -4.26982501e+000  
h = 5.04451229e-001  
i = -5.14140226e-004  
j = 5.01516148e-005  
CPcor = -9.5700e-008 (nominal)  
CTcor = 3.2500e-006 (nominal)

## ABCDM COEFFICIENTS

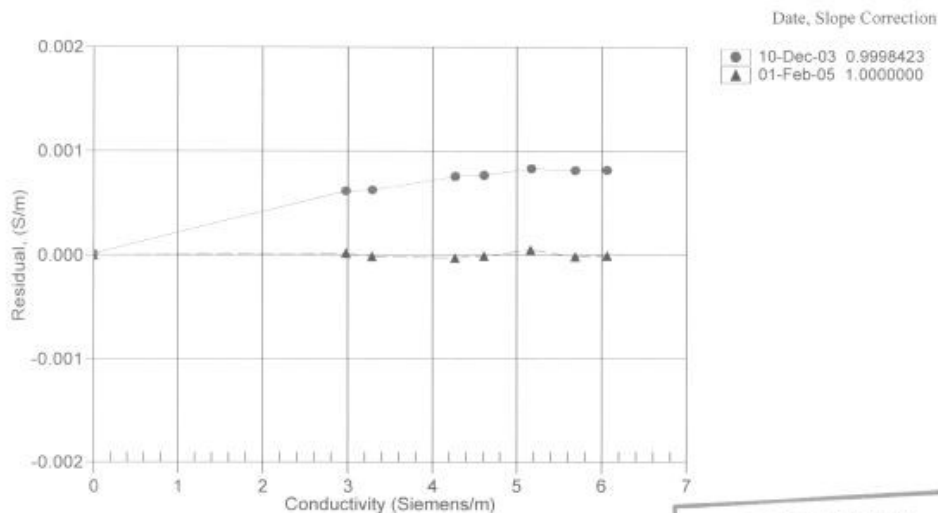
a = 1.64605226e-006  
b = 5.02580692e-001  
c = -4.26144824e+000  
d = -8.98538292e-005  
m = 5.0  
CPcor = -9.5700e-008 (nominal)

BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2.91244	0.00000	0.00000
0.9999	34.7963	2.97441	8.21830	2.97443	0.00002
4.4999	34.7760	3.28129	8.58001	3.28127	-0.00001
15.0000	34.7322	4.26239	9.64456	4.26236	-0.00003
18.5000	34.7227	4.60729	9.99140	4.60728	-0.00001
24.0000	34.7124	5.16487	10.52745	5.16492	0.00005
29.0000	34.7074	5.68649	11.00459	5.68647	-0.00001
32.5001	34.7057	6.05889	11.33265	6.05888	-0.00001

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

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

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

$$\text{Residual} = (\text{instrument conductivity} - \text{bath conductivity}) \text{ using } g, h, i, j \text{ coefficients}$$


**POST CRUISE  
CALIBRATION**

## Underway Temperature Sensor

### 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: 3198  
CALIBRATION DATE: 01-Feb-05SBE21 TEMPERATURE CALIBRATION DATA  
ITS-90 TEMPERATURE SCALE

## ITS-90 COEFFICIENTS

$g = 4.22378538e-003$   
 $h = 6.27547484e-004$   
 $i = 1.87696196e-005$   
 $j = 1.08059211e-006$   
 $f0 = 1000.0$

## ITS-68 COEFFICIENTS

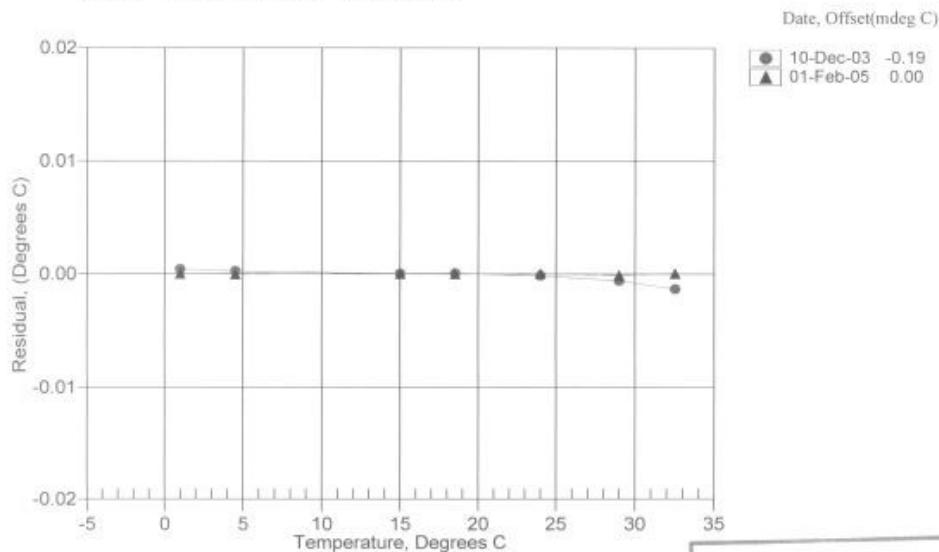
$a = 3.64763575e-003$   
 $b = 5.95164358e-004$   
 $c = 1.57386940e-005$   
 $d = 1.08194901e-006$   
 $f0 = 2568.337$

BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	2568.337	0.9999	0.00002
4.4999	2775.111	4.4998	-0.00004
15.0000	3467.500	15.0000	0.00002
18.5000	3723.427	18.5000	0.00000
24.0000	4152.232	24.0000	0.00004
29.0000	4571.184	28.9999	-0.00009
32.5001	4881.480	32.5001	0.00005

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

$$\text{Temperature ITS-68} = 1 / \{ a + b[\ln(f_0/f)] + c[\ln^2(f_0/f)] + d[\ln^3(f_0/f)] \} - 273.15 \text{ (}^\circ\text{C)}$$
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 Remote Temperature Sensor (primary)****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: 27-Jan-05SBE3 TEMPERATURE CALIBRATION DATA  
ITS-90 TEMPERATURE SCALE

## ITS-90 COEFFICIENTS

$g = 4.76634262e-003$   
 $h = 6.64670506e-004$   
 $i = 2.85058534e-005$   
 $j = 2.64012684e-006$   
 $f_0 = 1000.0$

## ITS-68 COEFFICIENTS

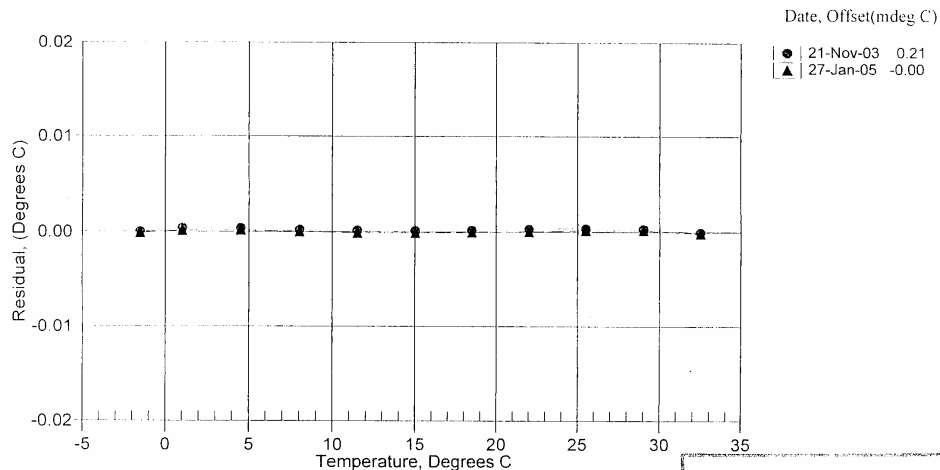
$a = 3.68121281e-003$   
 $b = 5.89542737e-004$   
 $c = 1.47371122e-005$   
 $d = 2.64160048e-006$   
 $f_0 = 5707.057$

BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.4999	5707.057	-1.5000	-0.00014
1.0002	6042.071	1.0003	0.00011
4.5002	6534.710	4.5004	0.00017
8.0002	7055.658	8.0002	0.00002
11.5002	7605.713	11.5001	-0.00013
15.0002	8185.648	15.0001	-0.00012
18.5002	8796.166	18.5001	-0.00006
22.0002	9437.953	22.0002	0.00001
25.5002	10111.682	25.5003	0.00014
29.0002	10817.954	29.0004	0.00017
32.5002	11557.311	32.5000	-0.00017

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

$$\text{Temperature ITS-68} = 1/\{a + b[\ln(f_0/f)] + c[\ln^2(f_0/f)] + d[\ln^3(f_0/f)]\} - 273.15 \text{ (}^\circ\text{C)}$$
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 Transmissometer**

PO Box 518  
620 Applegate St.  
Philomath, OR 97370



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

**C-Star Calibration**

Date	September 27, 2004	Customer	National Science Foundation	Work order	005
Job #	0102007	S/N#	CST-439DR	Pathlength	25 cm

	Analog meter
$V_d$	0.060 V
$V_{air}$	4.803 V
$V_{ref}$	4.694 V

Temperature of calibration water	22.3 °C
Ambient temperature during calibration	22.8 °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.

cstarcalsheet

Revision A

6/23/03

**Seacats and Current Meter****Seacat 19 #1 (s/n 2178)***SEACAT 19-01 S/N 2178***SEA-BIRD ELECTRONICS, INC.**1808 136th Place N.E., Bellevue, Washington 98005 USA  
Phone: (425) 643 - 9866 Fax: (425) 643 - 9954 Internet: seabird@seabird.comSENSOR SERIAL NUMBER = 2178  
CALIBRATION DATE: 27-Dec-01TEMPERATURE CALIBRATION DATA  
ITS-90 TEMPERATURE SCALE

## ITS-90 COEFFICIENTS

$$\begin{aligned} g &= 4.20266013e-03 \\ h &= 6.05642849e-04 \\ i &= 5.16962657e-06 \\ j &= -1.67616970e-06 \\ f_0 &= 1000.000 \end{aligned}$$

## IPTS-68 COEFFICIENTS

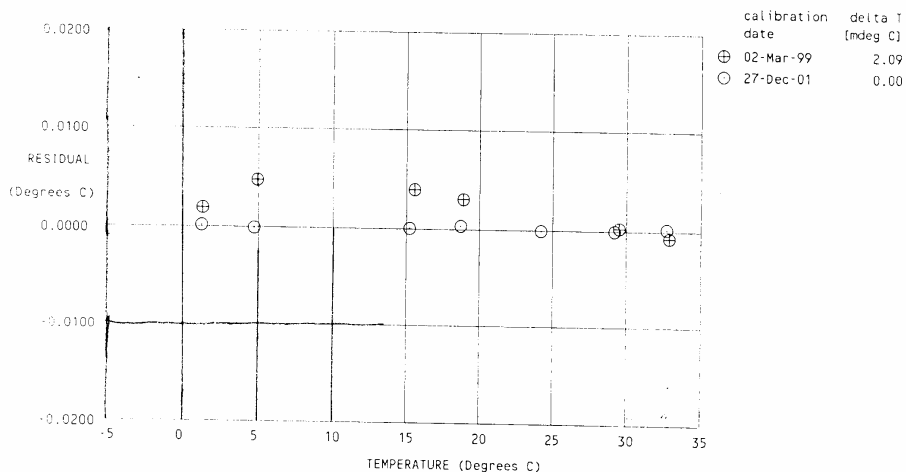
$$\begin{aligned} a &= 3.64763395e-03 \\ b &= 5.91899149e-04 \\ c &= 9.85106959e-06 \\ d &= -1.67564319e-06 \\ f_0 &= 2524.227 \end{aligned}$$

BATH TEMP (ITS-90 °C)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90 °C)	RESIDUAL (ITS-90 °C)
1.0000	2524.227	1.0001	0.00008
4.5002	2728.466	4.5001	-0.00013
14.9999	3410.978	14.9999	-0.00003
18.4998	3662.871	18.5001	0.00025
23.9999	4084.507	23.9997	-0.00016
29.0000	4496.184	28.9999	-0.00012
32.5000	4800.947	32.5001	0.00010

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

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

Residual = instrument temperature - bath temperature



**Seacat 19 #2 (s/n 2221)****Seacat 19-02 s/n 2221****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: 2221  
CALIBRATION DATE: 12-Dec-03SBE19 TEMPERATURE CALIBRATION DATA  
ITS-90 TEMPERATURE SCALE

## ITS-90 COEFFICIENTS

$g = 4.17792732e-003$   
 $h = 5.88907779e-004$   
 $i = -3.56029152e-006$   
 $j = -3.65735255e-006$   
 $f0 = 1000.0$

## ITS-68 COEFFICIENTS

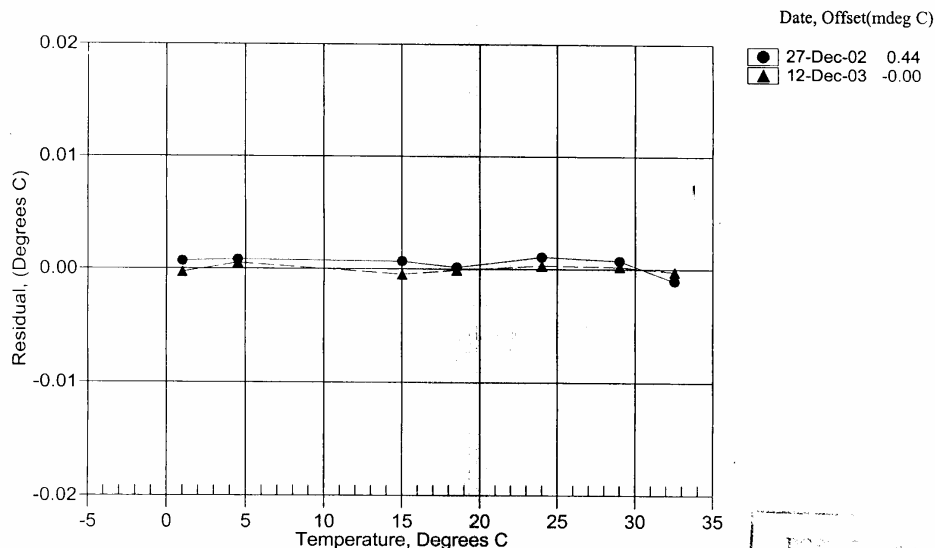
$a = 3.64764018e-003$   
 $b = 5.86567607e-004$   
 $c = 6.33967559e-006$   
 $d = -3.65738653e-006$   
 $f0 = 2459.810$

BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	2459.810	0.9996	-0.00029
4.5000	2660.685	4.5005	0.00054
15.0000	3331.615	14.9995	-0.00047
18.5000	3579.283	18.4999	-0.00009
23.9999	3993.969	24.0002	0.00032
29.0000	4398.979	29.0002	0.00022
32.5000	4698.901	32.4998	-0.00024

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

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



**Aanderaa RCM9 Current Meter (s/n 70)**

## Calibration Sheet

Recording Current Meter, RCM 9

Serial No.: 70Reference( channel 1): 596

The calibration coefficients listed below are valid for the sensors with the following serial numbers

Sensor	Range	Serial No.
Doppler Current Sensor 3620		562
Temperature Sensor 3621		80
Conductivity cell 3619		377
→ Pressure sensor 3615 D	0 - 20 MPa	389
Turbidity sensor 3612	0 - 20 NTU	67
Oxygen Sensor 3675		

## Calibration Coefficients:

Ch.No.	Parameter	A	B	C	D	Unit
1	Reference	0	1.000E+00	0	0	
2	Current Speed	0	4.889E-01	0	0	cm/s
3	Current Direction	0	3.516E-01	0	0	Deg.M
4	Temperature .....					
	Wide range	-6.304E-01	3.420E-02	-6.292E-06	4.800E-09	Deg.C
→	Low range	-2.790E+00	2.410E-02	-2.238E-06	2.056E-09	Deg.C
	High range	9.789E+00	2.392E-02	-5.941E-07	2.820E-09	Deg.C
	Arctic range	-3.097E+00	8.991E-03	-3.476E-07	1.134E-10	Deg.C
5	Conductivity .....					
	0-74mS/cm	-2.198E-01	7.327E-02	0	0	mS/cm
	37-74mS/cm	3.474E+01	4.022E-02	0	0	mS/cm
	0-2mS/cm	-3.531E-01	2.675E-03	0	0	mS/cm
6	Pressure	-3.991E-01	2.103E-02	-3.997E-07	0	MPa
7	Turbidity	-2.073E+00	3.784E-02	-4.982E-08	1.411E-08	NTU
	Oxygen			0	0	%

Date: 18/3-99 Sign: Nathaniel B. Palmer