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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," identifiable 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

process/ 0306jgof.tar
0306mgd.tar
0306proc.tar
0306pco2.tar
0306qcps.tar

NBP0306.trk
NBP0306.mgd
NBP0306.gmt

plots/ *Cruise Plots*

rvdas/uw/ 0306bat.tar
0306flr.tar
0306grv.tar
0306met.tar
0306pco2.tar
0306sim.tar
0306svp.tar
0306tsg.tar
0306mbdp.tar
0306oyo.tar
0306syn.tar

Volume 2

rvdas/nav/0306adu.tar
0306adcp.tar
0306gyr.tar
0306seap.tar
0306PCOD.tar

adcp/ pingdata files
config files

imagery/ *TeraScan satellite images*

ocean/ 0306ctd.tar
0306xbt.tar

report/ *Data Report*
rvdascal.txt

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

Cruise Track

The distribution DVD includes a GMT cruise track file (NBP0306.trk). It contains the longitude and latitude at one-minute intervals extracted from the NBP0306.gmt file.

Satellite Images

Satellite Images processed for this cruise can be found in the directory, /Imagery in two subdirectories, ice and wx (weather). Files are named using the convention, IdDDDYYA.jpg where:

Id = image type (is = ice ssmi, iv = ice visible, cw = seawifs, wx = weather)
DDD = year-day
YY = year
A = allows for multiple images of one type for one day

NBP Data Products

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

JGOFS

The JGOFS data set can be found on the distribution media in the file /process/0306jgof.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	μEinsteins/meter^2 sec
10	Sea surface temperature	°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)

Field	Data	Units
16	Ambient air temperature	°C
17	Relative humidity	%
18	Barometric pressure	mBars
19	Sea surface fluorometry	volts (0-5 FSO)
20	Not used	-
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 NBP0306.mgd. Also at the root level, NBP0306.gmt is the output of the mgd77togmt utility using NBP0306.mgd as input. The <cruiseid>.gmt file can be used by GMT plotting software.

The data used to produce the <cruiseid>.mgd file can be found on the distribution media in the file /process/0306proc.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)

Col	Len	Type	Contents	Description, Possible Values, Notes
67-72	6	real	Magnetics total field, 2ND sensor	In tenths of nanoteslas (gammas), for trailing sensor
73-78	6	real	Magnetics residual field	In tenths of nanoteslas (gammas). The reference field used is in Header Seq. 13
79	1	int	Sensor for residual field	1 = 1st or leading sensor 2 = 2nd or trailing sensor 9 = Unspecified
80-84	5	real	Magnetics diurnal correction	In tenths of nanoteslas (gammas). (In nanoteslas) if 9-filled (i.e., set to "+9999"), total and residual fields are assumed to be uncorrected; if used, total and residuals are assumed to have been already corrected.
85-90	6	F6.0	Depth or altitude of magnetics sensor	(In meters) + = Below sea level 3 = Above sea level
91-97	7	real	Observed gravity	In 10th of mgals. Corrected for Eotvos, drift, tares
98-103	6	real	EOTVOS correction	In 10th of mgals. E = 7.5 V cos phi sin alpha + 0.0042 V*V
104-108	5	real	Free-air anomaly	In 10th of mgals G = observed G = theoretical
109-113	5	char	Seismic line number	Cross-reference for seismic data
114-119	6	char	Seismic shot-point number	
120	1	int	Quality code for navigation	5=Suspected, by the originating institution 6=Suspected, by the data center 9=No identifiable problem found

Science of Opportunity

ADCP

The shipboard ADCP system measures currents in 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/0306adcp.tar. The archive consists of a single file for each day of data collection. The files are named `PINGDATA.xxx` where `xxx` is a day number that is NOT a year-day. For the date, use the file's creation date.

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 `0306adcp.tar` in the directory `/rvdas/nav`.

PCO_2

The NBP carries Lamont-Doherty Earth Observatory's (LDEO) pCO_2 system and RPSC staff maintains it. Data is sent to LDEO at the end of each cruise. The pCO_2 data is transmitted and archived on RVDAS. You will find it in a file named `NBP0306pco2.tar` in the /`process` directory, which contains the pCO_2 instrument's data merged with GPS, meteorological and other oceanographic measurements. For more information contact Colm Sweeney (csweeney@ldeo.columbia.edu) for additional information.

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 0306`xbt.tar` in the `/ocean` directory.

RVDAS

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

Daily data processing of the RVDAS (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 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: `NBP0107.met1.d317`

- The CruiseID is the numeric name of the cruise, in this case, <cruiseid>.
- 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	Eppley PIR
PSP (SW radiation)	met1	continuous	1 sec	Eppley PSP
PAR	met1	continuous	1 sec	BSI QSR-240
GUV	guv	not collected	2 sec	BSI PUV-511
PUV	puv	not collected		BSI PUG-500

Geophysics

Measurement	Channel ID	Collect. Status	Rate	Instrument
Gravimeter	grv1	Continuous	10 sec*	LaCoste & Romberg
Magnetometer	mag1	Continuous	15 sec	EG&G G-866
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	
Transmissometry	tsg1	Continuous	6 sec	WET Lab C-Star
pCO_2	pco2	Continuous	70 sec	(LDEO)
ADCP	adcp	Continuous	varies	RD Instruments

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

Syntron Data (syn1)

```
00+120:10:46:30.665 *GCS 900228     005
811.00001E00/04/29:10:45:5311060600000000403000-0.050.023    00000000-
00101AP1N 000156498-0100002AP1N 00016350100100003AP1N 000162497-
0200004AP1N 00015850000000005AP1N 00015550100100006AP1N 000157500000000
```

Field	Data	Units
1	RVDAS time tag	
2	String tag	
3	Number of bytes	
4	Line number	
5	Shotpoint number	

Navigational Instruments

Measurement	Channel ID	Collect. Status	Rate	Instrument
Attitude GPS	Adu1	continuous	1 sec	Ashtech ADU2
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

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 18 for calculations.

Gravimeter (grv1)

```
99+099:00:18:19.775 your_line#1999 99 01818 9735.4
```

Field	Data	Conversion	Units
1	RVDAS time tag		
2	Text string		
3	Gravity device date	yyyydddhhmmss	
4	Gravity count	mgal = count x 1.0047 + offset	count

Magnetometer (mag1)

```
99+099:00:00:23.203 %  0  98 235928    0? 372453
```

Field	Data	Units
1	RVDAS time tag	
2	% 0 denotes G-866 magnetometer	
3	Year-day	
4	Time	
5	0? Denotes high noise condition	
6	Magnetic data (last digit is 10^{th}'s place)	nT

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

Field	Data	Format / Possible Values	Units
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 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	

Field	Data	Format / Possible Values	Units
		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
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)

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 20 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_2

```
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_2 time tag (decimal is fractional time of day)	yyyddd.ttt
3	Raw voltage	mV
4	Barometer	mBar
5	Cell temperature	°C
6	Flow rate	ml/min
7	Concentration	ppm
8	pCO_2 pressure	microAtm
9	Equilibrated temperature	°C
10	Latitude (not collected)	
11	Longitude (not collected)	

Navigational Data

Seapath GPS (seap)

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
BPGGA,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	

INVTG

```
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	$INVTG	
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	

Field	Data	Units
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	

Ashtech GPS (3df1)

The Ashtech GPS outputs three NMEA standard data strings:

- Measurement data (PBN)
- Attitude data (ATT)
- GPS position fix (GGA)

Measurement data (PBN)

```
01+324:00:00:00.064 $PASHR,PBN,172812.00,2129908.6,-1869076.7,-5694992.4,
-063:41.9477,-041:16.0918,00066.2,000.16,002.85,-000.90,08,????,02,01,01,
01*3A
```

Field	Data	Units
1	RVDAS time tag	
2	$PASHR	

Field	Data	Units
3	PBN	
4	GPS Time sec. of the week	seconds
5	Station Position: ECEF X	meters
6	Station Position: ECEF Y	meters
7	Station Position: ECEF Z	meters
8	Latitude (- = South)	deg:min
9	Longitude (- = West)	deg:min
10	Altitude	meters
11	Velocity in ECEF X	m/sec
12	Velocity in ECEF Y	m/sec
13	Velocity in ECEF Z	m/sec
14	Number of satellites used	
15	Site name	
16	PDOP	
17	HDOP	
18	VDOP	
19	TDOP	

GPS Position Fix – Geoid/Ellipsoid (GGA)

```
01+324:00:00:00.323 $GPGGA,235959.00,6341.9477,S,04116.0918,W,1,08,00.9,
+00066,M,,M,,*77
```

Field	Data	Units
1	RVDAS time tag	
2	$GPGGA	
3	UTC time at position	hhmmss.ss
4	Latitude	ddmm.mmm
5	North (N) or South (S)	
6	Longitude	ddmm.mmm
7	East (E) or West (W)	
8	GPS quality: (1 = GPS, 2 = DGPS)	
9	Number of GPS satellites used	
10	HDOP	
11	Antenna height	meters
12	M for Meters	
13	Geoidal height (no data in the sample string)	meters
14	M for meters	
15	Age of diff. 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)	

Attitude Data (ATT)

```
01+324:00:00:00.845 $PASHR,ATT,172813.0,137.88,+000.52,-001.41,0.0029,
0.0254,0*2F
```

Field	Data	Units
1	RVDAS Time tag	
2	$PASHR	
3	ATT	
4	GPS Time sec. Of the week	seconds
5	Heading (rel. to true North)	degrees
6	Pitch	degrees
7	Roll	degrees
8	Measurement RMS error	meters

Field	Data	Units
9	Baseline RMS error	meters
10	Attitude reset flag	

Trimble P-Code GPS (PCOD)

The Trimble GPS 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 $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

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_2 time tag (decimal is time of day)	yyyddd.ttt
3	Raw voltage	mV
4	Barometer	mB
5	Cell temperature	°C
6	Flow rate	cm^3/min
7	Concentration	ppm

Field	Data	Units
8	PCO_2 pressure	microAtm
9	Equilibrated temperature	°C
10	Flow Source (Equil = pCO_2 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

Seismic Time Clock Data (stc1)

```
00+019:23:59:46.976 ##r yyyydddhhmmssuuuuuuSSCC      (format)

00+347:00:00:05.013 ## B FFFF 347 00 00 04 956831 15 29    (example string)
```

Field	Data	Units
1	RVDAS time tag	
2	r is the input time code "B" for IRIG-B	
3	yyyy is the year (FFFF if IRIG input)	
4	ddd is the 3 digit year-day	
5	hh is 2 digit hour of day	
6	mm is 2 digit minute of hour	
7	ss is 2 digit second of minute	
8	uuuuuu is 6 digits for microseconds digits	
9	SS is 2 hex character DP-Extd_Sts dual port RAM value	
10	CC is checksum	

Oyo

```
04+009:08:21:53.799   3388     31     49
```

Field	Data	Units
1	RVDAS Time Tag	
2	OYO Shot	
3	Reel	
4	Channel	

Calculations

The file *rvdascal.txt* located in the `/reports` 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 rvdascal.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 = $1/\{g + h[ln(f_0/f)] + i[ln^2(f_0/f)] + j[ln^3(f_0/f)]\} - 273.15$ (°C)

Calculating Conductivity – ITS-90

C = decimal equivalent of bytes 5-8
Conductivity Frequency f = sqrt(C*2100+6250000)
Conductivity = $(g + hf^2 + if^3 + jf^4)/[10(1 + \delta t + \varepsilon p)]$ (siemens/meter)
t = temperature (°C); p = pressure (decibars); δ = Ctcor; ε = CPcor

Calculating Fluorometry Voltage (Subject to nonlinear A/D errors)

(*Fluormeter Digital Signal is better*)

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

Calculating Transmittance

V_{dark} = 0.058 V
V_{ref} = 4.765 V
t = decimal equivalent of bytes 18 – 20
Transmissometer Voltage (V_{signal}) = t/819
% Transmittance = $(V_{signal} - V_{dark}) / (V_{ref} - V_{dark})$

PAR

raw data = mV
calibration scale = 6.08 V/(μEinstiens/cm ^{2}sec)
offset (V_{dark}) = 0.3 mV
(*raw* mV - V_{dark})/scale x 10^4 cm^2/m^2 x 10^{-3} V/mV= μEinstiens/m^2sec
or
(*data* mV – 0.3 mV) x 1.65 (μEinstiens/m^2sec)/mV = μEinstiens/m^2sec

PIR

raw data = mV

calibration scale = 4.13 x 10^{-6} V/(W/m^2)
data mV / (scale x 10^3 mV/V) = W/m^2
or
data mV x 242.1(W/m^2)/mV = W/m^2

PSP

raw data = mV
calibration scale = 8.28 x 10^{-6} V/(W/m^2)
data mV / (scale x 10^3 mV/V) = W/m^2
or
data mV x 120.7 (W/m^2)/V = W/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	End	Description
005 12:00		Data Collection Begins
006 03:35	006 03:45	FRAM (Display Server) locked. System rebooted and displays reset.
006 04:13	006 05:27	FRAM StorageWorks Tape Back Up lock. System PM'd, diagnostics run, system put back online.
007 03:54	007 04:35	FRAM StorageWorks Tape Back Up lock / Failure. System taken offline and manual data tape back up system employed.
008 03:05	008 05:48	MultiBeam System (Glacier) down; restored and operational.
	0015	End Data Collection

Appendix: Sensors and Calibrations

NBP0306 Sensors:

Shipboard Sensors

Sensor	Description	Serial #	Last Calibration Date	Status
Meteorology & Radiometers				
Port Anemometer	RM Young 5106	WM46834	04/11/01	Collect
Stbd Anemometer	RM Young 5106	WM46263	04/11/01	Collect
Barometer	RM Young 61201	01705	06/01/01	Collect
Air Temp/Rel. Hum.	RM Young 41372LC	06134	06/01/01	
Mast PRR	BSI PRR-610			Not used
UW PRR	BSI PRR-600			Not used
PIR (Pyrgeometer)	Eppley PIR	32845F3	02/22/01	Collect
PSP (Pyranometer)	Eppley PSP	33850F3	02/09/01	Collect
Mast PAR	BSI QSR-240	6356	2/15/01	Collect
GUV				Not used
PUV				Not used
Underway				
TSG	SeaBird SBE21	857	02/07/01	Collect
TSG Remote Temp	SeaBird 3-01/S	1267	01/12/01	Collect
Fluorometer	Turner 10-AU-005 Lamp: daylight 10-045; ref. filter: 10-052, em. filter: 10-051, ex. filter: 10-050	5651 FRTD	N/A	Collect
Transmissometer	WET Labs C-Star	CST-423PR	01/02/01	Collect
Magnetometer	EG&G G-866			Not used
Gravimeter	LaCoste & Romberg Gravity Meter			Collect
Bathymetry	Simrad EK500	3001	11/1/95	Collect
Bathymetry	Knudsen 320B/R			Collect
Bathymetry	Bathy 2000			Collect
Other				
P-Code GPS	Trimble 20636-00 (SM)	0220035116	Key expires 07/10/02	Collect
Attitude GPS	Ashtech 12	700273F2114 FW 7B13-D1-C21	N/A	Collect

Meteorology System

Anemometer (Port)

RM Young Anemometer Calibration, Model 05106

S/N: 45262 **Date:** 25-Feb-03 **Cal'd By:** Bruce Felix

Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s	Knots
0	0.00	0.0	0.0	0
200	0.98	0.9	0.1	1.904
500	2.45	2.3	0.2	4.76
1000	4.90	4.8	0.1	9.52
1500	7.35	7.3	0.0	14.28
2000	9.80	9.8	0.0	19.04
3000	14.70	14.8	-0.1	28.56
4000	19.60	19.8	-0.2	38.08
5000	24.50	24.8	-0.3	47.6
6000	29.40	29.8	-0.4	57.12
7000	34.30	34.7	-0.4	66.64
8000	39.20	39.7	-0.5	76.16
9000	44.10	44.7	-0.6	85.68
10000	49.00	49.6	-0.6	95.2
12000	58.80	59.4	-0.6	114.24

Direction	Measured Direction	Delta Direction
0	0	0
30	28.5	1.5
60	59	1
90	90	0
120	120	0
150	149	1
180	179	1
210	209	1
240	240	0
270	269.5	0.5
300	300	0
330	330	0
0	0	0

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

Counter Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s
0	0.00	0.0	0.0
200	0.98	0.9	0.1
500	2.45	2.3	0.2
1000	4.90	4.8	0.1
1500	7.35	7.3	0.0
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	34.7	-0.4
8000	39.20	39.7	-0.5
9000	44.10	44.7	-0.6
10000	49.00	49.7	-0.6
12000	58.80	59.5	-0.7

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

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: 51143 Date: 15-Jun-03 Cal'd By: S. Blackman

Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s	knots
0	0.00	0.0	0.0	0.0
200	0.98	0.9	0.1	1.9
500	2.45	2.3	0.2	4.8
1000	4.90	4.8	0.1	9.5
1500	7.35	7.4	-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	29.7	-0.3	57.1
7000	34.30	34.7	-0.4	66.6
8000	39.20	39.7	-0.5	76.2
9000	44.10	44.7	-0.6	85.7
10000	49.00	49.6	-0.6	95.2
12000	58.80	59.5	-0.7	114.2

Direction	Measured Direction	Delta Direction
0	0	0
30	29	1
60	59	1
90	89	1
120	120	0
150	150	0
180	180	0
210	210	0
240	242	-2
270	273	-3
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	0.1	-0.1
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	14.8	-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	34.7	-0.4
8000	39.20	39.7	-0.5
9000	44.10	44.7	-0.6
10000	49.00	49.6	-0.6
12000	58.80	59.5	-0.7

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

This instrument does not appear to have been used. It's new cal date should start with it's installation.

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

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: eplab@mail.bbsnet.com Internet: www.eppleylab.com

EPLAB
Scientific Instruments for Precision Measurements Since 1917

STANDARDIZATION OF EPPLEY PRECISION INFRARED RADIOMETER Model PIR

Serial Number: 32845F3

Resistance: 739 Ω at 23 °C
Temperature Compensation Range: -20 to 40 °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^{-2} and an average ambient temperature of 24 °C.

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

$$4.14 \times 10^{-6} \text{ volts/watts meter}^{-2}$$

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 ±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:
Raytheon Polar Services
Port Hueneme, CA

S.O. Number: 59471
Date: July 3, 2003

Date of Test: June 9, 2003

In Charge of Test: R T Eppley

Reviewed by: Thomas D Kuh

Remarks:

PSP

Biospherical Instruments Inc.

CALIBRATION CERTIFICATE

Calibration Date	2/3/03	
Model Number	QSR-240	Mast PAR
Serial Number	6356	
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:	1.2	mA

Probe Output Voltage:

Probe Illuminated	92.4	mV
Probe Dark	0.4	mV
Probe Net Response	92.0	mV

Corrected Lamp Output:

Output In Air (same condition as calibration):

9.14E+15	quanta/cm²sec
0.015	uE/cm²sec

Calibration Factor:

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

Dry:	1.01E-17	V/(quanta/cm²sec)
	6.06E+00	V/(uE/cm²sec)

Notes:

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

:240R 05/24/95

PAR

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

EPLAB
Scientific Instruments for Precision Measurements Since 1917

STANDARDIZATION OF EPPLEY PRECISION SPECTRAL PYRANOMETER Model PSP

Serial Number: 32850F3

Resistance: 706 Ω at 23 °C
Temperature Compensation Range: -20 to 40 °C

This radiometer has been compared with Standard Precision Spectral Pyranometer, Serial Number 21231F3 in Eppley's Integrating Hemisphere under radiation intensities of approximately 700 watts meter^{-2} (roughly one-half a solar constant). The adopted calibration temperature is 25 °C.

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

8.12 x 10^{-6} volts/watts meter^{-2}

The calculation of this constant is based on the fact that the relationship between radiation intensity and emf is rectilinear to intensities of 1400 watts meter^{-2}. This radiometer is linear to within ± 0.5% up to this intensity.

The calibration of this instrument is traceable to standard self-calibrating cavity pyrheliometers in terms of the Systems Internationale des Unites (SI units), which participated in the Ninth International Pyrheliometric Comparisons (IPC IX) at Davos, Switzerland in September-October 2000.

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

Shipped to:
Raytheon Services
Port Hueneme, CA

Date of Test: July 3, 2003

In Charge of Test: R. T. Eppley

S.O. Number: 59471
Date: July 3, 2003

Reviewed by: Thomas D. Kirk

Remarks: Sensitivity before repainting 7.97

Installed 11/2/03 0300 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/cm²sec
0.015	uE/cm²sec

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

Dry:	1.01E-17	V/(quanta/cm²sec)
	6.10E+00	V/(uE/cm²sec)

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

QSR240R 05/24/95

TSG Calibration Files

Underway Conductivity Sensor

Inst. Ht. 1/1/03 21:40 GM

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: 1390
CALIBRATION DATE: 29-May-03

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

GHIJ COEFFICIENTS

g = -3.92868160e+000
h = 4.69806858e-001
i = 7.64098134e-004
j = -1.60788378e-005
CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

ABCDM COEFFICIENTS

a = 3.67483151e-002
b = 4.29412267e-001
c = -3.91316767e+000
d = -9.02523180e-005
m = 2.1
CPcor = -9.5700e-008 (nominal)

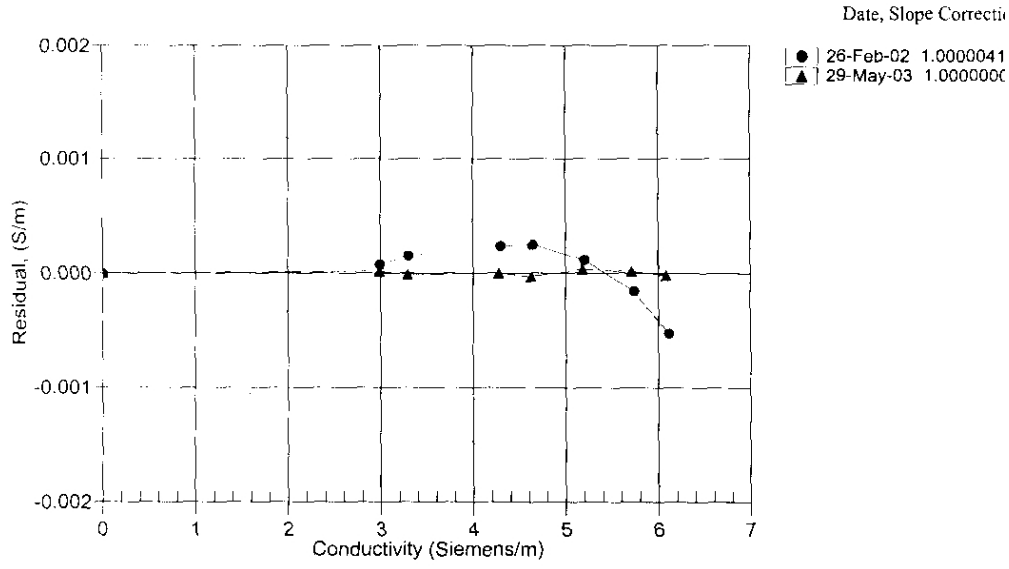
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2.88542	0.00000	0.00000
1.0000	34.8296	2.97699	8.42198	2.97701	0.00001
4.4999	34.8298	3.28586	8.79780	3.28585	-0.00001
15.0001	34.8286	4.27297	9.90293	4.27297	-0.00000
18.4998	34.8281	4.61975	10.26266	4.61971	-0.00003
24.0000	34.8272	5.18007	10.81853	5.18010	0.00003
28.9999	34.8259	5.70370	11.31305	5.70372	0.00002
32.5000	34.8235	6.07710	11.65274	6.07708	-0.00002

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

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

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

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



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

SENSOR SERIAL NUMBER = 857
CALIBRATION DATE: 11-Feb-03

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

GHIJ COEFFICIENTS

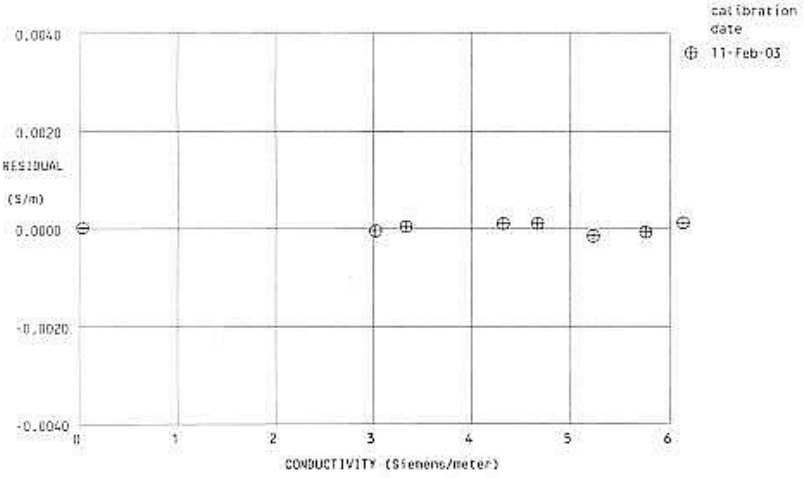
g = -3.88487313e+00
h = 4.63101992e-01
i = 1.34441099e-03
j = -3.93800080e-05
CPcor = -9.57e-08 (nominal)
CTcor = 3.25e-06 (nominal)

ABCDM COEFFICIENTS

a = 4.56144948e-02
b = 4.15067913e-01
c = -3.87643249e+00
d = -1.63462167e-04
m = 2.1
CPcor = -9.57e-08 (nominal)

BATH TEMP (ITS-90 °C)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2.88531	0.00000	0.00000
1.0000	35.0014	2.99027	8.46371	2.99021	-0.00006
4.4999	35.0000	3.30033	8.84134	3.30035	0.00002
15.0000	34.9951	4.29122	9.95142	4.29131	0.00009
18.5001	34.9938	4.63937	10.31285	4.63946	0.00009
24.0001	34.9932	5.20202	10.87115	5.20186	-0.00016
29.0001	34.9903	5.72761	11.36808	5.72753	-0.00008
32.5000	34.9866	6.10232	11.70953	6.10242	0.00010

Conductivity = $(g + hf^2 + if^3 + jf^4) / [10(1 + \delta t + \epsilon p)]$ Siemens/meter
Conductivity = $(af^m + bf^2 + c + dt) / [10(1 + \epsilon p)]$ Siemens/meter
t = temperaure [deg C]; p = pressure [decibars]; δ = CTcor; ϵ = CPcor;
Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



Underway Temperature Sensor

Installed 11/5/03 21:40 GMT

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: 1390
CALIBRATION DATE: 29-May-03

SBE21 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS
g = 4.21019024e-003
h = 5.94640281e-004
i = 4.44891723e-006
j = -1.86469051e-006
f0 = 1000.0

ITS-68 COEFFICIENTS
a = 3.64763709e-003
b = 5.81167551e-004
c = 9.81916346e-006
d = -1.86421698e-006
f0 = 2600.237

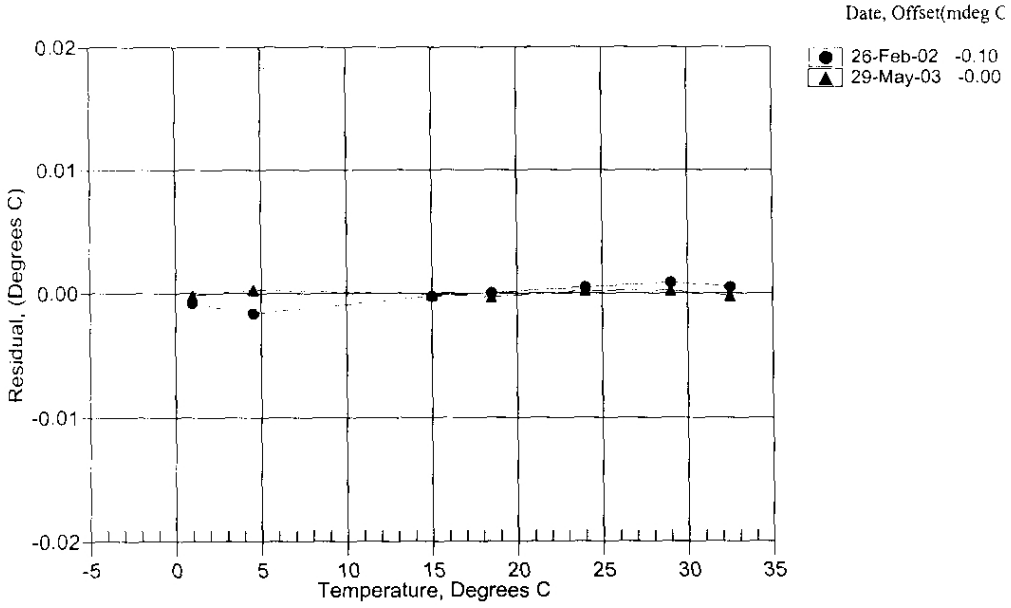
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
1.0000	2600.237	0.9998	-0.00016
4.4999	2814.700	4.5002	0.00028
15.0001	3533.544	15.0000	-0.00008
18.4998	3799.584	18.4995	-0.00029
24.0000	4245.942	24.0002	0.00022
28.9999	4682.643	29.0001	0.00022
32.5000	5006.484	32.4998	-0.00019

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

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

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

Residual = instrument temperature - bath temperature



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

SENSOR SERIAL NUMBER = 857
CALIBRATION DATE: 11-Feb-03

TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.24049398e-03
h = 5.98239597e-04
i = 3.89001102e-06
j = -1.91364373e-06
f_0 = 1000.000

IPTS-68 COEFFICIENTS

a = 3.64763895e-03
b = 5.84844252e-04
c = 9.65980297e-06
d = -1.91318848e-06
f_0 = 2720.216

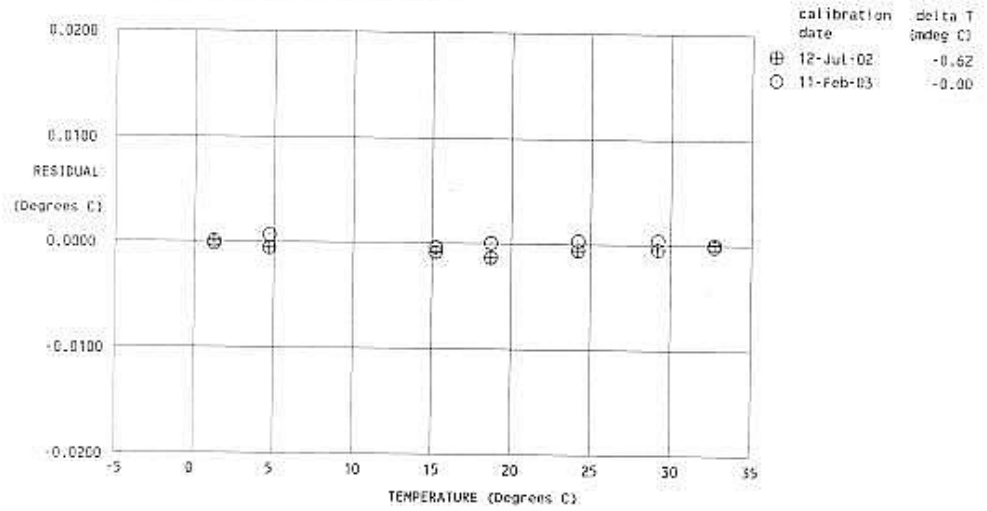
BATH TEMP (ITS-90 °C)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90 °C)	RESIDUAL (ITS-90 °C)
1.0000	2720.216	0.9997	-0.00030
4.4999	2943.126	4.5005	0.00055
15.0000	3689.274	14.9995	-0.00049
18.5001	3965.221	18.5001	-0.00004
24.0001	4427.700	24.0003	0.00023
29.0001	4879.863	29.0004	0.00033
32.5000	5214.905	32.4997	-0.00028

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

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

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

Residual = instrument temperature - bath temperature



Underway Remote Temperature Sensor

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

SENSOR SERIAL NUMBER = 2593
CALIBRATION DATE: 06-Feb-03s

TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.27986177e-03
h = 6.19586021e-04
i = 2.06496791e-05
j = 1.61096809e-06
f_0 = 1000.000

IPTS-68 COEFFICIENTS

a = 3.68121114e-03
b = 5.83363745e-04
c = 1.58585118e-05
d = 1.61237533e-06
f_0 = 2709.478

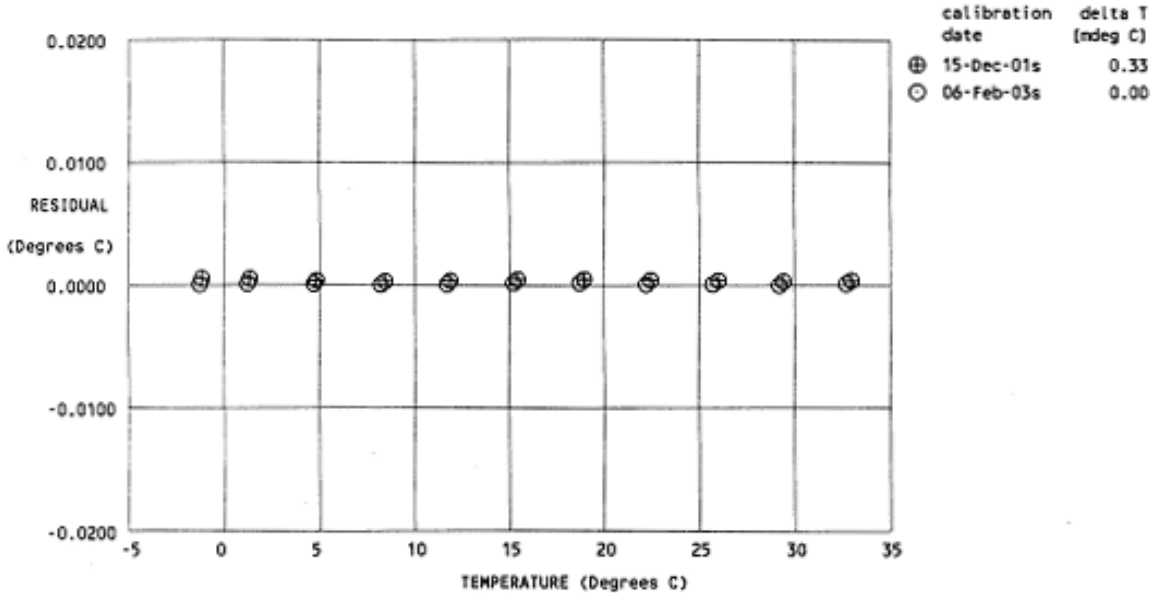
BATH TEMP (ITS-90 °C)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90 °C)	RESIDUAL (ITS-90 °C)
-1.4999	2709.478	-1.4999	-0.00001
1.0001	2870.267	1.0001	0.00003
4.5001	3106.997	4.5001	0.00001
8.0001	3357.687	8.0000	-0.00006
11.5001	3622.778	11.5001	-0.00003
15.0001	3902.688	15.0002	0.00005
18.5001	4197.822	18.5002	0.00007
22.0002	4508.589	22.0002	-0.00004
25.5001	4835.381	25.5001	-0.00000
29.0002	5178.600	29.0001	-0.00007
32.5001	5538.610	32.5001	0.00005

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

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



Underway Transmissometer

PO Box 518
620 Applegate St.
Philomath OR 97370

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

WET Labs

C-Star Calibration Sheet

Date:	**02/24/03**
Customer:	**National Science Foundation**
Serial Number:	**CST-422PR**
Job Number:	**0012016**
Work Order:	**005**

V_d = V dark	**0.058**
V_{air} = V out in air	**4.884**
V_{ref} = V out in water	**4.772**
Calibration temperature of water	**19.6**
Ambient temperature	**21.8**

% Transmission = $(V_{sig}-V_d)/(V_{ref}-V_d)$
$Tr = e^{-cx}$
To solve for the attenuation coefficient **c** in units of m^{-1} use the following equation.
$c = -1/x\ (\ln(V_{sig}-V_d)/(V_{ref}-V_d))$
For further information on these calculations please see C-Star User's Guide, Section 2.

Temperature Error: 0.02% F.S./°C

NOTES

- **(V_d)**—analog output of the instrument with the beam blocked. This is an instrumental offset.
- **(V_{air})**—analog output voltage of the instrument with a cleared beam path.
- **(V_{ref})**—analog output voltage of the instrument with clean H_2O in the path.
- **(Calibration Temperature of water)**—temperature of the clean water used to obtain V_{ref}.
- **(Ambient Temperature)**—temperature of the instrument during the calibration procedures.
- **(V_{sig})**—measured signal voltage of the C-Star.

Gravity Tie Meter

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: 12/15/2003
Location: Lyttelton/Christchurch, New Zealand
Station: Ranger's Hut, Botanical Gardens
Latitude: 43 31.77 S
Longitude: 172 37.18 E
Elevation: 6.7 meters
Gravity: 980494.29

Reference Code Numbers:

ADIC	0217-0
IGC	48732A
DSIR	P11
GW	79
NHO	16

	Value	Time (GMT)
Ship's meter before gravity tie (Digital Gravity)	8156.2	19:22
Ship's meter after gravity tie (Digital Gravity)	8156.2	23:05
Average	8156.2	
Ship Gravimeter's Calibration Constant	1.0046	
Corrected ship's meter (Digital Gravity)	8193.7	

	Value	Time (GMT)
Ship's meter before gravity tie (serial, RVDAS)	8193.7	19:33
Ship's meter after gravity tie (serial, RVDAS)	8193.8	23:15
Average (for comparison check only)	8193.8	

Portable Gravimeter Correction Divisor 1.007937

Station	Value	Time (GMT)	Temp	Date	OBS mgal, averaged
Pier measurement 1	4119.53	19:49	53.5	December 15, 2003	
Pier measurement 2	4119.43	19:52	53.5	December 15, 2003	4087.09
Pier measurement 3	4119.62	19:54	53.5	December 15, 2003	
Average	4119.53				
Station measurement 1	4088.11	21:11	53.5	December 15, 2003	
Station measurement 2	4088.12	21:14	53.5	December 15, 2003	4055.94
Station measurement 3	4088.16	00:00	53.5	December 15, 2003	
Average	4088.13				
Pier measurement 4	4119.66	23:05	53.5	December 15, 2003	
Pier measurement 5	4119.64	23:07	53.5	December 15, 2003	4087.22
Pier measurement 6	4119.69	23:11	53.5	December 15, 2003	
Average	4119.66				

Gravity offset from last tie 972337.78
Drift since last tie -6.52

OBS Differences	
Station to Pier (1, 2, & 3 averaged)	31.15
Station to Pier (4, 5, & 6 averaged)	31.29
Averaged Differences	31.22
Gravity at pier	980525.51
Elevation of pier above gravimeter, meters	-1.8
Earth differential gravity, mgal/meter	0.3
Gravity at ship's gravimeter	980524.98
Gravity Offset	972331.26

Comments

Tie completed by W. Gallagher and F. Trujillo. Rebuilt gyros were installed by J. Otten during the port period just prior to this tie.