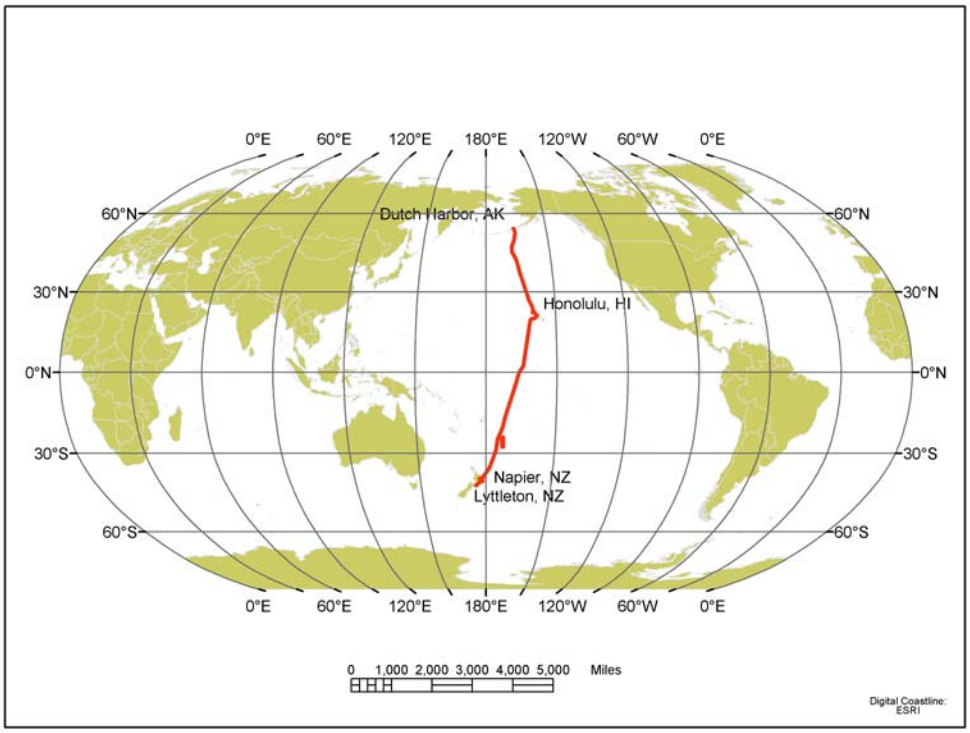
Data Report
NBP0304B-C-D

Stock/Cande/Jeffreys

Aug 28 – Oct 14, 2003



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Introduction

This data distribution includes three legs of the south bound cruise from Dutch Harbor to New Zealand. NBP0304B, C and D. All data sets having the designator of B include C and D as well.

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-ROM (DVD-R) written in ISO9660 level-1 format. It is readable by virtually every computing platform.

All the data have 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 decompressing 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.

SEISMIC DATA

The NBP also collected seismic data on days 270 – 275 in international waters and on days 282 – 285 off the coast of New Zealand. This data is being distributed to New Zealand and Cal Tech on DVD. There are a DLT tape copy and DVD copy on the NBP.

For days 270 – 275 the seismic data are three sets of disks. There were 2 lines of seismic data collected. The raw data for each line is on its own set of disks. The processed ISIS data is on a third set of 2 disks (DVDs).

Set 1 (line 1) spans 2 DVDs and one CDROM.

DVD 1 Contents (Title NBP0304B_L1_P1)

TOCL1_1.TXT	Table of Contents text file
L1_PRT1.TAR	Seismic data and corisponding lat/long data
L1_INFO1.TAR	Lat/long data and seismic report (gun setup)

DVD 2 Contents (Title NBP0304B_L1_P2)

TOCL1_2.TXT	Table of Contents text file
L1_PRT2.TAR	Seismic data and corisponding lat/long data
L1_INFO2.TAR	Lat/long data and seismic report (gun setup)

CD 1 Contents (Title NBP0304B_L1_P3)

TOCL1_1.TXT	Table of Contents text file

L1_PRT1.TAR	Seismic data and corisponding lat/long data
L1_INFO1.TAR	Lat/long data and seismic report (gun setup)

Set 2 (line 2) spans 3 DVDs and one CDROM.

DVD 1 Contents (Title NBP0304B_L2_P1)

TOCL1_1.TXT	Table of Contents text file
L1_PRT1.TAR	Seismic data and corisponding lat/long data
L1_INFO1.TAR	Lat/long data and seismic report (gun setup)

DVD 2 Contents (Title NBP0304B_L2_P2)

TOCL1_2.TXT	Table of Contents text file
L1_PRT2.TAR	Seismic data and corisponding lat/long data
L1_INFO2.TAR	Lat/long data and seismic report (gun setup)

DVD 3 Contents (Title NBP0304B_L1_P3)

TOCL1_1.TXT	Table of Contents text file
L1_PRT1.TAR	Seismic data and corisponding lat/long data
L1_INFO1.TAR	Lat/long data and seismic report (gun setup)

Seismic data from days NBP0304D spans 4 DVDs

DVD 1 Contents (Title 0304_NZ_SEISMIC_1)

Gzipped SEG-Y data	
D1_TOC.TXT	Table of Contents

DVD 2 Contents (Title 0304_NZ_SEISMIC_1)

Gzipped SEG-Y data	
D2_TOC.TXT	Table of Contents

DVD 3 Contents (Title 0304_NZ_SEISMIC_1)

Gzipped SEG-Y data	
D3_TOC.TXT	Table of Contents

DVD 3 Contents (Title 0304_NZ_SEISMIC_4)

Gzipped SEG-Y data	
D4_TOC.TXT	Table of Contents

Distribution Contents at a Glance

DVD Contents

304B.trk
304B.mgd
304B.gmt
304Bdata.doc
304Bcoef.txt
b304Btrk.ps
304Btrk.ps
s304Btrk.ps

process/ 304Bjgof.tar
304BMGD.tar
304Bpco2.tar
304Bproc.tar
304Bqcps.tar
304Btsg.tar

rvdas/nav/ 304Badcp.tar
304Badu.tar
304Bgyr.tar
304Bpcod.tar
304Bseap.tar

rvdas/uw/ 304Bbat.tar
304Beng.tar
304Bgrv.tar
304Bmbdp.tar
304Bmet.tar
304Bpco2.tar
304Bsim.tar
304Bsvp.tar
304Btsg.tar

adcp/ 304Badcp.tar

puvguv/ 304Bguv.tar*
304Bsr18.tar*

ocean/ 304Bctd.tar
304Bxbt.tar

*There was a Biosphereical Instruments PUV 511 C in use on this cruise. It is the property of Dr Wade Jeffreys. We do not have the documentation on board to provide details of the data it collects. There is however a description of the data in the file headers.

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
```

Gzipped 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 (304B.trk). It contains the longitude and latitude at one-minute intervals extracted from the 304B.gmt file.

Three PostScript cruise track files have been produced and placed in the / directory. 304Btrk.ps is standard US Letter sized (8.5" x 11"). s304Btrk.ps is standard US Letter sized (8.5 x 11") showing the main CTD survey area. b304Btrk.ps is archE size.

Satellite Images

No images were gathered on this cruise.

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/304Bjgof.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. During the cruise, the JGOFS data set produces the daily data plots. Note: Null, unused, or unknown fields are indicated as "NAN" or 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/meters^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)
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

Field	Data	Units
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 304B.mgd. Also at the root level, 304B.gmt is the output of the mgd77togmt utility using 304B.mgd as input. The 304B.gmt file can be used by GMT (Generic Mapping Tool) plotting software.

The data used to produce the 304B.mgd file can be found on the distribution media in the file /process/304BMGD.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	
21-22	2	int	Hour	
23-27	5	real	Minutes x 1000	
28-35	8	real	Latitude x 100000	+ = North - = South. (–9000000 to 9000000)
36-44	9	real	Longitude x 100000	+ = East - = West. (–18000000 to 18000000)
45	1	int	Position type code	1=Observed fix 3=Interpolated 9=Unspecified
46-51	6	real	Bathymetry, 2- way travel time	In 10,000th of seconds. Corrected for transducer depth and other such corrections
52-57	6	real	Bathymetry, corrected depth	In tenths of meters.
58-59	2	int	Bathymetric correction code	This code details the procedure used for determining the sound velocity correction to depth.
60	1	int	Bathymetric type code	1 = Observed 3 = Interpolated (Header Seq. 12) 9 = Unspecified
61-66	6	real	Magnetics total field, 1^{ST} sensor	In tenths of nanoteslas (gammas)
67-72	6	real	Magnetics total field, 2^{ND} sensor	In tenths of nanoteslas (gammas), for trailing sensor
73-78	6	real	Magnetics residual field	In tenths of nanoteslas (gammas). The reference field used is in Header Seq. 13.
79	1	int	Sensor for residual field	1 = 1^{st} or leading sensor 2 = 2^{nd} or trailing sensor 9 = Unspecified
80-84	5	real	Magnetics diurnal correction	In tenths of nanoteslas (gammas). (In nanoteslas) if 9-filled (i.e., set to "+9999"),

Col	Len	Type	Contents	Description, Possible Values, Notes
				total and residual fields are assumed to be uncorrected; if used, total and residuals are assumed to have been already corrected.
85-90	6	F6.0	Depth or altitude of magnetics sensor	(In meters) + = Below sea level 3 = Above sea level
91-97	7	real	Observed gravity	In 10^{th} of mgals. Corrected for Eotvos, drift, tares
98-103	6	real	EOTVOS correction	In tenths of mgals. E = 7.5 V cos phi sin alpha + 0.0042 V*V
104-108	5	real	Free-air anomaly	In tenths of milligals 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/304Badcp.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 `304Badcp.tar` in the directory, `/rvdas/nav`.

PCO_2

The NBP carries Lamont-Doherty Earth Observatory's (LDEO) pCO_2 system and RPSC staff maintain 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 `npb304Bpco2.tar` in the rvdas/uw 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)..

Cruise Science

CTD

The ctd data have been placed in the tar file `ocean/304Bctd.tar`. Raw data are contained in the archive's `ctd/raw` directory.

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 SeaBeam system. The data files from these launches are included as 304B`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 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 archives under the top level rvdas directory: `/rvdas/uw`, and `/rvdas/nav`. Each instrument or sensor produces a data file named with its channel ID. Each data file is gzipped 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, 304B.
- The Channel ID 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 5106
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

Geophysics

Measurement	Channel ID	Collect. Status	Rate	Instrument
Gravimeter	grv1	continuous	10 sec*	LaCoste & Romberg
Bathymetry	bat1	Continuous	Varies	ODEC Bathy 2000

Bathymetry	sim1	depth < 2500 m	Varies	Simrad EK500 Sonar
Magnetometer	mag1	Varies	10/sec	Geometrics G-881 Cesium
Magnetometer	mag1	Varies	2 sec	Geometrics G-877 Proton

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

Oceanography

Measurement	Channel ID	Collect. Status	Rate	Instrument
Conductivity	tsg1	Continuous	3 sec	SeaBird 21
Salinity	Tsg1	Continuous	3 sec	Calc. from pri. temp
Sea Surface Temp	tsg1	Continuous	3 sec	SeaBird 3-01/S
Fluorometry	flrtsg1	Continuous	3 sec	Turner 10-AU-005
Transmissometry	tsg1	Continuous	3 sec	WET Lab C-Star
pCO_2	pco2	Continuous	150 sec	(LDEO)
ADCP	adcp	Continuous	varies	RD Instruments

Navigational Instruments

Measurement	Channel ID	Collect. Status	Rate	Instrument
Primary GPS	seap	Continuous	1 sec	Seapath 200
Secondary GPS	PCOD	Continuous	1 sec	Trimble 20636-00SM
Primary Attitude GPS	seap	Continuous	1 sec	Seapath 200
Secondary attitude GPS	adu1	Continuous	1 sec	Ashtech ADU2
Gyro	gyr1	Continuous	0.2 sec	Yokogawa Gyro

Data

Data are 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

Bathy 2000 (bat1)

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

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

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

Simrad (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		

Magnetometer (mag1)

Geometrics G-877 (Proton)

The G-877 output string was modified via software to emulate the data string output but the G-881.

```
Geometrics G-877

The G-887:  03+275:00:00:42.890 $ 45102.296 1627   25
```

Field	Data	Units
1	RVDAS time tag	
2	Header	
3	Magnetic field strength	nano-Teslas
4	Signal strength. 0 to 500	Arbitrary
5	Depth	Meters (uncorrected)

```
Geometrics G-881 (Cesium)

The G-881:  03+249:00:00:00.827 $ 38256.512,0388,3311
```

Field	Data	Units
1	RVDAS time tag	
2	Header	
3	Magnetic field strength	nano-Teslas
4	Signal strength of magnetometer. (Analog channel 1)	9999=full scale, 0 to +5 volts
5	Analog channel 2	9999=full scale, 0 to +5 volts

Thermosalinograph (tsg1)

```
00+019:23:59:46.976 15A16CFC163F8C2C100
```

Field	Data	Units
1	RVDAS time tag	
2	Seabird hex string (see page 18 for conversion to real 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	cm^3/min
7	Concentration	ppm
8	pCO_2 pressure	microAtm
9	Equilibrated temperature	°C
10	Latitude (not collected)	
11	Longitude (not collected)	
10	Flow source (Equil = pCO_2 measurement)	

Navigational Data

Seapath GPS (seap)

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

- INZDA
- INGGA
- INVTG
- INHDT
- PSXN, 22
- PSXN, 23

INZDA

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

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

INGGA

```
02+253:00:00:00.938
INGGA,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	$INGGA	
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	,	

Field	Data	Units
6	M	
7	speed over ground in knots	k.k
8	N	
9	,	
10	K	
11	Mode	
12	Checksum	

INHDT

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

Field	Data	Units
1	RVDAS time tag	
2	$INHDT	
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 (adu1)

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

Field	Data	Units
1	RVDAS time tag	
2	$PASHR	
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
9	Baseline RMS error	meters

Field	Data	Units
10	Attitude reset flag	

Trimble P-Code GPS (PCOD)

The P-Code GPS outputs four NMEA standard data strings:

- Position fix (GGA)
- Latitude / longitude (GLL),
- Track and ground speed (VTG)
- Recommended Minimum Specific GNSS Data (RMC)

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	

RMC: GPS Recommended Minimum Specific GNSS Data

```
03+180:00:00:00.517 $GPRMC,235959.449,A,3802.8974,N,16515.3288,W,
010.7,350.0,280603,12.5,E*47
```

Field	Data	Units
1	RVDAS time tag	
2	$GPRMC	
3	UTC of position fix	hhmmss.ss
4	Status (A=Data valid)	
5	Latitude	degrees
6	North or South	
7	Longitude	
8	East or West	
9	Speed over ground	knots
10	Course over ground	degrees true
11	Date	ddmmyy
12	Magnetic variation	degrees
13	East or West	
14	Mode Indicator	
15	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	kn
5	Ship Speed relative to reference layer, north vector	kn
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

Ocean

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
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

Calculations

The file *304Bcoefl.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 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

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
257:19:00		Leave Honolulu DAS started
258:05:00	258:05:20	Reboot eltanin. Not sure how long it had been down. It is backup for MB data.
263:05:30	263:05:56	Fram crashed hard. Had to reboot. No errors in /var/log/message
275:00:48		Rebooted eltanin. Had crashed hard, no video. dead
285:04:07	285:04:25	Fram crashed hard. Had to reboot. No errors in /var/log/message
286:20:00		Endo of cruise
	229	End RVDAS data collection

Appendix: Sensors and Calibrations

Shipboard Sensors

Sensor	Description	Serial #	Last Calibration Date	Status
Meteorology & Radiometers				
Port Anemometer	RM Young 5106	WM46262	02/25/03	Collected
Stbd Anemometer	RM Young 5106	WM46263	12/08/02	Collected
Barometer	RM Young 61201	01705	05/30/03	Collected
Air Temp/Rel. Hum.	RM Young 41372LC	06135	04/09/03	Collected
PIR (Pyrgeometer)	Eppley PIR	33023F3	11/07/02	Collected
PSP (Pyranometer)	Eppley PSP	33090F3	01/24/03	Collected
Mast PAR	BSI QSR-240	6356	02/03/03	Collected
Underway				
TSG	SeaBird SBE21	2131020-3198	11/22/02	Collected
TSG Remote Temp	SeaBird 3-01/S	032593	02/06/03	Collected
Fluorometer	Turner 10-AU-005 Lamp: daylight 10-045; ref. filter: 10-032, em. filter: 10-051, ex. filter: 10-050	5651 FRTD	04/20/02	Collected
Transmissometer	WET Labs C-Star	CST-422PR	02/24/03	Collected
Gravimeter	LaCoste & Romberg Gravity Meter			Collected
Bathymetry	Simrad EK500	3001	11/1/95	Collected
Bathymetry	ODEC Bathy 2000			Collected
Other				
P-Code GPS	Trimble 20636-00 (SM)	0220035116	Key expired	Collected
Attitude GPS	Ashtech ADU2	700273F2114 FW 7B13-D1-C21	N/A	Collected
Seapath GPS	Kongsberg Seatex Seapath 200	2253	N/A	Collected

CTD

Sensor	Comments	Serial #	Last Calibration Date	Status
Fish	SBE-9+	094857-0377	6/3/03	Collected
Pressure Sensor #2	410K-105	58949	6/3/03	Collected
Temperature #11	Primary	2438	05/20/03	Collected
Temperature #5	Secondary	1649	11/16/02	Collected
Conductivity #5	Primary	41431	11/07/02	Collected
Conductivity #11	Secondary	42069	11/14/02	Collected
Fluorometer #1	Chelsea Mk III Aquatracka	88080	2/23/03	Collected
Transmissometer	Wetlabs CST-397DR	CST-397DR	2/25/03	Collected
PAR Sensor	Biospherical Instruments QSP-200L4S	4361	11/11/02	Collected
Pump	Primary	051646 3.0K	2/2/02	
Pump	Secondary	051645 3.0K	2/2/02	
Carousel Water Sampler	SBE-32	3211265-0066		
Deck Unit	SBE 11-Plus	11P19858-0490		Collected

Calibrations

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

Gravity Tie Dutch Harbor

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: 8/27/2003
Location: Dutch Harbor, Alaska
Station: Dutch Harbor Airport
Latitude: 53 Deg 54.8 N
Longitude: 166 deg 32.3 W
Elevation: 3.7 m
Gravity: 981538.37 mgal

Reference Code Numbers:

DOD	2178-0
WA	342
IGB	19736

	Value	Time (GMT)	
Ship's meter before gravity tie (Digital Gravity)	9142.2	18:35	August 27, 2003
Ship's meter after gravity tie (Digital Gravity)	9146.2	20:35	August 27, 2003
Average	9144.2		
Ship Gravimeter's Calibration Constant	1.0046		
Corrected ship's meter (Digital Gravity)	9186.3 mgal		

	Value	Time (GMT)	
Ship's meter before gravity tie (serial, RVDAS)	9184.2	18:35	August 27, 2003
Ship's meter after gravity tie (serial, RVDAS)	9187.0	20:35	August 27, 2003
Average (for comparison check only)	9185.6		

Portable Gravimeter Correction Divisor 1.007937

Station	Value	Time (GMT)	Temp	Date	OBS mgal, averaged
Pier measurement 1	5109.37	18:42	53.5	August 27, 2003	
Pier measurement 2	5109.37	18:44	53.5	August 27, 2003	5069.11
Pier measurement 3	5109.29	18:45	53.5	August 27, 2003	
Average	5109.34				
Station measurement 1	5121.38	20:05	53.5	August 27, 2003	
Station measurement 2	5121.48	20:07	53.5	August 27, 2003	5081.12
Station measurement 3	5121.49	20:09	53.5	August 27, 2003	
Average	5121.45				
Pier measurement 4	5109.34	20:29	53.5	August 27, 2003	
Pier measurement 5	5109.37	20:30	53.5	August 27, 2003	5069.13
Pier measurement 6	5109.38	20:31	53.5	August 27, 2003	
Average	5109.36				

Gravity offset from last tie 972338.57 7/3/2003
Drift since last tie 2.14

OBS Differences	
Station to Pier (1, 2, & 3 averaged)	12.01
Station to Pier (4, 5, & 6 averaged)	11.99
Averaged Differences	12.00
Gravity at pier	981526.37
Elevation of pier above gravimeter, meters	2.0
Earth differential gravity, mgal/meter	0.3
Gravity at ship's gravimeter	981526.97
Gravity Offset	972340.71

Comments

Gravity Tie done by Brent Evers and Jerry Bucher .

Gravity Tie Honolulu

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: 9/8/2003
Location: Honolulu, HI
Station: Honolulu Harbor - Berth 1
Latitude: 021 17' 51.6" N
Longitude: 157 52' 06.8"W
Elevation: xxx meters
Gravity: 978922.1

Reference Code Numbers:
DOD 0070-G
Station No. 0010.59

	Value	Time (GMT)
Ship's meter before gravity tie (Digital Gravity)	6553.2	14:32
Ship's meter after gravity tie (Digital Gravity)	6551.6	15:28
Average	6552.4	
Ship Gravimeter's Calibration Constant	1.0046	
Corrected ship's meter (Digital Gravity)	6582.5	

	Value	Time (GMT)
Ship's meter before gravity tie (serial, RVDAS)	6576.6	14:35
Ship's meter after gravity tie (serial, RVDAS)	6582.9	15:30
Average (for comparison check only)	6579.8	

Portable Gravimeter Correction Divisor 1.007937

Station	Value	Time (GMT)	Temp	Date	OBS mgal, averaged
Pier measurement 1	2534.68	14:47	54	September 8, 2003	
Pier measurement 2	2534.59	14:48	54	September 8, 2003	2514.68
Pier measurement 3	2534.65	14:50	54	September 8, 2003	
Average	2534.64				
Station measurement 1	2529.84	15:06	54	September 8, 2003	OBS mgal, averaged
Station measurement 2	2529.91	15:08	54	September 8, 2003	2509.94
Station measurement 3	2529.83	15:10	54	September 8, 2003	
Average	2529.86				
Pier measurement 4	2534.68	15:24	54	September 8, 2003	OBS mgal, averaged
Pier measurement 5	2534.76	15:25	54	September 8, 2003	2514.76
Pier measurement 6	2534.71	15:27	54	September 8, 2003	
Average	2534.72				

Gravity offset from last tie 972340.71
Drift since last tie 3.21

OBS Differences	
Station to Pier (1, 2, & 3 averaged)	4.74
Station to Pier (4, 5, & 6 averaged)	4.82
Averaged Differences	4.78
Gravity at pier	978926.88
Elevation of pier above gravimeter, meters	-1.4
Earth differential gravity, mgal/meter	0.3
Gravity at ship's gravimeter	978926.45
Gravity Offset	972343.92

Comments

Gravity Tie done by Floyd Trujillo and Sheldon Blackman.

Gravity Tie Napier

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: 10/7/2003
Location: Napier, NZ
Station: Harbour Base #1
Latitude: 39 28.65' S
Longitude: 176 55.05 E
Elevation: 2.9 meters
Gravity: 980039.35

Reference Code Numbers:

(980054.56 mgal referenced to NZ Primary Gravity Network)

	Value	Time (GMT)
Ship's meter before gravity tie (Digital Gravity)	7665.5	21:10
Ship's meter after gravity tie (Digital Gravity)	7668.1	22:32
Average	7666.8	
Ship Gravimeter's Calibration Constant	1.0046	
Corrected ship's meter (Digital Gravity)	7702.1	

	Value	Time (GMT)
Ship's meter before gravity tie (serial, RVDAS)	7701.2	21:09
Ship's meter after gravity tie (serial, RVDAS)	7703.2	22:31
Average (for comparison check only)	7702.2	

Portable Gravimeter Correction Divisor 1.007937

Station	Value	Time (GMT)	Temp	Date	OBS mgal, averaged
Pier measurement 1	3636.63	21:21	53.5	October 7, 2003	
Pier measurement 2	3636.75	21:24	53.5	October 7, 2003	3608.05
Pier measurement 3	3636.69	21:26	53.5	October 7, 2003	
Average	3636.69				
Station measurement 1	3636.49	21:46	53.5	October 7, 2003	
Station measurement 2	3636.50	21:47	53.5	October 7, 2003	3607.86
Station measurement 3	3636.51	21:49	53.5	October 7, 2003	
Average	3636.50				
Pier measurement 4	3636.64	21:57	53.5	October 7, 2003	
Pier measurement 5	3636.71	21:58	53.5	October 7, 2003	3608.07
Pier measurement 6	3636.76	21:59	53.5	October 7, 2003	
Average	3636.70				

Gravity offset from last tie	972340.03
Drift since last tie	-2.25

OBS Differences	
Station to Pier (1, 2, & 3 averaged)	0.19
Station to Pier (4, 5, & 6 averaged)	0.20
Averaged Differences	0.20
Gravity at pier	980039.55
Elevation of pier above gravimeter, meters	1.0
Earth differential gravity, mgal/meter	0.3
Gravity at ship's gravimeter	980039.85
Gravity Offset	972337.78

Comments

Tie performed by Jeff Otten
Ship's gravity meter developed oscillation problems due to bad gyros during previous cruise. Ship's meter gravity tie readings were taken when no oscillations had been present for previous 10 minutes.

CTD

CTD Pressure Sensor

0305N377CON.txt

```
S/N: Pressure Sensor-Fish
58949-0377
Cal Date: 03-June-2003

T1:   2.998410e+01
T2: -2.451935e-04
T3:   3.711743e-06
T4:   2.102236e-09
T5:   0.000000e+00

C1: -4.839620e+04
C2:   3.519636e-01
C3:   8.922267e-03

D1:   3.977913e-02
D2:   3.026373e-05
AD590M:   1.250000e-02
AD590B: -1.000000e+01

Slope:    1.00000000
Offset:   0.00000
```

Scripps Pressure Sensor Calibration

CTD Temperature (primary)

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 = 2438
CALIBRATION DATE: 16-Nov-02s

TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.31135680e-03
h = 6.42019001e-04
i = 2.30921661e-05
j = 2.20241386e-06
f_0 = 1000.000

IPTS-68 COEFFICIENTS

a = 3.68121028e-03
b = 6.02095484e-04
c = 1.64135573e-05
d = 2.20398252e-06
f_0 = 2759.314

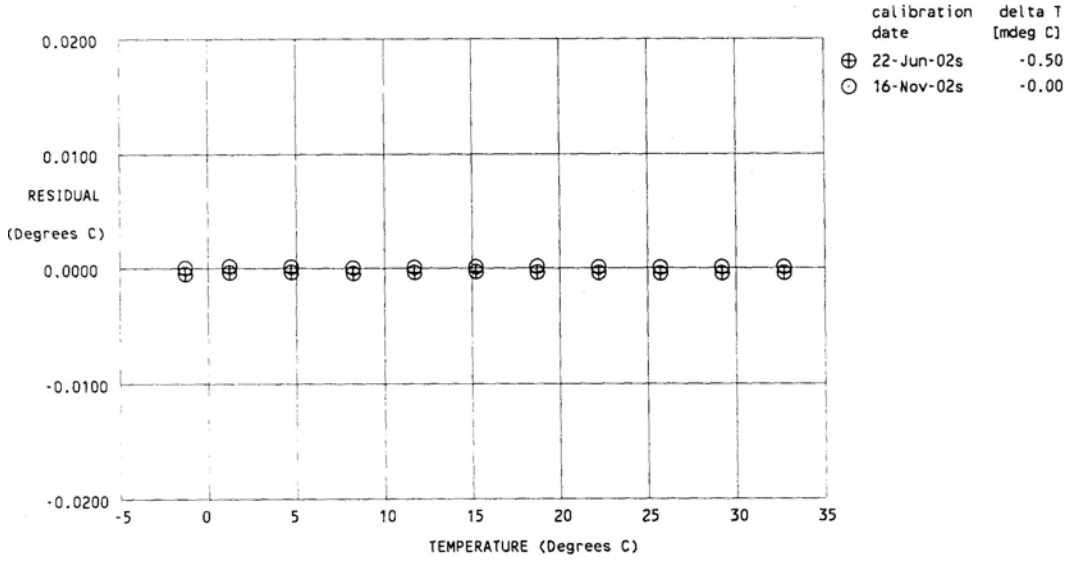
BATH TEMP (ITS-90 °C)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90 °C)	RESIDUAL (ITS-90 °C)
-1.4998	2759.314	-1.4998	-0.00005
1.0002	2917.820	1.0003	0.00008
4.5002	3150.651	4.5002	0.00003
8.0002	3396.564	8.0001	-0.00008
11.5002	3655.929	11.5002	-0.00003
15.0002	3929.080	15.0002	0.00002
18.5002	4216.347	18.5003	0.00005
22.0002	4518.048	22.0002	-0.00000
25.5002	4834.504	25.5002	-0.00002
29.0002	5166.014	29.0002	-0.00001
32.5002	5512.863	32.5002	0.00001

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



CTD Temperature (secondary)

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 = 1649 S
CALIBRATION DATE: 16-Nov-02s

TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.80572433e-03
h = 6.63231640e-04
i = 2.09757326e-05
j = 1.34155196e-06
f_0 = 1000.000

IPTS-68 COEFFICIENTS

a = 3.68120399e-03
b = 6.01324018e-04
c = 1.38196406e-05
d = 1.34281130e-06
f_0 = 5958.194

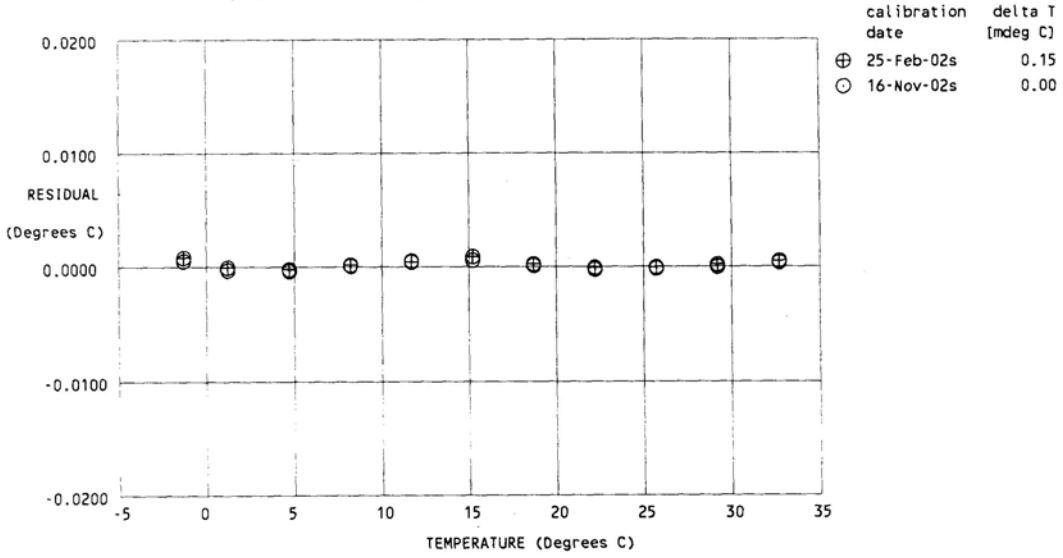
BATH TEMP (ITS-90 °C)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90 °C)	RESIDUAL (ITS-90 °C)
-1.4998	5958.194	-1.4994	0.00041
1.0002	6300.693	0.9998	-0.00040
4.5002	6803.734	4.4997	-0.00045
8.0002	7334.834	8.0002	-0.00000
11.5002	7894.658	11.5006	0.00042
15.0002	8483.868	15.0007	0.00047
18.5002	9103.129	18.5002	0.00000
22.0002	9753.230	21.9999	-0.00033
25.5002	10434.885	25.4999	-0.00027
29.0002	11148.679	29.0001	-0.00010
32.5002	11895.248	32.5005	0.00026

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



CTD Conductivity (primary)

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 = 1431
CALIBRATION DATE: 07-Nov-02s

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

GHIJ COEFFICIENTS

```
g = -4.24743833e+00
h =  5.51022999e-01
i = -5.57514084e-05
j =  3.19733106e-05
CPcor = -9.57e-08 (nominal)
CTcor = 3.25e-06 (nominal)
```

ABCDM COEFFICIENTS

```
a =  1.67772881e-05
b =  5.50996610e-01
c = -4.24776031e+00
d = -8.97575747e-05
m =  4.2
CPcor = -9.57e-08 (nominal)
```

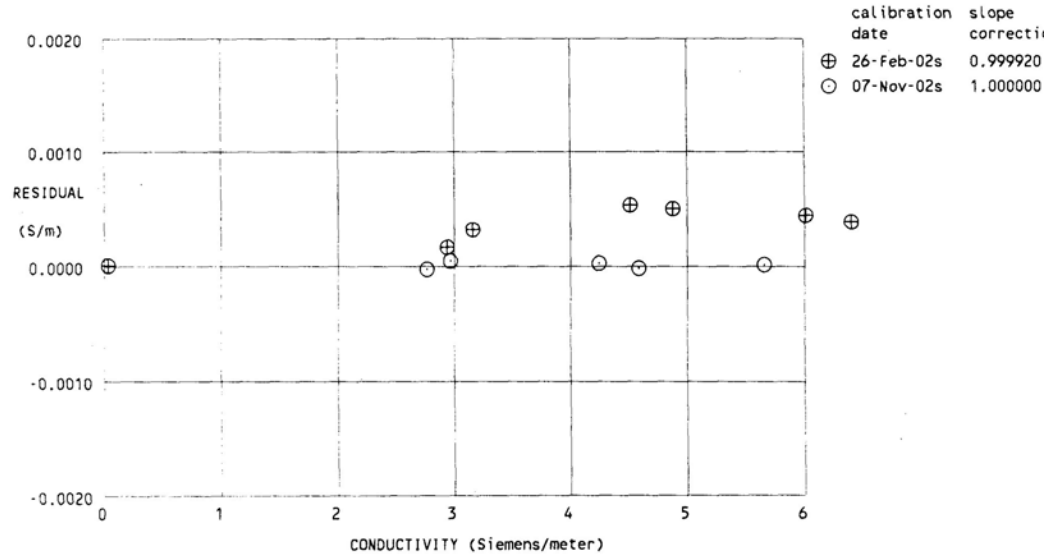
BATH TEMP (ITS-90 °C)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.77615	0.00000	0.00000
-1.4001	34.2897	2.73269	7.56007	2.73266	-0.00003
0.9999	34.2892	2.93516	7.79808	2.93520	0.00004
14.9999	34.2904	4.21385	9.15725	4.21387	0.00002
18.5000	34.2902	4.55604	9.48748	4.55601	-0.00003
28.9999	34.2865	5.62521	10.45121	5.62522	0.00001

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

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

t = temperaure [deg C]; p = pressure [decibars]; δ = CTcor; ϵ = CPcor;

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



CTD Conductivity (secondary)

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

SENSOR SERIAL NUMBER = 2069 S
CALIBRATION DATE: 14-Nov-02s

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

GHIJ COEFFICIENTS

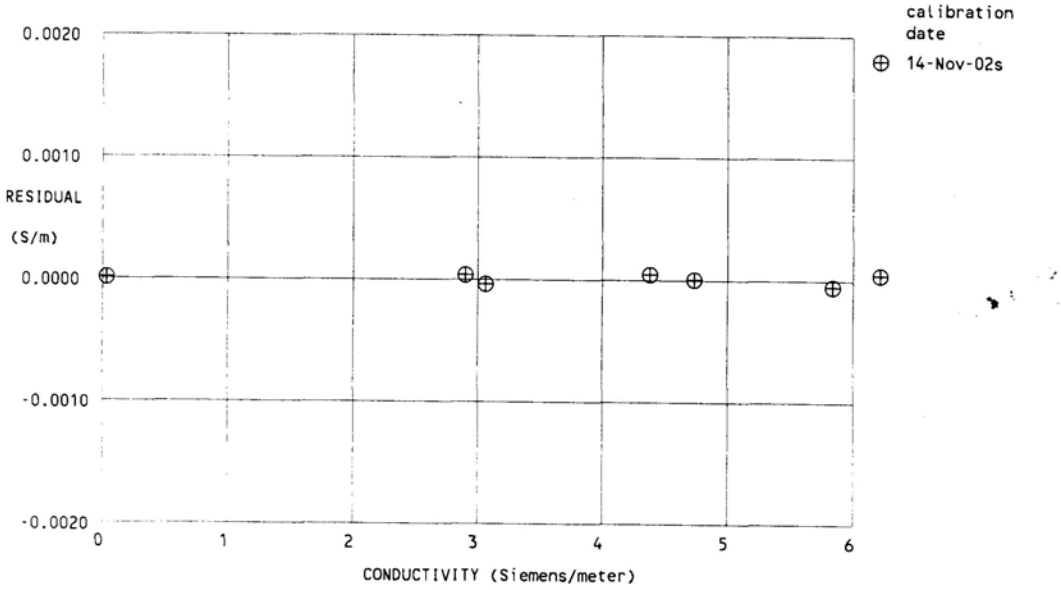
g = -1.02739394e+01
h = 1.43390864e+00
i = -3.82948758e-03
j = 3.51174783e-04
CPcor = -9.57e-08 (nominal)
CTcor = 3.25e-06 (nominal)

ABCDM COEFFICIENTS

a = 1.23826185e-08
b = 1.42215106e+00
c = -1.02439029e+01
d = -5.86132763e-05
m = 8.0
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)
0.0000	0.0000	0.00000	2.68401	0.00000	0.00000
-0.8700	35.5412	2.86867	5.23164	2.86870	0.00003
1.0000	35.5417	3.03198	5.34015	3.03194	-0.00004
14.9999	35.5428	4.35116	6.14671	4.35120	0.00004
18.4999	35.5430	4.70421	6.34501	4.70421	-0.00000
28.9999	35.5407	5.80742	6.92769	5.80736	-0.00006
32.4999	35.5333	6.18667	7.11686	6.18671	0.00004

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
= temperaure [deg C]; p = pressure [decibars]; δ = CTcor; ϵ = CPcor;
Residual = (instrument conductivity - bath conductivity) using g, h, i, j coefficients



CTD PAR

Biospherical Instruments Inc

CALIBRATION CERTIFICATE

UNDERWATER PAR SENSOR WITH LOG AMPLIFIER

Calibration Date: 11/11/02 **Job No.:** R8185
Model Number: QSP200L
Serial Number: 4361
Operator: TPC
Standard Lamp: 91773(4/12/01)
Operating Voltage Range: 6 to 15 VDC (+)

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

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

With the appropriate (solar corrected) Irradiance Calibration Factor:

Dry Calibration Factor:	**2.42E+12**	**quanta/cm² sec/"amps"**	**4.01E-06**	**µEinsteins/cm² sec/"amps"**
Wet Calibration Factor:	**4.07E+12**	**quanta/cm² sec/"amps"**	**6.76E-06**	**µEinsteins/cm² sec/"amps"**

Sensor Test Data and Results[4)]

Sensor Supply Current (Dark):	75.8	mA			
Supply Voltage:	6	Volts			
Lamp Integrated PAR Irradiance:	8.64E+15	quanta/cm² sec	0.01434	µEinsteins/cm²sec	
SC3 Immersion Coefficient:	0.594	Scalar Correction:	1	PAR Solar Correction:	1.0000

Nominal Filter OD	Calibrated Trans.	Sensor Voltage	Measured Trans.	Measured Signal (Amps)	Estimated Signal (Amps)	Calc. Output (Volts)	Error (Volts)	Error (%)	Test Irrad. (quanta/ cm² sec)
No Filter	100.00%	3.553	100.00%	3.57E-07	3.57E-07	3.553	0.000	0.0	8.64E+15
0.3	36.10%	3.117	36.62%	1.31E-07	1.29E-07	3.111	-0.006	-1.4	3.16E+15
0.5	27.60%	3.005	28.25%	1.01E-07	9.86E-08	2.994	-0.010	-2.3	2.44E+15
1	9.27%	2.560	10.13%	3.62E-08	3.31E-08	2.522	-0.038	-8.5	8.75E+14
2	1.11%	1.683	1.31%	4.69E-09	3.97E-09	1.613	-0.070	-15.4	1.13E+14
3	0.05%	0.677	0.10%	3.42E-10	1.91E-10	0.511	-0.166	-44.2	8.27E+12

Dark Before: 0.125 Volts
Light - No Filter Hldr.: 3.553 Volts
Dark After - NFH: 0.125 Volts
Average Dark 0.125 Volts

I_{Ref} = 1.00E-10 Amps
I_{Dark} = 1.33E-10 Amps
10^{VDark} = 1.333521 Amps

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

CTD Fluorometer

CERTIFICATE OF CALIBRATION

Chelsea Technologies Group

55 Central Avenue
West Molesey
Surrey KT8 2QZ
United Kingdom
Tel: +44 (0)20 8481 9000
Fax: +44 (0)20 8941 9319
sales@chelsea.co.uk
www.chelsea.co.uk

Date of issue 23rd February 2003

Description Mk III Aquatracka (Chlorophyll-a)

Serial Number 088080

REPORT

The fluorimeter was exposed to various concentrations of Chlorophyll-a dissolved in acetone in addition to pure water and pure acetone. The following formula was derived from the readings to relate instrument output to chlorophyll-a concentration.

$$\text{Conc.} = (0.0157 \times 10^{\text{Output}}) - 0.037$$

Where:-

conc. = fluorophor concentration in µg/l
Output = Aquatracka output in volts

The above formula can be used in the range 0 - 100 microgrammes per litre to an uncertainty of 0.02 microgrammes per litre plus 8% of value.

Notes

The above formula has been derived using Chlorophyll-a dissolved in acetone. No guarantee is given as to the performance of the instrument to biologically active chlorophyll in sea-water.

The zero offset has been determined in the laboratory using purified water from a reverse osmosis/ion exchange column. It is possible that purer water may be found in clean deep ocean conditions. Under these conditions, the offset shown in the above formula should be replaced by the antilogarithm of the Aquatracka output in the purest water found, multiplied by the scale factor.

Fluorimeter calibration readings

Ambient temperature 20°C

Output for detector mechanically blanked 0.296 Volts

Output for pure water 0.375 Volts

chlorophyll concentration in acetone (µg/l)	Output (volts)
Acetone (pure)	0.3297
0.1038	0.9715
0.3114	1.3278
1.038	1.8172
3.10362	2.3170
10.2762	2.8166
30.2058	3.2842
94.3542	3.7660

The uncertainty of the chlorophyll concentration is estimated not to exceed 3%. The uncertainty of output voltage measurement is estimated not to exceed 2mV.

Signed [signature] Date 23.02.03

CTD PAR (on mast)

PO Box 518
620 Applegate St.
Philomath OR 97370

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

C-Star Calibration Sheet

Date:	**02-25-03**
Customer:	**National Science Foundation**
Serial Number:	**CST-397DR**
Job Number:	**0009009**
Work Order:	**002**

V_d = V dark	**0.059**
V_{air} = V out in air	**4.818**
V_{ref} = V out in water	**4.778**
Calibration Temperature of water	**19.4**
Ambient Temperature	**20.5**

% 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.

CTD Transmissometer

Wetlabs C-Star Transmissometer
N.B.Palmer Onboard Calibration Sheet

Calibration Date: **02/25/03**

Serial Number: **CST-397DR**

Technician: ***Wetlabs Job #0009009 (from Wetlabs Cal Sheet)***

Use the following table to enter voltages when performing an annual calibration of the instrument:

$Y_0 = V_d$	**0.059**	Voltage Blocked
$A_0 = V_{air}$	**4.818**	Voltage in air
$W_0 = V_{ref}$	**4.778**	Voltage in pure filtered H_2O from the Nanopure system.
Cal. Temp of Water	**19.4**	Temperature of the water during calibration. (Centigrade)
Ambient Temp	**20.5**	Air temperature during the calibration. (Centigrade)

The following equation is used by RVDas to obtain % of Transmittance:

% Transmission **= 100% * ($V_{sig} - V_d$) / ($V_{ref} - V_d$)** **V_{sig} = Signal Voltage at any point in time.**

Use the following table to enter measured voltages when putting the instrument in use:

Note: **Use the system that the instrument is being installed in to measure the voltage.**
(i.e., CTD: Use the CTD Deck unit and read the voltage on the CTD Computer with the system on.)

Make sure the lenses are clean and dry!

Date:
Technician: **System:**

	Value	Comments
$Y_1 = V_{dark\ (current)}$		Current measured blocked voltage.
$A_1 = V_{air\ (current)}$		Current measured voltage in air.
Tw	**100%**	%Transmission in pure water.

Use the following equations to obtain the M and B constants for Seasave for both the CTD and Thermosalinagraph:

(Select **Chelsea/Seatech/ Wetlab CStar** in ***Seasave for Windows*** or **Transmissometer** in ***Seacon for DOS***).
(Do **NOT** select Beam Transmissometer or WetLab AC3)

$M = (T_w / W_0) * (A_0 - Y_0) / (A_1 - Y_1)$ **$B = -M\ Y_1$**

M = (100 /) * (–) / (–) **B =**

M = **B =**

Path Length **(M) = 0.250**

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: 46263 **Date:** 8-Dec-02 **Cal'd By:** Unknown

Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s	knots
0	0.00	0.1	-0.1	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	49.7	-0.7	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	119	1
150	150	0
180	179	1
210	210	0
240	240	0
270	270	0
300	300	0
330	331	-1
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	7.4	-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	29.7	-0.3
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
Calibration measurements copied to new formatted cal sheet. Technician who performed calibration is unknown.

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: 33023F3

Resistance: 764 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 23 °C.

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

$$3.92 \times 10^{-6} \text{ volts/watts meter}^{-2}$$

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:
National Science Foundation
Port Hueneme, CA

S.O. Number: 59204
Date: November 6, 2002

Date of Test: October 28, 2002

In Charge of Test: R. T. Eppley

Reviewed by: Thomas D. Kirk

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

EPLAB
Scientific Instruments for Precision Measurements Since 1917

STANDARDIZATION OF EPPLEY PRECISION SPECTRAL PYRANOMETER Model PSP

Serial Number: 33090F3

Resistance: 699 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:

8.52 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:
National Science Foundation
Port Hueneme, CA

Date of Test: January 24, 2003

In Charge of Test: R. T. Eppley

S.O. Number: 59285
Date: January 24, 2003

Reviewed by: Thomas D. Kirk

Remarks:

PAR

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/cm^{2}sec

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/cm^{2}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.

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 Internet: seabird@seabird.com

SENSOR SERIAL NUMBER = 3198
CALIBRATION DATE: 22-Nov-02

SBE 21 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

GHIJ COEFFICIENTS

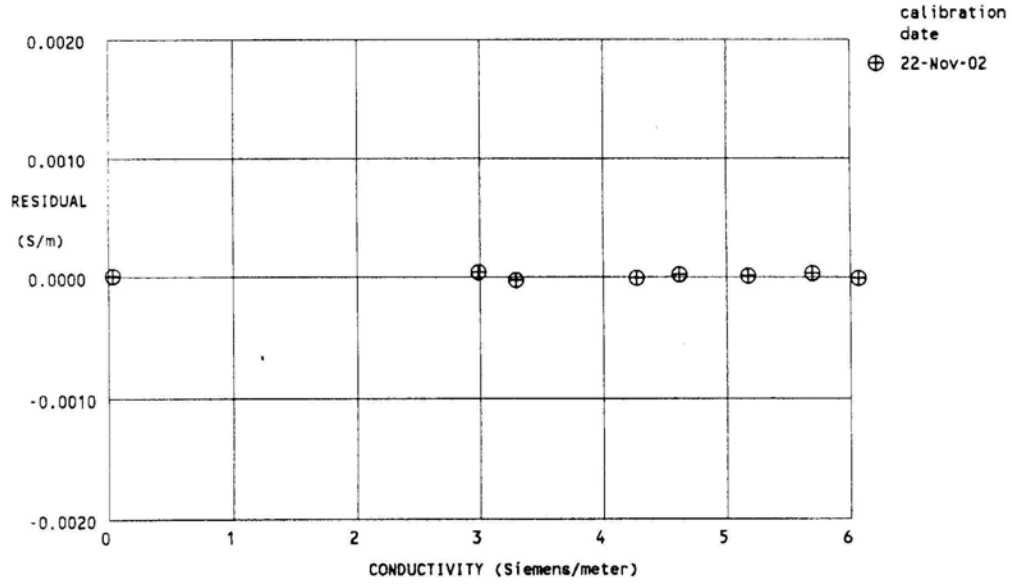
g = -4.26466745e+00
h = 5.03825293e-01
i = -4.53054017e-04
j = 4.74361958e-05
CPcor = -9.57e-08 (nominal)
CTcor = 3.25e-06 (nominal)

ABCDM COEFFICIENTS

a = 2.82777974e-06
b = 5.02162048e-01
c = -4.25671660e+00
d = -8.80276752e-05
m = 4.8
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	2.91204	-0.00000	-0.00000
1.0000	34.5582	2.95600	8.19797	2.95603	0.00003
4.5000	34.5588	3.26281	8.56061	3.26278	-0.00003
14.9999	34.5576	4.24321	9.62714	4.24319	-0.00002
18.5000	34.5572	4.58769	9.97436	4.58770	0.00001
24.0000	34.5565	5.14423	10.51052	5.14423	0.00000
28.9999	34.5551	5.66432	10.98738	5.66434	0.00002
32.5002	34.5531	6.03528	11.31483	6.03526	-0.00002

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

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 = 3198
CALIBRATION DATE: 22-Nov-02

SBE 21 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

ITS-90 COEFFICIENTS

g = 4.22450290e-03
h = 6.29160453e-04
i = 1.99900644e-05
j = 1.39971759e-06
f_0 = 1000.000

IPTS-68 COEFFICIENTS

a = 3.64763597e-03
b = 5.95326037e-04
c = 1.60560574e-05
d = 1.40113836e-06
f_0 = 2568.397

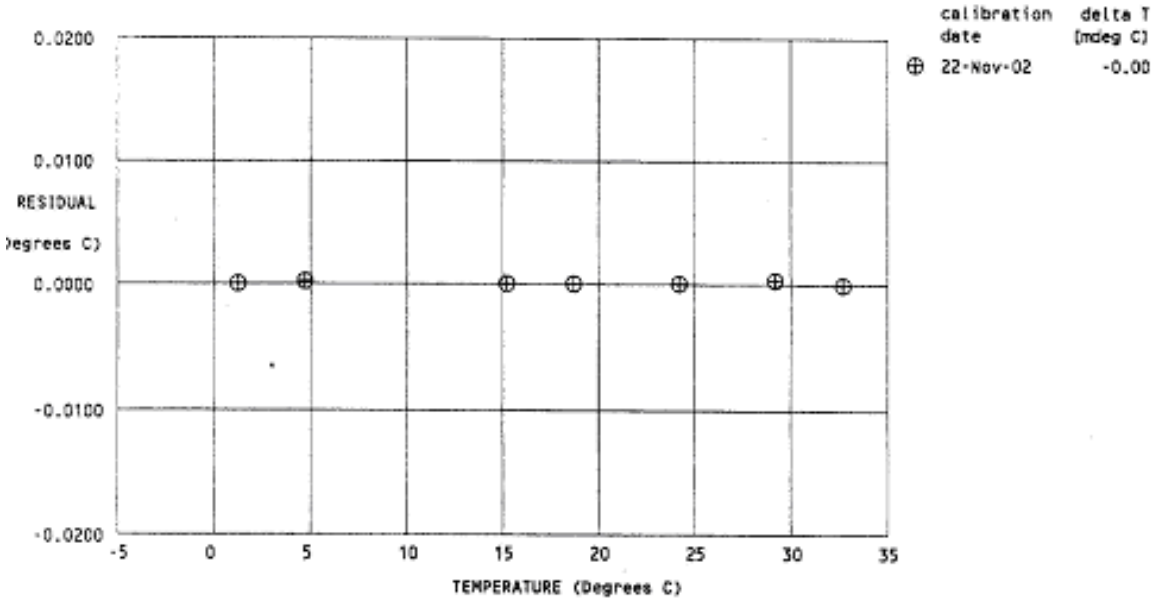
BATH TEMP (ITS-90 °C)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90 °C)	RESIDUAL (ITS-90 °C)
1.0000	2568.397	0.9999	-0.00008
4.5000	2775.144	4.5001	0.00013
14.9999	3467.400	14.9998	-0.00006
18.5000	3723.305	18.4999	-0.00006
24.0000	4152.042	24.0000	-0.00004
28.9999	4570.926	29.0001	0.00025
32.5002	4881.105	32.5001	-0.00015

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 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

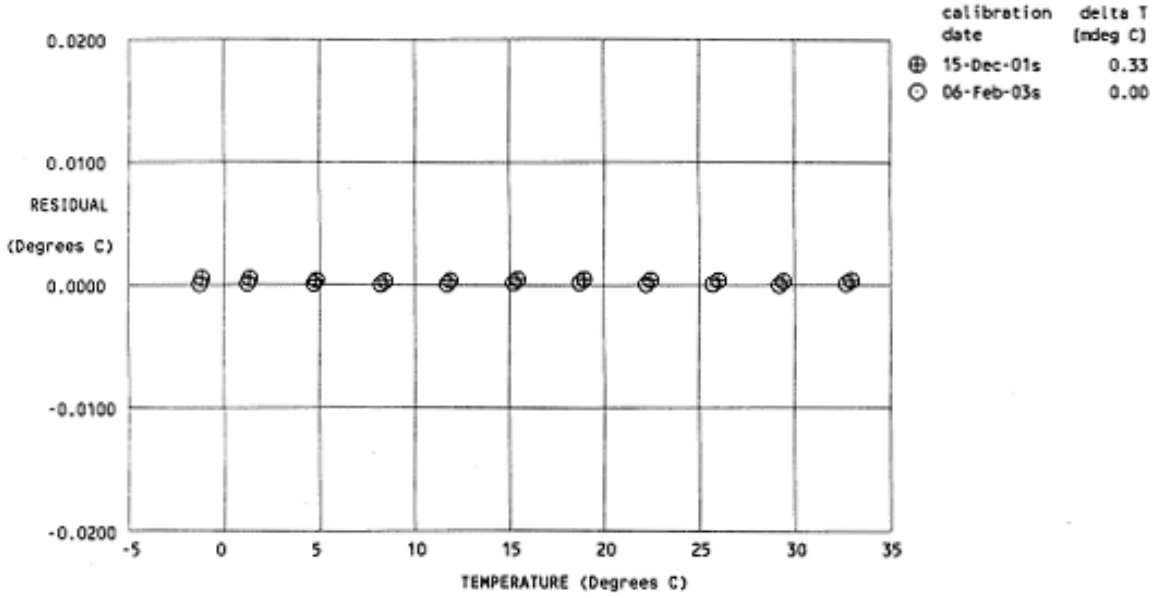
BATH TEMP (ITS-90 °C)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90 °C)	RESIDUAL (ITS-90 °C)
-1.4999	2709.478	-1.4999	-0.00001
1.0001	2870.267	1.0001	0.00003
4.5001	3106.997	4.5001	0.00001
8.0001	3357.687	8.0000	-0.00006
11.5001	3622.778	11.5001	-0.00003
15.0001	3902.688	15.0002	0.00005
18.5001	4197.822	18.5002	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

WET Labs

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

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.