NBP0409
Working Copy

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Table of Contents

Introduction

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

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

The data is distributed on a DVD-R or CD-ROM written in ISO9660 level-1 format. It is readable by virtually every computing platform.

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

MultiBeam and BathyW data, if collected, are distributed separately.

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

Distribution Contents at a Glance

Volume 1 (Disk 1 of 1)

Directory	Files
/	0409data.doc instcoef.txt NBP0409.trk NBP0409.mgd NBP0409.gmt trk0409.ps
adcp/	pingdata files config files
images/	images.tar
ocean/ctd/	Process.tar Raw.tar SV.tar
process/	0409jgof.tar 0409mgd.tar 0409pco2 0409proc 0409qcps xrvdas.txt
scirep/	sci_rep.tar
rvda/nav/	0409adcp.tar 0409gp02.tar 0409gyr.tar 0409PCOD.tar 0409seap.tar 0409trax.tar
rvdas/uw/	0409bat.tar 0409flr.tar 0409grv.tar 0409knud.tar 0409mbdp.tar 0409met.tar 0409pco2.tar 0409pguv.tar 0409sim.tar 0409sr18.tar 0409svp.tar 0409tsg

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 (<cruiseid>.trk). It contains the longitude and latitude at one-minute intervals extracted from the <cruiseid>.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 (ice = ice, wx = weather)
DDD = year-day
YY = year
A = allows for multiple images of one type for one day

Science Report

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

NBP Data Products

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

JGOFS

The JGOFS data set can be found on the distribution media in the file /process/<cruiseino>.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

Field	Data	Units
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
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 <cruiseid>.mgd. Also at the root level, <cruiseid>.gmt is the output of the mgd77togmt utility using <cruiseid>.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/<cruiseno>proc.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

Col	Len	Type	Contents	Description, Possible Values, Notes
				3 = Interpolated (Header Seq. 12) 9 = Unspecified
61-66	6	real	Magnetics total field, 1ST sensor	In tenths of nanoteslas (gammas)
67-72	6	real	Magnetics total field, 2ND sensor	In tenths of nanoteslas (gammas), for trailing sensor
73-78	6	real	Magnetics residual field	In tenths of nanoteslas (gammas). The reference field used is in Header Seq. 13
79	1	int	Sensor for residual field	1 = 1st or leading sensor 2 = 2nd or trailing sensor 9 = Unspecified
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/<cruiseno>adcp.tar. For more information on data format, visit http://currents.soest.hawaii.edu

Some ADCP data is also transmitted to RVDAS. East and north vectors for ship's speed relative to the reference layer and ship's heading are archived as `<cruiseno>adcp.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 `<cruiseno>pco2.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).

Cruise Science

CTD

The ctd data have been placed in the tar file `/ocean/<cruiseno>ctd.tar`. The archive contains tar files `<cruiseno>proc.tar`.

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	continuous	2 sec	BSI PUV-2511

Geophysics

Measurement	Channel ID	Collect. Status	Rate	Instrument
Gravimeter	grv1	continuous	10 sec*	LaCoste & Romberg
Magnetometer	mag1	not collected	15 sec	EG&G G-866
Bathymetry	bat1	Continuous	Varies	ODEC Bathy 2000
Bathymetry	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

Navigational Instruments

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

Data

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

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

where

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

All times are reported in UTC.

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

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

Underway Data

Sound Velocity Probe (svp1)

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

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

Meteorology (met1)

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

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

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 1.0046 + 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 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	

Field	Data	Format / Possible Values	Units
		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

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 18 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)	yyyyddd.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)	
12	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:

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

GPZDA

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

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

GPGGA

`02+253:00:00:00.938`

`GPGGA,235947.70,6629.239059,S,06827.668899,W,1,07,1.0,11.81,M,,M,,*6F`

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

GPVTG

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

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

GPHDT

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

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

PSXN,22

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

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

PSXN,23

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

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

Trimble GPS (PCOD)

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

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

GGA: GPS Position Fix – Geoid/Ellipsoid

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

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

GLL: GPS Latitude/Longitude

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

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

VTG: GPS Track and Ground Speed

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

Field	Data	Units

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

Gyro Compass (gyr1)

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

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

ADCP Course (adcp)

`00+019:23:59:59.099 $PUHAW,UVH,-1.48,-0.51,250.6`

Field	Data	Units
1	RVDAS time tag	
2	$PUHAW	
3	UVH (E-W, N-S, Heading)	
4	Ship Speed relative to reference layer, east vector	knots
5	Ship Speed relative to reference layer, north vector	knots
6	Ship heading	degrees

Sound Velocity Probe (svp1)

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

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

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
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 *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

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^2secPIR
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
353		Departed Lyttleton, NZ
353 0835Z		Enabled Flourometer Logger Enabled PC02 Logger
353 2230Z		TSG Conductivity Fixed
354 0112Z		Enabled Knudsen Logger
360		PUV attached to GUV deck box
003 0310Z		Simrad EK500 Enabled
007		XRVDAS loggers stopped to replace XRVDAS. Data missing from 20:29 – 20:39; 21:38 – 21:46
		Gen2 logger colleceted SR18 Data
	025 0100Z	Arrive McMurdo Station.

Appendix: Sensors and Calibrations

NBP0408 Sensors:

Shipboard Sensors

Sensor	Description	Serial #	Last Calibration Date	Status
Meteorology & Radiometers				
Port Anemometer	RM Young 5106	WM51143	09/27/04	Collect
Stbd Anemometer	RM Young 5106	WM51144	09/27/04	Collect
Barometer	RM Young 61201	00872	05/13/04	Collect
Air Temp/Rel. Hum.	RM Young 41372LC	06733	08/07/04	
Mast PRR	BSI PRR-610			Not used
UW PRR	BSI PRR-600			Not used
PIR (Pyrgeometer)	Eppley PIR	33023F3	12/18/03	Collect
PSP (Pyranometer)	Eppley PSP	32850F3	06/22/04	Collect
Mast PAR	BSI QSR-240	6357	6/24/03	Collect
GUV				Not used
PUV				Not used
Underway				
TSG	SeaBird SBE21	2131020-3198	12/10/03	Collect
TSG Remote Temp (primary)	SeaBird 3-01/S	031267	11/21/03	Collect
TSG Remote Temp (secondary)	SeaBird 3-01/S	032691	10/21/03	Collect
Fluorometer	Turner 10-AU-005 Lamp: daylight 10-045; ref. filter: 10-052, em. filter: 10-051, ex. filter: 10-050	5333-FRXX	N/A	Collect
Transmissometer*	WET Labs C-Star	CST-557DR	01/12/04	Collect
Transmissometer*	WET Labs C-Star	CST-533DR	12/31/03	Collect
Transmissometer*	WET Labs C-Star	CST-423PR	05/25/04	Collect
Transmissometer*	WET Labs C-Star	CST-422PR	06/15/04	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				
Trimble GPS (formerly P-Code)	Trimble 20636-00 (SM)	0220035116	Key no longer used	Collect
Attitude GPS	Ashtech 12	700273F2114 FW 7B13-D1-C21	N/A	Collect

* See previous page *Acquisition Problems and Events*

NBP0408 CTD Sensors:

Sensor	Description	Serial #	Last Calibration Date	Status
CTD Fish	SeaBird model SBE 9+	09P7536-0328	02/08/03	Collect
CTD Fish Pressure	Paroscientific model 410K-105 pressure sensor	53980	02/08/03	Collect
CTD Deck Unit	SeaBird model SBE 11+	11P19858-0490		Collect
Primary Temperature Sensor	SeaBird model 3-02/F	031457	12/18/03	Collect
Secondary Temperature Sensor	SeaBird model 3-02/F	031541	12/18/03	Collect
Primary Conductivity Sensor	SeaBird model 4-02/0	040924	12/18/03	Collect
Secondary Conductivity Sensor	SeaBird model 4C	041314	12/19/03	Collect
Dissolved Oxygen Sensor (primary)	SeaBird model 13-02-B	0150	12/17/03	Collect
Dissolved Oxygen Sensor (secondary)*	SeaBird model 13-02-B	0082	11/19/03	Collect
Transmissometer*	WET Labs C-Star	CST-533DR	12/31/03	Collect
Transmissometer*	WET Labs C-Star	CST-557DR	12/31/03	Collect

* See page 22 *Acquisition Problems and Events*

Calibrations

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

CTD

Pressure Sensor

REC'D 2/24/03 GBF

Pressure Calibration Check . 03 February 2003

pressure sensor model: Digiquartz 410K-105
sensor serial number: 53990
installed in: CTD 09P7536-0328

This pressure calibration is a check of the 'test' sensor against a stable reference pressure sensor. The reference pressure sensor is itself checked several times per year against a NIST-traceable pressure standard maintained at Paroscientific, Inc.. The circumstances of this pressure check introduce no more than 1.5 psia total error in 10,000 psi (0.015 %) in addition to the error resident in the Paroscientific site standard. The check offers a very high level certification of the health and proper operation of the 'test' sensor.

Input Pressure* [psia]	Sensor Output [hz]	Sensor Temperature [deg C]	Pressure Factory Coef [psia]	Pressure Corrected [psia]	Error [psia]
14.739	33053.13	18.4	15.416	14.770	0.031
2014.807	33613.00	18.5	2015.792	2015.143	0.336
4015.169	34162.06	18.6	4015.928	4015.277	0.108
6015.370	34700.87	18.7	6015.956	6015.303	-0.067
8015.212	35229.94	18.7	8015.987	8015.332	0.120
10015.411	35749.65	18.8	10015.754	10015.097	-0.314
8015.408	35229.95	18.8	8016.019	8015.364	-0.044
6015.276	34700.91	18.8	6016.072	6015.419	0.143
4015.174	34162.11	18.9	4016.056	4015.405	0.231
2015.132	33613.02	18.9	2015.799	2015.151	0.019
14.729	33052.98	19.0	14.811	14.165	-0.564

Input pressure is generated with a Ruska model 5201 dead-weight tester, serial number 23330/380, and is determined by measurement with reference pressure sensor model Digiquartz 410K-105, serial number 73292.

Sensor Temperature: pressure sensor internal temperature.

Pressure Corrected: pressure computed with original factory coefficients and then corrected with a slope and offset to give the best linear agreement with the 'reference' Input pressure.

Error: Corrected pressure - Input pressure

A linear fit of this calibration data, between sensor pressure computed with factory coefficients and the Input pressure, yields correction coefficients:
Corrected pressure = psi slope * Factory pressure + psi offset [psia]
psi slope = 1.00000 and psi offset = -0.65 [psia]

These are converted to Slope and Offset for use in the SEASOFT programs by:
Slope = psi slope = 1.00000
Offset = 0.689476 * (psi offset - 14.7 * (1 - psi slope)) = -0.4455 [dbars]

Slope and Offset coefficients are entered into the pressure sensor calibration coefficient section of the <>.CON file using the program SEACON.

Digiquartz Coefficients:

C1 = -5.847002e+04
C2 = 6.910390e-01
C3 = 1.753360e-02
D1 = 4.241600e-02
D2 = 0.000000e+00
T1 = 3.026040e+01
T2 = -1.938830e-04
T3 = 4.330190e-06
T4 = 2.020250e-09

AD590 Pressure Temperature Coefficients:

AD590M = 0.01133
AD590B = -8.47592

Calibration Correction:

Slope = 1.00000
Offset = -0.4455

Primary Temperature Sensor

Primary

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

SENSOR SERIAL NUMBER: 2299
CALIBRATION DATE: 07-May-04

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS
g = 4.33174784e-003
h = 6.43374147e-004
i = 2.32968854e-005
j = 2.22690386e-006
f0 = 1000.0

ITS-68 COEFFICIENTS
a = 3.68121258e-003
b = 6.02064853e-004
c = 1.63307820e-005
d = 2.22846996e-006
f0 = 2848.664

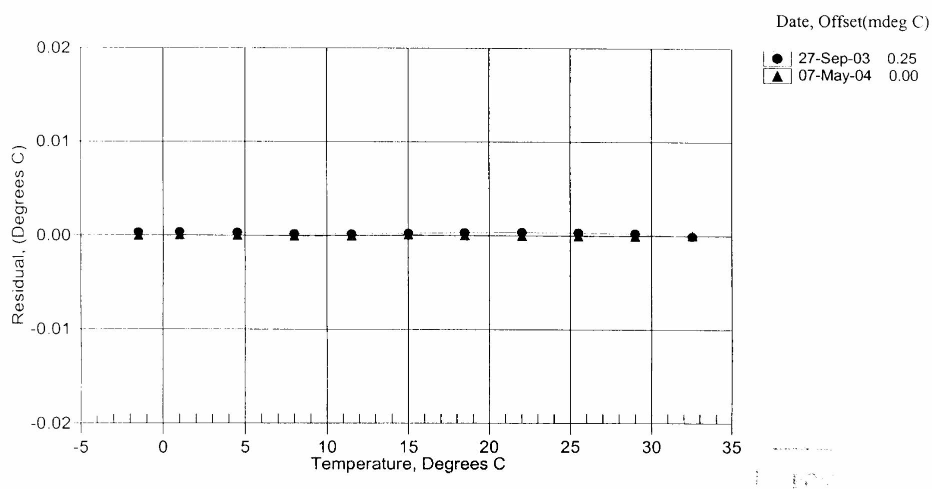
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	2848.664	-1.5000	-0.00002
1.0000	3012.306	1.0000	0.00005
4.5000	3252.683	4.5000	0.00000
8.0000	3506.564	7.9999	-0.00006
11.5000	3774.321	11.5000	-0.00003
15.0000	4056.308	15.0001	0.00008
18.5000	4352.848	18.5000	0.00003
22.0000	4664.285	22.0000	-0.00000
25.5000	4990.937	25.5000	-0.00005
29.0000	5333.118	29.0000	-0.00003
32.5000	5691.121	32.5000	0.00003

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



Secondary Temperature Sensor

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

SENSOR SERIAL NUMBER: 2367
CALIBRATION DATE: 07-May-04

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS

g = 4.33455525e-003
h = 6.42860124e-004
i = 2.35824883e-005
j = 2.26629980e-006
f0 = 1000.0

ITS-68 COEFFICIENTS

a = 3.68121276e-003
b = 6.00884319e-004
c = 1.64517086e-005
d = 2.26787763e-006
f0 = 2865.846

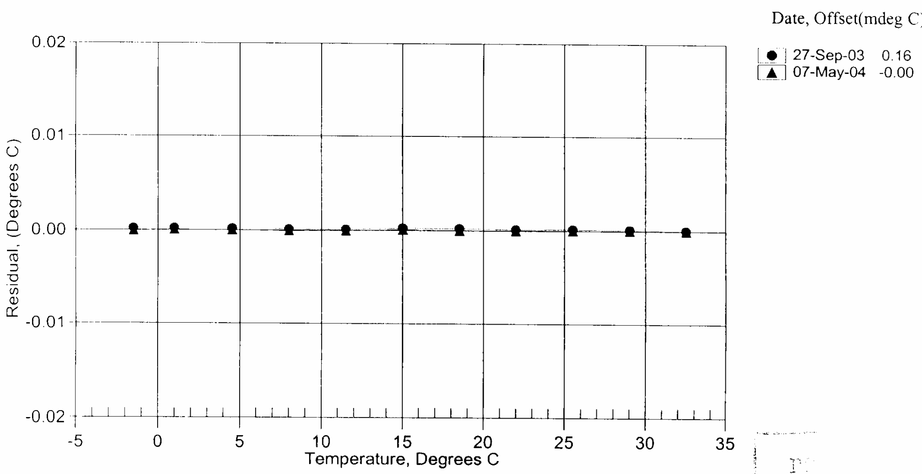
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	2865.846	-1.5000	-0.00003
1.0000	3030.812	1.0001	0.00006
4.5000	3273.174	4.5000	0.00002
8.0000	3529.201	7.9999	-0.00006
11.5000	3799.273	11.5000	-0.00004
15.0000	4083.755	15.0001	0.00009
18.5000	4382.968	18.5000	-0.00001
22.0000	4697.276	22.0000	-0.00003
25.5000	5027.004	25.5000	0.00001
29.0000	5372.457	29.0000	0.00000
32.5000	5733.940	32.5000	-0.00000

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



Dissolved Oxygen Sensor (Primary)

Primary Dissolved Oxygen

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: 0161
CALIBRATION DATE: 04-May-04p

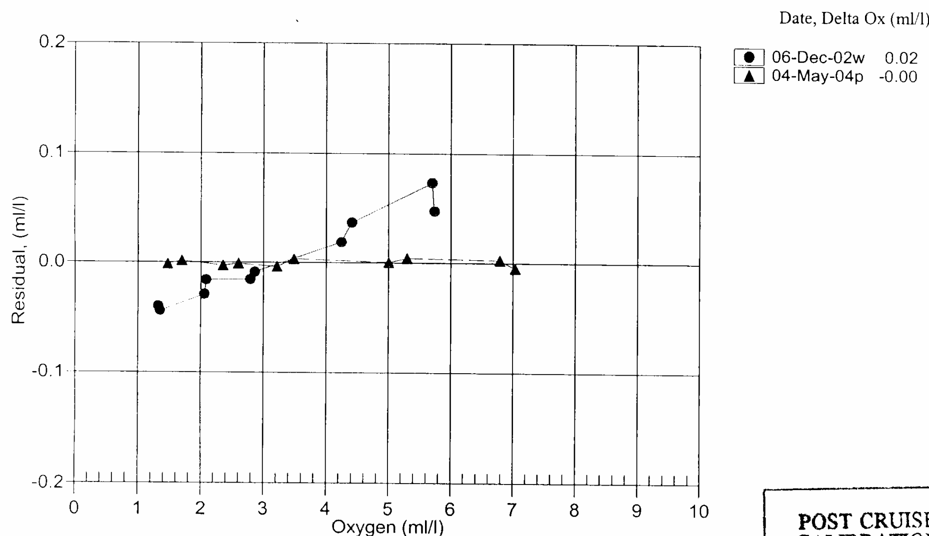
SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS
Soc = 0.4286
Boc = 0.0000
Voffset = -0.5073

TCor = 0.0003
PCor = 1.350e-04

BATH OX (ml/l)	BATH TEMP ITS-90	BATH SAL PSU	INSTRUMENT OUTPUT(VOLTS)	INSTRUMENT OXYGEN(ml/l)	RESIDUAL (ml/l)
1.47	25.00	0.01	1.096	1.46	-0.00
1.69	5.00	0.00	0.948	1.69	0.00
2.35	25.00	0.01	1.449	2.34	-0.00
2.59	5.00	0.00	1.184	2.59	-0.00
3.21	25.00	0.01	1.798	3.21	-0.00
3.48	5.00	0.00	1.417	3.48	0.00
5.00	25.00	0.01	2.518	5.00	0.00
5.30	5.00	0.00	1.891	5.30	0.00
6.78	25.00	0.01	3.235	6.79	0.00
7.03	5.00	0.00	2.341	7.03	-0.00

oxygen (ml/l) = (Soc * (V + Voffset)) * exp(Tcor * T) * Oxsat(T,S) * exp(Pcor * P)
V = voltage output from SBE43, T = ocean temperature [deg C]
S = ocean salinity [PSU] from CTD, P = ocean pressure [dbar] from CTD
Oxsat(T,S) = oxygen saturation [ml/l]
Residual = instrument oxygen - bath oxygen



POST CRUISE CALIBRATION

Dissolved Oxygen Sensor (Secondary)

Secondary

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: 0152
CALIBRATION DATE: 04-May-04p

SBE 43 OXYGEN CALIBRATION DATA

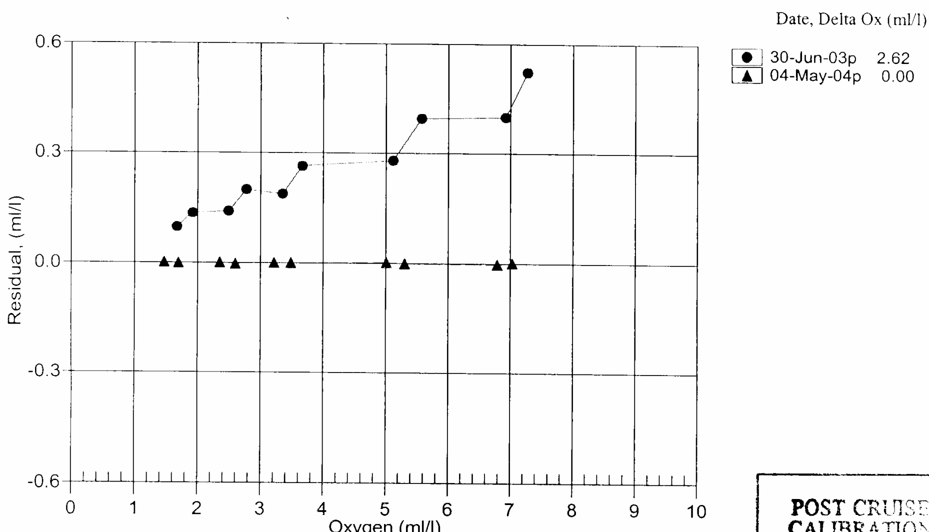
COEFFICIENTS

Soc = 0.5572
Boc = 0.0000
Voffset = -0.4989

TCor = 0.0010
PCor = 1.350e-04

BATH OX (ml/l)	BATH TEMP ITS-90	BATH SAL PSU	INSTRUMENT OUTPUT(VOLTS)	INSTRUMENT OXYGEN(ml/l)	RESIDUAL (ml/l)
1.47	25.00	0.01	0.944	1.47	0.00
1.69	5.00	0.00	0.836	1.69	-0.00
2.35	25.00	0.01	1.211	2.35	0.00
2.59	5.00	0.00	1.017	2.59	-0.00
3.21	25.00	0.01	1.474	3.21	0.00
3.48	5.00	0.00	1.195	3.48	0.00
5.00	25.00	0.01	2.017	5.01	0.00
5.30	5.00	0.00	1.558	5.30	-0.00
6.78	25.00	0.01	2.555	6.78	-0.00
7.03	5.00	0.00	1.905	7.03	0.00

oxygen (ml/l) = (Soc * (V + Voffset)) * exp(Tcor * T) * Oxsat(T,S) * exp(Pcor * P)
V = voltage output from SBE43, T = ocean temperature [deg C]
S = ocean salinity [PSU] from CTD, P = ocean pressure [dbar] from CTD
Oxsat(T,S) = oxygen saturation [ml/l]
Residual = instrument oxygen - bath oxygen



POST CRUISE
CALIBRATION

PAR

Transmissometer

Biospherical Instruments Inc

CALIBRATION CERTIFICATE

UNDERWATER PAR SENSOR WITH LOG AMPLIFIER

Calibration Date: 05/26/04 **Job No.:** R8730
Model Number: QSP200L
Serial Number: 7154
Operator: TPC
Standard Lamp: 99133 (12/26/03)
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:	**4.64E+13**	**quanta/cm²·sec/"amps"**	**7.70E-05**	**µEinsteins/cm²·sec/"amps"**
Wet Calibration Factor:	**7.81E+13**	**quanta/cm²·sec/"amps"**	**1.30E-04**	**µEinsteins/cm²·sec/"amps"**

Sensor Test Data and Results[4)]

Sensor Supply Current (Dark):	51.8	mA			
Supply Voltage:	6	Volts			
mp Integrated PAR Irradiance:	9.20E+15	quanta/cm^2·sec	0.01528	µEinsteins/cm²sec	
SC3 Immersion Coefficient:	0.594	Scalar Correction:	1	PAR Solar Correction:	1.0000

minal Filter OD	Calibrated Trans.	Sensor Voltage	Measured Trans.		Measured Signal (Amps)	Estimated Signal (Amps)	Calc. Output (Volts)	Error (Volts)	Error (%)	Test Irrad. (quanta/ cm^2·sec)
No Filter	100.00%	2.300	100.00%		2.00E-08	2.00E-08	2.303	0.003	0.0	9.20E+15
0.3	36.10%	1.873	36.96%		7.38E-09	7.21E-09	1.866	-0.007	-2.3	3.40E+15
0.5	27.60%	1.764	28.58%		5.71E-09	5.51E-09	1.752	-0.012	-3.4	2.63E+15
1	9.27%	1.336	10.25%		2.05E-09	1.85E-09	1.298	-0.038	-9.5	9.43E+14
2	1.11%	0.604	1.36%		2.71E-10	2.22E-10	0.549	-0.055	-18.2	1.25E+14
3	0.05%	0.185	0.10%		2.07E-11	1.07E-11	0.156	-0.029	-48.4	9.52E+12

Dark Before:	0.122	Volts			
Light - No Filter Hldr.:	2.301	Volts	I_{Ref} =	1.00E-10	Amps
Dark After - NFH:	0.123	Volts	I_{Dark} =	1.33E-10	Amps
Average Dark	0.1225	Volts	$10^{V_{Dark}}$ =	1.325867	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.

QSP-200L .xls

Transmissometer (continued)

Biospherical Instruments Inc

CALIBRATION CERTIFICATE

UNDERWATER PAR SENSOR WITH LOG AMPLIFIER

Calibration Date: 12/29/03 **Job No.:** R8588
Model Number: QSP200L
Serial Number: 4469
Operator: TPC
Standard Lamp: 99132 (12/26/03)
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:	**9.88E+12**	**quanta/cm²·sec/"amps"**	**1.64E-05**	**µEinsteins/cm²·sec/"amps"**
Wet Calibration Factor:	**1.66E+13**	**quanta/cm²·sec/"amps"**	**2.76E-05**	**µEinsteins/cm²·sec/"amps"**

Sensor Test Data and Results[4)]

Sensor Supply Current (Dark):	63.9	mA			
Supply Voltage:	6	Volts			
Lamp Integrated PAR Irradiance:	8.94E+15	quanta/cm²·sec	0.01484	µEinsteins/cm²sec	
SC3 Immersion Coefficient:	0.594	Scalar Correction:	1	PAR Solar Correction:	1.0000

minal Filter OD	Calibrated Trans.	Sensor Voltage	Measured Trans.		Measured Signal (Amps)	Estimated Signal (Amps)	Calc. Output (Volts)	Error (Volts)	Error (%)	Test Irrad. (quanta/ cm²·sec)
No Filter	100.00%	2.957	100.00%		9.06E-08	9.06E-08	2.958	0.001	0.0	8.94E+15
0.3	36.10%	2.516	36.12%		3.27E-08	3.27E-08	2.516	0.000	0.0	3.23E+15
0.5	27.60%	2.399	27.56%		2.50E-08	2.50E-08	2.400	0.001	0.2	2.46E+15
1	9.27%	1.928	9.21%		8.35E-09	8.40E-09	1.931	0.003	0.6	8.24E+14
2	1.11%	1.050	1.09%		9.84E-10	1.01E-09	1.059	0.009	2.1	9.71E+13
3	0.05%	0.309	0.07%		6.49E-11	4.84E-11	0.273	-0.037	-25.5	6.41E+12

Dark Before:	0.143	Volts			
Light - No Filter Hldr.:	2.958	Volts	I_{Ref} =	1.00E-10	Amps
Dark After - NFH:	0.143	Volts	I_{Dark} =	1.39E-10	Amps
Average Dark	0.143	Volts	$10^{V_{Dark}}$ =	1.389953	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.

QSP-200L .xls

Primary Conductivity Sensor

Primary

SEA-BIRD ELECTRONICS, INC.

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

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

SENSOR SERIAL NUMBER: 1799
CALIBRATION DATE: 07-May-04

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

GHIJ COEFFICIENTS

g = -4.35470164e+000
h = 5.27950726e-001
i = -7.13854167e-004
j = 6.34330337e-005
CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

ABCDM COEFFICIENTS

a = 6.53135805e-007
b = 5.25409090e-001
c = -4.34630598e+000
d = -8.49133214e-005
m = 5.4
CPcor = -9.5700e-008 (nominal)

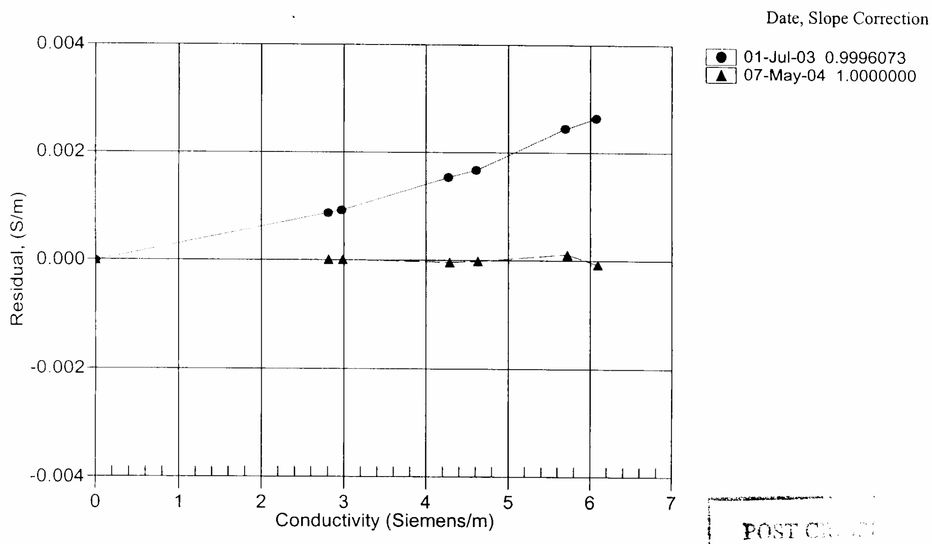
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.87615	-0.00000	-0.00000
-1.0002	34.9151	2.81177	7.85522	2.81178	0.00001
0.9997	34.9155	2.98361	8.05994	2.98362	0.00001
14.9997	34.9169	4.28262	9.46317	4.28258	-0.00004
18.4997	34.9170	4.63025	9.80407	4.63024	-0.00002
28.9998	34.9149	5.71662	10.79857	5.71674	0.00011
32.4998	34.9103	6.09050	11.11946	6.09043	-0.00008

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



POST C... CALIBR...

Secondary Conductivity Sensor

Secondary

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: 1852
CALIBRATION DATE: 18-May-04

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

GHIJ COEFFICIENTS

g = -4.12426890e+000
h = 5.26594563e-001
i = -5.52792139e-004
j = 5.51738387e-005
CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

ABCDM COEFFICIENTS

a = 1.40938133e-006
b = 5.24732637e-001
c = -4.11859899e+000
d = -8.69423387e-005
m = 5.1
CPcor = -9.5700e-008 (nominal)

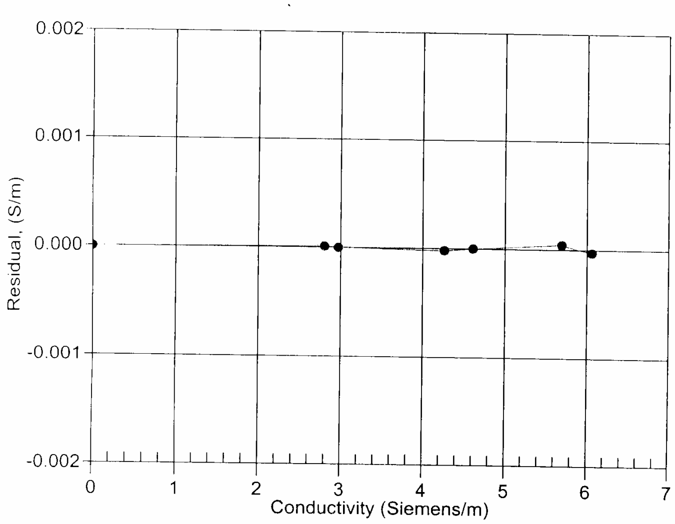
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
0.0000	0.0000	0.00000	2.80153	-0.00000	-0.00000
-1.0002	34.7152	2.79717	7.81411	2.79718	0.00001
0.9997	34.7157	2.96816	8.01906	2.96816	-0.00000
14.9997	34.7171	4.26070	9.42328	4.26068	-0.00002
18.4998	34.7172	4.60662	9.76430	4.60662	0.00000
28.9998	34.7159	5.68770	10.75897	5.68774	0.00004
32.4997	34.7123	6.05987	11.08011	6.05984	-0.00003

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



Date, Slope Correction

18-May-04 1.0000000

Meteorology System

Anemometer (Port)

RM Young Anemometer Calibration, Model 05106

S/N: 51143 **Date:** 19-Sep-04 **Cal'd By:** W. Gallagher

Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s	Knots
0	0.00	0.0	0.0	0.0
200	0.98	0.9	0.1	1.9
500	2.45	2.3	0.2	4.8
1000	4.90	4.8	0.1	9.5
1500	7.35	7.4	-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	34.8	-0.5	66.6
8000	39.20	39.8	-0.6	76.2
9000	44.10	44.8	-0.7	85.7
10000	49.00	49.8	-0.8	95.2
12000	58.80	59.5	-0.7	114.2

Direction	Measured Direction	Delta Direction
0	0	0
30	28	2
60	58	2
90	88	2
120	118	2
150	148	2
180	179	1
210	210	0
240	240	0
270	270	0
300	300	0
330	330	0
0	0	0

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

Counter Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s
0	0.00	0.0	0.0
200	0.98	0.9	0.1
500	2.45	2.4	0.0
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	29.8	-0.4
7000	34.30	34.8	-0.5
8000	39.20	39.8	-0.6
9000	44.10	44.8	-0.7
10000	49.00	49.7	-0.7
12000	58.80	59.5	-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

Installed new housing assy and wind direction potentiometer coupling. Good calibration.

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

Anemometer (Starboard)

RM Young Anemometer Calibration, Model 05106

S/N: 51144 **Date:** 20-Sep-04 **Cal'd By:** W. Gallagher

Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s	Knots
0	0.00	0.0	0.0	0.0
200	0.98	1.0	0.0	1.9
500	2.45	2.3	0.2	4.8
1000	4.90	4.8	0.1	9.5
1500	7.35	7.3	0.0	14.3
2000	9.80	9.8	0.0	19.0
3000	14.70	14.7	0.0	28.6
4000	19.60	19.6	0.0	38.1
5000	24.50	24.6	-0.1	47.6
6000	29.40	29.4	0.0	57.1
7000	34.30	34.3	0.0	66.6
8000	39.20	39.2	0.0	76.2
9000	44.10	43.9	0.2	85.7
10000	49.00	48.7	0.3	95.2
12000	58.80	58.1	0.7	114.2

Direction	Measured Direction	Delta Direction
0	0	0
30	30	0
60	60	0
90	90	0
120	120	0
150	151	-1
180	182	-2
210	212	-2
240	242	-2
270	272	-2
300	302	-2
330	332	-2
0	0	0

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

Counter Clockwise Cal Motor RPM	Calculated Windspeed m/s	Measured Windspeed m/s	Delta m/s
0	0.00	0.0	0.0
200	0.98	0.9	0.1
500	2.45	2.3	0.2
1000	4.90	4.8	0.1
1500	7.35	7.3	0.0
2000	9.80	9.8	0.0
3000	14.70	14.6	0.1
4000	19.60	19.6	0.0
5000	24.50	24.5	0.0
6000	29.40	29.4	0.0
7000	34.30	34.3	0.0
8000	39.20	39.1	0.1
9000	44.10	43.8	0.3
10000	49.00	48.2	0.8
12000	58.80	57.7	1.1

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

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

Additional Comments

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

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

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:

3.91 $\times 10^{-6}$ volts/watts meter^{-2}

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

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

Shipped to:
National Science Foundation
Port Hueneme, CA

S.O. Number: 59674
Date: December 19, 2003

Date of Test: December 18, 2003
In Charge of Test: R.T. Gegman
Reviewed by: Thomas 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: info@eppleylab.com Internet: www.eppleylab.com

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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:

$$8.05 \times 10^{-6} \text{ volts/watts meter}^{-2}$$

The calculation of this constant is based on the fact that the relationship between radiation intensity and emf is rectilinear to intensities of 1400 watts meter^{-2}. This radiometer is linear to within ± 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 Polar Services Co.
Port Hueneme, CA

S.O. Number: 59901
Date: June 25, 2004

Date of Test: June 22, 2004

In Charge of Test:

Reviewed by:

Remarks:

GUV

DASSN	DASdescription	DAStype	DASnavisionJob	Firmware	Tag	SystemSN
0069	Ed0	GUV-2511	R8785	005024HB v.0001 03-06-11	4	25110203114

ChannelDelay	Offset1	Offset16	Offset256	Gain1	Gain16	Gain256	Gain1to16
500	-0.00274658	9.5367E-05	0.00023365	-78	1259	-376	0.3125

Gain16to256	Gain16to1	Gain256to16	ResistorStoM	ResistorMtoL	ResistorMtoS	ResistorLtoM
0.01953125	0.546875	0.03417969	0.01953125	0.01953125	8.75	8.75

PAR (ship's mast)

Installed 11/8/03 03:00 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

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

SENSOR SERIAL NUMBER: 3198
CALIBRATION DATE: 10-Dec-03

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

GHIJ COEFFICIENTS
```
g =  -4.269144856+000
h =   5.04385767e-001
i =  -5.28033538e-004
j =   5.13505352e-005
CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

ABCDM COEFFICIENTS
```
a =  1.68075864e-006
b =  5.02459202e-001
c = -4.26050708e+000
d = -9.04472870e-005
m =  5.0
CPcor = -9.5700e-008 (nominal)
```

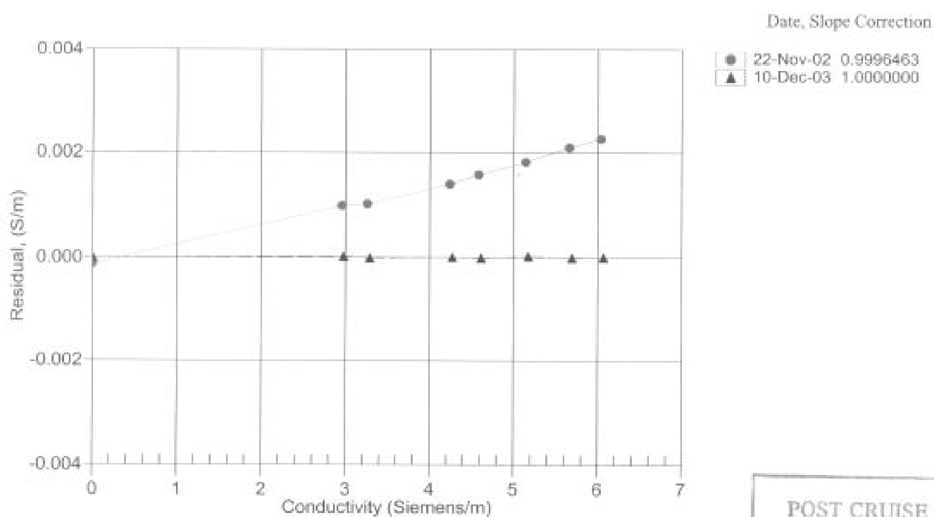
BATH TEMP (ITS-90)	BATH SAL (PSU)	BATH COND (Siemens/m)	INST FREQ (kHz)	INST COND (Siemens/m)	RESIDUAL (Siemens/m)
22.0000	0.0000	0.00000	2.91249	-0.00000	-0.00000
0.9999	34.8336	2.97729	8.22249	2.97731	0.00002
4.4999	34.8127	3.28441	8.58435	3.28439	-0.00002
15.0000	34.7689	4.26641	9.64948	4.26642	0.00000
18.5000	34.7599	4.61169	9.99651	4.61168	-0.00001
23.9999	34.7503	5.16988	10.53287	5.16990	0.00002
28.9999	34.7454	5.69200	11.01026	5.69199	-0.00001
32.5000	34.7436	6.06475	11.33844	6.06474	-0.00000

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



POST CRUISE CALIBRATION

Underway Temperature Sensor

SEA-BIRD ELECTRONICS, INC.

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

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

SENSOR SERIAL NUMBER: 3198
CALIBRATION DATE: 10-Dec-03

SBE21 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS

g = 4.22427999e-003
h = 6.28774124e-004
i = 1.97842562e-005
j = 1.36006195e-006
f0 = 1000.0

ITS-68 COEFFICIENTS

a = 3.64763667e-003
b = 5.95222584e-004
c = 1.59625049e-005
d = 1.36147300e-006
f0 = 2568.358

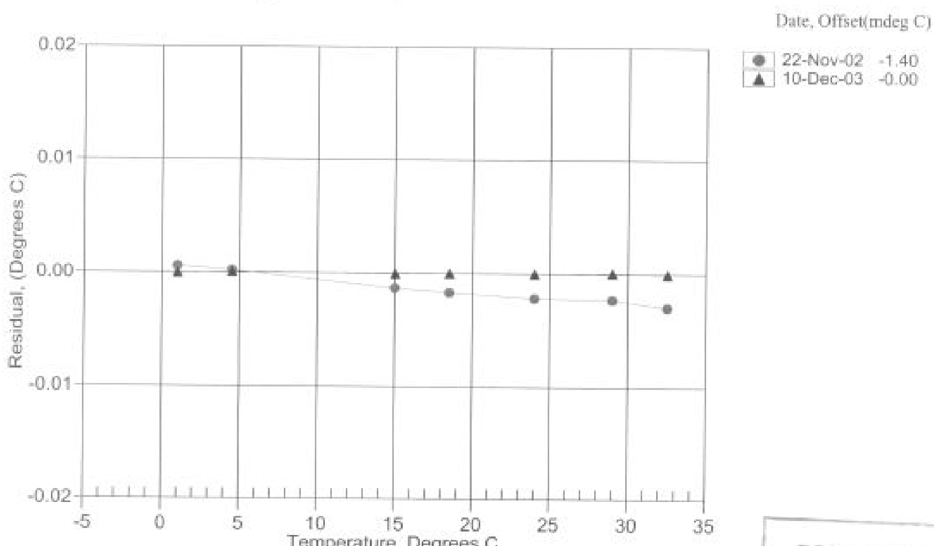
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
0.9999	2568.358	0.9999	-0.00003
4.4999	2775.129	4.5000	0.00005
15.0000	3467.500	15.0000	-0.00004
18.5000	3723.433	18.5000	-0.00000
23.9999	4152.211	23.9999	-0.00001
28.9999	4571.132	29.0000	0.00006
32.5000	4881.353	32.5000	-0.00004

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



POST CRUISE CALIBRATION

Underway Remote Temperature Sensor

For JBP

SEA-BIRD ELECTRONICS, INC.

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

SENSOR SERIAL NUMBER: 1267
CALIBRATION DATE: 21-Nov-03

SBE3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPRATURE SCALE

ITS-90 COEFFICIENTS		ITS-68 COEFFICIENTS	
g =	4.76644674e-003	a =	3.68121454e-003
h =	6.64834752e-004	b =	5.89542081e-004
i =	2.85938689e-005	c =	1.47437327e-005
j =	2.65570196e-006	d =	2.65717814e-006
f0 =	1000.0	f0 =	5707.067

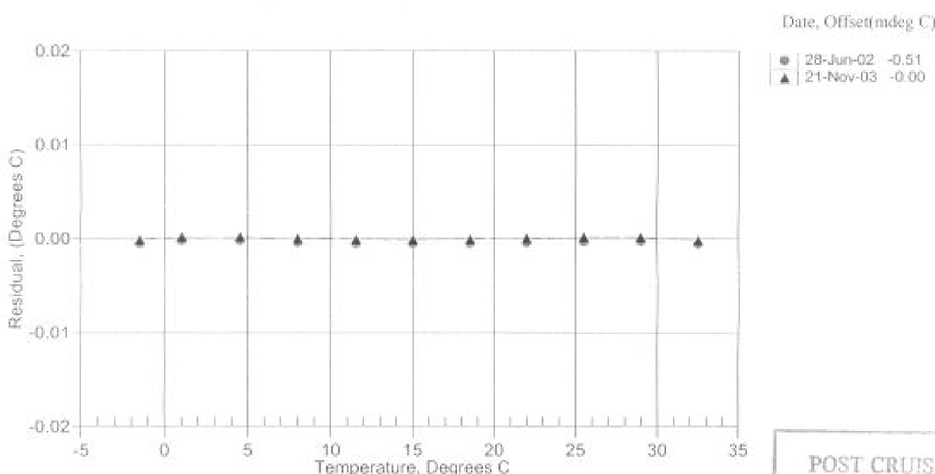
BATH TEMP (ITS-90)	INSTRUMENT FREQ (Hz)	INST TEMP (ITS-90)	RESIDUAL (ITS-90)
-1.5000	5707.067	-1.5002	-0.00016
1.0000	6042.079	1.0002	0.00016
4.5000	6534.713	4.5002	0.00016
8.0000	7055.660	8.0000	-0.00001
11.5000	7605.725	11.4999	-0.00011
15.0000	8185.654	14.9999	-0.00014
18.5000	8796.173	18.4999	-0.00007
22.0000	9437.967	22.0000	0.00005
25.5000	10111.686	25.5002	0.00015
29.0000	10817.942	29.0001	0.00015
32.5000	11557.289	32.4998	-0.00017

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



POST CRUISE CALIBRATION

Underway Transmissometer

PO Box 518
620 Applegate St.
Philomath, OR 97370

WET Labs

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

C-Star Calibration

Date	6/15/2004	Customer	National Science Foundation	Work order	007
Job #	0012016	S/N#	CST-422PR	Pathlength	25 cm

	Analog meter
V_d	0.061 V
V_{air}	4.786 V
V_{ref}	4.687 V

Temperature of calibration water	21.3 °C
Ambient temperature during calibration	22.5 °C

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

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

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

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

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Underway Transmissometer (2)

PO Box 518
620 Applegate St.
Philomath, OR 97370

WET Labs

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

C-Star Calibration

Date 5/25/2004	Customer National Science Foundation	Work order 008
Job # 0012016	S/N# CST-423PR	Pathlength 25 cm

	Analog meter
V_d	0.059 V
V_{air}	4.807 V
V_{ref}	4.791 V

Temperature of calibration water	22.1 °C
Ambient temperature during calibration	22.4 °C

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

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

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

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