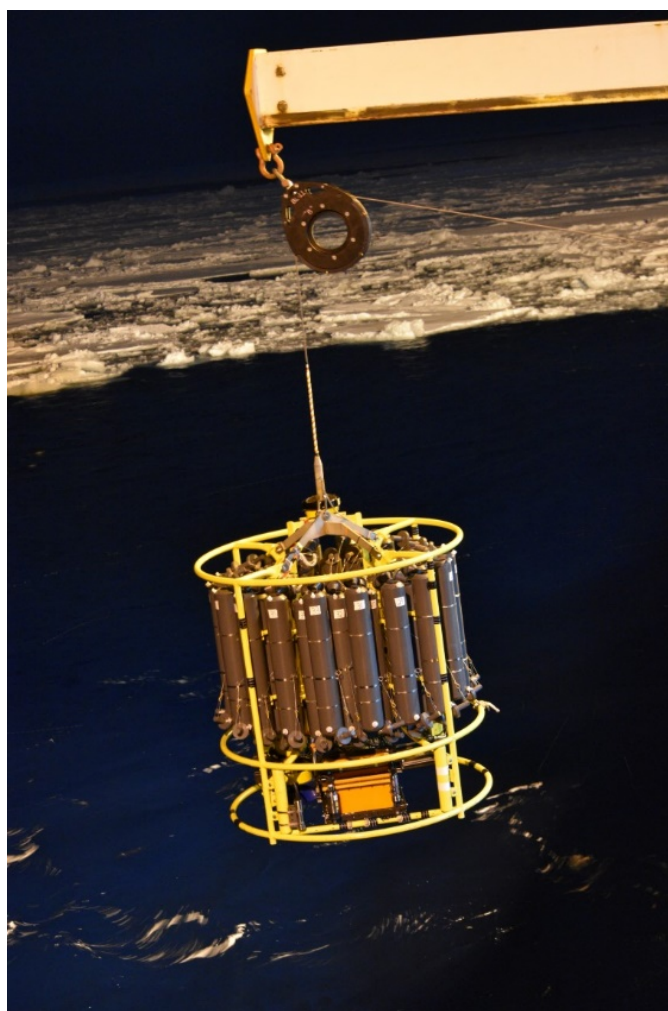


GO-SHIP S04P

Data Report NBP18-02

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United States Antarctic Program

Data Report Prepared By:
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[BE SURE TO UPDATE ToC (Right click, `update field`. Then `update entire table`)]

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Introduction

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

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

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

All the data has been archived using 'tar' and compressed using 'gzip', identified by the '.tz' extension. Tools are available on all platforms for uncompressing and de-archiving these formats: On Macintosh use the built-in Archive Utility, or tar in the terminal. On Windows operating systems use WinZip or 7Zip.

MultiBeam and Bathymetry 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

[Change the directory structure shown below to reflect your distribution media]

Volume 1 of 1: 1802

File	Description
/	Root level directory
1802.gmt	GMT binary file of MGD77 data
1802.mgd	Full Cruise MGD77 data file
1802.trk	Text file of cruise track
1802.kmz	Track KMZ (not 100% compliant)
1802DATA.docx	Data Report 1802 (MS Word)
1802DATA.pdf	Data Report 1802 (PDF format)
INSTCOEF.TXT	Instrument Coefficient File
/plots	Track Maps
NBP1802-study-area.ps	Postscript track map
NBP1802-study-area.pdf	PDF track map
/process	Processed data
1802JGOF.tz	JGOFS format data files
1802MGD.tz	MGD Data
1802PCO2.tz	Merged pCO ₂ data files
1802PROC.tz	Other processed data
1802QC.tz	Daily RVDAS QC postscript plots
/rvdas/nav	Navigation data
1802adcp.tz	ADCP Data Sets
1802ais1.tz	Science AIS receiver data
1802gyr1.tz	Gyro raw data
1802gp02.tz	Bridge Furuno
1802s330.tz	Seapath 330 data
1802seap.tz	Seapath 200 data
/rvdas/uw	Underway data
1802bwnc.tz	Baltic winch data
1802ctdd.tz	CTD depth data
1802engl.tz	Engineering data
1802grv1.tz	Gravimeter data
1802hdas.tz	HydroDAS raw data
1802knud.tz	Knudsen raw data
1802mbdp.tz	Multi-beam depth
1802mwx1.tz	Meteorology raw data
1802ndfl.tz	Fluorometer data
1802pco2.tz	pCO ₂ raw data
1802pguv.tz	GUV raw data
1802rtmp.tz	Remote Temperature data
1802tsg1.tz	Micro TSG1 data
1802tsg2.tz	Micro TSG2 data
/Imagery	Cruise Imagery
1802Imag.tz	Collection of Imagery Files
/ocean	Ocean data
1802ctd.tz	CTD Data

Extracting Data

The data files will have a “.tz” extension on the filename. The “.tz” extension is for files whose contents have been archived using the “tar” utility and compressed with the “gzip” utility.

An example of creating a compressed archive file:

```
tar -czvf archive_filename files_to_archive
```

An example of listing the files in an archive:

```
tar -tzvf archive_filename
```

An example redirecting the list output to a file, where `contents.list` is the name of the file to create:

```
tar -tzvf archive_filename > contents.list
```

An example extracting all files from the archive:

```
tar -xzf archive_filename
```

An example extracting specific files from the archive:

```
tar -xzf archive_filename list_of_files_to_extract
```

Distribution Contents

Cruise Track

The distribution DVD includes a GMT cruise track file (1802.trk). It contains the longitude and latitude at one-minute intervals extracted from the 1802.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, IdDDDYA.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

NBP Data Products

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

The data processing scripts used to produce JGOFS and MGD77 data sets create a lot of intermediate files. These files are included on the data distribution media in a file called 1802proc.TAR. They are included to make re-processing easier in the event of an error, but no extensive detail of the formats is included in this document. If you have any questions, please contact itvessel@usap.gov.

JGOFS

The JGOFS data set can be found on the distribution media in the file /process/1802JGOF.tar. The archive contains one file produced for each day named jgDDD.dat.gz, where DDD is the year-day the data was acquired. The “.gz” extension indicates that the individual files are compressed before archiving. Each daily file consists of 22 columnar fields in text format as described in the table below. The JGOFS data set is created from calibrated data decimated at one-minute intervals. Several fields are derived measurements from more than a single raw input. For example, Course Made Good (CMG) and Speed Over Ground (SOG) are calculated from gyro and GPS inputs. Daily plots during the cruise are produced from the JGOFS data set. Note: Null, unused, or unknown fields are indicated as “NAN” as 9999 in the JGOFS data.

Field	Data	Units
01	UTC Date	dd/mm/yy
02	UTC Time	hh:mm:ss
03	Seapath Latitude (negative is South)	tt.tttt
04	Seapath 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	μEinstein's/meter ²
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 (max speed windbird)	meters/sec
15	True Wind Direction (max speed windbird)	degrees (azimuth)
16	Ambient Air Temperature	°C
17	Relative Humidity	%
18	Barometric Pressure	mBars
19	Sea Surface Fluorometry	volts (0-5 FSO)
20	Transmissometry	%
21	PSP	W/m ²
22	PIR	W/m ²

MGD77

The MGD77 data set is contained in a single file for the entire cruise. It can be found in the top level of the distribution data structure as 1802.mgd. The file 1802.gmt is created from the MGD77 dataset using the “mgd77togmt” utility. 1802.gmt can be used with the GMT plotting package.

The data used to produce the 1802.mgd file can be found on the distribution media in the file /process/1802proc.tar. The data files in the archive contain a day’s data and follow the naming convention Dddd.fnl.tz, 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 chars 13-27) to UTC when added; 0=UTC
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	Positive = North, Negative = South. (-9000000 to 9000000)
36-44	9	real	Longitude x 100000	Positive = East, Negative = 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	Bathymetric, 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"), total and residual fields are assumed to be uncorrected; if used, total and residual are assumed to have been already corrected.
85-90	6	F6.0	Depth or altitude of magnetics sensor	(In meters). Positive = Below sea level, 3 = Above sea level
91-97	7	real	Observed gravity	In 10 th of mgals. Corrected for Eotvos, drift, tares
98-103	6	real	EOTVOS correction	In 10 th of mgals. $E = 7.5 V \cos \phi \sin \alpha + 0.0042 V * V$
104-108	5	real	Free-air anomaly	In 10 th of mgals, G = observed, G = theoretical
109-113	5	char	Seismic line number	Cross reference for seismic data
114-119	6	char	Seismic shot-point number	
120	1	int	Quality code for navigation	5 = Suspected, by the originating institution 6 = Suspected, by the data center 9 = No identifiable problem found

Science of Opportunity

ADCP

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

A data feed is sent from the ADCP system to RVDAS whenever a reference layer is acquired. This feed contains east and north vectors for ship's speed, relative to the reference layer, and ship's heading. Collected files (one per day) are archived in 1802adcp.tar in the directory /rvdas/nav.

pCO₂

The NBP carries a pCO₂ measurement system from Lamont-Doherty Earth Observatory (LDEO). pCO₂ data is recorded by RVDAS and transmitted to LDEO at the end of each cruise. You will find pCO₂ data in a file named 1802pco2.tar in the /process directory, which contains the pCO₂ instrument's data merged with GPS, meteorological and other oceanographic measurements. For more information contact Colm Sweeney (csweeney@ldeo.columbia.edu).

Cruise Science

CTD

The CTD data has been placed in the tar file /ocean/1802ctd.tar. The archive contains tar files 1802proc.tar.

XBT

During a cruise, eXpendable BathyThermographs (XBTs) may have been used to obtain water column temperature profiles, providing corrections to the sound velocity profile for the multibeam system. The data files from those launches would be included as 1802xbt.tar in the /ocean directory. **No XBTs were collected on this cruise.**

RVDAS

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

Daily data processing of the RVDAS data is performed to calibrate and convert values into useable units and as a quality-control on operation of the DAS. Raw and processed data sets from RVDAS are included in the data distribution. The tables below provide detailed information on the sensors and data. Be sure to read the “Significant Acquisition Events” section for important information about data acquisition during this cruise.

Sensors and Instruments

RVDAS data is divided into two general categories, *underway and navigation*. They can be found on the distribution media as subdirectories under the top level rvdas directory: /rvdas/uw, and /rvdas/nav. Processed oceanographic data is in the top level directory, /process. Each instrument or sensor produces a data file named with its channel ID. Each data file is g-zipped to save space on the distribution media. Not all data types are collected every day or on every cruise.

The naming convention for data files produced by the sensors and instruments is

NBP[CruiseID][ChannelID].dDDD

Example: 1802mwx1.d025

- The CruiseID is the numeric name of the cruise, in this case, 1802.
- The ChannelID is a 4-character code representing the system being logged. An example is “mwx1,” the designation for meteorology.
- DDD is the day of year the data was collected

Underway Sensors

Meteorology and Radiometry

Measurement	String ID	Collection Status	Rate	Instrument
Air Temperature	mwx1 (met)	Continuous	1/sec	RM Young 41372LC
Relative Humidity	mwx1 (met)	Continuous	1/sec	RM Young 41372LC
Wind Speed / Direction	mwx1 (pus,sus)	Continuous	1/sec	Gill Instruments 1390-PK-062
Barometer	mwx1 (met)	Continuous	1/sec	RM Young 61201
PAR	mwx1 (met)	Continuous	1/sec	Biospherical Instruments QSR-240
PIR	mwx1 (met)	Continuous	1/sec	Eppler PIR
PSP	mwx1 (met)	Continuous	1/sec	Eppler PSP
GUV	pguv	Continuous	2/sec	Biospherical Instruments GUV-2511

Geophysics

Measurement	String ID	Collection Status	Rate	Instrument
Gravimeter	grv1	Continuous	1/sec	BGM3/210
Bathymetry	knud	Continuous	varies	Knudsen Chirp
Bathymetry	mbdp	Continuous	varies	Kongsberg EM122

Oceanography

Measurement	String ID	Collection Status	Rate	Instrument
Conductivity	tsg1,tsg2	Continuous	0.5/sec	Sea-Bird SBE 45
Ocean Surface Temperature	rtmp	Continuous	1.2/sec	Sea-Bird SBE 38
Transmissometer	hdas	Continuous	0.5/sec	WetLabs C-Star
Fluorometer	hdas	Continuous	0.5/sec	WetLabs AFLT
pCO ₂	pco2	Continuous	0.017/sec	LDEO instrumentation
ADCP	adcp	Continuous	1/sec	UHDAS
Bathymetry	sim1	Continuous	varies	Simrad EK60 Sonar

Navigational Instruments

Measurement	String ID	Collection Status	Rate	Instrument
Heading, Speed, Course, GPS, Heave, Roll and Pitch	s330	Continuous	1/sec	Seapath 330 GPS
Heading, Speed, Course, GPS, Heave, Roll and Pitch	seap	Continuous	1/sec	Seapath 200 GPS
Heading, Speed, Course, and GPS	PCOD	Continuous	1/sec	Furuno GP-330B
Heading	gyr1	Continuous	0.2/sec	Yokogawa Compass

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.

Each section on the next page describes a type of data file (file name extension in parentheses) followed by a typical line of data in the file. In the table(s) for each section is a description of the fields within each line of data. Note: most data files listed below will be included with each cruise's data distribution; however some types of files may be omitted if the instrument was not operating during the cruise. The available data files can be found in the /rvdas/uw and /rvdas/nav directories on the distribution disc.

Underway Data /rvdas/uw**Sound Velocity Probe (svp1)**

15+055:20:27:24.018 1535.43

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Sound Velocity, from ADCP sonar well	xxxx.xx	m/s

Meteorology (mwx1)**MET**

15+055:20:27:24.636 MET,12.1,-39,-6.07,77.4,178.0729,0.809536,-0.1235019,268.1754,267.9648,970.7878

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	MET Flag		
3	Power Supply Voltage	vv.v	V
4	Enclosure Relative Humidity (not implemented)	xx.x	%
5	Air Temperature, Celsius	xx.x	C
6	Air Relative Humidity	xx.x	%
7	PAR (Photosynthetically Available Radiation)	xxx.xxxx	mV
8	PSP (Shortwave Radiation)	x.xxxxxx	mV
9	PIR Thermopile (Longwave Radiation)	x.xxxxxx	mV
10	PIR Case Temperature	xxx.xxxx	K
11	PIR Dome Temperature	xxx.xxxx	K
12	Barometer	xxx.xxxx	mBar

PUS

15+055:21:47:42.452 PUS,A,037,014.36,M,+325.38,-010.29,60,0F

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	PUS Flag		
3	A	x	A
4	Port Wind Relative Direction	xxx	degrees
5	Port Wind Relative Speed	xxx.xx	m/s
6	M = Meters (for previous)	x	M
7	Sound Speed	xxx.xx	m/s
8	Sonic Temperature	xxx.xx	C
9	Unit Status*	xx	numeric
10	Checksum	xx	alphanumeric

Status

00 = Good, 60 = Good. Any other value indicates fault

SUS

15+055:21:50:48.409 SUS,A,338,012.63,M,+326.15,-009.05,60,0F

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	SUS Flag		
3	A	x	A
4	Starboard Wind Relative Direction	xxx	degrees
5	Starboard Wind Relative Speed	xxx.xx	m/s
6	M = Meters (for previous)	x	M
7	Sound Speed	xxx.xx	m/s
8	Sonic Temperature	xxx.xx	C
9	Unit Status*	xx	numeric
10	Checksum	xx	alphanumeric

Status

00 = Good, 60 = Good. Any other value indicates fault

Knudsen (knud)

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	3.5kHz = Low frequency in use	x.xxxx	3.5kHz
3	Low Frequency Depth	xxxx.xx	m
4	Valid Flag	x	0
5	12.0kHz = High frequency in use	xx.xxxx	12.0kHz
6	High Frequency Depth	xxxx.xx	m
7	Valid Flag	x	0
8	Sound Speed Velocity	xxxx	m/s
9	Latitude	xx.xxxxxx	degrees
10	Longitude	xx.xxxxxx	degrees

Gravimeter (grv1)

15+056:14:21:21.153 01:025268 00

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	01:	xx:	01
3	Gravity Count*	xxxxxx	Flit Count
4	Error Flag	xx	numeric

Error Flag

00 = All well, 01 = CPS malfunction, 02 = Sensor Malfunction, 03 = CPS and sensor Malfunction

A gravity tie is taken at the start of the cruise and applied throughout the cruise. There is no accounting for drift after the pre-cruise gravity time. The post cruise gravity tie is available by requesting it from ethq@usap.gov.

pCO₂ (pco2)

15+056:14:41:10.392 2015056.60236 2608.36 30.14 977.91 48.25 368.76 353.92 -1.18 -1.26 0.00 Equil

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	pCO ₂ time tag*	yyyyddd.ttt	UTC
3	Raw Voltage (IR)	xxxx.xx	mV
4	Cell Temperature	xx.xx	C
5	Equilibration Pressure	xxx.xx	mBar
6	Flowrate	xxx.xx	cm ³ /min
7	pCO ₂ Pressure	xxx.xx	μAtm
8	VCO ₂ Concentration	xx.xx	ppm
9	Equilibrator Temperature, RTD	xx.xx	C
10	Equilibrator Temperature, SBE38	xx.xx	C
11	Valve Position	xx	numeric
12	Flow Source*		text

pCO₂ time tag

ttt = fractional time of day

Flow SourceEquil = pCO₂ Measurement**Micro TSG (tsg1, tsg2)**

15+056:15:06:06.644 -1.1809, 2.73404, 34.0574, 1442.367

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Temperature	xx.xxxx	C
3	Conductivity	xx.xxxx	s/m
4	Salinity	xx.xxxx	PSU
5	Sound Velocity	xxxx.xxx	m/s

Remote Temperature (rtmp)

15+056:15:10:38.244 -1.4644

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Temperature, Seawater Intake	xx.xxxx	C

GUV (pguv)

15+057:14:51:33.808 022615 065133 .000132 .010878 .047479 .004407 -.002799 .014652 .027558 .094395
 .417814 -4.466095

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Date	mmddyy	UTC-4
3	Time	hhmmss	UTC-4
4	Ed0GND (sensor ground voltage)	xxxxxx	V
5	Ed0320 (downwelling 320nm irradiance)	xxxxxx	μW
6	Ed0340 (downwelling 340nm irradiance)	xxxxxx	μW
7	Ed0313 (downwelling 313nm irradiance)	xxxxxx	μW
8	Ed0305 (downwelling 305nm irradiance)	xxxxxx	μW
9	Ed0380 (downwelling 380nm irradiance)	xxxxxx	μW
10	Ed0PAR (downwelling 400-700nm irradiance)	xxxxxx	μE
11	Ed0395 (downwelling 395nm irradiance)	xxxxxx	μW
12	Ed0Temp (sensor array temperature)	xxxxxx	C
13	Ed0Vin (input voltage)	x.xxxxxx	V

Engineering (eng1)

15+057:16:41:24.536 12.25 23.21 507.8 0.6 162.6 -751.9 0 0 NAN NAN -10.3 7.2

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Supply Voltage	xx.xx	V
3	Case Temperature	xx.xx	C
4	Seawater Flow, Aquarium Room	xxx.x	l / min
5	Seawater Flow, Helo-deck	x.x	l / min
6	Seawater Flow, Hydro-lab	xxx.x	l / min
7	Seismic Air Pressure	xxx.x	lbf/in ²
8	Not Currently Hooked Up	x	0 or NAN
9	Not Currently Hooked Up	x	0 or NAN
10	Not Currently Hooked Up	x	0 or NAN
11	Not Currently Hooked Up	x	0 or NAN
12	Altimeter for Yo-Yo Camera - Rarely used*	xx.xx	m
13	Transmissometer for Yo-Yo camera - Rarely used*	xxx.x	%

Altimeter

This is rarely used, and only provides real data when connected. When not connected, provides a value approx = -10.

Transmissometer

This is rarely used, and only provides real data when connected. When not connected, provides a value range of approx = 0 to 10.

Hydro DAS (hdas)

15+057:16:07:09.456 12.15038 12.39402 336.5517 4431.724 -1 20.5 64 33.5 43.5

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Supply Voltage	xx.xxxxx	V
3	Case Temperature	xx.xxxxx	C
4	Fluorometer	xxx.xxxx	mV
5	Transmissometer	xxxx.xxx	mV
6	Sea Water Valve*	x	-1 or 0
7	Flow Meter 1 Frequency	xx.x	Hz
8	Flow Meter 2 Frequency	xx.x	Hz
9	Flow Meter 3 Frequency	xx.x	Hz
10	Flow Meter 4 Frequency	xx.x	Hz

Sea Water Valve

-1 = Stern Thruster Valve, 0 = Moon Pool Valve

Winch (bwnc, cwnc, twnc)

15+057:14:12:24.405 02RD,2015-02-26T14:55:32.051,STBD TRAWL,00000064,-00000.0,-00023.2,3594

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	LAN ID		alphanumeric
3	LCI-90i Date and Time	yyyy-mm-ddThh:mm:ss.sss	
4	Winch Name		alphabetical
5	Tension	xxxxxxxx	lbs
6	Speed	xxxxx.x	m/min
7	Payout	xxxxx.x	m
8	Checksum	x.xxxx	numeric

Multibeam (mbdp)

15+058:22:04:52.826 \$KIDPT,594.68,7.67,12000.0*43

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	KIDPT	x.x	m
3	Depth at Transducer	x.x	m
4	Distance to Waterline from Transducer	x.x	m
5	Maximum Range in Use	x.x	alphanumeric
6	Checksum	xx	UTC

Fluorometer (ndfl)

18+121:00:00:21.785 99/99/99 99:99:99 0.71 695 155 559

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Ignore	x.x	n/a
3	Ignore	x.x	n/a
4	Chlorophyll signature	xx.xx	µg/l
5	Wavelength (Not used)	xxx	nanometers
6	Chlorophyll Counts	xxxx	Counts
7	Internal Thermistor (Not used)	xxx	Therm

Navigational Data */rvdas/nav***GPS (s330, seap, PCOD)**

1. ***Seapath 330***
 - a. NMEA 0183 strings
 - i. GPZDA
 - ii. GPGGA
 - iii. GPVTG
 - iv. GPHDT
 - v. GPRMC
 - b. Proprietary Strings
 - i. PSXN 20
 - ii. PSXN 22
 - iii. PSXN 23
2. ***Seapath 200***
 - a. NMEA 0182 strings
 - i. GPZDA
 - ii. GPGGA
 - iii. GPVTG
 - iv. GPHDT
 - b. Proprietary Strings
 - i. PSXN 20
 - ii. PSXN 22
 - iii. PSXN 23
3. ***Furuno GP-330B***
 - a. NMEA 0183 strings
 - i. GPZDA
 - ii. GPGGA
 - iii. GPVTG
 - iv. GPRMC
 - v. GPGLL
 - vi. GPDTM

GPZDA

15+051:21:02:04.507 \$GPZDA,210204.39,20,02,2015,,*6F

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$GPZDA		
3	Time	hhmmss.ss	UTC
4	Day	dd	UTC
5	Month	mm	UTC
6	Year	yyyy	UTC
7	(empty field)	x	Blank or 0
8	Checksum	xx	alphanumeric

GPGBA

15+051:21:02:02.507 \$GPGBA,210202.38,7712.979244,S,16741.040258,W,1,12,0.7,-5.04,M,-55.90,M,,*6F

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$GPGBA		
3	Time	hhmmss.ss	UTC
4	Latitude	ddmm.mmmmmm	degrees
5	North or South (for previous)	x	N or S
6	Longitude	ddmm.mmmmmm	degrees
7	East or West (for previous)	x	E or W
8	GPS quality indicator*	x	0,1,2,3,4,5, or 6
9	Number of satellites in use (00-99)	xx	00-99
10	HDOP	x.x	
11	Antenna height	x.xx	m
12	M = Meters (for previous)	x	M
13	Geoidal height	x.xx	m
14	M = Meters (for previous)	x	M
15	Age of DGPS corrections (seconds)	x.x	seconds
16	Station ID of DGPS (if used)	x	numeric
17	Checksum	xx	alphanumeric

Quality

0 = invalid, 1 = GPS SPS, 2 = DGPS, 3 = PPS, 4 = RTK, 5 = float RTK, 6 = dead reckoning

GPVTG

15+051:16:47:06.625 \$GPVTG,357.84,T,251.99,M,9.5,N,17.7,K,A*15

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$GPVTG		
3	Heading	x.xx	degrees
4	T = True (for previous)	x	T
5	Heading	x.xx	degrees
6	M = Magnetic (for previous)	x	M
7	Speed over Ground (knots)	x.x	knots
8	N = knots (for previous)	x	N
9	Speed over Ground (kilometers per hour)	x.x	km/h
10	K = km per hour (for previous)	x	K
11	Mode*	X	A,D,E, or N
12	Checksum	xx	alphanumeric

Modes

A = GPS used, D = DGPS used, E = Dead reckoning used, N = Invalid position / velocity

GPRMC

15+051:21:02:04.741 \$GPRMC,210204.38,A,7712.979182,S,16741.063669,W,9.4,270.82,200215,105.6,E,A*06

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$GPRMC		
3	Time	hhmmss.sss	UTC
4	Status*	x	A or N
5	Latitude	ddmm.mmmmmm	degrees
6	North or South (for previous)	x	N or S
7	Longitude	ddmm.mmmmmm	degrees
8	East or West (for previous)	x	E or W
9	Speed over Ground, True	x.x	knots
10	Course over Ground True	x.xx	degrees
11	Date	ddmmyy	UTC
12	Magnetic Variation	x.x	degrees
13	East or West (for previous)	x	E or W
14	Mode*	x	alphanumeric
15	Checksum	xx	UTC

GPHDT

15+051:21:02:04.741 \$GPHDT,268.87,T*06

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$GPHDT		
3	Heading, True	x.xx	degrees
4	T = True (for previous)	x	T
5	Checksum	xx	alphanumeric

GPGLL

16+077:00:00:00.725 \$GPGLL,6356.6505,S,05716.0002,W,000000,A,A*4F

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$GPGLL		
3	Latitude	ddmm.mmmmmm	degrees
4	North or South (for previous)	x	N or S
5	Longitude	ddmm.mmmmmm	degrees
6	East or West (for previous)	x	E or W
7	Time of Position (not received)	hhmmss.ss	UTC
8	Status*	x	A or V
9	Mode*	x	alphanumeric
10	Checksum	xx	alphanumeric

Status

A = Data Valid, V = Data not valid

Modes

A = GPS used, D = DGPS used, E = Dead reckoning used, M = Manual input mode, S = Simulator Mode, N = Invalid position / velocity

GPDTM

16+077:00:00:02.527 \$GPDTM,W84,,0000.0000,N,00000.0000,E,0.0,W84*5F

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$GPDTM		
3	Local Datum Code*	XXX	alphanumeric
4	Local datum subdivision code	x	numeric
6	Lat offset	x	alphanumeric
7	North or South (for previous)	x	N or S
8	Lon offset	x	alphanumeric
9	East or West (for previous)	x	E or W
10	Altitude offset, meters	x,x	numeric
11	Reference datum code*	xxx	alphanumeric
12	Checksum	xx	alphanumeric

Datum Codes

W84 = WGS84, W72 = WGS72, S85 = SGS85, P90 = PE90, 999 = User defined

PSXN 20

15+051:22:20:58.740 \$PSXN,20,1,0,0,0*3A

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$PSXN		
3	20		
4	Horizontal position and velocity quality*	x	0,1,2
5	Height and vertical velocity quality*	x	0,1,2
6	Heading quality*	x	0,1,2
7	Roll and pitch quality*	x	0,1,2
8	Checksum	xx	alphanumeric

Qualities

0 = Normal, 1 = Reduced Performance, 2 = Invalid data

PSXN 22

15+051:22:20:59.019 \$PSXN,22,0.43,0.50*3B

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$PSXN		
3	22		
4	Gyro calibration value since system startup	x.xx	degrees
5	Short-term gyro offset	x.xx	degrees
6	Checksum	xx	alphanumeric

PSXN 23

15+051:22:20:58.748 \$PSXN,23,-0.20,-0.09,279.85,0.24*34

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$PSXN		
3	23		
4	Roll, port side up is positive	x.xx	degrees
5	Pitch, bow up is positive	x.xx	degrees
6	Heading, True	x.xx	degrees
7	Heave, positive is down	x.xx	m
8	Checksum	xx	alphanumeric

Gyro Compass (gyr1)

15+055:20:27:23.653 \$HEHDT,087.31,T*12

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	\$HEHDT		
3	Heading	x.xx	degrees
4	T = True (for previous)	x	T
5	Checksum	xx	alphanumeric

ADCP Course (adcp)

15+049:20:20:57.327 \$PUHAW,UVH,-0.07,-4.59,179.3

Field	Data	Format	Unit
1	RVDAS time tag		
2	\$PUHAW		
3	UVH		
4	Ship Speed relative to reference layer, east vector	x.xx	knots
5	Ship Speed relative to reference layer, north vector	x.xx	knots
6	Ship heading	x.xx	degrees

Processed Data /process**pCO₂ – Merged**

15+055:11:24:43.960 2015055.46596 2534.72 32.41 975.33 48.86 356.94 341.67 -1.20 -1.27 0.00 Equil -
 75.9209 178.9696 -1.435 33.852 2.26 7.86 137.38 975.34 163.80 9.31 253.75 NaN -1.27 33.84 -1.14 -
 1.0

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	pCO ₂ time tag*	yyyyddd.ttt	UTC
3	Raw Voltage (IR)	xxxx.xx	mV
4	Cell Temperature	xx.xx	C
5	Equilibration Pressure	xxx.xx	mBar
6	Flowrate	xxx.xx	cm ³ /min
7	pCO ₂ Pressure	xxx.xx	μAtm
8	VCO ₂ Concentration	xx.xx	ppm
9	Equilibrator Temperature, RTD	xx.xx	C
10	Equilibrator Temperature, SBE38	xx.xx	C
11	Valve Position	xx	numeric
12	Flow Source*		text
13	Latitude	xx.xxxxx	degrees
14	Longitude	xxx.xxxxx	degrees
15	Sea Water Intake Temperature	xx.xxx	C
16	Sea Surface Salinity	xx.xxx	PSU
17	Sea Surface Fluorometry	x.xxx	mg/m ³
18	True Wind Speed	x.xx	m/s
19	True Wind Direction	x.xx	degrees
20	Barometric Pressure	xxx.xx	mBar
21	Hydro-Lab H ₂ O Flow Rate	xxx.x	l / min
22	Speed over Ground	x.xx	knots
23	Course Made Good	xx.xx	degrees
24	Unused		
25	TSG2 Temperature	x.xx	C
26	TSG2 Salinity	xx.xx	PSU
27	TSG1 Temperature	x.xx	C
28	Sea Water Valve*	x	-1 or 0

pCO₂ time tag

ttt = fractional time of day

Flow Source

Equil = pCO₂ Measurement

Sea Water Valve

-1 = Stern Thruster Valve, 0 = Moon Pool Valve

Calculations

PAR

Coefficients `parc1` and `parcv` for this cruise can be found in the `instrument.coeff` file as the variable labeled PAR, respectively. Variable `par` is the raw data in mV, as described in the “mwx1” file description. The calibration scale and probe offset dark are values taken from the PAR Cal Sheet.

```
par = raw data mV
calibration scale = 5.8644 V/(μEinstiens/cm2sec)
parc1 = 1 / scale = .17
probe offset dark = -.1 mV
parcv = dark x 1000 mV/V = -0.0001 V
((par / 1000 mV/V) - parcv) x parc1 x 10000 cm2/m2 = μEinstiens/m2sec
```

Calculations (extracted from the C code):

```
/* Convert from mV to V */
par /= 1000;
/* (par V - vdark V) / Calibration Scale Factor V/uE/cm2sec */
parCalc = (par - parcv) * parc1 * 10000;
```

PSP

Coefficient `pspCoeff` for this cruise can be found in the `instrument.coeff` file as the variable labeled PSP1. Variable `psp` is the raw data in mV, as described in the “mwx1” file description.

```
psp = raw data mV
calibration scale = pspCoeff x 10^-6 V/(W/m2)
psp / (scale x 1000 mV/V) = W/m2
```

Calculations (extracted from the C code):

```
/* Convert from mV to W/m^2 */
pspCalc = (psp * 1000 / pspCoeff);
```

PIR

Coefficient `pirCoeff` for this cruise can be found in the `instrument.coeff` file as the variable labeled `PIR1`. Variable `pir_thermo` is the raw data in mV, `pir_case` is the PIR case temperature in Kelvins and `pir_dome` is the PIR dome temperature in Kelvins, as described in the “`mwx1`” file description. Hard-coded “C” coefficients are shown below:

```
Dome constant = 3.5
```

```
Sigma = 5.6704e-8
```

```
pir_thermo = raw data mV
```

```
calibration scale = pirCoeff x 10-6 V/(W/m2)
```

```
pir_thermo / (scale x 1000 mV/V) = W/m2
```

Calculations (extracted from the C code):

```
/* convert mV to W/m^2 */  
pirCalc = (pir_thermo * 1000 / pirCoeff)  
/* correct for case temperature */  
pirCalc += sigma * pow(pir_case,4)  
/* correct for dome temperature */  
pirCalc -= 3.5 * sigma * (pow(pir_dome, 4) - pow(pir_case, 4))
```

Acquisition Problems and Events

This section lists problems with acquisition noted during this cruise including instrument failures, data acquisition system failures and any other factor affecting this data set. The format is ddd:hh:mm (ddd is year-day, hh is hour, and mm is minute). Times are reported in UTC.

Start	End	Description
069+06:03		Data collection begins at 46 43.644194 S, 149 39.208028 E
18+071:10:47	18+071:10:46	Time set backwards on the data acquisition system! (note 1)
18+071:13:35	18+071:13:35	Time set backwards on the data acquisition system! (note 1)
18+085:10:35	18+085:10:34	Time set backwards on the data acquisition system! (note 1)
18+085:12:28	18+085:12:27	Time set backwards on the data acquisition system! (note 1)
18+089:10:48	18+130+19:12	Ongoing malfunctions of the Seapath 330 GPS (notes 2 and 3)
18+099:10:47	18+099:10:46	Time set backwards on the data acquisition system! (note 1)
18+099:13:52	18+099:13:52	Time set backwards on the data acquisition system! (note 1)
18+113:10:45	18+113:10:44	Time set backwards on the data acquisition system! (note 1)
18+113:12:39	18+113:12:38	Time set backwards on the data acquisition system! (note 1)
	130+19:12	Data collection ends at 59 56.651897 S, 068 14.500494 W

Notes:

1. Due primarily to an NTP configuration error and other associated issues, time was set backwards on several occasions during the cruise. Unfortunately, this type of error is not apparent on QC graphs. All loggers that were active during these time intervals were affected. Check the individual data files for exact times as necessary.
2. The Seapath 200 (logged files with String ID seap) should be considered the primary GPS. The Seapath 330 experience multiple malfunctions. The first recognized malfunction on this cruise was on 30 March 2018.
3. Due to the ongoing malfunctions of the Seapath 330 GPS, the Electronics Technician fed the Seapath 200 data stream to the distribution multiplexers for the Seapath 330. Consequently, the logged data files for the Seapath 330 actually contain data from the Seapath 200 for most of the cruise as detailed below.
 - a. Prior to all data logged for the Seapath 330 is Seapath 330 data
 - b. On Julian days 103-105 the data logged for the Seapath 330 is a mix of Seapath 330 and Seapath 200 data
 - c. After Julian day 105 all the data logged for the Seapath 330 is actually Seapath 200 data.

Appendix A: Sensors

1802 Sensors

Sensor	Serial No.	Manufacturer	Model	Last Cal Date	Comments
Meteorology and Radiometry					
Anemometer	WM128975	RM Young	5106	10/27/11	ECO BridgeWindbird
Anemometer, U/S	847014	Gill Instruments	1390-PK-062	9/29/10	Stbd Side (SUS)
Anemometer, U/S	924057	Gill Instruments	1390-PK-062	11/18/09	Port Side (PUS)
Barometer	01705	RM Young	61201	1/22/16	Do Not Cal, spare
Barometer	M2750443	Vaisala	PTB210B	7/13/16	
Humidity/Wet Temp	06733	RM Young	41382LC	10/6/16	
PAR for Mast	20531	Biosph. Inst.	QSR-2200	3/8/17	
PIR	33023F3	Eppley	PIR	10/19/16	
PSP	33090F3	Eppley	PSP	10/18/16	
GUV (Mast)	25110203113	Biosph. Inst.	GUV-2511	5/31/17	
GUV Deckbox	SPARE - 1126	Biosph. Inst.	GUV-2511	N/A	Only GUV

Sensor	Serial No.	Manufacturer	Model	Last Cal Date	Comments
Underway Seawater Sampling System					
Micro-TSG	4549120-0226	Sea-Bird	SBE 45	2/19/2017	Primary
Micro-TSG	4550449-0242	Sea-Bird	SBE 45	4/2/2017	Secondary
Digital Remote Temp	3846730-0352	Sea-Bird	SBE 38	1/27/2016	
Fluorometer	FLRTD-397	WET Labs	FLRTD	4/20/2017	
Transmissometer	CST-1581DR	WET Labs	C-Star	3/30/2016	

Sensor	Serial No.	Manufacturer	Model	Last Cal Date	Comments/Stations
CTD (CTD information provided by GO-SHIP S04P. See note below)					
Rosette	Yellow		36-place	—	901-10000
CTD	1281	Sea-Bird	SBE9+	—	901-10000
Pressure Sensor	136428	Paroscientific	DigiQuartz	17-Dec-17	901-10000
Primary Temperature	35844	Sea-Bird	SBE3+	30-Jan-18	901-10000
Primary Conductivity	44546	Sea-Bird	SBE4C	8-Feb-18	901-10000
Primary Pump	54377	Sea-Bird	SBE5	—	901-12, 75
Primary Pump	58691	Sea-Bird	SBE5	—	13-14
Primary Pump	51646	Sea-Bird	SBE5	—	15-74
Primary Pump	58692	Sea-Bird	SBE5	—	76-10000
Secondary Temperature	32309	Sea-Bird	SBE3+	30-Jan-18	901-10000

Secondary Conductivity	41880	Sea-Bird	SBE4C	2-Feb-18	901-10000
Secondary Pump		Sea-Bird	SBE5	—	901-14
Secondary Pump	55644	Sea-Bird	SBE5	—	15-10000
Transmissometer	CST-1803DR	WET Labs	C-Star	16-Sep-16	901-10000
Fluorometer Chlorophyll and Backscatter	FLBBRTD-3698	WET Labs	FLBBRTD	23-Sep-14	901-10000
Primary Dissolved Oxygen	430255	Sea-Bird	SBE43	22-Nov-17	901-10000
Oxygen Optode	296	JFE Advantech	RINKO	7-Apr-17	901-10000
Reference Temperature	35	Sea-Bird	SBE35	1-Feb-18	901-10000
Carousel	1178	Sea-Bird	SBE32	—	901-10000
Altimeter		Tritech	LPA200	—	901-1
Altimeter	59116	Valeport	Valeport 500	—	3-Feb
Altimeter	51520	Valeport	Valeport 500	—	4-10000
Underwater Vision Profiler	207	CNRS/UPMC	UVP5	1/18/2018	901-10000

Note: For additional information about the CTD system or its components, contact ODF or the individual PI's for the instruments.

Appendix B: Calibration Sheets

Gravity

The portable gravimeter is currently out for ERR. This is the last.

BGM3 ship-to-shore gravity tie report

AUKON/CHIN, vessel: R/V Palmer

Release Date: 2017/06/17 03:11:38 UTC

Sensor: S210

Software version: 1.2

Port/Pier/Berth: LYTTLETON PIER 7

Gravity station number	486732A CHRISTCHURCH
Station name	NEW ZEALAND NATIONAL GRAVITY BASE STATION
mGal at pier	980505.71
Tie start time UTC	2017/06/17 02:10:19.792
Samples used	3600
Land tie used	Yes
Water height to pier 1	12 ft 3 in
Water height to pier 2	12 ft 8 in
Water height to pier 3	12 ft 11 in
Average of filtered counts	25034.809182694
Filter length	181
Scale factor	4.994070552
NEW BIAS	855481.29

Table 1: Gravity tie information

Meteorology

Anemometers

Cal sheet not required

Barometer



R.M. Young Company
2801 Aero Park Drive
Traverse City, Michigan 49586 USA

CALIBRATION REPORT**Barometric Pressure**

Customer: *Lockheed Martin*

Test Number: 6122-01B

Customer PO: 4102344091

Test Date: 22 January 2016

Sales Order: 5254

Test Sensor:

Model: 61201

Serial Number: BP01705

Description: Barometric Pressure Sensor

Report of calibration comparison of test barometric pressure sensor with National Institute of Standards and Technology traceable standard pressure calibrator at five pressures in the R.M. Young Company controlled pressure facility. Calibration accuracy ± 1.0 hPa.

Reference Pressure (hPa)	Voltage Output (millivolts)	Indicated (1) Pressure (hPa)
800.0	0	800.0
875.0	1250	875.0
950.0	2501	950.0
1025.0	3750	1025.0
1100.0	4998	1099.9

(1) Calculated from voltage output

All reference equipment used in this calibration procedure have been tested by comparison to traceable standards certified by the National Institute of Standards and Technology.

Reference Instrument

Druck Pressure Controller Model DPI515

Fluke Multimeter Model 8060A

Serial # NIST Test Reference

51500407 0046591

4865407 8804887

Tested By: *R. Palmer*

METEOROLOGICAL INSTRUMENTS

Tel: 231-946-3880 Fax: 231-946-4772 Email: metales@youngusa.com Website: youngusa.com
ISO 9001:2008 CERTIFIED

Barometer

VAISALA
1 (1)
Certificate report no. H44-15280021

CALIBRATION CERTIFICATE

Instrument PTB210B Digital Barometer
Serial number M2750443
Manufacturer Vaisala Oyj, Finland
Calibration date 13th July 2015

The above instrument was calibrated by comparing the readings of the instrument to the factory working standard of Vaisala.

The pressure readings of the factory working standard have been calibrated at an ISO/IEC 17025 accredited calibration laboratory (FINAS), Vaisala Measurement Standards Laboratory (MSL), by using MSL working standards traceable to NIST.

Calibration results

Reference hPa	Observed hPa	Correction* hPa	Acceptance limit hPa
510.0	510.0	0.0	± 0.2
610.0	610.0	0.0	± 0.2
700.0	700.0	0.0	± 0.2
810.0	810.0	0.0	± 0.2
910.0	910.0	0.0	± 0.2
950.0	950.0	0.0	± 0.2
1000.0	1000.0	0.0	± 0.2
1098.0	1098.0	0.0	± 0.2

*To obtain the true pressure, add the correction to the barometer reading.
 Interpolated corrections may be used at intermediate readings of the scale of the barometer.

Equipment used in calibration		Calibration date	Certificate number
Type PFC4	Serial number 670	2015-08-21	K008-Y01989

Uncertainty (95 % confidence level, k=2)
 Pressure ± 0.15 hPa

Ambient Conditions
 Humidity 39 %RH ± 5 %RH
 Temperature 21 °C ± 1 °C
 Pressure 1002 hPa ± 1 hPa

Technician

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Doc223087-0

Vaisala Oyj | PO Box 26, FI-00042 Vaisala, Finland

Temperature / Humidity



R.M. Young Company
2801 Aero Park Drive
Troy, Michigan 48066 USA

CALIBRATION REPORT**Temperature**

Customer *Lockheed Martin*

Test Number: 8006-01T
Test Date: 8 October 2018

Customer PO: 4102685716
Sales Order: 5771

Test Sensor:

Model: 41382LC2 Serial Number: TS06733
Description: Temperature/Relative Humidity Sensor

Report of calibration comparison of test temperature sensor with National Institute of Standards and Technology traceable standard thermometer at three temperatures in the R.M. Young Company controlled temperature calibration facilities. Calibration accuracy $\pm 0.2^\circ$ Celsius.

Reference Temperature (degrees C)	Current Output (mA)	Indicated (1) Temperature (degrees C)	Calculated (2) Temperature (degrees C)
45.29	19.27	45.47	45.28
19.95	15.24	20.27	19.97
-10.38	10.41	-9.94	-10.38

(1) Calculated from current output.
(2) Calculated values using derived formula: $T = -75.745 + \text{mA} \times 6.27899$

All reference equipment used in this calibration procedure have been tested by comparison to traceable standards certified by the National Institute of Standards and Technology.

Reference Instrument:

Brooklyn Thermometer Model 43-FC
Brooklyn Thermometer Model 22332-D6-FC
Brooklyn Thermometer Model 2X400-D7-FC
Keithley Multimeter Model 191

Serial # NIST Test Reference

8006-118 W204690
25071 W204691
77532 W204692
15232 7124815

Tested By: *S. Sage*

METEOROLOGICAL INSTRUMENTS
Tel: 231-946-3580 Fax: 231-545-4772 Email: met.salsa@youngusa.com Website: youngusa.com
ISO 9001:2008 CERTIFIED

Temperature / Humidity



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

CALIBRATION REPORT**Relative Humidity**

Customer: *Lockheed Martin*

Test Number: 6006-01R

Customer PO: 4102685716

Test Date: 6 October 2016

Sales Order: 5771

Test Sensor:

Model: 41362LC2

Serial Number: 7506733

Description: Temperature/Relative Humidity Sensor

Report of calibration comparison of test relative humidity sensor with National Institute of Standards and Technology traceable standard relative humidity sensor at five humidity levels in the R.M. Young Company controlled humidity chamber facility. Calibration accuracy $\pm 2.0\%$.

Reference Humidity (%)	Current Output (milliamps)	Indicated (1) Humidity (%)
10.1	5.7	10.8
30.1	8.9	30.9
50.0	12.3	51.6
70.0	15.4	71.3
90.1	18.6	91.1

(1) Calculated from voltage output

All reference equipment used in this calibration procedure have been tested by comparison to traceable standards certified by the National Institute of Standards and Technology.

Reference Instrument

Vaisala Humidity Sensor Model 35A/C
Fluke Multimeter Model 8060A

Serial # NIST Test Reference

N475040 TN 266152
4865407 8604897

Tested By: *S. Sage*

METEOROLOGICAL INSTRUMENTS

Tel: 231-946-3960 Fax: 231-946-4772 Email: met.sales@youngusa.com Website: youngusa.com
ISO 9001:2008 CERTIFIED

PIR

**THE EPPLEY LABORATORY, INC.**

12 Sheffield Avenue, PO Box 419, Newport, Rhode Island USA 02840
Phone: 401.847.1020 Fax: 401.847.1031 Email: info@eppleylab.com

Calibration Certificate

Instrument: Precision Infrared Radiometer, Model PIR, Serial Number 33023F3

Procedure: This pyrometer was compared against Eppley's Blackbody Calibration System under radiation intensities of approximately 350 Wm^{-2} with an average ambient temperature of 23°C according to procedures described in Technical Procedure, TP05 of The Eppley Laboratory, Inc.'s Quality Assurance Manual on Calibrations.

Transfer Standard: Eppley Precision Infrared Radiometer, Model PIR, Serial Number 32227F3

Results: **Sensitivity:** $S = 3.91 \mu\text{V} / \text{Wm}^{-2}$
Uncertainty: $U_{95} = \pm 1.7\%$ (95% confidence level, $k=2$)
Resistance: 739Ω at 23°C

Date of Test: October 19, 2016

Traceability: This calibration is traceable to the International Practical Temperature Scale (IPTS). Additionally, transfer standard PIR 32227F3 provides traceability to the World Infrared Standard Group (WISG) of pyrometers housed at the Infrared Radiometry Section of the World Radiation Centre (WRC-IRS). Unless otherwise stated in the remarks section below or on the Sales Order, the results of this calibration are "AS FOUND / AS LEFT".

Due Date: Eppley recommends a minimum calibration cycle of five (5) years but encourages annual calibrations for highest measurement accuracy.

Customer: Leidos Innovations Corp
Port Hueneme, CA

Signatures: D GIENTY
In Charge of Test:

Thomas D. Kuh
Reviewed by:

Eppley SO 64821

Date of Certificate October 19, 2016

Remarks: Customer Instrument #866-00030843

End of Report

PSP

**THE EPPLEY LABORATORY, INC.**

12 Sheffield Avenue, PO Box 419, Newport, Rhode Island USA 02840
Phone: 401.847.1020 Fax: 401.847.1031 Email: info@eppleylab.com

Calibration Certificate

Instrument: Precision Spectral Pyranometer, Model PSP, Serial Number 33090F3

Procedure: This pyranometer was compared in Eppley's Integrating Hemisphere according to procedures described in *ISO 9847 Section 5.3.7* and Technical Procedure, TP01 of The Eppley Laboratory, Inc.'s Quality Assurance Manual on Calibrations.

Transfer Standard: Eppley Standard Precision Pyranometer, Model SPP, Serial Number 37501F3

Results:
Sensitivity: $S = 7.90 \mu V / W m^{-2}$
Uncertainty: $U_{95} = \pm 0.91\%$ (95% confidence level, k=2)
Resistance: 700 Ω at 23°C

Date of Test: October 18, 2016

Traceability: This calibration is traceable to the World Radiation Reference (WRR) through comparisons with Eppley's AHF standard self-calibrating cavity pyrheliometers which participated in the Twelfth International Pyrheliometric Comparisons (IPC XII) at Davos, Switzerland in September-October 2015. Unless otherwise stated in the remarks section below or on the Sales Order, the results of this calibration are "AS FOUND / AS LEFT".

Due Date: Eppley recommends a minimum calibration cycle of five (5) years but encourages annual calibrations for highest measurement accuracy.

Customer: Leidos Innovations Corp
Port Huacame, CA

Signatures:
In Charge of Test: D. Gieny
Reviewed by: Thomas Kuch

Eppley SO: 64822

Date of Certificate: October 19, 2016

Remarks: Customer Instrument ID #866-00038044

End of Report

PAR (Mast)

Biospherical Instruments Inc.

CALIBRATION CERTIFICATE

Calibration Date 3/8/2017
 Model Number QSR2200
 Serial Number 20531
 Operator TPC
 Standard Lamp 91453(7/20/16)
 Probe Excitation Voltage Range: 6 to 18 VDC(+)

Output Polarity: POSITIVE

Probe Conditions at Calibration (in air):

Calibration Voltage: 6 VDC(+)

Probe Current: 4.0 mA

Probe Output Voltage:

Probe Illuminated 90.1 mV
 Probe Dark 1.0 mV
 Probe Net Response 89.1 mV
 RG780 1.1 mV

Corrected Lamp Output:

Output in Air (same condition as calibration):

8.379E+15 quanta/cm²sec
0.013914 uE/cm²sec

Calibrator Scale Factor:

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

Dry: 1.0633E-17 V/(quanta/cm²sec)
5.4030E+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

GUV (Mast) Page 1



Biospherical Instruments Inc.

System Calibration Certificate

THE INSTRUMENTS REFERENCED BELOW WERE FACTORY TESTED AND CALIBRATED BY

BIOSPHERICAL INSTRUMENTS INC.5340 Riley Street
San Diego, California 92110 USA**Instruments: GUV-2511 No 25110203113****Optical Calibrations:**

NIST Traceability. For wavelengths longer than 313 nm, the specific instruments cited here were calibrated using a 1000W FEL #V-039 (7/20/16) following procedures and standards traceable to NIST Standard of Spectral Irradiance F-616. Traceability paths and all procedures for all calibrated lamps and associated apparatus (shunts, power supplies, DMMs, etc) are maintained following calibration methodologies per National Bureau of Standards (US) (NBS) Special Publication 250-20 Spectral Irradiance Calibrations (1987) and NBS Publication 594-13 Optical Radiation Measurements: The 1973 Scale of Spectral Irradiance (1977).

Solar Calibrations. Lamp calibrations are problematic for solar UV measurements (wavelengths below 320 nm) because the solar spectrum is radically different from the lamp spectrum and changes greatly as a function of wavelength. Solar calibrations are achieved through direct comparison with measurements of a high resolution scanning spectroradiometer in San Diego (SUV-100), which is part of the National Science Foundation's UV Monitoring Network. The SUV-100 instrument has a bandwidth of 1 nm. Calibrated filter radiometer data therefore report spectral irradiance at the channel's nominal wavelengths with a bandwidth of 1 nm. Solar calibrations are typically accurate to within $\pm 10\%$ for solar zenith angles smaller than 75° . At larger solar zenith angles, UV channels have a greater uncertainty due to the rapid change of the solar UV spectrum.

Note that this certificate contains a subset of the information delivered in the calibration database 25110203113v9.mdb. This database is required for operation of this system using Biospherical Instruments Inc.'s Logger® software.



Biospherical Instruments Inc.

GUV-2511 Calibration Certificate

System Serial Number		25110203113		Date of Calibration		5/31/2017	
Calibration database		25110203113v9.mdb		Date of Certificate		5/31/2017	
DASSN		0068		Standard of Spectral Irradiance		V-039(7/20/16)	
Microprocessor Tag Number		2		Operator		TC	

Monochromatic	Channels	Address	Wavelength [nm]	Responsivity [Amps per $\mu\text{W}/(\text{cm}^2\text{-nm})$]	ScaleSmall [Volts per $\mu\text{W}/(\text{cm}^2\text{-nm})$]	ScaleMedium [Volts per $\mu\text{W}/(\text{cm}^2\text{-nm})$]	ScaleLarge [Volts per $\mu\text{W}/(\text{cm}^2\text{-nm})$]	OffsetSmall [volts]	OffsetMedium [volts]	OffsetLarge [volts]	Measurement Units
	Ed0320	2	320	2.5669E-10	2.6182E-05	7.6493E-03	2.7081E+00	8.7011E-05	8.5714E-05	4.3851E-04	$\mu\text{W}/(\text{cm}^2\text{-nm})$
	Ed0340	6	340	2.0781E-10	2.1196E-05	6.1927E-03	2.1835E+00	3.7847E-04	3.8104E-04	1.3278E-03	$\mu\text{W}/(\text{cm}^2\text{-nm})$
	Ed0313	8	313	2.2231E-10	2.2675E-05	6.6247E-03	2.3650E+00	3.5302E-05	3.7066E-05	6.5847E-04	$\mu\text{W}/(\text{cm}^2\text{-nm})$
	Ed0305	10	305	1.6361E-11	1.6688E-06	4.8755E-04	1.5082E-01	4.6550E-04	4.5669E-04	-2.1536E-03	$\mu\text{W}/(\text{cm}^2\text{-nm})$
	Ed0380	12	380	6.2595E-11	6.3847E-06	1.8653E-03	6.2206E-01	1.0328E-03	1.0241E-03	-1.5881E-03	$\mu\text{W}/(\text{cm}^2\text{-nm})$
	Ed0395	18	395	3.3548E-10	3.4219E-05	9.9974E-03	3.2656E+00	9.7613E-05	9.8620E-05	2.5961E-04	$\mu\text{W}/(\text{cm}^2\text{-nm})$

Broadband	Channels	Address	Wavelength [nm]	Responsivity [Amps per $\mu\text{E}/(\text{cm}^2\text{-s})$]	ScaleSmall [Volts per $\mu\text{E}/(\text{cm}^2\text{-s})$]	ScaleMedium [Volts per $\mu\text{E}/(\text{cm}^2\text{-s})$]	ScaleLarge [Volts per $\mu\text{E}/(\text{cm}^2\text{-s})$]	OffsetSmall [volts]	OffsetMedium [volts]	OffsetLarge [volts]	Measurement Units
	Ed0PAR	13	400-700	1.8717E-05	1.9091E+00	5.5776E+02	1.9859E+05	9.0359E-04	8.9635E-04	-1.2834E-03	$\mu\text{E}/(\text{cm}^2\text{-sec})$

Auxiliary	Channels	Address	Wavelength	Responsivity	ScaleS	ScaleM	ScaleL	OffsetS	OffsetM	OffsetL	Measurement Units
	Ed0Gnd	0	0	1	1.00	1.00	1.00	0	0	0	V
	Ed0Temp	22	0	1	0.01	0.01	0.01	0	0	0	C
	Ed0Vin	27	0	1	-0.25	-0.25	-0.25	0	0	0	V

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Calibration Data – Do Not Destroy

page 2 of 2

Underway Seawater Sampling System

Micro-TSG 1 (Primary)

Sea-Bird Electronics, Inc.

13431 NE 20th Street, Bellevue, WA 98005-2010 USA

Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0228
CALIBRATION DATE: 15-Feb-17SBE 45 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -1.017502e+000
h = 1.573125e-001
i = -4.708889e-004
j = 6.170250e-005CPcor = -9.5700e-008
CTcor = 3.2500e-006
WBOTC = 9.8072e-007

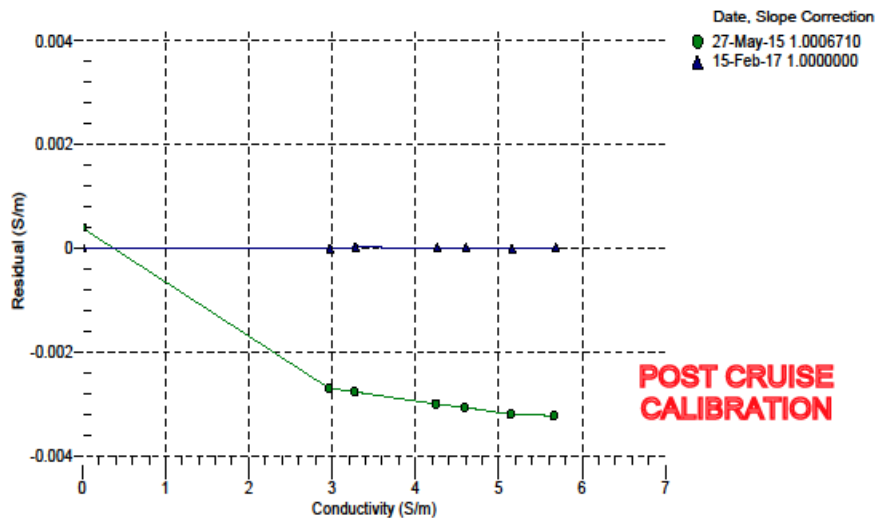
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2549.69	0.00000	0.00000
1.0000	34.7695	2.97235	5049.05	2.97233	-0.00001
4.5000	34.7494	3.27903	5239.02	3.27905	0.00001
15.0000	34.7062	4.25953	5803.96	4.25954	0.00001
18.5000	34.6971	4.60426	5989.64	4.60426	0.00000
24.0000	34.6870	5.16151	6277.86	5.16150	-0.00002
29.0000	34.6813	5.68269	6535.58	5.68270	0.00001
32.5000	34.6778	6.05456	6713.29	6.05474	0.00018

$$f = \text{Instrument Output(Hz)} * \sqrt{1.0 + \text{WBOTC} * t} / 1000.0$$

t = temperature (°C); p = pressure (decibars); $\delta = \text{CTcor}$; $\epsilon = \text{CPcor}$;

$$\text{Conductivity (S/m)} = (g + h * f^2 + i * f^3 + j * f^4) / 10 (1 + \delta * t + \epsilon * p)$$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



Sea-Bird Electronics, Inc.

13431 NE 20th Street, Bellevue, WA 98005-2010 USA

Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0226
CALIBRATION DATE: 19-Feb-17SBE 45 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

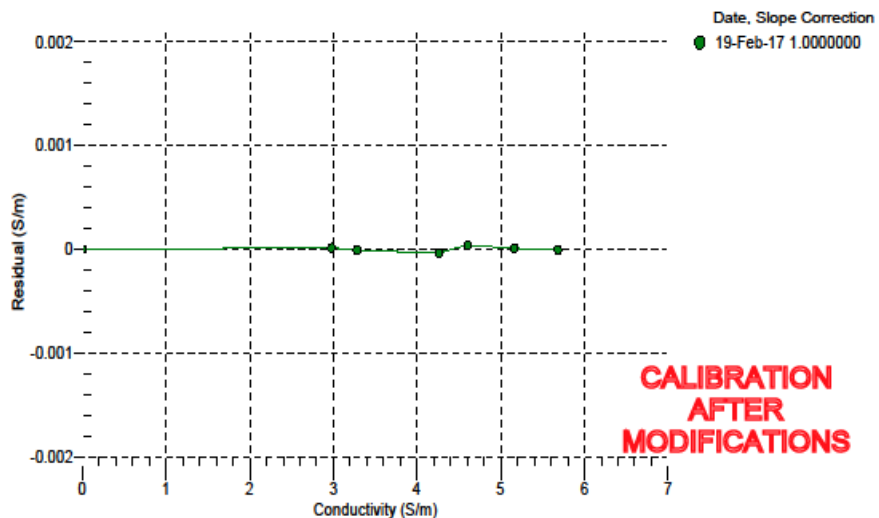
COEFFICIENTS:

g = -1.013733e+000
h = 1.569130e-001
i = -5.222989e-004
j = 6.723089e-005CPcor = -9.5700e-008
CTcor = 3.2500e-006
WBOTC = 9.8072e-007

BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2548.99	0.00000	0.00000
1.0000	34.7782	2.97302	5055.47	2.97303	0.00001
4.4999	34.7582	3.27977	5245.81	3.27976	-0.00001
15.0001	34.7152	4.26053	5811.87	4.26049	-0.00004
18.5000	34.7063	4.60535	5997.94	4.60538	0.00004
24.0000	34.6972	5.16286	6286.70	5.16287	0.00001
29.0000	34.6931	5.68441	6544.93	5.68440	-0.00001
32.5000	34.6918	6.05673	6722.93	6.05661	-0.00012

 $f = \text{Instrument Output(Hz)} * \sqrt{1.0 + \text{WBOTC} * t} / 1000.0$ t = temperature (°C); p = pressure (decibars); $\delta = \text{CTcor}$; $\epsilon = \text{CPcor}$;Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / (1 + \delta * t + \epsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



Sea-Bird Electronics, Inc.

13431 NE 20th Street, Bellevue, WA 98005-2010 USA

Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0228
CALIBRATION DATE: 15-Feb-17SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

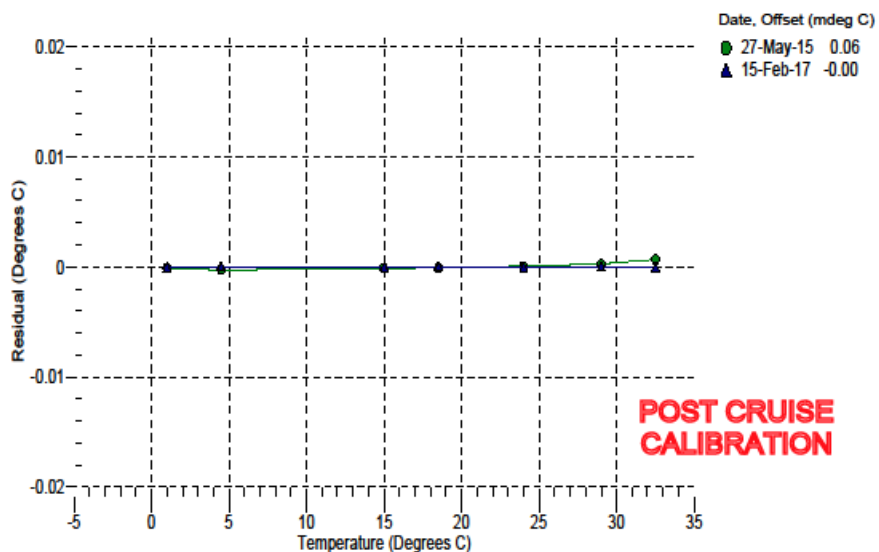
a0 = -3.757691e-005
a1 = 2.804472e-004
a2 = -2.777133e-006
a3 = 1.623117e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	744347.0	1.0000	-0.0000
4.5000	636500.2	4.5000	0.0000
15.0000	405780.8	15.0000	-0.0000
18.5000	351395.6	18.5000	0.0000
24.0000	281937.9	24.0000	-0.0000
29.0000	232177.6	29.0000	0.0000
32.5000	203337.4	32.5000	-0.0000

n = Instrument Output (counts)

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

Residual (°C) = instrument temperature - bath temperature



Sea-Bird Electronics, Inc.

13431 NE 20th Street, Bellevue, WA 98005-2010 USA

Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0228
CALIBRATION DATE: 19-Feb-17SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

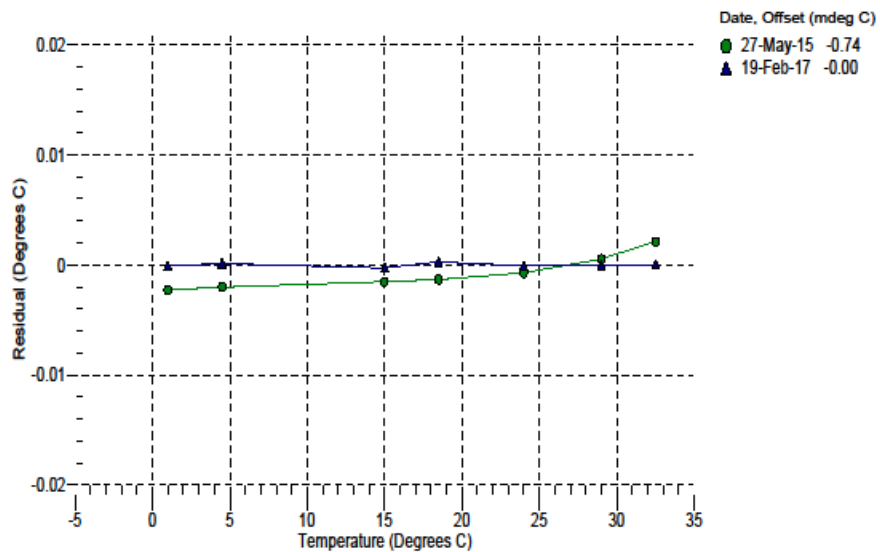
a0 = -1.625436e-004
a1 = 3.092515e-004
a2 = -4.990410e-006
a3 = 2.190124e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	744277.3	0.9999	-0.0001
4.4999	636452.3	4.5000	0.0001
15.0001	405760.1	14.9998	-0.0003
18.5000	351373.2	18.5003	0.0003
24.0000	281929.6	23.9999	-0.0001
29.0000	232180.3	29.0000	-0.0000
32.5000	203348.2	32.5000	0.0000

n = Instrument Output (counts)

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

Residual (°C) = instrument temperature - bath temperature



Micro-TSG2 (Secondary)

Sea-Bird Electronics, Inc.

13431 NE 20th Street, Bellevue, WA 98005-2010 USA
 Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0389
 CALIBRATION DATE: 05-Oct-16

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

COEFFICIENTS:

g = -1.011215e+000
 h = 1.476175e-001
 i = -8.280491e-004
 j = 7.730207e-005

CPcor = -9.5700e-008
 CTcor = 3.2500e-006
 WBOTC = 1.2700e-007

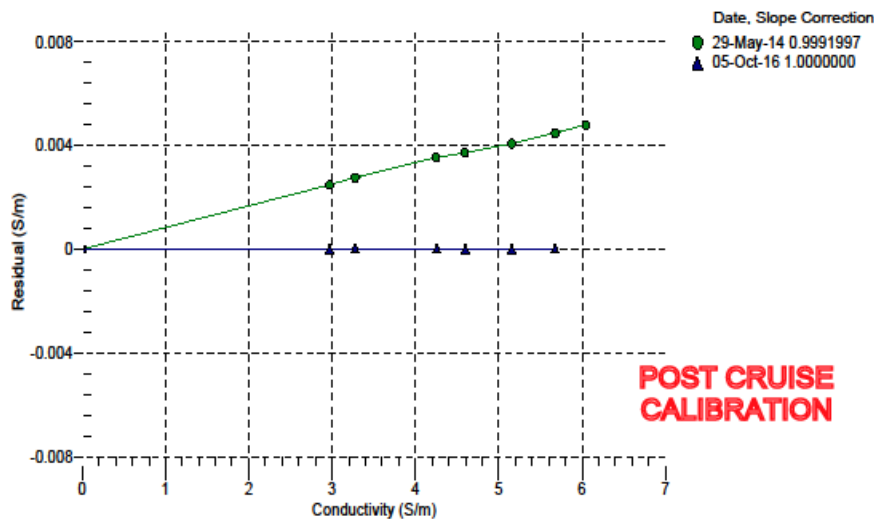
BATH TEMP (°C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2631.99	0.00000	0.00000
1.0000	34.7178	2.96835	5231.58	2.96833	-0.00002
4.5000	34.6978	3.27464	5429.24	3.27466	0.00002
14.9999	34.6545	4.25385	6016.97	4.25386	0.00001
18.5000	34.6448	4.59807	6210.08	4.59806	-0.00001
24.0000	34.6345	5.15456	6509.85	5.15455	-0.00002
29.0000	34.6289	5.67507	6777.88	5.67508	0.00001
32.5000	34.6261	6.04656	6962.65	6.04663	0.00007

$f = \text{Instrument Output(Hz)} * \text{sqrt}(1.0 + \text{WBOTC} * t) / 1000.0$

t = temperature (°C); p = pressure (decibars); $\delta = \text{CTcor}$; $\epsilon = \text{CPcor}$;

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / (1 + \delta * t + \epsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



Sea-Bird Electronics, Inc.

13431 NE 20th Street, Bellevue, WA 98005-2010 USA

Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0389
CALIBRATION DATE: 05-Oct-16SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

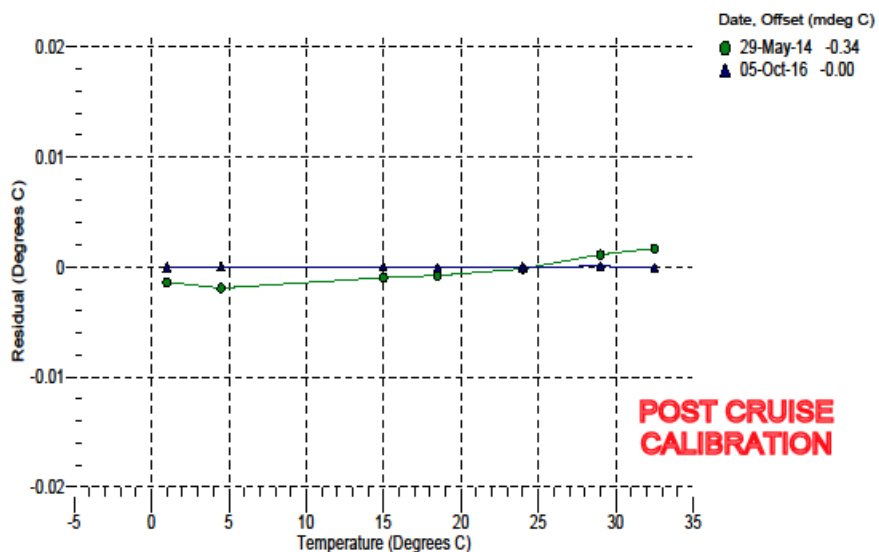
$a_0 = 3.090837e-005$
 $a_1 = 2.658070e-004$
 $a_2 = -1.844963e-006$
 $a_3 = 1.332162e-007$

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	828418.5	1.0000	-0.0000
4.5000	706628.0	4.5000	0.0000
14.9999	447305.9	14.9999	0.0000
18.5000	386484.7	18.4999	-0.0001
24.0000	309027.4	24.0000	-0.0000
29.0000	253718.2	29.0001	0.0001
32.5000	221745.8	32.4999	-0.0001

n = Instrument Output (counts)

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

Residual (°C) = instrument temperature - bath temperature



Digital Remote Temp

Sea-Bird Electronics, Inc.

13431 NE 20th Street, Bellevue, WA 98005-2010 USA
 Phone: (+1) 425-643-9866 Fax (+1) 425-643-9954 Email: seabird@seabird.com

SENSOR SERIAL NUMBER: 0323
 CALIBRATION DATE: 23-Jan-16

SBE 38 TEMPERATURE CALIBRATION DATA
 ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

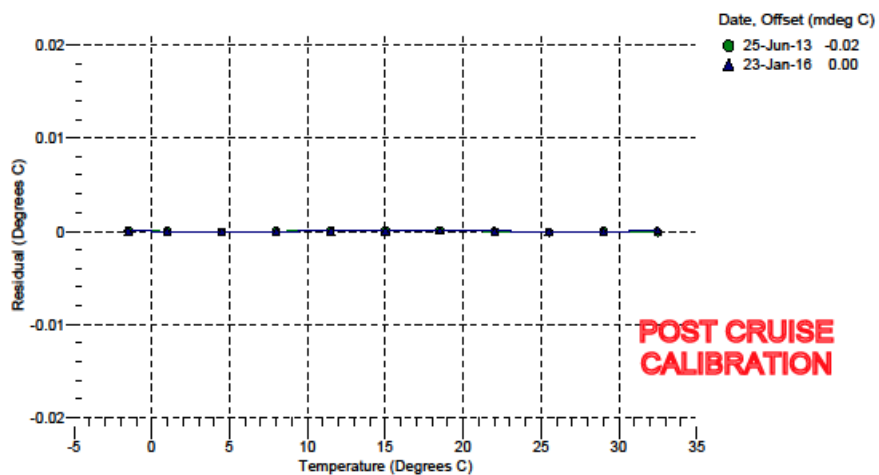
a0 = 1.374421e-005
 a1 = 2.751852e-004
 a2 = -2.335169e-006
 a3 = 1.567304e-007

BATH TEMP (°C)	INSTRUMENT OUTPUT (counts)	INST TEMP (°C)	RESIDUAL (°C)
-1.5000	711106.6	-1.5000	0.0000
1.0000	635152.2	1.0000	-0.0000
4.5000	543801.6	4.4999	-0.0001
8.0000	467106.4	8.0000	-0.0000
11.5000	402497.5	11.5000	0.0000
15.0000	347892.6	15.0000	0.0000
18.5000	301594.1	18.5001	0.0001
22.0000	262216.7	22.0000	0.0000
25.4999	228625.3	25.4998	-0.0001
29.0002	199879.9	29.0001	-0.0001
32.5000	175217.4	32.5001	0.0001

n = Instrument Output (counts)

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

Residual (°C) = instrument temperature - bath temperature



Transmissometer

PO Box 518
620 Applegate St.
Philomath, OR 97370



(541) 929-5850
Fax (541) 929-5277
www.wetlabs.com

C-Star Calibration

Date	3.30.16	S/N#	CST-1581DR	Pathlength	25cm
		Analog output	Digital output		
V_d		0.004 V	0 counts		
V_{air}		4.806 V	15795 counts		
V_{ref}		4.699 V	15445 counts		
Temperature of calibration water				20.5 °C	
Ambient temperature during calibration				22.5 °C	

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

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

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

V_d Meter output with the beam blocked. This is the offset.

V_{air} Meter output in air with a clear beam path.

V_{ref} Meter output with clean water in the path.

Temperature of calibration water: temperature of clean water used to obtain V_{ref} .

Ambient temperature: meter temperature in air during the calibration.

V_{sig} Measured signal output of meter.

Revision L

6/9/09

Fluorometer

PO Box 518
620 Applegate St.
Philomath, OR 97370



(541) 828-5650
Fax (541) 828-5277
www.wetlabs.com

ECO Chlorophyll Fluorometer Characterization Sheet

Date: 4/20/2017

S/N: FLRTD-397

Chlorophyll concentration expressed in µg/l can be derived using the equation:

$$\text{CHL (}\mu\text{g/l)} = \text{Scale Factor} * (\text{Output} - \text{Dark Counts})$$

	Analog Range 1	Analog Range 2	Analog Range 4 (default)	Digital
Dark Counts	0.102	0.063	0.043 V	63 counts
Scale Factor (SF)	6	13	25 µg/l/V	0.0077 µg/l/count
Maximum Output	4.98	4.98	4.98 V	16330 counts
Resolution	0.8	0.8	0.8 mV	1.0 counts

Ambient temperature during characterization

22.0 °C

Analog Range: 1 (most sensitive, 0–4,000 counts), 2 (midrange, 0–8,000 counts), 4 (entire range, 0–16,000 counts).

Dark Counts: Signal output of the meter in clean water with black tape over detector.

SF: Determined using the following equation: $SF = x \div (\text{output} - \text{dark counts})$, where x is the concentration of the solution used during instrument characterization. SF is used to derive instrument output concentration from the raw signal output of the fluorometer.

Maximum Output: Maximum signal output the fluorometer is capable of.

Resolution: Standard deviation of 1 minute of collected data.

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

FLRTD-397

Revision J

3/17/08

CTD

Altimeter

VALEPORT

This document certifies that the instrument detailed below has been calibrated according to Valeport Limited's Standard Procedures, using equipment with calibrations traceable to UKAS or National Standards.

Calibration Certificate Number: 49383

Instrument Type: Altimeter

Instrument Serial Number: 51520

Calibrated By: J. Harper

Date: 07/10/2015

Signed: 

Full details of the results from the calibration procedure applied to each fitted sensor are available, on request, via email. This summary certificate should be kept with the instrument.



Valeport Ltd | St Peter's Quay | Looe | Devon | TQ9 5EW | UK
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Conductivity (primary)



SEA-BIRD
SCIENTIFIC

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13431 NE 20th Street
Bellevue, WA 98005
USA

+1 425-843-9886
seabird@seabird.com
www.seabird.com

SENSOR SERIAL NUMBER: 4548
CALIBRATION DATE: 08-Feb-18

SBE 4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -9.90838065e+000
h = 1.60083819e+000
i = -1.58153324e-003
j = 1.99854164e-004

CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

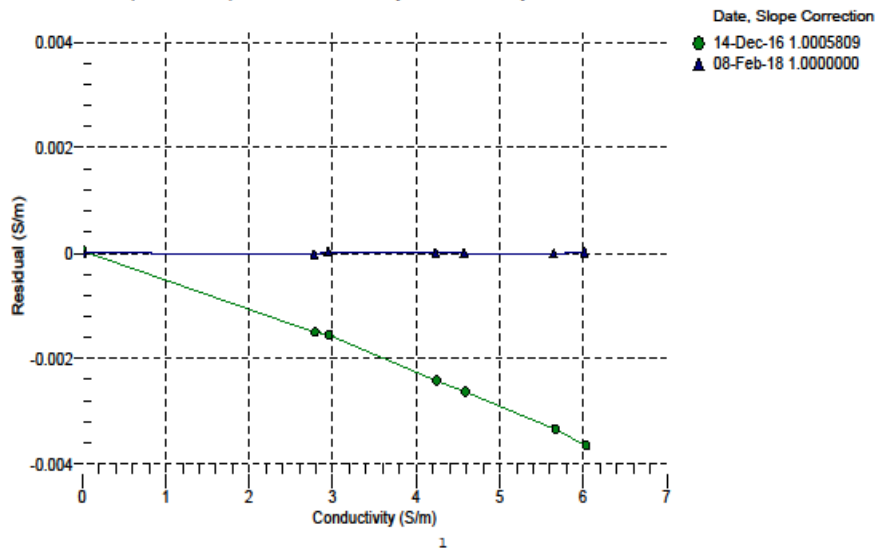
BATH TEMP (°C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.48997	0.00000	0.00000
-1.0000	34.4399	2.77706	4.85598	2.77704	-0.00003
1.0001	34.4402	2.94687	4.96418	2.94690	0.00003
15.0001	34.4401	4.23033	5.71557	4.23033	0.00001
18.5001	34.4390	4.57369	5.90029	4.57369	-0.00000
29.0001	34.4310	5.64628	6.44303	5.64626	-0.00002
32.5000	34.4164	6.01409	6.61882	6.01410	0.00001

f = Instrument Output (kHz)

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

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / (1 + \delta * t + \epsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



Conductivity (secondary)



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seabird@seabird.com
www.seabird.com

SENSOR SERIAL NUMBER: 1880
CALIBRATION DATE: 02-Feb-18

SBE 4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

g = -3.96678467e+000
h = 4.84542307e-001
i = -6.60474581e-004
j = 5.63015941e-005

CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

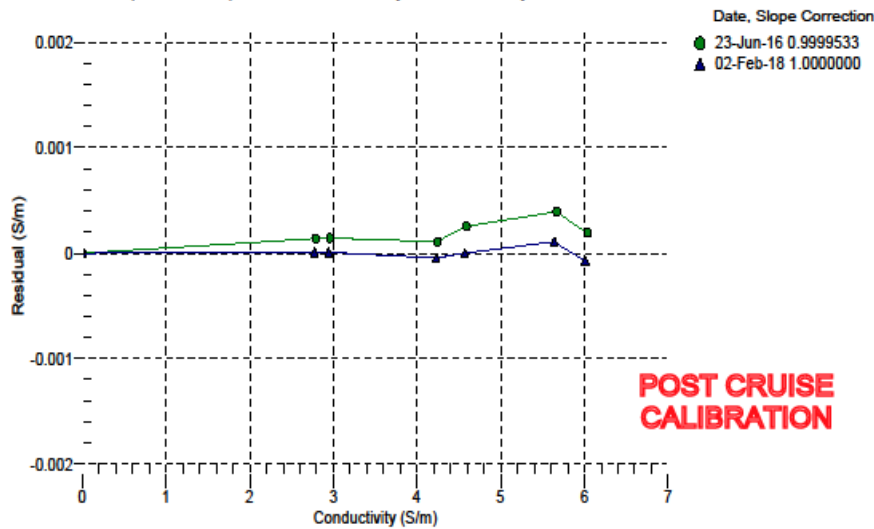
BATH TEMP (°C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.86546	0.00000	0.00000
-1.0000	34.4274	2.77615	8.10588	2.77616	0.00001
1.0001	34.4277	2.94590	8.31943	2.94591	0.00001
15.0000	34.4273	4.22891	9.78153	4.22886	-0.00005
18.5000	34.4258	4.57212	10.13631	4.57212	-0.00000
29.0000	34.4165	5.64416	11.17027	5.64426	0.00011
32.5000	34.4009	6.01169	11.50253	6.01162	-0.00007

f = Instrument Output (kHz)

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

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / (1 + \delta * t + \epsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



Fluorometer

Information provided by GO-SHIP:

For the FLBB and the transmissometer, people can contact ODF or contact the PI directly for more information.

At this moment in time it should be:

FLBB: Emmanuel Boss, emmanuel.boss@maine.edu

Pressure Sensor

Pressure Calibration Report

STS Calibration Facility

SENSOR SERIAL NUMBER: 1281
 CALIBRATION DATE: 12-DEC-2017
 Mfg: SEABIRD Model: 09P CTD Prs s/n: 136428

C1= -4.160303E+4
 C2= -4.604479E-1
 C3= 1.585404E-2
 D1= 3.546467E-2
 D2= 0.000000E+0
 T1= 3.013997E+1
 T2= -3.831629E-4
 T3= 3.608677E-6
 T4= 1.200552E-8
 T5= 0.000000E+0
 AD590M= 1.27846E-2
 AD590B= -9.25586E+0
 Slope = 1.00000000E+0
 Offset = 0.00000000E+0

Calibration Standard: Mfg: FLUKE Model: P3125 s/n: 70856

$t0 = t1 + t2 \cdot td + t3 \cdot td^2 + t4 \cdot td^3 + t5 \cdot td^4$

$w = 1 - t0 \cdot t0^{\frac{1}{2}}$

$Pressure = (0.6894759 \cdot ((c1 + c2 \cdot td + c3 \cdot td^2) \cdot w^2 \cdot (1 - (d1 + d2 \cdot td) \cdot w) - 14.7))$

Sensor Output	Standard	Sensor New Coefs	Standard-Sensor Prev Coefs	Standard-Sensor NEW Coefs	Sensor_Temp	Bath_Temp
33192.918	0.27	0.19	-0.00	0.07	28.04	27.370
33537.972	600.30	600.34	-0.14	-0.04	28.05	27.372
33878.938	1200.32	1200.36	-0.17	-0.04	28.06	27.372
34104.071	1600.33	1600.36	-0.17	-0.03	28.07	27.372
34438.600	2200.36	2200.36	-0.17	-0.01	28.07	27.371
34659.451	2600.36	2600.17	0.01	0.19	28.08	27.372
34988.130	3200.38	3200.64	-0.46	-0.26	28.08	27.371
35527.535	4200.37	4200.32	-0.18	0.05	28.09	27.370
34987.957	3200.38	3200.32	-0.14	0.06	28.09	27.371
34659.542	2600.36	2600.33	-0.14	0.03	28.09	27.372
34438.595	2200.36	2200.34	-0.15	0.01	28.10	27.372
34104.064	1600.33	1600.34	-0.15	-0.01	28.10	27.371
33878.934	1200.32	1200.34	-0.15	-0.02	28.10	27.371
33537.967	600.30	600.32	-0.12	-0.01	28.10	27.371
33190.468	0.27	0.18	0.17	0.08	17.05	16.244
33535.477	600.32	600.34	0.04	-0.02	17.05	16.244
33876.394	1200.34	1200.37	0.02	-0.02	17.04	16.244

Dissolved Oxygen (primary)



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seabird@seabird.com
www.seabird.com

SENSOR SERIAL NUMBER: 0255
CALIBRATION DATE: 22-Nov-17

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS:

Soc = 0.4274
Voffset = -0.4984
Tau20 = 0.99

A = -2.9883e-003
B = 1.5984e-004
C = -2.4626e-006
E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS

D1 = 1.92634e-4
D2 = -4.64803e-2
H1 = -3.300000e-2
H2 = 5.00000e+3
H3 = 1.45000e+3

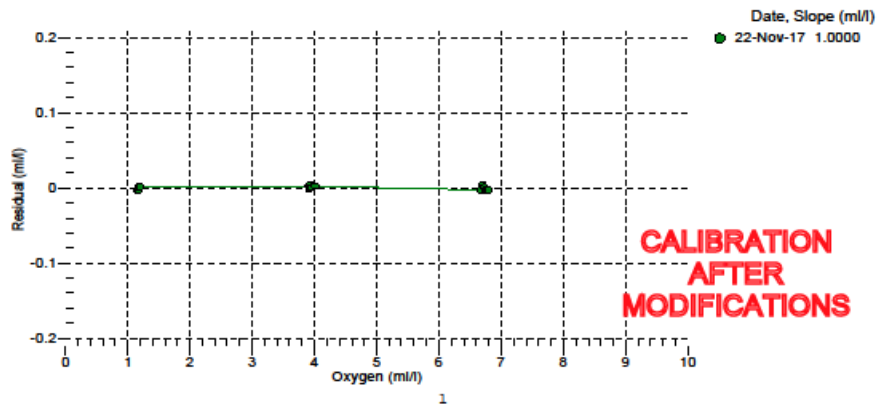
BATH OXYGEN (ml/l)	BATH TEMPERATURE (°C)	BATH SALINITY (PSU)	INSTRUMENT OUTPUT (volts)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.15	2.00	0.00	0.776	1.15	-0.00
1.16	20.00	0.00	0.931	1.16	0.00
1.16	12.00	0.00	0.863	1.16	-0.00
1.16	6.00	0.00	0.812	1.16	-0.00
1.17	26.00	0.00	0.986	1.17	0.00
1.19	30.00	0.00	1.031	1.19	0.00
3.91	2.00	0.00	1.447	3.91	0.00
3.91	6.00	0.00	1.562	3.92	0.00
3.92	12.00	0.00	1.732	3.91	-0.00
3.93	20.00	0.00	1.964	3.93	0.00
3.95	26.00	0.00	2.144	3.95	0.00
4.01	30.00	0.00	2.294	4.01	0.00
6.67	2.00	0.00	2.116	6.66	-0.00
6.70	6.00	0.00	2.321	6.71	0.00
6.73	26.00	0.00	3.307	6.73	0.00
6.74	12.00	0.00	2.623	6.74	-0.00
6.77	20.00	0.00	3.026	6.77	-0.00
6.80	30.00	0.00	3.541	6.80	-0.00

V = instrument output (volts); T = temperature (°C); S = salinity (PSU); K = temperature (°K)

Oxsol(T,S) = oxygen saturation (ml/l); P = pressure (dbar)

Oxygen (ml/l) = Soc * (V + Voffset) * (1.0 + A * T + B * T² + C * T³) * Oxsol(T,S) * exp(E * P / K)

Residual (ml/l) = instrument oxygen - bath oxygen



Oxygen Optode

For post cruise calibration information people can contact ODF or contact the PI directly.

Temperature Calibration Certificate

Model : ARO-CAV
 Serial No. : 0296
 Date : April 07, 2017
 Location : Production Section
 Method : Calibration equation is determined from third order regression of samples of the reference temperature against instrument voltages. Samples are taken at approximately 3, 10, 17, 24, and 31 °C.

1. Equation $\text{Instrument temperature} [^{\circ}\text{C}] = A + B \times V + C \times V^2 + D \times V^3$ V : Instrument voltage [V]

2. Coefficients
 A = -5.305905e+00
 B = +1.886857e+01
 C = -2.142681e+00
 D = +4.582805e-01

3. Calibration results

Reference temperature [°C]	Instrument voltage [V]	Instrument temperature [°C]	Residual error [°C]	Acceptance [°C]	OK/NG
2.437	0.46243	2.437	0.000	±0.020	OK
10.737	1.07715	10.735	-0.002	±0.020	OK
17.463	1.57625	17.466	0.003	±0.020	OK
24.123	2.07288	24.121	-0.002	±0.020	OK
31.105	2.58635	31.105	0.000	±0.020	OK

4. Verification

Criteria of judgement : Residual error of the instrument temperature at arbitrary point is within the acceptance value.

Reference temperature [°C]	Instrument temperature [°C]	Residual error [°C]	Acceptance [°C]	Judgement
20.066	20.066	0.018	±0.020	Passed

Examined

R. Koshida

Approved

A. Fukuoaka

JFE Advantech Co., Ltd.

Dissolved Oxygen Calibration Certificate

Model : ARD-GAV
 Serial No. : 0298
 Date : April 10, 2017
 Location : Production Section
 Method : Calibration is performed with the nitrogen gas (zero) and the oxygen saturated water (span) kept by air bubbling.
 Film No. : 164312BA

1. Equation $DO(\%) = G + H \times P^i$
 Here, $P^i(\%)$ consists of the coefficients A-F determined by the initial calibration.

2. Coefficients

A =	-4.524084e+01	E =	+4.000000e-03
B =	+1.449377e+02	F =	+6.250000e-05
C =	-3.051590e-01	G =	+0.000000e+00
D =	+1.065300e-02	H =	+1.000000e+00

3. Verification

Criteria of judgment : Residual error of the instrument DO at arbitrary point is within the acceptance value. The test is performed 3 times.

Acceptance: $\pm 0.5\%$ of full scale

Test for DO 0 %

	Test condition		Instrument DO [%]	Residual error [%]	Acceptance [%]	Judgement
	Atm. pressure [hPa]	Reference DO [%]				
1st	1015.7	0.00	0.02	0.02	± 1.00	Passed
2nd	1015.7	0.00	0.02	0.02	± 1.00	Passed
3rd	1015.7	0.00	0.02	0.02	± 1.00	Passed

Test for DO 100 %

	Test condition			Instrument DO [%]	Residual error [%]	Acceptance [%]	Judgement
	Water T. [°C]	Atm. pressure [hPa]	Reference DO [%]				
1st	25.1	1015.0	100.18	99.89	-0.29	± 1.00	Passed
2nd	25.1	1015.0	100.18	99.94	-0.24	± 1.00	Passed
3rd	25.1	1014.9	100.17	99.95	-0.22	± 1.00	Passed

Examined M. TAKEISHI

Approved a. Jukuoka

JFE Advantech Co., Ltd.

2 / 2

Pump (primary)

Multiple pumps were used; the USAP unit Test Certificate is given below. Contact GO-SHIP for more information about the pumps.



Sea-Bird Electronics, Inc.

13431 NE 20th St. Bellevue, Washington 98005 USA
www.seabird.com

Phone: (425) 643-9866

Fax: (425) 643-9954

Email: seabird@seabird.com

Pressure Test Certificate

Test Date: 2017-02-11

Description: SBE-5T Submersible Pump

Sensor Information:

Replaced the main piston "O"-Rings.

Model Number: SBE-5T

Serial Number: 05T-1646

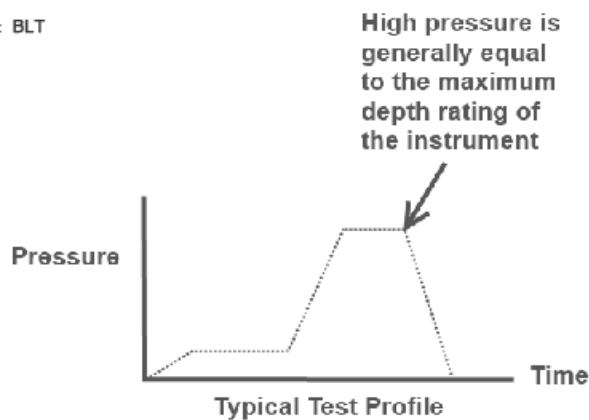
Pressure Test Protocol:

Low Pressure Test: 50 PSI Held For: 15 Minutes

High Pressure Test: 10000 PSI Held For: 30 Minutes

Passed Test: True

Tested By: BLT



Pump (secondary)

Multiple pumps were used; the USAP unit Test Certificate is given below. Contact GO-SHIP for more information about the pumps.



Sea-Bird Electronics, Inc.

13431 NE 20th St. Bellevue, Washington 98005 USA
www.seabird.com

Phone: (425) 643-9866

Fax: (425) 643-9954

Email: seabird@seabird.com

Pressure Test Certificate

Test Date: 2017-02-11

Description: SBE-5T Submersible Pump

Sensor Information:

Replaced the main piston "O"-Rings.

Model Number: SBE-5T

Serial Number: 05T-5644

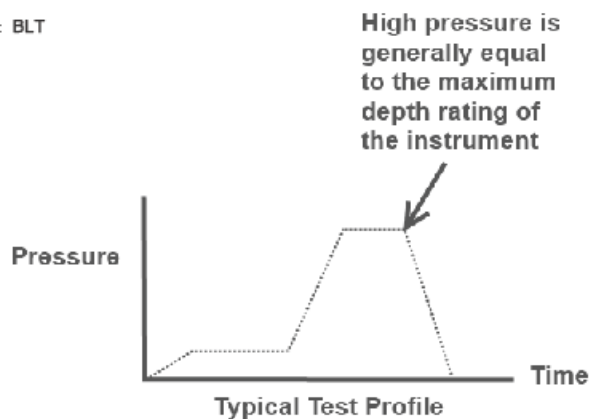
Pressure Test Protocol:

Low Pressure Test: 50 PSI Held For: 15 Minutes

High Pressure Test: 10000 PSI Held For: 30 Minutes

Passed Test: True

Tested By: BLT



Temperature (primary)

Temperature Calibration Report

STS Calibration Facility

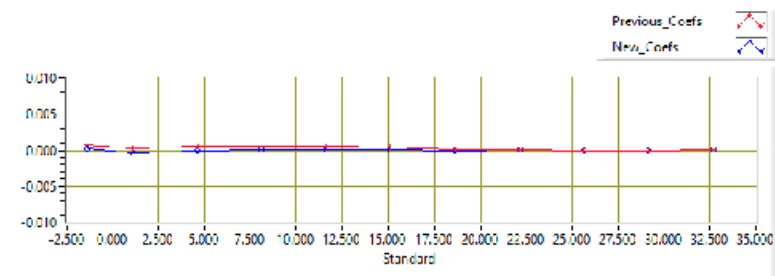
SENSOR SERIAL NUMBER: 5844
 CALIBRATION DATE: 30-Jan-2018
 Mfg: SEABIRD Model: 03
 Previous cal: 11-Apr-17
 Calibration Tech: CAL

ITS-90_COEFFICIENTS IPTS-68_COEFFICIENTS

$g = 4.36593732E-3$ $a = 4.36613846E-3$
 $h = 6.30830930E-4$ $b = 6.31038862E-4$
 $i = 2.06378769E-5$ $c = 2.06689583E-5$
 $j = 1.63292939E-6$ $d = 1.63430084E-6$
 $f_0 = 1000.0$ Slope = 1.0 Offset = 0.0

Calibration Standard: Mfg: Isotech Model: MicroK100 s/n: 291088-2
 Temperature ITS-90 = $1/[g+h[\ln(f_0/f)]+i[\ln^2(f_0/f)]+j[\ln^3(f_0/f)]] - 273.15$ (°C)
 Temperature IPTS-68 = $1/[a+b[\ln(f_0/f)]+c[\ln^2(f_0/f)]+d[\ln^3(f_0/f)]] - 273.15$ (°C)
 $T_{68} = 1.00024 * T_{90}$ (-2 to -35 Deg C)

SBE3 Freq	SPRT ITS-T90	SBE3 ITS-T90	SPRT-SBE3 OLD Coefs	SPRT-SBE3 NEW Coefs
3080.2217	-1.4141	-1.4143	0.00076	0.00024
3260.8575	1.0899	1.0902	0.00024	-0.00032
3526.5248	4.5965	4.5965	0.00050	-0.00005
3807.6804	8.1049	8.1049	0.00053	0.00003
4104.7634	11.6151	11.6150	0.00049	0.00009
4417.1077	15.1147	15.1146	0.00045	0.00015
4747.0667	18.6251	18.6252	0.00011	-0.00007
5094.0188	22.1350	22.1350	0.00009	0.00001
5458.5869	25.6462	25.6464	-0.00010	-0.00011
5840.8984	29.1566	29.1566	-0.00006	-0.00004
6241.5384	32.6677	32.6677	0.00006	0.00007



Temperature (Secondary)

Temperature Calibration Report

STS Calibration Facility

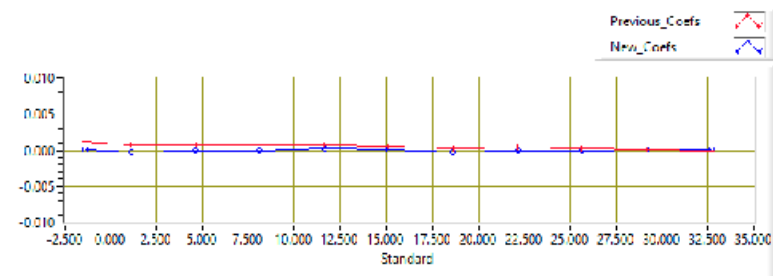
SENSOR SERIAL NUMBER: 2309
 CALIBRATION DATE: 30-Jan-2018
 Mfg: SEABIRD Model: 03
 Previous cal: 18-Apr-17
 Calibration Tech: CAL

ITS-90_COEFFICIENTS IPTS-68_COEFFICIENTS

$g = 4.35781951E-3$ $a = 4.35801776E-3$
 $h = 6.45070776E-4$ $b = 6.45282154E-4$
 $i = 2.42988411E-5$ $c = 2.43316076E-5$
 $j = 2.35822338E-6$ $d = 2.35982046E-6$
 $f_0 = 1000.0$ Slope = 1.0 Offset = 0.0

Calibration Standard: Mfg: Isotech Model: MicroK100 s/n: 291088-2
 Temperature ITS-90 = $1/[g+h[\ln(f_0/f)]+i[\ln^2(f_0/f)]+j[\ln^3(f_0/f)]] - 273.15$ (°C)
 Temperature IPTS-68 = $1/[a+b[\ln(f_0/f)]+c[\ln^2(f_0/f)]+d[\ln^3(f_0/f)]] - 273.15$ (°C)
 $T_{68} = 1.00024 * T_{90}$ (-2 to -35 Deg C)

SBE3 Freq	SPRT ITS-T90	SBE3 ITS-T90	SPRT-SBE3 OLD Coefs	SPRT-SBE3 NEW Coefs
2976.5664	-1.4141	-1.4142	0.00112	0.00015
3148.1687	1.0899	1.0901	0.00069	-0.00019
3400.3512	4.5965	4.5966	0.00069	-0.00008
3666.9395	8.1049	8.1049	0.00068	0.00000
3948.3190	11.6151	11.6149	0.00076	0.00017
4243.8576	15.1147	15.1146	0.00061	0.00010
4555.7184	18.6251	18.6252	0.00028	-0.00016
4883.2760	22.1350	22.1351	0.00034	-0.00001
5227.0836	25.6462	25.6463	0.00024	-0.00001
5587.2448	29.1566	29.1565	0.00014	0.00001
5964.2596	32.6677	32.6677	0.00000	0.00001



Temperature Reference

Temperature Calibration Report

STS Calibration Facility

SENSOR SERIAL NUMBER: 0035
 CALIBRATION DATE: 01-Feb-2018
 Mfg: SEABIRD Model: 35
 Previous cal: 13-Apr-17
 Calibration Tech: CAL

ITS-90 COEFFICIENTS

a0 = 4.791527218E-3

a1 = -1.309090597E-3

a2 = 1.955082742E-4

a3 = -1.086552076E-5

a4 = 2.316911178E-7

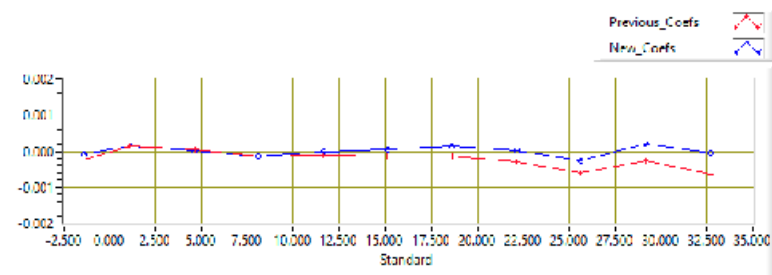
Slope = 1.000000 Offset = 0.000000

Calibration Standard: Mfg: Isotech Model: MicroK100 s/n: 291088-2

Calibration Standard: Mfg: Isotech Model: MicroK100 s/n: 291088-2

Temperature ITS-90 = $1/(a_0 + a_1[\ln(f)] + a_2[\ln^2(f)] + a_3[\ln^3(f)] + a_4[\ln^4(f)] - 273.15$ (°C)

SBE35 Count	SPRT ITS-T90	SBE35 ITS-T90	SPRT-SBE35 OLD Coefs	SPRT-SBE35 NEW Coefs
656379.7725	-1.4147	-1.4147	-0.00022	-0.00008
588220.4937	1.0889	1.0887	0.00014	0.00015
505645.6124	4.5957	4.5957	0.00006	0.00001
435835.2087	8.1031	8.1032	-0.00014	-0.00014
376639.0090	11.6137	11.6137	-0.00012	-0.00003
326489.0904	15.1148	15.1148	-0.00014	0.00005
283649.9587	18.6268	18.6267	-0.00013	0.00013
247110.8773	22.1359	22.1359	-0.00029	0.00003
215838.7256	25.6449	25.6452	-0.00062	-0.00026
188993.4830	29.1564	29.1562	-0.00025	0.00019
165901.6355	32.6672	32.6673	-0.00063	-0.00004



Transmissometer

Information provided by GO-SHIP:

For the FLBB and the transmissometer, people can contact ODF or contact the PI directly for more information.

At this moment in time it should be:

Transmissometer: Wilf Gardner, wgardner@ocean.tamu.edu