

Thwaites - Amundsen Sea Polynia

Data Report NBP2202

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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 USB Drive that is formatted as NTFS. It is readable by virtually every computing platform.

All the data except for ADCP has been archived using 'tar' and compressed using 'gzip', identified by the '.tz' extension; or '.zip'. 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 data are included with this distribution.

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 of 1: NBP2202

File

```

/
  EOCmsg.txt
  INSTCOEF.TXT
  NBP2202.gmt
  NBP2202.mgd
  NBP2202.trk
  2202DATA.docx
  2202DATA.pdf
/uhdas
  ADCP.zip
/Imagery
  2202Imag.tz
/MB
  edited.zip
  raw.zip
  wc.zip
/ocean
  2202ctd.tz
  2202xbt.tz
/plots
  NBP2113.kml
  NBP2113_trk.png
/process
  2202JGOF.tz
  2202MGD.tz
  2202PCO2.tz
  2202PROC.tz
  2202QC.tz
  xrvdas.log
/rvdas/nav
  2202gyr1.tz
  2202s330.tz
  2202s380.tz
/rvdas/uw
  2202bwnc.tz
  2202ctdd.tz
  2202eng1.tz
  2202grv1.tz
  2202hdas.tz
  2202knud.tz
  2202mbdp.tz
  2202mwx1.tz
  2113ndfl.tz
  2113oxyg.tz
  2202pco2.tz

```

Description

```

Root level directory
  Log file of data distro creation
  Instrument Coefficient File
  GMT binary file of MGD77 data
  Full Cruise MGD77 data file
  Text file of cruise track
  Data Report NBP2202 (MS Word)
  Data Report NBP2202 (PDF format)
ADCP data
  Cruise ADCP data
Cruise specific imagery
  Cruise imagery
Cruise multibeam data
  Edited multibeam(.gsf & .nsf format)
  Raw multibeam files (.all format)
  Watercolumn data (.wcd format)
Ocean data
  CTD data
  XBT data
Cruise track plots
  KML formatted file of cruise track
  PNG image of cruise track plot
Processed data
  JGOFs format data files
  MGD data
  Merged pCO2 data files
  Other processed data
  Daily RVDAS QC postscript plots
  Start/Stop times of data collection
Navigation data
  Gyro raw data
  Seapath 330 data
  Seapath 380 data
Underway datanfl
  Baltic winch data
  CTD depth data
  Engineering data
  Gravity Raw data
  HydroDAS raw data
  Knudsen raw data
  Multi-beam depth
  Meteorology raw data
  Fluorometer
  Oxygen Optode data
  pCO2 raw data

```

2202pguv.tz
2202rtmp.tz
2202tsg1.tz
2202tsg2.tz
2202twnc.tz

GUV raw data
Remote Temperature data
Micro TSG1 data
Micro TSG2 data
Trawl winch data

Extracting Data

The data files will have a “.tz” or a “.zip” 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 -xzvf archive_filename
```

An example extracting specific files from the archive:

```
tar -xzvf archive_filename list_of_files_to_extract
```

Distribution Contents

Cruise Track

The distribution media includes a GMT cruise track file (NBP2202.trk). It contains the longitude and latitude at one-minute intervals extracted from the NBP2202.gmt file.

Satellite Images

Satellite Images processed for this cruise can be found in the directory, /Imagery in three subdirectories; amsr, other, and extra. File names contain a yyymmdd string within them to designate the corresponding date. Naming conventions vary.

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 2202PROC.tz. 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/NBP2202JGOF.tz. 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 NBP2202.mgd. The file NBP2202.gmt is created from the MGD77 dataset using the “mgd77togmt” utility. NBP2202.gmt can be used with the GMT plotting package.

The data used to produce the NBP2202.mgd file can be found on the distribution media in the file /process/2202proc.tz. 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.

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 2202PCO2.tz 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/NBP2202ctd.tz. The archive contains three folders process, raw, and sv.

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 2202xbt.tz in the /ocean directory.

RVDAS

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

Daily data processing of the RVDAS 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].ddd

Example: NBP2202mwx1.d025

- The CruiseID is the numeric name of the cruise, in this case, NBP2202.
- 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	Rotronic HC2A-S3 (Primary)
Air Temperature	mwx1 (met)	Continuous	1/sec	RM Young 41372LC (Secondary)
Relative Humidity	mwx1 (met)	Continuous	1/sec	Rotronic HC2A-S3 (Primary)
Relative Humidity	mwx1 (met)	Continuous	1/sec	RM Young 41372LC (Secondary)
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
Oxygen	oxyg	Continuous	6/min	Oxygen Optode Aanderaa 4835
Total Dissolved Gas Pressure	tdgp	Continuous	1/sec	Mini TDGP Pro Oceanus 0-2 BAR

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	s380	Continuous	1/sec	Seapath 380 GPS
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**Meteorology (mw1)****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, -6.07, 77.4

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.xx	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
13	Air Temperature, Celsius (Secondary Sensor RMYoung)	xx.xx	C
14	Air Relative Humidity (Secondary Sensor RMYoung)	xx.x	%

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

Total Dissolved Gas Pressure (tdgp)

21+324:23:59:52.063 P 2021, 11, 20, 23, 59, 14, 6.85, 1008.85, 12.0

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	Start of data line	x	P
3	Year	xxxx	
4	Month	xx	
5	Day	xx	
6	Hour	xx	
7	Minute	xx	
8	Second	xx	
9	Temperature	xx.xx	C
10	Dissolved Gas Pressure	xxxx.xx	mBar
11	Supply Voltage	xx.x	V

Oxygen (oxyg)

21+353:15:24:44.286 MEASUREMENT 4835 1038 O2Concentration[uM] 386.255 AirSaturation[%]
 96.963 Temperature[Deg.C] 5.051 CalPhase[Deg] 32.416 TCPhase[Deg] 33.516 C1RPh[Deg]
 41.837 C2RPh[Deg] 8.321 C1Amp[mV] 635.4 C2Amp[mV] 736.0 RawTemp[mV]
 657.1

Field	Data	Format	Unit
1	RVDAS time tag	yy+ddd:hh:mm:ss.sss	UTC
2	"MEASUREMENT"	string	N/A
3	Measurement	xxxx	
4	Measurement	xxxx	
5	"O2Concentration[uM]"	string	N/A
6	O2 Concentration	xxx.xxx	uM
7	"AirSaturation[%]"	string	N/A
8	Air Saturation	xx.xxx	%
9	"Temperature[Deg.C]"	string	N/A
10	Temperature	x.xxx	Deg.C
11	"CalPhase[Deg]"	string	N/A
12	Cal Phase	xx.xxx	Deg
13	"TCPhase[Deg]"	string	N/A
14	TC Phase	xx.xxx	Deg
15	"C1RPh[Deg]"	string	N/A
16	C1R Ph	xx.xxx	Deg
17	"C2RPh[Deg]"	string	N/A
18	C2R Ph	x.xxx	Deg
19	"C1Amp[mV]"	string	N/A
20	C1 Amp	xxx.x	mV
21	"C2Amp[mV]"	string	N/A
22	C2 Amp	xxx	mV
23	"RawTemp[mV]"	string	N/A
24	Raw Temp	xxx.x	mV

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 Signal	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, s380)**

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 380*
 - a. NMEA 0182 strings
 - i. GPZDA
 - ii. GPGGA
 - iii. GPVTG
 - iv. GPHDT
 - b. Proprietary Strings
 - i. PSXN 20
 - ii. PSXN 22
 - iii. PSXN 23

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

GPGGA

15+051:21:02:02.507 \$GPGGA,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	\$GPGGA		
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

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 “`mw1`” file description. Hard-coded “C” coefficients are shown below:

Dome constant = 3.5

Sigma = 5.6704×10^{-8}

`pir_thermo` = raw data mV

calibration scale = `pirCoeff` $\times 10^{-6}$ V/(W/m²)

`pir_thermo` / (scale $\times 1000$ 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
		Mini TDGP was not collected on this cruise due to problems with the instrument
008:16:57		Data collection begins. -57 47.3311S -74 59.9625W
009:11:30		Gravity Restored
014:02:00		Water wall fluorometer was found to be not receiving flow. Corrected at this time.
020:19:09	020:21:37	Water wall: turned off TSG1 for cleaning
020:19:28	020:19:35	Water wall: turned off fluorometer for cleaning
020:19:40	020:19:47	Water wall: turned off transmissometer for cleaning
020:23:23	021:01:07	Water wall: turned off TSG2 for cleaning
026:00:00		TMC Transmissometer replaced with CST-439DR (Effective cast TMC075 and onward)
044:12:22		Waterfall Winch output became inconsistent
044:14:23	044:14:24	Restarted xrvdas due to unresponsiveness.
050:01:37		ADCP turned off to allow EK60 38 kHz
050:15:39	050:19:51	75kHz ADCP turned on
050:22:24	050:22:50	EK60 stopped. Computer rebooted itself for Windows updates
050:13:15		EK60 Stopped, ADCP turned back on, Knudsen turned back on.
065:21:58		Data collection stops -58 6.854S -62 41.479W

Appendix A: Sensors

NBP2202 Sensors

Meteorology and Radiometry

Sensor	Serial No.	Manufacturer	Model	Last Cal Date	Comments
Anemometer	WM128975	RM Young	5106	10/27/2011	ECO Bridge Windbird
Anemometer, U/S	847014	Gill Instruments	1390-PK-062	9/29/2010	Stbd Side (SUS)
Anemometer, U/S	1004041	Gill Instruments	1390-PK-114	10/1/2013	Port Side (PUS)
Barometer	M2750444	Vaisala	PTB210B	7/13/2016	
Humidity/Temp/Dew Pt	0020286073	Rotronic	HC2A-S3	7/12/2018	Primary Temp/RH
Humidity/Wet Temp	06135	RM Young	41372LC	7/31/2017	Secondary Temp/RH
PAR	20546	Biosph. Inst.	QSR-2200	7/29/2019	Mast PAR
PIR	33023F3	Eppley	PIR	8/14/2018	
PSP	33090F3	Eppley	PSP	8/9/2018	
GUV (Mast)	25110203113	Biosph. Inst.	GUV-2511	9/4/2018	Mast
GUV Deckbox	SPARE - 1126	Biosph. Inst.	GUV-2511	N/A	Deckbox

Underway Seawater Sampling System

Sensor	Serial No.	Manufacturer	Model	Last Cal Date	Comments
Digital Remote Temp	3846730-0323	Sea-Bird	SBE 38	4/13/2018	Intake Temperature
Fluorometer	FLRTD-855	WET Labs	FLRTD	5/16/2018	
Micro-TSG	4550449-0242	Sea-Bird	SBE 45	6/6/2019	Primary TSG
Micro-TSG	4566350-0389	Sea-Bird	SBE 45	2/29/2020	Secondary TSG
Mini TDGP	41-861-31	Pro Oceanus	0 -2 BAR	N/A	Installed 11/18/2021
Oxygen Optode	1038	Aanderaa	4835	N/A	Installed 11/17/2021
Transmissometer	CST-892DR	WET Labs	C-Star	7/10/2019	

CTD

Sensor	Serial No.	Manufacturer	Model	Last Cal Date	Comments/Stations
Altimeter	51520	Valeport	VA-500	7/10/2015	
Bottom Contact Switch	#3	Sea-Bird	90149.2	N/A	
Carousel Water Sampler	32-1097	Sea-Bird	SBE-32	N/A	24 Bottle Rosette
Conductivity	042513	Sea-Bird	4C 6800m	5/14/2019	Primary Cond.
Conductivity	044151	Sea-Bird	4C 6800m	5/17/2019	Secondary Cond.
CTD Fish	09P70675-1130	Sea-Bird	SBE 9+	3/22/2021	
CTD Pressure Sensor	120089	Paroscientific	410K-105	3/22/2021	
CTD Pump	051626 3.0K	Sea-Bird	5T, PN 90160	3/11/2020	Primary Pump
CTD Pump	051627 3.0K	Sea-Bird	5T, PN 90160	3/11/2020	Secondary Pump
Dissolved Oxygen	430150	Sea-Bird	SBE 43	12/18/2021	Primary DO
Dissolved Oxygen	430161	Sea-Bird	SBE 43	12/18/2021	Secondary DO
Fluorometer	FLRTD-1482	WET Labs	FLRTD	8/29/2018	
Fluorometer (BAS)	FLNTU-2952	WET Labs	FLNTU	10/28/2015	BAS provided
PAR	4361	Biosph. Inst.	QSP-200L4S	3/4/2021	
SBE 11+ Deck Unit	11P19858-0490	Sea-Bird	11+	N/A	
SPAR	20546	Biosph. Inst.	QSR-2200	7/29/2019	Mast PAR
Temperature	031649	Sea-Bird	3F 6800m	2/04/2020	Primary Temp.
Temperature	03P2186	Sea-Bird	3plus 6800m	8/23/2018	Secondary Temp.
Transmissometer	CST-1581DR	WET Labs	C-Star	8/23/2018	

TMC

Sensor	Serial No.	Manufacturer	Model	Last Cal Date	Comments/Stations
Altimeter	56636	Valeport	VA-500	09/16/2016	
Bottom Contact Switch	N/A	Sea-Bird		N/A	
Carousel Water Sampler	1052	Sea-Bird	SBE 322	N/A	
Conductivity	044380	Sea-Bird		12/23/2016	Primary Cond.
Conductivity	044422	Sea-Bird		12/29/2016	Secondary Cond.
CTD Fish	1315	Sea-Bird	SBE 9+	03/21/2017	
CTD Fish Pressure	138503	Parscientific	510K-134	03/21/2017	
Dissolved Oxygen	433170	Sea-Bird	SBE 43	04/11/2018	Primary DO
Dissolved Oxygen	432512	Sea-Bird	SBE 43	08/01/2017	Secondary DO
Fluorometer	FLRTD-3928	Wet Labs	FLRTD	12/19/2016	
Fluorometer (BAS)	FLNTU-2951	WET Labs	FLNTU	10/28/2015	BAS provided
Pump	059000	Sea-Bird		01/23/2017	Primary Pump
Pump	058275	Sea-Bird		01/19/2017	Secondary Pump
SBE 11+ Deck Unit	11P19858-0490	Sea-Bird	SBE 11+	N/A	
Slip-Ring Assembly	Meridian rotocon 215772	Sea-Bird		N/A	
SPAR	20546	Biosph. Inst		7/26/2019	
Temperature	035786	Sea-Bird	3Plus 6800m	12/23/2016	Primary Temp.
Temperature	03P5097	Sea-Bird	3Plus 6800m	01/12/2017	Secondary Temp.
Transmissometer	CST-889DR	Wet Labs		05/04/2021	Used through TMC042
Transmissometer	CST-439DR	Wet Labs		05/04/2021	Used from TMC076

Appendix B: Calibration Sheets

Gravity

Gravity Tie Spreadsheet

The fields outlined in BOLD MUST BE FILLED IN for this spreadsheet to operate properly. The automatically calculated values show up in the shaded fields.					
Date:	1/3/2022			Reference Code Numbers:	
Location:	Punta Arenas, Chile			Station no.	9337-50
Station:	Harbour Admin. Bldg.			ISGN no.	51230N
Latitude:	53 09 S				
Longitude:	070 55 W				
Elevation:					
Gravity:	981320.82				
		Value	Time (GMT)		
Ship's meter before gravity tie (Filt Counts)		25065.89	16:04		
Ship's meter after gravity tie (Filt Counts)		25065.87	17:24		
Average		25065.88			
Ship Gravimeter's Calibration Constant		4.99407055			
Corrected ship's meter (QC Grav (mgal))		125180.77			
		Value	Time (GMT)		
Ship's meter before gravity tie (serial, RVDAS)		981306.8	16:04		
Ship's meter after gravity tie (serial, RVDAS)		981306.6	17:24		
Average (for comparison check only)		981306.7			
Portable Gravimeter Interval Factor		1.01007		From Table 1 of Model G #807 Meter	
Station		Value	Time (GMT)	Temp	Date
Pier measurement 1		4913.20	16:31	53.6	January 3, 2022
Pier measurement 2		4913.40	16:33	53.6	January 3, 2022
Pier measurement 3		4913.33	16:35	53.6	January 3, 2022
Average		4913.31			
Station measurement 1		4913.77	16:50	53.6	January 3, 2022
Station measurement 2		4913.81	16:53	53.6	January 3, 2022
Station measurement 3		4913.75	16:55	53.6	January 3, 2022
Average		4913.78			
Pier measurement 4		4912.90	17:17	53.6	January 3, 2022
Pier measurement 5		4913.10	17:18	53.6	January 3, 2022
Pier measurement 6		4913.00	17:19	53.6	January 3, 2022
Average		4913.00			
				Date of last tie	8/29/2020
				Gravity Bias from last tie	856212.25
				Drift since last tie	-72.53
				Drift RATE since last tie	-4.48
				Comments	
OBS Differences					
Station to Pier (1, 2, & 3 averaged)		-0.47			
Station to Pier (4, 5, & 6 averaged)		-0.78			
Averaged Differences		-0.63			
Gravity at pier		981320.19			
Elevation of pier above gravimeter, meters		1.0			
Earth differential gravity, mgal/meter		0.3			
Gravity at ship's gravimeter		981320.49			
Gravity Bias (for reference only)		856139.72			
Gravity Bias from GUI (USE IN RVDAS)					
Note about Elevation of Pier: If pier is below the ship's gravimeter, this value is negative. If above, positive.					

Meteorology

Anemometers

Cal sheet not required

Barometer

VAISALA

Certificate report no. H44-16280022
1 (1)

CALIBRATION CERTIFICATE

Instrument PTB210B Digital Barometer
Serial number M2750444
Manufacturer Vaisala Oyj, Finland
Calibration date 13th July 2016

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

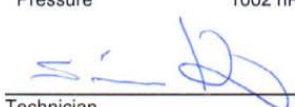
*To obtain the true pressure, add the correction to the barometer reading.
Interpolated corrections may be used at intermediate readings of the scale of the barometer.

Equipment used in calibration

Type	Serial number	Calibration date	Certificate number
PPC4	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

This report shall not be reproduced except in full, without the written approval of Vaisala.

doc223087-B

Vaisala Oyj | PO Box 26, FI-00421 Helsinki, Finland

Humidity / Temperature / Dew Pt (Primary)

CERTIFICATE		 LEADING IN HUMIDITY MEASUREMENT	
Device type	HC2A-S3		
Serialnumber	0020286073		
RPC-number	19-0356518119		
ROTRONIC AG certifies that this instrument meets the published specifications. It has been calibrated using standards and instruments as stated below and corresponds to the process requirements of ISO 9001:2008. The references are traceable to national standards. The calibrated values are only valid at the time of measurement and are referenced to the indicated references and working standards.			
FACTORY CALIBRATION			
<i>Adjustment</i>			
Temperature	23.55°C		
Humidity 1	11.52%rH (@23.56°C)		
Humidity 2	34.68%rH (@23.61°C)		
Humidity 3	79.27%rH (@23.71°C)		
<i>Calibration</i>			
	Device	Reference	
Temperature	23.60°C	23.60°C	
Humidity	50.27%rH	50.14%rH	
Date of calibration: 12.07.2018			
<i>Reference System</i>			
HC2-S (SCS certified)			
FUNCTION TEST			
Firmware	V1.2		
Analog Output	Out1: Humi 0..100%rH (0..1V) Set: 40.00%rH, measured 40.01%rH (0.400V)		
	Out2: Temp -40..60°C (0..1V) Set: 20.00°C, measured 20.01°C (0.600V)		
Printnumber	66.1085.0301		
Final test passed – 16.08.2018 – quality engineer: V. Doan Control number: 304			
 ROTRONIC AG, Grindelstrasse 6, CH - 8303 Bassersdorf www.rotronic.com			

Humidity / Temperature (Secondary)



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

CALIBRATION REPORT Temperature & Humidity

Customer: *Leidos Innovations Corp*

Test Number: 7731-01T
Test Date: 31 July 2017

Customer PO: 21800
Sales Order: 6363

Instrument Under Test (IUT)

Model: 41372LC
Description: Temp / Humidity Sensor

Serial Number: TS06135

Temperature: Report of calibration comparison with National Institute of Standards and Technology traceable standard thermometer(s) at three temperatures in the R.M. Young Company controlled temperature calibration facility. The following data describe the relationship between actual temperature, as determined by the NIST calibrated thermometer, and test sensor temperature, as determined by its output.

Reference Temperature Celcius	IUT Output mA	Indicated (1) Temperature Celcius
-49.85	4.0	-49.93
-0.01	12.0	0.07
50.03	20.0	50.01

(1) Calculate from IUT voltage output.

Calibration accuracy $\pm 0.1^\circ$ Celcius.

Humidity: Report of calibration comparison with National Institute of Standards and Technology traceable standard humidity sensor at five humidity levels in the R.M. Young Company controlled humidity chamber. The following data describe the relationship between actual humidity, as determined by the NIST calibrated humidity sensor, and test sensor humidity, as determined by its output.

Reference Humidity %	IUT Output mA	Indicated (1) Humidity %
10.0	6	11.9
30.0	9	31.4
50.0	12	51.8
70.0	15	71.2
90.0	18	88.3

(1) Calculate from IUT voltage output.

Calibration accuracy ± 2.0 %.

National Institute of Standards and Technology Reference

Brooklyn Thermometer Model 43-FC
Brooklyn Thermometer Model 22332-D5-FC
Brooklyn Thermometer Model 2X400-D7-FC
Keithley Multimeter Model 191
Vaisala Humidity Sensor Model 35AC
Fluke Multimeter Model 8060A

Serial No.	Reference No.
8006-118	W204690
25071	W204691
77532	W204692
15232	8604897
N475040	TN 266152
4865407	8604897

Tested By

S. Sage

METEOROLOGICAL INSTRUMENTS

Tel: 231-946-3980 Fax: 231-946-4772 Email: met.sales@youngusa.com Website: youngusa.com
ISO 9001:2008 CERTIFIED

PAR (Mast)

Biospherical Instruments Inc.

CALIBRATION CERTIFICATE

Calibration Date 7/26/2019
 Model Number QSR2200
 Serial Number 20546
 Operator TPC
 Standard Lamp V-039(1/3/19)
 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 103.5 mV
 Probe Dark 1.1 mV
 Probe Net Response 102.4 mV
 RG780 1.2 mV

Corrected Lamp Output:

Output In Air (same condition as calibration):

8.903E+15 quanta/cm²sec
0.014784 uE/cm²sec

Calibration Scale Factor:

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

Dry: 1.1503E-17 V/(quanta/cm²sec)
6.9271E+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

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 pyrgeometer was compared against Eppley's Blackbody Calibration System under radiation intensities of approximately 350 Wm^{-2} with an average ambient temperature of 25°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: $S = 3.85 \mu\text{V} / \text{Wm}^{-2}$

Uncertainty: $U_{95} = \pm 1.7\%$ (95% confidence level, $k=2$)

Resistance: 739Ω at 23°C

Date of Test: August 14, 2018

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 pyrgeometers 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: NSF/Leidos/Antarctic Support
Port Hueneme, CA

Signatures:

Debra L. Shultz
In Charge of Test:

Thomas J. Kirk
Reviewed by:

Eppley SO: 65265

Date of Certificate: August 14, 2018

Remarks:

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 5.3.1* 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: $S = 7.82 \mu V / W m^{-2}$

Uncertainty: $U_{95} = \pm 0.91\%$ (95% confidence level, $k=2$)

Resistance: 700Ω at $23^{\circ}C$

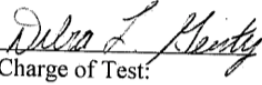
Date of Test: August 9, 2018

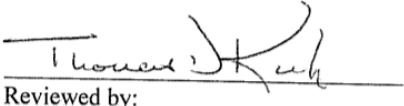
Traceability: This calibration is traceable to the World Radiation Reference (WRR) through comparisons with Eppley's AHF standard self-calibrating cavity pyrheliometers which participated in the Twelfth International Pyrheliometric Comparisons (IPC XII) at Davos, Switzerland in September-October 2015. 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: NSF/Leidos/Antarctic Support
Port Hueneme, CA

Signatures:

In Charge of Test: 

Reviewed by: 

Eppley SO: 65266

Date of Certificate August 14, 2018

Remarks:

End of Report

GUV (Mast)

**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-040 (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 **25110203113v10_9-4-2018.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	9/4/2018
Calibration database	25110203113v10_9-4-2018.mdb	Date of Certificate	9/4/2018
DASSN	0068	Standard of Spectral Irradiance	V-040(7/20/16)
Microprocessor Tag Number	2	Operator	TC

Monochromatic Channels	Address	Wavelength [nm]	Responsivity [Amps per $\mu\text{W}/(\text{cm}^2\cdot\text{nm})$]	ScaleSmall [Volts per $\mu\text{W}/(\text{cm}^2\cdot\text{nm})$]	ScaleMedium [Volts per $\mu\text{W}/(\text{cm}^2\cdot\text{nm})$]	ScaleLarge [Volts per $\mu\text{W}/(\text{cm}^2\cdot\text{nm})$]	OffsetSmall [volts]	OffsetMedium [volts]	OffsetLarge [volts]	Measurement Units
Ed0320	2	320	2.6678E-10	2.7211E-05	7.9499E-03	2.8146E+00	8.0571E-05	8.2059E-05	4.5436E-04	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Ed0340	6	340	2.1498E-10	2.1928E-05	6.4063E-03	2.2588E+00	3.6257E-04	3.6048E-04	1.2823E-03	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Ed0313	8	313	2.2362E-10	2.2809E-05	6.6638E-03	2.3790E+00	3.3288E-05	3.7850E-05	6.4498E-04	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Ed0305	10	305	1.7052E-11	1.7393E-06	5.0813E-04	1.5719E-01	4.4831E-04	4.3677E-04	-2.1414E-03	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Ed0380	12	380	6.3715E-11	6.4989E-06	1.8987E-03	6.3320E-01	1.0314E-03	1.0204E-03	-1.5066E-03	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$
Ed0395	18	395	3.4491E-10	3.5181E-05	1.0278E-02	3.3574E+00	8.5662E-05	7.9751E-05	2.4058E-04	$\mu\text{W}/(\text{cm}^2\cdot\text{nm})$

Broadband Channels	Address	Wavelength [nm]	Responsivity [Amps per $\mu\text{E}/(\text{cm}^2\cdot\text{s})$]	ScaleSmall [Volts per $\mu\text{E}/(\text{cm}^2\cdot\text{s})$]	ScaleMedium [Volts per $\mu\text{E}/(\text{cm}^2\cdot\text{s})$]	ScaleLarge [Volts per $\mu\text{E}/(\text{cm}^2\cdot\text{s})$]	OffsetSmall [volts]	OffsetMedium [volts]	OffsetLarge [volts]	Measurement Units
Ed0PAR	13	400-700	1.9092E-05	1.9474E+00	5.6893E+02	2.0257E+05	8.8037E-04	8.7318E-04	-1.2620E-03	$\mu\text{E}/(\text{cm}^2\cdot\text{sec})$

Auxiliary Channels	Address	Wavelength [nm]	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

© Biospherical Instruments Inc., 5340 Riley Street, San Diego, California 92110 USA. Contact support@biospherical.com for more information.

Underway Seawater Sampling System

Digital Remote Temp



SEA-BIRD
SCIENTIFIC

Sea-Bird Scientific
13431 NE 20th Street
Bellevue, WA 98005
USA

+1 425-643-9866
seabird@seabird.com
www.seabird.com

SENSOR SERIAL NUMBER: 0323
CALIBRATION DATE: 13-Apr-18

SBE 38 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

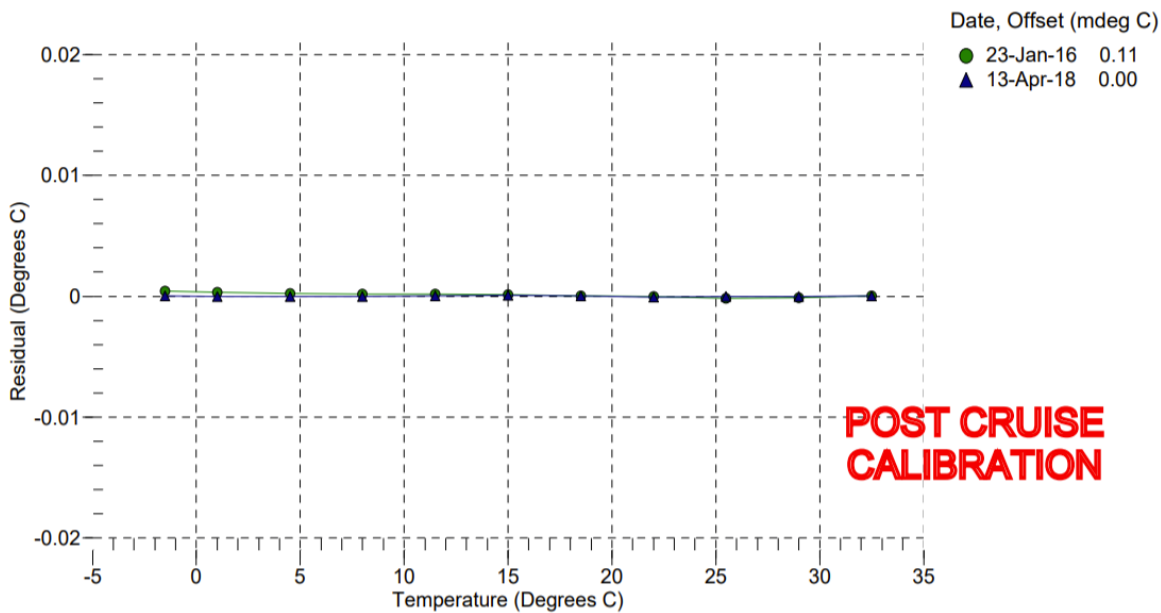
a0 = 6.739541e-006
a1 = 2.767952e-004
a2 = -2.458043e-006
a3 = 1.598430e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
-1.5000	711119.8	-1.5000	0.0000
1.0000	635161.5	1.0000	-0.0000
4.5000	543807.5	4.5000	-0.0000
8.0000	467110.4	8.0000	-0.0000
11.5000	402499.8	11.5000	0.0000
15.0000	347893.2	15.0001	0.0001
18.5000	301594.2	18.5000	0.0000
22.0000	262217.0	21.9999	-0.0001
25.5000	228623.2	25.5000	-0.0000
29.0000	199880.6	29.0000	-0.0000
32.5000	175217.5	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



Fluorometer

PO Box 518
620 Applegate St.
Philomath, OR 97370



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

ECO Chlorophyll Fluorometer Characterization Sheet

Date: 5/16/2018

S/N: FLRTD-855

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	0.113	0.070	0.049 V	71 counts
Scale Factor (SF)	7	14	29 µg/l/V	0.0079 µg/l/count
Maximum Output	4.98	4.98	4.98 V	16326 counts
Resolution	0.6	0.6	0.6 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-855

Revision J

3/17/08

Micro-TSG 1



SEA-BIRD
SCIENTIFIC

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13431 NE 20th Street
Bellevue, WA 98005
USA

+1 425-643-9866
seabird@seabird.com
www.seabird.com

SENSOR SERIAL NUMBER: 0242
CALIBRATION DATE: 06-Jun-19

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

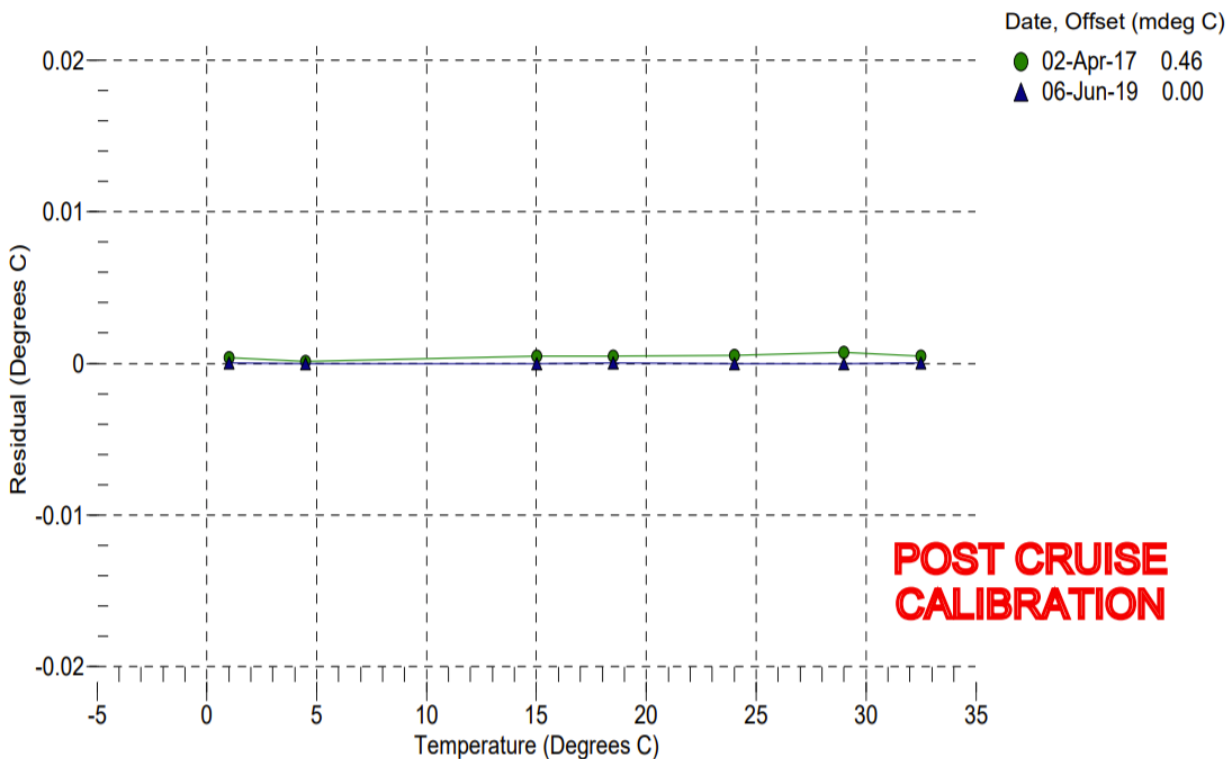
a0 = 7.914946e-005
a1 = 2.654600e-004
a2 = -1.702678e-006
a3 = 1.336561e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
0.9996	649840.9	0.9996	0.0000
4.4999	554894.1	4.4999	-0.0000
15.0000	352334.1	15.0000	-0.0000
18.5000	304724.1	18.5000	0.0000
24.0000	244017.0	24.0000	-0.0000
29.0000	200606.2	29.0000	-0.0000
32.5000	175481.6	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 Scientific
13431 NE 20th Street
Bellevue, WA 98005
USA

+1 425-643-9866
seabird@seabird.com
www.seabird.com

SENSOR SERIAL NUMBER: 0242
CALIBRATION DATE: 06-Jun-19

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

COEFFICIENTS:

g = -1.000213e+000
h = 1.525795e-001
i = -5.017470e-004
j = 6.159773e-005

CPcor = -9.5700e-008
CTcor = 3.2500e-006
WBOTC = -0.0000e+000

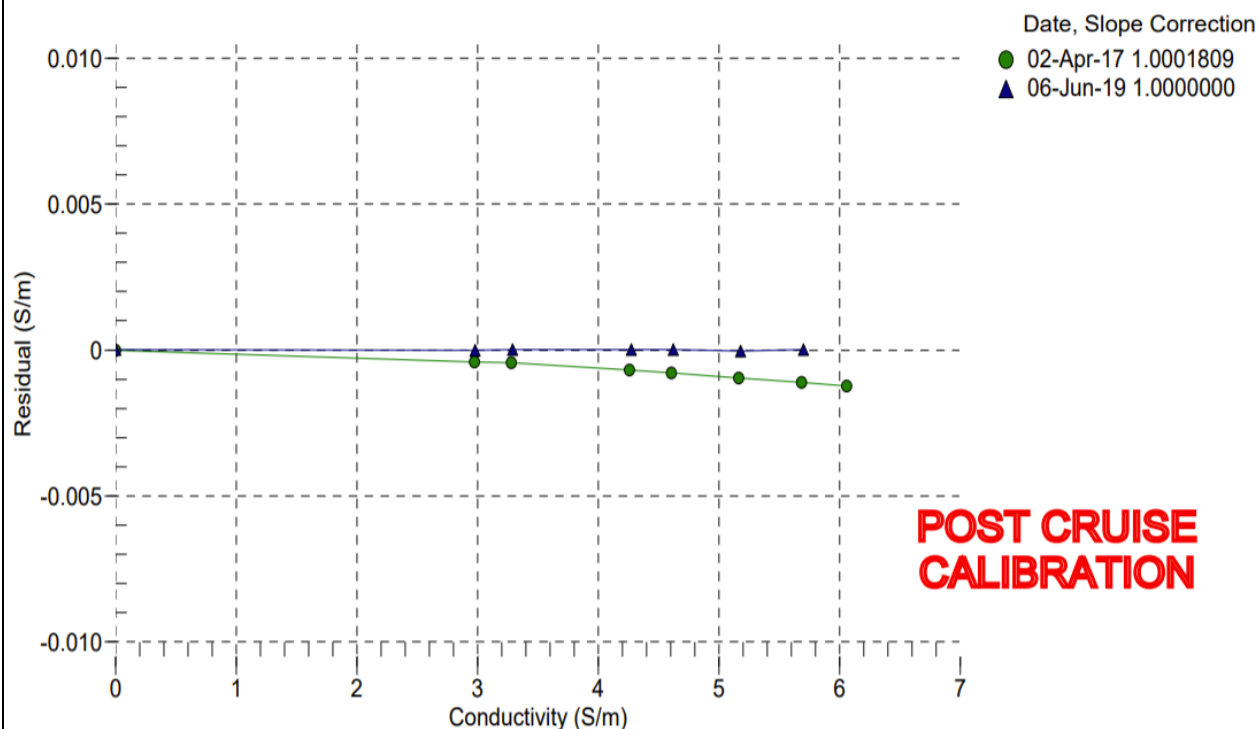
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2567.78	0.00000	0.00000
0.9996	34.9141	2.98349	5125.74	2.98348	-0.00001
4.4999	34.8939	3.29131	5319.65	3.29133	0.00001
15.0000	34.8504	4.27535	5896.05	4.27537	0.00001
18.5000	34.8412	4.62132	6085.44	4.62132	0.00000
24.0000	34.8309	5.18056	6379.35	5.18053	-0.00003
29.0000	34.8243	5.70348	6642.08	5.70350	0.00002
32.5000	34.8200	6.07656	6823.16	6.07669	0.00013

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

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



Micro-TSG2



SEA-BIRD
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SENSOR SERIAL NUMBER: 0389
CALIBRATION DATE: 21-Feb-20

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

COEFFICIENTS:

g = -9.987670e-001
h = 1.458131e-001
i = -4.646471e-004
j = 5.625507e-005

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

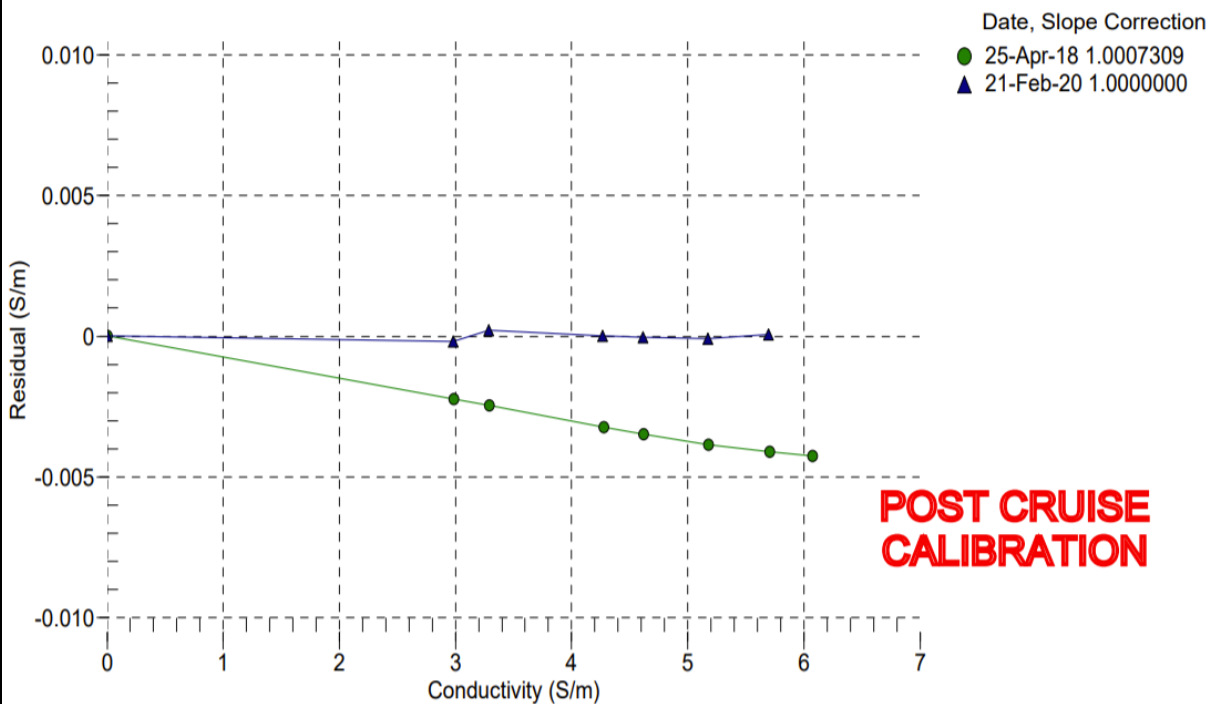
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2624.68	0.00000	0.00000
1.0000	34.8475	2.97838	5238.51	2.97819	-0.00018
4.5000	34.8272	3.28565	5436.89	3.28587	0.00022
15.0000	34.7834	4.26800	6025.79	4.26803	0.00002
18.5000	34.7736	4.61332	6219.26	4.61329	-0.00003
24.0000	34.7626	5.17152	6519.54	5.17142	-0.00010
29.0000	34.7557	5.69351	6788.06	5.69357	0.00006
32.5000	34.7509	6.06587	6973.21	6.06635	0.00047

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

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





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SENSOR SERIAL NUMBER: 0389
CALIBRATION DATE: 29-Feb-20

SBE 45 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

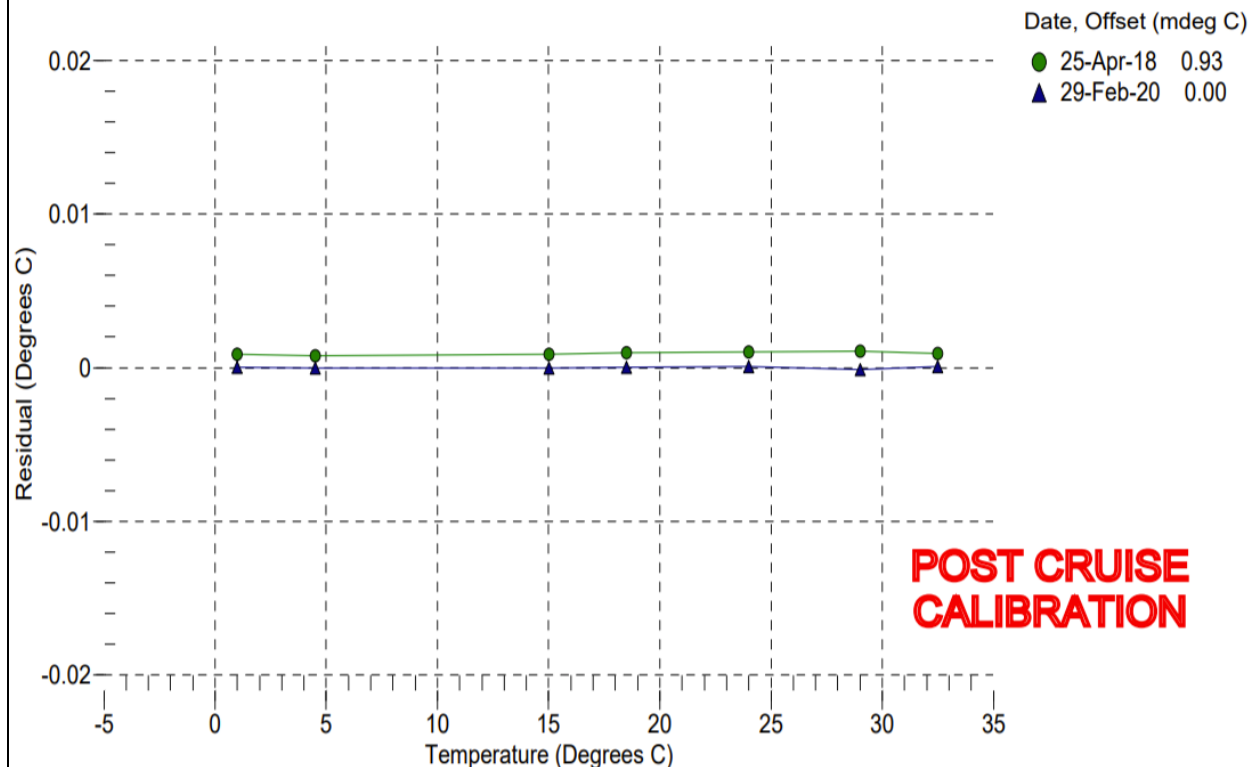
a0 = 3.598183e-005
a1 = 2.646702e-004
a2 = -1.759682e-006
a3 = 1.310622e-007

BATH TEMP (° C)	INSTRUMENT OUTPUT (counts)	INST TEMP (° C)	RESIDUAL (° C)
1.0000	828509.7	1.0000	0.0000
4.5000	706703.3	4.5000	-0.0000
15.0000	447344.3	15.0000	-0.0000
18.5000	386515.1	18.5000	0.0000
24.0000	309048.6	24.0001	0.0001
29.0000	253736.4	28.9999	-0.0001
32.5000	221757.1	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





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SENSOR SERIAL NUMBER: 0389
CALIBRATION DATE: 29-Feb-20

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

COEFFICIENTS:

$g = -1.018913e+000$
 $h = 1.483222e-001$
 $i = -2.723188e-004$
 $j = 4.474899e-005$

$CP_{cor} = -9.5700e-008$
 $CT_{cor} = 3.2500e-006$
 $WBOTC = 1.2700e-007$

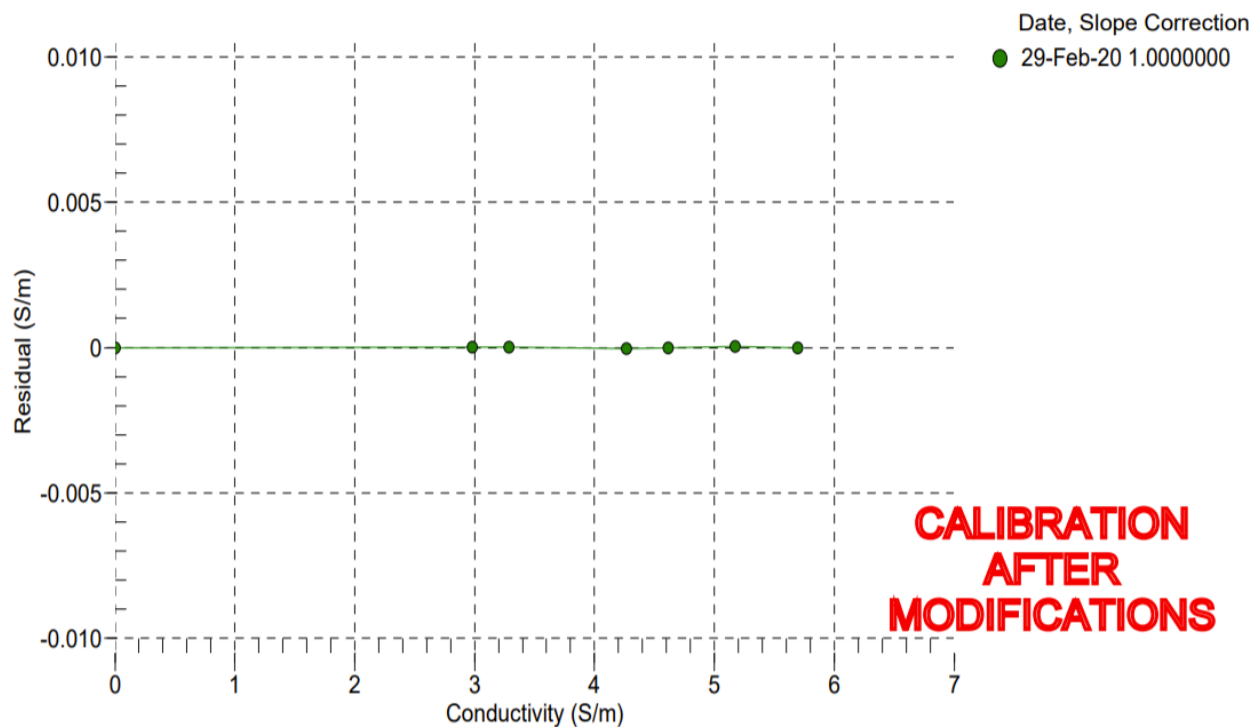
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
22.0000	0.0000	0.00000	2624.59	0.00000	0.00000
1.0000	34.8572	2.97913	5195.47	2.97913	0.00001
4.5000	34.8368	3.28647	5390.77	3.28647	0.00000
15.0000	34.7926	4.26901	5971.61	4.26899	-0.00003
18.5000	34.7826	4.61438	6162.50	4.61438	-0.00000
24.0000	34.7714	5.17268	6458.85	5.17273	0.00004
29.0000	34.7651	5.69488	6723.81	5.69486	-0.00002
32.5000	34.7598	6.06725	6906.34	6.06718	-0.00007

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

$t = \text{temperature (°C)}$; $p = \text{pressure (decibars)}$; $\delta = CT_{cor}$; $\epsilon = CP_{cor}$;

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

$\text{Residual (Siemens/meter)} = \text{instrument conductivity} - \text{bath conductivity}$



Mini TDGP

Instrument was not operational during this cruise

Oxygen Optode

	TEST & SPECIFICATIONS Form No. 712 V3, May 2020
Program Version: V5.1.1	Product: Oxygen Optode 4835 Serial No: 1038

Visual and Mechanical Checks:

- 1.1 Soldering quality
- 1.2 Visual surface
- 1.3 Galvanic isolation between housing and electronics

Current Drain and Voltages:

2.1 Average current drain at 0.5 Hz sampling (Max.: 33 mA)	20.0	mA
2.2 CANBus Current drain at 0.5 Hz sampling (Max.: 33 mA)	19.0	mA
2.3 Current drain in sleep (Max.: 270 μ A)	105	μ A
2.4 CANBus Current drain in sleep (Max.: 180 μ A)	99	μ A
2.5 DSP IO voltage, J4.18 (3.3 $\pm$ 0.15V)	3.29	V
2.6 DSP Core voltage, J4.17 (1.8 $\pm$ 0.05 V)	1.80	V
2.7 Excitation driver voltage, C4 Analog Board (4.3 $\pm$ 0.1 V)	4.35	V

Performance test:

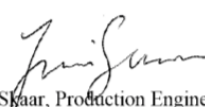
	Channel:	Blue	Red
3.1 Average of Receiver readings (0 $\pm$ 150mV)		-26.4 mV	-16.9 mV
3.2 Standard Deviation of Receiver readings (Max.: 45mV/10mV)		2.39 mV	0.64 mV
3.3 Amplitude measurement with non-fluorescence foil (<60mV/650-1200mV)		7.4 mV	775 mV
3.4 CANBus Output test			

Function test from 0 to 40°C:

	Channel:	Blue	Red
4.1 Minimum amplitude measurement (Blue: >550 mV, Red >550 mV)		694.4 mV	629.8 mV
4.2 Maximum amplitude measurement (Blue: <1600 mV, Red <1400 mV)		1007.8 mV	953.9 mV
4.3 Minimum phase measurement (Blue: >32°, Red: >3°)		36.52 °	8.77 °
4.4 Maximum phase measurement (Blue: <45°, Red: <10°)		42.4 °	9.21 °
4.5 Maximum standard deviation of Phase measurement: (< 0.07°)		0.04 °	0.03 °
4.6 Minimum temperature raw data measurement: (<-200 mV)			-455 mV
4.7 Maximum temperature raw data measurement: (>450 mV)			700 mV

Date: 07 Apr 2021

Sign:



Juni Skaar, Production Engineer



CALIBRATION CERTIFICATE

Form No. 710, Nov 2013

Sensing Foil Batch No: 2019
Certificate No:

Product: Oxygen Optode 4835
Serial No: 1038
Calibration Date: 23 Jan 2021

This is to certify that this product has been calibrated using the following instruments:

Parameter: Internal Temperature:

Calibration points and readings:

Temperature (°C)	1.03	11.99	24.01	35.99
Reading (mV)	777.64	438.03	43.17	-329.34

Giving these coefficients

Index	0	1	2	3	4	5
TempCoef	2.53423E01	-3.09388E-02	2.87117E-06	-4.22893E-09	0.00000E00	0.00000E00

Parameter: Oxygen:

	O2 Concentration	Air Saturation
Range:	0-500 µM ¹⁾	0 - 120%
Accuracy ¹⁾ :	< ±8µM or ±5% (whichever is greater)	±5%
Resolution:	< 1 µM	< 0.4%
Settling Time (63%):	< 25 seconds	

Calibration points and readings²⁾:

	Air Saturated Water	Zero Solution (Na ₂ SO ₃)
Phase reading (°)	3.29175E+01	6.22911E+01
Temperature reading (°C)	9.89441E+00	1.94275E+01
Air Pressure (hPa)	9.58514E+02	

Giving these coefficients

Index	0	1	2	3
PhaseCoef	-1.10000E00	1.00000E00	0.00000E00	0.00000E00
ConcCoef				

¹⁾ Valid for 0 to 2000m (6562ft) depth, salinity 33 - 37ppt
²⁾ The calibration is performed in fresh water and the salinity setting is set to: 0

Date: 25 Jan 2021

Sign:

 Tor-Ove Kvalvaag, Calibration Engineer



PRESSURE CERTIFICATE

Form No. 667, Sept 2009

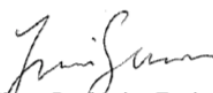
Product: Oxygen Optode 4835**Certificate No:** 1831611851038**Serial No:** 1038**Date:** 07.04.2021

This is to certify that this product has been pressure tested with the following instrument, and we confirm that no irregularities were found during the test:

Autoklav 800 bar – sn: 0210005

Pressure readings:

Pressure (Bar)	Pressure time (hour)
30	1

Date: 07 Apr 2021**Sign:**
Juni Spaar, Production Engineer

Transmissometer

PO Box 518
620 Applegate St.
Philomath, OR 97370



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

C-Star Calibration

Date 7.10.19

S/N#

CST-892DR

Pathlength 25 cm

Analog output

 V_d 0.058 V V_{air} 4.811 V V_{ref} 4.701 V

Temperature of calibration water 24.2 °C

Ambient temperature during calibration 23.5 °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 M

7/26/11

CTD

Altimeter



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.





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Conductivity (primary)



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SENSOR SERIAL NUMBER: 2513
CALIBRATION DATE: 14-May-19

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

COEFFICIENTS:

g = -1.01443403e+001
h = 1.56455174e+000
i = -1.28993141e-003
j = 1.88314322e-004

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

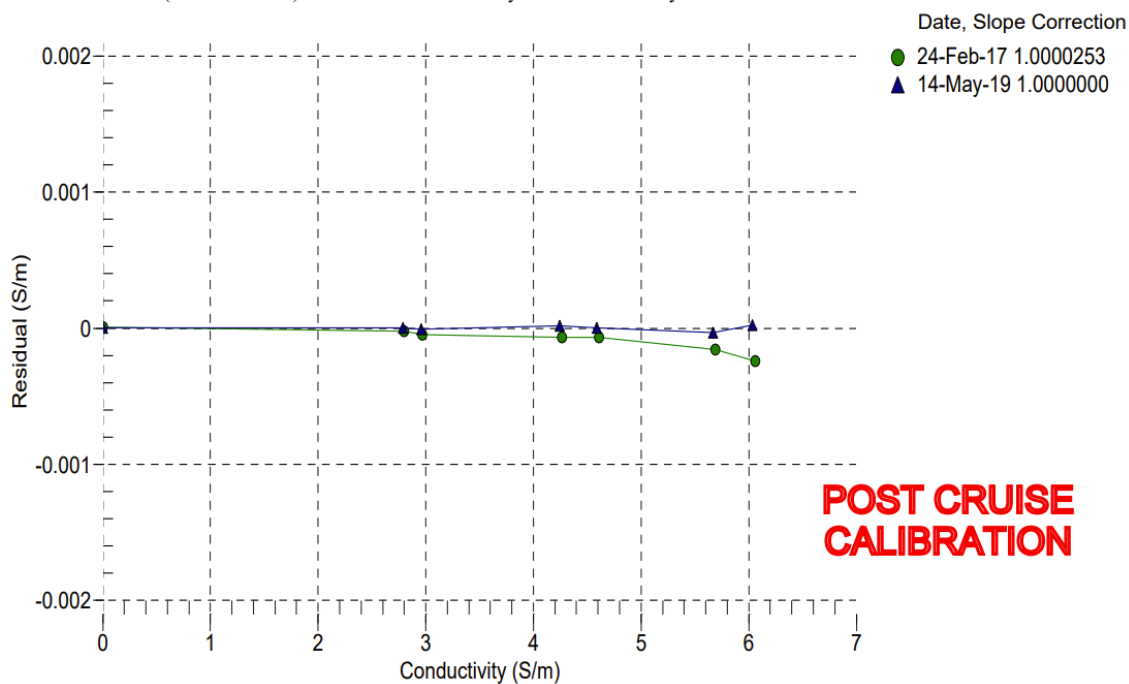
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.54803	0.00000	0.00000
-1.0001	34.5779	2.78715	4.93213	2.78715	0.00000
0.9999	34.5786	2.95757	5.04136	2.95756	-0.00001
14.9999	34.5773	4.24538	5.80041	4.24539	0.00002
18.4999	34.5759	4.58990	5.98705	4.58990	0.00000
28.9999	34.5679	5.66618	6.53557	5.66615	-0.00003
32.4999	34.5518	6.03505	6.71318	6.03507	0.00002

f = Instrument Output (kHz)

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

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

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



Conductivity (secondary)



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www.seabird.com

SENSOR SERIAL NUMBER: 4151
CALIBRATION DATE: 17-May-19

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

COEFFICIENTS:

g = -1.02542139e+001
h = 1.45297399e+000
i = -8.72063941e-004
j = 1.33605404e-004

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

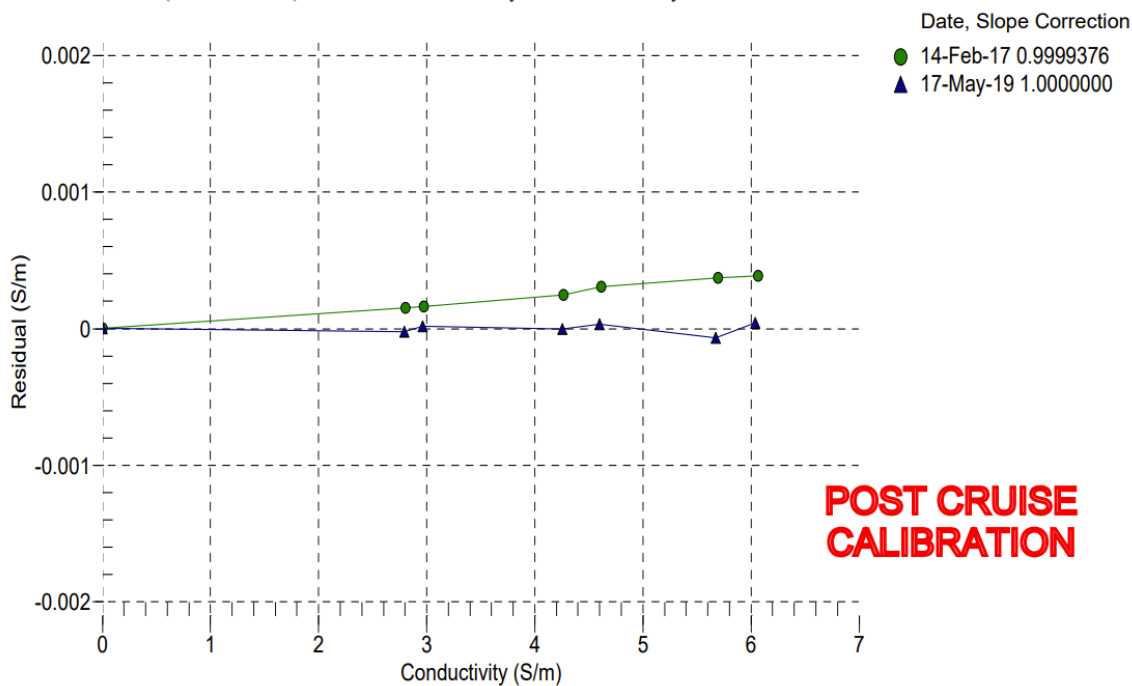
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.65783	0.00000	0.00000
-1.0001	34.6580	2.79300	5.12808	2.79298	-0.00002
0.9999	34.6561	2.96356	5.24129	2.96358	0.00002
15.0000	34.6470	4.25304	6.02827	4.25303	-0.00000
18.4999	34.6364	4.59706	6.22136	4.59709	0.00003
29.0000	34.6065	5.67181	6.78889	5.67174	-0.00007
32.4999	34.5647	6.03705	6.97121	6.03709	0.00004

f = Instrument Output (kHz)

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

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

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



Dissolved Oxygen (primary)



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SENSOR SERIAL NUMBER: 0150
CALIBRATION DATE: 19-Mar-21

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS:

Soc = 0.4494

Voffset = -0.4826

Tau20 = 1.38

A = -4.9436e-003

B = 2.4333e-004

C = -3.4201e-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

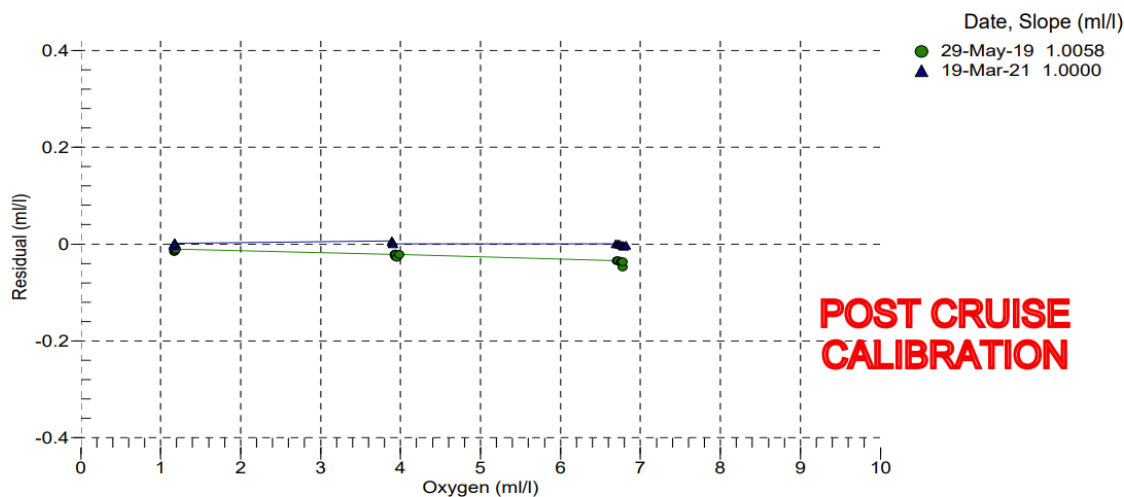
BATH OXYGEN (ml/l)	BATH TEMPERATURE (°C)	BATH SALINITY (PSU)	INSTRUMENT OUTPUT (volts)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.17	12.00	0.00	0.837	1.16	-0.00
1.17	6.00	0.00	0.786	1.16	-0.00
1.17	20.00	0.00	0.905	1.17	0.00
1.17	2.00	0.00	0.754	1.17	-0.00
1.18	30.00	0.00	0.989	1.18	0.00
1.18	26.00	0.00	0.956	1.18	0.00
3.89	30.00	0.00	2.158	3.90	0.01
3.90	20.00	0.00	1.889	3.90	0.00
3.90	26.00	0.00	2.051	3.90	0.00
3.90	2.00	0.00	1.388	3.90	0.00
3.90	6.00	0.00	1.502	3.91	0.00
3.90	12.00	0.00	1.671	3.90	0.00
6.69	2.00	0.00	2.036	6.69	0.00
6.72	6.00	0.00	2.237	6.72	0.00
6.74	12.00	0.00	2.533	6.74	-0.00
6.78	20.00	0.00	2.922	6.77	-0.00
6.79	30.00	0.00	3.402	6.79	-0.00
6.82	26.00	0.00	3.220	6.82	-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



Dissolved Oxygen (secondary)



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SENSOR SERIAL NUMBER: 0161
CALIBRATION DATE: 14-Feb-20

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS:
Soc = 0.5615
Voffset = -0.5073
Tau20 = 1.11
A = -4.5836e-003
B = 1.6647e-004
C = -2.6221e-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

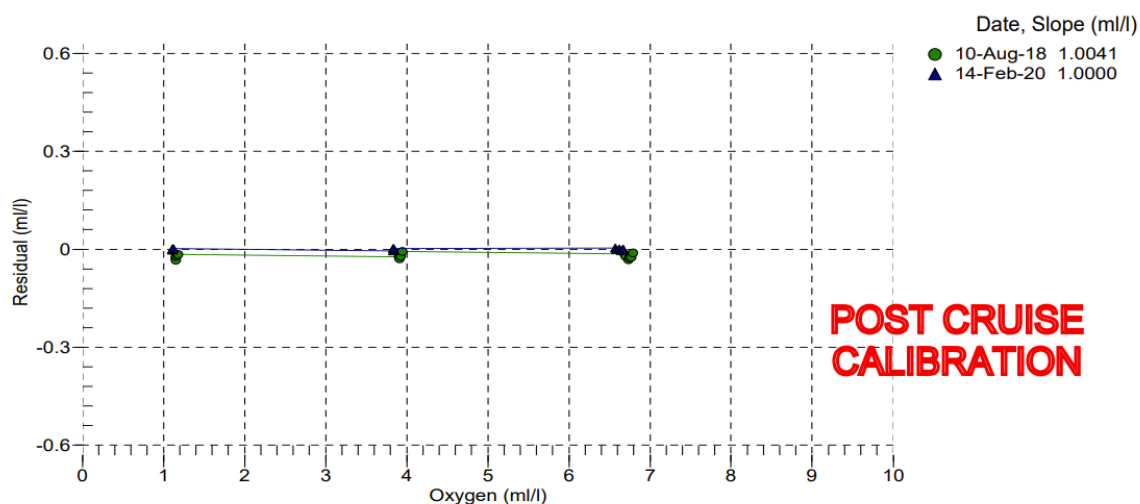
BATH OXYGEN (ml/l)	BATH TEMPERATURE (°C)	BATH SALINITY (PSU)	INSTRUMENT OUTPUT (volts)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.11	6.00	0.00	0.739	1.11	-0.00
1.11	12.00	0.00	0.779	1.11	0.00
1.11	2.00	0.00	0.713	1.11	-0.00
1.12	20.00	0.00	0.836	1.12	0.00
1.13	26.00	0.00	0.881	1.13	0.00
1.13	30.00	0.00	0.911	1.13	0.00
3.83	2.00	0.00	1.217	3.83	-0.01
3.83	6.00	0.00	1.309	3.83	0.00
3.84	12.00	0.00	1.446	3.84	0.00
3.84	30.00	0.00	1.881	3.84	0.00
3.84	20.00	0.00	1.635	3.84	0.00
3.84	26.00	0.00	1.781	3.85	0.00
6.57	2.00	0.00	1.728	6.58	0.00
6.59	6.00	0.00	1.885	6.59	-0.00
6.62	12.00	0.00	2.129	6.62	0.00
6.64	30.00	0.00	2.881	6.64	-0.00
6.65	20.00	0.00	2.458	6.65	-0.00
6.67	26.00	0.00	2.715	6.67	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



Fish


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 SENSOR SERIAL NUMBER: 1130
CALIBRATION DATE: 22-Mar-21

 SBE 9plus PRESSURE CALIBRATION DATA
10000 psia S/N 120089

DIGIQUARTZ COEFFICIENTS:

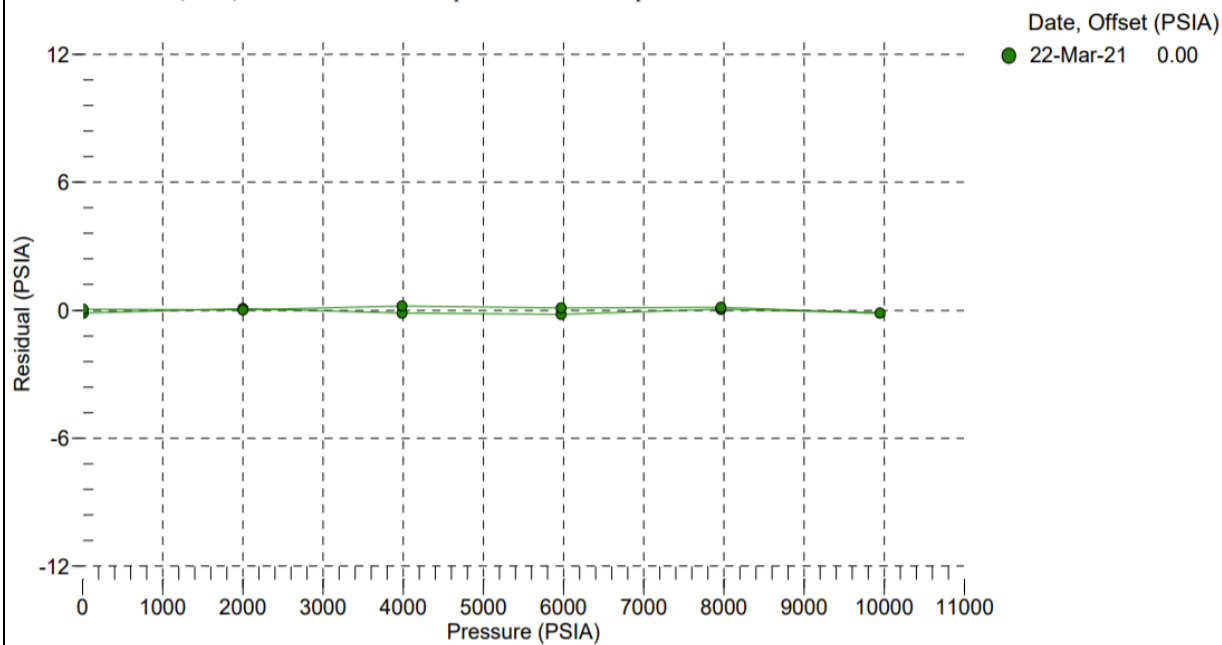
 C1 = -4.230776e+004
C2 = 1.490078e-001
C3 = 1.507500e-002
D1 = 3.473000e-002
D2 = 0.000000e+000
T1 = 3.002251e+001
T2 = -2.774200e-004
T3 = 4.796030e-006
T4 = 1.754420e-009
T5 = 0.000000e+000

AD590M, AD590B, SLOPE AND OFFSET:

 AD590M = 1.28100e-002
AD590B = -8.83931e+000
Slope = 0.99999
Offset = 1.2528 (dbars)

PRESSURE (PSIA)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT TEMPERATURE (°C)	INSTRUMENT PRESSURE (PSIA)	CORRECTED PRESSURE (PSIA)	RESIDUAL (PSIA)
14.531	33317.40	21.1	12.581	14.398	-0.133
2000.754	34089.30	21.3	1999.023	2000.816	0.062
3988.219	34842.00	21.3	3986.325	3988.093	-0.126
5975.739	35576.50	21.3	5973.808	5975.552	-0.187
7963.340	36294.00	21.3	7961.673	7963.393	0.053
9951.154	36995.30	21.4	9949.321	9951.017	-0.137
7963.255	36294.00	21.4	7961.662	7963.382	0.127
5975.681	35576.60	21.4	5974.051	5975.795	0.114
3988.143	34842.10	21.4	3986.557	3988.325	0.182
2000.761	34089.30	21.4	1998.977	2000.770	0.009
14.539	33317.50	21.5	12.757	14.575	0.036

Residual (PSIA) = corrected instrument pressure - reference pressure



Fluorometer

PO Box 518
620 Applegate St.
Philomath, OR 97370



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

ECO Chlorophyll Fluorometer Characterization Sheet

Date: 8/29/2018

S/N: FLRTD-1482

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	0.066	0.034	0.018 V	50 counts
Scale Factor (SF)	6	12	24 µg/l/V	0.0073 µg/l/count
Maximum Output	4.99	4.99	4.99 V	16380 counts
Resolution	0.7	0.7	0.7 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: $SF = x / (\text{output} - \text{dark counts})$, 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.

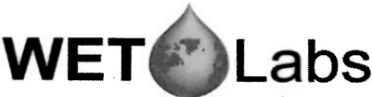
FLRTD-1482

Revision J

3/17/08

Fluorometer (BAS)

FINAL CAL



PO Box 518
620 Applegate St.
Philomath, OR 97370

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

FLNTU Characterization Sheet

Date: October 28, 2015 S/N: FLNTURTD-2952

Chlorophyll Scale Factor

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

CHL (µg/l) = Scale Factor x (Output - Dark Counts)

	Analog	Digital
Dark Counts	0.063 V	47 counts
Scale Factor (SF)	6 µg/l/V	0.0073 µg/l/count
Maximum Output	4.98 V	4130 counts
Resolution	0.7 mV	1.0 counts
Ambient temperature during calibration	22.3 °C	

Nephelometric Turbidity Unit (NTU) Scale Factor

Turbidity units expressed in NTU can be derived using the equation:

NTU = Scale Factor x (Output - Dark Counts)

	Analog	Digital
Dark Counts	0.080 V	50 counts
NTU Solution Value	3.25 V	2671 counts
Scale Factor (SF)	2 NTU/V	0.0024 NTU/count
Maximum Output	4.98 V	4130 counts
Resolution	0.1 mV	1.0 counts
Ambient temperature during calibration	22.3 °C	

Definition of terms:

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

NTU Solution Value: Signal output of the turbidity sensor when measuring a sample of interest.

SF (CHL): 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.

SF (NTU): Scale factor is determined using the following equation: $SF = xx \div (\text{Output} - \text{Dark counts})$, where xx is the value of a Formazin concentration. For example: $12.2 \div (2011 - 50) = 0.0062$.

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

Resolution: standard deviation of 1 minute of collected data.

FLNTURTD-2952 flntuchar

Revision H

10/2/07

PAR

Biospherical Instruments Inc

CALIBRATION CERTIFICATE

UNDERWATER PAR SENSOR WITH LOG AMPLIFIER

Calibration Date: 06/04/19		Job No.: R13636							
Model Number: QSP200L4S									
Serial Number: 4361									
Operator: TPC									
Standard Lamp: V-039(1/3/19)									
Operating Voltage Range: 6 to 15 VDC (+)									
Note: The QSP200L4S uses a log amplifier to measure the detector signal current with $V = \log I \text{ (Amps)} / I_{\text{Ref}}$ 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:	1.49E+13	quanta/cm ² ·sec per volt	2.47E-05 μEinsteins/cm ² ·sec per volt						
Wet Calibration Factor:	2.62E+13	quanta/cm ² ·sec per volt	4.36E-05 μEinsteins/cm ² ·sec per volt						
Sensor Test Data and Results ⁴⁾									
Sensor Supply Current (Dark):	75.4	mA							
Supply Voltage:	6	Volts							
Lamp Integrated PAR Irradiance:	8.90E+15	quanta/cm ² ·sec	0.01478 μEinsteins/cm ² ·sec						
SC3 Immersion Coefficient:	0.5664	Scalar Correction:	1						
		PAR Solar Correction:	1.0000						
Nominal Filter OD	Calibrated Trans.	Sensor Voltage	Measured Trans.	Measured Signal (Amps)	Estimated Signal (Amps)	Calc. Output (Volts)	Error (Volts)	Error (%)	Test Irrad. (quanta/cm ² ·sec)
No Filter	100.00%	2.779	100.00%	6.01E-08	6.01E-08	2.780	0.001	0.0	8.90E+15
0.3	36.10%	2.338	36.05%	2.17E-08	2.17E-08	2.339	0.002	0.1	3.21E+15
0.5	27.60%	2.224	27.68%	1.66E-08	1.66E-08	2.224	0.000	-0.3	2.46E+15
1	9.27%	1.758	9.31%	5.59E-09	5.57E-09	1.757	-0.001	-0.4	8.28E+14
2	1.11%	0.911	1.10%	6.63E-10	6.67E-10	0.914	0.003	0.6	9.83E+13
3	0.05%	0.295	0.07%	4.37E-11	3.21E-11	0.268	-0.026	-26.6	6.48E+12
Dark Before: 0.186 Volts				I _{Ref} = 1.00E-10 Amps					
Light - No Filter Hldr.: 2.779 Volts				I _{Dark} = 1.53E-10 Amps					
Dark After - NFH: 0.186 Volts				10 ^{V_{Dark}} = 1.534087		RG780		0.219	
Average Dark: 0.186 Volts									
Notes:									
1. Annual calibration is recommended.									
2. The collector should be cleaned frequently with alcohol.									
4) This section is for internal use and for more advanced analysis.									

QSP200L-QSP2300 (4-2013-).xls

Pressure Sensor



Sea-Bird Scientific
13431 NE 20th Street
Bellevue, WA 98005
USA

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seabird@seabird.com
www.seabird.com

SENSOR SERIAL NUMBER: 1130
CALIBRATION DATE: 22-Mar-21

SBE 9plus PRESSURE CALIBRATION DATA
10000 psia S/N 120089

DIGIQUARTZ COEFFICIENTS:

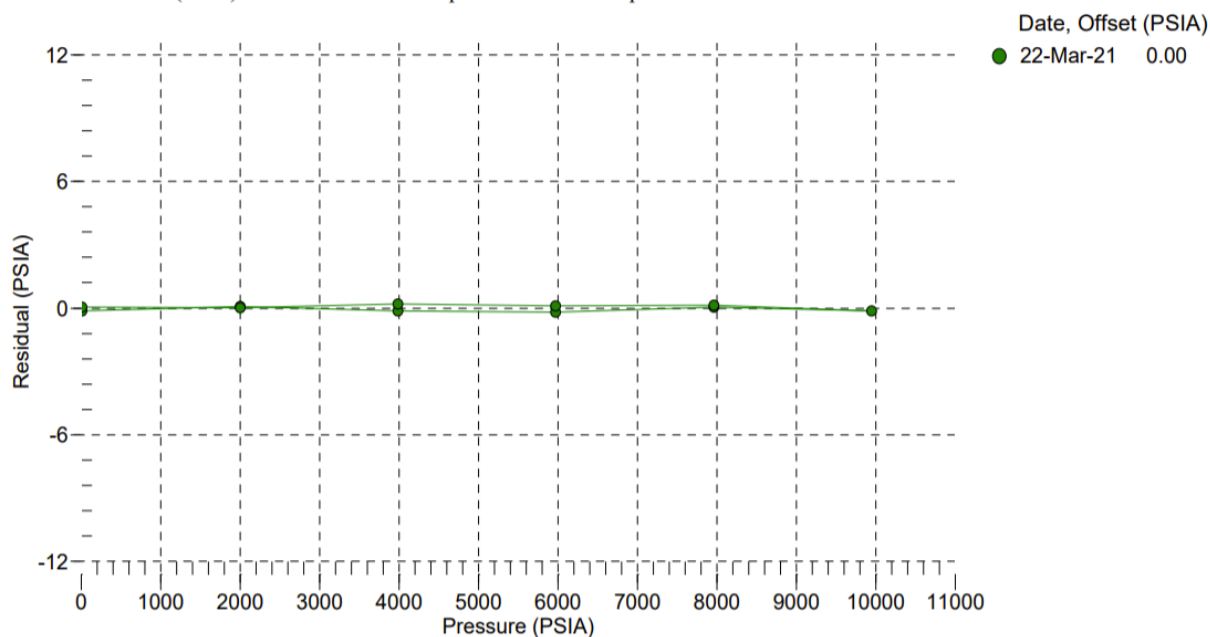
C1 = -4.230776e+004
C2 = 1.490078e-001
C3 = 1.507500e-002
D1 = 3.473000e-002
D2 = 0.000000e+000
T1 = 3.002251e+001
T2 = -2.774200e-004
T3 = 4.796030e-006
T4 = 1.754420e-009
T5 = 0.000000e+000

AD590M, AD590B, SLOPE AND OFFSET:

AD590M = 1.28100e-002
AD590B = -8.83931e+000
Slope = 0.99999
Offset = 1.2528 (dbars)

PRESSURE (PSIA)	INSTRUMENT OUTPUT (Hz)	INSTRUMENT TEMPERATURE (°C)	INSTRUMENT PRESSURE (PSIA)	CORRECTED PRESSURE (PSIA)	RESIDUAL (PSIA)
14.531	33317.40	21.1	12.581	14.398	-0.133
2000.754	34089.30	21.3	1999.023	2000.816	0.062
3988.219	34842.00	21.3	3986.325	3988.093	-0.126
5975.739	35576.50	21.3	5973.808	5975.552	-0.187
7963.340	36294.00	21.3	7961.673	7963.393	0.053
9951.154	36995.30	21.4	9949.321	9951.017	-0.137
7963.255	36294.00	21.4	7961.662	7963.382	0.127
5975.681	35576.60	21.4	5974.051	5975.795	0.114
3988.143	34842.10	21.4	3986.557	3988.325	0.182
2000.761	34089.30	21.4	1998.977	2000.770	0.009
14.539	33317.50	21.5	12.757	14.575	0.036

Residual (PSIA) = corrected instrument pressure - reference pressure



Pump (primary)**SEA-BIRD
SCIENTIFIC**Sea-Bird Scientific
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Bellevue, WA 98005
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seabird@seabird.com
www.seabird.com

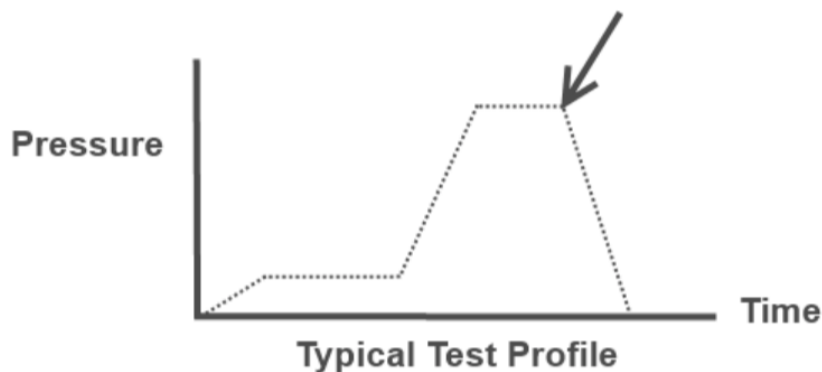
Pressure Test Certificate

Test Date: **2017-08-02**Description: **SBE-5T Submersible Pump****Sensor Information:**

Replaced the main piston "O"-Rings.

Model Number: **SBE-5T**Serial Number: **05T-1626****Pressure Test Protocol:**Low Pressure Test: **50** PSI Held For: **15** MinutesHigh Pressure Test: **10000** PSI Held For: **30** MinutesPassed Test: **True**Tested By: **BLT**

High pressure is
generally equal
to the maximum
depth rating of
the instrument

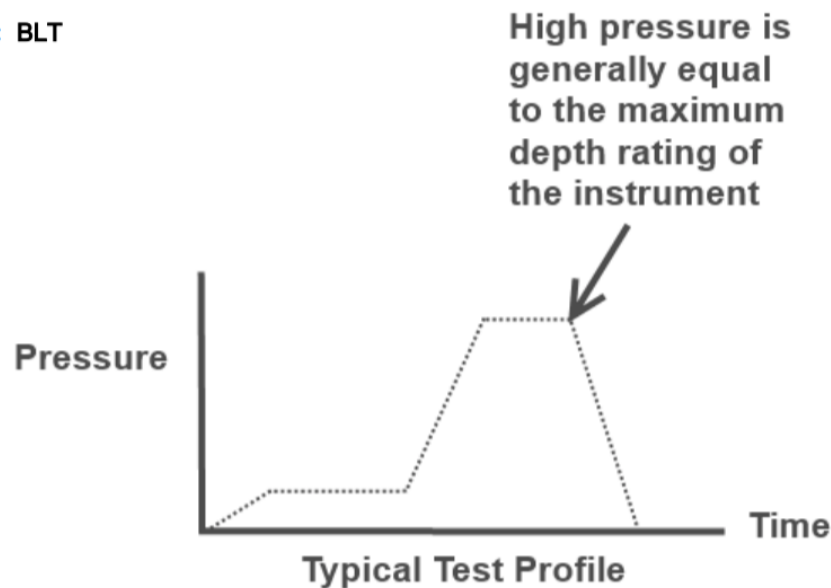


Pump (secondary)**SEA-BIRD
SCIENTIFIC**Sea-Bird Scientific
13431 NE 20th Street
Bellevue, WA 98005
USA+1 425-643-9866
seabird@seabird.com
www.seabird.com

Pressure Test Certificate

Test Date: **2017-08-02**Description: **SBE-5T Submersible Pump****Sensor Information:**

Replaced the main piston "O"-Rings.

Model Number: **SBE-5T**Serial Number: **05T-1627****Pressure Test Protocol:**Low Pressure Test: **50** PSI Held For: **15** MinutesHigh Pressure Test: **10000** PSI Held For: **30** MinutesPassed Test: **True**Tested By: **BLT**

Temperature (primary)



SEA-BIRD
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SENSOR SERIAL NUMBER: 1649
CALIBRATION DATE: 23-Jul-20

SBE 3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

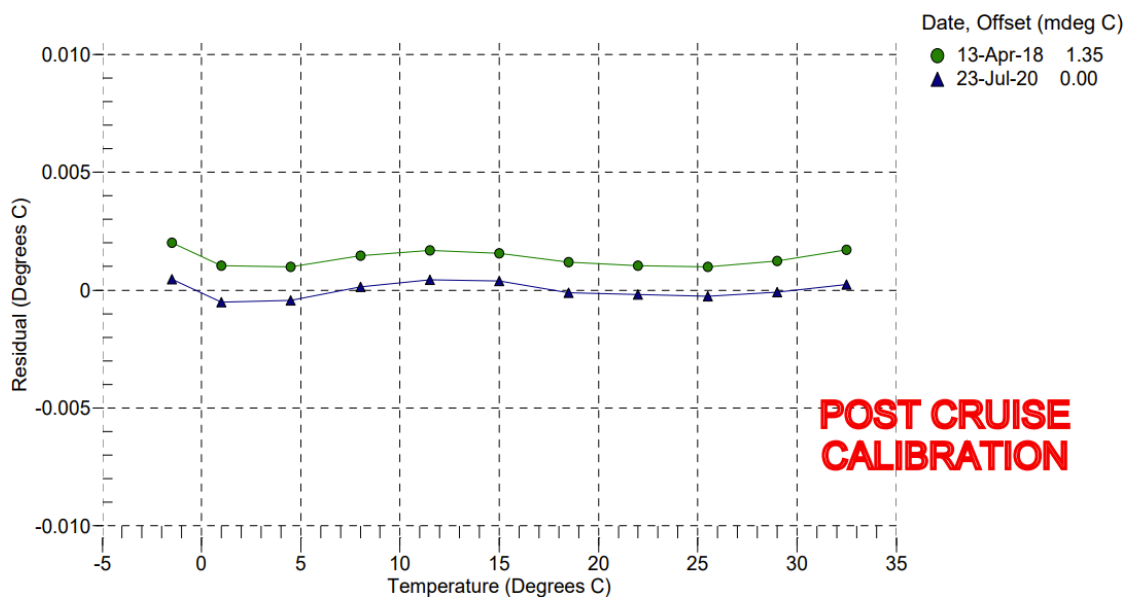
g = 4.80818184e-003
h = 6.66648327e-004
i = 2.25677037e-005
j = 1.58605560e-006
f0 = 1000.0

BATH TEMP (° C)	INSTRUMENT OUTPUT (Hz)	INST TEMP (° C)	RESIDUAL (° C)
-1.5001	5958.562	-1.4996	0.00046
1.0000	6301.043	0.9995	-0.00051
4.5000	6804.110	4.4996	-0.00045
8.0000	7335.265	8.0001	0.00013
11.5000	7895.127	11.5004	0.00043
15.0000	8484.393	15.0004	0.00038
18.5000	9103.730	18.4999	-0.00012
22.0000	9753.967	21.9998	-0.00019
25.5000	10435.676	25.4997	-0.00027
29.0000	11149.537	28.9999	-0.00010
32.5000	11896.139	32.5002	0.00024

f = Instrument Output (Hz)

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

Residual (°C) = instrument temperature - bath temperature



Temperature (Secondary)



SEA-BIRD
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www.seabird.com

SENSOR SERIAL NUMBER: 2186
CALIBRATION DATE: 04-Feb-20

SBE 3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

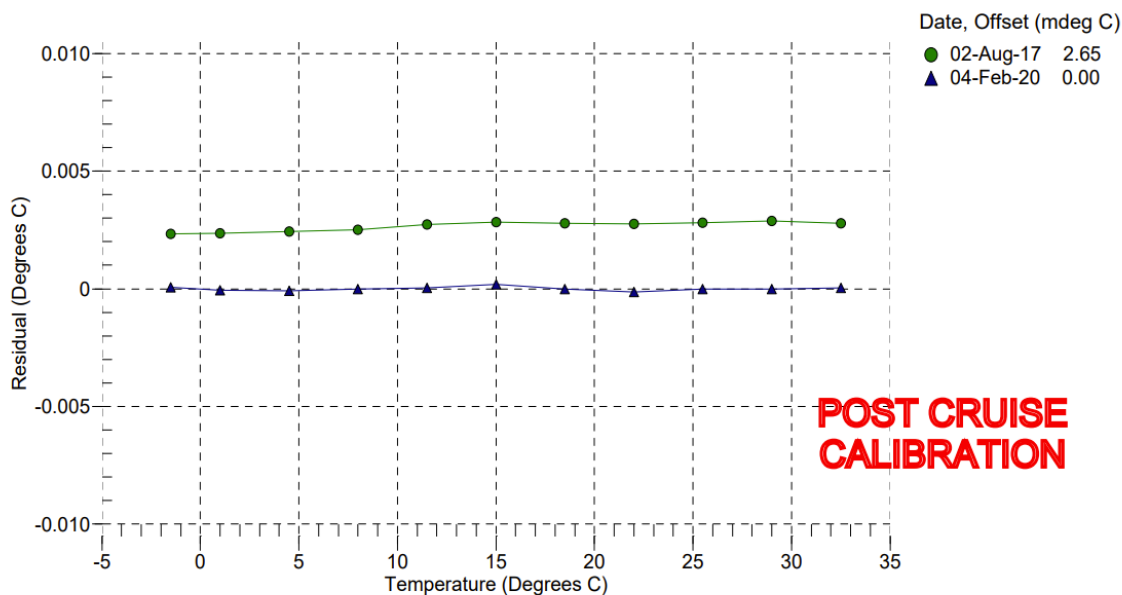
g = 4.34004933e-003
h = 6.44444795e-004
i = 2.30605112e-005
j = 2.14190409e-006
f0 = 1000.0

BATH TEMP (° C)	INSTRUMENT OUTPUT (Hz)	INST TEMP (° C)	RESIDUAL (° C)
-1.5000	2882.022	-1.4999	0.00007
1.0000	3047.310	0.9999	-0.00006
4.5000	3290.096	4.4999	-0.00008
8.0000	3546.495	8.0000	-0.00002
11.5000	3816.867	11.5000	0.00003
15.0000	4101.576	15.0002	0.00018
18.5000	4400.928	18.5000	-0.00002
22.0000	4715.294	21.9999	-0.00013
25.5000	5045.010	25.5000	-0.00000
29.0000	5390.352	29.0000	-0.00001
32.5000	5751.633	32.5000	0.00004

f = Instrument Output (Hz)

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

Residual (°C) = instrument temperature - bath temperature



Transmissometer

PO Box 518
620 Applegate St.
Philomath, OR 97370



(541) 929-5650
Fax (541) 929-5277
www.sea-birdscientific.com

C-Star Calibration

Date **August 23, 2018** S/N# **CST-1581DR** Pathlength **25**

	Analog output	Digital output
V_d	0.004 V	0 counts
V_{air}	4.817 V	15830 counts
V_{ref}	4.701 V	15447 counts

Temperature of calibration water	24.3 °C
Ambient temperature during calibration	21.7 °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

TMC

Altimeter



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:	46554
Instrument Type:	Altimeter
Instrument Serial Number:	56636
Calibrated By:	L.Bicknell
Date:	16/09/2016
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 | Totnes | Devon | TQ9 5EW | UK
T: +44 (0) 1803 869292 | F: +44 (0) 1803 869293

Conductivity (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: 4380
CALIBRATION DATE: 23-Dec-16SBE 4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

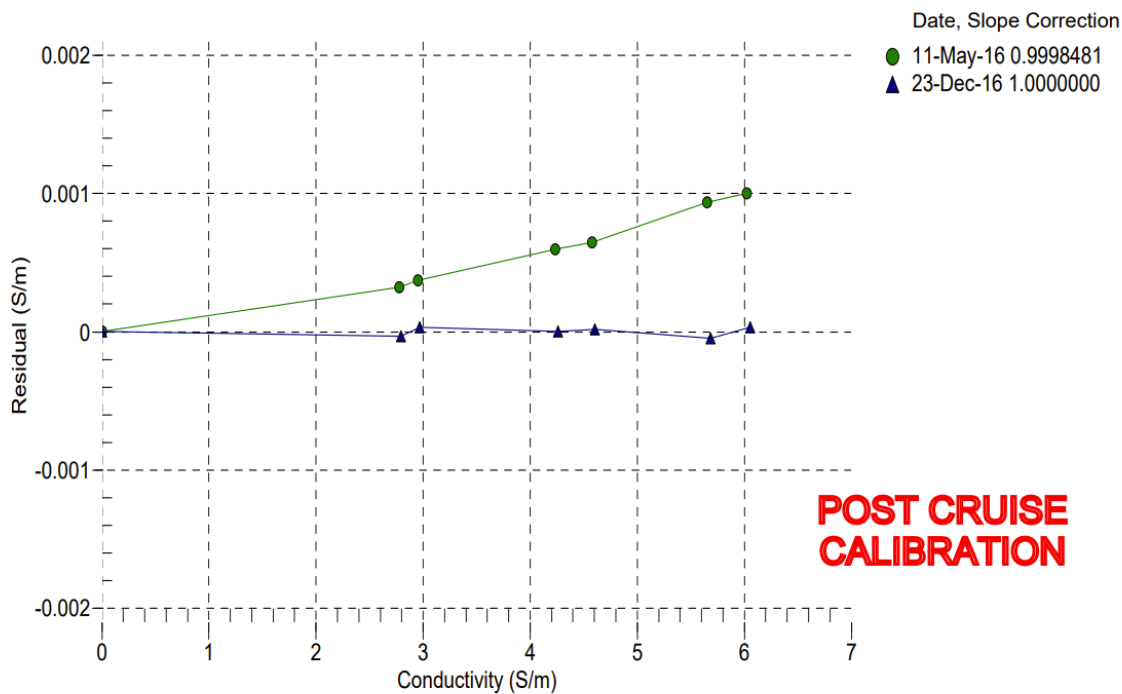
g = -9.92889365e+000
h = 1.38051526e+000
i = -1.02664687e-003
j = 1.44204936e-004CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

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	2.68349	0.00000	0.00000
-1.0000	34.6904	2.79538	5.24108	2.79535	-0.00003
1.0000	34.6904	2.96623	5.35790	2.96626	0.00003
15.0000	34.6912	4.25789	6.16926	4.25789	0.00000
18.5000	34.6909	4.60353	6.36875	4.60354	0.00001
29.0000	34.6888	5.68378	6.95506	5.68373	-0.00005
32.5000	34.6788	6.05472	7.14524	6.05475	0.00003

f = Instrument Output (kHz)

t = temperature (°C); p = pressure (decibars); δ = CTcor; ϵ = CPcor;Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / 10 (1 + \delta * t + \epsilon * p)$

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



Conductivity (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: 4422

CALIBRATION DATE: 29-Dec-16

SBE 4 CONDUCTIVITY CALIBRATION DATA

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

COEFFICIENTS:

g = -9.82623697e+000

h = 1.70863897e+000

i = -1.40109875e-003

j = 2.11233792e-004

CPcor = -9.5700e-008 (nominal)

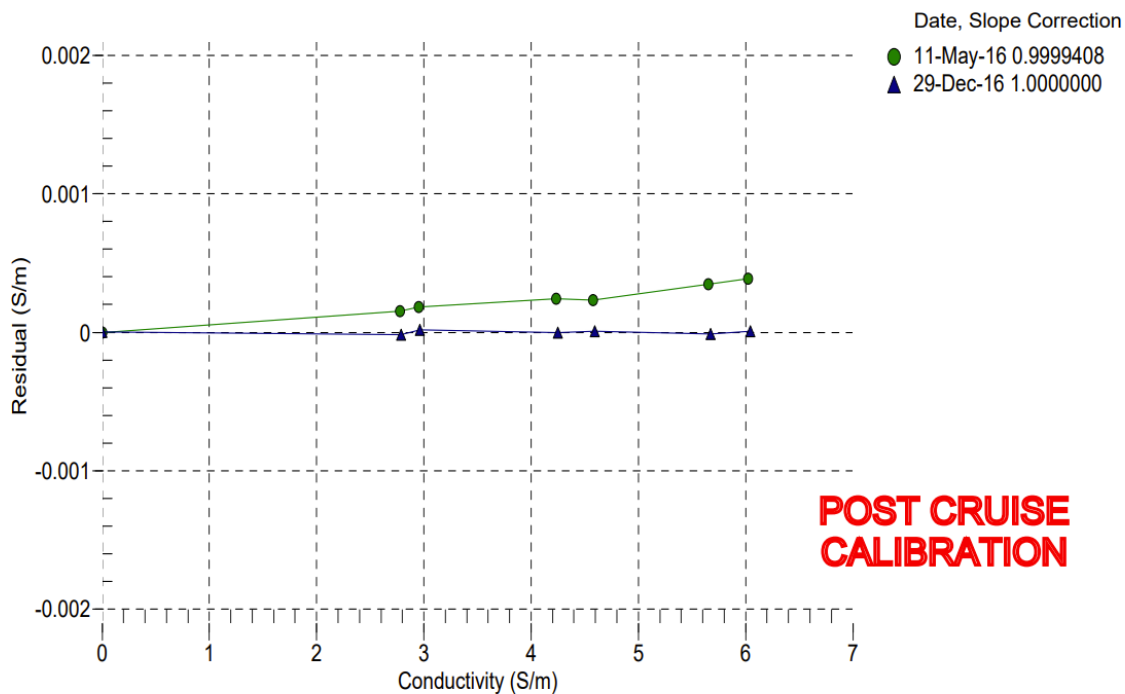
CTcor = 3.2500e-006 (nominal)

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	2.39961	0.00000	0.00000
-1.0000	34.6182	2.79010	4.70159	2.79008	-0.00002
1.0000	34.6182	2.96064	4.80662	2.96066	0.00002
15.0000	34.6176	4.24981	5.53603	4.24981	-0.00000
18.5000	34.6166	4.59473	5.71532	4.59473	0.00001
29.0000	34.6152	5.67308	6.24244	5.67306	-0.00001
32.5000	34.6085	6.04384	6.41359	6.04385	0.00001

f = Instrument Output (kHz)

t = temperature (°C); p = pressure (decibars); δ = CTcor; ϵ = CPcor;Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / 10 (1 + \delta * t + \epsilon * p)$

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



Fish



SEA-BIRD ELECTRONICS, INC.
 13431 NE 20th St, Bellevue Washington 98005 USA
 Phone: (425) 643-9866 Fax: (425) 643-9954 Email: seabird@seabird.com

Digiquartz Pressure Calibration dP/dT Corrected Coefficients

(Changed coefficients are posted in italics)

Pressure Transducer Serial Number: 138503
 Original Calibration Date: 16-Mar-17
 Date of Correction: 2017-03-21
 Installed in: SBE 9Plus S/N 1315

PRESSURE COEFFICIENTS

<i>C1</i>	<i>-42793.59</i>	<i>psia</i>
<i>C2</i>	<i>0.0341051</i>	<i>psia/deg C</i>
<i>C3</i>	<i>1.178200e-002</i>	<i>psia/deg C²</i>
<i>D1</i>	<i>3.724300e-002</i>	
<i>D2</i>	<i>0.000000e+000</i>	
<i>T1</i>	<i>30.25805</i>	<i>μsec</i>
<i>T2</i>	<i>-2.99834e-04</i>	<i>μsec/deg C</i>
<i>T3</i>	<i>3.761720e-006</i>	<i>μsec/deg C²</i>
<i>T4</i>	<i>3.353750e-009</i>	<i>μsec/deg C³</i>
<i>T5</i>	<i>0.000000e+000</i>	

Slope = 1.0
 Offset = 0.0

Corrected at Sea-Bird Electronics as per Paroscientific Calibration and Sea-Bird Electronics dP/dT tests. The original calibration from Paroscientific assumes an operating temperature range of 0 to 125 degrees C. dP/dT correction adjusts this operating range to a nominal range of 0 to 22 degrees C. This increases the accuracy of the transducer in this temperature range.

NOTE: Original coefficients from Paroscientific are attached to this form for informational purposes and should not be used.

Dissolved Oxygen (Primary)

SEA-BIRD
SCIENTIFICSea-Bird Scientific
13431 NE 20th Street
Bellevue, WA 98005
USA+1 425-643-9866
seabird@seabird.com
www.seabird.comSENSOR SERIAL NUMBER: 3170
CALIBRATION DATE: 11-Apr-18

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS:

Soc = 0.3645

Voffset = -0.4888

Tau20 = 1.00

A = -4.0098e-003

B = 2.4416e-004

C = -3.4696e-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

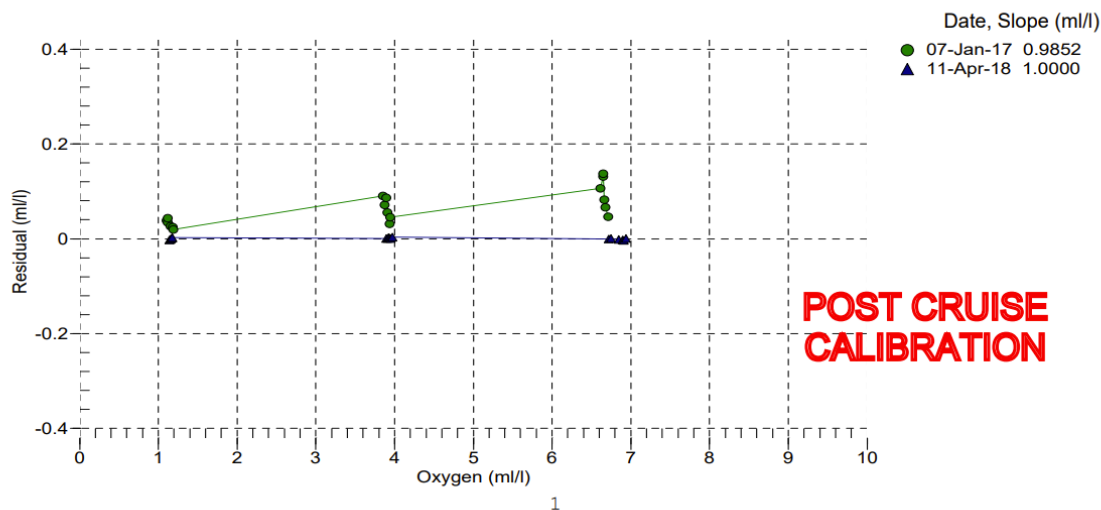
BATH OXYGEN (ml/l)	BATH TEMPERATURE (°C)	BATH SALINITY (PSU)	INSTRUMENT OUTPUT (volts)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.14	2.03	0.00	0.813	1.14	-0.00
1.14	6.00	0.00	0.853	1.14	-0.00
1.15	12.00	0.00	0.916	1.15	-0.00
1.16	20.00	0.00	0.996	1.16	0.00
1.18	26.00	0.00	1.058	1.18	0.00
1.18	30.00	0.00	1.096	1.18	0.00
3.90	2.05	0.00	1.603	3.90	0.00
3.91	6.00	0.00	1.741	3.91	0.00
3.92	12.00	0.00	1.945	3.93	0.00
3.94	20.00	0.00	2.206	3.94	0.00
3.95	26.00	0.00	2.400	3.95	0.00
3.98	30.00	0.00	2.541	3.98	0.00
6.72	2.05	0.00	2.410	6.72	-0.00
6.74	6.00	0.00	2.648	6.75	0.00
6.84	12.00	0.00	3.026	6.84	-0.00
6.90	20.00	0.00	3.492	6.89	-0.00
6.91	30.00	0.00	4.049	6.90	-0.00
6.94	26.00	0.00	3.843	6.94	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



Dissolved Oxygen (Secondary)

SEA-BIRD
SCIENTIFICSea-Bird Scientific
13431 NE 20th Street
Bellevue, WA 98005
USA+1 425-643-9866
seabird@seabird.com
www.seabird.comSENSOR SERIAL NUMBER: 2512
CALIBRATION DATE: 01-Aug-17

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS:

Soc = 0.5713

Voffset = -0.4956

Tau20 = 1.16

A = -4.7689e-003

B = 1.9998e-004

C = -2.9427e-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

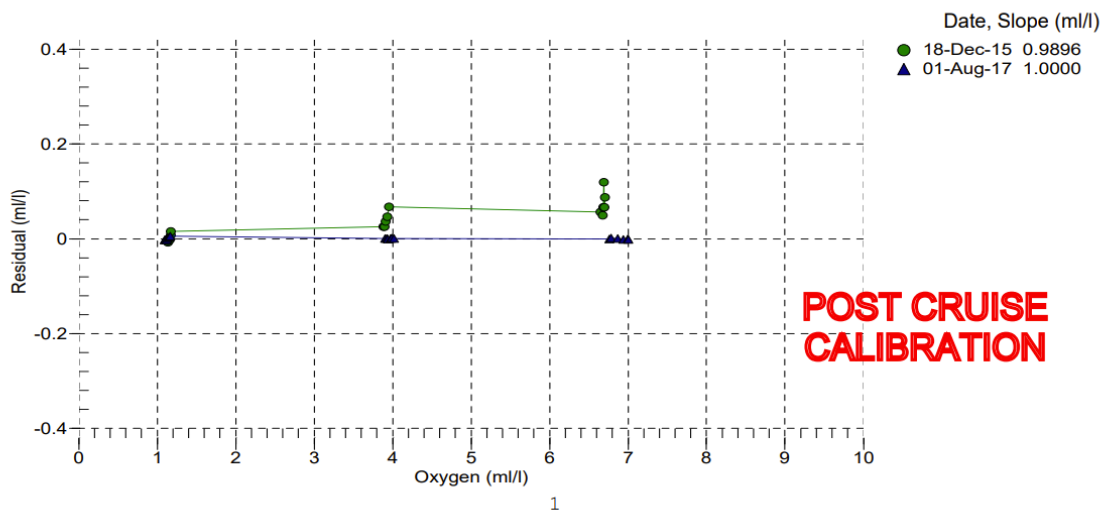
BATH OXYGEN (ml/l)	BATH TEMPERATURE (°C)	BATH SALINITY (PSU)	INSTRUMENT OUTPUT (volts)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.09	2.00	0.00	0.695	1.09	-0.00
1.10	6.00	0.00	0.722	1.10	-0.00
1.12	12.00	0.00	0.763	1.11	-0.00
1.13	20.00	0.00	0.821	1.13	0.00
1.15	26.00	0.00	0.867	1.16	0.00
1.16	30.00	0.00	0.900	1.17	0.01
3.91	2.00	0.00	1.209	3.91	0.00
3.92	6.00	0.00	1.302	3.92	0.00
3.94	12.00	0.00	1.442	3.94	-0.00
3.97	20.00	0.00	1.633	3.97	0.00
3.99	26.00	0.00	1.779	3.99	0.00
4.01	30.00	0.00	1.883	4.02	0.00
6.76	2.00	0.00	1.729	6.76	-0.00
6.79	6.00	0.00	1.890	6.79	0.00
6.87	12.00	0.00	2.146	6.87	0.00
6.94	20.00	0.00	2.482	6.94	-0.00
6.99	26.00	0.00	2.743	6.99	-0.00
7.00	30.00	0.00	2.914	7.00	-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



Fluorometer

PO Box 518
620 Applegate St.
Philomath, OR 97370



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

ECO Chlorophyll Fluorometer Characterization Sheet

Date: 12/19/2016

S/N: FLRTD-3928

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	0.073	0.042	0.026 V	51 counts
Scale Factor (SF)	6	12	25 µg/l/V	0.0075 µg/l/count
Maximum Output	4.96	4.96	4.96 V	16380 counts
Resolution	1.2	1.2	1.2 mV	1.0 counts

Ambient temperature during characterization

21.7 °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-3928

Revision J

3/17/08

Fluorometer (BAS)

FINAL CAL



WET Labs

PO Box 518
620 Applegate St.
Philomath, OR 97370

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

FLNTU Characterization Sheet

Date: October 28, 2015 S/N: FLNTURTD-2951

Chlorophyll Scale Factor

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

CHL (µg/l) = Scale Factor x (Output - Dark Counts)

	Analog	Digital
Dark Counts	0.063 V	47 counts
Scale Factor (SF)	6 µg/l/V	0.0073 µg/l/count
Maximum Output	4.98 V	4130 counts
Resolution	0.5 mV	1.0 counts
Ambient temperature during calibration	22.3 °C	

Nephelometric Turbidity Unit (NTU) Scale Factor

Turbidity units expressed in NTU can be derived using the equation:

NTU = Scale Factor x (Output - Dark Counts)

	Analog	Digital
Dark Counts	0.080 V	50 counts
NTU Solution Value	3.25 V	2670 counts
Scale Factor (SF)	2 NTU/V	0.0024 NTU/count
Maximum Output	4.98 V	4130 counts
Resolution	0.1 mV	1.0 counts
Ambient temperature during calibration	22.3 °C	

Definition of terms:

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

NTU Solution Value: Signal output of the turbidity sensor when measuring a sample of interest.

SF (CHL): 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.

SF (NTU): Scale factor is determined using the following equation: $SF = xx \div (\text{Output} - \text{Dark counts})$, where xx is the value of a Formazin concentration. For example: $12.2 \div (2011 - 50) = 0.0062$.

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

Resolution: standard deviation of 1 minute of collected data.

FLNTURTD-2951 flntuchar

Revision H

10/2/07

Pump (Primary)**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: **2017-01-23**

Description: **SBE-5T Submersible Pump**

Sensor Information:

Model Number: **SBE-5T**

Serial Number: **9000**

Pressure Test Protocol:

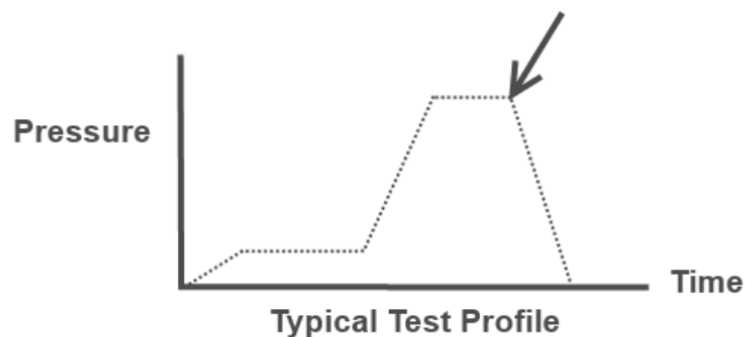
Low Pressure Test: **40** PSI Held For: **15** Minutes

High Pressure Test: **10000** PSI Held For: **15** Minutes

Passed Test: **True**

Tested By: **sa**

High pressure is
generally equal
to the maximum
depth rating of
the instrument



Pump (Secondary)

**Sea-Bird Electronics, Inc.**

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

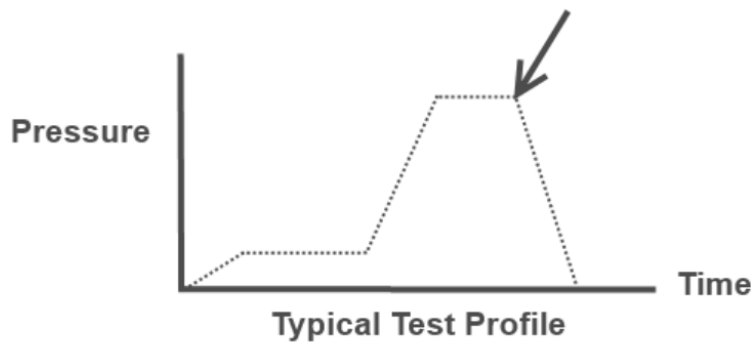
Phone: (425) 643-9866
Fax: (425) 643-9954
Email: seabird@seabird.com

Pressure Test CertificateTest Date: **2017-01-09**Description: **SBE-5T Submersible Pump****Sensor Information:**

Replaced the main piston "O"-Rings.

Model Number: **SBE-5T**Serial Number: **8275****Pressure Test Protocol:**Low Pressure Test: **40** PSI Held For: **15** MinutesHigh Pressure Test: **10000** PSI Held For: **30** MinutesPassed Test: **True**Tested By: **tb**

High pressure is
generally equal
to the maximum
depth rating of
the instrument



Temperature (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: 5786
CALIBRATION DATE: 23-Dec-16SBE 3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

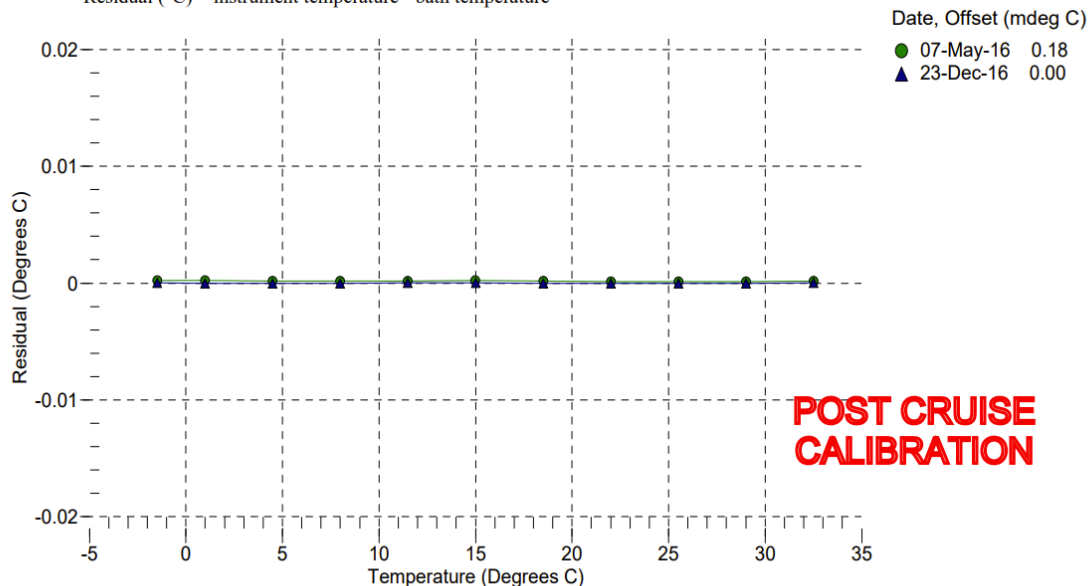
COEFFICIENTS:

$g = 4.36746645e-003$
 $h = 6.41111345e-004$
 $i = 2.27474595e-005$
 $j = 2.10859711e-006$
 $f0 = 1000.0$

BATH TEMP (° C)	INSTRUMENT OUTPUT (Hz)	INST TEMP (° C)	RESIDUAL (° C)
-1.5000	3033.188	-1.5000	0.00003
1.0000	3208.463	1.0000	-0.00003
4.5000	3466.022	4.5000	-0.00001
8.0000	3738.143	8.0000	-0.00002
11.5000	4025.228	11.5000	0.00003
15.0000	4327.656	15.0000	0.00004
18.5000	4645.800	18.5000	-0.00001
22.0000	4980.032	22.0000	-0.00000
25.5000	5330.693	25.5000	-0.00004
29.0000	5698.131	29.0000	-0.00000
32.5000	6082.661	32.5000	0.00002

 $f = \text{Instrument Output (Hz)}$ Temperature ITS-90 (°C) = $1 / \{g + h[\ln(f0 / f)] + i[\ln^2(f0 / f)] + j[\ln^3(f0 / f)]\} - 273.15$

Residual (°C) = instrument temperature - bath temperature



Temperature (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: 5097
CALIBRATION DATE: 12-Jan-17SBE 3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

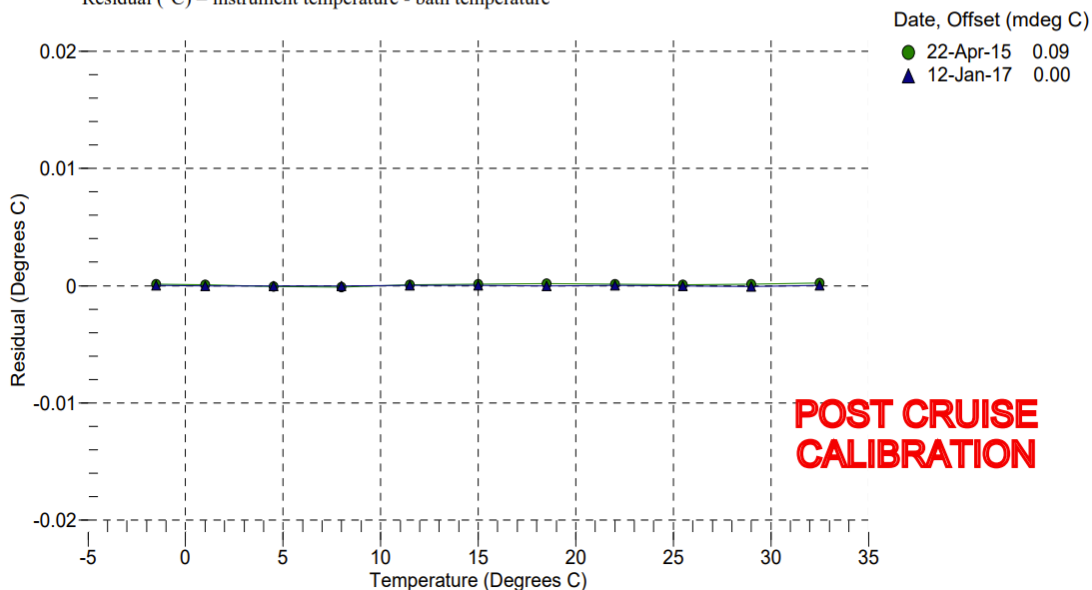
COEFFICIENTS:

$g = 4.39462001e-003$
 $h = 6.45694805e-004$
 $i = 2.32661593e-005$
 $j = 2.18382243e-006$
 $f0 = 1000.0$

BATH TEMP (° C)	INSTRUMENT OUTPUT (Hz)	INST TEMP (° C)	RESIDUAL (° C)
-1.5000	3149.334	-1.5000	0.00003
1.0000	3330.535	1.0000	-0.00002
4.5000	3596.718	4.5000	-0.00003
8.0000	3877.854	8.0000	-0.00000
11.5000	4174.339	11.5000	0.00001
15.0000	4486.563	15.0000	0.00003
18.5000	4814.896	18.5000	-0.00000
22.0000	5159.711	22.0000	0.00001
25.5000	5521.349	25.5000	-0.00002
29.0001	5900.159	29.0000	-0.00006
32.5000	6296.450	32.5000	0.00005

 f = Instrument Output (Hz)Temperature ITS-90 (°C) = $1 / \{g + h[\ln(f0 / f)] + i[\ln^2(f0 / f)] + j[\ln^3(f0 / f)]\} - 273.15$

Residual (°C) = instrument temperature - bath temperature



Transmissometer (Up through TMC042)

PO Box 518
620 Applegate St.
Philomath, OR 97370



(541) 929-5650
Fax (541) 929-5277
www.sea-birdscientific.com

C-Star Calibration

Date	May 4, 2021	S/N#	CST-889DR	Pathlength	25
			Analog output	Digital output	
V _d			0.002 V	0 counts	
V _{air}			4.803 V	15816 counts	
V _{ref}			4.700 V	15476 counts	
Temperature of calibration water				20.5 °C	
Ambient temperature during calibration				23.0 °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.

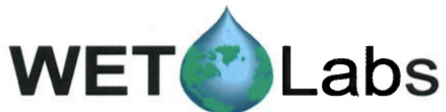
V_{sig} Measured signal output of meter.

Revision L

6/9/09

Transmissometer(TMC076 and onward)

PO Box 518
620 Applegate St.
Philomath, OR 97370



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

C-Star Calibration

Date **May 4, 2021** S/N# **CST-439DR** Pathlength **25**

Analog output

V_d **0.060 V**
 V_{air} **4.804 V**
 V_{ref} **4.699 V**

Temperature of calibration water **18.9 °C**
Ambient temperature during calibration **23.1 °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 M

7/26/11