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: 6553
CALIBRATION DATE: 05-Nov-20

SBE 3 TEMPERATURE CALIBRATION DATA
ITS-90 TEMPERATURE SCALE

COEFFICIENTS:

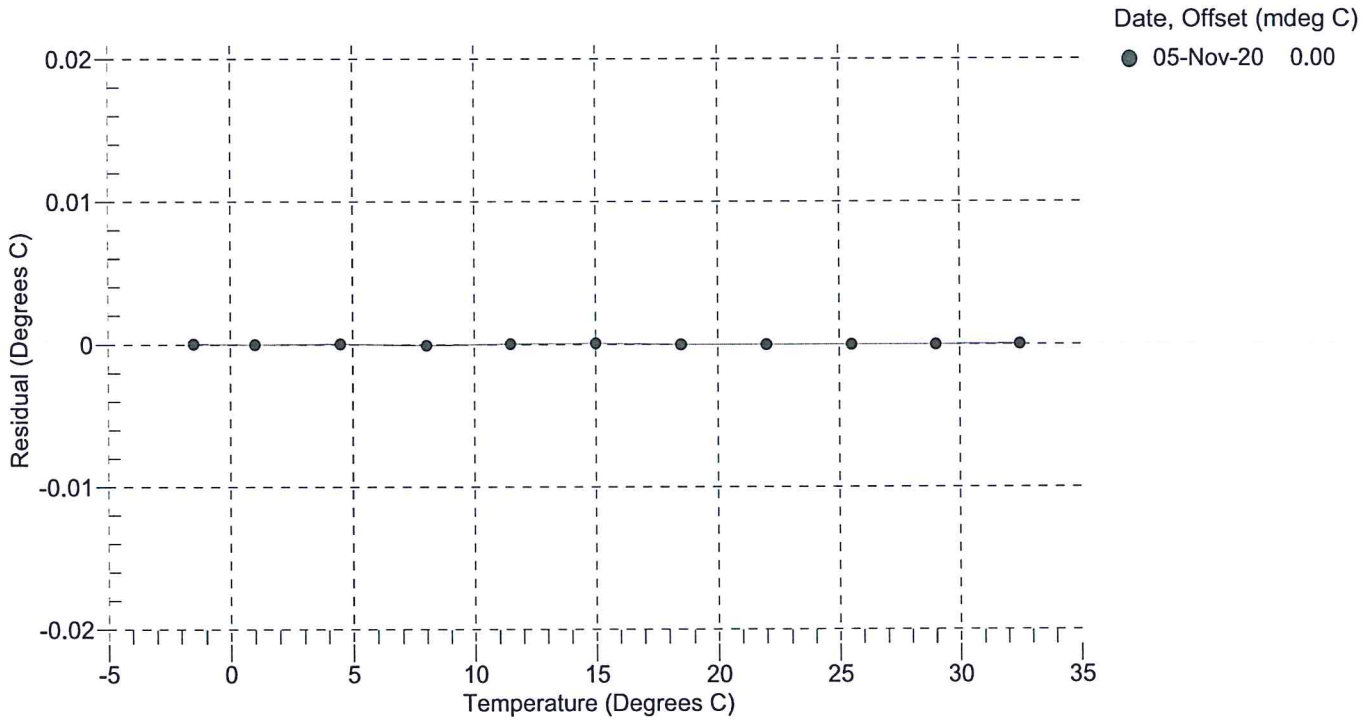
g = 4.40634768e-003
h = 6.43921488e-004
i = 2.31753689e-005
j = 2.21150186e-006
f0 = 1000.0

BATH TEMP (° C)	INSTRUMENT OUTPUT (Hz)	INST TEMP (° C)	RESIDUAL (° C)
-1.5000	3221.643	-1.5000	0.00001
1.0000	3407.690	1.0000	-0.00001
4.5000	3681.042	4.5000	0.00002
8.0001	3969.803	8.0000	-0.00007
11.5000	4274.388	11.5000	0.00003
15.0001	4595.211	15.0002	0.00006
18.5000	4932.617	18.5000	-0.00002
22.0000	5287.028	22.0000	-0.00003
25.5000	5658.791	25.5000	-0.00000
29.0000	6048.247	29.0000	-0.00000
32.5000	6455.731	32.5000	0.00001

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



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SENSOR SERIAL NUMBER: 5014
CALIBRATION DATE: 11-Nov-20

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

COEFFICIENTS:

```
g =  -1.01191772e+001
h =   1.39517123e+000
i =  -1.42472505e-003
j =   1.74050378e-004

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

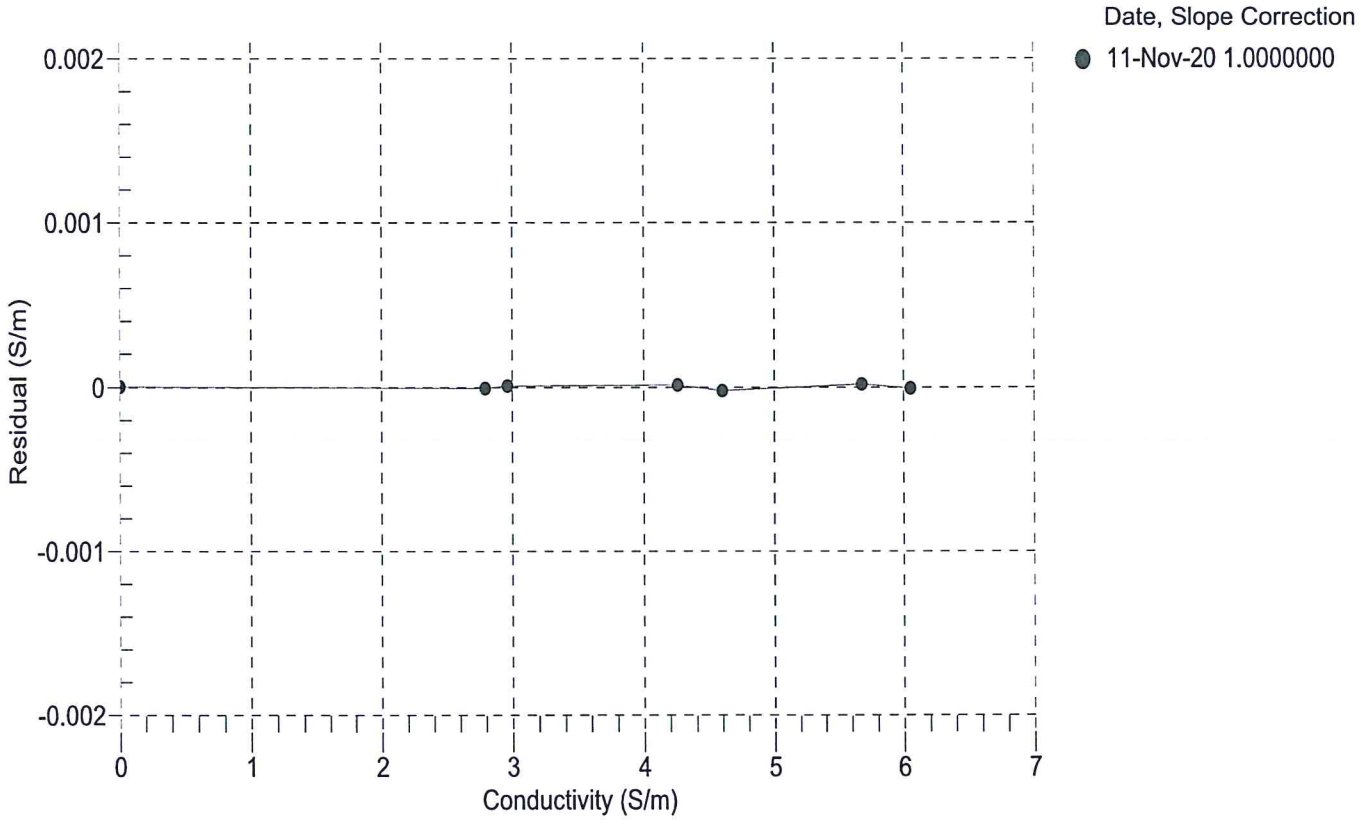
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.69563	0.00000	0.00000
-1.0001	34.6652	2.79353	5.22766	2.79352	-0.00001
0.9999	34.6654	2.96428	5.34359	2.96429	0.00001
14.9999	34.6658	4.25509	6.14917	4.25510	0.00001
18.4999	34.6656	4.60052	6.34729	4.60050	-0.00002
28.9999	34.6635	5.68009	6.92976	5.68011	0.00002
32.4999	34.6570	6.05134	7.11892	6.05133	-0.00001

f = Instrument Output (kHz)

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

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

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



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SENSOR SERIAL NUMBER: 4048
CALIBRATION DATE: 31-Oct-20

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS:
Soc = 0.5741
Voffset = -0.5189
Tau20 = 1.32
A = -4.5841e-003
B = 1.8021e-004
C = -2.7815e-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

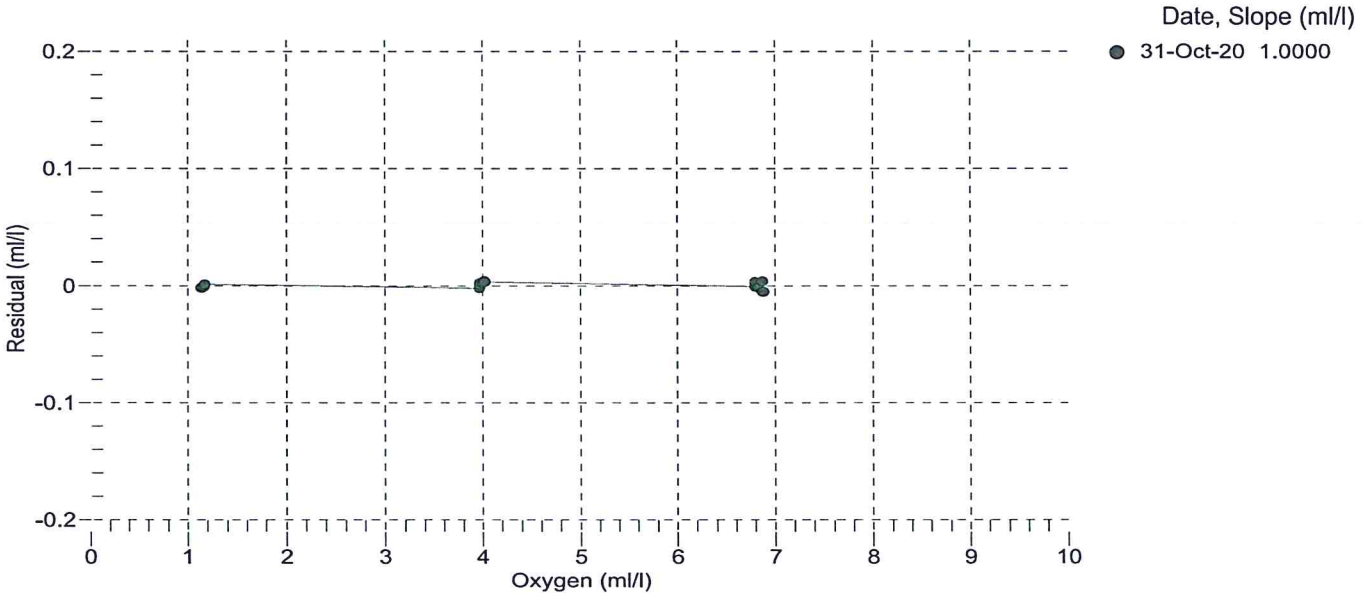
BATH OXYGEN (ml/l)	BATH TEMPERATURE (° C)	BATH SALINITY (PSU)	INSTRUMENT OUTPUT (volts)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.14	2.06	0.00	0.725	1.13	-0.00
1.14	12.00	0.00	0.791	1.14	-0.00
1.14	6.00	0.00	0.752	1.14	-0.00
1.16	20.00	0.00	0.850	1.16	-0.00
1.17	26.00	0.00	0.895	1.17	0.00
1.17	30.00	0.00	0.926	1.17	0.00
3.96	2.07	0.00	1.239	3.96	-0.00
3.97	6.00	0.00	1.330	3.97	0.00
3.98	12.00	0.00	1.469	3.98	0.00
4.00	20.00	0.00	1.662	4.00	0.00
4.01	26.00	0.00	1.811	4.02	0.00
4.02	30.00	0.00	1.914	4.02	0.00
6.79	2.06	0.00	1.753	6.79	-0.00
6.79	6.00	0.00	1.908	6.80	0.00
6.82	12.00	0.00	2.149	6.82	-0.00
6.87	20.01	0.00	2.480	6.86	-0.01
6.87	26.00	0.00	2.729	6.87	0.00
6.88	30.00	0.00	2.904	6.88	-0.01

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

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

$$\text{Oxygen (ml/l)} = \text{Soc} * (V + \text{Voffset}) * (1.0 + A * T + B * T^2 + C * T^3) * \text{Oxsol}(T,S) * \exp(E * P / K)$$

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



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Philomath, OR 97370

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C-Star Calibration

Date October 1, 2020 S/N# CST-2038DR Pathlength 25 cm

	Analog output	Digital output	
V_{dark}	0.010 V	0 counts	
V_{air}	4.800 V	15729 counts	
V_{ref}	4.703 V	15408 counts	
Temperature of calibration water			24.9 °C
Ambient temperature during calibration			22.7 °C

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

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

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

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

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ECO Chlorophyll Fluorometer Characterization Sheet

Date: 9/10/2020 S/N: FLRTD-6497

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

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

	Analog Range 1	Analog Range 2	Analog Range 4 (default)		Digital
Dark Counts	0.043	0.020	0.009	V	38 counts
Scale Factor (SF)	6	12	25	µg/l/V	0.0075 µg/l/count
Maximum Output	4.99	4.99	4.99	V	16380 counts
Resolution	0.1	0.1	0.1	mV	0.6 counts

Ambient temperature during characterization 21.5 °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 ÷ (output - 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.

Chelsea Technologies Ltd
Certificate Of Calibration

CALIBRATION CERTIFICATE
PAR Irradiance Meter

Chelsea Technologies

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West Molesey
Surrey KT8 2QZ
United Kingdom

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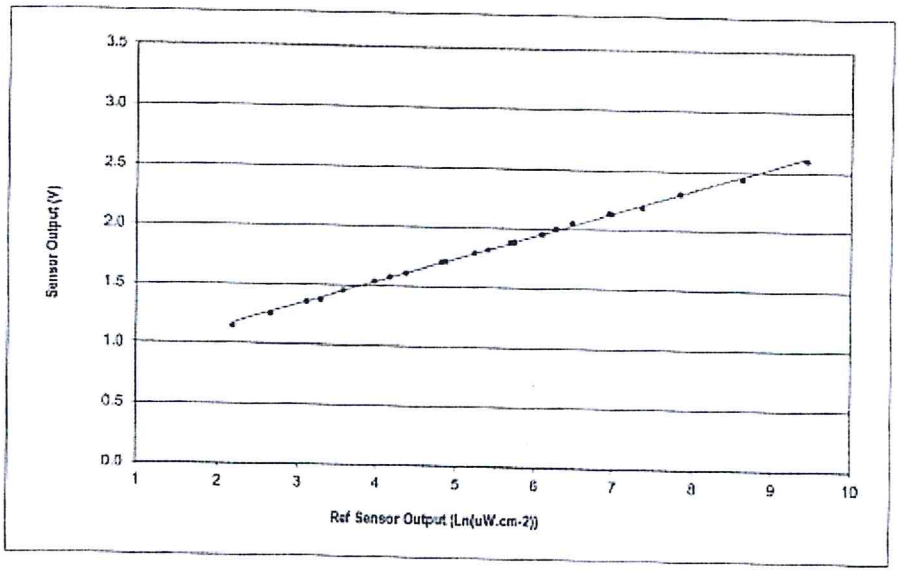
E sales@chelsea.co.uk

chelsea.co.uk

Date of Cal: 19-Oct-2020
Part Number: 0046-3097-13
Job Number: JN34601i
Serial Number: 19-0003-004

Calibration Equation
PAR (Ln(uW.cm-2)) = 0.0050344 x mVolts - 3.734453
PAR(uW.cm-2) = PAR(uE.m-2.s-1) / 0.04234
PAR (Ln(uE.m-2.s-1)) = 0.0050344 x mVolts - 6.896476
A1 Ao



Calibration

Coeff A (slope):	0.0050344
Coeff B (intercept):	-3.734453
RSQ:	0.9988

Lamp Stability

Within cal:	6.32%
Between cal:	6.39%

Multimeter

Manufacturer:	FLUKE 8846A
SN:	4549021
Cal Due Date:	Cal. Checked

Supply Volts
12.00

Electral Offset (mv)
0.0

Observations:
Sensor Condition: na
Accessories: Sensor Cap

Instrument calibrated at Chelsea Technologies Group as described in section 3 of the PAR sensor handbook.

Name: LJ Gibson
Signed:

Issue Date: 19 October 2020

Calibration Constant: $10^9/0.046 = 21739130435$

$M = 1/(0.4342944819 \times A_1 \times 1000) = 0.45737$

$B = -A_0/(A_1 \times 1000) = 1.36988$