# Setup and Calibration Information for Acrobat TUV on BenDIM01

**SeaSciences Acrobat w/ SeaBird SeaLogger 25 & Brooke Ocean Laser Optical Plankton Counter**

- **CTD Setup ----- SeaBird Setup information from a SeaBird ASCII Storage Format (*.cnv):**
    - **Instrument: SeaBird SeaBird SeaLogger 25 --** S/N:3543354-0405

```
* Sea-Bird SBE 25 Data File:
* FileName = C:\Acrobat_towfish\SBE_setup\2008_05_16_0244am_tow1.hex
* Software Version Seasave V 7.12
* Temperature SN = 4443
* Conductivity SN = 2908
* Append System Time to Every Scan
* System UpLoad Time = May 16 2008 02:45:40
* NMEA Latitude = 30 13.1337 N
* NMEA Longitude = 086 28.7082 W
* NMEA UTC (Time) = May 16 2008 01:45:40
* Store Lat/Lon Data = Append to Every Scan
** Ship: R/V Pelican
** Station: BenDIM Acrobat Tow #1
** Operator:
# nquan = 23
# nvalues = 16636
# units = specified
# name 0 = scan: Scan Count
# name 1 = timeY: Time, System [seconds]
# name 2 = timeJ: Julian Days
# name 3 = longitude: Longitude [deg]
# name 4 = latitude: Latitude [deg]
# name 5 = depSM: Depth [salt water, m]
# name 6 = t090C: Temperature [ITS-90, deg C]
# name 7 = potemp090C: Potential Temperature [ITS-90, deg C]
# name 8 = c0S/m: Conductivity [S/m]
# name 9 = sal00: Salinity [PSU]
# name 10 = sigma-È00: Density [sigma-theta, Kg/m^3]
# name 11 = flSP: Fluorescence, Seapoint
# name 12 = flSP1: Fluorescence, Seapoint, 2
# name 13 = seaTurbMtr: OBS, Seapoint Turbidity [FTU]
# name 14 = sbeox0PS: Oxygen, SBE 43 [% saturation]
# name 15 = sbeox0Mg/L: Oxygen, SBE 43 [mg/l]
# name 16 = par: PAR/Irradiance, Biospherical/Licor
# name 17 = spar: SPAR/Surface Irradiance
# name 18 = upoly0: Upoly 0, ISUS
# name 19 = v3: Voltage 3
# name 20 = upoly1: Upoly 1, ISUS
# name 21 = v4: Voltage 4
# name 22 = flag: 0.000e+00
# span 0 =          1,          16636
# span 1 = 1210902340, 1210906499
```

```
# span 2 = 137.073380,  137.265914
# span 3 =  -86.48400,   -86.47394
# span 4 =   30.19918,    30.22444
# span 5 =          -0.076,    25.913
# span 6 =    21.9668,     22.8503
# span 7 =    21.9624,     22.8503
# span 8 =   1.624590,    5.146203
# span 9 =    10.1659,     35.8012
# span 10 =        5.4567,     24.8307
# span 11 = 0.0000e+00,  4.9060e+00
# span 12 = 9.6459e-02,  8.3639e-01
# span 13 =        0.000,     25.000
# span 14 =   38.03479,   101.86219
# span 15 =    3.12261,     7.19111
# span 16 = 1.7705e+00,  3.9945e+01
# span 17 = 0.0000e+00,  6.4738e+00
# span 18 = -1.6608910,   103.43829
# span 19 =        0.2454,  4.1306
# span 20 = -3.2503920,   51.870866
# span 21 =        0.0000,  4.9060
# span 22 = 0.0000e+00,  0.0000e+00
# interval = seconds:  1
# start_time  = May 16 2008 01:45:40
# bad_flag  = -9.990e-29
# sensor 0 = Frequency  0  temperature,  4443, 08/10/06
# sensor 1 = Frequency  1  conductivity, 2908, 09/07/06,  cpcor = -9.5700e-08
# sensor 2 = Pressure  Voltage,  0592, 09/22/06,  cpcor = -9.5700e-08
# sensor 3 = Extrnl  Volt  0  Oxygen,  SBE,  primary,  1101,  04/25/08p
# sensor 4 = Extrnl  Volt  1  seapoint  turbidity  meter,  10961,  09/26/06
# sensor 5 = Extrnl  Volt  2  userpoly  0, 108, 02/10/2008
# sensor 6 = Extrnl  Volt  3  userpoly  1, 108, 02/10/2008
# sensor 7 = Extrnl  Volt  4  Fluorometer,  Seapoint,  primary
# sensor 8 = Extrnl  Volt  5  Fluorometer,  Seapoint,  secondary
# sensor 9 = Extrnl  Volt  6  irradiance  (PAR),  primary,  20201,  09/26/06
# sensor 10 = Extrnl  Volt  8  surface  irradiance  (SPAR),  degrees = 0.0
# datcnv_date  = May 20 2008 16:06:06,  7.12
# datcnv_in  =
# datcnv_skipover = 0
# file_type  = ascii
*END
```

- **CTD Data Calibration Information - SeaBird SeaLogger 25 --** S/N:3543354-0405
    - **Cruise:** **BenDim1**
    - **Dates:** **05/16/2008 – 5/20/2008**

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- **Pressure Calibration Date:**
- Sensor = S/N 0592
- Calibration Date = 9/22/2006
- Calibration Coefficients:
    - PA0 = 3.193917e+002
    - PA1 = -8.858974e-002
    - PA2 = 1.781994e-008
    - N = PressAD
    - Pressure in PSI = PA0 + PA1 * N + PA2 * N^2
    - Pressure in DB = (Pressure in PSI - 14.7) * .689476

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- **Temperature:**
- Sensor = S/N 4443
- Calibration Date = 08/10/2006
- Calibration Coefficients:
    - g = 4.4113071 2 e -003
    - h = 6.4198074 9 e -004
    - I = 2.1952719 4 e -005
    - j = 1.8917480 6 e -006
    - $f_0$ = 1000.0
    - f = temperature output in frequency [Hz]
- Equation: $T\ [°C] = [1 / (g + h \ln(fo/f) + i \ln^2(fo/f) + j \ln^3(fo/f) )] - 273.15$

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- **Salinity Calibration Data**
- Sensor = S/N 2908
- Calibration Date = 09/07/2006
- Practical Salinity Scale 1978: C(35,15,0) = 4.2914 [Siemens/meter]
- Calibration Coefficients:
    - g = -9.4405084 6 e +000
    - h = 1.2716381 2 e +000
    - i = 1.9949871 2 e -003
    - j = -2.0031438 1 e -005
    - CPcor = -9.570 0 e -008 (nominal)
    - CTcor = 3.250 0 e -006 (nominal)
    - t = temperature [°C]
    - p = pressure [decibars]
    - d = thermal coefficient of expansion ($3.25 \times 10^{-06}$)
    - e = bulk compressibility ($-9.57 \times 10^{-08}$) borosilicate cell
- Equation: $Conductivity\ [S/m] = ( g + hf^2 + if^3 + jf^4 ) / 10 (1 + \delta t + \varepsilon p)$
- Compute salinity from conductivity:

**1978 PRACTICAL SALINITY SCALE EQUATIONS**, from IEEE Journal of Oceanic Engineering, Vol. OE-5, No. 1, January 1980, page 14.

## CONCLUSIONS

Using Newly generated data, a fit has been made giving the following algorithm for the calculation of salinity from data of the form:

$$R = \frac{C(S,T,P)}{C(35,15,0)}$$

$T$ in °C (IPTS '68), $P$ in decibars.

$$R_T = \frac{R}{R_P r_T};\ R_P = 1 + \frac{P \times (A_1 + A_2 P + A_3 P^2)}{1 + B_1 T + B_2 T^2 + B_3 R + B_4 R T}$$

$$r_T = c_0 + c_1 T + c_2 T^2 + c_3 T^3 + c_4 T^4$$

$A_1 = 2.070 \times 10^{-5}$ $\quad B_1 = 3.426 \times 10^{-2}$

$A_2 = -6.370 \times 10^{-10}$ $\quad B_2 = 4.464 \times 10^{-4}$

$A_3 = 3.989 \times 10^{-15}$ $\quad B_3 = 4.215 \times 10^{-1}$

$B_4 = -3.107 \times 10^{-3}$

$c_0 = 6.766097 \times 10^{-1}$

$c_1 = 2.00564 \times 10^{-2}$

$c_2 = 1.104259 \times 10^{-4}$

$c_3 = -6.9698 \times 10^{-7}$

$c_4 = 1.0031 \times 10^{-9}$

$$S = \sum_{j=0}^{5} a_j R_T^{j/2} + \frac{(T-15)}{1 + k(T-15)} \sum_{j=0}^{5} b_j R_T^{j/2}$$

$a_0 = 0.0080$ $\quad b_0 = 0.0005$ $\quad k = 0.0162.$

$a_1 = -0.1692$ $\quad b_1 = -0.0056$

$a_2 = 25.3851$ $\quad b_2 = -0.0066$

$a_3 = 14.0941$ $\quad b_3 = -0.0375$

$a_4 = -7.0261$ $\quad b_4 = 0.0636$

$a_5 = 2.7081$ $\quad b_5 = -0.0144$

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- **Dissolved Oxygen Calibration:**
- Sensor = S/N 1101
- Calibration Date = 09/20/2006
- Calibration
- *Oxsol(T,S)* = oxygen solubility function (ml/L), which converts oxygen partial pressure (sensor measurement) to oxygen concentration (*Garcia and Gordon, 1992*).
- Oxygen Solubility Calibration Coefficients
    - A0 = 2.00907d0
    - A1 = 3.22014d0
    - A2 = 4.0501d0
    - A3 = 4.94457d0

- A4 = -0.256847d0
- A5 = 3.88767d0

- B0 = -0.00624523d0
- B1 = -0.00737614d0
- B2 = -0.010341d0
- B3 = -0.00817083d0

- C0 = -0.000000488682d0
- T = Temp
- S = Salinity
- Ts = alog((298.15 - T) / (273.15 + T))

- Equation: $Oxsol\ (T,S) = exp\ (A0 + A1(Ts) + A2(Ts)^2 + A3(Ts)^3 + A4(Ts)^4 + A5(Ts)^5 + S\ (\ B0 + B1(Ts) + B2(Ts)^2 + B3\ (Ts)^3) + C0\ (S)^2\ )$

- Coefficients for Owens-Millard equation

  - *V* = SBE 43 output voltage signal (volts)
  - *dv/dt* = time derivative of SBE 43 output
  - *T* = CTD temperature (°C)
  - *S* = CTD salinity (psu)
  - *P* = CTD pressure (dbars)
  - *K* = CTD temperature (°K = °C + 273.15)
  - *tau(T,P)* = sensor time constant at temp and press
  - *Oxsol(T,S)* = oxygen solubility function (ml/L), which converts oxygen partial pressure (sensor measurement) to oxygen concentration (*Garcia and Gordon, 1992*). See *Appendix A* in SeaBird Application Note 64: *Background Information, Deployment Recommendations, and Cleaning and Storage* for values at various temperatures and salinities.
  - Soc = 3.04e-001
  - Boc = 0.000
  - Voffset = -.5276
  - TCor = 0.00
  - PCor = 0.00

Equation: $Oxygen\ (ml/L) = [Soc * (V + Voffset + tau(T,P)\ dV/dt)]\ Oxsol\ (T,S)\ (1.0 + AT + BT^2 + CT^3) * e^{(E*P/K)}$
Equation: *Oxygen (mg/l) = Oxygen (ml/l) * 1.42903*
Equation: *Oxygen Saturation Pressure = (Oxygen (ml/l) / 100. Oxygen Solubility (T,S)*

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- **SeaPoint Turbidity**
- Sensor = S/N 10961
- Calibration Date = 09/26/06
- Calibration
  - Gain = 100
  - Scale = 1

- Equation: *Turbidity [FTU] = (500 * Scale * Voltage) / Gain*

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- **SeaPoint Fluorometric Chlorophyll**
- Sensor = S/N 2826

- Calibration Date = 09/26/06
- Calibration
    - Gain = 30
    - Scale = 1

- Equation: *Chlorophyll [µg/l] = (Voltage * 30./gain) + offset*

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- **SeaPoint CDOM UltraViolet Fluorometer**
- Sensor = S/N 6154
- Calibration Date = 09/26/06)
- Calibration
    - Gain = 30.
    - Offset = 0.0

- Equation: *CDOM [µg/l] = (voltage * 30./gain) + offset*

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- **PAR Biospherical QSP-2200**
- Sensor = S/N 20201
- Calibration Date = 02/14/05
- Calibration
    - Calibration Constant = 0.20140000
    - Multiplier = 1.00000000
    - M = -0.76325237
    - B = -3.49925121
    - Surface_cc = 0.00000000
    - Surface_r = 0.00000000
    - Offset = 0.00000000
    - V = Voltage

- Equation: *PAR [µEinsteins/$m^2$] = [multiplier * ($10^9$ * $10^{(V-B)/M)}$ / calibration constant) + offset*
- Equation: *CPAR [µEinsteins/$m^2$] = corrected PAR = 100 * ratio multiplier * underwater light / surface light*

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- **PAR Biospherical QSR-2200 BIOSPHERICAL SURFACE PAR LIGHT SENSOR**
- Sensor = S/N 20259
- Calibration Date = 08/11/2006
- Calibration

    - CTD configured to record light data from a Surface BIOSPHERICAL Quantum sensor.
        - The 0 – 5 volt output of this sensor corresponds on a logarithmic scale to light measurement over the measurement range.

    - Conversion Factor = Output in Air / Probe Net Response (**µ**Einsteins/m2-sec )
      = (Output in Air * 10,000) / (Probe Net Response )
      = 1767.36

    - Multiplier = 1 (Set multiplier to 1 for output in µEinsteins/m2 -sec.)

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- **Brook Oceans Laser Optical Plankton Counter (LOPC) Setup, Calibration and Analysis**
    - Sensor = S/N10404
    - Sensor Tunnel = S/N10410
    - The measurement of plankton is characterized by two size ranges – single-element plankton (SEP) and multi-element plankton (MEP).
    - The ACROBAT/LOPC dataset includes the SEP volumetric biomass for each individual bin and the SEP representation of the MEP data for each individual bin from [0 – 15] μm to [1905 -1920] μm
    - The MEP data itself, which can be used to construct plankton shape files (see attached document, **LOPC DATA Analyses – Standard LOPC, by Alex Herman),** are not reported but are available from the investigators on request.
    - **Setup:**
    - **Header Information from LOPC Unprocessed Data File: same setup used on all Tows**

```
# __ PC DATE-TIME _____
# Date: Friday, May 16, 2008
# Time: 02:33:43

# __ USER SUPPLIED HEADER ___
#

# __ LOPC SOFTWARE CONFIG __
# Software_Version:        1.32.1
# External_Instrument:  SBE 19plus (Sea-Bird)
# Ext_Instr_Serial#:       None
# Ext_Instr_Link:  Direct to LOPC
# Survey_Lat:      24.0000
# Tunnel_Type:   Standard
# Counter_Constant:        0.134356
# Aux_Port_Mode:           GPS/NMEA Input
# Data_Directory:          C:\Acrobat_towfish\LOPC_data\
# File_Naming:   Auto Naming
# NAV Configuration:
#          Sentence_To_Parse:  $GPGGA
#          LatPos: 3, NS: 4, LongPos: 5, LongEWPos: 6, TimePos: 2.

# -- SBE 19plus (Sea-Bird) --
# OUTPUTFORMAT:        0
# SBE_ANALOGS:    0
# Log_Raw_Data_To_Ascii_File:    YES
# A0: 0.0, A1: 0.0, A2: 0.0, A3: 0.0
# G: 0.0, H: 0.0, I: 0.0, J: 0.0, CPcor: -9.5700e-008,  CTcor: 3.2500e-006
# PA0: 0.0, PA1: 0.0, PA2: 0.0, PTCA0: 0.0, PTCA1: 0.0, PTCA2: 0.0, PTCB0: 0.0, PTCB1: 0.0, PTCB2: 0.0,
PTEMPA0: 0.0, PTEMPA1: 0.0, PTEMPA2: 0.0
**********
# CFXVER=2.42
# DSPVER=2.32
# Threshold=100
# MinSamples=3
# MaxSamples=1000
```

```
# CalFactr=4096
# MinBkgnd=512
# MinusThrsld=-100
# MinusTimout=995
# MinFlow=10
# MaxFlow=20
# FirstElm=0
# LastElm=34
# CombinedElm=2
# MinLaserVal=1650
# MaxLaserVal=2500
# LaserIncVal=1
# CtrlInterval=10
# LaserControl=1
# InitLaserVal=2100
# LaserCtrlOut=2550
# BkndCoefA=327
# BkndCoefB=65209
# SgnlCoefA=39320
# SgnlCoefB=26216
# MaxMulti=32
# Direct232Mode=0
# FileNum=3
# Port0485or232=1
# Port0Comms=1
# Port0BaudStr=4800
# AcqTime=123553
**********
M 27 36421 6 193
M 26 36420 3 122
M 24 36422 3 32915
M 23 36424 3 130
M 22 36427 2 110
M 28 37615 3 32898
M 27 37616 10 152
M 26 37619 1 101
M 30 37894 10 33070
M 29 37895 9 343
M 28 37891 6 269
M 32 38011 9 33054
M 31 38013 8 242
M 30 38014 8 192
M 25 38018 8 32958
M 24 38019 6 239
M 23 38015 11 533
C 147BF31ABAF30A52BD00AD1FC9572830D10B9F 0 0
M 22 38016 10 444
M 21 38017 7 219
M 10 38559 14 33114
M 9 38555 16 212
```

**Short Sample of LOPC Unprocessed Data**

**M = MEP = Multi-element Plankton Shape Information**

(not included with data set - available upon request from PI's)

**C = CTD data scan in SeaBird HEX Data format**

M 8 38553 5 118
M 7 38554 2 115
M 23 39593 10 33102
M 22 39597 12 584
M 21 39604 17 406
M 14 39613 10 33142
M 13 39614 8 222
M 12 39615 6 168
M 28 39832 3 32888
M 27 39830 6 146
M 26 39826 6 136
M 17 39984 4 32888
M 16 39985 4 147
M 15 39984 6 149
M 32 40406 7 33041
M 31 40402 11 621
M 30 40409 4 129
M 29 40411 17 164
M 28 40414 6 172
M 27 40416 8 292
M 26 40422 5 225
M 14 41686 6 32953
M 13 41671 18 546
M 12 41682 8 312
M 15 41790 6 32945
M 14 41776 19 274
M 13 41774 9 213
M 32 41798 4 32902
M 31 41794 14 229
M 30 41786 10 188
L1 0 0 0 0 0 0 38 106 93 74 47 46 30 22 23 11 13 10 16 11 6 5 8 6 5 6 2 1 3 3 2 2
L2 2 3 0 1 6 1 1 2 1 0 0 1 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 **L1-L4 = SEP Size Information**
L3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
L4 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
L5 0 100 35955 207 2017 0 2553 0 0 2284 **L5 = SEP Collection Information**

- ***Single Element Plankton (SEP) Data***

  - L1-L4: 128 bins of plankton counts in steps of 15 microns. As noted above, significant counts begin to appear in the 8th bin of L1 representing 105-120 microns.
  - L5: The LOPC ½ sec. time counter appears as the 3rd number in L5, ie, '426'. The flow counts appear as the 4th & 5th number of L5. The number '207' represents the number of plankton counts used in the estimate while the number '2017' represents the summed flow time (counter). Therefore the average flow time counts were 2017/207=7.2.

  - Biomass can be simply represented by the volumetric equation of a sphere;
    - Biomass Volume (per particle) = $4/3 \times \pi \times (esd/2)^3$ (spherical volume)
    - esd = bin centroid

- Since most zooplankters are ellipsoidal in shape, biomass estimates based on spherical volume is overestimated. If desired, an additional correction can be made which adjusts the volume based on a mean ellipsoidal shape based on the ratio (R) of the major to minor axes which typically ranges from 2-4 for zooplankton (ie., =1 for a sphere). The correction is given by;
  - Ellipsoidal Volume = (Spherical Volume) x ($1/R^{½}$ )
  - **Reported Ellipsoidal Volume (R=3) per bin = (Spherical Volume) x (0.577350269)**

- **Total Volumetric Biomass:**
  - **Includes the summation of the volumetric biomass for each individual bin + the volumetric biomass representation of the multi-element plankton.**
- ***MEP Data***
  - **See the Document: LOPC DATA Analyses – Standard LOPC, by Alex Herman**
  - *Transit Time:* The reconstruction of MEP shape profiles requires the processing of transit times measured for each element through the laser beam.
  - Flow Speed Measurement
  - Integrating MEP counts into the SEP binned Size Distribution