TRANSPORT- FSBT CTD Processing R/V Sharp Cruises FSBT11 and FSBT12:

Prepared by: Steve Suttles

1. **TSS & Chla calibrations from collected water samples.-** These calibrations are necessary to calibrate optical measurements of fluorescence and turbidity to mass concentrations of chlorophyll-a and total suspended solids (TSS). The WetLabs ECO-FLNTU sensor was used for both the fluorescence and turbidity measurements.

    1.1. Use "Data Conversion" module in SeaBird Data Processing software to convert raw hex CTD data from R/V Sharp 9/11plus CTD to converted ascii file (cnv). Select convert from "Upcast and downcast" for calibrations. Use configuration file "CTD001.xmlcon" from raw data folder. This file was created at time of real-time data collection from the master configuration file used on the cruise. Save these cnv files in folder called "tssflcal".

    1.2. Variables to output into cnv file for TSS & Chla calibration:
        1.2.1. # name 0 = scan: Scan Count
        1.2.2.# name 1 = timeS: Time, Elapsed [seconds]
        1.2.3.# name 2 = timeJ: Julian Days
        1.2.4.# name 3 = prDM: Pressure, Digiquartz [db]
        1.2.5.# name 4 = t090C: Temperature [ITS-90, deg C]
        1.2.6.# name 5 = c0S/m: Conductivity [S/m]
        1.2.7.# name 6 = sal00: Salinity, Practical [PSU]
        1.2.8.# name 7 = density00: Density [density, Kg/m^3]
        1.2.9.# name 8 = v0: Voltage 0 – ECO-FLNTU fluorescence voltage
        1.2.10. # name 9 = v1: Voltage 1- ECO-FLNTU turbidity/backscatter voltage
        1.2.11. # name 10 = v4: Voltage 4- C-Star 25cm Transmissometer voltage
        1.2.12. # name 11 = sbeox0Mg/L: Oxygen, SBE 43 [mg/l]
        1.2.13. # name 12 = sbeox0PS: Oxygen, SBE 43 [% saturation]
        1.2.14. # name 13 = altM: Altimeter [m]
        1.2.15. # name 14 = flag: 0.000e+00

    1.3. Use Matlab script "rdcnv4tssflcal.m" to read cnv files into MatLab workspace and save as one Matlab (.mat) file with all data ({CruiseID}_CTD_tssflcal.mat).
    1.4. Read all bottle files (.bl) that have time and scan information when water samples for TSS & Chla analysis were collected into Matlab using script "rdCTDblfiles.m". Save bottle data into Matlab (.mat) file ({CruiseID}_CTD_BLdata.mat).
    1.5. Find mean ECO-FLNTU voltages (v0 = FLR & v1 = NTU) for scan range for each bottle firing from the CTD upcast/downcast data in mat file using script "mkCTDbldata".
    1.6. Convert voltages from ECO-FLNTU into fluorescence units (FLR) and NTU using factory calibration from WetLabs for correct serial number (ECO-FLNTURT-090) and year.

Calibrations from provided pdf sheets were saved in files "ECOFLNTU_90_2011.mat" & "ECOFLNTU_90_2012.mat" for easy import into Matlab workspace.

1.7. Read in TSS and Chla water sample data from lab report and match to NTU and FLR calculated from bottle data, and do linear regression. Use scripts "mkTSSCal.m" and "mkChlaCal.m" .

1.8. See if there are any **obvious** outliers that can/should be removed to improve fit.

1.9. Plot and save results. Use scripts "TSSCalfits.m" and "ChlaCalfilts.m".

2. **Oxygen alignment calibration-** It is typically necessary to align the oxygen sensor to the primary CTD measurements (conductivity, temperature, and pressure) because of delays in water travel time in the plumbing and instrument response times. The oxygen sensor on the R/V Sharp for FSBT11 and FSBT12 cruises was a SeaBird SBE 43 on A/D voltage 2.

2.1. Use "Data Conversion" module in SeaBird Data Processing software to convert raw hex CTD data from R/V Sharp 9/11plus CTD to converted ascii file (cnv). Select convert from "Upcast and downcast" for calibrations. Use configuration file "CTD001.xmlcon" from raw data folder. This file was created at time of real-time data collection from the master configuration file used on the cruise. Save these cnv files in folder called "updwn".

2.2. Variables to output into cnv file for O2 alignment calibration (append "_updwn" to CTD filename):

2.2.1. # name 0 = scan: Scan Count
2.2.2. # name 1 = timeS: Time, Elapsed [seconds]
2.2.3. # name 2 = timeJ: Julian Days
2.2.4. # name 3 = prDM: Pressure, Digiquartz [db]
2.2.5. # name 4 = latitude: Latitude [deg]
2.2.6. # name 5 = longitude: Longitude [deg]
2.2.7. # name 6 = t090C: Temperature [ITS-90, deg C]
2.2.8. # name 7 = T2-T190C: Temperature Difference, 2 - 1 [ITS-90, deg C]
2.2.9. # name 8 = c0S/m: Conductivity [S/m]
2.2.10. # name 9 = C2-C1S/m: Conductivity Difference, 2 - 1 [S/m]
2.2.11. # name 10 = sal00: Salinity, Practical [PSU]
2.2.12. # name 11 = density00: Density [density, Kg/m^3]
2.2.13. # name 12 = v0: Voltage 0
2.2.14. # name 13 = v1: Voltage 1
2.2.15. # name 14 = v2: Voltage 2
2.2.16. # name 15 = v4: Voltage 4
2.2.17. # name 16 = altM: Altimeter [m]
2.2.18. # name 17 = sbeox0V: Oxygen Voltage, SBE 43
2.2.19. # name 18 = flag: 0.000e+00

2.3. Use "Align CTD" module from SeaBird Data Processing Software and advance Oxygen Voltage, SBE 43 (#name 17) by desired amount (generally 1 – 5 seconds). Advances of 1, 1.5,2, 2.5, 3, 3.5, and 5seconds were tried on some portion of the CTD casts for FSBT11 and FSBT12.

2.4. USE "Derive" module from SeaBird Data Processing Software to derive parameters below from aligned cnv file. Select 2 s window size for oxygen and descent rate calculation, and

select apply Tau correction for oxygen. Append "_derive" to output cnv files and save in "derive" folder.

2.4.1. Descent Rate, [m/s]
2.4.2. Oxygen, SBE 43 [mg/l]
2.4.3. Oxygen, SBE 43 [% saturation]

2.5. Read in "_updwn_align##_derive" cnv files into Matlab using "rdcnvderive2.m" and save.
2.6. Plot Oxygen, SBE 43 [mg/l] for multiple casts to compare the different O2 voltage advances tested, differentiating upcast and downcast. Use scripts "mkO2align2plt.m" and mkO2align3plt.m" to make and save plots (png format).
2.7. Select O2 advance that appears to have the best overall agreement between upcast and downcast over a broad sampling of the CTD casts.
2.8. A **3 second advance** was selected.

3. Downcast processing

3.1. Use "Data Conversion" module in SeaBird Data Processing software to convert raw hex CTD data from R/V Sharp 9/11plus CTD to converted ascii file (cnv). Select convert from "downcast". Use configuration file "CTD001.xmlcon" from raw data folder. This file was created at time of real-time data collection from the master configuration file used on the cruise. Append "_dwncast" to output cnv files and save in folder called "dwncast".
3.2. Variables to output into cnv file for downcast (same as for O2 calibration in section 2):

3.2.1. # name 0 = scan: Scan Count
3.2.2. # name 1 = timeS: Time, Elapsed [seconds]
3.2.3. # name 2 = timeJ: Julian Days
3.2.4. # name 3 = prDM: Pressure, Digiquartz [db]
3.2.5. # name 4 = latitude: Latitude [deg]
3.2.6. # name 5 = longitude: Longitude [deg]
3.2.7. # name 6 = t090C: Temperature [ITS-90, deg C]
3.2.8. # name 7 = T2-T190C: Temperature Difference, 2 - 1 [ITS-90, deg C]
3.2.9. # name 8 = c0S/m: Conductivity [S/m]
3.2.10. # name 9 = C2-C1S/m: Conductivity Difference, 2 - 1 [S/m]
3.2.11. # name 10 = sal00: Salinity, Practical [PSU]
3.2.12. # name 11 = density00: Density [density, Kg/m^3]
3.2.13. # name 12 = v0: Voltage 0
3.2.14. # name 13 = v1: Voltage 1
3.2.15. # name 14 = v2: Voltage 2
3.2.16. # name 15 = v4: Voltage 4
3.2.17. # name 16 = altM: Altimeter [m]
3.2.18. # name 17 = sbeox0V: Oxygen Voltage, SBE 43
3.2.19. # name 18 = flag: 0.000e+00

3.3. Use "Filter " module from SeaBird Data Processing Software to smooth pressure signal with low-pass filter B, with 0.15s time constant. Append "_filter" to processed cnv files and save in "filter" folder.

3.4. Use “Align CTD ” module from SeaBird Data Processing Software to advance Oxygen Voltage, SBE 43 (#name 17) relative to other sensors, use 3 sec advance. Append “_align30” to processed cnv files and save in “align” folder.

3.5. Use “Derive” module from SeaBird Data Processing Software to derive parameters below from aligned cnv file. Select 2 s window size for oxygen and descent rate calculation, and select apply Tau correction for oxygen. Append “_derive” to output cnv files and save in “derive” folder.

3.5.1. Descent Rate, [m/s]

3.5.2. Oxygen, SBE 43 [mg/l]

3.5.3. Oxygen, SBE 43 [% saturation]

3.6. Use “Loop Edit ” module from SeaBird Data Processing Software to remove data were CTD is not profiling. Select “Fixed minimum velocity” type and use 0.075 m/s for minimum CTD velocity. Also select “remove surface soak” with soak depth of 1.5 meters, and minimum and maximum soak depths of 1m and 2m; respectively. Append “_loopedit” to output cnv files and save in “loopedit” folder.

3.7. Use “Bin Average” module from SeaBird Data Processing Software to bin average data into 0.25 meter pressure bins. Append “_binavg” to output cnv files and save in “binavg” folder.

3.8. Use Matlab script “ctdprocess_{cruiseid}.m” to read in binavg cnv files into Matlab, calculate additional variables, and do some QA/QC. Here are the details;

3.8.1. Calls script “rdcnvbinavg.m” to read in all processed, bin averaged, downcast cnv files described above and put into matlab structured variable called “CTD”.

3.8.2. Loads in ECO-FLNTU calibrations to convert voltages to fluorescence (FLR) and NTU values and add to CTD structure (“CTD.fluor” and “CTD.ntu”).

3.8.3. Loads in TSS and Chla calibrations made with collected water samples and calculates CTD.tss and CTD.chla values into CTD structure.

3.8.4. Removes data where CTD descent rate is less than 0.05 meters per second.

3.8.5. Sets any O2 values < 0, to 0.

3.8.6. Calculates matlab time format using Julian Days from processed CTD data. Saved to “CTD.mtime” variable.

3.8.7. Save results into “{CruiseID}_CTD_processed_downcast.mat”

3.9. Use Matlab script “ctdpostprocess.m” to perform additional processing of processed CTD data.

3.9.1. Removes data where pressure bins < 1.5 meters.

3.9.2. Removes data where the conductivity difference between the primary and secondary conductivity sensor on the CTD is > 0.5. (CTD.conddiff > 0.5).

3.9.3. Flags suspect altimeter data and converts those to NaN (Not A Number).

3.9.4. Saves results to “{CruiseID}_CTD_processed_downcast_postprocess.mat”

3.10. Make plots of each profile that show 1) salinity, 2) temperature, 3) TSS, 4) Chla, and 5) Dissolved Oxygen. Use script “mkctdprofileplt2.m” to make plots of each cast and automate making of all plots from a cruise with script “runmkctdprfplts.m”. Save png files of all profile plots.

3.11. Make comma delimited (csv) file of post-processed downcast CTD database for each cruise.

4. Results files Data Attribute Information:

4.1. Post-processed Bin Averaged CTD csv results file ("{CruiseID}_CTD_processed_donwcast_postprocess.csv")-

4.1.1. **year-** Calendar year.
4.1.2. **month-** Calendar month.
4.1.3. **day-** Day of month.
4.1.4. **hrUTC-** hour of day in UTC time base.
4.1.5. **min-** Hour in UTC time base (same as GMT).
4.1.6. **sec-** Seconds of minute.
4.1.7. **Julian_Day-** Numeric time in Julian day for year in UTC time base.
4.1.8. **CruiseID**- Cruise identification string.
4.1.9. **CTDCast**- CTD cast number (integer).
4.1.10. **CTDfilen**- Name (w/o extension) of source CTD datafile.
4.1.11. **scan**- Scan number of CTD (integer).
4.1.12. **elapsed_time**- Elapsed time from start of CTD cast, seconds.
4.1.13. **latitude-** Latitude geographic coordinate from ship in decimal degree format.
4.1.14. **longitude-** Longitude geographic coordinate from ship in decimal degree format. Minus indicates western hemisphere.
4.1.15. **pressure**- Mid-point of pressure bin, [decibars].
4.1.16. **temp1**- Water temperature from primary temp sensor, [^{o}C].
4.1.17. **tempdiff-** Temperature difference between primary and secondary temperature sensor, [^{o}C].
4.1.18. **cond1-** Conductivity from primary sensor, [Siemens per meter].
4.1.19. **conddiff-** Conductivity difference between primary and secondary sensor, [Siemens per meter].
4.1.20. **salinity**- Salinity.
4.1.21. **density**- Density, [kilograms per cubic meter].
4.1.22. **voltage0**- A/D voltage 0 = Fluorescence voltage from ECO-FLNTU sensor.
4.1.23. **voltage1-** A/D voltage 1 = Turbidity voltage from ECO-FLNTU sensor.
4.1.24. **voltage2-** A/D voltage 2 = SBE 43 oxygen sensor.
4.1.25. **voltage4-** A/D voltage 4 = CStar transmissometer.
4.1.26. **altimeter**- Altimeter distance to seabed, [meters]. NaN values are readings that were flagged suspected bad values in post-processing step.
4.1.27. **O2voltage-** Oxygen voltage, SBE 43 advanced 3 seconds.
4.1.28. **descent_rate**- Descent rate of CTD in meters per second.
4.1.29. **O2mgpl-** Dissolved oxygen concentration in milligrams per liter.
4.1.30. **O2sat**- Percent dissolved oxygen saturation.
4.1.31. **ntu**- Nephelometric Turbidity Units (NTU) from ECO-FLNTU sensor.
4.1.32. **tss-** Total Suspended Solids (TSS) from calibration of collected water samples analyzed in the lab for TSS and NTU from ECO-FLNTU.

4.1.33. **fluor-** Fluorescence units from ECO-FLNTU sensor.
4.1.34. **chla**- Chlorophyll-a from calibration of fluorescence to analysis of water samples for chla, units of micrograms per liter.
4.1.35. **nbins**- Number of samples averaged in pressure bin.
4.1.36. **flag**- Data flag from SeaBird Data Processing Software(0 = good).

4.2. Post-processed Bin Averaged CTD matlab results file ("{CruiseID}_CTD_processed_donwcast_postprocess.mat")-
4.2.1. **CTD**- structure containing all data and metadata
4.2.1.1. **filename: {cell}-** Complete filename of processed binavg cnv where data was contained**.**
4.2.1.2. **scan: [int32]-** Scan number of CTD**.**
4.2.1.3. **etime: [double]-** Elapsed time from start of CTD cast, seconds.
4.2.1.4. **JDay: [double]-** Numeric time in Julian day for year in UTC time base.
4.2.1.5. **Pdb: [double]-** Mid-point of pressure bin, [decibars].
4.2.1.6. **latitude: [double]-** Latitude geographic coordinate from ship in decimal degree format.
4.2.1.7. **longitude: [double]-** Longitude geographic coordinate from ship in decimal degree format. Minus indicates western hemisphere.
4.2.1.8. **temp1: [double]-** Water temperature from primary temp sensor, [^{o}C].
4.2.1.9. **tempdiff: [double]-** Temperature difference between primary and secondary temperature sensor, [^{o}C].
4.2.1.10. **cond: [double] -** Conductivity from primary sensor, [Siemens per meter].
4.2.1.11. **conddiff: [double] -** Conductivity difference between primary and secondary sensor, [Siemens per meter].
4.2.1.12. **salt: [double]** - Salinity.
4.2.1.13. **density: [double]-** Density, [kilograms per cubic meter].
4.2.1.14. **v0: [double]** A/D voltage 0 = Fluorescence voltage from ECO-FLNTU sensor.
4.2.1.15. **v1: [double] -** A/D voltage 1 = Turbidity voltage from ECO-FLNTU sensor.
4.2.1.16. **v2: [double] -** A/D voltage 2 = SBE 43 oxygen sensor.
4.2.1.17. **v4: [double] -** A/D voltage 4 = CStar transmissometer.
4.2.1.18. **altimeter: [double]** - Altimeter distance to seabed, [meters]. NaN values are readings that were flagged suspected bad values in post-processing step.
4.2.1.19. **O2volts: [double]-** Oxygen voltage, SBE 43 advanced 3 seconds.
4.2.1.20. **descent: [double] -** Descent rate of CTD in meters per second.
4.2.1.21. **O2mgpl: [double] -** Dissolved oxygen concentration in milligrams per liter.
4.2.1.22. **O2sat: [double]** - Percent dissolved oxygen saturation.
4.2.1.23. **nbins: [int32]** - Number of samples averaged in pressure bin.
4.2.1.24. **flag: [int32]** - Data flag from SeaBird Data Processing Software(0 = good).

4.2.1.25. **ntu: [double]** - Nephelometric Turbidity Units (NTU) from ECO-FLNTU sensor.
4.2.1.26. **fluor: [double] -** Fluorescence units from ECO-FLNTU sensor.
4.2.1.27. **tss: [double] -** Total Suspended Solids (TSS) from calibration of collected water samples analyzed in the lab for TSS and NTU from ECO-FLNTU.
4.2.1.28. **chla: [double]** - Chlorophyll-a from calibration of fluorescence to analysis of water samples for chla, units of micrograms per liter.
4.2.1.29. **mtime: [double]-** Date/time in matlab format. Time base is UTC.
4.2.1.30. **process: [struct]-** Structure containing processing notes.

4.2.2. **HDR**- cell array containing header lines of last cnv file read into CTD structure.