

## **CTD Data Processing**

Contributors to this document: Kate Yezhova, Janine Hunt, Pascal Guillot

This document discusses processing of the rosette CTD dataset from the 2022 James Bay and Belcher Islands Expedition. The procedure is based on what Janine and Kate were taught by Pascal, and the SBE Data Processing Manual (<https://www.seabird.com/asset-get.download.jsa?id=55174002258>). Page 20 of the manual outlines the steps for processing data.

Instrument: SBE 19plus V2 SeaCAT Profiler CTD SN7798 in an SBE 32 Carousel Water Sampler SN32-1173 (Rosette CTD)

Vessel: RV *William Kennedy* and its small boats

Cruise date: July 20 – August 24, 2022

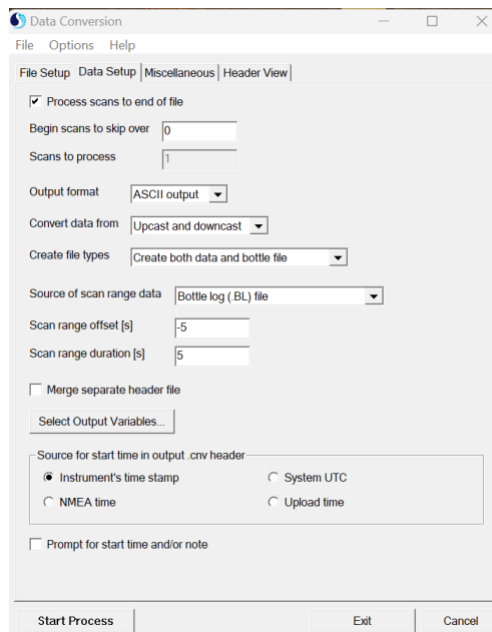
Spatial region: Hudson and James Bays

Notes: NA

The following steps were taken to process the data:

1. Create the following folder structure:
  - a. 2022\_wk\_ros\_ctd\_sn7798
    - i. logbooks
    - ii. originals
    - iii. r\_scripts
    - iv. seabird\_psa\_and\_xmlcon
    - v. data
      1. 00\_raw
      2. 01\_datacnv
      3. 02\_section
      4. 03\_filter
      5. 04\_align
      6. 05\_ctmass
      7. 06\_loopedit
      8. 07\_derive
      9. 08\_binavg
      10. 09\_split
      11. 10\_bottlesum
      12. 11\_final
2. Into the logbooks folder, place the ship logbook.
3. Into the originals folder, place all original data from the field (data files, logbooks, calibration files, etc.); zipped to prevent accidental modification.
4. Ensure CTD files all follow the same naming structure, and that the casts correspond to entries in the digital logbook.

5. All .xmlcon files in the raw data were checked, all identical. The main .xmlcon file (non-cast specific) is identical to the cast-specific .xmlcon files.  
 The main .xmlcon file was checked against calibration documents to ensure all values were correct. The main .xmlcon file will be used for all casts.  
 The main .xmlcon file was also checked against the .xmlcon file used in 2021. Identical except in 2022 NMEA time and Scan time were added.
6. Convert raw .hex files to .cnv files, and .bl files to .ros files
  - a. SBE Data processing → Run → Data Conversion (#1) → File Setup
    - i. Open *01\_DatCnv\_SN7798\_ROSCTD.psa* file from the seabird\_psa folder
    - ii. Under Instrument configuration file, load the .xmlcon file in the “seabird\_psa\_and\_xmlcon” folder, uncheck “Match instrument configuration to input file”
    - iii. Under Input directory, select all .hex files from “00\_raw” folder
    - iv. Under Output directory, select “01\_datacnv” folder
  - b. ... → Data Setup. The chosen scan range offset and duration mean the software will extract scans from the 5 seconds before each bottle is fired.



- i. Click Select Output Variables..., and choose the following:

Seq. #	Variable Name [unit]
1	Scan Count
2	Descent Rate [m/s]
3	Pressure, Strain Gauge [db]
4	Depth [salt water, m]
5	Temperature [ITS-90, deg C]
6	Conductivity [mS/cm]
7	Salinity, Practical [PSU]
8	Oxygen raw, SBE 43 [V]
9	PAR/Irradiance, Biospherical/Licor [ $\mu\text{mol photons/m}^2/\text{sec}$ ]
10	Fluorescence, WET Labs CDOM [ $\text{mg/m}^3$ ]
11	Fluorescence, WET Labs ECO-AFL/FL [ $\text{mg/m}^3$ ]
12	Fluorescence, WET Labs ECO-AFL/FL, 2 [ $\text{mg/m}^3$ ]
13	Voltage 0
14	Voltage 1
15	RS-232 WET Labs raw counts 0

a.

Seq. #	Variable Name [unit]
16	RS-232 WET Labs raw counts 1
17	RS-232 WET Labs raw counts 2
18	Frequency 0
19	Frequency 1
20	Frequency 2
21	Julian Days
22	SPAR, Biospherical/Licor [ $\mu\text{mol photons/m}^2/\text{sec}$ ]
23	CPAR/Corrected Irradiance [%]
24	Bottle Position in Carousel
25	Bottles Fired
26	Latitude [deg]
27	Longitude [deg]
28	
29	
30	

b.

c. Click Start Process

7. Preparing an Excel sheet for taking notes

a. Open the 01\_datacnv folder

b. Under Type, choose "CNV File" to display only the .cnv files

c. Select all files (Ctrl+A)

d. Right click, select copy as path

e. Go to Excel and paste (Ctrl+V)

f. Select column A, go to Find & Select -> Replace -> Type out the beginning of the paths in "find what", and replace with blank. Type ".cnv" and replace with blank too.

g. Add title row "cast id, start scan, end scan, notes"

h. Save the file, titled "section.xlsx", into the logbooks folder

8. Plotting casts

a. SBE Data Processing → Run → Sea Plot (#20) → File Setup

- i. For Program setup file, choose 02\_SeaPlot\_SN7798\_ROSCTD.psa
    - ii. For Input directory, select all files in 01\_datacnv folder
    - iii. For Output directory, select any folder (the plots do not get automatically saved)
  - b. → Plot Setup
    - i. Title: datacnv
    - ii. For variables, choose the following:
      - 1. y-axis: pressure
      - 2. x-axis 1: scan count
      - 3. hide other x-axes
  - c. Click Start Process
  - d. In the plot window select View → Show Cursor Position
  - e. Record scan # of beginning of downcast (when the CTD begins a descend after acclimating at ~1-5m depth for some time), and the end of the upcast (just before the CTD comes out of water at the end) for each cast in the Excel sheet you created in the previous step.
- 9. Cutting out soaking period (must go one file at a time)
  - a. In SBE Data Processing: Run → Section (#16) → File Setup
    - i. Program setup file: 03\_Section\_SN7798\_ROSCTD.psa
    - ii. Input: one cast at a time from 01\_datacnv. (Definitely not the most time efficient method but the simplest at this point.)
    - iii. Output: 02\_section folder
  - b. → Data Setup
    - i. Section based on: scan count
    - ii. Input minimum and maximum value for each cast and click Start Process, one cast at a time
- 10. Run the 01\_section\_check.R script to check that correct values were entered in the Section module and that none of the pressure/depth values ended up being negative (indicating measurements in the air).
- 11. Typically, a pump check R script would be run at this point to ensure that the pump started working before the downcast began (the pump typically only starts working once the minimum conductivity frequency is met and the pump delay elapses). However, there is no information in .hex or .hdr files regarding pump delay. Possibly there was no pump delay, and the pump started working immediately upon the SBE19Plus being turned on. This step is being skipped for this dataset. All casts had a proper equilibration period.
- 12. Run the 02\_sal\_check.R to check the minimum conductivity measurements to ensure none of the samples were freshwater, as the processing steps are slightly different from seawater. SBE said in personal communication that the rough threshold for freshwater for data processing purposes is 0.6 S/m, i.e., 6 mS/cm.
  - a. The following casts at first appeared to have captured samples with conductivity of less than or equal to 6 mS/cm; however, looking at the rosette logs and comparing the downcasts and upcasts for these casts, it is evident that the low conductivity values in the downcast are a result of CTD pump issues. In the final file, upcasts will be used for

these two casts, and the upcasts do not have any conductivity values less than or equal to 6 mS/cm:

- i. WK\_08122022\_017
- ii. WK\_08192022\_023

### 13. Filtering

- a. SBE Data processing → Run → Filter (#2) → File Setup
  - i. Program setup file: 04\_Filter\_SN7798\_ROSCTD.psa
  - ii. Input directory: 02\_section folder (all casts)
  - iii. Output directory: 03\_filter folder
- b. → Data Setup
  - i. Low pass filter A, time constant (s): 1.0
  - ii. Low pass filter B, time constant (s): 0.5
  - iii. Specify Filters...
    1. Clear all
    2. Pressure, Strain Gauge (db): Low pass filter A
    3. Temperature (ITS-90, deg C): Low pass filter B
    4. Conductivity (mS/cm): Low pass filter B
- c. Click Start Process

### 14. Align CTD (advance parameters in time relative to pressure)

- a. SBE Data processing → Run → Align CTD (#3) → File Setup
  - i. Program setup file: 05\_Align\_SN7798\_ROSCTD.psa
  - ii. Input directory: 03\_filter folder (all casts)
  - iii. Output directory: 04\_align folder
- b. → Data Setup → Enter Advance Values
  - i. Clear all
  - ii. Temperature (ITS-90, deg C): +0.5 seconds
    1. This is the recommended value for SBE19plusV2 in the data processing manual
  - iii. Conductivity (mS/cm): +0.5 seconds
    1. Note that the manual gives contradicting statements. First statement is: "For an SBE 19plus or 19plus V2 with a standard 2000-rpm pump, do not advance conductivity." Second statement is: "If temperature is advanced relative to pressure and you do not want to change the relative timing of temperature and conductivity, you must add the same advance to conductivity."
    2. Pascal applies a +0.5 second advance to both temperature and conductivity, Pascal's method will be followed.
- iv. Oxygen raw, SBE43 (V): no advance
  1. The data processing manual suggests +3 to 7 seconds for an SBE19Plus
  2. Janine noted that this only works if the Oxygen raw, SBE43 (V) variable is being aligned. Janine tried several delays and the 0s delay seemed best for 2021 data.

3. Pascal noted that at the beginning, he tried to estimate the right correction. You need to remove the gap between the downcast and upcast because of the long sensor response time. When you are going to apply a correction, you shift all oxygen values X seconds below their original place. Therefore, if you are moving at a speed of 1m/s, a +5 second shift would shift all values 5 m below where they were recorded. For oceanic waters with little variation, this could be okay. But for Arctic waters with chlorophyll maxima and oxygen peaks, this could create a big shift between these two events (SCM and O<sub>2</sub> peak). In Pascal's opinion, it is scientifically incorrect to create a gap between SCM and O<sub>2</sub> peak. Pascal either does not apply an oxygen correction, or he applies a 0.5s correction (same as for temperature and conductivity).

c. Click Start Process

#### 15. Cell Thermal Mass

- a. As per the data processing manual, "Perform conductivity cell thermal mass correction if salinity accuracy of better than 0.01 PSU is desired in regions with steep gradients. Note: do not use Cell Thermal Mass for freshwater data."
  - i. Note that Cell Thermal Mass is being used here on two casts that at first appeared to have captured samples with conductivity of less than or equal to 6 mS/cm; however, looking at the rosette logs and comparing the downcasts and upcasts for these casts, it is evident that the low conductivity values in the downcast are a result of CTD pump issues. In the final file, upcasts will be used for these two casts, and the upcasts do not have any conductivity values less than or equal to 6 mS/cm:
    1. WK\_08122022\_017
    2. WK\_08192022\_023
- b. SBE Data processing → Run → Cell Thermal Mass (#4) → File Setup
  - i. Program setup file: 06\_CTMass\_SN7798\_ROSCTD.psa
  - ii. Input directory: 04\_align folder (all casts)
  - iii. Output directory: 05\_ctmass folder
- c. → Data setup → Correct primary conductivity values
  - i. Thermal anomaly amplitude (alpha): 0.04
  - ii. Thermal anomaly time constant (1/beta) = 8.0
- d. Click Start Process

#### 16. Loop Edit (flags scans with very low and backward velocity)

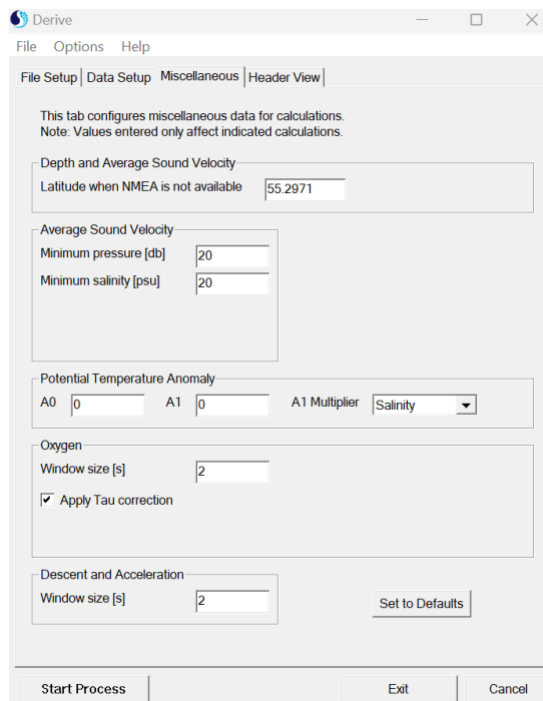
- a. SBE Data processing → Run → Loop Edit (#5) → File Setup
  - i. Program setup file: 07\_LoopEdit\_SN7798\_ROSCTD.psa
  - ii. Input directory: 05\_ctmass folder (all casts)
  - iii. Output directory: 06\_loopedit folder
- b. → Data Setup
  - i. Minimum velocity type: Fixed minimum velocity
  - ii. Minimum CTD velocity (m/s): 0.05. Note that Pascal recommended using velocity < 0.1 m/s (as opposed to the SBE recommended 0.25 m/s).
  - iii. Uncheck "Remove surface soak"
  - iv. Check "Exclude scans marked bad"

- c. Click Start Process
- 17. Derive (computes thermodynamic properties based on EOS-80 (practical salinity))
  - a. SBE Data processing → Run → Derive (#6) → File Setup
    - i. Program setup file: 08\_Derive\_SN7798\_ROSCTD.psa
    - ii. Instrument configuration file: ROS\_7798\_2022.xmlcon
    - iii. Input directory: 06\_loopedit folder (all casts)
    - iv. Output directory: 07\_derive folder
  - b. → Data Setup → Select Derived Variables

Select Derived Variables

Seq. #	Variable Name [unit]
1	Density [density, kg/m <sup>3</sup> ]
2	Density [sigma-theta, kg/m <sup>3</sup> ]
3	Depth [salt water, m]
4	Oxygen, SBE 43 [ml/l]
5	Oxygen, SBE 43 [umol/kg]
6	Oxygen, SBE 43 [% saturation]
7	Potential Temperature [ITS-90, deg C]
8	Salinity, Practical [PSU]
9	Specific Volume Anomaly [10 <sup>-8</sup> * m <sup>3</sup> /kg]

- i. → Miscellaneous
  - i. Latitude when NMEA is not available: average starting latitude of all casts from the logbook (55.2971)



- d. Click Start Process
- e. Optional step that was not done: Use Derive TEOS-10 (absolute salinity) module to derive variables based on TEOS-10.

## 18. Bin Average

- a. SBE Data processing → Run → Bin Average (#8) → File Setup
  - i. Program setup file: 09\_BinAvg\_SN7798\_ROSCTD.psa
  - ii. Input directory: 07\_derive folder (all casts)
  - iii. Output directory: 08\_binavg folder
- b. → Data Setup
  - i. Bin type: Pressure
  - ii. Bin size = 0.5

The screenshot shows the 'Bin Average' software window with the 'Data Setup' tab selected. The 'Bin type' is set to 'Pressure' and the 'Bin size' is 0.5. There are three checked options: 'Include number of scans per bin', 'Exclude scans marked bad', and 'Include surface bin'. The 'Begin scans to skip over' and 'End scans to omit' are both set to 0. The 'Min scans per bin' is 1 and the 'Max scans per bin' is 2147483647. The 'Cast to process' is set to 'Upcast and downcast'. At the bottom, there are three buttons: 'Start Process', 'Exit', and 'Cancel'.

iii.

- c. Click Start Process

## 19. Split (splitting the downcast from upcast)

- a. SBE Data processing → Run → Split (#17) → File Setup
  - i. Program setup file: 10\_Split\_SN7798\_ROSCTD.psa
  - ii. Input directory: 08\_binavg folder (all casts)
  - iii. Output directory: 09\_split folder
- b. → Data Setup
  - i. Output files: upcast and downcast (it will rename each file for downcast with a "d" and upcast with a "u" in front of the file name)
  - ii. Check "Exclude scans marked bad"
- c. Click Start Process

## 20. Merging with logbook (using R)

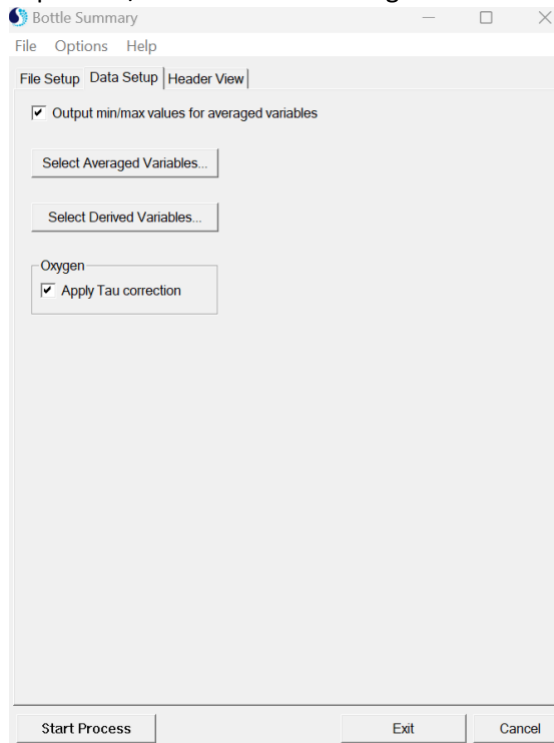
- a. Run the 03\_final\_file.R script to merge CTD data with the logbook and output Excel and ODV files.

## 21. Create bottle files

- a. SBE Data Processing → Run → Bottle Summary (#9) → File Setup
  - i. Program setup file: 11\_BottleSum\_SN7798\_ROSCTD.psa
  - ii. Instrument configuration file: ROS\_7798\_2022.xmlcon



- iii. Input directory: select all .ros files in 01\_datacnv folder
- iv. Output directory: 10\_bottlesum folder
- b. → Data Setup
  - i. Check Output min/max values for averaged variables



- 1.
- ii. Under Select Averaged Variables, Select All
- iii. Under Select Derived Variables, select the following:

Seq. #	Variable Name [unit]
1	Density [density, kg/m <sup>3</sup> ]
2	Density [sigma-theta, kg/m <sup>3</sup> ]
3	Oxygen, SBE 43 [ml/l]
4	Oxygen, SBE 43 [umol/kg]
5	Oxygen, SBE 43 [% saturation]
6	Potential Temperature [ITS-90, deg C]
7	Specific Volume Anomaly [10 <sup>-8</sup> * m <sup>3</sup> /kg]
8	
9	
10	
11	
12	
13	
14	
15	

- 1.
- iv. Start Process

22. Create final bottle data file

- a. Run the 04\_read\_bottle\_files.R script to output a user-friendly rosette bottle data file.