## REVISION NOTICE TABLE

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| DATE | DESCRIPTION OF REVISION |
| 18 March 2025 | Updated TSG channel names and formats. GG |

## PROCESSING NOTES

Cruise: 2023-032

Agency: OSD

Other Participating Groups: Council of the Haida Nation, Gwaii Haanas program team members

Location: Haida Gwaii

Project: Haida Gwaii Collaborative Ocean Science and Monitoring Expedition

Chief Scientist: Page S.

Platform: John P. Tully

Cruise Dates: 18 September 2023 – 9 October 2023

Processed by: Germaine Gatien

Date of Processing: 8 May 2024 – 23 May 2024

Number of original HEX files: 45 Number of processed CTD files: 44

Number of rosette casts: 24 (1 test, 7 bulk water) Number of processed CHE files: 16

Number of original TSG files: 1 (in 2 formats) Number of processed TOB files: 13

# INSTRUMENT SUMMARY

CTD #1515 was mounted in a rosette and attached were 2 Wetlabs CSTAR transmissometer (1185DR & #1883DG), a SBE 43 DO sensor on the primary pump (#1119), SeaPoint Fluorometer on the secondary pump (#3950), a Biospherical QSP-400 PAR sensor (#70613), a SPAR sensor (#16504) and an altimeter (#79787).

A thermosalinograph (SeaBird 45 S/N 0789) was mounted with a Wetlabs WETStar fluorometer (#1656) and separate flow meters for the TSG and fluorometer; sampling interval was 5s.

Seasave version 7.26.7.121 was used for acquisition.

The data logging computer WP #104.

The deck unit was a Seabird model 11+ #508.

An IOS rosette with 24 10L bottles was used.

# SUMMARY OF QUALITY AND CONCERNS

The Daily Science Log Book and rosette log sheets were in good order with comments about problems encountered and a detailed list of equipment. A bottle summary file was provided that is very useful. There is no mention in the log that a TSG was in use and no comments about any problems with it.

There were two deployment procedures used during this cruise, as follows:

* For most casts there was a soak at about 2m which lasted typically lasted for about 80 minutes after the pumps came on; then the full cast was run. A wait of at least 2 minutes is recommended.
* For some casts the CTD was taken to 10m for a soak of 80 to 100 seconds with pumps on, after which it was brought up to about 2m and soaked for 5 to 30s after which the full cast was run. A longer wait at 2m is recommended, on the order of 1 minute.

There was no record in the log about the deployment strategy.

For rosette casts:

Niskin bottles closed from 0 to 200db had a wait time of 60 seconds.

 Niskin bottles deeper than 200db had a wait time of at least 30 seconds.

There were 2 WetLabs CStar transmissometers in use during this cruise:

 Channel Transmissometer refers to sensor #1185DR (650nm - red)

 Channel Transmissometer:Green refers to sensor #1883DG (530nm - green)

For comparison with other Institute of Ocean Sciences cruises, note that the transmissometer wavelength is 650nm unless otherwise stated.

Event #43 had an unusual upcast, with all variables (except PAR) offset vertically from the downcast by about 30m through the pycnocline. The downcast temperature is within the climatology but some of the upcast is not. Upcast and downcast are close in T-S space so it does not look like the CTD malfunctioned. Pumps were on throughout. While stopped for a bottle at 100db temperature rose steadily from 7.3°C. to 8.2°C. There are other casts with significant vertical offsets in that region, but not as noticeable as #43 and none with temperature outside the climatology.



The comparison of fluorescence with extracted chlorophyll showed an unusual relationship for casts 47, 49 and 53 with fluorescence being higher than expected relative to CHL. Those casts are all near Oshawa Seamount.

There are too few data to make an estimate of errors in CTD Dissolved Oxygen. But the results from below 200db indicate that the sensor was working very well with differences <<0.006mL/L; above that level differences were <0.04mL/L which is typical of near-surface performance.

The fluorometer on the TSG appears to need service as the offset in the calibration no longer is appropriate. This was reported to the CTD technician who believes the lamp needs replacement. Reasonable values were obtained by setting the offset to 0. Values should be considered nominal.

Both flow meters were malfunctioning. The flow meter to the TSG fluorometer had many low values including many 0s. The fluorescence looks similar to the CTD fluorescence even when the flow rate was 0, so the fluorometer appears to have been working well for the most part. Occasionally, the 0 flow rate appears to have been accurate and fluorescence data were padded for those sections. The flow meter for the TSG was also unreliable; zero values appear accurate, but the large variations in rate were found to be inaccurate when checks were made at sea. The flow meter channels have been removed from the final files since the data are unreliable.

TSG salinity was recalibrated by adding 0.182psu based on comparisons with CTD salinity.

A post cruise factory service report for the thermosalinograph noted little drift tin temperature but excessive drift in conductivity. There was a cruise between 2023-032 and the factory service.

# PROCESSING SUMMARY

##### Seasave

This step was completed at sea; the raw data files have extension HEX.

##### Preliminary Steps

The Log Book and rosette log sheets were obtained.

* Nutrients, extracted chlorophyll, dissolved oxygen and salinity data were obtained in QF spreadsheet format from the analysts.
* The cruise summary sheet was completed.
* The history of use of the pressure, conductivity and dissolved oxygen sensors was obtained.

They were all used during part of cruise 2023-066, all of 2023-088 and 2023-026 since they were last serviced at the factory.

The configuration files were checked and no problems were found.

##### BOTTLE FILE PREPARATION

The HEX files were converted to ROS files using file 2023-032-ctd.xmlcon.

The ROS files were converted to IOS format.

The IOS files were put through CLEAN to create BOT files.

Temperature and salinity were plotted for all BOT files to check for significant outliers. Casts #21, 43 and 66 needed light editing of salinity using CTDEDIT. The output files \*.ED1 were copied to \*.BOT.

A preliminary header check was run; and no errors were found.

A cross-reference list showed an error in station name for event #20. That was corrected in all relevant files..

The BOT files were bin-averaged on bottle number.

The output was used to create file ADDSAMP.csv. First, the file was sorted on event number and Bottle Position order. Then sample numbers were added based on the rosette logs.

The ADDSAMP file was then reordered on event # & sample #.

The ADDSAMP file was used to add sample numbers to the BOT files – output \*.SAM.

The SAM files were bin-averaged on bottle # and called SAMAVG.

The SAMAVG file for event #1 was removed since there was no sampling.

The addsamp.csv file was converted to CST files, which will form the framework for the bottle files.

Next, each of the analysis spreadsheets were examined to see what comments the analysts wanted included in the header file. These were used to create file 2023-032-bot-hdr.txt which will be updated as needed during processing.

There were no loop samples.

DISSOLVED OXGYEN

Dissolved oxygen data were provided in spreadsheet QF2023-032\_OXY\*.xlsx which includes flags, comments and a precision study. Draw temperatures are available. The spreadsheet page with the final data was simplified and saved as 2023-032oxy.csv. That file was converted into individual \*.OXY files.

EXTRACTED CHLOROPHYLL

Extracted chlorophyll and phaeo-pigment data were obtained in file QF2023-032\_CHL QF\*.xlsx. The file included comments and flags and a precision study. A simplified version of the spreadsheet was prepared and saved as 2023-032chl.csv. The csv file was then converted to individual CHL files.

SALINITY

Salinity analysis was obtained in file QF2023-032\_SAL.xlsx which included a precision study. The analyses were carried out in a temperature-controlled lab 31 to 40 days after collection. The files were simplified and saved as 2023-032sal.csv. That file was then converted to individual SAL files.

NUTRIENTS

The nutrient data were obtained in spreadsheet QF2023-032\_NUTS\*.xlsx. This includes a precision study. The file was simplified, saved as 2023-032nuts.csv. The file was converted to individual NUT files.

The SAL, CHL, OXY and NUT files were merged with CST files in 4 steps.

After the 4th step the files were put through CLEAN to reduce the headers to File and Comment sections only.

These files are ordered on sample number, but the SAMAVG files are ordered on bottle number, so one or the other set needs to be reordered in order to merge them. The MRGCLN1 files were reordered on Bottle\_Number and saved as \*. MRGCLN1s.

The MRGCLN1s files were then merged with SAMAVG files using merge channel Bottle\_Number.

The output of the MRG files were exported to a spreadsheet and compared to file 2023-032\_Bottle\_Summary.xlsx to look for omissions. No problems were found:

##### Compare

Salinity

Compare was run with pressure as reference channel.

There is a lot of noise in the fit above 200db, some due to noisy CTD data and others that are likely due to incomplete flushing of Niskin bottles.

When bottles above 200db, and samples with salinity standard deviation >0.001psu are excluded there is 1 outlier. That came from the bottom of a cast and very close to the seabed. When that was excluded the fit of differences versus pressure is quite flat with primary salinity low by an average difference of 0.0085psu (std dev 0.0015) and secondary salinity low by 0.0074psu (std dev 0.0014).

These differences suggest drift since the previous use during 2023-026, but the data available are very limited, with 2 shallow casts and 1 deep one.

Cast #43 has suspicious data in the upcast with a larger vertical offset between downcast and upcast than usual. Later investigation suggests this is the effect of an internal wave, not instrumental trouble.

When only the deep cast is included the primary is low by 0.0078db and the secondary by 0.0069db.

The secondary is quite close to the 2023-026 results when the primary and secondary were low by 0.0053psu and 0.0063psu. There may be a little drift, with more in the primary than secondary.

For full details for the COMPARE run see file 2023-032-sal-comp1.xls.

Dissolved Oxygen

COMPARE was run with pressure as the reference channel.

Sampling was done at only a single cast which was deep and in exposed water, so flushing of bottles should be fairly good.

When the offset found best for 2023-026 was selected the fit found for (CTD DO – OXY BOT) vs CTD DO was:

CTD DO Corrected = CTD DO \* 1.0144 - 0.0319

Which is remarkably close to that found during 2023-026:

 CTD DO Corrected = CTD DO \* 1.0148 - 0.0319

So using the result from 2023-026 looks appropriate for recalibration of CTD DO.

For full details for the COMPARE run see file 2023-032-dox-comp1.xls.

Fluorescence

COMPARE was run with extracted chlorophyll and CTD Fluorescence using pressure as the reference variable.

The comparison of CTD fluorescence with extracted chlorophyll looks noisier than usual with distinct groups of casts. When the data were separated into West and East groups simpler pictures emerged.

West of Haida Gwaii CTD fluorescence is much higher relative to CHL than for Eastern Haida Gwaii even though the range of CHL is similar.

The distribution in the eastern section is tighter. To the west there is still a distinct group in the plots with the 4 casts from near Oshawa Seamount standing out.

For full details for the COMPARE run see file 2023-032-fl-chl-comp1.xls.

##### Conversion of Full Files from Raw Data

Hex files were converted to CNV files using 2023-032-ctd.xmlcon.

The Tau function and the hysteresis function were selected since there was deep sampling. Depth was included in the conversion.

A few casts were examined and all expected channels are present. A few small spikes in conductivity were seen.

Cast #43 looks very strange, with a large offset between downcast and upcast. This was not near a seamount.

##### WILDEDIT

Program WILDEDIT was run to remove spikes from the pressure, depth, conductivity and temperature on the CNV files.

Parameters used were: Pass 1 Std Dev = 2 Pass 2 Std Dev = 5 Points per block = 50

The parameter “Keep data within this distance of the mean” was set to 0 so all spikes would be removed.

Conductivity spikes noted in the previous step were removed.

##### ALIGN DO

ALIGNCTD was run on all casts using +2.5s since it is generally found to be the best choice. Tests were run after derivation of oxygen concentration and the alignment was much improved by this step.

##### CELLTM

CELLTM was run using default values (α = 0.0245, β=9.5) for both the primary and secondary conductivity. Tests were run after DERIVE was run and the T-S curves for downcast and upcast were much closer after this step.

##### DERIVE and Channel Comparisons

Program DERIVE was run on all casts to calculate primary and secondary salinity and dissolved oxygen concentration.

Checks were made to see that steps 6, 7, 8 worked reasonably well and they did.

Cast #43 looks reasonable in T-S space. There was some drift during the cast so the offset may be partially geographic but mostly due to internal wave action. There were many stops for bottles so the DO alignment is hard to assess.

The alignment of dissolved oxygen with temperature looks ok.

Celltm worked well to bring downcasts and upcasts into agreement in T-S space.

DERIVE was run a second time on some of the deeper casts to find the differences between the pairs of temperature, conductivity and salinity channels.

All differences were very small, but there is a slight pressure dependence.

The shaded entries are from previous cruises during which this CTD was in use since last factory service.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cast # | Press | T1-T0  | C1-C0 | S1-S0 | Descent Rate |
| 2023-066-0046 | 1000 | -0.0002 | -0.00007 | -0.0008 | High, Noisy |
|  | 2000 | -0.0003 | -0.00009 | -0.0008 | “ |
|  | 2500 | -0.0003 | -0.00009 | -0.0007 | High, Noisy |
| 2023-066-0052 | 1000 | -0.0002 | -0.00004 | -0.0003 | “ |
|  | 2000 | -0.0005 | -0.00006 | -0.0003 | “ |
|  | 2500 | -0.0007 | -0.00007 | -0.0002 | “ |
|  | 3000 | -0.0008 | -0.00006 | -0.0001 | “ |
|  | 3500 | -0.0008 | -0.00008 | 0 | “ |
| 2023-088-0033 | 1000 | -0.0003 | +0.00002 | +0.0003 | High, Moderate |
| “ | 2000 | -0.0005 | -0.00002 | +0.0003 | “ |
| “ | 3000 | -0.0006 | -0.00003 | +0.0005 |  |
| 2023-088-0064 | 1000 | -0.0003 | -0.00009 | -0.0009 | Mod, VNoisy |
| “ | 2000 | -0.0005 | -0.00012 | -0.0010 | “ |
| “ | 3000 | -0.0007 | -0.00012 | -0.0007 | “ |
| “ | 3900 | -0.0008 | -0.00012 | -0.0007 | “ |
| 2023-088-0076 | 1000 | -0.0003 | -0.00014 | -0.0015 | High, Noisy |
| “ | 2000 | -0.0005 | -0.00015 | -0.0015 | “ |
| “ | 3000 | -0.0007 | -0.00016 | -0.0013 | “ |
| “ | 4000 | -0.0009 | -0.00017 | -0.0011 | “ |
| 2023-026-0036 | 500 | -0.0001 | -0.00006 | -0.0004 | High, Moderate |
|  | 1000 | -0.0003 | -0.00007 | -0.0007 | “ |
| 2023-026-0098 | 500 | -0.0002 | -0.00005 | -0.0003 | High, F. Noisy |
|  | 1000 | -0.0003 | -0.00007 | -0.0007 | “ |
| 2023-026-0150 | 500 | -0.0002 | -0.00004 | -0.0003 | High, Noisy |
|  | 1000 | -0.0003 | -0.00006 | -0.0005 | High, V. Noisy  |
| 2023-032-0006 | 1000 | -0.0003 | +0.00007 | +0.0012 | High, V. Noisy |
|  | 1800 | -0.0005 | +0.00006 | +0.0012 |  |
| 2023-032-0053 | 1000 | -0.0002 | +0.00004 | +0.0007 | High, Noisy |
|  | 1800 | -0.0004 | +0.00002 | +0.0006 |  |
| 2023-032-0061 | 800 | -0.0002 | +0.00007 | +0.0009 | High, F.Noisy |

The temperature differences are very close to those seen previously while the conductivity differences have changed sign and salinity differences are slightly higher than in most of the previous uses.

##### Conversion to IOS Header Format

The IOSSHELL routine was used to convert Sea-Bird 911+ CNV files to IOS Headers.

CLEAN was run to add event numbers and to replace pad values in the pressure channel with interpolated values based on record number.

Notes in the log said that the NMEA feed was not connected, but no problems were found in a cross-reference list and there are NMEA entries in the files. Probably a work-around was in use at sea. In any case there are no corrections needed.

Most casts had acquisition begin after the 10db soak but 11 started from the beginning.

CLIP was run on casts 14, 26, 29, 36, 39, 40, 43, 47, 60 and 69 to remove a number of records based on plots of pressure versus scan number.

Cast #25 was removed from the processing stream as it only contained surface data; the log indicates the cast was not run due to high winds.

##### Checking Headers

* The cross-reference check was run and compared to the Daily Science Log. There station names in 6 casts did not match the log entries, one of which was just a spelling error. The names were corrected in the headers.
* The header check were run. There are off-scale values that will likely disappear in processing.
* Surface check was run and the average surface value was 0.164db with a few negative values but none <-0.13db.
* During cast #21 the CTD appears to have been right at the surface at the end of the cast when pressure was roughly 0.1db, judging by 0 transmissivity.
* The bottle file header check shows silicate will not need recalibration for the final file.
* Cruise tracks were plotted and added to the end of this report.

The bottle comparison led to suspicions about cast #43 (station DE3) upcast data. While this will not affect the final CTD files, some investigation was done to see if there was an equipment problem that led to this.

* Preliminary plotting showed a large vertical offset between the downcast and upcast.
* The upcast temperature is well outside the climatology from ~45-85db, while the downcast is all within it. Salinity is within the climatology both down and up.
* In T-S space downcast and upcast are reasonably close.
* While stopped for a bottle at 100db temperature rose steadily from 7.3°C to 8.2°C.
* The COMPARE file for salinity was examined to see if the data were out of line; there are only 3 casts and #43 is too shallow to make a comparison reliable, but CTD salinity values were mostly lower than bottles by more than for the other 2 casts.
* The standard deviations in the CTD salinity in the rosette files were very high from 100 to 200db. Above 50db all salinity values looked like those expected in this well-mixed surface section.
* The pumps were on; while there may have been some problem with pumps there is no evidence of that in the profiles.

The upcast data are unusual but the downcast looks normal. There are other casts with significant vertical offsets, the second largest being at station DE1 (event 40), but temperature does not fall outside the climatology.

The altimeter and water depth readings from the headers of the CLN files were exported to a spreadsheet. A check value was calculated by subtracting water depth from maximum depth sampled plus altimetry header.

Some casts did not get within 15m of the bottom, so there is no entry in the header.

There were 10 cases of the check value being ≥5db and 1with no water depth entered in the header.

Because of the nature of this cruise it is likely that using sounder readings from the bottom of the cast are more appropriate for the CTD casts, and in particular, for bottle files.

Where the sounder reading was available from the bottom, those were entered into the spreadsheet and check values calculated.

In most cases the log entries improve the results significantly, so those depths were entered into the headers of 8 CLIP files that had improved results: : 1, 6, 10, 14, 21, 41, 47, 59.

The changes were also applied to the SAM files for #6, 14, 21 and 47.

SAMAVG, MERGE and CLEAN were rerun after that step.

##### Shift

Fluorescence

SHIFT was run on the SeaPoint fluorescence channel in all casts using the usual advance of +24 records. Plots show that the fluorescence offset is reasonably close to the temperature offset after this step.

Dissolved Oxygen

The Dissolved Oxygen voltage channel was aligned earlier. A few casts were checked to see if the alignment looked ok, and it did. No further alignment is needed for the DO concentration channel.

Conductivity

Tests were run on a 2 casts to see if the alignment shift used during 2023-026 looked best for the 2 conductivity sensors as judged by noise in T-S space; those settings looked best for the primary data but for the secondary better results were found using -0.4 for the secondary instead of -0.6.

SHIFT was run twice on all SBE911 casts using -0.35 records for the primary and -0.4 for the secondary. Salinity was recalculated for both channels.

##### DELETE

The following DELETE parameters were used:

Surface Record Removal: Last Press Min

Maximum Surface Pressure (relative): 10.00

Surface Pressure Tolerance: 1.0 Pressure filtered over 15 points

Swells deleted. Warning message if pressure difference of 2.00

Drop rates < 0.30m/s (calculated over 11 points) will be deleted.

Drop rate applies in the range: 10db to 10db less than the maximum pressure

Sample interval = 0.042 seconds. (taken from header)

COMMENTS ON WARNINGS: There were no warnings.

##### Other Comparisons

Experience with these sensors since last factory service –

The pressure, temperature, conductivity and dissolved oxygen sensors were used for 4 cruises between the last factory service and this cruise.

* 2023-066 -The pressure, temperature, conductivity and dissolved oxygen sensors were used for part of the cruise. Results were not as secure as usual due to spiking and some casts had averaging of CTD data in acquisition. Primary salinity was low by 0.0018psu; secondary was low by 0.0023psu; standard deviation was 0.0013 for both channels. Pressure was thought to be low by 0.5db, but lab tests later showed no significant error. Oxygen was corrected using linear correction with slope 1.0227 and offset 0.0113. Fluorescence comparisons with extracted chlorophyll were very noisy but roughly as expected.
* 2023-069 – Salinity estimated to be low by 0.002psu for both channels. Dissolved oxygen was recalibrated using preliminary results of 2023-088. Pressure was considered ±0.2db.
* 2023-088 – Time-dependent correction applied to salinity channels. Pressure did not need recalibration. DO correction was:

CTD DO Corrected = CTD DO \* 1.0165 + 0.025

* 2023-026 – No time dependence noted in salinity. Pressure fine. Added 0.0053psu to the primary salinity and 0.0063 to the secondary salinity. DO correction:

CTD DO Corrected = CTD DO \* 1.0148 - 0.0319

Historic ranges – Profile plots were made with 3-standard deviation climatology ranges of T and S superimposed.

* Downcast data from the offshore area were all within the climatology. The deep waters in Dixon Entrance had lower salinity and higher temperatures below 150-200db. Much of the data in the narrow passages of Haida Gwaii fell outside the climatology since it is mostly based on Hecate Strait casts. These excursions do not suggest calibration problem.

Post-Cruise Calibration – None available.

##### DETAILED EDITING

The DEL files were sent to the QC program for predictions.

The primary sensor pair were chosen to edit and archive but the secondary pair looked almost as good.

All DEL files were copied to \*.EDT.

CTDEDIT was used to remove records that appear to be corrupted by shed wakes. Salinity was cleaned to remove spikes that appear to be due to small misalignment or instrumental noise.

All files required some editing. Notes about editing applied were added to the files.

After editing, T-S plots were examined for all casts; a few casts have some unstable features but they were close to the surface or in areas where tidal mixing does occur. Cast #41 needed a little more editing. After bin averaging most of those features look stable except for a couple of very well-mixed shallow casts. No further editing was applied.

##### Corrections to Salinity and Dissolved Oxygen Concentration

There was no salinity <25psu in CTD salinity in the bottle files (MRG) so silicate does not need correction in the bottle files.

CALIBRATE was run on MRG and SAM files using file 2023-032-recal1.ccf to add 0.0078psu to the primary salinity and 0.0069 to the secondary salinity and to apply the following correction to dissolved oxygen concentration:

 CTD DO Corrected = CTD DO \* 1.0148 - 0.0319

COMPARE was rerun for dissolved oxygen and shows that the correction improved the fit greatly. When all data were included, the SBE DO was found to be low by an average of 0.006mL/L and standard deviation of 0.029mL/L. This shows the recalibration worked well for at least the 1 cast with sampling.

COMPARE was rerun for salinity and when the same data were included as in the original fit the primary salinity was low by an average of 0.0005psu and the secondary was low by 0.0004psu. Standard deviations were 0.0015psu for the primary and 0.0014 for he secondary. When only cast #6 was included the differences were 0.0000psu for both.

CALIBRATE was then run on the EDT files using file 2023-032-recal1.ccf.

##### Final Calibration of DO

The initial recalibration of dissolved oxygen corrects for sensor calibration drift. Alignctd corrects for transit time errors. Those 2 steps may partly correct for response time errors, but to see if a further correction is needed, a comparison is made of downcast CTD data to upcast bottle data at the same pressure. Small differences are expected due to ship drift, temporal changes, incomplete flushing of Niskin bottles and delayed response and noise in CTD data.

The downcast file was bin-averaged to 0.5m bins cast #49 as it was the only ones with DO bottle samples. That file was then thinned and compared to the bottle values in the MRG files. COMPARE was run to study the differences between the downcast CTD DO data and the titrated samples from upcast bottles.

The CTD DO was lower than the titrated samples by an average of 0.040mL/L when outliers were removed based on residuals but the standard deviation was 0.152mL/L. Below 100db the CTD DO is low by 0.002mL/L.

There are too few data to make an estimate of errors in CTD DO. But the results from 200db down indicate that the sensor was working well. Differences above that level are within the range found during the previous cruise.

##### Fluorescence Processing

A median filter, size 11, was applied to the fluorescence channel in the COR1 files. Plots of a few casts showed that the filter was effective. (Output:\*.FIL)

##### BIN AVERAGE of CTD files

The following Bin Average values were applied to the FIL files (output AVG):

Bin channel = pressure Averaging interval = 1.000 Minimum bin value = .000

Average value will be used. Interpolated values are NOT used for empty bins.

On-screen T-S plots were examined and no problems noted.

Profile plots were examined. Transmissivity at depth was noisy for casts near Haida Gwaii. No other issues were noted.

##### Final CTD File Steps (REMOVE and HEADEDIT)

REMOVE was run to remove the following channels:

Scan\_Number, Temperature:Secondary, Conductivity:Secondary, Oxygen:Voltage:SBE, Descent\_Rate, Status:Pump, Altimeter, Salinity:T1:C1, Prediction\_Flag and Flag.

PAR was removed from casts: 6,9,10,11,12,49,53,59,60,61

At this stage the EDT files were zipped and sent to Lee Croft using CTD-QC-Client 1.1.0.

A second SBE DO channel (with umol/kg units) was added.

REORDER was run to get the two DO channels together.

HEADER EDIT was used to fix formats and channel names and to add comments about processing.

The Standards Check routine was run and no problems were found.

The Header Check was run; no problems were found except that the project name was truncated; it was shortened for the headers.

Profile and T-S plots were examined. A few small unstable features were found but may well be due to active mixing. No other problems were found.

The sensor history was updated.

##### Dissolved Oxygen Study

As a final check of dissolved oxygen data, % saturation was calculated and plotted. Values at 2 to 3m ranged from ~65% to 103%. The highest values were west of Haida Gwaii and in Saanich Inlet and the Discovery Islands area. The offshore values were 97%-99% which is a little lower than usual but the casts were well-mixed.

##### Final Bottle Files

SORT was run to arrange casts in pressure order.

REMOVE was run to remove the following channels:

Scan\_Number, Temperature:Secondary, Conductivity:Secondary, Oxygen:Voltage:SBE, Descent\_Rate, Status:Pump, Altimeter, Salinity:T1:C1 and Flag.

PAR was removed from casts: 6,9,10,11,12,49,53,59,60,61

A second SBE DO channel with mass units was added for both the CTD DO and titrated DO and REORDER was run to get the pairs of DO channels together.

EDIT HEADERS was run to fix formats and channel names and to add comments about analyses and CTD processing.

The standard check was run and the only problem found is that files had been produced for casts with no sampling. Those were cases where the only sampling was for bulk water for the use of Mike Stainton. No CHE files will be sent to the main archive for those cast, but bottle files will be saved in case needed later.

Data were exported from the CHE files to file 2023-032-bottles-final.xlsx. A few random checks were made by comparing with the rosette log sheets and no problems were found.

A header check were run. No problems were found.

The track plot looks ok.

Plots of each file were examined and no problems were found.

A cross-reference listing and header check were produced for the CHE files.

##### Thermosalinograph Data

An IOS TSG45 was used for this cruise.

Data were delivered in 1 file.

Flow was off for both thermosalinograph and fluorometer for the first 8.6 hours and the last 10 minutes. Those data were removed from the files.

Flow to TSG on for 2 minutes so flow is stabilized: Sept. 21 17:59. Flow to TSG off: Oct. 3.14:30

Flow rate to the TSG was erratic and the flow meter for the fluorometer had many 0 values. Both problems may be due meter malfunctions rather than the flow itself.

The date and time were in a single column. Ultraedit was used to separate them.

The spreadsheets were adjusted as follows:

* 2 lines of headers were added – channel names and units.
* A column with pressure was added with all values set to 4.5 (to enable derivation of salinity).
* A temperature difference column was included in the data file (Lab - Intake).
* The fluorescence channel is in volts. It was moved to column M. Then a concentration value was calculated in column F using scale 14.6 as determined in the most recent factory recalibration of the fluorometer. The factory clean water offset value was 0.081. For previous uses of this equipment it was has been found necessary to adjust the offset to avoid negative values. The offset used has steadily decreased. During the previous cruise a value of 0.062 was used. When that value was used for these data, the fluorescence values were frequently negative. There were problems with flow rates, so a check was made at times of 2 CTD casts when TSG flow rate looked steady and fairly high:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Event # | Station | TSG FL | CTD FL | CHL | Comments |
| 26 | LSK1 | 0.17 | 1.1-1.7 | 2.2 | Expect TSG FL to be ~1 close to CTD FL and CHL |
| 47 | Oshawa | 0.56 | 1.7-1.8 | 1.4 | Expect TSG FL to be close to CTD FL and CHL |

These comparisons do suggest a problem with either sensor calibration or flow. But when the offset was set to 0, the values look much better, about 0.9 for event #26 and 1.4 for event #47. The maximum and minimum for the cruise look reasonable with that choice. So the offset 0 will be used for initial values; that can be adjusted later if there is any evidence to suppose that choice. The lamp may be a problem.

The files were then converted to IOS Header format with header info added.

There are 13 IOS files, each covering all or part of 1 day. The plots were separated into 2 groups for time-series plotting.

CLEAN was run to reset the number of records, min and max values, set the start and end times, and latitude and longitude limits.

ADD TIME CHANNEL was used to add Julian dates – i.e. Decimal Year. A record number was also added to enable averaging (for use in comparison to CTD files). Time zero was set to 31 December 2022 0:00:00. (Note that this step leads to problems plotting until REORDER is run.)

DERIVED QUANTITIES was run twice, first to derive salinity using the lab temperature and again to derive sigma-T.

REORDER was run to move the Julian date after the Time/Date channels and salinity and fluorescence after the lab temperature. Also the record # was moved to the end. Channels not selected were removed.

a.) Plots

A track plot was produced and added to the end of this report.

Time-series plots were produced:

* As noted earlier there are many instances of flow to the fluorometer being very low or 0. There is some question of whether this is due to low flow or meter malfunction.
* The flow rate to the TSG varies a lot with no flow late on the 24th September and when flow comes on again it is at a much higher rate than usual. That rate stays fairly high but gradually lowers as time goes on. When the flow was 0 the intake temperature rises indicating that this was a real stop in flow, not a meter malfunction.
* There is no obvious relation between flow rate to the fluorometer and fluorescence traces, but this was a complex cruise visiting many different ecosystems.
* Salinity has only a few large single-point spikes.
* The temperature differences are very noisy but most values are between 0.2 and 0.3C°. Where intake waters were cooler we expect more warming but often the flow rate was higher which reduces warming, so no simple relationship is likely to emerge.
* There is unusual small scale variability in the intake temperature on Sept. 24th and 25th at times when the ship was in open waters east of Haida Gwaii.

b.) Checking Time Channel

The CTD files were thinned to reduce the files to a single point from the downcast at or within 0.5db of 4.5db. These were exported to a spreadsheet which was saved as 2023-032-tsg-ctd-loop-comp.xlsx. There were 40 points of comparison

For comparison with CTD data, the TSG files were averaged over 6 records (30s) on record number to reduce the noise and file size. Standard deviations were included. Then required records (times, positions, temperatures with standard dev, salinity with standard dev, fluorescence with standard dev, flow rates) were exported to a spreadsheet and that file was thinned to the closest times of CTDs and added to file 2023-032-tsg-ctd-rosette-comp.xlsx.

A comparison was made of positions for the CTD and TSG data to check for good matches. The differences in positions are expected to be small despite the averaging because the ship was stopped at these times. The median differences were 0.0000º for latitude and 0.0002º for longitude. There were no differences> 0.0007º. So the matches are good.

c.) Comparisons

* Comparison of T, S and Fluorescence from TSG and CTD data

|  |  |  |  |
| --- | --- | --- | --- |
|  | Using all casts |  |  |
|  | Tint-Tctd | Tlab-Tint | Stsg-Sctd | FLtsg/FLctd |
| min | -0.6163 | 0.1563 | -3.6158 | 0.48 |
| max | 0.6866 | 1.1208 | 1.0080 | 2.07 |
| median | 0.0028 | 0.2972 | -0.1840 | 0.96 |
| average | 0.0049 | 0.3225 | -0.4270 | 1.10 |
| std dev | 0.1868 | 0.1634 | 0.7968 | 0.39 |

Excluding some casts based on standard deviations in the TSG temperature and salinity data reduced the standard deviations in the comparison and brought average and median values closer, but it had little effect on the median differences.

|  |  |  |  |
| --- | --- | --- | --- |
| exclusion standard | stdev >0.01 or diff >0.5C | stdev >0.005 | diff>0.005psu |
| # of outliers excluded  | 8 | 4 | 8 |
|  |  |  | Tint-Tctd | Tlab-Tint | Stsg-Sctd |
|  |  | min | -0.0333 | 0.1563 | -0.2255 |
|  |  | max | 0.1353 | 0.6844 | -0.1604 |
|  |  | median | 0.0028 | 0.2927 | -0.1828 |
|  |  | average | 0.0128 | 0.2907 | -0.1829 |
|  |  | std dev | 0.0322 | 0.0895 | 0.0123 |

The extreme outliers all came from the latter part of the cruise, nearshore and especially in inlets. The TSG intake temperature is as close to the CTD temperature as can be expected. TSG salinity is low but for most casts consistently lower than the CTD by about 0.182psu ±0.012. Fluorescence is close to the TSG on average, reading higher at low values and lower at high values.

The comparison of TSG fluorescence with CTD fluorescence looked good. The TSG values were higher at the low end of the range and lower at the high end.

* Comparisons of Rosette Samples and TSG data

There were only 2 near-surface salinity samples from the rosette. The TSG salinity was lower than the rosette salinity by 0.29 and 0.19psu.

There were 16 rosette CHL samples that were compared to TSG fluorescence. The TSG fluorescence was higher than the CHL samples by a median of 18%, but when the ratio TSG/CHL was plotted against CHL the usual pattern was seen with TSG reading higher for low CHL and lower for high CHL. The range of CHL was small.

* There were no loop samples
* Heating in the Loop

The difference between the Intake temperature and Lab temperature due to heating in the loop shows the usual relationship to the intake temperature. The fit would suggest that there would be no heating if the input temperature was about 18°C, which is likely close to the ambient temperature of the ship.

* Flow rate study

The flow meter to the fluorometer was clearly malfunctioning. When flow was 0 the comparison of TSG and CTD fluorescence looks to be unaffected.

The flow meter to the TSG looks better though rates varied from 0.9 to 1.6 during CTD casts. There appears to be no relation between the flow rate and heating in the loop. We would expect heating to be low at higher flow rates. The distribution is too noisy to consider it proof, but there is no suggestion that the flow was varying widely. The CTD technician reported serious problems with the flow meters and checks were made at sea to confirm that flow was actually in the normal range.

d.) Calibration History

The TSG was serviced and recalibrated in early 2022.

* During 2023-066 the intake temperature data looked bad throughout the cruise, with sudden shifts and did not compare well with CTD temperatures. A proxy for intake temperature was created by subtracting 0.53C from the lab temperature based on comparisons to CTD data. Salinity comparisons varied greatly but were, on average, reasonably close to CTD salinity. It was not recalibrated and was reported with 3 significant figures to indicate decreased quality. TSG fluorescence was about 80% of CTD fluorescence in the offshore and about 92% close to shore. Fluorescence was converted with scale 14.6 and offset 0.69.
* During 2023-019 the intake thermistor malfunctioned. TSG salinity was recalibrated by adding 0.03psu which was thought to be an error due to bubbles. Fluorescence was converted using a scale of 14.6 and offset of 0.69. TSG fluorescence was about 80% of CTD fluorescence and 70% of loop samples.
* During 2023-069 the flow rates varied greatly with little effect on the data. Intake temperature was higher than CTD by ~0.002C°. The lab temperature was higher than intake temperatures by 0.273C°. Salinity was recalibrated by adding 0.011psu based on comparisons with CTD and loops. TSG Fluorescence was ~67% of that from the CTD fluorometer and about 50% of extracted CHL samples from the loop.
* During 2023-088 the flow rates had some major drop-outs with more variability in the flow to the fluorometer than to the TSG. TSG salinity was recalibrated by adding 0.12psu based on comparisons to the loop samples, CTD and rosette samples. Fluorescence was about 50% of that from the CTD.
* During 2023-026 the TSG performed well overall, but there were some large gaps in acquisition and some areas where flow was very low or off. Salinity was recalibrated by adding 0.132psu. The intake temperature was higher than the CTD temperature at ~4.5db by 0.008 Cº. The TSG lab temperature was higher than CTD temperature by a median of 0.267Cº.
* A post cruise calibration report noted little drift tin temperature but excessive drift in conductivity. There was a cruise between 2023-032 and the factory service.

e.) Conclusions re TSG

1. The TSG clock worked well and position information is reliable.

2. The flow meters to the TSG and TSG fluorometer were malfunctioning. Checks at sea indicated that the flow rate was in the recommended range even when the flow rate indicated otherwise. Flow rates will not be archived.

3. The TSG salinity was lower than CTD salinity by a median of 0.182psu. TSG salinity was lower than the 2 near-surface rosette samples by 0.29 and 0.19psu. The larger difference came from early in the cruise when the TSG standard deviations were very large. There are some small single-point spikes likely due to small bubbles. They are mostly low by ~0.01psu; a few larger single-point spikes will be addressed in graphical editing. TSG salinity was lower than the 2 near-surface rosette samples by 0.29 and 0.19psu.

4. The TSG intake temperatures are higher than the CTD by about 0.003Cº which is good agreement.

5. The TSG lab temperature was higher than CTD temperature by a median of 0.293Cº. Plots of differences versus intake temperature show the expected relationship of heating decreasing as the intake temperature approaches the ambient temperature of the ship.

6. TSG fluorescence was about close to CTD fluorescence, on average, reading a little higher at the low end of the scale and lower at the high end. A similar result was found when TSG fluorescence was compared to rosette CHL samples.

7. There were no loop samples so all observations are from times when the ship was stopped.

f.) Editing

All REO files were copied to EDT.

All files were opened in CTDEDIT; 6 required no editing.

Small salinity spikes <0.01psu were not edited but a few larger ones were cleaned by interpolation.

Sept. 21 – A few initial fluorescence values removed.

Sept. 23 – Removed one large single-point spike in channel Fluorescence.

Sept. 24 – The temperature differences were very high for about 2 hours between stations HSC1 and JPS6. This corresponds to an area of 0 flow rate. Comparisons with CTD data before and after this section look ok. CTDEDIT was used to remove data from channels Temperature: Intake, Temperature:Lab, Salinity and Fluorescence between 18:15 and 20:20 UTC because flow appears to have been off.

Comparisons with CTD data at 17:45 and 21:47 UTC look good even though flow rate was very low during one of those CTD casts. It is likely that the low rate was not reliable, but the 0 rate was. The meter is known to have problems reporting accurate rates.

Sept. 25 – The pattern of temperature, salinity and fluorescence is odd between about 1:27 and 9:23 UTC. The temperature differences are very noisy which is likely due to rapidly varying temperatures in both lab and intake that are slightly mis-aligned. There is no intersecting CTD cast, but cast #29 at 00:30 UTC at SWI2 compared well. Perhaps this was a tidal effect. No editing was applied.

Sept. 28 – When the ship stopped at station TR1 (cast #44) the fluorescence became noisy with a very large spike midway through the stop. The Fluorometer flow rate changed to 0 during this period, and in this case the zero value appears to be accurate. CTD #44 run through that period shows a maximum of 2ug/L. The fluorescence data were removed from that section, 14:51 to 15:26 UTC.

Sept. 29 – A few spikes in salinity were removed by interpolation and the last 3 fluorescence values were removed.

Sept. 30 – Fluorescence data were removed from a few sections where it appears that the flow to the fluorometer was off.

Oct. 3 – Salinity was cleaned lightly and the last 3 records were removed as flow appears to have been turned off.

The \*.EDU files were copied to \*.EDT.

Plots were made and 2 cases of NaN entries were found in casts from Sept. 23 and 26. Those were fixed with a text editor.

g.) Calibrate and Remove

CALIBRATE was run using file 2023-032-tsg-recal.ccf to add 0.182psu to channel Salinity.

REMOVE was run to remove channels Temperature:Difference and Record #, Flow\_Rate and Flow\_Rate\_FL. (The flow rates were removed because they are unreliable.)

h) Preparing Final Files

HEADER EDIT was used to change the DATA DESCRIPTION to THERMOSALINOGRAPH and add the depth of sampling to the header and to change channel names to standard names and formats and to add comments.

The TSG sensor history was updated.

As a final check plots were made of the cruise track and time-series and all looks fine.

P**articulars - Notes from Daily Science Log and Rosette Logs**

TSG notes

No notes found

CTD notes

1. No stop on upcast. Bottles fired only as test. No sampling.

14. Rosette brought out of water by LARS, did the soak twice to clear air out of pumps

33, 34, 35. NMEA feed not connected.

38. Ship repositioning during the soak. extra few minutes at the surface

39. All stop at 20m, all stop at 185 m on the down cast

41. Extra minutes on soak for reposition stopped at 13.5 meters.. aft lead- 26 meter stopped aft lead

61. NEMA feed still not working

PAR off: 6,9, 11,12, 49, 53, 59, 60, 61.

**CRUISE SUMMARY – CTD 2023-032**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **CTD#** | **Make** | **Model** | **Serial#** | **Used with Rosette?** | **CTD Calibration Sheet Competed?** |
| **1** | **SEABIRD** | **911+** | **1515** | **Yes** | **Yes** |

|  |
| --- |
| **Calibration Information - 1515** |
| **Sensor** | **Pre-Cruise** | **Post Cruise** |
| **Name** | **S/N** | **Date** | **Location** | **Date** | **Location** |
| **Temperature** | **6754** | **24Jan2023** | **Factory** |  |  |
| **Conductivity** | **6141** | **24Jan2023** | **Factory** |  |  |
| **Secondary Temp.** | **6736** | **3Feb2023** | **Factory** |  |  |
| **Secondary Cond.** | **6146** | **24Jan2023** | **Factory** |  |  |
| **Transmissometer** | **1185DR** | **23Mar2023** | **Factory** |  |  |
| **Transmissometer** | **1883DG** | **23Mar2023** | **Factory** |  |  |
| **SBE 43 DO sensor** | **1119** | **10Feb2023** | **Factory** |  |  |
| **PAR sensor** | **70613** | **24Feb2021** | **Factory** |  |  |
| **SeaPoint Fluor.** | **3650** |  |  |  |  |
| **Pressure Sensor** | **1515** | **17-Jan-2023** | **Factory** |  |  |
| **Valeport Altimeter** | **79487** |  | **Factory** |  |  |
| **Reference PAR** | **16504** | **3Mar2016** | **Factory** |  |  |

# TSG Make/Model/Serial#: SEABIRD/45/0789

|  |
| --- |
| **Calibration Information** |
| **Sensor** | **Pre-Cruise** | **Post Cruise** |
| **Name** | **S/N** | **Date** | **Location** | **Date** | **Location** |
| **Temperature** | **45-0789** | **1Feb22** | **Factory** |  |  |
| **Conductivity** | **45-0789** | **1Feb22** | **Factory** |  |  |
| **Wetlabs WETStar Fluor.**For depths deeper than, and including, 125 dbar, we would wait 30 seconds before closing a bottle. For depths shallower than, and including, 100 dbar, we would wait 60 seconds before closing a bottle.  | **1656** | **4Jan2022** | **Factory** |  |  |



See below for details from northern part of the cruise





