## REVISION NOTICE TABLE

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| DATE | DESCRIPTION OF REVISION |
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## PROCESSING NOTES

Cruise: 2022-013

Agency: OSD

Location: Strait of Georgia / Juan de Fuca Strait

Project: Salish Sea Biophysical Survey

Chief Scientist: O’Neill C.

Platform: Vector

Date: 1 April 2022 – 6 April 2022

Processed by: Germaine Gatien

Date of Processing: 22 August 2022 – 14 September 2023

Number of original HEX files: 74 Number of processed CTD files: 74

Number of rosette casts: 29 Number of processed CHE files: 29

# INSTRUMENT SUMMARY

CTD #0550 was mounted in a rosette and attached were a Wetlabs CSTAR transmissometer (1185DR), a SBE 43 DO sensor on the primary pump (# 1119), SeaPoint Fluorometer on the secondary pump (#3949), a Biospherical QSP-400 PAR sensor (#70613), SPAR sensor (#20518), a pH sensor (#0691). A LISST-200X sensor (#2203), and an altimeter (#73171).

Seasave version 7.26.7.121 was used for acquisition.

The data logging computer was the new Vector ThinkCentre

The deck unit was a Seabird model 11+ #425.

An IOS rosette with 24 10L bottles was used.

# SUMMARY OF QUALITY AND CONCERNS

The Daily Science Log Book and rosette log sheets were mostly in good order with comments about problems encountered and a detailed list of equipment. There was a few errors in event numbers on rosette sheets that led to some confusion among analysts.

Fluorescence values were very high in Saanich Inlet and the fluorometer went off-scale. The sensor range was set to 0-15ug/L. Extracted chlorophyll samples from 1.5m and 5.5m had values of 35.44ug/L and 57.17ug/L. Off-scale fluorescence values were replaced with pad values.

Salinity calibration sampling was excellent with extra samples taken at the mouth of Juan de Fuca Strait where flushing of Niskin bottles tends to be best, and in the central basin of the Strait of Georgia where vertical salinity gradients are likely to be low.

Flushing of Niskin bottles was likely improved by waiting 60s before firing bottles, but the comparison of dissolved oxygen samples and CTD sensor oxygen data suggests that there is still decreased flushing in protected areas where the CTD moves fairly smoothly during the upcast. The oxygen comparison near the mouth of Juan de Fuca gave results similar to those from offshore during a previous cruise that used the same sensor, while the result from the northern Strait of Georgia is notably different in a way that can be explained by incomplete flushing of Niskin bottles.

The SBE DO sensor has a fairly long response time so data accuracy is not as high when it is in motion as it is during stops for bottles. This will be especially true when vertical DO gradients are large. To get an estimate of the accuracy of the SBE DO data during downcasts (after recalibration) a rough comparison was made between downcast SBE DO and upcast titrated samples. Some of the difference will be due to problems with flushing of Niskin bottles and/or analysis errors and small mismatches in depth in the presence of large DO gradients, so the following statement likely underestimates SBE DO accuracy.

Downcast (CTD files) Oxygen:Dissolved:SBE data for this cruise are considered, very roughly, to be:

±0.30 mL/L from 0-100db except in areas of very large DO gradients

±0.20 mL/L from 100db-200db

±0.06 mL/L below 200db

No TSG data were acquired due to a COM port problem.

# PROCESSING SUMMARY

##### Seasave

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

No description was available of the deployment scheme, but it is assumed the usual 10m soak was done before acquisition began and waits before firing bottles appears to have been at least 60s.

##### Preliminary Steps

The Log Book and rosette log sheets were obtained as well as a cruise report.

* Nutrients, extracted chlorophyll, dissolved oxygen and salinity data were obtained in QF spreadsheet format from the analysts.
* The cruise summary sheet was completed.
* The histories of the pressure sensor and conductivity and dissolved oxygen sensors were checked. The pressure, temperature and conductivity sensors had been used once since the last use. The dissolved oxygen sensor had been used on 5 other cruises.

The CTD technician noted that the pressure seemed a little low during the first cast in Saanich Inlet. The last Niskin was closed at 0.9db which does seem unlikely. For the next cast in Haro Strait it was noted by another operator that pressure seemed ok. For many of the casts conditions were very rough, so it may have been hard to tell. Preliminary rosette files were prepared for some places with calmer conditions and they include data from between 0.8db and 1.2db, which is closer to the surface than usual. During the last use of this CTD a +0.5db correction was applied to pressure and a preliminary look at a cruise that followed also indicated pressures were low by 0.2db to 0.6db. Adding 0.5db at this stage looks appropriate.

The configuration file used at sea was checked. There was an error in the offset for the PAR sensor. That was corrected, the pressure offset of was changed from -0.21561 to +0.285db and the file was saved as 2022-013-ctd.xmlcon.

There were 2 channels included from sensor LISST-200X sensor, a particle mean diameter and particle volume concentration. They were tentatively added to the Seabird PAR file in a Full version of IOS SHELL. These files are not needed by the researcher, so will not be sent to the main archive, but will be kept in the files up to the REMOVE stage.

##### BOTTLE FILE PREPARATION

The ROS files were created using file 2022-013-ctd.xmlcon

The ROS files were converted to IOS format.

The IOS files were put through CLEAN to create BOT files and to pad off-scale fluorescence values in Saanich Inlet.

Temperature and salinity were plotted for all BOT files to check for significant outliers. Some of the near-surface data are noisy from Event #5 but sea conditions were very rough and it looks like the CTD was probably bouncing around.

A preliminary header check was run and a problem was found in the pH data from late in the cruise; values are much too high. The CTD technician was informed.

A track plot was produced and no problems were found.

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. A few problems were found:

* Event 22 – 2 bottles were fired at the bottom, presumably by accident. Only 1 Sample # was assigned. There is no indication of which was sampled – assume it was Niskin #1.
* Event 53 – Every Niskin bottle was fired twice. There is no note on the rosette log about this. The addsamp file had to be adjusted to add 1 sample # per Niskin.

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 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 2022-013-bot-hdr.txt which will be updated as needed during processing.

DISSOLVED OXGYEN

Dissolved oxygen data were provided in spreadsheet QF2022-013\_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 2022-013oxy.csv. That file was converted into individual \*.OXY files.

The flags on samples #14 and 38 were marked “ALL” so nutrients will also be affected.

EXTRACTED CHLOROPHYLL

Extracted chlorophyll and phaeo-pigment data were obtained in file QF2022-013\_CHL QF\*.xlsx. The file included comments and flags and a precision study. A simplified version of the spreadsheet was prepared and saved as 2022-013chl.csv. The csv file was then converted to individual CHL files.

SALINITY

Salinity analysis was obtained in file QF2022-013\_SAL.xlsx which included a precision study. The analyses were carried out in a temperature-controlled lab 15 to 20 days after collection. The files were simplified and saved as 2022-013sal.csv. That file was then converted to individual SAL files.

NUTRIENTS

The nutrient data were obtained in spreadsheet QF2022-013\_NUTS\*.xlsx. This includes a precision study. The file was simplified, saved as 2022-013nuts.csv. The file was converted to individual NUT files. Samples #14 and 38 were flagged “2” and “3” respectively, based on comments from oxy analyst.

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.

The files were then 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 the rosette log sheets to look for omissions. Some discrepancies were found:

* Event 1 – The DO samples were not in sample # order so were not added properly. This was corrected in the \*.oxy file.
* Event 7 – There is a rosette sheet for event #7 and sampling was done with the sample #s given, but no ROS file was created because the BL file was empty. The time on the rosette sheet does not agree with the log entry. The rosette sheet should be labelled as Event #12. There is no indication that there was ever a plan to sample station 76 which was event #7. Two of the samples had event #7 and the other 2 had #12. All were changed to #7 and the CHL and Nutrient analysts informed of the error.
* Event #70 – Rosette log created but should be #71 as per Daily Science Log.

After corrections to those 3 files, the merge process was repeated. Data were exported again and the comparisons with rosette sheets repeated and no further problems were found.

The spreadsheet was saved in XLSX format and will be updated at the end of bottle file processing.

##### Compare

Salinity

Compare was run with pressure as reference channel. In a fit of CTD Salinity versus Bottle Salinity most of the differences were within ±0.003psu, but there were significant outliers. When outliers were excluded based on standard deviation in CTD Salinity being >0.001psu, the primary salinity was found to be low by an average of -0.0003psu and the secondary high by an average of +0.0014psu ( standard deviations of 0.0017 and 0.0016psu, respectively ). The standard deviations in the secondary CTD salinity were slightly higher, on average, than those in the primary.

When only casts were included where either the flushing of the Niskin bottles is expected to be good (mouth of Juan de Fuca) or vertical salinity gradients expected to be low (central basin of Strait of Georgia) the average differences were very similar, -0.0003 and +0.0015psu. This is not surprising as these casts dominate the main comparison.

There is a little more pressure dependence than we would like, but with so little sampling it is hard to judge this. However, it is notable that the shallowest samples show no indication of poor flushing. While there was no salinity sampling above 100m, this is still encouraging and may be due to longer waits before closing bottles. Salinity was also analyzed quickly so bottle salinity should be relatively free of effects of evaporation or desorption. There is no need to recalibrate either of the salinity channels.

One outlier was studied where the CTD data were not particularly noisy

* Event #47 – 250db – While not a huge outlier this stands out since it came from an area that usually has fairly low salinity gradients, though perhaps not above 300db. The standard deviation was low in the CTD salinity during the 10s window, but examination of the salinity during the whole stop shows considerable variation. The salinity was quite low early in the stop but then rose and settled to a steady value. Shed wakes or poor flushing would not explain this and there is no evidence of instrumental spiking, so there must have been considerable natural variability. Examination of the full profile shows a lot of variability above 300db. No flag is justified for this outlier.

For full details for the COMPARE run see file 2022-013-sal-comp1.xls.

Dissolved Oxygen

COMPARE was run with pressure as the reference channel.

The fit including all casts excluding some outliers based on residuals was:

CTD DO Corrected = CTD DO \* 1.0127 + 0.0489 R2 = 0.70 (Fit 1)

We expect CTD DO to read lower than bottles, but if the Niskin bottles contain water from lower in the water column the difference will usually be reduced because DO generally decreases with depth. The last time the sensor was used was in open waters during a Line P cruise with excellent DO sampling. The fit found at that time did have a larger correction, as expected:

CTD DO Corrected = CTD DO \* 1.0153 + 0.0461 R2 = 0.87 2022-001

That cruise (2022-001) also had more sampling in low DO waters, so the offset is likely more reliable. Using the same data as in Fit 1, but forcing the offset to +-0.0461 the fit was:

CTD DO Corrected = CTD DO \* 1.0133 + 0.0461 R2 = 0.74 (Fit 2)

Fits were then applied to 3 regions with offset forced to =+0.0461:

Western Juan de Fuca Strait (casts 5 and 8)

CTD DO Corrected = CTD DO \* 1.0166 + 0.0461 R2 = 0.81 (Fit 3)

Central Strait of Georgia 9casts 38, 42, 47, 53)

CTD DO Corrected = CTD DO \* 1.0124 + 0.0461 R2 = 0.52 (Fit 4)

Northern Strait of Georgia (casts 75, 79, 83)

CTD DO Corrected = CTD DO \* 1.0100 + 0.0461 R2 = 0.48 (Fit 5)

As expected, the correction decreases as the likelihood of good flushing of Niskin bottles is reduced. The only surprise is having so high a slope for Fit 3. This may be a matter of too few samples from too shallow water to get a reliable fit. It is also possible that there was a little drift in the DO calibration between the 2 cruise, but, if so, it is slight.

Using the 2022-001 fit looks like the best choice since it was based on extensive sampling in deep water.

Outliers in the comparison were examined:

* Event #1 had many outliers which is typical of Saanich Inlet. The bottles near the bottom were flagged as anoxic and the CTD cannot achieve 0 which makes it appear to be reading high. At mid-depths DO varied little and had small reversals so the CTD would be expected to compare better than it would in a high gradient. Near the surface the gradient was very high, changing by 1mL/L over 1db, so very small flushing errors can lead to a difference of 1mL/L. The CTD response would also be challenged and the distance between the bottle and CTD add to the complications. None of these outliers can be blamed on analysis or collection problems with so many other possible explanations for the differences. No flags are justified.
* Sample 109, Event 26. CTD < Bottle. Sample was flagged 4 by analyst. No change suggested.
* Sample 120, Event 30. CTD < Bottle. Sample was flagged 26. 2 samples. Analyst meant to reject 6.308 and report 4.848, but the reverse was done. That was corrected and the flag was set to 2.
* Event 53, Sample 188. Sample value much too high in COMPARE and in profile. Analyst noted bubbles – was flagged 3. Analyst padded value and changed flag to 5.
* Event 60 – Sample 219 – High gradient – probably incomplete flushing. No flag suggested.
* Event 71 – Sample 266 – Odd DO profile. No flag suggested.
* Event 79 – Sample 312 – Noisy CTD data, no flag on sample. No change suggested.
* Event 79 - Sample 306 – Flagged 46. In Compare Dup A looks bad, Dup B better. But CTD DO during the stop much more variable than expected. So having different dups is not necessarily wrong, but Dup B better reflects time when bottle was closed. Analyst changed flag to 36 with comment about high variability noted in CTD DO during bottle stop.

For full details for the COMPARE run see file 2022-013-dox-comp1.xls.

Fluorescence

COMPARE was run with extracted chlorophyll and CTD Fluorescence using pressure as the reference variable. We expect fluorescence to be higher than CHL when CHL is very low. But for this cruise there were few samples with CHL <0.5ug/L and the minimum was 0.15ug/L. The ratio FL/CHL is about 1 for CHL<1ug/L, 0.8 for CHL~2ug/L and 0.6 for CHL~4ug/L and 0.4 to 0.5 for CHL in the range 6-10ug/L. There are a number of cases where fluorescence is lower than CHL by more than usually seen in the 1-2ug/L range; the cases that look particularly out of line tend to be from samples taken very close to the surface where the height of the Niskin bottle above the CTD may have been more significant than would be offset by inefficient flushing of Niskin bottles. The Niskin bottle may have captured very near-surface conditions better than the CTD sensor.

For full details for the COMPARE run see file 2022-013-fl-chl-comp1.xls.

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

File 2022-013-ctd.xmlcon was used to convert all files. The Tau function was chosen, but not the hysteresis function since there was no deep sampling. Depth was included in the conversion.

A few casts were examined and all expected channels are present. As usual the downcast temperature and conductivity channels are close but upcast traces are very noisy. The altimetry had some spikes near the bottom but there is a clear signal. Fluorescence, Transmissivity look ok. PAR and SPAR values are reasonable. pH looks ok at the beginning of the cruise but after cast #65 it looks bad.

##### WILDEDIT

Program WILDEDIT was run to remove spikes from the pressure, depth, conductivity & temperature only in the full cast files (\*.CNV).

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.

##### ALIGN DO

A few casts were examined; both temperature channels were noisy during upcasts so the tests were not easy to interpret, but using +2.5s improved the alignment and overall looks like a good choice. That value is the one most often chosen for the SBE911s.

ALIGNCTD was run on all casts using +2.5s.

##### CELLTM

The noise in the upcast data makes tests for the best parameters for this routine very difficult to interpret. In the past when upcast data were not so noisy, the default setting of (α = 0.0245, β=9.5) was generally found to be the best choice. A few casts were checked for this cruise and the default setting does improve the data. CELLTM was run using (α = 0.0245, β=9.5) for both the primary and secondary conductivity.

##### DERIVE and Channel Comparisons

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

DERIVE was run a second time on 2 of the deeper casts to find the differences between the pairs of temperature, conductivity and salinity channels. There are no deep casts where the comparisons are most reliable. At 350m there appears to be a slight increase in the differences. The salinity difference is larger than that found in the bottle comparison (~0.0017psu) so may indicate some issues found while in motion; that would not affect the values found when the CTD is stopped. Calibration drift would not cause this, but differences in flow while in motion could.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cast # | Press | T1-T0 | C1-C0 | S1-S0 | Descent Rate |
| 2022-001-0024 | 350 | -0.0001 | +0.00009 | +0.0013 | High, XNoisy |
|  | 1000 | -0.0003 | +0.00013 | +0.0018 | “ |
|  | 2000 | -0.0002 | +0.00018 | +0.0024 | “ |
| 2022-001-0061 | 350 | 0 | +0.00010 | +0.0013 | High, XNoisy |
|  | 1000 | 0.0000 | +0.00016 | +0.0019 |  |
|  | 2000 | +0.0001 | +0.00018 | +0.0020 | “ |
| 2022-001-0082 | 350 | 0 | +0.00015 | +0.0017 | High, XNoisy |
|  | 1000 | -0.0001 | +0.00019 | +0.0023 | “ |
|  | 2000 | -0.0001 | +0.00021 | +0.0027 | “ |
| 2022-013-0047 | 370 | -0.0004 | +0.00027 | +0.0029 | Med, Moderate |
| 2022-013-0075 | 350 | -0.0002 | +0.00019 | +0.0025 | High, Quiet |

##### 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. Fluorescence values in the range 14.87-15ug/L were padded.

##### Checking Headers

The cross-reference check and header check were run. A few possible problems were noted:

* There were negative pressures found in cast #42. That was a case where the CTD appears to have come out of the water for about 6s at the end of a cast.
* As noted earlier there are some high pH values.

Track plots were produced and were added to the end of this report. The sites look right.

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. Where that number was > 5m checks were made to see if the log entry differed from the header entry and whether the altimetry signal at the bottom provided a good header value. No problems were found in the altimetry headers despite some casts having many spikes at the bottom.

The following decisions were made:

* The header readings were changed to those found in the log for casts: 1, 18, 20, 27, 64 as they produced much better check values. In several cases the entries were clearly edited at some point, so it was likely a case of the ship drifting after the original entries.
* For events #47 and #65 the depth in the log and header are the same, but less than the maximum depth sampled and the check values were high (17m and 12m), so a calculated value was substituted based on Max Depth Sampled + Altimetry Header.
* For events #52 and #53 the check values were only 6m, so no change was made to the headers.
* The same changes were made to the SAM files for the events with bottle sampling; the bin-averaging of SAM files and Merge steps were repeated as needed.

See file 2022-013-altimeter-ctd.xlsx for details.

Surface Check was run. The mean value was 1.95db. That is a little lower than usual for the Vector; the casts nearest the mouth of Juan de Fuca where rough conditions lead to deeper CTD starts, and began between 2.8db and 3.6db, which is typical for that area. Clearly adding 0.5db to pressure offset during conversion was not too large a correction. Any error in pressure after that correction appears to be small.

##### 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 selection of casts to find the alignment shift best for the 2 conductivity sensors into as judged by noise in T-S space. When last used the best choice was -0.7 records for both primary and secondary channels. For this cruise -0.5 and -0.6 each look better for the primary for 2 of the 4 casts tests, so -0.55 records was selected as a compromise.

SHIFT was run twice on all SBE911 casts using -0.55 records for the primary and -0.9 for the secondary. Salinity was recalculated for both channels.

pH SHIFT was run on pH:SBE using +15 records.

##### 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, and conductivity sensors have been used on 1 other cruise since the last factory service. The dissolved oxygen sensor had been used for a few cruises but only 1 had calibration sampling

During 2022-001 the primary salinity was found to be lower than bottles by ~0.0013psu and the secondary salinity higher by an average of ~0.0014psu. Allowing for some error due to evaporation/desorption and incomplete flushing of bottles, the primary was chosen for archiving without recalibration. The dissolved oxygen sensor was recalibrated using slope 1.0153, offset + 0.0461.

Historic ranges – Profile plots were made with 3-standard deviation climatology ranges of T and S superimposed. There were only minor excursions from the climatology. Event #44 had salinity values lower than the climatology around 15db that look like a case of surface mixing being a little deeper than usual. None of the excursions suggest problems with calibration.

Post-Cruise Calibration – None available.

Repeat Casts –None.

##### DETAILED EDITING

Because the downcast salinity differences found in section 9 were larger than those noted in bottle stops in the comparison with calibration samples and larger than noted during 2022-001, the downcast CTD salinity was compared with bottle samples for casts #47 and #75, to see which salinity channel is closest. We might expect that the CTD salinity would read a little lower than the bottles due to incomplete flushing of Niskin bottles. However, for 3 of the 4 salinity samples both channels read higher than samples, but both channels had downcast salinity that matched bottle values within 4m of the bottle firing depth. For 3 of the 4 the primary was closest to the bottles. The primary was high by an average of 0.004psu and the secondary high by 0.007psu. These values seem out of line with the general bottle comparison. Profile plots reveal high variability with frequent reversals in salinity, so expecting to match downcast to upcast is not justified. No sampling was available from a section with low variability and steady salinity gradients.

The primary channels were chosen for editing as there appears to be a little less noise in the T-S plots and the primary salinity is closer to the bottle salinity; they were also chosen when the CTD was used last.

All DEL files were copied to \*.EDT.

During the editing session a test version of DEL files, called DELPRE were used that used AI predictions of where there might be bad data.

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. While some unstable features remained, no further editing was applied as the casts were from inlets where they may be due to real conditions. Instability was noted in the cast at station 56 during the downcast and was also seen in the CTD data from the upcast while stopped for bottle sampling.

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

No further recalibration is required for pressure.

The primary salinity was found to be very close to bottle salinity though allowing for a small error due to incomplete flushing of Niskin bottles, the CTD salinity may be reading a little high. At the mouth of Juan de Fuca where rough conditions likely produced good flushing, the primary salinity was high by an average of 0.0005psu. No recalibration is justified.

Dissolved oxygen does require recalibration. The results of the bottle comparison during cruise 2022-001 are likely more reliable than from this cruise, but they are in reasonable agreement with the comparison from the mouth of Juan de Fuca Strait where flushing of bottles is usually good.

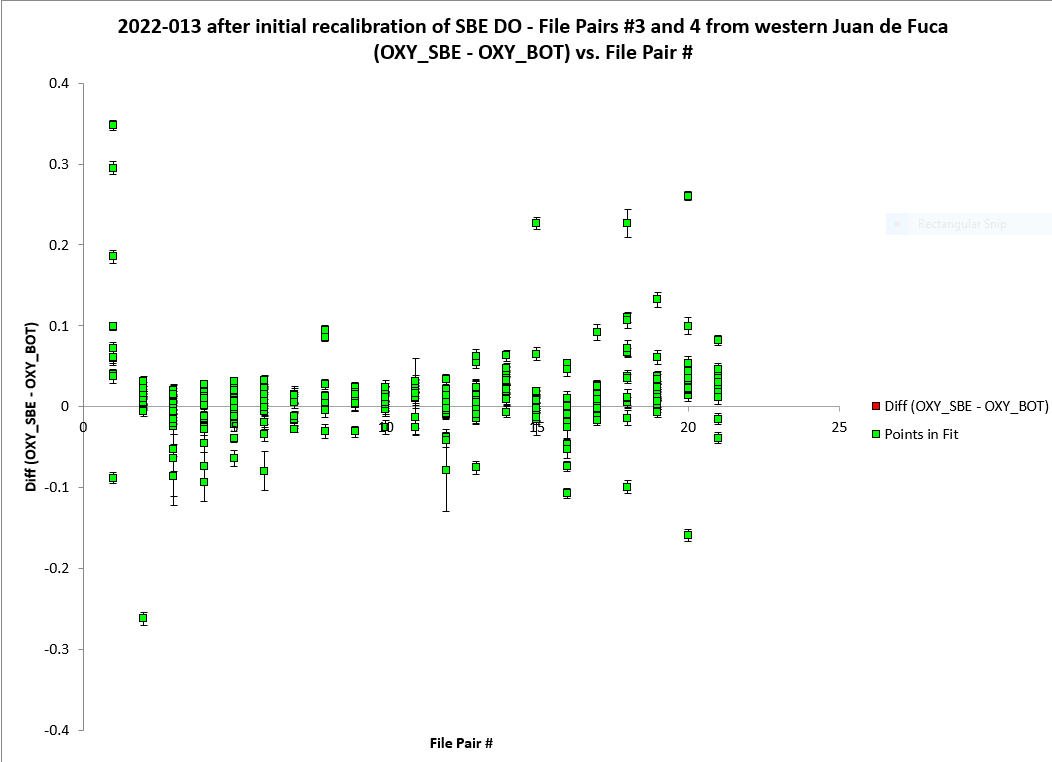
File 2022-013-recal1.ccf was prepared to apply dissolved oxygen correction:

CTD DO Corrected = CTD DO \* 1.0153 + 0.0461

This correction was first applied to the SAM and MRGCLN2 files.

COMPARE was rerun for dissolved oxygen and shows that the correction was applied properly. When data are excluded based on using the same points as in the original fit, the CTD DO is higher than the bottle DO by an average of 0.009mL/L, with a standard deviation of 0.011mL/L. This is higher than we usually expect, but when only the 2 casts from the western end of Juan de Fuca Strait are including the CD DO is lower than bottles by an average of 0.001mL/L with a standard deviation of 0.017mL/L.

See file 2022-013-DO-comp2.xls for details. This fits the expectation that bottles from the Strait of Georgia will not have flushed well so would generally have values that are a little lower than ambient DO values. A plot of differences versus file pair number makes this very clear.



CALIBRATE was then run on the EDT files using the same recalibration file.

##### 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 bottle data from 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.

Downcast files were bin-averaged to 0.5m bins for the casts with DO bottle samples. Those files were 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.

A few obvious outliers were excluded based on high standard deviation in the CTD DO, or there was no CTD reading for that level or differences were >0.3mL/L; all Saanich Inlet samples were also excluded due to the extreme gradients.

The CTD DO was higher than the titrated samples by an average of ~0.052mL/L but the standard deviation was 0.062mL/L.

The recalibration was obviously effective, but as expected the CTD DO reads slightly high in Juan de Fuca Strait and that difference grows with distance from open water.

Downcast (CTD files) Oxygen:Dissolved:SBE data for this cruise are considered, very

roughly, to be:

±0.30 mL/L from 0-100db except in areas of very large DO gradients

±0.20 mL/L from 100db-200db

±0.06 mL/L below 200db

For more detail see file 2022-013-dox-comp3.xls.

##### Fluorescence Processing

There are were some off-scale fluorescence values in the inlet section of this cruise, so CLEAN was rerun on all casts to replace fluorescence values >14.86 with pad values.

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.

Profile plots were examined. The only unstable features noted are very small.

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

For all casts 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, Particle Mean Diameter, Particle Volume Conc, Prediction Flag and Flag.

pH was removed for events #67-94.

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.

Profile and T-S plots were examined. A few small unstable features were found in areas likely to have 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. As usual, there is large variability in the region. Saanich Inlet reached ~192% and fluorescence went off scale. With the exception of station SI, all values at 2 to 3m ranged between ~73% to 108%. As usual values were <<100%.in eastern Juan de Fuca Strait, Haro Strait and near the Gulf Islands. They were highly variable in the Strait of Georgia with values from about 85% to 108% in the central section.

These highly variable results do not offer any useful evidence about the DO calibration.

##### Final Bottle Files

SORT was run to arrange casts in pressure order.

For all casts 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, Particle Mean Diameter, Particle Volume Conc and Flag.

pH was removed for events #67-94.

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 and to move Temperature:Draw.

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

Data were exported from the CHE files to file 2022-013-bottles-final.xlsx. The entries were compared with the rosette log sheets and a few problems were found:

* Salinity sample was mislabelled as from event 74, should be 75.
* Line for Niskin #2 should be removed from event 22 – no sampling and no sample #.
* Line for Niskin #5 should be removed from event 87 – no sampling but there was a sample #.
* Lines for Niskins #3 and 6 should be removed from event 91 – no sampling and no sample #s.

The extraneous lines were removed from the SAMAVG files and the steps from \*.MRG to \*.CHE were rerun.

Standards check and 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.

P**articulars – mostly notes from logs**

1. Pressure seems low. Niskin 6 not sampled.

3. Pressure seems normal.

5. Bad swell. Large wire angle. Winch operator went back to 100m by mistake. Stn 101 cast cancelled due to swell.

8. Reduce descent rate to 0.5m/s to avoid hitting bottom due to swell.

22. 2 bottles fired at the bottom; no indication of what samples came from what bottles.

30. Misfire – 2 bottles at 40db.

43. Not archived. Station 41. Repeated later.

53. Every Niskin bottle was fired twice.

55. Not archived. Station 28. Repeated later.

60. Surface - missed 1 CHL, no NUT samples.

61. Bottle #24 lanyard shortened after cast.

72. PAR had seaweed on it after it was back on deck.

87. Niskin #5 not sampled, not needed in file.

88. Repeated Station 28.

90. Repeated station 41.

91. Bottle 3 fired at 3.7db by accident. Bottle 6 fired by accident – no sampling.

**2022-013**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **CTD#** | **Make** | **Model** | | **Serial#** | | **Used with Rosette?** | | **CTD Calibration Sheet Competed?** | | |
| **1** | **SEABIRD** | **911+** | | **0550** | | **Yes** | | **Yes** | | |
| **Calibration Information** | | | | | | | | | | | |
| **Sensor** | | | | | **Pre-Cruise** | | | | **Post Cruise** | | |
| **Name** | | | **S/N** | | **Date** | | **Location** | | **Date** | **Location** | |
| **Temperature** | | | **2106** | | **16Aug2021** | | **Factory** | |  |  | |
| **Conductivity** | | | **2280** | | **20Aug2021** | | **Factory** | |  |  | |
| **Secondary Temp.** | | | **2663** | | **16Aug2021** | | **Factory** | |  |  | |
| **Secondary Cond.** | | | **2754** | | **3Sep2021** | | **Factory** | |  |  | |
| **Transmissometer** | | | **1185DR** | | **28Apr2021** | | **IOS** | |  |  | |
| **SBE 43 DO sensor** | | | **1119** | | **5Feb2021** | | **Factory** | |  |  | |
| **pH** | | | **691** | | **23Feb2021** | | **Factory** | |  |  | |
| **LISST-200X** | | | **2203** | |  | |  | |  |  | |
| **PAR sensor** | | | **4565** | | **24Feb2021** | | **Factory** | |  |  | |
| **SPAR** | | | **20518** | | **24Feb2021** | | **Factory** | |  |  | |
| **SeaPoint Fluor.** | | | **3949** | |  | |  | |  |  | |
| **Pressure Sensor** | | | **0550** | | **11Oct2021** | | **Factory** | |  |  | |
| **Valeport Altimeter** | | | **73171** | | **20Jan2021** | | **Factory** | |  |  | |

