## REVISION NOTICE TABLE

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| DATE | DESCRIPTION OF REVISION |
| 28 March 2023 | Added HPLC data. J.R. |

## PROCESSING NOTES

Cruise: 2021-022

Agency: OSD

Location: Strait of Georgia / Juan de Fuca Strait

Project: Salish Sea Biophysical Survey

Chief Scientist: Chandler P.

Platform: Vector

Date: 5 October 2021 – 10 October 2021

Processed by: Germaine Gatien

Date of Processing: 4 February 2022 – 14 February 2022

Number of HEX files: 80 (1 cast just to fire 1 bottle) Number of CTD files processed: 79

Number of rosette files: 29 (1 split cast) Number of bottle casts processed: 28

# INSTRUMENT SUMMARY

CTD #0443 was mounted in a rosette and attached were 2 Wetlabs CSTAR transmissometers (1185DR & #1883DG), a SBE 43 DO sensor on the primary pump (#3791), SeaPoint Fluorometer on the secondary pump (#3950), a Biospherical/Licor PAR sensor (#4565), a SPAR sensor (20518), an altimeter (#76341) and an SBE pH sensor (#691).

Seasave version 7.26.7.121was used for acquisition.

The data logging computer was WP Mini #102.

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

A Guildline model 8400B Autosal serial # 68572 was used to analyze salinity samples.

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 many comments about problems encountered and weather conditions.

Waits before firing bottles were about 60s. This is a change from the usual 30s waits. The change was based on a hope that the flushing of Niskin bottles would improve so that the contents would match ambient conditions better. Based on comparisons between salinity and dissolved oxygen samples and CTD data, this appears to have had the desired effect, though stormier conditions than usual may also have helped with flushing. It is recommended that this protocol be followed in future for all cruises in inland areas.

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:

 ±0.15 mL/L from 0-1000db

 ±0.05 mL/L below 100db

The Reference PAR sensor produced no useful data.

The data from channel pH:SBE were removed from Events #1 to 42 as the data looked bad, rising steadily through the cast. The upcast data could possibly be reliable, but there was no way to confirm this.

The pH:SBE:Nominal data should be used with caution; no field calibration data were gathered. Calibration is required for each cast to get absolute values, although general trends within a cast are likely real.

# PROCESSING SUMMARY

##### Seasave

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

##### Preliminary Steps

* The configuration files used at sea were changed twice to correct errors in the PAR sensor offset and fluorometer gain. One file with corrected parameters was saved as 2021-022-ctd.xmlcon
* 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 histories of the pressure sensor, conductivity and dissolved oxygen sensors were checked. They all were used during 6 previous cruises since the last factory recalibration. For the last 2 cruises the secondary T/S channels were selected and salinity was not recalibrated. Dissolved oxygen was recalibrated with similar parameters found during 2 recent deep-water cruises. The pressure sensor was recalibrated by subtracting 0.8db for the previous 3 cruises.

##### BOTTLE FILE PREPARATION

The ROS files were created using files 2021-022-ctd.xmlcon.

They were converted to IOS Header format with extension \*.IOS.

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

File 2021-095 contains a single bottle firing that should be part of cast #94. UltraEdit was used to change the Bottle Firing # from 1 to 17 in the IOS file. The output file was put through CLEAN. File #94 was renamed as 94.IOSa and file #95 as 94.IOSb. JOIN was run to combine them as 94.IOS and that file was then put through CLEAN.

Temperature and salinity were plotted for all BOT files to check for outliers. None were found.

A preliminary header check was run and no problems 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.

The file was sorted on sample number.

The ADDSAMP file was adjusted and 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 2021-022-bot-hdr.txt which will be updated as needed during processing.

DISSOLVED OXGYEN

Dissolved oxygen data were provided in spreadsheet QF2021-022\_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 2021-022oxy.csv. That file was converted into individual \*.OXY files.

At this point note was made of all comments in the DO file that had comments starting with “ALL:”. There were 4. The rosette sheets were checked to note what other samples were taken from the same bottle so the flags will be applied to all samples from the other csv files that are affected by the DO analyst’s observation.

EXTRACTED CHLOROPHYLL

Extracted chlorophyll and phaeo-pigment data were obtained in file QF2021-022\_CHL QF\*.xlsx. The file included comments and flags and a precision study. A simplified version of the spreadsheet was prepared and saved as 2021-022chl.csv. The csv file was then converted to individual CHL files.

SALINITY

Salinity analysis was obtained in file QF2021-022\_SAL.xlsx which included a precision study. The analyses were carried out in a temperature-controlled lab within 7 weeks of collection. The files were simplified and saved as 2021-022sal.csv. That file was then converted to individual SAL files.

NUTRIENTS

The nutrient data were obtained in spreadsheet QF2021-022\_NUTS\*.xlsx. This includes a precision study. The file was simplified, saved as 2021-022nuts.csv and converted to individual NUT files.

The flags were changed to 3 for the 1 sample noted by the oxygen analyst as having a problem that would affect all samples. The file was then converted to individual files.

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

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 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. One salinity sample had been flagged with no explanation – there was no flag in the QF file for the sample, so the flag was removed from all files for that cast.

The spreadsheet was sorted on CTD Salinity and the nutrient analyst was sent a summary of all cases where salinity < 25psu. The nutrient analyst did corrections to 4 Silicate samples and sent the results.

Corrections were made in files for events 52 and 56. (See file 2021-022-low-sal-nutrients.xlsx.)

##### Compare

Salinity

Compare was run with pressure as reference channel.

There were 19 salinity bottles from depths 100db to 300db.

There was a lot of scatter in the fits, but most of it is due to noise in the CTD salinity. This area tends to have calm conditions that mean the bottles don’t move much during stops, but this cruise experienced rougher conditions and also had 60s waits before firing bottles. There are 3 regions in which we tend to get better comparisons with bottles, depending on conditions.

* Near the mouth of Juan de Fuca Strait the sampling is not particularly deep but sea states tend to be conducive to Niskin bottles flushing better than in more protected waters. Those 3 have results that suggest the primary is low by about 0.005 and the secondary very close to bottles.
* In the central basin the water is deep enough that vertical gradients are generally low, minimizing the effect of poor flushing. There were 3 casts there and they show the primary being low by an average of 0.007psu and the secondary low by 0.003psu. However, 1 differs from the other 2 which have the primary low by 0.005 and the secondary by <0.001psu. The vertical salinity gradient at 300db explains why one of the casts differs from the other, as the local gradient was very low for 2 and higher for the other.
* To the north there were 2 casts that experienced very windy conditions. The one that is deeper at 300db showed the primary to be low by 0.004psu and the secondary very close to bottles. The other cast was shallow; at 123db the primary was low by 0.006 and the secondary by 0.002psu.

The deep cast from the north is in good agreement with the casts from the mouth of Juan de Fuca and 2 of those from the central basin.

These results also agree quite well with the results of previous cruises, when it is taken into account that there was a longer delay in analysis for the earlier cruises. There was a 7-week analysis delay for this cruise which may mean that salinity bottle values may be high by ~0.0015psu due to desorption.

The fits against time and against pressure are similar for both channels with the primary salinity being slightly flatter against time and the secondary flatter against pressure. Allowing for a small error due to delayed analysis the primary is likely low by ~0.003psu and the secondary was high by ~0.001psu.

For full details for the COMPARE run see file 2021-022-sal-comp1.xls.

Dissolved Oxygen

COMPARE was run with pressure as the reference channel.
There was less scatter than usual for this region. This may be due to rougher conditions than usual, but it may also be due to longer stops (60s) before firing bottles. When all casts were included and outliers removed based on residuals the fit was:

CTD DO Corrected = CTD DO \* 1.0463 + 0.0100 R2 = 0.90

The offset is much larger than usual but there were no DO samples < 0.9mL/L so we can’t expect a good estimate of offset. Offsets noted in recent offshore cruises were 0.0012 and 0.0004. If the offset is forced to = 0 the fit is:

 CTD DO Corrected = CTD DO \* 1.0434 R2 = 0.99

When only the 3 bottle casts from the western end of Juan de Fuca Strait are included the fit was:

CTD DO Corrected = CTD DO \* 1.0494 - 0.0109 R2 = 0.88

Or when the offset is forced to = 0

 CTD DO Corrected = CTD DO \* 1.0457 R2 = 0.97

That region generally has the best flushing.

When the same casts are selected as were picked for the salinity comparison and outliers excluded based on residuals the fit was:

CTD DO Corrected = CTD DO \* 1.0476 - 0.0096 R2 = 0.91

Or when the offset is forced to = 0

 CTD DO Corrected = CTD DO \* 1.0446 R2 = 0.98

It is expected that this fit would not be as reliable as the one for salinity since the choice of the central basin casts was based on low vertical gradients at the salinity sampling depths. The dissolved oxygen samples come from a variety of depths, so the low gradient criterion is not met for those samples. Nonetheless, the fit is similar to others as it includes some areas where flushing is likely better.

All the fits are reasonably close to those found for 2 earlier cruises using the same equipment and sampling in offshore waters where flushing should be good:

 CTD DO Corrected = CTD DO \* 1.0465 + 0.0012 R2 = 0.98 (2021-012 – Sept.)

 CTD DO Corrected = CTD DO \* 1.0445 + 0.0004 R2 = 0.95 (2021-008 – Aug.)

As expected, the fit from the mouth of Juan de Fuca Strait is the closest.

Plots of Titrated DO and CTD DO against CTD salinity were examined. No further outliers were found.

No outliers were identified that require further flagging of DO samples.

Fluorescence

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

The fit of CTD fluorescence versus extracted CHL samples indicates that the data fall onto 2 distinct lines of different slopes.

To study the source of the 2 lines, a plot of CHL and CTD Fluorescence versus event number was prepared.

The patterns in n the southern Gulf Islands and Juan de Fuca Strait differ markedly from those in the Strait of Georgia. Extracted CHL is lower in the Strait of Georgia ranging from 0.17 to 2.9 ug/L and in Juan de Fuca Strait and the southern Gulf Islands it ranged from 0.17 to 5.8ug/L. Fluorescence was close to CHL in the Strait of Georgia but only 27% of CHL in Juan de Fuca and the southern Gulf Islands.

It is a typical response from this type of fluorometer, reading relatively high when CHL is low and vice versa, but it is unusual to have higher chlorophyll in Juan de Fuca than in the Strait of Georgia.

Saanich Inlet was left out of the comparison as it is usually an outlier with very high CHL and low FL.

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

All files were converted using 2021-022-ctd.xmlcon.

The Tau function was selected but not the hysteresis function since there was no deep sampling. Depth was included in the conversion.

A few casts were examined. There are pressure spikes in the first file. All data look reasonable except for the Surface PAR data which appears to have a signal but extremely low values. Similar results were noted during cruise 2021-076 which immediately followed this cruise. No solution was found for this result. The channel will be kept in the file until near the end of processing in case future investigation leads to a method to recover useful data.

The T and C pairs were reasonably close during downcasts with upcasts very noisy. There are some spikes in both conductivity channels, but they appear to affect only the upcast.

Fluorescence, PAR and Dissolved Oxygen profiles looked normal. The altimetry data look excellent.

The pH profiles are odd for some casts with low surface values, rising through the downcast with a profile that looks reasonable for the upcast though that is far from certain. Some casts look normal.

##### 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.

The spikes noted in cast #1 were resolved by this step.

The small spikes in upcast conductivity were not 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 certainly improves the alignment and overall looks like a good choice for both sensors. That setting has worked well for many SBE DO sensors in recent years.

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 3 casts to find the differences between the pairs of temperature, conductivity and salinity channels. The shaded values come from other 2021 cruises using these sensors.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cast # | Press | T1-T0  | C1-C0 | S1-S0 | Descent Rate |
| 2021-006-0020 | 375 | +0.0004 | +0.00044 | +0.0043 | High, Noisy |
|  | 1200 | +0.0002 | +0.00042 | +0.0050 | “ |
| 2021-006-0039 | 1200 | 0 | +0.00042 | +0.0049 | High, XNoisy |
| “ | 2000 | -0.0002 | +0.00044 | +0.0055 | “ |
| “ | 3000 | -0.0003 | +0.00044 | +0.0057 | “ |
| 2021-006-0052 | 1200 | 0  | +0.00043 | +0.0057 | High, XNoisy |
| “ | 2000 | -0.0005 | +0.00042 | +0.0056 | “ |
| “ | 3000 | -0.0005 | +0.00044 | +0.0060 | “ |
| 2021-006-0077 | 1200 | -0.0005 | +0.00042 | +0.0059 | High XNoisy |
|  | 2000 | -0.0007 | +0.00044 | +0.0063 | “ |
|  | 3000 | -0.0006 | +0.00045 | +0.0062 | “ |
| 2021-005-0099 | 1000 | -0.0002 | +0.00050 | +0.0058 | High, Noisy |
|  | 1900 | -0.0004 | +0.00050 | +0.0064 | High, V. Noisy |
| 2021-005-0140 | 1000 | -0.0002 | +0.00055 | +0.0065 | High, Noisy |
|  | 1900 | -0.0005 | +0.00055 | +0.0072 | F. High, NOisy |
| 2021-069-0009 | 500 | +0.0002 | +0.00040 | +0.0044 | High, Noisy |
|  | 900 | -0.0001 | +0.00040 | +0.0048 | “ |
|  | 1850 | -0.0004 | +0.00041 | +0.0054 | “ |
| 2021-008-0028 | 1000 | 0 | +0.00060 | +0.0072 | High, V Noisy |
|  | 2000 | -0.0002 | +0.00060 | +0.0076 | “ |
|  | 3000 | -0.0005 | +0.00053 | +0.0069 | “ |
| 2021-008-0063 | 1000 | -0.0004 | +0.00046 | +0.0059 | High, Moderate |
|  | 2000 | -0.0006 | +0.00048 | +0.0063 | “ |
|  | 3000 | -0.0007 | +0.00049 | +0.0068 | “ |
| 2021-008-0077 | 1000 | -0.0003 | +0.00043 | +0.0055 | High, Noisy |
|  | 2000 | -0.0007 | +0.00043 | +0.0060 | “ |
|  | 3000 | -0.0008 | +0.00045 | +0.0063 | “ |
|  | 4000 | -0.0009 | +0.00047 | +0.0065 | “ |
| 2021-012-0046 | 1000 | -0.0004 | +0.00035 | +0.0044 | High, Moderate |
|  | 1800 | -0.0003 | +0.00035 | +0.0048 | “ |
| 2021-012-0127 | 1000 | -0.0003 | +0.00033 | +0.0042 | High, Moderate |
|  | 2000 | -0.0006 | +0.00034 | +0.0048 | “ |
| 2021-012-0156 | 1000 | -0.0004 | +0.00032 | +0.0042 | High, V.Noisy |
|  | 2000 | -0.0007 | +0.00032 | +0.0047 | “ |
| 2021-022-0012 | 215 | -0.0005 | +0.00042 | +0.0050 | Mod, Noisy |
| 2021-022-0063 | 360 | -0.0004 | +0.00039 | +0.0042 | High, V. Steady |
| 2021-022-0094 | 350 | -0.0005 | +0.00038 | +0.0042 | High, F. Steady |

The casts are shallow, but the conductivity and salinity differences are similar to those during the previous cruise using these sensors, 2021-012.

##### 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.

CLIP was run on file 2021-022-0041.IOS to remove records from the soak period. CLEAN was run on that file.

##### Checking Headers

* The cross-reference check was run. The format for the station name for cast 79 was changed in the profile and bottle files to match the log entry. Cast #95 was removed from the file list; this was a shallow dip to collect surface samples missed during cast #94.
* The header check was run and showed a very high pH value in Saanich Inlet. A text editor was used to replace 3 single-point spikes with pad values.
* Surface check was run and found an average of 3.1db which is fairly deep for this project but the pressure is thought to be reading high by 0.8db.
* Cruise tracks were plotted and look fine; they were added to the end of this report.

The altimeter and water depth readings from the headers of the CLN files were exported to spreadsheets. A check value was calculated as follows:

 CHECK VALUE = Max Depth Sampled + (Altimetry Header – 1) - Water Depth from Header

The altimetry averages over 2m so the header values are likely high by ~1m.

There are bound to be small variations due to water depth changes through the cast, but those changes should be fairly random.

There were 16 casts with check values ≥ 4m. In 9 cases the entries in found in the log improve the check values, so they were entered in the headers of the CLN files and in 3 affected SAMAVG files. For one cast there was a comment giving the bottom depth when the CTD was at the bottom and it gives a much better check value so that was used. For the other 6 casts the altimetry looks fine at the bottom. For 4 of the casts the check value is <6m and may just reflect variations through the cast. That left 2 with check values >6m so a calculated depth based on the check value was entered in the headers.

##### 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 few casts to assess what settings are best to align conductivity with temperature (as judged by the effect on salinity as seen in T-S space). The best settings were -0.7records for the primary and -0.9 for the secondary. SHIFT was run twice on all SBE911 casts using those settings. Salinity was recalculated for both channels.

pH:SBE

Tests on a few of the current casts indicate that a shift of +18 records looks best at aligning up/down profile offsets with those of the temperature traces. That is the same choice as was used last time this sensor was used.

SHIFT was run on channel pH:SBE to advance the records by 18 records.

As noted earlier, there is a problem with the pH data for many casts in the early part of the cruise. The upcast data may be ok, though without pH sampling this can’t be determined. From cast #45 to the end the profiles look normal.

##### 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 –

* 2021-020 – The salinity channels started out close and gradually drifted apart. Based on information from the Line P section of cruise 2021-006 it appeared that the primary salinity did not drift much during this cruise. The drift in secondary salinity appears to have been fairly sudden and then settled down. Dissolved oxygen was recalibrated using slope/offset =1.0515/-0.0131 based on cruise 2021-006. This correction seemed high since it was first use since previous factory calibration. Pressure looked ok. No TSG.
* 2021-006 Dissolved oxygen recal slope/offset = O 1.0515/-0.0131; Primary very close to bottles selected for archive; secondary high by 0.006psu.
* 2021-005 Dissolved oxygen recal slope/offset = 1.0536/-0.0018; Primary sal high by about 0 to 0.001psu, selected for archive; secondary high by 0.005 to 0.006psu. TSG salinity low by 0.191; intake temp high by 0.02C degrees – no recal applied.
* 2021-069 Poor info for recal of DO and SAL. Used 2021-005 correction for dissolved oxygen and salinity. Primary T/S selected for archive. Pressure corrected by subtracting 0.8db.
* 2021-008 Salinity channels lower than bottles by 0.012psu and 0.0055psu. Estimate of errors in bottles ~0.005psu, so estimate primary low by 0.007 and secondary low by 0.0005psu. Secondary was selected for archive and was not recalibrated. Pressure corrected by subtracting 0.8db. Dissolved oxygen recal slope/offset = 1.0445/+0.0004.
* 2021-012 Salinity channels lower than bottles by 0.0079psu and 0.0035psu. Estimate of errors in bottles ~0.005psu, so rough estimate is that primary is low by 0.002 and secondary high by 0.002psu. Secondary was selected for archive and was not recalibrated. Pressure was recalibrated by subtracting 0.8db. Dissolved oxygen recal slope/offset = 1.0465/+0.0012.

Historic ranges – Profile plots were made with 3-standard deviation climatology ranges of T and S superimposed. There was only 1 excursion from the temperature climatology with a small section of high temperature at about 30m at station 11 in the northern SoG. Salinity had small excursions towards low values in the top 15 to 40m in the southern SoG and low to 50m at stations 18 and 20. Salinity was high around 100m at some stations south and west of Texada Island. The excursions are small and some are likely due to stormy conditions. They do not suggest any problems with calibration given rapidly varying conditions in this region and the lack of any systematic excursions.

Post-Cruise Calibration – There were no post-cruise calibrations available.

##### DETAILED EDITING

The decision on which channels to use is not obvious. There are small spikes in both channel pairs, though more large ones in the secondary. There are small unstable features in both but perhaps more in the primary. The secondary salinity is closer to bottles and has been selected for the most recent cruises using this equipment, so the secondary channels were selected for editing and archiving.

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. 77 of 79 files required some editing, mostly removing records near the top and bottom of casts and some light editing of salinity. Notes about editing applied were added to the files.

The edited files were copied to \*.EDT.

After editing T-S plots were examined for all casts. The only unstable features found were from areas where some unstable features are expected and could be real. No further editing was done.

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

Pressure was found to be high by 0.8db during 2021-069 when many surface values were available.

All 2021 cruises were affected by delayed analysis of salinity samples and incomplete flushing of bottles, but the estimated errors in bottle comparisons due to those effects vary from cruise to cruise. Results from the spring cruises using this equipment suggest that the secondary salinity was high by 0.005 to 0.006psu after probable errors were considered. Cruise 2012-069 lacked reliable information to estimate calibration but suggested the secondary was high by about 0.004 to 0.005psu. Cruise 2021-008 suggested a large shift in the calibration of both salinity channels, with the secondary being lower than bottles by <0.001psu after applying an estimated correction. For the most recent use during 2021-012, the secondary looked slightly high by roughly 0.002psu after allowing for delayed analysis.

For this cruise, after allowing for analysis delay, the secondary salinity is likely high by ~0.001psu. Given small errors in analysis and noise in CTD records plus likely differences in evaporation and flushing errors, this is a small difference. There is insufficient evidence to justify recalibration of salinity. The standard deviation in the fits of CTD against bottles is 0.002psu and the error estimate used is rough.

For the dissolved oxygen channel the fit from 2021-012 is based on heavier sampling including offshore casts. The westernmost Juan de Fuca casts from this cruise had a fit close to that of 2021-012. The fit from 2021-012 will be applied to this cruise.

File 2021-022-recal.ccf was prepared to subtract 0.8db from the pressure and to apply the following correction to channel Oxygen:Dissolved:

CTD DO Corrected = CTD DO \* 1.0465 + 0.0012

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 average is 0.012mL/L, with a standard deviation of 0.016mL/L. See file 2021-022-DO-comp2.xls for details.

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 recalibrated downcast CTD DO data and the titrated samples from upcast bottles. The scatter in the comparison is greater than seen in offshore casts, which is likely due to data being included that have incomplete flushing of bottles. When the comparison was restricted to the

When outliers were removed based on standard deviations in the CTD DO data, the CTD DO was higher than the titrated samples by an average of ~0.04mL/L and the standard deviation was 0.10mL/L using all hydro casts. Using only the 2 westernmost casts from Juan de Fuca it was high by 0.03mL/L with a standard deviation of 0.13mL/L. The correction worked appropriately.

Since the Juan de Fuca casts likely have the best flushing of Niskin bottles, accuracy of the CTD DO was estimated based on those data. Plots against pressure suggest that the CTD DO data are good to roughly ±0.15mL/L from 0 to 100db and ±0.05 below 100db. These are very rough estimates.

##### 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. There are some small unstable features but from this region of active mixing they may well be real.

Profile plots were examined to see if there any problems. No problems were noted.

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

For events #1 - 42 REMOVE was run to remove the following channels:

Scan\_Number, Temperature:Primary, Conductivity:Primary, Oxygen:Voltage:SBE, Descent\_Rate, Status:Pump, Altimeter, Salinity:T0:C0, PAR:Reference, pH:SBE, and Flag.

For events #45-113 REMOVE was run to remove the following channels:

Scan\_Number, Temperature:Primary, Conductivity:Primary, Oxygen:Voltage:SBE, Descent\_Rate, Status:Pump, Altimeter, Salinity:T0:C0, PAR:Reference and Flag.

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 the 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. No 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 between ~50% to 108%, with the only value over 100% coming from Saanich Inlet. Values in the northern Strait of Georgia were mostly in the 85%-99% range. Casts with low saturation values look well mixed in the top 25m. This area is subject to active mixing and high variability, so the low values cannot be considered evidence of a problem with SBE dissolved oxygen calibration.

##### Final Bottle Files

MRGSORT was run to get files in pressure order.

For events #1 - 42 REMOVE was run to remove the following channels:

Scan\_Number, Temperature:Primary, Conductivity:Primary, Oxygen:Voltage:SBE, Descent\_Rate, Status:Pump, Altimeter, Salinity:T0:C0, PAR:Reference, pH:SBE, and Flag.

For events #45-113 REMOVE was run to remove the following channels:

Scan\_Number, Temperature:Primary, Conductivity:Primary, Oxygen:Voltage:SBE, Descent\_Rate, Status:Pump, Altimeter, Salinity:T0:C0, PAR:Reference and Flag.

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.

HEAD EDIT was run to add comments to the headers.

Data were exported from the CHE files to file 2021-022-bottles-final.xlsx. The entries were compared with the rosette log sheets and no data were missing but one dissolved oxygen value and flag were obviously wrong. The correct problems were found.

A Header Check and Standard Check were prepared and 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.

**Particulars - Notes from Daily Science Log and Sampling Notes**

14. Offset in con file PAR setting corrected.

26. Gain setting corrected in con file. Should be 3X.

28. Stop at 82m to correct wire angle.

38. Bottom depth wrong in header – should be 61.

41. Archiving started during soak.

63. Bottle at 371db – no rosette sheet. One was prepared post-cruise.

74. Spontaneous computer restart – Seasave started, files/header set to 2021-022. Used default con file.

79. After this cast con file reset.

82. Lot of floating vegetation.

95. Cast just to close bottle 17 for station 12. (Join with event 94.)

99. Wind gusting to 40 knots from SE.

101. Stormy, gusting to 40 kt.

102. Slow descent at 100m – large lead aft – resumed.

103. Stormy. 35kt winds.

106. Depth 297 at bottom of cast.

113. Ragged fluorescence signal.

**2021-022**

**CRUISE SUMMARY – CTD**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **CTD#** | **Make** | **Model** | **Serial#** | **Used with Rosette?** | **CTD Calibration Sheet Competed?** |
| **1** | **SEABIRD** | **911+** | **0443** | **Yes** | **Yes** |
| **Calibration Information - 0506** |
| **Sensor** | **Pre-Cruise** | **Post Cruise** |
| **Name** | **S/N** | **Date** | **Location** | **Date** | **Location** |
| **Temperature** | **4700** | **12Dec2020** | **Factory** |  |  |
| **Conductivity** | **3531** | **06Jan2021** | **Factory** |  |  |
| **Secondary Temp.** | **4888** | **12Dec2020** | **Factory** |  |  |
| **Secondary Cond.** | **4513** | **18Dec2020** | **Factory** |  |  |
| **Transmissometer** | **1185DR** | **28Apr2021** | **Factory** |  |  |
| **Transmissometer** | **1883DG** | **28Apr2021** | **Factory** |  |  |
| **SBE 43 DO sensor** | **3791** | **22Dec2020** | **Factory** |  |  |
| **PAR sensor** | **70613** | **24Feb2021** | **Factory** |  |  |
| **SPAR** | **20518** | **24Feb2021** | **Factory** |  |  |
| **SBE43 pH** | **691** | **23 Feb 2021** | **Factory** |  |  |
| **SeaPoint Fluor.** | **3950** |  | **Factory** |  |  |
| **Pressure Sensor** | **0443** | **07Jan2021** | **Factory** |  |  |
| **Valeport Altimeter** | **76341** | **10Feb2021** | **Factory** |  |  |

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