## REVISION NOTICE TABLE

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| DATE | DESCRIPTION OF REVISION |
| 18 March 2025 | Updated channel names & formats in TOB files. G.G. |

## PROCESSING NOTES

Cruise: 2022-040

Agency: OSD

Location: Strait of Georgia / Juan de Fuca Strait

Project: Salish Sea Biophysical Survey

Chief Scientist: O’Neill C.

Platform: Vector

Date: 23 June 2022 – 29 June 2022

Processed by: Germaine Gatien

Date of Processing: 24 August 2022 – 12 January 2023

Number of original HEX files: 76 Number of processed CTD files: 74

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

Number of TSG files: 6 Number of processed TOB files: 6 (4 have positions only)

# INSTRUMENT SUMMARY

Two CTDs were used for this cruise. The first was replaced after the first cast.

CTD #0550 was mounted in a rosette and attached were a Wetlabs CSTAR transmissometer (983DR), a SBE 43 DO sensor on the primary pump (# 1119), SeaPoint Fluorometer on the secondary pump (#3949), a Biospherical QSP-200L4S PAR sensor (#4565), SPAR sensor (#20518), a pH sensor (#0691), an altimeter (#73171) and a LISST-200X (2203).

CTD #1222 was mounted in a rosette and attached were a Wetlabs CSTAR transmissometer (983DR), a SBE 43 DO sensor (#1438) on the primary pump, a Seapoint Fluorometer (#3685) on the secondary pump, a pH sensor (#0691), PAR sensor (4565), and an altimeter (#73171) and a LISST-200X (2203) .

An SBE-21 TSG (#3411) was used.

Seasave version 7.26.7.121 was used for acquisition.

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 was in good order with comments about problems encountered and a detailed list of equipment. The rosette sheets were not printed and the digital format was hard to use since every station was on a separate tab. For data processing a single sheet is very useful. Thank you Mark Belton for quickly producing a version that served the purpose very well.

The entries for bottom depth were identical for beginning, bottom and ends of casts. Checks made to ensure the sounder depths are accurate make use of the altimetry readings taken at the bottom of casts, so depth when the CTD is at the bottom is useful when there is significant ship drift. Position information was recorded, so there is some evidence of drift, just not depth. If it is inconvenient to record bottom depth, it is best left blank.

The NMEA feature had not been ticked in the configuration files when the CTD was switched, so positions taken from the CTD log were added.

Problems were experienced during the first cast, so the CTD was swapped. Dissolved oxygen recalibration for the first CTD was based on a previous cruise since there was little calibration sampling. Pressure was increased by 1db since it appeared to be low. For the 2nd CTD the pressure offset in the configuration file was adjusted based on results of earlier cruises and oxygen recalibration was based on many calibration samples..

The pH sensor malfunctioned as it has on 2 previous cruises. That channel was removed from all casts.

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 or analysis errors and small mismatches in depth in the presence of large DO gradients, so the following statement likely underestimates SBE DO accuracy.

For CTD #1222, downcast (CTD files) Oxygen:Dissolved:SBE data for this cruise are considered, very roughly, to be:

 ±0.20 mL/L from 0-50db except in areas of very large DO gradients

 ±0.06 mL/L from 50db-200db

 ±0.01 mL/L below 200db

No estimate of accuracy was made for the DO sensor on CTD #0550.

6 TSG files were produced but the first 4 contain only position information because the loop flow was off. Temperature, salinity and conductivity data were also removed from a large section of File #6 because flow was not on. The comparisons with CTD data had a lot of scatter. Recalibration was based on the results of Vector cruises run before and after this one using the same TSG. A proxy for intake temperature was created by subtracting 0.20C° from the lab temperature. Salinity was recalibrated by adding 0.02psu. High near-surface gradients lead to noise due to variable errors in matching the depths of TSG intake and CTD sampling. Bubbles can account for the salinity reading low.

# PROCESSING SUMMARY

##### Seasave

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

There were 76 hex files but 1 was a test and 1 was from a cast that had to be restarted.

##### Preliminary Steps

The digital Log Book and rosette log sheets were obtained. Unfortunately, the rosette logs were in separate tabs, so inconvenient to use. Mark Belton provided a more convenient file.

* 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.
* CTD #0550 was used for only the first cast. There is adequate history available to recalibrate the dissolved oxygen data, salinity does not need recalibration. Based on previous uses, the pressure offset in the configuration file was adjusted to add 0.5db, based on 3 previous uses.
* CTD #1222 had not been used since the latest service. It was used during 2022-017 immediately after this cruise but there was no calibration sampling.

The configuration files were saved as 2022-040-ctd1.xmlcon and 2022-040-ctd2.xmlcon.

The log indicates that the SPAR was in use for the first CTD but it was not included in the configuration file, so no data were acquired from it. It was not listed for the second CTD.

##### BOTTLE FILE PREPARATION

The ROS files were created using files 2022-040-ctd1.xmlcon and 2022-040-ctd2.xmlcon as appropriate.

There were 2 files for event 35 – the first had no bottles fired and was not processed. File 2022-040-0035-2.ros was renamed 2022-040-0035.ros.

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 #77 and 80 had some small spikes and were opened in CTDEDIT for cleaning.

The output files, \*.ed1, were copied to \*.bot.

Cast #88 appears to have more serious problems, with noise in both salinity channels but very bad data in the primary salinity from 75m to 250m. Temperature looks ok. No attempt was made to edit that cast. The log notes poor upcast data for this cast, and flushing of the system was done before the next cast.

A preliminary header check was run. No position data were found in the headers for casts #4 to 91. The NMEA feature had not been ticked in the configuration files when the CTD was switched.

A spreadsheet was prepared using position information from the digital log and “Merge CTD File to Headers” was run to create \*.MRH files. A track plot looks fine.

The header check was rerun and the only problem found was that the pH data are bad and will be removed later. This sensor has been found to be faulty on a previous cruise.

A track plot was produced and no problems were found.

A cross reference list turned up no errors.

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 adjustments were needed:

* Event #1 - 12 bottles sampled but 24 were fired, so entries for bottles 13-24 were removed.
* Event #62 – Bottle #1 was fired but not sampled, so that entry was removed.
* Event #73 - Bottle #1 was fired but not sampled, so that entry was removed.

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 bottles not sampled as noted above were removed from the SAMAVG files.

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 2022-040-bot-hdr.txt which will be updated as needed during processing.

DISSOLVED OXGYEN

Dissolved oxygen data were provided in spreadsheet QF2022-040\_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 2022-040oxy.csv. That file was converted into individual \*.OXY files.

There were flag comments “ALL” for samples #107 and #118.

EXTRACTED CHLOROPHYLL

Extracted chlorophyll and phaeo-pigment data were obtained in file QF2022-040\_CHL QF\*.xlsx. The file included comments and flags and a precision study. A simplified version of the spreadsheet was prepared and saved as 2022-040chl.csv. The csv file was then converted to individual CHL files.

SALINITY

Salinity analysis was obtained in file QF2022-040\_SAL.xlsx which included a precision study. The analyses were carried out in a temperature-controlled lab 12 to 20 days after collection. The files were simplified and saved as 2022-040sal.csv. That file was then converted to individual SAL files.

NUTRIENTS

The nutrient data were obtained in spreadsheet QF2022-040\_NUTS\*.xlsx. This includes a precision study. The file was simplified, saved as 2022-040nuts.csv. The file was converted to individual NUT files.

Flag 3 was added to salinity and nutrient samples #107 and 118. There was no CHL sampling affected.

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. Columns from the rosette log summary spreadsheet were added and checks made that all expected samples were present. There were some samples missing but all had appropriate explanatory comments and flags.

There are salinity values <25psu so silicate will need recalibration.

##### Compare

Salinity

Compare was run with pressure as reference channel.

The first cast used different sensors from the others.

Cast #1: The primary salinity was found to be low by 0.0081psu and the secondary by 0.0124psu.

This is based on only 1 bottle and the CTD data are very noisy just before the bottle was fired. There are nearby salinity values that match the bottle value. When last used no recalibration was applied for these sensors and none is recommended for this cast. The difference between the 2 channels (0.006psu) was slightly higher than found in section 9 (0.005psu).

Casts #6-89: There were a few major outliers right at the surface, as expected, and a few other minor outliers. Cast #88 had bad data in the primary CTD and noisy data in the secondary. When those data were excluded plus outliers based on standard deviation in the CTD salinity being >0.0008psu, the primary salinity was high by an average of 0.0009psu (std dev 0.0025) and the secondary was high by 0.0036psu (std dev 0.0026psu.). There are fewer bottles to compare for the secondary due to more noise in the CTD data. If there are flushing errors, both channels may be reading a little higher than found in this comparison.

Cast #88 had bad data in the primary CTD though the effect was not too bad at the sampling level. Nonetheless, the sample was removed from the primary comparison although it did look ok. This raised the average difference to 0.0009psu. It was also removed from the secondary because the CTD data were noisy. The downcast data look ok except possibly near the bottom.

The difference between the 2 channels (+0.0029) compares well with that found in section 9 (+0.003psu) and during the cruise that followed (+0.002psu). No recalibration is needed for the primary.

For full details for the COMPARE run see file 2022-040-sal-comp1.xls.

Dissolved Oxygen

COMPARE was run with pressure as the reference channel.

There were 2 DO sensors in use:

Cast #1 – This cast was in Saanich Inlet where fits usually look out of line with casts from other areas. The comparison for this cruise has too much scatter to say which bottles are outliers.

The fit found when only 5 out of 12 bottles were included that were fairly close to a linear fit was:

CTD DO Corrected = CTD DO \* 1.0202 + 0.028.

The recalibration applied for other cruises using this CTD was based on cruise 2022-001:

CTD DO Corrected = CTD DO \* 1.0153 + 0.0461

When the offset for 2022-040 was forced to match that from 2022-001, the slope was 1.0162.

The 2022-001 correction is the only one that can be justified for this cast.

Casts #14 to 89 – There were a number of very clear outliers from cast #88. Profiles and log notes indicate there was clearly a problem in the upcast data from the primary channels during that cast until the CTD reached 97db on the upcast. The fit found when the offset was forced to 0 (since there were no DO values <1.5muL/L), bottles from cast 88 below 97db and outliers based on residuals was:

CTD DO Corrected = CTD DO \* 1.0475

This correction seems unusually large given the sensor had been serviced recently, but the fit is quite tight.

A check was made for temporal drift. This program samples markedly different regions, but casts were chosen in areas with fairly open waters. The fits for Juan de Fuca Strait and the central Strait of Georgia casts were remarkably close, adding more confidence to the general fit.

The major outliers were mostly associated with bad CTD data. One was not:

Sample 165, cast #52 looks out of line in profile and in comparison to the CTD DO. The nutrients also look out of line, so the analysts agreed to the addition of 3 flags as a possible case of the bottle closing in shallower water.

For full details for the COMPARE run see file 2022-040-dox-comp1.xls.

Fluorescence

COMPARE was run with extracted chlorophyll and CTD Fluorescence using pressure as the reference variable. The usual patterns were seen. CTD Fluorescence is much higher than CHL when CHL is near 0, but it drops sharply to a ratio FL/CHL ~ 1 as CHL approaches 0.5ug/L. For CHL>2 fluorescence is about 50% to 60% of CHL and much lower for the one CHL sample >10ug/L.

The fit of CTD fluorescence versus extracted chlorophyll has an overall slope of 0.6 but as noted above the slope is higher for low CHL and lower at high values. This pattern is typical of this type of fluorometer.

The only samples that looks like an outlier is from cast #61 at 5m. It is likely that both the CTD fluorescence and chlorophyll sample values are ok. There is a very large gradient seen in the downcast with Fluorescence rising from 2 to 9ug/L over 2m at about 8m depth so even a slight mismatch in depths from which the FL and CHL were sampled could explain most of the difference.

For full details for the COMPARE run see file 2022-040-fl-chl-comp1.xls.

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

File 2022-040-ctd1.xmlcon was used to convert cast #1 and 2022-040-ctd2.xmlcon was used for casts #4 to #91. The Tau function was chosen, but not the hysteresis function since there was no sampling deeper than 500db.

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 has a clear signal. Fluorescence, PAR and Transmissivity channels look normal. The pH data look bad as they have on the last 2 cruises on which this sensor was used. These data should be removed later.

##### WILDEDIT

No large spikes wee noted in the casts checked, but WILDEDIT was run in case there are some. A few small ones were noted and successfully removed.

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, so the default setting was selected.

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.

Plots were examined to ensure the previous steps worked well. The oxygen alignment looks good and CELLTM worked well in bringing downcasts and upcasts closer in T-S space.

DERIVE was run again on a selection of casts to find differences between channel pairs.

There was just 1 cast using the same CTD as cast #1 and it was very shallow. The differences were compared with data from somewhat similar depths from previous cruises that used these sensors:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cast # | Press | T1-T0  | C1-C0 | S1-S0 | Descent Rate |
| 2022-001-0024 | 350 | -0.0001 | +0.00009 | +0.0013 | High, XNoisy |
| 2022-001-0082 | 350 | 0 | +0.00015 | +0.0017 | High, XNoisy |
| 2022-013-0047 | 370 | -0.0004 | +0.00027 | +0.0029 | Med, Moderate |
| 2022-013-0075 | 350 | -0.0002 | +0.00019 | +0.0025 | High, Quiet |
| 2022-015-0036 | 300 | -0.0002 | +0.00012 | +0.0016 | High, F.Steady |
| 2022-015-0152 | 300 | -0.0002 | +0.00019 | +0.0020 | High V.Steady |
| 2022-040-0001 | 175 | -0.0006 | -0.00055 | -0.0050 | High, Moderate |

The conductivity and salinity differences are strikingly different.

This was the first use of CTD #2 since factory service. Differences around 300db were noisy:

∆ Temperature ~+0.0001, ∆ Salinity ~+0.003, ∆ Conductivity ~+0.0003.

This is reasonably close to the results when the sensors were next used on 2022-017:

∆ Temperature ~+0.0004, ∆ Salinity ~+0.002, ∆ Conductivity ~+0.0002.

##### 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. The only high fluorescence value came from the surface at the end of cast #16.

MERGE CSV file to Headers was run to add position data. Cast #1 already had positions, so 2022-040-0001.CLN was copied to \*.MRH so there is a complete set of MRH files.

##### Checking Headers

The cross-reference check and header check were run. A few problems were found in the MRH headers due to one format problem in the log file and cast #1 was missed since it already had positions. Those issues were resolved (in both bottle and CTD files) and the checks were rerun. A few problems or points of interest were noted:

* Fluorescence values did not go off-scale and there were no negative values. There were some 0 and near-maximum values during cast #1, but only at the end of the upcast.
* For cast #1 (CTD 0550) the pressure at the end of the cast was ~-1db and pumps were running. Salinity bounced between extremely low values at about 1.5psu. PAR was extremely high and at the end fluorescence was 0. At the beginning of the cast the pressure was 1.6db which seems right given that it was likely started with the top of the rosette at the surface, but it is also possible that 1.6db was based on the pressure sensor reading rather than the position of the rosette. The pressure offset had been updated on previous cruises and that setting was used in conversion. The problem could be hysteresis or the pressure sensor calibration drift has continued. The latter is more likely, so pressure will be recalibrated by adding 1db. This affects only cast #1.
* Pressure from the other casts (CTD 1222) is also rather low, but many of these casts were in protected areas where there may have been a particular desire to get near-surface data. It looks like many casts started with the rosette partly out of water. Cast #12 started with pressure ~0 and salinity and transmissivity have “in-water” values; on the way up conductivity from one channel appears to be out of water when pressure ~0.1db. So the surface does appear to be at ~0db. In more open waters the surface pressure is higher. Cast #13 started at 2.7db. On the upcast there are data with pumps off, but transmissivity drops to near-zero at about 0.2 to 0.3db. So the pressure may be slightly low, but not by enough to justify recalibration.
* Surface Report gives an average surface pressure at the beginning of casts as 1.2db; this is when the acquisition started, not the actual surface. The only sites with low starting pressure are in more protected areas.

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

The altimeter 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. Because of the nature of this cruise there are expected to be larger differences than usual when the ship is in narrow channels with steep slopes.

There were 4 differences > 6m for which checks were made:

* Plots of altimetry at the bottom confirm that all altimetry header entries are good to ±1.5db
* Depths at the bottom and end of casts were checked, but there was no difference in any of them. This is unlikely so it looks like there was no real observation made after the first. So it is impossible to judge if there might have been a significant change during the cast. There is a record of positions at all 3 times and there was some drift.
* Track plots were examined to see if the larger check values came from areas likely to have steep slopes and they did. All came from near-shore locations.

There is no evidence to suggest the sounder was not working well.

See file 2022-040-altimeter-ctd.xlsx for details.

##### Shift

Fluorescence

SHIFT was run on the SeaPoint fluorescence channel in all casts using the usual advance of +24 records.

For CTD #0550 there was only 1 cast with many stops so plotting was not useful but this is the same setting that was used for this sensor in the past.

For CTD #1222 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

For CTD #0550 the settings used for the last cruise were applied.

SHIFT was run twice on cast #1 using -0.65 records for the primary and -1.0 for the secondary. Salinity was recalculated for both channels.

For CTD #1222 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. Settings of +0.3 records looks best for the primary and -0.3 records for the secondary.

SHIFT was run twice on all SBE911 casts using +0.3 records for the primary and -0.3 for the secondary. Salinity was recalculated for both channels.

pH Sensor malfunctioned – no alignment applied.

##### 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 –

* CTD#0550

Dissolved oxygen sensor on CTD 0550 had been used for a 7 previous cruises but only 3 had calibration sampling. The result from 2022-001 was considered the most reliable (slope 1.0153, offset 0.0461).

The other sensors on CTD #0550 were used for 3 previous cruises. Primary salinity was chosen and was very close to bottles for all 3 cruises. Pressure was found to be high by about 0.5db for 2022-001, so subsequent cruises added 0.5db to the offset at the conversion stage.

* CTD#01222

This was the first use of CTD #1222 and the dissolved oxygen sensor since they were last serviced at the factory. It was used during cruise 2022-017 which followed this cruise immediately, but there was no calibration sampling. No recalibration was applied.

Historic ranges – All temperature data all fell within the historic ranges. Salinity had many excursions from the historic ranges but they varied in depth and sign. At the south-west site at the entrance to Juan de Fuca Strait salinity was high near the surface and at the northern side of Juan de Fuca it was low around 60 to 100m. Salinity was also low around 10-20m along the western side of the Strait of Georgia near the Gulf Islands. There were no systematic excursions, so no indication of a calibration problem.

Post-Cruise Calibration – None available.

Repeat Casts –None.

##### DETAILED EDITING

The primary channels were chosen for editing. There is little to distinguish between the 2 pairs though the primary salinity might be very slightly smoother and the calibration may be slightly better.

The DEL files were uploaded to an AI model which produced files \*.delpred which contained a Prediction\_Flag column which had value 1 where the model predicted editing would be required.

All DELPRED files were copied to \*.EDT.

Editing was done using the DELPRED files.

CTDEDIT was used to remove records that appear to be corrupted by shed wakes; most were near the top and bottom of the cast. Salinity was cleaned lightly in all files except those for events #26, 71 and 81.

Cast #88, which had bad upcast data, also had poor data below 298db in the downcast, so those records were removed. The secondary data looked better near the bottom, but had some spikes.

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 was applied as they may reflect real conditions.

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

Recalibration file 2022-040-recal-SIL.ccf was used to correct silicate where salinity <25psu in MRGCLN2 files. Output: MRGCLNSIL.

File 2022-040-recal1.ccf was prepared to apply separate corrections for the 2 CTDs:

* For cast #1 pressure will be corrected by adding 1db, depth by adding 1m and dissolved oxygen will be corrected using the results found during 2022-001:

CTD DO Corrected = CTD DO \* 1.0153 + 0.0461.

* For casts 4-91 dissolved oxygen will be corrected using:

CTD DO Corrected = CTD DO \* 1.0475

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

COMPARE was rerun for dissolved oxygen and shows that the correction was applied properly.

For CTD #0550, with just 1 cast and only 4 bottles included in the fit, the CTD DO was high by an average of 0.0011mL/L (std dev 0.0558).

For CTD #1222, with the same points excluded as in the original fit, the CTD DO was high by an average of 0.0004mL/L (std dev 0.0258).

See file 2022-040-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, averaging of CTD data 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.

Using all data from the CTD #1222, DO was lower than the titrated samples by an average of ~0.033mL/L with a standard deviation of 0.177mL/L. When outliers were removed based on │differences│>0.015 the CTD DO was high by an average of 0.002mL/L (std dev 0.038mL/L). The recalibration was obviously effective. From a plot of differences versus pressure an estimate of accuracy of the sensor on CTD #1222 was made as follows:

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

 *±0.20 mL/L from 0-50db except in areas of very large DO gradients*

 *±0.06 mL/L from 50db-200db*

 *±0.01 mL/L below 200db*

No estimate was made for CTD #0550.

For more detail see file 2022-040-dox-comp3.xls.

##### 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.

Profile plots were examined. No problems were noted.

##### 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, pH:SBE, Prediction\_Flag 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 some header entries 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. No other problems were found.

The sensor history was updated.

##### Dissolved Oxygen Study

As a final check of dissolved oxygen data, % surface saturation was calculated and plotted. Values at 2 to 3m ranged between ~60% to 140%, with low values on the southern and eastern sites in Juan de Fuca Strait, Haro Strait and the north end of the Strait of Georgia. High values were found in the central Strait of Georgia. Great variability is expected given the variety of sites and the season; the values do not suggest any problem with 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, pH:SBE 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.

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

Data were exported from the CHE files to file 2022-040-bottles-final.xlsx. The entries were compared with the sampling spreadsheet. Two differences were noted:

* Niskin #9, Sample #9 has duplicates, but the plan was to take duplicates from Niskin #8, sample #8. The spreadsheet was checked and it does appear duplicates were taken from Niskin 9, not 8. The replicate match is excellent if the sample is reassigned to #8B and the resulting values for samples 8 and 9 both look much better in comparison to SBE DO. The analyst was notified.

The error was corrected at the \*.REM stage and the final steps were rerun for that cast.

* Event #80, Niskin samples #269 have a comment but no flag – flag 2 was added to those data.

Standards check and a header check were run. No further 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

There were 6 thermosalinograph files.

There were no loop samples, flow meter or intake thermistor. The intake is at about 2m. The only method to check calibration is to compare with the CTD casts.

a.) Checking calibrations

The configuration file used at sea was correct.

b.) Conversion of Files

The cnv files were converted to IOS HEADER format.

CLEAN was run to add End times and Longitude and Latitude minima and maxima to the headers.

ADD TIME CHANNEL was used to add Time and Date channels and record #.

A time-series plot was produced. There was obviously no flow during the first 4 files since salinity is ~0, but positions are present, so they do at least show the ship track.

File #5 has about 1.5 hours of data that look ok.

File #6 has about 5 hours of useful data, then a section of about 12.5 hours length with flow obviously off, then good data for about 33 hours.

All files will be archived, though the first 4 only contain ship position information.

For file #6 a section will need to be edited to remove T and S.

The track plot looks fine and was added to the end of this report.

c.) Checking Time Channel

* The CTD files were thinned to reduce the files to a single point from the downcast within 0.5db of 2db. These were exported to a spreadsheet which was saved as 2022-040-ctd-tsg-comp.xlsx. Data from events #4-32 and 39-49 were removed since no temperature or salinity data are available during those periods. There were 33 CTD casts with data available from ~2m that overlapped with TSG data with flow on.
* There were no CTD casts that overlapped with file 2022-040-0005, File 2022-040-0006.atc was opened in Excel. Median and standard deviations (over 5 records) were calculated for lab temperature and salinity and the file was reduced to the times of CTD files. Those data were added to 2022-040-ctd-tsg-comp.xlsx.
* To check for problems in the TSG clock or bad matches of TSG and CTD data, the differences between latitudes and longitudes were found. The median and average differences were both 0.0000º with no difference >0.0003º.

d.) Comparison of T and S from TSG and CTD data

When all 33 casts were included the differences were:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Lat diff | Long diff | Tlab-Tctd | Slab-Sctd |
| median | 0.00000 | 0.00000 | 0.3622 | -0.2696 |
| average | 0.00000 | 0.00000 | 0.7466 | -0.6653 |
| stdev | 0.00007 | 0.00010 | 1.2230 | 1.2676 |
| max | 0.00011 | 0.00021 | 5.0489 | 1.8627 |
| min | -0.00017 | -0.00026 | -0.6486 | -3.9578 |

When the data were ordered on standard deviation for temperature and salinity, and only the 10 with the lowest standard deviation included in the averages the results were:

|  |  |  |
| --- | --- | --- |
|  | Tlab-Tctd | Slab-Sctd |
| median | 0.3032 | -0.0414 |
| average | 0.4352 | -0.1054 |
| stdev | 0.3307 | 0.1599 |

Between casts 77 and 91 standard deviations were low for both temperature and salinity. When only those casts were included the results were:

|  |  |  |
| --- | --- | --- |
|  | Tlab-Tctd | Slab-Sctd |
| median | 0.2643 | -0.0311 |
| average | 0.3188 | -0.0638 |
| stdev | 0.1743 | 0.0801 |

It is expected that the TSG salinity will be a little lower than the CTD salinity due to bubbles in loop water. The temperature difference is primarily due to heating in the loop. This varies with flow rate which is unknown and with intake temperature.

See 2020-040-ctd-tsg-comp.xls for details.

Calibration History

The TSG temperature and conductivity were recalibrated in December 2019 and was used for 2020-031 and 2022-012 before this cruise and 2022-017 immediately after this cruise. Heating in the loop on the Vector was about 0.2Cº for all cruises. There was insufficient information available to assess salinity for 2020-031 but for 2022-012 it was estimated to be low by 0.028psu and for 2022-017 it was estimated to be low by 0.02psu.

Conclusions

1. The TSG clock worked well.

2. The TSG lab temperature was higher than the CTD temperature by a median of ~0.26C° for the latter part of the cruise. This is slightly higher than observed during other 2022 Vector cruises, but the standard deviation was very high. A proxy for intake temperature will be derived by subtracting 0.20C° from the lab temperature since that value was found for Vector cruises before and after this one.

3. The TSG Salinity is generally lower than the CTD salinity but the noise level was very high. High near-surface gradients lead to noise due to variable errors in matching the depths of TSG intake and CTD sampling. Bubbles likely account for many of the low salinity readings, and applying a correction to account for bubbles is justified. The cruise after this one had a lower standard deviation in salinity differences, perhaps due to better mixed near-surface data. So a correction will be made by adding 0.02psu to the TSG salinity channel.

f.) Editing

For file #6 only:

CTDEDIT was run twice to remove temperature, salinity and conductivity in a section where flow was clearly off between 2022/06/26 20:42:52 and 2022/06/27 07:30:22. The output file was \*.EDU.

g.) Recalibration (For file 5 applied to \*.atc and for file 6 applied to \*.edu)

Add Channels was used to add Channel Temperature:Lab with values set equal to Temperature:Primary.

Calibrate was run using file 2022-040-tsg-recal1.ccf to subtract 0.2 from Temperature:Primary and to add 0.02psu to channel Salinity:T0:C0. Output: \*.COR1.

h.) Preparing Final Files

REMOVE was used to remove the following channels: Scan Number and Flag channels from all files and Temperature:Primary and Salinity:T0:C0 from files 1 to 4.

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.

The TSG sensor history was updated.

Plots were made of the cruise track and time-series and all look fine. The cruise plot was added to the end of this report.

Standards check turned up a few problems that were resolved.

Header check was run until all problems were resolved.

P**articulars – notes from log**

1. Differences between channel pairs looked large.

4. Swapped CTD to #1222. Altimeter on CTD rather than rosette – pointing wrong way. Problems with altimeter due to wrong serial number in configuration file. Fixed after this cast.

12. Further changes to configuration file.

24-25. Fluorescence data really noisy

26. Flushed fluorometer cell.

41. 3.5 cables SSE of station 57 because of traffic.

42. Stopped at 10m above seafloor then went to 5m above. Drifting so fast into shallower waters that bottom-5 bottle shallower than 200m bottle, no samples taken from 200m bottle. 0.81nm drift during stop.

72. Rosette lowered to seafloor after we were at bottom – 5m.

84. After cast Niskin 12,16, 20 lanyards were shortened by one knot to keep bottom caps open better.

88. Poor upcast data – flushed when back at surface.

**CTD & TSG EQUIPMENT LIST**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **CTD#** | **Make** | **Model** | **Serial#** | **Used with Rosette?** |
| **1** | **SEABIRD** | **911+** | **0550** | **Yes** |
| **2** | **SEABIRD** | **911+** | **1222** | **Yes** |
|  |
| **Calibration Information - 0550** |
| **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** | **983DR** | **28Apr2021** | **IOS** |  |  |
| **SBE 43 DO sensor** | **1119** | **5Feb2021** | **Factory** |  |  |
| **SeaPoint Fluor.** | **3949** |  |  |  |  |
| **pH** | **691** | **23Feb2021** | **Factory** |  |  |
| **PAR sensor** | **4565** | **24Feb2021** | **Factory** |  |  |
| **LISST** | **2203** |  |  |  |  |
| **Valeport Altimeter** | **73171** | **20Jan2021** | **Factory** |  |  |
| **Pressure Sensor** | **0550** | **11Oct2021** | **Factory** |  |  |
|  |
| **Calibration Information - 1222** |
| **Sensor** | **Pre-Cruise** | **Post Cruise** |
| **Name** | **S/N** | **Date** | **Location** | **Date** | **Location** |
| **Temperature** | **5013** | **11Mar2022** | **Factory** |  |  |
| **Conductivity** | **4434** |  **04Mar2022** | **Factory** |  |  |
| **Secondary Temp.** | **5725** | **11Mar2022** | **Factory** |  |  |
| **Secondary Cond.** | **4448** | **04Mar2022** | **Factory** |  |  |
| **Transmissometer** | **983DR** | **28Apr2021** | **IOS** |  |  |
| **SBE 43 DO sensor** | **1438** | **2Apr2022** | **Factory** |  |  |
| **SeaPoint Fluor.** | **3685** |  | **Factory** |  |  |
| **pH** | **691** | **23Feb2021** | **Factory** |  |  |
| **PAR sensor** | **4565** | **24Feb2021** | **Factory** |  |  |
| **LISST** | **2203** |  |  |  |  |
| **Altimeter** | **73171** | **20Jan2021** |  |  |  |
| **Pressure Sensor** | **1222** | **17Mar2022** | **Factory** |  |  |

|  |
| --- |
| **TSG Calibration Information** |
| **Sensor** | **Pre-Cruise** | **Post Cruise** |
| **Name** | **S/N** | **Date** | **Location** | **Date** | **Location** |
| **Temperature** | **3411** | **14Nov18** | **Factory** |  |  |
| **Conductivity** | **3411** | **14Nov18** | **Factory** |  |  |

 