## 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: 2022-012

Agency: OSD

Location: Central Coast B.C.

Project: Inlets

Chief Scientist: Spear D.

Platform: Vector

Date: 6 April 2022 – 19 April 2022

Processed by: Germaine Gatien

Date of Processing: 24 August 2022 – 14 November 2022

Number of original HEX files: 115 Number of processed CTD files: 115

Number of rosette files: 46 Number of processed CHE files: 46

Number of TSG files: 1 Number of processed TOB files: 1

# INSTRUMENT SUMMARY

CTD #0550 was mounted in a rosette and attached were 2 Wetlabs CSTAR transmissometer (1185DR & 1883DG), a SBE 43 DO sensor on the primary pump (# 1119), SeaPoint Fluorometer on the secondary pump (#3949), a Biospherical QSP-400 PAR sensor (#70613), SPAR sensor (#20518), a pH sensor (#0691) and an altimeter (#73171).

Seasave version 7.26.7.121 was used for acquisition.

The data logging computer was the new Vector Thinkcenter

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 in good order with comments about problems encountered and a detailed list of equipment. There was also a note from C. Wright about the deployment scheme and some problems that arose.

Deployment Scheme: There was no 10m soak. The CTD soaked at about 1m with bottles out of water where possible. Data acquisition began immediately. The pumps came on after highly variable wait times.

There were several problems with labels, with sample #s repeated or mislabelling of samples and 1 extracted chlorophyll sample had no label.

Niskin #14 appears to have closed prematurely during 2 casts; affected sample values were padded.

Dissolved oxygen sampling was limited to 4 casts and flushing of Niskin bottles is likely to be poor in this region, so recalibration was based on the results of cruise 2022-001 when the same sensor was used.

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:

±0.40 mL/L from 0-100db except in areas of very large DO gradients

±0.20 mL/L from 100db-200db

±0.05 mL/L below 200db

The TSG lab temperature was higher than the CTD temperature by a median of ~0.20C°. This is a reasonable value for the Vector based on previous cruises. A proxy for intake temperature was derived by subtracting 0.20C° from the lab temperature. 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 can account for the salinity reading low. The results from 2022-014 look more reliable, so -0.02psu was added to the salinity channel.

# PROCESSING SUMMARY

##### Seasave

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

##### Preliminary Steps

The Log Book and rosette log sheets were obtained 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 twice since the last use. The dissolved oxygen sensor had been used on 6 other cruises.

There were 17 deck pressure measurements noted in the log, ranging from -0.01 to -0.76db. The median value was -0.38db. See file 2022-012-Deck-Pressure.xlsx for details. While the pressure is only considered ±1m, it was found to be low by 0.5db during 2022-001. The pressure calibration offset was changed for 2022-013 by adding 0.5db and the results were good, so the same adjustment was applied for this cruise.

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 2022-012-ctd.xmlcon.

##### BOTTLE FILE PREPARATION

This cruise visited many areas with low salinity, so a preliminary processing of bottle files was done in order to supply the nutrient analyst with information needed to correct silicate values.

The ROS files were created using file 2022-012-ctd.xmlcon

The ROS files were converted to IOS format.

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

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

A preliminary header check was run. The pH data looks bad, as was the case in the latter half of the previous cruise. Values are much too high and the channel will be removed. The CTD technician was informed. The fluorescence went off-scale for at least one cast, so CLEAN was rerun to replace values >14.85ug/L with pad values.

A track plot was produced and no problems were found.

A cross reference list turned up an error in the station name of event #110; this was corrected.

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. One potential problem was found though adjustments made at sea and/or by analysts may make this clear:

Event 83 –Sample #s 276, 277, 278, 279 were each used twice (at different depths). The analysts assigned #s 9276, 9277, 9278, 9279 to the 2nd instances of each. Special care will be needed to ensure proper assignments of samples for this cast.

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 2022-012-bot-hdr.txt which will be updated as needed during processing.

DISSOLVED OXGYEN

Dissolved oxygen data were provided in spreadsheet QF2022-012\_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 2022-012oxy.csv. That file was converted into individual \*.OXY files.

There were no flag comments “ALL” in the original spreadsheet.

EXTRACTED CHLOROPHYLL

Extracted chlorophyll and phaeo-pigment data were obtained in file QF2022-012\_CHL QF\*.xlsx. The file included comments and flags and a precision study. A simplified version of the spreadsheet was prepared and saved as 2022-012chl.csv. The csv file was then converted to individual CHL files.

Some problems were found in sample labels; the analyst made corrections that are noted in the QF file.

SALINITY

Salinity analysis was obtained in file QF2022-012\_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 2022-012sal.csv. That file was then converted to individual SAL files.

* Sample #279 was changed to #9279 if the rosette sheet is correct. While from the same depth, there is a better match to CTD salinity with the correction. The analyst changed the sample #.
* Duplicate labels on one sample – 368 and 396. Bad fit to be 368 and is within 0.002psu of the CTD sal if it is #396. Move to 396 with 2 flag. For 368 the analyst entered a pad and 9 flag with a note of explanation.

NUTRIENTS

The nutrient data were obtained in spreadsheet QF2022-012\_NUTS\*.xlsx. This includes a precision study. The file was simplified, saved as 2022-012nuts.csv. The file was converted to individual NUT files.

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

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

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

At this point the flags on all samples from the samples for event #83 with #s that were used twice were given flag 2 and the following comments were used to replace those that had only referred to NUTS.

Sample\_Number 276: ALL: Samples mislabelled with duplicate numbers, 2nd instance was prepended

with a '9' to differentiate.

Sample\_Number 277: ALL: Samples mislabelled with duplicate numbers, 2nd instance was prepended

with a '9' to differentiate.

Sample\_Number 278: ALL: Samples mislabelled with duplicate numbers, 2nd instance was prepended

with a '9' to differentiate.

Sample\_Number 279: ALL: Samples mislabelled with duplicate numbers, 2nd instance was prepended

with a '9' to differentiate.

Sample\_Number 9276: ALL: Samples mislabelled with duplicate numbers, 2nd instance was

prepended with a '9' to differentiate.

Sample\_Number 9277: ALL: Samples mislabelled with duplicate numbers, 2nd instance was

prepended with a '9' to differentiate.

Sample\_Number 9278: ALL: Samples mislabelled with duplicate numbers, 2nd instance was

prepended with a '9' to differentiate.

Sample\_Number 9279: ALL: Samples mislabelled with duplicate numbers, 2nd instance was

prepended with a '9' to differentiate.

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. Event #83 looks fine, but a few problems were found:

* Event #18 – bottles 8-10 were fired in air and bottles 11-13 were fired to replace them, so bottles 8-10 were removed from the samavg file and MERGE was rerun.
* Event 22 – bottle 11, sample 88 was fired for pc02 system only – left n place in case needed later.
* Event 36 – bottle 4 misfired; line removed from SAMAVG and MERGE rerun.
* Event 41 – missing CHL sample 163 –another sample has no label – likely 163.
* Event 89 – Salinity sample 306 indicated as duplicate on rosette sheet but only 1 sample in raw data. Assume dup not taken. Flagged 2 with comment.
* Event 157 – no samples from Niskin 10 and no sample # assigned. Removed that record from SAMAVG and remerged.
* Event 159 – sample #s were missing. Fixed.

The analyst asked for information about the following samples:

* 43 – Event 14 – FL=0.19 CHL=0.26 (dups 0.32 & 0.20). At low CHL expect CHL<FL, so 0.2 maybe more likely and profile suggests 0.2 during upcast. But upcast fluorescence does tend to read lower than downcast and downcast was 0.25ug/L. So the average looks good. Not enough evidence form COMPARE to justify a change.
* 228 -Event 71 – Fl=0.73. Both dups >FL – expect FL and CHL should be close in value, but high variability during bottle stop. 2m lower the CHL is higher, ~1ug/L. Very slight flushing error could explain value and variability if Niskin contents not completely mixed. Not enough evidence from COMPARE to justify a change.
* 308 – Event #89. Fluorescence is 0.75; CHL 0.14 and 0.42. At this level expect CHL slightly lower than  FL. So 0.42 is more likely but not certain. Limited evidence suggests 0.14 could be rejected.
* 422 – Event 128. CHL is an outlier in the comparison. Fluorescence is 4.18 and quite well-mixed, so CHL seems extremely high. Phaeo was rejected. The evidence is strong enough to reject CHL as well.

The analyst made changes to the spreadsheet – see NOTES page in QF document for details.

##### Compare

Salinity

Compare was run with pressure as reference channel.

There were many outliers right at the surface, as expected, but 3 major outliers from >10db were studied:

* Event 116 – SAL – sample 368 – as noted earlier this sample was double-labelled. It is a very bad fit to be #368 and looks very close to CTD sal if it is #396. Assumed to be #396. No sample was found that looks like it came from this Niskin bottle. Pad value, flag 1 and comment:

*Sample\_Number 368: SAL: Double labeled, 368 and 396; salinity value very*

*bad fit for #368*

* Event 116 – Sample 376 – SAL and Nuts out of line in profile and CHL suspicious. Looks like premature closing of Niskin 14. All values padded with flag 5 and comment:

*Sample\_Number 376: ALL: Apparent premature closing of Niskin #14.*

* This is not an outlier but had to be fixed after reassigning value from event 116.

Event 119- SAL sample 396 – as noted earlier the label for this sample was on the same bottle as sample 368. The sample from that bottle is definitely not from 368db. Tentatively flagged 2 with comment.

*Sample\_Number 396: SAL: Sample double labeled, 368 and 396; salinity value good fit for 396.*

* Event 151, sample 487 said to be fired at 21db had salinity bottle value too high by 0.7psu. DO and NUTS also out of line but CHL looks ok. Don’t all look like came from same depth but if bottle not fully closed there could be some leakage leading to some variability within the bottle. Think all should be padded with a 5 due to premature closure. CHL could be from the other Niskin but can’t prove that. Suggest comment:

Sample\_Number 487: ALL: Bottle likely closed prematurely.

COMPARE was rerun after those changes were made.

A fit was done excluding stops above 100db and cases where the standard deviation in the CTD salinity during the 10s window was >0.0008psu. The primary salinity was lower than bottles by an average of ~0.0011psu (std dev 0.0033psu) and the secondary salinity was high by an average of 0.0007psu (std dev 0.0032psu). The difference between the fits is 0.0018psu which corresponds fairly well with the differences between downcast salinity channels reported in section 9.

There are a few small outliers that were investigated:

Event 32 at 317.0db – sample 120 Sal 0 higher than bottle by 0.010psu

Event 36 at 150.5db – sample 149 Sal 0 lower than bottle by 0.012psu

Event 148 at 326.7db – sample 465 Sal 0 higher than bottle by 0.007psu.

The two cases where the CTD read higher than bottles were from 5m off the bottom so any error due to shed wakes would lead to the CTD reading high. Bottles right at the bottom do tend to have larger flushing errors.

The outlier from event #36 was marked by a large shed wake early in the stop and then very steady pressure after so flushing would have been impeded somewhat resulting in a sample with higher salinity than ambient waters.

These outliers were excluded from the fits but there is no indication that the values do not represent the Niskin contents. No flag was attached.

After those exclusions the primary salinity was lower than bottles by an average of ~0.0013psu (std dev 0.0020psu) and the secondary salinity was high by an average of 0.0005psu (std dev 0.0019psu). The difference between the fits is 0.0018psu which corresponds fairly well with the differences between downcast salinity channels reported in section 9.

The pressure dependence is slightly higher in the secondary than the primary.

A plot of differences versus file pair with only points above 0102db shows variations from one inlet to another, perhaps due to variations in flushing.

For full details for the COMPARE run see file 2022-012-sal-comp1.xls.

Dissolved Oxygen

COMPARE was run with pressure as the reference channel.

The data came from 4 casts only. The scatter was unusually large, likely due to the casts mostly being in inlets where flushing of Niskin bottles is likely to be poor. When a plot was made of differences against file pair # the only one that had low scatter was event #110 which was also the only one that was in fairly open water, in Queen Charlotte Strait (station QCS2).

Plots of differences against SBE DO were made for individual casts. There were no low DO values sampled, so the offset was set to 0.

Using all casts outliers were identified that all came from either the top 10db or 100db; they all had differences -0.03 and +0.43mL/L. We do not expect this type of sensor to ever read higher than titrated samples. Such values usually result from the bottle samples coming from lower in the water column where DO is lower. The effects of incomplete flushing of Niskin bottles is greatest where vertical DO gradients are large. Profile plots show very large DO gradients at the surface and at 100db except at QCS2. For the cast at KN8 the DO gradient is very complex between 50db and 150db with several reversals.

Because there were no samples with DO<1.7mL/L the offset estimate in the trendline is not reliable. We can set it to 0 or choose an offset found during a previous use in deep water. During 2022-001 with a lot of DO sampling in offshore waters, an offset of -0.0461mL/L was found. The same value looked reasonable for 2022-013, especially near the mouth of Juan de Fuca Strait where flushing is expected to be quite good.

The fit found for 2022-001 was:

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

An initial fit for this cruise excluding the outliers detailed above was:

CTD DO Corrected = CTD DO \* 1.0086 + 0.0829 R2 = 0.12 2022-012 - unforced offset

The lower slope than for 2022-001 is expected due to incomplete flushing leading to the SBE DO sensor not appearing to read as low as expected because it is being compared to samples that represent conditions deeper in the water column.

Forcing the offset to 0 produces the fit:

CTD DO Corrected = CTD DO \* 1.0266 R2 = 0.84 2022-012 -forced offset

The slope now looks higher than expected. The R2 value is higher, but visually the fit looks poor and would lead to under-correction of deeper values and over-correction near the surface.

Forcing the fit to match that used for 2022-001 and 2022-013 leads to the fit:

CTD DO Corrected = CTD DO \* 1.0166 + 0.0461 R2 = 0.12 2022-012 -forced offset

The R2 value is low but it looks better for both low and high DO, though there is a lot of noise at intermediate DO values. Removing outliers based on residuals would normally be applied until the R2 value was much higher but there are too few data available to do this with confidence.

The data from QCS2 were examined alone. There are only 10 samples. The fits done using only those are:

CTD DO Corrected = CTD DO \* 1.024 R2 = 0.97 QCS2 -forced offset 0

CTD DO Corrected = CTD DO \* 1.0157 + 0.0461 R2 = 0.07 QCS2 -forced offset 0.0461

CTD DO Corrected = CTD DO \* 1.0051 + 0.1044 R2 = 0.07 QCS2 -free offset

While the R2value is low when the offset if forced to match 2022-001, the slope is very similar to 2022-001. The fit with free offset has a much smaller slope than found in previous uses; it would be most unusual to have calibration drift towards smaller errors. There are too few points to remove outliers based on residuals.

One other issue with the sampling is that 4 of the samples came from the bottom of casts where flushing errors lead to errors of the opposite sign and where the noise in the data tends to persist longer. Local vertical gradients tend to be low there, so these errors are not usually large. When bottom bottles from the 4 casts were checked the one from KN8 looked significantly out of line, but the other 3 did not.

Overall, the results are not considered reliable for calibration purposes due to having few samples in waters where flushing is expected to be good. Using the 2022-001 fit is the best choice available.

One outlier, Event 151, sample 487, was out of line in profile for all samples, so was padded with a 5 due to premature closure.

As noted in the salinity comparison samples from event 151, sample #487 were flagged 5 as the bottle appears to have closed prematurely. While there are other outliers, they can all be explained as the results of incomplete flushing of Niskin bottles leading to low values in most cases and high values for bottles fired at the bottom.

No further outliers were identified in plots of Dissolved Oxygen versus Salinity.

For full details for the COMPARE run see file 2022-012-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 higher than CHL when CHL is very low, then drops sharply to a ratio FL/CHL ~ 1 as CHL approaches 1ug/L. For CHL>1 fluorescence is about 50% of CH dropping even lower for CHL>22ug/L.

There were a number of outliers in the plot of fluorescence versus extracted CHL, especially for CHL>20ug/L. It appears that the fluorometer signal dropped out at the surface. Casts involved are #22 and 74.

* Cast #22 – This is a case of the fluorometer going off-scale; during CLEAN the values were replaced with PAD values.
* Cast #74 – In this case the fluorometer dropped to 0 or lower; the pumps were on and the CTD was clearly in water and no other readings were affected. Three surface values were padded in the SAMAVG file and it was merged again with MRGCLN1s.

Other outliers were investigated and look like they are due to extreme gradients near the surface so slight mismatches in depth would be significant. Most were in the Discovery Islands region. Spiky fluorescence can lead to values looking higher or lower than expected.

A few bottles were checked more closely at the request of the analyst:

* 43 – Event 14 – FL=0.19 CHL=0.26 (dups 0.32 & 0.20). At low CHL expect lower than FL, so 0.2 maybe more likely and profile suggests 0.2 during upcast. But upcast fluorescence does tend to read lower than downcast and downcast was 0.25ug/L. So the average looks good. Not enough evidence form COMPARE to justify a change.
* 228 -Event 71 – Fl=0.73. Both dups >FL – expect FL and CHL should be close in value, but high variability during bottle stop. 2m lower the CHL is higher, ~1ug/L. Very slight flushing error could explain value and variability if Niskin contents not completely mixed. Not enough evidence from COMPARE to justify a change.
* 308 – Event #89. Fluorescence is 0.75; CHL 0.14 and 0.42. At this level expect CHL slightly lower than FL. So 0.42 is more likely but not certain. Limited evidence suggests 0.14 could be rejected.
* 422 – Event 128. CHL is an outlier in the comparison. Fluorescence is 4.18 and quite well-mixed, so CHL seems extremely high. Phaeo was rejected. The evidence is strong enough to reject CHL as well.

One sample had no label and sample #163 was missing. As the value was in reasonable agreement with CTD fluorescence corresponding to #163, the sample was recorded by the analyst as #163 with flag and comment.

For full details for the COMPARE run see file 2022-012-fl-chl-comp1.xls.

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

File 2022-012-ctd.xmlcon was used to convert all files. The Tau function was chosen, but not the hysteresis function since there was no sampling deeper than 800db. 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 has a clear signal. Fluorescence and the 2 Transmissivity channels look normal., PAR and SPAR values look reasonable but SPAR is much lower than PAR.

The pH data malfunctioned during the latter half of the previous cruise on which it was used. It was not actually wanted for this cruise, looks bad for at least some casts with upcast differing notably from downcast and most values look unusually high. There is a note in the log at Event 12 that the cap was no longer being removed from the sensor. The channel will be removed.

##### WILDEDIT

No large spikes wee noted in the casts checked, but WILDEDIT was run in case there are some.

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.

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 a second time on 2 of the deeper casts to find the differences between the pairs of temperature, conductivity and salinity channels. Values highlighted in grey are from previous cruises.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 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 |
| 2022-012-0036 | 300 | -0.0002 | +0.00012 | +0.0016 | High, F.Steady |
|  | 600 | -0.0003 | +0.00018 | +0.0022 | “ |
|  | 700 | -0.0003 | +0.00019 | +0.0024 | “ |
| 2022-012-0085 | 300 | -0.0004 | +0.00019 | +0.0022 | High, V.Steady |
|  | 600 | -0.0004 | +0.00011 | +0.0015 | “ |
| 2022-012-0152 | 300 | -0.0002 | +0.00019 | +0.0020 | High V.Steady |
|  | 500 | -0.0003 | +0.00015 | +0.0018 | “ |

There were no casts deep enough to compare with 2022-001 but the differences are similar.

##### 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 14.855-15ug/L were padded.

The times for the pumps to come was highly variable and often long. In one case

##### Checking Headers

The cross-reference check and header check were run. A few potential problems were found:

* There were no negative fluorescence values; there were some 0 values but those appear to be during the soak period and are likely to disappear when CLIP and/or DELETE are run.
* Negative temperature, conductivity and dissolved oxygen values were also found during the soak period when pumps were off; these should disappear by the DELETE stage.
* There were pressure values as low as -1db but they came from after the pumps were turned off and the CTD appeared to have moved through the surface.

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

CLIP was run to remove records with pumps off. Near-surface data are very noisy which may be due to real conditions or the lack of a 10m soak as bubbles were released.

Water depth readings were not available in the CLN files so they were obtained from the digital log.

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.

Where the difference was > 7m checks were made:

* Plots of altimetry at the bottom confirm that all header entries are good to ±1.5db
* Depths at the bottom and end of casts were checked, where available. For cast #41 the check value was 53.7 using the start sounder reading and 85.7 using the bottom reading. It was noted in the log that the problem was likely steep slopes. For cast #130 the same reading was found in both start and bottom readings; the difference was not large, ~6m. For cast #158 there was no sounder reading at the surface; the bottom reading was 190m and the check value for that was ~0 so that value was entered in the header.
* Track plots were examined to see if the larger check values came from areas likely to have steep slopes. All came from near-shore, and the largest values were in inlets & likely near fjord sills.
* Casts that were not close to shore were checked and all had low check values.

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

See file 2022-012-altimeter-ctd.xlsx for details.

File 2022-012-merge-hdr.csv was prepared and used to add water depth readings to the headers using routine “Merge:CSV file to Headers”.

Surface Check was run. The mean value was 0.3db. As acquisition was generally started with the Niskin bottle out of water, this is reasonable. A check of data at the end of cast #126 when the CTD was running as it came out of water, transmissivity indicates the surface was at -0.03db.

There were 17deck pressure readings ranging from -0.2 to -0.6db with an average of -0.38db.

Based on the results of 2 previous cruises, conversion of the 2022-012 data was done with an addition of +0.5db to the offset in the factory calibration. So that would change the average deck pressure readings from -0.38 to +0.12db. (See 2022-012-deck-pressure.xlsx.)

The pressure calibration parameters used for this cruise have had a good result.

##### 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 -0.55 records for the primary conductivity and -0.9 records for the secondary. For this cruise -0.65 records looks best for the primary though -0.60 also looks good. For the secondary settings from -0.9 to -1.1 records looked best for various features, but overall -1.0 records was selected as a compromise.

SHIFT was run twice on all SBE911 casts using -0.65 records for the primary and -1.0 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 –

The pressure, temperature, and conductivity sensors have been used on 2 other cruises since the last factory service. The dissolved oxygen sensor had been used for a few cruises but only 3 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 archival without recalibration. The dissolved oxygen sensor was recalibrated using slope 1.0153, offset + 0.0461. Pressure was recalibrated by adding 0.5db.

During 2022-013 the primary salinity was found to be lower than bottles by ~0.0003psu and the secondary salinity higher by an average of ~0.0014psu. Allowing for some error due to incomplete flushing of bottles, the primary was chosen for archival without recalibration. The dissolved oxygen sensor was recalibrated using slope 1.0153, offset + 0.0461 based on the previous cruise and similar results near the mouth of Juan de Fuca Strait. Pressure was not recalibrated since it was adjusted in conversion by adding 0.5db.

Historic ranges – Local climatology was available for only event #1. Temperature and salinity data all fell within the historic ranges for that cast.

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. Salinity was cleaned to remove spikes that appear to be due to small misalignment or instrumental noise. Some near-surface records were removed that may be due to variability before equilibration was achieved or shed wakes. Most files required some editing. Exceptions were event #s: 89, 125.

Editing in the inlets was limited as unstable features that were not clearly caused by shed wakes might be real.

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 were from inlets where they may be due to real conditions.

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

Silicate values were corrected by the analyst for samples where salinity was <25psu.

The pressure channel requires no recalibration.

Salinity is close enough to bottles to require no recalibration.

File 2022-012-recal1.ccf was prepared to apply a correction to dissolved oxygen based on results from cruise 2022-001:

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 though there is still a lot of noise. When data are excluded based on using the same points as in the original fit, the average is -0.010mL/L, with standard deviations of 0.04mL/L. When 2 further outliers were removed the SBE DO was low by an average of 0.004mL/L. For cast #110 which was considered the most likely to have good flushing of bottles, the SBE DO was low by an average of 0.003mL/L. See file 2022-012-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 downcast CTD DO data and the titrated samples from upcast bottles.

The CTD DO was higher than the titrated samples by an average of ~0.04mL/L with a standard deviation of 0.10mL/L. The recalibration was obviously effective, but with a lot of noise. Near the surface there are some large differences that are likely due to extreme gradients. The differences are <0.1mL/L between 10db and 200db and <0.05mL/L below 200db. There are too few data to make an estimate of errors in SBE dissolved oxygen data but combined with results from 2022-001 and 2022-013 an estimate was made as follows:

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

*±0.40 mL/L from 0-100db except in areas of very large DO gradients*

*±0.20 mL/L from 100db-200db*

*±0.05 mL/L below 200db*

For more detail see file 2022-012-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 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 unstable features were found in the inlets, but those are likely real. No other problems were found.

The sensor history was updated.

##### Dissolved Oxygen Study

As a final check of dissolved oxygen data, % saturation was calculated and plotted. Values at 2 to 3m ranged between ~80% to 210% with the majority between 90% & 115%. 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. REDO WHEN CHL COMMENTS READY

Data were exported from the CHE files to file 2022-012-bottles-final.xlsx. The entries were compared with the rosette log sheets and no problems were found.

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.

##### Thermosalinograph Data

There was 1 thermosalinograph file.

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.

A time-series plot was produced. There was obviously no flow at the beginning and 1 drop-out early in the record. The traces look good with good detail and no suspicious spikes though there are sections with fairly noisy salinity that could be real. The first few records are bad and should be removed.

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 2022-012-ctd-tsg-comp.xlsx. There were 114 CTD casts with data available from 2m; all overlapped with TSG data.
* File 2022-012-0001.atc was opened in EXCEL and the first 2 records were removed since flow had obviously just been turned on. Median and standard deviations (over 5 records) were calculated for lab temperature and salinity and the files were reduced to the times of CTD files. Those data were added to 2022-012-ctd-tsg-comp.xls.
* 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 casts are included the TSG temperature is higher than the CTD temperature by an average of 0.25 C° and a median of 0.20C° with standard deviation of 0.26C°. Salinity is lower by an average of 0.565psu and median of 0.206psu and standard deviation of 1.272psu. Plots against casts numbers show that the largest differences were towards the north. Plots against standard deviations proved less useful, especially for salinity, as there are many outliers even when the standard deviations were low.

When casts were selected with the 20 lowest standard deviations in temperature the median difference was 0.1921C° and the standard deviation was ~0.15C°. The median using all data looks reasonably close to that for the “best” 20 despite the high standard deviation. This suggests a random error that could be due to slight differences between the intake depth and depth of data that went into the CTD average. This result is close to results from past cruises on the Vector. Subtracting 0.2 C° from the lab temperature to produce a proxy intake temperature looks reasonable.

When casts were selected with the 20 lowest standard deviations in salinity the TSG salinity was lower than the CTD salinity by a median of -0.028spu and the standard deviation was 0.32psu. For salinity the median using all data is much lower than that for the “best” 20, which suggests the errors are not random. Since the cause of lower salinity tends to be bubbles, this makes sense as “errors” tend to be 1-sided.The differences appear to be a little larger than during 2 other 2022 cruises on the Vector. The noise in the comparison is much greater than for those 2 cruises, so using the earlier results looks wise and salinity should be increased by 0.02psu.

See 2020-012-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 2022-017. Heating in the loop on the Vector was about 0.2Cº for both cruises. There was insufficient information available to assess salinity for 2020-031 so a typical historical value was used to recalibrate. Salinity was low by about ~0.02psu for 2022-017 (cruise run in June/July 2022).

Conclusions

1. The TSG clock worked well.

2. The TSG lab temperature was higher than the CTD temperature by a median of ~0.20C°. This is a reasonable value for the Vector based on previous cruises. A proxy for intake temperature will be derived by subtracting 0.20C° from the lab temperature.

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 can account for salinity reading low. The results from 2022-014 look more reliable. So -0.02 will be added to the salinity channel.

f.) Editing

The file required editing to remove the first record which had spikes in temperature and salinity. CTDEDIT was used to do this.

g.) Recalibration

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

Calibrate was run using file 2022-012-tsg-recal1.ccf to subtract 0.2 from Temperature:Primary and to add 0.02psu to channel Salinity:T0:C0.

h.) Preparing Final Files

REMOVE was used to remove the following channels: Scan Number and Flag channels.

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.

As a final check 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.

P**articulars**

1. All bottles fired - Niskins 10-24 not sampled.

12. pH sensor cap no longer being removed, small hole drilled in bottle.

14. GPS from daily log not reporting latitude properly. NMEA feed fine.

18. tripped 3 extra surface bottles as there was a concern surface bottles tripped in air

36. bottle 4 misfired at b-5. We dumped it. Bottle at 250 was not fired

39. bottle #6 came up with bottle closed.

41. BE estimated - NMEA failed.

41. Sounder must have been seeing side of channel.

50. No event - misfire.

74. Pump was left running after previous cast

83. Error associated with sample numbers. See Rosette log

106. Log crashed - BE entry a bit late.

110. BE a bit late

113. cast stopped at 100m. Wire jumped off sheave on winch

114. Ship discharging soapy water. Waited at 5m until water not too sudsy,

went back down to 10m (x2) to flush and then up to 5 to sample.

115. Log crashed, BE a bit late

125. Strong current - drifted of station

126. Downcast started 16s after pumps turned on.

128. TOC sample 418 missed.

143. Did not wait full 60 sec at start due to high winds and current:

sensors were agreeing well. Took phyto due to dark brown material in plankton net.

144. Took phyto from bottle 9 of cast 144 due to the very dark brown

nature of the zooplankton catch

158. BE missed: logging a bit buggy. See SBE data files

**2022-012**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **CTD#** | **Make** | **Model** | | **Serial#** | | **Used with Rosette?** | | **CTD Calibration Sheet Competed?** | | |
| **1** | **SEABIRD** | **911+** | | **0550** | | **Yes** | | **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** | | | **1185DR** | | **28Apr2021** | | **IOS** | |  |  | |
| **Transmissometer** | | | **1883DG** | | **28Apr2021** | | **IOS** | |  |  | |
| **SBE 43 DO sensor** | | | **1119** | | **5Feb2021** | | **Factory** | |  |  | |
| **pH** | | | **691** | | **23Feb2021** | | **Factory** | |  |  | |
| **PAR sensor** | | | **4565** | | **24Feb2021** | | **Factory** | |  |  | |
| **SPAR** | | | **20518** | | **24Feb2021** | | **Factory** | |  |  | |
| **SeaPoint Fluor.** | | | **3949** | |  | |  | |  |  | |
| **Pressure Sensor** | | | **0550** | | **11Oct2021** | | **Factory** | |  |  | |
| **Valeport Altimeter** | | | **73171** | | **20Jan2021** | | **Factory** | |  |  | |

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





