## REVISION NOTICE TABLE

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| DATE | DESCRIPTION OF REVISION |
| 18 Mar 2025 | Updated channel names & formats in TOB files. |
| 11 April 2023 | Removed Channel Fluorescence:URU:SeaPoint from CHE and CTD files. Values very low in comparison to CHL. Data available upon request. |

## PROCESSING NOTES

Cruise: 2022-067

Agency: OSD

Location: Kitimat / WCVI

Project: Kitimat Fjords & WCVI Oceanographic Survey

Chief Scientist: Blanken H.

Platform: Sir John Franklin

Date: 15 July 2022 – 1 August 2022

Processed by: Germaine Gatien and Hana Hourston

Preliminary Processing by Hana Hourston: Dec. 20-23, 2022

Final Processing: 3 March 2023 – 21 March 2023

Number of HEX files: 182 Number of CTD files processed: 182

Number of rosette files: 45 (2 tests) Number of bottle casts processed: 43

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

# INSTRUMENT SUMMARY

CTD #0585 was mounted in a rosette and attached were a Wetlabs CSTAR transmissometers (1201DR), a SBE 43 DO sensor on the primary pump (#1176), SeaPoint Fluorometer on the secondary pump (#2225) and an altimeter (#75321).

Seasave version 7.26.7.121was used for acquisition.

The deck unit was a Seabird model 11+ #1043.

A Guildline model 8400B Autosal serial # 73274 was used to analyze salinity samples.

An IOS rosette with 24 10L bottles was used.

A thermosalinograph (SeaBird 21 S/N 2488) was mounted with a Wetlabs WETStar fluorometer (#1656) and flow meter; sampling interval was 30s.

# SUMMARY OF QUALITY AND CONCERNS

The Daily Science Log Book and rosette log sheets were generally in good order with many comments about problems encountered. However, digital logging was a new process. Many data files had the wrong event number or station name. While some errors were noted in the paper version of the Daily Science log, they were not entered in the sampling log or the digital log. So the information did not always get to the analysts, making the preparation of bottle files difficult.

Both temperature and conductivity channels were close during downcasts, but were unusually noisy during upcasts. Fortunately, during stops for bottles, the noise disappeared. The noise was present even when ascent rates of the CTD were very smooth.

The dissolved oxygen sensor calibration appears to be drifting and the correction is quite high. There appeared to be a sudden shift during the previous cruise on which it was used (2022-015), but there were geographic differences as well, complicating interpretation. The comparison with bottles from this cruise is reasonably close to that from the latter part of the 2022-015, but suggests further calibration drift may have occurred. For both this cruise and 2022-015 analysis was done at IOS. A comparison of early and late samples from this cruise showed no evidence that the length of wait before analysis caused any degradation of samples.

There were at least 60s waits before most bottle firings and this appears to have improved the flushing of Niskin bottles.

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

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

 ±0.25 mL/L from 0-100db except in areas of very large DO gradients

 ±0.07 mL/L from 100db-150db

 ±0.02 mL/L below 150db

The time in the TSG files was wrong by 4.2 hours; this was corrected. There was no intake thermistor, flow meter or loop samples. The only previous experience with processing TSG data from the Franklin was a short file with only 1 CTD cast available to check calibrations. Pumps for the loop malfunctioned during the cruise but the timing and duration of the problem are unknown. Recalibration was based on comparison with 181 casts, but there was a lot of noise in the comparison and the differences looked unusually large. A proxy for intake temperature was derived from a comparison with CTD casts and called Temperature:Primary. The TSG data are considered of lower quality than usual.

# PROCESSING SUMMARY

##### Seasave

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

##### Preliminary Steps

* The configuration files used at sea was checked. The transmissivity parameters were incorrect and pH was listed in some versions but not actually mounted. Corrections were made to one file which was saved as 2022-067-ctd.xmlcon.
* During 2022-015 processing it was discovered that the fluorometer gain setting in the configuration file was wrong so values were low by a factor of 10. It is likely that it was also low for this cruise but there are no chlorophyll samples to enable confirmation of that.

Cruise 2022-010 visited some nearby sites in July, though no exact matches could be made. The following pair gave the best match in time and space:

2022-067-0097.cln 0097 CS05 50 55.96 N 129 0.01 W UTC 2022/07/25 14:03

2022-010-0100.ctd 0100 10653 50 55.68 N 128 43.79 W UTC 2022/07/21 00:45

For 2022-067 the maximum fluorescence was 0.77ug/L while it was 13ug/L for the 2022-010 cast. CHL was also available and was ~15ug/L.

A second match was found that was close in space but 2 weeks apart. For that one the maximum fluorescence was 15.1 for 2022-010 and 0.86 for 2022-067. So it looks quite clear that the configuration file should be changed to gain 1X.

* The Log Book and rosette log sheets were obtained. They were in good order with many useful comments.
* Dissolved oxygen and salinity data were obtained in QF spreadsheet format from the analysts.
* The cruise summary sheet was completed.
* The history of the sensors was checked and all were used during 2022-002 and 2022-015.

##### BOTTLE FILE PREPARATION

The ROS files were created using files 2022-067-ctd.xmlcon.

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

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

Temperature and salinity were plotted for all BOT files to check for outliers. No editing was found necessary.

A preliminary header check was run; there are some slightly negative SBE DO values but it looks like they will disappear in bin averaging.

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.

There were many cases where bottles were fired but not sampled, including one with 24 bottles fired, likely as a test.

The ADDSAMP file was sorted on sample numbers.

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 2022-067-bot-hdr.txt which will be updated as needed during processing.

DISSOLVED OXGYEN

Dissolved oxygen data were provided in spreadsheet QF2022-067\_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 2022-067oxy.csv. That file was converted into individual \*.OXY files.

There were 2 samples in the DO file that had comments starting with “ALL:” but only DO was taken from those bottles.

SALINITY

Salinity analysis was obtained in file QF2022-067\_SAL.xlsx which included a precision study. The analyses were carried out in a temperature-controlled lab within 21-42 days of collection. The files were simplified and saved as 2022-067sal.csv. That file was then converted to individual SAL files.

The SAL and OXY files were merged with CST files in 2 steps.

The files were then put through CLEAN to reduce the headers to File and Comment sections only.

These files are ordered on sample number, but the SAMAVG files are ordered on bottle number, so the MRGCLN1 files were reordered on Bottle\_Number and saved as \*. MRGCLN1s.

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

The output of the MRG files were exported to a spreadsheet and compared to the rosette log sheets to look for omissions. A number of problems were found due to problems in the salinity analysis QF file. Those were resolved and the process rerun.

##### Compare

Salinity

Compare was run with pressure as reference channel.

There were 48 bottles between 30m and 500m., 1 salinity sample per cast and none were from the bottom of casts.

All bottles with standard deviation in the CTD DO >0.0008psu were excluded; they all came from ≤50m.

There were many errors in the salinity analysis QF spreadsheet, most being due to errors in file names, and a few due to some errors in transferring information to the spreadsheet.

When outliers were excluded based on standard deviation in the CTD Salinity >0.001 plus 1 large outlier and 2 smaller ones, the primary salinity was found to be low by an average of 0.0081psu (std dev 0.0036) and the secondary was low by an average of 0.0024psu (std dev 0.0033).

There are likely to be small errors due to incomplete flushing of Niskin bottles in inlets, but given long waits and mostly low gradients, these errors are likely small. Nevertheless, the CTD salinity is likely a little closer to bottles than this analysis suggests. Salinity profile plots from 9 casts that included sampling were examined at the sampling levels to see what vertical distance would produce salinity values differing by 0.002psu; it varied from 0 to 13m.

The major outlier was from cast #184 at 30m. By the time the bottle was closed the CTD salinity was steady but during the stop the salinity dropped by about 0.4psu. so finding the bottle salinity to be higher than the CTD by ~0.18psu is not surprising. The analysis was likely fine, so no flag is recommended.

The other outliers were either associated with very noisy CTD data or were from the top 100m where errors due to incomplete flushing are likely larger due to higher vertical gradients.

The primary salinity difference is higher than during 2022-002 and slightly higher than during 2022-015. The primary salinity was slightly higher than during 2022-002 and the same as during 2022-015.

There is evidence that the primary conductivity calibration is drifting, though the standard deviations in the fits are fairly high at ~0.0035psu.

For full details for the COMPARE run see file 2022-067-sal-comp1.xls.

Dissolved Oxygen

COMPARE was run with pressure as the reference channel.

During the previous use of this sensor the results changed markedly between 2 parts of the cruise and it was not known if this was due to a change of region sampled or a change in the sensor. For this cruise there is no clear split in fits, and only a few minor outliers. The fit is close to the one from the latter part of 2022-015.

There is an apparent variation with time with the slope decreasing but that looks like it is due to more shallow sampling later in the cruise. Errors due to incomplete flushing tend to be larger there due to higher vertical gradients, that type of error tends to reduce differences.

Using all bottles, except for 3 excluded based on residuals, the fit is:

CTD DO Corrected = CTD DO \* 1.0882 + 0.0343 (1)

That fit appears to put too much emphasis on the higher values which are less reliable as they are from high vertical gradient areas where flushing errors are more significant.

When more outliers were excluded, the fit looked better overall and the offset fell in the middle of the very low DO values. The fit was:

CTD DO Corrected = CTD DO \* 1.0939 + 0.0255 (2)

A fit against file pair suggests time dependence, with higher differences up to cast #80 and lower ones after that. Since the analysis was done at IOS, there was a concern that a long wait might have affected early samples more than later ones. However, when the data were divided into 2 sections (#4-80 & #85-208) a different explanation emerged. The values in the early casts were all quite high. It is hard to compare 2 fits with such different ranges, but there did not appear to be any significant difference when they were forced to have the same offset. So, it appears doing the analysis at IOS did not affect samples differentially.

The fit for the later part of 2022-015 was:

CTD DO Corrected = CTD DO \* 1.0726 + 0.0449

There may be some drift in the DO sensor. If the change were due to more sampling in protected waters we would expect a smaller slope, not larger.

There were no extreme outliers. Of the 3 values rejected from the comparison based on residuals 2 were from inlets, above 100m and in fairly high vertical gradients, with smaller differences than in the general fit, which is expected if flushing is weak. The 3rd was from 200m during cast #42 which was also in an inlet, but the difference was below the general fit. The difference was -0.038 while the general fit would be about ‑0.32mL/L. The bottle was fired about 16m above the bottom of the cast and the descent rate was very steady, so it could contain water from the bottom of the cast or even from the downcast. Values at the bottom of the cast were higher than at 200db by up to 0.04mL/L, which would account for most of the difference. No flag is justified.

For full details for the COMPARE run see file 2022-067-dox-comp1.xls.

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

Many edits were done to the data based on discoveries during the comparisons. Some other changes were made: there are 2 bottles each in casts #203, 206 and 208 that were not sampled. Those were removed from the SAMAVG files. Then MERGE was rerun.

CLEAN was run with output MRGCLN2 to fix headers and add 0 flags, as needed..

Output of the MRGCLN2 files was exported to a spreadsheet and compared to sampling log sheets and no further problems were found.

A header check and cross-reference listing were produced and no problems were found.

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

All files were converted using 2022-067-ctd.xmlcon.

The Tau function was selected but not the hysteresis function since there was no sampling below 700m. Depth was included in the conversion.

A few casts were examined.

The T and C pairs were close during downcasts but not upcasts. There is always more noise in upcast temperature and conductivity channels than in downcasts, but for these data they are noisier than usual. Fortunately, the noise stops during bottle stops.

The descent rate is generally high with very steady rates in inlets and moderate noise level in more open waters.

The transmissivity, DO, altimetry and fluorescence traces look normal.

The dark value for fluorescence was ~0.55ug/L. This seems high, but that is likely due to the gain setting being 1X.

##### WILDEDIT

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

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

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

There is no obvious difference in profiles after this step, but the only spikes noted before this step contained many records.

##### ALIGN DO

A few casts were examined; both temperature channels were noisy during upcasts so the tests were not easy to interpret, but using +2.5s certainly improves the alignment and overall looks like a good choice for both sensors. That setting has worked well for many SBE DO sensors in recent years. ALIGNCTD was run on all casts using +2.5s.

##### CELLTM

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

##### DERIVE and Channel Comparisons

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

DERIVE was run a second time on 3 casts deeper than 500m to find the differences between the pairs of temperature, conductivity and salinity channels. Because there appeared to be some time-dependence more casts were added, but they are shallower.

Data are included from the 2 previous cruises since the last factory calibration.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cast # | Press | T1-T0  | C1-C0 | S1-S0 | Descent Rate |
| 2022-002-0058 | 1000 | +0.0002 | +0.00031 | +0.0035 | High, XNoisy |
|  | 1900 | +0.0001 | +0.00025 | +0.0030 | “ |
| 2022-0002-0065 | 1000 | +0.0002 | +0.00030 | +0.0037 | High, XNoisy |
|  | 1900 | +0.0002 | +0.00027 | +0.0032 | “ |
| 2022-002-0142 | 1000 | +0.0001 | +0.00033 | +0.0040 | High, XNoisy |
|  | 1900 | +0.0002 | +0.00029 | +0.0033 | “ |
| 2022-015-0046 | 1000 | +0.0002 | +0.00040 | +0.0047 | High, Very Noisy |
|  | 1900 | +0.0002 | +0.00035 | +0.0041 | “ |
| 2022-015-0048 | 1000 | +0.0001 | +0.00040 | +0.0048 | High XNoisy |
|  | 1900 | +0.0000 | +0.00036 | +0.0043 | “ |
| 2022-015-0057 | 1000 | +0.0001 | +0.00043 | +0.0051 | High, VNoisy |
| 2022-015-0077 | 1000 | +0.0002 | +0.00045 | +0.0052 | High, Moderate |
| 2022-067-0008 | 600 | +0.0002 | +0.00067 | +0.0072 | High, Steady |
| 2022-067-0066 | 300 | +0.0001 | +0.00063 | +0.0066 | High, Steady |
| “ | 400 | +0.0001XN | +0.00063 | +0.0064 | “ |
| “ | 600 | +0.0002 | +0.00061 | +0.0072 | “ |
| 2022-067-0075 | 400 | +0.0003 | +0.00055 | +0.0054 | High, Steady |
| 2022-067-0086 | 300 | +0.0003 | +0.00050 | +0.0053 | High, Steady |
| 2022-067-0106 | 400 | +0.0003 | +0.00048 | +0.0050 | High, Steady |
| 2022-067-0119 | 500 | +0.0002 | +0.00067 | +0.0073 | High, Moderate |
| 2022-067-0143 | 400 | +0.0002 | +0.00047 | +0.0045 | High, Moderate |
| 2022-067-0206 | 300 | +0.0002 | +0.00037 | +0.0038 | High, Steady |

Temperature differences vary little and are similar to previous cruises. Conductivity and salinity differences are higher than from the previous cruise except at 300 and 400db where they are similar to 2022-015. Salinity differences appear to have some pressure dependence though without more deeper sampling this is hard to judge.

The differences between CTD salinity channels based on the COMPARE result was 0.0057psu, on average, and there was a suggestion that the primary salinity was drifting.

Using the data in the COMPARE file, a comparison was made between the 2 CTD salinity channels (rather than looking at differences from bottles). Plots of (Sal1-Sal0) versus pressure offer a slight suggestion of an increase with pressure, while the plot against event # makes it clear that the difference is increasing with time. Pressure is also decreasing with time. The problem is likely a combination of pressure dependence in the primary conductivity together with calibration drift. Since the plot against time shows much smoother change, it must be calibration drift that is more significant.



The secondary salinity will likely be chosen for archiving since it is closer to bottles and shows less pressure dependence and time dependence in comparison to bottles.

##### Conversion to IOS Header Format

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

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

CLIP was run using file CLIP.csv because 1 cast had data from the soak period included. For other casts no records were removed.

##### Checking Headers

* The cross-reference check was run. No problems were found, though it is hard to be sure with contradictory log records.
* The header check was run and showed pressures got as low as -1.07db. Values with 0 transmissivity are found at -0.85db with pumps off. Some problems have been noted from the Franklin with deck pressures.
* Surface check was run and found an average of 1.5db after the 10db soak.
* Cruise tracks were plotted and were added to the end of this report.
* For most casts the CTD was kept running as the CTD left the water, giving us an estimate of surface pressure. Pressure readings at the end of casts ranged from about 0 to -1db, with a mean of -0.5db. The files were put through REVERSE and a surface check was made. This enabled plotting of surface pressure versus maximum cast pressure; this showed clearly that there was some hysteresis in the pressure. The deepest casts had surface readings ~ -1db while shallow casts trended towards about ~0.2db; no readings were <-1db. So, the error due to hysteresis is <1db which is the expected accuracy for this sensor. For the downcast the error is likely considerably smaller. No recalibration is needed. See 2022-067-pressure-calibration-study.xlsx.
* Water depth header entries were checked. Header values for altimetry and water depth were exported to file 2022-067-altimeter-ctd.xlsx. A “check value” was calculated as follows:

Check Value = Absolute Values {(Altimetry header-1) + Max. depth sampled - Water depth in Header}

This value is expected to be close to 0, but in an area with narrow channels and steep slopes larger check values are common. There were also reports in the log of the sounder being obviously wrong. Cases with check value >10db were investigated. The larger values do not seem to be related to depth of casts. In 8 cases the water depth from the log differs by enough to produce a reasonable check value. Of the cases not brought into line by using the log depth values, there were 11 casts with check values >20db; for those, a calculated value was entered in the header:

 Calculated Value = Maximum depth sampled + Altimetry header-1

Those values should better reflect the water depth at the time the CTD was at the bottom of the cast.

Changes were made to 19 CLIP files and 5 SAMAVG files.

##### 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 closer to the temperature offset after this step.

Dissolved Oxygen

The Dissolved Oxygen voltage channel was aligned earlier and the results look good. No further alignment will be applied.

Conductivity

Tests were run on 3 casts to assess what settings are best to align conductivity with temperature (as judged by the effect on salinity as seen in T-S space). The best settings were -0.7 records for the primary and -0.1 records for the secondary conductivity.

SHIFT was run twice on all SBE911 casts using those settings. Salinity was recalculated for both channels.

##### DELETE

The following DELETE parameters were used:

Surface Record Removal: Last Press Min

Maximum Surface Pressure (relative): 10.00

Surface Pressure Tolerance: 1.0 Pressure filtered over 15 points

Swells deleted. Warning message if pressure difference of 2.00

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

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

Sample interval = 0.042 seconds. (taken from header)

COMMENTS ON WARNINGS: There were no warnings.

##### Other Comparisons

Experience with these sensors since last factory service –

* During 2022-002 pressure was thought to be reading low by 0.6db.The primary salinity was lower than bottles by 0.0052psu & secondary salinity lower by 0.0019psu; primary was recalibrated by adding 0.0033psu and was selected for archiving. Dissolved oxygen was recalibrated using slope/offset=1.0076/0.0507.
* During 2022-015 the DO calibration appeared to shift so 2 recalibrations were applied with slope/offset= 1.0158/0.0449 and 1.0726/0.0449 for the early and late casts, respectively. The primary salinity was low by 0.0072psu and the secondary was low by 0.0024psu. Fluorescence values were low by a factor of 10 due to an error in the configuration. Pressure looked good.

Historic ranges – Profile plots were made with 3-standard deviation climatology ranges of T and S superimposed. Many of the sites are likely not well represented in the climatology being near-shore and/or in deep fjords; most deep casts in the climatology would be from further from shore. Salinity values were frequently below the historic minimum near the surface and in deep waters. Low near-surface salinity is frequently seen in recent years, partly due to real change, and partly due to more near-shore areas being sampled. Temperature values are mostly within the local climatology except a few cases where near-surface values are a little high and in deep water where higher values are also seen. Excursions in this area are not considered indicative of calibration problems with the sensors.

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

##### DETAILED EDITING

The decision on which channel pair to use was clear since the secondary salinity is closer to bottles and the primary salinity shows some sign of calibration drift.

CTDEDIT was used to remove records that appear to be corrupted by shed wakes or ship effects and to clean salinity where small spikes appear to be due to small misalignment or instrumental noise.

Many inlet casts needed only light editing at the top and/or bottom of casts.

The following casts required no editing:17,18,20,24,25,27,33,37-39,53,59,63,71,77,79,85,103,167,193,208.

Notes about editing applied were added to the files.

The edited files were copied to \*.EDT.

After editing T-S plots were examined for all casts. Small unstable features remain in many casts which is expected with most casts near-shore and in areas of tidal mixing.

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

No correction is needed to pressure or secondary salinity.

For dissolved oxygen, test recalibrations using equations (1) and (2) from §4 showed equation (2) produced better results.

File 2022-067-recal1.ccf was prepared to apply the following correction to channel Oxygen:Dissolved:

CTD DO Corrected = CTD DO \* 1.0939 + 0.0255

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

(Silicate does not require recalibration since there was no nutrient sampling.)

COMPARE was rerun and shows that the corrections were applied properly When 3 major outliers were excluded, the SBE DO was found to be high by an average of 0.003mL/L with a standard deviation of 0.017mL/L. When the same outliers were excluded as in fit (2), the average difference was 0.001mL/L with a standard deviation of 0.010mL/L. We expect the values to be slightly high due to incompletely flushed bottles. When plotted against pressure it appears that most of the deepest samples were reading lower than bottles, which may be because any error associated with poor flushing would be small due to very low gradients. Overall the results are good with small errors given the limitations of the comparison method.

Calibrate was then run the EDT files.

##### 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 and imperfect matching of levels.

Downcast files were bin-averaged to 0.5m bins for the casts with DO bottle samples. Those files were then thinned and compared to the bottle values in the MRG files. COMPARE was run to study the differences between the recalibrated downcast CTD DO data and the titrated samples from upcast bottles.

When a few outliers were removed based on standard deviations in the CTD DO data, the CTD DO was higher than the titrated samples by an average of ~0.006mL/L and the standard deviation was 0.017mL/L using all hydro casts. Since the downcast SBE DO may be reading slightly high due to slow response time and the bottle DO may be a little low due to incomplete flushing of bottles, a small positive difference is expected above the oxygen minimum; the opposite is expected below the minimum and sometimes close to the surface. For these data the shallow samples mostly have differences >0 and deeper ones close to or <0, suggesting shallow samples have some error due to incomplete flushing.

The downcast CTD dissolved oxygen values are likely reading slightly higher than bottles, as expected, but the differences are very small. No further calibration will be applied.

A plot of differences versus pressure was then done, excluding outliers as determined in a fit against bottle DO. Based on this an estimate is made of errors in DO in different pressure ranges. This is likely too severe a method given time differences and inexact matches in depths.

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

 ±0.25 mL/L from 0-100db except in areas of very large DO gradients

 ±0.07 mL/L from 100db-150db

 ±0.02 mL/L below 150db

For more detail see file 2022-067-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. There are many near-surface unstable features but from this complex region of intersecting narrow channels and active mixing they may well be real.

Profile plots were examined to see if there any problems. Bad data were found in the DO and Fluorescence channels of cast #127 and 1 bad record for all channels. These bad data were related to a pressure spike. A return was made to the CTDEDIT stage for that cast, bad data removed and calibration and bin-averaging steps were rerun.

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

REMOVE was run to remove the following channels:

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

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

REORDER was run to get the two DO channels together.

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

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

The Header Check was run; no problems were found.

Profile and T-S plots were examined. No problems were found.

The sensor history was updated.

##### Dissolved Oxygen Study

As a final check of dissolved oxygen data, % saturation was calculated and plotted. Given the wide variety of environments sampled it is not surprising that values at 2m ranged between 75% and 165%. The lowest values were in Queen Charlotte Strait and Quatsino; the highest, in some of the northern inlets. There was no chlorophyll sampling, but fluorescence is generally higher in the same areas as have high DO saturation.

##### Final Bottle Files

MRGSORT was run to get files in pressure order.

REMOVE was run to remove the following channels:

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

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

HEAD EDIT was run to add comments to the headers.

Data were exported from the CHE files to file 2022-067-bottles-final.xlsx. The entries were compared with the rosette log sheets and no data were missing.

A Header Check and Standard Check were prepared and no problems were found.

The track plot looks ok.

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 believed to be at about 6 to 6.5m. The only method to check calibration is to compare with co-incident CTD casts.

At the end of the cruise the Chief Scientist was informed that there was a malfunction in the loop but the timing was unknown.

a.) Checking calibrations

The configuration file used at sea had the correct parameters.

b.) Conversion of Files

The CNV file was 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. The salinity trace has good detail without spikes, but the values are highly variable. There are sections with very low salinity and other areas with little variation.

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

Bin Average was run on the ATC file (5 records per bin) and standard deviations were included. The output data were exported to a spreadsheet which was saved as file 2022-067-ctd-tsg-comp.xlsx. Unnecessary columns were removed, including standard deviations except for temperature, salinity and positions.

c.) Checking Time Channel

All 182 CTD casts occurred while the TSG was acquiring data, but 1 cast had no data above 10db.

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

There are 181 casts available for comparison.

Binned CTD files were thinned to 6db and those data were added to a sheet in file 2022-067-tsg-ctd-comp.xlsx.

An initial comparison was made to check the clock by matching times in the log with times in the TSG file and comparing positions. The result was bad with very different positions found. Fortunately, there was a note in the log that the TSG was started at ~3:15UTC on July 16th (20:15 PDT). The first record in the TSG file was at 23:03:43 on July 15th. That is about 251 minutes earlier.

There is a note in the log that the time was found to be off by about 4minutes on July 25th. Perhaps this was a typo and it should be 4 hours.

To check that the error is constant through the cruise, comparisons were made with Events #7, #55 and #209. Keeping in mind that an exact match is not possible since the ship would be moving slightly during the cast, and might occupy the same spot repeatedly. The first occasion when the latitude and longitude are both very close to the log position was selected, and remarkably, the same time difference was found. The TSG clock was reading about 252 minutes early, 4.2 hours.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|   | Time in log | Latitude in Log | Longitude in log | Time in TSG file to match log | Time difference |
| TSG turned on | 2022-07-16 3:15 | n/a | n/a | 2022-07-15 23:03 | 251 |
| Event 7 | 2022-07-18 14:27 | 53.00797 | 129.25777 | 2022-07-18 10:15 | 252 |
| Event 55 | 2022-07-21 20:27 | 53.29773 | 128.88970 | 2022-07-21 16:15 | 252 |
| Event 209 | 2022-08-01 0:40 | 49.69532 | 126.51388 | 2022-07-20:27:43 | 252 |

ADD TIME CHANNEL was rerun to add 4.2 hours to each record and to the start and end times; a few values were checked and looked fine. The full comparison was then run.

The file was bin-averaged over 5 records (2 minutes) for comparison to CTD data with standard deviations included.

The bin-averaged TSG file was opened in EXCEL and reduced to the times when CTD casts were run.

CTD and TSG positions, temperature and salinity were compared.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Lat Diff | Long Diff | Ttsg-Tctd | Stsg-Sctd |
| median | -0.00003 | -0.00003 | 2.2223 | -0.8638 |
| std dev | 0.00089 | 0.00135 | 1.0812 | 2.5802 |

Positions

Latitudes and longitudes differed by a median of 0.00003°, but the standard deviations were 0.00089° for latitude and 0.00135° for longitude. The overall matches are good; given averaged TSG data, inexact matches in times and some regions with strong currents, these results are reasonable. This confirms the time correction was good.

Temperature

* The TSG temperature was higher than that from the CTD by a median of 2.22C° with a standard deviation of 1.08°C. This suggests much more heating in the loop than we normally see, but we have little experience with the Franklin. Since the intake is deeper than for other ships studied, it is likely the loop is longer. There may also have been a flow problem.
* Typical values found from other ships range from 0.2 C° to 0.5 C°, so the result is surprising.
* During the previous use of the equipment on the Franklin, the difference was much smaller (~0.34C°) but only 1 CTD cast was available for comparison.
* A plot of “heating in the loop” versus CTD temperature show the usual pattern of reduced heating when intake temperatures are higher.
* A plot against event # shows the highest variability late in the cruise, starting at event #165. The vertical temperature gradients near the surface are very high in that section, so even a slight offset in depths of CTD and TSG could account for a 2 C° difference in those areas. For cast #98 which had the smallest difference the equivalent vertical gradient would be about 0.01 C°/m around 6m.
* For the 5 casts with the lowest vertical gradients around 6m, the TSG temperature was higher than CTD temperature by a median of 0.8C°; this is not a lot of data as the gradients were mostly very large, and even for those 5 there was likely some error due to vertical offset between CTD and TSG.
* To create a proxy for intake temperature, the best choice is the median difference; this will produce values too high for cases where the vertical temperature gradient is low at 6m and values that are too low where that gradient is large. However, the lab temperature is even more out of line, so there is no harm in creating the proxy. Subtract 2.2 C°.

Salinity

* TSG salinity was lower than CTD salinity by a median of 0.86psu and a standard deviation of 2.88psu. This is very much higher and noisier than expected; it is 10X the difference found during the previous Franklin use, but there was only 1 CTD cast available for comparison with the TSG for that cruise. The noise level likely reflects the great variety of environments sampled.
* There is much less variation in the differences between TSG and CTD salinity in the latter half of the cruise. Two section were chosen for comparison.
	+ Between casts #12 and #80 the surface salinity is very low and vertical gradients high.
	+ Between casts #108 and 176, most casts are well-mixed vertically.
	+ The median difference was -3.04psu for the high gradient group and ‑0.15psu for the well-mixed casts. (The median temperature gradients were the same for both groups.)\
* During the previous use of the equipment on the Franklin, the difference was much smaller (~0.087C°) but only 1 CTD cast was available for comparison.
* Recalibration to match the CTD should be based on the low-gradient area, so add +0.15psu.

Conclusions

* If the flow in the loop was impeded, there would be little effect on salinity and much on temperature. It may be that the pump failure was brief and had no significant effect. Or it may have lasted throughout, slowing flow and leading to more heating in the loop. There are variations in the plots of temperature differences against time, but most features can be explained by variable gradients.
* Temperature is reading higher than CTD data and that is likely due to a combination of heating in the loop and drawing water from slightly higher than 6m. Subtracting 2.2C from all Temperature:Lab values to create a proxy for Intake Temperature is reasonable.
* Salinity is likely reading low partly due to bubbles and partly due to small vertical offsets due to the TSG drawing water from a little higher than 6m. Using 0.15psu based on well-mixed casts is reasonable.
* F8.3 formats will be used for temperature and salinity and notes added to the headers to state the limitations of these data.

Calibration History

This TSG was used during 2022-015 when only a single CTD cast available for comparison. The TSG temperature was higher than that from the CTD by ~0.34 C°. The TSG salinity was lower than that from the CTD by about 0.087psu. The TSG salinity was full of small spikes that were likely due to bubbles. There were only records from Juan de Fuca Strait.

f.) Editing

No editing was required.

g.) Recalibration

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

Calibrate was run using file 2022-067-tsg-recal1.ccf to subtract 2.2C° from Temperature:Primary and to add 0.15psu to Salinity:T0:C0.

h.) Preparing Final Files

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

At the time of processing details about the TSG set-up on the Franklin were not available.

HEADER EDIT was used to change the DATA DESCRIPTION to THERMOSALINOGRAPH and add the estimated 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.

**Particulars - Mainly notes from log of concern in processing + some notes on processing**

2. Test cast done in Queen Charlotte Strait.

25. Downcast acquisition started at 11db.

69. Sounder gave depth as 510, clearly wrong.

69. Jellyfish tentacles all over the rosette. Cleaned manually, back-flushed pumps. Not rosette cast.

74. Bottom ill-defined by echosounder; potentially soft substrate.

84. Might have hit bottom.

87. Steeply sloped bottom.

106. Niskin #2 failed integrity check. 2nd today. OK on next 2 casts. (Rosette sampling sheet named 107– corrected on paper and scan.)

107. Test fired Niskin #2 – no sampling.

108. 2 bottles fired – presume as test – no sample #s.

111. Saved as 109. (fixed) Drifting into deeper water during cast.

113. Stopped at 123 db for a few seconds, winch lost altimeter feed.

118. Strong EK80 signal from ~180-250 m correlates with conductivity spikes.

125. Drifting into deeper water.

127. Large spike in all channels at about 18 m.

130. Drifting into deeper water.

131. Sloping bathymetry.

139. Oxygen spike at bottom of cast. Altimeter went to zero briefly at bottom.

141. Noisy DO sensor, especially 15-60 m. Sensor cable plug for DO was cleaned and lubricated after cast. Backflushed pump on DO/C1 side. Also cleaned bulkhead connector on CTD. Oxygen and conductivity channels looked much improved on the next CTD cast (143).

145. Rosette was lowered to 8 m then back to surface.

148. Drifting into deeper water. Niskin #2 O-ring replaced.

153. Drifting deeper.

155. Spike in all channels at bottom of cast, no modulo error recorded. Error message was, “Unsupported model message: 20312E from SBE Carousel”.

164. Temperature, salinity, and oxygen spikes at surface.

172. Drifting into shallower water.

173. Spikes in all channels on upcast at ~10 m. Modulo error recorded, but no error message. Upcast continued without problems. Continuing to monitor for these isolated spikes.

178. Called 177 in sampling log. (fixed)

181 &188. Drifting into shallower water.

193. Bottles 1 & 2 failed integrity test – minor dripping. Error in Daily Log – station NS07 should be NS05. Corrected in paper log and scanned log. No error found in data files.

198. Spike in temperature at surface after upcast.

203. 4 bottles fired but only 2 sampled. All contain same CTD values.

206 11 bottles fired, only 9 sampled.

208. 4 bottles fired only 2 sampled.

TSG

* Started at 20:15 on July 15
* Cleaned fluorometer at 18:00 PDT July 25. Noted NMEA time is ~4 minutes fast for the TSG. (actually 4.2 hours)
* July 25 – notified chief engineer flow strainer needed cleaning. July 26 am - flow back to normal.
* Loop mentioned in log on July 16 - no sample found in salinity QF file. Probably just a reference to starting TSG.
* The Chief Engineer mentioned at end of trip that pumps for scientific seawater sampling loop had malfunctioned during the trip and data may be compromised. Timing of malfunction unclear.

**2022-067**

**CRUISE SUMMARY – CTD**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **CTD#** | **Make** | **Model** | **Serial#** | **Used with Rosette?** | **CTD Calibration Sheet Competed?** |
| **1** | **SEABIRD** | **911+** | **0585** | **Yes** | **Yes** |
| **Calibration Information - 0506** |
| **Sensor** | **Pre-Cruise** | **Post Cruise** |
| **Name** | **S/N** | **Date** | **Location** | **Date** | **Location** |
| **Temperature** | **2449** | **28Jan2021** | **Factory** |  |  |
| **Conductivity** | **1764** | **01Feb2021** | **Factory** |  |  |
| **Secondary Temp.** | **4484** | **02Feb2021** | **Factory** |  |  |
| **Secondary Cond.** | **2128** | **02Feb2021** | **Factory** |  |  |
| **Transmissometer** | **1201DR** | **17Feb2022** | **Factory** |  |  |
| **SBE 43 DO sensor** | **1176** | **04Feb2021** | **Factory** |  |  |
| **SeaPoint Fluor.** | **2225** |  | **Factory** |  |  |
| **Pressure Sensor** | **0585** | **17Feb2021** | **Factory** |  |  |
| **Valeport Altimeter** | **75321** | **23Sept2020** | **Factory** |  |  |
| **Calibration Information** |
| **Sensor** | **Pre-Cruise** | **Post Cruise** |
| **Name** | **S/N** | **Date** | **Location** | **Date** | **Location** |
| **Temperature** | **2488** | **10 Sep 21** | **Factory** |  |  |
| **Conductivity** | **2488** | **10 Sep 21** | **Factory** |  |  |



