## REVISION NOTICE TABLE

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| DATE | DESCRIPTION OF REVISION |
| 13 March 2025 | Updated TSG channel names and formats. GG |

## PROCESSING NOTES

Cruise: 2023-019

Agency: OSD

Location: WCVI

Project: La Perouse

Chief Scientist: Nelson J.

Platform: John P. Tully

Cruise Dates: 16 May 2023 – 25 May 2023

Processed by: Germaine Gatien

Date of Processing: 15 November 2023 – 14 December 2023

Number of original HEX files: 88 (1 split cast) Number of processed CTD files: 87

Number of rosette casts: 50 Number of processed CHE files: 50

Number of original TSG csv files: 1 Number of processed TOB files: 9

# 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 (#3791), SeaPoint Fluorometer on the secondary pump (#3640 & #4108), a Biospherical QSP-400 PAR sensor (#70613) and an altimeter (#76341).

A thermosalinograph (SeaBird 45 S/N 0789) was mounted with a Wetlabs WETStar fluorometer (#1656) and flow meter; sampling interval was 10s.

Seasave version 7.26.7.121 was used for acquisition.

The data logging computer WP #102.

The deck unit was a Seabird model 11+ #424.

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.

The standard deployment procedure for this cruise was as follows:

The rosette was brought to the surface. Pumps were turned ON. The rosette was brought down to 10m and kept there for 30 seconds. Once back at the surface, the data started to be archived, with the rosette at the surface for 30 seconds longer. Then the cast would start.

For all rosette casts:

Niskin bottles closed from 0 to 400 db had a wait time of 60 seconds.

All Niskin bottles deeper than 400 db had a wait time of 30 seconds.

There were 2 WetLabs CStar transmissometers in use during this cruise:

Channel Transmissometer refers to sensor #1185DR (650nm - red)

Channel Transmissometer:Green refers to sensor #1883DG (530nm - green)

For comparison with other Institute of Ocean Sciences cruises, note that the transmissometer wavelength is 650nm unless otherwise stated.

This cruise was plagued with problems. There were many spikes in all CTD channels that were eventually tracked down to a bad wire. While most spikes were removed in processing there may remain some effects on data. It is unusual to have spikes in the dissolved oxygen and PAR channels. While transmissivity data are usually highly variable, they were clearly also affected by spikes.

Fluorescence had some large spikes and odd increases in values in deep water. All fluorescence data was padded below 300db for downcasts. CTDEDIT was used to remove spikes in fluorescence above that level. The upcast fluorescence data were more heavily affected so data were removed below 80db. The fluorometer was eventually replaced and appeared to be ok on the first downcast (#136), but for the rest of the cruise it produced very low values that compared poorly with extracted chlorophyll. The fluorescence channel was removed from CTD files #138-153 and from CHE files #136-153. Fluorescence was also removed from 2023-019-0120.CHE due extremely high values and a very poor comparison with chlorophyll samples. The downcast fluorescence for that cast looked normal.

Two casts had extensive areas of bad data in the secondary channels and three had some bad data in the primary channels. So primary temperature and salinity were chosen for most casts but secondary channels were chosen for events #46, 48 and 50. Salinity was recalibrated to bring the 2 channels into agreement based on comparisons with 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 incomplete flushing of Niskin bottles and imperfect matches in levels from the two data sets as well as errors in sample analysis/collection, so the following statement likely underestimates SBE DO accuracy. The results are encouraging given the many problems with spikes, though there may be isolated incidences of lower quality SBE DO due to spikes.

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

±0.50 mL/L from 0 - 75db except in areas of very large DO gradients

±0.20 mL/L from 75db - 200db

±0.05 mL/L from 200db - 500db

±0.03 mL/L below 500db

The intake thermistor for the thermosalinograph malfunctioned as happened during cruise 2023-066 which immediately preceded 2023-019. A proxy for intake temperature was created by recalibrating the lab temperature using a linear fit from a comparison with CTD casts. During 2023-066 the temperature range was smaller and a constant correction was used. That constant correction is close to what the linear fit correction would be if applied to the average lab temperature in the 2023-066 comparison. This lends some confidence to both methods, but the proxy does not have the accuracy or detail that an intake thermistor supplies.

TSG salinity comparisons with CTD and loop samples were very noisy in some parts of the cruise. Recalibration was based on results in areas with well-mixed near-surface waters. Recalibration was applied by adding 0.03psu. Bubbles in the loop water can lower salinity, so this should not be considered a measure of calibration drift.

TSG fluorescence was about 80% of CTD fluorescence and 70% of loop extracted chlorophyll.

# 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.

* Nutrients, extracted chlorophyll, dissolved oxygen, salinity and NH4 data were obtained in QF spreadsheet format from the analysts.
* The cruise summary sheet was completed.
* The history of use of the pressure, conductivity and dissolved oxygen sensors was obtained.

2023-066 was the only cruise that had used them since they were last serviced at the factory.

The configuration files were checked; there was a change of fluorometer starting at cast #136.

##### BOTTLE FILE PREPARATION

The HEX files were converted to ROS files:

* using 2023-019-ctd1.xmlcon for casts 1- 134.
* using 2023-019-ctd2.xmlcon for casts 136-153.

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.

4 casts had some outliers in salinity : 53 (Pri), 63 (Sec), 74 (Pri), 140 (Sec)

Because of spiking issues in dissolved oxygen and fluorescence, those channels were also plotted.

Dissolved oxygen looked ok, but there were clearly problems in fluorescence. We do not usually edit fluorescence given the spiky nature of the data, but where data were obviously bad they were removed.

Fluorescence data looked obviously bad in parts of files: 42, 46, 108, 120, 136.

The suspect files were opened in CTDEDIT. Obviously bad data were removed from events 42, 46 and 108, but the data in casts 120 and 136 all look bad, so this channel will be removed later.

Note was made in the headers of files which were edited.

The fluorometer was on the secondary pump, so secondary temperature and salinity were displayed with the fluorescence to see if pump issues may explain the bad sections, but there was no evidence of that.

After editing the ED1 files were copied to \*.BOT.

Patches with very high fluorescence were seen only during upcasts. Downcasts look ok in most cases, but towards the end of the cruise there are patches with no signal in downcasts. This will be studied later.

A preliminary header check was run; no problems were found.

The BOT files were bin-averaged on bottle number.

The output was used to create file ADDSAMP.csv. First, the file was sorted on event number and Bottle Position order. Then sample numbers were added based on the rosette logs.

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 SAMAVG file for event #1 was reduced to just 1 record as only Niskin 1 was sampled.

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 2023-019-bot-hdr.txt which will be updated as needed during processing.

Loops samples were moved from the salinity and chlorophyll CSV files to a combined loop data file for later use.

DISSOLVED OXGYEN

Dissolved oxygen data were provided in spreadsheet QF2023-019\_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 2023-019oxy.csv. That file was converted into individual \*.OXY files.

EXTRACTED CHLOROPHYLL

Extracted chlorophyll and phaeo-pigment data were obtained in file QF2023-019\_CHL QF\*.xlsx. The file included comments and flags and a precision study. A simplified version of the spreadsheet was prepared and saved as 2023-019chl.csv. The csv file was then converted to individual CHL files.

SALINITY

Salinity analysis was obtained in file QF2023-019\_SAL.xlsx which included a precision study. The analyses were carried out in a temperature-controlled lab 11 to 20 days after collection. The files were simplified and saved as 2023-019sal.csv. That file was then converted to individual SAL files.

NUTRIENTS

The nutrient data were obtained in spreadsheet QF2023-019\_NUTS\*.xlsx. This includes a precision study. The file was simplified, saved as 2023-019nuts.csv. The file was converted to individual NUT files.

AMMONIUM

NH4 data were obtained in spreadsheet QF2023-019 QF NH4\*.xlsx. This includes a precision study. The file was simplified and saved as 2023-019NH4.csv. This file was converted to NH4 files.

The SAL, CHL, OXY, NUT and NH4 files were merged with CST files in 5 steps.

After the 5th step the files were put through CLEAN to reduce the headers to File and Comment sections only.

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

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

The output of the MRG files were exported to a spreadsheet and compared to the rosette log sheets to look for omissions. A few problems were found including an error in file #114 caused by sample numbers being out of order.

The following problems were referred to analysts:

* For CHL there were 2 flags that seemed inappropriate and there was one extraneous line. Fixed in QF file and CHL csv file.
* for NH4 there was confusion over duplicate sample #s. Fixed in QF and NH4 csv file.
* For Oxygen two event #s were wrong in the QF spreadsheet. Fixed in oxy csv file.
* For Nutrients 2 samples were missing – 9444 and 9445 – they are in the nutrient spreadsheet – just didn’t get included into MRG files due to ordering issue. Re-run successfully. Because sample #s not in pressure order this requires reordering on sample # for the merge process.

A few other problems were found in the bottle comparison.

Cast #114 was tricky to handle because sample numbers were given a leading 9 to distinguish them from the same numbers on the previous cast. So they were not in the usual order.

The merge process was repeated after corrections.

##### Compare

Salinity

Compare was run with pressure as reference channel. A fit was done excluding cases where the standard deviation in the CTD salinity during the 10s window was >0.0008psu and data from the top 10db. The primary salinity was higher than bottles by an average of ~0.0023psu (std dev 0.0012psu) and the secondary salinity was higher by an average of ~0.0003psu (std dev 0.0013psu).

The differences between the 2 fits are smaller than the differences between downcast salinity channels reported in section 9, except in very deep water where they are reasonably close. The larger difference when in motion is likely due to slight misalignment rather than calibration difference.

The primary salinity is out of line at the bottom of cast #39; the upcast and downcast differ from 1250db to the bottom of the cast. The downcast is probably ok and data in rosette files are likely only affected for the bottom bottle.

Plots against time were both very flat.

There were no outliers that were not explained by very noisy CTD salinity or being from the top 10db.

Analysis was done very quickly and waits in the top 400m were generally 60s before firing bottles.

For full details for the COMPARE run see file 2023-019-sal-comp1.xls.

Dissolved Oxygen

COMPARE was run with pressure as the reference channel.

Because hysteresis was noted during the previous use of this sensor leading to a change of factor E in the configuration file, a check was first made to see if that choice is appropriate for these data.

A fit was done of the difference between the CTD DO and titrated DO samples versus CTD DO. All data above 900db were excluded from the fit so that the deep samples showed up in green on the plot. The green points fell within the general distribution; one very minor outlier had fairly high standard deviation in the CTD DO. So the adjustment for hysteresis appears to be suitable for these data.

In the general fit there were many cases of CTD DO being higher than bottles, which is not expected for these sensors. For some outliers the standard deviation in the CTD data was very high, but not for many of them. Most of the outliers came from casts 27, 29 and 31 with cast #25 being a little out of line. Many of the samples were flagged 4 by the analyst:

Outliers:

Cast #23 – One outlier is from the bottom of the cast where samples are often lower than samples. Samples #35 and #36 are reversed. When switched sample #35 is still slightly out of line but not enough to justify flagging it 3 and sample #36 is no longer out of line.

Cast #25 – All were flagged 4 due to the lack of a water seal, but most values are not significantly out of line, so they could be left as is with flag 4.

Casts #27 and 29 are way out of line and were flagged 4 by the analyst due to having no water seal, precipitate not uniform and not properly mixed. Flag 5 and padding values were recommended given the poor comparison to CTD DO.

Cast #31 has some outliers. The CTD DO had many spikes but not during bottle stops. Given possible problems in the CTD data, it does not seem justified to flag the samples; but perhaps flag 2 or 3 and a comment might be appropriate for samples from 150db down. “Poor agreement with CTD OXY but may be due to problems with the CTD sensor.”

All cases with flag 3 on DO values were checked and no further flagging is recommended; in the case of replicates there was no obvious evidence of which value might be a better choice.

The analyst agreed with recommended changes and sent an updated QF file.

The fit when outliers were removed based on flagged samples, noisy CTD data or outliers based on residuals was:

CTD DO Corrected = CTD DO \* 1.0245 + 0.0143

A fit was done for cast #108, a deep cast near the end of the open ocean section of the cruise that had no problems with spiking of CTD DO data and the fit was similar that for the whole cruise:

CTD DO Corrected = CTD DO \* 1.0252 + 0.0155

During the previous cruise (2023-066) the correction used was:

CTD DO Corrected = CTD DO \* 1.0115 - 0.0094

There were many problems with spiking during that cruise as well.

For full details for the COMPARE run see file 2023-019-dox-comp1.xls.

Fluorescence

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

Two fluorometers were in use and there were problems with both.

* #3640

For Fluorometer #3640 fluorescence mostly compared well with CHL with the notable exception of all bottles from cast #120 and one bottle from cast # 17. For those “bad” cases the fluorometer had values of ~22.5ug/L no matter what the chlorophyll level. Cast #120 was already identified as having all fluorescence data bad.

The CTD fluorometer data show the usual comparison with Extracted Chlorophyll data. CTD fluorescence was mostly higher than CHL when CHL<1.5 with the ratio FL/CHL falling to about 1 when CHL=1ug/L and about 0.5 for CHL>2.5ug/L.

The fit of FL vs CHL when forced through the origin has a slope of 0.5 but, as expected, the scatter is very high.

* #4108

Fluorometer #4108 was installed due to the bad performance of the other fluorometer. The CHL values available ranged from 0.5 to 3 where the fluorometers usually agrees fairly well with CHL, but the fluorescence values were very low.

At first sight this suggested an error in the gain setting, but examination of full plots showed erratic behaviour with a few downcasts having believable values near the surface but high values at depth and some with clear patches of offset high values. Others had large sections of 0 values. These data are not reliable so the Fluorescence channel should be removed from casts 136 to the end.

For full details for the COMPARE run see file 2023-019-fl-chl-comp1.xls.

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

Hex files were converted to CNV files:

* using 2023-019-ctd.xmlcon for casts 1- 134. (The file was later named 2023-019-ctd1.xmlcon)
* using 2023-019-ctd2.xmlcon for casts 136-153.

The only difference between the two xmlcon files was the fluorometer.

The Tau function and the hysteresis function were selected since there was deep sampling. Depth was included in the conversion.

A few casts were examined and all expected channels are present, but there are many spikes in some files, mostly below 400m. Pressure, temperature, conductivity and dissolved oxygen voltage had spikes. None were seen when stopped for bottles in the files checked.

##### WILDEDIT

Program WILDEDIT was run to remove spikes from the pressure, depth, conductivity, temperature and dissolved oxygen voltage on the CNV files. It is unusual to apply this step to dissolved oxygen but there were many spikes in that channel.

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.

Conductivity spikes noted in the previous step were 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

CELLTM was run using default values (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.

A few casts were examined to see how well the previous 3 steps worked.

It is hard to judge the alignment of DO due to the noisy upcast temperature, but it looks reasonably good.

Similarly the CELLTM adjustment is hard to evaluate.

WILDEDIT worked well on the oxygen voltage channel but the derived DO concentration channel still has significant single-point spikes. Running WILDEDIT on channel Oxygen:Dissolved:SBE left only small, insignificant spikes in the casts tested.

Transmissivity channels also had more spikes than usual, especially channel Transmissivity:Green. We do not usually apply WILDEDIT to those channels because they are spiky by nature, but large single-point spikes are not typical, especially at depth. Tests were run to see if WILDEDIT would improve these profiles without compromising real features and it appears to do so.

WILDEDIT was rerun applying the same parameters as described in section 3 but choosing channels

Oxygen:Dissolved:SBE, Transmissivity1 and Transmissivity2.

DERIVE was run a second time on 4 of the deeper casts to find the differences between the pairs of temperature, conductivity and salinity channels.

All differences were small, but there is a slight pressure dependence.

The shaded entries are from the previous cruise which had much deeper sampling. The differences at 2000db are consistent with those from the latter part of 2023-066, so there does not appear to be significant calibration drift.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cast # | Press | T1-T0 | C1-C0 | S1-S0 | Descent Rate |
| 2023-066-0052 | 1000 | -0.0002 | -0.00004 | -0.0003 | High, Noisy |
|  | 2000 | -0.0005 | -0.00006 | -0.0003 | “ |
|  | 2500 | -0.0007 | -0.00007 | -0.0002 | “ |
|  | 3000 | -0.0008 | -0.00006 | -0.0001 | “ |
|  | 3500 | -0.0008 | -0.00008 | 0 | “ |
| 2023-066-0079 | 1000 | -0.0002 | -0.00023 | -0.0026 | High, Noisy |
|  | 2000 | -0.0005 | -0.00020 | -0.0020 | “ |
|  | 2500 | -0.0004 | -0.00019 | -0.0019 | “ |
|  | 3000 | -0.0003 | -0.00019 | -0.0020 | “ |
|  | 3500 | -0.0001 | -0.00017 | -0.0021 | “ |
| 2023-066-0086 | 1000 | +0.0003 | -0.00025 | -0.0032 | High, XNoisy |
|  | 2000 | -0.0002 | -0.00023 | -0.0026 | “ |
|  | 2500 | -0.0004 | -0.00022 | -0.0023 | “ |
|  | 3000 | -0.0002 | -0.00021 | -0.0024 | “ |
|  | 3500 | -0.0001 | -0.00020 | -0.0024 | “ |
|  | 4000 | +0.0001 | -0.00020 | -0.0025 | “ |
| 2023-019-0039 | 500 | +0.0003 | -0.00041 | -0.0047 | High, FSteady |
|  | 1000 | +0.0003 | -0.00029 | -0.0036 | “ |
|  | 1400 | +0.0002 | -0.00022 | -0.0033 | “ |
| 2023-019-0071 | 500 | +0.0003 | -0.00034 | -0.0045 | High, Noisy |
|  | 1000 | +0.0002 | -0.00027 | -0.0035 | “ |
|  | 1500 | +0.0002 | -0.00024 | -0.0032 | “ |
| 2023-019-0092 | 500 | +0.0001 | -0.00040 | -0.0046 | High, Noisy |
|  | 1000 | +0.0001 | -0.00030 | -0.0037 | “ |
|  | 1500 | +0.0000 | -0.00027 | -0.0033 | “ |
|  | 2000 | -0.0004 | -0.00024 | -0.0025 | “ |
| 2023-019-0108 | 500 | +0.0002 | -0.00033 | -0.0040 | High, V Noisy |
|  | 1000 | +0.0002 | -0.00024 | -0.0041 | “ |
|  | 1500 | +0.0000 | -0.00023 | -0.0031 | “ |
|  | 2000 | -0.0004 | -0.00020 | -0.0021 | “ |

##### 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.

##### Checking Headers

* Initial track plots turned up an error in station name for cast #65; this was corrected in the full cast and bottle files.
* The cross-reference check and header check were run.
* The minimum pressure was -0.05db. It occurred with the pumps on and pressure quite noisy. Conductivity did not go very low, but the pressure was only negative for a few scans. Transmissivity went down somewhat, so the CTD was likely close to the surface.
* There are clearly bad values in temperature, conductivity oxygen and salinity channels that appear to be only at the surface. These should be removed by DELETE.
* Transmissivity1, Transmissivity2 and dissolved oxygen concentration look much better after the second run of WILDEDIT. There are small spikes that may be inaccurate, but insignificant. DELETE may remove a few more. There are some larger spikes in the upcasts that DELETE will remove.
* There are many extreme values in temperature, salinity, oxygen, descent rate that appear to all be at the surface and should disappear when DELETE is run.
* Surface check was run and the average surface value was 1.8db. This is the measure after the 10m soak which is reasonable.
* The bottle file header check shows silicate will need recalibration for the final file, but it is easiest to run all casts on that step.
* Cruise tracks were plotted and added to the end of this report.
* Initial plots show that fluorescence channel has frequent unrealistic values in deep water. There are mostly single-point spikes; most of the problems are below 300db where data are of no particular interest. The simplest approach is to pad values below that level and use CTDEDIT to approach the few problems that remain.
* There are a few instances of noisy transmissivity that will need investigation in CTDEDIT.

What little evidence exists regarding the pressure accuracy, it is clearly not reading high, but it may be low since conductivity was still high when pressure was -0.5db. During the previous cruise there was more evidence available and a correction of +0.8db was applied for this CTD. There is no need to recalibrate before running DELETE since no useful data has negative pressures that would lead to data loss. It will be recalibrated at the same time as other recalibrations are applied.

The altimeter and water depth readings from the headers of the CLN files were exported to a spreadsheet. A check value was calculated by subtracting water depth from maximum depth sampled plus altimetry header.

Some casts did not get within 15m of the bottom. That should lead to there being no altimetry reading in the header, but for many casts there were spikes to less than 15m and the general shape of the altimetry shows the CTD never really got that close to the bottom.

The following changes were made to the altimetry headers in IOS files and CLEAN was rerun.

* The log entry for depth differs from that in the file headers and using the log entry leads to a check entry <5m. The header entry was adjusted for those casts: 19, 30, 68, 71.
* The header entries were removed from casts: 29, 31, 33, 39, 66, 70, 74, 78, 80, 89, 92, 97, 95, 97, 108, 111, 114, 122.

The same changes were made to SAM files, where applicable. SAMAVG and MERGE were rerun.

##### Shift

Fluorescence

SHIFT was run on the SeaPoint fluorescence channel in all casts using the usual advance of +24 records. Plots show that the fluorescence offset is reasonably close to the temperature offset after this step.

Dissolved Oxygen

The Dissolved Oxygen voltage channel was aligned earlier. A few casts were checked to see if the alignment looked ok, and it did. No further alignment is needed for the DO concentration channel.

Conductivity

Tests were run on a few casts to find the alignment shift best for the 2 conductivity sensors as judged by noise in T-S space. The best choice was -0.8 records for the primary and -0.65 records for the secondary channels.

SHIFT was run twice on all SBE911 casts using -0.8 records for the primary and -0.65 for the secondary. 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 warnings for a few casts which concerned upcast data so are of no concern. 1 warning did concern downcast data but DELETE handled the jump in pressure appropriately.

##### Other Comparisons

Experience with these sensors since last factory service –

The pressure, temperature, conductivity and dissolved oxygen sensors were used for only 1 cruise between the last factory service and this cruise.

* During 2023-066 the primary salinity was high by 0.0011psu and the secondary was low by 0.0001psu. Pressure calibration looked very good. There was hysteresis noted in the dissolved oxygen channel so the configuration parameter E was changed to 0.033. The DO data were recalibrated using slope 1.0115 and offset -0.0094. Fluorometer 3640 compared reasonably well with CHL with the usual pattern.

Historic ranges – Profile plots were made with 3-standard deviation climatology ranges of T and S superimposed.

* Temperatures were slightly high near the surface for many casts, but that likely reflects real conditions. There is an odd temperature reversal around 25m seen during 2 casts at station LC09. The temperature goes above the climatology briefly. The first cast was aborted due to an equipment problem, but the second cast shows the same feature in both downcast and upcast. The reversal is stable in T-S space, appearing to be an intrusion of warm salinity water.
* There are a few excursions from the climatology for salinity, mostly cases of low salinity near the surface. The most notable excursions were at Brooks Peninsula where salinity was high around 50m. The excursions are not systematic, so not an indication of poor sensor calibration.

Post-Cruise Calibration – None available.

Repeat Casts –The only repeat casts were #41 and #42 at LC09. The start times differ by 46 minutes. At about 500m the T-S plot is quite smooth, so there was likely minimal change between the 2 casts at that level. The differences in temperature and salinity along lines of constant density were ~0.006Cº and ~0.0008psu. This is excellent repeatability. At a level where there was obviously mixing going on, the differences are much larger.

##### DETAILED EDITING

Casts #32 and #64 each have a large section of bad secondary salinity data in the downcast, likely due to something stuck in the plumbing, so the primary T and S were be chosen for archiving.

In the course of editing 3 successive files were found with some sections of poor primary salinity near the surface and the secondary salinity channel looked much better: 46, 48, 50.

For those files the secondary channels were selected.

There is no indication of a problem noted at sea and dissolved oxygen (on the primary pump) does not stand out in comparison with bottles for cast #50. No significant problem was found with spikes in that cast. There was a lot of variability that could be instrumental or real.

The secondary salinity appears to be more accurate than the primary, so recalibration will be applied later to the primary salinity by subtracting 0.002psu to bring the 2 salinity channels into line.

All DEL files were copied to \*.EDT.

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.

In some casts the salinity was very noisy in deep water, but the variations were 2-sided and likely to be ok after bin-averaging.

There were some casts with heavy corruption by spikes – many were removed using WILDEDIT but some remain. Temperature and salinity were cleaned to remove those spikes.   
A check was made to ensure pressure had been adequately smoothed and it had.

There were some spikes in fluorescence; those in deep water will be removed later by padding all values below 300db. CTDEDIT was used to remove spikes in fluorescence above that level. These 2 steps will lead to better selections of automatic scaling of fluorescence plots.

All files required some editing. Notes about editing applied were added to the files.

After editing, T-S plots were examined for all casts; 3 were opened again in CTDEDIT but no further editing was applied; there are some near-surface unstable features that may be real and it is not obvious which data are unreliable. (Two files were later given a little further editing.)

CLEAN was run to pad fluorescence values below 300db. (Output \*.clnfl)

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

Because the choice of primary or secondary channels differed among the casts, it is important to bring them into line as well as possible. The primary salinity was selected for most casts. The secondary salinity was closest to bottles. The primary salinity will be recalibrated by subtracting 0.002psu. The differences during downcasts were higher but that may be partly to slight misalignment between the two systems.

There was salinity <25psu in CTD salinity in the bottle files (MRG) so silicate needs correction in the bottle files.

CALIBRATE was run on the MRGCLN2 files using file 2023-019-sil.ccf to correct silicate when salinity < 25psu, with output \*.MRGCORSIL.

CALIBRATE was run on MRGCORSIL and SAM files using file 2023-019-recal1.ccf to apply the following corrections:

* Add 0.8 to Pressure and Depth
* CTD DO Corrected = CTD DO \* 1.0245 + 0.0143
* CTD Salinity:T0:C0 Corrected = CTD Salinity:T0:C0 – 0.002psu

COMPARE was rerun for dissolved oxygen and shows that the correction improved the fit greatly. When outliers were removed based on standard deviation in the CTD DO and residuals, the SBE DO was found to be high by an average of 0.0026mL/L and standard deviation of 0.017mL/L.

CALIBRATE was then run on the EDT files using file 2023-019-recal1.ccf.

##### 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 upcast bottle data at 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. Events 25, 27 and 29 were not included as all bottles were flagged 5 or 4.

The CTD DO was lower than the titrated samples by an average of 0.023mL/L when outliers were removed based on residuals (standard deviation 0.121mL/L). This is a reasonably good result given the many problems with dissolved oxygen data from the CTD. We expect the downcast data to be slightly too high due to slow response and the bottle data to be too high above the OMZ due to incomplete flushing.

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. The deepest bottles read somewhat lower than bottles while the shallow ones trend to be higher. This is partly due to incomplete flushing leading to the bottles having higher values than ambient conditions above the OMZ and lower below the OMZ.

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

±0.50 mL/L from 0 - 75db except in areas of very large DO gradients

±0.20 mL/L from 75db - 200db

±0.05 mL/L from 200db - 500db

±0.03 mL/L below 500db

For more detail see file 2023-019-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 and no problems noted.

Profile plots were examined and a few items investigated:.

* The bottom 2 bins for cast #120 had bad fluorescence values, so those were removed using a text editor and the header range adjusted. That cast had bad data throughout the upcast, but most of the downcast looks ok.
* Fluorescence data in bottle files from casts #136 to #153 were padded; so the downcast data were examined to see if the fluorescence from the downcasts should also be padded. The downcast data from #136 looks close to the CHL sample taken during that cast. After that the fluorescence looks very low and for the 3 casts with CHL samples the CTD values are much lower than expected. So Fluorescence should be removed from casts #138 to 153.
* The T-S plot for cast #56 has an unstable feature around 6m. This was re-examined in CTDEDIT, but the feature looks like it may be real, and if it isn’t, it is not clear which data are unreliable, so no change was made.

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

For casts 1-44 and 51-153 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 and Flag.

Fluorescence was removed from casts 138-153.

For casts 46-50 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 comments about processing.

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

The Header Check was run; no problems were found.

Profile and T-S plots were examined. A few small unstable features were found but may well be due to active mixing. No other problems were found.

The sensor history was updated.

##### Dissolved Oxygen Study

As a final check of dissolved oxygen data, % saturation was calculated and plotted. Values at 2 to 3m ranged from ~90% to 150%. The lowest values were near Brooks Peninsula, Queen Charlotte Strait and Johnston Strait, areas likely subject to tidal mixing. Casts on the southern shelf area had the highest values. Offshore sites to the south ranged from 110-120% while to the north they ranged from 105% to 110%. Transmissivity was generally low where saturation was high, as expected. The values are reasonable for the time of year, and do not suggest a DO calibration problem.

##### Final Bottle Files

SORT was run to arrange casts in pressure order.

Fluorescence looks unreliable below 80db during bottle stops and entirely bad during upcasts for events #120 and 136-153.

CLEAN was run to replace values below 80db for all MRGCOR1 files.

For casts 1-44 and 51-153 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 and Flag.

Fluorescence was removed from casts 120 and 136-153.

For casts 46-50 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. (Note that Temperature\* and Salinity\* were chosen for CTD T and S since there was a mix of primary and secondary channels in the data set.)

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

The standard check was run and showed that the fluorescence channel was empty, but it was left as-is since there had been fluorescence measured but the data were bad. No other problems were found.

Data were exported from the CHE files to file 2023-019-bottles-final.xlsx. A few random checks were made by comparing with the rosette log sheets and no problems were found.

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

An IOS TSG45 was used for this cruise and data were saved in 1 file, 2023-09.txt

The time format was not appropriate so the file was opened in ULTRAEDIT so column editing could be used to fix that. The file was saved as 2023-019-time.txt and opened in EXCEL where it was saved as 2023-019-TSG.csv

The spreadsheets were adjusted as follows:

* 2 lines of headers were added – channel names and units.
* Flow was off to the TSG and fluorometer and the ship was not moving at the beginning of the file. The first 2368 records were removed until flow had been on for 2 minutes. Records were also removed from the final 10 minutes when flow was off.
* A column with pressure was added with all values set to 4.5 (to enable derivation of salinity).
* A temperature difference column was added (Lab-Intake).
* The fluorescence channel is in volts. It was moved to column M. Then a concentration value was calculated in column F using scale 14.6 as determined in the most recent factory recalibration of the fluorometer. The clean water offset value was 0.081. For previous uses of this equipment it was sometimes found necessary to adjust the offset to obtain reasonable values. There are some negative values so the offset was decreased until all values were positive. The offset required for this was 0.076, but a choice of 0.069 leads to a minimum of 0.10ug/L which looks more reasonable than 0 and it is the value chosen when the TSG was used during the previous cruise, 2022-066. An offset of 0.069 was selected.
* A quick comparison was made between the fluorescence values in the TSG file and CTD values around 4.5m from a selection of casts. Where available comparisons were also made with extracted chlorophyll samples. Unfortunately, the CTD fluorometry was bad late in the cruise.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Event #** | **TSG FL** | **CTD FL (down)** | **CHL (up)** | **TSG FL/ CTD FL(down)** | **TSG FL/ CHL** | **CTD FL (down)/ CHL** |
| 3 | 2.16 | 4.7 | 7.3 | 0.5 | 0.3 | 0.6 |
| 7 | 11.46 | 10.6 |  | 1.1 |  |  |
| 25 | 0.57 | 0.7 | 0.5 | 0.8 | 1.2 | 1.5 |
| 46 | 0.25 | 0.4 | 0.2 | 0.7 | 1.1 | 1.5 |
| 56 | 0.47 | 0.9 | 0.6 | 0.5 | 0.8 | 1.5 |
| 122 | 0.96 | 1.3 |  | 0.8 |  |  |
| 132 | 1.05 | 2.6 |  | 0.4 |  |  |
| 134 | 0.50 | 0.9 |  | 1.2 |  |  |
| 136 | 0.77 | 1.6 | 1.7 | 0.5 | 0.5 | 0.9 |
| 153 | 1.33 |  | 3.2 |  | 0.4 |  |

Given different deployment methods and slightly different depths, the comparison is very rough.

When CHL was high we normally see fluorometers reading lower and that is true for both TSG and CTD during event #3, but the TSG is especially low. Overall the TSG reads lower than the CTD fluorometer but it may be drawing water from higher in the water column. For low CHL the CTD is higher than CHL, as usual, but the TSG is lower than CHL. The TSG fluorescence also read lower than the CTD during the previous cruise, but since there were few casts with high CHL during that cruise the effect was not as significant as for this cruise.

* The file break column was filled with date info so that a new file would be created at the beginning of each day. After conversion the format was 2023-019-20230516. (Cruise # plus date for the file.)
* In fixing the file break column it was found that the date was wrong for times a second before midnight. Those were corrected.

The files were then converted to IOS Header format with header info added.

Initial conversion failed because there were a few NULL entries in date and time, though other channels were ok; the bad entries were replaced with appropriate data.

There are 9 IOS files, each covering all or part of 1 day.

CLEAN was run to reset the number of records, min and max values, set the start and end times, and latitude and longitude limits.

ADD TIME CHANNEL was used to add Julian dates – i.e. Decimal Year. A record number was also added to enable averaging (for use in comparison to CTD files). Time zero was set to 31 December 2022 0:00:00. (Note that this step leads to problems plotting until REORDER is run.)

DERIVED QUANTITIES was run twice, first to derive salinity using the lab temperature and again to derive sigma-T.

REORDER was run to move the Julian date to after the Time/Date channels and to put salinity and fluorescence after the lab temperature. Also the record # was moved to the end. Channels not selected will be removed.

a.) Plots

A track plot was produced and added to the end of this report.

Time-series plots were produced:

* Salinity has some small spikes that are likely due to bubbles but not large enough to justify editing; There is one section of low salinity, but it corresponds to a time the ship was very close to shore, so it is likely accurate.
* There is one very large spike in lab temperature on May 19th which was caused by a pad value. This was fixed in all files.
* There are some spikes in fluorescence; most are likely real, but a large single-point spike was removed by interpolation using a text editor in the file for May 21 at 12:59:19.
* The flow rates were fairly steady, mostly ~1.2 for the TSG and ~1 for the fluorometer.
* Temperature differences are very noisy with intake temperature sometimes higher than lab temperature and sometimes lower; there is a lot of variability in intake temperature.

b.) Checking Time Channel

The CTD files were thinned to reduce the files to a single point from the downcast at or within 0.5db of 4.5db. These were exported to a spreadsheet which was saved as 2023-019-tsg-ctd-loop-comp.xlsx. All CTD casts overlapped with TSG records. There are 64 points of comparison.

For comparison with CTD data, the TSG files were averaged over 6 records (30s) on record number to reduce the noise and file size. Standard deviations were included. Then required records (times, positions, temperatures with standard dev, salinity with standard dev, fluorescence with standard dev, flow rates) were exported to a spreadsheet and that file was thinned to the closest times of CTDs and added to file 2023-019-tsg-ctd-loop-comp.xlsx.. The same file was thinned to the closest times to loop samples and added to the TSG-Loop comparison. There were 5 loop samples that overlapped with TSG records.

A comparison was made of positions for the CTD and TSG data to check for good matches. The differences in positions are expected to be small despite the averaging because the ship was stopped at these times. The median differences were 0.0000º for latitude and 0.0002º for longitude. There were no differences> 0.002º. So the matches are good.

c.) Comparisons

* Comparison of T, S and Fluorescence from TSG and CTD data

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Tintake-Tctd | Tlab-Tctd | Stsg-Sctd | FLtsg/FLctd |
| average | 0.4391 | 0.6364 | -0.1448 | 0.7520 |
| median | 0.2377 | 0.4529 | -0.0268 | 0.7629 |
| std dev | 0.6099 | 0.5015 | 0.4553 | 0.2392 |
| min | -1.1455 | -0.1775 | -3.4208 | 0.1684 |
| max | 2.0381 | 2.5760 | 0.1995 | 1.5135 |

The intake temperature is much higher than the CTD temperature on average, confirming the problem noted in the time-series plots when TSG intake temperatures were often higher than lab temperatures. The intake temperature was not archived during the previous cruise due to similar problems.

Plots were made to study the problem further. Most instructive were plots against event #.

CTD temperatures were lower in the southern gyre area and in the northern part of the cruise. The gyre and northern casts were also well-mixed near the surface. The differences between TSG and CTD were generally highest in the well-mixed areas. In the less well-mixed areas the differences are generally lower. 2 casts in inland waters at the end of the cruise were excluded due to extreme gradients. The comparisons are subject to many possible errors including averaging of both data sets and ship-effects, but give a general understanding of what is happening.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Tintake-Tctd | Tlab-Tctd | Stsg-Sctd | FLtsg/FLctd |
| Events 20-84 |  |  |  |  |
| Median | 0.0362 | 0.3719 | -0.0156 | 0.79 |
| Std Dev | 0.3069 | 0.3585 | 0.1343 | 0.19 |
| Events 1-19 & 89-140, 145-147 |  |  |  |  |
| Median | 0.8947 | 0.5722 | -0.0330 | 0.71 |
| Std Dev | 0.4223 | 0.6098 | 0.1308 | 0.30 |

The intake temperature is higher than expected in both regions, but especially so where the vertical gradients are low, ruling out mismatches in depth as significant factors. The TSG is likely drawing water from higher in the water column resulting in smaller differences from CTD data when gradients are larger. If that is the case then salinity should also be closer to CTD salinity in less well-mixed areas and it is. The intake temperature will not be archived.

For the lab temperature the picture is less clear because heating in the loop is dependent on intake temperature, so tends to be higher for cooler intake water. So lower gradients and lower intake temperatures would have opposite effects. For salinity, having lower gradients should lead to smaller differences but there is also the effect of bubbles in the loop to complicate the picture. In any case the differences are fairly small for both groups and we expect some variability in the bubble effect.

The 2nd CTD fluorometer performed badly and was not included in the comparison. Fluorescence variation is more complex, but the correspondence between the CTD fluorescence and TSG fluorescence is slightly higher and the standard deviation lower in the well-mixed group. A rough estimate is that the TSG fluorescence is about 80% of CTD fluorescence.

The intake temperature will not be archived, so we want to provide a proxy for that channel by recalibrating the lab temperature based on a comparison with the CTD temperature. 32 records were selected where the lab temperature standard deviation over 30s minute was <0.005, excluding 2 values that were outliers in the plot. This gives us a rough estimate to enable creating a proxy for intake temperature.

A check was made to ensure that this fit was based on a good selection of sites and it was.

So a new TSG channel will be created called Temperature:Primary:

Temperature:Primary = 1.0587\*Temperature:Lab -1.1785

This equation was applied to the Temperature:Lab values and the CTD value subtracted. The average difference between the two using the same data used for the fit was +0.0021Cº but the standard deviation was 0.0887Cº. This method will provide a proxy for surface water temperature, but clearly it is less reliable than a well-functioning intake thermistor.

Salinity differences looked noisy. The largest difference was for cast #153 which had an extremely high vertical gradient, rising from 23psu at 2.8m to 26.6 at 4.2m. The TSG probably draws water from a little above the intake. The median difference for the well-mixed casts suggests it is low by 0.033psu but the standard deviation is high at 0.131psu.

* Comparisons of Loop samples and TSG data

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Event #** | Loop CHL | **Flag:Chl** | TSG FL | TSG FL/ CHL | Loop Salinity | TSG Salinity | Std Dev TSG Salinity | TSG\_SAL-Loop\_Sal |
| 88 | 1.97 | 6 | 1.34 | 0.68 | 30.5028 | 30.5053 | 6.89E-03 | 0.0025 |
| 103 | 0.75 | 6 | 0.49 | 0.65 | 31.9246 | 31.9459 | 1.63E-02 | 0.0213 |
| 121 | 0.82 | 26 | 1.01 | 1.23 | 31.6861 | 31.6490 | 5.01E-04 | -0.0371 |
| 142 | 2.65 | 36 | 1.85 | 0.70 | 31.2025 | 31.3274 | 4.32E-02 | 0.1249 |
| 152 | 2.18 | 36 | 0.58 | 0.39 | 30.5144 | 30.4774 | 1.24E-03 | -0.0370 |
|  |  |  | average | 0.73 |  |  |  | 0.0149 |
|  |  |  | median | 0.68 |  |  |  | 0.0025 |
|  |  |  | stdev | 0.31 |  |  |  | 0.0665 |

There were 5 loop Salinity and Chlorophyll samples taken while underway. The loops were compared with TSG data. TSG fluorescence is usually higher than loop samples when CHL is low, and lower when CHL is high. The average ratio FL/CHL is 0.73. With only 5 points and a “noisy” quantity, this comparison suggests the TSG fluorometer was reading slightly lower than expected.

Similarly, there is a lot of variability in the salinity comparison with the TSG salinity reading higher than loops by an average of 0.0149, a median of 0.0025 and standard deviation of 0.0667psu. When plotted against standard deviation in the TSG Salinity over 1 minute the two cases with TST salinity reading lower than CTD salinity by 0.037psu are the ones with very low standard deviation.

No comparison was possible between loops and rosette samples as all loops were taken underway.

d.) Calibration History

**The TSG was serviced and recalibrated shortly before cruise 2023-066; only the fluorometer has useful history available before that.**

* During 2021-001 the TSG fluorescence values were about 32% of fluorescence from the CTD and 74% of the loop CHL samples and loop chlorophyll was about 75% of that from the rosette.
* During 2021-006 the TSG fluorescence values were about 50% higher than those from the CTD and higher than loop CHL samples by 50 to 300%. For the cases where the CHL was in the range 0.49 to 5.0ug/L, the TSG fluorescence was higher than loop samples by 8%, but the loop chlorophyll values were lower than rosette samples.
* During 2021-005 TSG fluorescence values were close to those from the CTD and higher than rosette CHL samples for low CHL and about 50% of CHL when CHL>4ug/L.
* During 2021-069 TSG fluorescence values were reasonably close to those from the CTD fluorometer and about 50% of rosette CHL samples when CHL>4ug/L.
* During 2021-008 the TSG fluorescence values were about 1.4 times those from the CTD and higher than loop CHL samples by a median of 3.5, For the cases where the CHL was <0.5ug/L, the TSG fluorescence was higher than loop samples by a median factor of 3.5 but for the few values between 1 and 2ug/L the TSG fluorescence is close to the CHL values.
* During 2022-008 the TSG fluorescence was higher than Extracted CHL by up to a factor of 2.5 for the samples with CHL < 0.4ug/L. It dropped sharply as CHL increased. It was close to CHL for CHL=0.7ug/L and about 20% of CHL for CHL=11.6ug/L. The TSG salinity was lower than the loop samples by a median of 0.021psu (std dev 0.024psu).
* During 2023-066 the intake temperature data looked bad throughout the cruise, with sudden shifts and did not compare well with CTD temperatures. A proxy for intake temperature was created by subtracting 0.53C from the lab temperature based on comparisons to CTD data. Salinity comparisons varied greatly but were, on average, reasonably close to CTD salinity. It was not recalibrated and was reported with 3 significant figures to indicate decreased quality. TSG fluorescence was about 80% of CTD fluorescence in the offshore and about 92% close to shore.

e.) Conclusions re TSG

1. The TSG clock worked well and position information is reliable.

2. Both flow rates were in a good range.

3. The TSG salinity was higher than loops by an median of 0.0025psu but the 2 with the lowest standard deviation in the TSG salinity both showed TSG salinity to be low by 0.037psu. It was lower than CTD salinity by 0.033psu in the area with well-mixed surface waters. The previous cruise had too much variability to make an estimate, except to say that the values were reasonably close to the CTD. Both the salinity comparisons are noisy, but the one versus CTD in well-mixed waters and the one versus loops when TSG data had low variability are in rough agreement. Even in areas where the comparison CTD data was very noisy, the TSG values mostly look low. The difference of ~0.03psu is readily explained by bubbles. The comparison is noisy but clearly salinity is reading a little low; 0.03psu will be added as a reasonable estimate that will reduce the effect of bubbles.

4. The intake temperature was high for a few hours during 2022-008 and there were many patches of variable performance during 2023-066. For this cruise it appears that the variations are mainly due to how well mixed the surface waters were. In well-mixed waters the TSG intake temperatures are high by about 0.6Cº which was probably the case for the whole cruise. The intake temperature will not be archived.

5. The TSG lab temperature was higher than CTD temperature by a median of 0.045Cº and by 0.57Cº in well-mixed areas. Plots of differences versus CTD temperature show the usual relationship of heating decreasing as the intake temperature approaches the ambient temperature of the ship.

5. TSG fluorescence was about 70% of CTD fluorescence. It was 72% of loop samples, which is lower than during the previous cruise, though that may be because CHL was a little higher for this cruise and these sensors tend to read lower as CHL rises.

f.) Editing

One large single-point spike in fluorescence for May 18th was padded using a text editor. There are many spikes in fluorescence but most are either multi-points or look like they could be real.

g.) Add Channel, Calibrate and Remove

ADD Channel was used to add channel Temperature:Primary which will serve as a proxy for intake temperature and was initially set to equal Temperature:Lab.

CALIBRATE was run using file 2023-019-tsg-recal.ccf to add 0.03psu to channel Salinity and to set

Temperature:Primary = 1.0587\*Temperature:Lab -1.1785

During 2023-066 Temperature:Primary was derived by subtracting a constant, 0.053Cº, from the lab temperature. That is equivalent to the correction shown above if the lab temperature was about 9º. During 2023-066 the range of temperatures was smaller (7.6ºC to 10.9ºC) with an average of 8.8ºC, so the simple correction was appropriate and is close to the fit used for this cruise. For 2023-019 it is appropriate to use a more complex fit given the larger temperature range.

REMOVE was run to remove channels Temperature:Intake, Pressure, Temperature:Difference and Record #.

h) Preparing Final Files

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 and to add comments.

The TSG sensor history was updated.

As a final check plots were made of the cruise track and time-series and all looks fine.

P**articulars - Notes from Daily Science Log and Rosette Logs**

TSG notes

Loop samples taken.

CTD notes

Raw files with error in event # in file names: 003→0033, 036→0036, 039→0039

13. Stop at 81m for ship reposition

23. Swapped Niskin 1 for new Niskin 2 off spare rosette.

30. Spikes in O2 ~700m. Deck unit chirp.

31. Spikes starting at ~600m. Deck unit chirps

36. Test pylon dummied. Stop @1854 for 5 min.

39. Pylon swapped to SN 0676. Spikes in DO, SAL, Temp, bottle 6 didn’t shut.

Swapped carousels, bottle #6 still didn’t fire. Solenoid #6 on new carousel does not work.

40. Dummied off carousel for LC10 to test noise – spike in salinity at 920m.

41. Split cast. 41up not needed - no Niskin sampling. Rerun as event #42. Downcasts similar - both kept..

41. Forgot to reconnect pylon after testing at last station.

42. Re run of LC09. Fluorometer spikes on upcast. Downcast similar to #41.

46. Bottle 6 fired – data recorded in ROS file, but not sampled – no note as to whether it closed or not.

50. Bottle #6 skipped.

61. Ran UHF radio interference check – click, click, click during cast to see if there are spikes.

New Pylon - #1218

67. DO spike ~650m right after UHF radio call from LARS to bridge. Another deck unit chirp ~700m after using UHF radio (closet and LARS).

68. DO spike ~800m, DO and SAL spike ~950m, FL spike ~360m. During 10m soak oil spotted on water surface, needed to bring CTD back on board to inspect for cause of oil slick.

68. DO spike ~800, DO and SAL spikes ~950m. Fluor spike ~360m.

70. Fluor spike ~170m and 280

71. Fluor spike ~500 upcast

78. Fluor spike ~1200m

80. DO spike~900 upcast. Sounder power off to re-organize rack.

81. Sounder power back on.

89-92. UHF

94. Archive started at ~10m downcast. VHF

100. Fluor spike on upcast ~60m.

104. VHF

106. Spikes at bottom. Variable sound ~1200m. FL spike, chirp. USB stick in computer. VHF

111. After cast flushed secondary cell with fresh warm water.

114. Vent cap loose on #23. Sample #s changed from 444 & 445 to 9444 & 9445 for Oxy, Nuts.

136. Swapped FL#3640 for FL#4108. Stopped winch payout at 155m for 2min for wire adjustment.

138. Gain cable swapped – but gain the same 3X.

150. Rosette brought back on board after 10m soak to clean oil. FL was high on downcast 220-360m - coupled with transmissivity.

**2023-019**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **CTD#** | **Make** | **Model** | **Serial#** | **Used with Rosette?** | **CTD Calibration Sheet Competed?** |
| **1** | **SEABIRD** | **911+** | **0550** | **Yes** | **Yes** |

**CRUISE SUMMARY – CTD**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Calibration Information - 0550** | | | | | |
| **Sensor** | | **Pre-Cruise** | | **Post Cruise** | |
| **Name** | **S/N** | **Date** | **Location** | **Date** | **Location** |
| **Temperature** | **2663** | **15Feb2023** | **Factory** |  |  |
| **Conductivity** | **2280** | **14Feb2023** | **Factory** |  |  |
| **Secondary Temp.** | **2106** | **3Feb2023** | **Factory** |  |  |
| **Secondary Cond.** | **2754** | **24Jan2023** | **Factory** |  |  |
| **Transmissometer** | **1185DR** | **23Mar2023** | **Factory** |  |  |
| **Transmissometer** | **1883DG** | **23Mar2023** | **Factory** |  |  |
| **SBE 43 DO sensor** | **3791** | **10Feb2023** | **Factory** |  |  |
| **PAR sensor** | **70613** | **24Feb2021** | **Factory** |  |  |
| **SeaPoint Fluor.** | **3640** |  |  |  |  |
| **SeaPoint Fluor.** | **4108** |  |  |  |  |
| **Pressure Sensor** | **0550** | **20Feb2023** | **Factory** |  |  |
| **Valeport Altimeter** | **37171** |  | **Factory** |  |  |

# TSG Make/Model/Serial#: SEABIRD/45/0789

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Calibration Information** | | | | | |
| **Sensor** | | **Pre-Cruise** | | **Post Cruise** | |
| **Name** | **S/N** | **Date** | **Location** | **Date** | **Location** |
| **Temperature** | **45-0789** | **1Feb22** | **Factory** |  |  |
| **Conductivity** | **45-0789** | **1Feb22** | **Factory** |  |  |
| **Wetlabs WETStar Fluor.**  For depths deeper than, and including, 125 dbar, we would wait 30 seconds before closing a bottle. For depths shallower than, and including, 100 dbar, we would wait 60 seconds before closing a bottle. | **1656** | **12Mar2021** | **Factory** |  |  |





