## REVISION NOTICE TABLE

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| --- | --- |
| DATE | DESCRIPTION OF REVISION |
| 13 March 2025 | Updated TSG channel names and formats. GG |
| 19June2024 | File 2023-069-0006.ctd replaced. Wrong file saved with that name. |

## PROCESSING NOTES

Cruise: 2023-069 Agency: OSD

Location: North-East Pacific Project: West Coast Moorings Cruise

Chief Scientist: Robert M. Platform: John P. Tully

Date: 25 July 2023 – 8 August 2023

Processed by: Germaine Gatien Date of Processing: 6 February 2024 – 5 March 2024

Number of original HEX files: 91 Number of processed CTD files: 90

Number of rosette casts: 35 Number of processed CHE files: 33

Number of original TSG csv files: 1 Number of processed TOB files: 12

# INSTRUMENT SUMMARY

CTD #1515 was mounted in a rosette and attached were 2 Wetlabs CSTAR transmissometer (1185DR & #1883DG), a SBE 43 DO sensor on the primary pump (#1119), SeaPoint Fluorometer on the secondary pump (#3950), a Biospherical QSP-400 PAR sensor (#70613) and an altimeter (#73171 for casts #1-121 & 145 and #79487 for casts 122-178 except #145).

A thermosalinograph (SeaBird 45 S/N 0789) was mounted with a Wetlabs WETStar fluorometer (#1656)

and flow meter; sampling interval was 5s.

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 until event #32 when it was changed to #0508.

An IOS rosette with 24 10L bottles was used.

# SUMMARY OF QUALITY AND CONCERNS

The deployment procedure for this cruise was not described in the log. A sample of cast files was examined to determine the deployment method. It appears that the CTD was held at the surface briefly (from a few seconds to 2.5 minutes) with pumps off. It was lowered to about 2m, where pumps were turned on. After a soak of from 1.25 to 1.75 minutes the cast began.

For all rosette casts there were generally waits of about 60s before Niskins were closed except below 400db where it was about 30s.

The sampling logs have many errors including sampling shown as having taking place where bottles failed to close. Analysts reported missing samples that could never have existed. These problems slow down analysis and data processing. While the Daily Science log also had some errors, the many detailed comments entered are much appreciated as are the deck pressure measurements recorded.

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.

Altimeter #73171 malfunctioned during events #111 to #121. It was replaced after #121 except that during cast #145 it was reinstalled for a test. It did not work properly, so was replaced again. The wrong configuration file was used at sea for cast #145, but converting with the right one did not help.

No useful data were acquired during cast #157. Examination of the HEX file shows that acquisition stopped in the middle of a record while at the surface with pumps off; there had been several stops due to inboard leads, but those were not at the surface.

Given limitations due to CTD problems that were experienced during this cruise, the calibration sampling was good. However, samples taken at the bottom of a cast are not the best choice for calibration even if the CTD is 10m above bottom. Niskin bottles are generally not as well flushed at the bottom of casts as during stops on the upcast, so unless the vertical gradients are very low the results are less useful. The samples may be needed for other purposes, but sampling from the first Niskin fired during the upcast would be more valuable for calibration. No duplicate salinity samples were collected.

Please use the naming scheme for loop samples that consists of a leading 5 plus event #, example 5034.

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

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

 ±0.40 mL/L from 0-300db except in areas of very large DO gradients

 ±0.07 mL/L from 300db-600db

 ±0.025 mL/L below 600db

The flow rate to the thermosalinograph was highly variable with sudden large changes and even some persistent negative flow rates. The negative readings suggest a problem with the gauge rather than the flow in the loop, but comparisons between TSG data and co-incident CTD casts do look out of line during those times. A graphical editor was used to remove data where flow was very low, very high or highly variable. Separate editing was done for fluorescence since it had a separate flow meter; most problems occurred simultaneously in both TSG and fluorometer flows, but were different in character, with fluorescence having fewer bad data than the other channels. There were notes in the log about problems with the de-bubbler and possible clogging of the loop.

Salinity was recalibrated by adding 0.11psu based on comparisons with CTD data and loop samples. This error is likely due to bubbles and that effect would vary through the cruise, so it is only a rough estimate. Salinity is reported with only 3 decimal places to indicate less confidence than usual in values.

TSG fluorescence was about 70% of CTD fluorescence and 50% of loop chlorophyll and rosette samples; this is somewhat lower than expected but the quality of comparisons are limited due to high near-surface gradients.

# PROCESSING SUMMARY

##### Seasave

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

The deployment procedure for this cruise was not described in the log. A sample of cast files was examined to determine the deployment method. It appears that the CTD was held at the surface briefly (from a few seconds to 2.5 minutes) with pumps off. It was lowered to about 2m, where pumps were turned on. After a soak of from 1.25 to 1.75 minutes the cast began.

For all rosette casts there were generally waits of about 60s before Niskins were closed except below 400db where it was about 30s.

##### Preliminary Steps

The Log Book and rosette log sheets were obtained.

* Corrections were made to 1 station name based on the log notes.
* Notes was made of deck pressure records and which altimeter was in use for which casts.
* Nutrients, extracted chlorophyll, dissolved oxygen and salinity were obtained in QF spreadsheet format from the analysts.
* The cruise summary sheet was completed.
* The history of use of the pressure sensor, conductivity and dissolved oxygen sensors was found.

The configuration files were checked. There were 2 different configurations used during the cruise. The only difference is which altimeter was used. The only error was the configuration file was not changed for cast #145 when altimeter #731071 was re-tested for just the one cast.

2023-069-ctd1.xmlcon Casts 1 to 121 & 145 Altimeter 73171

2023-069-ctd2.xmlcon Cast 122-144 & 146-178 Altimeter 79487

##### BOTTLE FILE PREPARATION

The ROS files were created using configuration files with matching names for casts 1-58.

ROS files were created using 2023-069-ctd1.xmlcon for casts #1-121 & 145.

ROS files were created using 2023-069-ctd2.xmlcon for casts #122-144 & 146-178.

A ROS file was created for cast #1 but there was no sampling, so this file was not processed further.

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

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

A preliminary header check was run; 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.

A few problems were found:

* Several rosette sheets are incomplete with no sample numbers or event #, so it is assumed that the cast never occurred. A note on the rosette log sheet would save time for analysts and data processors.
* For cast #44 15 bottles were listed on the log but only 13 actually fired. There was some confusion about this since the failure to close was not noted in the log.
* During event #44 DIC sampling was missed; cast #45 was run to get DIC samples. At 40db DIC and other samples were taken. These can be moved to cast #44. But samples at 25 and 50db were given the same sample number as would have been used during cast #44 with the intent of adding them to #44. But we can’t combine nutrients and other samples from #44 with the DIC from #45 since they come from different Niskin bottles. This is ok for sample #101 as the full suite of samples was taken just as planned and will be added as a separate record.
* Cast #45 had one bottle fired that was not included in file #44, so it is not possible to combine the 2 cast files in the early stage of processing. The extra line will be added later in the MRG file.
* Loop samples should be identified with a leading 5, example 5030 where 30 is the event #. This would simplify the work of analysts and data processors. Preparing bottle files requires that Niskin samples are separated from loop samples, and this is more easily done with distinct numbering systems.

The ADDSAMP file was then reordered on event # & sample #.

The ADDSAMP file was used to add sample numbers to the BOT files – output \*.SAM.

The SAM files were bin-averaged on bottle # and called SAMAVG.

The addsamp.csv file was converted to CST files, which will form the framework for the bottle files.

Next, each of the analysis spreadsheets were examined to see what comments the analysts wanted included in the header file. These were used to create file 2023-069-bot-hdr.txt which will be updated as needed during processing.

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

DISSOLVED OXGYEN

Dissolved oxygen data were provided in spreadsheet QF2023-069\_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 2023-069oxy.csv. That file was converted into individual \*.OXY files.

EXTRACTED CHLOROPHYLL

Extracted chlorophyll and phaeo-pigment data were obtained in file QF2023-069\_CHL QF\*.xlsx. The file included comments and flags and a precision study. A simplified version of the spreadsheet was prepared and saved as 2023-069chl.csv. The csv file was then converted to individual CHL files.

SALINITY

Salinity analysis was obtained in file QF2023-069\_SAL.xlsx which included a precision study. The analyses were carried out in a temperature-controlled lab 4 to 14 days after collection. The files were simplified and saved as 2023-069sal.csv. That file was then converted to individual SAL files.

NUTRIENTS

The nutrient data were obtained in spreadsheet QF2023-069\_NUTS\*.xlsx. This includes a precision study. The file was simplified, saved as 2023-069nuts.csv. The file was converted to individual NUT files.

Any loop samples were added to the loop file and removed from the csv files above.

Comments marked ALL in the dissolved oxygen spreadsheet were recorded and flag 3 added to any other samples gathered from the same Niskin bottles.

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

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

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 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 single line of data from file 2023-069-0045mrg was added to file 2023-069-0044.mrg. From this point on the bottle cast #45 will not be processed.

The output of the MRG files were exported to a spreadsheet and compared to the rosette log sheets to look for omissions. CTD salinity was checked and there are many values <25psu, so silicate correction is needed.

##### Compare

Salinity

Compare was run with pressure as reference channel.

There was one very deep cast but unfortunately, there were problems with the CTD during the upcast. The only sample available was from the bottom of the cast.

One cast to 450m had samples from many depths.

A comparison excluding all data from above 150db indicates that the primary salinity is high by an average of 0.0002psu and the secondary is high by 0.0005psu. Standard deviations were 0.0038psu for both. The difference between the two CTD channels indicates that the secondary salinity is higher than the primary by about 0.0003psu which is very close to the difference of ~0.0002psu between the 2 sensors noted in downcasts as shown in section 9.

Since most of those bottles were fired at the bottom of casts, any flushing error should lead to the CTD reading higher than bottles, so in fact the actual calibration may be that the sensors are reading slightly low. However, it is noted that the deepest bottle has a higher salinity than the CTD. There was a stop of 1.5 minutes at the bottom before firing Niskin 2 and some vertical motion so flushing was likely reasonably good. However, there is no salinity in the CTD record as high as that in the bottle. There is a comment that there was only 1 reading for that sample. The value may be too high but the difference is too small to justify changing the flag.

There was one cast with many bottles, though it only went to 450db and was in protected waters. It was examined to see if there is evidence of “upcast” comparisons being different from bottom comparisons where flushing is likely to be poor. The bottom bottles shows the CTD to be high by 0.0025psu. The bottle salinity matches CTD salinity about 20m above the firing level. For all other comparisons the CTD is reading lower except at 300db where it is high by 0.0018psu. The cases where CTD salinity is lower than bottles are likely also somewhat affected by incomplete flushing of Niskin bottles, though the longer waits before firing bottles does appear to have produced good results. Below 150m the differences are all within ±0.003psu. Above that the standard deviations in the CTD data are high and differences large, all indications of high vertical gradients, where even slight flushing inefficiency has a large effect on the comparison.

This does show slight evidence of the problems with firing at the bottom of casts, but the data are too shallow and too few for any proof. It does show the good effect of longer waits before firing bottles.

Another factor investigated was whether the distance above bottom was significant. Most stops were 5m off bottom, but some were 10 m above and 1 was 20m above. Most of the bottles fired at bottom minus 5m had CTD salinity higher than bottles. All of the 4 fired 10 or 20m above bottom had CTD salinity lower than bottles which suggests they flushed better. Is flushing poorer close to bottom or is this just chance?

All of the large outliers came from very shallow samples where the standard deviation in the CTD salinity was high during the 10s window around firing time. No flagging of samples is recommended.

For full details for the COMPARE run see file 2023-069-sal-comp1.xls.

Dissolved Oxygen

COMPARE was run with pressure as the reference channel.

The fit was noisy with variable results depending on which casts were included, how outliers were identified and how the offset was determined.

When outliers were removed based on a visual examination plus others based on residuals the fit was

 CTD DO Corrected = CTD DO \* 1.0123 + 0.0249

When only cast #28 was used – a deep open ocean cast – using all 6 bottles including 2 with DO~0.25mL/L, the fit was

 CTD DO Corrected = CTD DO \* 1.0165 + 0.042

When casts #12, 28 and 52 were used – all from exposed areas – excluding 2 outliers based on residuals the fit was:

 CTD DO Corrected = CTD DO \* 1.0162 + 0.032

Using the offset that was found during 2023-066 which had many low DO samples available, the slopes are higher at 1.0153, 1.0458 and 1.0206 respectively for the 3 fits and setting the offset to zero produced even higher slopes but the fits looked very poor.

Most sampling was shallow where poor flushing will lead to the CTD appearing to be reading higher than normal; since it usually does read low, this will just reduce the slope of the fit. For cast #28 there was only 1 sample below the OMZ where the flushing error is of opposite sign, so it is no surprise that the is higher for that cast than for the general fit. Since little of the sampling during this cruise was deep, that fit is not appropriate. The fit for the whole cruise is most appropriate but the correction may be too small due to flushing errors. The fit during 2023-066 was based on a wide variety of depths:

 CTD DO Corrected = CTD DO \* 1.0227 + 0.0113

There were a lot of problems with CTD data during 2023-066 so a preliminary comparison was done using 2023-088 data that followed this cruise. The resulting fit when the offset was forced based on a visual examination:

 CTD DO Corrected = CTD DO \* 1.0183 + 0.02

Excluding deep samples (>800db) had little effect on the fit. This looks like a reasonable fit to use for this cruise. There is no “right” fit for this cruise.

Major outliers were investigated and only 1 appeared to justify adding a flag:

* Sample 76 – 75db ; standard deviation in CTD DO very high and local DO reversal in plots. No evidence of problem in bottle value.
* Sample 243 –267db. standard deviation in CTD data low; bottle value out of line in profile. Nutrients look fine so no evidence of bottle closing at wrong level. The analyst changed the flag to 4.
* Sample 304 –2db, very high local gradient and reversal; std dev in CTD data fairly high.
* Sample 320 - 5db, very high local gradient and reversal; std dev in CTD data fairly high.

The replicate outliers for sample 105 were examined and the 2nd reading is closer to the overall fit, but not significantly out of line and this was a sample from the bottom where shed wake corruption makes such a judgment difficult.

For full details for the COMPARE run see file 2023-069-dox-comp1.xls.

Fluorescence

COMPARE was run with extracted chlorophyll and CTD Fluorescence using pressure as the reference variable. Chlorophyll had a wide range of values from 0.1 to 23.6ug/L.

The comparison looks as expected with fluorescence reading higher than CHL when CHL is low (<2ug/L) and dropping to a Fl/CHL ratio between 0.4 and 1.4 for most samples.

The fit of fluorescence versus chlorophyll has a slope of 0.9, but is higher for CHL<5ug/L.

For full details for the COMPARE run see file 2023-069-fl-chl-comp1.xls.

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

Hex files were converted using the configuration files of the same names.

##### WILDEDIT

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

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

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

The only significant spikes noted after this cast are from the surface.

##### ALIGN DO

ALIGNCTD was run on all casts to advance the oxygen voltage by +2.5s, a setting which has worked well in the past for this type of sensor.

The results were examined during step #9 and found to be good.

##### 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 of the deeper casts. Data from 2 previous cruises using this CTD are included. The data from 2023-066 were deeper but also suffered from some CTD spiking issues.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cast # | Press | T1-T0  | C1-C0 | S1-S0 | Descent Rate |
| 2023-066-0046 | 1000 | -0.0002 | -0.00007 | -0.0008 | High, Noisy |
|  | 2000 | -0.0003 | -0.00009 | -0.0008 | “ |
|  | 2500 | -0.0003 | -0.00009 | -0.0007 | High, Noisy |
| 2023-066-0052 | 1000 | -0.0002 | -0.00004 | -0.0003 | “ |
|  | 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 | “ |
| 2023-034-0002 | 300 | -0.0005 | 0.0002 | 0.0030 | High, Mod |
| 2023-034-0004 | 300 | -0.0003 | 0.0001 | 0.0015 | High, NOisy |
| 2023-069-0028 | 500 | -0.0003 | +0.00002 | +0.0006 | High, Noisy |
| “ | 1000 | -0.0003 | -0.00001 | +0.0002 | “ |
| “ | 2000 | -0.0005 N | -0.00003 | +0.0002 | “ |
| 2023-069-0111 | 500 | -0.0003 | -0.00002 | +0.0002 | High, Moderate |
| 2023-069-0154 | 500 | -0.0002 | -0.00001 | +0.0002 |  |

All differences were very small and similar or small as in previous cruises.

##### 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.

Initial plots were examined and showed the only data in file #157 was from the surface, so it will not be processed further. The log does not note a problem with acquisition but does mention two stops during the cast due to wire issues. The hex files stops in the middle of a record indicating a serious problem with acquisition.

##### Checking Headers –

* The header check shows very high transmissivity2 during cast 130, but a plot shows this was right at the surface, possibly in air. In-water values look ok. The minimum pressure was -0.6db but that was in a surface spike.
* The surface check gives an averaged value of +0.33db; that includes a few deeper values so the median is likely ~0.25db. Transmissivity values when pressure is 0.2db to 0.3db appear to indicate the CTD was in water. Values around 0.4 to 0.5db on upcasts are low, suggesting near-surface.
* On-deck pressure measurements varied from +0.1db to +0.3db.
* Any pressure error is well within specifications and all initial observations are immediately after acquisition started so sensors may not have equilibrated.
* The cross-reference check was checked against the log; no problems were found – an error mentioned in the log had already been corrected.
* Cruise tracks were plotted and added to the end of this report.

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. Where that number was > 5m the log depth entry was compared with the header entry and plots were made to see if altimetry header algorithm worked well at ignoring spikes. The check values were remarkably low in most cases, so both sounder and altimeter appear to be working well. A plot of check values versus depth gives no indication of significant pressure dependence in either altimeter or sounder.

Events investigated were:

* Event 59 – While spiky at the bottom, the altimetry header reading looks good. The log depth is slightly different from the header but not enough to explain the check value of -13.7, but this cast was in in Juan de Fuca Strait and local gradients could well be high. The log depth recorded for the associated mooring site a short distance away was 223m compared to 241m for the CTD cast. So the altimetry reading is likely accurate and will not be adjusted.
* Event 61 – Very large check values. While spiky at the bottom, the altimetry header reading looks good. The header depth entry was clearly wrong – not updated from the previous cast. It was changed to 131m.
* Event 62 – Large check value. Altimetry signal clean and value in header looks good. The 3 depth entries in the log vary, but are all higher than that in the header. This was in a narrow channel, so likely an area of shoaling. Choosing the log entry when the CTD was at the bottom looks appropriate. Water depth was changed to 243m.
* Event 148 – Check value large. Log depth entry is similar to header. Altimetry signal clean and value in header looks good. Note in log indicates water depth increased by 10 during soak – so clearly steep bottom which explains the difference. No changes needed to log depth or altimetry.

These changes were made to the IOS, CLN and CLIP files for casts #61 and 62 and to the SAM and SAMAVG file for cast #61. MERGE and CLEAN were rerun for the bottle files.

##### Shift

Fluorescence

SHIFT was run on the SeaPoint fluorescence channel using the usual setting of +24 records. The results were good in bring the vertical offset between down and up casts into line with those for temperature.

Dissolved Oxygen

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

Conductivity

Tests were run on a selection of casts to find the alignment shift best for the 2 conductivity sensors as judged by noise in T-S space. The best choice was -0.5 records for both the primary and secondary channel.

Salinity was recalculated for both channels.

##### DELETE

DELETE was run on the SHFC1 files.

The following DELETE parameters were used for casts 1-39:

Surface Record Removal: Last Press Min

Maximum Surface Pressure (relative): 10.00

Surface Pressure Tolerance: 1.0 Pressure filtered over 9 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 = 042 seconds. (taken from header)

COMMENTS ON WARNINGS: There were no warnings.

##### Other Comparisons

Experience with these sensors since last factory service –

* 2023-066 -The pressure, temperature, conductivity and dissolved oxygen sensors were used for part of cruise. Results were not as secure as usual due to spiking and some casts had averaging of CTD data in acquisition. Primary salinity was low by 0.0018psu; secondary was low by 0.0023psu; standard deviation was 0.0013 for both channels. Pressure was thought to be low by 0.5db but lab tests later showed no significant error. Oxygen was corrected using linear correction with slope 1.0227 and offset 0.0113. Fluorescence comparisons with extracted chlorophyll were very noisy but roughly as expected.

Historic ranges – Profile plots were made with 3-standard deviation climatology ranges of T and S superimposed. Where local climatology was available most temperature and salinity data fell within the ranges; the excepts were all at the top or bottom of casts that were very close to shore where salinity was often low and temperature high. There was a small section of high temperature for one cast in Hecate Strait. The climatology is too severe for near-shore casts and there have been many reports of high temperature and low salinity from other cruises. None of these excursions suggest CTD calibration problems.

Post-Cruise Calibration – None available.

Repeat Casts –No suitable casts were found to do a deep comparison.

##### DETAILED EDITING

The choice of which channel pair is not obvious. Both salinity channels are close to bottles and close to each other. The cruise that followed found both sensor reading log but still very close to each other. It is likely that the sensors are reading a little low since so many samples came from the bottom of casts where flushing errors lead to bottle values having lower salinity than ambient waters.

The primary T-S plots look a little less noisy than the secondary.

So the primary channels were selected for editing for all casts.

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. All files required light editing only except for casts #115, 121, 143 and 146 which required no editing.

Notes about editing applied were added to the files.

After editing, T-S plots were examined for all casts and a little further editing was found necessary for 1 cast; another has an unstable feature but looks real; it does not appear to be due to instrumental issues so no further editing was applied..

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

File 2023-069-recal-sil.ccf was prepared to correct channel Silicate since some salinity values were <25psu. This will only be run on bottle files. See section 22.

Pressure does not require correction based on deck measurements during this cruise and lab tests, deck measurements and observations during a cruise in January 2024. Pressures are considered good to ±0.2db, well within specifications for this sensor.

The salinity comparison with bottles suggests that the CTD salinity was accurate, but given the nature of the sampling it is likely that is actually reading lower than it appears. Most samples came from the bottom of casts or near the surface. The only cast with some mid-depths samples was not very deep but suggests that both salinity channels are low by about 0.002psu. A preliminary study of the cruise that followed, 2022-088, which had more extensive salinity sampling, showed that both CTD salinity channels were reading low by 0.004psu; deep salinity values at station P26 were also lower than those observed over the previous 15 years by between 0.001psu and 0.005psu. Preliminary examination showed slightly more drift during the cruise after 2022-088, 2022-026.

It is likely both salinity channels were reading a little low during this cruise, with an estimate of 0.002psu looking reasonable as being half way between the cruises before and after this one

Dissolved oxygen needs recalibration. The most reliable comparisons available come from cruise 2023-088, so that will be applied.

For the CTD files 2023-069-recal1.ccf was prepared to add 0.002psu to the CTD salinity and to apply the following dissolved oxygen correction:

 CTD DO Corrected = CTD DO \* 1.0183 + 0.02

CALIBRATE was run on the MRGCLN2 files using file 2023-069-recal-SIL.ccf to correct silicate where salinity is <25psu. (output: MRGCORSIL)

CALIBRATE was run on the MRGCORSIL files and SAM files using file 2023-069-recal1.ccf to correct channels Salinity:T0:C0, Salinity T1:C1 and Oxygen:Dissolved:SBE.

COMPARE was rerun to check whether the DO and SAL corrections were applied correctly and they were.

Overall, the salinity looks too high, but focusing on cast #116 between 200db and 400db, salinity is high by an average of +0.0008psu. However, the scatter is very large.

The CTD DO values are higher than samples at the high end of the range and lower at the low end. This is not surprising given the limitations of the comparison and the use of results from another cruise.

See file 2023-069-dox-comp2.xls.

CALIBRATE was then run on 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.

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.

Outliers were removed based on residuals. The average differences between Downcast CTD DO and Titrated Bottles was 0.035mL/L (Std Dev 0.050mL/L). Near the surface the SBE DO is higher than bottles and below 600db it is slightly lower. The recalibration worked as well as can be expected given limited calibration sampling so that the results of another cruise was used to recalibrate SBE dissolved oxygen. We expect the recalibrated CTD data to look a little higher than bottles due to incomplete flushing of Niskin bottles and slow response time in CTD data except for bottles fired at the bottom where incomplete flushing will lead to CTD DO values being slightly lower. Based on differences versus pressure, rough estimates were made of SBE DO accuracy. The results were in the same range as those found during 2023-066 when this sensor was last used.

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

 ±0.40 mL/L from 0-300db except in areas of very large DO gradients

 ±0.07 mL/L from 300db-600db

 ±0.025 mL/L below 600db

For details see files 2023-069-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.

Profiles were examined to look for problems.

For events #28-41 there is no PAR signal. This matches log entries except that the log says the PAR was on for event #28. Since there is no signal and it is unlikely to have been mounted given the depth of the cast, the channel will be removed from that cast.

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

For all casts REMOVE was run to remove the following channels:

Scan\_Number, Temperature:Secondary, Conductivity:Secondary, Oxygen:Voltage:SBE, Descent\_Rate, Status:Pump, Altimeter, Salinity:T1:C1 and Flag.

PAR was removed for casts # 28-41.

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 and no problems were found.

A cross-reference list was created and no problems were found.

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

##### Dissolved Oxygen Study

As a final check of dissolved oxygen data, % saturation was calculated and plotted. Values at 2 to 3m ranged between ~70% at station CPEI to 140% at GA05. The deepest cast, #28, had a saturation of about 105% which is typical of offshore values. As usual this does not prove the recalibration worked well, but the results are not out of line for this region and season.

##### Final Bottle Files

SORT was run to arrange casts in pressure order.

For all casts REMOVE was run to remove the following channels:

Scan\_Number, Temperature:Secondary, Conductivity:Secondary, Oxygen:Voltage:SBE, Descent\_Rate, Status:Pump, Altimeter, Salinity:T1:C1 and Flag.

PAR was removed for casts # 28-41.

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

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

Data were exported from the CHE files to file 2023-069-bottles-final.xlsx. The entries were compared with the rosette log sheets.

Standards check and a header check were run. No problems were found.

The track plot looks ok.

Profile and T-S 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. Data were found in 2 files, but the first pre-dates this cruise; only the 2nd file was processed.

Formatting problems included having Data and Time in single columns, some NaN entries.

The file was opened in Ultraedit to separate the Date and Time columns.

That file was then opened in EXCEL and saved as 2023-069-tsg1.csv. In opening DELIMITED was selected, TAB deselected, COMMA and Space selected.

The NaN entries were replaced with pad values.

Headers were added with 2 lines with variable names and units.

A column with pressure (all values = 4.5) was added to enable derivation of salinity.

A column was entered with format 2023-069-YYYMMDD-HHSSMM. This will be used to separate the files into individual days to enable plotting. Other wise the file is much too big.

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 type of equipment it was sometimes found necessary to adjust the offset to obtain reasonable values, with 0.69 used for the last 2 cruises. Negative fluorescence values were found but only associated with a deep spike. A minimum of 0.1 was found when the spiky data were not included, so the offset looks appropriate.

A few checks were made by finding data from co-incident CTD casts with chlorophyll sampling.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Event # | CTD Fluorescence | TSG FL using offset 0.069 | Flow Rate TSG FL | Extracted CHL from Niskin Bottles |
| 44 | 5.00 | 3.44 | 1.2 | 5.33 |
| 52 | 0.87 | 0.60 | 1.2 | 0.49 |
| 61 | 5.54 | 2.06 | 1.6 | 9.03 |
| 111 | 10.18 | 12.94 | 1.0 | 5.06 |
| 116 | 5.50 | 5.44 | 0.8 | 13.22 |
| 121 | 2.65 | 1.38 | 0.8 | 3.79 |

The SBE fluorometers generally give higher values than CHL for low CHL and lower for high CHL.

We expect similar results for the CTD and TSG. In general, the TSG fluorometer is reading lower than the CTD fluorometer except at cast #111; sometimes they are close sometimes the TSG seems lower than expected. The comparison with CHL generally follows the usual pattern with the exception of cast #111 and the TSG fluorescence is lower than expected during cast #61. Adjusting the offset will not make a significant difference.

The flow rate to the TSG was highly variable with large sections of 0 or very low flow to some sections with high rates and some with negative rates. The flow rate to the fluorometer was variable with a few sections of no flow, but was much steadier than the flow to the TSG.

The files were converted to IOS Header format with header info added. There are 12 IOS files, each covering all or part of 1 day.

Files lists were prepared for all casts, and for 3 groups of 4 days each to enable plotting full files.

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

The track plot looked good and was added to the end of this report.

ADD TIME CHANNEL was used to add Julian dates (Offset from Time Zero – i.e. Day of 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.

a.) Plots

Time-series plots were produced. As expected given frequent variations in flow rates, with large sections with 0 flow, there are many data that will need to be removed. Occasionally it seems like the problem might be with the meter rather than the flow, especially in areas with negative flow rate. But there is evidence that flow was often impeded, so it will be assumed that is always the case for low flow. Where flow rates are unusually high we can expect less warming in the loop but it will be hard to judge because local variability in temperature and fluorescence are often very high. Editing of data will be done later after comparisons with CTD casts was that may help establish how much very high flow rates affected the TSG data.

There are many cases where the intake temperature is higher than that in the lab, which is hard to explain whether there is flow in the loop or not. Rapid variations in local conditions together with time delay may account for some of this.

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 2023-069-tsg-ctd-loop-rosette-comp.xlsx. data were removed from the list for times when the TSG was not recording. This left 80 points of comparison. Flow was on for all the matches though the level varied greatly.

The TSG files were averaged over 6 records (1 minute) 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 opened in EXCEL, thinned to the closest times of CTDs and added to file 2023-069-tsg-ctd-loop-rosette-comp.xlsx..

The same files were thinned to the closest times to loop files and added to the TSG-Loop comparison. There were 9 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 both latitude and longitude, with the largest differences being 0.0012º. Some drift is expected during casts in areas of strong currents, so this is a good result. The clocks are in good agreement.

c.) Comparisons

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

The initial comparison between TSG and CTD data using all casts was:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | TSG Intake - CTD Temp | TSG Lab-CTD Temp | TSG Sal – CTD Sal | TSG FL / CTD FL |
| Average | 0.2170 | 0.7192 | -1.0745 | 0.6286 |
| Median | 0.0504 | 0.4933 | -0.1419 | 0.6072 |
| Std Dev | 0.7268 | 0.8164 | 2.6197 | 0.3135 |
| Max | 2.3720 | 3.7104 | 3.2819 | 1.9699 |
| Min | -2.3319 | -1.3529 | -14.5437 | 0.0519 |

The variability is much higher than expected with the maxima and minima especially out of line with expectations. The median values are somewhat large, but possible.

A plot of temperature differences between the intake and lab versus the flow rate to the TSG makes it clear that large sections of the TSG record are unreliable. However, interpretation is complicated since the difference could be due to flow rate or geography as near-surface gradients may be very high in inlets compared to further from shore so that depth differences between the CTD reading and the level from which the TSG is drawing water. And that “draw” level may vary with flow rate. CTD data are frequently noisy at this level.

A track plot shows that the cases with the highest TSG intake temperatures relative to CTD temperatures are from a narrow channel. A few casts from that area were examined to see if the near-surface temperature gradients were large and for some casts they were. So the high values may be at least partly due to a mismatch in levels. However, for cast #129 even allowing for the loop drawing from 2m didn’t explain the difference. Of course there are also time differences. For salinity differences there is more expectation that bubbles in the loop might vary with location and flow rate.

When the data set were reduced to casts for which the difference between CTD and TSG Intake temperatures was less than 0.05C, most were found to be in open waters. Most had normal flow rates with the exceptions of cast #28 which had a 0 flow rate and cast #85 had the puzzling rate of -1.4. It is hard to say whether the records look out of line with so much variability in the comparisons, and such variable flow rates, so there could be a problem is in the flow meter itself rather than the loop flow.

Using just the reduced set of casts the differences found were:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   | TSG Intake -CTD Temp | TSG Lab-CTD Temp | TSG Sal – CTD Sal | TSG FL / CTD FL |
| Average | 0.0017 | 0.3199 | -0.3090 | 0.71 |
| Median | 0.0021 | 0.2729 | -0.1084 | 0.67 |
| Std Dev | 0.0295 | 0.3276 | 0.6407 | -0.27 |
| Max | 0.0492 | 1.6049 | 0.1347 | 1.39 |
| Min | -0.0495 | -0.3394 | -2.8742 | 0.15 |

These are smaller differences but still large, and standard deviations are large. Only the fluorescence looks reasonable as we do expect larger variability in that channel.

Profiles were examined to see if any had particularly well-mixed near-surface waters (2m to 5m) and only a few were found.

* For temperature only cast #28 was well mixed. For that cast the CTD temperature was found to be high by 0.0008C° and lab temperature was higher than intake temperature by 0.2014C°. Unfortunately, the flow rate to the TSG is 0 during cast #28.
* For salinity casts 28, 37 and 70 were quite well mixed. The TSG salinity was lower than CTD salinity by 0.1187pus, 0.1048psu and 0.1126psu, respectively. We expect salinity to be low but not by that much, but if flow rates were high bubbles might be more extensive which would lower TSG salinity.

The casts for which flow rates were ≤0 were examined and the lab and intake temperatures are clearly unreliable based on comparison with CTD data. Yet the time series plots show considerable variability in both temperature channels following a similar pattern of falls and rises. It is easy to explain temperature changes in the lab, but why it would mirror those at the intake is puzzling. Salinity has reasonable values and variability, but could just be changing because temperature values vary. While there could be a flow meter problem, comparisons during the low flow readings are out of line, so these data must be removed.

Finally heating in the loop was studied. Using all casts produced a very noisy result, but the reduced set has the usual appearance of heating increasing as temperature decreases, as expected. It suggests that the ambient temperature of the ship was about 18°C.

* Comparisons of Loop samples and TSG data

Salinity

There were 9 salinity loop samples. The TSG salinity was lower than loops by a median of 0.1218psu, with differences ranging from -0.0992 to -0.3889psu. When 2 samples where local salinity was very low were excluded since they are likely to be from casts with high vertical gradient, the result was almost the same. The average when the 2 largest differences were excluded was -0.1190psu. So the TSG salinity is reading low by about 0.12psu. This may be due to problems with the de-bubbler, as noted in the log.

There were 8 loop CHL samples. The TSG fluorescence was close to CHL when CHL values <1 and lower for higher values. The pattern is familiar though the fluorescence values were relatively lower than usual.

* Comparison of Loops and 5m Niskin Samples

Loop samples were taken at the end of some rosette casts; 5m data from the rosettes were compared with loop salinity and chlorophyll samples.

* 1. There were only 2 Loop salinity samples at the same time as 5m Niskin samples were taken. In one cast the loop salinity was extremely low due to very low flow in the loop. For the other, the loop salinity was lower than the rosette salinity by 1.22psu.
	2. There were 20 loop CHL samples at the same time as 5m Niskin CHL samples. The median radio of loop CHL to Niskin CHL was 0.53 but the range was 0.06 to 2.05. The TSG fluorescence looks closer to CHL when the flow rate to the fluorometer was higher. It displays the usual pattern of being higher than rosette chlorophyll for CHL<1.5 and lower above that; however, there is a lot of scatter so this is a rough judgment.

d.) Calibration History

The TSG was serviced and recalibrated shortly in early 2022.

* 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. Fluorescence was converted with scale 14.6 and offset 0.69.
* During 2023-019 the intake thermistor malfunctioned. TSG salinity was recalibrated by adding 0.03psu which was thought to be an error due to bubbles. Fluorescence was converted using a scale of 14.6 and offset of 0.69. TSG fluorescence was about 80% of CTD fluorescence and 70% of loop samples.

e.) Conclusions re TSG

1. The TSG clock worked well and position information was available.

2. The flow rate to the TSG had some large and puzzling variations. The largest occurred primarily in the inlet section of the cruise. The flow to the fluorometer varied too, but not as extensively as to the TSG and often in the opposite direction. Notes in the log mentioned a possible clog and problems with the de-bubbler.

3. The comparisons show very large variations. When the casts were reduced to those with differences between the CTD and TSG intake temperatures being <0.5Cº , the casts were almost all from the offshore area. This suggests that the problems were associated with inshore work where near-surface gradients are larger, thrusters may be in use and timing of observations is more significant than offshore.

4. The flow rates are hard to understand as plots generally look ok when the rate was 0 or negative with reasonable detail in the plots. Plots do not suggest any clear influence of flow rate with outliers associated with different flow rates. However, the differences from CTD data are somewhat larger than those seen in the reduced set mentioned above. The fact that they are reasonable close may be due to the near-surface water temperatures being fairly close to lab temperatures so the warming of water in the TSG when flow stops is not so obvious.

5. Intake temperature was higher than CTD temperature by a median value of 0.002C° when the reduced set of casts was used. This is as good agreement as can be expected given fairly high vertical temperature gradients and temporal variability. The lab temperature was higher than intake temperatures by 0.273C° which is reasonable given water temperatures being a little lower than ship temperatures.

6. Salinity is lower than CTD salinity by a median of 0.1419psu based on all casts, by 0.1084psu based on the reduced set and lower than loops by a median of 0.1218psu using all samples and 0.1211psu excluding 2 outliers. Two very well-mixed casts had TSG salinity low by 0.1048 and 0.1126psu. Recalibration by adding 0.11psu looks like a reasonable correction to offset the effect of bubbles, but the actual error is highly variable. This is a higher correction than usually found but the comparisons with the loop and CTD are reasonably consistent and the flow rate was often high and problems with the de-bubbler were reported.

7. TSG Fluorescence was ~67% of that from the CTD fluorometer and about 50% of extracted CHL samples from the loop. These fluorometers do read lower than CHL when CHL is high, but there are some cases of low FL when CHL is low.

f.) Editing

CTDEDIT was used to remove intake and lab temperature, salinity, sigma-T and conductivity when the flow rate was very low or highly variable. The files from August, 27, 29 and 31 and September 1 required editing.

A second run of CTDEDIT was used to edit the fluorescence channel in the same files since it had its own flow rate channel. Editing was not as extensive as there were fewer incidents of 0 flow, though there were some very high flow rates not seen in the TSG flow.

g.) CALIBRATE

CALIBRATE was run using file 2023-069-tsg-recal.ccf to add 0.11psu to channel Salinity.

h) Preparing Final Files

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

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 (though some are non-standard on purpose) 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.

A cross-reference list was prepared:



TSG notes from log

Initial problems with flows to Valves 1 and 2 – erratic and ever changing.

* Wed, July 27, around 11:00 Top valve of de-bubbler was found to be wide open. Once closed slightly, flow resumed normally. First part of TSG record will show weird flow ratings.
* July 29th Midnight PDT flow started to go down. Notice it had no flow in V1 or V2 at 700 PDT. Played with valves and outflows, then a spike in flow and flow resumed. We believe it to be a clog somewhere in the line. We do suspect that there is an issue with the de-bubbler since the start of the cruise.
* Cast 142, Stn GC60 – thrusters on – note impact on TSG while on station

CTD notes

Deck pressure measurements varied from 0.1db to 0.3db.

PAR off: 31-41 Appears to have been off for 28, may have been hard to tell at night. Should have been off since 28 was a deep cast.

17. Should be Quat2, not Quat1. (Correct in HDR file)

26. Cast failed at 70m. Issue with computer. Swapped out to spare computer. Cast rerun as Event #27. Both casts processed since data look ok – close in space but 2 hours apart so some change.

28. Lost communication with CTD at ~450m on upcast. Similar issue as earlier at #26 but for CTD port, not pump port.

30. Issue due to ports on the original computer. Deck unit changed to SN0508.

44 PAR on.

45. Cast run only to collect DIC data that were missed during 44. Two of sample #s repeated but no nutrients/DO. No bottle file created. Record for sample 101 moved to cast #44.

54. Timed out NMEA. GPS from Seasave. (NMEA Data ok in HDR file.)

85. Latitude seems to be missing from NMEA on Seasave. See daily log.

89. Brought back on board to check bottles were ready.

99. Strong current drifted shallower during downcast by ~5m.

107. Looking at historical Chatham Sound data, it does seem like noisy fluor signal is common.

110-121. Altimeter not working.

122. New altimeter.

124. Vent on bottle 8 leaking – replaced.

140. Very low surface salinity (2); very high fluorescence at 7m (18).

140. Stn GC44 -wrong in header (header changed from CH44.)

141. surface salinity =1, Fluor max ~2 -very murky water.

142. Gardner Canal – very shallow surface layer. Things get mixed and TSG sal goes up a lot and T goes down. When there is a strong chl-a max at 7m even that gets mixed into surface. Use of TSG data will have to exclude when on station. Note in meta data for TSG.

145. Put original altimeter back on; did not work. Stopped cast at 226m.

146. Put back on the spare altimeter.

149. Slow rise 10m to surf to pin-point fluor max depth.

150. Station seems shallower (415m) than historical (445m)

157. Stop at 47m downcast due to inboard lead, 2nd stop upcast at 25m for inboard lead. Only surface data recorded. Hex file shows acquisition stopped in the middle of a record.

178. Surface DO 4ml/l seems very low; same on upcast.

178. All stop at 124m on upcast.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **CTD#** | **Make** | **Model** | **Serial#** | **Used with Rosette?** | **CTD Calibration Sheet Competed?** |
| **1** | **SEABIRD** | **911+** | **1515** | **Yes** | **Yes** |
| **Calibration Information - 1515** |
| **Sensor** | **Pre-Cruise** | **Post Cruise** |
| **Name** | **S/N** | **Date** | **Location** | **Date** | **Location** |
| **Temperature** | **6754** | **24Jan2023** | **Factory** |  |  |
| **Conductivity** | **6141** | **24Jan2023** | **Factory** |  |  |
| **Secondary Temp.** | **6736** | **3Feb2023** | **Factory** |  |  |
| **Secondary Cond.** | **6146** | **24Jan2023** | **Factory** |  |  |
| **Transmissometer** | **1185DR** | **23Mar2023** | **Factory** |  |  |
| **Transmissometer** | **1883DG** | **23Mar2023** | **Factory** |  |  |
| **SBE 43 DO sensor** | **1119** | **10Feb2023** | **Factory** |  |  |
| **PAR sensor** | **70613** | **24Feb2021** | **Factory** |  |  |
| **SeaPoint Fluor.** | **3685** |  |  |  |  |
| **SeaPoint Fluor.** | **3640** |  |  |  |  |
| **Pressure Sensor** | **1515** | **17-Jan-2023** | **Factory** |  |  |
| **Valeport Altimeter** | **73171** |  | **Factory** |  |  |
| **Valeport Altimeter** | **79487** |  |  |  |  |

# 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** |  |  |







