## REVISION NOTICE TABLE

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| --- | --- |
| DATE | DESCRIPTION OF REVISION |
| 18 March 2025 | Channel names & formats updated for TSG and Loop files. GG&SH |

## PROCESSING NOTES

Cruise: 2023-088 Agency: OSD

Location: North-East Pacific Project: Line P

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

Date: 8 August 2023 – 24 August 2023

Processed by: Germaine Gatien Date of Processing: January 1, 2024 - May 30, 2024

Number of original HEX files: 36 Number of processed CTD files: 36

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

Number of original TSG txt files: 1 Number of processed TOB files: 15 (1 per day)

# INSTRUMENT SUMMARY

A SeaBird 911+ CTDs was used for this cruise.

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 (#3685 for casts 1-41 and #3640 for casts #44-58), 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 5s.

Seasave version 7.26.7.121 was used for acquisition. The data logging computer was TULLY. The deck unit was a Seabird model 11+ #508. An IOS rosette with 24 10L bottles was used.

# SUMMARY OF QUALITY AND CONCERNS

The Daily Science Log Book was in excellent order with comments about problems encountered and a detailed list of equipment. The sampling logs were in good order.

The standard deployment procedure for this cruise 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 on Line P:

Niskin bottles closed from 0 to 400 db (except for cast #67) had a wait time of 60 seconds.

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

 All bottles for cast #67 had a wait 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.

As noted during the spring Line P cruise, 2023-066, transmissivity values in deep water at Station Papa were higher than noted in other cruises over the past few years. Red transmissivity was 70 to 71%/m. The sensors had been recalibrated very recently. However, in the past some values from recently calibrated sensors were still lower than found during this cruise and the previous one.

Both salinity channels showed evidence of calibration drift through this cruise and preliminary evidence suggests that drift continued during the next cruise. A time-dependent correction was derived based on event numbers. The corrections are not large but significant enough to justify recalibration.

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 0-200db

 ±0.15 mL/L from 200db to 400db

 ±0.08 mL/L below 400db

The TSG data look good overall, but there were intermittent problems with flow to both the TSG and the fluorometer (plumbed separately) between August 11th and 13th.

TSG salinity was recalibrated by adding 0.12psu based on comparisons with loop samples and data from 4 to 5db during co-incident CTD casts. This is similar to the result found during 2023-069 when the system was last used. The intake temperature was higher than CTD temperature by about 0.02C° which is as close as can be expected. The TSG lab temperature was higher than the intake by a median of 0.27C° which is typical of heating in the loop in August when surface waters are relatively warm. The TSG fluorometer had values that were roughly 50% of those from the CTD fluorometer; this did not seem related to flow rate variations. The TSG fluorescence showed the usual pattern of being higher than extracted CHL when CHL was low and about 50% of CHL when CHL>0.5ug/L, but there were few CHL samples above 0.5ug/L.

Loop chlorophyll samples had slightly lower values than 5m samples from Niskin bottles.

# PROCESSING SUMMARY

##### Seasave

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

The standard deployment procedure for this cruise 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 (both included) had a wait time of 60 seconds except for cast #67 when it was 30s.

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

##### Preliminary Steps

The Log Book and rosette log sheets were obtained.

* Nutrients, extracted chlorophyll, dissolved oxygen, salinity and DMS/DMSP data 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 did not change during the cruise. All parameters were correct.

##### BOTTLE FILE PREPARATION

ROS files were created using 2023-088-ctd.xmlcon for all casts. The hysteresis correction and tau corrections were selected.

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.

CTDEDIT was used clean salinity lightly in casts 6, 10 and 12.

The output ED1 files were copied to \*.BOT.

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 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 2023-088-bot-hdr.txt which will be updated as needed during processing.

Loops samples were copied 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 QF2023-088\_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 2023-088oxy.csv. That file was converted into individual \*.OXY files.

EXTRACTED CHLOROPHYLL

Extracted chlorophyll and phaeo-pigment data were obtained in file QF2023-088\_CHL QF\*.xlsx. The file included comments and flags and a precision study. A simplified version of the spreadsheet was prepared and saved as 2023-088chl.csv. The csv file was then converted to individual CHL files.

SALINITY

Salinity analysis was obtained in file QF2023-088\_SAL.xlsx which included a precision study. The analyses were carried out in a temperature-controlled lab 13 to 26 days after collection. The files were simplified and saved as 2023-088sal.csv. That file was then converted to individual SAL files.

NUTRIENTS

The nutrient data were obtained in spreadsheet QF2023-088\_NUTS\*.xlsx. This includes a precision study. The file was simplified, saved as 2023-088nuts.csv. The file was converted to individual NUT files.

An error was found on the Loops page; sample # was changed from 5186 to 33.

DMS

DMS data were obtained in spreadsheet DMS Summary (2023-088).xls which includes duplicate analysis. Details on analysis are in file 2023-088 DMS report\*.doc. Only 2 figures are considered significant. Event #s were added to the file.

All stations were run on two separate systems: an older 7890 DMS System in use since 2013

and a new system with a 8890 gas chromatograph which was being used for the first time.

Detailed notes on analysis and comparison of the two systems are in file 2023-088 DMS report\*.doc.

DMSP\*

DMSP-D and DMSP-T data were obtained in file DMSP 2023-088 Summary\*.xls. Details on analysis are in file 2023-088 DMS report\*.doc. The data were converted into DMSP files. Only 2 figures are considered significant. Event #s were added to the file.

The SAL, CHL, OXY, NUT, DMS and DMSP files were merged with CST files in 6 steps.

After the 6th 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 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 no values <25psu, so silicate correction is not needed.

Some issues investigated

* Event #28 was missing CHL and NUTS because they were mislabelled as coming from event 29. They were corrected and the merges rerun. Analysts informed.
* Event #42 Salinity and CHL samples labelled as #221 should be #222. The rosette sheet was amended after printing. Analysts informed and QF file updated.
* Events 42, 45 and 53 had many bottles fired only for bulk water and no sampling. The SAMAVG files were edited to remove those bottles and the merge with \*.MRGCLN1s files were repeated.
* Event 66 – bottle 9 failed integrity test but as a surface bottle affect should be slight and salinity compares well with CTD. Suggest flag 2 and comment. Analysts informed. Flag 2 added to all.
* Event 76 - enter 9 flag for salinity sample #512. Bottle did not close – other planned samples have 9 flag – added that to the salinity sample.

##### Compare

Salinity

Compare was run with pressure as reference channel.

When 2 outliers were removed plus data from above 150db the primary salinity was low by an average of 0.0042psu (std dev 0.0014psu) and the secondary by 0.0048psu (std dev 0.0016psu).

The outliers were:

Event 17 – Sample 67 is out of line in comparison and compares badly with another bottle from the same depth. Looks like could be from Niskin #1 where no sample was planned. Should be rejected as bad.

Event 62 – Sample 406 at 1250m is an outlier in comparison and in profile. Other sample types seem ok. Salinity very close to sample 408 from 800m.

There is little pressure dependence in either channel. Above 150db there is more variability than below but even small problems with incomplete Niskin flushing are more significant in high gradients.

Because there is evidence that these sensors were drifting with time, a fit of differences versus file pair number was done using all bottles (excluding outliers) or all bottles in different depth ranges.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Prim Sal – Bot cast 17 | Prim Sal – Bot cast 76 | Prim Sal –cast 76 –cast 17 | Sec Sal– Bot cast 17 | Sec Sal – Bot cast 76 | Sec Sal –cast 76-cast 17 |
| All data  | -0.0044 | -0.0043 | +0.0004 | -0.0041 | -0.0057 | -0.0016 |
| 700-1300db | -0.0034 | -0.0057 | -0.0023 | -0.0059 | -0.0075 | -0.0046 |
| 1350-4000db | -0.0027 | -0.0050 | -0.0023 | -0.0016 | -0.0062 | -0.0046 |
| 1000-5000db | -0.0030 | -0.0051 | -0.0021 | -0.0022 | -0.0062 | -0.0040 |

All comparisons show that the primary CTD salinity is closer to bottles than the primary.

The depth-limited comparisons show a similar temporal drift for each sensor. The smaller drift found when using all data appears to be due to a few outliers above 150db during casts 54 and 64 which are associated with high standard deviation in the CTD salinity channels.

But the full comparison indicates a smaller temporal drift. This may be due to including data above 500db since some casts have unusual features including salinity reversals that are stable at P16 and there are variable gradients in mixed layers with larger gradients to the east and smaller offshore. These could all lead to differences tending to be higher early in the cruise than later.

The primary data looks closest to bottles overall, and a time-dependent fit looks best. But a fit versus time is awkward and a fit versus event number is justified since time in use matters most. So files containing event numbers (\*.event) were created and merged into the SAM and MRG files (\*samevt and \*.mrgevt.)

Looking at the fit versus file pair number for bottles below 1000db, differences were found at casts 17 and 76 (file pair numbers 1 and 24). Then fits versus event number were determined based on those differences.

* A fit for the primary salinity was made based on casts 17 and 76 differences:
 Salinity:T0:C0\_Corrected = Salinity:T0 :C0 + 0.00003 \* Event\_Number +0.0024

This leads to corrections of 0.0024psu for cast #1, 0.0029psu for cast #17 and 0.0047psu for cast #76.

* Doing the same for the secondary salinity the correction is:
 Salinity:T1:C1\_Corrected = Salinity:T1 :C1 + 0.00008 \* Event\_Number +0.0009

This gives corrections of 0.0009psu for cast #1, 0.0022 for cast #17 and 0.0068 for cast #76.

These corrections look reasonable and fit the fact that both sensors were lower than bottles by about 0.002psu during 2023-066. The data from cruise 2023-069 were not considered reliable. The drift between sensors noted during this cruise appears to have continued, based on preliminary processing of the cruise that immediately followed this one (2023-026).

Note that to enable an event-dependent correction the MRG files had to be recreated as follows:

* files with an event # channel added were created with output \*.EVENT
* \*.EVENT files were merged with the SAM files with output \*.SAMEVT
* \*.SAMEVT files were merged with MRGLCN1s files to create new MRG files.

For full details for the COMPARE run see file 2023-088-sal-comp1.xls.

Dissolved Oxygen

COMPARE was run with pressure as the reference channel.

Outliers were examined:

FP1 -Cast 4 – DO bottom bottle at 225db out of line in comparison and in profile. Based on CTD profile looks like a mis-sample as it fits 100db well. Analyst informed and new QF file received.

FP2 -Cast 9 – CTD data very noisy for surface sample. For sample at 25m slight DO reversal. No flag suggested.

FP3 -Cast #10 has a very unusual DO profile with reversals at several levels. The upcast is confused due to a missed bottle and return to deeper water to get those samples, but the final rise from 100db shows a similar DO profile. The T-S plot indicates considerable variability, but not clear about T-S properties where the reversals occur. We can’t expect a good fit from this cast. No flags suggested.

FP4 – Cast 17 – 2 bottles fired at 100db. DO sample values differ by 0.08.(0.306 and 0.227) Sample #67 significant outlier in comparison with CTD DO. There are a lot of DO bottles with low values and only sample #367 stands out as odd.

FP5 -Cast 28 -251db. The DO sample looks like an outlier in profile. CTD data shows no such feature. Appears more likely to have been sampled from 400m than 250m. Analyst informed and new QF file received.

The first run of Compare did not look good at the low and high ends of the DO range. Removing a few outliers helped but not much. Forcing an offset of -0.2mL/L produced good results at the low end of the range where there are many samples, as well as at mid-range. But the high end appears over-corrected with that fit. Examination of profiles shows that DO was well-mixed close to the surface but in the offshore it rose to a broad maximum around 25-40db. So a general fit is unlikely to work well for upcast bottles in the top 40db.

When significant outliers were excluded the fit was:

 CTD DO Corrected = CTD DO \* 1.0113 + 0.0381

But the slope of the fit looked poor near the DO=0 where there were many bottle samples available.

When the slope was forced to = 0.02 it looked much better but the near-surface samples looked more out of line.

 CTD DO Corrected = CTD DO \* 1.0154 + 0.02

That fit looked good for low DO, fair at other levels. For high DO values there is a lot of scatter. Most casts had subsurface maxima around 30 to 50m, and the fit will not do well in such areas. When those were excluded the fit was once again poor with the offset left free, but when set to -0.02 it looked much better and even better with -0.025:

 CTD DO Corrected = CTD DO \* 1.0165 + 0.025

A hysteresis check was run using files 17 to 76 and excluding data from 0 to 800db. The red points fell well among the green points. There is no evidence of significant hysteresis.

For full details for the COMPARE run see file 2023-088-dox-comp1.xls.

Fluorescence

COMPARE was run with extracted chlorophyll and CTD Fluorescence using pressure as the reference variable. There was only 1 CHL sample >3ug/L.

As usual for Line P there are many very low chlorophyll values, and fluorescence tends to read much higher than CHL. For CHL<1ug/L fluorescence reads higher than CHL but for CHL>1ug/L the ratio FL/CHL gradually falls from about 1 to 0.5. As the ship moves offshore the ratio FL/CHL gradually rises.

This is typical performance for this type of sensor.

For full details for the COMPARE run see file 2023-088-fl-chl-comp1.xls.

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

Hex files were converted using configuration file 2023-088-ctd.xmlcon.

All expected channels were found and profiles look reasonable.

##### 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.

No change in spikes were noted but there were no single-point spikes were noted before the run.

##### 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.

Plots were examined and the alignment of dissolved oxygen looks good. T-S plots show that the CELLTM step worked properly.

DERIVE was run a second time on some of the deeper casts to find the differences between the pairs of temperature, conductivity and salinity channels. A few casts from earlier cruises are included to help study the temporal drift.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| 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 | “ |
| 2023-069-0154 | 500 | -0.0002 | -0.00001 | +0.0002 | High, Moderate |
| 2023-088-0017 | 1000 | -0.0002 | -0.00001 | +0.0005 | High, Moderate |
| 2023-088-0033 | 1000 | -0.0003 | +0.00002 | +0.0003 | “ |
| “ | 2000 | -0.0005 | -0.00002 | +0.0003 | “ |
| “ | 3000 | -0.0006 | -0.00003 | +0.0005 |  |
| 2023-088-0044 | 1000 | -0.0003 | -0.00003 | 0 | High, XNoisy |
| “ | 2000 | -0.0005 | -0.00005 | 0 | “ |
| “ | 3000 | -0.0008 | -0.00005 | +0.0002 | “ |
| 2023-088-0054 | 1000 | -0.0003 | -0.00003 | -0.0001 | Mod, Noisy |
| “ | 2000 | -0.0005 | -0.00005 | -0.0002 | “ |
| “ | 3000 | -0.0007 | -0.00006 | +0.0004 | “ |
| 2023-088-0064 | 1000 | -0.0003 | -0.00009 | -0.0009 | Mod, VNoisy |
| “ | 2000 | -0.0005 | -0.00012 | -0.0010 | “ |
| “ | 3000 | -0.0007 | -0.00012 | -0.0007 | “ |
| “ | 3900 | -0.0008 | -0.00012 | -0.0007 | “ |
| 2023-088-0076 | 1000 | -0.0003 | -0.00014 | -0.0015 | High, Noisy |
| “ | 2000 | -0.0005 | -0.00015 | -0.0015 | “ |
| “ | 3000 | -0.0007 | -0.00016 | -0.0013 | “ |
| “ | 4000 | -0.0009 | -0.00017 | -0.0011 | “ |

The temperature differences are small with some pressure dependence.

Conductivity differences are increasing with time with the largest change between casts 54 and 64.

Salinity differences are small until cast #43 after which they also increase.

The salinity differences are small since the temperature and conductivity differences are compensating in their effect on salinity.

From the COMPARE run we found that early in the cruise the primary was lower than the secondary by about 0.0008pus and at the end it was higher by 0.0011psu. The same pattern is seen in this analysis with the primary higher than the secondary early and lower later. Both conductivity and temperature differences are drifting,

##### 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 –

* The cross-reference check and header check were run. No problems were noted.
* Surface check was run and the average surface value was 2.3db. This looks reasonable for the deployment scheme used.
* 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 checks were made to see if the log entry differed from the header entry and whether the altimetry signal at the bottom provided a good header value. A few problems were noted:

* The altimetry was generally good at the bottom of casts, but for cast #25 there were only spikes, so the header entry should be removed.
* One log entry was clearly wrong and obviously due to a typing errors; 311m should be replaced with the estimated value of 811m in event #13.
* In 7 cases the differences were >10m. These were all in deep water and could be due to the sounder not being well calibrated for local conditions. The altimetry has less scope for error than the sounder, as it measures a short distance, so it is assumed to be correct. There are likely errors in water depth in deep water, but many casts don’t get close enough to the bottom to have useful altimetry. There could be errors in the depth derivation as well, though those are not as likely a source of trouble as sounder readings.

These changes were made to the CLN files and to affected files bottle files for event #13.

##### Shift

Fluorescence

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

Dissolved Oxygen

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

Conductivity

Tests were run on a selection of casts to find the alignment shift best for the 2 conductivity sensors as judged by noise in T-S space.

The best choice was -0.35 records for the primary and -0.6 records for the 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.
* 2023-069 – Salinity estimated to be low by 0.002psu for both channels. Dissolved oxygen was recalibrated using preliminary results of 2023-088. Pressure was considered ±0.2db.

Historic ranges – Profile plots were made with 3-standard deviation climatology ranges of T and S superimposed. Salinity was slightly low between P12 and P16 at varying levels between 200 and 300db, with one cast at P16 having such an excursion and another not. For temperature there are similar low features at those stations, but the temperature only goes below the range minimum at P14 and P15. These excursions are presumed to be due to active incursions of water from the north rather than evidence of instrumental problems. They show up clearly in T-S space as stable but rapidly varying. Temperature was high in the top 10db at P2 and P3.

Post-Cruise Calibration – None available.

Repeat Casts –The only repeat casts showed great variability even in deep water with primary channels recording warmer and fresher conditions than the secondary alternating with nearby sections with the opposite condition. Differences along constant density lines were up to 0.01C° and 0.002psu at 600m. This is an order of magnitude larger than usually found at these depths, but they are likely due to real variations as the sign of the differences vary rapidly and appear to be due to mixing.

##### DETAILED EDITING

The primary channels were chosen for editing (and hence archival) since the primary T-S curves showed fewer unstable features and the primary salinity was closer to bottles.

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 some editing.

Notes about editing applied were added to the files.

After editing, T-S plots were examined for all casts and no further editing was found necessary.

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

There was no salinity <25psu in the bottle files so silicate does not require recalibration.

For the CTD files 2023-088-recal1.ccf was prepared to apply corrections:

* CTD DO Corrected = CTD DO \* 1.0165 + 0.025
* Salinity:T0:C0\_Corrected = Salinity:T0 :C0 + 0.00003 \* Event\_Number +0.0024
* Salinity:T1:C1\_Corrected = Salinity:T1 :C1 + 0.00008 \* Event\_Number +0.0009

CALIBRATE was run on the SAMEVT files to create SAMCOR1 files.

CALIBRATE was run on the MRGCLN2 files to create MRGCOR1 files in order to run the post-correction COMPARE step.

COMPARE was rerun after recalibration.

Salinity:T0:C0 was lower than bottles by an average of 0.0003psu below 1000db and Salinity:T1:C1 was higher by the same amount. This is excellent agreement.

Plots against file pair number suggest that Salinity:T0:C0 is falling slightly and Salinity:T1:C1 rising but any drift is <0.001psu.

Channel Oxygen:Dissolved:SBE channel is in good agreement with bottles.

See files 2023-088-sal-comp2.xls and 2023-088-dox-comp2.xls.

Due to the complex recalibration a final check was made that showed that recalibration added ~0.003psu to the primary salinity early in the cruise and ~0.005psu late in the cruise. For the secondary salinity there was an addition of~0.001 early in the cruise and ~0.007psu late in the cruise.

The order of processing was varied in order to enable recalibration of the edited files based on event-number. Bin-averaging before adding event numbers makes this process simpler.

##### 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 significant differences were found from climatology.

The AVG files were exported to a spreadsheet with just scan number and event number from the header; the latter channel name was changed to EVENT.

The spreadsheet was then converted to EVENT files which contain scan # and Event #.

MERGE was run to add the EVENT # to AVG files, with output AVGEVT.

CALIBRATE was then run on the AVGEDT 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 (already bin-averaged to 1m-bins) were 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 recalibrated and thinned CTD DO and Titrated Bottles were 0.051mL/L (std dev 0.107mL/L) We normally find the CTD DO to read a little higher than bottles; this is a little higher than usual but the comparison had to be done on binned CTD data due to the complex recalibration scheme for salinity. The errors due to slow response of CTD DO and poor flushing of Niskins, both lead to the CTD appearing to read a little high. The recalibration worked as well as can be expected.

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

 ±0.40 mL/L from 0-200db

 ±0.15 mL/L from 200db to 400db

 ±0.08 mL/L below 400db with the exception of the deepest bottle which was an outlier and was fired at the bottom of a cast.

For details see files 2023-088-comp3.xls

##### 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, Event, Flag and PAR from casts 33, 44, 47, 54, 62, 64, 67 & 76.

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 and Header Check were run and no problems were found.

Profile and T-S plots were examined and look ok.

The transmissivity values below 4000db at P26 were ~70% for Red and ~100% for Green. Those values are similar to those noted during cruise 2023-066 which were considered to be very high. The highest value found in a cursory search of data from before 2023 was ~67.5% for Red during 2015-001. So there is some question about calibration. Since they were last recalibrated in March 2023 while those used in 2022 had been calibrated 16 months before the cruise, the results of this cruise are likely more reliable. But lower values were noted in most cruises in the past, with ~67.5% during 2015-001 being the highest values found at P26 in a brief search of the archive. (A year later at P26 transmissivity was down to 61%; that sensor had not been recalibrated in about 2 years.) It is possible that the results are due to improved calibration methods, different mounting or better cleaning of the sensor between casts; frequent recalibration is definitely a good idea.

##### Dissolved Oxygen Study

As a final check of dissolved oxygen data, % saturation was calculated and plotted. Values at 2 to 3m ranged between ~75% in Juan de Fuca and Haro Straits and 145% at station P1. Values in casts west of station P4 varied from 102% -108%. These values are in a typical range for the offshore.

##### Final Bottle Files

There was no salinity is <25psu so silicate did not need recalibration.

CALIBRATE was run using file 2023-088-recal1.ccf to correct Salinity:T0:CO, Salinity:T1:C1 and Oxygen:Dissolved:SBE.

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, Event, Flag and PAR from casts #33, 44, 47, 54, 62, 64, 67 & 76.

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 2023-088-bottles-final.xlsx. The entries were compared with the rosette log sheets and no problems were found.

Standards check was run. The only problem reported was non-standard channel names for the new DMS channels, so the standards file was updated..

The track plot looks fine.

Plots of each file were examined and the only odd things noted had already been flagged.

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, 2023-088.txt.

The file was opened in EXCEL.

In opening DELIMITED was selected, TAB deselected, COMMA and Space selected.

Formatting problems included having Date and Time columns combined, many NAN entries and quotation marks in many entries.

The file was opened using Ultraedit to separate Date and Time and to remove quotation marks and saved as a CSV file.

The NAN entries were replaced with pad values.

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

The first 1753 records were removed until both flow channels had been on long enough to equilibrate. Records from the end of the cruise when the ship was stopped and flow was off were removed.

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 factory clean water offset value was 0.081. For previous uses of this equipment it was sometimes found necessary to adjust the offset to above negative values. Most recently the offset used was 0.069 but for this cruise 0.066 was needed to avoid negative values.

A few quick checks were made to see how TSG fluorescence compared with loop samples and CTD fluorescence and rosette samples. No matter what offset is chosen the fluorescence values appear low compared to loop samples except when chlorophyll values are very low, and then it reads higher. It reads lower than the CTD fluorometer. It is likely that the scale is not appropriate, but a linear adjustment does not look right and the instrument likely needs servicing. Further checks will be made later.

A file break column was added and entries made with format 2023-008-2023MMDD-HHMMSS.

The files were then converted to IOS Header format with header info added. There are 15 IOS files, each covering all or part of 1 day.

Files lists were prepared for all casts, and for 3 groups of 5 days each to enable plotting.

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 (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. Pressure was dropped.

a.) Plots

A track plot was produced and looked fine; it was added to the end of this report.

Time-series plots were produced and there are some spikes in most channels that mostly line up with drop-outs in flow to the TSG. There are also some spikes in fluorescence and salinity that are not associated with low flow.

A plot of all differences (Lab Temp – Intake Temp) through the whole record shows variability, but in quieter sections heating in the loop is in the 0.2 to 0.3C° range which looks reasonable in summer.

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 2023-088-tsg-ctd-loop-rosette-comp.xlsx. There are 35 points of comparison.; one cast had no data available from that depth.

The TSG files were averaged over 6 records (30 seconds) to reduce the noise and file size. Standard deviations were included. REMOVE was run to remove unnecessary channels.

Necessary channels are date, time, Tintake & std dev, Tlab & std dev, Sal & std dev, FL & std dev, latitude, longitude, both flow rates and record #.

TSG records with times closest to the CTD times were found in the files and copied to file 2023-088-tsg-ctd-loop-rosette-comp.xlsx.

TSG data were also found at closest times to loops and added to the TSG-Loop comparison. There were 28 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. The largest differences were 0.001º.

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:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Tint-Tctd | Tlab-Tint | SALtsg-SALctd | FLtsg/FLctd |
| median | 0.0198 | 0.2689 | -0.1180 | 0.475 |
| average | 0.1245 | 0.2682 | -0.1257 | 0.506 |
| Std dev | 0.2226 | 0.2153 | 0.0414 | 0.193 |
| max | 0.9964 | 0.8728 | -0.0559 | 1.156 |
| min | -0.0093 | -0.3305 | -0.3420 | 0.158 |

The intake temperature is not as close to CTD temperature as expected, but when only the 10 casts with the lowest standard deviation in the TSG intake temperature over 30s are included it is high by a median of 0.01Cº. The lab temperature is higher than the intake temperature by a median of 0.269º or 0.246Cº using just the 10 with lowest standard deviation. The salinity difference is similar to the last time the TSG was used. Fluorescence from the TSG is 50% of that from the CTD, on average. There did not appear to be any dependence on fluorometer flow rate.

* Comparisons of Loop samples and TSG data

There were 28 loop samples.

The TSG salinity is lower than loop samples by a median of 0.120psu with a standard deviation of 0.004psu.

TSG Fluorescence is higher than Extracted Chlorophyll loop samples by a median factor of 2.01 but the standard deviation is 0.97. Most of the samples had very low CHL values <0.5ug/L. The 4 cases with CHL>1ug/L the TSG values ranged from 30% to 100% of loop CHL.

* Comparison of Loops and 5m Niskin Samples

CHL Loop samples were taken at the end of 9 rosette casts and salinity samples from 8 casts. 5m data from the rosettes were compared with loop salinity and chlorophyll samples.

* 1. Loop salinity was lower than Niskin salinity by a median of 0.0002psu (std dev 0.0017psu).
	2. The loop CHL was generally lower than the Niskin CHL samples, though most were very close. The median difference was 9% with a range of -21% to +5%. All samples had CHL≤0.5ug/L.

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.
* During 2023-069 the flow rates varied greatly with little effect on the data. Intake temperature was higher than CTD by ~0.002C°. The lab temperature was higher than intake temperatures by 0.273C°. Salinity was recalibrated by adding 0.011psu based on comparisons with CTD and loops. TSG Fluorescence was ~67% of that from the CTD fluorometer and about 50% of extracted CHL samples from the loop.

e.) Conclusions re TSG

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

2. Both flow rates were mostly in a good range, but there were some major drop-outs, with more variability in the Fluorometer flow than that to the TSG.

3. The intake thermistor read higher than the CTD temperature at 4 to 5m by 0.02C°. This was quite consistent in the offshore area where near-surface gradients were low so any effect of a mismatch of the loop intake level and the level from which the CTD data came is small. This difference could be due to the TSG drawing water from a little higher than the average bin depth of the CTD data, or there could be some heating of the thermistor near the entrance to the loop. The amount of heating in the loop is typical of summer when intake temperatures are quite close to the ambient temperature of the loop and lab.

4. The TSG salinity is lower than that from the CTD and loop samples by a median of 0.12psu. This is also close to the results of the previous cruise. Salinity will be recalibrated by adding 0.12psu. Some of the difference is likely due to small bubbles in the water.

5. TSG Fluorescence was about 50% of CTD fluorescence; the flow rate to the fluorometer did not appear to be a factor. As usual, TSG Fluorescence was higher than extracted CHL when CHL <0.5ug/L and about 50% of CHL when CHL>0.5ug/L.

f.) Editing

All \*.REO files were copied to \*.EDT.

All \*.REO files were opened in CTDEDIT but data from August 10, 21 and 23 require no editing.

Files from August 11 to 13 required heavy editing due to many times when flow was off or very low. Flow to the fluorometer was unusually variable on those days.

Files from August 14 and 15 each had a short period of no flow.

Files from August 16, 17, 18, 19, 20 and 22 had only light editing of salinity, mostly single-point spikes; these may be caused by bubbles.

Gradual drops in salinity that end with abrupt rises may also be due to build-up of bubbles that are suddenly released, but the errors involved are not large and editing would be too subjective as some such features may well be real.

The output files, \*.EDU, were copied to \*.EDT so there is a complete set of files whether editing was applied or not.

g.) CALIBRATE, REMOVE and CLEAN

CALIBRATE was run using file 2023-088-tsg-recal.ccf to add 0.12psu to channel Salinity.

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

Plots were examined and a few bad values were found and replaced with pad values using text editor.

CLEAN was run to reset the channel limits in the header.

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 look fine.

A cross-reference list was prepared:

 Filename Latitude Longitude Date Time

 ----------------------------------------------------------------------------------------

 2023-088-20230809 48 39.42 N 123 30.60 W UTC 2023/08/09 22:31

 2023-088-20230810 48 15.72 N 126 39.00 W UTC 2023/08/10 00:00

 2023-088-20230811 48 38.94 N 126 40.08 W UTC 2023/08/11 00:00

 2023-088-20230812 48 41.46 N 129 43.26 W UTC 2023/08/12 00:00

 2023-088-20230813 48 53.82 N 130 41.46 W UTC 2023/08/13 00:00

 2023-088-20230814 48 58.14 N 133 40.02 W UTC 2023/08/14 00:00

 2023-088-20230815 49 12.00 N 136 8.82 W UTC 2023/08/15 00:00

 2023-088-20230816 49 23.40 N 138 41.94 W UTC 2023/08/16 00:00

 2023-088-20230817 49 33.90 N 142 17.22 W UTC 2023/08/17 00:00

 2023-088-20230818 49 48.60 N 145 0.12 W UTC 2023/08/18 00:00

 2023-088-20230819 49 59.88 N 145 14.58 W UTC 2023/08/19 00:00

 2023-088-20230820 49 51.30 N 144 23.52 W UTC 2023/08/20 00:00

 2023-088-20230821 49 18.42 N 138 22.92 W UTC 2023/08/21 00:00

 2023-088-20230822 48 44.46 N 132 58.92 W UTC 2023/08/22 00:00

 2023-088-20230823 48 13.02 N 127 32.58 W UTC 2023/08/23 00:00

##### Loop File

File 2023-088-loops.csv was prepared with times for each loop sample plus results from analyses; the end time of casts were used when loops were during CTD casts.

Positions were added based on concurrent CHE files where available and e-log entries for the rest.

The sampling method column was added and filled with ROS.

Derived Quantities was run to derive Sigma-T for the CHE files.

CLIP was run to remove all data below 7m.

Data were then exported to spreadsheet 2023-088-loop-che-data.csv

This gives start times, but we really want time of the last bottle closed.

Times were adjusted base don end times for casts in the paper log book.

Column order was adjusted and then a 6-line header was inserted.

The date/time column was saved with in 2 columns with Date in one, Time in the other.

That file was saved as 2023-088-surface-6linehdr.csv. clip

The file break column was filled with value 1 so all data to ensure only a single file is created in conversion.

CONVERT was run to produce an IOS Header file.

CLEAN was run to get start and stop times and to add flag 0 to empty flag cells.

Plots were made that turned up a few errors in the 6-line header file; those were fixed and the previous 2 steps were rerun.

 comment file was prepared which was essentially the same as the one used in preparing CHE files, but including a description of the loop system and comments on the CTD data processing.

Header Edit was used to correct channel names and formats and to add comments. The final file was renamed as 2023-088-loop.txt.

The track plot looks reasonable and plots of temperature and salinity versus event numbers, latitude and longitude look reasonable.

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

Deployment schemes:

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 (except no 60s waits for cast 67):

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

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

PAR off: 33, 57-54, 62-64, 67, 76.

Casts run out of order: None I Think.

Split casts: None

Particulars - CTD

3. Test cast – all bottles fired at surface.

9. 15min stop during upcast.

10. Went past 100 on way up.

22. Samples numbers wrong in log, correct on labels.

28. Nuts and CHL samples had wrong event #.

33. PAR off. Bottle 18 misfired at 125m.

40. PAR on.

42 & 45. Bulk water at 2000db, except Niskins 23 and 24 with surface samples.

47-54. PAR off.

53. Bottom pressure keeps jumping between 3606 and ~3628.

53. Bulk water at 2000db, except Niskins 23 and 24 with surface samples.

55. PAR on.

56. Stop due to electronics with winch. Stop acquisition and overwrite. Relaunch excel program.

62. PAR off.

63. PAR on.

64. Spooling issue – respooling at 1235 started cast 1324.

67. PAR off.

67. All bottle stops 30s to save time. Bottle 9 cracked on bottom, failed integrity test. Swapped out after cast with new bottle.

76. PAR off. #2 didn’t fire.

PARTICULARS- TSG

13. TSG Pump2 not flowing, reading 0, cleaned fluorometer, dislodged biology.

18. TSG Pump #2 flow rate 0.2-0.3 Won’t change.

24. TSG Pump2 air bubbles & doliolids cleared out.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **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** | **20Feb2023** | **Factory** |  |  |
| **Transmissometer** | **1883DG** | **0Feb2023** | **Factory** |  |  |
| **SBE 43 DO sensor** | **1119** | **10Feb2023** | **Factory** |  |  |
| **PAR sensor** | **70613** | **24Feb2021** | **Factory** |  |  |
| **SeaPoint Fluor.** | **3950** | **May 2023** |  |  |  |
| **Pressure Sensor** | **1515** | **17-Jan-2023** | **Factory** |  |  |
| **Valeport Altimeter** | **79487** |  | **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** |  |  |





