## REVISION NOTICE TABLE

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| DATE | DESCRIPTION OF REVISION |
|  |  |
| 18 March 2025 | TSG & Loop file channel names/units updated. Time:Julian added to TSG files. GG & SH |

## PROCESSING NOTES

Cruise: 2024-002 Agency: OSD

Location: North-East Pacific Project: Line P

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

Date: 23 January 2024 – 9 February 2024

Processed by: Germaine Gatien Date of Processing: August 14, 2024 – 2 October, 2024

Number of original HEX files: 62 Number of processed CTD files: 59

Number of rosette casts: 48 Number of processed CHE files: 46

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

# INSTRUMENT SUMMARY

Two SeaBird 911+ CTDs was used for this cruise:.

1. Events 1-32: 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 WetLabs fluorometer (#2216), a Biospherical QSP-400 PAR sensor (#70613) and a Valeport altimeter (#79487).

2. Events 47-140: CTD #506 was mounted in a rosette and attached were 2 Wetlabs CSTAR transmissometer (1185DR & #1883DG), a SBE 43 DO sensor on the primary pump (#0997), SeaPoint Fluorometer on the secondary pump (#3945), a WetLabs fluorometer (#2216), a Biospherical QSP-400 PAR sensor (#70613) and a Valeport altimeter (#79487 for events 47-115 and #70613 for events 116 -40).

A thermosalinograph (SeaBird 45 S/N 0789) was mounted with a Wetlabs WETStar fluorometer (#1656), intake thermometer (SeaBird 38 #603) 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. There were reports from the Chief Scientist outlining sampling methods and problems, and one from the CTD technician on problems with the CTD including a sea-cable break and odd altimetry.

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 had a wait time of 60 seconds if there was dissolved oxygen sampling and 30 seconds if there was no dissolved oxygen sampling..

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

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

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

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

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

During 2024 there is a plan to deploy pairs of fluorometers on many cruises to determine the impact of switching from using SeaPoint fluorometers to ECO fluorometers. This was the first 2024 cruise processed that had pairs on the CTD; the CTD was switched after event #32 and a different pair of fluorometers were used on the second CTD as well. For this cruise the 2 SeaPoint Fluorometers and one of the ECO fluorometers were in good agreement and the second ECO came into good agreement when a large dark value was subtracted. However, low chlorophyll levels limit confidence in the comparison. Only SeaPoint data are included in the files in the OSD archive.

Something affected the primary conductivity sensors during events 116-129; before and after those casts there was no problem. Secondary channels were selected for archiving. There was no significant drift in calibration during the cruise in either CTD system.

Transmissivity values in deep water at Station Papa were lower than those recorded during 2023-066 and 2023-088, with the red at 60.7%/m and Green at 94.3%/m. The high values seen in 2023-066 were out of line with historical values with red about 70 to 71%/m and green about 100%/m. The transmissometers are now being tested yearly for dark values and initial study suggests this will provide useful calibration offset data, which should lead to more reliable transmissivity data.

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 both sensors used during this cruise are considered, very roughly, to be:

±0.30 mL/L from 0-100db

±0.10 mL/L from 100db to 200db

±0.05 mL/L below 200db

There were problems encountered at sea in collecting thermosalinograph data. There are large data gaps: January 26 at 15:00 to January 28 at 14:17; February 2 at 9:41 to February 3 at 16:14; and February 6 from 20:49 to 22:50. Sometimes flow looked fine but no data were acquired. At some other times one or other flow rate is zero but the data look ok, so it is assumed the issue was with the flow meter and not the flow itself. When the flow rates were non-zero, they were mostly very steady.

Comparisons in the offshore sections of this cruise were aided by very low surface gradients especially in salinity, but the gaps in TSG data limited the number of casts useful for comparison. Temperatures from intake and lab looked good. Salinity values in the offshore were corrected by adding 0.04psu based on comparisons to loops and CTD data; the low salinity may be due mostly to bubbles in the loop water. In the Strait of Georgia TSG salinity was much lower than CTD salinity; this was presumed to be due mainly to larger salinity gradients. It is not clear which is more reliable, CTD or TSG salinity, so no correction was applied to TSG salinity in the Strait of Georgia.

TSG Fluorescence was about 70% of CTD fluorescence in all areas. The offset in the calibration for the TSG fluorometer has been found to decrease with time. A value of 0.69 was used in converting these data, but TSG fluorescence was recalibrated by adding 0.02ug/L, which is equivalent to using an offset of 0.676. This brought the two data sets into much better correspondence.

The 3 offshore loop salinity samples were in very good agreement with the rosette samples as were the 5 chlorophyll samples. The salinity loop sample from the Strait of Georgia was lower than the rosette sample by 0.173psu, but it was only lower than the CTD salinity from the bottle file by 0.015psu. So the loop data look good, but likely come from a little higher in the water column than the 5m rosettes.

# PROCESSING SUMMARY

##### Seasave

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

##### Preliminary Steps

The Log Book and rosette log sheets were obtained.

* Nutrients, extracted chlorophyll, dissolved oxygen, salinity and 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 for CTD #1515. CTD #505 had not been used on other cruises since the most recent factory service.

The configuration files changed during the cruise. Files used in conversion were:

* 2024-002-ctd1.xmlcon for events #1-32.(CTD #1515)
* 2024-002-ctd2.xmlcon for events #47-115. (CTD #0506 with altimeter 79487.
* 2024-002-ctd3.xmlcon for events #116-140. (CTD #0506 with altimeter 70613.

##### BOTTLE FILE PREPARATION

ROS files were created using 2024-002-ctd\*.xmlcon. 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 channel Salinity:T0:C0 very lightly around 600m in cast #14.

The output ED1 file was 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.

Casts #1 and #48 were removed from the list since no CHE file is required.

The file was then 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 2024-002-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 QF2024-002\_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 2024-002oxy.csv. That file was converted into individual \*.OXY files.

EXTRACTED CHLOROPHYLL

Extracted chlorophyll and phaeo-pigment data were obtained in file QF2024-002\_CHL QF\*.xlsx. The file included comments and flags and a precision study. A simplified version of the spreadsheet was prepared and saved as 2024-002chl.csv. The csv file was then converted to individual CHL files.

SALINITY

Salinity analysis was obtained in file QF2024-002\_SAL.xlsx which included a precision study. The analyses were carried out in a temperature-controlled lab 11 to 25 days after collection. The files were simplified and saved as 2024-002sal.csv. That file was then converted to individual SAL files.

NUTRIENTS

The nutrient data were obtained in spreadsheet QF2024-002\_NUTS\*.xlsx. This includes a precision study. The file was simplified, saved as 2024-002nuts.csv. The file was converted to individual NUT files.

DMS

DMS data were obtained in spreadsheet DMS Summary (2024-002).xls which includes duplicate analysis. Details on analysis are in file 2024-002 DMS report.doc. Only 2 figures are considered significant. Event #s were added to the file.

All stations were run on an 8890 gas chromatograph.

Detailed notes on analysis are in file 2024-002 DMS report\*.doc.

DMSP\*

DMSP-D and DMSP-T data were obtained in file DMSP 2024-002 Summary\*.xls. Details on analysis are in file 2024-002 DMS report.doc. The data were converted into DMSP files. Only 2 figures are considered significant.

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. DMS data were missing due to a mis-named channel in the merge process, so that was rerun.

CTD salinity was checked and there are values <25psu, so silicate correction is needed.

##### Compare

Salinity

Compare was run with pressure as reference channel.

The comparison was done in two parts due to the change in CTD.

***CTD 1515***

For CTD #1515 there were only 5 casts with salinity sampling and for two of those there were only surface samples.

The fits against pressure were quite flat, particularly that for the secondary sensors. There was only one outlier (sample #165, cast #28) and that was not particularly out of line; removing it made the fit flatter with little effect on the average difference. This was likely a case of a Niskin just not flushing quite as well as for the others.

The primary salinity was lower than samples by an average of 0.0084psu (std dev 0.0004psu) and the secondary was low by 0.0052psu (std dev 0.0005psu). These results are a little better than noticed when the CTD was last used, but that cruise had few samples.

The fit against time is as flat as can be expected given so few casts and samples. The primary is flatter, but the secondary would be flatter if one more bottle was dropped as an outlier.

Including the surface samples affected pressure dependence in the fits, but had little effect on the average differences. The differences are reasonably close to those from autumn 2023 cruises.

***CTD #0506***

For CTD #0506 the picture is much more complicated. There are many more samples and a great variety in water depths and geographic character. This was the first use of these sensors since factory service, so we expect good results

The issue is complicated by having sampling in both open ocean and in the Strait of Georgia.

The initial comparisons turned up one very clear outlier that turned out to be a surface sample mislabelled as being from 2000db. That was fixed.

The range of values at each depth is larger in the primary than the secondary. This is likely due to more noise in the primary signal than the secondary, though the difference is slight averaged over the 10s window.

There was one very large outlier from cast #122, but that was from a surface sample and there was an extremely high salinity gradient at the surface, with salinity dropping by about 5psu in a few metres.

There were many near-surface outliers from the Strait of Georgia with differences >0.015psu.; these were dropped from the comparison as they are also from relatively high salinity surface gradients.

Outliers below the surface were investigated. None had been flagged by the analyst and the flagged samples did not look particularly out of line:

Event 50

* Sample 222 - 4000db – Not at bottom. CTD data not particularly noisy. Out of line with cast by about 0.003psu for primary but not secondary. Local vertical gradient low. DO sample looks ok, so not a mis-sample. Probably just caused by spike in primary salinity.

Event 96

* Sample 470 -200db – Minor outlier – CTD not noisy during 10s window but lot of vertical motion and variability in CTD data at other times. Sample likely fine.
* Sample 471 – 149db – CTD not noisy in 10s window but salinity variable during stop with large shed wakes. Sample likely fine.
* Sample 472 – 125db – CTD data very noisy. Sample likely fine.
* Sample 473 – 99db – CTD data fairly noisy. Sample likely fine.

Event 122 at 422db

* Sample 520 -422db -BOT-5 – Noisy CTD near bottom but nothing nearly as high in primary salinity as in the bottle sample. However, the secondary CTD is slightly higher than the bottles values. Sample probably fine – problem is with primary CTD conductivity.

Event 126 at 300db

* Sample 524 at 300db – upcast well off bottom. Data not noisy in 10s window, but during the stop the CTD data shows huge shed wake passing through so having the CTD look low is reasonable. Sample likely fine.

Event 127 at 350db

* Sample 531 not near bottom and CTD not noisy during 10s window. The CTD went above that level and came back down to fire, so expect CTD to read higher than bottle, not lower. This is like Event 122 – problem with primary conductivity, not sample.

Event 134 at 317db –

* Sample 544 at 317 – BOT-5. Fired at the bottom of the cast and near sea bottom. Looks like Niskin had water from about 8-10m above firing level. Sample likely fine. Not much of an outlier in secondary – there was a spike in primary salinity so maybe shed wake going through.

The primary was found to be high by an average of 0.0020 and the secondary high by an average of 0.0003psu. The standard deviation was 0.0009psu for both.

When those outliers were removed the fit is very flat for the primary sensor. It is acceptable in the secondary fit though not as good as the primary.

Test fits were done excluding data above 200db to see if it would improve the pressure dependence. It made little difference to the secondary and made the primary worse. It changed the average differences slightly with the primary high by 0.0021 and the secondary high by 0.0005psu.

Having well-mixed surface waters in the offshore enables clear evidence that pressure dependence is acceptable in both sensors.

There is a little more noise in the primary traces than the secondary. This is not a serious issue but explains why there is a larger range of results for particular depths in the primary than the secondary.

Two items were examined further.

1, Cast #96 at P14 has many outliers. Plots of full casts in this region show well-mixed salinity to 90db and then steep salinity gradients between 90db and 200db. Only at cast #98 were salinity samples taken in those depths. So it is no surprise they stand out in the fits.

2. Most of the casts in the Strait of Georgia were outliers. This is not surprising given that flushing of Niskin bottles tends to be poor. Adding to the limitations are the fact that many of the samples came from the bottom of casts and some of those were near the sea bottom. Both those factors tend to lead to different matches between CTD salinity and bottles than during upcast sampling. Niskin contents don’t match ambient conditions well in quiet waters. On upcasts this leads to samples being higher than ambient salinity while on downcasts the opposite is the case. If near the sea floor the CTD data are very noisy and suggest that shed wakes may bounce back and forth from the rosette to the bottom. So matches are not great with a tendency for the CTD salinity to look higher than samples.

3. While Strait of Georgia casts are expected to be a little out of line in the fits, the primary salinity stands out as very poor for many of the casts.

* At station 12 the sample was near the ocean floor. The comparison of CTD and sample fell into the general fit. There was a 60s wait and a fairly low salinity gradient in the bottom 5m may have helped.
* At station 24 there was again a sample near the ocean floor. CTD salinity varied quite a lot during the stop; that could be real variability or shed wakes. Pressure also increased through the stop but the change in CTD salinity went up, not down, so this is more likely some other effect, possibly shed wake. The CTD primary salinity was significantly lower than the bottle salinity by ~0.012psu but the secondary wasn’t out of line.
* At station 27 the bottle was closed during the upcast. Both CTD salinity channels were lower than the bottles but the primary was -0.026 and the secondary by ~0.013psu despite a 60s wait. There is clear evidence in the CTD salinity of a shed wake passing through the area at the beginning of the stop. This is likely what was in the bottle. Even a long wait can’t stir things up when the Niskin is not being moved about vertically. The pressure was very steady. So while both look affected by a shed wake, the primary salinity difference is out by much more.
* At station GEO1 the deep bottle was fired during the upcast. There is a lot of variability in the CTD salinity, though the picture is complex because the CTD had overshot the planned level and had to go back down to 350db. The wait was fairly short, ~30s. The most interesting thing is how far apart the two CTD channels are. We might expect the CTD too look slightly high given the drop to 350db and the secondary does. The primary looks significantly low.
* At station 42 – fired at bottom. Both CTD sensors look higher than samples, so this is likely a case of incomplete flushing. The pressure looks steady, so little mixing likely. Water with the same salinity as the sample is only a about 5m higher. The 2 channels are in reasonable agreement.

So it appears that something affected channel Salinity:T0:C0 during some casts.

Downcast files were plotted to see precisely which casts were affected and they were #116-129. Cast #115 looks ok both downcast and upcast, though the upcast surface data is hard to judge as it is noisy. The downcast looks ok.

Conclusions re Strait of Georgia

* The differences between secondary and primary were larger by about 0.01psu for casts 116-129 than before and after those casts. Bottle comparisons show the problem was in the primary. The conductivity channel differences are affected but not temperature. This does not seem like a problem in the flow to the conductivity sensor, because of the consistent size of the offset and profile features line up vertically. The difference is large during bottle stops and in areas of low vertical gradients, so it doesn’t look like a question of alignment as it would required an unrealistically large vertical shift in areas of low salinity gradient. There are no log notes of relevant problems at the beginning of this group, but the problem does start after the altimeter was changed. Whatever the cause, it is resolved before cast 131. There was no change in the configuration file.
* The CTD technician suggests that something might have become attached to the conductivity cell itself.
* Bottles fired at the bottom are problematic, but long waits and low vertical gradients reduce errors.

General Conclusions

For casts 1-32 the secondary sensors are closer to bottles and differences are less pressure dependent, but there are few casts in the fits and both sensor pairs performed well.

For casts 47-115 the primary is slightly flatter against pressure, the secondary is slightly flatter against time, the range of values at each depth is tighter in the secondary and the secondary is closest to bottles.

For casts 116-129 the primary data are bad

For casts 131-140 there is little to go by, but probably like 47-115.

Overall the secondary sensors look appropriate for casts 1-32 and 116-129.

For the other casts either pair are good, though the secondary may be best and would simplify processing. However, a decision should be based on how noisy the data look at the editing stage.

For full details for the COMPARE run see file 2024-002-sal-comp1.xls.

Dissolved Oxygen

COMPARE was run with pressure as the reference channel.

There was a change of sensor so this was done in two parts.

* CTD #1515 DO Sensor1119

Comparisons have been variable in previous uses of this sensor.

When a few outliers were excluded based on residuals the fit was:

CTD DO Corrected = CTD DO \*1.0082 + 0.0358 (1)

The last cruise using this sensor that had sufficient sampling for recalibration gave the result:

CTD DO Corrected = CTD DO \* 1.0148 + 0.0319 (2)

When the offset for fit (2) was applied to the current data the fit was:

CTD DO Corrected = CTD DO \*1.0089 + 0.0319 (3)

So this fit has a smaller correction than noted in other cruises, but it looks reasonably tight with all outliers associated with high standard deviations in the CTD dissolved oxygen.

* CTD #0506 DO Sensor 0997 Casts #50 to #134

This sensor was serviced since it was last used, so there is no useful history available.

A check of hysteresis is recommended after a DO sensor is serviced and recalibrated.

This cruise offers a chance to do that since there was deep sampling. Unfortunately, there are only 3 suitable casts with DO sampling. Further complications are that the downcast data have high vertical DO gradients from about 100db to 400db, then a fairly low gradient from 500db to 1400db. Then the gradient reverses and had a moderate vertical gradient to the bottom. So errors due to incomplete flushing will be slight at the surface and between 1000db and 1600db, but elsewhere they will have opposite effects above and below the OMZ. This is further complicated by the depth of minimum DO values varying from about 1000db to 1300db.

Differences were displayed in green for samples taken below the DO minimum that could be compared with shallower data in the same DO range AND low vertical gradient; the latter were displayed in red. This left few data points but they fell well within the scatter of RED points. Attempts at a fuller comparison showed the differences below the OMZ being slightly larger than above the OMZ. That is likely due to the high gradients above the OMZ leading to the CTD DO looking higher than samples due to incomplete flushing of Niskin bottles.

So with what little information is available, there appears to be little hysteresis in this sensor.

A fit based on offshore casts and excluding high-DO gradient zones and a few outliers based on residuals was:

CTD DO Corrected = CTD DO \*1.0232 + 0.032

Outliers: The only significant outlier came from 5db during cast #115. CTD DO varied from 5.5mL/L to 6.5mL/L. There was a large shed wake during the bottle stop; if water from that wake was in the Niskin that would explain the difference. The descent rate was very steady during the stop, so this is quite possibly the case. No change to the quality flag is suggested.

For full details for the COMPARE run see file 2024-002-dox-comp1.xls.

Fluorescence –

**During 2024 pairs of fluorometers were deployed together on many cruises to determine the impact of switching from using SeaPoint fluorometers to ECO fluorometers.**

**Reports with data and comments will be assembled with sections for each cruise.**

**Details below concern only how each sensor compared to CHL to determine what should be archived.**

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

There was a SeaPoint/ECO pair used throughout, but the sensors were both changed before cast #47.

All chlorophyll values were low.

First the SeaPoint fluorometers were examined.

* Sensor 3950 has the usual pattern of reading too high compared to CHL when CHL is very low, and gradually drops to values close to CHL when CHL is ~0.7 ug/L.

The fit of Fluorescence versus CHL looked odd and very dependent on the offset chosen. When cast #32 was removed from the comparison, it looks excellent. All samples from that cast had been flagged by the analyst due to possibility of contamination. It looks like that did occur.

The fit of FL versus CHL is dependent on the offset with various choices of offset affecting the result. While choosing 0 or free offset both produce reasonable fits, the one that looks best by eye is the one using the dark value as the offset: FL = 1.42 \* CHL + 0.09

* Sensor 3949 has the usual pattern of reading too high compared to CHL when CHL is very low, and gradually comes close to CHL values for CHL> 0.9ug/L.

The fit of Fluorescence versus CHL also looks best by eye using the dark value, though no fit looks great. The fit with the best

FL = 1.39 \* CHL + 0.04

The fit of FL/CHL vs file pair number shows a distinct change around cast 96, which may be due to a rise in CHL values as the ship got closer to shore. This also explains the poorer fit of FL vs CHL than found with the other fluorometer.

Next, the two ECO fluorometers were examined in the same way.

* Sensor 2216 has the usual pattern of reading too high compared to CHL when CHL is very low, but drops to values close to CHL for CHL> 0.5ug/L.

Just as seen for SeaPoint 3950, the fit of Fluorescence versus CHL looked odd and very dependent on the offset chosen. When cast #32 was removed from the comparison, it looks excellent. All samples from that cast had been flagged by the analyst due to possibility of contamination.

The fit of FL versus CHL is dependent on the offset with various choices of offset affecting the result, but the differences were slight. The dark value varies a little in deep water, so picking the best for fits is not as clear as for the SeaPoint sensors. A uranine test was available that indicated a value of 0.055 while one deep plot suggested 0.06, so that is likely a good estimate. The fit found was value:

FL = 1.3228 \* CHL + 0.055

* Sensor 2215 has the usual pattern of reading too high compared to CHL when CHL is very low, and gradually drops to values closer to CHL but never gets as close as ECO #2216 does.

CHL values are slightly higher for this group. The fit of FL versus CHL is dependent on the offset but the best fit by far is using the dark value as the offset. The fit found was value:

FL = 1. \* CHL + 0.26

Conclusions:  
ECO 2216 gave results similar to SeaPoint 3950.

ECO 2215 had a higher dark value than SeaPoint 2949 and is higher compared to CHL samples than the 2 SeaPoint fluorometers and the ECO 2216 fluorometer.

For this cruise it is likely best to archive the SeaPoint fluorometer data rather than the ECO.

Subtracting the dark value from all fluorescence data will produce better results, though the difference is very slight for all but ECO 2215.

For more detail see file 2024-002-fl-chl-comp1.xls.

Beyond comparing each fluorometer with chlorophyll, there was further study of how the pairs compare.

* General comments are in “SeaPoint\_ECO\_Comparisons.docx”
* Data and plots are in report “SeaPoint\_ECO\_Data\_For\_Comparisons.xlsx”.

The intention is to accumulate observations during 2024 from a variety of cruises.

Analysts were informed of 2 issues:

DO – event at P4 should be event #18, not 19. (samples 91-107). Changed in QF file.

CHL – cast #32 – all CHL samples outliers in fit against fluorescence. Flags changed to 4 by analyst in QF file.

File #32 was updated with new flags.

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

Hex files were converted using configuration files 2024-002-ctd\*.xmlcon.

All expected channels were found and profiles look reasonable.

Descent rate and SBE salinity will be derived later.

##### 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.

CELLTM does not work well when temperature increases with depth but is useful overall.

##### DERIVE and Channel Comparisons

Program DERIVE was run on all casts to calculate primary and secondary salinity, dissolved oxygen concentration and descent rate. Plots were examined and the alignment of dissolved oxygen looks good although both temperature and DO are noisy.

WILDEDIT removed some spikes.

T-S plots show that the CELLTM step worked properly in the offshore casts, but where temperature was mostly increasing with depth it did not work well. So casts 106 to 140 were rerun skipping that step.

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. For CTD 1515 a few casts from earlier cruises are included to check for temporal drift. For CTD 0506 there are no previous cruises for comparison since the last service.

CTD #1515

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cast # | Press | T1-T0 | C1-C0 | S1-S0 | Descent Rate |
| 2023-088-0033 | 1000 | -0.0003 | +0.00002 | +0.0003 | High, Moderate |
| “ | 2000 | -0.0005 | -0.00002 | +0.0003 | “ |
| “ | 3000 | -0.0006 | -0.00003 | +0.0005 |  |
| 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 | “ |
| 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 | “ |
| 2023-026-0098 | 500 | -0.0002 | -0.00005 | -0.0003 | High, F. Noisy |
|  | 1000 | -0.0003 | -0.00007 | -0.0007 | “ |
| 2023-026-0150 | 500 | -0.0002 | -0.00004 | -0.0003 | High, Noisy |
|  | 1000 | -0.0003 | -0.00006 | -0.0005 | High, V. Noisy |
| 2023-032-0006 | 1000 | -0.0003 | +0.00007 | +0.0012 | High, V. Noisy |
|  | 1800 | -0.0005 | +0.00006 | +0.0012 |  |
| 2023-032-0053 | 1000 | -0.0002 | +0.00004 | +0.0007 | High, Noisy |
|  | 1800 | -0.0004 | +0.00002 | +0.0006 |  |
| 2023-032-0037 | 500 | ~0 | +0.00022 | +0.0027 | High, Noisy |
|  | 1000 | -0.0002 | +0.00017 | +0.0023 | “ |
|  | 1500 | -0.0003 | +0.00016 | +0.0022 | “ |
| 2023-032-0039 | 500 | -0.0002 | +0.00022 | +0.0027 | High, Noisy |
|  | 1000 | -0.0002 | +0.00019 | +0.0024 | “ |
|  | 2400 | -0.0005 | +0.00010 | +0.0024 | “ |
| 2024-002-023 | 500 | -0.0001 | +0.00028 | +0.0033 | High, X Noisy |
|  | 1000 | -0.0001 | +0.00025 | +0.0030 | “ |
|  | 1900 | -0.0003 | +0.00024 | +0.0030 | “ |
| 2024-002-028 | 500 | -0.0001 | +0.00028 | +0.0030 | High, X Noisy |
|  | 1000 | -0.0002 | +0.00027 | +0.0030 | “ |
|  | 1900 | -0.0003 | +0.00024 | +0.0030 | “ |
|  | 3000 | -0.0006 | +0.00023 | +0.0030 | “ |

The temperature differences are close to those in previous cruises with a slight increase in conductivity and salinity differences. The salinity difference is in line with the differences seen in the bottle sample comparison.

CTD 0506 – no previous use on record – used as backup

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cast # | Press | T1-T0 | C1-C0 | S1-S0 | Descent Rate |
| 2024-002-0050 | 1000 | -0.0003 | -0.00006 | -0.0006 | High, V Noisy |
|  | 2000 | -0.0004 | -0.00004 | -0.0002 | “ |
|  | 3000 | -0.0005 | -0.00001 | +0.0002 | “ |
|  | 4000 | -0.0007 | +0.00003 | +0.0011 | “ |
| 2024-002-0057 | 1000 | +0.0002 | -0.00014 | -0.0018 | Low, X Noisy |
|  | 2000 | 0 | -0.00010 | -0.0013 | “ |
|  | 3000 | 0 | -0.00007 | -0.0008 | “ |
|  | 4000 | -0.0005 | -0.00003 | +0.0001 | High, V Noisy |
| 2024-002-0074 | 1000 | +0.0004 | -0.00015 | -0.0023 | High, X Noisy |
|  | 2000 | +0.0003 | -0.00012 | -0.0018 | “ |
|  | 3000 | -0.0001 | -0.00009 | -0.0010 | “ |
|  | 4000 | -0.0005 | -0.00006 | -0.0001 | “ |
| 2024-002-0090 | 1000 | +0.0003 | -0.00018 | -0.0024 | High, X Noisy |
|  | 2000 | -0.0001 | -0.00016 | -0.0020 | “ |
|  | 3000 | -0.0003 | -0.00012 | -0.0012 | “ |

The differences are small, but there is some pressure dependence. Slight misalignment can explain some reduction in differences with depth since the vertical gradient generally gets lower. However, that would not affect the bottle comparison since these data are averaged at a time when the CTD is stopped. The differences down to 2000db agree fairly well with the bottle comparison. Below 2000db there is a conductivity reversal but not a reversal in temperature, so alignment issues are more complex and likely explain the small changes with depth.

A return was made to the bottle comparison to see if there is any notable variations with time in a variety of pressure ranges. At 2000db the difference rose after the first bottle cast at event #50 (0.0007psu) to about 0.002psu, with little variation thereafter. Similar results were seen at 3000db. At 3500db there was little change throughout, including Cast #50. There is only one bottle from 4000db and that is an outlier in the primary comparison, suggesting a possible problem with the primary conductivity.

There may be slight increases with time but the extremely noisy descent rates make comparisons rough.

##### Conversion to IOS Header Format

The IOSSHELL routine was used to convert Sea-Bird 911+ CNV files to IOS Headers. This required handling in 3 steps as the CTD # and the area of study changed.

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 for each CTD.
  + For CTD 1515 the average surface value was 3.1 with a minimum of 0.19db. During cast #1 acquisition started in air and pressure reads about 0.1db to 0.2db during that time. It appears to enter water at about 0.2db judging by transmissivity. At the end of that cast it appears to break the surface at about 0.2db.
  + For CTD 0506, the average surface value was 2.8db. This looks reasonable for the deployment scheme used. The lowest pressure recorded was -0.7 during cast #98. When pressure reaches about -0.2 to -0.3db transmissivity drops to 0.
* 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:

* In 3 cases the header entry was wrong - when changed to log entry the check value was ok.
* In 8 cases there was good altimetry, so a calculated value (Max depth sampled + Altimetry at bottom) was used for headers. Checks were made of previous cruises to ensure the values were reasonable.
* In 1 case there was no altimetry available. The header was replaced with a value from another cast at the same site.
* In 2 cases there was no altimetry available, and no other cast at the same site from this cruise, so readings were found from previous cruises at the same sites.

These changes were made to the CLN and SAM files.

The SAM files were averaged again and merged with the MRGCLN1s files.

CLIP was run on cast #1 to remove 7000 scans at the beginning of the cast likely to be selected by DELETE. The output was copied to CLN.

##### 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 conductivity sensors as judged by noise in T-S space. Both data sets are very noisy, so this judgement was rough.

CTD #1515 The best choice was no change for the primary and -0.3 records for the secondary channel.

CTD #0506 The best choice was -0.7 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: The only warning was for cast #47 as it only has shallow data and will not be processed further.

##### Other Comparisons

Experience with these sensors since last factory service –

For CTD #0550 there is no history (used as backup only since last service).

For CTD #1515 there has been a lot of use:

* 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.
* 2023-026 – No time dependence noted in salinity. Pressure fine. Added 0.0053psu to the primary salinity and 0.0063 to the secondary salinity. DO correction:

CTD DO Corrected = CTD DO \* 1.0148 - 0.0319

* 2023-088 – Time-dependent correction applied to salinity channels. Pressure did not need recalibration. DO correction was:

CTD DO Corrected = CTD DO \* 1.0165 + 0.025

* 2023-032 – No time dependence noted in salinity during the cruise. Pressure fine. Added 0.0078psu to the primary salinity and 0.0069 to the secondary salinity. There was only 1 cast with DO sampling which gave similar results to 2023-026, so the 2023-026 correction was applied.:

CTD DO Corrected = CTD DO \* 1.0148 - 0.0319

* 2023-081 - 2023-081 – Primary Salinity estimated low by -0.0110psu and secondary by 0.009psu. Few samples but in line with previous drift. Dissolved oxygen used 2023-026 results.

Historic ranges – Profile plots were made with 3-standard deviation climatology ranges of T and S superimposed. Salinity was slightly high in part of the halocline at P20 and P23 which is likely due to a shallower mixed layer rather than a calibration issue. At P23 and Scott2 salinity was a little low at the base of the mixed layer, which could be due to deeper mixing than usual, or a general reduction in mixed-layer salinity which has been widely reported in this region. There were a few instances of slightly low salinity at the surface in Queen Charlotte Strait. Temperature data were all within the climatology with the except of casts at Scott2, Scott3 and LBA-1 where temperatures were high at mid-depths. For LBA-1 the deep climatology did not look reasonable, suggesting there were no deep casts in the climatology data base for this site. There is no evidence of calibration errors.

Post-Cruise Calibration – None available.

Repeat Casts –The only repeat casts were limited to comparisons at 600db. The differences at P26 were extremely small along lines of constant density, with the temperature differences <0.0015C° and salinity<0.0005psu. Most differences were much smaller than that. At P16 the differences are somewhat larger at temperature differences <0.02C° and salinity differences <0.003psu. At P16 the active mixing level is deeper than at P26. So repeatability is not expected to be as good.

##### DETAILED EDITING

The \*.DEL files were zipped in 2 batches and submitted to the CTD-QC-File Processor. DELPRED files were returned. 1 file was not included since it only had surface data. It will not be processed further (#47)

The choices of which channels to edit was difficult because many of the casts were extremely noisy.

For CTD 1515, the secondary salinity was closer to bottles while the primary was slightly flatter in plots of differences versus pressure. In the noisiest casts, both sensor pairs look hard to edit, possibly the primary was slightly easier but there was almost no difference. However, in casts with less noise, the secondary looked like the best choice. So secondary were chosen for editing.

For CTD 0506 the secondary salinity was very close to bottles while the primary was slightly flatter but noisier. As for the other CTD editing of casts with a lot of noise will be difficult for both channel pairs, but when the noise level was low later in the cruise, the secondary looks like the best choice. There are a few casts with bad primary salinity late in the cruise. Overall, secondary looks like the better choice to edit.

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.

Cast #57 required extremely heavy editing due to the unusually large number of CTD descent rate reversals. This was due to a low descent rate (to straighten the cable). combined with very rough weather; there may also have been problems with the crane and crew training in its operation.

After editing, T-S plots were examined for all casts and no further editing was found necessary; a few unstable features remain but may be real.

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

File 2024-002-recal-sil.ccf was prepared to recalibrate silicate where salinity is <25psu.

File 2024-002-recal1.ccf was prepared apply corrections as follows:

* For casts 1- 32 CTD #1515, 0.0084psu was added to channel Salinity:T0:C0 and 0.0052psu was added to Salinity:T1:C1 and dissolved oxygen was recalculated as:

CTD DO Corrected = CTD DO \*1.0089 + 0.0319

* For casts 47-140 CTD #0506, dissolved oxygen was recalculated as:

CTD DO Corrected = CTD DO \*1.0232 + 0.032

COMPARE was rerun after recalibration.

For salinity, only the secondary was studied since no recalibration was applied to the primary and the secondary channels have not been prepared for the archive.

Salinity:T1:C1 for CTD #1515 was lower than bottles by 0.0052psu before recalibration and high by 0.00005psu after recalibration when the same outliers are excluded from the comparison.

So the recalibration worked properly. While it appears that the data are reasonably accurate, there are too few samples in this set to have great confidence in that statement.

Channel Salinity:T1:C1 was not recalibrated for CTD #0506, but a check was made to ensure no error was made in recalibration. No values had changed, as planned.

Channel Oxygen:Dissolved:SBE channel is in very good agreement with bottles for both CTDs when the same bottles are included as in the original fits. There is a lot of noise in the CTD#0506 fit but there was in the original fit as well. Differences at the high and low ends of the DO scale looks fine, with most outliers coming from high vertical gradient levels.

See files 2024-002-sal-comp2.xls and 2024-002-dox-comp2.xls.

##### Fluorescence Processing

A median filter, size 11, was applied to the fluorescence channel in the COR1 files. Plots of a few casts showed that the filter was effective. (Output:\*.FIL)

##### BIN AVERAGE of CTD files

The following Bin Average values were applied to the FIL files (output AVG):

Bin channel = pressure Averaging interval = 1.000 Minimum bin value = .000

Average value will be used. Interpolated values are NOT used for empty bins.

On-screen T-S plots were examined and no significant differences were found from climatology.

##### 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 (bin-averaged to 0.5m-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 in a fit against DO. Plots were then made against pressure using the same data.

For CTD #1515 the average differences between downcast recalibrated and thinned CTD DO and Titrated Bottle samples were 0.020mL/L (std dev 0.077mL/L). There were a few outliers at mid-depths from event #28, but they are from a depth where downcast and upcast were more unlike than usual. 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 above the OMZ and low below that. That is the pattern seen in these data. The recalibration worked as well as can be expected. The differences are smaller than usually seen near the surface, likely due to lower gradients as those levels were mostly well mixed.

For CTD #0506 the CTD DO was high by an average of 0.001mL/L (0.031mL/L). The lower average than for the other CTD is mainly due to the many very deep samples from this group. Values above the OMZ were mostly high and below the OMZ mostly low.

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

±0.30 mL/L from 0-100db

±0.10 mL/L from 100db to 200db

±0.05 mL/L below 200db.

For details see files 2024-002-dox-comp3.xls

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

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

Scan\_Number, Temperature:Primary, Conductivity:Primary, Oxygen:Voltage:SBE, Descent\_Rate, Status:Pump, Altimeter, Salinity:T0:C0, Flag and PAR from casts 19, 20, 28, 47, 48, 49, 50, 57, 64, 66, 70, 72, 74, 83, 90, 94, 96.

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; no problems were found.

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

The transmissivity values at 4000db at P26 were ~60.7% for Red and ~94.3% for Green.

At the Seamount they were 60.8% and 94.4%.

These are much lower values than those seen in August 2023 when transmissivity values below 4000db at P26 were ~70% for Red and ~100% for Green. Those values were similar to those noted during cruise 2023-066, which were also 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.It is possible there was a problem with the calibration in spring 2023. There was another calibration done in January 2024, shortly before this cruise.

##### Dissolved Oxygen Study

As a final check of dissolved oxygen data, % saturation was calculated and plotted. Values at 2 to 3m ranged between ~73% in Saanich Inlet to 135% at station P3. All other values were between 95% and 100% with the majority around 99%. These values are slightly lower than usually seen offshore, but near-surface gradients were unusually low.

##### Final Bottle Files

There was salinity is <25psu so silicate was recalibrated using file 2024-002-recal-sil.ccf.

CALIBRATE was run using file 2024-002-recal1.ccf to correct Salinity:T1:C1 for CTD #1515 and Oxygen:Dissolved:SBE for both CTDs.

SORT was run to arrange casts in pressure order.

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

Scan\_Number, Temperature:Primary, Conductivity:Primary, Oxygen:Voltage:SBE, Descent\_Rate, Status:Pump, Altimeter, Salinity:T0:C0, Flag and PAR from casts 19, 20, 28, 47, 48, 49, 50, 57, 64, 66, 70, 72, 74, 83, 90, 94, 96.

At this stage records associated with no sampling were removed from files.

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 2024-002-bottles-final.xlsx. The entries were compared with the rosette log sheets and no problems were found.

Standards check was run. No problems were found.

The track plot looks fine.

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 linked to an external thermistor and separate flow to a fluorometer in the lab.

There were many files containing TSG data with a document explaining which data were in each file.

Some had no data from the TSG itself but did have intake temperature and fluorescence as well as positions. Some files overlapped.

The files were reduced to 3 files with continuous records:

Jan 25-26 – There are no TSG temperature and conductivity data in the early part of this file.

There is a gap from Jan 26 at 15:00 to Jan 28 at 14:17

Jan 28-Feb2 – All channels have data.

There is a gap from February 2 at 9:41 to Feb. 3 at 16:14.

Feb 3-8 – From Feb 3 at 16:14 to Feb 8 at 16:41, but there is a gap from 20:49 to 22:50 with a single value at 22:09:23 that looks bad compared to CTD data available at that time. The time-series plot shows the gap. This can be addressed in editing stage.

Next the files with no TSG data from the lab were examined to see if they overlap with the files above. One file contained data from the beginning of the cruise, but there are some gaps in it and the data changes abruptly. These data will not be processed.

Another file did have some data for January 25 that was contiguous with the data in the Jan 25-26 file, so that was added. There were other files with earlier records, but with the wrong date and the ship was not moving, so they are not worth adding.

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

The 3 files were rearranged to separate date and time, convert fluorescence in volts to ug/L, add a pressure column with all values set to 4.5 and add a scan #.

All NAN values were replaced with -99.

A “File Name” column was then added with format “2024-002-2024MMDD”. This will be used as a file break column to create 1 file per day.

These files were saved in CSV format.

The fluorescence voltage was converted to chlorophyll units using the scale factor from the last calibration and an offset based on previous cruises. Often the offset needs reducing to avoid negative values. The first estimate for the offset was 0.69. A few spot checks showed the fluorescence was generally a little lower than loop samples except for when the latter had very low values and the TSG values were higher. There was one early case where the TSG reading was much lower than the loop sample and a sample from a 5m loop. This raises the possibility that fluorescence from early in the cruise may not be reliable, but that can be investigated later. For every 0.01 volts subtracted from the offset will increase fluorescence by ~0.15ug/L and the offset has been drifting downwards in the past.

It is easy to recalibrate fluorescence later if the offset chosen (0.69) proves to be inappropriate.

Files lists were prepared for all casts, and for 2 groups of 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 2023 0:00:00. (Note that this step leads to problems plotting until REORDER is run.)

DERIVED QUANTITIES was run to derive salinity using the lab temperature. (Sigma-T was derived later.)

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 large distinct spikes in salinity that can mostly be removed using a graphical editor. There is a noisy intake temperature section while the ship was stopped at P20; none of the other channels show any significant variation. There are some spikes in fluorescence. The flow rate for the TSG

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 0.4 to 0.5C° range which looks reasonable in winter.

The flow rates both show some odd variations that are not reflected in the salinity or fluorescence data.

* Jan. 25/26 – Flow rates look fine but no Temp and Cond data until 19:54 when flow changes to negative but Temp and Cond are looking good. Fluorescence has a signal throughout, though values are very low, but quite possibly correct given the region.
* Jan. 28 to Feb 4 – Both flow rates look fine. All channels have reasonable values. Big spike on Jan 31st in all channels including flow. Some small spikes.
* Feb. 5 – brief dropout in main flow rate but data seems ok.
* Feb 6 – Editing needed near end.
* Feb 7 – No FL flow recorded but fluorescence data seems ok.
* Feb 8 – No FL flow recorded but fluorescence data seems ok.

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 2024-002-tsg-ctd-loop-rosette-comp.xlsx. There was no TSG data to match 13 of the casts and 5 casts had no CTD available at the intake depth, so there are 41 points of comparison.

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 #.

Data from the REM files were exported to spreadsheet.

Records were picked out for the times that match the CTD casts and added to the spreadsheet 2024-002-tsg-ctd-loop-rosette-comp.xlsx. Columns were added to calculate the differences between TSG and CTD latitude and longitude. This is used to ensure the matches are good.

TSG records with times closest to the CTD times were found in the files and copied to file 2024-002-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 23 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 0.0000° for latitude and 0.0002° longitude. The largest differences were 0.0017° at P1.

c.) Comparisons

There are some doubts about the quality of fluorescence data from early in the cruise when TSG temperature and conductivity were not being recorded. The value is very low compared to the CTD at JF2 and there is no loop to confirm that it is correct, so it was dropped from the comparison.

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

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Tintake-Tctd** | **Tlab-Tctd** | **TSG Sal-CTD Sal** | **TSGfl/TSGctd** |
| **average** | 0.0196 | 0.4491 | -0.2150 | 0.80 |
| **stdev** | 0.1178 | 0.1085 | 0.2861 | 0.31 |
| **median** | 0.0095 | 0.4501 | -0.1413 | 0.81 |
| **min** | -0.2167 | 0.1585 | -1.5001 | 0.25 |
| **max** | 0.5587 | 0.7796 | 0.3384 | 2.04 |

The median and average differences are far apart suggesting significant outliers, so data were sorted on the standard deviation in the TSG channel over 30s. The 20 casts with the lowest standard deviation in the relevant channel were then averaged, except that the fluorescence was based on the temperature standard deviation since it is so naturally noisy.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Tintake-Tctd** | **Tlab-Tctd** | **TSG Sal-CTD Sal** | **TSGfl/CTDfl** |
| **average** | -0.0090 | 0.4346 | -0.2266 | 0.82 |
| **stdev** | 0.0590 | 0.0599 | 0.1767 | 0.26 |
| **median** | 0.0052 | 0.4511 | -0.2478 | 0.82 |
| **min** | -0.2167 | 0.3408 | -0.5861 | 0.16 |
| **max** | 0.0702 | 0.5334 | -0.0382 | 1.45 |

This still left some significant outliers in the intake temperature that turned out to be mostly from the Strait of Georgia where vertical gradients were much larger than offshore. Unfortunately, there is less TSG data offshore, limiting the comparison, so all 17 offshore casts (2 had no T or S) were included:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Tintake-Tctd** | **Tlab-Tctd** | **TSG Sal-CTD Sal** | **TSGfl/TSGctd** |
| **average** | 0.0295 | 0.4649 | -0.0380 | 0.62 |
| **stdev** | 0.0253 | 0.0517 | 0.0012 | 0.30 |
| **median** | 0.0190 | 0.4624 | -0.0382 | 0.67 |
| **min** | -0.0014 | 0.3634 | -0.0399 | 0.16 |
| **max** | 0.0639 | 0.5731 | -0.0358 | 1.33 |

This did bring the average and median values closer together and made the differences in temperature and salinity larger.

The offshore surface salinity is very well-mixed, so vertical offsets between TSG and CTD sampling depths should not cause large errors. The differences offshore are quite consistent; they are likely due primarily to bubbles in the loop water. In the Strait of Georgia differences may be due to vertical offsets if the TSG data was drawing from shallower water than 4.5m.

Temperature was not as well-mixed offshore; it was noisy at the surface and mostly increased slightly with depth near the surface, but not consistently. This can explain the highly variable differences offshore. Nearshore the gradients were fairly large and increasing with depth. The fact that the TSG often read lower than CTD temperature may mean it was drawing water from a little higher in the water column. This is consistent with the lower TSG salinity as well.

Heating in the loop showed little variation through the cruise. The intake temperature didn’t vary much which likely explains that. The median difference is typical of winter values.

* Comparisons of Loop samples and TSG data

There were 23 loop CHL samples and 19 salinity samples.

The TSG salinity is lower than loop samples by a median of 0413psu with a standard deviation of 0.06psu, but that includes one clear outlier from the Strait of Georgia. When that is excluded the median is just slightly lower at 0.0408psu, but the standard deviation is 0.005psu.

The loop CHL values are all low, so the fit is not very informative. The ratio of TSG fluorescence to extracted CHL loop samples has a median of 1.05, average of 1.08 and standard deviation of 0.56. There was one outlier that may be associated with bad TSG data, but eliminating that has little effect on the average but does lead to a better fit of FL vs CHL with a slope of 0.9 when forced through the origin. However, the scatter makes the fit weak.

A better notion of the relationship between TSG FL and Loop CHL is seen when both are plotted against event #. Casts 57 to 98 are the furthest offshore and

The events from about 30 to 100 were well offshore, where CHL is low and fluorescence usually does read higher than CHL. The early samples are from Juan de Fuca where CHL was extremely low.

* Comparison of Loops and 5m Niskin Samples

CHL Loop samples were taken at the end of 5 rosette casts and salinity samples from 4 casts. 5m data from the rosettes were compared with loop salinity and chlorophyll samples.

* 1. Loop salinity was lower than CTD salinity during the bottle stop by a median of 0.0014psu and if one outlier was excluded 0.0017psu.
  2. Loop salinity was very close to the rosette samples for the 3 offshore sites (median difference -0.0002psu), but lower by 0.1729psu in the Strait of Georgia.
  3. The loop CHL samples were close to the rosette samples from 5m with differences varying from -0.01 to +0.03ug/L and a median difference of 0ug/L. The % differences ranged from the loop being low by 3% to high by 9%.

d.) Calibration History

* During 2022-008 the TSG fluorescence was higher than Extracted CHL by up to a factor of 2.5 for the samples with CHL < 0.4ug/L. It dropped sharply as CHL increased. It was close to CHL for CHL=0.7ug/L and about 20% of CHL for CHL=11.6ug/L. The TSG salinity was lower than the loop samples by a median of 0.021psu (std dev 0.024psu).
* During 2022-022 TSG fluorescence was lower than loop CHL for all but 1 sample. It was also lower than CTD fluorescence. For the 2 samples with CHL>7ug/L fluorescence was 50-60% of CHL values which is typical of this type of fluorometer. The TSG salinity was lower than the loop samples by a median of 0.0365psu and CTD by 0.0368psu. It was recalibrated by adding 0.036psu.
* During 2022-068 TSG fluorescence was higher than loop samples but CHL was extremely low. TSG fluorescence was higher than CTD fluorescence by about 38%, while the CTD fluorometer compared reasonably well with CHL from rosette casts. It was thought that the TSG fluorometer might be reading too high but it was hard to judge. TSG salinity was lower than loops by a median of 0.052psu and lower than CTD salinity b 0.047psu.

e.) Conclusions re TSG

1. There were serious problems encountered at sea in collecting these data. Sometimes flow looked fine but no data were acquired. At other times there were problems in the flow rate data but the TSG data look ok, so it is assumed the issue was with the flow meter and not the flow itself.

2. When the flow rates were present, they were mostly very steady, but there were some major drop-outs that will be examined in the editing process.

3. The best comparisons with CTD data occur where near-surface gradients are low. This was the case in the offshore sections of this cruise, but the TSG data had large gaps in the offshore, limiting the comparison to 15 casts for temperature and salinity and 17 for fluorescence. The change of CTDs was a minor complication, but after recalibration it was assumed that the two sets of data were compatible. Conditions at sea were extremely rough and the near-surface data are very noisy which is most noticeable in temperature since the vertical gradients were higher than for salinity.

3. The intake thermistor read higher than the CTD temperature at 4 to 5m by a median of 0.019C° offshore, but the standard deviations were large at 0.025C°. Inshore the difference between intake and CTD temperature was low, on average, but varied greatly in sign. This reflects differences in the near-surface gradients with some casts having temperature increase with depth and others decreasing or well-mixed.

4. The lab temperature was higher than the CTD temperature by 0.45C° overall and 0.46C° offshore. This is a reasonable difference for winter when intake temperatures are low. The standard deviation was 0.05C°.

5. TSG salinity was lower than CTD salinity by 0.038psu in the offshore (standard deviation 0.0012psu.) and lower than loops by 0.041psu It was much lower compared to CTD in the Strait of Georgia where vertical gradients were much higher. This suggests that the TSG is drawing water from above 4.5m. The low values offshore are likely due mainly to bubbles in the water given the rough conditions. Most of the loops are from the offshore as well. Adding 0.4psu to all values will bring the offshore values into line with CTD and loop data. Casts #103 and 105 were not included in either group in the comparison, but they do look close to offshore values. For the inshore casts the differences were much higher, with a median difference of 0.314psu. Since this is more likely due to the level from which the TSG is drawing water, than any error in calibration, no recalibration seems justified for this section of the cruise. Both the CTD and TSG values are subject to errors due to higher surface gradients. There is no reason to assume the CTD data are more reliable than the TSG data at these levels. So 0.4psu will be added up to February 6 and no correction will be applied to the data from Feb 7 and Feb. 8.

6. TSG Fluorescence was about 67% of CTD fluorescence offshore and 70% inshore. The casts from the first CTD have the TSG fluorescence reading significantly lower than the CTD and the few loop and rosette CHL samples available do not indicate that CHL was particularly low. The offsets in the calibration for the TSG fluorometer has been found to decrease with time. If the value of 0.69 is decreased by 0.02, that will increase the fluorescence by ~0.3. Tests were done by adding values from 0.1 to 0.3 to all TSG fluorescence and 0.2 was found to have a good effect. The median ratio of TSG/CTD fluorescence with that addition was 1.01 for the whole cruise, 0.90 offshore and 1.08 inshore. This effectively changes the offset to 0.67.

7. The 3 offshore loop salinity samples were in very good agreement with the rosette samples as were the 5 chlorophyll samples. The salinity loop sample from the Strait of Georgia was lower than the rosette sample by 0.173psu but it was only lower than the CTD salinity from the bottle file by 0.015psu. So the loop data look good, just likely from a little higher in the water column than the 5m rosettes.

f.) Editing

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

All \*.REO files were opened in CTDEDIT.

There were no data for Jan. 27.

No editing was applied to Jan. 28 and Jan. 29.

Jan. 25 – Deleted 1st record and padded negative flow rate data after 19:54.

Jan. 26 – Padded negative flow rate data.

Jan. 30, Jan. 31, Feb. 1, Feb. 2, Feb. 3, Feb. 4 – Cleaned Sal.

Feb. 5 – Cleaned Sal and padded data in channels Temperature:Lab, Salinity and Fluorescence when flow was clearly off briefly.

Feb. 6 - Cleaned Sal and padded data in channels Temperature:Lab, Salinity and Fluorescence when flow was off near end of cast. Main flow meter looked ok at end of cast but flow to fluorometer was 0 and that continued for the next day. Fluorescence data looked ok though little variation. Believe flow meter malfunction, but not certain so left 0 values.

Feb. 7 - Cleaned S and padded data in channels Temperature:Lab, Salinity and Fluorescence when flow was off briefly. Flow meter for fluorometer appears to have malfunctioned through whole day – fluorescence looks ok but not certain so left 0 flow without padding.

Feb. 8 – Records were removed from the end of the file since flow was off and the ship was not moving.

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 2024-002-tsg-recal.ccf to add 0.2ug/L to the TSG fluorescence and 0.04psu to channel Salinity for the offshore data. No salinity correction was applied to the data from February 7 and February 8.

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

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

editor and the file for Feb. 5th was put through another round of CTDEDIT.

Sigma-T was not derived earlier, as planned, so was done at this point. First, Pressure needed to be added to enable the calculation. ADD CHANNEL was run to add pressure = 4.5db. Then DERIVE was run to derive sigma-T.

REMOVE was rerun to remove channel Pressure.

The flow rate channels were left in the files.

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.

##### Loop File

The chief scientist provided file 2024-002-loops.csv with times for each CTD rosette surface bottle and loop sample plus results from analyses; the end time of casts were used when loops were during CTD casts.

The sampling method column indicates ROS or USW for loops.

6-line headers were added and the usual headers removed.

The columns were rearranged in the usual order of the 6linehdr files.

Sigma-T data were missing. Derived Quantities was run to derive Sigma-T for the CHE files. Sigma-T, event # and sample # were exported to a spreadsheet, ordered on pressure and all P>7db were removed. Sample #s from the 6linehdr file were added and the file was reorganized so that sample #s matched and blanks were entered for loop samples. The sigma T data were then added to the 6linehdr.

The file was then saved as 2024-002-6linehdr.csv.

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.

Edit Headers was used to add header comments about the cruise, CTD data and sample analysis.

Plots were made and no errors were found.

The track plot looks good.

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: 19, 20, 28, 47, 48, 49, 50, 57, 64, 66, 70, 72, 74, 83, 90, 94, 96

Split casts: None

Particulars - CTD

1-32. Used CTD #1515

47-140.

PARTICULARS- TSG

106. Problem with TSG Pump 2 flow 0 but water still flowing through. Stopped flow both pumps and cleaned out chunks.

Many files.

Missing data from ~500 on 26 Jan to ~1500 on 28 Jan

CTD

1. Test cast to fire all bottles. No CHE file needed.

3. No samples from Niskin 13 and 14 –records removed from MRG stage onwards.

6. Lots of current at bottom -5 minutes correcting after Bottle 2. Small SeaPoint fluorescence spikes at ~105, 62.

6. Bottles 15 and 16 tripped, but not sampled – no samples 29 or 30 – records removed at MRG stage onwards

9. Water depth changed to 135 after header entered. Fixed in raw files. Long 10m soak during LARS accumulators hooked up.

18. 30s soak below 400m 60s soak 0-400m.

20. Check bottom depth. – in previous cruises 2121 to 2540 – mostly around 2550, not 3005! (used 2500)

22. 5m loop water for barrel water for DMS. 24 bottles fired but only 1 needed in CHE file. Extra lines removed from files from MRGCLN2 stage on.

26. 23 bottles closed at 2000db not needed in CHE file. Only surface bottle needed. Extra lines removed from files from MRGCLN2 stage on.

28. Forgot second 3000m bottle (#161), at 2940m returned to 3000m to get it.

32. DMS cast. Weather getting rough.

38. Loop – depth may not be accurate.

48. Test cast for CTD#506. May not have pulled rosette out of water before cast 50. No CHE file needed and no CTD file prepared due to excessively noisy descent rate.

49. The wire wrap where things started getting funky on the winch drum was ~90m until ~150m. The LARS operator started descent at 0.5m/s during those depths to make sure things looked okay. then started paying out at normal 1m/s below ~150m. No CTD file prepared due to excessively noisy descent rate.

50. Stop on ascent at 1526m – winch issue.

57. 0.5m/s down, no up and down at surface – acquisition from start. Station name changed from “Gibson near” to “Seamount” in raw files. Extremely noisy descent with many complete reversals.

60. Loop -depth wrong?

61. loop - depth wrong?

76. P20 - some labels may indicate P16 – most corrected.

83 Stop at 300m downcast for ship position adjustment.

85. Forgot to uncheck "sequential bottle fire" in "configure inputs" in seasave prior to starting archive, thus had to change sample labels to reflect change in bottle number of the 5m bottle (was 1, now is 3)

87. Missed loop during cast, took soon after departure from P17

90. Niskin 5 accidentally closed at 2570db. Niskins 6, 7, 8 not at planned depth. No sample from 1250db.

94. Had to return to surface and start file again.

96. Depth in file 3833; should be 3315 based on max depth sampled plus altimetry at bottom.

103. Altimeter noisy near surface

111. to 5m off bottom.

116. New altimeter put on. Still fluctuated a bit at the surface but kicked in properly at 100m off the bottom and value descended nicely without spikes.

118. mushy bottom altimeter hits off plankton layer

116-129. Salinity:T0:C0 offset by about 0.015psu.

120. Salinity difference 0.01-0.02psu.

122. Acquisition starts before 10m soak.

134. Fraser River delta – lots of sediment in water.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **CTD#** | **Make** | **Model** | **Serial#** | | **Used with Rosette?** | | **CTD Calibration Sheet Competed?** | | |
| **1** | **SEABIRD** | **911+** | **1515** | | **Yes** | | **Yes** | | |
| **2** | **SEABIRD** | **911+** | **506** | | **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** | | **11Jan2023** | | **Factory** | |  |  | |
| **Transmissometer** | | **1883DG** | | **11Jan2023** | | **Factory** | |  |  | |
| **SBE 43 DO sensor** | | **1119** | | **10Feb2023** | | **Factory** | |  |  | |
| **PAR sensor** | | **70613** | | **24Feb2021** | | **Factory** | |  |  | |
| **SeaPoint Fluor.** | | **3950** | | **May 2023** | | **Factory** | |  |  | |
| **WetLabs Fluor.** | | **2216** | | **8 Mar2017** | | **Factory** | |  |  | |
| **Pressure Sensor** | | **1515** | | **17-Jan-2023** | | **Factory** | |  |  | |
| **Valeport Altimeter** | | **79487** | | **23Nov2021** | | **Factory** | |  |  | |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Calibration Information - 506** | | | | | |
| **Sensor** | | **Pre-Cruise** | | **Post Cruise** | |
| **Name** | **S/N** | **Date** | **Location** | **Date** | **Location** |
| **Temperature** | **2374** | **16Feb2023** | **Factory** |  |  |
| **Conductivity** | **3184** | **18Jan23** | **Factory** |  |  |
| **Secondary Temp.** | **4883** | **23Feb2023** | **Factory** |  |  |
| **Secondary Cond.** | **4395** | **18Jan2023** | **Factory** |  |  |
| **Transmissometer** | **1185DR** | **11Jan2023** | **Factory** |  |  |
| **Transmissometer** | **1883DG** | **11Jan2023** | **Factory** |  |  |
| **SBE 43 DO sensor** | **997** | **25Jan2023** | **Factory** |  |  |
| **PAR sensor** | **70613** | **24Feb2021** | **Factory** |  |  |
| **SeaPoint Fluor.** | **3949** | **May 2023** | **Factory** |  |  |
| **WetLabs Fluor.** | **2215** | **27Nov2018** | **Factory** |  |  |
| **Pressure Sensor** | **0506** | **22Feb2023** | **Factory** |  |  |
| **Valeport Altimeter** | **79487** | **23Nov2021** | **Factory** |  |  |
| **Valeport Altimeter\*** | **70613\*** | **24Feb2024** | **Factory** |  |  |

# \*altimeter changed to 70613 before cast 116

# TSG Make/Model/Serial#: SEABIRD/45/0620

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Calibration Information** | | | | | |
| **Sensor** | | **Pre-Cruise** | | **Post Cruise** | |
| **Name** | **S/N** | **Date** | **Location** | **Date** | **Location** |
| **Temperature-SBE45** | **45-0620** | **12Jan22** | **Factory** |  |  |
| **Conductivity-SBE45** | **45-0620** | **12Jan22** | **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** |  |  |
| **Temperature-SBE38** | **603** | **4Jan 2024** | **Factory** |  |  |





