## EVISION NOTICE TABLE

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| DATE | DESCRIPTION OF REVISION |
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## PROCESSING NOTES

Cruise: 2024-041

Agency: OSD

Location: North-East Pacific

Project: Offshore Deepsea Hecate

Chief Scientist : Du Preez C.

Platform: John P. Tully

Date: August 13, 2024 – September 3, 2024

Processed by: Germaine Gatien

Final Processing: 25 June 2025 – 24 July 2025

Number of HEX files: 49 Number of CTD files processed: 49

Number of rosette files: 45 Number of CHE files processed: 44 (1 file test only, no sampling)

Number of TSG txt files: 7 Number of TOB files processed: 18 (one per day)

# INSTRUMENT SUMMARY

CTD #0443 was mounted in a rosette and attached were 2 Wetlabs CSTAR transmissometers (1185DR and 1883DG), a SBE 43 DO sensor on the primary pump (#4372), SeaPoint Fluorometer (#4186) with 3X gain on the secondary pump, WetLabs ECO fluorometer (#2216), a PAR sensor (#70613) and an altimeter (#76341).

No changes were made to equipment during the cruise.

Seasave version 7.26.7.121was used for acquisition.

The data logging Computer was a Lenovo ThinkCentre (#102).

The deck unit was a Seabird model 11+ #508.

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

An IOS rosette with 24 10L bottles was used.

A thermosalinograph (SeaBird 45 S/N 620) was mounted with a WetStar fluorometer (WSCHL-1656).

# SUMMARY OF QUALITY AND CONCERNS

The Daily Science Log Book was in good order with a complete list of CTD equipment. There were no changes during the cruise.

Two fluorometers were mounted as part of a test to see if future use of ECO sensors will provide data consistent with older data from SeaPoint sensors. Results from earlier cruises confirmed that the ECO compares well with Seapoint. The comparison for this cruise showed good correspondence as well. Comparison of fluorometers with extracted chlorophyll was not very useful given mostly very low CHL values and a very high vertical chlorophyll gradient for the only sample >2ug/L.

There were a few repeated sample numbers and an error in an event number in the sampling log. However, given all sampling was done at night on a heaving ship with only 1 person operating the CTD and sampling, it is remarkable that there were only a few problems in the records.

PAR values are mostly very low due to casts being run at night.

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, 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:

 ±0.10 mL/L from 0-100db

 ±0.06 mL/L from 100db to 500db

 ±0.02 mL/L below 500db.

Thermosalinograph fluorescence data did not compare well with CTD fluorescence. The TSG readings were very low compared to the CTD fluorescence and it was much lower than the 2 loop samples. The comparison with samples from 5m rosettes also showed the TSG fluorescence to be low, though not as low as in the other comparisons. All sampling was at night and only 1 Loop and 2 Niskin samples had CHL>1ug/L. The data should be considered nominal. The flow to the fluorometer was good, with little variation.

Thermosalinograph salinity was recalibrated based on comparisons with CTD salinity, rosette samples and 2 loop samples. The correction (+0.24psu) is a rough estimate as there was significant variability. The low salinity is likely due to bubbles in the loop water.

Thermosalinograph intake temperatures were higher than CTD temperatures by more than could be explained as being due to a mismatch in the depths of TSG and CTD data sources. In some cases there were no temperatures in the full CTD profile as high as those seen in the TSG record at the same time. The temperature sensor was recently calibrated. A possible explanation is some heating from the ship.

It is recommended to take more loop samples when using a thermosalinograph, especially in areas where higher chlorophyll values are expected. Daytime sampling is especially useful when only running CTD casts at night.

# PROCESSING SUMMARY

##### Seasave

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

##### Preliminary Steps

* The configuration files used at sea were checked. No errors were found nor changes during the cruise.
* The configuration was saved as 2024-041-ctd.xmlcon.
* The Log Book and rosette log sheets were obtained. They were in good order.
* Dissolved oxygen, extracted CHL, nutrient and salinity data were obtained in QF spreadsheet format from the analysts.
* The cruise summary sheet was completed.
* The history of the T, C and P sensors was checked and noted in section 14.

##### BOTTLE FILE PREPARATION

The ROS files were created using file 2024-041-ctd.xmlcon.

The ROS files were converted to IOS Header format with extension \*.BOT.

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

Temperature and salinity were plotted for all BOT files to check for outliers. In a few casts there were significant differences in salinity channels but no obvious problem in either one.

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 sorted on sample numbers.

There was no sampling from bottles fired during event #2

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 2024-041-bot-hdr.txt which will be updated as needed during processing. The 2 loop samples were copied to file 2024-041-loops.xlsx.

DISSOLVED OXGYEN

Dissolved oxygen data were provided in spreadsheet QF2024-041\_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 2024-041oxy.csv. That file was converted into individual \*.OXY files.

There were 2 samples (174 and 264) in the DO file that had comments starting with “ALL:” Salinity was drawn from one of those bottles, so the same flag was added to the SAL file. No samples were taken from #264 because the cast was too shallow.

EXTRACTED CHLOROPHYLL

Extracted chlorophyll and phaeo-pigment data were obtained in file QF2024-041\_CHL QF\*.xlsx. The file included comments, flags and a precision study. A simplified version of the spreadsheet (without loop samples) was prepared and saved as 2024-041chl.csv.

The csv file was then converted to individual CHL files.

NUTRIENTS

The nutrient data were obtained in spreadsheet QF2024-041\_NUTS\*.xlsx. This includes a precision study. The file was simplified, saved as 2024-041nuts.csv. The file was converted to individual NUT files.

SALINITY

Salinity analysis was obtained in file QF2024-041\_SAL.xlsx; this includes a precision study. The analyses were carried out at IOS 10-15 days after collection. The files were simplified and saved as 2024-041sal.csv. That file was then converted to individual SAL files.

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

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

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

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

There was no sampling from event #2, so it was dropped from the file list.

The output of the MRG files were exported to a spreadsheet. A few problems were found and corrected:

* No data were found for event #27 because the Sampling Log had the wrong event #. Nutrient and CHL analysts were informed.
* Event 14, sample 49 and 50 are missing nutrients. The NUT file needed rearranging before merging due to duplicate sample numbers used at sea. A leading 9 had been placed in the 2nd instance of 4 sample numbers. The merge process was repeated after reordering in increasing sample # order.

A header check and cross-reference listing were produced. PAR values were all low, but since all CTD casts were run at night, this is reasonable. No other problems were noted.

A track plot looks fine.

##### Compare

Salinity

Compare was run with pressure as reference channel. There were 3 casts with salinity samples.

Records were excluded if the standard deviation in the CTD salinity was >0.0008psu plus samples in the top 250m. One outlier was excluded; it was sample already flagged by the oxygen analyst due to a leaking spigot. The primary salinity was low by an average of 0.0006psu (standard deviation 0.0005psu) and the secondary was low by an average of 0.0021psu (standard deviation 0.0008psu). The fit for the primary was very flat while the secondary has a little pressure dependence. This was also noted on earlier cruises, but does not appear to be getting worse.

While the primary salinity has usually been chosen for archiving in recent cruises using this CTD, there does appear to have been some bad data during upcasts for a few files. A quick look at full files suggests there are spikes in both channels at the surface, with the primary being a little worse than the secondary. However, more severe problems were found in the secondary for at least 1 cast.

Sample 264 was flagged 4 by the oxygen analyst with a comment that applies to all samples due to failing the Niskin integrity test. There was also a large bubble in the DO sample. The salinity sample flag was set to 46. The salinity QF spreadsheet was updated with the 4 flag since it is also an outlier in comparison with the CTD salinity. The updated file was sent to the salinity analyst.

For full details for the COMPARE run see file 2024-041-sal-comp1.xls.

Dissolved Oxygen

COMPARE was run with pressure as the reference channel.

Recent cruises using this CTD including DO sensor #4372 have had anomalous comparisons between CTD and titrated samples with the CTD values reading higher than samples instead of the usual pattern of mostly reading lower.

The first fit included all samples except the one flagged 3 by the analyst.

SBE DO Corrected = 0.972\*SBE DO original + 0.04

This is close to the results from 2024-006.

SBE DO Corrected = 0.987\*SBE DO original + 0.03

The offset is not expected to vary but we don’t have enough data from any one cruise to nail down the value and the behavior of this sensor is most unusual. There were some very low DO samples from this cruise, so the offset of 0.04 looks appropriate.

For full details for the COMPARE run see file 2024-041-dox-comp1.xls.

There are no significant outliers in the fits though the one already flagged is slightly out of line.

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

Fluorescence

COMPARE was run with pressure as the reference channel.

Uranine tests in February 2024 found a voltage threshold of 0.001 for the SeaPoint Fluorometer (gain 3x)and 0.058 for the ECO.

Tests were done to see how well the ECO and Seapoint fluorometers compared and differences were found to be slight.

First, the dark values were found by examining plots below 300db.

Dark Values: SeaPoint 4186 +0.012ug/L

ECO 2216 +0.02ug/L (rough value)

The configuration file for the Seapoint had an offset of -0.044 which is lower than the uranine test by 0.012, which matches the dark value. We could subtract 0.012ug/L though that would lead to some negative values.

The ECO has a jitter of ±0.025, so subtracting the dark value or uranine value will lead to a lot of negative values in ECO fluorescence.

Some will exist in deep water anyway, so CLEAN will be run to set those to 0.

Corrections were not applied since they are insignificant, particularly for the ECO with its jittery signal.

Making corrections by subtracting those values made little difference in the comparisons. The average ratio of ECO/SP was 2.54 using uncorrected values and 2.55 using corrected values. The corrections would lead to many negative values in ECO readings. Calibration errors appear to be insignificant.

The two fluorometers are very close with the ECO reading slightly higher.
All CHL values were low, in a range where fluorometers tend to read too high.

No corrections will be applied to either fluorescence channel.

The comparison of fluorescence with extracted CHL looks unusual with both sensors reading high.

However, the chlorophyll values are low, with only 1 sample having a value >2ug/L.

The highest CHL value was 2.45 ug/L and the 2 fluorometers had values 5.00ug/L and 5.02ug/L. Examination of the profile shows a sharp gradient so the difference could easily be due to the Niskin containing water from a few metres lower in the water column. For cases of CHL being lower than 1ug/L the fluorometers are expected to read higher than CHL. The relationship seems a little out of line with the usual distribution, but there is usually a lot of variability.

The plots of ECO/CHL and Seapoint/CHL versus CHL have the right general shape though with few high CHL samples this is hard to judge. There are a few samples that seem out of line but in one case there is likely an error in sample number and in another there is a very sharp gradient so even minor flushing errors may explain the outlier.

The analyst had some suspicions about samples being mislabelled for event 14 and sample 49A and loop 9049. The comparison with fluorometers is not very helpful in confirming this when CHL values are very low, but mislabelling does seem plausible.

The analyst also had suspicions about samples 234 and 235B being swapped and this does appear to be the case. Both fluorometers indicate a normal profile with the lowest value corresponding to sample 234.

Notes were sent to the analyst who made changes to data from event #66. The plots above were updated.

The deep sample had extremely low CHL so the ratios of fluorescence to CHL were not reasonable and were dropped from the study.

For more details see document 2024-041-fl-chl-comp1.xls.

A report on the comparison between ECO and SEAPOINT fluorometers was prepared based on data from 4 earlier cruises using several sensors of each type. The ECO sensor generally compared well with the Seapoint sensors. Uranine tests are now done regularly which are important for good calibration of the ECO sensors. No further comments were added as the current results are in good agreement with those studied previously.

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

Preliminary processing of these files were done in December 2024.

Tests were run to see if the choices made at that time were appropriate.

All files were converted using 2024-041-ctd.xmlcon.

The Tau function and the hysteresis function were selected since there was at least 1 deep cast. Depth was included in the conversion.

A few casts were examined. Shed wake corruption was obvious in some casts and there were some small spikes in conductivity,. Altimetry was 100 at the bottom for some casts, but likely the CTD did not get close to the bottom for those cases..

##### 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.

A few spikes noted in conductivity were successfully removed by this step.

##### ALIGN DO

ALIGNCTD was run on all casts using +2.5s, the setting that usually works best.

##### CELLTM

CELLTM was run using (α = 0.0245, β=9.5) for both the primary and secondary conductivity.

The CELLTM step is run to lower salinity where temperature is decreasing (cell warms water raising conductivity but temperature sensor reading is correct, so salinity is overestimated. Conversely, it raises salinity where temperature is increasing (conductivity too low). This brings downcast and upcast traces closer together, so T-S downcast and upcast plots are in better agreement after this step.

##### DERIVE and Channel Comparisons

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

Tests were run to see if the previous steps performed as expected:

* Some spikes noted in conductivity profiles were removed by WILDEDIT.
* The temperature and oxygen upcasts are quite noisy so hard to assess, but the alignment is definitely improved and downcast features are in good agreement with temperature traces, so ALIGNCTD appears to have worked well.
* The data were too noisy to see much difference between plots where CELLTM was run and those where it was skipped. In a few quieter sections it did appear to improve the correspondence between upcast and downcast in T-S space.

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

The sensors were used during cruise 2024-001 and 2024-069. Differences were found to be small during 2024-006 but values were not available.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cast # | Press | T1-T0  | C1-C0 | S1-S0 | Descent Rate |
| 2024-001-0030 | 550 | -0.0003 | -0.00038 | -0.0038 | High, V. Steady |
| 2024-001-0050 | 550 | -0.0004 | -0.00033 | -0.0037 | High, F. Steady |
| 2024-001-0074 | 550 | -0.0003 | -0.00032 | -0.0031 | High, F. Steady |
| 2024-069-0025 | 500 | -0.0010 | -0.00014 | -0.0008 | High, Moderate |
|  | 1000 | -0.0006 | -0.00017 | -0.0015 | “ |
|  | 1500 | -0.0003 | -0.00020 | -0.0020 | “ |
|  | 2000 | -0.0001 | -0.00021 | -0.0024 | “ |
| 2024-069-0036 | 500 | -0.0005 | -0.00014 | -0.0011 | High, Moderate |
|  | 1000 | -0.0004 | -0.00016 | -0.0016 | “ |
|  | 1500 | -0.0002 | -0.00017 | -0.0019 | ‘ |
|  | 2000 | +0.0001 | -0.00018 | -0.0023 | ‘ |
| 2024-069-0069 | 500 | -0.0006 | -0.00014 | -0.0011 | High, V. Steady |
| 2024-069-0180 | 500 | -0.0008 | -0.00024 | -0.0018 | High, V. Steady |
| 2024-041-0052 | 500 | -0.0008 | -0.00018 | -0.0010 | High XNoisy |
|  | 1000 | -0.0004 | -0.00022 | -0.0020 | “ |
|  | 1900 | +0.0002 | -0.00027 | -0.0032 | “ |
| 2024-041-0066 | 500 | -0.0008 | -0.00014 | -0.0008 | High XXNoisy |
|  | 1000 | -0.0005 | -0.00016 | -0.0016 | “ |
|  | 1900 | 0.0000 | -0.00024 | -0.0028 | “ |
| 2024-041-0082 | 500 | -0.0007 | -0.00009 | -0.0003 | High XXNoisy |
|  | 1000 | -0.0004 | -0.00015 | -0.0013 | “ |
|  | 1900 | +0.0002 | -0.00020 | -0.0028 | “ |

Temperature differences are small but those in conductivity and salinity are increasing with depth.

The pressure dependence in the salinity differences together with the pressure dependence in the secondary salinity comparison with bottles, suggests that the primary channels are more dependable. Unfortunately, the primary is a little spikier. Most casts are shallow where differences are only about 0.001psu.

##### 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.

There are some negative values in the ECO fluorescence channel; they are very small coming from a jitter in the signal when it is very low. Most will be removed by CLIP, DELETE or BIN AVERAGE. Any that remain will be removed later.

A cross-reference list was produced; station names were compared to those in the log; log entries were substituted where there were differences:

* Event 78 station name changed from TW04 to TW02
* Event 78 station name changed from TW07 to TW04

It is assumed that there was a 10m soak. There was a wait of between 20s and 50s after acquisition started.

##### Pressure, Water Depth and Position checks

* Surface check was run and found an average of 2.8db for downcasts and 2.9db for upcasts.
* A header check was run and the lowest pressure was found to be 1.11db during cast #43. There were pressures <1.3db for 21 scans (less than 1 second). The pumps were on. Both transmissivity channels dropped to near-zero very briefly. Conductivity remained very high for most records but there were a few pad values in conductivity. It appears that the CTD was very close to the surface. This is in line with other recent cruises when pressure was found to be high by 1.1db. Recalibration will be applied later to pressure and depth
* Cruise tracks were plotted, looked reasonable and were added to the end of this report.
* Header values for altimetry and water depth were exported to file 2024-041-altimeter-ctd.xlsx. The water depth when the CTD is at the bottom of casts is of more interest than when it is at the surface, especially if there is bottle sampling.

A “check value” was calculated as follows:

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

This value is expected to be close to 0, but in an area with narrow channels and steep slopes or near seamounts, larger check values are common. All cases with that value >5m were checked. There were 8 such casts. For 6 casts the CTD did not get within 15m of bottom, so no check is possible.

* First water depth entries were checked against the log entry for depth; where available and in 2 cases the log entry looks better.
* For 6 other casts the altimetry profiles were checked and the signal looks clear at the bottom of the cast. There are often problems with sounders in deeper water. Some of these casts are near seamounts and others near the shelf break, so shoaling during a cast may also account for the differences. In any case the depth of which we can be fairly certain is the depth when the CTD was at the bottom of the cast if altimetry shows it was within 15m of the seabed.
* A calculated water depth applicable to when the CTD was at the bottom of the cast was used to replace the header depth entries.
* Changes were made to the CLN files for the affected casts: 43, 45, 48, 49, 54, 64, 68,70.
* The same changes were made to the SAMAVG files for those events; MERGE and CLEAN were rerun.

##### Shift

Fluorescence

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

No change was made to the ECO fluorometry since it is not pumped and the alignment looks ok.

Dissolved Oxygen

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

Conductivity

Tests were run on a few casts to assess what settings are best to align conductivity with temperature (as judged by the effect on salinity as seen in T-S space). The best setting was -0.8 records for the primary and -0.15 for the secondary.

SHIFT was run twice to apply those settings on all casts. Salinity was recalculated.

##### DELETE

The following DELETE parameters were used:

Surface Record Removal: Last Press Min

Maximum Surface Pressure (relative): 10.00

Surface Pressure Tolerance: 1.0 Pressure filtered over 15 points

Swells deleted. Warning message if pressure difference of 2.00

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

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

Sample interval = 0.042 seconds. (taken from header)

COMMENTS ON WARNINGS: There were no warnings.

##### Other Comparisons

Experience with these sensors since last factory service –

CTD #0443 has been used for many previous cruises since it was last serviced at the factory. One of those cruises has not yet been processed.

* Pressure has been used on 12 previous cruises and for the last few a correction of -1.1db has been applied.
* The dissolved oxygen sensor was used during 9 previous cruises, of which only 3 had dissolved oxygen sampling. For 2024-001 there was only inland sampling; the fit of differences against bottles looked much different from the normal drift, so an estimate of drift was made at that time, but later reversed due to results of 2024-006. For 2024-001, 2024-006 and 2024-069 it was found the CTD DO was reading high, which was an unusual result.
* The primary conductivity sensor has been used for many cruises with variable comparisons but all within ±0.0025psu. During Line P in May 2024 it appeared to be low by about 0.0015psu. At the factory check in Dec. 2024 it appeared to be within 0.001psu.
* The secondary conductivity sensor has been used for 5 previous cruises with the only comparisons available showing it to be within ±0.002psu and the factory check before service in Dec. 2024 suggests salinity was very slightly low.

Historic ranges –Profile plots were made with 3-standard deviation climatology ranges of T and S superimposed where local climatology was available. All salinity data fell within the climatology ranges. There were 2 casts with temperature slightly above the climatology maxima for about 60m near 550m; both were casts close to the shelf break with water depths 1500m and 1800m. These values are likely correct and do not suggest calibration problems.

Post-Cruise Calibration – Factory checks were available for conductivity from December 2024 and conductivity from November 2024. There were significant errors in dissolved oxygen (reading high by roughly 5%) while salinity values looked to be within 0.002psu.

##### DETAILED EDITING

The decision on which channel pair to choose for archival is not clear. Both pairs had significant outliers but overall the primary looked easier to edit and the comparison did suggest slight pressure dependence in the secondary. So the primary was selected for editing.

The DEL files were zipped and submitted to the QC CTD program.

The DEL files were copied to \*.EDT to ensure there would be a complete set of EDT files whether they needed editing or not.

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

All casts needed editing.

The descent rate of the CTD was extremely noisy in the offshore part of the cruise, with many complete reversals of direction.

Notes about editing applied were added to the files.

The edited files were copied to \*.EDT.

After editing T-S plots were examined for all casts. A few small unstable features remain in a few near-shore casts, but no further editing appears justified.

The output files were compressed and submitted to the QC CTD program.

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

Silicate does not require recalibration since there was no salinity <25psu in bottle files.

The pressure sensor had been used on 12 previous cruises and for the last few a correction of -1.1db has been applied; that setting looks appropriate for this cruise as well.

The primary conductivity and temperature sensors have also been used on many previous cruises since last service and salinity was found to be within ±0.0025psu. During 2024-006 it was found to be low by about 0.0025psu and at the factory check later in the year it appeared to be within 0.001psu. During this cruise it was found to be low by 0.0006psu. No recalibration appears necessary.

The correction for the dissolved oxygen sensor was based on the bottle comparison and is in reasonable correspondence with results from other recent cruises that used this sensor.

File 2024-041-recal1.ccf was prepared to apply the following corrections:

 Pressure Corrected = Pressure -1.1

SBE DO Corrected = 0.972\*SBE DO original + 0.04

Note: Depth should have been recalibrated at this stage but was missed and Delete was run later to subtract 1.1m from depth.

These corrections were first applied to the SAM and MRGCLN2 files.

COMPARE was rerun on salinity and dissolved oxygen and shows that the corrections were applied properly

Pressures were also found to have been corrected appropriately.

Calibrate was then run the EDT files.

*The following information was entered in the sensor history.*

*Pressure*

*#0443 – high by ~1.1db– subtracted 1.1db.*

*Conductivity*

*#2754 – Based on COMPARE -Salinity- Low by 0.0008; no recalibration applied.*

*#1766 – Based on COMPARE -Salinity - Low by 0.0021; not archived & not recalibrated..*

*Oxygen-Dissolved - #4372 – COMPARE fit: DO Corrected = 0.972\*SBE DO original + 0.04.*

##### 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 recalibrated 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.

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

 ±0.10 mL/L from 0-100db

 ±0.06 mL/L from 100db to 500db

 ±0.02 mL/L below 500db.

Below the OMZ most downcast values were slightly lower than bottle DO, while above the OMZ the opposite is true. This is likely due to incomplete flushing of bottles as the gradient reverses at the minimum.

For details see files 2024-041-dox-comp3.xls

##### Fluorescence Processing

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

##### BIN AVERAGE of CTD files

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

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

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

On-screen T-S plots were examined. There were no significant unstable features.

Profile plots were examined to see if there any problems. The only problem noted was in the ECO fluorometer channel which had extremely high values above 2db. Those values were padded in he bin-averaged file.

There are some slightly negative values in ECO fluorescence (-0.015ug/L), CLEAN was run to reset header limits and to replace negative fluorescence values with 0.

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

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

REORDER was run to get the two DO channels together.

REMOVE was run to remove the following channels:

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

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

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

The Header Check was run; no problems were found.

CALIBRATE was run a second time to correct the depth (2024-041-recal2.ccf).

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

##### Dissolved Oxygen Study

As a final check of dissolved oxygen data, % saturation was calculated and plotted. Values at 2m ranged between 94% and 108%, with only 2 casts outside the 102-108% range. These values are typical of offshore results.

##### Final Bottle Files

MRGSORT was run to get files in pressure order.

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

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

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

HEAD EDIT was run to add comments to the headers.

CALIBRATE was run a second time to correct the depth (2024-041-recal2.ccf).

Data were exported from the CHE files to file 2024-041-bottles-final.xlsx. The entries were compared with the compiled sampling document and no data were found to be missing.

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

The track plot looks ok.

A cross-reference listing was produced for the CHE files.

##### TSG

An IOS TSG45 was used for this cruise and data were saved in multiple text files.

6 files were opened. There was one 2-minute gap from 2:45:00 on Aug. 13 to 2:47:20. No other gaps were found between the files, so they could be combined.

The file was renamed as CSV and opened in EXCEL.

Formatting problems included having Date and Time columns combined and a few NAN entries.

The file was opened in Ultraedit to separate Date and Time with quotation marks around both.

The NAN entries were replaced with pad values.

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

The first 10892 records were removed since the ship was not moving and for most of the records flow rate was 0.

Records from the last few minutes of the record were also removed as the ship was stopped and flow was off.

The fluorescence channel is in volts. It was moved to column M with Paste Special to retain values and a concentration value was calculated in column F using scale 14.6 as determined in the most recent factory recalibration of the fluorometer. The offset was 0.081 when last calibrated but that was in 2021 and this value has been steadily reduced over the years, with 0.066 being the most recent value used. But when applied to these data the result was very poor with many negative values. In order to get positive values the offset had to be lowered to 0.028.

Even with that change the calculated TSG fluorescence values were an order of magnitude lower than loop samples and 2 to 4 times smaller than a few 5m rosette values that were selected. Normally TSG fluorescence reads higher than extracted CHL when the latter values are low. The only high TSG fluorescence was in Johnstone Strait where there were no CTD casts or loops.

The results here are puzzling. The fluorescence values must be considered nominal.

A file break column was added and entries made with format 2024041-MMDD-HHMMSS.

The files were then converted to IOS Header format with header info added. There are 18 IOS files, each covering all or part of 1 day.

Files lists were prepared for all casts, and for 4 groups of 4 or 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 to derive salinity using the lab temperature.

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. There were no significant spikes. There was a 14-minute section with 0 flow to both TSG and Fluorometer on August 21.

CTDEDIT was used to pad values in Temperature:Intake, Temperature:Lab, Salinity, Conductivity and Fluorescence channels for that section. The flow rate and position data for that section were left unedited. The output file was copied to \*.REO.

No other editing was found necessary.

A plot of all differences (Lab Temp – Intake Temp) through the whole record shows enormous variability, with an average difference of 0.33Cº and a median difference of 0.31Cº 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 2024-041-tsg-ctd-loop-rosette-comp.xlsx. There are 49 CTD casts in the comparison and 2 loop samples.

On one worksheet the CTD data were combined with TSG data.

The TSG files were averaged over 6 records (30 seconds) to reduce the noise and file size. Standard deviations were included.

Data were extracted with TSG time closest to CTD cast start times.

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

TSG data were found at closest times to the 2 loops and added to the Loop vs TSG worksheet.

A comparison was also made of extracted CHL from near-surface rosette samples and TSG fluorescence at the beginning of casts. The times don’t match exactly but as the ship was stopped there is not likely much temporal variation.

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 0.0002º for both latitude and longitude. The largest differences were 0.003º during cast #28.

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:

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Using all data |  |
|  | Tint-Tctd | Tlab-Tctd | Tlab-Tint | SALtsg-SALctd | FLtsg / FLctd |
| median | 0.1527 | 0.4210 | 0.2947 | -0.2331 | 0.212 |
| average | 0.2149 | 0.5114 | 0.2965 | -0.2314 | 0.200 |
| stdev | 0.3404 | 0.3591 | 0.1242 | 0.0394 | 0.045 |
| max | 1.8998 | 2.1470 | 0.7272 | -0.0384 | 0.309 |
| min | -0.1158 | 0.2408 | 0.0295 | -0.3182 | 0.065 |

When the 20 casts were chosen that had the lowest standard deviation over 30s for each variable, the median differences were:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Tint-Tctd | Tlab-Tctd | Tlab-Tint | SALtsg-SALctd | FLtsg / FLctd |
| median | 0.0529 | 0.4098 | 0.3742 | -0.2344 | 0.212 |

* The intake temperature is higher than the CTD temperature by more than we would like, but given TSG and CTD data may come from slightly different levels any vertical temperature gradient does affect this result. While a small mismatch in level can explain small differences, checks of a few casts could find no temperature reading in CTD files (before editing and binning) that are as high as measured by the TSG. It seems likely that the temperature near the intake thermistor is subject to heating from the ship that vary depending on factors like sea state or wind direction. Given that the differences were higher later in the cruise, there could be a storm‑related factor. The sensor was recently services though calibration drift is still possible. Recalibration will not be attempted since the variability is so high.
* The lab temperature is higher than the CTD temperature by a median of 0.421 Cº or 0.410Cº using just the 20 with lowest standard deviation. This is slightly lower than the 0.45Cº during 2024-002 (January/February) though we expect less heating in summer than winter. Since the intake temperature appears to be reading a little higher than the CTD, a better measure of heating in the loop is the differences between lab temperature and intake temperature; the lab temperature is higher than the intake temperature by a median of 0.374Cº.
* Differences between CTD and TSG salinity are highly variable, due to variations in vertical salinity gradients and density of bubbles in the loop water. For example, during 2024-002 the TSG salinity appeared to be low by 0.038psu offshore and 0.314psu inshore. During this cruise the differences were quite consistent early in the cruise at about 0.23psu, but gradually increased to about 0.26psu later in the cruise. The descent rate of the CTD was extremely noisy in the offshore part of this cruise; a storm passing through would likely increase the presence of bubbles in the water, which may explain the lower salinity later in the cruise.
* Fluorescence is the hardest variable to understand. The TSG fluorescence values are a median of 21% of CTD fluorescence values. The ratio of TSG/CTD fluorescence dropped from about 0.25 to 0.15 through the cruise. The flow rate to the fluorometer was quite steady and minor variations are not correlated with variations in the ratio. CHL vertical gradients may be a factor, but that does not explain the overall low values.
* Comparisons of Loop samples and TSG data

There were 2 loop samples, both taken in daytime.

TSG salinity was lower than the loop salinity by 0.1940psu and 0.2787psu.

TSG fluorescence was 9% of loop CHL for a sample with CHL=5.39ug/L and 12% for a sample with CHL=0.94ug/L.

* Comparison of TSG and 5m Niskin Samples

Comparisons were made between Niskin sampling and TSG data, but to simplify the task TSG data were taken from the beginning of the casts. Since the ship was stopped this should not introduce too large an error.

There were only 3 Niskin salinity samples. The TSG salinity was lower than the rosette samples by an average of 0.025psu with a range of -0.2385 to -0.2745psu. The 3 differences are in good agreement with the comparison with CTD salinity.

There were 27 CHL rosette samples. These were compared with CTD fluorescence at the beginning of casts. What is typically seen from these fluorometers is that fluorescence readings much lower when CHL is very low and gradually falls to being close to CHL at about 1ug/L and becomes lower than that as CHL rises, settling at about 40-50% of CHL for high CHL. For these data the general pattern is there but the fluorometers appears to drop faster than expected so that it is only 40% of CHL when CHL=1.5ug/L. This is further evidence that the fluorometer is reading lower than expected. However, all sampling was at night which may be affecting this result. And results do vary a lot in studies of fluorometer versus CHL.

d.) Calibration History

The TSG was serviced and recalibrated in early 2022. The intake thermistor was recalibrated in early 2024.

* 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.
* During 2024-002 salinity was low by 0.038psu in the offshore and 0.314psu in the Strait of Georgia. It was lower than loops by 0.041psu. The intake temperature was high by a median of 0.019C° but standard deviations were 0.025C°. Heating in the loop was about 0.45C°. TSG Fluorescence was about 67% of CTD fluorescence offshore and 70% inshore

e.) Conclusions re TSG

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

2. Both flow rates were in a good range, with just one 14-minute drop-out on August 21.

3. Thermosalinograph fluorescence data did not compare well with CTD fluorescence. The TSG readings were very low compared to the 2 loops available and CTD fluorescence. The comparison with samples from 5m rosettes also showed the TSG fluorescence to be low, though not as low as the other comparison. All sampling was at night and only 1 Loop and 2 Niskin samples had CHL>1ug/L. The data should be considered nominal as there is insufficient evidence to conclude that the data are good or bad.

4. Thermosalinograph salinity was recalibrated based on comparisons with CTD salinity, rosette samples and 2 loop samples. The correction is a rough estimate (+0.24psu) as there was significant variability. More loop samples would have been very helpful.

5. Thermosalinograph intake temperatures were higher than CTD temperatures by more than could be explained as being due to vertical offsets in the presence of temperature gradients. Intake temperatures may be raised by variable ship effects as temperatures were found that were higher than any seen during co-incident CTD casts.

6. More loop samples would have been very helpful for fluorescence and salinity calibration checks.

f.) Editing

No graphical editing was applied.

g.) CALIBRATE, REMOVE and CLEAN

CALIBRATE was run using file 2024-041-tsg-recal.ccf to add 0.24psu to channel Salinity.

DERIVED QUANTITIES was run to derive salinity using the intake temperature to derive sigma-T.

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

h) Preparing Final Files

HEADER EDIT was used to change the DATA DESCRIPTION to THERMOSALINOGRAPH and add the depth of sampling to the header and to change channel names to standard names and formats and to add comments.

Plots were examined and a few large single-point spikes in salinity were found and replaced with pad values using a text editor.

Standards checks were run and a number of problems found; those were fixed in Header Edit until all issues were resolved.

As a final check plots were made of the cruise track and all look fine.

The TSG conductivity sensor history was updated.

**Particulars -**

2. Test cast – all bottles fired but no sampling.

6. Winch operator went slow.

14. The same sample number was applied to 2 different Niskins at 4 depths. In each cast a leading 9 was used for the sample number of the 2nd Niskin closed. Example: Niskin 3 was given sample # 0043 and Niskin 4 was given sample # 9043.

48. Sample 174 was planned at 1000db but depth was too shallow, so that sample # was not used.

**2024-041 CRUISE SUMMARY – CTD**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **CTD#** | **Make** | **Model** | **Serial#** | **Used with Rosette?** | **CTD Calibration Sheet Competed?** |
| **1** | **SEABIRD** | **911+** | **0443** | **Yes** | **Yes** |
| **Calibration Information - 0443** |
| **Sensor** | **Pre-Cruise** | **Post Cruise** |
| **Name** | **S/N** | **Date** | **Location** | **Date** | **Location** |
| **Temperature** | **2106** | **15Feb2023** | **Factory** |  |  |
| **Conductivity** | **2754** | **14Feb2023** | **Factory** |  |  |
| **Secondary Temp.** | **5130** | **18Mar2023** | **Factory** |  |  |
| **Secondary Cond.** | **1766** | **18Jan2023** | **Factory** |  |  |
| **Transmissometer** | **1185DR** | **11Jan2024** | **IOS** |  |  |
| **Transmissometer** | **1883DG** | **11Jan2024** | **IOS** |  |  |
| **SBE 43 DO sensor** | **4372** | **27Mar2023** | **Factory** |  |  |
| **PAR** | **70613** | **24Feb2024** | **Factory** |  |  |
| **SeaPoint Fluor.\*\*** | **4186** | **Aug 2023** | **Factory** |  |  |
| **WetLabs ECO Fluor** | **2216** | **8Mar2017** | **Factory** |  |  |
| **Pressure Sensor** | **0443** | **23Mar2022** | **Factory** |  |  |
| **Valeport Altimeter** | **76341** | **10Feb2021** | **Factory** |  |  |

# 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** |  |  |

Test cast near Victoria is not included to enable better display.



Test cast near Victoria is not included to enable better display.



