## REVISION NOTICE TABLE

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

## PROCESSING NOTES

Cruise: 2022-068

Agency: IOS, Ocean Sciences Division, Sidney, B.C.

Location: North-East Pacific

Project: Joint Canada-USA International Seamount Survey

Chief Scientist: Rooper C.

Platform: John P. Tully

Cruise Dates: 6 September 2022 – 20 September 2022

Processed by: Germaine Gatien Preliminary files prepared by: Hana Hourston

Date of Processing: 17 April 2023 – 8 May 2023

Number of original HEX files: 35 Number of processed CTD files: 35

Number of rosette casts: 19 Number of processed CHE files: 15 (4 eDNA only -no bottle files required)

Number of original TSG csv files: 1 Number of processed TOB files: 11 (1 per day)

# INSTRUMENT SUMMARY

CTD #0443 was mounted in a rosette and attached were 2 Wetlabs CSTAR transmissometer (1185DR & #1883DG), a SBE 43 DO sensor on the primary pump (#3791), SeaPoint Fluorometer on the secondary pump (#3641), a Biospherical QSP-400 PAR sensor (#70613), a SPAR sensor and an altimeter (#76341).

A thermosalinograph (SeaBird 45 S/N 0620) was mounted with a Wetlabs WETStar fluorometer (#1656) and flow meter; sampling interval was 5s.

Seasave version 7.26.7.121 was used for acquisition.

The data logging computer WP #102.

The deck unit was a Seabird model 11+ #425.

An IOS rosette with 24 10L bottles was used.

# SUMMARY OF QUALITY AND CONCERNS

Preliminary files were prepared by H. Hourston in December 2022 for the use of the chief scientist.

The Daily Science Log Book and rosette log sheets were generally in good order with comments about problems encountered and a detailed list of equipment. Especially appreciated were comments about computer problems affecting the thermosalinograph. There was some confusion about what sensors were in use. A Surface PAR was not in the log list, but was in the configuration file and towards the end of the cruise produced a very small signal of a size that was possible at night; none of the data looked useful, so the channel was removed. The column for PAR status had NO entered throughout but there were signals and normal-shaped profiles for PAR up to event #21, after which there is no signal. Values were very low for all casts except #1 since most were night-time casts.

A few casts had eDNA sampling only with no sample numbers assigned; no bottle files were created for those casts.

Events #4 and #16 were misnamed as ##5 and #15 in the Sample Master list, on sample labels and on the Sampling Log sheet. It was correct in the Daily Science Log.

There were only 4 salinity samples and 3 of them were from 10m off the bottom. For calibration purposes it is best to get samples further from the bottom.

There is no mention in the log of the PAR sensor being removed. The column for PAR status says NO throughout, but PAR is in the configuration file and the first cast does have a reasonable profile and fairly high values. A few others have the right profile shapes but very low values, but most casts were run at night, so low values are expected. For events #1-21 it appears there is a signal, but after that there is no signal. The Surface PAR has a signal but it is very low, even during cast #1 when the PAR was fairly high, so the data do not look useful. Channel PAR will be removed from casts #22 to the end of the cruise and channel PAR:Reference will be removed from all casts.

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.

There were dissolved oxygen maxima between 20m and 50m and associated transmissivity minima.

The comparison of Oxygen:Dissolved:SBE with dissolved oxygen samples suggests that the hysteresis factor in the sensor calibration file may need adjustment. There were too few deep samples to establish a better setting; this was only noticeable below 1700db and potential errors for this cruise would be <0.02mL/L.

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

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

roughly, to be:

 ±0.25 mL/L from 0-500db except in areas of very large DO gradients

 ±0.07 mL/L from 500db-600db

 ±0.04 mL/L below 500db

The Thermosalinograph worked well with good detail in temperature, salinity and fluorescence traces and few spikes in salinity. There were some gaps due to computer crashes. The flow rate to the CTD had more variability than usual, while the flow to the fluorometer was very steady. The intake temperature is in reasonable agreement with co-incident near-surface CTD observations. The differences between lab and intake temperatures were of an expected size. Salinity was recalibrated by adding 0.047psu based on comparisons with CTD salinity and loop samples. There has been a steady and significant drift in the calibration since it was last serviced. TSG fluorescence values were about 38% higher than those from the CTD fluorometer. Assessment of the TSG fluorometer was hampered by the very low extracted chlorophyll values; fluorometers always read much higher than CHL in those conditions.

# PROCESSING SUMMARY

##### Seasave

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

There was a SPAR sensor in the configuration files that was not included in the equipment list.

It is assumed that the standard deployment procedure was used 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. Then the full cast would start.

For all rosette casts:

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

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

##### Preliminary Steps

The Log Book and rosette log sheets were obtained.

* Nutrients, extracted chlorophyll, dissolved oxygen and salinity were obtained in QF spreadsheet format from the analysts.
* The cruise summary sheet was completed.
* The history of use of the pressure sensor and conductivity and dissolved oxygen sensors was obtained. 2022-008 and 2022-022 had used them since they were last serviced at the factory.

The configuration files were checked; there were no changes during the cruise and all entries were correct.

##### BOTTLE FILE PREPARATION

The ROS files were created using file 2022-068-ctd.xmlcon.

The ROS files were converted to IOS format.

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

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

A preliminary header check was run; no problems were found, though it is noted that the pumps were off for the last few records in at least one cast.

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.

Cast #42 had note of problems on the Sampling Log sheet – the notes were not accurate, but still useful.

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 2022-068-bot-hdr.txt which will be updated as needed during processing.

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

DISSOLVED OXGYEN

Dissolved oxygen data were provided in spreadsheet QF2022-068\_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 2022-068oxy.csv. That file was converted into individual \*.OXY files.

EXTRACTED CHLOROPHYLL

Extracted chlorophyll and phaeo-pigment data were obtained in file QF2022-068\_CHL QF\*.xlsx. The file included comments and flags and a precision study. A simplified version of the spreadsheet was prepared and saved as 2022-068chl.csv. The csv file was then converted to individual CHL files.

SALINITY

Salinity analysis was obtained in file QF2022-068\_SAL.xlsx which included a precision study. The analyses were carried out in a temperature-controlled lab 54 to 60 days after collection. The files were simplified and saved as 2022-068sal.csv. That file was then converted to individual SAL files.

NUTRIENTS

The nutrient data were obtained in spreadsheet QF2022-068\_NUTS\*.xlsx and includes a precision study. The file was simplified, saved as 2022-068nuts.csv. The file was converted to individual NUT files.

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

After the 4th step CLEAN was run 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. Only 1 problem was found:

* Event 42 – Niskin #12 was fired accidentally and there was no sampling or sample # for that bottle. So that line was removed from the SAMAVG file and the merge rerun.

The merge process was repeated for event #42.

Analysts were informed of a few errors that have been corrected on paper and digital logs but need fixing in the QF files:

* Event #4 should be #5 (NUT,OXY,CHL)
* Event #15 should be #16.(SAL,NUT,CHL)

The DO analyst was informed that for sample #21, flagged 46 by the analyst as replicate outliers, the lower value (2.168) looks much better in the fit (CTD DO 2.17mL/L after recalibration).

New QF files were received and DO in file 2022-068-0005.CHE was updated.

##### Compare

Salinity

Compare was run with pressure as reference channel. There were only 4 samples and 3 were from only 10m off the bottom. The primary salinity was found to be low by an average of 0.0023psu (std dev 0.0017) and the secondary was low by 0.0033psu (std dev 0.0017). When the 3 near the bottom are separated from the 1 far from the bottom there is a clear difference with the near bottom cases being low by 0.0015 and 0.0025psu while the 1 far from bottom being low by 0.0046psu and 0.0056psu.

The problem with choosing bottles at b-10m is that shed wakes come from above with salinity in the Niskin bottles likely to be lower than ambient conditions, and there may shed wakes coming from a long distance away and possibly bouncing between the rosette and the bottom. The 1 case with a bottle from far from bottom is more likely to have achieved ambient conditions as shed wakes would disappear.

So it is clear that the primary and secondary salinity are within 0.001psu of each other. If the analysis had been quick we might guess that they are low by approximately 0.0046 and 0.00056, but analysis was delayed by about 2 months, so there may well have been some evaporation/desorption of samples, so that error estimate may be too high.

During the previous cruise analysis was done very quickly. The primary salinity was lower than bottles by an average of ~0.0015psu and the secondary salinity was low by an average of ~0.0004psu. The primary was farther from bottles than the secondary, which is the opposite to what is observed here. All 4 samples show the primary being closer to bottles.

There are too few bottles to identify outliers.

For full details for the COMPARE run see file 2022-068-sal-comp1.xls.

Dissolved Oxygen

COMPARE was run with pressure as the reference channel.

There is a fairly tight fit with only 2 large outliers among the 5 identified based on residuals. Both come from around 25db in casts with large, sharp reversals at that depth. No further flagging of samples is justified.

A few notes of interest:

* Sample #21 was an outlier and had been flagged 46 by the analyst as replicate outliers. The lower value (2.168) looks better in the fit.
* The offset for the fit is of the opposite sign to that usually found in recent times.
* There is no evidence of time dependence.
* The casts were from 2 different areas. When separated into casts 3&5 and 16 to 54 with a few outliers removed, the fits are very similar.
* The largest outliers came from around 25db in the presence of very sharp DO gradients, so are not evidence of problems with samples.
* A hysteresis check was made and the bottles from below 1700db look very slightly out of line. There are too few bottles and considerable scatter and the error is too small to establish a suitable change to factor E in the DO configuration, but if this sensor is used again for deep sampling more tests should be run. At most the SBE DO values could be high by 0.02mL/L below 1700db.

The fit when a few outliers were excluded based on residuals is:

 CTD DO Corrected = CTD DO \* 1.0187 - 0.042 R2 = 0.88

During 2022-008 the fit from most casts was:

CTD DO Corrected = CTD DO \* 1.0156 + 0.0036

A few 2022-008 casts did not fit that pattern but there was insufficient sampling to establish a better fit.

For 2022-022 there was a change part-way through the cast with 2 fits used:

CTD DO Corrected = CTD DO \* 1.0164 + 0.0063

CTD DO Corrected = CTD DO \* 1.0204 + 0.0282

Fortunately, for this cruise no such changes were noted. The slope is reasonably close to those from earlier cruises, though the offset is quite different.

The only change recommended is to Sample #21 as mentioned above.

Plots were made of SBE DO and Titrated DO versus salinity and no further outliers were noted.

For full details for the COMPARE run see file 2022-068-dox-comp1.xls.

Fluorescence

COMPARE was run with extracted chlorophyll and CTD Fluorescence using pressure as the reference variable. There were no high CHL values, maximum 1.42ug/L, and at those levels the fluorometers almost always read higher than CHL. The ratio of CTD FL / CHL range from about 8 for CHL~0.2ug/L to 1.2 for CHL~1.4ug/L. The plots below show a rough split into 2 groups.

The CHL levels were especially low for the northern part of the cruise (Casts 3-10) and most of the points above the trendline in the first plot came from the north. To the south CHL values were a little higher, on average.

In the second plot there is a lower FL/CHL ratio in the south due to higher CHL values there.

The only significant outlier was from cast #42 at 25m. There was a peak in fluorescence at that level, so it is likely that the large difference is due to the sample and CTD data not coming from exactly the same depth.

For full details for the COMPARE run see file 2022-068-fl-chl-comp1.xls.

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

File 2022-068-ctd.xmlcon was used to convert all files. The Tau function and the hysteresis function were selected since there was deep sampling.

A few casts were examined and all expected channels are present.

The downcast T and C pairs look very close, while upcasts are noisier. There were a few isolated spikes in conductivity. The fluorescence dark value is ~0.085ug/L. Transmissivity looks normal for both sensors.

There is no mention in the log of the PAR sensor being removed. The column for PAR status says NO throughout, but PAR is in the configuration file and the first cast does have a reasonable profile and a maximum value >1100. A few others have the right profile shapes but very low values, but most casts were run at night, so low values are expected. For events #1-21 it appears there is a signal, but after that it looks like the sensor was not connected.

The Surface PAR occasionally has a signal but values are very low, even during cast #1 when the PAR was fairly high, so the data do not look useful.

PAR data will be reviewed at the REMOVE stage.

##### 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.

Conductivity spikes noted in the previous step were removed.

##### ALIGN DO

A few casts were examined; both temperature channels were noisy during upcasts so the tests were not easy to interpret, but using +2.5s improved the alignment and overall looks like a good choice. That value is the one most often chosen for the SBE911s. ALIGNCTD was run on all casts using +2.5s.

##### CELLTM

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

##### DERIVE and Channel Comparisons

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

The alignment of dissolved oxygen looks reasonable, though there are some sharp gradients and reversals in both that challenge the oxygen sensor response, so that upcast and downcast do look quite different at times.

DERIVE was run a second time on 3 casts to find the differences between the pairs of temperature, conductivity and salinity channels. The shaded entries are from previous cruises using the same equipment.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cast # | Press | T1-T0  | C1-C0 | S1-S0 | Descent Rate |
| 2022-008-0027 | 1000 | 0 | 0 | -0.0001 | High, Mod |
|  | 2000 | -0.0004 | 0.00002 | 0.0004 | “ |
| 2022-008-0067 | 1000 | -0.0002 | -0.00004 | -0.0003 | High, XNoisy |
|  | 2000 | -0.0006 | -0.00002 | 0.0002 | “ |
|  | 3000 | -0.0006 | -0.00003 | 0.0003 | “ |
|  | 4000 | -0.0007 | -0.00003 | 0.0004 | “ |
| 2022-008-0093 | 1000 | -0.0007 | -0.00007 | -0.0003 | High, VNoisy |
|  | 2000 | -0.0007 | -0.00005 | 0 | “ |
|  | 3000 | -0.0007 | -0.00006 | 0 | “ |
|  | 4000 | -0.0007 | -0.00005 | 0.0001 | “ |
| 2022-022-0044 | 1000 | -0.0005 | -0.00011 | -0.0009 | High, VNoisy |
| 2022-022-0053 | 1000 | -0.0004 | -0.00012 | -0.0010 | High, Noisy |
|  | 1400 | -0.0004 | -0.00011 | -0.0009 | “ |
| 2022-022-0104 | 1000 | -0.0001 | -0.00013 | -0.0014 | High, Mod |
|  | 1900 | -0.0004 | -0.00012 | -0.0011 | “ |
| 2022-022-0150 | 1000 | -0.0001 | -0.00012 | -0.0015 | High XNoisy |
|  | 1900 | -0.0005 | -0.00013 | -0.0012 | “ |
| 2022-068-0016 | 1000 | -0.0003 | -0.00015 | -0.0016 | High, VNoisy |
|  | 1900 | -0.0007 | -0.00015 | -0.0012 | “ |
| 2022-068-0041 | 1000 | -0.0004 | -0.00017 | -0.0017 | High, Mod |
|  | 1900 | -0.0006 | -0.00017 | -0.0012 | “ |
| 2022-068-0056 | 1000 | -0.0003 | -0.00020 | -0.0020 | High, XNoisy |
|  | 1900 | -0.0006 | -0.00020 | -0.0015 | “ |

All differences were small. There is little change in temperature differences but a small increase in conductivity and salinity differences over the 3 cruises.

##### Conversion to IOS Header Format

The IOSSHELL routine was used to convert Sea-Bird 911+ CNV files to IOS Headers.

CLEAN was run to add event numbers and to replace pad values in the pressure channel with interpolated values based on record number.

##### Checking Headers –

The cross-reference check looks fine.

A header check was run.

* Fluorescence did not go off-scale.
* There was high transmissivity from the Green sensor. The configuration parameters were entered correctly. A calibration done in February 2023 would produce even higher values. Examination of event #10 shows there was a spike during the upcast at about 555db. Both transmissometers have a few very low values. The red sensor gradually moves to values close to those before and after the drop, so this may well be a real change. But the green sensor looks like it overshot with 2 values >100% before it settled to values like those before and after the drop. A text editor was used to pad those 2 values. Header check was rerun to see if there were other casts affected the same way, and no other values were found >99.4%/m.
* The largest reading from the Surface Par was ~2.5 and was seen in single spikes. There does not appear to be any useful data from this sensor.
* There is some possibly useful PAR data.
* The lowest pressure recorded was 0.141 at the beginning of cast #56. The pumps were on, transmissivity at 0, conductivity looking like it was in water though a few pad values in the primary conductivity at 0.2db suggest it might have come out of water very briefly.

Surface check was run and the average surface value was 2.7db. This is the measure after the 10m soak which is reasonable for the Tully when in rough waters. The range was 1.5db to 9.9db with about 25% having values <2db. Two deck readings were recorded: +0.5db and +0.2db. The very low readings during cast #56 suggest pressure is reasonably accurate, well within specifications for the sensor.

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. Two casts were removed since they did not get close enough to the bottom for the altimeter to get <15m so no altimetry header was produced. Because this survey was near seamounts we cannot expect great matches as the depth may vary through a cast. The most useful entry is when the CTD is at the bottom of the cast. If the header entry for water depths was within 10m, they were considered fine.

For 14 cases the header entry looks ok. For cases with check value >10m the log was checked to see if the entries there provided better results and in 8 cases they did. For the other 13 cases a calculated value was used, Max Depth Sampled + Altimetry. This should reflect the depth when the CTD was at the bottom, if the altimeter was well calibrated.

No check possible: 6, 16 .

Log entries used: 1, 19, 20, 36, 43, 55.

Calculated value used: 9, 17, 21, 30, 37, 41, 42, 45, 48, 49, 57, 58, 59.

These changes were made to the CLN files.

The same changes were made to affected 7 affected SAMAVG files which were again merged with MRGCLN1s. and CLEAN.

File CLIP\_068 was prepared when preliminary files were processed. That file was used to remove data from the soak period since the pressure was varying greatly due to rough seas. The # of scans was chosen to capture the full downcast without data from the soak period.

CLIP was run on all files, though some had no data removed.

##### Shift

Fluorescence

SHIFT was run on the SeaPoint fluorescence channel in all casts using the usual advance of +24 records. There is a lot of noise in the fluorescence but plots show the offset is reasonably close to the temperature offset after this step.

Dissolved Oxygen

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

Conductivity

Tests were run on a selection of casts to find the alignment shift best for the 2 conductivity sensors as judged by noise in T-S space. The best choice was -0.7 records for the primary though the best choice did vary from feature to feature. The best was -0.75 records for the secondary channels.

SHIFT was run twice on all SBE911 casts using -0.7 records for the primary and -0.75 for the secondary. Salinity was recalculated for both channels.

##### DELETE

The following DELETE parameters were used:

Surface Record Removal: Last Press Min

Maximum Surface Pressure (relative): 10.00

Surface Pressure Tolerance: 1.0 Pressure filtered over 15 points

Swells deleted. Warning message if pressure difference of 2.00

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

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

Sample interval = 0.042 seconds. (taken from header)

COMMENTS ON WARNINGS: There were no warnings.

##### Other Comparisons

Experience with these sensors since last factory service –

* During 2022-008 the salinity channels were both close to bottles. Pressure was adjusted in the configuration file before conversion and no further change was required. Dissolved oxygen was recalibrated by multiplying values by 1.0163; 3 casts were somewhat out of line in the comparison, possibly due to unusually variable vertical gradients due to intrusions. There was insufficient information to apply a time-variable recalibration.
* During 2022-022 the primary salinity was high by 0.0014psu and the secondary salinity was high by 0.0003psu. The secondary T-S was less noisy and was selected for archiving. As during the previous cruise 2 recalibration schemes were used for DO: for casts 1-132 (slope 1.0164/offset -0.0063) and casts 133-231 (slope 1.0202/offset -0.0282).

Historic ranges – Profile plots were made with 3-standard deviation climatology ranges of T and S superimposed. Salinity was low in the top 50m in the Cobb Seamount area but recent observations of low salinity near the surface have been reported from other cruises and Argo observations. Temperature and salinity were both slightly low around 250m in the most northerly region of the survey. All other temperature data was within the climatology. The climatology for most sites covers large areas and may not include seamount sites.

None of the excursions are systematic and do not suggest calibration problems.

Post-Cruise Calibration – None available.

Repeat Casts –There were no repeat casts.

##### DETAILED EDITING

There is little difference between the channel pairs with similar amounts of noise in T-S space. Both are heavily corrupted by shed wakes.

The primary salinity was slightly closer to bottles but with only 4 bottles, most near the bottom and delayed processing, there is little to be learned. On the 2 previous cruises the secondary salinity was closer to bottles.

There was a slight change in the differences between primary and secondary salinity channels between 2022-008 and 2022-022. For this cruise the difference is very close to that of 2022-022 and if the bottles are reading high due to evaporation that would bring the secondary closer to bottles as it was for 2022-022. There is insufficient information to support one or the other choice.

The secondary channels were selected for the previous 2 cruises, and the traces look very slightly more stable, so the secondary temperature and salinity were selected for editing.

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

CTDEDIT was used to remove records that appear to be corrupted by shed wakes. Salinity was cleaned to remove spikes that appear to be due to small misalignment or instrumental noise. All files required some editing. Notes about editing applied were added to the files.

After editing, T-S plots were examined for all casts; Two files were opened again in CTDEDIT and very light editing was applied to the surface data in file #37. The other cast looked fine when examined in detail.

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

There were no salinity data <25psu in CTD salinity in the bottle files (MRG) so silicate does not need correction in the bottle files.

Pressure does not need recalibration.

There are too few salinity samples to trust the comparison, especially as analysis was delayed and there are likely flushing errors. From the 2 previous cruises it appears that both salinity channels are accurate to within 0.002psu, so no recalibration is required.

File 2022-068-recal1.ccf was prepared to apply the following correction to the SBE dissolved oxygen channel:

TD DO Corrected = CTD DO \* 1.0187 - 0.042

This correction was first applied to the SAM and MRGCLN2 files.

COMPARE was rerun for dissolved oxygen and shows that the correction was applied properly. The casts from late in the cruise do not stand out as different from the early section. When the same outliers are excluded as in the first comparison, the CTD salinity is higher than bottles by 0.0001mL/L but the standard deviation is 0.015mL/L.

CALIBRATE was then run on the EDT files using the same recalibration file.

##### Final Calibration of DO

The initial recalibration of dissolved oxygen corrects for sensor calibration drift. Alignctd corrects for transit time errors. Those 2 steps may partly correct for response time errors, but to see if a further correction is needed, a comparison is made of downcast CTD data to bottle data from the same pressure. Small differences are expected due to ship drift, temporal changes, incomplete flushing of Niskin bottles and delayed response and noise in CTD data.

Downcast files were bin-averaged to 0.5m bins for the casts with DO bottle samples. Those files were then thinned and compared to the bottle values in the MRG files. COMPARE was run to study the differences between the downcast CTD DO data and the titrated samples from upcast bottles.

The CTD DO was lower than the titrated samples by an average of 0.0018mL/L when 1 outlier was removed (standard deviation 0.061mL/L). We expect the values to be slightly too high, based on incomplete flushing of bottles and slow response in the DO sensor, but most of the cases with CTD looking low were from near the surface where there was a DO gradient reversal.

A plot of differences versus pressure was then done, excluding 1 outlier as determined in a fit against bottle DO. Based on this an estimate is made of errors in DO in different pressure ranges. This is likely too severe a method given time differences and inexact matches in depths.

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

 ±0.25 mL/L from 0-500db except in areas of very large DO gradients

 ±0.07 mL/L from 500db-600db

 ±0.04 mL/L below 600db

For more detail see file 2022-068-dox-comp3.xls.

##### Fluorescence Processing

There were no off-scale fluorescence values.

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

##### BIN AVERAGE of CTD files

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

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

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

On-screen T-S plots were examined and no problems were found.

Profiles of PAR and PAR:Reference were made to see when they were in use and producing reasonable data.

PAR data look ok for events 1-21 though most were at night so values are very low. The channel will be removed from casts #22-59.

PAR:Reference data have no signal until near the end. The last 3 casts have some signal but values are extremely low. There are no useful data, so the channel will be removed.

##### 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, PAR:Reference and Flag.

For events 22-59 channel PAR was also removed.

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

REORDER was run to get the two DO channels together.

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

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

The Header Check was run; no problems were found.

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

The sensor history was updated.

##### Dissolved Oxygen Study

As a final check of dissolved oxygen data, % saturation was calculated and plotted. Values at 2 to 3m ranged between ~102% to 105%. The values are typical of offshore observations.

##### Final Bottle Files

SORT was run to arrange casts in pressure order.

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

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

Channel PAR was also removed from casts #21 to 59.

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 2022-068-bottles-final.xlsx. A few random checks were made by comparing with the rosette log sheets and no problems were found.

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

The track plot looks ok.

Plots of each file were examined and no problems were found.

A cross-reference listing and header check were produced for the CHE files.

##### Thermosalinograph Data

An IOS TSG45 was used for this cruise and data were saved in 1 file, CR6Series\_Data.dat, which also contained data from the previous cruise.

The data file was adjusted as follows:

* The headers were reduced to 2 lines, one with channel names, the other with units.
* The Date and Time were separated by copying to separate columns with the appropriate formats.
* The NAN entries were replaced with pad values.
* A column with pressure was added with all values set to 4.5 (to enable derivation of salinity).
* The fluorescence channel is in volts. It was moved to column M. Then a concentration value was calculated in column F using scale 14.6 as determined in the most recent factory recalibration of the fluorometer. The clean water offset value was 0.081. For previous uses of this equipment it was sometimes found necessary to adjust the offset to obtain reasonable values. A quick comparison was made between the fluorescence values in the TSG file and CTD values around 4.5m from a few casts in variable environments. The TSG fluorometer was about 1.3ug/L when the CHL was about 0.16ug/L and varied from 0.4 to 0.9ug/L when CHL was about 0.5ug/L. There were no high CHL values and fluorometers tend to read significantly higher than CHL for low CHL values. The offset does not produce negative values and was found appropriate for the previous cruise. Another comparison will be done later.
* Because the file is too large to accommodate plotting, a file break column was added and filled with date info so that a new file would be created at the beginning of each day. Use formula ="2022-068-202209"&right(A3,2) to automate this process. After conversion the filename format was 2022-068-20220908. (Cruise # plus date -YYYYMMDD.)

The files were then converted to IOS Header format with header info added. (Dont convert the file break column!)

There are 11 IOS files, each covering all or part of 1 day each.

For the first 27 minutes on the first day, the flow rates to the TSG and the fluorometer were erratic starting very low, increasing to more than 3L/min and then settling back down closer to ~1.3L/min. A text editor was used to pad all measurements from the lab when flow rate was >1.9L/min (conductivity, lab temperature, salinity and fluorescence). The intake temperature looks ok and the flow rate was left in place for information.

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

ADD TIME CHANNEL was used to add Julian dates – i.e. Decimal Year. A record number was also added to enable averaging (for use in comparison to CTD files). Time zero was set to 31 December 2021 0:00:00. (Note that this step leads to problems plotting until REORDER is run.)

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

REORDER was run to move the Julian date after the Time/Date channels and to put salinity and fluorescence after the lab temperature. Also the record # was moved to the end.

a.) Plots

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

Time-series plots were produced. Salinity has a few spikes but they are small. A few problems were noted:

* After the initial period the intake flow rate was steady at about 1.2L/minute until 2:36 on the 1tth when it dropped to 1L/min rising to 1.2L/min at 19:49. At about 09:20 on September 15th it rose to 1.6L/m and kept that rate until the end of the record on the 18th.
* The flow rate to the fluorometer was about 1.4L/min throughout the cruise except from 09:20 to 19:49 on the 11th when it dropped to 1.2L/min.
* As noted in the log there were two gaps in the record due to computer crashes on September 11th from 02:36 to 02:48 and from 19:20 to 19:49. Between those 2 crashes the flow rate was slightly lower for both the TSG and fluorometer.
* There was a longer gap that was not noted in the log from 15:51 on Sept 12th to 8:28 on September 13th.
* The salinity and temperature traces look fine with only small occasional spikes in salinity. At times both fluorescence and intake temperature looked noisy but this may reflect real conditions.

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. The data were exported to a spreadsheet which was saved as 2022-068-tsg-ctd-loop-rosette-comp.xlsx. A few CTD casts did not have data from close to 4.5m and for 4 casts the TSG was stopped; there are 27 points of comparison.

For comparison with CTD data, the TSG files were averaged over 6 records (30s) on record number to reduce the noise and file size. Standard deviations were included for temperature and salinity. Then required records (times, positions, temperatures with standard dev, temperature difference, salinity with standard dev, fluorescence, flow rates) were exported to a spreadsheet and that file was thinned to the times closest to CTDs and added to file 2022-068-tsg-ctd-loop-comp.xlsx.. The same file was thinned to the closest times to loop files and added to the TSG-Loop comparison. There were 4 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 0.0002º for both latitude and longitude. There were no differences> 0.0008º. So the matches are good.

c.) Comparisons

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

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Lat diff | Long diff | TSG Intake-CTD Temp | TSG Lab-CTD Temp | TSG Sal-CTD Sal | TSG FL/CTD FL |
| median | -0.0002 | 0.0002 | 0.0055 | 0.3223 | -0.0473 | 1.41 |
| stdev | 0.0003 | 0.0004 | 0.0165 | 0.0450 | 0.0022 | 0.35 |
| avg | -0.0001 | 0.0001 | 0.0050 | 0.3145 | -0.0469 | 1.41 |
| max | 0.0008 | 0.0008 | 0.0265 | 0.3973 | -0.0400 | 2.18 |
| min | -0.0008 | -0.0005 | -0.0699 | 0.2163 | -0.0500 | 0.84 |

When 3 outliers were removed from the comparison the results were:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Lat diff | Long diff | TSG Intake-CTD Temp | TSG Lab-CTD Temp | TSG Sal-CTD Sal | TSG FL/CTD FL |
| median | -0.0002 | 0.0002 | 0.0062 | 0.3260 | -0.0474 | 1.38 |
| stdev | 0.0003 | 0.0004 | 0.0063 | 0.0446 | 0.0020 | 0.28 |
| avg | -0.0001 | 0.0001 | 0.0073 | 0.3157 | -0.0471 | 1.33 |
| max | 0.0008 | 0.0008 | 0.0207 | 0.3973 | -0.0400 | 1.79 |
| min | -0.0005 | -0.0005 | -0.0039 | 0.2163 | -0.0500 | 0.84 |

The intake temperature is higher than CTD temperature by about 0.006Cº (std dev 0.006) which is within expectations given small differences are likely between the intake depth and CTD depth and both data sets have been averaged. Plots of the differences versus standard deviation in the TSG intake temperature over 30s show that differences are mostly <0.006Cº when variability is very low. Late in the cruise the differences are slightly lower; that is likely due to lower variability.

Heating in the loop (Tlab-Tintake) varies from 0.21Cº to 0.38Cº with a median of 0.32Cº. As usual the heating decreases as the intake temperature increases, getting closer to the ambient temperature of the loop environment. As the flow rate in the loop increases there is more scatter in the comparison, though that might be due to local conditions rather than the flow rate.

The salinity differences are larger than expected with the TSG reading lower than the CTD by 0.047psu. A small part of that difference may be due to small bubbles in the loop, but there is no evidence of a large issue with bubbles. Salinity differences are largest in the middle part of the cruise, likely due to bubble density variations.

The TSG fluorescence is higher than CTD fluorescence by about 35%.

* Comparisons of Loop samples and TSG data

There were 5 loop samples but there was no TSG data to match one of them.

The TSG salinity was lower than the loop salinity samples by a median of 0.051psu with a standard deviation of 0.0014psu. This is remarkably consistent.

All extracted chlorophyll values were low, so it is not surprising that the Fluorescence was higher than CHL; this is normal fluorometer performance. However, it is higher by factors of 5 to 10 times, which is higher than usual.

* Comparison of TSG fluorescence with CHL and CTD Fluorescence from bottle files

There were 13 bottle casts with 5m samples that overlapped with TSG records. CTD Fluorescence and extracted Chlorophyll data were extracted and compared to the TSG fluorescence. The pattern of FL/CHL versus CHL was similar for both TSG and CTD, but the ratio from the TSG was higher than that using CTD fluorescence. For 2 samples with CHL~0.5ug/L the TSG fluorometer was about 4 times the CHL while the CTD fluorometer was 2.2 times CHL

* No loop samples were taken during rosette casts.

d.) Calibration History

The TSG was serviced and recalibrated shortly before cruise 2022-001; only the fluorometer has any history available for 2021 cruises.

* During 2021-001 the TSG fluorescence values were about 32% of fluorescence from the CTD and 74% of the loop CHL samples and loop chlorophyll was about 75% of that from the rosette.
* During 2021-006 the TSG fluorescence values were about 50% higher than those from the CTD and higher than loop CHL samples by 50 to 300%. For the cases where the CHL was in the range 0.49 to 5.0ug/L, the TSG fluorescence was higher than loop samples by 8%, but the loop chlorophyll values were lower than rosette samples.
* During 2021-005 TSG fluorescence values were close to those from the CTD and higher than rosette CHL samples for low CHL and about 50% of CHL when CHL>4ug/L.
* During 2021-069 TSG fluorescence values were reasonably close to those from the CTD fluorometer and about 50% of rosette CHL samples when CHL>4ug/L.
* During 2021-008 the TSG fluorescence values were about 1.4 times those from the CTD and higher than loop CHL samples by a median of 3.5, For the cases where the CHL was <0.5ug/L, the TSG fluorescence was higher than loop samples by a median factor of 3.5 but for the few values between 1 and 2ug/L the TSG fluorescence is close to the CHL values.
* During 2022-008 the TSG fluorescence was higher than Extracted CHL by up to a factor of 2.5 for the samples with CHL < 0.4ug/L. It dropped sharply as CHL increased. It was close to CHL for CHL=0.7ug/L and about 20% of CHL for CHL=11.6ug/L. The TSG salinity was lower than the loop samples by a median of 0.021psu (std dev 0.024psu).
* During 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 0.365psu and CTD by 0.368psu. It was recalibrated by adding 0.36psu.

e.) Conclusions re TSG

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

2. The flow rate to the TSG varied through the cruise. The flow rate to the fluorometer was steady.

3. The TSG salinity was lower than loops by a median of 0.051psu. It was lower than CTD salinity by a median of 0.047psu. This is a larger difference than in the previous cruise, (about -0.037psu) which was higher than the one before that (about -0.20psu), so there appears to be significant calibration drift. There is no evidence of large bubbles so those are unlikely to explain the large difference.

4. The intake temperature is reasonably close to the CTD temperature given both data sets have been averaged and depths are an inexact match. The result is better than during the previous cruise.

5. Heating in the loop was about 0.32Cº which looks normal and slightly lower than during the previous cruise. Heating increases with increased intake temperature, as expected.

6. TSG fluorescence was higher than loop samples by 5 to 10 times, but the chlorophyll values were extremely low ranging from 0.14 to 0.55ug/L, median 0.19ug/L. Fluorometers do generally read much higher than CHL when CHL is very low. However, TSG fluorescence was also higher than the CTD fluorescence by about 38%. The CTD fluorometer compared reasonably well with chlorophyll from rosette casts, showing no evidence of reading lower than usual. The TSG fluorometer may be reading too high, but this is difficult to judge when chlorophyll is so low.

f.) Editing

Time-series plots were examined and no further editing was found necessary.

g.) Calibrate & Remove

Calibrate was run to add 0.047psu to channel Salinity.

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

h) Preparing Final Files

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

The TSG sensor history was updated.

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

TSG Cross-reference list:

Filename Latitude Longitude Date Time

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 2022-068-20220908 48 15.72 N 129 9.06 W UTC 2022/09/08 00:54

 2022-068-20220909 48 4.14 N 133 11.16 W UTC 2022/09/09 00:00

 2022-068-20220910 48 1.50 N 132 53.04 W UTC 2022/09/10 00:00

 2022-068-20220911 46 41.70 N 132 47.40 W UTC 2022/09/11 00:00

 2022-068-20220912 46 38.82 N 131 29.82 W UTC 2022/09/12 00:00

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 2022-068-20220913 46 39.06 N 130 49.32 W UTC 2022/09/13 08:28

 2022-068-20220914 46 43.14 N 130 53.10 W UTC 2022/09/14 00:00

 2022-068-20220915 46 40.32 N 131 27.60 W UTC 2022/09/15 00:00

 2022-068-20220916 45 57.54 N 130 46.02 W UTC 2022/09/16 00:00

 2022-068-20220917 46 3.72 N 130 41.70 W UTC 2022/09/17 00:00

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 2022-068-20220918 46 24.48 N 130 42.18 W UTC 2022/09/18 00:00

P**articulars**

PAR off: Likely off for 21-59 – no signal.

ALL. SPAR values very low. Maximum =2.5

1.PAR signal - profile reasonable.

3-20. Small PAR signal – reasonable for nighttime casts.

6. Deck pressure 0.5db.

15/16. Event #16 was identified as #15 in Sampling Log. Corrected on paper and digital versions.

17. Sounder depth not accurate.

21-59. No PAR signal

40. Deck pressure 0.2db

44. CHL label wrong – 5042 should be 5044.

56, 57, 58, 59. Bottles taken for eDNA – no sample #s. No bottle files needed.

TSG notes

Loop salinity and chlorophyll samples were taken at casts 8, 12, 22, 40 and 44, but the time for sample #22 was not recorded clearly in the log.

It is noted in the log on 10 Sept (19:38 - ?) and 12 Sept (?-13:50) that computers running the TSG went down. There was another gap not noted in the log from 15:51 on Sept 12th to 8:28 on September 13th.

**2022-068**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **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** | **4700** | **5Jan2022** | **Factory** |  |  |
| **Conductivity** | **3531** | **8 Feb2022** | **Factory** |  |  |
| **Secondary Temp.** | **4888** | **14Jan2022** | **Factory** |  |  |
| **Secondary Cond.** | **4513** | **8 Feb2022** | **Factory** |  |  |
| **Transmissometer** | **1185DR** | **28Apr2021** | **Factory** |  |  |
| **Transmissometer** | **1883DG** | **28Apr2021** | **Factory** |  |  |
| **SBE 43 DO sensor** | **3791** | **18Mar2022** | **Factory** |  |  |
| **PAR sensor** | **70613** | **24Feb2021** | **Factory** |  |  |
| **Surface PAR** | **20518** | **24Feb2021** | **Factory** |  |  |
| **SeaPoint Fluor.** | **3641** |  |  |  |  |
| **Pressure Sensor** | **0443** | **23Mar2022** | **Factory** |  |  |
| **Valeport Altimeter** | **76341** | **10Feb2021** | **Factory** |  |  |

**CRUISE SUMMARY – CTD**

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

|  |
| --- |
| **Calibration Information** |
| **Sensor** | **Pre-Cruise** | **Post Cruise** |
| **Name** | **S/N** | **Date** | **Location** | **Date** | **Location** |
| **Temperature** | **0620** | **12Jan22** | **Factory** |  |  |
| **Conductivity** | **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** |  |  |

