## REVISION NOTICE TABLE

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| DATE | DESCRIPTION OF REVISION |
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## PROCESSING NOTES

Cruise: 2023-034 Agency: OSD

Location: North-East Pacific Project: Deep Sea Marine Conservation Survey – Leg 2

Chief Scientist: Norgard T. Platform: John P. Tully

Date: 11 July 2023 – 25 July 2023

Processed by: Germaine Gatien Date of Processing: 1 February 2024

Number of original HEX files: 5 (1 test) Number of processed CTD files: 4

Number of rosette casts: 1 Number of processed CHE files: 1

# INSTRUMENT SUMMARY

CTD #1515 was mounted in a rosette and attached were 2 Wetlabs CSTAR transmissometer (1185DR & #1883DG), a SBE 43 DO sensor on the primary pump (#1119), SeaPoint Fluorometer on the secondary pump (#3950) and an altimeter (#73171).

Seasave version 7.26.7.121 was used for acquisition. The data logging computer WP #102. The deck unit was a Seabird model 11+ #424. An IOS rosette with 24 10L bottles was used.

# SUMMARY OF QUALITY AND CONCERNS

The Daily Science Log Book was in good order.

Niskin bottles were closed after a wait time of 30-50 seconds. A wait of at least 60s is recommended before closing Niskin bottles above 400db if samples are to be used for calibration purposes.

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 was a problem with secondary conductivity in the top 60m of downcasts with odd swings in values. Below 60m and on upcasts it looked ok. The fluorometer was also mounted on the secondary system, but does not appear to have been affected; however, those data are very noisy, so this is not clear. The primary temperature and salinity were selected for archiving.

No recalibration was necessary for salinity. SBE Dissolved oxygen was recalibrated based on results from an earlier cruise since the only calibration sampling came from a single cast near Brooks Peninsula and was out of line with results from other 2023 cruises using the same oxygen sensor.

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

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

±0.50 mL/L from 0-40db except in areas of very large DO gradients

±0.15 mL/L from 40db-100db

±0.03 mL/L below 100db

# PROCESSING SUMMARY

##### Seasave

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

##### Preliminary Steps

The Log Book and rosette log sheets were obtained.

There were only 4 casts with Niskin sampling from only 1 cast.

The file names were non-standard; they were changed to 4 digits in the event # section.

Dissolved oxygen and salinity data were obtained in QF spreadsheet format from the analysts.

* The cruise summary sheet was completed.
* The history of use of the pressure sensor, conductivity and dissolved oxygen sensors was found.

The configuration files were the same for all cases; a small error in one of the transmissivity channels was corrected. One file was corrected and saved as 2023-034-ctd.xmlxon.

##### BOTTLE FILE PREPARATION

The ROS file was created using configuration file 2023-034-ctd.xmlcon.

The IOS file was put through CLEAN to create BOT files.

Temperature and salinity were plotted for the BOT files and no significant outliers were found.

A preliminary header check was run; no problems were found.

The BOT file was bin-averaged on bottle number.

The output was used to create file ADDSAMP.csv. First, the file was sorted on event number and Bottle Position order. Then sample numbers were added based on the rosette logs.

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

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

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

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

Next, the analysis spreadsheets were examined to see what comments the analysts wanted included in the header file. These were used to create file 2023-034-bot-hdr.txt which will be updated as needed during processing.

DISSOLVED OXGYEN

Dissolved oxygen data were provided in spreadsheet QF2023-034\_OXY\*.xlsx which includes flags, comments and a precision study. Draw temperatures are available. The spreadsheet page with the final data was simplified and saved as 2023-034oxy.csv. That file was converted into individual \*.OXY files.

SALINITY

Salinity analysis was obtained in file QF2023-034\_SAL.xlsx which included a precision study. The analyses were carried out in a temperature-controlled lab 20 days after collection. The file was simplified and saved as 2023-034sal.csv. That file was then converted to an individual SAL file.

The SAL and OXY files were merged with CST files in 2 steps.

After the 2nd step the file was put through CLEAN to reduce the headers to File and Comment sections only.

This file is ordered on sample number, but the SAMAVG file is ordered on bottle number, so one or the other set needs to be reordered in order to merge them. The MRGCLN1 file was reordered on Bottle\_Number and saved as \*. MRGCLN1s.

The MRGCLN1s file was then merged with the SAMAVG file using merge channel Bottle\_Number.

##### Compare

Salinity

Compare was run with pressure as reference channel.

All bottles above 65db are out of line with CTD values lower than bottles; this is likely the result of incomplete flushing of Niskin bottles in the presence of high vertical salinity gradients. A longer wait before closing the bottles might have helped.

When those bottles are excluded the primary salinity is low by ~0.0002psu and the secondary low by ~0.0001psu with a standard deviation of 0.0014psu for both. It is possible that the salinity channels are not as low as they appear due to incomplete flushing of Niskin bottles

There were no significant outliers.

For full details for the COMPARE run see file 2023-034-sal-comp1.xls.

Dissolved Oxygen

COMPARE was run with pressure as the reference channel.

There were 3 large outliers all from above 40db.When those are excluded the fit was:

CTD DO Corrected = CTD DO \* 1.04

Almost all cases show the SBE DO reading low.

Outliers are likely due to high variability, incomplete flushing of Niskin bottles and possibly a delay in analysis of 5 days. There is a very high gradient in the top 60db.

Outliers were studied:

* Samples #1 and 17 were flagged 4; sample #1 looks ok in the fit while sample #17 is out of line.
* Sample #20 was flagged 3 and is out of line, but the CTD data were noisy during the bottle stop, so no change to the flag is justified.
* Samples #18 and #19 are out of line in the fit, but in a way that is explained by poor flushing of Niskins at depths with very high vertical DO gradients.

No changes to flags are recommended..

For full details for the COMPARE run see file 2023-034-dox-comp1.xls.

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

Hex files were converted using configuration file 2023-034-ctd.xmlcon.

Initial plots show some odd conductivity profiles with the primary and secondary looking quite different when the CTD was in motion (especially above 60db), but very close during bottle stops. The differences may be due to minor misalignment in areas of high variability.

##### 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.

##### ALIGN DO

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

##### CELLTM

The noise in the upcast data makes tests for the best parameters for this routine very difficult to interpret. In the past when upcast data were not so noisy, the default setting of (α = 0.0245, β=9.5) was generally found to be the best choice. A few casts were checked for this cruise and the default setting does improve the data. CELLTM was run using (α = 0.0245, β=9.5) for both the primary and secondary conductivity.

##### DERIVE and Channel Comparisons

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

Plots were examined and checks made:

* to check for spikes since there were many when the CTD was last used. There are few spikes which confirms that the problem was with the wire, not the CTD itself.
* to see if the alignment of dissolved oxygen looks good and it does.
* to see if CELLTM worked properly and it did.
* to see if the odd conductivity in the top 60db is affecting both sensors or only 1. Plots of salinity comparing up and downcast casts make it pretty clear that something was affecting the secondary flow on downcasts until the CTD reached about 50m. This appears to have mostly cleared up after the 2nd cast. The log does not indicate whether there was a 10m soak or not. The dissolved oxygen sensor was on the primary pump and the fluorometer on the secondary. The dissolved oxygen alignment seems normal. Fluorescence does need realignment and will be examined later.

DERIVE was run a second time to find the differences between the pairs of temperature, conductivity and salinity channels. Casts from 2023-066 are included to help judge if there is temporal drift.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cast # | Press | T1-T0 | C1-C0 | S1-S0 | Descent Rate |
| 2023-066-0046 | 1000 | -0.0002 | -0.00007 | -0.0008 | High, Noisy |
|  | 2000 | -0.0003 | -0.00009 | -0.0008 | “ |
|  | 2500 | -0.0003 | -0.00009 | -0.0007 | High, Noisy |
| 2023-066-0052 | 1000 | -0.0002 | -0.00004 | -0.0003 | “ |
|  | 2000 | -0.0005 | -0.00006 | -0.0003 | “ |
|  | 2500 | -0.0007 | -0.00007 | -0.0002 | “ |
|  | 3500 | -0.0008 | -0.00008 | 0 | “ |
| 2023-066-0079 | 1000 | -0.0002 | -0.00023 | -0.0026 | High, Noisy |
|  | 2000 | -0.0005 | -0.00020 | -0.0020 | “ |
|  | 2500 | -0.0004 | -0.00019 | -0.0019 | “ |
|  | 3500 | -0.0001 | -0.00017 | -0.0021 | “ |
| 2023-066-0086 | 1000 | +0.0003 | -0.00025 | -0.0032 | High, XNoisy |
|  | 2000 | -0.0002 | -0.00023 | -0.0026 | “ |
|  | 2500 | -0.0004 | -0.00022 | -0.0023 | “ |
|  | 3500 | -0.0001 | -0.00020 | -0.0024 | “ |
|  | 4000 | +0.0001 | -0.00020 | -0.0025 | “ |
| 2023-034-0002 | 300 | -0.0005 | 0.0002 | 0.0030 | High, Mod |
| 2023-034-0004 | 300 | -0.0003 | 0.0001 | 0.0015 | High, Noisy |

Differences are small but quite variable. They are similar to those during 2023-066.

##### Conversion to IOS Header Format

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

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

##### Checking Headers –

* The cross-reference check and header check were run. No problems were found.
* Surface check was run and the average surface value was 1.9db which is a little low for offshore.
* The cruise track was plotted and added to the end of this report.

The altimeter and water depth readings from the headers of the CLN files were exported to a spreadsheet. A check value was calculated by subtracting water depth from maximum depth sampled plus altimetry header. That number was > 5m for 2 casts. For cast #1 the value was 23 but the log depth was very different from that in the header. When the log depth was used the value was ~3m. For cast #4 the check value was ~7 and using the log depth improved it slightly – this cast was fairly close to shore and there was obviously some shoaling. The other 2 casts had check values <1 suggesting that both the sounder and the altimeter were working well.

The change to cast #1 water depth was made to the CLN files; there was no bottle file for that cast.

##### Shift

Fluorescence

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

Dissolved Oxygen

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

Conductivity

Tests were run to find the alignment shift best for the 2 conductivity sensors as judged by noise in T-S space. The best choice was -0.3 records for the primary and -0.45 records for the secondary channel.

SHIFT was run on all casts using those settings.

##### 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 3 points

Swells deleted. Warning message if pressure difference of 3.00

Drop rates < 0.30m/s (calculated over 3 points) will be deleted.

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

Sample interval = 1 seconds. (taken from header)

COMMENTS ON WARNINGS: There were no warnings.

##### Other Comparisons

Experience with these sensors since last factory service –

The pressure, temperature, conductivity and dissolved oxygen sensors have been used for only 1 cruise between the last factory service and this cruise.

2023-066:

* The pressure appeared to be high aby about 0.5db but more recent comparisons suggest it was not reading high in January 2024.
* Primary salinity was found to be low by 0.0018 and secondary low by 0.0023psu, but sampling was limited.
* Dissolved oxygen was recalibrated using slope/offset 1.0227/0.0113, but sampling was also limited for DO.

Historic ranges – Profile plots were made with 3-standard deviation climatology ranges of T and S superimposed. All temperature and salinity data were well within the climatology.

Post-Cruise Calibration – None available.

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

##### DETAILED EDITING

As noted earlier the secondary conductivity did not perform well in the top 60m of downcasts. So the primary temperature and salinity were selected for editing and eventual archiving.

CTDEDIT was used to remove records that appear to be corrupted by shed wakes. Salinity was cleaned to remove spikes that appear to be due to small misalignment or instrumental noise. All files required light editing.

Notes about editing applied were added to the files.

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

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

With no nutrient sampling nor salinity <25psu, the silicate correction is not required for the bottle file.

Both salinity channels were found to be very close to bottles below 60m.

Pressure and Depth were found to be low by about 0.5db during 2023-066. Lab tests in January 2024 indicated that the pressure was reading well and initial studies from 2024-002 confirm that no correction was needed at that time. There are no near-surface data available from 2023-088 but during 2023-026 in late August 2023 there are some data from about 0.6db that are clearly in water but very close to the surface. So no recalibration will be applied to the pressure and depth based on later cruises and an understanding that there were many problems with data collected from CTD #1515 during 2023-066.

The decision for the dissolved oxygen sensor is more difficult since the finding from the one cast with DO sampling is out of line with the results from cruise 2023-066 which had more low-salinity sampling to enable a more accurate offset for the fit.

For 2023-066 when DO sensor #1119 was used for casts P1-P17 the fit was

CTD DO Corrected = CTD DO \* 1.0227 + 0.0113

For this cruise the fit is:

CTD DO Corrected = CTD DO \* 1.0315 + 0.0154

Or if the offset is set to 0 it is:

CTD DO Corrected = CTD DO \* 1.0399

Or if the offset from 2023-066 is selected (based on data that included many low DO values) the current fit would be:

CTD DO Corrected = CTD DO \* 1.0338 + 0.0113

Given such variable results a quick comparison was done for the next cruise that used this equipment, 2023-088, run in August. It had good sampling available with many low DO samples available. There was more deep sampling than during 2023-034 and for some casts lower vertical gradients, but others had gradient reversals in the top 25 to 50m. Flushing was likely good given rougher seas offshore and longer waits before firing bottles near the surface. A firm conclusion must wait until more processing is done, but the initial fit found had an even lower slope than those from 2023-066 or 2023-034.

CTD DO Corrected = CTD DO \* 1.0183 + 0.02

This does suggest that the fit using 2023-034 sampling is not reliable. The 2023-066 fit is more appropriate than 2023-088, since the region in which this CTD was used had more similar vertical DO gradients to 2023-034. However, there were problems with CTD data from that cruise and many outliers in the comparison. So no choice is idea.

For the CTD files 2023-034-recal1.ccf was prepared to apply the following correction:

* CTD DO Corrected = CTD DO \* 1.0227 + 0.0113

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

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

COMPARE was rerun to check whether the DO corrections were applied correctly and it was. The CTD DO are lower than bottles, but only by an average of 0.02mL/L. This could be due to poor flushing of Niskins or delays in analysis or slow CTD DO sensor response. Sampling was done near Brooks Peninsula with complex oceanography.

See file 2023-034-dox-comp2.xls.

CALIBRATE was then run on the EDT files.

##### Final Calibration of DO

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

The downcast file was bin-averaged to 0.5m-bins for the cast with DO bottle samples. That file was 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 average differences between Downcast CTD DO and Titrated Bottles was 0.038mL/L. The recalibration worked better than expected. We expect the recalibrated CTD data to look a little higher than bottles due to incomplete flushing of Niskin bottles and slow response time in CTD data. It may be that the upcast response of the sensor was poorer than usual and/or waits before firing bottles too short, so that the CTD sensor was reading lower during bottle stops than usual. The downcast data look to be ok.

Based on differences versus pressure, rough estimates were made of SBE DO accuracy.

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

±0.50 mL/L from 0-40db except in areas of very large DO gradients

±0.15 mL/L from 40db-100db

±0.03 mL/L below 100db

For details see files 2023-034-comp3.xls

##### Fluorescence Processing

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

##### BIN AVERAGE of CTD files

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

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

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

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

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

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

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

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

REORDER was run to get the two DO channels together.

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

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

The Header Check was run and turned up no problems.

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 2 to 3m ranged between ~103 to 107% for the 3 southern casts and 121% off Brooks Peninsula. The southern values are in a typical range for the offshore.

##### Final Bottle Files

No silicate correction is needed.

CALIBRATE was run using file 2023-034-recal1.ccf to correct Oxygen:Dissolved:SBE.

SORT was run to arrange casts in pressure order.

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.

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.

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

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

A header check was produced for the CHE file.

P**articulars - Notes from Daily Science Log and Sampling Notes**

No PAR sensor

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

