##  REVISION NOTICE TABLE

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| DATE | DESCRIPTION OF REVISION |
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## PROCESSING NOTES

Cruise: 2021-036

Agency: ESD

Location: North-East Pacific

Project: Seamounts

Chief Scientist: Norgard T.

Platform: John P. Tully

Date: 15 June 2021 – 28 June 2021

Processed by: Germaine Gatien

Date of Processing: 15 April 2022 – 27 April 2022

Number of original HEX files: 19 Number of processed CTD files: 19

Number of rosette files: 19 Number of processed CHE files: 19

# 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 (#3950) and an altimeter (#75321). The configuration file included a Biospherical QSP-400 PAR sensor (#70613) but no signal was found so that channel was removed.

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.

A Guildline model 8400B Autosal serial # 68572 was used to analyze salinity samples.

An IOS rosette with 24 10L bottles was used.

# SUMMARY OF QUALITY AND CONCERNS

The Daily Science Log Book and rosette log sheets were generally in good order with comments about problems encountered. The digitized version lacked the cover and equipment list; they are useful. It would be helpful to include in the log a description of the CTD deployment protocol used.

Waits before firing bottles were generally at least 30s.

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.

Because this cruise was sampling seamounts, bottom depths obtained from a sounder are not very useful; steep slopes mean the altimetry is a better measure of water depth when the CTD was near the bottom of casts. The bottom depth header entry as entered at sea was replaced by an estimate based on maximum depth sampled plus altimetry at the bottom of the cast. Altimetry plots were examined to ensure that the altimetry header entries were reasonable. Even in the presence of very noisy altimetry data the algorithm worked very well at determining reasonable values for altimetry at the bottom.

Comparison of CTD salinity with bottle samples was problematic. The results were out of step with those from cruises before and after this one and with a post-cruise calibration. There was also more pressure dependence than usual. Since both T/C pairs were affected in a similar way, it is assumed that the problem came from the bottle data. No significant problems were found in the analysis. The most likely explanation is that something was impeding flow through the Niskin bottles, so that flushing was incomplete.

Similarly, since poor flushing would affect dissolved oxygen samples, recalibration was based on bottles from 300db to the bottom of cast, where vertical DO gradients are fairly low. The correction found was midway between those used for the cruises before and after this one that used the same equipment. The near-surface dissolved oxygen saturation values were between 103% and 106%, within the typical range for offshore results.

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 recalibrated 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:

 ±0.20 mL/L from 0-110db

 ±0.10 mL/L from 120-500db

 ±0.04 mL/L from 500-3000db

 ±0.06 mL/L below 300db

# PROCESSING SUMMARY

##### Seasave

This step was completed at sea; the raw data files have extension HEX. The deployment protocol was not described in the log, but is believed to have included a 10m soak and return to the surface before data acquisition began. During bottle stops there was a wait of about 30s before bottles were closed.

##### Preliminary Steps

The Log Book and rosette log sheets were obtained.

* Nutrients, dissolved oxygen, salinity data were obtained in QF spreadsheet format from analysts.
* The cruise summary sheet was completed.
* The histories of the pressure sensor, conductivity and dissolved oxygen sensors were checked. The temperature, conductivity and dissolved oxygen sensors had been used on 4 previous cruises since the last factory recalibrations and there were 4 cruises after this one using the equipment. See section 14 for details.

The configuration file was checked. There were errors in the parameters for transmissometer 1883DG; that was corrected in file 2021-036-ctd.xmlcon.

##### BOTTLE FILE PREPARATION

The ROS files were created using files 2021-036-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 outliers.

The file for event 37 was opened in CTDEDIT and channel Salinity:T1:C1 was edited very lightly.

The output file was copied to \*.BOT.

A preliminary header check was run and showed no signal for the PAR sensor. No other problems were noted.

The BOT files were bin-averaged on bottle number.

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

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

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

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

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

Next, each of the analysis spreadsheets were examined to see what comments the analysts wanted included in the header file. These were used to create file 2021-036-bot-hdr.txt which will be updated as needed during processing.

DISSOLVED OXGYEN

Dissolved oxygen data were provided in spreadsheet QF2021-036\_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 2021-036oxy.csv. That file was converted into individual \*.OXY files.

There were no samples in the DO file that had comments starting with “ALL:”

SALINITY

Salinity analysis was obtained in file QF2021-036\_SAL.xlsx which included a precision study (only 2 duplicates). The analyses were carried out in a temperature-controlled lab 32 to 39 days after collection. The files were simplified, saved as 2021-036sal.csv and then converted to individual SAL files.

Note that a few samples flagged 2 had outer caps missing.

NUTRIENTS

The nutrient data were obtained in spreadsheet QF2021-036\_NUTS\*.xlsx. This includes a precision study. The file was simplified, saved as 2021-036nuts.csv and converted to individual NUT files.

The SAL, OXY and NUT files were merged with CST files in 3 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 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 resulting \*.MRG files was exported to a spreadsheet and compared to the rosette log sheets to look for omissions. None were found.

##### Compare

Salinity

Compare was run with pressure as reference channel.

There were 33 salinity bottles, 3 of which had standard deviations >0.0008psu during the 10s window. Those all came from above 500m. When those outliers were excluded the primary salinity was found to be low by 0.0139psu (std dev 0.0022psu) and the secondary low by 0.0096 (std dev 0.0023psu).

Excluding 4 samples missing outer caps made no significant difference to the average difference.

The comparison implies an average difference between the channels of ~0.0043 which is consistent with the differences between CTD channels noted in section 9, but smaller than from cruises before and after this one.

There is slightly more pressure dependence than seen in 2021-008 in both channels.

The differences between the primary and secondary vary little with an average of 0.0042 ± 0.0004psu, but differences are slightly higher at depth.

More than half of the bottles in the fit came from a single cast, so it is possible that particular cast was out of step with others. Plots were made of all bottles between 1700db and 2300db to see if that cast stands out from the others. There were only 3 bottles from other casts in that depth range. There is significant scatter in the plot, but no obvious temporal trend.

There were no outliers that suggest a need to alter quality flags.

There was a delay in analysis of 32-39 days after sample collection which is expected to result in a little evaporation and desorption of samples. This could lead to sample salinity being high by about 0.002psu and there could be a further error due to flushing errors. We would not normally expect these to be large given fairly rough conditions.

The scatter in the fits and the pressure dependence are a little higher than usual. Evaporation tends to be random leading to scatter and incomplete flushing of Niskin bottles leads to pressure dependence.

The changes in comparison between 2021-069 and 2021-036 and between 2021-036 and 2021-008 are puzzling. Understanding is limited by the fact that analysis of samples was delayed more than usual for many other cruises that used this CTD. Evaporation and desorption of glass were assumed to have raised salinity in samples but only rough estimates can be made for those effects. Cruise 2021-069 had few deep casts and some sampling issues. The post-cruise calibration of T and C sensors suggests that the primary salinity was significantly low, probably by ~0.0065psu while the secondary salinity was high by about 0.002. There were 4 cruises between this one and that post-cruise calibration; however, drift appears to have been slow through the autumn.

Finding both sensor pairs producing bottle comparisons out of line with 2021-005 by approximately the same amount, ~0.014psu and ~0.015psu, suggests a problem with bottle data rather than with CTD data. There is no evidence of a problem with the analysis or collection except for a few samples that lacked outer caps. A speculative explanation is that something impeded flushing of the Niskin bottles; this would explain the pressure dependence as well.

For full details for the COMPARE run see file 2021-036-sal-comp1.xls.

Dissolved Oxygen

COMPARE was run with pressure as the reference channel.

The fit was remarkably tight after 8 outliers were removed based on standard deviations in the CTD DO during the 10s window or as residuals in the fit:

 CTD DO Corrected = CTD DO \* 1.0528 + 0.0009 R2 = 0.99 (1)

There were many low DO samples and the offset is close to zero.

This is not an area where we expect significant flushing errors; descent rates were mostly very noisy.

Two outliers were investigated:

Cast #4, 1500db – Std. dev. in CTD DO not very high. An analyst reviewed the analysis records and found a problem with the sample. Flag 5 was added and the value changed to -99.0000.

Cast #49, 1825db – Std. dev. in CTD DO was very high, so bottle value likely fine.

The results of the salinity comparison suggest there might have been poorer flushing of Niskin bottles than expected. Such errors would be largest where 3<DO<6mL/L since gradients are large at those values. Near the OMZ the gradients are low, and errors due to poor flushing above and below the minimum will average out. In the top 50-100m there is usually a reversal, so the errors there may vary in sign. If only data with DO<3mL/L are included and outliers removed based on residuals, the fit is:

 CTD DO Corrected = CTD DO \* 1.0490 + 0.0009 R2 = 0.95 (2)

Fit (1) is close to that found for cruise 2021-005 in May in the offshore while fit (2) is midway between those for the 2021-005 in May and 2021-008 in August; both those cruises had a lot of deep sampling and flushing of Niskin bottles was not a particular problem for either. Using fit (2) looks like the best choice.

The post-cruise calibration showed that the calibration had drifted low by about 1.5% , but DO corrections are typically higher than would be expected from only calibration drift.

The one sample flagged by the analyst as a possible issue did not stand out as an outlier, so no change is recommended to the flag.

For full details for the COMPARE run see file 2021-036-dox-comp1.xls.

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

File 2021-036-ctd.xmlcon was used to convert all files.

The Tau function and the hysteresis function were selected since there was deep sampling. Depth was included in the conversion.

A few casts were examined and all expected channels are present. The T and C pairs were reasonably close during downcasts except at the surface. The altimetry looked ok even though the signal was sometimes noisy at the bottom of casts.

##### 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

A few casts were examined; both temperature channels were noisy during upcasts so the tests were not easy to interpret, but using +2.5s certainly improves the alignment and overall looks like a good choice for both sensors. That setting has worked well for many SBE DO sensors in recent years.

ALIGNCTD was run on all casts using +2.5s.

##### 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 except in sections that have very noisy descent rates and T/C reversals.

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.

DERIVE was run a second time on 3 of the deeper casts to find the differences between the pairs of temperature, conductivity and salinity channels. The shaded values come from other 2021 cruises that used the same equipment before and after this cruise.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cast # | Press | T1-T0  | C1-C0 | S1-S0 | Descent Rate |
| 2021-006-0039 | 1200 | 0 | +0.00042 | +0.0049 | High, XNoisy |
| “ | 2000 | -0.0002 | +0.00044 | +0.0055 | “ |
| “ | 3000 | -0.0003 | +0.00044 | +0.0057 | “ |
| 2021-006-0052 | 1200 | 0  | +0.00043 | +0.0057 | High, XNoisy |
| “ | 2000 | -0.0005 | +0.00042 | +0.0056 | “ |
| “ | 3000 | -0.0005 | +0.00044 | +0.0060 | “ |
| 2021-006-0077 | 1200 | -0.0005 | +0.00042 | +0.0059 | High XNoisy |
|  | 2000 | -0.0007 | +0.00044 | +0.0063 | “ |
|  | 3000 | -0.0006 | +0.00045 | +0.0062 | “ |
| 2021-005-0099 | 1000 | -0.0002 | +0.00050 | +0.0058 | High, Noisy |
|  | 1900 | -0.0004 | +0.00050 | +0.0064 | High, V. Noisy |
| 2021-005-0140 | 1000 | -0.0002 | +0.00055 | +0.0065 | High, Noisy |
|  | 1900 | -0.0005 | +0.00055 | +0.0072 | F. High, NOisy |
| 2021-069-0009 | 500 | +0.0002 | +0.00040 | +0.0044 | High, Noisy |
|  | 900 | -0.0001 | +0.00040 | +0.0048 | “ |
|  | 1850 | -0.0004 | +0.00041 | +0.0054 | “ |
| 20221-036-0008 | 500 | +0.0001 | +0.00033 | -0.0030 | High, Noisy |
|  | 1000 | +0.0004 | +0.00032 | +0.0034 | “ |
|  | 2000 | -0.0006 | +0.00032 | +0.0042 | “ |
|  | 2500 | -0.0005 | +0.00031 | +0.0045 | “ |
| 2021-036-0056 | 500 | -0.0002 | +0.00027 | +0.0033 | High, Noisy |
|  | 1000 | +0.0002 | +0.00029 | +0.0033 | “ |
|  | 2000 | -0.0005 | +0.00029 | +0.0040 | “ |
|  | 2500 | -0.0005 | +0.00030 | +0.0042 | “ |
|  | 3000 | -0.0005 | +0.00030 | +0.0042 | “ |
| 2021-036-0071 | 500 | +0.0003 | +0.00030 | +0.0031 | High, Noisy |
|  | 1000 | 0 | +0.00029 | +0.0034 | “ |
|  | 2000 | -0.0005 | +0.00030 | +0.0041 | “ |
|  | 2500 | -0.0006 | +0.00031 | +0.0043 | “ |
| 2021-008-0046 | 1000 | 0 | +0.00051 | +0.0060 | High, Noisy |
|  | 2000 | -0.0004 | +.000051 | +0.0067 | “ |
|  | 3000 | -0.0005 | +0.00053 | +0.0069 | “ |
| 2021-008-0063 | 1000 | -0.0004 | +0.00046 | +0.0059 | High, Moderate |
|  | 2000 | -0.0006 | +0.00048 | +0.0063 | “ |
|  | 3000 | -0.0007 | +0.00049 | +0.0068 | “ |
| 2021-012-0127 | 1000 | -0.0003 | +0.00032 | +0.0042 | High, Moderate |
|  | 2000 | -0.0006 | +0.00032 | +0.0047 | “ |

The temperature differences are in line with cruises before and after this one, but the salinity and conductivity differences are significantly lower at all depths. However, they are similar to those from cruise 2021-012 and fairly close to 2021-069. It would appear that the variations are, at least partly, due to something other than calibration drift. The traces are relatively smooth, so perhaps it is due to better alignment between T and C, so the 2 channel pairs are in better agreement.

##### 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

An initial header check showed evidence of some spikes but all appear to be from the surface.

The cross-reference check and header check were run. The station name for cast 40 was wrong; it was changed to match the log entry. The file for event #22 was mistakenly saved as #21, so was changed in both profile and bottle files.

Cruise tracks were plotted and added to the end of this report.

The surface check report shows the average surface pressure was 3.0db. For other cruises using this sensor 0.8db was subtracted from pressure.

The altimeter and water depth readings from the headers of the CLN files were exported to a spreadsheet.

The altimetry was often very noisy at the bottom of casts so plots were made to check that the algorithm that estimates altimetry based on values in the bottom 2m had produced reasonable results and it had worked well. Next, a check value was calculated by subtracting water depth from maximum depth sampled plus altimetry header. We usually expect this number to be small, but as expected near seamounts and as noted in the log, the sounder readings are not reliable. An estimate of actual depth was made by adding maximum depth in the files plus altimetry reading – 1m. The depth recorded in the log was added to the file. The log depths were lower than the maximum depth sampled in 8 cases. For the other cases the log entry was mostly within 10m of the estimated depth from altimetry though the maximum difference was 29m. Since the water depth when the CTD was at the bottom is likely of most interest and most accurate, the estimated depths based on altimetry were entered in the headers of the CLN files.

For details see document “2021-036-altimeter-ctd.xlsx”.

##### 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 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 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 last time these sensors were used the best settings were -0.8 records for the primary channels and -1.4 records for the secondary. Those settings worked well on these data, but -1.2 records looked slightly better for the secondary.

SHIFT was run twice on all SBE911 casts using -0.8 records for the primary conductivity channel and ‑1.2 records for the secondary channel. 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 –

The pressure, temperature, and conductivity sensors were used between the last factory visit this cruise and during 4 after this one:

* 2021-020 – The salinity channels started out close and gradually drifted apart. Based on information from the Line P section of cruise 2021-006 it appeared that the primary salinity did not drift much during this cruise. The drift in secondary salinity appears to have been fairly sudden and then settled down. Dissolved oxygen was recalibrated using slope/offset =1.0515/-0.0131 based on cruise 2021-006. This correction seemed high since it was first use since previous factory calibration. Pressure looked ok. No TSG.
* 2021-006 Dissolved oxygen recal slope/offset = O 1.0515/-0.0131; Primary very close to bottles selected for archive; secondary high by 0.006psu.
* 2021-005 Dissolved oxygen recal slope/offset = 1.0536/-0.0018; Primary sal high by about 0 to 0.001psu, selected for archive; secondary high by 0.005 to 0.006psu. TSG salinity low by 0.191; intake temp high by 0.02C degrees – no recal applied.
* 2021-069 Poor info for recal of DO and SAL. Used 2021-005 correction for dissolved oxygen and salinity. Primary T/S selected for archive. Pressure corrected by adding 0.8db.
* 2021-008 Salinity channels lower than bottles by 0.012psu and 0.0055psu. Estimate of errors in bottles ~0.005psu, so estimate primary low by 0.007 and secondary low by 0.0005psu. Secondary was selected for archive and was not recalibrated.
* 2021-012. Preliminary comparison in deep offshore water shows primary salinity low by 0.008 and secondary by 0.0034psu, but . The fit for dissolved oxygen was: slope/offset = 1.0465/ 0.0012
* 2021-022 – Secondary channels selected. Primary sal thought to be low by ~0.003, secondary high by ~0.001. Used 2021-012 DO fit. Pressure subtracted 0.8db
* 2021-076 – Secondary channels were selected; there was no calibration sampling.

Historic ranges – Profile plots were made with 3-standard deviation climatology ranges of T and S superimposed. Salinity data all fell within the climatology; in the UN section values were close to the minimum in the halocline. Temperature values were all within the climatology except for temperatures at the bottom of station TW06 which were above the climatology maximum; this did not look like a case of calibration drift; it is more likely due to the particular area not being well represented in the climatology.

Post-Cruise Calibration – There was a factory calibration after cruise 2021-076 that indicated there was significant drift in the primary T & C sensors both contributing to primary salinity being low, probably by about ~0.0065psu and secondary salinity was high by ~0.0016psu.

Repeat Casts – There were no repeat casts.

##### DETAILED EDITING

The choice of which sensors to use for archival and how to recalibrate them is difficult. For the cruises before this one the primary channels were found best and after this one there were some problems with the primary, so the secondary were used. For this cruise the T-S plots are smoother for the primary and there is no sign of the problems noted during 2021-008 in the primary channels.

For many of the cruises in 2021 using this CTD there were significant delays in analysis of samples, so estimates had to be made as to the effects of desorption of glass & evaporation as well as the usual estimates for errors due to incomplete flushing of Niskin bottles. Some of the cruises had no sampling or inadequate sampling for calibration purposes. The history of bottle comparisons is very confusing.

The spring Line P and La Perouse cruises are usually very useful for calibration, but analysis was delayed by 2 to 3 months. Estimating errors suggested that the primary salinity was fairly accurate and the secondary salinity high by about 0.005psu. The Seamount cruise results show a large change in both salinity channels from the cruise before. Changes on the order of 0.014psu and 0.015psu are unusual and since both channels were affected, this is not likely due to a change in CTD calibration. The changes between the Seamount cruise and 2021-008 were of the opposite sign and estimated to be about 0.007psu and 0.009psu. This does make 2021-036 stand out as odd.

No obvious explanation was found as to why CTD salinity was reading lower relative to bottle samples during this cruise than during all other cruises using this equipment despite relatively prompt analysis and being offshore where flushing is expected to be relatively good.

The secondary salinity compared well with bottles for the last 4 uses and the post-cruise calibration showed little drift, but it is noisier. Using the primary channels and stating that there are concerns about accuracy appears the most reasonable choice. For recalibration, the post-cruise estimate is the best information available and suggests that salinity is low by 0.0065psu.

The primary channels were chosen for editing because there is less noise in the traces and it was found best for the 4 cruises that preceded it due to excessive noise in the secondary salinity.

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.

The edited files were copied to \*.EDT.

After editing, T-S plots were examined for all casts. A few near-surface small unstable features remain in some casts but may well be real. No further editing was done.

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

Based on results of other cruises using this CTD, pressure is considered high by 0.8db.

As noted earlier the evidence concerning salinity calibration is confusing. The COMPARE routine indicated that both the primary and secondary salinity were lower than bottles by much more than from any other cruises using this equipment since the calibrations of winter 2020/2021, despite fairly prompt analysis and no expectation of large flushing errors. Allowing for delayed analysis of samples and flushing errors, the cruises immediately before and after this one had salinity low by ~0.003psu and ~0.007psu. The most reliable information comes from the factory check of conductivity and temperature sensors in early 2022. Using the post-cruise calibrations salinity was found to be higher by 0.0065psu. So 0.0065psu will be added to the primary salinity for this cruise.

File 2021-036-recal.ccf was prepared to add 0.0065psu to channel Salinity:T0:C0, subtract 0.8db from pressure and to apply the following correction to channel Oxygen:Dissolved:

CTD DO Corrected = CTD DO \* 1.0490 + 0.0009

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 correction looks good below 110db but above that the CTD DO is generally lower than the bottles. This is presumed to be due to a reversal in DO gradients at about 100m.

See file 2021-036-DO-comp2.xls for details.

COMPARE was rerun for salinity and shows that the correction was applied properly, but, as expected, the CTD primary salinity is still reading significantly lower than bottles. When outliers are excluded based on standard deviation in the CTD data the average differences is -0.0074psu.

See file 2021-036sal-comp2.xls for details.

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.

When 5 outliers are excluded based on residuals, the downcast CTD DO was higher than the titrated samples by an average of ~0.003mL/L (standard deviation 0.039mL/L). This is a good result, though values in the top 110m tend to be slightly low, which is expected given how the correction was derived. Near the surface CTD DO is generally within 1% of titrated DO. Near the OMZ % differences are large as small differences look more significant, but mostly the CTD looks high. Below 2000m the CTD generally reads a little low, but within 2%.

Based on the differences plotted against pressure a rough estimate of the downcast DO is:

 ±0.20 mL/L from 0-110db

 ±0.10 mL/L from 120-500db

 ±0.04 mL/L from 500-3000db

 ±0.06 mL/L below 300db

For more detail see file 2021-036-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. No problems were noted.

##### 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, PAR, 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 the 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 ~103% to 106%, typical values for the offshore region.

##### 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, PAR, 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.

Data were exported from the CHE files to file 2021-036-bottles-final.xlsx. The entries were compared 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.

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

4, Bottles files out of order

22. Descent rate slowed down ~1660m

56. Real pressure > sounder reading. 4 salinity samples lacked outer caps.

**2021-036**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **CTD#** | **Make** | **Model** | **Serial#** | **Used with Rosette?** | **CTD Calibration Sheet Competed?** |
| **1** | **SEABIRD** | **911+** | **0443** | **Yes** | **Yes** |
| **Calibration Information - 0506** |
| **Sensor** | **Pre-Cruise** | **Post Cruise** |
| **Name** | **S/N** | **Date** | **Location** | **Date** | **Location** |
| **Temperature** | **4700** | **12Dec2020** | **Factory** | **5Jan2022** | **Factory** |
| **Conductivity** | **3531** | **06Jan2021** | **Factory** | **8Feb2022** | **Factory** |
| **Secondary Temp.** | **4888** | **12Dec2020** | **Factory** | **14Jan2022** | **Factory** |
| **Secondary Cond.** | **4513** | **18Dec2020** | **Factory** | **8Feb2022** | **Factory** |
| **Transmissometer** | **1185DR** | **28Apr2021** | **Factory** |  |  |
| **Transmissometer** | **1883DG** | **28Apr2021** | **Factory** |  |  |
| **SBE 43 DO sensor** | **3791** | **22Dec2020** | **Factory** |  |  |
| **PAR sensor** | **70613** | **24Feb2021** | **Factory** |  |  |
| **SeaPoint Fluor.** | **3950** |  |  |  |  |
| **Pressure Sensor** | **0443** | **07Jan2021** | **Factory** |  |  |
| **Altimeter** | **75321** |  | **Factory** |  |  |



