## REVISION NOTICE TABLE

|  |  |
| --- | --- |
| DATE | DESCRIPTION OF REVISION |
|  |  |
| 27 Mar 2025 | Updated channel names & formats in TOB files. G.G. |
| 25 May 2022 | Added 0 to empty flag channels. G.G. |

## PROCESSING NOTES

Cruise: 2015-61

Agency: Ocean Sciences Division

Location: North-West Coast Vancouver Island

Project: World Class Oil Tanker / Cape Scott Environment

Party Chief: Romaine S.

Platform: John P. Tully

Date: 13 October 2015 – 22 October 2015

Processed by: Germaine Gatien

Date of Processing: 15 February 2016 – 8 April 2016

Number of original CTD HEX files: 41 Number of CTD files: 39

Number of original Bottle files: 15 Number of CHE files: 13

Number of original TSG HEX files: 5 Number of TOB files: 5

# INSTRUMENT SUMMARY

SeaBird Model SBE 911+ CTD (#0585) was used for this cruise. Attached were an SBE 43 DO sensor (#1119) on the primary pump and a Seapoint Fluorometer (#3685) on the secondary pump and a WetLabs transmissometer (#1185DR), SBE18 pH sensor (#0692), a Biospherical QSP200L4S PAR sensor (#4615) and an altimeter (#62354).

The computer was the Tully laptop.

The deck unit was a Seabird model 11, serial number 0619.

The salinometer used at IOS was a Guildline model 8400B Autosal, serial # 68572.

An SBE21 Thermosalinograph (serial #3363) sampled every 30s.

# SUMMARY OF QUALITY AND CONCERNS

The Daily Science Log was generally in good order although some comments were either hard to read or to understand. They at least made it clear that the cast required extra attention.

There were several cases of times in the log book being different from those in the file headers by 10 minutes or more. This raises problems in choosing what TSG data to select for comparisons with CTD data. The system upload time does compare well with the log entries but NMEA time is what is in the file headers. And if there is ship movement during the wait the positions could also be off somewhat, though that was not a significant problem for this cruise.

There was a problem during cast #106. The CTD stopped during the downcast at about 570db, then reversed direction going up to about 525db and then resumed going down; there is no mention of that event in the log, but presumably there was a winch/wire problem. As the CTD was going down Niskin #1 was fired by mistake at 558db. There is a note in the log about the misfire and the steps taken to adjust for this, but those steps were not appropriate. Since only 20 bottles were needed, bottle #21 could have been fired at the bottom and then the rest in the planned order. Instead, Niskin #6 was fired at the bottom, then bottles 2, 3, 4, 5, 7, 8 etc. were fired. The sample intended to be taken at 500m was taken from Niskin #1, so it is not from the standard depth and it was fired on the fly. Any order of firing can be dealt with in processing. Taking samples on the fly is not a good choice.

There were some errors in the labelling of salinity samples. One sample had a station name and sample number that were inconsistent and there were two samples with the same sample number where the rosette log did not indicate that duplicates were to be taken. It was impossible to establish the source of one sample.

The two conductivity channels were far apart for the first half of the cruise. This was noted at sea so it was decided to change sensors. Thankfully, lots of salinity sampling was done before the change so it is obvious that the secondary conductivity sensor was the problem. Conductivity sensor #2399 was found to be damaged during a post-cruise factory assessment.

The comparison between bottle and CTD salinity has more scatter than expected. The scatter is seen for both configurations of temperature/conductivity sensors so this does not appear to be a problem with particular CTD sensors. The samples were analyzed fairly quickly and there is no evidence that the seals were poor, so evaporation and adsorption should be small, estimated to be ~0.004. A post-cruise calibration was available for the primary sensors from the first configuration. It shows that salinity was reading high by ~0.003 after this cruise, yet the comparison with bottles shows it to be low by ~0.002. The precision study, though limited to 4 duplicates, showed poor results. The only explanation found for the scatter and the difference between the post-cruise calibration and bottle comparison is that the bottles have values that are too high due to a combination of small factors: adsorption, evaporation, and incomplete flushing, all of which would lead to higher bottle values.

The comparison of Oxygen:Dissolved:SBE with titrated Do samples had a group of outliers that turned out to be from some shallow casts at depths where the DO gradient was low and where there were frequent small reversals in DO. The fit used for recalibration was based on the 3 deepest casts. There may be some overcorrection of the low gradient sections but the error is small, likely <0.03mL/L.

The Oxygen:Dissolved:SBE data are considered, very roughly, to be:

 ±0.5 mL/L from 0 to 50db

 ±0.2 mL/L from 50db to 250db

 ±0.05 mL/L below 250db

The thermosalinograph performed well and comparisons were made with CTD and loop samples of extracted chlorophyll and salinity. The intake thermistor malfunctioned, so a proxy was created by subtracting 0.23Cº from the TSG temperature in the lab, based on a comparison of the TSG and CTD temperatures. Flow in the loop was high and steady until near the end of the final file.

There were frequent spikes in the salinity towards lower values; these were less common in the latter half of the cruise and during the return trip. There is no apparent difference in frequency of spikes between times when the ship is stopped or moving. Salinity was recalibrated by adding 0.04psu based on comparisons with CTD salinity and loop samples during periods when there was lower variability in the salinity. A post-cruise calibration shows that the TSG salinity was actually reading high, so calibration drift does not explain the results. A possibility is that bubbles lead to low TSG salinity values.

The TSG fluorometer data is archived in volts. No calibration parameters were available and the comparison with a CTD fluorometer and extracted chlorophyll samples from the loop was not considered robust enough to justify recalibration. As a rough guide, the fluorescence in ug/L is about 7 times the voltage.

# PROCESSING SUMMARY

##### Seasave

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

##### Preliminary Steps

The Log Book was obtained. There were notes about problems during a few casts, with stops to correct wire angles being most common. In a few cases the notes are unclear, but they at least give warning of potential problems. It would be helpful to have comments about changes indicate whether they occurred before or after the event beside which they are entered.

The temperature and conductivity sensors were changed before cast #102.

The cruise summary sheet was completed.

The history of the pressure sensor, conductivity, fluorometer and DO sensors were obtained. There was no history of use for the temperature and conductivity sensors for the 2nd configuration.

The extracted chlorophyll, dissolved oxygen, nutrient and salinity analysis spreadsheets were obtained.

The calibration constants were checked for all instruments and no errors were found.

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

Files were converted using con file 2015-61-ctd1.xmlcon for events #1-77 and 2015-61-ctd2.xmlcon for events 102-135 with the hysteresis correction turned on since there are some deep casts.

File 2015-61-0106.CNV contains only downcast data. The upcast was acquired in a separate file, 2015-61-0106B.cnv.

A few casts were examined and all expected channels are present. The two temperature channels were close during downcasts, with the usual larger differences on the upcast. The fluorescence, PAR, pH and dissolved oxygen traces look normal.

The conductivity channels are far apart, by >0.01, for the first configuration. A quick comparison was made of one cast with many salinity samples and it appears that the problem is with the secondary conductivity sensor.

##### WILDEDIT

Program WILDEDIT was run to remove spikes from the pressure, conductivity & temperature only.

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.

##### BOTTLE FILE PREPARATION

The ROS files were created using files 2015-61-ctd1.xmlcon and 2015-64-ctd2.xmlcon.

File 2015-61-0106.ROS contains only 1 bottle. File 2015-61-106B contains the rest of the bottles.

The files from event #106 were examined to understand what happened. The CTD stopped during the downcast at about 570db, then reversed direction going up to about 525db and then resumed going down; there is no mention of that event in the log. Shortly after that reversal Niskin #1 was fired by mistake at 558db during the downcast; that was mentioned in the log. The steps taken after that were not appropriate. Since only 20 bottles were needed, bottle #21 could have been fired at the bottom and then the rest in the planned order. Instead, a new file was started at the bottom and Niskin #6 was fired at the bottom, then bottles 2,3,4,5,7, 8… were fired, and the sample intended to be taken at 500m was taken from Niskin #1. Sample #81 is from Niskin #6 at the bottom of the cast. There was no salinity sample there.

There are two ways to approach creating a bottle file for event #106. The file originally named 2015-61-0106 was renamed 2015-61-0106a. It will not be processed as it contains only the 1 bottle.

* Data from file #106a could be inserted into the middle of the data in file 106B. The bottle numbers (order of firing) would have to be changed throughout the file and it would be misleading to users to suggest that samples from Niskin #1 were gathered in the same way as the others. File 2015-61-0106c was prepared for testing and then renamed 2015-61-9106. If this file is used, it will have to be noted that the CTD travelled about 8m in the 10s window around firing time.
* The downcast firing of Niskin #1 can be ignored. This would mean there is no sampling reported but since it was gathered on the fly the actual depth for the samples is meaningless. Even when stopped there is some doubt about the source of water in a Niskin bottle, but when taken on the fly this uncertainty is much higher. The file originally named 106b was renamed as 2015-61-0106 and does not contain the 558m data.

Tests were done using both approaches. An initial examination shows that for Niskin #1 the CTD salinity decreased steadily during the 10s window with a difference of about 0.008 between the start and end of the window. It was decided to drop Niskin #1 and rename file 2015-61-0106b as 2015-61-0106.

Cast #1 was only a test with no sampling, so it was dropped from the bottle cast list.

The ROS files were converted to IOS format.

They were put through CLEAN to create BOT files.

Temperature and salinity were plotted for all BOT files to check for outliers.

* Cast #38 had a lot of noise in all variables at 50m, but this just reflects general variability with no clearly bad records, so no editing was applied.
* Cast #45 had a little noise in both salinity channels, but it was minor and could be real.
* Cast #9106 shows a steady change in temperature and salinity values but that is because the CTD was moving. Editing won’t help.
* Cast #135 has a few bad points in the primary salinity. They were removed. The output file was copied to 2015-61-0135.BOT.

A preliminary header check was done and no problems were found. Fluorescence did not go off-scale.

The BOT files were bin-averaged on bottle number and the output was used to create file ADDSAMP.csv. Sample numbers were added to the file based on the rosette log records.

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

SAM files were created using the Add Sample Number routine. Those files were bin averaged on bottle number.

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 2015-61-bot-hdr.txt which will be updated as needed during processing.

EXTRACTED CHLOROPHYLL

Extracted chlorophyll and phaeo-pigment data were obtained in file QF2015-61chl\*.xls. The file included comments, flags and a precision study. A simplified version of the spreadsheet was prepared in which some columns were removed and the file was saved as 2015-61chl.csv, the data for event 106 were repeated for event 9106, and the file was then converted to individual CHL files.

DISSOLVED OXGYEN

Dissolved oxygen data were provided in spreadsheet QF2015-61oxy.xls which includes flags, comments and a precision study. Draw temperatures are available. The spreadsheet page with the final data was simplified, the data for event 106 were repeated for event 9106 and the file was then saved as 2015-61oxy.csv. That file was converted into individual \*.OXY files.

SALINITY

Salinity analysis was obtained in 2015-61SAL.xls. The analysis was done within 36 to 44 days of collection. The files were simplified, the data for event 106 were repeated for event 9106 and saved as 2015-61sal.csv. Loop files were removed from that file and saved in file 2015-61-loop data.xlsx. The csv file was then converted to individual SAL files.

NUTRIENTS

The nutrient data were obtained in spreadsheet QF2015-61nuts.xls.

Then the file was simplified, reordered on sample numbers and saved as 2015-61-nuts.csv. The the data for event 106 were repeated for event 9106 and 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 the files were put through CLEAN to reduce the headers to File and Comment sections only.

The merged 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. The output files were named MRGCLN1s. Those files were then merged with SAMAVG files choosing the Bottle\_Number from the SAMAVG files.

The output of the MRG files were exported to a spreadsheet and compared to the rosette log sheets to look for omissions. There were problems with the order and the addsamp.csv file needed to be fixed and the merges repeated. Problems remain with the 9106 version but editing the MRGCLN2 file by hand produced what is likely correct. Further effort was not pursued since this file does not look useful.

CLEAN was run on the MRG files to add 0 flags to empty flag channels and to update header limits. (MRGCLN2)

##### Compare

Salinity

Compare was run with pressure as reference channel.

There was 1 very large outlier from event #125; sample #137 from 250m has salinity lower than the CTD by about 1.8psu and it looks like a surface sample. This appears to be a case of a discrepancy between the rosette sheet entries and what was actually sampled. There was likely also some confusion of event # and sample # and station names may be wrong on labels. There are 3 casts involved:

* Event #118 – station MT-52 – The log shows salinity samples #123 and 135 with no duplicates. Sample labels include #123 (station MT52) and two samples labelled #135 station MT-72. Sample #123 and one of the samples #135 are in reasonable agreement with the CTD salinity. The analyst corrected the station name to MT-52 for the first sample labelled as sample #135 and that appears to be right. For the second sample labelled as #135 the station name was right for #137 and there was no sample #137, so the analyst renamed it as #137. That appears to be wrong.
* Event #125 – station MT-72 – The log shows sample #137, no duplicate. The sample renamed as #137 by the analyst is way out of line with the CTD salinity and it looks like a surface sample, not one from 250m. It looks extremely close to sample #160, but it could also be from the surface bottle from event #125.
* Event #135 – station SS45 – log shows sample #160, no duplicate. The sample is reasonably close to the CTD salinity and very close to the 2nd sample originally named #135. Since sample #160 is from event #135, it is possible that the 2nd sample labelled #135 could have confused the event number with the sample number.

The evidence is too weak to establish the source of the 2nd sample labelled as #135. The analyst decided it was best to replace the sample that had been renamed as #137 with a pad value and flag 5.

COMPARE was rerun after that correction. Bottles were excluded that had a standard deviation in the CTD salinity >0.0008 and for bottles above 200db.

The sensors were changed after cast #77, so the comparisons were split into 2 groups.

1. Sensor pairs for casts #1 - 77 (T:4752/C:3396 & T:2449/C:2399)

* The primary salinity for the first sensor pair has smaller differences from bottles than the secondary, but there is more scatter in the comparison than usual. When bottles are excluded for which the standard deviation in the CTD salinity is >0.008, the differences below 200db range from +0.005 to -0.007. The salinometer is stated to be good to ±0.002 when working well. The CTD itself is also subject to errors on that order as well, including errors that arise from the derivation of salinity. There were only 4 duplicates with precision Sp = 0.004 and differences ranging from 0.004 to 0.007, which is a poorer result than usual. The post-cruise calibration shows that the CTD was reading high by about 0.0026psu; that is an estimate based on monthly conductivity drift plus temperature drift. A test conversion of a deep cast using the post-cruise calibration suggests a slightly larger drift, between 0.0029 and 0.0034. If we assume that the CTD is reading high by 0.003, then the best results from the salinity comparison come from around 100-200m and 500m.The worst are around 300m and below 1000m. There are probably too few data to make sense of this result, but it appears likely that bottle salinity values are too high but not in a systematic way.

We can expect the bottle salinity to be a little too high because of adsorption which might account for ~0.0015psu increase. Evaporation would be random depending on how well bottles were sealed. The analyst noted no poor seals, so we don’t expect that evaporation should be worse than usual. If the seals are good we expect evaporation might raise salinity by as much as 0.003 after 1.5 months. Another cause for bottle salinity to be high is poor flushing of Niskin bottles so that the bottles contain water from lower in the water column. These outliers are mostly deep where vertical gradients are fairly low and the casts are in areas where the CTD moved a lot during the bottle stops which is likely to help the contents approach in situ values. Nonetheless, the differences are small, so even slight inefficiency in flushing can account for bottle values being a little high, and that would be somewhat random.

SeaBird recommend removing outliers until a flat fit of differences versus pressure is achieved, but there is no reasonable way to do it with these data. Below 200m, the CTD salinity is lower than bottles by an average of 0.0016 and the standard deviation is 0.0034. So if we assume the bottles are reading higher than they should be 0.0015(adsorption) + 0.003(evaporation), then the CTD is reading high by ~0.003. The average looks good, but it is based on few data with a very large standard deviation, so this is not very strong evidence.

* The secondary salinity was higher than bottles by between 0.1 and 0.22psu. The secondary conductivity cell was found to be damaged after the cruise. This explains the large salinity differences noted at sea.

2. Sensor pairs for casts #102 – 135 (T:5725/C:4448 & T:5724/C:4434)

* The primary CTD salinity was found to read lower than bottles in all cases that had not been excluded based on depth and CTD salinity noise. As found for the other pair of primary sensors there is a lot of scatter in the comparison with differences ranging from -0.008 to -0.001. The CTD salinity is lower than bottles by an average of 0.0045 and the standard deviation is 0.0025.
* The secondary CTD salinity is lower than bottles by an average of 0.0016 and the standard deviation is 0.0025.
* The fact that the scatter in the fits for the 2nd set of sensors is almost as high as in the first set and is found for both sensor pairs likely rules out a CTD problem as an explanation. As noted for the primary sensors from the first configuration flushing problems are likely small but not negligible. Absorption of samples and evaporation can explain a small part of the differences, ~0.004. The only other explanation is a salinometer problem.

The analyst noted only one case of poor stability in analysis. When deep sub-standard water samples were run the first was slightly higher than the others, but only by 0.001psu, and the rest were within ±0.0003psu.

The 4 duplicates all have the B sample with a lower salinity than the A sample. Comparing the samples with the CTD value shows the 2nd sample was closer to the primary CTD salinity in every case. This might suggest that rinsing is a problem but there was no pattern in whether duplicates were run after samples with higher or lower salinity. The CTD salinity is lower than the 3 A samples for the 1st set of sensors by an average of -0.0046 and higher than the B samples by an average of 0.0007. The B results are in reasonably close agreement with the post-cruise calibration allowing for a little adsorption, evaporation or incomplete flushing of bottles.

There is no indication of salinity dependence in the differences, so salinometer non-linearity is not a suspect in the case.

No clear explanation emerged from this study. There are likely a number of factors leading to higher bottle values including adsorption of samples, evaporation of samples and incomplete flushing of Niskin bottles. In general the samples were run in order of decreasing salinity within each cast, so if there are small errors caused by inadequate rinsing, they would contribute fairly systematically towards the bottle salinity being too high. More duplicates would have helped greatly. It is unfortunate that almost every source of error produces differences of the same sign and most have some randomness.

For full details for the COMPARE run see file 2015-61-sal-comp1.xls.

Dissolved Oxygen

COMPARE was run with pressure as the reference channel.

There were no noteworthy outliers but there was a lot of scatter.

From a plot of differences versus pressure there appeared to be a group of bottles that stood out as different. When they were removed from the fit so they appeared red on the plot, and were then re-plotted versus CTD DO they mostly stood out in that display as well. The outliers are from between 30 and 300db and mostly from casts 112 to 135. Examination of the DO profiles for the DO bottle casts show great variability in DO gradients in the 50 to 400db range with frequent sections of low gradients or a series of small reversals for others. The fit that is found using all the data will overcorrect some areas, under-correct others. Attempts were made to find pressure-dependent fits or fits that divided the cruise into 2 sections, but none look convincing.

When only the 3 deepest bottle casts were included the scatter is much reduced if the very well-mixed surface waters are excluded. This looks like the best that can be achieved from an area with such variable conditions.

CTD DO Corrected = CTD DO \* 1.0363 +0.0806 (R2 = 0.96)

While the offset seems quite large, there was reasonable consistency among the bottles with DO<0.4mL/L and the analyst considered the precision for the DO analysis to be good. The casts selected are well offshore where flushing is likely to be fairly good.

This fit may overcorrect the DO for the low-gradient sections of casts #112-135, but a comparison with a correction based on a fit featuring those sections suggests that the effect is small, <0.03mL/L.

For more detail see document 2015-61-dox-comp1.xlsx.

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

Fluorescence

COMPARE was run with extracted chlorophyll and CTD Fluorescence using pressure as the reference variable. The CTD fluorometer was a SeaPoint sensor. There was a small range of CHL values, 0.6ug/L to 2.9ug/L with most samples being between 1 and 2ug/L. The shape of the plot of FL/CHL vs CHL was typical of these instruments with the Fluorometer high for the lowest CHL value, close to 1 for 1<CHL<2ug/L and about half the CHL value for CHL>2.5ug/L.

For full details of the comparison see file 2015-61-fl-chl-comp1.xlsx.

##### ALIGN DO

Tests were run on a few casts to determine the best setting to align the dissolved oxygen sensor traces with the temperature. A setting of +4.5s produced the best results.

ALIGNCTD was run applying that setting to the SBE Dissolved Oxygen channel.

##### CELLTM

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

##### DERIVE

Program DERIVE was run twice:

on all casts to calculate primary and secondary salinity and dissolved oxygen.

on a few casts for each of the 2 configurations to calculate the differences between primary and secondary channels for temperature, conductivity and salinity. These were placed in a test directory and will not be archived.

##### Test Plots and Channel Check

The only other cruise during which the primaryary sensors were used was 2015-15 which has not been fully processed but the differences between sensors has been checked, so they are listed above the 2015-61 data. All those casts were shallow. The secondary sensors have not been used on any cruise that has been processed since they were last recalibrated. The differences were:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Cast # | Pressure | T1-T0  | C1-C0 | S1-S0 | Descent Rate |
| Previous cruise |  |  |  |  |  |
| 2015-15-0002 | 240 | +0.0013 | -0.0006 | -0.0076 | Steady, Mod |
| 2015-15-0007 | 240 | +0.0013 | +0.0498 | +0.0509 | Steady, High |
| 2015-15-0123 | 240 | +0.0014 | +0.0443 | +0.0453 | Steady,Mod |
| 2015-15-0245 | 240 | +0.0004 | +0.0184 | +0.2023 | Noisy, High |
| 2015-15-0362 | 240 | +0.0013 | +0.0422 | +0.4308 | Steady, Mod |
|  |  |  |  |  |  |
| 2015-61-0014 | 240 | +0.0010 | +0.0067 | +0.0728 |  |
| “ | 950 | +0.0007 | +0.0074 | +0.0870 | FNoisy, High |
| 2015-61-0076 | 950 | +0.0008 | +0.0090 | +0.1057 | XNoisy, Mod |
| “ | 1500 | +0.0011 | +0.0092 | +0.1109 | XNoisy, High |
| 2015-61-0077 | 950 | +0.0011 | +0.0163 | +0.1937 | XNoisy, High |
| “ | 1500 | +0.0010 | +0.0167 | +0.2028 | XNoisy, High |
| Change of sensors |  |  |  |  |  |
| 2015-61-0105 | 180 | -0.0004 | +0.0002 | +0.0021 | VNoisy, High |
| “ | 950 | -0.0005 | +0.0002 | +0.0027 | XNoisy, High |
| “ | 1500 | -0.0006 | +0.0003 | +0.0028 | XNoisy, High |
| 2015-61-0108 | 180 | -0.0004 | +0.0002 | +0.0023 | VNoisy, High |
| “ | 950 | -0.0005 | +0.0002 | +0.0027 | XNoisy, High |
| “ | 1500 | -0.0005 | +0.0002 | +0.0027 | XNoisy, High |
| “ | 1950 | -0.0006 | +0.0002 | +0.0027 | XNoisy, High |
| 2015-61-0135 | 180 | -0.0002 | +0.0002 | +0.0022 | Noisy, High |

For the first set of sensors there is clearly a problem with at least one of the conductivity sensors, and it is growing with time. The downcast for 2015-15-0002 looked ok, but during the upcast the secondary salinity suddenly rose and stayed high. There is pressure dependence in the salinity differences which suggests a bad cell on the secondary conductivity sensor. The difference between the temperature sensors is a little high, but not bad and if there is any temporal drift it is impossible to say because there is a lot of noise in the traces.

For the second set of sensors the temperature and conductivity differences are small. The salinity difference is fairly small, though we might hope for smaller differences given these sensors do not appear to have been used since they were last recalibrated. The only deep casts were close in time, but differences for shallow casts look similar, so there is no obvious temporal drift.

##### Conversion to IOS Headers

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 header check was run and the only oddity noted was negative pH values, but that was from a cast for which the sensor was not mounted.

The surface check gave an average value of 2.4db which is fairly shallow for the Tully. The minimum pressure was ~0.6db at the end of an upcast. During the previous cruise using this sensor, there were records with pressure ~0.4db with pumps on and data clearly indicating the CTD was in water. With pumps off there are cases of very low salinity with pressures ~0.2db, so that could have been in or out of water. So pressure looks good to ±0.2db.

The cross-reference check was compared with the log book and no errors were found. However, there were cases where times in the log were more than 10 minutes later than those in the headers. This is problematic in doing comparisons with thermosalinograph data, especially in a region like this where temporal variability is high. On some other recent cruises there have been cases where not only times were different, but also positions. This suggests that the header information was collected while the ship was still moving. For this cruise that does not appear to be the case.

The cruise track was plotted and added to the end of this report. No problems were found.

##### Shift

Fluorescence

A shift of +24 is the usual setting used to align the SeaPoint fluorometer data with temperature.

SHIFT was run on all casts to advance the fluorescence by +24 records.

Checks made after the shift (looking at casts with no stops for bottles) show good results.

pH

This is the first known use of this sensor since it was last recalibrated so there is no history on how to align it.

Because of hysteresis in the pH signal, tests are best run on casts with distinctive features in the pH traces. This was done by finding the distance between such features in the upcast and downcast and comparing that with the temperature offset after applying a variety of shifts. A setting of +90 records produced the best results overall. SHIFT was run on all casts with the setting +90 records.

Conductivity

Because conductivity sensors were switched after cast #77, tests had to be done in two groups.

For the first group only the primary sensors will be aligned since the primary conductivity was bad through most of the previous cruise and that continued through this cruise.

Tests were run on 3 casts from each section and the optimal choice was -0.5 records for the primary conductivity for both sections and for the secondary conductivity from the 2nd second section.

Three runs of SHIFT were used to apply advance the primary by -0.5 records for all casts and the secondary by -0.5 records for casts #102 to #135.

Dissolved Oxygen

Plots were examined to see if the alignment applied earlier was sufficient and it was.

##### DELETE

DELETE was run using SHFC0 as input for casts 1-77 and SHFC1 for casts 102-135.

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.

The altimetry and water depth header entries were exported to spreadsheets from both the bottle and profile data files.

* The water depths were checked against log entries and differences of more than 2m were investigated. In 3 cases the log entry looks better and was used to replace the header entry. In one case the log entry was changed but both are much shallower than the CTD cast, so the header was removed. Another case has 2 log entries and both are a bit high, but the later log entry was used to replace the header entry. It is assumed depths were changing rapidly through many of these casts. The changes were made in the DEL files and the SAM and SAMAVG files (before adding the chemistry data).
* Altimetry was checked for a few casts and the entries were all found to be appropriate.

In checking these entries it was found that cast #8 was incomplete, stopping about 17db above the bottom and there are no upcast data. There is no explanation of what happened in the log book.

##### Other Comparisons

Previous experience with these sensors –

*Salinity:*

The conductivity sensors used for casts #1-77 were recalibrated in December 2014 and January 2014 and the only known use of them was during 2015-15. That cruise is only partly processed and has very limited calibration sampling, but it is clear that the secondary conductivity performed badly.

The temperature sensors used for casts #1-77 were recalibrated in January 2014 and April 2011.

For casts #102-135 the T and C sensors were all recalibrated in January or February 2015 and had not been used on other cruises since then.

*Dissolved Oxygen Sensor:*

The sensor was recalibrated in January 2014 and the only known use since then was during 2015-15 from which there is no calibration sampling. There is no useful history.

*Pressure:*

The pressure sensor was recalibrated in Dec 2013 and the factory offset has been used since then.

Historic ranges – All temperature and salinity from the Hecate Strait casts fell within the 3-standard-deviation climatology. From the Cape Scott area most casts had temperatures a little above the top of the climatology range for some part of the 40-80db depths. Similar deviations from the climatology have been found from other cruises in the Strait of Georgia and Queen Charlotte Sound. The climatology is considered too severe for areas near the coast.

Repeat Casts – There were no repeat casts.

Post-Cruise Calibration – A post-cruise calibration became available during processing. It confirmed that there was damage to the secondary conductivity cell. It also showed that the primary salinity was high by about 0.003psu based on conductivity and temperature drift. The dissolved oxygen sensor was found to read low by roughly 2.5-3%.

##### DETAILED EDITING

The first issue is to decide which sensor pair to edit. For casts #1 to 77 there is no question as we must use the primary sensors. For casts #102 – 135 the choice is unclear. The secondary salinity is closer to bottles, but we have reason to expect that the bottle values are reading higher than in situ values, so the primary results may better reflect actual conditions. If the bottle values are high by at least 0.003 then the primary CTD channels are more accurate than the secondary. The noise level in the two channel pairs is similar. The primary channels will be selected for both sensor pairs.

CTDEDIT was used to remove spikes that appear to be due to instrumental problems and likely to affect the bin-averaged values and records corrupted by shed wakes including some surface records. During downcasts there were some cases of very high descent rate with frequent sudden deceleration.

All casts required some editing.

##### Initial Recalibration

The pressure does not need recalibration.

For casts #1-77 there is some doubt about how to recalibrate the primary salinity. The post-cruise calibration shows the salinity was high by about 0.003. There were no cruises between this one and the factory calibration, but it is possible some drift occurred over the intervening 2 months. The comparison with bottles was very confusing, but when all the possible errors are considered, it could be consistent with the post-cruise calibration. The post-cruise calibration will be used to apply the correction:

 Salinity Corrected = Salinity (T0:C0) -0.003 (Casts 1-77)

For casts 102 to 135 there are also doubts about the calibration. An estimate was made that the primary salinity is within ±0.002 and no recalibration will be applied.

For dissolved oxygen the following correction will be applied to all casts:

CTD DO Corrected = CTD DO \* 1.0363 +0.0806

File 2015-61-recal1.ccf was prepared to apply the above corrections.

CALIBRATE was 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 always expected due to ship drift, temporal changes, incomplete flushing of Niskin bottles 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 scatter in the comparison is very high especially in the top 100m. The CTD DO is in good agreement with bottles at the top and bottom of the DO range, but generally higher than bottles in between, which is what we expect if flushing is incomplete as the bottles contain water from deeper in the water column where DO is lower. The vertical gradients at the top and bottom of the cast are lower than at mid-depths, so there is less effect there. The CTD DO is higher by an average of 0.039mL/L but the standard deviation is 0.071mL/L. These differences are most likely due to incomplete flushing and no further calibration of CTD DO is justified.

##### Fluorometer Processing

At this stage a median filter, fixed size=11, is usually applied to reduce spikiness in fluorescence channels, but examination of all casts shows little spikiness, so this step was skipped. It looks like the sampling rate was set low on the sensor.

##### 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.

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

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

Scan\_Number, Temperature:Secondary, Salinity:T1:C1, Conductivity:Primary, Conductivity:Secondary, Oxygen:Voltage:SBE, Status:Pump, Descent\_Rate and Flag. Channels PAR and pH:SBE were removed from casts #76-112 and pH:SBE was removed from cast #133.

Profile plots were produced at this point to check for errors. No problems were found.

T-S plots were produced; there are some small unstable features that likely reflect real conditions.

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 following comments:

*----------------------------------------------------------------------------------*

*Data Processing Notes:*

*----------------------*

*Fluorescence, transmissivity, PAR and pH data are nominal and unedited except*

 *that some records were removed in editing temperature and salinity.*

*The comparison of CTD salinity with bottle salinity showed a lot of*

 *variability. The analyst found the salinity analysis precision to be poor,*

 *but noted that there were only 4 duplicates available. The bottle salinity*

 *values appear to be too high, on average, based on a post-cruise calibration*

 *of one set of temperature/conductivity sensors. This is likely due to a*

 *combination of small effects: evaporation and adsorption of samples and*

 *incomplete flushing of Niskin bottles. The primary salinity for the first*

 *configuration was recalibrated based on the post-cruise calibration. No*

 *correction was applied to the primary salinity for the second configuration.*

*The Oxygen:Dissolved:SBE data are considered, very roughly, to be:*

 *±0.5 mL/L from 0 to 50db*

 *±0.2 mL/L from 50db to 250db*

 *±0.05 mL/L below 250db*

*WARNING: The pH:SBE:Nominal data should be used with caution; no field*

 *calibration data were collected. Calibration is required for each cast to get*

 *absolute values, although general trends within a cast are likely real.*

*For details on the processing see the report: 2015-61\_Processing\_Report.doc.*

*---------------------------------------------------------------------------------------------*

The cross-reference list was produced and no problems were found.

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

The Header Check was run and no problems were found.

The final files were named CTD.

The track plot looks fine.

The sensor history files were updated.

##### Dissolved Oxygen Surface Saturation

Dissolved Oxygen saturation was derived and plotted. The surface saturations varied from about 90% to 110%. The casts in the most exposed waters had values around 103% which is what we expect. Values were a little lower in Hecate Strait and lowest in Saanich Inlet.

##### Final Bottle Files

CALIBRATE was run on the MRGCLN2 files and then the MRGCOR1 files were put through SORT to order on increasing pressure.

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

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

Channels PAR and ph:SBE were removed from casts #76-112.

A second SBE DO channel was added for both the CTD DO and bottle DO, with mass units and REORDER was run to get the 2 SBE DO channels together.

HEADER EDIT was run to ensure formats and units are correct, change the channel name Bottle\_Number to Bottle:Firing\_Sequence and the name Bottle:Position to Bottle\_Number and to add a comment about quality flags and analysis methods and a few notes about the CTD data processing.

Standards check and a header check were run on all files and no errors were found.

The track plot looks ok.

Data from the CHE files were exported to a spreadsheet and compared with rosette sheets and no errors were found. That file was saved as 2015-61-bottles-final.xlsx, but will not be placed in the OSD Data Archive since it is liable to change and is difficult to keep accurate.

Plots of each file were examined to ensure no problems had crept in and no problems were found.

##### Thermosalinograph

Data were provided in 5 hex files. There was an external thermistor and flow meter.

There were loop salinity samples taken.

a.) Checking calibrations

The configuration files were identical as to equipment and the calibration parameters for those were correct. One of these files was saved as 2015-61-tsg.xmlcon.

4 casts had the NMEA input connected to the PC and 1 to the deck unit.

b.) Conversion of Files

All files were converted to CNV files using configuration file 2015-61-tsg.con.

Converting all the files with a single configuration file appears to work fine.

Those CNV files were then converted to IOS HEADER format.

CLEAN was run to add End times and Longitude and Latitude minima and maxima to the headers.

ADD TIME CHANNEL was used to add Time and Date channels.

A time-series plot showed that the data look reasonable though there are frequent one-sided spikes (towards lower values) in the salinity of up to size ~0.5 though most are much smaller than that. The flow rate was very steady at ~1 for most of the cruise, but the flow was off for the last 3 hours of the last file.

The temperature difference is unusually large and has the wrong sign – the intake temperature is higher than the lab temperature. A cursory comparison was made with some CTD casts and the lab temperature and salinity compare reasonably well. The intake temperature is much too high and by a highly variable amount, so this variable will not be useful. (This sensor will be sent to SeaBird for service.)

The spikes in the salinity are rare in the latter half of the cruise and during the return trip. There is no apparent difference in frequency of spikes between times when the ship is stopped or moving.

The track plot looks fine. The plot was added to the end of this report.

c.) 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 4db and exported to a spreadsheet which was saved as 2015-61-ctd-tsg-comp.xls. There were 37 casts which overlapped with TSG files.

The TSG files were opened in EXCEL, median and standard deviations (over 5 records) were calculated for intake temperature, lab temperature, salinity and fluorescence and the files were reduced to the times of CTD files and loop samples.

To check for problems in the TSG clock or bad matches of TSG and CTD data, the differences between latitudes and longitudes were found. Most differences in latitude and longitude were <0.0004°. Exceptions were both latitude and longitude for casts #76 and 77 which had very large differences, and casts #40 and 42 which had longitude differences of 0.0008° and 0.0005°, respectively. When the two very poor results were excluded, the median differences in both were 0.0000°. Investigation of casts #76 and 77 shows that the TSG positions were became stuck at scan 2782 of file #3. The other channels updated, so we can use the data to compare with the CTD since we know the time. But the positions are unknown, so that data needs to be padded in the TSG file. In all other parts of the record the study shows both the times and positions are reliable for both systems.

d.) Comparison of T, S and Fl from Loop & Rosette Samples and TSG and CTD data

* T1 vs T2 The intake temperature sensor provided data throughout the cruise, but as noted from the time-series plots, the values look bad. The intake temperature is higher than the CTD values by from 0.4C° to 0.8C°.
* Flow Rate The flow rate was very steady and close to 1 for all the CTD casts.
* TSG vs CTD The spreadsheet comparing CTD and TSG files was then examined to find the differences between the salinity, fluorescence and temperature channels for the CTD and the TSG.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | lat diff | long diff | Tint-Tctd | Tlab-Tctd | Stsg-Sctd | FLtsg/FLctd |
|  | excluding 76/77 | all |
| average | -0.00003 | -0.00007 | 0.77338 | 0.24588 | -0.06227 | 0.21852 |
| median | 0.00000 | 0.00000 | 0.77760 | 0.22990 | -0.05230 | 0.19704 |
| std dev | 0.00012 | 0.00020 | 0.17339 | 0.04295 | 0.02587 | 0.05158 |
| maximum | -0.00033 | -0.00083 | 0.36760 | 0.17530 | -0.12930 | 0.15174 |
| minimum | 0.00017 | 0.00017 | 1.17720 | 0.38460 | -0.03880 | 0.39855 |

1. *Intake Temperature* As noted elsewhere the intake temperature is >> CTD temperature. The CTD temperatures ranged from 11°C to 15°C.

2. *LAB TEMP* The lab temperature was higher than the CTD temperature by a median value of 0.230 C° (standard deviation 0.043C°). This is typical value for heating in the loop on the Tully when intake temperatures are in the range measured by the CTD casts.

3. *SALINITY* TSG salinity values are lower than the CTD salinity by a median value of 0.052psu (standard deviation 0.043psu). When the differences are plotted against the standard deviations in the TSG salinity the difference approaches a value closer to 0.04psu. Most interesting is that the differences are much lower later in the cruise than earlier. This change corresponds roughly to when the salinity spikes become much less common in the TSG traces. The standard deviation in both the TSG lab temperature and salinity decrease as well.

4. *FLUORESCENCE*

The TSG fluorescence data are uncalibrated and expressed in volts. The ratio of the TSG fluorescence to that from the CTD has a range of 0.15 to 0.40 with a standard deviation of 0.05.

The fit of CTD Fluorescence (ug/L) vs TSG Fluorescence (Volts) was:

CTD FL = 6.62 \* TSG FL - 0.40

Recalibration is not justified given the scatter and the fact that the fits are likely not linear, with some dependence on chlorophyll.

(See 2015-61-ctd-tsg-comp.xls.)

* Loop Bottle - TSG Comparisons

The comparison of TSG salinity with loop samples is similar to that found in the comparison to CTD salinity with differences decreasing through the cruise. The median difference is 0.05psu.

The comparison of TSG fluorescence with extracted CHL loop samples leads to a fit:

Loop CHL = 7.28 \* TSG FL (volts) + 0.024

The ratio of TSG Fluorescence to extracted CHL loop samples does not show any pattern with event number. However when plotted against loop CHL there is a pattern that turns up repeatedly in comparisons with all fluorometers and CHL. At low CHL the fluorometers read relatively high, while they read lower for high CHL.

(See 2015-61-loop-TSG-comp.xlsx.)

* Calibration History

The temperature and conductivity sensors were recalibrated in December 2013 and have been used for 10 other cruises since then. It was mounted on the Vector for 1 of those.

The fluorometer has only been used twice before with this equipment. During 2015-10 the fluorometer values were about 15% of the CTD fluorometer, but there was high variability with the fit:

CTD FL = 16.068 \* TSG FL - 0.9642

The fit against TSG fluorescence from 2015-21was:

CTD FL = 15.61 \* TSG FL - 0.81.

For both 2015-10 and 2015-21 fluorescence voltage was archived.

During 2014-21 the TSG salinity was found to be lower than loop samples and CTD salinity by ~0.03 but the difference varied with flow rate which was highly variable. No recalibration was applied due to the variability in the comparisons and the fact that such a large drift in calibration on its first use seemed unlikely. During 2014-19 the TSG salinity was found to be low by ~0.02. 2014-22 results were not trusted. For 2015-01, -20 and -09 the salinity was lower than loop samples and the CTD salinity by about 0.02, 0.025 and 0.03, respectively. During 2015-18 the salinity was found to be low by 0.014 but the TSG was so noisy that this was not trusted. 2015-01 salinity data were recalibrated by adding 0.02. For 2015-10 the salinity was recalibrated by adding 0.17 since it was lower than loop samples by that amount and lower than the CTD by 0.1 to 0.18. For 2015-21 the salinity was found to be lower than the CTD salinity by 0.18 using the cases with the lowest TSG standard deviation.

During 2014-19 the TSG temperature was found to be higher than the CTD temperature by ~0.005Cº. For 2015-09 the intake temperature was higher than CTD temperatures by 0.004 to 0.006, and salinity was lower than loop samples and CTD salinity by about 0.03. During 2015-10 the intake temperature was found to be higher than CTD temperature by from 0.004Cº to 0.007Cº. For 2015-21 the intake temperature was higher than the CTD temperature by a median of 0.011Cº. Heating in the loop was 0.19Cº. There was no useful comparison from 2015-46.

Conclusions

1. The TSG clock worked well.

2. The TSG flow rate was steady at ~1.

3. The TSG latitude and longitude were stuck for about 2.75 hours late on October 17. Other data appear normal.

4. The TSG intake temperature was not useful, so an estimate of heating in the loop was based on comparison with the CTD temperature at about 0.23Cº.

5. The TSG Salinity is lower than the CTD salinity by between 0.04 and 0.1. The smallest differences occur later in the cruise and are associated with fewer spikes in the salinity traces and a lower standard deviation in TSG salinity over 2 minutes. The comparison with loop samples is similar with a median difference of 0.05psu. The standard deviation in the temperature comparison with the CTD has lower values later in the cruise as well. It has been suspected that recent problems with TSG salinity reading low and spikes in the salinity traces was due to bubbles. Seeing high standard deviation in TSG temperature as well makes it seem that the explanation may not be quite so simple, or that bubbles have a small effect on temperature too.

6. The fit of CTD fluorescence in ug/L against TSG fluorescence in volts indicates that the TSG fluorescence is reading low by a factor of roughly 7.

Loop CHL = 7.28 \* TSG FL (volts) + 0.024

CTD FL = 6.62 \* TSG FL - 0.40

The previous 2 cruises showed very different fits but that is likely due to CHL values being higher during those cruises.

CTD FL = 16.068 \* TSG FL - 0.9642 (2015-10)

CTD FL(ug/L) = 15.61 \* TSG FL (volts) -0.81 (2015-21)

No recalibration will be applied as there are too many variables to consider, but a note will be made in the header comments that a rough estimate of fluorescence in ug/L may be obtained by multiplying by 7.

7. There were many spikes towards low salinity, up to about 0.5psu. These may be caused by bubbles and might account for low overall TSG salinity. Editing will remove some of the spikes but it is likely that there are other small ones that are not as obvious.

8. A post-cruise calibration showed the salinity to be too high by ~0.015. This confirms that the salinity is not low due to calibration drift. There may be small errors in salinity samples like those discussed in the CTD processing, but there must be some source of larger errors and the effect of bubbles on the TSG is the most likely cause.

9. The best choice would appear to be to correct the salinity by adding 0.04 and to create a proxy for intake temperature by subtracting 0.23Cº from the lab temperature. The salinity correction may not be high enough for the early part of the cruise, but no correction will suit all the data.

f.) Editing

The ATC files were copied to \*.EDT.

Each file was opened in CTDEDIT and the salinity channel was cleaned by removing single-point spikes towards lower values.

For file #3 the latitude and longitude values were replaced with pad values for scans 2775 to 3103 in file #3 since those values were “stuck”.

For file #5 records were removed from records #12559 to the end of the file because the flow in the loop had stopped.

g.) Recalibration

First, program Add Channel to create channel Temperature:Lab and set it equal to Temperature:Primary.

File 2015-61-tsg-recal.ccf was prepared to add 0.04 to the salinity channel and subtract 0.23C from Temperature:Primary.

h.) Preparing Final Files

REMOVE was used to remove the following channels from all casts: Scan Number, Temperature:Secondary, Temperature:Difference, Conductivity:Primary, Flag and Position:New channels.

HEADER EDIT was used to add a comment, change the DATA TYPE to THERMOSALINOGRAPH and add the depth of sampling to the header and to change channel names to standard names and formats.

Those files were saved as TOB files.

The Standards Check and Header Check were run and no problems were found.

The TSG sensor history was updated.

As a final check plots were made of the cruise track and it looks fine, with just the small gap at the end of file #3 due to removing some positions.

The cruise plot was added to the end of this report.

Particulars

Loops: 2,3,4,10,35,45,50,63,74,80,91,101,111,120,130,134,137,138.

pH and PAR: 1-75 and 115-135/

1. Bottles closed at surface as test.

5. Cable failure – no cast.

8. Transmissometer not cleaned. File stops 17db above bottom – no upcast data. No explanation in log.

40. Large difference between salinity channels ~0.11.

42. Stop at ~13db of upcast because of wire angle.

75. Paused ~60db for wire angle adjustment.

76. PAR and pH removed. Stopped ~303 on downcast because of wire angle.

77. Salinity difference ~0.2

102. Temperature and conductivity sensors changed before this cast.

105. Stop @876db because of wire angle, note about weird DO signal but looks ok.

106 & 106b. Bottle 1 tripped by accident at 558db, so file restarted at the bottom and switched to user defined firing to put the B-10 bottle @6 and the 500m bottle, originally bot 6 was taken from bot 1. The bottles and sample numbers were switched also.

108. Long pause @168db for a wire angle correction.

115. pH and PAR back on.

133. pH sensor cap left on.

# Institute of Ocean Sciences

# CRUISE SUMMARY

**CTDs**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **CTD#** | **Make** | **Model** | **Serial#** | **Used with Rosette?** | **CTD Calibration Sheet Competed?** |
| 1 | SEABIRD | 911+ | 0585 | No | Yes |

|  |
| --- |
| **Calibration Information CTD #585 (change of T and C sensors mid-cruise)** |
| **Sensor** | **Pre-Cruise** | **Post Cruise** |
| **Name** | **S/N** | **Date** | **Location** | **Date** | **Location** |
| **Temperature** | **4752** | **23Jan2014** | **Factory** |  |  |
| **Conductivity** | **3396** | **19Dec2014** | **Factory** |  |  |
| **Secondary Temp.** |  **2449** | **06Apr2014** | **Factory** |  |  |
| **Secondary Cond.** | **2399** |  **17Jan2014** | **Factory** |  |  |
| **Temperature**  | **5725** | **24Feb2015** | **Factory** |  |  |
| **Conductivity** | **4448** | **25Feb2015** | **Factory** |  |  |
| **Secondary Temp.** | **5724** | **29Jan2015** | **Factory** |  |  |
| **Secondary Cond.** | **4434** | **12Feb2015** | **Factory** |  |  |
| **Transmissometer** | **1185DR** | **Feb2014** | **IOS** |  |  |
| **SBE 43 DO sensor** | **1119** | **21Jan2014** | **Factory** |  |  |
| **Seapoint Fluorometer** | **3685** |  |  |  |  |
| **PAR** | **4615** | **16Mar2011** | **Factory** |  |  |
| **Altimeter** | **62354** |  |  |  |  |
| **Pressure Sensor** | **0585** | **30Dec2013** | **Factory** |  |  |

#  TSG

 **Make/Model/Serial#: SEABIRD/21/3363 Cruise ID#: 2015-61**

|  |
| --- |
| **Calibration Information** |
| **Sensor** | **Pre-Cruise** | **Post Cruise** |
| **Name** | **S/N** | **Date** | **Location** | **Date** | **Location** |
| **Temperature** | **3363** | **28Dec13** | **Factory** | **17Dec15** | **Factory** |
| **Conductivity** | **3363** | **28Dec13** | **Factory** | **17Dec15** | **Factory** |
| **Fluorometer** | **ws3s-953p** | **n/a (volts)** |  |  |  |
| **Temperature:Secondary** | **?** | **?** |  |  |  |
| **Flow Meter** | **n/a** | **n/a** |  |  |  |



**Station Names excluding event #1 at Station SI**

****