## REVISION NOTICE TABLE

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| DATE | DESCRIPTION OF REVISION |
| 27 Mar 2025 | Updated channel names & formats in TOB files. |

## PROCESSING NOTES

Cruise: 2014-012

Agency: OSD

Location: North Pacific / Bering Sea / Chukchi Sea

Project: Canada’s Three Oceans / Distributed Biological Observatory

Party Chief: Vagle S.

Platform: Sir Wilfrid Laurier

Date: July 4, 2014 - July 23, 2014

Processed by: Germaine Gatien

Date of Processing: 10 July 2019 – 19 July 2019

Number of CTD HEX files: 47 Number of CTD files: 47 Number of CHE files: 34

Number of TSG HEX files: 10 Number of TOB files: 10 (1 deleted and 1 split)

# INSTRUMENT SUMMARY

A SeaBird Model SBE 911+ CTD (#0941) was used for this cruise. It was mounted in a custom-built compact 24-bottle rosette sampler and attached were a Wetlabs CSTAR transmissometer (#CST-1050-DR), an SBE 43 DO sensor (#1117), a SeaPoint Fluorometer (#2745), a Biospherical QSP-200L4S PAR sensor (#70123) and an altimeter (#40853).

24 OceanTest Equipment 10L bottles were used mounted on the rosette.

A thermosalinograph (SeaBird 21 S/N 3274) was mounted with a fluorometer (SCF3275) and a remote temperature sensor #0271.

The data logging computer was a Dell Optiplex 755 (WGBCIOS101655.)

The data acquisition program was Seasave 7.23.2.

The deck unit was a Seabird model 11, serial # 11P53201-0800; it included a NMEA board to automatically add GPS positions into the header of the data files.

The salinometer used at IOS was a Guildline model 8400B Autosal, serial # 69086. Bottles were analyzed on 6 January 2015.

# SUMMARY OF QUALITY AND CONCERNS

The Daily Science Log Book and rosette log sheets as well as spreadsheets detailing sampling were provided. Notes in the log include the scan number for the beginning of the full cast which was very helpful. There are many deck pressure measurements recorded.

The file names included event numbers that correspond to the consecutive CTD casts but do not correspond to the events in the Daily Science Log and on the rosette log sheets. Since the analysts used the consecutive CTD numbers the file names will not be changed. A table was prepared to relate the 2 sets of event numbers.

The CTD was held at the surface for 2 to 5 minutes, then lowered to between 5 and 10m for a soak of 2.5 to 3.5 minutes after which it was returned to about 3m. After a brief stop (usually ~15 seconds though occasionally much longer) the full cast was run. There is a note for each CTD cast indicating what scan marks the beginning of the full cast. This is very helpful as the data from the soak period needs to be removed to produce the best near-surface data. However, the downcasts seem to have started a little earlier than indicated, so the numbers were adjusted to ensure near-surface data are included.

There was confusion in the records about which SeaPoint fluorometer was in use. As is usual for these instruments values were lower than extracted chlorophyll except when CHL values are below ~1ug/L.

There was no calibration sampling for the dissolved oxygen sensor but there was a post-cruise calibration that indicated drift to lower values by about 1% but we don’t know when that drift occurred. The dissolved oxygen surface saturation values ranged from 85% to 135%, with most above 95%, so values are not notably low. No recalibration was applied to dissolved oxygen. These shallow casts with high DO vertical gradients are a big challenged for this type of sensor.

There was calibration sampling for salinity which indicated that CTD salinity was reading low by about 0.01psu. The results were not trusted because delayed analysis and incomplete flushing of Niskin bottles both lead to bottle salinity values being too high. The post-cruise calibrations show that the primary salinity had drifted low by about 0.0025psu but we don’t know when that drift occurred. Salinity data was recalibrated by adding 0.001psu as some drift downwards was likely. Calibration is likely within 0.002psu, but other, larger errors in salinity are expected due to minor misalignment in the presence of large vertical temperature gradients, especially near the surface.

A new pressure offset was determined at sea and used in processing and frequent deck measurements showed that no further correction was necessary.

The first TSG file was short and contained no useful information so will not be archived. The final file was huge, so was divided into 2 files. Each file was renamed based on cruise # - date -time.

Comparisons between TSG and CTD data suggest that the intake temperature is reading high but a post-cruise calibration shows insignificant drift. It is possible that the TSG was drawing water from higher in the water column than the TSG, or that there is some heating of water near the intake thermistor. The TSG salinity is reading significantly low, by much more than the post-cruise calibration supports. Comparisons with loop salinity and CTD rosette samples are in rough agreement with the CTD-TSG comparison. Errors may be from a combination of mismatch of sampling levels, delayed analysis and bubbles in the loop water, with bubbles probably the most significant factor. There were some sections in the last file that had prolonged salinity offsets that are likely due to ice particles in the loop. Clearly bad salinity data were removed from the last file. Salinity was recalibrated by adding 0.11psu.

# PROCESSING SUMMARY

##### Seasave

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

Files had standard names with cruise number followed by a 4-digit event number. However, the event numbers in the files did not match the event numbers in the Daily Science Log book. They are in order of CTD casts, while the log book includes all in-water science activities such as nets, grabs, XCTD, UCTD and float launches. Since the chemistry data spreadsheet also has the consecutive CTD cast #s, it is safest to stick to those event numbers. However, the event numbers on the rosette sheets match those in the Daily Log.

Note that there is a record of the consecutive CTD casts in the Daily Science Log Book in the column marked “Watch keepers”.

For a guide to how the 2 different set of event numbers relate, see file “2014-012-event-number-guide.csv” in the documents folder for this cruise. Station names are included in that file.

While the raw data had the cruise number in format 2014-12, the standard changed to 3 digits before the data were processed, so the processed data have format 2014-012.

##### Preliminary Steps

The Daily Science Log Book and rosette log sheets were obtained. A post-cruise report was available.

Spreadsheet 2014-12\_SWL\_Chem and Logs.xlsx contains a sampling log with details on bottles fired and results of analyses.

The cruise summary sheet was completed.

There was no history available for the pressure sensor, conductivity and DO sensors and this was likely the only cruise on which they were used between calibrations.

The configuration files did not change through the cruise.

The calibration constants were checked for all instruments. In many cases parameters had been truncated, so the full entries were entered. The pressure offset was different, but this was likely done on purpose based on shipboard observations. There is confusion about which fluorometer was in use. A note was found saying:

“\*SCF 2575 installed for plumbing fit until McBH unit arrives.”

There is also a picture of the fluorometer labelled “before fix”, so it seems likely that #2575 was not to be used during the cruise. The configuration file indicates that the fluorometer was #2575 though there was a test configuration created at sea on the day of the first CTD cast that has #2745 entered. while the log book has #274 entered. There is no such fluorometer as #274 listed in the Arctic inventory but there is a #2745 and that was the sensor used in 2013. The configuration file was changed to say the sensor was #2745. This will not affect results since only the gain setting and offset are entered. PAR and SPAR parameters were not found.

The CTD was held at the surface for 2 to 5 minutes, then lowered to between 5 and 10b for a soak of 2.5 to 3.5 minutes after which it was returned to about 3m. After a brief stop (usually ~15 seconds though occasionally much longer) the full cast was run. There is a note for each CTD cast indicating what scan marks the beginning of the full cast. While this is very helpful the numbers entered usually correspond to the CTD having already started the descent.

The pressure offset differed from that in the last factory recalibration, but was deliberately changed at sea, so the adjusted setting will be used. There were a number of deck readings of pressure that were all between -0.2db and +0.2db which is well within the specifications for the sensor.

There was no deep sampling, so no hysteresis tests were done.

##### BOTTLE FILE PREPARATION

The ROS files were converted in the same way as the full files except that bottle number and bottle position channels were included and oxygen concentration and salinity were derived.

The files were then converted to IOS Header files with BOT extensions.

A preliminary header check turned up no problems. There was no off-scale fluorescence.

Temperature and salinity were plotted for all BOT files. There were some spikes, mostly in the secondary salinity, but a few in primary temperature and salinity. There were other areas with a lot of noisy data, but these appear to be real variations during the stop, not of instrumental source. They were not edited. CTDEDIT was used to clean spikes in casts #18, 19, 21, 23, 29, 38 and 46. The edited files were copied to BOT. A note was made in the header of each file about any editing done.

The BOT files were averaged on bottle number and those files were used to prepare an ADDSAMP file.

That file was edited to add sample numbers.

The ADDSAMP file was used to add sample numbers to the BOT files, creating SAM files. Those were bin-averaged on bottle number to create SAMAVG files.

Next, text file 2014-012-bot-hdr.txt was prepared to add an explanation of quality flags and some general comments from analysts.

Spreadsheet “2014-012\_SWL\_Chem and Logs \_219-02-08.xls” contained final analysis data. The file was simplified and saved as “2014-012\_Chem-simplified.csv” in preparation for combining with the CTD data from the rosette files.

The comments from various channels were combined into a single comment column.

The Bottle Integrity Column was renamed Flag: Niskin\_Bottle and the flags were changed to be in line with the flag definitions used for other channels. There was only 1 non-zero flag which was changed from 1 to 3. A comment was entered for the Niskin bottle that had been flagged.

A 6-line header was added to ensure proper channel names, formats and pad values were entered and comments added to the header.

File 2014-012\_Chem-simplified.csv with the 6-line header was converted to MRG1 files.

The MRG1 files were put through CLEAN to reduce the header to just the File Comments section. SORT was run on channel bottle # and then merged with the SAM files with output MRG.

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

To see if the altimetry and/or bottom depth entriesa re reasonable a check value was calculated:

 Check = Water Depth – Altimetry – Max Depth Sampled

The altimetry value is calculated with an algorithm taking data from the bottom 2db so we can’t expect the check value to be exact. But for the 11 casts where the value was >2m the log entries were checked and always differed from the header depth in a way that would reduce the check value is <2m. So the headers were adjusted to match the log for those casts. Plots were made of altimetry near the bottom for a few casts and they support the altimetry headers.

These changes were made to the SAM files and the merge with the bottle data was repeated.

These files were put through CLEAN to remove SeaBird headers and comments from the secondary file.

##### Compare

Salinity

Compare was run with pressure as reference channel. The data are all shallow and analysis was delayed, so it is not a surprise to see most cases showing the CTD to read lower than bottle salinity.

When outliers were removed with standard deviation in the CTD Salinity >0.001psu, there remained only 3 outliers with differences >0.06psu. Two were bottles from the bottom with CTD reading higher than bottles; this is likely since poor flushing would lead to errors of the opposite sign at the bottom to those fired on the upcasts. The other outlier was at station SEC8 where there was a very sharp interface at the depth of sampling, with temperature dropping by 2C° in less than 1m. The CTD salinity was lower than the bottle salinity by about 0.07psu, which could be due to very slight inefficiency in the flushing of the Niskin bottle. None of these outliers justify flagging of salinity bottle data.

When those outliers are excluded the primary salinity was found to be low by a median of 0.0117psu and the secondary by 0.0123psu. Standard deviations in the comparison was ~0.01psu for both channels. So there is very little difference between the sensors and that difference could be accounted for by a combination of incomplete flushing and aging of samples.

A check was made of samples from below 40m excluding the same outliers. The average differences were only slightly lower at 0.0093psu and 0.0104psu. Then the bottom bottles were excluded which left only 8 bottles; the primary was low by 0.0132psu and secondary by 0.0138psu.

Some of the outliers excluded in the fit because of noisy CTD salinity are more significant than others, with differences >0.3psu. Those include a few near the surface where the distance between the CTD and Niskin bottles can account for CTD salinity appearing to read higher than bottles.

There are 5 cases where the CTD is lower than the bottles by >1psu. Those were investigated. They all came from a single cast, event #2. The secondary channel looked worse than the primary. The primary salinity was reasonably close for the 2 bottles close to bottom while the secondary salinity was poor even at that level, though not as bad as from 50m up. Further investigation required a preliminary look at the full CTD files. This showed very poor performance by the CTD sensors during the upcast for event #2 from about 50m up. So the problem is with the CTD conductivity sensors, not the bottles. The sensor pairs are in good agreement during the soak period but start to drift apart during the return to the surface and get worse shortly after starting the upcast. While it is possible that one channel is ok and the other malfunctioning, the bottle vs CTD salinity comparison suggests otherwise.

A plot of differences versus file pair number is difficult to interpret because of the varying depths and gradients sampled.

For full details for the COMPARE run see file 2014-012-sal-comp1.xls.

Extracted Chlorophyll versus CTD Fluorescence

In the usual pattern the CTD fluorescence tends to read higher than extracted chlorophyll when the latter values are very low. For CHL>2.5ug/L the fluorescence is generally about 50% of the extracted CHL.

The fluorescence was about 67% of extracted CHL overall.

See file 2014-012-fl-chl.comp.xls.

##### Conversion of Full files from Raw Data

All files were converted using 2014-012-ctd.xmlcon. The hysteresis correction was not selected since all casts were shallow; the Tau correction will be used.

The file names were in standard format but the standards had changed for cruise numbers since 2014.

The cruise names were changed from 2014-12 to 2014-012.

All channels were plotted for a few casts to check for problems in the conversion. All casts were shallow so variability is high throughout and upcasts are quite different from downcasts in the top 30m or so. The temperature and conductivity channels track well in the better-mixed areas on downcasts, but there are larger differences during upcasts. Transmissivity, altimetry, PAR, Spar and Fluorescence traces look normal. The dissolved oxygen has the usual offset, but the high temperature gradients in a shallow cast will challenge the instrument, and we can expect a problem aligning the data, especially since there are frequent stops for most casts so the upcast cannot be expected to match the downcast. Descent rates are mostly high.

##### 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.

##### ALIGN DO

Tests were run on some casts with no stops for bottles to see what advance in DO Voltage works best to bring the offset between downcast and upcast closest to that found in the temperature profiles. The results vary but 4.5s seems the best choice. It is noted the DO takes a long time to equilibrate at the bottom of some casts and during some bottle stops suggesting that the response time is slower than usually seen. However, this may be just a matter of larger gradients than usually seen near the bottom.

ALIGNCTD was used to advance the DO Voltage by 4.5s relative to the pressure.

##### CELLTM

As for ALIGNCTD tests are not helpful for these shallow casts with so many stops and high variability, so settings were used that are always found reasonable, and often the best choice.

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

##### DERIVE

Program DERIVE was run on all casts to calculate primary and secondary salinity and dissolved oxygen concentration (using the Tau correction).

##### Tests

Normally a second run of DERIVE is done to study the differences between channels for a few test casts, but these casts are so shallow that little can be learned from that. However, tests were run at this point to compare the pre-cruise calibrations with the post-cruise, with particular attention to the dissolved oxygen.

File 2014-012-ctd-post.xmlcon was prepared using updated calibrations for temperature, conductivity and dissolved oxygen.

A selection of casts were converted using the post-cruise con file. They were put through WILDEDIT, ALIGNCTD, CELLTM and DERIVE. Then plots were examined to see how much calibrations changed through the cruise. It was found that the differences between the post-cruise and pre-cruise values were the same for casts #8, 45 and 47. Cast #2 was also examined and it looked very strange. This confirms the conclusion of the salinity comparison that the pumped channels for cast #2 are bad.

At the end of the cruise the 2 temperature channels appeared to be reading 0.001C lower than found from the post-cruise calibrations and the conductivity channels were low by 0.00025 and 0.00030. Salinity was lower by 0.002 and 0.003psu. It is likely that most of the drift occurred after this cruise since the sensors had been recently calibrated and there was no drift observed during the cruise.

Dissolved Oxygen values were lower using the pre-cruise calibrations than from the post-cruise values for all casts checked. Looking at 6 casts (2, 8, 11, 23, 45 and 47) the differences near the bottom were .06, 0.05, 0.07, 0.07, 0.09 and 0.08mL/L, respectively. The difference appeared to increase with time, but the ambient DO levels also increased with time. Since calibration drift from this type of sensor is usually an approximately linear function of DO, the differences were expressed as % of DO and were 1.00, 0.94, 1.00, 1.06, 1.06 and 0.99%. So there is no indication of significant drift through the cruise.

In the course of studying the dissolved oxygen calibration, it was noted that he response time seemed longer than expected at the bottom of some casts, but these were shallow casts with high vertical DO gradients. Such casts are a great challenge for this type of sensor.

##### 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.

* There were some negative pressure values during event #12. These occurred at the beginning of the cast before the sub-surface soak and conductivity has near-surface values, so the CTD may well have come out of the water. The pumps were off. There are a few spikes to negative values at the end of the cast as well, but these appear to be in the noise level of the instrument with average values showing the CTD to be in water, though very close to the surface, and the pumps were off. Cast #15 is another case of negative pressures but again, only where pumps were off.
* Some very high salinity values were found to be from spikes before the pumps came on.
* There are some spikes in dissolved oxygen that occur at the beginning of very sharp gradients. A few tests were run to see if these might be due to slight misalignment with temperature but varying the DO alignment setting changed the maximum values only slightly, and the alignment setting that was chosen earlier produced lower DO maximum values than slightly higher and slightly lower settings did.

Surface check was run and shows an average surface pressure for the cruise was 0.15db.

The pressure values look to be accurate – frequent pressure checks on deck were between -0.2db and +0.2db.

The cross-reference check was compared with the log book and no errors were found.

The altimeter readings and bottom depths from the headers of the CLN files were exported to a spreadsheet. As described in section 3 the check value was calculated and where it was >2m the entry was investigated. As with the rosette files, changing the water depth to match the log book entry produced a better result for all such casts. The log entries appeared to have been changed in many cases, so were likely recorded closer to deployment than those in the headers. The altimetry header entries look fine for all casts that were checked by examining altimetry traces at the bottom.

The 10m-soak data need to be removed so that DELETE will select the most appropriate data.

There was a record in the log book of the first record # to be kept but it needed adjustment so that good data were not missed near the surface. For an initial guess an extra 240 scans were included.

CLIP was used to remove all records before that. Plots were made after CLIP and some settings were fine-tuned until enough data are removed to ensure that DELETE will select the appropriate data.

The cruise tracks (with event #s and station names) were plotted and added to the end of this report. No problems were found.

##### Shift

The casts are too shallow, have too many stops for bottles and data too variable to allow meaningful testing of alignment for conductivity and fluorescence. The same sensors were used for 2010-05, 2011-18, 2012-09 and 2013-05 so the settings used in alignment for those cruises were applied for this cruise. Plots were examined before and after and the alignment was improved by these steps.

Fluorescence

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

Conductivity

SHIFT was run applying an advance of -0.4 records to the primary conductivity and -0.5 records to the secondary conductivity.

Dissolved Oxygen

The Dissolved Oxygen voltage channel was aligned earlier. There is no obvious further adjustment that would improve the comparison between downcast and upcast traces.

##### 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: The were no warnings.

##### Other Comparisons

Previous experience with these sensors – This was the first known use of the temperature, conductivity and dissolved oxygen sensors after the previous factory calibration. The pressure sensor was calibrated in late 2009, but checks made at sea were used to update the offset parameter.

Post-Cruise Calibration -

As described in section 10 the post-cruise calibration shows that temperature channels had drifted low by ~0.001C° and conductivity had drifted low by ~0.0003 S/m resulting in salinity drifting low by about 0.0025 to 0003psu. Dissolved oxygen was low by about 1%. There was no indication that the drift occurred during this cruise.

Historic ranges – There was no local climatology available.

Repeat Casts – There were no repeat casts; nearby casts are too shallow to test repeatability.

##### DETAILED EDITING

At this point a decision was needed as to which channel pair should be selected to edit. The post-cruise calibration showed some drift in the all temperature, conductivity and dissolved oxygen channels. The drift during the cruise appears to be insignificant, implying that most drift occurred either before and/or after this cruise. Salinity derived using the pre-cruise calibration parameters is lower by approximately 0.003psu than using post-cruise parameters for both channels. This is smaller than the error suggested by the bottle comparison which was ~0.1psu. This is likely due to the errors thought to affect the bottle comparison (incomplete flushing of bottles and lengthy storage of samples). There is no evidence to establish when the drift occurred. It seems more likely to have happened after this cruise, but in any case the calibration drifts are not large.

There is little difference between the primary and secondary channels. The primary salinity is slightly closer to the bottle salinity and the post-cruise drift estimate shows less slightly drift in the primary. For at least event #2 the secondary salinity looks bad. Both channels look bad for the upcast, but the primary seems ok during the downcast. This was checked by comparing the upcast bottles with the downcast CTD salinity. CTD salinity values were found in the DEL files by matching the temperature values in the bottle files (MRG) and a second run picked them out based on depth. Since the upcast temperature may well be affected by the same problems as the salinity it is not likely to provide a good match. Matching depth is also problematic because we don’t really know what depth the water came from that is in the Niskin. The results should be most reliable near the bottom of the cast where the vertical salinity gradients were low.

|  |  |
| --- | --- |
|  | Comparing Downcast CTD Salinity with Upcast Bottle Samples |
|  | Matching temperature | Matching depth |
| Pressure | Sal0-bottle | Sal1-bottle | Sal0-bottle | Sal1-bottle |
| 76.2 | -0.0008 | -0.2476 | -0.0009 | -0.2498 |
| 75.2 | -0.0113 | -0.2645 | -0.0011 | -0.2496 |
| 50.1 | 0.0026 | -0.2507 | -0.0076 | -0.2604 |
| 35.7 | -0.0402 | -0.2839 | -0.0088 | -0.2499 |
| 24.8 | -0.0143 | -0.2491 | 0.0084 | -0.1994 |
| 14.8 | -0.0216 | -0.2424 | -0.0181 | -0.2171 |
| 5.5 | -0.0146 | -0.2589 | -0.0045 | -0.2750 |

The results make it clear that the secondary salinity is not reliable in the downcast. The CTD primary salinity looks very close to the bottles near the bottom and reasonably close at all levels.

The primary temperature and salinity were selected for editing and archival.

CTDEDIT was used to remove some near-surface records that look like they are affected by shed wakes or ship effects and many records corrupted by shed wakes, mostly near the bottom of the cast. Salinity was cleaned, mostly in areas with high temperature gradients that lead to spiky features that are unstable.

There are many unstable features that are small and may well be real; they were left unedited.

All cast required some editing.

Plots were made to see if further editing was required. Many unstable features remain but most are fine-scale or would require removal of data where there is no obvious instrumental effect. A few casts were re-examined in CTDEDIT to see if further editing would be useful but in no case was extra editing applied.

##### Initial Recalibration

The bottle comparison indicates CTD salinity is low by 0.012psu and the post-cruise calibration shows it to be low by 0.0025psu. The bottle comparison is unreliable due to delayed analysis and probable incomplete flushing of Niskin bottles. The post-cruise drift would include drift after this cruise, but it is reasonable to expect some drift. Adding 0.001psu looks like a reasonable choice since if the real error is anywhere between +0.001 and -0.003, the corrected values will be within 0.002psu.

For dissolved oxygen a test run was done to find surface saturation to see if the DO values appear to be low. The range of values was about 90% to 135%. Only 3 casts had values <95% and those were very well-mixed vertically. So there is no evidence of DO reading low.

Pressure calibration looks fine.

CALIBRATE was run using file 2014-012-recal1.ccf to add 0.001 to the primary salinity.

##### Special Fluorometer Processing

A median filter, fixed size=11, was applied to the fluorescence channel in the COR1 files to reduce spikiness. A few casts were examined before and after this step and showed that the filter was effective.

##### BIN AVERAGE of CTD files

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

Bin channel = pressure Averaging interval = 0.5 Minimum bin value = .000

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

After averaging, page plots were examined on screen. Many unstable features remain as described in section 16. Very heavy editing would be needed to remove them and often the unstable feature is due to a very small reversal in salinity. No further editing was applied.

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

REMOVE was run on the AVG files to remove the following channels (Output \*.REM):

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

A second SBE DO channel (with umol/kg units) was added to the REM files.

REORDER was run to get the two DO channels together.

HEADER EDIT was used to fix formats and channel names and one header item and to add the following comments:

 *Data Processing Notes:*

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

*The event numbers used correspond to the consecutive CTD casts rather than those found*

*on the rosette sampling log sheets and in the Daily Science Log Book. Since the analysts*

*also used the consecutive CTD event numbers, no change was made to file names. There*

*are notations in the log book in column "Watch Keepers" that contain the cast numbers*

*that are used in these files for event numbers.*

*See document "2014-012-event-number-guide.csv" to relate the two sets of event numbers.*

*Transmissivity, Fluorescence: SeaPoint, PAR and PAR:Reference are nominal and unedited*

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

*There was no calibration sampling for dissolved oxygen. Calibration drift in this type*

*of sensor generally leads to values that are low. The dissolved oxygen surface saturation*

*values ranged from 85% to 135%, with most above 95%, so values are not notably low.*

*Since a post-cruise calibration indicates only a slight drift, with values low by about 1%, and*

*we don’t know when that drift occurred, no recalibration was applied to dissolved oxygen.*

*The bottle comparison indicated salinity was reading low by about 0.01psu but the results were*

*not trusted due to delayed analysis and probable incomplete flushing of Niskin bottles. The*

*post-cruise calibrations show that the primary salinity had drifted low by about 0.0025psu.*

*Salinity data was recalibrated by adding 0.001psu as some drift downwards was likely.*

*Calibration is likely within 0.002psu, but larger errors are expected due to minor misalignment*

*in the presence of large vertical temperature gradients, especially near the surface.*

*For further processing details see the processing report 2014-012\_Processing\_Report.doc.*

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

The Header Check was run and no problems were found.

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

The final files were named CTD.

Profile plots were made and look ok.

The track plot looks ok.

The sensor history files were updated.

##### Final Bottle Files

CALIBRATE was run to add 0.001 to primary salinity.

The MRGCOR1 files were put through SORT to order on increasing pressure.

REMOVE was run on the MRGSORT files to remove the following channels (Output \*.MRGREM):

Scan\_Number, Temperature:Primary, Salinity:T0:C0, Conductivity:Secondary, Oxygen:Voltage:SBE, Altimeter, Status:Pump, Descent\_Rate and Flag.

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

Standards Check was run on the final files until all problems were found and addressed; the only non-standard item is Phosphate which has had a change in format since 2014.

A Header Check was run and no problems were found.

A cross-reference list turned up no errors

The track plot was produced on screen and no errors were found.

For a final check the CHE bottle data were exported to a spreadsheet and compared with the rosette log sheets and no errors were found in IOS sampling. There were a few discrepancies for other sampling. There were no entries in the logs for chlorophyll sampling and a few cases where samples were not taken or taken from different bottles, but the entries match the chemistry file records.

##### Thermosalinograph Data

Date were provided in 10 hex files, most of which contained few data.

The TSG files have non-standard names with format YYYY-MM-DD followed by a letter where there was more than one file on a single day. These will be adjusted after conversion.

Document “2014 TSG and Underway Log.xls” contains details on loop sampling and a few comments about other issues.

There was an intake thermistor but no flow meter.

a.) Checking calibrations

The calibrations were checked. There were no changes in temperature and conductivity parameters through the cruise and they are correct. The fluorometer gain setting varies and from July 7th onwards there are 2 fluorometers in the con files; both had the same serial number but different gain settings. This was presumably done to make it easy to shift between 3X & 10X. There are no notes about this in the Daily Science log or the TSG log but there is a note in the TSG log that on July 6th the fluorometer gain was changed from 10X to 3X because values were going off-scale.

An initial conversion of files shows that fluorescence data from the first 7 files look bad – either 0 values or at the maximum value. Many of these files are very short. They will be converted in case other data looks useful, though there will be no CTD data to compare with the TSG data. For the last file there will be overlap with many CTDs.

There was no CHL loop sampling found but CTD fluorescence and bottle CHL from rosettes may help determine whether the correct setting was used in conversion. However, this will only be useful for the last file because there were no CTD casts early in the cruise.

There was salinity loop sampling.

b.) Conversion of raw files.

The configuration file used for the final file was saved as 2014-012-tsg.xmlcon and was used to convert all the files, but it is likely there will only be useful data from the 2nd fluorescence channel with 3X gain.

After conversion the file names were changed to format 2014-012-MM-DD-HHMMSS.cnv based on the start time of the file.

Plots were examined and there were many spikes in salinity and no fluorescence signal in the files from July 5 and 6. The file starting on July 12 was too large to plot.

The July 12 file was very large so it was split using the SECTION routine with the second file being named 2017-07-18-000001.cnv.

WILEDIT was used to minimize salinity spikes using settings:

Parameters used were: Pass 1 Std Dev = 2 Pass 2 Std Dev = 2 Points per block = 50

The files were then converted to IOS Header format.

Plots show that some spikes remain in salinity and there are segments of data that are offset. These look odd but will be examined later.

The 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 based on the Julian time.

Time-series plots were produced. A few problems were noted:

* There are no useful fluorescence data from the first 7 files.
* The file starting on July 5 at 15:12 was very short and both temperature channels look very odd suggesting that steady flow had not been achieved.
* For the first 7 files neither fluorescence channel contains a signal.
* For the last 4 files there is a signal in channel Fluorescence:URU:Seapoint:2

All files will be processed, but later channel Fluorescence:URU:Seapoint will be removed from all files, Fluorescence:URU:Seapoint:2 from the first 7 files and the 1st file will probably not be archived.

c.) Editing

All files were opened in CTDEDIT but most had no obvious bad data. The files starting on the following dates had some odd features:

* July 7 – CTDEDIT was used to remove some points from temperature, salinity and fluorescence where there appeared to be a flow problem.
* July 12 – A few odd looking features that may be due to bubbles building up, then breaking or could be real features with some spiking due to minor misalignment and T and C. No editing was attempted for this file.
* July 18 - There are a few fairly large jumps in salinity values like those in the previous file that look suspicious but are not clearly bad or easily edited. There are also some sections with offset salinity and conductivity values. These cannot be explained by bubbles and the flow does not seem to be off since the 2 temperature channels continue to track well. Ice particles could be a factor since the temperatures are <0°C. A quick check against CTD and loop samples make it clear these data are bad and should be removed. The last few minutes of the file looks like the flow was off so temperature, salinity, conductivity and fluorescence data were padded using CTDEDIT.

d.) Bin-averaging

The files were bin-averaged over 6 scans.

The track plot looks good. It was added to the end of this file.

e.) Checking Time Channel

The CTD data were thinned to reduce the files to a single point from the downcast at or within 0.5db of 5db.

Only the last 2 TSG files overlapped with CTD casts. They were opened in EXCEL and reduced to the times of CTD files. There were 46 matches.

To check for problems in the TSG clock or bad matches of TSG and CTD data, the differences between latitudes and longitudes were found. The average and median differences in latitude and longitude were all <0.0001° The largest differences were ~0.0007°. Small differences are expected as the TSG data were averaged and the CTD times are not exactly the time of sampling at 5m.

This comparison shows that both the times and positions are reliable for both systems.

This spreadsheet will also be used in step (f) to compare temperature, salinity and fluorescence from the CTD and TSG.

f.) Comparison of T, S and Fl from Loop and Rosette samples and TSG and CTD data

* T1 vs T2 The intake thermistor was connected throughout the cruise. The differences between the two TSG temperatures were between 0.14 and 0.31Cº. This is typical of the C3O cruises in this area. As expected, the heating in the loop is greatest where intake temperatures are lowest.
* TSG vs CTD The spreadsheet comparing CTD and TSG files was examined to find the differences between the salinity, fluorescence and temperature channels for the CTD and the TSG.

The differences between TSG and CTD channels vary more than usual.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | Tint-Tctd | Tlab-Tctd | Stsg-Sctd | FLtsg/FLctd |
| Maximum | 0.70860 | 1.01630 | 0.06384 | 2.72449 |
| minimum | -0.57640 | -0.28120 | -3.00930 | 0.59114 |
| average | 0.18323 | 0.19800 | 0.15014 | 0.47550 |
| median | 0.07562 | 0.29276 | -0.13851 | 1.05760 |
| std deviation | 0.25884 | 0.26826 | 0.80863 | 0.46031 |

The TSG salinity is lower than the CTD salinity by a median of 0.139psu but the standard deviation is 0.81psu. Delay in analysis of loop samples may have raised bottle values by up to 0.01psu, so that is not a large contribution to the differences. If we only look at cases that include CTD casts #1 to 33 the CTD salinity is low by a median of 0.113 and standard deviation of 0.065psu. Using a larger group of casts that appear to be well-mixed it was low by 0.120psu Examination of CTD profiles near the surface show that vertical gradients increase markedly starting with event #34 and the sign of the temperature gradient varies. So a slight mismatch between the depth of the CTD and TSG intake would be more significant for the later casts. Cast #43 was well-mixed near the surface and the difference from the CTD is similar to the earlier casts. The extreme outliers are associated with intake temperatures <0 Cº, so ice particles may be a factor, but that does not affect the result from casts 1 to 33.

The TSG intake temperature is higher than the CTD temperature by 0.076Cº with a standard deviation of 0.259Cº. Using only casts #1 to 33, it is higher by a median of 0.070 Cº and standard deviation of 0.230 Cº.

Picking 26 casts that appear to be well-mixed near the surface the salinity is lower than the CTD by a median of 0.120psu and standard deviation of 0.065psu. Using the same casts the temperature is lower than the CTD by a median of 0.106 Cº and standard deviation of 0.224 Cº.

A fit of TSG fluorescence versus CTD fluorescence has a slope of 0.66 if forced through the origin. The ratio of TSG fluorescence to CTD fluorescence ranges from 0.6 to 2.7 with a median of 1.05.and standard deviation of 0.46ug/L. At very low values the TSG fluorescence reads higher than the CTD fluorometer and at high values it reads lower. There are few cases where CTD FL was >2ug/L. For the well-mixed casts the two fluorescence values are very close. The higher fluorescence readings tend to be in casts that are not well-mixed.

(See 2010-05-ctd5-tsg-comp.xls.)

* Loop Bottle - TSG Comparisons A spreadsheet was prepared by combining all loop sample data with TSG salinity.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| bottle label | **Loop Salinity** | Date | Time | TSG Sal | TSG-loop |
| tsg 1 | 32.0695 | 10-Jul-14 | 23:00:00 | 32.0523 | -0.0172 |
| tsg 2 | 31.7761 | 12-Jul-14 | 20:19:00 | 31.5917 | -0.1844 |
| tsg 3 | 31.3187 | 14-Jul-14 | 21:27:00 | 31.2079 | -0.1108 |
| tsg 4 | 32.6237 | 15-Jul-14 | 22:41:00 | 32.5120 | -0.1117 |
| tsg 5 | 31.9735 | 16-Jul-14 | 21:53:00 | 31.9354 | -0.0381 |
| tsg 6 | 31.8634 | 17-Jul-14 | 21:44:00 | 31.7853 | -0.0781 |
| tsg 7 | 31.6755 | 18-Jul-14 | 23:00:00 | 31.5079 | -0.1676 |
| tsg 8 | 29.0150 | 20-Jul-14 | 02:47:00 | 31.1225 | 2.1075 |
| tsg 9 | 28.0119 | 22-Jul-14 | 20:42:00 | 26.4140 | -1.5979 |
|  |  |  |  | median | -0.1108 |
|  |  |  |  | stdev | 0.9411 |
|  |  |  |  | max | 2.1075 |
|  |  |  |  | min | -1.5979 |

There is a lot of variability with the TSG being way out of line with the loop samples for the last 2 samples. (These TSG data have been removed in the editing process.) The loops could be reading a little high due to long storage before analysis, but that error would be relatively small, on the order of 0.01psu. There is a lot of variability in the TSG record so an exact match is impossible. That may well explain most of the variability, but not the case of the last 2 loops. The median difference is close to that seen in the CTD-TSG comparison for well-mixed casts.

(See 2014-012-CTD-TSG-Loop-Rosette-comp.xls.)

* 5m rosette samples – There were no CHL loop samples but there are samples from 5m rosettes. The rosette CHL and Salinity bottle values were extracted and combined with the TSG fluorescence and salinity. CTD values from the rosette files were also included. The times were matched but it was based on the start times for the casts, so there will be significant errors due to the difference in time between start and end of the casts. There is also likely incomplete flushing of Niskin bottles which would lead to CHL that is a little low and SAL a little high but many of these casts are well mixed which will minimize that error.

The TSG fluorescence has a median value of ~0.66 times the rosette bottle values based on 33 bottles, but the range was from 0.025 to 4.42. As usual TSG Fluorescence is higher than Extracted CHL for low CHL and lower for CHL>1ug/L. The CTD fluorescence is in reasonable agreement with the TSG fluorometer, showing that this is just how fluorometers behave

When 3 bad TSG salinity values were removed, the TSG salinity is lower than the rosette bottles by a median of 0.0.165psu but the standard deviation is 0.85psu. The CTD is within 0.0075 of bottle salinity, but this is expected to be closer because they were taken at the same time.

* Calibration History

The TSG primary temperature and conductivity were recalibrated in November 2012. There was a post-cruise calibration in November 2015. At that time the temperature was said to have drifted by +0.00044 C°/year and the salinity to have drifted by -0.0005psu/month. If the drift was linear with time the temperature would have been high by 0.0007C° at the time of this cruise and the salinity low by 0.01psu. The drift in the external temperature sensor was +0.00001Cº per year.

Conclusions

1. The TSG clock appears to have worked well.

2. The temperature in the loop increases by between 0.15 and 0.35Cº with the greatest heating when intake temperatures are low, as expected. The range is large, but this is to be expected when intake temperatures vary greatly.

3. The TSG intake temperature reads higher than the CTD by a median of 0.075Cº. The post-cruise calibration shows little drift in both the intake and lab TSG temperature sensors. So the difference likely reflects mismatches in the levels from which the CTD and TSG data came. It is also possible that there is slight heating of water near the intake thermistor.

4. The TSG Salinity is likely reading low by no more than 0.02psu assuming all the drift noted during the post-cruise calibration occurred by the time of this cruise. But the TSG salinity was found to be lower than the CTD by 0.113psu or 0.120psu during well-mixed casts and lower than loops by 0.111psu. It was also lower than rosette samples by 0.165psu but that is a less reliable comparison due to depth and time mismatches and incomplete flushing. The difference from loop samples is the most convincing that the differences are due to bubbles or some problem with TSG other than calibration. Ice particles in samples are not a likely issue as temperatures were well above 0ºC for the well-mixed casts. Adding 0.11psu to all salinity values is appropriate.

5. The fluorescence from the TSG is similar to that from the CTD. As usual it reads higher than CHL for low CHL values and lower when CHL rises. There were no loop samples.

g.) Recalibration

CALIBRATE was run using file 2014-012-recal1.ccf to add 0.11 to all TSG salinity data.

i.) Preparing Final Files

REMOVE was used to remove the following channels from all files: Scan Number, Fluorescence:URU:Seapoint, Temperature:Difference and Flag.

For files from July 5th and 6th channel Fluorescence:URU:Seapoint:2 was also removed.

It was decided to drop file 2014-012-05-151214 since all channels except time and positions were removed and it was short and at the beginning of the cruise. Keeping it in the list makes time-series plotting difficult.

HEADER EDIT was used to add a comment, change the DATA TYPE to THERMOSALINOGRAPH and add the depth of sampling to the header. Those files were saved as TOB files.

A special note was added to the first file to explain why only time and location data were included.

The TSG sensor history was updated.

As a final check plots were made of the cruise track and it looks fine.

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

##### Producing final files

A cross-reference listing was produced for CTD and CHE files.

The sensor history was updated.

# Institute of Ocean Sciences

# CRUISE SUMMARY

**CTDs**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **CTD#** | **Make** | **Model** | **Serial#** | **Used with Rosette?** | **CTD Calibration Sheet Competed?** |
| 1 | SEABIRD | 911+ | 0941 | Yes | Yes |

|  |
| --- |
| **Calibration Information CTD #941** |
| **Sensor** | **Pre-Cruise** | **Post Cruise** |
| **Name** | **S/N** | **Date** | **Location** | **Date** | **Location** |
| **Temperature** | **5048** | **9Dec2013** | **Factory** | **19Dec2014** | **Factory** |
| **Conductivity** | **3579** | **10Dec2013** | **Factory** | **18Dec2014** | **Factory** |
| **Secondary Temp.** |  **5073** | **7Dec2013** | **Factory** | **23Dec2014** | **Factory** |
| **Secondary Cond.** | **3581** | **10Dec2013** | **Factory** | **17Dec2014** | **Factory** |
| **Transmissometer** | **1050DR** | **14June2014** |  | **12Apr2016** |  |
| **SBE 43 DO sensor** | **1117** | **31Dec2013** | **Factory** | **19Dec2014** | **Factory** |
| **SeaPoint Fluorometer** | **2745** |  |  |  |  |
| **PAR** | **70501** | **7Mar2012** |  |  |  |
| **Surface PAR** | **20279** | **13Mar2007** |  |  |  |
| **Pressure Sensor** | **941** | **07Dec2009** | **Factory** | **6April 2015** | **Factory** |
| **Altimeter** | **40853** |  |  |  |  |

# TSG Make/Model/Serial#: SEABIRD/21/3274

|  |
| --- |
| **Calibration Information** |
| **Sensor** | **Pre-Cruise** | **Post Cruise** |
| **Name** | **S/N** | **Date** | **Location** | **Date** | **Location** |
| **Temperature** | **3274** | **2Nov2012** | **Factory** | **10Dec2015** | **Factory** |
| **Conductivity** | **3271** | **2Nov2012** | **Factory** | **10Dec2015** | **Factory** |
| **Temperature SBE38** | **0271** | **2Nov2012** | **Factory** | **10Dec2015** | **Factory** |
| **WETStar Fluorometer** | **3275** | **?** | **Factory** |  |  |



