REVISION NOTICE TABLE

DATE	DESCRIPTION OF REVISION
20 Dec 2017	Added flag and comment for missing CHL sample 55, event 64
27 Sept 2019	Padded nutrient samples 118 and added 4 flags to Dissolved Oxygen sample 374.

PROCESSING NOTES

Cruise: 2017-01
Agency: OSD
Location: North-East Pacific
Project: Line P
Party Chief: Robert M.
Platform: John P. Tully
Date: 6 February 2017 – 23 February 2017

Processed by: Germaine Gatien
Date of Processing: 12 April 2017 – 6 July 2017
Number of original HEX files: 66 Number of CTD files: 66
Number of bottle files: 62 Number of bottle casts processed: 60
Number of original TSG files: 7 Number of processed TSG files: 5

INSTRUMENT SUMMARY

A SeaBird Model SBE 911+ CTD (#0443) was used for this cruise. It was mounted in a rosette and attached were a Wetlabs CSTAR transmissometer (#1185DR), a SBE 43 DO sensor (#1438), a SeaPoint Fluorometer (#3642) with gain 30X, QSP-400 PAR sensor (#70613) and an altimeter (#1253). The fluorometer and dissolved oxygen sensors were pumped but the log does not indicate primary or secondary pump for either.

A thermosalinograph (Seacat 21 S/N 3411) was mounted with a Wet Labs WETstar fluorometer (S/N ws-3s 889p), remote temperature sensor and a flow meter.

Seasave version V7.26.1.8 was used for acquisition.
The data logging computer was the Tully CTD Laptop (Acer).
The deck unit was a Seabird model 11+, serial number 0425.
All casts were run with the LARS mid-ship station.
The salinometer used at IOS was a Guildline model 8400B Autosal, serial #68572.
The oxygen kit was Scripps kit #2.
An IOS rosette with 24 10L bottles was used.

SUMMARY OF QUALITY AND CONCERNS

Note that as of January 2017 a change has been made to the threshold levels for quality flags 3and 4 for Extracted Chlorophyll. Flag=3 will now be 10%CV (formerly 15%) and Flag=4 will now be 30% (formerly 50%).

The Daily Science Log, rosette log sheets and analysis logs were generally in good order with detailed comments on problems. Notes from the Chief scientist were very helpful as was the log of loop sampling.

During several casts the pumps turned off part-way through the cast. They were turned on again as soon as it was noted. For those casts (21, 42, 81 & 85) all data from pumped channels were replaced with pad values at the depths where the pumps were off and for events 21 and 42 the records were removed below about 1000m. This problem did not affect the CHE files.

There were many problems in the transmissivity data, with sudden shifts in values and large variations in values during repeat casts at a single site. In the offshore waters we expect consistent values below about 500m with minimal pressure dependence, though the value may vary from cruise to cruise due to instrument calibration drift. Values at 2000m at P26 ranged from 46%/m to 57%/m. Similar variations are seen between P12 and P26 with no temporal or spatial pattern. The transmissivity channel was removed from all files, but the data are available, by request, from the chief scientist.

Both the CTD salinity channels were lower than salinity bottles by about 0.002psu. Some of that difference may be due to slight evaporation or absorption of samples and slight inefficiency in flushing of Niskin bottles, so no recalibration was applied.

While CTD fluorescence data are expressed in concentration units, they do not always compare well to extracted chlorophyll samples. The data show the usual pattern for this type of fluorometer with the ratio FL/CHL being high at very low CHL values and dropping as CHL rises.

The comparison of titrated dissolved oxygen samples with CTD dissolved oxygen looks quite tight for the Line P section of the cruise. However, the comparison from the Strait of Georgia is noisier and leads to a significantly different fit. This is presumed to be due to incomplete flushing of Niskin bottles in the more protected waters combined with higher vertical dissolved oxygen gradients so that oxygen in the bottles is lower than in the ambient waters.

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

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

±0.25 mL/L from 0 to 125db
±0.2 mL/L from 125db to 400db
±0.1 mL/L from 400db to 600db
±0.05 mL/L from 600db to 1500db
Low by up to 0.08mL/L below 1500db

There was some small-scale noise in the PAR signal at depth and some noise was seen during casts when the sensor was not mounted.

There were severe problems with flow to the Thermosalinograph. The salinity data were so heavily corrupted by one-sided spikes that the channel was removed. The spikes are presumed to be caused by bubbles. The intake temperature sensor operated throughout the record and the temperature data from the intake and lab both looked good. TSG Fluorescence is uncalibrated and given in volts. Comparisons with loop samples, rosette samples and CTD fluorescence suggest a problem with the TSG fluorescence during file #1.

PROCESSING SUMMARY

1 Seasave

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

2 Preliminary Steps

The Log Book and rosette log sheets were obtained.
Sampling notes from the chief scientist noted a number of issues. One station name was corrected in the raw files.

Nutrients, extracted chlorophyll, dissolved oxygen, DMS and salinity data were obtained in QF spreadsheet format from the analysts.
The cruise summary sheet was completed.
The history of the pressure sensor, conductivity and DO sensors were checked. They had all been recalibrated since they were last used and it appears that the DO sensor 3234 had never been used since purchased.

The configuration changed before event #17 when the DO sensor was switched.
The configuration file for casts 1 and 17 were saved as 2017-01-ctd1.xmlcon and 2017-01-ctd2.xmlcon.
While the configuration file was not changed after that, the altimeter was switched after cast #25. The serial number for the 2nd altimeter is unknown and there are no parameters to enter so no data values are affected, but the header information will be incorrect, so file 2017-01-ctd3 was prepared to be used for casts after #25.
All parameters in the configuration files were correct.

3 Conversion of Full Files from Raw Data

Files 1, 2 and 16 were converted using 2017-01-ctd1.xmlcon.
Files 17 to 25 were converted using 2017-01-ctd2.xmlcon.
Files 32 to 136 were converted using 2017-01-ctd3.xmlcon.
The hysteresis and Tau functions were selected. There are some deep casts. Depth was included in the conversion.

A few casts were examined and all expected channels are present.
The altimetry looks suspicious for cast #23 and bad for cast #23. The sensor was replaced after cast #25 and looks ok after that for the few casts that got near the bottom.
PAR looks ok near the surface, but for at least casts #42 and 43 there is a lot of small-scale noise at depth which is unusual. Most of the noise is during the upcasts.
Transmissivity increased abruptly when the pumps were turned on during the cast #42 upcast. The upcast values are very different from the downcast at depths at which the pumps were on for both. There are obvious problems in some other casts as well. This will need to be checked carefully later and bad data removed. Some sudden changes look real as they match the bottom of the surface mixed layer.
Fluorescence looks ok.
The Dissolved Oxygen looks bad for the first 3 casts and normal thereafter.
The temperature traces track well but are a little further apart than we would like.
The conductivity traces track well and are close.

4 BOTTLE FILE PREPARATION

The ROS files were created using file 2017-01-ctd1.xmlcon for the first 3 files and 217-01-ctd2.xmlcon for the rest. Depth was included.
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. There were no significant outliers but the surface casts look noisier than usual because there was a lot of vertical motion during the stops.

A preliminary header check and no problems were found. CTD 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. First, the file was sorted on event number and Bottle Position order. Then sample numbers were added based on the rosette logs. A few alterations were needed:

- Cast #21 had 3 bottles closed but no samples taken. The sample numbers entered on the log sheet were not used for this cast; they were used for the substitute cast #23. No bottle file is needed for this cast so it was removed from the addsamp file.

The ADDSAMP file was then sorted on event number & then sample number.
It was used to add sample numbers to the BOT files – output *.SAM.
The SAM files were bin-averaged on bottle # and called SAMAVG.
The lines for Niskin bottle 2 was dropped from file 2016-06-0074.SAMAVG.

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

Next, each of the analysis spreadsheets were examined to see what comments the analysts wanted included in the header file. These were used to create file 2017-01-bot-hdr.txt which will be updated as needed during processing.

EXTRACTED CHLOROPHYLL

Extracted chlorophyll and phaeo-pigment data were obtained in file QF2017-01chl*.xlsx. The file included comments and flags and a precision study. A simplified version of the spreadsheet was prepared and saved as 2017-01chl.csv. Loop data were saved in a separate file. The csv file was then converted to individual CHL files.

DISSOLVED OXGYEN

Dissolved oxygen data were provided in spreadsheet QF2017-01oxy.xlsx which includes flags, comments and a precision study. Draw temperatures are available. The spreadsheet page with the final data was simplified and loop data were moved to a separate file. The rosette file was saved as 2017-01oxy.csv. That file was converted into individual *.OXY files.

SALINITY

Salinity analysis was obtained in file 2017-01SAL.xlsx which included a precision study. The analysis was done between 7 and 25 days. Precision is lower than expected given the timely analysis. The nylon inserts used were those that were found to provide poor seals, not the inserts we normally use.
The files were simplified and saved as 2017-01sal.csv. File 2017-01sal.csv was then converted to individual SAL files.

NUTRIENTS

The nutrient data were obtained in spreadsheet QF2017-01_nutrients*.xlsx. This includes a precision study. The file was simplified and the saved as 2017-01-nuts.csv. The file was converted to individual NUT files.

DMS

DMS data were obtained in file DMS summary (2017-01).xls. Values given as < were changed to 0 and those given as – were replaced with pad values; the comments that will go into the header will explain

that 0 means below minimum detectable level. DMS: was entered before comments. The file was then saved as 2017-01DMS.csv and converted to individual DMS files. There was a separate report on analysis techniques and problems.

The SAL, CHL, OXY, NUT and DMS files were merged with CST files in 5 steps.
After the 5th step the files were put through CLEAN to reduce the headers to File and Comment sections only.
NOTE: A change was made to the threshold levels for extracted chlorophyll quality flags. This led to changes to some flags and comments. Changes were made to the MRGREO files and header edit was rerun. So the data in the intermediate files are not corrected. This affects events 75, 101, 109, 111, 116, 119.

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. Some problems were found:

- Event #21 – no sampling – removed from list of hydro files as event #23 replaced it.
- P35 rosette sheet was found between events #43 and 44 – it had only sample #224 entered. The salinity analysis sheet indicates that station was skipped.
- Event #99 has a single DMS sample (#571) indicated on the rosette sheet but no value was found in the DMS spreadsheet. It would be very unusual to take only 1 sample in a cast. The entry was pencilled in after the printed sheet was produced, so it may refer to sampling by another group or something useful for analysis but not to be reported.

There are loop data in the salinity, nutrient, chlorophyll and oxygen spreadsheets, so those data were moved to file 2017-01-loops.xlsx.

The chief scientist provided a log of loop sampling. There are loops taken while underway and others were taken at the end of CTD casts while the 5m rosette was being fired.

Times were added to the loop file based on the end time of CTD casts or the loop time if there was no CTD cast at the time.

5 Compare

Salinity

Compare was run with pressure as reference channel.

If we exclude data with standard deviation in the CTD Salinity >0.0008, Pressure<25db and one outlier, we find:

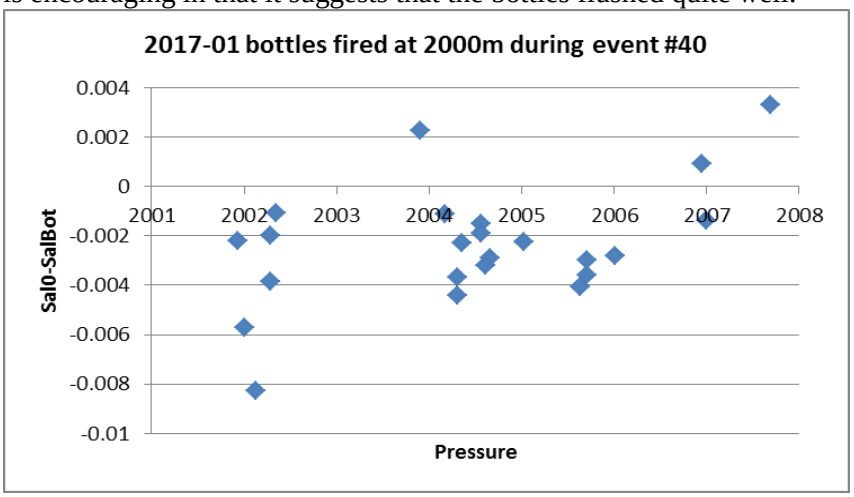
	Average Difference	Standard Deviation	Median Difference	Fit against Pressure
Sal0 – Sal Bottle	-0.0017	0.0019	-0.0017	Diff = -4E-07*Press - 0.0010
Sal1 – Sal Bottle	-0.0020	0.0019	-0.0021	Diff = -1E-07*Press - 0.0018

There is little difference between the two CTD salinity values with the primary slightly closer to bottles and the secondary differences slightly flatter against pressure.

The one outlier that was not associated with noisy CTD salinity was from event #50 at ~3000db (sample 292). There was no flag on that sample. The dissolved oxygen also looks out of line. The nutrients are not obviously out of line but they could be from a little shallower than it appears. It seems quite possible that the Niskin closed late or leaked.

Flag 46 was attached to the sample 291 from 3500db. While the difference between the 3500db samples is 0.008, one is lower than the CTD and the other higher, so the average value does not stand out as particularly bad.

The study of 23 bottles fired at 2000db during cast #40 shows a standard deviation of 0.0024 in the differences between bottles and both salinity channels. Plots were made to see if the variability might be due to the order of firing. While some of the first bottles fired did have the largest differences, there was also a lot of vertical motion early in the stop. A plot of differences versus pressure suggests that is the greater influence. There was quite a lot of vertical movement during the stop (a range of 6m). This result is encouraging in that it suggests that the bottles flushed quite well.



Some of the variability will be from analysis and/or sampling errors; the analyst was disappointed in the precision given the quick analysis, but he commented that the seals were not of the best quality. Evaporation may account for much of the difference between bottles and CTD salinity. That factor is somewhat random, but would, on average, lead to bottle values being slightly high. The error should not be large, given the quick analysis, but taken together with adsorption by the glass bottles, it could account for the CTD looking low by 0.002. So recalibration of CTD salinity is not justified. The case with the largest difference was flagged 3; poor flushing could not explain the difference.

None of the samples included in the comparison came from the Strait of Georgia casts since the only sample that was not from the surface had a high standard deviation in the CTD salinity.

For full details for the COMPARE run see file 2017-01-sal-comp1.xls.

Dissolved Oxygen

COMPARE was run with pressure as the reference channel.
A check was made to see if there is significant hysteresis and down to 3000db there was not. Below that SBE DO values may be slightly low but incomplete flushing leads to errors above the oxygen minimum that may make the differences look smaller especially in the high-gradient zone where DO values are fairly close to those from the deepest samples.

When outliers were removed based on residuals, the fit was:

CTD DO Corrected = CTD DO * 1.0453 + 0.0468 (R^2 = 0.9501)

Using only the casts from the Line P section of the cruise, and removing all bottles from cast #16 and other outliers based on residuals, the fit is:

CTD DO Corrected = CTD DO * 1.0484 + 0.0413 (R^2 = 0.9475)

For the Strait of Georgia casts the fit is:

CTD DO Corrected = CTD DO * 1.0333 + 0.0921 (R^2 = 0.759)

There is a lot of scatter in the last fit. There are no DO values <2mL/L, so tests were done using either a 0 offset or the offset found from the Line P data, but those fits were not as good.

The difference between fits for the Line P and Strait of Georgia sections is most likely due to the poorer flushing of bottles in protected waters together with higher vertical DO gradients.

A few major outliers were explained by noisy CTD dissolved oxygen, and just 5 look to be due to major bottle problems.

- Event 16, samples 105 and 106 – problems are due to a malfunction of the DO sensor. The sensor was replaced after this cast and it should not be included in any comparisons.
- Event 50, sample 292 is an outlier reading almost 10% lower than the CTD DO where we expect it to be higher by about 4.5%. Given that salinity is very clearly out of line, it looks like the bottle either closed a little late or it leaked. Flags were changed to 4 for all samples.
- Event 90, sample 546 was flagged 46 and it is a major outlier in the comparison with CTD DO. The flag was changed to 5 and the value padded.

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

One question that arises is which fit will be suitable for correction of the DO data from the Strait of Georgia. If the goal is to make the CTD match the bottle data, then it is clear. However, we want to make the CTD data as accurate as possible. If the differences are due to poor flushing of Niskin bottles in the inland waters, then using the open water results are the best choice. As well as probably flushing better, the inclusion of many bottles from below the oxygen minimum zone would help offset errors due to poor flushing. If the differences are due to slow sensor response in the presence of higher average vertical DO gradients, the local fit would be best. However, slow response would lead to the CTD looking lower relative to the bottles, not higher as seen in the comparison. Furthermore, we don't expect significant error due to slow response given there was a 30s wait before firing bottles.

More salinity sampling might have established if the regional differences are due to flushing variability, but the only deep salinity sample from the SoG had too much noise in the CTD data to help.

A further complication is that the vertical gradients in the SoG were highly variable with a subsurface reversal at many casts between roughly 60m and 120m. Some bottles from that level were outliers on the low side in the graphs, which is consistent with flushing errors of the opposite sign to those from areas where DO was decreasing with depth. The complex profiles will also explain the very high noisy level in the comparison for the SoG.

uncorrected DO value	0	1	2	3	4	5	6	7
correction using Line P fit	0.0413	1.0897	2.1381	3.1865	4.2349	5.2833	6.3317	7.3801
correction using SoG fit	0.0921	1.1254	2.1587	3.1920	4.2253	5.2586	6.2919	7.3252
Difference Line P-SoG	-0.0508	-0.0357	-0.0206	-0.0055	0.0096	0.0247	0.0398	0.0549

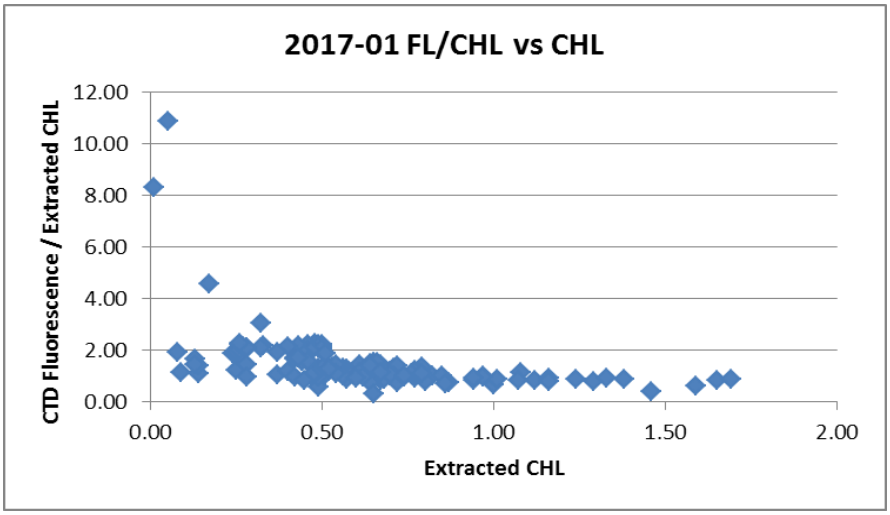
The differences between the two fits are significant especially at the high and low end of the DO range. However, there are no values <2mL/L in the Strait of Georgia data. The puzzle here is that the differences at 2 and 3mL/L show the SoG fit producing larger differences than offshore. The gradients are very low at the bottom of the SoG casts so flushing errors would be small whereas for Line P, the gradients are higher around 2mL/L so even small flushing errors may have some effect on the fit. Combining some of those near-bottom SoG bottles with the Line P bottles produced only a very small difference in the fit.

CTD DO Corrected = CTD DO * 1.0477 + 0.0440 (R^2 = 0.966)

Differences between that fit and the Line P fit are all ≤0.002mL/L except for DO<1mL/L. The change in offset does not work so well near the origin where samples all come from Line P. So the Line P fit looks like the best choice overall for al casts.

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 narrow range of CHL values with most values <1ug/L. The data show the usual pattern for this type of fluorometer with the ratio FL/CHL being high at very low CHL values and dropping as CHL rises. The highest CHL values came from the Strait of Georgia section of the cruise.



For full details of the comparison see file 2017-01-fl-chl-comp1.xlsx.

6 WILDEDIT

Program WILDEDIT was run to remove spikes from the pressure, conductivity & temperature only in the full cast files (*.CNV).

Parameters used were: Pass 1 Std Dev = 2 Pass 2 Std Dev = 5 Points per block = 50

The parameter "Keep data within this distance of the mean" was set to 0 so all spikes would be removed.

7 ALIGN DO

Tests were run on a few casts but the results were hard to judge because the temperature traces were noisy. But a setting of +2s looked best overall. ALIGNCTD was run on all casts using +2s.

8 CELLTM

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

9 DERIVE and Channel Comparisons

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

DERIVE was run a second time on a few of the deeper casts to examine differences between sensor pairs.

Cast #	Press	T1-T0	C1-C0	S1-S0	Descent Rate
2017-01-0050	1000	-0.0011	-0.0001	+0.0002	High, XNoisy
	1900	-0.0012	-0.0001	+0.0001	"
	2900	-0.0014	-0.0001	-0.0001	"
	3400	-0.0013	-0.0001	0	"
2017-01-0068	1000	-0.0013	-0.0001	+0.0002	High, XNoisy
	1900	-0.0013	-0.0001	0	"
	2900	-0.0013	-0.0001	+0.0001	"
	3400	-0.0013	-0.0001	0	"
2017-01-0077	1000	-0.0011	-0.0001	-0.0001	High, XNoisy
	1900	-0.0010	-0.0001	0	"
	2900	-0.0011	-0.0001	-0.0002	"

The temperature differences are higher than usual, though not terrible. The conductivity differences are small and salinity differences are negligible. The conductivity and temperature differences clearly cancel each other out in affecting salinity, so we have no way of determining which temperature sensor is more accurate. The differences between the 2 CTD salinity channels and bottle salinity data found in section 5 implies that S1-S0 = -0.0003psu, which is close to the results above. There is no obvious pressure dependence.

10 Conversion to IOS Header Format

The IOSSHELL routine was used to convert SEA-Bird 911+ CNV files to IOS Headers.
CLEAN was run to add event numbers and to replace pad values in the pressure channel with interpolated values based on record number.

11 Checking Headers

A cross-reference list was checked against the log book. A few discrepancies in station names were found and corrected in the CLN files.

The cruise track was plotted and added to the end of this report.

A surface check was run and shows an average surface pressure for the cruise was 1.8db. This is a little lower than usual for the Tully, but most offshore values are on the higher end of the range which was 0.7db to 3.5db. The Strait of Georgia casts were mostly shallower than offshore casts, as expected in protected waters. But there are low surface values for some offshore casts as well. Those are likely due to the rapidly varying pressures in heavy seas so that the CTD occasionally appears to have come out of the water very briefly.

The header check showed that there were spikes in many channels. There are some negative pressures. One such cast was checked and it looks like the CTD was probably bouncing in and out of water, so the pressure is likely ok. A negative DO value was checked and it was due to a spike.

The altimeter and water depth readings from the headers of the CLN and SAMAVG files were exported to a spreadsheet. Water depths were compared with the log book entries and a few errors were found and corrected.

No depth was given for station P19 (event 59) and the CTD did not get close enough to the bottom to enable an estimate. There was a loop with depth recorded at P19 (event 30) on the outward journey but the position is not close enough to the later P19 cast. A value of 3900m was entered as a rough average of values recorded during previous occupations of this site. The depth for event 63 looks wrong at 3555m in the header and 3565 in the log. It was changed to 3655 as that is closer to observations in previous years at P17. The cast was to ~2000m only so there is no altimetry data to help.

For many casts the CTD did not get within 15m of the bottom so there is no altimetry header entry. In a few cases where there were shallow casts in deep water, there is an altimeter header that is clearly wrong; such entries were removed from the headers of the CLN and SAM files. As a rough check of other entries, a calculation was made:

Check= (Pressure*0.99 -Depth +Altimeter Reading)

Where the result is <5m the entry was considered ok. That works reasonably well down to 1500m, but not at 3000 to 4000db, so the formula was varied a little, using values from 0.985 to 0.984. No further bad altimetry header entries were found.

After correcting the SAM files they were bin averaged again and the final merge step was run for the bottle files; the CLEAN step was repeated as well.

12 Shift

Fluorescence

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

Dissolved Oxygen

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

Conductivity

Tests were run on 4 casts to see what shift in conductivity does the best job of removing noise in the salinity channels. There is a lot of noise in the data and no alignment will remove it all. For the primary salinity shift between -0.5 and -0.7 improved the data with -0.7 best overall. For the secondary there is a noticeable improvement with a shift of +0.8 to +1.2 records.
SHIFT was run on all casts using -0.7 records for the primary conductivity.
SHIFT was run on all casts using +1.0 records for the secondary conductivity.
Salinity was recalculated for both channels.

13 DELETE

The following DELETE parameters were used:
Surface Record Removal: Last Press Min
Maximum Surface Pressure (relative): 10.00

Surface Pressure Tolerance: 1.0 Pressure filtered over 15 points
Swells deleted. Warning message if pressure difference of 2.00
Drop rates < 0.30m/s (calculated over 11 points) will be deleted.
Drop rate applies in the range: 10db to 10db less than the maximum pressure
Sample interval = 0.042 seconds. (taken from header)

COMMENTS ON WARNINGS: There were no warnings.

14 Other Comparisons

Previous experience with these sensors –
The temperature, conductivity and dissolved oxygen sensors had all been recalibrated in late 2015 and have not been used since then, so there is no useful history available.
Historic ranges – Profile plots were made with 3-standard deviation climatology ranges of T and S superimposed. Salinity was slightly high just below the base of the mixed layer at station P20 and low between about 100 and 150m in the northern part of the Strait of Georgia and near the mouth of Juan de Fuca Strait. Temperature data were all within the climatology except some low surface values at P20 and P21 and near the bottom of 2 casts in the Strait of Georgia. These excursions from the climatology are not systematic and do not suggest any problems with calibration.
Repeat Casts – There were repeat casts. Casts #44 and #50 occurred about 6 hours apart at P26. Differences along lines of constant σ_t were almost indistinguishable before bin-averaging and after binning they were <0.002º for the primary temperature and <0.0005psu for the primary salinity at σ_t= 27.5 (near 1680m). This shows excellent repeatability.
Post-Cruise Calibration – There were no post-cruise calibrations available.

15 DETAILED EDITING

The comparison with salinity samples showed little difference between the two channel pairs. An initial examination of T-S plots showed that the secondary T/S were slightly noisier with more unstable features, so the primary were selected for editing and eventual archiving.

CTDEDIT was used to remove large spikes, remove or clean smaller 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 records from near the top and bottom of the casts. Some bad salinity points were removed from a few files. All files required some editing. The descent rate was generally very noisy for the offshore casts with many complete reversals of direction so there was a lot of corruption by shed wakes.

There were 4 occasions when the pumps turned off during a cast. Once this was noticed they were turned on again without restarting the file. The primary temperature and salinity channels were removed in the first pass through CTDEDIT, but an extra pass was required to remove the secondary temperature, salinity, SBE dissolved oxygen and fluorescence channels. The following casts were affected:

- Cast 21 – remove pumped channels from 1000 to bottom for CTD. There was no bottle sampling.
- Cast 42 - remove pumped channels from 1000 down - bottle file ok since only surface sample.
- Cast 81 – remove pumped channels between about 400 and 800 – bottle file ok.
- Cast 85 – remove pumped channels between about 317 and 481 – bottle file ok.

The *.ED1 files were copied to *.EDT; then the *.ED2 files were copied to *.EDT.
After editing T-S plots were examined for all casts. One bad salinity point was found and smoothed by interpolation. There are other small unstable features but some may be real and others are likely due to shed wake corruption but it is impossible to tell the good data from bad so the data were not edited further.

16 Recalibration

There is no evidence to suggest that pressure should be recalibrated. The sensor has not been used since the last factory servicing when the offset was adjusted.

The salinity was found to be lower than the bottle salinity by an average of 0.0017psu. None of the sensors had been used since the last factory calibration and the two salinity channels were in excellent agreement. However, the temperature sensors did differ more than usual. The conductivity differences were of the opposite sign and offset the temperature effect somewhat. We have no way of knowing which sensors had the best calibration though the worst choice would lead to errors no larger than 0.0012psu. The combination of slight evaporation/adsorption and slight inefficiency in flushing of Niskin bottles can account for the CTD salinity being lower than that of the bottles by ~0.002psu.

Salinity will not be recalibrated.

Dissolved oxygen recalibration was discussed in section 5.

File 2017-01-recal1.ccf was prepared to apply the following correction to channel Oxygen:Dissolved:SBE:

CTD DO Corrected = CTD DO * 1.0484 + 0.0413

This correction was first applied to the SAM and MRGCLN2 files. COMPARE was rerun for dissolved oxygen using roughly the same points as in the fit used for recalibration. The average of differences in the DO fit was +0.002mL/L and the standard deviation was 0.027mL/L. The fit against CTD DO was fairly flat.

(See file 2017-01-DO-comp2.xlsx for details.)

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

17 Final Calibration of DO

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

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

When outliers were removed based on residuals the CTD DO was higher than the titrated samples by an average of ~0.028mL/L (standard deviation of 0.067mL/L). When only the offshore casts are included the average is 0.019mL/ L (standard deviation of 0.064mL/L). and for the casts from Juan de Fuca Strait and the Strait of Georgia it is 0.039mL/ L (standard deviation of 0.072mL/L). The standard deviations vary little but the differences do. Looking at the differences versus pressure shows that the sensor DO tends to be a little high above 1500m and lower below 1500m.

If the differences are due to slight inefficiency in the flushing of Niskin bottles, these are the results we would expect because offshore flushing is likely better and inshore vertical DO gradients are higher, on average. And finding errors of opposite signs below the oxygen minimum zone also supports this as a

source of error. If the differences are due to the CTD sensor response time, then we would expect the same result with the sensor reading too high above the OMZ and too low below. In the offshore areas the vertical gradients at depth are quite low so errors there from either poor flushing or poor response should be low, so there may be some hysteresis at play as well. The hysteresis checks done earlier showed good results to about 2000m, but below that CTD DO values are a little low.

No further recalibration is justified. See 2017-01-dox-comp3.xlsx for details.

18 Further editing

Plots examined later in the processing indicated a need to do some editing to channels that are not normally edited. Doing it at the end of processing is not a good idea because there are often corrections applied to some of the later steps. If that happened we would lose the edited values and have to do it again.

There as one spike in fluorescence for cast #32 at about 850db. The bad data were replaced with pad values in the COR1 file and filter and bin-average were rerun on that cast.

The depth for cast #63 was changed to 3666 as it fits other records for P17 better than 3566.
The records below 1014 and 1012db were removed from casts 21 and 42 respectively since the only data remaining are transmissivity and PAR after the pumped channels are removed; the transmissivity data are suspect and PAR at those depths is of no interest.

There were many problems in the transmissivity channel, with sudden shifts in values starting anywhere between 40 and 1000m and persisting thereafter. The problem casts were #16 (upcast only above 600m), 18 (320m down), 21 (1000m down), 73(80m down), 84 (500 down), 85 (1 spike), 92 (900 down), 93 (450 down). While we generally do not edit transmissivity and state that the results are nominal, these shifts are out of line with nearby casts that have no shifts. So a text editor was used to replace the bad data with pad values in both the COR1 files and in 1MRGCOR1 file, and for most of the affected bottle files the column was removed since they were all bad (18, 73, 84, 92, 93).

19 Fluorescence Processing and special files for Dr. Peña

The COR1 files were clipped to 150db and processed in 2 ways, with a filter and without a filter, followed by 0.5m-bin averaging in both cases. The SAM files were put through REMOVE and HEADEDIT. Those files were set aside for Dr. Peña.

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

20 BIN AVERAGE of CTD files

The following Bin Average values were applied to the FIL files (output AVG):
Bin channel = pressure Averaging interval = 1.000 Minimum bin value = .000
Average value will be used. Interpolated values are NOT used for empty bins.
On-screen T-S plots were examined.

21 Final CTD File Steps (REMOVE and HEADEDIT)

At the end of processing it was decided that the transmissivity channel was too unreliable to archive. There were many problems in the transmissivity data, with sudden shifts in values and large variations in values during repeat casts at a single site. In the offshore waters we expect consistent values below about 500m with minimal pressure dependence, though the value may vary from cruise to cruise due to instrument calibration drift. Values at 2000m at P26 ranged from 46%/m to 57%/m. Similar variations

are seen between P12 and P26 with no temporal or spatial pattern. The transmissivity channel will be removed from all CHE and CTD files to be archived, but the data are available, by request, from the chief scientist.

Copies of CTD files prepared WITH transmissivity were saved so that those who request the data can be provided with the files.

For all casts REMOVE was run to remove the following channels:
Scan_Number, Temperature:Secondary, Salinity:T1:C1, Conductivity:Primary, Conductivity:Secondary, Oxygen:Voltage:SBE, Transmissivity, Altimeter, Status:Pump, Descent_Rate and Flag.
PAR was removed from casts 32, 44, 47, 48, 50, 68, 69, 70, 77, 81.
Oxygen:Dissolved:SBE was removed from cast 16.

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 and PAR data are nominal and unedited except that some records were removed in editing temperature and salinity and a large spike in fluorescence was removed from cast #32.

Transmissivity data were removed because of frequent shifts in values during casts and large variations between values during repeat casts. The data are available, by request, from the chief scientist.

For details on how the transmissivity calibration parameters were calculated see the document in folder "\cruise_data\documents\transmissivity".

NOTE: While the CTD fluorescence data are expressed in concentration units, they do not always compare well to extracted chlorophyll samples, particularly for casts far from shore. It is recommended that users check extracted chlorophyll values where available.

Dissolved oxygen was calibrated using the method described in SeaBird Application Note #64-2, June 2012 revision, except that a small offset in the fit was allowed.

The Dissolved Oxygen sensor used during events #1, 2 and 16 malfunctioned so the DO channel was removed from those files.

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

of Niskin bottles and/or analysis errors, so the following statement likely underestimates SBE DO accuracy.

Downcast (CTD files) Oxygen:Dissolved:SBE data are considered, very roughly, to be:
±0.25 mL/L from 0 to 125db
±0.2 mL/L from 125db to 400db
±0.1 mL/L from 400db to 600db
±0.05 mL/L from 600db to 1500db
Low by up to 0.08mL/L below 1500db

For details on the processing see document: 2017-01_Processing_Report.doc.

At the end of processing it was discovered that the final files included transmissivity so REMOVE was run to remove that channel from the CHE and CTD files to be archived.

The Standards Check routine was run and no problems were found.
The Header Check was run; a problem was found in cast #42 where not all the bad SBE DO had been removed. This was fixed at the COR1 stage and the steps after that were rerun.
A cross-reference list was produced.
The sensor history was updated.
The track plot looks fine.

22 Dissolved Oxygen Study
As a final check of dissolved oxygen data, % saturation was calculated and plotted. The values ranged from 85% to 100% with values from P10 to P26 ranging from 98% to 101%. The lowest values were in Haro Strait, Baynes Sound, Saanich Inlet and at Station 12 in the northern Strait of Georgia. The results are consistent with good dissolved oxygen calibration.

23 Final Bottle Files
The MRGCOR2 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.
PAR was removed from casts 32, 44, 47, 48, 50, 68, 69, 70, 77, 81.
Oxygen:Dissolved:SBE was removed from cast 16.

A second SBE DO channel with mass units was added for both the CTD DO and titrated DO and REORDER was run to get the pairs of DO channels together.
NOTE: A change was made to the threshold levels for extracted chlorophyll quality flags. This led to changes to some flags and comments. Changes were made to the MRGREO files and header edit was rerun. The data in some intermediate files are not corrected. This affects events 75, 101, 109, 111, 116, 119.
The header comments for CHL were also changed.

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.

Data were exported from the CHE files to file 2017-01-bottles-final.xlsx. The entries were compared with the rosette log sheets to ensure no samples had been missed. A few problems were found and corrected:

- Event 74: There were 2 bottles fired but only 1 sampled, so the unused bottle was removed from the file. (Change made to COR1 stage and beyond.)
- Event 90: A correction to DO sample 546 had not been made. (Change made to all relevant files.)

Standards check and a header check were run on all files. No problems were found.
The track plot looks ok.
Plots of each file were examined and no problems were found.
A cross-reference listing and header check were produced for the CHE files.

24 Thermosalinograph Data
There were 7 hex files. Some are very small. There were severe problems with flow to the TSG until file #7 and the chief scientist reported many spikes in salinity and some odd temperature data.

a.) Checking calibrations
The configuration file did not change through the cruise, but contained an error in the identification of the fluorometer in use. The fluorometer parameters were changed to slope 1 and offset 0 in order to obtain fluorescence in volts as the calibration parameters are not considered reliable and on other recent uses did not compare well with chlorophyll sampling. One file was renamed as 2017-01-tsg.xmlcon and the fluorometer identification and calibration parameters were fixed.

b.) Conversion of Files
7 files were converted to CNV files using configuration file 2017-01-tsg.con.
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 there were problems with flow rate and salinity. Notes from the chief scientist note that there were problems with the flow that were not resolved until the beginning of file #7. Most of the water was going to the fluorometer and little to the TSG. Fortunately, file #7 covers the return trip from about P22 eastwards. The flow rate was generally steady, at about 0.75 for the first 6 files and close to 1 for the final file. The salinity has many one-sided spikes to lower values of size ~0.5psu (occasional deeper spikes) that are likely due to bubbles. For the first 6 files there are too many such spikes to be removed by editing. There are fewer spikes in the final file but close examination shows that editing is impractical. Salinity values drop slowly and recover suddenly. Identifying good data is far too subjective and time-consuming. There may be no “good” data.

The temperature difference varies from about -0.15 to -0.35C with the smaller differences associated with higher intake temperature, as expected. There are some temperature changes that seem rather abrupt but they are seen in the intake as well as the TSG so this is likely not due to a flow problem.

Files #3 and #6 are very short and the flow was off in the middle of both, so there are insufficient data to assess quality and they are too short to be worth processing. Files #2 and #5 are also short but the flow was steady so those are likely worth processing. Only files 1, 4 and 7 overlap with CTD casts.

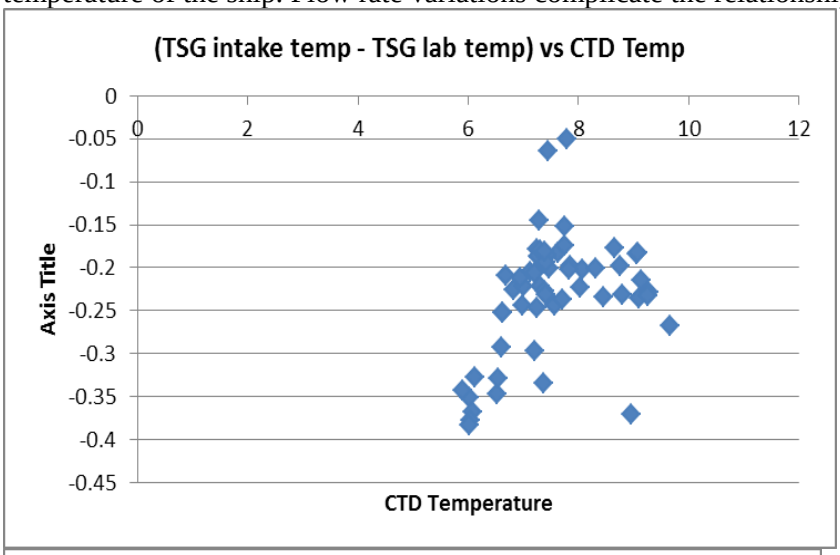
TSG files #1, 4 and 7 were opened in EXCEL, median and standard deviations (over 5 records) were calculated for intake temperature, lab temperature, temperature difference, salinity and fluorescence and

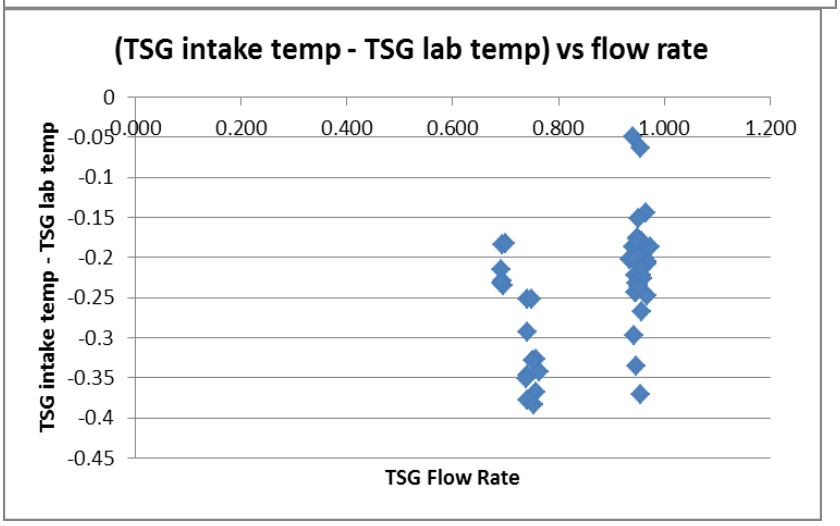
the files were reduced to the times of CTD files and loop samples. They were then separated into TSG and loop groups.

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 differences in latitude and longitude were all ≤0.0003° and the median differences were 0.0000° for both. This 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 worked throughout the cruise. The differences decrease slightly as temperatures increase as is expected as the intake temperature gets closer to the temperature of the ship. Flow rate variations complicate the relationship.





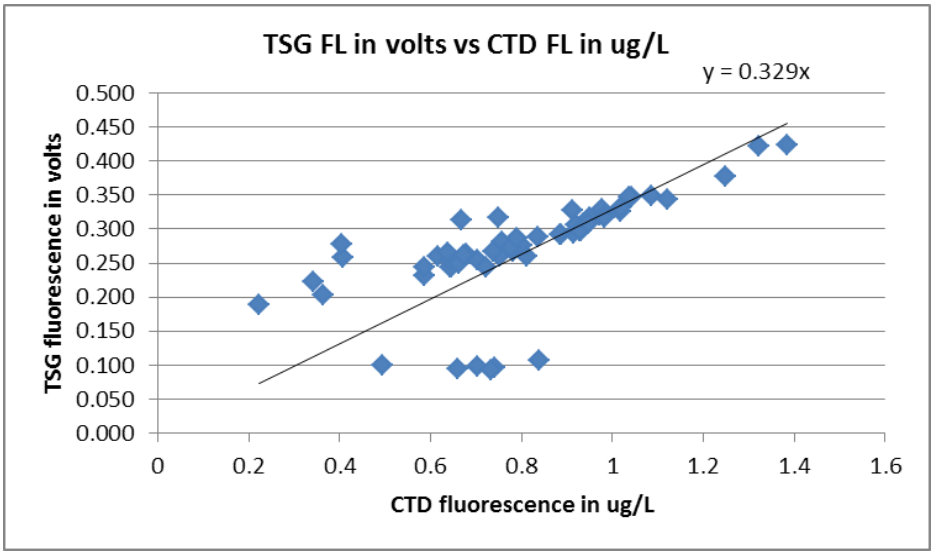
- Flow Rate The flow rate was ~0.75 for all files except #7 for which it was ~1.

- 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.

Ttsg lab-	Ttsg int-	Stsg-	TSG FL/

	Tctd	Tctd	Sctd	TSG CTD
Max	0.3993	0.1142	0.1072	0.84
Min	-0.2893	-0.3536	-2.8594	0.13
Median	0.2132	0.0067	-0.0671	0.34
median when flow rate was ~1	0.2071	0.0050	-0.0612	0.34
Median when flow rate ~1 offshore only	0.2010	0.0082	-0.0608	0.37

- The differences between the lab and intake temperatures are lower when the flow rate was higher, as expected.
- The flow rate has little effect on the salinity median difference, but the standard deviation in the TSG salinity is generally lower for the offshore casts with higher flow rate.
- The intake temperature is higher than the CTD temperature by a median value of ~0.008C° for the offshore section with a higher flow rate. When other values are included there is a lot more noise in the comparison. When all values are included the differences is lower. When including all cases with a flow rate of 1, it is higher. The latter may be due to the inclusion of Strait of Georgia casts where the vertical gradients are higher so slight mismatches in depth of observations will matter.
- The TSG salinity is lower than the CTD salinity by a median value of 0.067psu with a standard deviation or 0.43psu. When only casts with a flow rate of ~1 are included the TSG salinity is lower by a median value of 0.061psu and standard deviation of 0.50psu when outliers are excluded. And when only the offshore casts with a flow rate of ~1 are included the difference is also 0.061psu but the standard deviation is much lower at 0.01psu.
- The TSG fluorescence data are uncalibrated and expressed in volts. The ratio of the TSG fluorescence to CTD fluorescence has a median value of 0.34 and standard deviation of 0.1. The ratio is lower for file #1.



See 2017-01-ctd-tsg-comp.xls.

- Loop vs Rosette

	Rosette Samples - Loop Samples					
	SAL	CHL	OXY	NITRATE	SILICATE	PHOSPHATE
Median Diff	-0.0002	-0.0100	-0.2600	-0.0400	-0.0200	-0.0100

Min	-0.0043	-0.0900	-0.5570	-0.5600	-1.0800	-0.0980
Max	0.0016	0.1400	-0.2290	0.0500	0.1900	0.0150
Std Dev	0.0021	0.0841	0.1284	0.1929	0.4052	0.0358

- The loop salinity was higher than the rosette salinity by a median of 0.0002psu with a standard deviation of 0.002psu.
- CHL loop and rosette samples were within 18% with no trend and differences between 0.09 to 0.14ug/L
- Dissolved Oxygen loop samples were always higher than rosette samples, by from 0.23 to 0.56mL/L or 4% to 7%.
- The differences of Nitrate, Silicate and Phosphate were all within 4%, 5% and 7% respectively with the loop values generally higher than from the rosette.

Loop Bottle - TSG Comparisons

The TSG salinity was lower than loop samples by a median of 0.074psu with a standard deviation of 0.187. When only samples taken during file #7 are included the TSG salinity was lower by a median of 0.058psu and standard deviation of 0.019. There were serious problems with flow rate for the outward journey. On the return trip the data look somewhat better but there are obvious problems with one-sided spikes that are likely due to bubbles.

Extracted chlorophyll values ranged from 0.3 to 1.3ug/L. The TSG fluorescence falls into 2 groups with most values ~0.1volts in file #1 and ~0.25 to 0.3volts after that. So the shift came before the flow as registered by the flow meter changed, though the flow to the fluorometer may have changed. Data were collected at station P4 at the beginning and end of the cruise and the results are quite different. And for JF4 the CHL reaches its highest value and the CTD fluorescence is in agreement with that value, yet the TSG fluorescence is near its minimum. Within each of the 2 groups there is only a suggestion of a trend to higher fluorescence as CHL rises. The regular header note should be adjusted to say that the relation between TSG fluorescence and extracted CHL differs between file #1 and files 2 to 7.
There are insufficient data to see a difference between stopped and underway comparisons given the variations in flow rate.
(See 2017-01-loops-tsg-rosette-comp.xls.)

- Calibration History

  The temperature and conductivity sensors were recalibrated in November 2015 and were used during 2016-01, 2016-47, 2016-06, 2016-08 and 2016-62.
  2016-01: The salinity was spiky so comparisons with loops and CTD were not trusted. There were also variations in flow rates that complicated comparisons. The TSG fluorometer values were about 24% of the CTD fluorometer for 2016-01. Chlorophyll values were low for that cruise. The fluorescence data were archived in volts.
  2016-47: Salinity quality was higher than for 2016-01 but there was too much scatter in the comparisons to justify recalibration. Fluorescence was left in voltage and a multiplier of 7.5 was suggested for a rough estimate in concentration units in areas where CHL>0.5ug/L.
  2016-06: Salinity was recalibrated by adding +0.015 based on differences while underway which were higher than while stopped. Fluorescence was archived in volts and for those who wanted a rough estimate it was suggested that fluorescence be multiplied by 3 while stopped and 4 while underway where CHL<1ug/L. For higher values no estimate was recommended.

2016-08: The intake temperature sensor malfunctioned. There was a lot of variability in the various comparisons of TSG salinity with loop and rosette sampling, but the correction used for 2016-06 looks reasonable, so salinity was recalibrated by adding 0.015psu.
2016-62: The intake temperature sensor malfunctioned. Salinity was recalibrated by adding 0.015psu based primarily on the 2 previous cruises.

Conclusions

1. The TSG clock worked well.
2. The TSG flow rate was low for files 1-6 and ~1 and generally steady for file #7.
3. The temperature increases in the loop by roughly 0.19C°.
4. The TSG intake temperature was higher than the CTD temperature by a median of about 0.008C°. There have some indications in the past that there can be some heating right at the intake, so no correction will be applied.
5. There are many spikes in the TSG salinity with a gradual drop, then a sudden recovery. There are fewer spikes during stops though even then there are some large spikes that are not seen in the temperature or fluorescence. These spikes are presumed to be due to bubbles building up gradually and then bursting suddenly.
6. The TSG Salinity is lower than the CTD salinity by about 0.0067 using all cases but is a little closer for file #7, at about -0.061psu, which is presumed to be because there are fewer spikes. Compared to loop samples TSG salinity is low by 0.074psu overall but 0.058psu for file #7. Compared to rosette samples it is low by 0.075psu overall and 0.055psu for file #7. These are reasonably consistent results, but are not useful for recalibration due to the many spikes.
7. The TSG fluorescence is given in volts. The TSG fluorescence values are about 15% of loop chlorophyll for file #1 which is unusually low when fluorescence values are fairly low. For files #4 and 5 the values are quite close. For file #7 the TSG fluorescence dropped to about 25% of the extracted CHL, perhaps because the flow to the fluorometer was changed to enable more water to go to the TSG. No explanation was found for why the values were so low for file #1, but there may have been an adjustment to the TSG set-up as attempts were made to fix the salinity problem.
8. Recalibration of the salinity looks pointless given the large errors due to spikes.
9. The loop and rosette samples are in reasonable agreement except for dissolved oxygen which was always higher in the loop than from the rosette by from 0.1 to 0.6mL/L.

f.) Editing

Each file was opened in CTDEDIT but it was clear that editing salinity was not practical with gradual drops in salinity followed by sudden increases. There would not be much data left if all those features were removed and identification of which data are good is very subjective. No editing was applied.

g.) Recalibration

No recalibration was applied.

h.) Preparing Final Files

REMOVE was used to remove the following channels from all casts: Scan Number, Salinity:T0:C0, 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 standardize channel names and formats.
Those files were saved as TOB files.

The Standards Check and Header Check were run; 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.
The cruise plot was added to the end of this report.

25 Loop File
The CHE files were put through program DERIVE to obtain sigma-t.
Data from those files were exported to file 2017-01-che-surface.csv.
Because there are real loop DO samples, the DO channel in mass units was not included in the spreadsheet, but Temperature:Draw was included. It is simplest to derive DO in mass units for both rosette and real loop values at the same time.

Data from below 7m were removed.
Sample number and sample method columns were added. ROS was entered for the method.
The Start Time was copied into a second column and the first was formatted for date and the second for time. Columns were rearranged to fit a model 6-line header.

Times were corrected for rosette samples to match the end of casts.

The data were sorted on event number, then pressure and added to the 6-line header file.
Loop data had been prepared earlier for use in comparisons with the TSG data. That included adding date/time based on log entries. The data were added to the spreadsheet and lined up appropriately. The sampling method column was entered as USW. Positions were added.

The file break column was filled with value 1 so all data will be in a single file when converted.
The file was sorted on event numbers, sample method and pressure.
The file was then saved as 2017-01-surface-6linehdr.csv.
(Note: For future reference on another occasion this step failed several times and no cause could be found. Closing and reopening IOS SHELL and doing a reboot did not help. Closing all EXCEL files and opening and closing some convert spreadsheet routines in other projects but not actually running them eventually worked – the program conversion program seemed to remember an input file that had since been fixed.)

CONVERT was run to produce an IOS Header file.
CLEAN was run to get start and stop times and positions and to add flag 0 to empty flag cells.
A comment file was prepared which was essentially the same as the one used in preparing CHE files but including a description of the loop system and comments on the CTD data processing.

NOTE: A change was made to the threshold levels for extracted chlorophyll quality flags. This led to changes to some flags and comments. Changes were made to the REO file for samples 587 and 627 and header edit was rerun.

Header Edit was used to correct channel names and formats and to add comments. The final file was renamed as 2017-01-surface.loop. The track plots looks reasonable and a plot of temperature and salinity versus longitude looks reasonable.

Particulars – from log book and Chief Scientist's sampling notes
PAR OFF: 32, 44, 47, 48, 50, 68, 69, 70, 77, 81
Out of Order firing: 22 & 51
Casts with no bottles closed: 2, 96, 130, 134
Deployment Method – Rosette brought to surface, pumps turned on, rosette taken to 10m and back up. Start archiving and wait 30s, then cast run.

TSG – Wrong values in the configuration file for fluorometer, problems with flow to TSG until file 7, salinity spiky and temperature odd.

CTD:
1-32: CTD computer clock is 7.5 minutes ahead.
33-43: CTD computer had the wrong date (28 Feb to 2 March)
1. Test cast – bottles closed but not needed. DO looks strange.
2. Test cast – "didn't clear the water before starting". Went to 50m to check DO and it looked "a touch better". Probably not worth archiving, but check it out.
16. DO reading very low, definitely not working, altimeter stuck at 10 on the way up. DO sensor changed after this cast. Niskin #1 leaky on bottom cap – tightened up after the cast.
18. Altimeter not kicking in near bottom. May have hit bottom - transmissivity near zero.
21. Pressure spike at 1014db. Rerun as event 23.Bottles were not sampled, but the downcast at least as far as 1014db worth saving, if possible.
25. Altimeter swapped after this cast. Serial # unknown and configuration file not changed at sea.
32. PAR off.
33. PC Clock reset. NMEA slow to start.
37. Stopped at ~2800m to straighten wire and again at ~370 on way up.
42. Spike at 1012 during downcast. Pump turned itself off on downcast ~1000m (large oxygen spike) although trace looked normal after that until noticed on upcast ~900m.
44. Stopped ~820m down to straight wire and ~25m up. Shutdown at 5m for easier recovery.
63. Depth in log 3555 – looks wrong based on previous observations at this site – changed to 3655
68. PAR off.
74 – Spare Niskin (Bottle 2) closed at 5db but was not needed. Remove that line from bottle file.
81. Pump turned off from 400-800 on down cast, then turned back on. REMOVE pumped channels for that depth range.
85. Spike on downcast ~316db. Pump turned off ~350-500 on way down, turned back on. New lanyard on Niskin #10.
96. Station name wrong in header – change to Gliders.
100. Bottom coming up but no altimeter reading.
106 – Spike at end of cast after closing last Niskin. DO sensor "did not recover". Error message re carousel.
113. In DO analysis event 113 changed to 114
114. Event given as 114 in DO analysis should be 116.
130 – Spike ~305db upcast

TSG:
15:19UTC 9Feb – COM not working on TSG. Tried to start file 4, won't start,
18:22UTC 9 Feb - start file 4.
18:12UTC 12 Feb – start file 5
15:14UTC 14Feb – stopped TSG to try to take air out of TSG. Started file 6, played with plumbing to try to increase flow. Data may not be great. Put in a valve before the fluorometer to be able to adjust flow. Got flow to 6. Stopped and started file 7.

CRUISE SUMMARY

CTDs

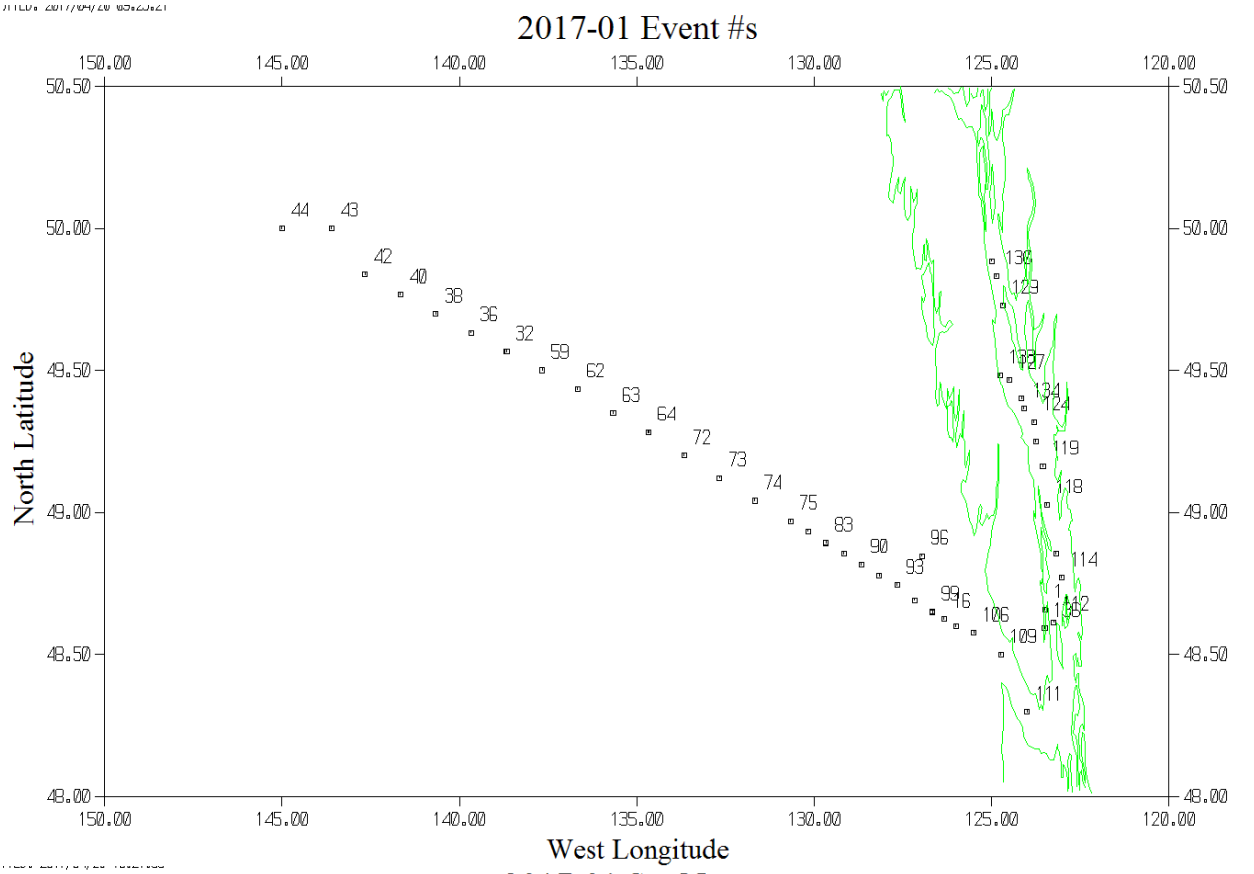
CTD#	Make	Model	Serial#	Used with Rosette?	CTD Calibration Sheet Competed?
1	SEABIRD	911+	0506	Yes	Yes

Calibration Information					
Sensor		**Pre-Cruise**		**Post Cruise**	
Name	**S/N**	**Date**	**Location**	**Date**	**Location**
Temperature	**2023**	**10Sep2015**	**Factory**		
Conductivity	**1763**	**10Sep2015**	**Factory**		
Secondary Temp.	**5013**	**10Sep2015**	**Factory**		
Secondary Cond.	**3394**	**10Sep2015**	**Factory**		
Transmissometer	**1185DR**	**27Apr016**	**IOS**		
SBE 43 DO sensor	**1438**	**24Sep2015**	**Factory**		
SBE 43 DO sensor	**3234**	**3Nov2015**	**Factory**		
PAR	**70613**	**21Mar2016**	**Factory**		
SeaPoint Fluor.	**3642**	**n/a**			
Pressure Sensor	**0506**	**14Sep2015**	**Factory**		
Altimeter	**1253**	**n/a**	**Factory**		

CRUISE SUMMARY TSG

Make/Model/Serial#: SEABIRD/21/3411 Cruise ID#: 2017-01

Calibration Information					
Sensor		**Pre-Cruise**		**Post Cruise**	
Name	**S/N**	**Date**	**Location**	**Date**	**Location**
Temperature	**3411**	**7Nov15**	**Factory**		
Conductivity	**3411**	**7Nov15**	**Factory**		
WetLabs Fluorometer	**Ws3s-889p**	**4Dec09**	**?**		
Temperature:Secondary	**842**				
Flow meter	**?**	**n/a**			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48.50
48.00
North Latitude
West Longitude
44
43
42
40
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59
62
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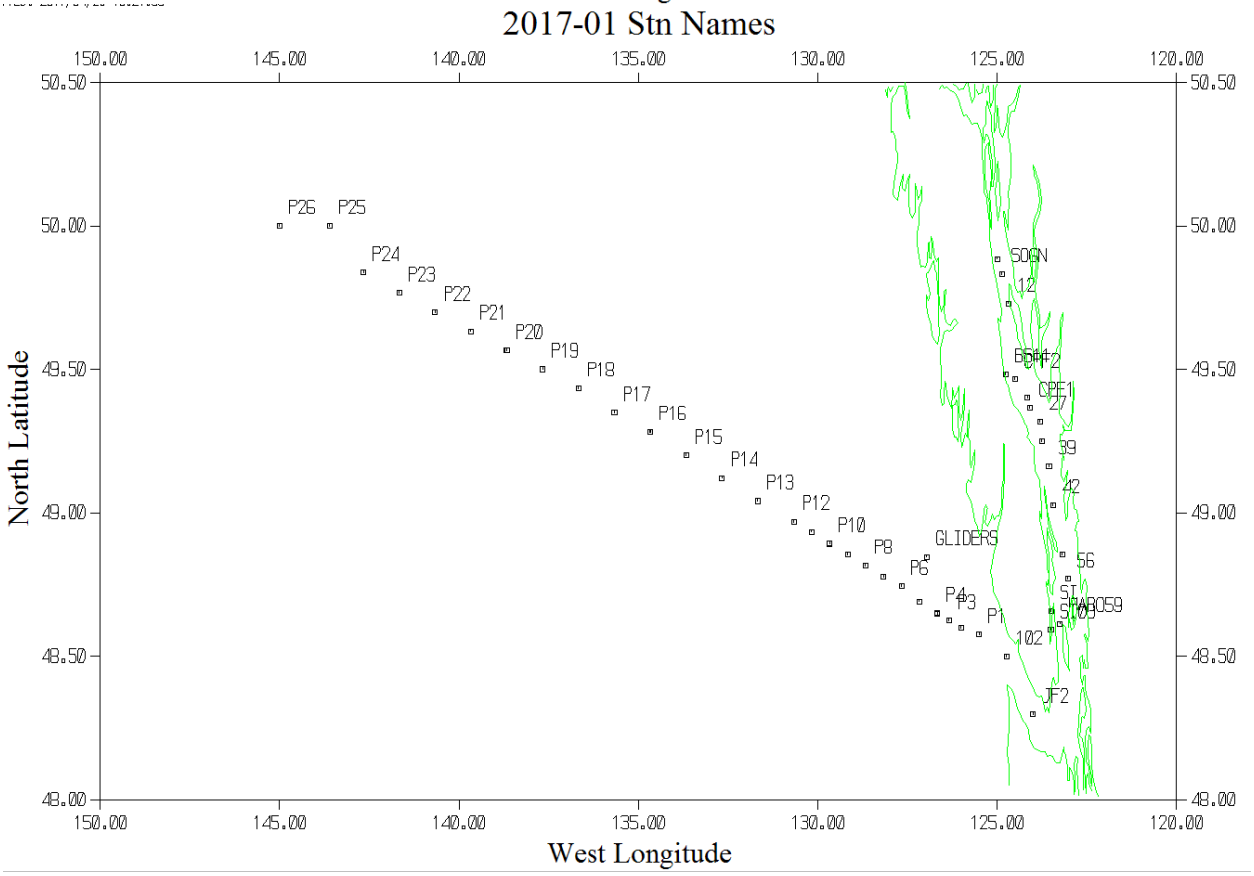
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North Latitude
West Longitude
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P25
P24
P23
P22
P21
P20
P19
P18
P17
P16
P15
P14
P13
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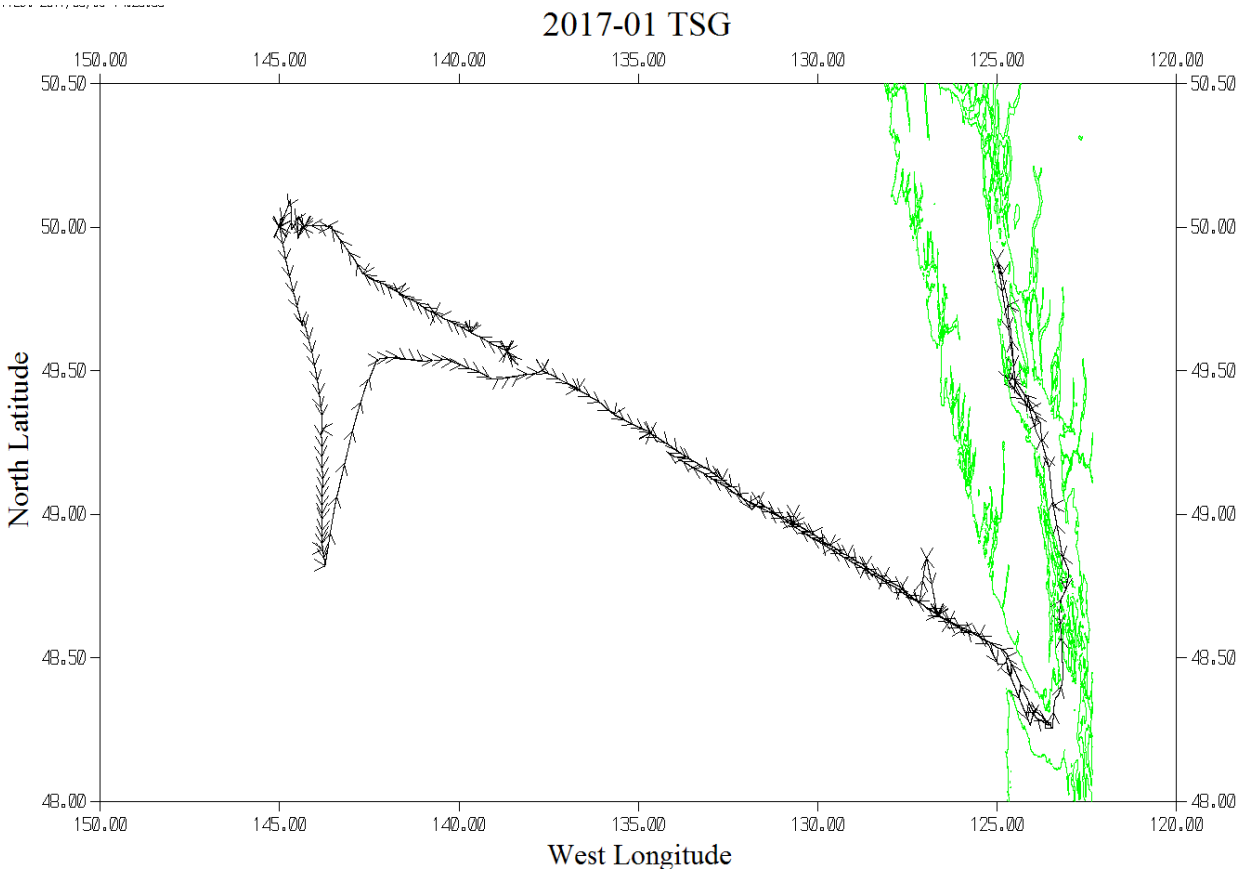
2017-01 TSG
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North Latitude
West Longitude