REVISION NOTICE TABLE

DATE	DESCRIPTION OF REVISION
4 Nov. 2015	Updated CHL spreadsheet. Correction to CHL in file 2014-19-0010.che.
30 March 2015	1. Post-cruise calibration reports showed that the recalibration applied to temperature and recalculation of salinity were inappropriate. That step was reversed. For details see note at end of this report after §27. 2. Header notes about salinity bottle inserts were corrected in CHE files.
17 March 2015	Fixed errors in loop file 2014-19-surface.loop G.G.

PROCESSING NOTES

Cruise: 2014-19
Agency: OSD
Location: North-East Pacific
Project: Line P
Party Chief: Robert M.
Platform: John P. Tully
Date: 19 August 2014 – 2 September 2014

Processed by: Germaine Gatien
Date of Processing: 2 December 2014 – 25 February 2015
Number of original HEX files: 69 Number of CTD files: 59
Number of bottle files: 55 Number of bottle casts processed: 53 (2 were joined)
Number of original TSG files: 5 Number of processed TSG files: 5

INSTRUMENT SUMMARY

Two SeaBird Model SBE 911+ CTDs (#0506 and #0443) were used for this cruise.
1. CTD #0506 was mounted in a rosette and attached were a Wetlabs CSTAR transmissometer (#1396DR), an SBE 43 DO sensor (#1438) on the secondary pump, a SeaPoint Fluorometer (#3641) with a 3X cable on the primary pump, a Biospherical QSP-200 PAR sensor (#4615) and an altimeter (#1204). This CTD was used for casts before #7 of which only cast #3 is to be processed.

2. CTD #0443 was mounted in a rosette and attached were a Wetlabs CSTAR transmissometer (#1396DR), an SBE 43 DO sensor (#0997) on the secondary pump, a SeaPoint Fluorometer (#3642) with a 3X cable on the primary pump, a Biospherical QSP-200 PAR sensor (#4615) and an altimeter (#1204). This CTD was used for cast #7 and all casts thereafter except for some test casts that are not to be processed. The configuration was changed before Event #57 with the transmissometer and fluorometer positions reversed.

A thermosalinograph (Seacat 21 S/N 3363) was mounted with a Wetlabs/Wetstar fluorometer (WS3S-713P), remote temperature sensor and a flow meter.

The data logging computer was #3. Seasave version V7 22.4 was used for acquisition.
The deck unit was a Seabird model 11, serial number 0471.
All casts were run with the LARS mid-ship station.
The salinometer used at IOS was a Guildline model 8400B Autosal, serial # 68572.
An IOS rosette with 24 10L bottles was used.

SUMMARY OF QUALITY AND CONCERNS

The Daily Science Log Book and rosette sampling log sheets were generally in good order, but there were two problems:

- There is no list of equipment for the first CTD used. One useful cast was acquired from that CTD and even if there were none, it may be useful information in the future. No sheets with information entered should be removed from the Daily Science log book or rosette logs. To update information draw a line through entries believed to be in error and add notes of explanation as needed.
- There were no entries for the TSG. Sometimes TSG data does not get downloaded with the CTD data and it is a good idea to make it clear that the system was used.

The Chief Scientist provided sampling notes that were very helpful in processing a complex cruise.

There was some confusion over the correct pressure calibration parameters for CTD #0443. The sensor had been tested at the factory in both June and July 2014. The values used at sea were those from July but the date of calibration shown was wrong. The July calibration sheet was not available to the processor so it was thought that the June date was right, but the parameters wrong. The confusion was resolved by getting the calibration data from the factory. The problem may have arisen because the calibration reports were received just before the cruise and were taken to sea, so some of the information may have been misplaced on the ship. This confusion caused considerable delay in processing.

There were 2 cases of a cast being interrupted by a computer crash. It was restarted with a new event number. It is recommended that any Niskin bottles that had already been fired during the acquisition of the 1st file be fired again at the beginning of the 2nd file. This makes the combining of the files easier and so helps avoid errors.

The pressure was recalibrated for CTD #0506; this was used for event #3 only.

The sensors for CTD #0443 had all been factory serviced shortly before the cruise. The primary salinity was found to be lower than the bottle salinity by an average of 0.003 while the secondary salinity was very close to bottles. However, the secondary temperature and salinity traces were very noisy making editing extremely difficult. The primary profiles were also noisy but much less so than the secondary. So it was decided to archive the primary channels. Usually a simple offset correction is used to recalibrate salinity, but for this cruise it appears likely that the temperature sensor is the cause of the offset rather than the usual case of conductivity calibration drifting. A comparison of the primary and secondary temperature channels was used to determine a reasonable correction to the former, and primary salinity was recalculated using the corrected temperature. Small adjustments were made to the correction until the primary temperature and salinity were both reasonably close to the secondary channels.

The fit of the Oxygen:Dissolved:SBE data against dissolved oxygen bottles for the DO sensor on CTD #0443 fell into 2 groups, with the first looking like those we typically see, while the 2nd group had an unusual fit. Both were roughly linear with fairly small slopes, but the offset was much larger for the second group, with the CTD DO reading higher than expected when titrated sample values were low. An investigation into the analysis of samples turned up no evidence of significant problems, and the titrated values in the oxygen minimum zone were consistent with those observed in the past. There is evidence of something odd happening during cast #49 that may have led to a shift to higher SBE DO values. The DO signal was generally very noisy below 1000m, but the fit against bottles looks fairly consistent within the 2 groups of casts. A study of 2 subsequent cruises using the same DO sensor show similar results to the 2nd group. Recalibration was applied separately to the two groups.

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

±0.5mL/L from 0db to 150db
±0.3mL/L from 150db to 300db
±0.1mL/L from 300db to 1000db
±0.05mL/L from 1000db to 2000db
±0.1mL/L below 2000db

The dissolved oxygen channel had some large spikes that were not removed by bin-averaging, so some editing was done to that channel for all the casts deeper than 100m. At the same time some bad fluorescence values were removed from many casts and bad transmissivity data were removed from 1 cast.

The TSG salinity was generally smooth with some small discrete spikes, possibly due to air bubbles. The flow rate was very steady throughout the cruise.

PROCESSING SUMMARY

1. Seasave

This step was completed at sea; the raw data files have extension HEX.
An initial cast was sent from sea for initial processing. It looked fine but that CTD malfunctioned and had to be replaced.
Some corrections were made to headers of the raw files based on notes from the Chief Scientist.

2. Preliminary Steps

The Log Book and rosette log sheets as well as various analysis logs were obtained.
Sampling notes from the Chief Scientist were reviewed. Many files have the cruise number entered incorrectly. This will be corrected after conversion to SeaBird CNV and ROS format.
Extracted chlorophyll, DMS, nutrients, dissolved oxygen and salinity data were obtained in spreadsheet format from the analysts.
The cruise summary sheet was completed.
The history of the pressure sensor, conductivity and DO sensors were obtained, but none of the sensors had been used since their last factory visits.

The calibration constants were checked for all instruments. There were 4 configurations used, 1 for CTD #0506 and 2 for CTD #0443 (the only difference between the two was that the fluorometer and transmissometer were on different voltage channels.) A few small errors in spelling were fixed and the 3 variations were then saved as saved as 2014-19-ctd1.xmlcon, 2014-19-ctd2.xmlcon and 2014-19-ctd3.xmlcon.

The PAR sensor was not always mounted.
Cast lists of PAR and NO PAR were prepared based on log notes.

3. BOTTLE FILE PREPARATION

The ROS files were converted using files 2014-19-ctd*.xmlcon with Tau and Hysteresis corrections selected. Those files were put through CLEAN to add event numbers (*.BOT).

Temperature and salinity were plotted for all BOT files. The only problems found were with cast #12 which was very noisy at about 20m. Bottle #7 was not sampled and it looks like that bottle was fired on the fly. This is presumed to be accidental as the plan for sampling was changed to skip that bottle.

Header Check was run on the BOT files and the only problem noted was that there were 25 bottles fired during cast #117, but there were actually only 24 bottles present. Niskin #9 was apparently fired twice. Only the first 4 Niskins were to be sampled and other bottles were being fired only to close them.

The BOT files were then averaged to enable an ADDSAMP file to be prepared. First, the file was sorted on event number and Bottle Position order. Then sample numbers were added based on the rosette logs.

Casts #69/70 and #109/110 were interrupted during the upcasts, so the BOT files for the first file in each set was renamed as BOTx, while the second files in the sets were renamed with the number of the first file plus BOTy. It is easier to combine such files if the bottles fired during the 1st part are fired again at the beginning of the 2nd file. That didn't happen this time. The bottle positions are correct in all files, but the bottle firing numbers needed to be fixed in the second file of each pair. The bottle numbers were adjusted in the 2nd files using Ultraedit and then JOIN was used to create new files, 2014-19-0069.bot and 2014-19-109.bot.

Sort was used to ensure that the ADDSAMP file was in sample number order.
SAM files were created using the Add Sample Number routine and those files were then bin-averaged.
Altimetry and Water Depth headers were fixed in the SAM files based on study describe in12.
Bin-average was then run using bottle numbers for bins to produce SAMAVG files.

Lines were removed from the SAMAVG files for cases with no sampling numbers and no need to keep the information (based on notes from the Chief Scientist).

The addsamp.csv file was ordered on sample number and converted to CST files. The CST files will form the framework for the bottle files.

Next, each of the analysis spreadsheets were examined to see what comments the analyst wanted included in the header file. These were used to create file 2014-19-bot-hdr.txt.

EXTRACTED CHLOROPHYLL
Extracted chlorophyll and phaeo-pigment data were obtained in file QF2014-19CHL.xls which included a comparison of duplicates. Event numbers were missing so those were added. A simplified version of the spreadsheet was saved as 2014-19chl.csv which was then converted to individual CHL files. Loop data were added to file 2014-19-loops.csv.

DISSOLVED OXGYEN
Dissolved oxygen data were provided in spreadsheet QF2014-19oxy.xls which includes a precision study. Draw temperatures are available. The spreadsheet page with the final data was simplified by removing a few unnecessary columns and the file was then saved as 2014-19oxy.csv. That file was converted into individual *.OXY files.

SALINITY
Salinity analysis was provided in spreadsheet QF2014-19SAL.xls which included a precision study. The file was simplified, loop samples were removed and the file was saved as 2014-19sal.csv. That file was converted to individual SAL files. The salinity data were analyzed 4 to 19 days after collection. Loop samples were saved to 2014-19-loops.csv.

NUTRIENTS

The nutrient data were obtained in spreadsheet QF2014-19nuts.xls which included a report on precision. The file was simplified, reordered on sample numbers and the file was saved as 2014-19nuts.csv. The file was converted to individual NUT files. The loop data were copied to file 2014-19-loops.csv.

DMS

DMS data were obtained in file DMS summary (2014-19).xls. Values given as < were changed to 0 and the comments that will go into the header will explain that 0 means below detectable level. (There was a separate report on analysis techniques and problems.) The file was simplified, the comments were amended by putting "DMS:" at the beginning. The event number 69/70 was changed to 69 as the split cast has been joined and named 69. The file was then saved as 2014-19DMS.csv and converted to individual DMS files.

There were nutrient, salinity and chlorophyll data from the TMR CTD, but there are no CTD data to go with them, so they will not be picked up in the following steps.
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.

A few files have no sampling, so were removed from the cast list: 22, 45 and 71.

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 MRG files were exported to a spreadsheet and compared to the rosette sheets. Some inconsistencies were found:

- Event #12. The rosette sheet entries indicate that bottle #7 was not fired, but there was a note at the bottom of the sheet that bottle #7 was tripped by accident. The Niskin #s had been adjusted to reflect this, but not the firing #s. That was adjusted in the ADDSAMP file. The line for bottle #7 was removed from the MRG file.
- Event #25 – Salinity sample 134 is missing & presumed not collected since it is not among the raw salinity data. The sample number was added to the SAL file with a pad value and flag 9.
- Event #39 – It was believed at sea that Niskins #1and 2 were accidentally fired at the surface. In fact Niskin #2 was fired at the surface, but #1 was fired so quickly that a BL file was not created and the data were not acquired. So Niskin #3 was fired at 2000m as recorded on the rosette sheet, but it was fired 2nd, not 3rd, and so on. This was fixed in the ADDSAMP file. Niskin 2 was removed from the file.
- Event #55 – Sample 336 – The salinity box is checked but there is no value. There is a sample 335 (Event #53) but no such sample is indicated on the rosette sheets. On the analysis sheet there is a sample #336, so it appears that this was a typo when the info was entered to the analysis file. Sample 335 was changed to 336. The salinity file for event #53 was removed.
- Event #66 – There were 2 bottles fired that have no sampling. They have no sample numbers and the lines should be removed from the MRG file later.
- Events #69/70 – The nutrients were in file 70 and everything else in 69, so the nutrients were renamed. The DMS data were mostly missing – the DMS spreadsheet was reconverted successfully. The ADDSAMP file was fixed to match the BOT file.
- Event #72 – The salinity was missing because it was mislabelled as from event #71. This was corrected.

- Event #117 – The salinity bottle data were missing because the CTD data were misnamed as file 115 on the rosette sheet so the wrong sample numbers were entered in the ADDSAMP file – that was fixed. Niskins 4-24 were closed but not sampled so were removed from the MRG file.

After these corrections the ADDSAMP file was converted to CST files again and the MERGE process was repeated.

An initial header check did not turn up any problems.

4. COMPARE

Dissolved Oxygen

COMPARE was run using DO from the MRG and SAM files.

First, hysteresis checks were done by looking at 4 deep casts and excluding points below 2500db to see if they stand out from the fit of points from above 2500db. There was scatter to either side of the fit, with no evidence of hysteresis.

Next, differences were plotted against CTD DO for cast #3, the only one with DO sensor #1438. The range of DO values is small and there are no cases of DO<2.5mL/L, so the offset was set equal to 0. When 3 outliers were excluded the fit was:

DOX_BOT = 1.0296 * DOX_CTD

Given the location in Haro Strait we expect some local reversals that likely explain most of the scatter. Only 1 of the outliers looks significant and it was already flagged 3 due to a bubble in the sample. There is no justification to change any of these flags.

Next casts 7 to 104 were examined as they all used DO sensor #0997. The fit is extremely noisy until the casts are divided into 2 groups:

- For casts #7, 10, 12, 25 and 39 the fit after a few outliers were excluded was:
  DOX_BOT = 1.0245 * DOX_CTD -0.0036

  Choosing a zero intercept as suggested by the manufacturer has only a slight affect with the slope becoming 1.0237.
- For casts #49, 64, 79 and 104 the fit after a few outliers were excluded was:
  DOX_BOT = 1.0326 * DOX_CTD -0.1050

Choosing a zero intercept looks very bad.

The 2nd fit is unusual because of the large offset, but other large offsets were found for 2 other cruises in 2014 which had a different DO sensor. The cruises were 2014-06 in the Strait of Georgia & Juan de Fuca Strait and 2014-15 in Hecate Strait & Douglas Channel. The DO sensor was #1119. Both cruises had relatively shallow sampling and steady descent rates that might inhibit Niskin bottle flushing. Neither had any low DO values (<2mL/L).

For this cruise, there were rough seas and a lot of deep sampling where local gradients are low, so flushing should not be an issue (except very close to the surface). The DO range was high and there were lots of low DO values. If the low values were excluded from the fit, it made little difference to the result. Given that the odd results are found in the deepest casts where there are many bottles below the DO minimum, the data were examined to see if this might lead to a complicated fit since poor flushing would cause the bottles to be higher than expected below the minimum and lower above it. Fits were tried using data from above 750m and then from below 2000m; as expected from the hysteresis test, there was no significant difference in those fits.

There is a lot of noise in the DO signal especially at depth but that does not explain the odd fits even above 500m.

Tests were run looking at each cast to ensure they were in the right group. Cast #12 is very messy and doesn't seem to fit either group, but the DO profile is very complex with high gradients and several reversals, so a good fit is not expected. There are some other cases where a few samples from one group look closer to the other group; some of those were flagged by the analyst while most look like normal scatter.

A check was made to see if the titrated DO values at the DO minimum level look like what we expect from previous years. The difference between the 2 fits is ~0.1mL/L for the lowest DO values, so we might expect to see bottle values about 0.1mL/L lower for this cruise than for other Line P cruises. The minimum titrated values are all in reasonable agreement with the June 2014 and September 2013 cruises. (See table below.) The analyst noted a few problems with temperature of samples, but this concerns only a few samples.

Some other possible sources of a shift in the fits were investigated:
1. The 2 SBE temperature channels differ by more than usual, but this did not change through the cruise.
2. There is noise in the CTD DO channel, almost all below the DO minimum, but this is seen before the shift in the fit, and does not affect the shallow data.
3. The draw temperatures were noted to be farther from the CTD temperatures than usual, but what does that tell us? It could indicate misfiring of bottles or bad thermometers or bad CTD Temperature. The differences were examined to see if there were patterns with time, surface temperature, temperature range or descent rate. The differences were higher at P20 than at P26. There were 2 things that distinguish those two casts. It took more time for the CTD to get from 4000m to the surface for the cast at P20 and the temperatures were higher at P20 in the top 150m, so the contents of the Niskin bottle likely did warm more. Comparing temperatures from the Line P cruise in August/September 2013 we find much higher temperatures in the top 150m for 2014. The thermometer used to get the draw temperature is clearly inaccurate, but the differences from cast to cast are likely due to in situ temperatures and length of the upcast.
4. There was a problem in the analysis with flask numbers; however, that affected only the early casts that have the normal fit, so the correction that was made appears to have been appropriate.
5. The oxygen minima as measured by the titrated samples are similar to those found in other years, with minor variations in either direction. The oxygen minima from the SBE DO, on the other hand, are higher from about P12 onwards. The following table contains estimates of minimum DO from downcast and upcast SBE data plus minimum bottle values from 3 Line P cruises. The estimates of minima from SBE DO data are rough as the signal was often very noisy; what looked like a median value was chosen in noisy areas. Note that the SBE DO are uncorrected, but the correction at low values is usually small.

Station	Event #	Sept 2014 SBE DO min down	Sept 2014 SBE DO min up	Sept 2014 Min SBE Up - Min SBE Down	Sept 2014 DO min Bottle	Sept 2013 DO min Bottle	June 2014 DO min Bottle	2014-19 Min SBE down - Min Bottle	2014-19 Min SBE up - Min Bottle
P4	25	0.20	0.18	-0.02	0.21	0.21	0.22	-0.01	-0.03
P4	28	0.21	0.19	-0.02					
P4	30	0.21	0.20	-0.01					
P5	32	0.22	0.21	-0.01					

P6	33	0.22	0.21	-0.01					
P7	35	0.24	0.24	0.00					
P8	39	0.27	0.26	-0.01	0.24	0.21	0.22	0.03	0.02
P9	41	0.26	0.25	-0.01					
P10	42	0.24	0.24	0.00					
P11	44	0.28	0.27	-0.01					
P12	49	0.26	0.32	0.06	0.23	0.29	0.25	0.03	0.09
P12	52	0.28	0.28	0.00					
P12	53	0.27	0.27	0.00					
P13	56	0.34	0.31	-0.03					
P14	57	0.37	0.35	-0.02					
P15	61	0.35	0.35	0.00					
P16	64	0.40	0.38	-0.02	0.27	0.27		0.13	0.11
P17	72	0.36	0.36	0.00					
P18	73	0.38	0.37	-0.01					
P19	75	0.35	0.35	0.00					
P20	79	0.45	0.44	-0.01	0.37	0.32	0.37	0.08	0.07
P21	85	0.43	0.44	0.01					
P22	87	0.46	0.44	-0.02					
P23	88	0.53	0.53	0.00					
P24	90	0.55	0.51	-0.04					
P25	94	0.58	0.55	-0.03					
P35	96	0.53	0.50	-0.03					
P26	104	0.56	0.52	-0.04	0.46	0.50	0.52	0.10	0.06
P26	109	0.55	0.51	-0.04					
P26	112	0.53	0.52	-0.01					

The minima during upcasts were almost all < or = to those from the downcast which makes sense given that local gradients are higher above the minima than below. The SBE DO does quite well at handling low DO but the response is a little poorer at those low levels, so the SBE DO may not have had enough time to reach the minima during downcasts.

The 2 exceptions are casts #49 and #85 which had upcasts higher than downcasts, though the difference is very small for #85. Both of those casts had shifts to higher DO values by ~0.05mL/L at or just below the DO minimum zone, and both were preceded by a spike. The shifts occurred at ~880db and ~1070db. There are other casts with significant spikes, and sometimes a brief shift in values, but there is a fairly quick return to normal values. For cast #85 there may also be a return, though it is little hard to judge as the OMZ is very complex at P21 with 2 local minima in the DO profiles separated by a section of slightly higher DO.

So the shift in fits in COMPARE appears much more likely to be due to a change in the SBE DO than in analysis problems. Finding an odd shift in DO values during cast #49 plus the change in fits in COMPARE makes it seem likely that this was when the problem first arose. Supporting this is the fact that the downcast DO from #49 has a minimum value close to that of the bottles while the upcast does not. In the absence of bottle data from the casts between 39 and 49, it will be assumed that the 1st fit should be applied to casts #7 to 44 and the 2nd fit should be applied to casts #50 to the end. The decision for cast #49 is that the 1st fit probably suits the downcast and the 2nd fit is best for the upcast.

There were 3 outliers that stand out in the fits:
Cast #3 – sample #6 at 100m. This sample was already flagged 3 due to a bubble, so a comment will be added to say it was an outlier in COMPARE. The flag was changed to 4 as it is out of line by 0.4mL/L.
Cast #12 – sample 39 at 6m. This sample was flagged 3 by the analyst. Given the depth, it is not a significant outlier as it is only out of line by about 0.15mL/L. No flag change was made but the comment was amended.
Cast #12 – sample #38 at 11db. The CTD data are a little noisy and there is a complex local gradient that can explain the difference. A flag 2 was added along with a comment.

For more details see 2014-19-dox-comp1.xls.

Salinity

Compare was run with pressure as reference channel. Salinity samples were analyzed within 4 to 19 days of collection so we expect no problem with evaporation.

An initial comparison was done that showed that when only bottles below 500db were included, the primary salinity was lower than bottles by about 0.003 and the secondary salinity was within 0.0001 of bottles, on average; the standard deviation in both fits was 0.001. The only major outlier was at 11db from event #53 – salinity=32.3804. The sample is higher than the 11db CTD salinity by 0.18. The local gradient is not high enough to suggest this difference is due to poor flushing of the Niskin bottle and the value does not suggest it came from some other Niskin bottle. The bottle could have fired prematurely, but there is no other sampling to help determine that. There is no indication on the rosette sheet that a salinity sample was actually taken from this bottle, so this is likely a mis-sample. According to the rosette sheet for the next cast, #35, there is a missing sample (#336) from about 68db. Sample #355 was renamed as #356. The bottle value still is not a major outlier with that assignment; it is a little out of line, but there was a lot of noise in the salinity during that bottle stop. No quality flag is recommended.

Above 75db bottles tend to be higher than CTD salinity, likely due to incomplete flushing, with this most notable above 25db. Most cases for which bottle salinity looks a little low are associated with noisy CTD data.

There were 22 bottles fired at 2000m during one cast. The average of differences was -0.0033 for the primary and -0.0001 for the secondary salinity with a standard deviation for both of ~0.0012. The scatter is small, so there was likely minimal evaporation of samples and the sampling and analysis quality fine.

For full details for the COMPARE run see file 2014-19-sal-comp1.xls.

Fluorescence

COMPARE was run to see how the SeaPoint fluorescence channel compared with extracted chlorophyll. The SeaPoint Fluorescence has the usual general pattern of being higher than extracted CHL, by up to 6X, for CHL<1ug/L and falling to lower ratios above that. For this cruise most CHL values are very low with a few very high values. The ratio Fluor/CHL is ~1 for 2 samples with CHL between 20 and 30ug/L and 0.6 for 5 samples with CHL between 40 and 50ug/L.
For more detail see file 2014-19-fl-chl-comp.xlsx.

5. **Conversion of Full Files from Raw Data**

All files were converted using con files 2014-19-ctd*.xmlcon with hysteresis and Tau corrections chosen.
A few casts were examined and all expected channels are present.
The two temperature and conductivity channels are fairly close to each other during the downcasts. Upcast data are much noisier with many spikes.
The transmissivity looks bad at depth for one cast, but not the others checked.
Fluorescence also looks bad at depth for some casts. It may be best to remove all deep fluorescence, but more checks will be done later. PAR looks normal.
The dissolved oxygen profiles are a little odd with some excursions at depth. This may be due to the presence of some odd gradients or there may be a problem with the CTD DO. The COMPARE result suggests we should investigate this further.
The altimetry is sometimes very noisy but it looks like a reasonable reading can be found by plotting if the header algorithm fails to do so.

6. **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.

7. **ALIGN DO**

DO sensor #1438 was used for only 3 shallow casts (2 for testing only). Plots suggest that the vertical offset between downcast and upcast DO is about 4m greater than in temperature. With descent and ascent rates being close to 1m/s, this implies about a 2s offset. A test run Of ALIGN using an advance of 2s relative to pressure produced good results with T and DO offsets similar.

For DO sensor #0997 there are many more casts but most have many stops for bottles. The high variability in temperature makes upcasts and downcasts hard to compare. It is thus difficult to determine the best alignment setting to use, but a choice of +2.5s produces reasonable results.

ALIGNCTD was used to advance the DO Voltage by 2s relative to the pressure for casts #1-3 and +2.5s for casts &-117.

8. **CELLTM**

The usual test for CELLTM settings is to check which ones produce the best correspondence between downcast and upcast traces on a T-S plot. Tests were run on cast #3 for CTD#0506 and 3 deep casts with few bottles fired (#57,#73 and #87) for CTD #0443, using a variety of settings that have been found to produce good results on other cruises. The tests are hard to interpret because the temperature data are noisy, but all choices improved the data. The choice of ($\alpha = 0.03$, β=9) produced the best results overall for both conductivity sensors and for both CTDs.
CELLTM was run using ($\alpha = 0.03$, β=9) for the primary and secondary conductivity for all casts.

9. **DERIVE**

Program DERIVE was run twice:

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

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

10. **Test Plots and Channel Check**

A sample of casts was plotted to check for agreement between the pairs of T and C sensors. The differences were very noisy.

Cast #	Press	T1-T0	C1-C0	S1-S0	Descent Rate
2014-19-0035	1000	-0.0036	~0	0.0034 VN	High, X Noisy
"	1980	-0.0034	+0.0004 XN	0.0039 XN	"
2014-19-0049	1000	-0.0034	~0 N	0.0025 VN	High, Noisy
"	1950	-0.0033	~0 XN	0.0033 N	"
"	2980	-0.0036	~0 N	0.0039	"
2014-19-0064	1000	-0.0035 XN	~0	0.0025 XN	High, V Noisy
"	1950	-0.0034 N	~0 N	0.0031 VN	"
"	2980	-0.0034	~0	0.0033 VN	"
2014-19-0079	1000	-0.0030	~0 N	0.0024 XN	High, V Noisy
	1980	-0.0033	~0 N	0.0030 N	"
	2980	-0.0035	~0 N	0.0035 N	"
	3900	-0.0036 N	~0 N	0.0036 VN	"
2014-19-0104	1000	-0.0036	-0.0001 XN	0.0026 N	High, X Noisy
	1980	-0.0034	~0	0.0031 N	"
	2980	-0.0035	~0	0.0033 N	"
	3900	-0.0037	~0	0.0035 N	"
2014-19-0109	1000	-0.0033 XN	-0.0002 XN	0.0016	High, X Noisy
	1980	-0.0034 XN	-0.0001 XN	0.0021	"
	2980	-0.0035	~0	0.0033	"
	3900	-0.0037	~0	0.0035	"

The descent rate of the CTD was very noisy producing many spikes. Even in quieter sections the temperature profiles show a jitter, and those look the same in both channels so may be related to a jitter in the winch.

The differences between the conductivity channels are noisy, but all look very small, as expected from newly calibrated sensors. There is no significant change with pressure or time.
For temperature the differences are much higher than usual, especially for sensors that had just been serviced. There is no obvious trend in the differences with pressure or time.
The resultant effect on salinity is for differences ~0.003. There is the usual small pressure dependence that is likely due to minor differences in alignment that are most notable where local gradients are higher. There is no temporal trend.
The salinity differences are close to those found in section 4.

11. 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.

12. Checking Headers

The header check was run. No problems were found though there are some cases of very high descent rate that could cause a problem with salinity data. Examination of cast #104 shows some extreme deceleration rates.

The surface check gave an average value of 1.9db. The only cast using CTD# 0506 had a surface value of 0.9db.

There was a deck pressure reading of -1.25db in the log but it is not clear to which CTD it refers though it seems likely to have been #0506. This is a fairly large correction given that both pressure sensors do not appear to have been used since the last factory check. There is usually considerable variability from one test to another.

- CTD #0506.
  Checks we have for CTD #0506 are from casts #1, 2 and 3.
  - Cast #1 was clearly in water at 0.8db with pumps running at the beginning of the cast, but there are pressures of -1.4db at the end of the upcast with values still looking to be "in water" but the pumps were turned off around +0.6db so it is not clear what sort of data to expect. While there could be some hysteresis it is not expected to be very high for such a shallow cast.
  - Cast #2 was clearly in water with pumps running at 0.6db.
  - Cast #3 was clearly in water with pumps running at 0.9db. The surface rosette bottle was at pressure ~0.5db which seems too shallow, more likely it would be ~1.5db to 2db.

  These results suggest that the pressure might be a little low, by from 1db to 1.4db.
  Adding 1.25db to pressure looks like a reasonable adjustment so likely the deck pressure reading was with this CTD; the only cast to be archived is #3.
- CTD #0443.
  - While the study of CTD #0506 suggests that the deck pressure reading recorded in the log (-1.25db) refers to that CTD, a study was made to see if it made sense for CTD #0443. The offset from the factory for #0443 was 0db. Given the surface checks it looks unlikely that the 1.25db reading was for #0443.
  - CTD #0443 was used for most of the cruise so there are a few other checks. Deck pressure readings were -0.33db (before cast #25) and -0.29 before cast #33 which look reasonable.
  - There were also 2 casts that were started on deck and the CTD passed through the surface. In one case the conductivity signal suggests the surface was at pressure +0.2db while the transmissivity suggests -0.2db. For the other cast, both variables suggest -0.2db. The minimum pressure was -0.9db for one and -0.5db for the other

  Recalibration does not look necessary as the pressure is likely within 0.2db.

CALIBRATE was run using file 2014-19-recal1.ccf to add 1.25db to cast #3 only. (It is best to do this early before DELETE is run so that routine does not remove values with negative pressure that will be positive after recalibration.)

The cross-reference check was compared with the log book and the only discrepancy was 1 station name which was corrected.

The altimeter, maximum pressure and water depth were exported from the headers of the CLN and MRG files to spreadsheets.

The depths were checked against the log book; the difference between maximum pressure (changed to depth) + altimeter reading at the bottom were also compared to the bottom depth entry. Where there are significant differences changes will be made to match the log entries if those are believable. For event #109 neither the log nor the header looks reasonable given the maximum sampling depth, so an estimate was entered. For event #56 header and log values look too high, so an estimate of 3000m was entered.

Plots were made to check altimetry entries and all look appropriate when the CTD got within 20m of the bottom. There are many cases, especially in the CHE files where there is a reading even though the CTD was not within 20m of the bottom. In such cases the altimetry header will be removed from the headers.

These corrections were made to the CLN and SAMAVG files and the final merge was repeated.

The cruise track was plotted and added to the end of this report. No problems were found.
The shallow casts # 45, 59 and 89 are not needed and will not be processed further.

13. Shift

Fluorescence

Normally a shift of +24 records is used to align SeaPoint fluorescence with temperature. Tests were run to see if that setting improves the alignment and it does.
SHIFT was run on all casts to advance the SeaPoint fluorescence by +24 records.

Conductivity

Tests were run on a few casts using a variety of settings to see which shift produces reasonably stable T-S plots.
The tests on cast #3 showed no alignment setting improved the primary salinity for CTD #0506. The secondary was improved by using +0.9 records.
Tests on 4 casts with CTD #0443 showed the best results when the choice was -0.7 for the primary conductivity and +0.7 for the secondary.
SHIFT was run on cast #3 applying a shift of +0.9records to the secondary conductivity.
SHIFT was run twice on all other casts applying a shift of -0.7 records to the primary conductivity and +0.7records to the secondary conductivity.
SALINITY was recalculated after each of the conductivity shifts.

Dissolved Oxygen

The Dissolved Oxygen voltage channel was aligned earlier. A few casts were checked to see if further alignment is needed for the DO concentration channel. The alignment looks as good as we are likely to achieve.

14. DELETE

Events 45, 59 and 89 will not be processed further.

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.

Changes were made to the headers at this stage to fix altimetry and water depth entries as described in section 12.

15. Other Comparisons

Previous experience with these sensors –There is no record of these sensors being used on any other cruises since they were last serviced at the factory.
Historic ranges – Profile plots were made with 3-standard deviation climatology ranges of T and S superimposed. There were some excursions with temperatures that were a little high around 50m depths between P7 and P12 and around 25m at P26 and some low temperatures around 200-400m at P16 to P17. September 2014 Argo observations show anomalously warm, fresh conditions in the upper 100m in this region and anomalously cool water below 150m in the western part of Line P. Salinity values were slightly low around 200m at P7, P10, P11 and P16. Given the outliers were mostly shallow and not systematic, these are not considered indicative of calibration problems.
Repeat Casts – There were some repeat casts. At P26 2 deep casts separated by ~18 hours were compared and the variability in the temperature at ~1600db was ~0.002C° and salinity varied by ~0.0005. This is good repeatability.
Post-Cruise Calibration
There were no post-cruise calibrations available.

16. Choice of Channels to Archive

The choice of which temperature and salinity channels to select for editing and archiving is more complex than usual because of the larger than usual difference between temperature channels (see section 10). We usually just correct the salinity, as necessary, not the temperature. Since the sensors were freshly calibrated shortly before this cruise it is a reasonable assumption that only 1 has drifted significantly. The combination of the salinity bottle comparison and the differences between channels suggests that the primary temperature sensor is the one that has drifted most and correcting that should bring the CTD primary salinity closer to bottles.

Given that the secondary salinity looks very close to bottles let's assume that the secondary temperature is reliable. COMPARE was run to look at the difference between the primary and secondary temperature to see if there is a simple correction that can be made to the primary temperature. Below 1500m the variability in the differences is quite low. At those depths the fit of differences between the 2 temperature channels versus pressure was:

Temperature_Primary_Corrected = Temperature:Primary - 9E-09 * Pressure - 0.0032

An initial test applying that correction led to an overcorrection of salinity. The pressure dependence is so slight and that using a simple offset looks appropriate, so a 2nd test was run which applied a simple offset of -0.0033C°. Again the resultant salinity was too high. An iterative process found that using -0.0022C° produced primary salinity very close to bottles, but that correction still leaves a fairly large difference between the 2 temperature channels. Using a correction of 0.003C° improves both temperature and salinity comparisons and looks like a reasonable compromise. COMPARE runs show salinity was high by an average of 0.0007 though as in the original comparison the fit was noisy. The temperature was low by an average of 0.0003 C°. (See 2014-19-temp-comp1.xlsx, 2014-19-temp-comp2.xlsx. and 2014-19-sal-comp2.xlsx.)

17. DETAILED EDITING

The first issue is to decide which sensor pair to edit. The secondary salinity is very close to the bottle salinity without recalibration, but it is noisier than the primary and may prove hard to edit. The dissolved oxygen sensor was on the secondary channel and the DO traces are much noisier than usual. Since the primary temperature can be recalibrated and the recalculated primary salinity is close to the bottle salinity, the primary channels are a good choice, so they were selected for editing and eventual archiving.

CTDEDIT was used to remove spikes that appear to be due to instrumental problems and likely to affect the bin-averaged values and records corrupted by shed wakes including some surface records. As noted

on other recent Tully cruises, there were some odd excursions in salinity that do not appear to be related to shed wake corruption or stray spikes. These unstable features look like they are caused by misalignment of temperature and conductivity, and are mostly associated with high deceleration rates of the CTD and are mostly found in the top 200 metres where temperature gradients are higher but salinity is quite well mixed, so that a small mismatch leads to a notable spike in salinity. Where these features were noted salinity points were removed, but not whole records.
All casts required some editing. T-S plots were examined after editing and a little more editing was applied to a few casts.

Because some problems were noted at sea and some profile plots show unexpectedly noisy data in the dissolved oxygen, transmissivity and fluorescence channels, some files were examined in CTDEDIT to see if editing of those channels is appropriate. For many files the dissolved oxygen data were extremely noisy below 1000m, but the spikes are mostly 2-sided and it is not always clear which data are good and which bad. Metre-averaging reduces the noise but leave some noise; editing was applied for some of the largest spikes. For fluorescence there are some sections of clearly bad data, so those were removed. For one cast there was a section of poor data that were also removed. This stage of editing only involves deep casts.

18. Initial Recalibration

Recalibration is complicated because there are 2 CTDs, a change in DO calibration mid-way that has to be applied differently for bottle files and CTD files and the 1st step was applied earlier to the CTD files, but not the bottle files.

1. The pressure correction had already been applied to the full file for cast #3, but not to the bottle file. So CALIBRATE was run using file 2014-19-recal1.ccf to apply a +1.25db pressure correction to file 2014-19-0003.MRGCLN2 and 2014-19-0003.SAM. All files were run through this step but it has no effect on most of them. Output files: MRGCOR1, SAMCOR1.

2. The initial fit of SBE Dissolved Oxygen versus titrated bottle samples showed a change part-way through the cruise. Because the change in DO fit is so unusual, processing was suspended to check the fits for cruises 2012-60 and 2012-22 which followed and used the same equipment. Those 2 cruises had similar fits to each other and the slope was similar to that of the latter part of cruise 2012-19, but the offset was even larger at about 0.2mL/L. So it appears that what happened during 2014-19 got worse and then stabilized. However, there are no SBE DO values below 1.6mL/L during 2014-60, so there is less confidence in the offset as it is influenced by how outliers are chosen.

Based on the bottle comparison described in section 4 the dissolved oxygen channel was recalibrated using the fits:

DOX_BOT = 1.0296 * DOX_CTD (Cast #3 only)
DOX_BOT = 1.0245 * DOX_CTD -0.0036 (casts #7-49 for CTD and 7-46 for CHE)
DOX_BOT = 1.0326 * DOX_CTD -0.1050 (casts #50-117 for CTD and 49-117 for CHE)

Note that the because the DO calibration shift appears to have occurred during cast #49, different corrections were applied to the downcast and upcast; to get the right cast ranges for the DO recalibration, separate calibration control files were prepared and named 2014-19-recal2-ctd.ccf and 2014-19-recal2-che.ccf.
CALIBRATE was run on the MRGCOR1, SAMCOR1 and EDT files using those files.

3. Based on the study described in section 16, file 2014-19-recal3.ccf was prepared to subtract 0.003C° from the primary temperature. This was applied to MRGCOR2, SAMCOR2 and COR1 and salinity was recalculated.

COMPARE was rerun to check that the corrections were done correctly and they were.
(See files 2014-19-dox-comp2.xls, 2014-19-temp-comp2.xlsx and 2014-19-sal-comp2.xlsx.)

19. Final Calibration of DO

Downcast files were bin-averaged to 0.5m bins for the casts with DO bottle samples. Those files were then thinned to the usual levels for bottles and compared to the bottle values in the MRG files. COMPARE was used to study the differences between the downcast CTD DO data and the upcast bottles. We expect that the downcast SBE DO will be a little high because of slow response in the sensor and above the DO minimum the bottle values are liable to be a little low because of incomplete flushing. But in this case the DO values are high by about 0.024mL/L both above and below the DO minimum except in the top 500m where the differences are much larger. However, when the data are separated into groups based on the different calibrations used, the picture is different. For cast #3 the average difference is -0.006mL/L with a lot of scatter which is not surprising given this was a shallow cast. For casts #7 to 39 below 600m the differences are very small near the DO minimum and high by roughly 0.005mL/L overall, but the casts are not very deep. For casts 64-104 where there are many deep casts the DO is high by an average of 0.028mL/L below 600m, with differences near the DO minimum lower than the average.

The results indicate that the SBE DO is reading a little higher than bottles above the DO minimum for sensor #0997, but this may be at least partly due to incomplete flushing of Niskin bottles. At the DO minimum the differences are small. Below the DO minimum the SBE DO looks a little high but there is a lot of scatter in the fit and excluding a few deep bottles makes a big difference in the average. These data come mostly from the group of casts with the unusual corrections applied. The scatter is too high to put confidence in such a small correction; the standard deviation in the differences is about twice the average difference. There were some problems in DO analysis late in the cruise, not large enough to explain the shift in fits, but may well account for some of the outliers seen in this fit. And this approach to checking on downcast data is a very rough one. The evidence is too weak to determine what if any further corrections would be appropriate.

A plot of differences against pressure was used to make a final study of outliers and to make a rough estimate of the accuracy of downcast CTD dissolved oxygen.

20. Special Fluorometer Processing

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

21. 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.
After averaging, page plots were examined on screen and no further editing was considered appropriate.

22. Final CTD File Steps (REMOVE and HEADEDIT)

Cast lists of events with and without PAR sensor were prepared.
REMOVE was run on all casts with a PAR sensor mounted 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

REMOVE was run on all casts with no PAR sensor mounted to remove the following channels:

Scan_Number, Temperature:Secondary, Salinity:T1:C1, Conductivity:Primary, Conductivity:Secondary, Oxygen:Voltage:SBE, Altimeter, PAR, Status:Pump, Descent_Rate and Flag

Profile and T-S plots were produced at this point to check for errors. No problems were found.

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, to add "Mid-ship" to the instrument location section, to fix the platform name and to add the following comments:

Data Processing Notes:

Transmissivity, Fluorescence and PAR data are nominal and unedited except that
some records were removed in editing temperature and salinity.
For details on how the transmissivity calibration parameters were calculated
see the document in folder "\cruise_data\documents\transmissivity".
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 calibration for Dissolved Oxygen sensor #0997 shifted during the cruise.
This appears to have been an abrupt change, so separate corrections
were applied for events #7-49 and #52-117.
The Oxygen:Dissolved:SBE data are considered, very roughly, to be:
±0.5mL/L from 0db to 150db
±0.3mL/L from 150db to 300db
±0.1mL/L from 300db to 1000db
±0.05mL/L from 1000db to 2000db
±0.1mL/L below 2000db

For details on the processing see the report: 2014-19_Processing_Report.doc.

The cross-reference list was produced and no problems were found.
The Standards Check routine was run and no problems were found.
The Header Check was run and no problems were found.
The final files were named CTD.
Profile plots were made and look ok.
The track plot looks fine.
The sensor history files were updated.

23. Dissolved Oxygen Study

As a final check of dissolved oxygen data, % saturation was calculated and plotted. The near-surface values were ~75% in Haro and Juan de Fuca Straits which is not unusual due to strong vertical mixing. It was between 135% and 150% during casts at stations P1 and P2; DO, extracted chlorophyll and nutrients all show evidence of high productivity at P2. For P3 to P26 surface saturation ranged from 102% to 108% with most values near the lower end of that range; these are normal values for those sites..

24. Final Bottle Files

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

REMOVE was run on all casts with a PAR sensor mounted to remove the following channels:
Scan_Number, Temperature:Primary, Salinity:T0:C0, Conductivity:Primary, Conductivity:Secondary, Oxygen:Voltage:SBE, Altimeter, Status:Pump, Descent_Rate and Flag
REMOVE was run on all casts with no PAR sensor mounted to remove the following channels:
Scan_Number, Temperature:Primary, Salinity:T0:C0, Conductivity:Primary, Conductivity:Secondary, Oxygen:Voltage:SBE, Altimeter, PAR, Status:Pump, Descent_Rate and Flag

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

T-S and profile plots were examined on-screen and the only problem found was in the fluorescence traces. As was seen in downcast data there were many cases of spikes and odd values at depth where we expect very low values (Events #49, 53, 64, 79, 104 &109). Where values looked unreasonable the fluorescence values were replaced with pad values and a note was added to the header to explain this.

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 and to add a comment about quality flags and analysis methods and a few notes about the CTD data.

For a final check the CHE bottle data were exported to a spreadsheet and compared with the rosette log sheets. Two problems were found:

- Sample #243 CHL – duplicates had labels "242A and 242B, P10, Bottle 2, 50m". The bottle number and depth correspond to #243 so the sample number was changed. The values do not make sense for sample #242 which is from 200m.
- There are DMS samples shown for cast #112 (samples #745-747) but no samples were received by the analyst. It is believed this was due to cancellation of a test for which they were needed. Flag 9 was added to the 3 samples with comment "Sample not collected because test abandoned."

A header check was run and no errors were found.
Plots were made of CTD Salinity versus SBE Dissolved Oxygen and bottle DO and no further outliers were identified.
Standards check was run on all files 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.

25. Thermosalinograph Data

There were loop nutrients, extracted chlorophyll and salinity samples taken, some while stopped and some while underway.

a.) Checking calibrations
The configuration files for the 5 files are identical. One file was renamed as 2014-19-tsg.xmlcon. No errors were found in the calibration parameters.

b.) Conversion of Files
The 5 files were converted to CNV files using configuration file 2014-19-tsg.con. They 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.

Time-series plots were produced. The flow rate was about 1 and very steady throughout. The traces look reasonable with small, discrete spikes in salinity that might be due to bubbles.
The track plot looks fine. The plot was added to the end of this report.

c.) Checking Time Channel
The CTD files were thinned to reduce the files to a single point from the downcast at or within 0.5db of 4db and exported to a spreadsheet which was saved as 2014-19-ctd-tsg-comp.xls. There were 48 casts which overlapped with TSG files.

The 5 TSG files were opened in EXCEL, median and standard deviations (over 5 records) were calculated for intake temperature, salinity and fluorescence and the files were reduced to the times of CTD files and loop samples. The flow rate varied from 0.93 to 1.06 with a median value of 1.00; this is remarkably steady compared to other Tully cruises over the past few years.

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≤0.0002° and the medians in both were 0.0000°. This shows both the times and positions are reliable for both systems.

The loop samples were combined in file 2014-19-tsg-loop-rosette-comp.xlsx. Then 5m rosette salinity and CHL bottle data were added from 3 casts which occurred at the same time as loop sampling.

The two spreadsheets will be used in step (d) to compare temperature, salinity and fluorescence.

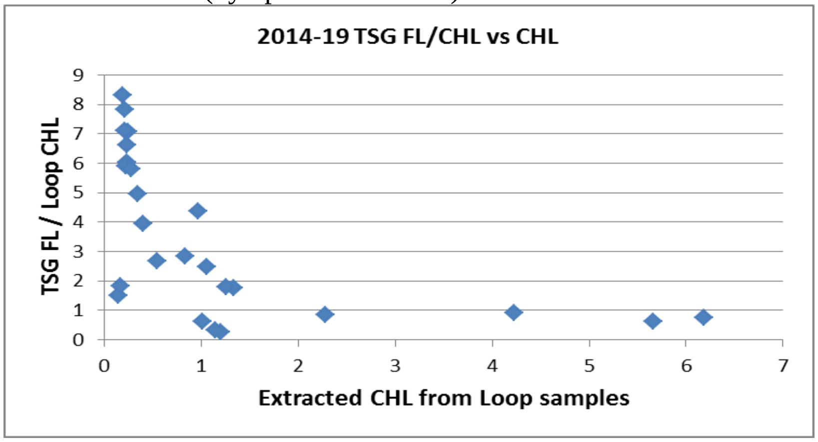
d.) Comparison of T, S and Fl from Loop & Rosette Samples and TSG and CTD data

- T1 vs T2 The intake temperature worked throughout the cruise. The median difference between intake temperature and lab temperature was 0.177C° with a range of roughly 0.15C° to 0.22C°. As usual, the heating in the loop increases as the intake temperature decreases.

- 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.
  1. *Intake Temperature* The intake temperature is higher than the CTD temperature by a median of 0.005C° when cases with high standard deviation in the TSG temperature were excluded (variations >0.001C° over 5 records – 2 minutes). The median value suggests that the TSG intake temperature is as close to the CTD as we can possibly expect.
  2. *LAB TEMP* The lab temperature was higher than the CTD temperature by a median value of 0.177C°, or by 0.174C° if we exclude cases with a std. dev. in the TSG temperature of >0.001C°.
  3. *SALINITY* The TSG salinity data are lower than the CTD salinity by a median value of 0.025 or 0.023 if cases are excluded with standard deviation in the TSG salinity >0.007.
  4. *FLUORESCENCE* The TSG fluorescence was lower than the CTD fluorescence, with a median ratio of ~0.8 and a range of 0.5 to 1.7. Plots of the ratio against the standard deviation in the TSG Fluorescence showed no trend with just as much variability at minimal variation in TSG FL as when the TSG data look quite noisy. As CTD Fluorescence increases the ratio appears to be decreasing somewhat.
  (See 2014-19-ctd-tsg-comp.xls.)

- Loop Bottle - TSG Comparisons

The comparison of TSG salinity and loop salinity varied a lot, but most of the variability was from the Juan de Fuca loops. Excluding those cases there was little variation and the median showed the TSG salinity was low by ~0.020. The offshore cases included 2 where the ship was stopped and 8 while moving; there was no significant difference between the 2 groups.
The TSG fluorescence is higher than the loop extracted chlorophyll by a median factor of ~3.9 but the variability is very high. As is usually the case, the TSG fluorescence reads too high at low CHL values (by up to a factor o 9). For CHL>1 the median ratio of TSG / loop was 0.80.



The ratio when stopped is lower than for underway sampling with similar CHL levels, but with only 3 such samples this may just be chance.
(See 2014-195-tsg-loop-rosette-comp.xlsx.)

- Surface rosette vs TSG (salinity and chlorophyll)
  There are 3 cases where we have CHL samples from both the loop and a 5m rosette and 2 points of comparison for salinity. For JF2 there is a lot of noise in the TSG indicating high local variability, which the other 2 cases are much quieter. The loop salinity is within 0.001 of the rosette samples. The CHL from the loop is higher than that from the JF2 rosette and the other two are very close with the loop CHL slightly lower.

- Calibration History
  The TSG temperature and conductivity were recalibrated in December 2013 and have been used for 2 cruises since then.
  During 2014-21 the TSG salinity was found to be lower than loop samples and CTD salinity by ~0.03 but the difference varied with flow rate which was highly variable. No recalibration was applied due to the variability in the comparisons and the fact that such a large drift in calibration on its first use seemed unlikely. During 2014-18 the salinity was found to be low by 0.014 but the TSG was so noisy that this was not trusted.
  The fluorometer was used during 2013-18 and 2014-21 and 2014-18. The TSG fluorometer was about 1.1 to 1.2 times the SeaBird fluorometer on the CTD when the flow rate was >1 during the first of those cruises and very close to the CTD fluorometer on the second. During 2014-21 the TSG fluorometer was ~79% of the loop CHL and 65% of the rosette CHL samples. During 2014-18 the TSG fluorescence was close to the CTD fluorescence. For low CHL it was higher than loop samples and for high CHL it was lower.

Conclusions

1. The TSG clock worked well.
2. The TSG flow rate was very steady at ~1.

3. The temperature in the loop increases by about 0.18Cº between the intake and lab based on comparisons during stops for CTD casts. The heating in the loop varies according to intake temperature.
4. The TSG intake temperature was higher than the CTD temperature by ~0.005Cº when outliers are excluded. No recalibration is justified.
5. The TSG Salinity is lower than the CTD salinity by a median of ~0.023 and lower than loop samples by a median value of 0.022 while underway and 0.019 when stopped. The first result could be a result of a slight mismatch in the sampling depth, while the 2nd could be affected by small bubbles in the TSG, but there is no evidence of significant bubbles and having the two results in such close agreement justifies a recalibration by adding 0.02.
6. Part of the salinity error could be due to temperature being a little too high. This could be due to a mismatch in the depths of sampling for the TSG and CTD, but the temperature gradients are very low at most casts near the surface. We have too little evidence to support a temperature recalibration.
7. The TSG fluorescence is about 80% of the CTD fluorescence and perhaps a bit lower for high values. The comparison with loop samples looks typical of this type of sensor with values too high at low CHL, very close in the 1-5ug/L range and too low for higher CHL values.
8. The values for CHL and salinity samples from the loop and rosette compare very well.
9. The flow rate was very steady and the salinity traces have relatively few spikes; this is a big improvement over most uses of this equipment over the past few years.

f.) Editing
The ATC files were copied to *.EDT.
Each file was opened in CTDEDIT and the following editing was applied:
File #1 - Salinity data cleaned very lightly – few isolated 1-sided spikes that look like bubbles.
File #2 – Salinity data cleaned very lightly – few isolated 1-sided spikes that look like bubbles. Some records removed near the end of the cast because flow was erratic.
File #3 –Few points removed from beginning of the file as flow apparently not well established.
File #4 – Few points removed from beginning of the file as flow apparently not well established; few isolated 1-sided spikes smoothed - look like bubbles.
File #5 - Few points removed from beginning of the file as flow apparently not well established; few isolated 1-sided spikes smoothed - look like bubbles.

g.) Recalibration
The salinity was found to be lower than loop and CTD salinity by about 0.02.
File 2014-19-tsg-recal.ccf was prepared to add 0.02 to the salinity channel and was applied to all *.EDT files.

h.) Preparing Final Files
REMOVE was used to remove the following channels from all casts: Scan Number, Temperature:Difference, Conductivity:Primary, Flag and Position:New channels.
The flow channel was not removed since it may be useful for further studies of optimal flow rate.

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

26. **Producing final files**

A cross-reference listing was produced for CTD and CHE files.
The sensor history was updated.

27. **Loop File**

The chief scientist prepared a file with all the near-surface rosette samples; sigma-t was included. This was saved as 2014-19-che-surface.csv.
The loop sample data prepared for the TSG processing were added to the file and lined up appropriately with the CHE data. The data were then ordered on event number and the file was saved as 2014-19-che-surface2.csv.
A sampling method column was added filled with ROS or UWS for rosette data and true loop data, respectively. Columns were rearranged.
A 6-line header was added to the csv file and the original header was removed.
The file break column was filled with value 1 so all data will be in a single file when converted.
The file was then saved as 2014-19-surface-6linehdr.csv.

A comment file was prepared which was essentially the same as the one used in preparing CHE files, with the addition of some details about the TSG.

CONVERT was run to produce an IOS Header file. The flags and comments were entered in the headers in the conversion process.
CLEAN was run to get start and stop times and positions.
Header Edit was used to add comments.
The final file was renamed as 2014-19-surface.loop. A track plot looks reasonable and a plot of temperature and salinity versus longitude looks reasonable.

CORRECTIONS – March 27, 2015: A post-cruise report on the drift in conductivity and temperature sensors showed that it was the secondary temperature sensor that was out of line, not the primary. So the corrections made in the original processing (subtracting 0.003 from the temperature and recalculating salinity) were inappropriate. The steps from the 2nd calibration to the end were rerun to produce new CTD and CHE files. The 2nd calibration step was changed to include only a correction for the Oxygen:Dissolved:SBE channel.
At the same time errors in the header comments about salinity bottle inserts were corrected in the CHE files.

<u>Particulars</u>
1/2. Test casts – aborted – not to be processed.
3. Only cast using CTD #0506 to be processed.
5. Test cast – not archived.
10. Came up to surface and then back down to 30m for bottle #2.
12. Bottle 7 closed by mistake so last 3 samples 38/39/40 came from bottles 8/9/10. Bottle 7 should be removed.
15. Bottles 8 and 13 were reversed – labels were changed to match.
17. Change file name to 18.
25. Pressure on deck before cast -0.33db.
33. Pressure on deck -0.29. Oxy bad below 1400db. Fluor bad 600db upwards.
35. Change depth in header to 2505
39. Niskins 1 and 2 closed by mistake at surface. Sampling starts at Niskin 3.
42. Niskins 2 and 24 regular, others for cesium.

44. Stop at 1718db to correct wire angle.
45 & 59. Casts started on deck and stopped just below the surface.
52. Planned rosette cast but all spigots open so only process only CTD file.
53. Rosette cast to replace 52.
54. No sampling so just produce CTD file.
55. Rosette file to replace 54.
57. Fluorometer and transmissometer switched voltage channels. No note of why.
66. Niskins 8 and 9 closed but not needed.
69&70. Computer crash at 5db – 2 files – 2 surface samples in file 70.
72. Fluorometer cable changed – still lots of noise.
79. High temp light came on ~1500m so paused for 15 minutes.
85. Stop at 600db to correct wire angle.
89. Very shallow – cesium loop
107/108. Test casts for CTD #0506. Do not process.
109/110. Crash at 200m upcast. Niskins 1-15 in first file, Niskins 16-24 in second.
117. Niskins 4-24 closed at the surface just to get them closed. Not needed in CHE file.
PAR ON: 3,7,10,12,15,16,18,20,22,46,60,71,83,93,102,113,117.

CRUISE SUMMARY 2014-19 CTDs

CTD#	Make	Model	Serial#	Used with Rosette?	CTD Calibration Sheet Competed?
1	SEABIRD	911+	0506	Yes	Yes
2	SEABIRD	911+	0443	Yes	Yes

Calibration Information CTD #0506

Sensor		Pre-Cruise		Post Cruise	
Name	**S/N**	**Date**	**Location**	**Date**	**Location**
Temperature	**2038**	**31Dec2013**	**Factory**		
Conductivity	**1763**	**1Jan2014**	**Factory**		
Secondary Temp.	**4883**	**1Jan2014**	**Factory**		
Secondary Cond.	**3394**	**3Jan2014**	**Factory**		
Transmissometer	**1396DR**	**5Feb2014**	**IOS**		
SBE 43 DO sensor	**1438**	**3Jan2014**	**Factory**		
PAR	**4615**	**16Mar2011**	**IOS**		
SeaPoint Fluor	**3641**	**Jan. 2014**			
Pressure Sensor	**77511**	**30Dec2013**	**Factory**		
Altimeter	**1204**	**n/a**			

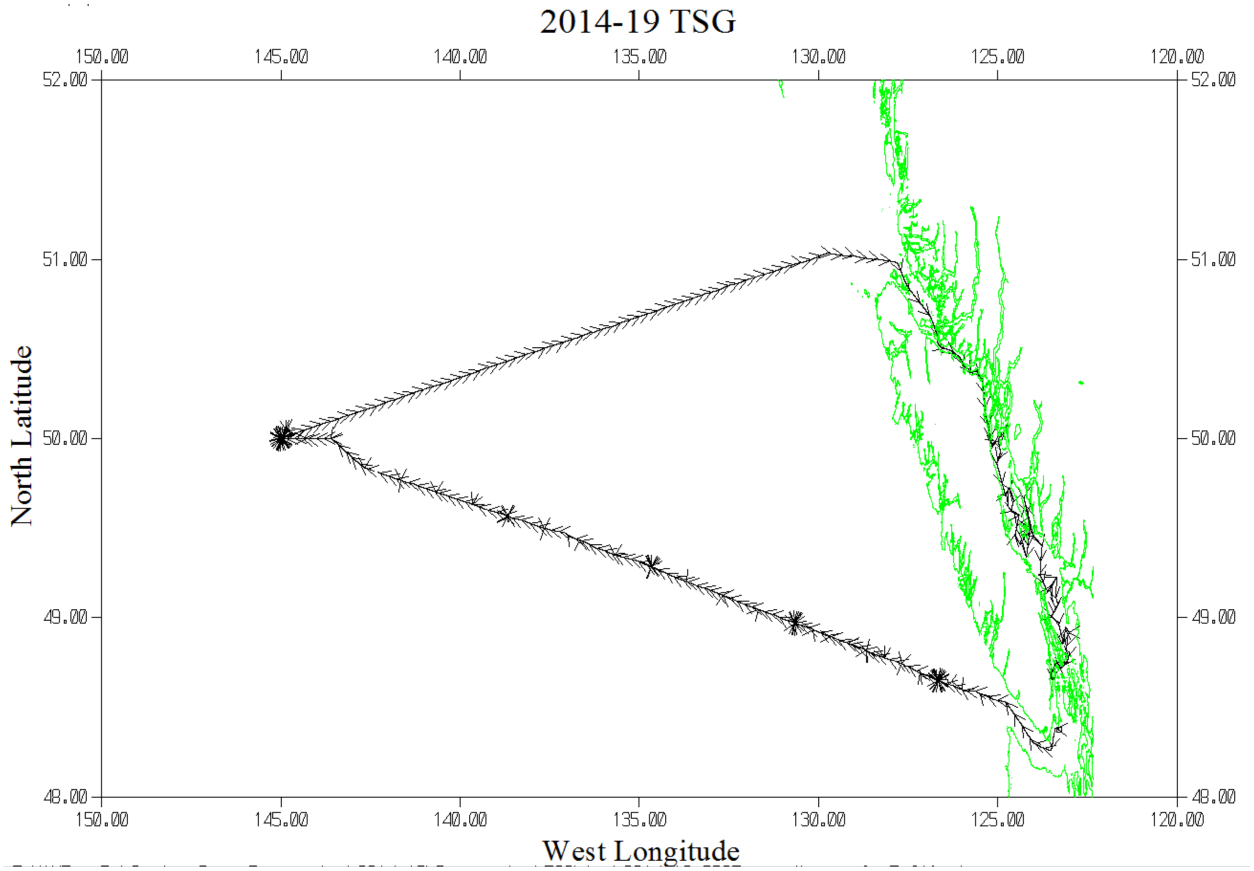
Calibration Information CTD #0443

Sensor		Pre-Cruise		Post Cruise	
Name	**S/N**	**Date**	**Location**	**Date**	**Location**
Temperature	**2106**	**7May2014**	**Factory**		
Conductivity	**2280**	**7May2014**	**Factory**		
Secondary Temp.	**2663**	**4Jun2014**	**Factory**		
Secondary Cond.	**2754**	**7May2014**	**Factory**		
Transmissometer	**1396DR**	**5Feb2014**	**IOS**		
SBE 43 DO sensor	**997**	**3May2014**	**Factory**		
PAR	**4615**	**16Mar2011**	**IOS**		
SeaPoint Fluor	**3642**	**Jan. 2014**			
Pressure Sensor	**77511**	**23Jun2014**	**Factory**		
Altimeter	**1204**	**n/a**			

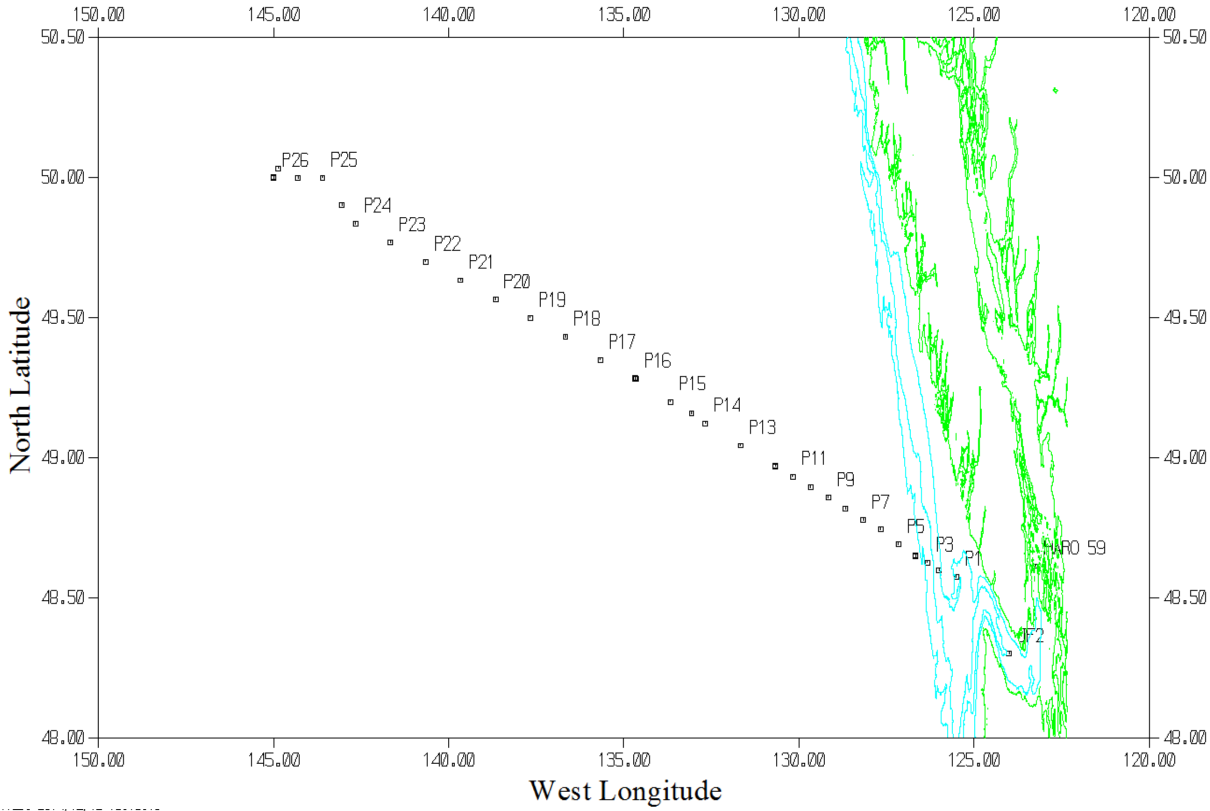
CRUISE SUMMARY TSG

Make/Model/Serial#: SEABIRD/21/2487 Cruise ID#: 2014-19

Calibration Information					
Sensor		**Pre-Cruise**		**Post Cruise**	
Name	**S/N**	**Date**	**Location**	**Date**	**Location**
Temperature	**3363**	**28Dec13**	**Factory**		
Conductivity	**3363**	**28Dec13**	**"**		
Wetlab/Wetstar FL	**WS3S-713P**	**Aug12**	**IOS**		
Temperature:Secondary	**0603**	**?**	**"**		
Flow meter	**?**	**n/a**			



2014-19 Stn Names



2014-19 Event