REVISION NOTICE TABLE

DATE	DESCRIPTION OF REVISION
8 July 2013	Corrections to Nitrate and Phosphate data; see headers for details.

PROCESSING NOTES

Cruise: 2012-12
Agency: OSD
Location: North-East Pacific
Project: Line P
Party Chief: Robert M.
Platform: John P. Tully
Date: May 22, 2012 – June 9, 2012

Processed by: Germaine Gatien
Date of Processing: 20 June 2012 – 20 November 2012
Number of original HEX files: 60
Number of CTD files: 60
Number of bottle casts: 60
Number of original TSG files: 11

INSTRUMENT SUMMARY

SeaBird Model SBE 911+ CTD (#0506) was used for this cruise. It was mounted in a rosette and attached were a Wetlabs CSTAR transmissometer (#1396DR), an SBE 43 DO sensor (#1119), a SeaPoint Fluorometer (#2228), a Wet Labs Eco-AFL/FL Fluorometer (#2215), a Biospherical QSP-200L4S PAR sensor (#4615) and an altimeter (#1204).

A thermosalinograph (SeaBird 21 S/N 2487) was mounted with a Wetlab/Wetstar fluorometer (WS3S-713P), remote temperature sensor #0603 and a flow meter.

The data logging computer was #3.
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 CTD log had an equipment list, plus details about the rosette, TSG and oxygen sampling kit. The rosette logs and dissolved oxygen analysis logs were in good order. The Chief Scientist provided sampling notes with a good description of problems relevant to processing.

Salinity samples were analyzed within 6 weeks of collection. The primary salinity was found to be low by 0.0075 and the secondary by 0.0017. There was some evidence of a calibration shift late in the cruise but since it looked the same for both channels that seems unlikely. It was helpful that the analysis was done "out of order" so that analysis problems could be ruled out as a cause for the shift. There is enough scatter in the comparison that the apparent shift may just have been due to chance, or it is possible that the fact that the samples collected last seemed closest to the CTD salinity was because evaporation was less significant due to either time or a change to sampling protocols. There was some odd CTD temperature data in both channels during cast #89 with values appearing to be "stuck" while salinity showed a large excursion to higher values. While the behaviour was not observed during other casts, it is possible there

was some instrumental trouble during bottle stops that might explain a shift in CTD salinity for the later casts.

The WetLabs ECO fluorometer and a SeaPoint fluorometer were both mounted on the CTD for this cruise. The ECO reads higher than the SeaPoint by a factor that decreases from ~3.5 at the lowest CHL values to ~1.6 at the high end of the range. There is a roughly linear fit between the two sensors at low CHL values but it flattens out as CHL increases. Both sensors read too high below the CHL max. For low CHL the SeaPoint is generally close to the CHL values and the ECO is much too high. As CHL increases the ECO gets closer though almost always reads too high, and SeaPoint tends to read increasingly low.

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

±0.1mL/L from 0 to125db
±0.06mL/L from 125 to500db
±0.04mL/L from 500db to 2000db
±0.02mL/L below 2000db

The thermosalinograph data are fraught with problems. The salinity calibration results varied greatly with a correction of +0.145, +0.007, +0.006 and +0.02 for files 1-2, 3-6, 7-10 and 11, respectively. The large shift between files 2 and 3 came after the pumps were stopped in order to clean the loop strainer and line. The flow rate varies greatly for files #7 to 11. The intake temperature was fine for files #1-6, but thereafter it is frequently very bad, with values often higher than lab temperatures. For those files a proxy for intake temperature was derived by applying a correction to the lab temperature based on estimates of the heating in the loop: -0.34 for files 7-10 and -0.29 for file #11.

The Flow_Rate channel is usually removed from the final files, but given the problems for these data it was left in case users find it helpful in assessing the data. Flow_Rate is a measure of flow in the loop that is usually kept between 0.8 and 1.2. The values are assumed to be non-dimensional. For this cruise it was highly variable and often very low.

The TSG Fluorescence data are raw and are given in volts. The Vblank and scale factor provided were found to be unsuitable producing obviously bad data. A comparison with extracted chlorophyll did not lead to a useful fit. However, when compared to the SeaPoint fluorometer mounted on the CTD, the fit was reasonably tight, with an R-squared value of 0.89. The CTD data ranged from 0 to 1.3ug/L and the fit was:

SeaPoint Fluorescence = 5.69 * Raw TSG Fluorescence (Volts) -0.45

This could be used to convert the TSG fluorescence to concentration units, but will likely produce values that are low for fluorescence values above the range in the fit.

Salinity was edited where only 1 or 2 points occur in a spike, but data were removed where more points were involved. Temperature, salinity and fluorescence data were removed where the flow was very low and/or data looked bad.

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 as well as sampling notes summarizing problems and points of interest with reference to processing. The only problems noted were with sample numbers in

casts #3 and 5 and some confusion over Niskin closing during casts #18 and 37; a hydro file provided gives the correct information. There is no mention in the log or rosette sheets to indicate that some casts used a different CTD and those data are being processed elsewhere; this was clear in the hydro file.

Extracted chlorophyll, nutrients, dissolved oxygen, DMS and salinity data were obtained in spreadsheet format from the analysts. The file creation date was added to the names of those files to avoid confusion if changes need to be made later. The draw temperature was recorded for DO sampling so concentration can be calculated in mass units as well as mL/L.

The cruise summary sheet was completed.
The history of the pressure sensor, conductivity and DO sensors were obtained. The conductivity sensors had been used on only 1 cruise since the last factory calibration in March 2011. The DO sensor had many uses since the July 2011 calibration. The pressure sensor had been used 5 times and a recent change was made to the offset applied.

The calibration constants were checked for all instruments. The only problem found was that the offset for the pressure sensor should be updated based on the results of 2 recent cruises, 2012-15 and 2012-25. The value was changed from -1.37 to -0.1 and the file was saved as 2012-12-ctd.xmlcon.

The dissolved oxygen Soc and Voffset parameters always drift and tests need to be done to update them. The entries were changed to the values that were found for cruise 2012-15. The sensor was also used for 2012-25; the preliminary results from 2012-25 are close to the ones found for 2012-15, so this looks like a useful starting point.

The PAR sensor was not always mounted. Based on notes from the chief scientist cast lists were prepared for casts with and without the PAR sensor mounted so that it will be easy to remove PAR as appropriate.

3. Initial Rosette File Conversion and DO Calibration Study

In order to study the SBE Dissolved Oxygen sensor calibration, rosette files were converted that included Oxygen Saturation (ml/l) and bottle position. The ROS files were converted to IOS HEADER format. Those files were put through CLEAN to add event numbers (*.BOT). The BOT files were then averaged to enable an ADDSAMP file to be prepared so that sample numbers can be added to the BOT files to produce SAM files. (Since bottles were fired out of order, the file was 1st ordered on bottle position, sample #s added and it was then reordered on bottle number.) Sample numbers were added to the ADDSAMP file based on rosette log records.

The ADDSAMP file was then used to add sample numbers to the BOT files and those files were bin-averaged on bottle numbers to produce SAMAVG files. Those files were then exported to a spreadsheet 2012-12-DO-cal.csv. The titrated DO values were added to that file and lines removed for which there was no DO sampling. A calculation was made of Φ using the equation:

$$\Phi = \text{Oxsol}(T,S) * (1.0 + A*T + B*T^2 + C*T^3) * e^{(E*P/K)}$$

where A, B, C and E are taken from the calibration sheet for the sensor and P,T and K are from the CTD channels – K is temperature in Kelvin degrees. Then the ratio Titrated DO/ Φ was calculated and plotted against the SBE DO Voltage. This fit provides the M and B for the following equation:

$$\text{Titrated DO}/\Phi = M*(\text{SBE DO Voltage}) + B$$

From M and B the parameters Soc and Voffset that are to be entered in the DO configuration are:

$$\text{Soc} = M$$
$$\text{Voffset} = B/M$$

When all values are included the R^2 value was 0.9981. Removing values flagged "3" or "4" produced better results. Most of the hypoxic samples from Cast #1 had been flagged, but the one that remains does not look out of line. It is difficult and tedious to pick our outliers on the plots and find and eliminate them from the fit. A simpler approach is to use the M and B values from the factory calibration to determine the difference from the fit for each sample, as follows:

Difference = M*Voltage – B – DO/Phi

When the data are sorted on that difference, fits can be done excluding flagged DO samples, and gradually removing outliers. At each step M and B are updated to the value from the previous fit and differences are calculated again. The process stops when obvious outliers have been removed as judged by visual inspection and the R^2 value, being careful to stop before the DO range is significantly reduced. For these data the changes were small as more data were removed, reflecting the fact that there were few major outliers.

The results are shown in the following table:

Summary of Soc Voffset including the original values in the factory calibration when E=0.036

Bottles used		m	b	Soc	Voffset	R^2
	Original	0.4278	-0.2186	0.4278	-0.5109	
168	Using 2012-15 fit	0.449	-0.2235	0.449	-0.4978	0.9880
158	all except cast #1	0.4491	-0.2237	0.4491	-0.4981	0.9980
157	excluding cast #1 and 1 outlier	0.4493	-0.2253	0.4493	-0.5014	0.9997
148	excluding diff >0.01	0.4497	-0.2261	0.4497	-0.5028	0.9999
137	excluding diff >0.005	0.4494	-0.2261	0.4494	-0.5031	1
129	excluding diff >0.004	0.4492	-0.2261	0.4492	-0.5033	1
111	excluding diff >0.003	0.4492	-0.2264	0.4492	-0.5040	1
	used for recal of 2012-26	0.4483	-0.2246	0.4483	-0.5010	

Removing data has little effect and the fit looks excellent with a wide range of DO values included. The highlighted value was selected and looks reasonable compared to the previous use during 2012-25 when Soc=0.4483 and Voffset = -0.5010 was used. It is expected that the correction should be slightly larger.

The samples flagged "2" and "3" were investigated to see if the values look off in the above comparison and the following was found:

Event_Number	Sample_Number	
1	9	bit off but not bad for such a high gradient
15	131	mild outlier
61	484	mild outlier
61	485	ok
61	486	ok
61	493	ok
61	505	ok
78	625	ok
78	627	ok
46	389	ok
107	821	ok

The Saanich Inlet surface sample is usually an outlier due to high gradients, so no change will be made to the flags at this point, though this will be checked again when COMPARE is run.
For more details see file 2012-12-do-cal-study.xls.

4. Hysteresis Study

Hysteresis tests were run using the spreadsheet from the previous section. In previous studies of hysteresis, varying parameters (H1 and H3) did not have a significant affect on hysteresis and tests of those variables are time-consuming. It is easy to test E by varying it in the calculation of Phi. A separate worksheet was opened for these tests, choosing only lines for data from 200 to 400db and 2000-4400db. Those 2 ranges had similar ranges of DO, though the deep water has a lot more values towards the bottom of the range. This enables comparing fits (of differences against DO) at levels subject to hysteresis to those where such affects are minimal.

Separate fits of DO Voltage against DObot/Phi were made for the 2 depth ranges. E was varied from 3.5 to 3.8 in the calculation of Phi and the resulting values of m and b were recorded. The difference between the two fits was found. The minimum differences for both m and b occurred when E=3.725. This is not a perfect test since the ranges aren't exactly the same, but it is the best we can do. For more details see the hysteresis worksheet in file 2012-12-do-cal-study.xls.

Because the value of E was updated that affected the slope/offset calculation done in the previous section, so the process was repeated with the following results:

Summary of Soc Voffset including the original values in the factory calibration when E=0.03725

Bottles used		m	b	Soc	Voffset	R2
	Original	0.4278	-0.2186	0.4278	-0.5109	
168	Using 2012-15 fit	0.4490	-0.2244	0.4490	-0.4998	0.9880
158	all except cast #1	0.4493	-0.2246	0.4493	-0.4999	0.9980
157	excluding cast #1 and 1 outlier	0.4497	-0.2265	0.4497	-0.5037	0.9997
149	excluding diff >0.01	0.4499	-0.2271	0.4499	-0.5048	0.9999
136	excluding diff >0.005	0.4496	-0.2272	0.4496	-0.5053	1.0000
126	excluding diff >0.004	0.4495	-0.2274	0.4495	-0.5059	1.0000
121	excluding diff >0.0035	0.4496	-0.2276	0.4496	-0.5062	1.0000

The settings that have been determined since the latest calibration show a fairly steady drift. The Voffset for 2012-04 might be out of line. We don't have enough experience yet to determine if settings vary only with time or if the DO range is significant to the fits.

	Soc	Voffset
Factory	0.4278	-0.5109
2012-04	0.4442	-0.4822
2012-25	0.4483	-0.5010
2012-12	0.4496	-0.5053

The configuration file was updated with the new values for parameters Soc and Voffset and E and saved with the name 2012-12-ctd-new.con.

5. BOTTLE FILE PREPARATION

The ROS files were recreated with the new configuration parameters. They were put through CLEAN to create BOT files. Temperature and salinity were plotted for all BOT files. A few spikes were noted and examined in CTDEDIT. The following casts were edited to remove spikes in one or the other or both salinity channels: 15, 37, 44, 50, 60, 100 and 102.

A preliminary header check indicates that the WetLabs fluorescence goes very slightly negative, but this is likely to disappear with editing and averaging. No other problems were noted.

The addsamp.csv file prepared in the DO calibration step was sorted on Event_Number and Sample_Number and then converted to CST files. The CST files will form the framework for the bottle files.
SAM files were created using the Add Sample Number routine and those files were then bin-averaged.

The last 11 bottles were removed from the SAMAVG file since there was no sampling.

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 2012-12-bot-hdr.txt; it may need further editing to reflect problems found during processing.

Dates of creation were added to the names of spreadsheets from analysts.

EXTRACTED CHLOROPHYLL

Extracted chlorophyll and phaeo-pigment data were obtained in file QF2012-12chl.xls. The file included comments and flags and an event-number column. A simplified version of the spreadsheet was prepared in which some columns were removed and the file was saved as 2012-12chl.csv which was then converted to individual CHL files. Loop data were not included, but were added to file 2012-12-loops.csv.

DISSOLVED OXGYEN

Dissolved oxygen data were provided in spreadsheet QF2012-12oxy.xls which includes flags, comments and 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 2012-12oxy.csv. That file was converted into individual *.OXY files. No loop data were included.

SALINITY

Salinity analysis was provided in spreadsheet QF2012-12SAL.xls. The file was simplified and saved as 2012-12sal.csv. That file was converted to individual SAL files. Loop data were not included, but were added to file 2012-12-loops.csv. The salinity data were analyzed within 4 to 7 weeks of collection, about 1 month after the end of the cruise.

NUTRIENTS

The nutrient data were obtained in spreadsheet QF2012-12nuts.xls which included a report on precisions. The file was simplified, reordered on sample numbers and saved as 2012-12-nuts.csv. The file was converted to individual NUT files.

DMS

The nutrient data were obtained in spreadsheet 2012-12-dms.xls and details on processing and precision in filet 2012-12 DMS report.doc. The data file was simplified and saved as 2012-12dms.csv. The file was converted to individual DMS files.

The SAL, CHL, OXY, NUT and DMS files were merged with CST files in 5 steps.
After the 4th step the files were put through CLEAN to reduce the headers to File and Comment sections only.

The merged files are ordered on sample number, but the SAMAVG files are ordered on bottle number, so one or the other set needs to be reordered in order to merge them. The MRGCLN1 files were reordered on Bottle_Number, the usual method used. The output files were named MRGCLN1s.
Those files were merged with SAMAVG files choosing the Bottle_Number from the SAMAVG files.

6. Compare

Salinity

Compare was run with pressure as reference channel.
There were 4 outliers, differences >0.02:
Cast #19, sample #181 – This sample was already flagged because there was no liner; a comment was added.
Cast #53, sample #435 – Surface sample. The value looks too high, nothing like it until almost 100m down. Flag 3.
Cast #107, sample #818 – This 400m sample looks like it may have been mis-sampled since it is very close to the 600m bottle. The DO looks ok, so not a misfire. Flagged 5 and replaced with pad value.
Cast #107, sample #825 – There is a high gradient around 100m, so this outlier is likely due to a mismatch of levels. The sample is likely fine. No flag was added.

When the outliers were excluded the primary salinity was found to be low by an average of 0.0075 (standard deviation - 0.002) and the secondary was low by an average of 0.0017 (standard deviation - 0.001). Neither sensor shows much pressure dependence, with the primary having the least. Time dependence is small and the same for both sensors.

The 22 bottles fired at 2000m during cast #71 were studied next. The standard deviations were 0.0013 for both salinity channels; the primary was low by an average of 0.0072 and a median of 0.0076 while the secondary was low by an average of 0.0014 and a median of 0.0018. The results are satisfactory, but not as good as the results from the February Line P when salinity data were analyzed very quickly. This may be further evidence that speedy analysis is valuable. Nonetheless, these results are good and show that sampling and analysis went well.

For both CTD sensors the differences become larger between casts #71 and #78 by about 0.001 and then smaller by about 0.003 between casts #78 and #81 and stay smaller for the final cast, #107. It was very useful that the analysis was done “out of order”, because this suggests that analysis problems will not account for the changes. To be sure of this, the comparison data were divided into 2 groups according to when the samples were analyzed, July 10 or July 11. First a look at the 1000db differences shows some variation, but no particular pattern in either group. Then for each analysis day, the average differences from 400db to 1250db were -0.0067 for July 10th and -0.0065 to July 11th. Given that the samples that look out of line were gathered late in the cruise, the smaller changes might be due to reduced evaporation, but that doesn’t explain the drop for cast #78.

When a plot is made of differences with time these late variations are seen to be mostly within the variability of the 22 bottles fired at the 2000db. However, at least one bottle from cast #107 is outside that

range and the offset between the two casts is fairly steady with pressure, so it suggests something non-random. The downcast traces look odd for cast #107, with some reversals and very noisy T and S data. Casts #78 and #81 at P26 differ significantly through the halocline, but look alike below that. These problems will be investigated later. Unusual properties at P4 could be real, but at P26 we should be able to see CTD problems if they exist.

For full details for the COMPARE run see file 2012-12-sal-comp1.xls.

Outliers: The only large outliers were 2 near-surface samples.

- Sample #181 had already been flagged due to missing liner. This was in well-mixed surface waters and the standard deviation in the CTD salinity is low, so it really is off. A comment was added.
- Sample #435 is also a little off but the CTD salinity is noisy, so no flag was added.

Dissolved Oxygen

COMPARE was run with pressure as the reference channel.
As expected the fit of differences against DO concentration is quite flat. When outliers with differences >0.08mL/L were excluded the average difference shows the sensor to be low by 0.002mL/L while the median indicates it is high by 0.001mL/L with a standard deviation of 0.02.

The outliers were investigated and half of them were associated with high standard deviation in the CTD DO. The others were:

- Sample 9, cast #1 – Local DO trace very complex – probably just mismatch in depth of CTD and bottle causing large difference. Because there is a 2 flag and comment about a bubble, the comment was amended. NO flag changed was made.
- Sample 131, cast #15 – In fairly high gradient, likely poor vertical match or slow DO sensor response accounts for difference. The analyst suggested this flag could be removed later if no further evidence of trouble, so flag and comment removed.
- Sample 484, cast #61 – Already flagged 2; outlier in compare, so changed flag from 2 to 3 and amended comment.
- Sample 820, cast 107 - not flagged by analyst but looks bad in profile and was higher than the CTD sensor by 1.5mL/L. CTD data was not noisy. Nutrients and draw temperature do not show a reversal. The flag was changed to 5 and the value replaced with a pad value.
- Sample 821, cast 107 - flagged by analyst as 3. It is an outlier in comparison with CTD but DO has a reversal near that level. Changed to 4.
- Sample 825, cast 107 - Outlier in comparison to CTD DO but local gradient very high and complex, so it may be ok. Added flag 3.

All other outliers in COMPARE are associated with high standard deviation in the CTD DO data or being near very high

As a final test for hysteresis a plot was made of differences against DO concentration, and points from below 2000db were excluded so the deep bottles show up in red. The plot shows no obvious difference above and below 2000db.

For more details see 2012-12-dox-comp1.xls.

Plots of Titrated DO and CTD DO against CTD salinity were examined and no further problems were detected.

Fluorescence

COMPARE was run using the Wet Labs ECO CTD fluorescence, the SeaPoint fluorescence and the Extracted Chlorophyll from bottles. The COMPARE fit sheets for ECO vs CHL and SeaPoint vs CHL were combined in a single worksheet. The aim of this study is to see if we can find a reliable way to relate data from the newer WetLabs ECO fluorometers to older data collected with SeaPoint fluorometers. There was only 1 bottle with an extracted CHL value >3ug/L. There are more deep samples from this cruise than we usually see. A variety of plots were prepared:

- In a plot of one fluorometer versus the other, the ECO reads higher than the SeaPoint and the slope of the fit depends on what range of CHL is included. The ECO is higher by a factor of up to 3.5 at the lowest CHL values but falls quickly to a factor of ~2 at CHL=0.5ug/L. It keeps falling and is 1.6 for the maximum CHL of 22.5ug/L. At the low end of the scale the fit is roughly linear, but flattens out as fluorescence rises.
- The SeaPoint fluorescence is generally close to extracted CHL at low values except that it is sometimes too low at the shallowest bottles, and reads too high for low values below the CHL maximum. It reads a little low when CHL>2 and is only 11ug/L for the one high CHL sample (22ug/L.). There is generally more variability at low CHL in the SeaPoint fluorescence than in the bottle CHL; the values are very low and errors in both bottles and CTD sensors limit the expectations for good fits.
- The ECO is generally higher than the extracted CHL, except for the highest value of extracted CHL when it reads low at 17ug/L (CHL=22ug/L) and below the CHL maximum when it reads up to 10 times too high. At the lowest levels the ECO is about 4 times the CHL but that factor drops to about 1.5 for CHL>2.
- For comparison with other cruises that do not include deep water, averages were calculated for bottles from the surface to 32db. These indicate that the SeaPoint is roughly equal to extracted CHL, the ECO is 1.9 times the CHL and the ECO is 2 times the SeaPoint. This is a higher ratio than noted on the previous cruise, 2012-25, but that one included a wider range of CHL, including more high values.

At this point the data from the MRGCLN2 files were exported to a spreadsheet for comparison with the rosette files to ensure no data were misplaced or missing. The following problems were found:

- Cast #3 – the nutrients were missing because the sample #s were wrong. This was corrected in the NUT file and then reran the Merge process for that cast..
- Cast #78 – Sample #605 – there were duplicates but they were not averaged or flagged. The values are 34.6835 and 34.6824. The 1st value had been used in the final sheet, but there is no reason to reject the 2nd. The average of 34.6830 was entered with flag "6".
- Cast #86 – flagged 3 originally, but is way off in profile and compared to another bottle at the same level so replaced with pad value and comment amended.

7. Conversion of Full Files from Raw Data

All files were converted using 2012-12-ctd-new.con.

A few casts were examined and all expected channels are present. The descent rate is extremely noisy for many casts with many complete reversals of direction during the descent and obvious shed wake corruption. The two temperature channels are fairly close during the downcasts though both channels have occasional spikes. During the upcasts traces differ more and there are odd excursions that are often seen in upcasts. This is likely something to do with how the CTD is mounted. The conductivity channels are similar to temperature, but have more spikes, especially in the primary channel.

Altimetry looks useful when the CTD got near the bottom, dissolved oxygen, fluorescence, PAR and transmissivity look normal.

8. 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.

9. ALIGN DO

Tests were done on 4 casts applying a variety of settings to make the offset between the upcast and downcast DO channel close to that for the temperature. It is very hard to judge because the temperature is so noisy on the upcast, the descent rate was very noisy and only casts with few stops for bottles are inappropriate. For 3 casts a 5s advance appears to have the best effect. The other cast seemed to vary from one feature to another with 4s to 5.5s advance looking best. During 2012-25 which immediately preceded this cruise a setting of +4.5s was used.
ALIGNCTD was used to advance the DO Voltage by 5s relative to the pressure.

10. CELLTM

The upcast data are extremely noisy so the usual tests for CELLTM settings were very hard to interpret. All settings tested improved the data with little to distinguish one from another, but ($\alpha = 0.02$, $\beta=9$) seemed slightly better than the others for the primary conductivity and either ($\alpha = 0.02$, $\beta=9$) or ($\alpha = 0.03$, $\beta=9$) for the secondary. During 2012-25 when the same sensors were used the best choice was ($\alpha = 0.02$, $\beta=9$) for both channels, so that was chosen for these data too.
CELLTM was run using ($\alpha = 0.02$, $\beta=9$) for both the primary and secondary conductivity channels.

11. 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.

12. 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 are extremely noisy so these are very rough estimates; if there was a spike at the given depth, nearby values were chosen. The largest spikes are associated with shed wakes in which the primary sensors systematically record larger changes than the secondary sensors. For comparison, values are listed for two casts from the cruise immediately preceding 2012-12 when the same equipment was used.

Cast #	Press	T1-T0	C1-C0	S1-S0	Descent Rate
2012-25-0037	500 1000 2000	-0.0008 -0.0003 -0.0001	+0.00015 +0.00025 +0.00030	+0.0025 +0.0035 +0.0040	High, V Noisy
2012-25-0068	500 1000 2000	-0.0001 -0.0001 0.0000	+0.00026 +0.00029 +0.00036	+0.0031 +0.0036 +0.0044	High, X Noisy
2012-12-0019	500 1000 2000	-0.0004 -0.0003 -0.0001	+0.00025 +0.00033 +0.00039	+0.0035 +0.0044 +0.0049	High, X Noisy
2012-12-0029	500 1000 2000 3000	-0.0003 -0.0001 +0.0002 +0.0002	+0.00028 +0.00036 +0.00042 +0.00046	+0.0034 +0.0046 +0.0050 +0.0055	High, V Noisy
2012-12-0038	500	-0.0004	+0.00036	+0.0045	Mod, Noisy

	1000 2000	+0.0001 +0.0002	+0.00043 +0.00047	+0.0052 +0.0056	
2012-12-0061	500 1000 2000 3000 4000	+0.0001 +0.0001 +0.0002 +0.0002 +0.0003	+0.00040 +0.00045 +0.00049 +0.00053 +0.00058	+0.0050 +0.0054 +0.0060 +0.0062 +0.0068	High, X Noisy
2012-12-0078	500 1000 2000 3000 4000	+0.0003 +0.0004 +0.0003 +0.0003 +0.0003	+0.00044 +0.00046 +0.00051 +0.00053 +0.00057	+0.0050 +0.0053 +0.0059 +0.0063 +0.0067	High, X Noisy
2012-12-0098	500 1000 2000 3000 4000	+0.0003 +0.0003 +0.0003 +0.0004 +0.0003	+0.00043 +0.00046 +0.00050 +0.00054 +0.00056	+0.0049 +0.0055 +0.0058 +0.0063 +0.0068	High, X Noisy
2012-12-0107	500 1000	-0.0003 +0.0002	+0.00035 +0.00042	+0.0043 +0.0048	High, X Noisy

There is a steady drift in temperature and conductivity with time, though the differences are not large. Salinity differences increase by about 0.001 up to cast #61 and change little after that. The changes do not look significant. The pressure dependence is slight for temperature and not bad in conductivity. The salinity differences may be exaggerated by the systematic nature of the spikes in the primary conductivity.

13. 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.

14. Checking Headers

The header check was run. There are some negative values in the WetLabs ECO fluorescence, as usual. A close look at a cast with such values shows that they occurred only in the top 3m and other channels all look very noisy, so these records are likely to be removed in editing. There are no off-scale SeaBird fluorescence values. There are no negative pressure or dissolved oxygen values. Speeds look reasonable.

Surface Check was run and shows an average surface pressure for the cruise was 3.1db which looks reasonable for the Tully.

The cross-reference check was compared with the log book and the only problems found were in station names for casts 2, 3, 83, 88, 93 and 101. The first 2 had format issues, P 1 should be P1. Others were said to be at P26 but according to the log and rosette sheets should be Argo. In one case it was named ARGO but should be Argo. The station name format for cast #94, PA 005 matched the log, but did not match the format used for PA-006, so it was changed to PA-005.

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

The altimeter readings from the headers of the CLN and SAMAVG files were exported to a spreadsheet. Most casts did not get within 15m of the bottom so there are no header entries. Problems found were:

- Spikes were misinterpreted for many casts that did not get close to the bottom. They include the profile files for casts: 7, 12, 14, 18, 42, 50, 60, 76, 83, 86 and 87. The altimetry headers will be removed from the CLN files for those casts.
- Spikes were also misinterpreted in the bottle files for casts: 14, 18, 42 and 74. The altimetry headers will be removed from the SAMAVG files for those casts.

Water depths will be corrected as follows:

- Cast #24 at P9 had no water depth entry and the log entry is "2500?". The standard depth used for this site is 2340 so that will be entered.
- For cast #61 the log notes that the depth is wrong in the file. It should be 4023.
- For cast #101 the log entry was 4217; the header showed 4252 but that was likely repeated from the previous group of casts, but the ship was in a slightly different position. It will be changed.

The necessary header corrections (station names, altimetry headers and bottom depths) will be applied later – see section 16.

15. Shift

Fluorescence

Tests were run on two casts to see what SHIFT value should be used to make the offset between the downcast and upcast fluorescence trace look like that of the temperature trace. This task was complicated by noisy upcast temperature data so the vertical offset is confused and extremely noisy descent and ascent rates resulting in very confused traces.

Tests suggest that using either +24 or +48 records would improve the SeaPoint fluorescence data while from 0 to 24 records looks appropriate for the WetLabs ECO fluorometer. During 2012-25 which preceded this cruise the choices made were +24 and +6 records for the 2 sensor types. In the past a higher SHIFT was found best for the ECO sensor, but there have been some adjustments in sampling rates and ranges for that sensor.
SHIFT was run twice on all casts to advance the SeaPoint fluorescence by +24 records and the ECO fluorescence channel by +6 records.
After this step a few plots were made to see if downcast peaks in the 2 fluorescence traces are in reasonable agreement and they are in better agreement than before either shift.

Conductivity

Tests were run on several casts to determine how to align the conductivity channels relative to temperature, so as to minimize noise in the salinity channels. The noisy descent rate makes the judgment difficult, but for the primary conductivity a shift of from -0.5 to -0.7 records looked best and for the secondary values between +0.4 and +0.8 looked best. During 2012-12 when the same sensors were used, the best SHIFT parameters were found to be -0.6 and +0.6 records for the primary and secondary.
SHIFT was run on all casts using -0.6 records for the primary conductivity and +0.6 records for the secondary conductivity.

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, but this does not appear necessary.

16. 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.

At this stage corrections noted in section 14 were made to headers of the DEL and SAM files. The final steps in the bottle merging process were repeated to capture those changes in the MRG and MRGCLN2 files. Corrections included fixing station names, removing or adjusting entries for the altimetry headers and fixing bottom depth entries.

17. DETAILED EDITING

The bottle comparison shows that the secondary salinity is closest to the bottles. There is also a larger drift in the primary sensors between cruises 2012-25 and 2012-12. There is little pressure-dependence or time-dependence in either sensor through this cruise. The odd shift towards the end of the cruise that was noted in the bottle comparison is the same for both sensor pairs. The secondary sensors were selected for editing and eventual archiving.

CTDEDIT was used to remove large spikes, smaller spikes that appear to be due to instrumental problems (chiefly mis-alignment of T and C) and likely to affect the bin-averaged values and records corrupted by shed wakes including some surface records. Most of the casts had extremely noisy descent rates so that despite a high average rate, there are many reversals corrupting data over many metres. Heavy editing was required for most casts.

Cast #89 had bad temperature and salinity data from ~835db to ~858db; both sensor pairs have temperature that appears to have "stuck" and the salinity rises unbelievably as a result. The records were removed.
The only cast that required no editing was #93.
Because of many crashes while the editor was running frequent saves were made; so the multiple entries of CTDEDIT in the processing history is not due to multiple runs of CTDEDIT.
All EDU files were copied to EDT.

18. Other Comparisons

Previous experience with these sensors –

1. Salinity:
   The sensors were both recalibrated in late March 2011 and were used for only 1 other cruise, 2012-25, when the primary salinity was found to be low by 0.005 and the secondary low by 0.0015. There was a hint of time-dependence in the primary salinity.
2. Dissolved Oxygen
   The DO sensor was recalibrated in April.2011. It was used for 7 other cruises since then. The only reliable calibration sampling was for 2012-04 in April 2012 and 2012-12 in May 2012, when Soc and Voffset found appropriate were 0.4442/-0.4822 and 0.4483/-0.5010.
3. Pressure
   The sensor was recalibrated in April 2011 and some drift was noted in cruises earlier this year, so an offset was applied in conversion. There is no evidence of further correction needed.

Historic ranges – Profile plots were made with 3-standard deviation climatology ranges of T and S superimposed. The only excursions were in temperatures which were slightly low between 200 and 300 at P16 and around 150m at P21, though for the P21 case the climatology itself does not look reasonable.

Repeat Casts –
There were many repeat casts and there at least 2 that went as deep as 1300db at P4, P12 and P26.
An initial look at P26 shows huge variability over 2.5 days at the base of the mixed layer. It looks like a case of advection. Even below that there is a lot of variability, but by 1600db the variations are ~0.002°C and ~0.0005psu along lines of constant density; when 2 casts within 4 hours are used the differences are only ~0.001°C and ~0.0003psu . At P4 there is more variability with cast #107 looking notably different from the earlier P4 casts at all depths. At 1100db the differences are ~0.015°C and 0.002psu. The bottom is at about 1300db and this is an area where great variability is often seen.

Post-Cruise Calibration
There were no post-cruise calibrations available.

19. Initial Recalibration

Before considering recalibration of the salinity channel, the shifts noted in section 6 (COMPARE) were studied further using the edited files.
1. There is no evidence that the difference between the two salinity channels changed notably during downcasts through the cruise.
2. During cast #89 the temperature from both sensors appeared to get stuck at one point, so there could be some unusual CTD problem. Such a problem is clear in the downcast data because if temperature stops decreasing the salinity compensates by rising sharply. During an upcast bottle stop this might not be obvious at all, but a close examination of CTD salinity during stops before and after the shift shows no tendency to rise or fall sharply while temperature stays constant. If the temperature sensors are not responding as quickly as usual it would, on average, lead to salinity being too high during bottle stops, so could explain the shift.
3. There could be something that affects the upcasts differently, but comparisons of downcast and upcast on T-S surfaces does not suggest this is the case.
4. The deep downcast data from all deep casts at P26 does not show any shift along T-S lines.
5. It was established earlier that the shift cannot be ascribed to analysis problems since the before and after sets are scattered through the analysis, not done as a block.
6. It seems unlikely that problems with Niskin flushing could account for that would produce results that are highly gradient dependent and that does not seem to be the case.
7. If the problem were due to evaporation in the bottles we would expect to find that the CTD looks lower than bottles for the earliest casts and closer towards the end, since the early bottles were stored longer. This is what we are seeing, though it seems odd that the shift should be as consistent as this.
8. A change to protocols such as a different type of seal being used late in the cruise might explain it, but there is no note of any such change in the log, the analysis notes or the notes from the chief scientist.

Since the comparison of the secondary salinity to the bottles before cast #81 looks very close to that found during 2012-25, it will be assumed that those results are reliable. If future use of these sensors suggests otherwise a recalibration can be applied later.

The pressure looks ok.
The dissolved oxygen looks fine in COMPARE so will not be calibrated further at this stage.
The secondary salinity was lower than bottles by an average of 0.0017 which is close the difference found during its previous use.
The only negative fluorescence values disappear with metre-averaging so no recalibration is required.

CALIBRATE was run using file 2012-12-recal1.ccf to add 0.0015 to the secondary salinity channel. This was applied to the EDT and MRGCLN2 files. COMPARE was rerun to check that the salinity was recalibrated appropriately and it was.

(See file 2012-12-sal-comp2.xls.)

20. 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 a further correction is sometimes found appropriate to further correct for response time errors found by comparing downcast CTD data to bottle data from the same pressure.

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.

COMPARE was run again. When the differences were plotted against DO concentration there is a lot of scatter. When outliers were excluded based on high standard deviation in the CTD DO, very low DO (cast #1) and a few large differences, the differences are close to zero for low DO and a little low for higher DO. The average difference was -0.0007mL/L but the standard deviation was 0.02mL/L. When the same data are plotted against pressure the values below 1000m appear to be a little high, but within the standard deviation. Recalibration does not appear justified because the fits are highly dependent on what data are included.

The plot against file pair number shows no hint of time-dependence, except that the Saanich Inlet cast looks out of line; that cast is always a misfit because of the thick hypoxic layer above which there is a very steep DO gradient, a great challenge for the DO sensor. No further recalibration will be applied.

21. Special Fluorometer Processing

There were no off-scale fluorescence data.

Special files were prepared for Dr. Peña by clipping the COR1 files to 150db. The clipped files were bin-averaged (0.25db bins), put through REMOVE and HEADEDIT and named as *.FCTD1 and saved. A second set, *.FCTD2, were created by filtering before bin-averaging. The SAM files were put through REMOVE and named *.BOF and saved. A readme.doc file was prepared with some notes on the preparation of those files.

A median filter, fixed size=11, was applied to the fluorescence channels in the COR1 files to reduce spikiness. Before and after plots of a few casts showed that the filter was effective.

22. 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 appeared to be necessary.

23. Final CTD File Steps (REMOVE and HEADEDIT)

CLEAN was run to remove the SeaBird Headers and comments from the secondary file.
SORT was run to rearrange data by 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 on casts with no PAR sensor to remove the following channels:

Scan_Number, Temperature:Primary, Salinity:T0:C0, Conductivity:Primary, Conductivity:Secondary, Oxygen:Voltage:SBE, Altimeter, Status:Pump, PAR, Descent_Rate and Flag

A second SBE DO channel (with umol/kg units) was added.
REORDER was run to get the two DO channels together.

HEADER EDIT was used to fix formats and channel names, to add "Mid-ship" to the instrument location section 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".

SBE DO calibration was done using the method described in the SeaBird Application Note #64-2.

The Oxygen:Dissolved:SBE data are considered, roughly, to be:
±0.1mL/L from 0 to 125db
±0.06mL/L from 125 to500db
±0.04mL/L from 500db to 2000db
±0.02mL/L below 2000db

For details on the processing see processing report: 2012-12-proc.doc.

The cross-reference list was produced and one typo in a station name was fixed.
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 ok.
The sensor history files were updated.

24. Dissolved Oxygen Study

As a final check of dissolved oxygen data, % saturation was calculated and plotted. The near-surface values ranged from 102% to 105% at stations P9 to P26 and between 105% and 110% for stations P2 to P8. The Saanich Inlet saturation was high, as usual, at 140%. These values are in the normal range.

25. Final Bottle Files

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

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

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

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

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.

A header check was run on the final files and no problems were found.

For a final check the CHE bottle data were exported to a spreadsheet and compared with the rosette log sheets and no errors were found.

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 a problem was found in the DMS format; that was fixed.
A cross-reference list turned up no further errors.
The track plot was produced on screen and no further errors were found.

At the end of processing it was discovered that transmissivity data had not been converted and that the SeaPoint fluorescence format was wrong. A first attempt to fix this produced some pad values that were incorrect, so a second attempt took those CHE files, renamed them as CHE1, sorted them on bottle number and had the SeaPoint channel removed. New ROS files were produced with the transmissivity channel, converted to IOS format files, bin-averaged on bottle number. The transmissivity data and SeaPoint fluorescence data from an earlier stage with the correct format were exported to a spreadsheet, reordered on bottle # and converted to *.fltr files. Those were then merged with the CHE5 files. They were reordered to put the channels in the usual order (*.CHE6) and were then sorted on pressure with output CHE. The final header check, standards check and cross-reference listing were repeated and no problems were found.

A few lines were removed for which there was no sampling:
File 37 Niskin #4 closed twice so 2nd instance was removed.
File 83, Niksin 1 closed by mistake – no sampling. Removed.

26. Thermosalinograph Data –
Data were provided in 11 hex files.

Loop data were combined in file 2012-12-loops.csv. These include 13 salinity, nutrient and extracted chlorophyll samples, but the time is missing for the sample labelled JF4. Two salinity samples were identified as JF1. The second listed was assumed to be JF2, but if the match to the TSG is better by reversing JF1 and JF2, this should be fixed. Time and date were added to the file to enable addition of the TSG data later.

Three of the loop samples coincide with rosette casts and the others were taken underway.

a.) <u>Checking calibrations</u>

The calibrations were checked and the only problem concerns the fluorometry. During 2012-01 and 2012-25 problems were found in the fluorometry. An initial test of the data from this cruise shows the same problem occurred.

Notes from 2012-25
The configuration file contains a Vblank value of 0.186 found in February 2012. The value from the 2001 check was 0.068 and that value was used at sea during 2012-01 and 2012-14. A few test conversions were done and the value of 0.186 led to many large negative values (as low as -1.5mg/m^3), as was also the case for the 2 earlier cruises. The shape of the data looks normal, so the negative values are not likely due to an instrument malfunction. Tests were also run selecting the old parameters and even assuming the value of 0.186 should be 0.086, but neither of these choices led to data that was consistently close to extracted chlorophyll values. It was decided to use Vblank=0 and scale factor=1 for the conversion as was done for the other 2012 cruises that had the same problem. Later, we can attempt to recalibrate if we have more information, though that did not prove to be the case for 2012-01 or 2012-14.

For this cruise, instead of changing the configuration file, Voltage:0 will be converted. The fluorescence in ug/L will be removed later and Voltage:0 will be renamed as Fluorescence:URU:Wetlabs but the units will be volts.

The CON file was saved as 2012-12-tsg.con.

b.) The files were converted to CNV files using the configuration files mentioned above. 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 based on the Julian time.

Time-series plots were produced. As noted by the Chief Scientist there were big problems with the flow in the loop, especially late in the cruise. The flow rate was fairly low during 2012-25 at about 0.7. For this cruise the following was observed:

- Flow rate was close to 1 for the first 6 files.
- For file #7 it starts very low then rises to about 0.5 to 0.6. There are some odd variations in intake temperature that look wrong. Temperature rises to about 10 and no values that high are observed in CTD casts during that period. Salinity is noisy.
- File #8 starts with flow ~0.85 and then gradually decreases to about 0.2, rises to 0.65 and stays there. For File #9 the flow starts at about 0.65 but again gradually falls to 0, later recovers to 0.65 and once again falls to 0.
- File #10 is very short and file #11 has a highly variable flow rate (0.4-1.2) and noisy T and S.

Between files #2 and 3 the loop pump was stopped to clean the strainer and line. There is no mention of why this was done, but the salinity values drop quickly from ~31 to ~16 at the end of file #2 and look ok in file 3. There is no obvious change in fluorescence or temperature between those 2 files.

c.) Checking Time Channel
The CTD data were thinned to reduce the files to a single point from the downcast at or within 0.5db of 4db and exported to a spreadsheet which was saved as 2012-12-ctd-tsg-comp.xls.

All files that overlapped for at least 1 CTD cast were opened in EXCEL, median and standard deviations (over 5 records) were calculated for intake temperature, lab temperature, salinity and fluorescence voltage, and the files were reduced to the times of CTD files. There were 53 matches. TSG values were

also found for times of underway loop sampling and added to file 2012-12-tsg-loop-rosette-comp.xls. The Saanich Inlet cast occurred only a minute or two after the loop flow was turned on, so is not expected to be a good match.

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 ≤0.00034° and the median differences were 0°, so there is no systematic error. This shows both the times and positions are reliable for both systems.
This spreadsheet will also be used in step (d) to compare temperature, salinity and fluorescence.

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

- T1 vs T2 The intake thermistor was connected throughout the cruise. The temperature difference (intake temperature minus the lab temperature) varied greatly but in quiet sections was about -0.24Cº for the first 6 files. For file #7 the difference was -0.5Cº when the intake temperature looked reasonable, but at other times the intake was higher than the lab by as much as 1.5Cº. File #8 was similar to #7 though the differences were about -0.32Cº in quiet sections. File #9 was highly variable with -0.35Cº being fairly common. File 10 was very short and the difference was ~-0.35Cº. File #11 had a difference of -0.28Cº in quiet sections but up to +1.4 Cº in other parts.

  The problems with the intake temperature arose at the same time as the flow rate dropped. It was ~1 for the first 6 files. There is no record of adjustments to the TSG at that point. File #7 started with reasonable intake temperature despite a flow rate of about 0.6, but soon it starts to look bad. File #8 started with a higher flow rate (~0.85) but that dropped off steadily, going as low as 0.2; the intake temperature which was ok at the beginning soon looks bad until the flow suddenly changes to ~0.6 and the intake temperature looks ok again. File #9 is similar to #8 except that the flow actually goes to 0 at the end. Since it is possible that the problem is with the flow meter rather than the flow itself, it would be good to check how the lab temperature behaved during that period. However, we have no CTD casts during that period, and the lab temperature rises by about 1Cº while the flow is ~0, so we have to assume there was no flow. Why bad intake temperatures are associated with lower flow could was not determined.

- TSG vs CTD The spreadsheets comparing CTD and TSG files were then examined to find the differences between the salinity, fluorescence and temperature channels for the CTD and the TSG. During stops the intake and lab temperatures differed by an average of 0.31Cº, but the range went from the intake being cooler than the lab by 2.9Cº to being warmer by 1.3Cº. The heating is greater than the 0.18Cº value found for Line P in May 2011, and the highest heating value for which I have records is 0.22Cº, with the exception of 2012-25 when it was 0.28Cº. The latter was a cruise during which surface waters were fairly cool which might explain the extra heating in the loop. The near-surface temperatures are also lower than usual for this cruise. Another likely cause for higher than usual heating are the unusually low flow rates.

  When all data were included the TSG intake temperature was higher than the CTD by average of 0.15Cº; the median difference was 0.018Cº and the standard deviation was 0.4Cº.

  The TSG salinity is lower than the CTD salinity by an average of 0.066, a median of 0.007 and a standard deviation of 0.24. When the 1st cast is excluded plus all casts for which the flow rate was <0.87, the average is -0.072 and the median is -0.04 with a standard deviation of 0.07. The casts corresponding to files #1 and 2 all stand out as having salinity notably lower than from other files, no matter what the flow rate. One loop sample from the same period, JF3, also stood out as the largest outlier in the comparison with TSG salinity. In both cases the TSG read lower than

expected. For casts #5 to #19 the TSG salinity is lower than the CTD by a median value of 0.145. The surface gradients might have been higher for those casts; there is no evidence of that in the CTD data but that does not go above 2.5m and is not very reliable at the surface. More likely the cleaning of the strainer accounts for the change after file #2, which ended with a sharp drop in salinity. Whatever the cause, it will force a different recalibration for different files. With that in mind the data were examined in groups including a group with only casts for which the TSG record looked reasonable.

TSG – CTD Salinity	Average difference	Median Difference	Flow Rate during CTD cast
Files 1-2	-0.1474	-0.1452	0.95
File 4-5	-0.0125	-0.0073	0.93
Files 7-10 – all	-0.0145	-0.0034	0.54
Files 7-10- good parts	-0.0043	-0.0030	0.65
File 11 (1 cast only)	-0.0368	n/a	1.0

The ratio of CTD SeaPoint fluorescence in ug/L to the raw TSG fluorescence in volts has a median of 1.6 for files 1-2 and then rises to a median of ~3 for the later files when only sections of good TSG records are included. This change is likely related to the lower CHL as we move offshore. The fit of TSG fluorescence against CTD SeaPoint Fluorescence is surprisingly tight with a slope of 5.7 and an offset of -0.45, but the maximum fluorescence is 1.2ug/L and only a single value is >0.9ug/L. A fit of the ratio of the CTD SeaPoint fluorescence / TSG Fluorescence (volts) versus flow rate shows no obvious trend. Further evidence that the flow rate does not have much effect on fluorescence (at least during stops) is that removing data from the fit of TSG versus CTD fluorescence when the flow rate is <0.88 makes little difference to the slope and offset. Fits against the CTD ECO fluorometer produce good fits as well but the scale and offsets are much larger.
(See 2012-12-ctd-tsg-comp.xls.)

- Loop Bottle - TSG Comparisons The spreadsheet described in section (c) contains all loop sample data with TSG salinity and TSG fluorescence in volts (median values over 2 minutes). The data from 3 rosette casts that coincided with loop sampling were added to the spreadsheet. (See 2012-12-tsg-loop-rosette-comp.xls.)

  The TSG salinity read lower than the loop salinity by an average of 0.024 while underway (excluding JF1 because loop flow had just been turned on before the sample was taken.). A plot of the differences shows no clear dependence on the flow rate (except when it was zero), which makes sense. A plot of the differences against the standard deviation in the TSG salinity calculated over 2 minutes shows that the largest differences are associated with rapidly changing salinity. The lowest occur during the stops for CTDs when the TSG salinity is low by about 0.007. While underway there is a lot of scatter and it is assumed that imperfect matches between the times of loop samples and TSG record account for some of that. There may also be more problems with bubbles while underway which could lower the TSG salinity. It is also notable that the most significant outliers are from the Juan de Fuca samples (even if the samples JF1 and JF2 are reversed, 2 of the 3 JF samples are outliers.) The JF samples would have had the most opportunity for evaporation before analysis and may be reading a little high. The only other significant outlier came from a time when the flow is off; why that should affect the TSG more than the loop sample is not known, though the absence of flow must affect how the TSG operates.

  The converted TSG fluorescence has been found to be bad, with many negative values, so the raw voltage will be archived until such time as reasonable calibration coefficients are obtained.

When the loop chlorophyll are plotted against the TSG fluorescence voltage, a line through the 2 samples with CHL>1ug/L intersect the origin with a slope of roughly 18. However, most samples have low CHL; for CHL<0.5ug/L a scale factor of 1.5-2 would be more appropriate and between 0.5 and 1 it would be ~5. The results of the TSG-CTD fluorometer comparison may be the best source of information. In the TSG-CTD comparison a fit was found with scale 5.7 and offset -0.45; if that is applied to the data in the loop sample comparison, most values are too high where CHL<0.4ug/L and too low for higher CHL.
(See 2012-12-TSG-loop-rosette-comp.xls)

- Loop Bottle -Rosette samples
  There were only 3 CTD casts that coincided with loop sampling. The extracted chlorophyll samples compared well, with the loop reading lower by 2.4%, 3.4% and 9.8%. All 3 values were on the order of 0.25ug/L. The smallest difference occurred early in the cruise when the flow rate was higher than for the other 2 cases.

  The TSG salinity was lower than the loop salinity by 0.006, 0.008 and 0.024.

  The loop nutrient data look very similar to the rosette nutrients. Of the 3 casts, the one with the largest differences, event #70, is the same one that had the largest differences in salinity and extracted CHL and the largest standard deviation in TSG salinity. The flow rate was a little low, but slightly higher than for event #61. It is likely that a small mismatch in time accounts for these differences.
  (See 2012-12-TSG-loop-rosette-comp.xls)

- 5m rosette samples – To do a few more checks against CHL, the 5m rosette values were extracted and combined with the TSG fluorescence and salinity. The match of times is poor since the start times were used for the casts, while the bottles were fired somewhat later. The errors caused by this will be somewhat lowered by the fact that the ship was stopped so variations are reduced and the error is fairly random so averaging will minimize it. (See sheet "Test" in file 2012-12-TSG-CTD-comp.xls.)

  The scale factor (CTD Rosette CHL / TSG raw fluorescence) has a median value of 2.4 based on 24 bottles. As found in the comparison with the CTD fluorometer, the ratio is highest for the near-shore casts where CHL is higher. For CHL<0.3ug/L the ratio is 2.0 and for the highest CHL (~1ug/L) it is 5.

  The TSG salinity is lower than the bottles by 0.013 when all bottles are included, and by 0.010 when files 1 and 2 are excluded.

- <u>Calibration History</u>

The TSG primary temperature and conductivity were recalibrated in March 2011 and have been used during 2012-01, 2012-14 and 2012-25. There was no intake temperature available on the first 2 of those cruises and 2012-25 was subject to similar problems with the intake temperature and flow rate as seen in this data set. Heating in the loop was estimated to be 0.27Cº for 2012-25 and salinity was corrected for all 3 cruises by adding 0.02, but there were problems with the comparisons. The fluorometer was cleaned and recalibrated shortly before 2012-01, but there was clearly something wrong with the data from all 3 cruises. Conversion produced large patches of significantly negative values. Fluorescence was archived only in raw form with volts as units.

While a different TSG was used for 2011-26, the spring Line P cruise, it is useful to note that heating in the loop averaged 0.18Cº during that cruise.

Conclusions

1. The TSG clock appears to have worked well.

2. The flow rate was fairly steady and high for files 1-6 and highly erratic for files 7-11.

3. The temperature in the loop increases by about 0.24Cº inshore of P17, files 1-6, which is higher than found during the 2011 spring Line P trip. However, the ambient temperatures are lower by about 1Cº than at the same time in 2011, so more heating would be expected. The difference between 2011 and 2012 becomes even greater as we move offshore with 2012 temperatures ~2Cº lower at P23. The heating in the loop is hard to judge for files 7-11 but in quiet patches it tends towards 0.34Cº. While cooler waters account for some of the difference, there is also a varying flow rate to consider. The plot of loop heating versus flow rate does suggest heating is increasing as the flow decreases. When the flow rate is <0.6 the scatter becomes significant and especially below 0.4 it is hard to distinguish signal from noise.

4. The TSG intake temperature looks reliable for files 1-6 and should be archived. For files 7-11 the intake temperature will be removed. The lab temperature will be recalibrated by subtracting 0.34Cº to produce a proxy for intake temperature. This will not be enough in sections where the flow rate is <0.4 but those data will be removed in editing.

5. The TSG Salinity has some noisy parts, but this is largely due to single point spikes. There is one patch with bad primary temperature and salinity in file #9. There are sections of zero flow at the beginning of file #1 and during file #9 and flow is very low at the beginning of file #7 and in part of file #9. Flow is irregular at other times and that is associated with noisy salinity.

6. The TSG salinity is consistently lower than the CTD and loop salinity but the differences vary through the cruise. Based on underway loop samples, salinity is low by from 0.04 to 0.09 in the outward track through Juan de Fuca Strait, by 0.004 to 0.007 seawards of P15 and by 0.017 and 0.02 on the return journey shoreward of P14 (1 other loop is associated with zero flow). When compared to loops taken while stopped the TSG salinity is low by ~0.008 at P11 and 0.007 and ~0.006 for at P21 and P22. Compared to the CTD salinity, the TSG salinity is low by ~0.145 for files #1 and 2, by 0.007 for file #4 (to P14) and by 0.003 for most of files #7 to 10 which are almost all west of P14. For file #11 at P4 the TSG is low by ~0.04. The lower flow rate for files #7 to 10 may explain the drop to 0.003 as there might be fewer bubbles, and the rate had gone up again by the final cast at P4. A salinity correction of +0.145 for files #1 and #2,

7. Recalibration of the TSG salinity is aimed at producing the best underway data. The TSG generally looks closer to the CTD when the ship is stopped, likely because the loop draws from shallower water when in motion. Four factors may contribute to the variability in the comparisons. There are likely more bubbles in samples when the flow rate is high, higher flow rate might lead to drawing from higher in the water column, the near-surface gradients are higher closer to shore and an adjustment was made to the loop after file #2 that clearly affected salinity. A reasonable estimate is that for underway data, the salinity is too low by roughly 0.145 for files #1-2, by 0.007 for files #3-6, by 0.006 for files 7-10 and by 0.02 for file #11.

8. The fluorescence data have been converted with Vblank = 0 and Scale Factor=1. The comparisons of extracted CHL from both the loop and the CTD rosette suggest that the TSG

fluorescence should be multiplied by a factor of ~1.5 to 2 for the lowest CHL values, by ~5 at 1ug/L and by 18 for CHL>4ug/L. The fit against the CTD SeaPoint fluorometer is remarkably tight with a scale factor of ~5.7, but includes no values higher than 1.3ug/L and few above 0.8ug/L. It might be justified to use that fit to recalibrate the TSG fluorescence, but it will produce values that are too low for CHL>1ug/L and sometimes too high for low CHL. Given the uncertainties, recalibration will not be attempted, but information about the fit will be entered in the header comments, allowing researchers to make up their own minds about the wisdom of calculating fluorescence in concentration units.

f.) Editing

The ATC files were copied to *.EDT.
The ATC files were opened in CTDEDIT. Single-point spikes in salinity that are not associated with temperature spikes were cleaned; where flow had just been started or was varying rapidly, the spiky salinity points were removed. Groups of out of line salinity points were removed.
File 1. T1, T0, Sal and FL were removed from scans 1-330 due to zero flow. Salinity was edited lightly.
File 2. The salinity drops off precipitously at the end of the file and both temperatures also look odd. The next file starts within a few minutes and has much higher salinity. T1, T0, Sal and Fl were removed from scans.
File 3. Salinity cleaned lightly.
File 4. Salinity cleaned for single-point spikes and removed for a group of bad points.
File 5. Salinity was cleaned lightly..
File 6. No editing needed.
File 7. Temperature:Primary, Temperature:Secondary, Salinity and Fluorescence points were removed for scans 1-88 because the flow rate was very low.
File 8. Temperature:Primary, Temperature:Secondary, Salinity and Fluorescence points were removed for scans 1800-3592 because the flow rate was low (<0.6) and variable and the data look unreliable. A few points after flow suddenly resumed a rate >0.6 were also removed because data had not yet settled down.
File 9. Temperature:Primary, Temperature:Secondary, Salinity and Fluorescence points were removed for scans 1-6040 & 12343-16719 because the flow was low and falling steadily, eventually reaching zero. The data look very noisy and unreliable. Flow suddenly rose and stayed steady, though low at 0.6 until a slow drop-off started again.
File 10. Salinity was cleaned lightly.
File 11. Salinity cleaned for single-point spikes and removed for a group of bad points, of which there were many. The flow rate varied but was only <0.6 in the last 12 hours. The data seems ok though it is hard to judge.

The edited files were copied to *.EDT.
Plots were examined and no further editing was deemed necessary.

g.) Recalibration -

Summarizes observations file by file::

Files 1 & 2: The TSG salinity reads low by from 0.04 to 0.09 based on underway loop samples all of which were in Juan de Fuca Strait, and by ~0.145 based on CTD comparisons from offshore. Whatever went wrong might have been developing in Juan de Fuca so salinity was not as low as it was offshore when the differences appear to be reasonably steady in the CTD comparison. Adding 0.145 looks like an appropriate correction. The intake temperature is fine, so no temperature adjustment is required.

For files 4-5, the TSG reads lower than the CTD by a median of 0.007 but there is a range from 0 to 0.04; the only loop sample was while the CTD was stopped and shows the TSG

low by 0.007. In the absence of any underway information, a correction of +0.007 will be applied. The intake temperature is fine, so no temperature adjustment is required.

For files 7-10 the TSG is lower than the CTD by ~0.003 but the standard deviation is 0.009. The TSG is lower than the underway loops by from 0.004 to 0.04, with a median of 0.007. If 2 loops are excluded for which the flow was very low, the median is -0.006. The evidence is sketchy but a correction of +0.006 will be applied. The intake temperature is not usable, so a proxy will be created by subtracting 0.34C° from the lab temperature.

For file #11 the loops show salinity to be low by ~0.02 while the comparison with the single CTD cast shows it low by ~0.04. The flow was variable but mostly >0.6, except in the final 12 hours; there is no evidence that the data are bad. The salinity will be corrected by adding +0.02. The intake temperature is not usable, so a proxy will be created by subtracting 0.29C° from the lab temperature.

ADD CHANNEL was run to add channel Temperature:Lab which was set equal to Temperature:Primary.

Since Temperature:Intake is not usable for files #7-11, Temperature:Primary will serve as the proxy for Temperature:Intake, and needs to be recalibrated.in files #7-11.

File 2012-12-tsg-recal1.ccf was prepared to apply the following corrections:
Files 1-2: Salinity +0.145
Files 3-6: Salinity +0.007
Files 7-10: Salinity +0.006; Primary temperature -0.34
Files 11: Salinity +0.020; Primary temperature -0.29

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.
For files 6-11 channel Temperature:Secondary was also removed.
It took 2 runs to remove Scan Number because it had been converted twice.

The flow rate channel was not removed since there were flow problems and users may need the information.

HEADER EDIT was used to add a comment, change file names UPLOY0 to Flow_Rate and rename Temperature:Secondary as Temperature:Intake for files 1-6, change the DATA TYPE to THERMOSALINOGRAPH and add the depth of sampling to the header. 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.
Header Check was run to ensure calibrations were applied correctly and they were, but an error in the project name was discovered and fixed.

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

The final loop file 2012-12-che-surface-loops.csv was prepared by the chief scientist including data from the final CTD files and samples from the loop or from 5m bottles. Header comments were removed and added to file 2012-12-loop-header-comments.txt. The spreadsheet was then simplified by removing a few unnecessary columns and a 6-line header was added and the file was saved as 2012-12-che-surface-loops-6linehdr.csv. It was converted to IOS format, put through CLEAN and HEADEDIT to get start and stop times and positions, and to add general comments and specific comments for flagged values. The final file was named 2012-12-surface.loop. A track plot looks reasonable and a plot of salinity versus date looks right.

Particulars

1. Niskins #12-24 closed at surface for testing. Only Niskins #1-11 sampled.
3. Sample numbers wrong. Use #148-155 instead of #14-21. Analysts were notified.
45. Sample #s in log 14-27, but labels have wrong #s 22-35. Analysts were notified.
18. Niskins 16 and 17 were fired twice. The correct order is in the hydro file. Niskin 16 at Fire_Order 16 and Niskin 17 at Firing Order 17 should be deleted.
37. Niskin 4 was fired twice. The first time it was closed at the incorrect depth of 157 (should have been 151), the second time it was closed at 151. Niskin 3 was supposed to be closed at 158 but got closed at the surface.
61. Wrong depth in file.
71. Calibration cast
93. Argo calibration cast.

The following casts had Niskin bottles fired out of order: 5, 7, 14, 18, 22, 27, 31, 37, 42, 44, 50, 59, 60, 62, 76, 81, 83, 86, 102, 107.
The following casts include a PAR sensor: 1-14, 18, 27, 37, 42 - 44, 60, 62, 83 – 88.
Loops were taken at P11, P21 and P22 at the same time as the 5m Niskin.
Loops 1 to 7 were taken on the way back.
There was no loop 3.
Loop 7 was taken at P4 shortly after the repeat of the deep cast.
There were 11 TSG files. There were lots of problems with the flow to the TSG.

Institute of Ocean Sciences
CRUISE SUMMARY
CTDs

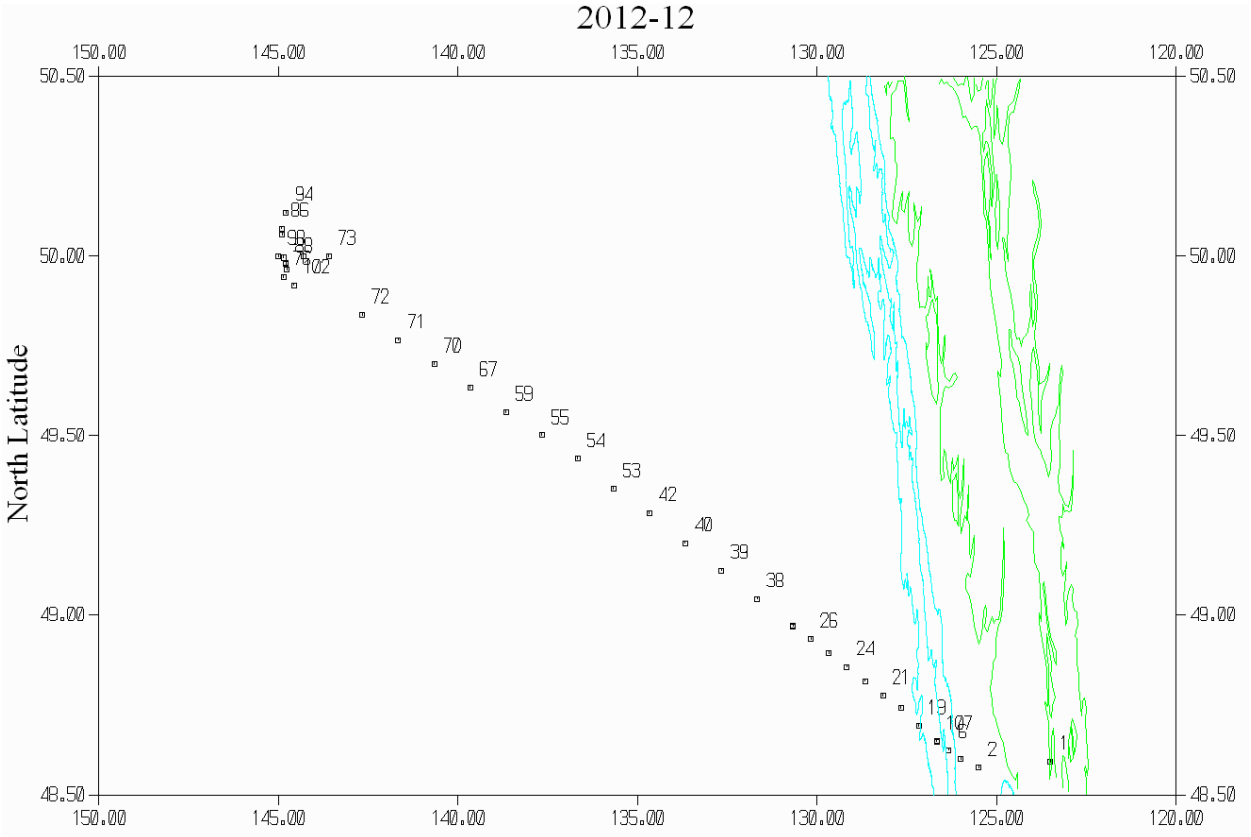
CTD#	Make	Model	Serial#	Used with Rosette?	CTD Calibration Sheet Competed?
1	SEABIRD	911+	0506	Yes	Yes

Calibration Information CTD #506					
Sensor		**Pre-Cruise**		**Post Cruise**	
Name	**S/N**	**Date**	**Location**	**Date**	**Location**
Temperature	**2023**	**5Apr2011**	**Factory**		
Conductivity	**2280**	**29Mar2011**	**Factory**		
Secondary Temp.	**2663**	**1Apr2011**	**Factory**		
Secondary Cond.	**2424**	**29Mar2011**	**Factory**		
Transmissometer	**1396DR**	**26Jan2012**	**IOS**		
SBE 43 DO sensor	**1119**	**29Mar2011**	**Factory**		
PAR	**4601**	**16Mar2011**	**IOS**		
SeaPoint Fluorometer	**2228**				
Eco-AFL Fluorometer	**2215**	**12May2012**			
Pressure Sensor	**69698**	**15Apr2011**	**Factory**		
Altimeter	**43281**				

TSG

Make/Model/Serial#: SEABIRD/21/2487 Cruise ID#: 2012-12

Calibration Information					
Sensor		**Pre-Cruise**		**Post Cruise**	
Name	**S/N**	**Date**	**Location**	**Date**	**Location**
Temperature	**2487**	**26Mar11**	**Factory**		
Conductivity	**2487**	**26Mar11**	**“**		
Wetlab/Wetstar FL	**WS3S-713P**	**1Feb12**	**IOS**		
Temperature:Secondary	**0603**	**03Mar11**	**“**		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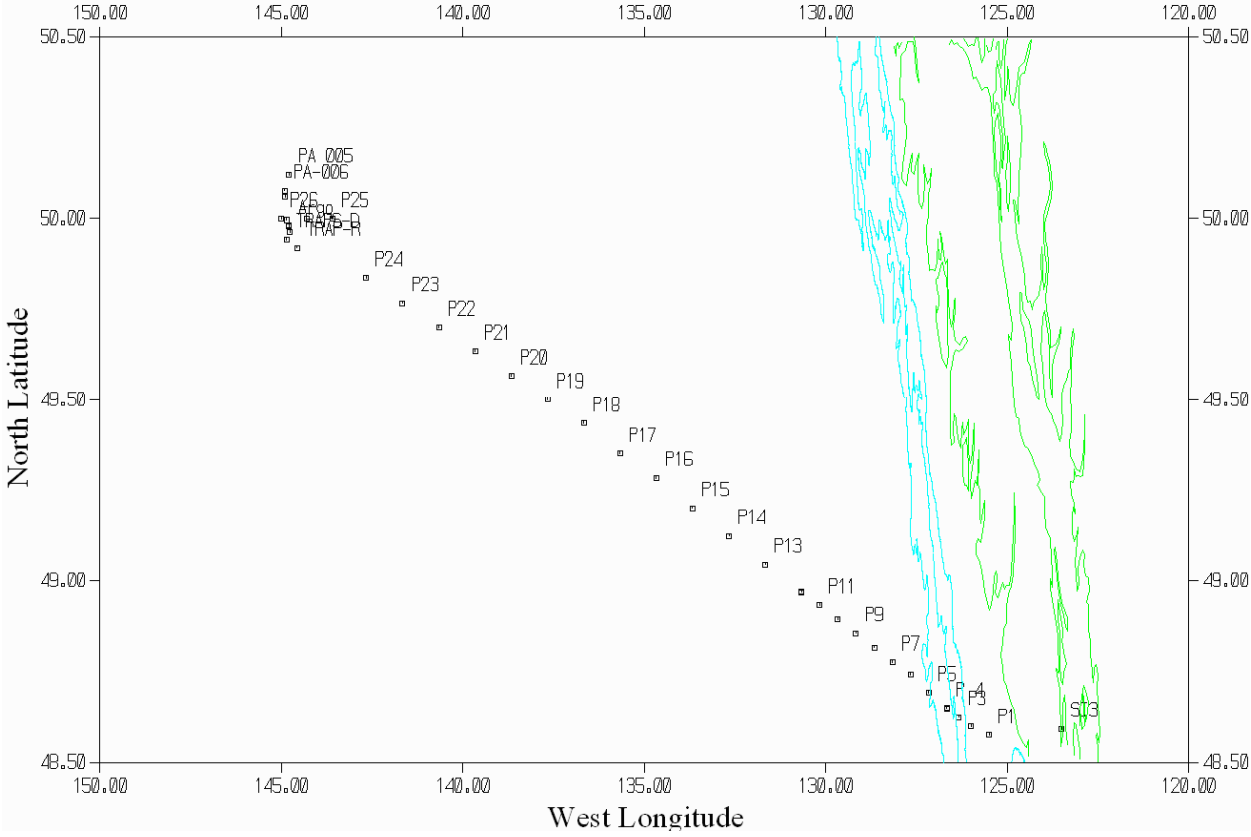
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P11
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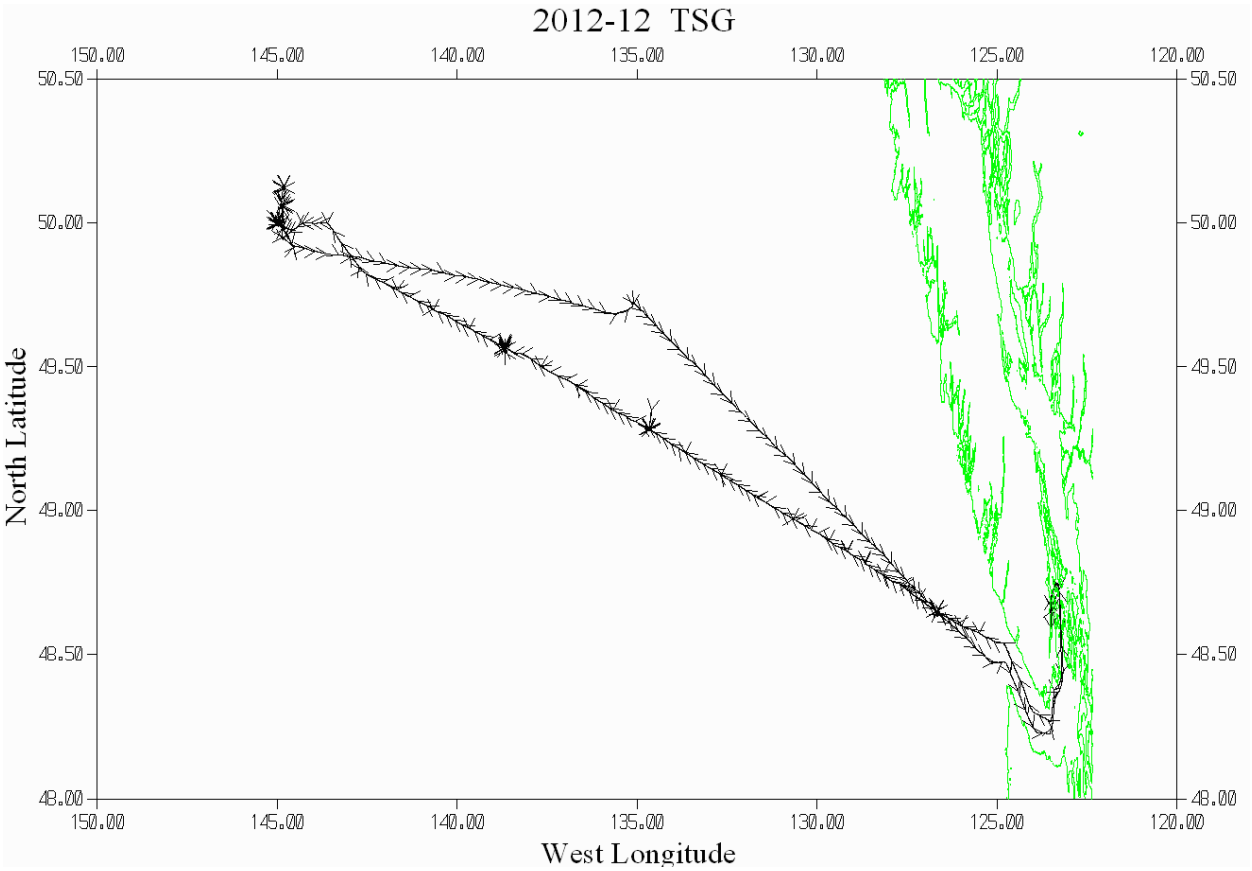
S13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