REVISION NOTICE TABLE

DATE	DESCRIPTION OF REVISION
8 July 2013	Corrections to Nitrate and Phosphate data; see headers for details.
11-Jun-2013	Added Iron profile files with cast numbers 8xxx from Keith Johnson's spreadsheet file which can be found in the cruise .DOC directory.
21-Jul-2011	Changed instrument serial number in the thermosalinograph files from 2487 to 3312 which was borrowed from the Arctic group.
18 August 2010	Transmissivity corrected; see end of report for details.
18 January 2010	Corrections to Dissolved Oxygen data in CHE files and 2009-04-oxygen-duplicates.xls. See end of report, after Particulars Section, for details.
7 Jan. 2010	Header Edit done to correct name BOTTLE_NUMBER in CHE files.
16 Nov. 2009	An error in transmissivity configuration was corrected. Original values removed and new values merged with file.

PROCESSING NOTES

Cruise: 2009-09
Agency: OSD
Location: North-East Pacific
Project: Line P
Party Chief: Robert M.
Platform: John P. Tully
Date: June 6, 2009 – June 23, 2009

Processed by: Germaine Gatien
Date of Processing: 13 July 2009 – 17 August 2009
Number of original CTD casts: 72* Number of CTD casts processed: 66
Number of bottle casts: 60* Number of bottle casts processed: 55
Number of original TSG files: 4 Number of TSG files processed: 4
* There were several cases of multiple files for a single cast due to computer crashes. They were combined to form a single file.

INSTRUMENT SUMMARY

A SeaBird Model SBE 911+ CTD (#0443) was used during this cruise. It was mounted in a rosette and attached were a Wetlabs CSTAR transmissometer (#1005DR), an SBE 43 DO sensor (#0997), a Seapoint Fluorometer (#2228) with a 10X cable (DO and FL both on the primary pump), 2 Biospherical QSP-400 PAR sensors (#4615 and 4601) and an altimeter (#1252). Two deck units were used –both were model 911+s (#619 for casts #87-94 and #508 for all other casts) and the logging computer was PAC 02588. All casts were done with the mid-ship winch. Seasave version 7.16 was used. The salinometer used was a model 8400B Autosal, serial # 68572.

A thermosalinograph (SeaBird 21 S/N 3312) was mounted with a Wetlab/Wetstar fluorometer (WS3S-713P); the remote temperature sensor was not connected.

SUMMARY OF QUALITY AND CONCERNS

The CTD and rosette logs were generally in good order though no information was entered about the thermosalinograph which was not the usual one for this ship.

Processing was extremely complicated because of frequent computer crashes which resulted in multiple files produced to obtain a single cast. Bottle sampling was also disrupted, so great care was needed to obtain useful files. The sampling notes from the chief scientist were invaluable in dealing with these problems.

Sea-Bird have a new algorithm for calculating dissolved oxygen with several parameters that need fine-tuning for each instrument to produce the best data. This requires bottle samples from deep casts, which were available for this cruise. The tests were done and the results should be usable for other cruises until the next recalibration.

The results of the dissolved oxygen titrations were sent as ADD files with some errors in formatting and some data entered incorrectly or missing. Some of these errors could be avoided by sending the data in spreadsheet format (with flag and comment columns), thus leaving the preparation of ADD files as part of the processing job. The spreadsheet would be archived so information about the details such as flask numbers would be available there.

Most of the salinity analysis was done using an Autosal at IOS, but some samples were run at sea using a Portasal. No standard water was available at sea, so the analyst used deep water for that purpose. The pattern of differences between the Portasal samples and the CTD salinity channels is very similar to that found using the Autosal samples, with little pressure dependence but significant time dependence in the secondary CTD salinity. However, the Portasal samples are consistently higher by about 0.012 units. This result lends confidence in the analyses by both salinometers, though clearly there needs to be some means of checking the Portasal offsets by either taking duplicates for later analysis at IOS, or having large sets of both types of data (distributed through the cruise) for later comparison.

The precision of the SBE dissolved oxygen channel is difficult to estimate because the comparison with bottles was very noisy, but roughly, the DO should be considered:

- *±0.4ml/l from 0- 150db*
- *±0.08ml/l from 150- 450db*
- *±0.04ml/l from 450-2000db*
- *±0.1ml/l below 2000db*

Note that the residual noise in the Dissolved Oxygen signal is amplified by the use of the Tau correction, particularly at depth, resulting in noise ~±0.01ml/l after metre-averaging. The correction was applied to improve the response in the high-gradient zone.

Upcast data were selected for cast #89 because the pumps did not come until the CTD was at 206db of the downcast.

There was excellent agreement between the loop salinity and extracted chlorophyll and corresponding surface CTD rosette samples. This shows that there is no significant amount of freshwater getting into the loop. Furthermore, this result supports using the rosette data for recalibration of the Thermosalinograph data; that is very useful since there are many more samples available from the rosette than from the loop.

There are 4 thermosalinograph files. The sampling interval was 5s which makes the files large and so unwieldy that the 4^{th} file had to be split to enable processing. At the end of processing the files were thinned to produce the usual 30s sampling interval and the files that had been split were rejoined.

The intake thermistor was not hooked up and no flow meter data were logged. The fluorometer channel was removed from the first 13 hours of the TSG record because the signal is extremely flat during a time when 4 loop samples show much higher values and variability. There is a sudden spike in the fluorescence at the time of the stop at station P1 and the data thereafter look reasonable. There was no note in the log of any problem noted with the TSG at that point. Flow meter data would have helped determine if the temperature and salinity data were also likely affected. The loop salinity data are confusing with two samples looking reasonably close to the TSG and 2 very different. Temperature and salinity data were left in the file, but caution should be used in interpreting this data. Salinity was cleaned lightly. Intake temperature was calculated by subtracting 0.16Cº from the lab temperature. This estimate was based on comparison with CTD data and past experience of ship heating on the TULLY at this time of year. Salinity was increased by 0.018 based on loop and CTD rosette samples.

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 a summary from the Chief Scientist of problems and points of interest with reference to processing. There were many problems with the acquisition computer resulting in several files for a single cast. Care will be needed to patch together the complete CTD and CHE files. Spreadsheet "files_prep_sheet.xls" was prepared to help keep track of the combining and deletion of files.

Other points to note are that the PAR was changed for cast #75 and the cruise number is wrong in the headers of files 1 and 14-22.

Extracted chlorophyll, nutrients, Autosal salinity and Portasal salinity and DMS data were obtained in spreadsheet format.

The titrated dissolved oxygen files were provided in individual ADD files with a flag channel but no flags were entered. There is a format problem with the comment entered for file #58. Both values were entered when there were duplicates. There are several samples which do not agree with the rosette sheet, so all entries will have to be checked.

The cruise summary sheet was completed.
The histories of the conductivity, pressure and DO sensors were obtained.

Two configuration files were prepared:
2009-09-ctd1.con – for all casts except #75 using PAR 4615
2009-09-ctd2.con – for cast #75 using PAR 4601

The calibration constants were checked for all instruments. There were a number of problems:

- The calibration information for dissolved oxygen sensor #0997 had the old Owens-Millard parameters. These were replaced with the new Sea-Bird parameters. The values for E, H1 and H3 are nominal. There is deep data available so these should be fine-tuned.
- The transmissivity date and parameters used at sea are wrong. These same values have been used for a few other cruises and the source of the information is unknown. The correct parameters were entered. (**Note: In November 2009 it was discovered that the old values had been inadvertently used in the conversion for all casts except #75, so the transmissivity was reconverted and substituted in the final CTD and CHE files**.)
- The pressure offset for CTD #0443 has been drifting, and for other recent cruises a setting of +6.7db has been used.
- A Surface PAR is included in the configuration file, but is not mentioned in the log book and a few casts tested had no signal in that channel, so it will not be converted.

3. Tests for DO parameters

One deep file (#71) was converted to see if varying the H1 and H3 parameters would reduce hysteresis. It was found that using -0.028 was slightly more effective than the default value of -0.033 for H1. For H3 a choice of 1350s is slightly better than the default value of 1450s. So the configuration file 2009-09-ctd1.con was adjusted to make H1= -0.028 and H3= 1350s.

Next tests were run varying E.

- First a downcast file was converted using E=3.6 and 3.8 and the resulting DO profiles were plotted together. There was no noticeable difference in hysteresis.
- Next, rosette files were converted for cast #71 using E=3.4, 3.6 and 3.8 and then SAM files were created, averaged and merged with the DO titrated data. Comparisons were made to the bottle values. The R^2 value for the fit of bottles to CTD DO was highest for 3.6 and lowest for 3.8, so two more runs using 3.5 and 3.55 were done. E=3.55 had the largest R^2 value. As another check two bottles were examined that had DO values of ~3ml/l, one at 150db and one at 4000db, so well above and well below the DO minimum. Looking at the % differences between bottle and CTD DO values, the best choice looks like E=3.6 because the corrections are closer than for E=3.55. However, basing a choice on just two values is risky.
- A second cast, #43, was examined using just two runs, E=3.55 and 3.6, and once again E=3.55 produced the least scatter. The differences between bottle and CTD for two levels with similar DO values above and below the DO minimum were very different, so this test does not look very useful unless there are more bottles available then from this cruise.

The best choice looks like 3.55 for E.
The configuration files were adjusted by setting E=3.55. The history file for this sensor was edited to add this information since these values should be consistent from cruise to cruise.

Tests were run on cast #71 to see if the TAU correction should be applied. The correction had good results in the high gradient zone around 100 to 300db, with a sharper gradient and upcast and downcast closer. At a depth of 4000db the noise level in the corrected data is up to ±0.015ml/l and after metre-averaging it is <±0.01ml/l. Those extremes are from noisy patches, so much of the data have lower noise levels. The TAU correction also produces higher DO values at depth, but the differences are small and closer to the bottle values, so this does not look like a problem. The improvement in the high gradient zone looks sufficient to justify the noise at depth, particularly since scientists tend to rely on the titrated bottle data at depth.

4. Conversion of Raw Data

Data were converted using the configuration files 2009-09-ctd1.con and 2009-09-ctd2.con.
A few casts were examined and all expected channels are present.

- The two temperature channels are generally very close during the downcast, but there are some spikes in the primary. The upcast data are much noisier so there are significant differences. Again spikes in the primary temperature are unusually large during the upcast. Could this be caused by having both dissolved oxygen and fluorescence connected to the primary pump affecting its efficiency? Conductivity is similar in spikiness, but the two channels are further apart than usual even during downcasts.
- The fluorescence looks smoother than usual with a dark value of about 0.13.
- Dissolved oxygen voltage has the usual offset between downcast and upcast.
- PAR look fine.
- The transmissivity has little hysteresis and only small spikes.
- The altimetry looks useful for some casts, but for most the CTD did not come near the bottom.
- There is a pH channel but all data has negative values and mirrors the temperature in profile. Scott Rose confirms that it was not actually mounted. Conversion was rerun without it.

Rosette files were converted using a start time of -5s and duration of 10s. The TAU correction was used. The cruise number was fixed in the headers of files 1 and 15-22.

The rosette files were then converted to IOS SHELL files. CLEAN was run to add event numbers, with output named *.BOT.
Temperature and salinity were plotted for all BOT files and a few outliers were noted for 6 casts (6, 39, 43, 45, 71 and 74). CTDEDIT was used to clean a few points in salinity for those casts – in 2 cases in the primary salinity and for 4, the secondary. The output files were then copied to *.BOT. Editing details were added to the header comments.

5. WILDEDIT

Program WILDEDIT was run to remove spikes from the pressure, conductivity and temperature channels only. Parameters used were: Pass 1 Std Dev = 2 Pass 2 Std Dev = 5 Points per block = 50

6. CELLTM

Tests were run comparing a variety of settings for CELLTM. The results were difficult to judge because the best setting varied from depth to depth and from cast to cast.
The best choice overall proved to be (α = 0.03, β=9) for the primary and (0.02, 7) for the secondary. CELLTM was run on all casts using those values.
The cruise number was fixed in the headers of files 1 and 14-22.

7. 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.

8. 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 often noisy so these are rough estimates.

Cast #	Press	T1-T0	C1-C0	S1-S0	Descent Rate
16	1000	-0.0003 N	+0.0010	+0.0121	High, noisy
	2000	~0 VN	+0.0011	+0.0126	
25	1000	-0.0004	+0.0008 N	+0.0097 N	High, moderate
	2000	~0 (±.0005)	+0.0008 N	+0.0105 N	
	3000	~0 (±.00025)	+0.0009	+0.0109	
43	1000	-0.0001 N	+0.0010	+0.0123	V. High, moderate
	2000	+0.0002	+0.0011	+0.0128	
	3000	+0.0002	+0.0011	+0.0132	
58	1000	-0.0001	+0.0011	+0.0127	V. High, moderate
	2000	+0.0003	+0.0011	+0.0133	
	3000	+0.0002	+0.0012	+0.0136	
	4000	+0.0002	+0.0012	+0.0140	
81	1000	~0 N	+0.0012	+0.0140	High, noisy
	2000	+0.0002	+0.0012	+0.0142	
93	1000	-0.0002	+0.0012	+0.0145	V. High, noisy
	2000	-0.0001	+0.0012	+0.0151	

There are slight variations with pressure, the conductivity and salinity differences being a little higher at depth. Time variations are complex. The conductivity and salinity differences are a little lower for cast

#25 than for #16, but otherwise they grow with time. These changes suggest that one of the conductivity cells had problems.
The temperature differences are quite noisy but are fairly small on average. Conductivity differences are higher than usual with some suggestion of time dependence. Salinity differences are also high.

9. 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 using linear interpolation based on scan number.

10. Checking Headers

The header check was run. No problems were found.
The cross-reference check was compared with the log book, and no errors were found.
The cruise track was plotted and added to the end of this report. No problems were found.

The surface values program was run. The average surface pressure was 2.03db. This seems a little low. For one cast the CTD was held near the surface with the pumps on at the end of the upcast and the salinity is ~31. For cast #73, there are some data at pressure -0.18db with pumps on. The salinity values are very low, so this must be right at the surface. The pressure offset entered in the configuration file is 6.5db whereas 6.7db has been used for cruises since August 2008. The pressure seems low by at least 0.2db and maybe a little more. So, it looks like it is time to increase the offset slightly. When the data are recalibrated 0.3db should be added to the pressure for a net offset of +6.8db.

The altimeter readings from the headers of the CLN files were exported to a spreadsheet and all casts with readings were checked. Plots were made and the log book was checked. The algorithm worked well where the CTD got close to the bottom, but it recorded erroneous low values for some casts when it did not get close to the bottom according to the log. The altimetry headers were removed from the CLN files of casts 50 and 77 because the algorithm didn't work well.
The water depth was missing from some files; entries were added (based on the log book entries) to the headers of casts #52, 53, 77 and 94.

11. BOTTLE FILE PREPARATION

The altimeter readings from the headers of the BOT files were exported to a spreadsheet and all casts with readings were checked. Plots were made and the log book was checked. The algorithm worked well where the CTD got close to the bottom, but it recorded erroneous low values for many casts when it did not get close to the bottom according to the log. The altimetry headers were removed from the BOT files for casts #6, 16, 50, 53, 88 and 89 because the algorithm didn't work well.
The water depth was added to the headers of casts #53, 77 and 94.

The BOT files were averaged to enable an addsamp file to be created. This file was edited to add sample numbers taken from the rosette sheets. A few problems were encountered (some were only found when COMPARE was run):

- Cast #23 – There were 2 surface bottles in the rosette file, but only one noted in the log. So it is assumed that the sample was from bottle #1 and the other was removed from the addsamp file.
- Cast #49/50 – Sample #340 should be assigned to cast #50 for now, but that file will later be renamed as #49.
- Cast #53/56 – Sample #342 is listed for both but it looks like they belong to 56. The sample for #53 should be 341.
- Casts #73/74 – Though 2 salinity samples were from cast #73, they will be assigned to cast #74 because there were computer problems during the first cast.

- Casts 82/83 – Repeat cast due to rosette problems - Bottles #1-15 belong to cast #82 and 16-24 to cast #83. Later these will be combined in a single file.
- Cast #90– 3 bottles (from ~75db, 7db & 7db) were fired, but only one indicated in log. The sample is said to be from the surface and Niskins #2 and #3 are near the surface. There are loop samples support this being a surface sample, but the gradients are not large here and there could be an error. An assumption was made that the samples are from Niskin #3, but a "c" flag was attached to all samples along with a comment indicating there is uncertainty about which bottle was sampled.
- Cast 94 – 3 bottles but only one sample number for each of these casts, log notes 2 deep samples taken for Kendra, so assume Niskin #3 is the surface sample.
- Cast #100 – bottle fired but no sample number assigned. Drop from cast list.

After those corrections were made to the addsamp.csv file, it was converted to CST files to be used as a framework for the bottle files. It was also used to add sample numbers to the BOT files. The SAM files were then bin-averaged.

At this point the bottle files affected by computer crashes and rosette problems were examined. Some files had to be renamed, deleted or combined. The cast list was adjusted as needed. Header comments were added to explain the steps taken and the event number in the header adjusted where appropriate. The addsamp file also needed to be fixed and CST files recreated to enable the merging with sample files.

- File #49 and 50 are from the same site and level. #50 was run only to close the surface bottle, but the samples were identified as #49. The BOT and SAM files from #49 were deleted and the second BOT and SAM files were renamed as #49 so they are associated with the full CTD cast #49.
- File #53 was renamed as #52 to match samples and the full data file. There was only one bottle file and the only bottle fired was at the surface.
- Cast #73 was deleted. There were 2 salinity samples gathered during that cast, but due to rosette problems there were no CTD data to match some of the bottles fired. The cast was rerun as #74, so the salinity samples were assigned to that cast. All other samples were gathered during #74.
- There was a computer crash during cast #76 at the surface. There was no IOS sampling at the surface, but we need to produce some surface data to match the needs of other investigators. The lines for bottles #11 and 12 from file #77 were added to file #76. Cast #77 was then deleted. Cast #76 was put through CLEAN to fix headers. SAM, SAMAVG and BOT were all combined.
- There was a problem with Niskin firings during cast #82; the water from bottles #16-24 was emptied, the other bottles were left closed and another cast was run to collect water for bottles 16-24. So the data from 2009-09-0083.samavg for bottles 16-24 were used to replace the data for those lines in 2009-09-0082.samavg. Note that the samples are not in pressure order.

Note that these adjustments required changes to BOT, SAM and SAMAVG files, cast lists and sample files such as SAL. There is a lot of room for error, and most changes were made early but a number of errors were found later. Those late changes may not be reflected in the header history.

<u>SALINITY</u>
Salinity analysis was done at IOS using Guildline Autosal #Model 8400B, serial # 68572 and at sea using Portasal #68627.

AUTOSAL DATA
The Autosal data were delivered in spreadsheet format and included duplicates and loop samples in file 2009-09June_Salinity Data Final_Mary Steel.xls. Mary reported that the equipment worked well with no stability problems. The samples were generally in good order with just a few cases of leaking bottles which are noted in the comments. The loop data were copied to spreadsheet 2009-09-sal-loop.csv.

The duplicates were copied to a separate spreadsheet, 2009-09-salinity-duplicates.csv. An error was found in the rosette summary page as sample #142 was reported to be a duplicate but the values were quite different and the analyst did not attach a flag “f”. The second sample should have been listed as from sample #14. The two values for #14 were found in the data logger results and entered in the duplicate spreadsheet. Sample #142 was removed from the duplicate spreadsheet.

The data logger sheet was saved as 2009-09-sal.csv. The loop and Go-Flo data were removed and the duplicates were replaced with the averages. The comments were transferred from the rosette sheet to this spreadsheet. One comment appears to have been placed on the wrong line since there is no sample #30. It was applied to #29 and the analyst confirms that is appropriate. The file was saved as 2009-09-sal.csv. Some adjustments had to be made to the salinity files to make samples numbers match the right cast numbers as noted in the previous section.

PORTASAL DATA

The Portasal data analyzed at sea were saved as “2009-09-SAL2-Port.txt”. This was opened in EXCEL. Some entries did not line up normally – those were corrected and lines with no data were removed. The data were reordered on sample number. Flag and comment channels were added, a flag “d’ was entered for all samples together with a comment that the data were analyzed without standard water. Deep water was used to calibrate the salinometer. There were 2 entries for most samples and more for some. A few problems were found and the following actions taken with the working spreadsheet 2009-09-sal-port.csv:

- There are 9 entries for sample #86 in the spreadsheet, but entries are missing for #87 and 88. The logsheet entries were averaged and entered.
- The two values identified as sample #18 are assumed to be #118 since that one is missing, the value is the same as on the Portasal Analysis Logsheet for that sample, and the time of the analysis is between #117 and #119.
- There are 3 values for sample #123; the first looks bad, so was deleted.
- There was only 1 value in the spreadsheet for sample #323 but there are two values on the logsheet, so the second value was added to the spreadsheet.
- There were 3 values for sample #389, but the first was scratched out on the logsheet, so was also removed from the spreadsheet.
- There are 2 readings for #547 in the spreadsheet and logsheet – the 2nd looks out of line, so was removed from the spreadsheet.
- There were 5 readings for #549 – looks unstable. Already flagged “d”, so just comment added.
- There are 3 values for #550 in the spreadsheet and logsheet – the 2nd looks out of line, so was removed from the spreadsheet.
- There are 5 values for #551 in the spreadsheet and 4 in the logsheet. The 3rd and 4th values from the log sheet were selected and the others removed from the spreadsheet.
- There are 6 values for #552 that never settle down. They were all averaged, and a comment added that the readings were unstable.
- There are 5 values for #553 that never settle down. They were all averaged, and a comment added that the readings were unstable.
- There are 3 readings for #554 in the spreadsheet and 4 on the logsheet – the missing one does not look any more out of line than the others - average all and mark as unstable.
- There are 3 readings for #555 –1st looks out of line, so was removed from the spreadsheet.
- There were 5 readings for #556, but last two look stable, so use those.
- There were 4 readings for #557 – 3rd out of line, so others averaged.
- There were 5 readings in the spreadsheet for #562 but only 3 on the logsheet and those look reasonably close, so the others were removed.

- For #563 it looks like 2 lines were repeated in spreadsheet –they were removed.
- There were 4 entries for #564 – the last 3 look stable so first was removed.

The data were averaged and unnecessary columns were removed.

The only one of these casts affected by the problems with crashes and rosette failures detailed above is #82 which needs to have the bottles of #83 added to it. This was done manually using a text editor to fix the CST file. The SAL file is ok because the spreadsheet had the two casts combined already. The SAM AVG file has already been combined as well.

The data were then converted to individual SALP files, merged with the CST files, then put through CLEAN and merged with the SAMAVG files.

Salinity Studies

(i) There were 7 pairs of duplicates that were analyzed on the Autosal. Using all Sp=0.0027 where Sp is defined as:

Sp = Square Root (sum of squares of differences / 2*number of pairs)

When 1 outlier (difference >0.01) was removed Sp=0.0018. For comparison, during 2007-26 the results were Sp=0.0017 using 7 pairs, and 0.0005 when one pair was excluded as an outlier. A "c" flag was attached to the outlier. The standard deviation is 0.005 using all data and 0.0028 excluding the outlier.

(ii) There were no duplicate samples analyzed on the Portasal.

(iii) There were no cases for which there was a sample analyzed on each of the Autosal and the Portasal.

(iv) From cast #91 there are 22 samples from about 2000db which were analyzed on the Autosal. The standard deviation of the CTD salinity during the 10s centered on the firing time was <0.0003 for all stops in both channels. The standard deviation in the bottle salinity was 0.008, but when one obvious outlier was removed it was 0.0017. For cast #62 there were 12 bottles fired around 1000db with CTD standard deviation of about 0.0003 for both CTD channels and all stops. The standard deviation in the bottle values is 0.0025, and when 2 minor outliers are excluded it is 0.0006.

(v) For cast #13, 14/15, 34, 35, 45, 47, 61, 81, 82 there are multiple salinity samples from single depths analyzed on the Portasal. The standard deviations for those below 20db were all less then <0.0018 except for cast #82 which had many unstable readings. For 10 of the 14 levels it was <0.001. So the repeatability is similar to that of the Autosal.

Conclusions

The repeatability looks very good from the CTD at depth, so the deep repeat bottles can be used to estimate that the errors from sampling and analysis are ~±0.002 for both salinometers. The duplicate study suggests higher errors, ~0.003. The analyst reported good stability from the Autosal, so it is hoped that the errors from the instrument are within the ±0.002 accuracy expected for the instrument. Some of the error is likely from sampling problems. The large number of bottles available for comparison should reduce the effects of that type of error.

DISSOLVED OXGYEN

Dissolved oxygen files (*.add) were provided, but there many problems with them.

- Where there are comments in the headers the format is wrong.
- When the rosette sheets are compared with the ADD files there are significant differences for sample #1 (0.2 in file, 0 on sheet), and #141 (0 in file, 3.199 on sheet)
- Many samples are missing that are shown on the rosette sheets.

Many of these problems arise because of the sample numbers given to duplicates not fitting the header formats in the OXY files. For example using format "44a" is not F6.0 format. The OXY files were copied to a test folder and duplicate samples were renamed in the format 44 and 9044. Then the data were exported to spreadsheet 2009-09-oxy.csv. Duplicates were copied to file 2009-09_oxy_duplicates.xls. The duplicates were averaged in the main spreadsheet and flag "f" attached. For sample #4 flags "f" and "c" were attached since the differences were much >10%, though the average was very low so this may not be significant. The pooled standard deviation of pairs of samples (Sp) was calculated by Sp = SQRT{sum (d*d)/2k} where k = no. of pairs and d = difference between pairs. When the 7 duplicates were used Sp = 0.010 and when sample #4 is excluded Sp = 0.008. These results are better than usual. (Note duplicate analysis was redone later by DO analyst using other criteria.)

The main spreadsheet was then converted to individual ADD files. Two minor problems were noted in the ADD files:

- Sample # 1 value differs from the rosette sheet. A comment was added but the value was not changed.
- Sample #141 entered twice, as 0.000 and 3.199 – the zero value was removed.

NUTRIENTS

The nutrient data were obtained in spreadsheet QF2009-09nuts.xls (later replaced by QF2009-09nutsrev1jebc.xls) which included a report on precisions. The file was simplified and saved as 2009-09nuts.csv. Extraneous columns were removed and header names were changed to standard format. Data were sorted on sample number. File 2009-09-nuts.csv was then converted to individual NUT files. There were loop samples in the original file; those were saved separately as 2009-09nuts-loop.csv.

EXTRACTED CHLOROPHYLL

Extracted chlorophyll data were obtained in file QF2009-09CHL.xls which included a report on precision. The file was edited to remove extraneous lines and columns, header names were changed to standard format, the file was sorted on sample number, and saved as 2009-09-chl.csv. There were loop samples in the main file; they were saved separately as 2009-09CHL-loop.csv.

DMS

DMS data were obtained in file DMS 2009-09 summary.xls. The file was saved as 2009-09-dms.csv and edited. There were flags and comments, but the flags were not in the usual format. After consultation with the analyst, those values with superscript 1 were flagged "c" and those with superscript 2 were flagged e and the values were replaced with pad values. All entries "<" were replaced with "0"; a note in the header will explain that the minimum detectable level is 0.1. Where there were duplicates they were averaged to get a single value for each bottle and an "f" flag was added. Headers were changed to standard format and unnecessary columns were removed. The file was then converted to individual DMS files.

The SAL, CHL, ADD, NUT and DMS files were merged with CST files in five steps. After the 5th step the files were put through CLEAN to reduce the headers to File and Comment sections only. That file was then merged with SAMAVG files (Output:MRG) and then put through CLEAN to remove Sea-Bird headers and comments from the secondary files.

Data were exported to spreadsheet 2009-09-che-bottles.xls and compared to the rosette sheets to ensure all expected data are present. A few problems were found – some missing or inappropriate "i" flags and the files from casts 82 and 83 hadn't been combined as needed. There is no nutrient sample #363 though it is indicated on the rosette sheet, but it appears there was no intention of taking that sample.

After those problems were addressed, CLEAN was rerun and a data exported again and found to be ok.

11) Compare

<u>Salinity</u>

AUTOSAL

Compare was run early using only the Autosal data. The results were surprising, with very large differences for both. When data from above 200db plus 2 outliers are excluded from the fits, the primary salinity was found to be low by 0.02 and the secondary by 0.007 with standard deviations in the differences of 0.0025 and 0.0028, respectively.

Looking at time dependence is a little trickier due to there being much shallower sampling at the very beginning and end of the cruise. When the same data were included as in the fits against pressure, the secondary differences appear to be getting smaller towards the end of the cruise, while there is no significant change in the primary. When data from a small pressure range were selected the same effect is seen. Using data from ~1000db, a fit was found that indicates the differences between bottles and CTD salinity are as follows for 2 casts that were studied in the tests described in section 8:

	Sal0-Sal_BOT from fit	Sal1-Sal_BOT from fit	Sal1-Sal0 from fit	Sal1-Sal0 from downcast see §8
Cast #16	-0.02088	-0.0094	0.0115	+0.0121
Cast #93	-0.01913	-0.0044	0.0147	+0.0145

So the drift in the secondary salinity accounts for most of the change. It is interesting that the drift is towards smaller errors for the secondary sensor pair.

The comparison of Autosal bottles with CTD turned up 1 severe outlier:
Cast #91, Sample #594 – multiple bottles were fired at 2000db – so very clear outlier. Flagged "d".

There were other minor outliers, some of which are probably explained by the noisy CTD salinity judging by the standard deviations. Samples #13 and 340 had already been flagged "c" due to leaky bottles, so notes were added indicating they were outliers in COMPARE. For the following samples a "c" flag was added along with a note of explanation.

- Cast #3, Sample # 14
- Cast #25, Sample #165
- Cast #43, Sample #292

(See 2009-09-sal-comp1A.xls.)

PORTASAL

COMPARE was run using only the samples run on the Portasal. There were samples from 9 casts with multiple bottles from 1 or 2 levels each. So the range of values is limited.

The primary CTD salinity was found to be lower than the bottles by an average of 0.032 and the secondary by 0.020. The primary differences were quite flat with pressure, but the secondary showed some time dependence. While there was instability in the sampling for the final cast, this does not seem to be a factor since the most of the primary differences for that cast are in line with other casts.

The Portasal bottles paint the same picture as the Autosal bottles except that the Portasal differences are about 0.012 lower for both sensor pairs. The consistency is encouraging and leads to the conclusion that the Portasal was reading high by 0.012. It is particularly encouraging that both sets of bottles show that the secondary CTD salinity calibration was drifting while the primary was not. Subtracting 0.012 from each of the Portasal values and then putting both Autosal and Portasal through the same recalibration will produce the best data possible, but it is still advisable to flag the Portasal values. (See 2009-09-sal-port-comp1.xls.).

The Portasal data in the spreadsheets were adjusted by subtracting 0.012 from each value. The data were reconverted and once again COMPARE was run and showed that the adjustment had been done correctly. (See 2009-09-sal-port-comp1-recal.xls.). (It was later discovered that 0.011 was subtracted rather than 0.012, so a further 0.001 was subtracted from the Portasal bottle salinity using CALIBRATE.)
The SAL files were copied to the main hydro folder and merges were rerun on the Portasal casts only so these data are included in the final bottle files, but so that the corrections done earlier were not lost.

Dissolved Oxygen –
COMPARE was run for Dissolved Oxygen.
The following outliers were examined to see if flags are appropriate:

- Cast #1, Sample 9, ~25db –Bottle slightly off in fit of DO vs Salinity. CTD DO was rising at time of firing, maybe still recovering from a shed wake, but that would not account for this large a difference. Flag “c”.
- Cast #3, Sample 14, ~100db – Bottle off in fit of DO vs Salinity. Value looks like it might be a mis-sample from one of the 75db bottles. Flag “d”
- Cast #3, Samples15 and 16 - the rosette sheet suggests they were really #17 and 18. Notes on samples indicated they were both from 75m, so sample numbers were changed and a “c” flag attached to each. Pad values were entered for 15 and 16.
- Cast #20, Sample 129, ~2000db – SBE DO looks very high and noisy at the bottom, but temperature was falling and DO rising towards the end of the bottle stop, so the problem may not be entirely due to poor SBE data. It is possible that there is a mismatch due to incomplete equilibration. A note was entered in the header, but no flag is justified.
- Cast #20, Sample 130, ~1500db – SBE DO looks a little high but it was still falling as the bottle was fired (and temperature was falling) so the bottle may be fine. A note was entered in the header, but no flag is justified.
- Cast #20, Sample 141, ~150db – Bottle is an outlier in profile and in DO vs Salinity plot. Flag “c”.
- Cast #20, Sample 145, ~50db – Bottle looks off in profile and in plot of DO vs Salinity. Flag “c”.
- Cast #20, Sample 146, ~25db – Bottle looks off in profile and in plot of DO vs Salinity. Flag “c”.

A fit was done excluding points below 1200db as a way to check for hysteresis. The red points are below the DO minimum and the green above. When we exclude the outliers noted above, the results look satisfactory. Another plot was done with points from P>3000db in red and they cluster either side of green points, so there is no need to exclude that data from the fit.

A few other outliers were excluded based on residuals and the fit was:

CTD_BOT = 1.0528 DOX_CTD - 0.0305

(See 2009-09-dox-comp1.xls.)

Plots were made of CTD Dissolved Oxygen and Titrated Dissolved Oxygen versus salinity. The only significant outliers were from bottles that had already been noted above.

Fluorescence
COMPARE was run using the CTD Fluorescence and the Titrated Chlorophyll from bottles. Plots were prepared of titrated CHLa versus CTD FL, the FL/CHL ratio versus event # and differences versus Fluorescence and pressure. There is a distinct difference between the near-shore casts and those offshore. The range of chlorophyll is very low offshore, with a maximum of 0.93ug/l and most values much lower than that. From cast #18 to 94 the fits look fairly tight with fluorescence averaging 2.5 times the extracted

chlorophyll. For casts #1 -6 the fluorescence is mostly lower than the chlorophyll and from casts #6-17 the results are similar to the offshore casts except that some surface values look like the near-shore ones. (See 2009-09-chl-fluor-comp.xls.)

13. Shift

Fluorescence

The usual method to find what shift is needed for the fluorescence is to examine upcast and downcast profiles for a few casts to determine the vertical offset of the temperature and fluorescence traces. The differences between these two offsets are treated as a measure of how much the fluorescence needs to be shifted. The "excess" offset for the fluorescence was divided by the sum of the descent and ascent rates to find the shift (in seconds) to remove that offset. This is usually a rough estimate as the upcast data are usually noisy, but for this cruise the results were clear, with the usual shift of 1s found to be appropriate. SHIFT was run on all casts to advance the fluorescence channel by +24 records. (Output: SHFFL)

Conductivity

Tests were run on the conductivity sensors for 3 casts using a variety of shifts. The best choice varies from feature to feature and from cast to cast. Settings of -0.2s and -0.7s worked best overall for the primary and secondary channels, respectively. SHIFT was run using those settings.

Dissolved Oxygen

Tests were run on a few casts for each sensor to determine the best SHIFT value to apply to the Dissolved Oxygen channel. This was judged by how the vertical offset between downcast and upcast traces compares with that of the temperature. Because there is an offset in values between upcast and downcast due to the time response, alignment will not produce traces that overlie each other exactly. Distinctive features aid this judgment. A value of +60 seemed best.
SHIFT was run using +60 records for all casts.

14. DELETE

The following DELETE parameters were used:

Surface Record Removal: Last Press Min
Maximum Surface Pressure (relative): 10.00
Surface Pressure Tolerance: 1.0 Pressure filtered over 15 points
Swells deleted. Warning message if pressure difference of 2.00
Drop rates < 0.30m/s (calculated over 11 points) will be deleted.
Drop rate applies in the range: 10db to 10db less than the maximum pressure
Sample interval = 0.042 seconds. (taken from header)

COMMENTS ON WARNINGS: The only warnings were for casts #50, 53 and 77 which contained only upcast data, so will not be processed further.

At this point the files were combined for casts interrupted during the downcasts and a few other files were deleted:

- Casts #14 / #15 were renamed 15.del1 and 15.del2, records were removed to avoid an overlap and the files were joined to make 15.del. Comments about this were entered in the header of the output file.
- Cast #50 contained only surface data so the file will not be processed further.
- Casts #51 / #52 were renamed 51.del1 and 52.del2 and the files were and joined to make 52.del. There is a gap from 740db to 840db. Comments about this were entered in the header of the output file.
- Cast #53 contained only surface data so the file will not be processed further.
- Casts #73 and #74 are repeats, but they have full data sets, so both will be processed.

- Casts #76 / #77 – Only #76 had data below 5db, so it will be used for the downcast file. #77 will not be processed further.
- Cast #83 contained only data to 47db and there is a full downcast file available, so the file will not be processed further.

15. DETAILED EDITING

The primary temperature and salinity channels were selected for editing. While they are further from the calibration bottles, there is less time dependence. The noise level is similar in both salinity channels. Graphical editing was done using program CTDEDIT. On-screen plots of descent rate and pump status were also used.

The salinity was quite noisy in the mixed layer. A revisit was made to the alignment step to see if a different shift setting would reduce this, but no better choice was found. It is possible that doing this step individually for each cast might produce better results, but it would be very time-consuming. Most of the spikes are quite small, standing out only because the salinity varies so little. However, where temperature gradients were larger they are more significant. Editing was used to remove spikes where they are systematic in direction and/or likely to affect the metre-averaged results. Records were removed that were corrupted by shed wakes or near the surface before the pumps were turned on.

All casts required some editing.

The altimeter header readings for casts #100 and #105 were adjusted because more than 1db of data was removed from the bottom of the casts.

16. Initial Recalibration

The MRG and SAM files were recalibrated using file 2009-09-recal1.ccf to add 0.3db to the pressure, add 0.02 from the primary salinity and to apply the following DO correction:

DOX_BOT = 1.0528 DOX_CTD - 0.0305

One cast was checked and the pressure recalibration was applied correctly.

COMPARE was rerun using only the Autosal data; this showed that the salinity correction had been applied properly. The standard deviation in the differences was 0.003 (See 2009-09-sal-comp2-A.xls.)

When the Portasal data were examined in COMPARE it was discovered that an error had been made in the initial recalculation to make the Portasal bottles match the Autosal data. Only 0.011 was subtracted and it should have been 0.012. CALIBRATE was run using file 2009-09-port-sal-recal.ccf to subtract a further 0.001 from the Salinity:Bottle channel. COMPARE was rerun and the comparison of Portasal bottles and primary CTD salinity shows the recalibrations worked well. (See 2009-09-sal-port-comp2.xls.)

COMPARE was run using the recalibrated dissolved oxygen data and again showed the recalibration was applied properly. (See 2009-09-dox-comp2.xls.)

17. Final Calibration of DO

The first recalibration of dissolved oxygen corrects for calibration drift. Shift corrects for transit time errors. Those 2 steps may partly correct for response time errors, but a further correction can be applied to further correct for response time 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. When outliers are excluded based on residuals, the average difference is +0.025ml/l with a trendline that is quite flat as DO varies. Given the nature of the comparison, this difference is too small to justify a further recalibration. It has been seen from other cruises that this 2nd DO recalibration is not needed when the new DO algorithm is used, especially if there is a fine-tuning of some of the parameters.
(See 2009-09-dox-comp3.xls.)

18. Special Fluorometer Processing

An examination of the fluorescence channel shows a dark value of ~0.13mg/m^3 .

The COR1 files were clipped to 150db and processed separately for A. Peña. 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 SAMCOR1 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 channel in the COR1 files to reduce spikiness. One cast was examined before and after this step and showed that the filter was effective.

19. 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.

20. Other Comparisons

Previous experience with these sensors –
1. Salinity:
- The primary conductivity sensor had repairs done in January 2009 followed by recalibration. They have been used for at least one cruise between January and June, 2009-08, but that cruise has not been processed yet.
- The secondary T and C sensors were used for 2008-61 and 2009-03. The comparison for 2008-61 was very noisy and the result was not trusted. For 2009-03 the salinity was found to be high by 0.006. They were also used for 2009-04 but that cruise has not been processed yet.

2. Dissolved Oxygen – The sensor was used for 2009-03 when there were serious problems with deep DO sampling. It was used for 2009-08 but the data have not been processed yet.
3. Pressure – The sensor is an older one prone to drift. An offset of +6.7db has been used since late August 2008.

Historic ranges – Profile plots were made with historic ranges of T and S superimposed. All salinity data fell within the local climatology. For near-surface temperature there were a few minor excursions in both directions – these do not look significant. At depth between 800m and 1100m the temperature was slightly above the historic maximum for casts just off shore of the shelf break: (stations P3, P4 and from LD8 to LD11). This is presumed to reflect the limitations in the local climatology which has not been updated since 1997.

Repeat Casts – There were a number of repeat casts. Casts at P26 were examined and variations in the top 100m were small, with temperature varying by no more than 0.1C˚ and salinity by <0.02 along lines of constant sigma-t . There were 3 casts that sampled to at least 1300m over a 19 hour period and at that depth, temperature and salinity varied by ~0.004C° and ~0.0004 along lines of constant σ_t,. The latter 2 of these casts (separated by 9 hours) were almost indistinguishable.

21. FINAL CTD files steps (REMOVE and HEADEDIT)

The following channels were removed from all casts: Scan_Number, Temperature:Secondary, Salinity:T1:C1, Conductivity:Primary, Conductivity:Secondary, Oxygen:Voltage:SBE, Altimeter, Status:Pump, Descent_Rate and Flag.
The PAR channel was removed from all casts except #1-10, 30, 31, 39, 40, 42, 55, 56 and 75 because the instrument was not mounted on the CTD for those casts.

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

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

Transmissivity and fluorescence are nominal and unedited except that some records were removed in editing temperature and salinity.

The precision of the SBE dissolved oxygen channel is difficult to estimate because the comparison with bottles was very noisy, but roughly, the DO should be considered:

- *±0.4ml/l from 0- 150db*
- *±0.08ml/l from 150- 450db*
- *±0.04ml/l from 450-2000db*
- *±0.1ml/l below 2000db*

The Standards Check routine was run and no problems were found.
The cross-reference list was produced and no problems were found.
The final files were named CTD.

Profile plots were made and no problems were found.
The track plot looks ok.

As a final check of dissolved oxygen data, % saturation was calculated and plotted. The near-surface value for Saanich Inlet was ~160% but a surface bottle confirms the value for the SBE DO. For the near-shore casts surface saturation was mostly between 110 and 130 %, while casts from P10 outwards had values between 105% and 110%. Station P1 had a surface saturation at ~90%; the upcast surface DO is in good agreement with the downcast. There was no bottle to confirm that the sensor was working properly but the proximity of Juan de Fuca Strait probably explains the value.

23. Final Bottle Files

The MRGCOR1 files were put through SORT to order on increasing pressure. REMOVE was run to remove Scan_Number, Temperature:Secondary, Salinity:T1:C1, Conductivity:Primary, Conductivity:Secondary, Oxygen:Voltage:SBE, Status:Pump, Descent_Rate, Altimeter and Flag.
Where there was no signal the PAR channel was also removed.
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 and to add a comment about quality flags and analysis methods.

The bottle data were exported to a spreadsheet to check that all data are present. The only problems noted were a few inconsistencies between the rosette sheet markings and the salinity samples analyzed:

- Cast #25, salinity sample 154 is missing, so an "i" flag was attached since it appears sampling was intended.
- Cast #61, salinity samples 407-412 are missing. These are from a UBC cast for which the salinity analyses were done at sea. According to the analysis sheet the Portasal broke down at the time sample #407 was run, so the analyst probably decided not to enter these data. None of the other missing samples are listed on the analysis sheet. So "e" flags were entered.
- Cast #74, there are 2 salinity bottles not indicated on the rosette sheet. The values agree very well with the CTD salinity so these are presumed to be last minute additions. No flag is needed.

A check was made at this point to ensure that comments had been entered properly to explain the combined data in the casts with misfires and computer crashes. Comments were added to files #49 and 82.

Standards check was run on all files and HEADEDIT adjusted until all format problems were resolved. A cross-reference list was produced and turned up no errors.

Jan. 7, 2010: It was discovered that during correction of transmissivity the BOTTLE_NUMBER channel had been renamed as FIRING_NUMBER. This was corrected by running HEADEDIT.

24. Thermosalinograph Data

The TSG used for this cruise was one belonging to the Arctic group. Data were provided in 4 hex files. There were 10 loop bottles. The results of nutrient, chlorophyll and salinity analysis were combined in a single file 2009-09-loop.csv.

a.) Checking calibrations

The calibrations were checked and those for the temperature and conductivity channel were fine, but there were no entries for the fluorometer. Scott Rose says that the usual fluorometer was used for the TSG, so the information was copied from the con file used for the TSG during 2009-03. The new con file was saved as 2009-09-tsg.con. The chief scientist reports that the intake thermistor was not connected. There was no flow meter data logged.

b.) The files were converted to CNV files using 2009-09-tsg.con and 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 run to add time and date channels.
Time-series plots were produced and the data looks reasonable. The only problems noted are some spikes in salinity and fluorescence, and a very flat section of FL data at the beginning that looks suspicious.

The track plot was produced and looks fine but there were many error messages; the plot was added to the end of this report.

c.) Checking Time Channel

The CTD data, after editing, but before metre-averaging, were thinned to reduce the files to a single point at or within 0.3db of 4.5db and exported to a spreadsheet which was saved as 2009-09-ctd-tsg-comp.xls. The TSG files were opened in EXCEL, median and standard deviations (over 5 records) were calculated for temperature and salinity, and the file was then reduced to the times when CTDs were run. Those files were added to the CTD data in file 2009-09-ctd-tsg-comp.xls. The positions were compared and were close, with average differences for latitude and longitude <0.0001º and all differences <0.0003º. So the TSG clock is working well.
This spreadsheet will also be used in step (e) to compare temperature, salinity and fluorescence.

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

- T1 vs T2 The intake thermistor was not connected.
- 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. There were 61 casts that could be used.

  The temperature differences were extremely noisy. The TSG lab temperature was higher than the CTD by an average of 0.30Cº but the median difference is 0.17 Cº. When data with high standard deviation in the TSG temperature and a few other outliers were excluded, the average difference of the 29 points used is 0.16Cº and the median is 0.15Cº. We expect some temperature dependence in the differences and there is some hint of it, but the scatter is high and the temperature range is not very large with most observations between 9.5ºC and 11.5 ºC, so there is no hope of resolving that.

  The TSG salinity is low by an average of 0.023 and a median of 0.018. If the 29 points with the lowest standard deviation in the TSG salinity are used, the average and median are the same with the TSG low by 0.016. There is some hint of the differences growing with time, but that is impossible to resolve with so much scatter at the beginning and end of the cruise. The TSG salinity had many spikes towards lower values near the end of the cruise which may account for some of the scatter and may make the TSG salinity look lower than it actually is.

  The ratio of TSG fluorescence to CTD fluorescence ranges from 1.8 to 5.0 with an average of 3.0 and a median of 2.7. When plotted against time the ratio appears to be related to sunlight, with the lowest values 8pm to 7am local time, though there are some high values between those hours. The variability in the two channels is similar. (See 2009-09-ctd-tsg-comp.xls.)

- Loop Bottle - TSG Comparisons The loop spreadsheet was edited and saved as 2009-09-loop-TSG-CTD-comp.xls. The nutrients were removed and columns were added for the TSG salinity, CTD salinity and Rosette bottle salinity and CTD fluorescence and Rosette CHL. The TSG salinity was lower than the Loop salinity by an average of 0.013 and by 0.022 if the median was used, but the standard deviation was 0.035. When 2 suspiciously high differences were excluded the TSG salinity was low by an average of 0.022. The smallest differences are 0.0174 for two different loops. The TSG fluorescence was higher than the Loop CHL by a factor of 3.5 using the average or 2.4 using the median; the range was from 0.5 to 9.4. The TSG fluorescence, which generally reads higher than loop samples, is much lower than the first 4 samples.

- Loop Bottle - Rosette Comparisons The loop and rosette samples were compared as a check of the quality of both. When 2 flagged values were excluded the rosette salinity was lower than the loop by 0.001, which is as close as we could hope to achieve given many possible sources of error. The rosette CHL was lower than the Loop CHL by an average of 0.048ug/l, but the median shows it low by only 0.006ug/l which is again, very close. This conclusion supports using the CTD comparison for recalibration of salinity since there is many more rosette samples available than loop samples. (See 2009-09-TSG-loop-comp.xls.)

- Calibration History

The TSG primary temperature and conductivity were recalibrated in February 2009 and there is no history of any other uses since that time. The estimate for ship heating for the Tully at this time of year is from ~0.13Cº to ~0.20Cº; that would vary with ambient temperatures and flow rate in the loop.

Conclusions

The fluorescence data between Saanich Inlet and station P1 looks too flat, and the loop samples confirm there should be more variability. The first record after this flat section is a large spike, followed by believable data. It is assumed that something was changed on the thermosalinograph to enable flow to the fluorometer. The temperature and salinity seem ok for the first section though 2 of the 4 loop salinity bottles from Juan de Fuca are outliers in the full comparison. So it is possible that the flow was not normal. The fluorescence data were removed but temperature and salinity were left. There is no overlap between TSG and CTD until station P1, so the temperature cannot be confirmed.

The lab temperature is higher than that of the CTD probably by between 0.15 and 0.17Cº. An estimate of the intake temperature will be made by subtracting 0.16Cº from the lab temperature.

When outliers are excluded the TSG salinity is lower than the loop by an average of 0.022 and lower than the CTD by from 0.016 to 0.023 depending on what data are included in the comparison. The lowest believable difference seen in the loop data is 0.17. Salinity will be recalibrated by adding 0.18 which is the median difference when all data are included. This seems a little high if the sensor was not used on any other cruises since recalibration, so the difference may include some systematic noise in the TSG salinity as well as calibration drift.

The TSG fluorescence ranges from 1.8 to 9.4 times the loop samples (ignoring the data before P1) and from 1.8 to 5.0 times the downcast CTD fluorescence.

The correspondence between the salinity and chlorophyll samples from the loop and the rosette bottles is excellent.

f.) <u>Editing</u>
The time-series plots were examined and editing was applied as follows:
File 1: A few spikes in salinity were cleaned where temperature and fluorescence were fairly smooth. Fluorescence was removed from the first 9384 records.
Files 2 & 3: Salinity was cleaned lightly.
File 4 – This file was too large to be edited, so it was split. The second file was named 5 and had to be put through REMOVE to remove the old record numbers and ADD TIME CHANNEL to add new record #s. Salinity was cleaned in both files, heavily near the end of 5, and some data were replaced with pad values at the end of 5. See file header for details.

g.) <u>Recalibration</u>
As the intake temperature is unavailable, a new channel will be derived. First ADD CHANNEL was used to add channel TEMPERATURE:LAB. That was then put through CALIBRATE using file 2009-09-recal1.ccf to set Temperature:LAB equal to Temperature:Primary. Then file 2009-09-recal2.ccf was used to recalibrate Temperature:Primary by subtracting 0.16 Cº and Salinity:T0:C0 by adding 0.018.

Thus we have:

- Temperature:Lab as the uncorrected temperature recorded in the lab.
- Temperature:Primary as the lab temperature adjusted to remove the effects of ship heating; this is a proxy for the intake temperature.

h.) <u>Preparing Final Files</u>
REMOVE was used to remove the following channels: Record #, Scan Number, Temperature:Intake, Temperature:Difference, Conductivity:Primary, Uploy0 and Flag from all files.

HEADER EDIT was used to add a comment, change the DATA TYPE to THERMOSALINOGRAPH and add the depth of sampling to the header. The comment includes notes to indicate that the Temperature:Primary was recalibrated to correct for heating in the loop based on the historic observations and comparison with CTD data. Those files were saved as TOB1 files.

Because the files were so unwieldy a second set of files were prepared by thinning the REM files so there are the usual 2 samples per minute. The 4^{th} and 5^{th} files were rejoined and named 2009-09-0004. These files were then put through HEADER EDIT to produce TOB files. Notes were added to the headers of both the TOB and TOB1 files explaining the two different sets of TSG files.

The TSG sensor history was updated.
As a final check plots were made of the cruise track and data; no problems were noted.

25. Producing final files

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

The final loop file 2009-09 loop.xls was prepared by the chief scientist including data from the final CTD files and salinity and chlorophyll samples from the loop or from 5m bottles. That spreadsheet was simplified, 6-line headers were added, header names and formats were adjusted and unneeded channels were removed and saved as a CSV file. It was converted to IOS format. For the flagged samples from the loop, the comments were adjusted to show the station site since there was no sample #. The file was then put through CLEAN and HEADEDIT to get start and stop times and positions, and to add general comments. The final file was named 2009-09-surface.loop.

NOTE: After processing was complete, but before archiving, an error was found in the derivation of the extracted chlorophyll data. A new spreadsheet was provided, 2009-09CHLeditJEBCsept09.xls. The new extracted chlorophyll data were substituted in the loop files and CHE files.

Particulars:
Remote TSG temperature not hooked up.
PAR 4615 on for 1, 2, 3, 6, 7, 10, 30, 31, 39, 40, 42, 55, 56.
PAR 4601 on for 75.
Loop samples at cast 2, 18, 36, 49, 90 and 93.

1. 11 bottles sampled – rest closed but no sampling. Leave out of CHE file.
13. Computer crashed on way up – rest of cast skipped.
14. Computer crashed on way down at 293db. Cast 15 contains rest of cast including rosette file. Probably should rename the downcast file as 15.
30. CTD only, no sampling
31. Sample depths not monotonic.
42. PAR left on for deep cast, so aborted at 1560db, so no sampling, no CHE file.
43. Repeat of 42 without PAR and with sampling.
49/50. Computer crashed at end – file 50 opened to enable closing of bottle at 5db.
51/52/53 – P19 – 51 is part downcast, 52 is rest of downcast and part upcast, 53 is rest of upcast.
55. No sampling.
56. Sample depths not monotonic.
73/74. Rosette problems – sampled Niskin #1 and #24. File 74 is repeat at this site. Samples 458 and 476 belong to #73. Make #73 a CTD cast only and consider samples to be from cast #74.
76/77. Cast #77 was started to enable closing of bottle at 5db. Samples 496-505 are from file 76. Samples 506 and 507 are from bottles 11 and 12 of file 77.
79 – Redone and overwritten because syringes had not been removed.
82/83 – Bottles 1-15 are from 82 and 16-24 from 83 – combine them and call it 82. See chief scientist's notes for more details. Went to 46db after surface sampling.
89. Pumps not turned on untiel about 200db.
99. No IOS sampling, but CHE file needed.
100. No samples kept – do not prepare CHE file.
107. No IOS sampling, but CHE file needed.
110. No IOS sampling, but CHE file needed.
112. No IOS sampling, but CHE file needed.
101, 103, 104, 105, 106, 109 – no bottle files.

REVISION: January 18, 2010: Final dissolved oxygen values do not match those output by AutoOxy (.oxy files) and those on rosette logs, due to a software error which resulted in the incorrect endpoint being used to calculate DO. Actual endpoints were determined by manual inspection of titration curve data and corrected DO values calculated. Duplicates were reanalyzed after this correction (see file 2009-09-oxy-cuplicates.xls.)

REVISION: August 18, 2010
Transmissometer #1005DR was calibrated in March 2008, and drifted significantly but steadily until July 2009; then a sudden shift occurred, so that maximum values between September 2009 and July 2010 were very low, ~25%/m. In August 2010 a study was made of transmissivity that led to a decision to apply post-processing corrections to all cruises between March 2008 and June 2010.

Transmissivity data from this cruise were corrected by multiplying the original values by correction factor 1.265. This was based on assumptions that deep offshore transmissivity from a June 2009 cruise should be about 62%/m and that drift was linear with time between March 2008 and July 2009. The corrections produced reasonable results for all cruises in that period.

For details on how the correction factor was derived see:
OSD_Data_Archive:\Cruise_Data\DOCUMENTS\Transmissometer 1005DR Corrections.doc
These data should be considered estimates.
Revisions done by: Germaine Gatien

Institute of Ocean Sciences
CRUISE SUMMARY
CTD

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

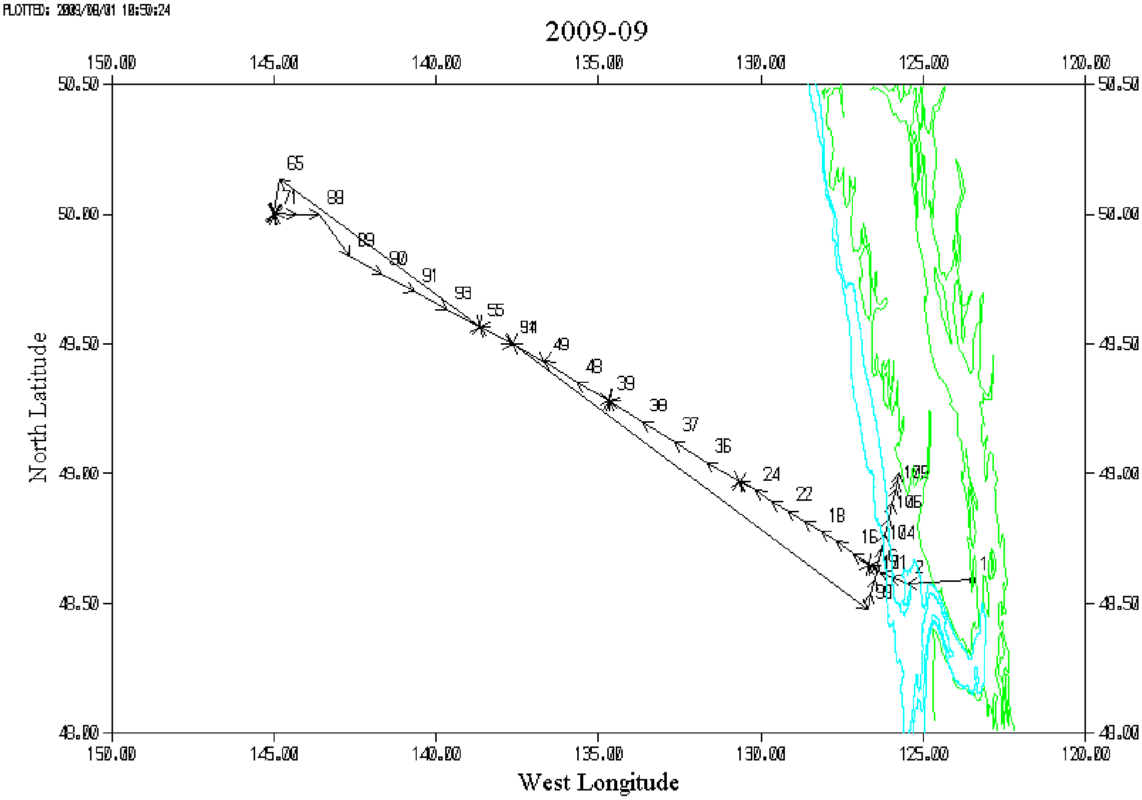
Calibration Information					
Sensor		Pre-Cruise		Post Cruise	
Name	S/N	Date	Location	Date	Location
Temperature	2038	06May08	Factory “		
Conductivity	2128	30Jan09	“		
Secondary Temp.	2449	6May08	“		
Secondary Cond.	2424	7May08	“		
Transmissometer	1005DR	28Dec08	IOS		
SBE 43 DO sensor	0997	01Mar2008	Factory		
PAR	4615	15Dec2000	IOS		
Fluorometer	2228	?	IOS		
Pressure Sensor	63507	25/Oct/2004	Factory		
Altimeter	1252	?	?		

TSG

Make/Model/Serial#: SEABIRD/21/3312 Cruise ID#: 2009-09

Calibration Information					
Sensor		Pre-Cruise		Post Cruise	
Name	S/N	Date	Location	Date	Location
Temperature	3312	27/02/09	Factory		
Conductivity	3312	27/02/09	“		
Wetlab/Wetstar FL	WS3S-713P	8/01/01	“		

PLOTTED: 2009/08/01 10:50:24



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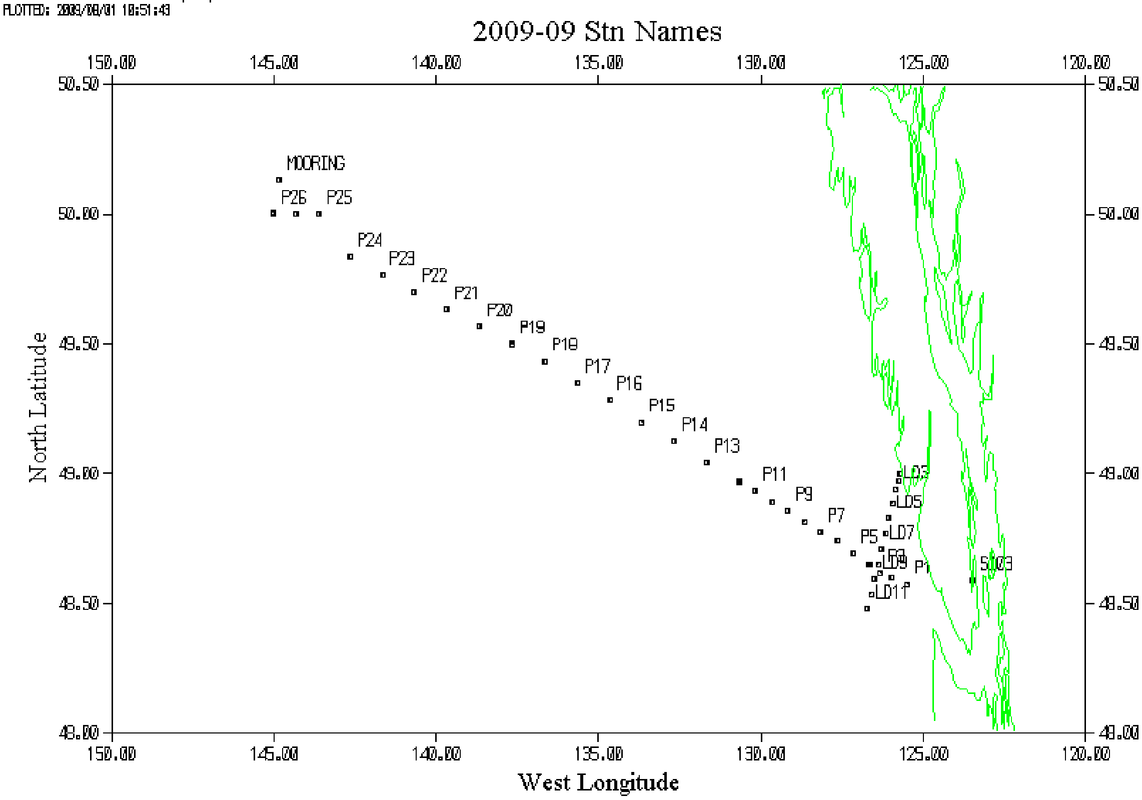
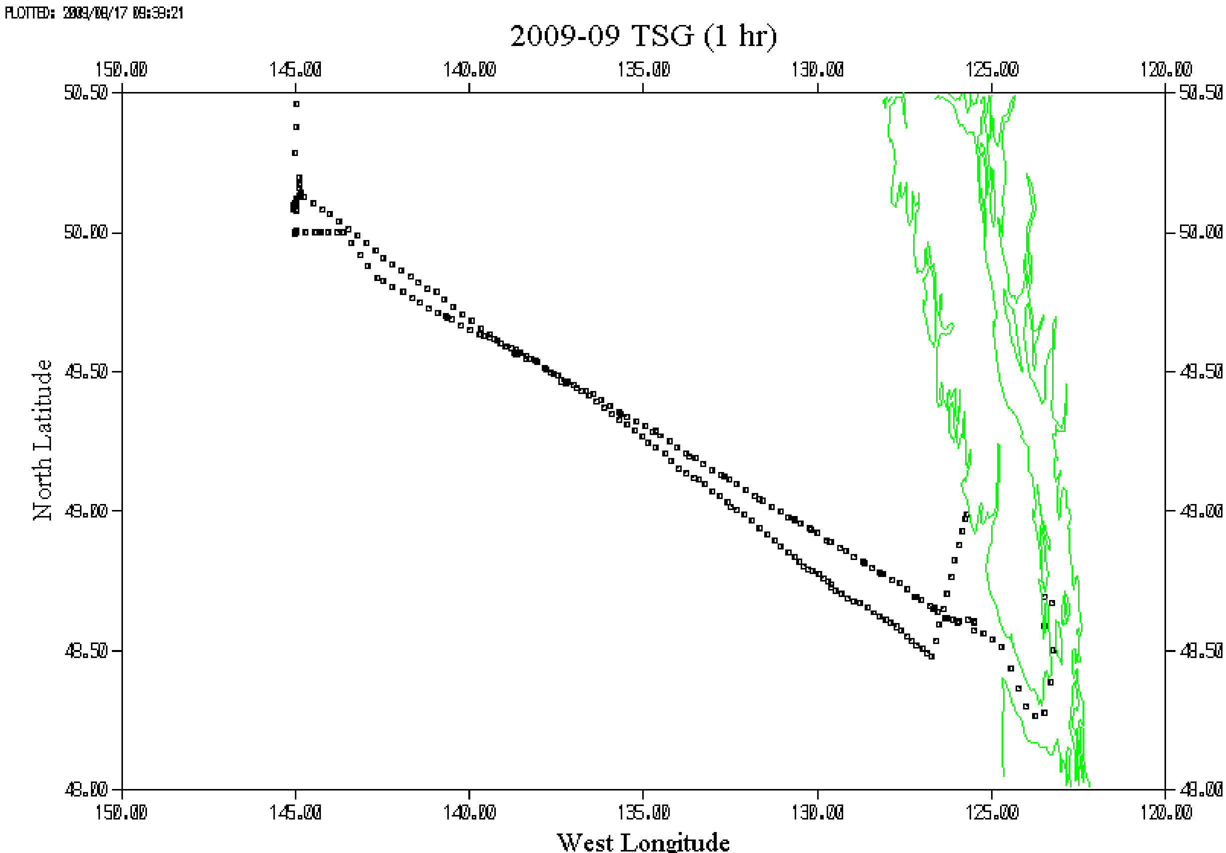


START TIME: UTC 2009/06/07 01:04:00 END TIME: o



FILE NAME: Q:\Cruise_Data_Processing\2009-09\Processing\TSG\ios\2009-09-0004.thn (Last of 4 files)
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