REVISION NOTICE TABLE

DATE	DESCRIPTION OF REVISION
20-Dec-2012	Replaced loop file with John Page's corrected version. John had corrected some erroneous dates and times. Details can be found in the COMMENT section of the header.
4 Sept.2012	Replaced some bad salinity and DO data in CHE files with pad values; fixed some comments; changed one DO flag from c to d. G.G.
5 July 2011	Reversed 2 CHL data points and added flags in 2008-27-0147.CHE
17 Aug 2010	Negative titrated DO values in cast #1 replaced with 0s. G.G.
08-May-2010	Added Lisa Miller's Dissolved Inorganic Carbon and Alkalinity data to the rosette files. J.L.
29 June 2009	CHE files edited for files 62, 69, 83, 86, 93 to insert pad values for extracted chlorophyll data considered bad. Loop file edited in same way for samples #360, 426 and 509 and USW samples from P21 and P23.

NOTE (April 2009): Post-cruise factory calibrations of the primary T and C sensors indicate there was no significant drift and errors in CTD salinity would be within 0.001.

PROCESSING NOTES

Cruise: 2008-27
Agency: OSD
Location: North-East Pacific
Project: Line P
Party Chief: Robert M.
Platform: John P. Tully
Date: August 12, 2008 – August 31, 2008

Processed by: Germaine Gatien
Date of Processing: 8 October 2008 – 2 December 2008

Number of original CTD casts:	70	Number of CTD casts processed: 69 (cast #5 bad)
Number of bottle casts:	70	Number of bottle casts processed: 69
Number of original TSG files:	5	Number of TSG files processed: 5

INSTRUMENT SUMMARY

A SeaBird Model SBE 911+ CTDs (#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 (#1176), (on the primary pump), a Seapoint Fluorometer (#2228) with a 10X cable (on the secondary pump), a Biospherical QSP-400 PAR sensor (#4656) and an altimeter (#1252). The deck unit was a model 911+ (#0424) and the logging computer was an HP Compaq. Seasave v7.16 was used.

A thermosalinograph (SeaBird 21 S/N 2487) was mounted with a Wetlab/Wetstar fluorometer (WS3S-713P) and a flow meter; temperature sensor #4652 was mounted at the intake.

SUMMARY OF QUALITY AND CONCERNS

The CTD and rosette logs were in good order. Notes from the chief scientist were very helpful.

For this cruise the CTD was lowered to ~10m, soaked and returned to the surface where pumps were turned on, acquisition begun and the full cast run. There is some evidence that this leads to noisy data in the top 10m in quiet waters. This is unlikely to be a concern along Line P due to ship drift, but in protected waters it seems wise to wait at least 15s at that surface before running the full cast.

No recalibration was applied to salinity due to doubts about both salinometers. While the Autosal showed no obvious sign of the linearity problems noted in the past year, and the early results appear to have been stable, the differences between bottles and CTD appear to have shifted as time went on. While this could be a problem with the CTD rather than the salinometer, stability problems noted later by the analyst make it more likely that the Autosal was not performing well. It is also notable that a loose hose was later found in the Autosal. For 2 early casts, with 2 bottles each at 2000db, the differences were ~0.001. But later, when 17 bottles were fired at 2000db and analyzed on the Autosal, the average difference was -0.0021 with a standard deviation of 0.005. When the analyst noted stability problems, she increased the flow rate and noted a shift in values thereafter.

The Portasal used at sea gives lower salinity values than the Autosal, but it is not clear by how much as there was a lot of noise in the comparison. When selecting bottle values for archiving, those analyzed on the Autosal were selected where possible; where Portasal values are used, they were flagged “c”. The Portasal values are likely to be low with a noise level of ~ ±0.015.

A new algorithm was used for the conversion of the SBE Dissolved Oxygen sensor data; tests were run to fine-tune one parameter. The sensor used for this cruise has given good results using the old algorithm, but the new one does reduce the hysteresis below 1500db and it is now possible to remove warnings about data being unreliable below 1000m. This sensor is performing very well, recording more detail in profiles than we are used to from older SBE sensors.
The dissolved oxygen data in the CTD files should be considered:

- ±0.5ml/l from 0 – 10db
- ±0.25ml/l from 10 – 500db
- ±0.1ml/l from 500 - 1500db
- ±0.05ml/l below 1500db

There are 5 thermosalinograph files which lacked positions. The positions were determined by using a pCO2 file that included times and positions. The intake temperature looked bad with values higher than the lab temperature (~2 to 3 degrees difference) throughout the record; this may have been due to poor flow to the sensor or sensor malfunction. A proxy for intake temperature, Temperature:Primary, was created by adjusting the lab temperature to remove estimated heating in the loop. Salinity data are sometimes noisy, and are considered ±0.03 salinity units due to high variability in the comparisons.

PROCESSING SUMMARY

1. **Seasave**

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

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. A number of problems were noted including maximum depths being entered incorrectly in 2 files, problems with sample numbers for a few casts, wrong station names, confused file names for chemistry samples for 1 cast, many problems with bubbles in the loop and occasional large differences between T and S channels.
Extracted chlorophyll, nutrients and DMS data were obtained in spreadsheet format.
There were separate spreadsheet files with salinity data from a Portasal used at sea and an Autosal used at IOS.

The titrated dissolved oxygen files were provided in individual ADD files with flags. There were some comments entered, but the formats were wrong.
The cruise summary sheet was completed.
The histories of the conductivity, DO and pressure sensors were obtained.
The calibration constants were checked for all instruments. No errors were found except that the wrong PAR sensor was entered for the first cast.

3. Conversion of Raw Data

The configuration file for the first cast has a different PAR sensor from all other casts, but there is no note in the log of a change. The PAR sensor was not mounted for that cast. So the con file for cast #3 is presumed to contain the correct PAR sensor serial number. There were no further changes in configuration files. File 2008-27-0003.con was saved as 2008-27-ctd.con.
The SBE Dissolved Oxygen calibration parameters in the file were updated to accommodate a new SeaBird algorithm. (The configuration used at sea was correct for the old algorithm, but that will no longer be used.) Initial tests showed the results were worse than with the old one, but on advice from SeaBird the value of parameter E was adjusted until better results were obtained. Tests then showed that the hysteresis could be reduced in this way, though this particular sensor has given good results even using the old algorithm. The configuration file was adjusted by setting E=3.85*E-02.

Data were converted using the configuration file 2008-27-ctd.con. Note that cast #5 should not be processed further because the syringes were left on. Cast #6 is a rerun at that site, but there were problems with that cast too, with large differences between the salinity channels, possibly due to a cap being left on a pump.
The maximum depth was corrected in two casts.

A few casts were examined and all expected channels are present.

- The two temperature channels are in reasonable agreement on the downcast. The upcast data are much noisier so there are significant differences. Conductivity is similar.
- The fluorescence looks a little spiky but ok.
- Dissolved oxygen voltage looks ok.
- PAR has spikes in one cast for which it is mostly zero, so may not have actually been mounted; generally it looks fine.
- Transmissivity traces contain small spikes; up and down are similar.
- The altimetry looks fine for some casts, but others look extremely noisy, so these will have to be checked carefully.

A few casts were examined to see if the deployment method is likely to affect the quality of data in the top 10db. For cast #20 at P6 there was a long soak at the top, so it is easy to see if salinity was varying. There was virtually no change, and when the CTD started down, there was no notable noise in T and S. For cast #22 at P7 the CTD acquisition started at 3db, the CTD came up to 1db and immediately went down. There is noise in the salinity but not temperature, and the noise does not look like it is caused by water from below mixing into surface water. It is possible this is caused by bubbles or some such problem in the 15s after the pumps were turned on. For cast #135 in Rivers Inlet there is considerable noise in both T and S while the CTD was stopped at the surface for 10s. The salinity started out low, went up, then went down again. There is a lot of noise in the data down to 7db, but this may have something to do with the low descent rate as well as any mixing by the rosette package; the pumps may not have been operating at peak yet as well, though generally they were on well before acquisition started.

Rosette files were converted using a start time of -5s and duration of 10s and bottom depths were corrected in 2 casts. The rosette files were then converted to IOS SHELL files. CLEAN was run to add event numbers and the output files were named *.BOT.

All BOT files were plotted. In general there is good correspondence between the two pairs of sensors, but as noted in the log, cast #5 was bad. Cast #6 had a huge difference between channels – it looks as though the primary is bad. The log notes that the cap might have been left on the pump. There were small spikes in salinity that were cleaned in casts 50, 62, 75 and 86, mostly in the primary, but for one cast it was the secondary. The edited files were copied to BOT. The bottle files from P2 were named as from event "6" to match the good CTD data.

4. 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

5. CELLTM

Tests were run on three casts using settings ($\alpha = 0.01$, $\beta=7$), (0.02, 7), (0.03, 7), (0.02, 9), (0.03, 9) and (0.0245, 9.5) to see what settings looked best for this cruise. The best choice overall was (0.0245, 9.5) for the primary channel and (0.03, 9) for the secondary. CELLTM was run on all casts using those values.

6. 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.

The bottom depth was corrected in the headers for casts 24 and 38.

7. Test Plots and Channel Check

A sample of casts using was plotted to check for agreement between the pairs of T and C sensors. The differences are noisy so these are very rough averages.

Cast #	Press	T1-T0	C1-C0	S1-S0	Descent Rate
30	500	+0.0008	+0.00005	-0.0004	High, Noisy
	1000	+0.0008	-0.00005	-0.0015	High, Noisy
	1800	+0.0008	-0.00006	-0.0017	High, Noisy
53	500	+0.0008	+0.00010	+0.0004	V High, noisy
	1000	+0.0009	-0.00002	-0.0010	High, V noisy
	1800	+0.0010	-0.00003	-0.0014	V High, ok
	3500	+0.0012	-0.00001	-0.0016	V High, noisy
72	500	+0.0006	+0.00008	+0.0004	V.High, V noisy
	1000	+0.0005	+0.00001	-0.0005	V High, V noisy
	1800	+0.0009	-0.00001	-0.0010	V High, V noisy
	3500	+0.0012	+0.00001	-0.0012	V High, noisy
	4200	+0.0014	+0.00003	-0.0013	V High, V noisy

Overall the differences are small. There is some pressure dependence in the temperature differences which is unusual, but has been noted previously for this sensor combination. It looks insignificant in the top 2000db, but grows somewhat below that level. The conductivity does not show such pressure-dependence. The salinity differences are slightly pressure dependent and time-dependent.

8. 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.

9. Checking Headers

The header check was run and checked. Random checks of times, positions and station names were made using the cross-reference listing. The cruise track was plotted. No problems were found.

The average surface pressure is 1.9db with a range of 0.2 to 3.8db; this is low for the Tully. The transmissivity is zero for the first few records of cast #128 which had the lowest pressure minimum (0.17db); during the upcast the CTD also got to very low pressures, ~0.5db with low transmissivity. This does suggest that the CTD was very close to the surface. The salinity channels showed a lot of variability at low pressure during the upcast, again a suggestion that it was very close to the surface. The best evidence that the offset is ok, is that 12 bottles were fired at the surface for cast #1 were fired with the rosette just below the surface. The pressures for these bottles range from 1.615db to 1.624db and 1.6m is the approximate distance from the top of the rosette to the CTD.

The altimeter readings from the headers of the CLN and BOT files were exported to spreadsheets and all casts 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 SAMAVG files for casts #13, 16, 36, 37, 39-51, 64, 73-97 because the algorithm didn't work well, and from all SAMAVG files for which no bottle was fired at the bottom of the cast because the information is misleading. The headers will be removed from the downcast files after DELETE is run.

10. BOTTLE FILE PREPARATION

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. There was a bottle file for cast #81 and the log says it was a ROS cast, but no sample numbers were assigned, so sample numbers 9998 and 9999 (these are easier to deal with in processing than pad values) were entered for sample numbers since these data might have been gathered for another group.
The ADDSAMP file 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 BOT files were then bin-averaged.

<u>SALINITY</u>

Salinity was analyzed at sea on a Portasal and at IOS on an Autosal. 14 duplicate pairs were run on the Portasal and 10 on the Autosal; 3 pairs were run on both salinometers (2 for each instrument).

The Portasal files were provided in spreadsheet format in a file that was renamed 2008-27-salinity-port.csv). That spreadsheet was simplified. There were some flags, but no comments to explain them. In many cases it is clear that the flags are due to results that were drifting, so the comment "Salinity: Readings did not stabilize" was added. A few complications arose:

- There were 3 entries for two sample #s of cast #6; in each case two were analyzed consecutively and the 3rd in the same session, but separated somewhat in time. For sample #14 the two runs at the same time are within 0.002, but a 3rd was lower than those 2 by 0.005 and 0.003. An average of the first 2 was entered in the bottle file, with "fc" flag and note of the 3rd reading in the header. For sample #17, the two run consecutively differ by 0.0026, but one was flagged "d" by the analyst. The 1st and 3rd were averaged, but they differed by 0.004, so the entry was flagged "fd".
- In many cases there were only two readings that differed by >0.0004 and had been flagged "d". Where differences were >0.0015 the "d" flag was left, for >0.0007 the "d" flag was changed to "c", and it was removed from the rest. A note was left in the headers if differences were >0.0004.

The Autosal data were delivered in a common file with a number of other cruises. The 2007-27 data were separated and saved as 2008-27-salinity-auto.csv. Loop samples were copied to 2008-27-sal-loop.csv and then removed from the main file. Where there were duplicates an "f" flag was added and the values were averaged. In 3 cases the differences were >0.003, so they were flagged "c" as well. The duplicates were also copied into a separate worksheet together with those from the Portasal and saved as 2008-27-sal-duplicates.xls. There is a note in the analysis file that indicates the flow was changed which may affect values from sample #565 onwards. A comment to that affect plus flag "c" was added to each of the affected samples: #565-573, 575-576 and 770-771. The file was saved as 2007-27-salinity-auto.csv.

The Portasal duplicates were averaged in the main spreadsheet and flagged "f", unless one of them was already flagged. In that case the unflagged value was used with no "f" flag. The flagged value was entered in the comments and mention made that it had been flagged by the analyst. In one case the duplicates differed by 0.003, so the average was flagged "c". The loop samples were added to file 2008-27-sal-loop.csv; those samples were then removed from the main spreadsheet.

Duplicate Studies from a single salinometer

(i) There were 14 pairs of duplicates that were analyzed on the Portasal but many of the analyses were unstable and were flagged "d". Using all 14 Sp=0.0023 where Sp is defined as:

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

When samples flagged "d" were removed there were 7 bottles and Sp=0.0014. For 6 of those bottles the differences between duplicates were <0.002, but for the 7^{th} it was 0.003. When that bottle was removed, Sp=0.0012. The average difference was 0.0005 when only the 6 bottles were used, with a standard deviation of 0.0018. (See 2008-27-sal-duplicates.xls) For comparison, during 2007-26 the results were Sp=0.0012 using 7 pairs, and 0.0005 when one pair was excluded as an outlier. One set of duplicates differed by 0.003 but neither had been flagged. A "c" flag was attached to those and when they were excluded from the calculation, Sp=0.0007 but only 4 pairs were left. (See Part 1 of 2008-27-sal-duplicates.xls.)

(ii) For the Autosal there were 10 duplicate analyses. Five of the differences were <0.001, three were >0.003. It is interesting that 2 of the 3 with large differences were run in two separate sessions. The 8 other duplicates were run close together in time. If all pairs are included Sp=0.0027 and Sp=0.0018 if the pair is excluded with the largest difference. If 3 outliers are excluded then Sp=0.0008. For 2008-26 the value was Sp=0.0017 or 0.0005 if 1 or 5 pairs was excluded. (See part 2 of 2008-27-sal-duplicates.xls)

(iii) There were 3 bottles from which 2 samples each were analyzed on the 2 salinometers. One of the Autosal results was excluded as an outlier. Combining the results of the 2 analyses and the CTD salinity, enables estimates of differences among Autosal, Portasal and CTD. The Autosal was lower than the Portasal by an average of 0.006, and the CTD primary and secondary salinity were lower than the Autosal by an average of 0.0036 and 0.0055. (See part 3 of 2008-27-sal-duplicates.xls.)

COMPARE runs on Autosal and Portasal

Compare will be run later on the combined results of Autosal and Portasal analyses, but first it was run on the two separate sets to see what could be learned about the reliability of each salinometer. The Portasal and Autosal spreadsheets were converted to SAL files in separate folders, Portasal and Autosal, (files were named sala and salp) which were merged with the averaged SAM files so that COMPARE could be run on each set. Finally the two data sets were combined and where there are samples analyzed on the both salinometers, a comparison was done.

(i) Autosal

The comparison of Autosal bottles with CTD turned up only one severe outlier, sample #331 which was supposed to be a surface sample but had a value of 34.6. That sample was flagged "e" and a pad value was entered in its place. When that outlier was removed plus minor outliers identified by residuals, the primary/secondary sensors were low by 0.0029/0.0044. There is some suggestion of time dependence in the fits, but it looks exactly the same for both sensors, so that is unlikely to be due to CTD calibration drift. There is some suggestion of a linearity problem since the CTD appears to be low by about 0.001 for salinity >34, but by ~0.005 for salinity <33; however, this is not really convincing since there are some values at low salinity that are similar to the deep bottles. The first 3 bottle casts look similar with the primary CTD low by averages of 0.0036, 0.0036 and 0.0035; the next 3 have the CTD low by smaller and gradually decreasing amounts, -0.0028, 0.0023 and 0.0013. The 7th cast included many bottles at 2000db and there was a great deal of variability in those differences.

Checks were made to ensure that this variation did not just reflect different pressure ranges. Roughly the same pattern is seen when a variety of limited pressure ranges are selected. The first 3 casts were analyzed on Sept. 9 & 25. The next 3 were analyzed on Sept. 29 and the 7th (the calibration cast) was analyzed in several small groups in October. The analyst suspended work when she noted problems with the equipment. So the time-dependence may reflect changes in the Autosal. When only the first 3 casts are included in the fit, the primary is low by an average of 0.0043 and the secondary by 0.006 7, but the secondary shows considerable pressure dependence and the averages include some points that were considered outliers in the general comparison. When only the data below 1400db are used (there are few data below that level for the first 2 casts) the average difference is 0.0022 for the primary, but there is a clear shift late in the cruise. The analyst noted problems for cast #91, but cast #72 is also out of line.

Multiple bottles during a single stop were studied next. There were 2 bottles each fired at 2000db during casts #53 and 63, and during cast #91 23 bottles were fired at 2000db. For the first two, the average differences were both 0.001 with the Autosal higher than the CTD with little differences between the two values - 0.0011 for cast #53 and <0.0001 for cast #63. For cast #91 Autosal values were found for 17 bottles. The analyst was obviously having problems during the time these samples were run as calibrations and test samples were run between small groups of samples and she noted that the flow rate was reset after sample #564 and she believed the values had shifted thereafter. The differences have a lot of scatter that reflect these problems. The first 3 show the CTD to be low by about 0.0025 to 0.0045; the next 3 have the CTD lower than bottles by 0.0075 to 0.0013, and the next is similar to the first 3; there is then a shift to values that are within ±0.002 of the bottles with the final 3 having the CTD higher than the bottles. The average difference is -0.0021 with a standard deviation of 0.005.

In conclusion the first two pairs suggest good repeatability, but the 17 bottles at a single stop show tremendous variability. The result from cast #91 is probably not applicable to all the Autosal data, but there is some concern about the quality of the comparison. A standard deviation of 0.005 is high for the Autosal. The differences between CTD and bottles have too much variability to be considered reliable enough for recalibration of the CTD. It is best to wait for the next factory estimate of drift.

(ii) Portasal

COMPARE was run. There were a number of outliers identified. Flags were assigned where the differences stood out markedly compared to the local gradient:

- Cast #1, sample #8 at 50db was flagged "c".
- All samples from cast #6 were far different from the primary CTD data, but this was due to the syringe being left on the sensor, so no flags were attached to the samples.
- Cast #14, sample #80 at 501db was flagged "d".
- Cast #16, sample #104 at 1000db was flagged "d". Many samples differ markedly from the secondary CTD salinity, but this is probably due to a cap being left on the CTD pump.

- Cast #52, sample #296 at 1000db was flagged "d".
- Cast #63, sample #366 at 2500db; this was not a severe outlier, but the sample had already been flagged because it was the average of duplicates that differed by 0.005.
- Cast #72, sample #436 at 800db was flagged "d".
- Cast #72, sample #440 – there were two entries for this sample. There had been 3 readings for sample #438. The first somehow got saved as a second entry for sample #438 and the 2nd two readings were averaged and correctly saved as #440. The mistaken #438 entry was removed.
- Casts #128, 132, 135, 141 and 142 had surface samples that were very different from the CTD salinity, but the salinity gradients were very high in the top 5m, so no flags were assigned.
- Cast #142, sample #702 had the value given on the analysis log sheet as #703 and there was no entry for #703. The values were changed to match the analysis sheet and this compared much better with the CTD data.

There is a lot of scatter in the fits against pressure. When differences >0.02 are excluded, the primary CTD is very close to the bottle values on average, whereas the secondary is lower by an average of 0.0017. There is no evidence of dependence on salinity values. There is a slight trend in the time-dependence but it is the same for both sensors as it was for the Autosal data, so is likely not indicative of problems with the CTD or salinometers.

Looking at the casts with many bottles from a single stop, excluding bottles that were removed from the fit in COMPARE, the results of Portasal analyses are as follows:

Cast	Pressure	# of bottles	Average difference	Standard Deviation in bottle samples	Standard deviation in primary CTD Sal
14	1300	12	+0.002198	0.000696	0.00004
	500	10	+0.001465	0.001196	0.00010
16	1000	12	+0.002634	0.00064	0.00005
36	2000	12	-0.0082	0.007083	0.00004
	500	12	-0.00592	0.003962	0.00029
37	1000	12	0.002872	0.000932	0.00021
	9	4	0.003601	0.000546	0.00038
51	2000	12	-0.00219	0.000693	0.00005
	500	12	-0.00232	0.000747	0.00018
52	1000	11	-0.00151	0.001008	0.00101
	11	4	0.000937	0.007597	0.00547
64	2000	13	-0.00243	0.001731	0.00003
	500	11	-0.00081	0.001942	0.00029
65	1000	12	-0.00234	0.001251	0.00027
	11	4	-0.00589	0.00272	0.00000
74	2000	12	-0.00397	-0.00397	0.00004
	500	12	-0.00223	0.000728	0.00034
75	1000	12	-0.00188	0.001113	0.00006
	9	4	-0.00704	0.002188	0.00006

Plots made of this data show no trend with time or pressure. The highlighting indicates cases where there is a much higher standard deviation in the bottle values than in the CTD readings. The only hint of a trend is when the differences were plotted against the date of analysis. The bottles analyzed on Aug. 20 have salinity higher than the CTD whereas it is lower on the 22nd and 23rd. Those run on August 24th are on 3 different salinity analysis sheets and there is quite a lot of scatter, but all are higher than the CTD salinity.

August 25th results are also on 3 different sheets; they are the most neutral, though still on the high side. (See file Study of multiple bottle stops.xls)

In conclusion there is a lot of variability in Portasal analyses. Based on the repeat bottles one would estimate Portasal results are good to ~ ±0.008, but the overall results of COMPARE would suggest ~ ±0.015.

Duplicates from Portasal and Autosal

There were many duplicate samples with one analyzed on the Portasal and one on the Autosal. These values were combined and added to the duplicates spreadsheet. Values flagged "d" were eliminated from the comparison, as were cases with differences >0.1. The average and mean differences between the two salinometers was found to be 0.007 with the Portasal reading lower than the Autosal. The standard deviation was 0.003. Looking at a plot of the differences against cast # (this roughly reflects order of analysis) suggests the day of analysis was significant. The last day of Autosal analysis appears to have been unreliable but none of these samples come from that cast. The scatter in the COMPARE run for the Portasal was high for the casts in this comparison. Because the casts with duplicates are all from Line P, the maximum pressure is gradually increasing. So while the fit against event # suggests the dates of analyses are significant, it is also possible that non-linearity in the Autosal could be a factor since the highest salinity would be found later in the cruise. However, the plot does not support this theory. (See part 4 of 2008-27-sal-duplicates.xls.)

Summary of salinometer characteristics

(i) Intercomparison

- The results of COMPARE run on Autosal and Portasal can be used to derive the difference between the two salinometers as follows:

Sal0-Autosal ~-0.0029	Sal1-Autosal ~-0.0044
Sal0-Portasal ~0	Sal1-Portasal ~-0.0017
→Portasal-Autosal ~-0.0029	→Portasal-Autosal ~-0.0027
&→Sal0-Sal1 ~-0.0015	→Sal0-Sal1 ~-0.0017

- The differences between samples from the same bottles run on each of the two salinometers indicate that the Portasal is lower than the Autosal by an average of 0.007 with a standard deviation of 0.003. There is considerable variation in the differences from one cast to another, which is likely related to date of salinity analysis. Variations in the performance of the Portasal were fairly random from day to day, whereas the Autosal differences were fairly steady for the first half of the cruise, then shifted and there were problems with stability near the end.
- The difference between these two estimates of difference must be due to the fact that there is a lot more Portasal data in COMPARE than in the duplicate comparison. The variability in the Portasal data is very high and not linear with sample number. There is some dependence on date of analysis, but that relationship looks too complex to form a basis for recalibration of Portasal salinity to match the Autosal, and some of the Autosal data look unreliable.
- The differences look larger than during 2008-26, but that cruise had severe problems with the Portasal data, many outliers were removed, and the results were probably not as reliable.
- There is no basis on which to recalibrate the Portasal to match the Autosal.

(ii) Repeatibility

- There was a lot of noise in the duplicates run on the same salinometers.
- Studying multiple bottles fired at a single stop suggests that the Autosal is good to ±0.005 and the scatter in COMPARE looks similar. For the Portasal the multiple bottle study suggests the data are good to ±0.008, but COMPARE suggests ±0.015.

- While there are problems in the Autosal data, they still look better than the Portasal data. However, they do not look good enough to justify recalibration of the CTD data.

The Portasal data were flagged "c" and a comment was added to indicate the data were analyzed on the Portasal. The Autosal and Portasal spreadsheets were then combined. The data were ordered on sample number and where there were samples from both salinometers, the Autosal data were selected. The resulting spreadsheet was then converted to SAL files. Some longer comments had to be entered by hand since they were truncated in the conversion.

DISSOLVED OXGYEN

Dissolved oxygen files (*.add) were provided. There were flags entered and comments in the headers, but there were a number of format errors in both data lines and headers. A text editor was used to fix those files (output:ADD1).

There were duplicates which had already been averaged; they were in a file named oxy avg.xls which contains a study of the duplicates, with a calculation of Sp=0.085 (using the definition of Sp given above in the salinity discussion). However, this included one outlier; if that is excluded the Sp=0.037. During 2008-26, the results were Sp=0.090 using all data and Sp=0.086 when one outlier was excluded. File oxy avg.xls was renamed 2008-27-DO-duplicates.xls.
The ADD file originally named 134 was renamed 135 – Event #134 was a bongo cast.

NUTRIENTS

The nutrient data were obtained in spreadsheet QF2008-27nuts.xls which was simplified and saved as 2008-27nuts.csv. Extraneous columns were removed, header names were changed to standard format and -99 was entered for blank values. Data were sorted on sample number. File 2008-27-nuts.csv was then converted to individual NUT files.

EXTRACTED CHLOROPHYLL

Extracted chlorophyll data were obtained in file QF2008-27CHL.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 2008-27-chl.csv. That file was converted to individual CHL files. There were loop samples which were saved separately as 2008-27 CHL-loop.csv and a separate file containing a comparison between CHL from the loop with that from the CTD was also saved as 2008-27 CHL loop-comp.csv.

DMS

DMS data were obtained in file DMS 2008-27 summary.xls. It was saved as 2008-27-dms.csv and edited. 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. Errors were found and corrected (after consultation with the analyst) in the sample numbers for cast #50.

The SAL, CHL, ADD, NUT and DMS files were merged with CST files in four steps. (Output: MRG1, MRG2, MRG3, MRG4 and MRG5), MRG5 was put through CLEAN to reduce the headers to File and Comment sections only. That file was then merged with SAMAVG files (Output:MRG).

Data were exported to a spreadsheet 2008-27-bottles.xls and compared to the rosette sheets to ensure all expected data are present. Where sampling is indicated on the rosette sheet but no value sample has been analyzed, an "i" flag was added; if there was some explanation a comment was added. A number of problems were found and fixed in the MRG files. CLEAN was rerun.

11) Compare

Salinity

COMPARE was run using the combined files with Autosal and Portasal results. Since it is clear that the results are different from the two salinometers, these plots will not be useful for recalibration of the CTD, but they should indicate how to recalibrate the secondary CTD salinity to make it match the primary; for cast #16 we will need to use the primary and for cast #6 the secondary. The primary salinity was found to be low by an average of 0.0038 and the secondary by 0.0054. So adding 0.0016 to the secondary will make it match the primary. This value falls between the two values (0.0015 and 0.0017) found from the separate analyses with Portasal and Autosal, as described in the previous section. (See 2008-27-sal-comp1.xls.)

Dissolved Oxygen

COMPARE was run early before other bottle data were available to test a new algorithm. The outliers were identified during that run.

The severe outliers were checked against flagged values in the ADD files, and previously flagged values that were not severe outliers were re-examined. The following flags were added or removed:

- Cast #1 – the flag at 100db was changed from "d" to "c" since it looks ok in COMPARE.
- Cast #6 – many of the bottles were severe outliers and all were at least slightly out of line. The pump was suspected as the cause and the DO sensor was on the primary pump, so it is likely that all the CTD data DO are suspect as well. The bottles are probably fine.
- Cast #24 –There were 4 samples that had been flagged "d" because the values were copied from the rosette sheet since they were not in the file. The flags were removed since they look fine in COMPARE. Sample #126 had been flagged "d" due to particles in the sample, but it looked ok in COMPARE, so the flag was changed to "c". Sample #127 had already been flagged "d" because the program crashed. A comment was added that it was also an outlier in COMPARE. Sample #137 had been flagged already and was a severe outlier, so mention of that was added to the comment. Sample #138 had not previously been flagged, so a "d" flag was added since it was a severe outlier. Sample #144 also had a comment about particles, but no flag was attached and it was not an outlier, so no change was made.
- Cast #38 – 4 samples had been flagged "d" due to problems with colorimeter, but the flags were changed to "c" since they look ok in COMPARE – values are so low, might be hard to recognize a problem. Sample 206 was flagged "c" as minor outlier in COMPARE.
- Cast #53 – Sample 308, flag changed from d to c because looks fine in COMPARE.
- Cast #63 _ sample #381 was already flagged and was severe outlier. Note added to comment.
- Cast #127 – The data in this file were found to not agree with the rosette log, but it was only pressures which were wrong. A tentative corrected file was prepared. Sample #639 is a minor outlier in COMPARE
- Cast #147 – sample #745 was already flagged "d" so a note was added to say "outlier in COMPARE". Sample #750 was flagged as outlier and profile looks wrong.

After other data were available, bottle files were prepared in the usual way and COMPARE was rerun to ensure there were no problems with the new files. During this run samples flagged "d" were excluded.

COMPARE was run using pressure as the reference channel. The only large outliers were near the surface. When outliers were removed, the fit was:

CTD-BOT = 1.071 DOX-CTD -002

A fit was then done which included only data from pressure>1500db. A plot was produced showing all the data, but the deep data were clearly identifiable as green dots, as opposed to red. This makes it very clear that the deep data fall close to the data from above 1500db. (See 2008-27-dox-comp1-new.xls.)

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

Fluorescence
COMPARE was run using the CTD CHL and the Titrated Chlorophyll from bottles. Plots were prepared of titrated CHLa versus CTD CHL. For titrated CHLa<2 the CTD CHL is higher than the bottle CHLa by a factor of 4. There were only 3 values with CHL >5, the cut-off with the 30X cable, and the CTD CHL read 3.3, 4.1 and 4.7ug/l, which supports that was really the cable used.. Since the 10X cable is usually used, a test was done by multiplying the CTD CHL by 3 and the fit does not look as good.
The ratio of CTD to Bottle CHL is 2.5 when all data are used, and gets lower when samples with small values of bottle CHLa are gradually reduced. The average is ~2.1 for CHLa>0.1 and it is ~1 for CHLa>1 ug/l. Note that the 3 samples with CHLa>5 were not included in these averages. (See 2008-27-chl-fluor-comp.xls.)

13. Shift

Fluorescence
To find what shift is needed for the fluorescence, upcast and downcast profiles were examined 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 averaged descent/ascent rate and divided by 2(since the shift will be applied to both up and downcast) to find the shift (in seconds) to remove that offset. This is a rough estimate as the upcast data are noisy. The usual shift of +24 records (1s) was found to be appropriate. This is the shift that has been used in most other cruises. (Output: SHFFL)

Conductivity
Tests were run on 3 casts using shifts between -1s and +1s and T-S plots were prepared to compare the results. A setting of -0.3s worked best overall for the primary sensor; +0.25s was best for the secondary sensor. The same settings were best for 2008-26 when the same sensors were used. All casts were put through two runs of SHIFT using those settings. (Output: *.SHFC0 and SHFC1).

Dissolved Oxygen
Tests were run on a few casts 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. There were few distinctive features to aid this judgment. Values of +80 to +110 seemed best with differing values looking better in different parts of the profiles; in previous use +110 or +120 proved best, but the new algorithm would probably affect this step.
SHIFT was run using +100 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: There were warnings for casts #76 and 81 because maximum pressures were <10db. The log confirms that was all the data logged.
For casts #13, 16, 36, 37, 39-51, 64 and 73-97 the altimeter reading was removed from the header of the DEL files.

15. DETAILED EDITING

A few files were examined in detail to see which sensor pair looked best. There are patches of noisy salinity data. The differences between the pairs are occasionally quite large and there are odd spikes as the CTD first starts upwards after stopping. None of these observations are likely to be significant during the bottle stops or downcasts. There are few bottle salinity samples from the high gradient regions so it is impossible to determine which sensors are performing better. At times it looks like both have problems and the noise might be due to vibrations in the package changing the vertical offset between the sensors. For cast #6 it is clear that the primary salinity is bad, while for cast #16 the secondary looks bad at depth. Looking in CTDEDIT the noise level is similar in the two channels, though the primary seems a little noisier later in the cruise.

There is little to choose between the two channels. The primary was selected only because it is slightly closer to the bottles. For cast #6, the secondary will be archived.

Graphical editing was done using program CTDEDIT. On-screen plots of descent rate and pump status were also used. All casts required editing.

As was noted during 2008-26, there was some small-scale noise in the salinity in the top 100db for off-shore casts, which is likely related to noisy descent rates for the CTD. The pump appears to be affected by acceleration as well as descent rate. Some attempt was made to edit this noise, but it is impossible to get rid of all unstable features without losing data that are probably useful.

There is some suggestion that for casts in quiet waters there is surface data corruption due to the CTD being lowered to 10db for soaking, then returned to the surface followed immediately by the full cast. In Saanich Inlet and Rivers Inlet the surface waters look noisier than expected based on the descent rate, though there could be other ship-related causes for this. In off-shore waters this is not seen, but it is expected that due to ship movement, the CTD would not be passing through waters affected by the upcast from 10db.

16. Initial Recalibration

File 2008-27-ctd.ccf was prepared to add 0.0016 to the secondary salinity and to apply the following equation to the CTD Dissolved Oxygen channel:

CTD-BOT = 1.071 DOX-CTD +0.002

This was applied to SAM and MRGCLN2 bottle files for both the combined Autosal and Portasal data.

COMPARE was then rerun. For salinity the two sensors were compared and the average difference was 0.0001 after recalibration of the secondary. For dissolved oxygen the CTD data are closer to the bottles after recalibration; when the same bottles are included as in the first fit, the average difference is 0.002ml/l. (See 2008-27-sal-comp2 and 2008-27-dox-comp2.xls.)

The same DO and salinity calibration was applied to the edited downcast files.

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.

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 all data are included except for a few outliers, the differences vary from +0.03ml/l at DO=0 to +0.05ml/l at DO=7 and the fit against pressure is

DOX_BOT = DOX_CTD +0.00001 * Pressure - 0.0451

(See 2008-27-dox-comp3.xls.)

The thinned files were recalibrated using the above equation and the comparison was rerun. That showed that the results were good. (See 2008-27-comp4.xls.)
Recalibration using file 2008-27-recal2.ccf was applied to the downcast files only. (Output:COR2)

18. **Special Fluorometer Processing**

The AVG 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 COR2 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. There were some slightly unstable features near the surface, but with noisy salinity this is hard to avoid without removing data that may be useful. No further editing was applied.

20. **Other Comparisons**

Previous experience with these sensors –
1. Salinity: Both sensors were used for 2008-26 and 2008-41. During the earlier cruise the primary was found to be low by 0.0029 and the secondary by 0.0022. During 2008-41 there were few bottles and a lot of scatter; the primary was found low by 0.0005 and the secondary high by from 0 to +0.002.
2. Dissolved Oxygen – Since the sensor was recalibrated in Feb. 2007 it has been used for 8 other cruises. Of these 1 had very short bottle stops, 1 was in a shallow inland area with a limited DO range and another gave very confusing results. The latest data were converted using a new algorithm, so the comparison may not be very useful, but in general this sensor performs well, with good detail in the profiles.
3. Pressure – This sensor is older and prone to drift, but has been stable for the past 7 cruises, with an offset of +6.5db being used since March 2008.

Historic ranges – Profile plots were made with historic ranges of T and S superimposed. There were many excursions from those ranges for temperature, with values higher than historic maxima below 500db at P3 and P4 and near the maxima for parts of P5, P6 and P7. The temperatures were at or below the historic minima around 100db for stations P14 to P17. The only off-shore excursions from the climatology for salinity were at P22 with low salinity around 200db. There were a few other excursions in T and S in the near-shore casts, but this probably just reflects local variations that are not well represented in the ranges. The temperature excursions are seen to be both high and low and consistent in certain areas, so do not look like instrumental errors.

Repeat Casts – There were a number of repeat casts. Examining 4 casts at P26 along lines of constant σ_t, temperature and salinity varied by <0.01Cº and <0.002 salinity units at ~550db. Those casts occurred over 19 hours. At 2000db differences were found to be ~0.003Cº and 0.0005 salinity units for 2 consecutive casts.

21. FINAL CTD files steps (REMOVE and HEADEDIT)

The following channels were removed from all casts except #6: Scan_Number, Temperature:Secondary, Salinity:T1:C1, Conductivity:Primary, Conductivity:Secondary, Oxygen:Voltage:SBE, Altimeter, Status:Pump, Descent_Rate and Flag.
The following channels were removed from cast #6: Scan_Number, Temperature:Primary, Salinity:T0:C0, Conductivity:Primary, Conductivity:Secondary, Oxygen:Dissolved:SBE, Oxygen:Voltage:SBE, Altimeter, Status:Pump, Descent_Rate and Flag.

The PAR channel was removed from casts #1, 11, 14-38, 42-46, 51-60, 63-81, 85, 89-113 and 149-152 because the instrument was not mounted on the CTD for those casts.
A second SBE DO channel (with umol/kg units) was added.

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 secondary salinity was recalibrated to make it match the primary salinity. There was no recalibration based on the bottle comparison because of uncertainties about the performance of the two salinometers used. Post-cruise checks from the factory were not yet available at the time of processing.

The dissolved oxygen data in the CTD files should be considered:

- *±0.5ml/l from 0 – 10db*
- *±0.25ml/l from 10 – 500db*
- *±0.1ml/l from 500 - 1500db*
- *±0.05ml/l below 1500db*

The Standards Check routine was run and HEADEDIT adjusted until no further problems were found. The final files were named CTD.

Profile plots were made and no problems were found.
The track plot looks ok. The cross-reference lists turned up one problem – the station name was corrected for cast #1.

As a final check of dissolved oxygen data, % saturation was calculated and plotted. The near-surface values for Saanich Inlet and the offshore casts (P1 – P26) were mostly ~105 - 115% with P3 slightly higher. For the SS line the range was 95-105%. Values were low in Rivers Inlet, ~90%, and in the 90-100% range for the final line along the coast. These values look reasonable.

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 except for cast #6 for which Temperature:Primary and Salinity:T0:C0 were removed instead of the secondary channels.
The SBE dissolved oxygen channel was removed from cast #6.
The PAR channel was removed from casts #1, 11, 14-38, 42-46, 51-60, 63-81, 85, 89-113 and 149-152 because the instrument was not mounted on the CTD for those casts.
A second SBE DO channel was added with different units.

HEADER EDIT was run to fix formats and units and to add a comment about quality flags and analysis methods. The following extra comments were entered:

WARNING: There were problems with both salinometers. Variations in the performance of the Portasal were fairly random from day to day, while the Autosal results were fairly steady for the analysis of samples from the first half of the cruise, but there may have been a shift later and the analyst reported problems with stability near the end.

Studying multiple bottles fired at a single stop suggests that the Autosal is good to ±0.005 and the scatter in COMPARE looks similar. For the Portasal the multiple bottle study suggests the data are good to ±0.008, but the larger comparison between bottles and CTD showed more scatter, ~ ±0.015.

Duplicate studies suggest that the Portasal was reading lower than the Autosal by ~0.007 with a standard deviation of 0.003, but the wider comparisons of bottles and CTD data suggest the Portasal is lower than the Autosal by ~0.003. Given the uncertainty in the comparisons no attempt was made to make the Autosal and Portasal results match. Similarly, the only recalibration to CTD salinity was to make the secondary salinity match the primary salinity. Recalibration may be applied later if factory recalibration indicates that there was significant drift.

Autosal values have been selected for Salinity:Bottle where possible. Where there are no Autosal values, the Portasal values were used, but were all flagged "c", except for those that had more severe flags attached for other reasons.

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 an error in the station name for cast #1; this was corrected.
A header note was added to cast #6 to explain why there were no SBE DO data and why the secondary T and S were selected.
A few errors were found late – sample #338 salinity was reassigned from cast #58 to cast #60.

24. Thermosalinograph Data

The TSG data were provided in 5 XLS files. The raw data had already been converted. There were no positions, so those were added by the chief scientist by matching the times in the TSG files with the times in the pCO2 files and using the positions in the latter. The flow rate was not included. The intake temperature is clearly wrong, being much higher than the lab temperature and near-surface CTD temperatures from about the same time.

The XLS files were edited to fix formats and header names were edited and unnecessary columns were removed; these were saved as CSV files. Because these files were not prepared in the usual way, there were a lot of problems getting time formats right. The CSV files were then converted to IOS files. A track plot looks fine. The temperature differences do not, with the intake temperature looking too high. The chief scientist said that there is reason to expect the intake temperature to be too high for part of the record as flow to the thermistor was shut off.

a.) Checking calibrations
All calibration information was correct in the con file.

b.) CLEAN was run to add End times and Longitude and Latitude minima and maxima to the headers. There was no need to run ADD TIME CHANNEL since the files have time and date channels, but the output files from CLEAN were renamed *.ATC. The time increment did not get written in the header, so these were added using a text editor and the zero time entry was removed.

Time-series plots were examined on-screen and confirmed that the secondary temperature does not look as usual; fluorescence and secondary temperature seem ok and salinity is mostly ok, but has one bad segment. The track plot looks fine.

c.) Checking Time Channel
The CTD data, after editing and metre-averaging, were thinned to reduce the files to a single point at or within .3db of 4db and exported to a spreadsheet which was saved as 2008-27-ctd-tsg-comp.xls. The TSG files were opened in EXCEL, median and standard deviations (over 2minutes) 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 2008-27-ctd-tsg-comp.xls. The positions were compared and were close, with average differences for both latitude and longitude of ~0.0001º and no difference greater than 0.00033º so the positions appear to be ok.
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 average difference over the whole record shows the lab temperature to be higher than the intake temperature by >2Cº. The differences show variations, but never do they have the usual situation of the lab being warmer than the intake. It is reported that flow to the intake thermistor was turned off for part of the cruise, but it was expected that it would look normal early and late in the record. The differences are smaller early and late in the cruise, but are still unusual. So another explanation is required. Either the sensor malfunctioned or the flow past it was impeded throughout the record. It is possible that a different sensor was installed than indicated in the configuration file, but the same one was used on 2008-26, so this is unlikely.
- 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.

  If all data are included the TSG lab temperature is found to be high by 0.20 Cº and the intake temperature by 2.6Cº. When a few outliers were excluded (identified in a plot of lab-ctd temperature versus cast numbers) the lab temperature was found to be high by 0.175 Cº and the intake temperature by 2.3 Cº. A plot of the ratio of Ttsg / Tctd vs Tctd was examined to see if there was any clear temperature-dependence in the heating. There is a lot of noise for the higher temperatures, so little could be concluded. It looks like an average value for this data is the best we can do.

  Using a similar approach for salinity, the TSG salinity is low by 0.020 using all data and by 0.217 using 53 casts, and 0.20 with 52 casts. The median is -0.14 with all data.

  The ratio of TSG fluorescence to CTD fluorescence ranges from 1.8 to 6.1 with an average of 3.3. Excluding outliers had no significant effect on that average. Plotting TSG against CTD FL gives a trendline with slope ~2.6, or ~3 if it is forced through the origin. During 2007-26 that slope was ~2.5 and 1.6 for 2008-01 (for that cruise it was noted that the TSG fluorometer was quite unresponsive, possibly due to a film build-up). (See 2008-27-ctd-tsg-comp.xls)

- Loop Bottle Comparisons There were 21 loop bottles, but there are no data from the TSG when the first 2 of them were taken. The results of chlorophyll and salinity analysis were combined in a single file 2008-27-TSG-loop-comp.xls. For the 4 loop samples taken during CTD casts, the rosette bottle salinity and CHL were also included. Most salinity samples were analyzed on the Portasal. The times and positions of loop samples were found in the log. The corresponding TSG fluorescence and salinity values (using a median over a 2-minute window) were found in the TSG files.

  The TSG salinity was lower than the loop bottle salinity by an average of 0.22 if all samples are used. If only those analyzed on the Portasal are included, and one sample flagged "d" is excluded, then the TSG is seen to be low by 0.16. Since the Portasal itself is probably reading low, then the TSG salinity is probably lower than 0.2. However, there was a lot of noise in the Portasal analysis, so the error bars are large. There were 5 samples analyzed on the Autosal but they came from late in the analysis when the results are suspect. The average showed the TSG salinity to be low by 0.36, or 0.16 if one clear outlier is excluded. In the comparison of CTD data to Autosal samples, those done late in the analysis appeared closer to bottles than during most of the analysis. There were 4 rosette bottle samples taken at the same time as loop samples – all were analyzed on the Portasal, one was flagged "d"; the average difference between these was 0.0001 which is a hopeful sign that the Portasal performed well, but given only 3 bottles, this does not offset the observations of great noise in the Portasal data.

  When loop CHL is plotted against TSG fluorescence there is so much noise that the trendline has an offset of ~4. When the ratio of TSG FL to Loop CHLa is plotted against the Loop CHLa, the best fit is as follows:

  $$\text{TSG FLUOR} = 4.7554 * \text{Loop-CHLa}^{-0.932}$$

  The ratio is near 1 for high CHLa and for low CHLa the ratio rises rapidly. The ratios closest to 1 are from samples in Juan de Fuca and the run from P4 to Alberni Inlet.

  There were 3 points of comparison between Rosette bottle CHL and Loop CHL. Those indicate that the Loop CHL ranged from 79% to 86% of the Rosette values. The CTD fluorometer readings when those bottles were fired were much higher than the extracted CHL values, though not by as much as the TSG fluorometer. (See 2008-27-TSG-loop-comp.xls.)

- Calibration History

The TSG primary temperature and conductivity were recalibrated in December 2007. They have been used on 3 other cruises that had calibration sampling.

1. During 2008-01 there was no intake thermistor and the lab temperature was estimated to be high by 0.19Cº. The salinity data were thought to be low by 0.055.
2. During 2008-32 the lab temperature was believed to be high by 0.228 Cº and the salinity data were bad.
3. During 2008-26 the lab temperature was considered high by 0.15 and salinity low by 0.125.

Conclusions

The lab temperature is higher than that of the CTD by an average of 0.175Cº, excluding outliers and the median is 0.172Cº. The temperature difference is affected by heating in the loop and drift in calibration. Because the intake temperature is bad, it is impossible to separate these two effects. While the temperature sensor drift is usually small, it is not always negligible. When last serviced in April 2007, it had drifted downwards by ~0.0033Cº per year, while on the two previous reports the drift estimates were +0.00004Cº/year and +0.0124Cº/year.

Looking over recent history for guidance, there are 3 cruises that used this TSG this year: 2008-01, 2008-32 and 2008-26. The ambient temperatures for those 3 cruises were somewhat lower than for this cruise, with the first being the coldest and the most recent closest to 2008-27. For those cruises the estimates for heating in the loop were 0.19, 0.23 and 0.15Cº. So heating by 0.17Cº seems a little high given that the ambient waters hadve a higher temperature, but temperature sensor drift may account for some of that. Subtracting 0.17Cº from the lab temperature to estimate intake temperature looks reasonable.

For salinity the TSG is lower than the loop salinity by ~0.22 using all data. Both Portasal and Autosal analyses are involved. The Portasal showed a lot of variability, and the Autosal results from the time when the loop samples were run were found unreliable, though the errors in those analyses are not likely to be more than ±0.015 and are likely to be systematic as the Portasal is reading low and the Autosal may have read low when the loop samples were run. So the differences may be a little higher than the -0.16 found for each of the salinometers when a few outliers were excluded. Comparison with CTD salinity shows the TSG to be low by an average of ~0.20 when a few outliers are excluded, with a median of -0.14. The CTD salinity may itself be low but probably by no more than 0.003. During 2008-01 and 2008-26 the sensor was found to be low by 0.055 and 0.125, respectively. During 2008-32 the salinity data were bad. The salinity is clearly low, by from 0.14 to 0.22. A choice of +0.17 was made as being slightly larger than the loop results show when outliers are excluded, and part way between the mean and median of CTD vs TSG comparison. A note was put in the header to indicate that this estimate is rough, ±0.03 salinity units.

The TSG fluorescence is fairly close to the extracted chlorophyll at high CHL values, but much higher for low CHL. It is about 3.3 times the CTD fluorescence, on average. The loop sample values are 79% to 86% of those of the rosette bottle samples for the 3 casts where comparison was possible.

f.) Editing

The time-series plots were examined and editing was applied as follows:
File 2: Initial records removed while flow was off and salinity removed from one section ~60 records.
File 4: One record removed and salinity cleaned at one point.
File 6: Salinity removed from one short section (~40 records) and 124 records removed from a section near P26 where all variables look like flow was impeded.
There were patches of noisy salinity data, which are probably caused by the bubbles noted in the log. Such data were not edited, as there is no way to distinguish good data from bad.

g.) Recalibration

As the intake temperature is considered unreliable, a new channel will be derived. First ADD CHANNEL was used to add channel TEMPERATURE:PRIMARY. That was then put through CALIBRATE using file 2008-27-recal1.ccf to set Temperature:Primary equal to Temperature:Lab. Then file 2008-27-recal2.ccf was used to recalibrate Temperature:Primary by subtracting 0.17 Cº and Salinity by adding 0.17 for all files.

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.) Preparing Final Files

REMOVE was used to remove channels Temperature:Intake 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 and that salinity recalibration has more uncertainties than usual.

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 2008-27 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, date calculated in DD/MM/YYYY format, header names and formats were adjusted and unneeded channels were removed and saved as a CSV file. 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 2008-27-surface.loop.

Particulars:
1. Wait for bottle at 200m was not 30s.
5/6. Syringes were not removed so cast was redone and labelled event #6.
6. CTD Primary data look bad.
11. Wrong start lat/long in logbook and rosette log.
13. PAR installed.
14. Cast restarted. Niskin #15 did not fire.
16. Problem with CTD secondary salinity at depth.
24. Bottom depth entered wrong in header – should be 2519. (Fixed.) Many sample # problems.
37. The loop was shut off at 15:50 and on at 1810.
38. Depth entered as 3215 – should be 3275. (Fixed)
40. Argo deployment.
44. Problems with TSG flow at 0700 on 17th – lot of bubbles. Flow rate increased. Did not help.
46. 1204 on 17th – lot of bubbles in TSG. Engineer to try some adjustments.
60. 1625 on 18th. TSG stopped and Loop pump switched back to original pump from cruise in attempt to fix bubble problem.
76. Two Niskin bottles fired, but only one sampled. Second line removed from bottle files.
81. Same as 76, first sample called #499.
127. Sample # problems.
135. Significant differences between temp and sal channels, disappeared by bottom.
143. Sample # problems.
147/148 may be file name confusion in chemistry files. Sample labelled #750 should be #749 – there is no sampling for #750.

Institute of Ocean Sciences

CRUISE SUMMARY

CTD

CTD#	Make	Model	Serial#	Used with Rosette?	CTD Calibration Sheet Competed?
1	SEABIRD	911+	0	Yes	Yes

Calibration Information

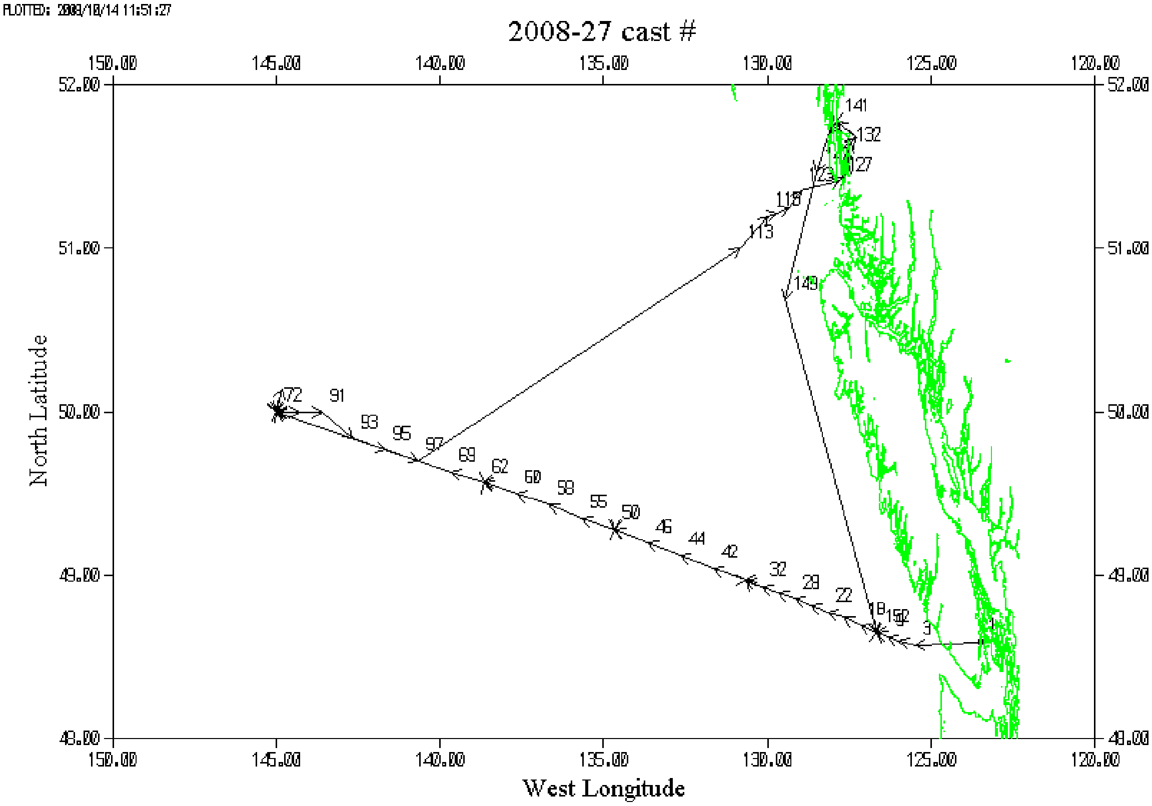
Sensor		Pre-Cruise		Post Cruise	
Name	**S/N**	**Date**	**Location**	**Date**	**Location**
Temperature	4054	16Jan08	Factory “		
Conductivity	1766	07May08	“		
Secondary Temp.	4700	16Jan08	“		
Secondary Cond.	2173	07May08	“		
Transmissometer	1005DR	5Mar08	IOS		
SBE 43 DO sensor	1176	14Feb2007	Factory		
PAR	4656	11Feb2003	IOS		
Fluorometer	2228	?	IOS		
Pressure Sensor	63507	25/Oct/2004	Factory		
Altimeter	1252	?	?		

TSG

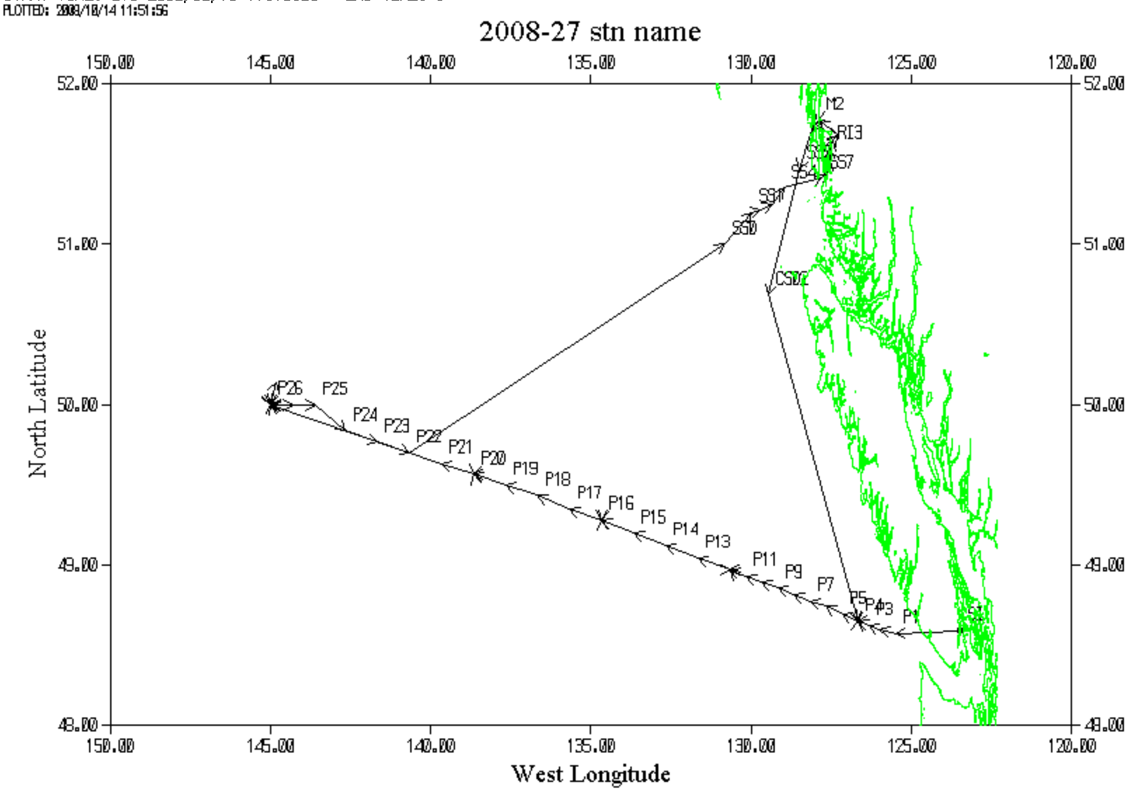
Make/Model/Serial#: SEABIRD/21/2487 **Cruise ID#:** 2008-27

Calibration Information

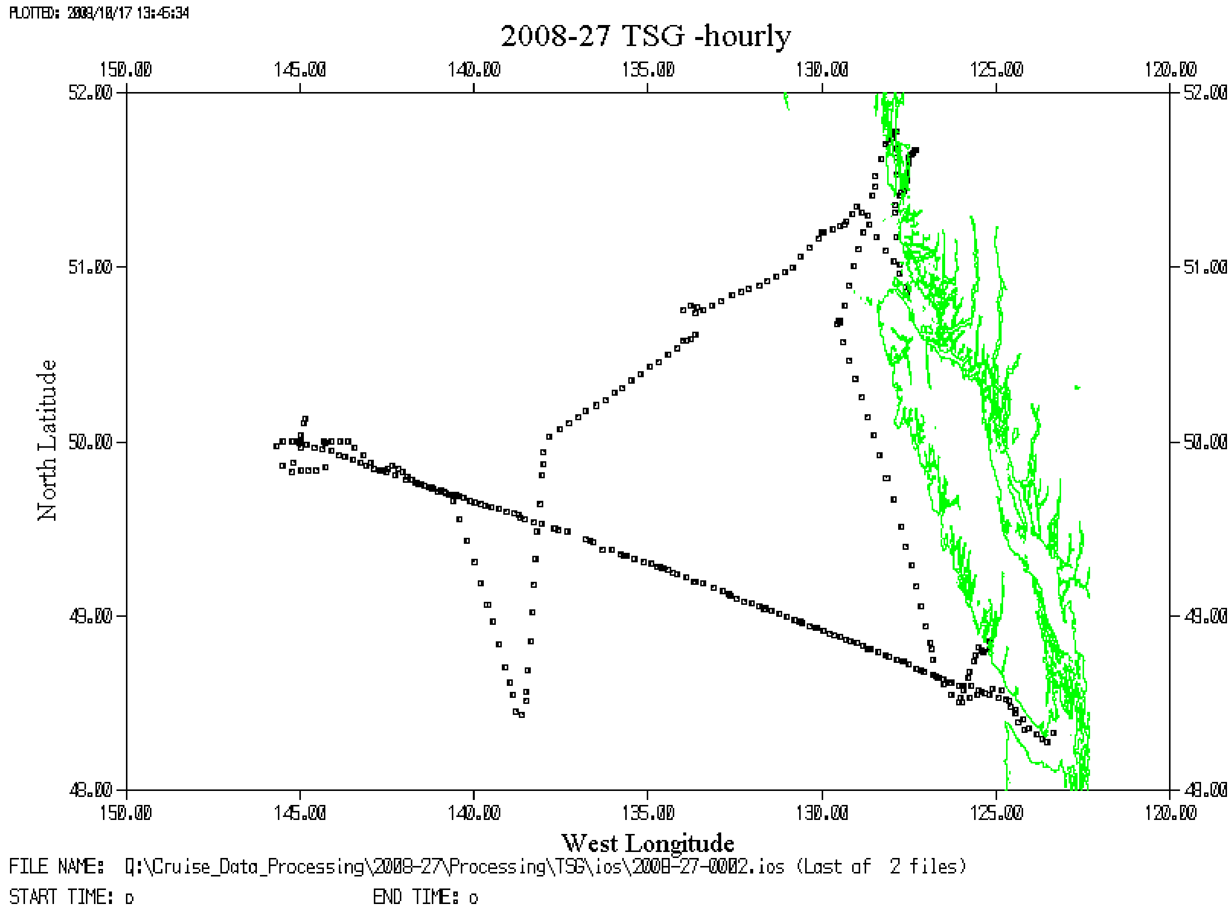
Sensor		Pre-Cruise		Post Cruise	
Name	**S/N**	**Date**	**Location**	**Date**	**Location**
Temperature	2487	01/12/07	Factory		
Conductivity	2487	01/12/07	“		
Wetlab/Wetstar Fluorometer	WS3S-713P	8/01/01	“		
Temperature 2	4652	22/Dec/06			
Flow Meter	?	?			



START TIME: UTC 2008/08/13 17:19:06 END TIME: o



START TIME: UTC 2008/08/13 17:19:06 END TIME: o


PLOTTED: 2008/10/17 13:45:34
2008-27 TSG -hourly
150.00
145.00
140.00
135.00
130.00
125.00
120.00
52.00
51.00
50.00
49.00
48.00
North Latitude
West Longitude
FILE NAME: Q:\Cruise_Data_Processing\2008-27\Processing\TSG\ios\2008-27-0002.ios (Last of 2 files)
START TIME: o
END TIME: o