REVISION NOTICE TABLE

DATE	DESCRIPTION OF REVISION

PROCESSING NOTES

Cruise: 2010-01
Agency: OSD
Location: North-East Pacific
Project: Line P
Party Chief: Robert M.
Platform: John P. Tully
Date: February 2, 2010 – February 16, 2010

Processed by: Germaine Gatien
Date of Processing: 22 April 2010 – 18 November 2010
Number of original CTD casts: 43 (45 files*)
Number of bottle casts: 44 ros files
Number of original TSG files: 10
Number of CTD casts processed: 43
Number of bottle casts processed: 37
Number of TSG files processed: 9

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), two SBE 43 DO sensor (#1438 and #1483) on the primary pump), a Seapoint Fluorometer (#2229) with a 10X cable (on the primary pump), a Biospherical QSP-400 PAR sensor (#4656), a pH meter (#0692) and an altimeter (#1252). The deck unit was a model 911+ (#424). All casts were run with the LARS mid-ship station. Seasave version 7.16 was used. The salinometer used was a model 8400B Autosal, serial # 69086.

A thermosalinograph (SeaBird 21 S/N 2248) was mounted with a Wetlab/Wetstar fluorometer (WS3S-713P), remote temperature sensor #2416 and a flow meter.

SUMMARY OF QUALITY AND CONCERNS

The CTD and rosette logs were generally in good order but there was no listing of the 2nd dissolved oxygen sensor that was used and there was no information about the thermosalinograph. The sampling notes from the Chief Scientist were extremely helpful in dealing with problems that occurred at sea.

The entry in the log book “# of Bottles” was used to enter the # of bottles sampled. Using this for bottles fired would be helpful in the process of associating sample numbers with the right bottle. When more bottles are fired than sampled (as judged by the sample #s in the adjacent column), it is a sign to check for comments or rosette sheet details. For this cruise there are notes in the log for most cases of bottles fired but without sample #s, but this is not always the case.

Many of the casts were corrupted by pressure spikes.

A table-driven method of firing bottles was used during 4 casts for this cruise. Because of recent changes in the software it is now possible to add the bottle position to the file so that it will be clear where samples come from. This worked well and required no special processing since sample numbers were assigned in the order of Firing # rather than Niskin #.

It is better to look at DO voltage rather than concentration when making decisions about sensor performance at sea. The first DO sensor was replaced because the data were very spiky, but that was most likely due to extremely noisy pressure and temperature data. In processing, most of the spikes are removed before oxygen concentration is derived, but at sea you are using raw data and DO is highly dependent on temperature.

The second DO sensor that was mounted for event #34 behaved very strangely for that cast and also for the upcast #40; the channel has been removed from profile and rosette files for 2010-01-0034 and rosette file for 2010-01-0040. The sensor also behaved very oddly for the upcast of event #42 but the downcast seems ok. There was no rosette file for that event. The sensor appears to have settled down after that based on inter-comparisons of casts at the same site and comparisons with bottles.

Because there were some deep casts, tests were done to fine-tune the values of parameters E, H1 and H3 for the DO configuration. However, the spikiness of data suggests the tests be repeated when possible.

The salinity analysis spreadsheet has sample number and station name in the same column. It would be much more efficient to record these in separate columns since someone else will need to separate them later and that process is error-prone. Having an event # column would also be helpful, but not essential.

The salinity analyst noted that some bottles had salt crystals on the lids, suggesting poor seals. In recent years there has been considerable doubt about the validity of the comparisons between bottles and CTD data. While this could be due to poor sampling habits or a faulty salinometer, the evidence is mounting that the problem is with the seals on bottles, which would lead to evaporation so that the CTD appears to be reading low. That is exactly what we are seeing. The solution to the poor seals may be to replace the liners more frequently and/or to replace chipped bottles.

The file for cast #15 does not start until 18db of the downcast because acquisition did not start until that level. There is no mention of this in the log, though it was noted that there was a large swell, so it is possible this was deliberate.

In two cases data acquisition was interrupted so that there are 2 files for each. For casts 39/40 at P20, all the downcast data were in #39 and all bottle data in #40. At the end of processing the CTD file will be renamed as 2010-01-0040.CTD. For casts 53/54 at P9 most of the data were in the #53 files so both downcast and bottle data were saved as 2010-01-0053. The only useful information in file #54 was a surface bottle firing and that record was added to 2010-01-0053.CHE.

Two Argo floats were launched during this cruise, so comparisons were done between those and CTD casts that were about 1 hour/6km and 1hour/1km apart. Rough comparisons and the float temperature and salinity data look remarkably close to those of the secondary CTD channels along density surfaces for both floats. Dissolved oxygen concentration from the floats is generally higher than that of the CTD. For one float the differences at depth are within the resolution of the Optode DO sensor. For the other float, the differences may be significant, and rosette data are close to the SBE DO values.

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:

- ±0.15ml/l from 0-100db
- ±0.5ml/l from 100-400db (Values tend to be too high)
- ±0.2ml/l from 400-600db (Values tend to be slightly high)
- ±0.04ml/l from 600-2000db (Values tend to be slightly low)
- ±0.01ml/l below 2500db

It has been noted in the past that the residual noise in the Dissolved Oxygen signal is amplified by the use of the TAU correction, particularly at depth. The size of spikes varies from cruise to cruise. For 2010-01 this effect produced noise up to ±0.017ml/l, but the largest spikes occurred mostly where the temperature was corrupted by shed wakes, so the bad records will mostly have been removed with the graphical editor. Metre-averaging should reduce the non-systematic noise. It is likely that the residual noise is <±0.01. One thing made clear from these data is that the spikes in oxygen are not a sign of quick response of the sensor to shed wakes, but are due to the effect of the temperature on the DO calculation. This is clear due to the direction of the spikes. It is hard to deduce from these data if the Tau correction is useful in shallow water given the very noisy descent rate for some casts and many pressure spikes for others. However, the correction does generally lead to better resolution in high-gradient zones.

There were many problems with the thermosalinograph record including corruption of records. The problem disappeared when the configuration file was changed and NMEA data were downloaded with a different option. Intermittent lines were missing 4 digits and were not converted; since time is calculated based on record number the times were wrong, and there were problems with positions as well. Reorganizing line lengths enabled conversion but the corrupted records were later removed. This approach achieved correct times in the remaining records but was extremely time-consuming.

The TSG flow rate doubled during file #3 which affected the recalibration scheme significantly. The higher flow rate leads to less heating in the loop which affects the TSG salinity error. Recalibration would have been easier if the change had been made between files, and more loop salinity samples would have helped. TSG fluorescence is also affected by the flow rate.

TSG file #1 contained only 1 record so was not processed. A few other very short files were processed.

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.

The PAR sensor was used for casts 1-7, 15, 23, 37. That channel will be converted for all casts, but will be removed at the end from casts with no signal.

Extracted chlorophyll, nutrients, dissolved oxygen, salinity and DMS data were obtained in spreadsheet format.
Preliminary pH analysis results were also received to aid study of the pH sensor. Final data will be added later.
The cruise summary sheet was completed.
The history of the pressure sensor, conductivity and DO sensors were obtained.

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

- The transmissometer calibration was old – there is one from 5 March 2008.
- The secondary conductivity calibration is an old one; the sensor was recalibrated on 13 June 2008.

3. Tests for DO parameters

DO sensors #1438 and 1483 have not been tested to determine the best choices for parameters E, H1 and H3. This cruise includes some deep DO sampling but there is only 1 for the first sensor and 2 for the second that look appropriate for the fine-tuning tests.

1. The first step was to investigate the value of E that minimizes hysteresis at depth.
1a. For sensor #1483 two deep casts with DO bottle sampling (34 and 48) were converted with TAU turned off and hysteresis correction selected. Values of E studied were 3.5, 3.6, 3.7, 3.8 and 3.9. SeaBird conversion was run with numbers included in file name to indicate E value. Those names were adjusted to fit the IOS name format and then they were converted to IOS HEADERS. Sample numbers were added to create SAM files; those were bin-averaged on bottle numbers to create SAMAVG files which were merged with the MRGCLN files (versions of the MRGCLN had to be created with the various run names to enable this.) Adding event numbers to the IOS files was a little awkward – they need to be edited to remove the extra digits used in the file names to distinguish the various runs. While awkward, this enabled all the runs to be put through COMPARE together. For sensor #1438 cast #25 was studied, though not in as much detail.

COMPARE was run using all the data and then plots of differences between the bottles and sensor versus the sensor DO were prepared. The lowest R^2 was with E=3.5, though E=3.6 was not very different. The deepest data were from cast #34 so plots were made of just that cast for E=3.5, 3.6 and 3.7. The DO minimum is at 1000db, so points were excluded below 1000db. The deep points then appear in red on the plot so it is easy to see if the deep data lie close to the shallower data. With E=3.5 the deep values lie slightly below the shallower ones implying the SBE_DO is slightly too low at depth, and with E=3.6 the opposite is seen. So the best value is presumed to be between these two at E=3.55. Tests on Cast #25 show little difference between DO values with the choices of 3.55 and 3.6.

2. Tests were next run on parameter H1. For the first sensor there is little data on which to make a judgment so the nominal value will be used. For the second sensor cast #34 was studied. Conversion was done with E=3.55 and H1 set to -0.023, -0.033 and -0.043. When examined in COMPARE in a similar way to the E tests described above, the choice of -0.033 was clearly better than the other two choices and the results are good enough that further tests are not warranted. H1=0.033 will be used. For the first sensor it also seems wisest to stick to the nominal value given there is little data to judge by.

3. Tests were run on parameter H3 in the same fashion using 1250s, 1450s and 1650s and again the nominal value of 1450s looks best for the 2nd sensor. A few points deep points lie lower and a few higher than the shallow points, so this is likely the best choice available and further testing will not be done. For the first sensor the nominal values will be chosen as well.

4. Finally, both hysteresis (with E, H1 and H3 as determined above) and the TAU correction were selected to see how well the TAU correction works and at what cost to the deep data noise level. Full profiles were converted and plotted. Tests were run on cast #34 to see if the TAU correction should be applied. At a depth of 4000db the noise level is ~±0.006ml/l without the correction and ~±0.017ml/l with the correction. This is reduced to ±0.01ml/l after metre-averaging. The correction clearly produces more variability in the DO trace. But is that noise or signal? A plot was produced with the DO with Tau correction and without alongside the temperature trace. This makes it clear that the Tau correction makes the DO look more like temperature. The descent rate was very noisy for this cast and the temperature shows clear effects of shed wake corruption. But the Tau correction produces spikes in DO that are in the opposite direction to what shed wakes would produce. Fortunately, in editing most such data will be removed.

The history file for these sensors was edited to add this information but it is mentioned that the comparison is not very reliable given the noise in the temperature sensor and the switch of sensors so that there are not many data available, especially for the first sensor used.

4. Conversion of Raw Data

Data were converted using configuration file 2010-01-ctd.con for casts #1 to 33 and 2010-01-ctd2.con for casts #34 to 67. A few casts were examined and all expected channels are present. However, there are many spikes in pressure, temperature, conductivity and dissolved oxygen voltage. So WILDEDIT was run before doing further examination of the files.

There was a note in the log about the change of dissolved oxygen sensors, but the serial number was not listed there or on the first page of the log. Since the two serial numbers were so similar, it looked like a typo when it changed in the configuration files. The log noted indicated that the sensor had been "swapped out" but I thought that possibly meant the sensor had been removed, cleaned and replaced. Had the serial number of the replacement sensor been listed it would have been completely clear.

Rosette files were converted using a start time of -5s and duration of 10s. The TAU and hysteresis corrections were chosen. Some rosette files had no data, so were deleted. They were not real rosette casts. 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 5 casts have outliers, some of which look like pressure spikes. Casts 1, 7, 41, 42 and 43 were opened in CTDEDIT and records with spikes in pressure, temperature or salinity were removed. The output files were then copied to *.BOT. Editing details were added to the header comments. (Further editing was found necessary for those casts later.)

5. WILDEDIT

Program WILDEDIT was run to remove spikes from the pressure, conductivity, temperature and descent rate channels only.
Parameters used were: Pass 1 Std Dev = 2 Pass 2 Std Dev = 5 Points per block = 50
The parameter "Keep data within this distance of the mean" was set to 0 so all spikes would be removed.

A few casts were examined and spikes seem to have been successfully removed from some casts, but at least one is still very spiky.

- The two temperature channels are generally close during the downcast, but there are some odd excursions in both. The upcast data are much noisier so there are significant differences. Conductivity is similar in spikiness.
- The fluorescence looks bad with large steps at depth. It is not clear if the near-surface data are ok or not. .
- Dissolved oxygen voltage has the usual offset between downcast and upcast. There are some spikes.
- PAR is probably ok, but there are spikes and some odd looking data in some files. This will need review later.
- The transmissivity has noticeable hysteresis, not large but more than usual, and is quite spiky at depth for some casts. Using WILDEDIT to remove spikes is tricky, since there are areas of no variation that may lead to noise in the instruments being interpreted as spikes.
- The altimetry looks remarkably good given the very noisy descent rates. There are spikes, but there always are.
- Even the pump status has a spike in cast #6. Whether this means the pump turned off or not is unknown. It was only for 1 scan, so it is unlikely to cause a problem.

Tests were run on cast #6 because it is so spiky, applying the routine to all channels except altimetry. It is risky to apply this routine to channels like PAR using the parameters given above; the deep data has so little variation that minor instrumental noise is interpreted as a spike. However, if those channels with very slight variations at depth are run with a setting that allows small spikes, then this should not be a problem. So a scheme was adopted to do 2 runs, first with distance 0 for the Pressure, temperature and conductivity channels and then with distance 0.02 for transmissivity, fluorescence, dissolved oxygen voltage, PAR and pH. The distance setting will leave some spikes, but does not appear to remove good data.

The chief scientist indicates that there were many spikes in the following casts: 1, 2, 6, 7, 10, 41, 42, 43, 51 and 55. Each of those casts was examined and spikes have been removed from most, but casts #42 and 43 still have some pressure spikes, so an extra run of WILDEDIT was applied to the pressure with parameters:

Pass 1 Std Dev = 2 Pass 2 Std Dev = 5 Points per block = 50

The parameter "Keep data within this distance of the mean" was set to 0.
This removed the remaining spikes in those casts.

It is difficult to examine every cast at this stage. After conversion to IOS header format it is easier to go through all files examining each parameter and at that point this step (followed by repeats of steps 6, 7 and 9) can be repeated if more spiky data are found.

6. CELLTM

Tests were run comparing a variety of settings for CELLTM. The results were difficult to judge because the data were very noisy and the best setting varied from depth to depth and from cast to cast.
The choice ($\alpha = 0.02$, $\beta=9$) looked best overall for the primary and ($\alpha = 0.02$, $\beta=7$) was best for the secondary. CELLTM was run on all casts using that setting.

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.

NOTE: For files 34-66 the conversion included a few unnecesssary channels which made some files so large they couldn't be converted so STRIP was run to remove the # of bottle fired and Bottle Position channels from files 34-66.

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 extremely noisy so these are very rough estimates.

Cast #	Press	T1-T0	C1-C0	S1-S0	Descent Rate
14	1200	~0 XN	+0.00044 N	-0.0053 XN	High, XX noisy
	1960	~0 XN	+0.00047 N	-0.0059 XN	High, XX noisy
34	1200	-0.0004 VN	+0.0005 N	+0.0065 XN	High, X Noisy
	1960	-0.00025 VN	+0.00055 N	+0.007 VN	High, X Noisy
	3000	-0.0002 VN	+0.0006 N	+0.0077 VN	High, X Noisy
	4000	~0 XN	+0.00065 N	+0.008 XN	High, X Noisy
39	1200	-0.0005 XN	+0.0005 XN	+0.0067 XN	High, X Noisy
	1960	-0.0005 XN	+0.00055 XN	+0.0074 VN	High, X Noisy

	3000 4000	-0.0003 XN ~0 XN	+0.0006 N +0.00065 N	+0.0079 VN +0.008 XN	High, X Noisy High, X Noisy
48	1200 1960 3000	-0.00068 XN -0.00056 XN -0.0005 XN	+0.0005 XN +0.00054 XN +0.0006 XN	+0.0065 XN +0.0072 XN +0.008 XN	V.High, XX Noisy V.High, XX Noisy V.High, XX Noisy
53	1200 1960	-0.0007 XXN -0.0006 XN	+0.00045 N +0.00055 N	+0.0065 XN +0.007 XN	High, X Noisy High, X Noisy

The temperature differences are reasonably small and while it is lower at depth, the pressure dependence is no more than expected due to the reduced gradients at depth. The conductivity and salinity have more some pressure dependence in the differences, which could indicate that one or other sensor has cell damage, though the variation is not large and there is usually a little pressure dependence.

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 a few problems were found:

- There were many small differences in times and positions. While this is often the case as the log entry may be just before or after the beginning of the cruise, the differences were larger than usual. For two casts the times were the same; in all other cases the log times are always later than the header times. For cast #20 the difference is 24 minutes and for cast #48 it is 15 minutes. For cast #48 the longitude was also significantly different. The header longitude is >1'east of the other P12 stations but the TSG data supports that position. Also the end of the Go Flo at P12 which immediately preceded this event has a position very close to the header position. For #20 there is no significant difference in position, but there is evidence that the longitude position was changed from the original. In the absence of any explanation for this, the header time was not changed.
- The station name was missing from cast #12.

The station name was fixed as were some header errors noted by the chief scientist in files 12 and 13. The same corrections were also made to the rosette files.

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 2.6db which is a little low for the Tully. Looking at individual files there are cases of pressures of about -0.2db with in-water but definitely near-surface values. It is possible that the CTD had just momentarily left the water. There are other cases with pressure ~0db with data that looks very close to the surface. So the pressure looks like it is within ±0.2db; the sensor had just been recalibrated, so no adjustment will be made at this point.

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 casts #7, 23, 37 and 54 when it did not get close to the bottom according to the log. The altimetry header was removed for those casts from both the CLN files and the MRG files.

The water depths were also checked; it was missing from the headers of 4 casts and was added based on the log book entry. The same changes were made to the bottle files at the MRG stage.

At this point casts were checked that were interrupted and then restarted.
For cast 39/40 and 53/54, the interruptions were during the upcast, so the CTD file will be prepared for casts #39 (this will be renamed as #40 later) and 53, but not #40 and 54.

11. 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; bottle numbers were also added since there were 4 casts that were table driven so that the order of bottles fired is irregular. The addsamp.csv file was converted to CST files (with bottle # included) to be used as a framework for the bottle files. It was used to add sample numbers to the BOT files. The SAM files were then bin-averaged.

A lot of errors were made in the ADDSAMP file because 24 bottles were fired but only one sample number was assigned. In most cases there was a comment about this in the log, but it would be clearer if the # of bottles entered were the # fired, not the # sampled.

<u>SALINITY</u>
Salinity analysis was done at IOS using Guildline Autosal #Model 8400B, serial #69086.
The Autosal data were delivered in spreadsheet "2010-01.xls" which included duplicates and loop samples; the analysis log sheets were also available. Loop data were copied to spreadsheet 2010-01-tsg-loop-comp.xls. There were no cases with both surface rosette samples and loop samples.
The format was awkward with sample numbers and station names entered in a single column. Those were separated and then the event numbers were added in another column. The resulting file was saved as 2009-10-sal.csv, loop data were removed and the file was then converted into individual *.SAL files.

The duplicates were copied to a separate spreadsheet, 2010-01-salinity-duplicates.slx. The averages were calculated. For two of the samples, #309 and 310 the differences were 0.004 and 0.4 and the rosette or log sheets do not indicate that duplicates were taken from those bottles, so these were investigated:

- For cast #33 there were 23 bottles closed at 2005db and only 1 at the surface, sample #309, and there is no mention of duplicates, but there is no rosette sheet, so the comment might just have been missed. This is a near-surface sample, so the difference is reasonable.
- For cast #34 sample #310 is not shown to be a duplicate and sample #319 is missing, so it is assumed that the label of #319 was misread as 310 – the values make sense, so the two values were assigned to either 310 or 319 as their values suggest. A "c" flag and comment were added to explain this. (It is also noted that the sample which is thought to be #319 was analyzed just before #320.)

When only the 5 deep samples (salinity >34) were included and #310 excluded, the average difference is 0.0002 with no difference larger than 0.0015. This shows good repeatability.
It is interesting to note that for duplicate samples #25 and #309 which differed by 0.006 and 0.004, the lower of the duplicates was a better fit in COMPARE, further evidence that when there are problems they are generally associated with samples with high values.

A few problems were found in an early run of COMPARE. Most were due to errors in the addsamp file. A few more complex problems were found:

- Sample #308, cast #32, was supposed to be a surface sample, but the sample looks like it is from 2000m. This looks like either a mis-sample or a misfire and the sample was flagged "e" and replaced with a pad value.

- Sample #415 from cast #43 – This sample was supposed to have been taken from Niskin #10 at 1000m but there is a comment "OOPS" without further explanation. The bottle value looks like it is from 500db. The sample # was changed to #416 which was for the adjacent Niskin bottle, #11, which was fired at 500db. Since this cast was plagued by pressure spikes and large differences between salinity channels, it is very useful to have this bottle, so it will be flagged "c". (Note: the nutrients also look like they are from 500db.)
- There were a number of samples with comments about missing liners and salt on the rims, but there were no flags. "d" flags were added. These will be reviewed after COMPARE is run.

DISSOLVED OXGYEN

Dissolved oxygen data were provided in spreadsheet 2010-01oxy.xls and a duplicate study is in file 2010-01-oxygen-duplicates.xls. The spreadsheet was simplified, and saved as 2010-01oxy.csv and that file was converted into individual *.ADD files. Note that the header information for cast #1 will be different from other casts since different analysis methods were used.

NUTRIENTS

The nutrient data were obtained in spreadsheet QF2010-01nuts.xls which included a report on precisions. The file was simplified and saved as 2010-01-nuts.csv. Extraneous columns were removed and header names were changed to standard format. Data were sorted on sample number. File 2010-01-nuts.csv was then converted to individual NUT files. There were loop samples in the original file; those data were moved to file 2010-01-tsg-loop-comp.xls. The main file was then converted to individual NUT files.

EXTRACTED CHLOROPHYLL

Extracted chlorophyll and Phaeo data were obtained in file 2010-01 CHL.xls which included flags and comments and a report on precision; the duplicates had been averaged. Loop data were moved to 2010-01-tsg-loop-comp.xls. The main 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 2010-01-chl.csv which was then converted to individual CHL files.

DMS

DMS data were obtained in file DMS 2010-01 summary.xls. The file was saved as 2010-01-dms.csv and edited. There were flag and comment columns, but no entries were made; the report 2010-01-DMS-report.doc indicates that none were needed. All entries "<" were replaced with "0"; a note in the header will explain that the minimum detectable level is 0.1. According to the rosette log and the DMS report, duplicates were taken. Duplicates were averaged and "f" flags attached. Headers were changed to standard format and unnecessary columns were removed. The file was then converted to individual DMS files.

pH

The pH data are provisional and will not be archived but were processed for study purposes. File 2010-01_condensed_may19.xls contains the analysis of pH samples. The file was simplified, duplicates averaged, header and flag formats changed to standard ones and unneeded columns removed and the file was saved as 2010-01-pH.csv. That was converted into individual pH files. An initial run of COMPARE was done early using provisional CTD rosette files (2010-01-pH-comp1.csv & xls). A general study was made of the pH data (2010-01-pH-study.slx) because information was required early on how the pH sensor performed. A description of the conclusions is found in file 2010-01-pH.doc. The analyst included some of these results in document 2010-01-pHprobe.doc. It does not appear that this needs repeating since the only changes to the rosette files that occurred after the comparison were minor editing and small changes to the dissolved oxygen channel.

The SAL, CHL, ADD, NUT, DMS and pH files were merged with CST files in 6 steps. After the 6th 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).

At this point the casts that were interrupted and restarted with new event #s were investigated.

- Cast #39/40 - For the bottle file, there was just one bottle fired for event #39. No sampling is available yet, but the CTD data from that firing at the bottom will be added to the CHE file later.
- Cast #53/54 is more complex. File #53 contains the downcast and part of the upcast. File #54 was run just to get surface data. The extracted chlorophyll sample was named #53 and the other samples were named #54. The only file being processed for the full profile is named #53, so that is probably the best choice. There was a ROS file named as #53 but it contains only data from the bottom from where there was no sampling. So the ROS, SAM and SAMAVG file from #54 will be renamed as #53 as will the SAL and NUT file. The merging process was repeated to get all the samples together.

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 the same casts noted in section 10 for the full files. The altimetry headers were removed from the BOT files for those casts. The water depths were corrected in the same way as for the full cast files as described in section 10.

12. Compare

Salinity

Compare was run and many significant outliers were found. The outliers were reviewed and the bottles already flagged were checked:

- Cast #1 – The only outliers were either already flagged or the CTD data were very noisy
- Cast #5 – The duplicate samples from #25 were not in good agreement, and if the one with the lower value is used instead of the average, the fit is much better. The other value looks closer to the bottom bottle, but not close enough to think it was taken from the wrong bottle. Comment amended.
- Cast #10 – Sample #52 was already flagged “d” because of salt on the bottle neck; it is slightly out of line, so flag will be left. Samples 50, 51 and 54 are out of line without any explanation. They will be flagged “c”.
- Cast #11 – Two previously flagged values confirmed as severe outliers. Comment amended.
- Cast #22 – Previously flagged sample is slight outlier in COMPARE. Comment amended.
- Cast #25 – Sample #238 was already flagged sample - severe outlier though CTD data are noisy so that may not be significant. Sample #239 is an unexplained outlier – flagged “c”.
- Cast #32 – 5 bottles are outliers and the CTD salinity is not noisy. The 5 are among 24 fired at 2000m and stand out from the others. They were not analyzed consecutively, but were fairly close in time. Seems more likely to be a sampling problem, poor seal or perhaps salt was spilled on the bottles? All have values higher than expected. Flagged “c”.
- Cast #33 – Duplicate samples differed by 0.006 so were flagged, but lower value looks best in COMPARE, so other value was rejected.
- Cast #34 – There were 3 outliers, one had noisy CTD data, one quiet, one so-so. Flagged “c” as outliers.
- Cast 39/40 – Sample #356 and 360 outliers and the CTD data is quiet. Flagged “c”.
- Cast #42 – Sample #400 – outlier but CTD data extremely noisy. No flag.
- Cast #43 – Sample #123 is an outlier with quiet CTD salinity. Flag “c”. They analyst reported that one of the duplicate samples #109 had salt crystals around the rim, but the two values were extremely close and the average does not stand out in COMPARE, so the flag was removed.

- Cast #52 – this cast was inadvertently left out of the list for the comparison. A check of the data shows the difference between bottle and CTD is close to the average.

A few other outliers are very close to the surface with noisy CTD data so were not considered for flags.

Most of the bottles flagged by the analyst did prove to be outliers, though often fairly minor ones that would probably not have been flagged on the basis of COMPARE alone. It does raise the question of whether many samples are compromised by salt crystals. Bottles without visible crystals may still have some, so this could account for the problems in recent cruises where the CTD appears to be reading lower than the bottles by more than seems likely given the history of the sensors.

Excluding obvious outliers the primary salinity was found to be low by an average of 0.0135 and the secondary was low by 0.0060. There is some pressure dependence though if data around 400-600db were dropped most of it would disappear. Since some casts were heavily corrupted by spikes, a comparison was done excluding those casts and the pressure dependence was less significant. From that comparison the two salinity channels were low by an average of 0.0138 and 0.0064. The time dependence is low for both, but least for the set without the spiky casts, though the differences are probably not significant. The results vary slightly depending on the window used to exclude outliers, but the variations are small.

Next all casts were plotted together but with the differences from known spiky casts in green and the others in red. The results show major outliers come from both groups and most outliers have CTD lower than bottles. Most outliers in the other direction are from the top 200db; the one exception is sample #400 from cast #42 which was a spiky cast and that case was noted above as having noisy CTD data. This does suggest that most outliers are not due to CTD problems, but rather bottle problems. The CTD spikes did not affect bottle files much and the files were edited to remove major spikes before the comparison was done.

Next repeatability was checked from the calibration cast, #32, for which 23 bottles were fired at 2000db; of those 5 have already been identified as outliers. The standard deviation in the remaining 18 bottles is 0.0018. When 1 other bottle is excluded the standard deviation is 0.0009. The CTD salinity was lower than the bottles by an average of 0.014 for the primary and 0.007 for the secondary. The same points are outliers for both CTD channels.

The differences between the two salinity channels are of about the same size as that found in section 8. (For more detail see 2010-01-sal-comp1.xls.)

<u>Dissolved Oxygen –</u>

After COMPARE was run it was discovered that the hysteresis correction had not been applied to the full data files. The rosette files were derived correctly, so no changes were needed to those.

COMPARE was run for Dissolved Oxygen. There is one severe outlier. Sample #999 is said to be from 1000db on the DO analysis spreadsheet. The log indicates the only sample was #284. Further reading of a comment in the log explains that bottle #22 was sampled for dissolved oxygen and there is no mention of the surface sample there. The comment was not easy to read. The bottle file was adjusted and COMPARE was run again. This time there were no severe outliers.

When the differences between the SBE DO sensor and the oxygen bottles are plotted against SBE DO the points fall onto 3 lines:

- Casts 1 to 31 have a reasonably tight fit with a slope of -0.0784 and offset of -0.0218, if the deep part of the first cast is excluded. The sensor takes some time to recover from the hypoxic conditions of Saanich Inlet, but by the time it reached 50m the values fall into line with the other casts. These casts had sensor #1438. When last used the slope was approx. -0.05.

- Casts 41, 48, 55 and 64 fall into a fairly tight group with a slope of -0.0981 & offset of -0.0175. These casts had sensor #1483.
- Casts 34 and 40 also had sensor #1483 but look quite different. They have a lower slope than the casts that followed. And within this group there is variation with the deep data from cast #34 looking different from the data above 120m and the data of cast #40. It is possible that the sensor took a while to acclimate, but the shift at the end of #34 is in the opposite direction to what is found in the later casts.

. (See 2010-01-dox-comp1.xls.)

<u>Fluorescence</u>
COMPARE was run using the CTD Fluorescence and the Extracted Chlorophyll from bottles. It is not surprising that there is a lot of scatter given the unusual data seen in the preliminary plots. Deciding which values are outliers and which are good is not easy. For example the data from P12 shows fluorescence sometimes about 3 times the extracted CHL and at other times it is much lower than the CHL. It looks quite random. Examination of the full profile makes this easy to understand with the higher values of FL presenting a reasonable trace, but many "drop-outs" to near zero. If the cases where FL is lower than CHL are treated as outliers and excluded from the fits, there is still a lot of scatter. It does not seem worth studying this any further. Later in the processing a decision will be made as to whether to archive fluorescence and the extracted chlorophyll may help with this decision.
(See 2010-01-chl-fluor-comp.xls.)

All MRG files were put through CLEAN to remove Sea-Bird headers and comments from the secondary files.

A study was made comparing preliminary pH samples with the SBE ph. Glenn Cooper prepared a document 2010-01-pHprobe.doc. There is currently insufficient information for recalibration of the probe data, but it may prove useful later, so it will be processed up to the REMOVE stage.

Data were exported to spreadsheet 2010-01-bottles.xls and compared to the rosette sheets to ensure all expected data are present. A few problems were found:

– The rosette sheet for cast #40 indicates nutrient sampling – there are none in the MRG file. These data are for analysis system tests only.
– There was a DO sample intended from sample #371, cast 39/40 –an "I" flag was added since the bottle leaked.
– For cast #41 there are 3 DO samples and 4 salinity samples not marked on the rosette sheet. The values look reasonable in COMPARE, so they are assumed to be correctly identified.
– For cast #43 the salinity sample named #415 looks much closer to #416. There is a note in the nutrient spreadsheet that bottle #10 was meant to be fired at 500m, not 1000m. It looks like the salinity sample was drawn from a 500m bottle, so it was renamed as sample #416. Is also looks like the same was done for the nutrient samples. This would be a reasonable step if that was were it was meant to be fired. Wendy Richardson agreed as long as note in header mentions what was on the label.

13. Shift
<u>Fluorescence</u>
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. For this cruise the fluorescence is frequently bad, the descent rate was extremely noisy and there were many spikes, so this test is impossible.
SHIFT was run on all casts to advance the fluorescence channel by +24 records. (Output: SHFFL)

Conductivity
Tests were run on the two conductivity channels using a variety of shifts on 3 casts and the results looked best overall when a shift of -0.5s was applied to both.
SHIFT was run on the primary and secondary conductivity with an advancement of -0.5s.

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. The data are unusually noisy, so this judgement is difficult, but overall a shift of +60 records seemed best for both.
SHIFT was run using +60 records for all casts.

pH
Tests were run to see if alignment of the pH channel looks appropriate. The unaligned data showed similar vertical offsets between downcast and upcast data as seen in the temperature traces. SHIFT was not run on that channel.

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 many warnings, not surprising given the many spikes in these data. In the following cases spikes in pressure were fixed using a text editor to interpolate:

- Cast #10 –records #11786-7 and 15491-2.
- Cast #42 – records #41544, 42715, 47283-84 and 48170-1. Other warnings for this file pertain to the upcast, so were not pursued.
- Cast #43 – Warnings only concern bottom and upcast data. No action taken.
- Cast #55 – Warning for upcast data only. No action taken.

For casts #10 and 42, the CLN files were put through the 5 SHIFT steps and DELETE again. The warnings that remain are the ones deemed not relevant to downcast.

15. Pre-editing studies

It is necessary to decide whether to use the primary or secondary channels for archiving. The secondary salinity data are closer to bottles, but there are grave doubts about the bottle data. There is also evidence of problems with one or other channel for a few casts, so at this point the DEL files were bin-averaged and plots made to see which sensor pair provide the most believable data. The following oddities were noted among the T-S plots:
P4 – Cast #7 stands out as different from the other 3 casts at this site, but both channels are in agreement the T-S feature that is odd, is stable. It is between 140 and 200db. There was a 7 hour break between this

cast and the next one at P4 and this is an area of considerable variability. It is noted that the primary channels have some slightly unstable features that seem stable in the secondary.
P20 – There is a lot of variability at this site in the top 500db, but it looks similar for both sensor pairs, though the primary was noisier for cast #42 in deep water.

Overall, it looks best to use the secondary channels.

Next all casts at P20 #34, 37, 39 (down only), 40 (up only) and 42 were examined to see if there is an obvious explanation for the odd dissolved oxygen calibration from rosette files 34 and 40. Cast #41 was too shallow to include in this comparison. From plots of DO (after alignment) against CTD Salinity, the following features are noted:

- For the downcasts, #34 stands out from all other casts at P20.
- The upcast #40 is similar to the upcast of #34.
- The down and upcasts of 37 and 43 and the downcast 39 (#40 is the upcast for that one) and the downcast of #42 are similar.
- Cast #42 upcast is weird, as was also seen in the profile plot – there is a sudden offset to lower DO values at about 1700db coincident with a very large spike. The difference gradually gets less notable as the cast proceeds. There is no such shift in salinity or temperature, so this does not look like a pump problem.

So the calibration information for the downcast data of casts 37, 39, 42 and 43 may well be in line with later casts. Since the only bottle data for P20 come from casts #34 and 40 (and 3 near-surface samples for #41), it is unwise to use this information to recalibrate the downcasts of #34 and #39. The recalibration that was found for casts #41 onwards will be applied to all the casts with DO sensor #1483.

The SBE:DO should be removed from bottle and CTD files for #34 and bottle file for #40.

16. Argo Comparison

Three Argo floats were launched during this cruise, and data from 2 of them are currently available. The initial profiles from those 2 correspond closely to some of the CTD casts. Comparisons focussed on the dissolved oxygen from the two floats because of concerns about the CTD sensor performance, and because there is a desire to know how well the Optode sensors performed. some checks were also made of how salinity and temperature compared along pressure and density surfaces.

Checks were made against Argo data from floats launched at P8 and P20, both with Optode DO sensors. The following comparisons were considered:

- Comparison of Argo Float 2100211_4901135 data with CTD 2010-01-0034.IOS – roughly 13 hours and 5km apart.

Unfortunately cast #34 has bad SBE DO data based on comparisons with bottles and with other CTD casts at the same site, but there are titrated DO samples from the rosette. This pair was examined quite closely since CTD #34 has the only bottle data available for comparison to this float.

- Comparison of Argo Float 2100211_4901135 data with CTD 2010-01-0039.IOS – roughly 8 hours and 1 km apart.

For cast #39 the profile went to 2000db, but there were no bottles. This file pair was not studied.

- Comparison of Argo Float 2100211_4901135 data with CTD 2010-01-0043.IOS – roughly 1hour *and 6km apart.*

For cast #43 the profile only went to 1000db and there were no bottles. Only a cursory study was made of this pair.

- Comparison of Argo Float 2100211_4901134 data with CTD 2010-01-0055.IOS – roughly 1hour and 1km apart.

For cast #55 the profile went to 2000db and there were rosette bottle data. This pair is also the best match in time/space and was examined with several approaches.

COMPARE was run first. While this is a convenient package for display purposed, it was not very useful for these data when pressure was used as reference channel. Producing good fits with sigma-theta proved impractical it does not vary much and with the thinning required in both data sets to enable COMPARE to work, the matches were not very good. However, a general impression is possible especially for salinity which has a low gradient at depth so the exact match is not so important:

- The secondary salinity at depth compares very well with the average difference below 1000db being ~0.001 for cast #55 at P8 with the CTD reading higher than the Argo Float. For cast #43 the average difference is small (~0.001) when a few surface outliers are excluded and the CTD is lower than the float below 1000db. (The primary salinity does not compare as well, so either the secondary channels are the better choice, or the differences from the float are larger.) Keeping in mind that the salinity bottle analysis is not trusted, it is of some comfort to see that the secondary salinity is close to the Argo float.
- There is a lot more variability in the temperature differences with no consistent direction, but for cast #43 the average difference below 1000db is <0.001C° but it is higher for cast #55 at +0.01C°. This is not surprising since there is more mixing at P8 as evidence in a noisier T-S plot.
- For cast #43 the Argo DO was higher than the CTD. After recalibration of the SBE DO based on titrated DO samples, the Argo DO ranged from low by 1% to high by 28%, with all but one difference being <10% below 350db. Only a few levels had the Argo value low and by only 1%. For cast #55 the picture is very similar with almost all differences on the high side for Argo by up to 40%.

For a more logical look at the DO data, sigma-theta was derived for both the float and CTD files. First T-S plots were examined to see how well the casts compared at a glance. Below the surface layer there is a good correspondence though of course there is less detail in the Argo data. Float 4901134 was within 0.02C° and 0.002 salinity units of the CTD at 1350db. Float 4901135 was even closer to cast #43 around 1400db and just slightly further apart for cast #39 at 1400db. These comparisons are limited by spacing of the Argo data, but these differences are similar to what we would expect from repeat CTD casts at the same sites, so this is encouraging.

Next, some values were recorded for the Argo floats (mostly deep, but one at 250db) and then CTD downcast data were found for the same sigma-theta. The differences were found. While checking DO, the temperature and salinity were also compared as a rough check of how similar the waters were when density matched.

- For the P8 cast (cast #55) the secondary CTD temperature and salinity values were very close to the Argo values for float 2100211_4901134. The primary salinity is not so close, being lower than the Argo salinity by ~0.008. The Dissolved Oxygen differences were all <10% with the Argo values higher for all 3 of the deep levels checked, but lower at 250m.
- For 2100211_4901135 at P20, two CTD casts were examined (#39 and 43) comparing 11 levels in total. The differences in DO are mostly smaller, but for both cases around 800-900db the Float DO is lower than the CTD, whereas below that the Float DO are higher. Profile plots offer no obvious explanation for this, except that DO is varying slowly as it approaches the minimum, while salinity and temperature, and density are varying faster. Even when the sigma-t values are close, temperature and salinity were not as close as for the P8 float, so even where we match density the waters being compared may reflect different mixing and could be slightly different in nature. For cast #43 three levels around 900db were studied and two showed the float lower by 9% and one higher by 0.3%. For cast #39 which was further away in time, the differences at all levels below 850db showed the float higher, but never by more than 7%; the two levels checked

Finally the titrated samples from the CTD rosette were compared to the Argo DO. Sigma-theta was derived for both sets of data, and then values were read from the Argo file to find the best possible match to the rosette bottle data.

- For Argo float 4901134 and cast #55, the difference between float and bottle values differs in sign, with the float generally giving higher values. Where the sigma-t match is within 0.002, the float-bottle difference was +11.4%, +11.3%, -3.5%, +31.1% and -3.0%. When those plus 6 other cases with sigma-t matches <0.005 are included, the average difference is 7.6% with the Argo Optode data higher. This comparison is rough because the Argo data has some density reversals especially near the surface and so there is room for confusion on which level to match. Checking the differences in temperature and salinity to see if those also agree, is one method to address that problem, but only one pair was found that matched really well and for that one the Argo DO is high by 11.4%.
- For Argo float 4901135 and cast #34, the differences were somewhat lower, with an average of 3.7% difference for the 5 levels at which sigma-t matches were within 0.005. The cases with the closest matches were examined for T and S matches and the best was at 2001db for which the float DO was high by 6.8%, but the 600db match was also quite close with the float DO high by only 0.2%.
- A second comparison of 4901135 and cast #34 was done with data selected if the differences between salinity, temperature and sigma-t were all small. For the 5 points of comparison chosen, (not the same 5 as in the previous comparison) the average difference showed the Argo DO high by an average of 3.3%.

The two Argo float DO sensors both look to be high, but for 4901135 the differences are probably within the resolution of the Optode instrument. For 4901134 the Argo DO looks to be high at a more significant level, perhaps by 7%. While there is cause for doubt about the SBEDO with which it was compared, the comparison with titrated bottle samples tells much the same story. This comparison could probably be improved by a more sophisticated approach.
(For more detail see DO_Argo-ctd-bottles.xls)

17. DETAILED EDITING

The secondary temperature and salinity channels were selected for editing.
Graphical editing was done using program CTDEDIT. On-screen plots of descent rate and pump status were also used. Editing was used to remove spikes where they are systematic in direction and/or likely to affect the metre-averaged results. As usual, records were removed that were clearly corrupted by shed wakes, but for this cruise the descent rate was extremely noisy with many complete reversals of direction of the CTD for most casts. This makes it difficult to separate corrupt data from good data. Fortunately, the mixed layer was quite deep and well mixed, so the effects of shed wakes are minimal there.

All casts required some editing, and it was heavy for most of them.
All EDU files were copied to EDT.

At this stage it was realized that the dissolved oxygen had not been put through the hysteresis correction, and that probably matters for the casts with deep sampling. So new files were created with just scan number, pressure, temperature, conductivity and dissolved oxygen voltage and concentration;

WILDEDIT was run on pressure, temperature and oxygen voltage.). Those files were converted to IOS format, put through SHIFT and merged with the EDT files to create EDTNEW files. Only the DO Concentration was chosen from the new files. Since the merge channel is Scan Number, this will ensure that DO will not be saved from records found to be corrupted in the editing process.

18. Initial Recalibration

The SAM files were recalibrated using file 2010-01-recal.ccf which includes a range of DO corrections.

Corrected CTD DO = 1.0784 * CTD DO + 0.0218 (casts 1-33)

Corrected CTD DO = 1.0981 * CTD DO + 0.0175 (casts 34-66)

This recalibration is unlikely to suit cast #34 and there are doubts about #40 but there is no better solution at hand; the downcast data will be examined later to see which casts have usable DO data.

After this step COMPARE was rerun to ensure the changes were as expected. Cast #1 had some outliers and cast #34 is all outliers with one possible exception. There is a lot of scatter, especially for the second sensor, but the calibration looks satisfactory. Cast #40 seems ok with this fit. (See 2010-01-dox-comp2.xls.)

Next the EDTNEW files were recalibrated with output COR1.

The profiles at P20 were compared to see which stand out. The dissolved oxygen for cast #34 does not fit with the others (at all depths). Temperature, salinity and T-S plots do not indicate any big problems at P20. It looks as though removing DO from cast #34 is all that is required. There was no pH on the bad cast.

Casts #34 and 39 were compared after thinning. The salinity differences below 2000db are all <0.002. There is more variability above that with differences <0.014 from 200db down. Temperatures are quite noisy, but differences are <0.1 below 2000db and <0.005 below 3000db. Since the comparison is at constant pressure rather than density, the results are satisfactory. The differences in DO confirm that there is no obvious method of recalibrating #34 to make it look more like #39.

19. 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. The results were analyzed separately for the two DO sensors:

- For sensor #1 there is a lot of scatter in the high DO gradient region of 100db -600db range. When differences >0.07mL/L were removed, the CTD data are low by an average of ~0.001 with no obvious DO or pressure dependence. No further recalibration of this data is justified.
- For sensor #2 the results are more complex. As expected, the cast #34 data looks bad. For the other casts there is a lot of scatter. If differences >0.015mL/L are excluded there is a flat fit with the CTD high by about 0.015, but that excludes mostly high values. Most of the outliers are from the high DO gradient zone between 75 and 400db; excluding those the CTD is high by an average of 0.016mL/L. Most of the outliers are on the high side. Recalibration would improve the high gradient zone, but make the top 100db and data from below 400db worse. Between the scatter in the data and the mixed effect recalibration would have, it was decided to leave the data as they are.

(See 2010-01-dox-comp3.xls.)

20. Special Fluorometer Processing

An examination of the fluorescence channel shows very noisy deep data, with no consistent dark value. Profiles were examined and it looks as though only the data from casts 1-14 look usable. Even for those casts the deep values are higher than usual and the fit against extracted chlorophyll has a large offset.

The COR1 files were clipped to 150db and set aside in case special files need to be prepared later.

A median filter, fixed size=11, was applied to the fluorescence channel in the COR2 files to reduce spikiness. A few casts were examined before and after this step and showed that the filter was effective. However, there do seem to be some problems with the fluorescence in some casts – possibly related to the pump problems. All these files will be examined later.

21. BIN AVERAGE of CTD files

The following Bin Average values were applied to the FIL files (output AVG):
Bin channel = pressure   Averaging interval = 1.000   Minimum bin value = .000
Average value will be used.   Interpolated values are NOT used for empty bins.
After averaging, page plots were examined on screen and no further editing appeared to be necessary.

On-screen plots were checked to see if there were any problems and the following were noted:

- Fluorescence looks possibly useful in casts 1-14 though there is an odd offset, so we could possibly subtract the dark value. After that cast, the data look unusable.
- PAR has odd spikes, but these are only noticeable if the maximum is low – so night casts looks bad. The spikes are mostly around 10db but for cast #6 there are spikes to 0.4 at about 75db. For most daytime casts, there are some barely noticeable bumps in the traces, but the overall shape is reasonable. Cast #2 is an exception with larger spikes at about 15db so that that the shape is very odd. Checks were made that these were not features somehow created in the processing stream, but they are present in the raw data. Since these data are always reported as nominal, the spikes are small and the surface values are reasonable, they will not be removed.
- DO has some odd features at P6 and P7 but so does salinity and the T-S is stable. A spike in cast #42 was caused by a single bad value, so was fixed using a text editor on the COR1 file. Filter and Bin-average were rerun on that file. No other problems were noted.

For cast #37 the fluorescence is mostly 0 from the surface to about 25db with some spikes. At about 18db it spikes just at the point where the PAR signal also spikes. This shows that the fluorescence problem is likely not caused by the pump.

22. Other Comparisons

<u>Previous experience with these sensors</u> –

1. Salinity:
   The primary conductivity sensor has been used for many cruises since it was last recalibrated, but calibration sampling was very limited. For cruises 2008-10 and 2008-50 it was found to be low by 0.007 and 0.01, respectively. The secondary sensor has been used on only 1 cruise with calibration sampling and that was only surface sampling. The salinity was found to be high by from 0.002 to 0.017.
2. Dissolved Oxygen – The sensor used for the first part of the cruise was used for 2009-43 when the slope/offset of the correction was 1.0534/+0.0087. The sensor used from cast #34 onwards has no history, so is assumed to never have been used before.
3. Pressure – The sensor is an older one but was recalibrated shortly before this cruise.

Historic ranges – Profile plots were made with historic ranges of T and S superimposed, but the only data available at the time of processing showed the 1 standard deviation limits. Much of the data falls outside those ranges, though deep offshore data did fall inside. At P12 most data was within the range except at consistent temperature minimum near 100db. This is presumed to be real and not signs of instrumental problems.

Repeat Casts – There were many repeat casts. Profile and T-S plots were made of groups of casts to see if anything stands out as suspicious:

- There is a lot of variability between 80db and 200db. At P20 the mixed layer varied from 80 to 100db first deepening and then shallowing during the time at that site. Around 1700m salinity varies by <0.001 and temperature by <0.01C° along lines of constant density.
- At P12 there is similar variability below the mixed layer, and around 300db there is some odd variability. Even at 1000db there is quite a lot of variability, but below 1500db differences are <0.001 salinity units and <0.005C°.

23. FINAL CTD files steps (REMOVE and HEADEDIT)

At this point plots were produced to decide what to do about the fluorescence. A spreadsheet was prepared from the bin-averaged data to study how the fluorescence varies with pressure. This showed high but fairly consistent dark values in the early part of the cruise, but after cast #20 there is very high variability with values as high as 0.9. There are casts where the fluorescence at 250db is higher than at the surface. Until cast #14 there appears to be a fairly consistent value below 100db. The later values can't be taken too seriously since the averages will include zeros and spikes, but examination of plots does show a great deal of noise at depth.

A quick check was made of data from 2009-03 to see what dark values were found at that time. There is variability from cast to cast with values continuing to go down below 1000db, though the differences are on the order of 0.01ug/L between 1000 and 2000db. The values at 1000db varied from 0.108 at P7, 0.183 at P12, 0.171 at P16 and 0.059 at P26. While these are small variations, they are significant when the peak values are <1 as they are for many of these casts. These checks suggest that subtracting dark values might be a good idea, but that it will be hard to pick a suitable value since the range goes from 0.05 to 0.15ug/L even in very deep water.
SeaPoint recommend frequent calibration of the instruments due to decreasing output from the light sources and scratches on the window.

Should we subtract an average dark value (~0.35ug/L) from casts #1 – 13? While the value is gradually decreasing, it is not obvious that this is justified. Since the cause of these large values is not known, we can't be sure that the near-surface values are equally offset. On the other hand the comparison with CHL does suggest that the surface is off by about 0.4ug/L. Subtracting 0.35 does lead to a reasonable fit.

Arguing against this approach is the fact that the deep values are gradually decreasing. For example at P16 the fluorescence value is still decreasing at 3500db. From cast #16 onwards, most of the data is spiky with sections of zero values and no hint of what the dark value would be. For cast #13 the dark value continues to decrease slightly even as the CTD reaches bottom and starts up again; only about 100db above the bottom does it reach its minimum value. While these variations are slight, they are surprising. Perhaps that is because this is not something that we usually examine in great detail.

After consultation with Dr. Peña it was decided that the fluorescence should not be archived. Separate files will be prepared that include that channel so that the chief scientist can provide these (with a word of caution) to anyone who requests the data.

The following channels were removed from all casts: Scan_Number, Temperature:Primary, Salinity:T0:C0, Conductivity:Primary, Conductivity:Secondary, Oxygen:Voltage:SBE, pH:SBE, Fluorescence:Seapoint, Altimeter, Status:Pump, Descent_Rate and Flag.

The PAR channel was removed from casts #10-14, 16-22, 24-36 & 38-66 because the instrument was not mounted on the CTD for those casts and for casts 6-7 because the noise was much more significant than the signal.
The Oxygen:Dissolved:SBE channel was removed from cast #34.

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 PAR data are nominal and unedited except that some records were removed in editing temperature and salinity.

Fluorescence data were removed because of severe problems with spikes and higher than usual values at depth suggesting problems with the cable. The data may be obtained from the chief scientist.

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:

- *±0.15ml/l from 0-100db*
- *±0.5ml/l from 100-400db (Values tend to be too high)*
- *±0.2ml/l from 400-600db (Values tend to be slightly high)*
- *±0.04ml/l from 600-2000db (Values tend to be slightly low)*
- *±0.01ml/l below 2500db*

For details on the processing see processing report: 2010-01-proc.doc.

A second recalibration was run to correct transmissivity. HEADEDIT was then run to add the following comments (2010-01-hdr2txt) and to fix a few errors in the headers.

****

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 2.26, which was based on the assumption that deep offshore transmissivity should be about 62%/m.

For details on the transmissometer post-processing see:
OSD_Data_Archive:\Cruise_Data\DOCUMENTS\Transmissometer 1005DR Corrections.doc

These data should still be considered nominal.

****

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.
Files that include fluorescence were named CTDFL.

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

For cast #34 the header note about SBE dissolved oxygen was replaced with a note about why that channel had been removed.

As a final check of dissolved oxygen data, % saturation was calculated and plotted. The near-surface values were all between 90% and 105% except for the Saanich Inlet cast. Most were between 97% and 101%. There is a surface bottle for Saanich Inlet and it is in good agreement with the SBE DO, so the 77% surface DO saturation does not appear to indicate a problem with the sensor.

24. Final Bottle Files

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

The following channels were removed from all casts: Scan_Number, Temperature:Primary, Salinity:T0:C0, Conductivity:Primary, Conductivity:Secondary, Oxygen:Voltage:SBE, pH:SBE, Fluorescence:Seapoint, Altimeter, Status:Pump, Descent_Rate and Flag.
Oxygen:Dissolved:SBE was removed from casts #34 and 40 (name changed to 39 later).
The PAR channel was removed from casts #10-14, 16-22, 24-36 & 38-66 because the instrument was not mounted on the CTD for those casts and from casts 6-7 because the noise was larger than the signal.

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

At this stage the data from file #39 was added to file #40; then file #40 was renamed 2010-01-0039.MRGOX. The bottle firing sequence was adjusted by adding 1 to each number to take into account the added bottle from file 39.
HEADER EDIT was run to fix formats and units, fix a few header errors and to add a comment about quality flags and analysis methods. Note that header 2010-01-bot-hdr1.txt is for cast #1 and 2010-01-bot-hdr2.txt is for all other casts because the method of DO analysis differed.
The Bottle Position channel name was changed to Bottle_Number and the Bottle_Number was changed to Bottle:Firing_Sequence.

The following note was added to the headers of #34 and 39 about why the DO channel was removed.

> The SBE Dissolved Oxygen data were removed from this cast due to poor
> comparison with bottles and with other casts at the same site.

CALIBRATE was run as a final step to recalibrate the transmissivity channel..

The bottle data were exported to a spreadsheet to check that all data are present. The only problems noted were already discussed in section 12.

Plots were made of CTD Salinity versus SBE Dissolved Oxygen and bottle DO and no outliers were identified.

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.

25. Thermosalinograph Data

Data were provided in 10 hex files. There were 4 loop bottles in Juan de Fuca and 8 during Line P – not during CTD casts. According to the log there were a lot of spikes in positions for files 1-3 due to a problem with the NMEA string. File 4 was almost all bad but most of that record was during the stop at P12. File 5 onwards looked ok.

Files of nutrients, chlorophyll and salinity loop samples were found and combined in spreadsheet 2010-01-tsg-loop-comp.xls.

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

The calibrations were checked and the only problems were in the fluorometer settings which had the wrong date and small errors in the parameters. It was noted that the CON file changed between files #4 and 5; this only concerned how NMEA data were downloaded. The two versions of the CON file were saved as 2010-01-tsg-test.con for files 1-4 and 2010-01-tsg.con for files 5-10.

b.) The files were converted to CNV files using the configuration files mentioned above. They were then converted to IOS HEADER format.

CLEAN was run to add End times and Longitude and Latitude minima and maxima to the headers.

Time-series plots were produced. File 1 contained only 1 data record and File #4 had 3 records. The hex file for #1 also contained only 1 record. Hex file #4 is larger, but examination of the raw file shows that there are only 3 records of the proper length. Files #2 and 3 show similar corruption.

Between files #4 and #5 the con file entry "NMEA device connected to Deck Unit" changed to "NMEA device connected to PC". The same con file can be used for all conversions as the NMEA connection is not relevant to the conversion. It seems most likely that the noise problem in file #4 is related to the NMEA connection and changing that led to better data in file #5.

At the end of file #3 the flow rate changed from about 0.6 to 1.2. It is presumed this was done in the hope that the data would improve, but there are still many spikes.

Salinity data are very noisy at the end of file #7 with no associated noise in any other channels. Files #8 and 9 are very short (~30 minutes) – the stops and starts are presumably failed attempts to improve the salinity. Much of file #10 has bad salinity data, so obviously no solution was found to that problem.

In the conversion process the corrupted records are skipped, so the calculated time is wrong in files #2-4 because it is based on record number. (This was discovered because initial track plots looked wrong.) Tests were run to see if there was a way to fix the files so the bad records are corrected. It was discovered that 2 to 4 digits were missing. The last 16 digits look reasonable and are the ones that contain position information. The first 4 also seem to all be ok and those contain the lab temperature. Adjusting the bad records by entering an appropriate number of spaces before the latitude/longitude information allows conversion, and that ensures the record numbers are correct. This was a time-consuming process was applied to files 2, 3 and 4 using Ultraedit. While many records had to be removed later, this did allow production of files with correct time.

Next a text editor was used to remove the bad records as judged by spikes in flow rate, fluorescence and temperature:secondary. It might be possible to save positions and the temperature:primary and salinity from those records, but that takes 3 times as much effort and it is not certain that those records are correct, so it was decided to take the short cut of removing all the suspect records.

All files were examined in CTDEDIT to see if further editing was required and the following steps were taken and the final edited files were saved as *.ED1:

- 2 – more records removed and some cleaning of spikes
- 3- more records removed
- 4 – more records removed
- 5 – no editing needed
- 6 – light cleaning of salinity
- 7 – removal of salinity from the end of the file and light cleaning of salinity elsewhere
- 8-9 – very short and all salinity bad, so salinity was removed
- 10 – large sections of salinity data removed or cleaned

After the editing Track Plots were run. File #3 looks odd but other records of ship movements confirm the ship went off the Line P normal track, perhaps because of a storm. For cast #4 the track looks very odd, but this is because the scale is small and the ship was on station throughout.
The ED1 files were copied to *.EDT.

c.) Checking Time Channel
In checking the odd track mentioned above, when one position was checked in the SCS record, the time differed from the TSG record by 3 minutes.

The CTD data, after editing, but before metre-averaging, were thinned to reduce the files to a single point at or within 0.5db of 4.5db and exported to a spreadsheet which was saved as 2010-01-ctd-tsg-comp.xls. All the data came from 4db. There was one cast with no match in the TSG record. Since the surface layer is quite well-mixed we hope that mismatches in depth won't matter too much.
The 6 TSG files that coincide with CTD casts (3-7 & 10) were opened in EXCEL, median and standard deviations (over 5 records) were calculated for temperature, salinity and fluorescence and the file was then reduced to the times when CTDs were run.

Those files were added to the CTD data in file 2010-01-ctd-tsg-comp.xls. There were 39 matches. In some recent uses of this equipment latitude and longitude have become stuck, so a few larger differences were investigated. There was no evidence of trouble in the files, so the differences are likely due to slight mismatches in time. The CTD times are from the beginning of acquisition so the length of time taken at the surface before getting to 4m could affect the match. There is no evidence of problems with the clock. 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 connected throughout the cruise. The average difference was 0.22Cº. The temperature ranged from 6.9 to 9.9ºC. That is typical amount of heating in the loop for a winter Tully cruise.

- 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 39 casts that could be used. The TSG intake temperature was higher than the CTD by an average of 0.011Cº with a median difference of 0.010Cº. When the 10 casts with the lowest standard deviation in TSG temperature were included it was high by 0.010Cº. As expected, the change in loop flow rate after cast #14 had no noticeable affect on the difference.

The TSG salinity is lower than the CTD by an average of 0.132 and a median of 0.091. When the 10 cases with the lowest standard deviations in the TSG salinity are included the TSG is lower by 0.057. Those cases mostly coincide with the lower flow rate at the beginning of the cruise. When the flow rate increased the salinity difference increased. The error in salinity is partly due to conductivity cell drift and partly because the temperature in the lab is higher than the in situ value. If the water has longer to warm up, the temperature effect will be larger. This suggests that for this equipment the warming is offsetting the conductivity error. The averages before and after the change in flow rate are -0.0635 and -0.1575. The differences get noisier even before the change of flow rate, but that might have been because of storms. When the data are reduced to well-mixed cases the averages are a little different, but the TSG salinity data is very noisy for many of the cases so the result is not as reliable as usual.

The ratio of TSG fluorescence to CTD fluorescence is ranges from 0.4 to 4.5 with an average of 1.96 and median 1.92. During last winter's Line P cruise the average was 2.2 with a median of 1.7. There are some doubts about the CTD fluorescence values on this cruise, but the TSG would suggest they are not too bad near the surface. The fluorescence ratio was 2.8 when the flow was low and 1.7 when it was high (or 2.6 and 1.8 using only well-mixed casts). There is one case where the flow rate is very high and the ratio very low. This was a part of the record with just a few high values in flow and wildly varying fluorescence including at least 1 negative value.

It is possible that the removal of records has had some bad effects on the comparisons as time may be slightly in error. (See 2010-01-ctd-tsg-comp.xls.)

- <u>Loop Bottle - TSG Comparisons</u> A comparison was done in spreadsheet 2010-01-TSG-loop-comp.xls of TSG salinity and extracted CHL and the corresponding loop samples. There were no loop samples that coincided with CTD casts. For salinity there are only 6 points of comparison and one looks like an outlier. The TSG is lower than the loop samples by an average of 0.96 but the standard deviation is 0.13. When one outlier is excluded the TSG is low by 0.05 with a standard deviation of 0.08. But the 3 samples when the flow rate was low average -0.015 but of those 3 two are close at ~-0.06 while the other shows the TSG high. For the high flow rate it is -0.13. The TSG fluorescence was higher than the Loop CHL by a factor of 4 with 12 samples to compare; the standard deviation in the ratio is 1.2. Excluding one outlier raises the ratio of 4.2 with a standard deviation of 1.1. When divided into low and high flow rate the averages are ~3.3 and ~4.5. The ratio for the low flow rate is similar to that found in comparison to the CTD fluorometer, but for the high flow it is quite different, confirming that the CTD fluorometer problem was worse later in the cruise. (See 2010-01-TSG-loop-comp.xls.)

- <u>Loop Bottle - Rosette Comparisons</u> For this cruise there were no cases of rosette casts and loop samples at the same time.

- <u>Calibration History</u>

The TSG primary temperature and conductivity were recalibrated in April 2009 and were used for two cruises in 2009. The estimate for ship heating for the Tully at this time of year is ~0.2C° with a flow rate of about 1.

<u>Conclusions</u>

1. The TSG clock appears to be working well.
2. At CTD cast #14 (near the end of TSG file #3) there was a dramatic change in the flow rate and this affected TSG salinity and fluorescence values.
3. After cast #14 the CTD fluorometer began working badly. The effects are obvious at depth, but cast doubts about the whole profile. The ratio of TSG to uncorrected CTD fluorescence went down markedly

when the flow rate increased, whereas the ratio to CHL went up slightly. This is probably further evidence that the CTD fluorescence is not reliable after cast #14. The CTD fluorescence was probably too high and the timing of the change near the time of the flow rate adjustment is likely coincidental. Even before cast #14 the CTD fluorescence values are probably high by 0.3ug/L based on dark values.
4. The temperature in the loop warms by about 0.26ºC when the flow rate is low and by 0.21ºC after the increase. The latter value is typical of winter conditions for the Tully.
5. Salinity is low by 0.064 and 0.0158 based on the CTD comparison for low and high flow rates, respectively. From the loop comparison there are few samples and some look like outliers. The two most believable samples from the low flow rate period suggest the salinity is low by ~0.06, while it is low by either 0.011 or 0.15 for the later period. Subtracting 0.06 for files 1-3 and 0.016 for files 4-10 looks like a reasonable recalibration scheme.
5. The fluorescence is higher than the CTD fluorescence and the loop CHL by about 3 times while the flow rate is low. When the flow rate was increased the TSG fluorescence is higher than the loop CHL by a factor of 4.5. Comparisons with the CTD fluorescence after cast #14 are not considered reliable.
7. The intake temperature is within 0.01ºC of the CTD temperature from 4m.This is as close as we can expect.
8. When the flow rate is changed it is especially helpful to take extra loop samples. Loop samples during CTD stations are also very useful for inter-comparisons of all systems.
9. File #1 contains only 1 record so will not be archived. Files #8 and #9 are short and the salinity data are bad, but the positions may be useful and the temperature looks fine.

f.) Editing

Plots were examined and no further editing was deemed necessary.

g.) Recalibration

File 2010-01-recal1.ccf was used to subtract 0.06 from the salinity for files 2 and 0.16 for files 4-10. The recalibration of file #3 is complicated because the lower correction applies to most of the file, but the last 6 hours should have the higher correction. Fracture was used to separate the file so the different corrections could be applied. They were later joined, and a note was added to the header describing what was done. However, the automatic IOS SHELL calibration statement applies to only the part up to 2010/02/05 17:13:20.

h.) Preparing Final Files

REMOVE was used to remove the following channels from all casts: Record #, Scan Number, Temeprature:Difference, Conductivity:Primary, Uploy0 and Flag.

REORDER was used to place Temperature:Secondary ahead of Temperature:Primary and to rename them as Temperature:Intake and Temperature:Lab. The reorder is to ensure that programs pick the intake temperature preferentially.

HEADER EDIT was used to add a comment, change the DATA TYPE to THERMOSALINOGRAPH and add the depth of sampling to the header. Those files were saved as TOB files. A note was added to file #3 explaining the change in salinity recalibration at 2010/02/05 17:13:20.

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

26. Producing final files

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

The final loop file 2010-01-loop.csv was prepared by the chief scientist including data from the final CTD files and samples from the loop or from 5m bottles. That spreadsheet was simplified, header names and formats were adjusted and unneeded channels were removed and saved as a CSV file and the 6-line header template inserted and adjusted as needed. The resulting file (2010-01-loop-6linehdr.csv) 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 2010-01-surface.loop.

Particulars – including notes from log, rosette sheets:
Many spikes: 1,2,6,7,10, 41,42,43,51,55. All channels.
Table driven: 37, 39/40, 41, 42.
PAR on: 1-10, 23, 37/
pH on: 1-10, 23, 37 (cast 2 had cap on so useless.)

2. Cap left on pH sensor.
6. Huge spikes in S, T, DO on downcast.
10. Spikes with new termination.
11. pH off, no spikes?
12. Computer crash. Header cruise # wrong.
13. Slow descent – lots of heave. Header cruise # wrong.
15. Big swell. Wrong depth in header
17. Cast aborted at 400m computer crash.
19. Cable snapped.
20. Reterminated cable before cast.
21. Stopped at 965db to changed operators.
22. Changed Oxy and trans cable. Spike in trans at 100m on upcast.
25. Corrosion on PAR pins.
29. Stopped at 934db to switch operators.
32. Calibration cast. Pause at 122m operator testing LARS.
33. Swapped out DO sensor as signal was fuzzy at depth. Also swapped altimeter.
34. Problems with DO sensor both down and upcasts
37. Table driven
39/40. Table driven. Computer crash part way through upcast. Continued in #40. One bottle in file #39, but no sampling, so CHE produced only for 40. DO bad in 40 upcast. At end of processing name bottle file as #39.
42. Spikes error flashing on deck unit.
43. Reseated sea cable, awful spikes, operator paused at 446.
46. CTD sensor test – data not archived.
48. Top bottle did not close, resent to 100m
51. NMEA problem.
52. Minor sal spikes
53/54. Computer crash at 60m of upcast. Continued in 54.
57. Cancelled at 380m – too rough.
61. Archiving did not start until 40m downcast.

Institute of Ocean Sciences
CRUISE SUMMARY
CTD

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

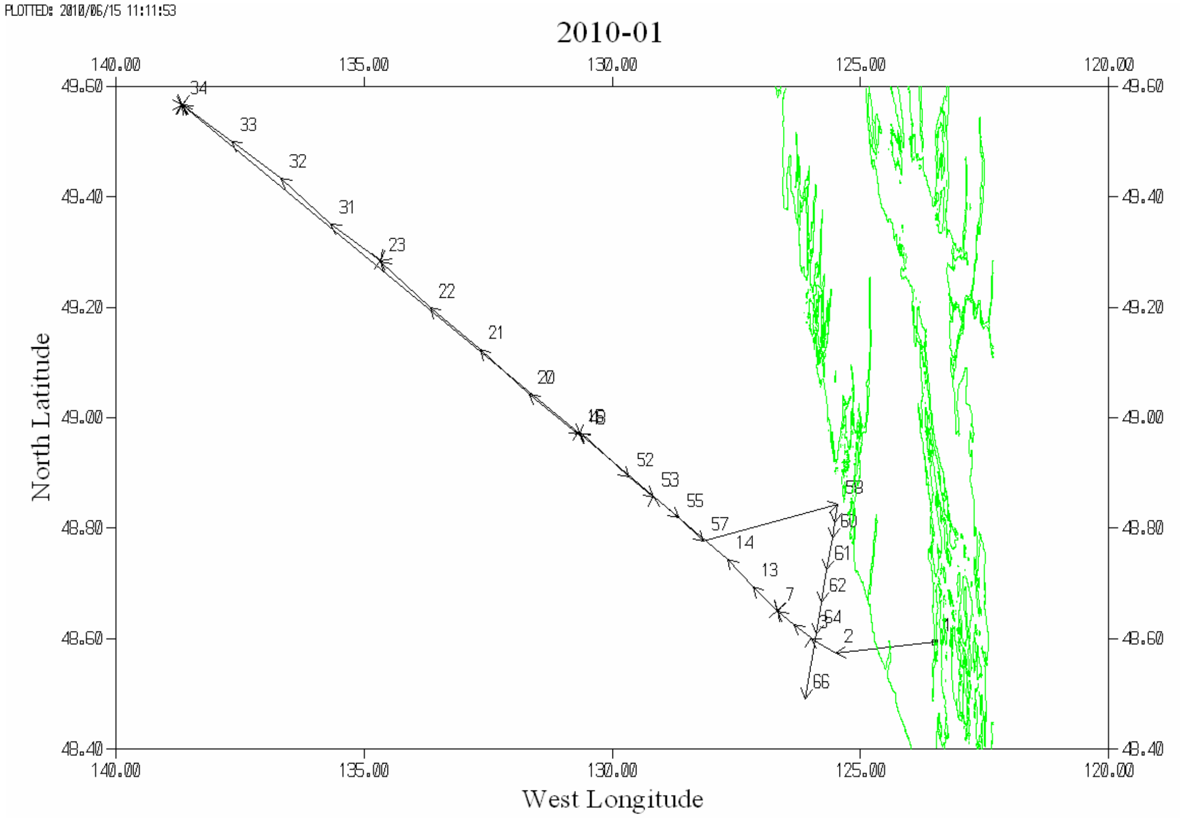
Calibration Information					
Sensor		**Pre-Cruise**		**Post Cruise**	
Name	**S/N**	**Date**	**Location**	**Date**	**Location**
Temperature	**4752**	**06Mar78**	**Factory**		
Conductivity	**2173**	**07May08**	**“**		
Secondary Temp.	**2968**	**22Aug07**	**“**		
Secondary Cond.	**2399**	**13Jun08**	**“**		
Transmissometer	**1005DR**	**5Mar08**	**IOS**		
SBE 43 DO sensor	**1438**	**03Feb2009**	**Factory**		
PAR	**4656**	**29Jan2009**	**IOS**		
Fluorometer	**2229**	**?**	**IOS**		
Pressure Sensor	**63507**	**11Dec2009**	**Factory**		
Altimeter	**1252**	**?**	**?**		

TSG

Make/Model/Serial#: SEABIRD/21/2488 Cruise ID#: 2010-01

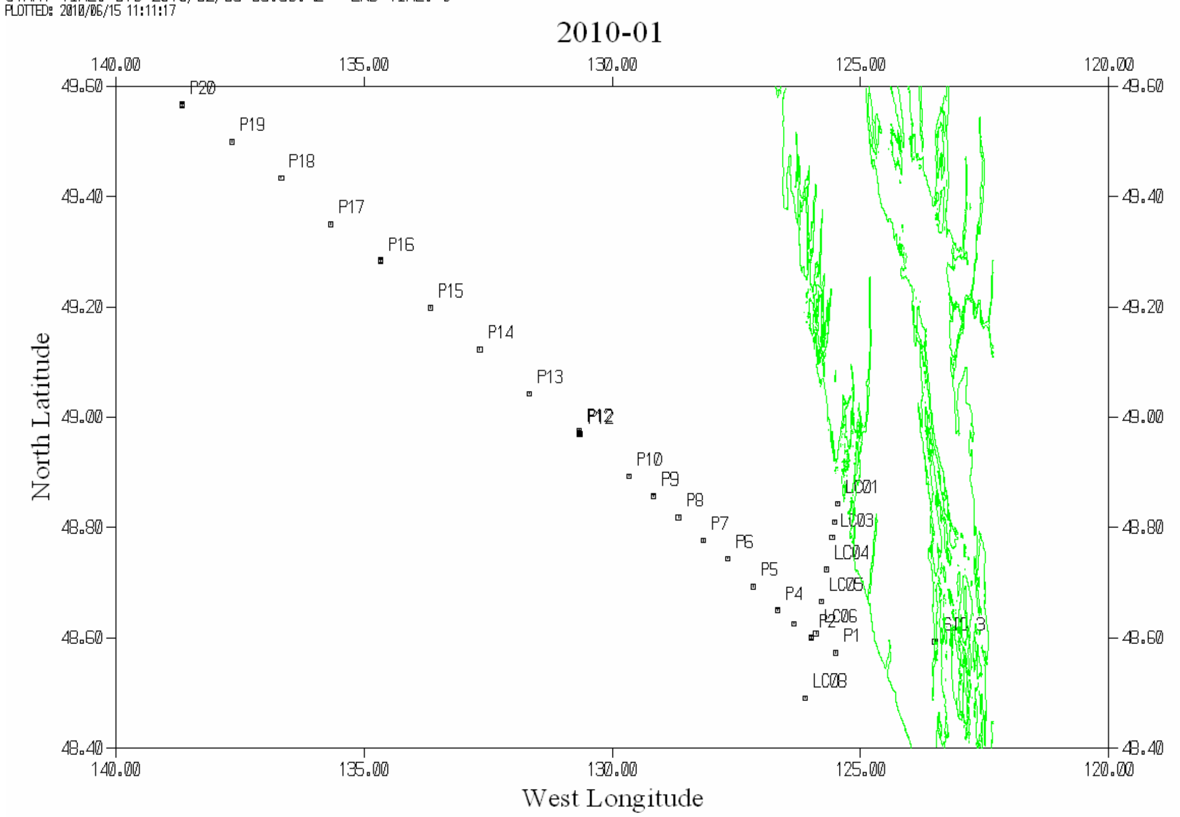
Calibration Information					
Sensor		**Pre-Cruise**		**Post Cruise**	
Name	**S/N**	**Date**	**Location**	**Date**	**Location**
Temperature	**2488**	**24Apr09**	**Factory**		
Conductivity	**2488**	**24Apr09**	**“**		
Wetlab/Wetstar FL	**WS3S-713P**	**18Jan01**	**“**		
Temperature:secondary	**2416**	**23Dec06**			

PLOTTED: 2010/06/15 11:11:53

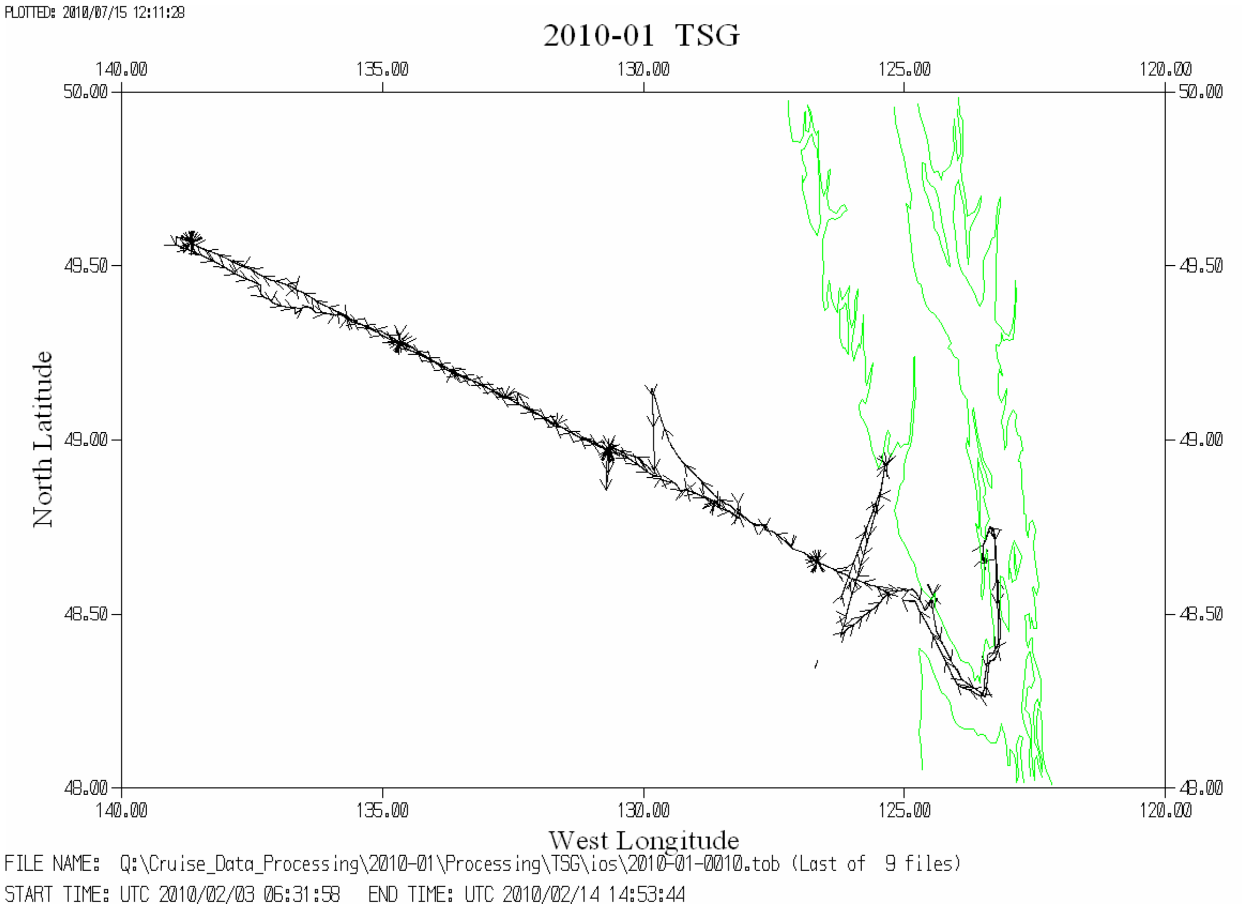


START TIME: UTC 2010/02/03 05:30:42 END TIME: 0

PLOTTED: 2010/06/15 11:11:17



START TIME: UTC 2010/02/03 05:30:42 END TIME: 0


PLOTTED: 2010/07/15 12:11:28
2010-01 TSG
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135.00
130.00
125.00
120.00
50.00
49.50
49.00
48.50
48.00
North Latitude
West Longitude
FILE NAME: Q:\Cruise_Data_Processing\2010-01\Processing\TSG\ios\2010-01-0010.tob (Last of 9 files)
START TIME: UTC 2010/02/03 06:31:58 END TIME: UTC 2010/02/14 14:53:44