REVISION NOTICE TABLE

DATE	DESCRIPTION OF REVISION
19June2019	Added DMSP-D and DMSP-T – only pad values due to contamination.

PROCESSING NOTES

Cruise: 2015-001
Agency: OSD
Location: North-East Pacific
Project: Line P
Party Chief: Robert M.
Platform: John P. Tully
Date: 11 February 2015 – 24 February 2015

Processed by: Germaine Gatien
Date of Processing: 12 May 2015 –

Number of original HEX files: 53	Number of CTD files: 50 (1 test, 1 split, 1 surface only)
Number of bottle files: 52	Number of bottle casts processed: 50 (1 test, 1 split)
Number of original TSG files: 3	Number of processed TSG files: 3

INSTRUMENT SUMMARY

SeaBird Model SBE 911+ CTD (#0506) was used for this cruise. It was mounted in a rosette and attached were a Wetlabs CSTAR transmissometer (#1396DR), a SBE 43 DO sensor (#1438) on the secondary pump, a SeaPoint Fluorometer (#3642) on the primary pump, a Biospherical QSP-400 PAR sensor (#4615), a surface PAR (#16504), a pH sensor (#0691), Rinko DO sensor (#062 - unpumped) and an altimeter (#62354).

A thermosalinograph (Seacat 21 S/N 3363) was mounted with a SeaPoint fluorometer (#2356), remote temperature sensor and a flow meter.

The data logging computer was #3. Seasave version V7 22.4 was used for acquisition.
The deck unit was a Seabird model 11, serial number 0471.
All casts were run with the LARS mid-ship station.
The salinometer used at IOS was a Guildline model 8400B Autosal, serial # 68572.
The oxygen kit was IOS model 665, kit #3.
An IOS rosette with 24 10L bottles was used.

SUMMARY OF QUALITY AND CONCERNS

The Daily Science Log, rosette log sheets and analysis logs were in good order.
Sampling notes from the chief scientist were very useful.

Event #65 was interrupted by a computer crash during the upcast, so a 2nd file was started with the event # 65-2. No bottles were sampled from the upcast portion of the first file. There were bottles sampled that correspond to the 2nd file, so the bottle file was renamed as #65 after conversion.

The comparison between salinity bottles and CTD salinity had more scatter than expected. Salinity analysis was prompt and plastic inserts were used in the bottles, so the scatter is likely due to considerable vertical motion of the CTD during stops for bottles. It is assumed this was largely due to rough seas. While the variability of the CTD salinity during the 10s window around firing time was generally low enough, the CTD package was moving around more than usual so that the contents of the bottle and the water sampled by the CTD during the stop likely differed more than usual. The smallest differences were found for casts which had the steadiest descent rates.

There were cups mounted on the rosette for event #85. There was some concern about whether this would interrupt flow to the CTD sensors. There was 1 salinity sample for this cast and it came from the surface; it did not stand out in the comparison to the CTD salinity, but there is high variability so that is not significant. Profile plots are very noisy in this area due to many stops for bottles and extremely noisy descent/ascent rates, so that attributing any differences from one cast to another to a particular cause is inadvisable.

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

±0.5 mL/L from 0 to 100db
±0.3 mL/L from 100db to 500db
±0.05 mL/L below 500db

The Thermosalinograph performed well with only minor 1-sided spikes in salinity. Recent improvements in the equipment set-up have put an end to the huge spikes that used to occur regularly. There is some evidence that there are still small bubbles. Salinity was found to read lower than that from the CTD by between 0.007 and 0.06 with the larger difference generally found in areas where sea conditions were rougher. These differences are likely due to both calibration drift and the effect of bubbles. Salinity was recalibrated by adding 0.02 which looks suitable for the most of the cruise but is likely an overcorrection for areas of quiet sea conditions.

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 analysis sheets for dissolved oxygen, extracted chlorophyll and salinity.
Nutrients, extracted chlorophyll, dissolved oxygen, DMS and salinity data were obtained in QF spreadsheet format from the analysts.
The cruise summary sheet was completed.
The history of the pressure sensor, conductivity and DO sensors were checked. Since the last factory visit the T, C, P and DO sensors were used during 2014-50 and most were also used for 1 cast during 2014-19 but there were problems with the CTD on that occasion. The other sensors used were also used for 2014-50.

The XMLCON files did not change through the cruise.
The calibration constants were checked for all instruments and the only correction needed was to add the date of calibration for the PAR sensor. The corrected file was saved as 2015-01-ctd.xmlcon. The pressure will likely need to be corrected later based on results of 2014-50. This will be checked after conversion to IOS headers.

3 Conversion of Full Files from Raw Data

A test was run to see which voltage channels have relevant information for the Rinko Oxygen sensor. Voltages 0, 1, 6 and 7 are assigned to various sensors in the configuration file. Voltage 3 has no signal, voltage 4 has a trace that mirrors the trace of the SBE DO voltage and voltage 5 is similar to the temperature.

All hex files (except test cast 2015-01-0001) were converted using 2015-01-ctd.xmlcon to create CNV files and voltages 4 and 5 were included.

A few casts were examined and all expected channels are present. The temperature and conductivity channels are close on downcasts though there were some spikes. As usual the upcasts are noisy and the differences are larger. File #35 contains only surface data – presumably this was recorded accidentally. That event # was for a loop sample. As noted in the log file 2015-01-0065-2 is the upcast for event #65. The altimetry looks useful and fluorescence, transmissivity, pH, PAR and SPAR look ok.
The descent rate of the CTD looks extremely noisy with many complete reversals in direction.

4 BOTTLE FILE PREPARATION
The ROS files were created using file 2015-01-ctd.xmlcon.
The ROS files were converted to IOS format.
They were put through CLEAN to create BOT files. Temperature and salinity were plotted for all BOT files to check for outliers. CTDEDIT was used to remove a section of noisy primary T and S data near 80m for event #16. The primary data was also noisy at 300m for event #87 and 400m for event #118, but the noise was general through the whole stop, so editing is not appropriate.
The edited file was copied to *.BOT.

A preliminary header check and a cross-reference check were run and no problems were found. Fluorescence did not go off-scale.

The BOT files were bin-averaged on bottle number and the output was used to create file ADDSAMP.csv. Sample numbers were added to the file based on the rosette log records.
A few bottles were removed from the list where there was no sampling and no sample number.
The addsamp.csv file was converted to CST files, which will form the framework for the bottle files. Those files were then bin-averaged and called SAMAVG.

Next, each of the analysis spreadsheets were examined to see what comments the analysts wanted included in the header file. These were used to create file 2015-01-bot-hdr.txt which will be updated as needed during processing.

<u>EXTRACTED CHLOROPHYLL</u>
Extracted chlorophyll and phaeo-pigment data were obtained in file QF2015-01chl*.xls. The file included comments and flags and a precision study. The loop samples were removed to a separate spreadsheet, 2015-01_loop_data.csv. A simplified version of the spreadsheet was prepared in which some columns were removed and the file was saved as 2015-01chl.csv, the event # 65/66 was changed to 65; the csv file was then converted to individual CHL files.

<u>DISSOLVED OXGYEN</u>
Dissolved oxygen data were provided in spreadsheet QF2015-01oxy.xls which includes flags, comments and a precision study. Draw temperatures are available. The spreadsheet page with the final data was simplified and the file was then saved as 2015-01oxy.csv.
That file was converted into individual *.OXY files.

SALINITY

Salinity analysis was obtained in 2015-01SAL.xls. The analysis was done within 10-22 days of collection. The files were simplified and saved as 2015-01sal.csv. The loop samples were removed to a separate spreadsheet, 2015-01_loop_data.csv. File 2015-01sal.csv was then converted to individual SAL files.

NUTRIENTS

The nutrient data were obtained in spreadsheet QF2015-01nuts.xls. This includes a precision study. The loop samples were removed to a separate spreadsheet, 2015-01_loop_data.csv. Then the file was simplified, reordered on sample numbers and saved as 2015-01-nuts.csv. The file was converted to individual NUT files.

DMS

DMS data were obtained in file DMS summary (2015-01).xls. Values given as < were changed to 0 and the comments that will go into the header will explain that 0 means below detectable level. (There was a separate report on analysis techniques and problems.) A comment was added to one sample that had been flagged 5; there was a relevant comment on the raw data page. The file was then saved as 2015-01DMS.csv and converted to individual DMS files.

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

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

The output of the MRG files were exported to a spreadsheet and compared to the rosette log sheets to look for omissions.
Errors found or things to be adjusted were:
5. The CHL data said to be from event #2 are actually from event #5.
10. The line for Niskin 23 is not needed, there was no sample number and no sampling, just a test. It was removed from the SAMAVG and then the final MERGE and CLEAN steps were repeated.
34. Same as for #10 – Niskin 9 is not needed.
35. The few data in the file all have negative pressures. This must have been an accidental firing, perhaps while replacing a Niskin bottle right after event 34. This cast will be removed from cast lists for CHE and CTD.
65/66. Some samples were named 65/66, some 66. These were changed to 65 and merges rerun.

5 Compare

Salinity

Compare was run with pressure as reference channel.
The comparison has an unusually large scatter despite quick analysis and the use of plastic liners in the bottles. When the surface samples are removed from the comparison and a few cases where the standard deviation in the CTD salinity is >0.001, the picture is only slightly improved. Excluding outliers based on distance from the averages produces a flat fit, but examining the rejected points turns up no consistent explanation. Looking at a plot against time suggests that the calibration was improving with time. That would be unusual. That could be due to geography rather than time as the offshore casts with deeper sampling might give better results due to low vertical gradients, but while most of the late casts are well

offshore, the final one in the comparison was at P4. The only explanation that seems to work is that sea conditions were very bad for most of the casts, particularly casts #30 and 67 which have the most severe outliers. Cast #30 had 2 bad replicates which might suggest problems with the salinometer, but more likely water in the Niskin bottles was not well mixed. There was a lot of vertical motion during many of the bottle stops that would lead to variability. Casts #80 and 93 were a little quieter and cast #121 was the quietest.

If we average all differences below 200db excluding 6 outliers the primary salinity is higher than bottles by 0.0032 and the secondary is high by 0.0017 with standard deviations about 0.001 for both. The fits are reasonably flat against pressure but not against time.

There were 22 bottles fired at 2000m during cast #80. That cast was a little quieter than the earlier ones and flushing efficiency should not be a big issue at 2000m due to low a salinity gradient.
The results were:

Sensor Pair	Average (CTD-Bottle)	Std. Dev. (CTD-Bottle)
Primary	+0.0029	0.0009
Secondary	+0.0016	0.0009

When only bottles between 800 and 1250m from the cast #121 are included, the primary salinity is found to be higher than the bottles by an average of 0.0020 and the secondary by 0.0008; however, if one of the differences is excluded because it looks like an outlier, the primary is high by 0.0023 and 0.0011.
When only bottles between 1000 and 1250 from cast #93 are included the primary salinity is high by 0.0026 and the secondary by 0.0009.
The 2000m bottles are likely the most reliable source of information and the median of those is 0.0013.
For full details for the COMPARE run see file 2015-01-sal-comp1.xls.

Dissolved Oxygen

COMPARE was run with pressure as the reference channel.
There are some clear outliers, but most of the data fall into a reasonably tight group.
When the large outliers were removed from the comparison and other points rejected based on residuals, the fit was:

CTD DO Corrected = CTD DO * 1.0187 + 0.0569

To test for hysteresis points below 1200m were also excluded and the fit was then:

CTD DO Corrected = CTD DO * 1.0199 + 0.0506

To the eye there was no obvious evidence of hysteresis. The corrections using the 2 fits are similar with differences ~0.006 at DO=0mL/L and ~0 at4.5mL/L. So the hysteresis parameters, E, H1 and H3 do not need fine tuning.

The major outliers were examined. The 2 most severe had already been flagged “4”.

- Sample #25 from event #5 looks very bad with the bottle being 1.7mL/L lower than the CTD DO, but this was a bottom sample and the temperature gradient was large near the bottom so it is just possible that there was DO drop that the CTD did not have time to respond to. So this value is probably bad, but will be left with a 4 since there is some room for doubt.
- Sample # 9 from event #3 is definitely out of line and that is explained by the analyst’s comment. Flag “4” looks appropriate.

The other 2 samples that were significant outliers are associated with fairly noisy CTD DO and were not flagged by the analyst.

- Sample #786, cast #93 was taken from an area with very high gradients in T, S and DO at the level of the sample, so slow response of the sensor plus the difference in heights between the bottle and sensor would both lead to the sensor looking lower. No flag is justified.

- Sample #258, cast #121 had a high standard deviation in the CTD DO. During the bottle stop even the temperature was still rising at firing time, so there is likely nothing wrong with the sample and no flag is justified.

Judging by the descent rate during the downcasts, the seas must have been very rough during most of the casts with DO sampling, but the first 2 were quiet and the last 2 fairly quiet. So the fits were examined in groups to see if this has any effect on the DO as it appeared to do on salinity. We might not expect much difference since the DO sensor is slower to respond to the changes during the stop. There is also the limitation that the first 2 casts which were very quiet were also shallow with a narrow DO range.

CTD DO Corrected = CTD DO * 1.0187 + 0.0569 (all casts)
CTD DO Corrected = CTD DO * 1.0172 + 0.0504 (quietest 4 casts)
CTD DO Corrected = CTD DO * 1.0208 + 0.0580 (3 fairly noisy casts)
CTD DO Corrected = CTD DO * 1.0197 + 0.0620 (3 noisiest casts)

Only the first fit had outliers removed beyond the 4 samples mentioned above, so there are bound to be differences. Given the limitations, the differences are likely not significant.

When the 4 shallowest casts were treated in the same way as the full set, by removing outliers based on residuals, the result was:

CTD DO Corrected = CTD DO * 1.0259 + 0.0073 (shallowest 4 casts)

The difference between the fit with all casts and this fit is about 0.007mL/L for DO=6.5mL/L and 0.01mL/L for DO=4.1mL/L; note that the lowest DO sample in the fit was 4.1mL/L. These casts are not all quiet, so the difference in the offset is likely due to the low DO vertical gradients, not the motion of the CTD during stops. The deepest and best-mixed of these casts was in Haro Strait where vertical mixing is very strong, so that was removed and then the fit was

CTD DO Corrected = CTD DO * 1.0234 + 0.0264 (3 shallow - not Haro Strait)

This fit included few points and gradually removing outliers based on residuals did not approach a stable result. But it does show that the low offset for the previous shallow fit was due to the Haro Strait cast.

If we then do a fit for the 6 deeper casts, again removing outliers based on residuals, the fit is:

CTD DO Corrected = CTD DO * 1.0191 + 0.057 (6 deep casts)

This is very similar to the fit for all casts, which is not too surprising given there are more bottles from the deep casts than the shallow.

When the one deep cast with a larger DO range and fairly quiet conditions was studied, the fit was:

CTD DO Corrected = CTD DO * 1.0189 + 0.0507 (cast 93 excluding 2 outliers)

That fit includes no samples with DO between 3.6 and 7.5mL/L.

The issue of the sensor readings changing rapidly due to the high variability caused by the CTD moving up and down during does seem less significant than seen in salinity.

The correction based on all casts looks like a reasonable compromise.

CTD DO Corrected = CTD DO * 1.0187 + 0.0569 (all casts)

Plots of Titrated DO and CTD DO against CTD salinity were examined. The only outliers of note were the 2 already flagged 4.

Fluorescence

COMPARE was run with extracted chlorophyll and CTD Fluorescence using pressure as the reference variable. The CTD fluorometer was a SeaPoint sensor.
Most CHL values were low<1.5ug/L with the exception of one value of ~2.61ug/L.
As usual, fluorescence reads higher than CHL for low CHL but is close to CHL for 0.8<CHL<1.5ug/L. For the one higher CHL value, the fluorescence is about 50% of the CHL. For full details of the comparison see file 2015-01-fl-chl-comp1.xlsx.

6 WILDEDIT

Program WILDEDIT was run to remove spikes from the pressure, conductivity & temperature only in the full cast files (*.CNV).
Parameters used were: Pass 1 Std Dev = 2 Pass 2 Std Dev = 5 Points per block = 50
The parameter “Keep data within this distance of the mean” was set to 0 so all spikes would be removed.

7 ALIGN DO

There are so many bottle stops in these data and shed wakes due to noisy descent and ascent rates that it is hard to judge what setting brings the SBE:DO trace into best alignment with temperature. Settings between +2.5s and +3.5s look reasonable and the last time the equipment was used an advance of +2.5s looked best.
ALIGNCTD was run on all casts using +2.5s.

8 CELLTM

The noise in the upcast makes the tests for the best parameters for this routine very difficult to interpret. During 2014-50 with the same equipment, a cast with a quiet section was tested using a variety of settings and there was little difference among them, with the default setting of (α = 0.0245, β=9.5) looking slightly better than the others for both conductivity channels. One cast was checked for this cruise and the default setting does improve the data.
CELLTM was run using (α = 0.0245, β=9.5) for both the primary and secondary conductivity.

9 DERIVE and Channel Comparisons

Program DERIVE was run on all casts to calculate primary and secondary salinity and dissolved oxygen concentration.
DERIVE was run a second time on a few of the deeper casts to examine differences between sensor pairs. A few results from an earlier cruise (shaded entries) are shown for comparison, but none of those are very deep.

Cast #	Press	T1-T0	C1-C0	S1-S0	Descent Rate
2014-50-0019	330	~0 N	-0.00008N	-0.0006N	Mod, V.Noisy
2014-50-0031	330	-0.0018	-0.00003	+0.0014	High, F.Steady
2014-50-0037	325	~0 VN	-0.00004	-0.0004	Mod, Steady
2015-01-0040	325	-0.0027	-0.00002	+0.002 XN	High, Very Noisy
“	1000	-0.0013	-0.00013	-0.0001	“
“	3000	-0.0007	-0.00013	-0.0011	“
2015-01-0049	325	-0.0032	-0.00016	+0.0013XN	High, Very Noisy
“	1000	-0.0013	-0.00014	-0.0002	“
“	3000	-0.0006	-0.00015	-0.0012	“
2015-01-0086	325	-0.0011XN	-0.00005	-0.0004	High, Very Noisy
“	1000	-0.0008	-0.00013	-0.0007	“
“	3000	-0.0006	-0.00016	-0.0013	“
“	4000	-0.0006	-0.00014	-0.0010	“

2015-01-0093	325	-0.0008	-0.00011	-0.0005	High, Very Noisy
“	1000	-0.0008	-0.00015	-0.0010	“
“	3000	-0.0006	-0.00016	-0.0014	“
“	4000	-0.0005	-0.00015	-0.0012	“

The differences are small and show no significant change through the cruise.

10 Conversion to IOS Header Format
The IOSSHELL routine was used to convert SEA-Bird 911+ CNV files to IOS Headers.
CLEAN was run to add event numbers and to replace pad values in the pressure channel with interpolated values based on record number.

11 Checking Headers
A cross-reference list was checked against the log book and no problems were noted.

The cruise track was plotted and added to the end of this report.

Surface check was run and shows an average surface pressure for the cruise was 1.8db which is lower than usual for the Tully especially given sea conditions were quite rough much of the time.

A header check was run. There were no negative or off-scale fluorescence values.
The only problem noted is some negative pressures, which when checked proved to occur with pumps running and salinity and conductivity values being clearly “in-water”. During 2014-50 when this pressure sensor was used the pressure was found to be low by about 1.25db.

A few casts were examined in detail. For cast #80 acquisition was started with pressures about -0.5db and the CTD was held at that level with the pumps on and the conductivity, transmissivity and fluorescence showing the CTD was in water. For cast #26 the pressure at the end of the cast was as low as -1.4db and again the pumps were on and the conductivity had “in-water” values.

During 2014-50 there were a number of casts with negative pressures that were associated with “in-water” salinity with the pumps on, and the transmissivity values look reasonable for near the surface. In most cases the minimum pressures in the files were ~-0.4db but for one cast there were some readings that appear to be in the water with pressure of -1.5db at both the beginning and end of the file but it is possible the CTD came out of water briefly as conditions were bad.

Clearly, the pressure is reading too low, but it is not clear how low; the values do vary from cast to cast. Adding 1.25db to the offset looks reasonable.

The altimeter and water depth readings from the headers of the CLN and MRGCLN2 files were exported to a spreadsheet. Plots were made of altimetry near the bottom for most casts and the headers look appropriate for all files except for casts #41 and 52 in the CLN files and #52 in the bottle files. These were shallow casts in deep water where altimetry spikes were misinterpreted as being near the bottom. Those altimeter headers were removed.

Water depth entries were compared with the log book entries. Most either matched the log entry or matched the entry for the cast that immediately followed. In some cases there was a significant difference between log and header; for many of these the log entry had obviously been changed. The header entry was corrected for 8 casts. For 2 casts at P16 the log entries look wrong; those casts never got near the

bottom so there is no clear evidence, but the subsequent casts at the same site are 400m deeper and the deeper entries are close to what is expected for P16, so those values were used for all P16 casts.
There was no water depth entry in the header for event #81 so that was added to the CLN, SAMAVG and MRGCLN2 files based on the log book entry.

12 Shift

Fluorescence

SHIFT was run on the SeaPoint fluorescence channel in all casts using the usual advance of +24 records. Examination of plots after this step shows that the fluorescence offset is reasonably close to the temperature offset.

Dissolved Oxygen

The Dissolved Oxygen voltage channel was aligned earlier. A few casts were checked to see if the alignment looked ok, and it did. No further alignment is needed for the DO concentration channel,

Conductivity

Tests were run on 3 casts using shifts close to those that proved best for cruise 2014-50. For the primary conductivity the best results were found with -0.6 records as was used for the earlier cruise. However, for the secondary the previous setting of -0.3 records made things worse. Tests were run on a variety of settings and the best results were with +1.0 records.
SHIFT was run on all casts using -0.6 records for the primary conductivity and +1.0 records for the secondary conductivity.

13 Initial Recalibration

As discussed in section 11 the pressure is obviously too low and during 2014-50 it was found appropriate to add 1.25db to all pressure measurements. That will be applied before running DELETE to prevent loss of good data with negative pressures.
File 2015-01-recal1.ccf was prepared to add 1.25db to all pressure readings.
CALIBRATE was run to apply this to the SHFc1 files and the MRGCLN2 and SAM files.

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 no warnings.

15 Other Comparisons

Previous experience with these sensors –

Conductivity, pressure and dissolved oxygen sensors were all recalibrated in late 2013 or early 2014. They were used for a few casts during 2014-19 and throughout 2014-50. Both T/C sensor pairs produced salinity within 0.001 of bottles. The pressure sensor was found to have drifted lower by about 1.25db during 2014-50. The dissolved oxygen sensor was corrected using a linear fit of slope 1.0281 since there was too little sampling of waters with low DO values to estimate an offset.

Historic ranges – Profile plots were made with 3-standard deviation climatology ranges of T and S superimposed. Salinity values were within the climatology though occasionally near the minimum or maximum. Temperature was near or above the maximum in the upper 60m at P1 and P2, and near the base of the mixed layer (~75 to 100m) from about P4 to P11. Anomalously high temperatures have been reported in the upper ocean of the north-east Pacific in 2014 and those came closer to shore in the autumn. These conditions are still present in 2015, so excursions towards the high side from the temperature climatology are expected.

Repeat Casts – There are some repeat casts but most include a deep and a shallow cast, so those are not good for checking repeatability. At P26 there were 3 very deep casts run over a 24-hour period. At about 3600m the temperatures vary by about 0.005C° and salinity by 0.001 along lines of constant sigma-T. The two casts furthest apart in time are closest on a T-S plot.

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

16 DETAILED EDITING

Since the secondary temperature and salinity channels seem a little less spikey, those channels were selected for archiving, and hence, editing.

CTDEDIT was used to remove large spikes, remove or clean smaller spikes that appear to be due to instrumental problems and likely to affect the bin-averaged values and records corrupted by shed wakes including some records from near the top and bottom of the casts. Salinity was cleaned lightly. Some salinity points were removed – generally these are associated with rapid deceleration of the CTD. All files required some editing.

17 Further Recalibration

The secondary salinity was found to be high by between 0.0008 and 0.0017 depending on what data were included in fits. The average and median difference from the 22 deep bottles at cast #80 were 0.0016 and 0.0013. When the sensors were last used the secondary sensor was found to be within 0.001 of bottles. A correction of -0.0015 was selected as a reasonable compromise among these various comparisons.

File 2015-01-recal2.ccf was created to subtract 0.0015 from secondary salinity and to correct the Oxygen:Dissolved:SBE channel using:

CTD DO Corrected = CTD DO * 1.0187 + 0.0569

This correction was first applied to the SAMCOR1 and MRGLCOR1 files. COMPARE was rerun and the results confirm that the recalibrations were applied properly. The average of differences in the DO fit once outliers were removed was +0.0007mL/L but the standard deviation is 0.01mL/L.
(See file 2015-01-DO-comp2.xlsx for details.)

CALIBRATE was then run on the EDT files.

18 Final Calibration of DO

The initial recalibration of dissolved oxygen corrects for sensor calibration drift. Alignctd corrects for transit time errors. Those 2 steps may partly correct for response time errors, but to see if a further correction is needed, a comparison is made of downcast CTD data to bottle data from the same pressure. Small differences are expected due to ship drift, temporal changes, incomplete flushing of Niskin bottles and noise in CTD data.

Downcast files were bin-averaged to 0.5m bins for the casts with DO bottle samples. Those files were then thinned and compared to the bottle values in the MRG files. COMPARE was run to study the differences between the downcast CTD DO data and the titrated samples from upcast bottles. When outliers were removed, the CTD DO was higher than the bottles by an average of ~0.012mL/L and standard deviation of 0.035mL/L; the results vary with depth with most differences <.05mL/L below 400m. In the top 100m there are outliers in both directions, but between 100 and 400m most outliers are cases of the CTD DO being higher than bottles. These come from areas with a high DO vertical gradient so even a slight delay in the sensor response would lead to higher DO from the sensor. The rough nature of the comparison, the high variability and the noise in the sensor data do not support further recalibration. See 2015-01-dox-comp3.xlsx for details.

19 Fluorescence Processing and special files for Angelica Peña
The COR2 files were clipped to 150db and processed in 2 ways, with a filter and without a filter, followed by 0.5m-bin averaging in both cases.
Those files were set aside for Dr. Peña.

A median filter, size 11, was applied to the fluorescence channel in the COR1 files. Plots of a few casts showed that the filter was effective. (Output:*.FIL)

20 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.

On-screen plots were examined. The T-S plots have some slightly unstable features in the cast from Haro Strait, but that is normal.

21 Final CTD File Steps (REMOVE and HEADEDIT)
REMOVE was run on all casts to remove the following channels:
Scan_Number, Temperature:Primary, Salinity:T0:C0, Conductivity:Primary, Conductivity:Secondary, Oxygen:Voltage:SBE, Altimeter, Status:Pump, Descent_Rate and Flag.
The PAR channel was removed from casts: #20-40, 46-67, 76-89, 93-115 and 121.

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:

Data Processing Notes:

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

For details on how the transmissivity calibration parameters were calculated see the document in folder "\cruise_data\documents\transmissivity".

Dissolved oxygen was calibrated using the method described in SeaBird Application Note #64-2, June 2012 revision, except that a small offset in the fit was allowed.

The Oxygen:Dissolved:SBE data are considered, very roughly, to be:
±0.5 mL/L from 0 to 100db

±0.3 mL/L from 100db to 500db
±0.05 mL/L below 500db

For details on the processing see the report: 2015-01_Processing_Report.doc.

The Standards Check routine was run and no problems were found.
The Header Check was run and no problems were found.
A cross-reference list was produced.
The sensor history was updated.
The track plot looks fine.

22 Dissolved Oxygen Study
As a final check of dissolved oxygen data, % saturation was calculated and plotted. Values were low in Haro Strait (75%) and Juan de Fuca Strait (96%). In the offshore most casts had saturations of 99% to 101% except for some higher values at the end of the cruise at P4. These values look reasonable.

23 Final Bottle Files
The MRGCOR2 files were put through SORT to order on increasing pressure.
REMOVE was run on all casts to remove the following channels:
Scan_Number, Temperature:Secondary, Salinity:T1:C1, Conductivity:Primary, Conductivity:Secondary, Oxygen:Voltage:SBE, Altimeter, Status:Pump, Descent_Rate and Flag.
The PAR channel was removed from casts: #20-40, 46-67, 76-89, 93-115 and 121.
A second SBE DO channel was added for both the CTD DO and bottle DO, with mass units and REORDER was run to get the 2 SBE DO channels together.

HEADER EDIT was run to ensure formats and units are correct, change the channel name Bottle_Number to Bottle:Firing_Sequence and the name Bottle:Position to Bottle_Number and to add a comment about quality flags and analysis methods and a few notes about the CTD data processing.

Standards check and a header check were run on all files and no errors were found.
The track plot looks ok.
Plots of each file were examined to ensure no problems had crept in and none were found.

A cross-reference listing was produced for the CHE files.
Data were exported from the CHE files to file 2015-01-bottles-final.xlsx. The entries were compared with the rosette log sheets to ensure no samples had been missed and no problems were found.

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

a.) <u>Checking calibrations</u>
The configuration files for the 3 files are identical. One file was renamed as 2015-01-tsg.xmlcon. No errors were found in the calibration parameters.

b.) <u>Conversion of Files</u>
The 3 files were converted to CNV files using configuration file 2015-01-tsg.con. They were then converted to IOS HEADER format.
CLEAN was run to add End times and Longitude and Latitude minima and maxima to the headers.
ADD TIME CHANNEL was used to add Time and Date channels.

Time-series plots were produced. The flow rate was about 1.1 for the first file and file #2 started at 1.1 but dropped suddenly to about 0.9 and stayed close to that value for the remainder of the file and for file #3. After the flow rate decreased the difference between the intake temperature and lab temperature increased.
There are a few distinct spikes in salinity but it is quite smooth for the most part.
The track plot looks fine. The plot was added to the end of this report.

c.) <u>Checking Time Channel</u>
The CTD files were thinned to reduce the files to a single point from the downcast at or within 0.5db of 4db and exported to a spreadsheet which was saved as 2015-01-ctd-tsg-comp.xls. There were 50 casts which overlapped with TSG files.

The 3 TSG files were opened in EXCEL, median and standard deviations (over 5 records) were calculated for intake temperature, lab temperature, salinity and fluorescence and the files were reduced to the times of CTD files and loop samples.

To check for problems in the TSG clock or bad matches of TSG and CTD data, the differences between latitudes and longitudes were found. The differences in latitude and longitude were all≤0.0008° and only one difference was >0.0003°; the medians in both were 0.0000°. This shows both the times and positions are reliable for both systems.

The loop samples were combined in file 2015-01-tsg-loop-rosette-comp.xlsx. There is only one case where loop samples were taken during a rosette cast. For event #5 there were samples from 1.9db and 6.7db. The rosette salinity, nutrients and CHL bottle data were combined with the loop sampling.

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

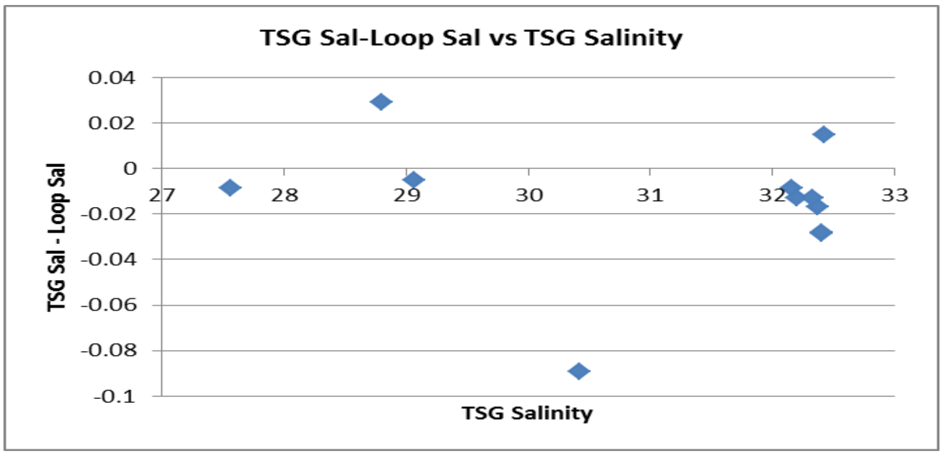
d.) <u>Comparison of T, S and Fl from Loop & Rosette Samples and TSG and CTD data</u>

- <u>T1 vs T2</u> The intake temperature sensor worked throughout the cruise. The median difference between intake temperature and lab temperature while the ship was stopped was 0.240C° with a range of roughly 0.217C° to 0.295C°. We expect that the heating in the loop will increase as the intake temperature decreases, but there was also a change of flow rate which will affect the loop heating. For the most part the highest flow rates overlap with the highest temperatures, so it is difficult to tease apart these two effects. However, there were some observations from the end of the cruise with higher temperatures and low flow rates. When we use only observations when the intake temperature was between 10.4 and10.9°C, the loop heating for high flow rate has a median value of -0.215C° and for low flow rate -0.232C°. So the flow does affect the heating, but probably not as much as the intake temperature does. This is not of importance for this cruise, but may be helpful information in future if there is no intake temperature sensor data.

- <u>TSG vs CTD</u> The spreadsheet comparing CTD and TSG files was then examined to find the differences between the salinity, fluorescence and temperature channels for the CTD and the TSG.
  1. *Intake Temperature* The intake temperature is higher than the CTD temperature by a median of 0.007C° (standard deviation 0.017C°). When differences are plotted against standard deviation in the TSG temperature the differences approach a somewhat lower difference ~0.005C°.
  2. *LAB TEMP* The lab temperature was higher than the CTD temperature by a median value of 0.24C°, but as mentioned above this varies with flow rate and intake temperature.

3. *SALINITY* The TSG salinity data are lower than the CTD salinity by a median value of 0.013 (standard deviation 0.048), but the average difference is 0.020. A plot of differences versus standard deviation in the TSG Salinity suggests the differences are mostly smaller when the salinity varies smoothly. All the outliers are in one direction, probably due to small bubbles in the TSG system.
4. *FLUORESCENCE* The TSG fluorescence was higher than the CTD fluorescence with the median ratio of FLtsg/FLctd being ~1.3 and a range of 1.2 to 2.4. The ratio does not vary much with fluorescence, though there are more outliers at lower fluorescence values and they are all on the high side (TSG FL being higher relative to CTD FL). A mismatch of depths would lead to some differences, but biological activity in the loop might be relevant. A plot against time does not suggest that there was a build-up on the lens leading to higher TSG values though outliers seem to be getting larger. Plots of the ratio against the standard deviation in the TSG Fluorescence show a trend towards 1.25. A study to see if the change of flow rate affected the TSG fluorescence was made by comparing a group of casts from early and late in the cruise with similar range of CTD fluorescence values. The difference was insignificant.
(See 2015-01-ctd-tsg-comp.xls.)

- Loop Bottle - TSG Comparisons
The TSG fluorescence is higher than the loop extracted chlorophyll for CHL <1ug/L by a factor of from 1 to 3. For the 3 higher CHL values (1.9 to 2.4ug/L), the TSG fluorescence reads low at about 50% of the CHL. This is a typical pattern for this type of fluorometer.
There is a lot of scatter in the comparison of TSG salinity and loop salinity. The median difference shows the TSG salinity being low by 0.013, but the standard deviation is 0.03.



(See 2015-01-TSG-loop-rosette-comp.xlsx.)

- Surface rosette vs TSG (salinity and chlorophyll)
There is only 1 case where we have samples from both the loop and a rosette. This was from the cast at JF2 with samples of CHL from 1 bottle and salinity and nutrients from 2. The vertical gradients near the surface are much higher at this site than off-shore, so it is not surprising to see significant differences between samples from these 2 bottles. The loop samples for salinity and nutrients are closer to the 1.9db bottle than the 6.6db one. For the nutrients it looks as though the loop sample might be from about 3db. This does suggest that the TSG is drawing water from a little higher than the intake depth, at least while stopped. The loop salinity sample looks like it might be from even higher in the water column.

Niskin Pressure	Stn	Sal_Loop	Sal_ROS	CHL_Loop	CHL_ROS	Ni_Loop	Ni_ROS	SIL_Loop	SIL_ROS	Phos_Loop	Phos_ROS
ROS-6.6db	JF2	29.0680	29.3428	2.096	2.57	15.65	17.13	32.51	33.9	1.283	1.399
ROS-1.9db	JF2	29.0680	29.0870			15.65	15.31	32.51	32.14	1.283	1.272

- <u>Calibration History</u>
  The TSG temperature and conductivity were recalibrated in December 2013 and have been used for 4 other cruises since then.
  During 2014-21 the TSG salinity was found to be lower than loop samples and CTD salinity by ~0.03 but the difference varied with flow rate which was highly variable. No recalibration was applied due to the variability in the comparisons and the fact that such a large drift in calibration on its first use seemed unlikely. During 2014-18 the salinity was found to be low by 0.014 but the TSG was so noisy that this was not trusted. During 2014-19 the TSG salinity was found to be low by ~0.02.
  During 2014-19 the TSG temperature was found to be higher than the CTD temperature by ~0.005Cº.
  The fluorometer in use for this cruise has not been used on a TSG before.

<u>Conclusions</u>

1. The TSG clock worked well.
2. The TSG flow rate was steady through file #1 at ~1.1, changed abruptly early in file #2 from ~1.1 to ~0.9, and was steady at ~0.9 for file #3.
3. The temperature in the loop increases by about 0.24Cº but this varied with flow rate and intake temperature.
4. The TSG intake temperature was higher than the CTD temperature by ~0.005Cº to 0.007Cº, which is like the observations of 2014-19. While this could be a real difference, it is more likely that the TSG water is coming from a little higher in the water column. No recalibration is justified.
5. The TSG Salinity is lower than the CTD salinity by a median of ~0.013 and lower than loop samples by a 0.013. While this is a wonderful agreement, the noise in the comparison with loops renders it somewhat less convincing. While the gradient at JF2 might mean a slight mismatch could explain a difference of this size, it will not work for most of the CTD casts where salinity is better mixed in the top 5m. Where the standard deviation in the TSG salinity is higher the salinity looks lower than CTD salinity by about 0.02. It makes sense that when sea conditions were worst (during file #2) there is both higher variability and more bubbles; in those conditions TSG salinity might read relatively lower compared to CTD salinity. So any correction to the salinity is likely to be addressing both calibration drift and the effects of small bubbles.
   For 2014-19 the salinity was recalibrated by adding 0.02 based on both loops and CTD. This looks like a reasonable choice for these data as well. It may be an overcorrection for files #1 and 3 and but looks appropriate for the largest of the files, #2.
6. Part of the salinity error could be due to temperature being a little too high. This could be due to a mismatch in the depths of sampling for the TSG and CTD, but the temperature gradients are very low at most casts near the surface. We have too little evidence to support a temperature recalibration.
7. The TSG fluorescence is about 130% of the CTD fluorescence. The comparison with loop samples looks typical of this type of sensor with values too high at low CHL and too low for CHL values between 1.9 and 2.4ug/L. Analysis of performance is very limited because there was only one CHL value during this cruise that was >1.5ug/L.

8. There are too few points of comparison between the loop and the rosette to comment, except that the nutrients are reasonably close given the only cast examined was in an area of relatively high gradients near the surface..
9. The flow rate changed suddenly. There are insufficient loop data and loop/rosette comparisons to see if this affected TSG fluorescence.
10. The overall quality of data was high with little of the spiking that has plagued this equipment in the past.

f.) Editing
The ATC files were copied to *.EDT.
Each file was opened in CTDEDIT and the following editing was applied:
File #1 – No editing applied.
File #2 – CTDEDIT was used to clean small 1-sided spikes in salinity that are likely due to small bubbles.
File #3 – CTDEDIT was used to clean small 1-sided spikes in salinity that are likely due to small bubbles.

g.) Recalibration
File 2015-01-tsg-recal.ccf was prepared to add 0.02 to the salinity channel and was applied to all *.EDT files.

h.) Preparing Final Files
REMOVE was used to remove the following channels from all casts: Scan Number, Temperature:Difference, Conductivity:Primary, Flag and Position:New channels.
The flow channel was not removed since it may be useful for further studies of optimal flow rate and there was a sudden change during file #2 that might be of importance to some users.

HEADER EDIT was used to add a comment, change the DATA TYPE to THERMOSALINOGRAPH and add the depth of sampling to the header and to change channel names to standard names and formats.
Those files were saved as TOB files.
The TSG sensor history was updated.
As a final check plots were made of the cruise track and it looks fine.
The cruise plot was added to the end of this report.

25 Loop File
The CHE files were put through program DERIVE to obtain sigma-t.
Data from those files were exported to file 2015-01-che-surface.csv. Data from below 10m were removed. Columns were rearranged to fit a model 6-line header.
Loop data were then added to the file and lined up appropriately. A sampling method column was added filled with ROS or UWS for rosette data and true loop data, respectively.
The data were sorted on event number, then time, then pressure and added to the 6-line header file.
The file break column was filled with value 1 so all data will be in a single file when converted.
The file was then saved as 2015-01-surface-6linehdr.csv.

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

CONVERT was run to produce an IOS Header file. The flags and comments were entered in the headers in the conversion process.
CLEAN was run to get start and stop times and positions.

Header Edit was used to add comments.
The final file was renamed as 2015-01-surface.loop. A track plot looks reasonable and a plot of temperature and salinity versus longitude looks reasonable.

Particulars
1. Test cast – do not process
10. Niskin 23 not needed in file.
34. Niskin 9 not needed in file.
49. Changed Niskin Bottle #7
52/53. Bottom depth entered wrong – should be 3633
63. Stop @50m on way down to straighten wire, boomed up, stop @200m on way down, straighten wire, boom up.
65. Computer crashed on upcast. New file started as 0065-2; bottle file should be renamed 0065 after conversion.
70. Niskin 14 was not fired.
85. Cups on – study to see if any interference with flow

PAR ON: 2-18, 40-41, 70, 118-120
PAR OFF: 20-37, 46-67, 76-115, 121

CRUISE SUMMARY

CTDs

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

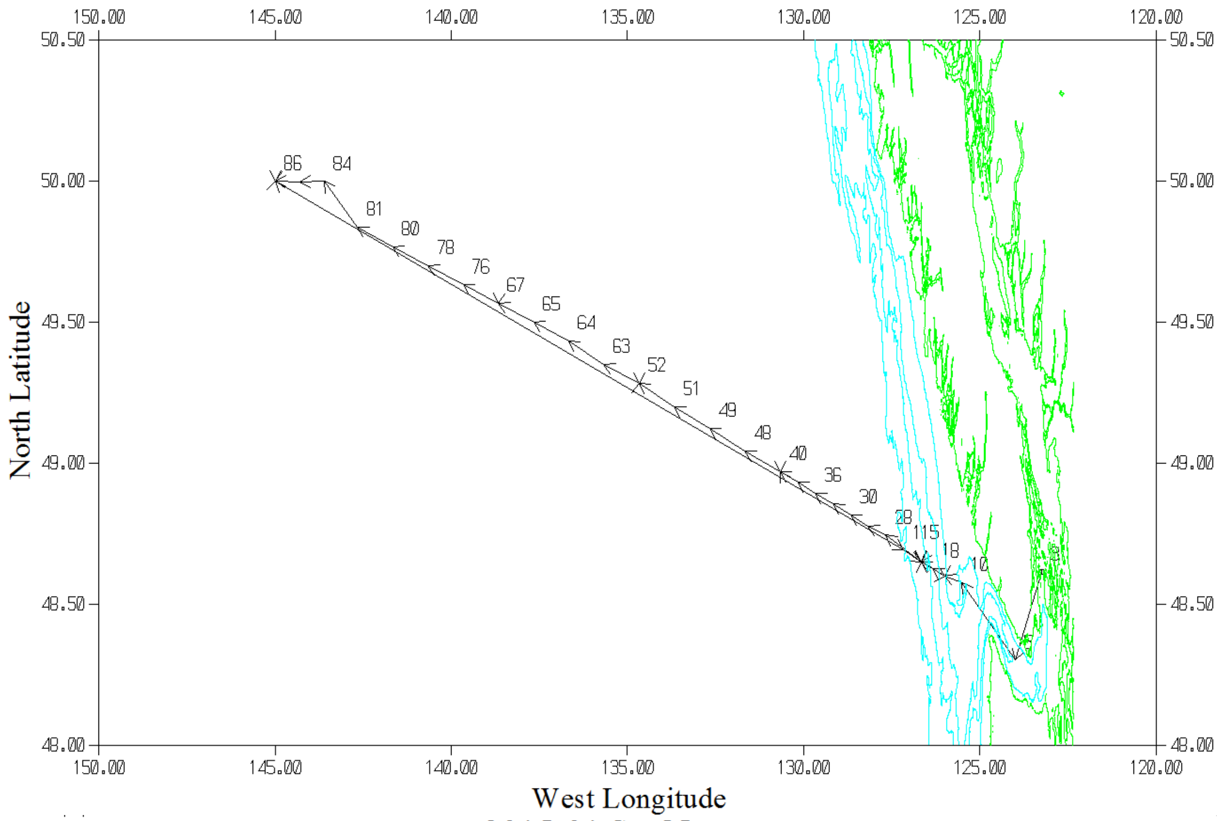
Calibration Information					
Sensor		**Pre-Cruise**		**Post Cruise**	
Name	**S/N**	**Date**	**Location**	**Date**	**Location**
Temperature	**2023**	**31Jan2013**	**Factory**		
Conductivity	**1763**	**1Jan2014**	**Factory**		
Secondary Temp.	**5013**	**27Feb2013**	**Factory**		
Secondary Cond.	**3394**	**3Jan2014**	**Factory**		
Transmissometer	**1396DR**	**5Feb2014**	**IOS**		
SBE 43 DO sensor	**1438**	**3Jan2014**	**Factory**		
PAR	**4615**	**16Mar2011**	**IOS**		
Surface PAR	**16504**	**16Mar2011**			
pH	**0691**	**29Dec2010**	**Factory**		
SeaPoint Fluor.	**3642**	**n/a**			
Pressure Sensor	**506**	**30Dec2013**	**Factory**		
Altimeter	**62354**	**n/a**	**Factory**		

CRUISE SUMMARY TSG

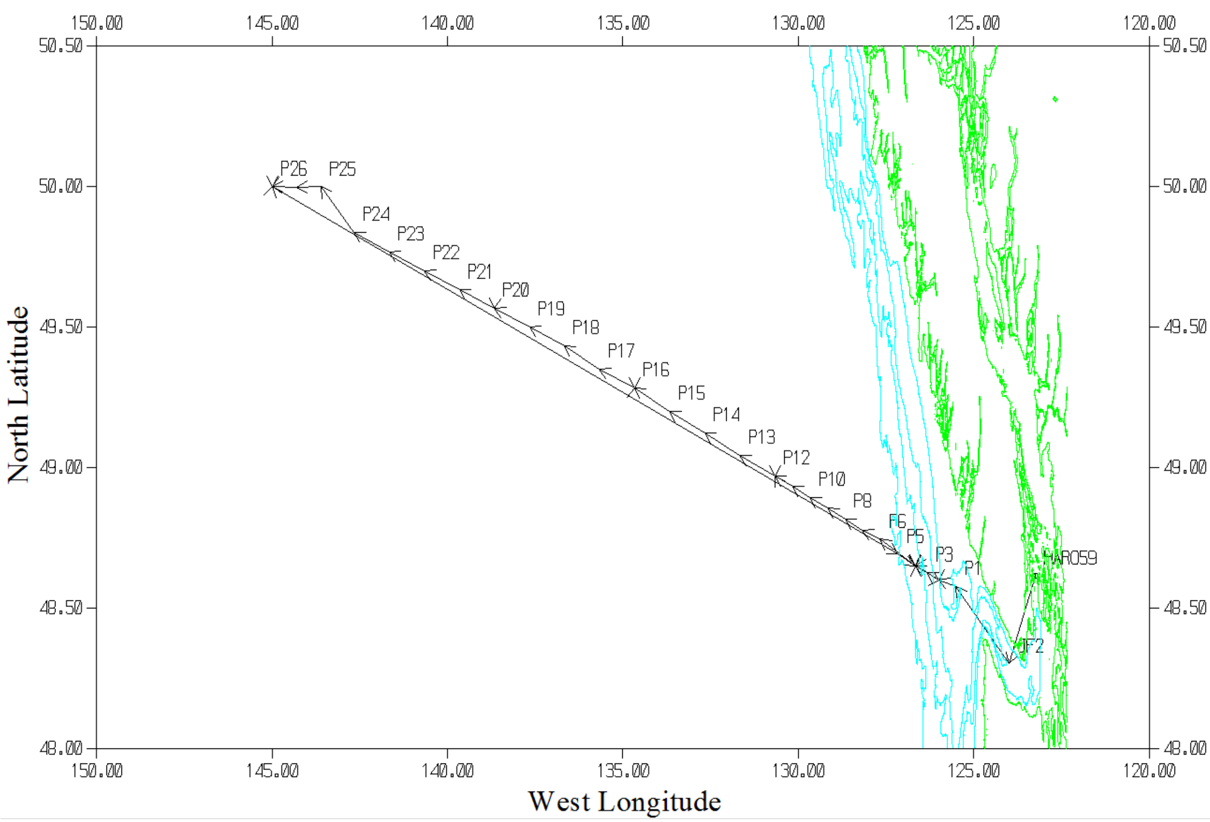
Make/Model/Serial#: SEABIRD/21/3363 Cruise ID#: 2015-01

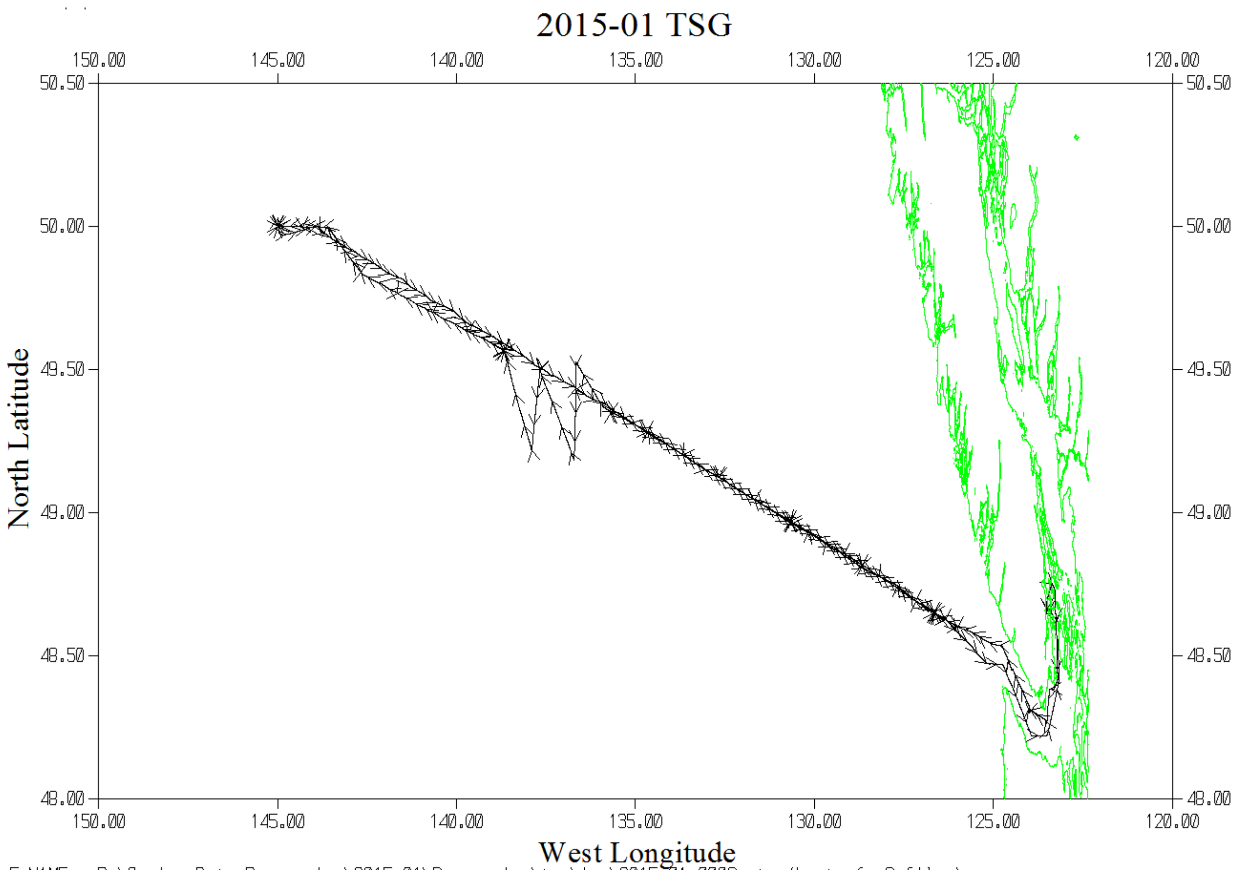
Calibration Information					
Sensor		**Pre-Cruise**		**Post Cruise**	
Name	**S/N**	**Date**	**Location**	**Date**	**Location**
Temperature	**3363**	**28Dec13**	**Factory**		
Conductivity	**3363**	**28Dec13**	**Factory**		
SeaPoint Fluorometer	**2356**				
Temperature:Secondary	**?**	**?**			
Flow meter	**?**	**n/a**			

2015-01



2015-01 Stn Names




2015-01 TSG
North Latitude
West Longitude
150.00
145.00
140.00
135.00
130.00
125.00
120.00
50.50
50.00
49.50
49.00
48.50
48.00