

## REVISION NOTICE TABLE

DATE	DESCRIPTION OF REVISION

## PROCESSING NOTES

Cruise: 2021-006

Agency: OSD

Location: North-East Pacific & Chatham Sound

Project: Line P & Chatham Sound

Chief Scientist: Robert M.

Platform: John P. Tully

Date: 2 May 2021 – 18 May 2021

Processed by: Germaine Gatien

Date of Processing: 9 August 2021 – 4 October 2021

Number of original HEX files: 94 (1 split cast, 1 pumps off & 4 test casts)

Number of processed CTD files: 88

Number of rosette files: 84

Number of processed CHE files: 84

Number of original TSG files: 2

Number of processed TOB files: 15

## INSTRUMENT SUMMARY

CTD #0443 was mounted in a rosette and attached were 2 Wetlabs CSTAR transmissometer (1185DR & #1883DG), a SBE 43 DO sensor on the primary pump (#3791), SeaPoint Fluorometer on the secondary pump (#3950), a Biospherical QSP-400 PAR sensor (#70613) and an altimeter (#75321).

A thermosalinograph (SeaBird 45 S/N 0620) was mounted with a Wetlabs WETStar fluorometer (#1656) and flow meter.

Seasave version 7.26.7.121 was used for acquisition.

The data logging computer WP #102.

The deck unit was a Seabird model 11+ #425.

A Guildline model 8400B Autosal serial # 68572 was used to analyze salinity samples.

An IOS rosette with 24 10L bottles was used.

## SUMMARY OF QUALITY AND CONCERNS

The Daily Science Log Book and rosette log sheets were in excellent order with comments about problems encountered and a detailed list of equipment. The sampling notes provided by the Chief Scientist were a big help in processing data.

For bottles fired above 125db there was a wait of 60s and from 125db downwards it was 30s. This was done to allow better flushing of Niskin bottles in high vertical gradients. The fit of oxygen samples versus CTD oxygen was tighter than usual, which could be partly due to better flushing.

For the Chatham Sound section of the cruise there was no 10m soak. After a stop at 1m with pumps off, the CTD was lowered to about 2.5m and the pumps were turned on. The wait at this level varied from 16s to 145s. The differences between temperature and salinity channels show the waits were generally too short. Even after the longest wait the differences were large until the CTD reached about a depth >15m. The problem appears to have been principally in the secondary system, so near-surface dissolved oxygen data are likely affected since the sensor was mounted on the secondary pump. The fluorometer was on the

primary pump and primary temperature and salinity channels were selected for archiving. A wait of 3 minutes is suggested as a minimum and longer if a large difference between channel pairs is noted.

There were 2 WetLabs CStar transmissometers in use during this cruise:

Channel Transmissometer refers to sensor #1185DR (650nm - red)

Channel Transmissometer:Green refers to sensor #1883DG (530nm - green)

For comparison with other Institute of Ocean Sciences cruises, note that the transmissometer wavelength is 650nm unless otherwise stated.

The Line P section of the cruise was chosen for calibration studies since the Chatham Sound section included mostly shallow casts with conditions likely to lead to poor flushing of Niskin bottles. The deepest bottles look unreliable since they were closed only 5m off the bottom. It is recommended that samples be taken at least 10m off the bottom or wait much longer before firing the bottles. Analyses of samples from Chatham Sound are likely accurate as to the Niskin contents but cannot be presumed to represent ambient conditions at the bottle firing depths.

There were a lot of spikes in the SBE dissolved oxygen and fluorescence channels for events #1 to #15. The problem was resolved when a Y-cable was replaced before event 16. The spikes in dissolved oxygen are 2-sided and will likely “average out” but the quality of the data may be lower than usual for these casts. Downcast fluorescence data were removed from casts 1 to 15, but data collected during bottle stops looked better, so those were not removed.

While CTD fluorescence data are expressed in concentration units, they do not always compare well to extracted chlorophyll samples. It is recommended that users check extracted chlorophyll values where available. The CTD fluorescence data are lower compared to extracted chlorophyll than usually observed.

The SBE DO sensor has a fairly long response time so data accuracy is not as high when it is in motion as it is during stops for bottles. This will be especially true when vertical DO gradients are large. To get an estimate of the accuracy of the SBE DO data during downcasts (after recalibration) a rough comparison was made between downcast SBE DO and upcast titrated samples. Some of the difference will be due to problems with flushing of Niskin bottles and/or analysis errors and small mismatches in depth in the presence of large DO gradients, so the following statement likely underestimates SBE DO accuracy.

Downcast (CTD files) Oxygen:Dissolved:SBE data for this cruise are considered, very roughly, to be:  $\pm 3\%$ , except in areas of very large DO gradients particularly at the base of the mixed layer where errors are likely to be larger.

The Thermosalinograph system functioned well with lots of detail in the traces. There were some single-point spikes in salinity in the offshore portion but overall the data were remarkably free of spikes. The salinity spikes were towards low values so were likely due to bubbles. The TSG salinity were recalibrated by adding 0.183psu based on comparisons with CTD data and loop samples; this correction shows little drift in this TSG system since it was last used in February 2021.

There was a separate flow meter on the TSG fluorometer. The TSG fluorescence values are about 50% higher than those from the CTD; the latter were considered somewhat lower than expected so the TSG values look reasonable. The ratio of TSG fluorescence to extracted chlorophyll samples varied greatly, which is expected given the wide range of CHL values during the cruise.

## **PROCESSING SUMMARY**

### **1. Seasave**

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

The chief scientist provided a summary of sampling protocols and problems.

The deployment protocol was:

- For casts 1-84: The rosette was brought to the surface. Pumps were turned ON. The rosette was brought down to 10m and kept there for 30 seconds. Once back at the surface, the data started to be archived, with the rosette at the surface for 30 seconds longer. Then the cast would start.
- For casts 88 – 141: No 10m dip – acquisition started at beginning of cast.
- For depths deeper than, and including, 125db, there was a wait for 30 seconds before closing a bottle. For depths shallower than, and including, 100db, the wait was 60 seconds before closing a bottle.

### **2. Preliminary Steps**

The Log Book and rosette log sheets were obtained as well as sampling notes from the Chief Scientist.

- Nutrients, extracted chlorophyll, dissolved oxygen, salinity, DMS and DMSP data were obtained in QF spreadsheet format from the analysts.
- The cruise summary sheet was completed.
- The histories of the pressure sensor, conductivity and dissolved oxygen sensors were checked. The temperature, conductivity and dissolved oxygen sensors had been used on 1 other cruise since the last factory recalibrations. See section 15 for details.

Based on notes from the chief scientist some water depth and station names were changed in the raw files.

The configuration file was checked. All parameters were correct except for one of the transmissometers that was found to produce very high values at sea. An error was found in the derivation of SeaBird parameters for the last calibration and the new slope and offset entered in file 2021-006-ctd.xmlcon.

### **3. BOTTLE FILE PREPARATION**

The ROS files were created using files 2021-006-ctd.xmlcon.

The ROS files were converted to IOS format.

The IOS files were put through CLEAN to create BOT files.

Temperature and salinity were plotted for all BOT files to check for outliers.

The files for events 67, 75 and 79 were opened in CTDEDIT and channel Salinity:T0:C0 was edited very lightly. The output files were copied to \*.BOT.

A preliminary header check was run and no problems were found.

The BOT files were bin-averaged on bottle number.

The output was used to create file ADDSAMP.csv. First, the file was sorted on event number and Bottle Position order. Then sample numbers were added based on the rosette logs.

The only problem found was that Event 16 used sample #31 which had already been used during event #14. The sample for event 16 was changed to #9031 since there was no IOS sampling for that cast so no change needs to be made the analyst's reports.

The ADDSAMP file was then reordered on event # & sample #.

The ADDSAMP file was used to add sample numbers to the BOT files – output \*.SAM.

The SAM files were bin-averaged on bottle # and called SAMAVG.

The addsamp.csv file was converted to CST files, which will form the framework for the bottle files.

All analysis files with file names 2021-006-0071 were changed to 2021-006-0070 as they contain the upcast corresponding to file 70. The event numbers in those files were changed to 70.

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 2021-006-bot-hdr.txt which will be updated as needed during processing.

Loops samples were moved from the salinity, chlorophyll and nutrient CSV files to a combined loop data file for later use.

#### DISSOLVED OXYGEN

Dissolved oxygen data were provided in spreadsheet QF2021-006\_OXY\*.xlsx which includes flags, comments and a precision study. Draw temperatures are available. The spreadsheet page with the final data was simplified and saved as 2021-006oxy.csv. That file was converted into individual \*.OXY files. There was 1 sample in the DO file that had comments starting with "ALL:" The only other sampling planned for that bottle (sample 153) was for nutrients and DIC; no nutrient samples were found and DIC data are not yet available.

#### EXTRACTED CHLOROPHYLL

Extracted chlorophyll and phaeo-pigment data were obtained in file QF2021-006\_CHL QF\*.xlsx. The file included comments and flags and a precision study. A simplified version of the spreadsheet was prepared and saved as 2021-006chl.csv. The csv file was then converted to individual CHL files.

#### SALINITY

Salinity analysis was obtained in file QF2021-006\_SAL.xlsx which included a precision study. The analyses were carried out in a temperature-controlled lab 41 to 84 days after collection. The files were simplified and saved as 2021-006sal.csv. That file was then converted to individual SAL files.

#### NUTRIENTS

The nutrient data were obtained in spreadsheet QF2021-006\_NUTS\*.xlsx. This includes a precision study. The file was simplified, saved as 2021-006nuts.csv. The file was converted to individual NUT files.

#### DMS

DMS data were obtained in spreadsheet QF2021-006\_DMS\*.xls which includes duplicate analysis. Details on analysis are in file 2021-006 DMS report.doc. Only 2 figures are considered significant.

#### DMSP

DMSP-D and DMSP-T data were obtained in file QF2021-006\_DMSP\_summary\*.xls. The data were converted into DMSP files. Only 2 figures are considered significant.

The SAL, CHL, OXY, NUT, DMS and DMSP (DMSP-D and DMSP-T) files were merged with CST files in 6 steps.

After the 6<sup>th</sup> step the files were put through CLEAN to reduce the headers to File and Comment sections only.

The files were then put through CLEAN to reduce the headers to File and Comment sections only.

These 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 and saved as \*.MRGCLN1s.

The MRGCLN1s files were then merged with SAMAVG files using merge channel Bottle\_Number.

The output of the MRG files were exported to a spreadsheet and compared to the rosette log sheets to look for omissions. At this point event #2 was removed from the file list since there was no sampling. The SAMAVG files were removed for events 2 and 15 and bottle 3 was removed from the SAMAVG file for cast 140. The final merge was rerun.

## **4. Compare**

### Salinity

Compare was run with pressure as reference channel.

When outliers were removed based on standard deviation in the CTD salinity  $>0.001$ psu, there remained 2 large outliers:

- Sample 747 and 752 from event 117 – Sample 747 is lower than the primary salinity by  $\sim 0.672$ psu. This looks like a mislabelling issue as sample 752 is higher by 0.668. The latter had a high standard deviation in the CTD as well so was already excluded from the comparison. The values were reversed, flagged 3 and a comment attached.
- Sample 862 from event 131 – The sample was low by  $\sim 0.08$ psu. That large a difference is unlikely to be due to poor flushing of the Niskin bottle even at the bottom and the descent rate was not particularly steady. Another bottle fired at the bottom had a DO sample that did not show any sign of poor flushing. The salinity sample could have come from the wrong Niskin but at no level does it look like a good match. The bottle was not fired early but it could have closed early. The analyst flagged the sample “3”. The only other samples from this bottle are not available.

This cruise was divided between 2 distinctive regions and both the deployment method and the near-bottom sampling scheme differed between them. For the Line P casts sampling was done at least 10m off the bottom and above the maximum depth of CTD sampling. For the Chatham Sound section the CTD was lowered to 5m off the bottom and the deepest sampling was done at that level. It is assumed that this was done on purpose due to a need to measure the bottle contents, but this is unlikely to reflect ambient values as either poor flushing or shed wakes will lead to water in the bottles having been gathered some distance above the firing level. The only other sampling was done at  $\sim 2$ m and  $\sim 50$ m for most casts.

Using all casts the comparison had quite a lot of scatter even after cases with noisy CTD data (Std Dev  $>0.001$ psu) were excluded. Excluding bottles above 200db improved the fit (the only shallow sampling was right at the surface). When plotted against pressure the fits were both quite flat with the primary salinity low by an average of 0.0024psu and the secondary high by 0.0036psu. Fits against time (using file pairs as time proxy) were fairly flat as well, but they were of opposite sign so that differences between sensors appeared to be growing slightly.

There is a lot of variability in the comparisons from Chatham Sound with many large differences of varying sign. In a plot made that excluded bottles fired at the bottom all of them were found to have salinity lower than the CTD, but most of the very large differences did not come from that level. When bottles were excluded for which the CTD salinity standard deviation was  $>0.001$ psu the only significant outliers that remain come from the 2 problem samples identified above from event #117. High standard deviations in CTD salinity generally indicate that the CTD was in a very high gradient area so that the imperfect match of CTD and bottle sampling levels plus errors due to incomplete flushing may lead to significant errors of either sign. Another possible influence is that there were sediments noted in some of the dissolved oxygen samples and this might also affect salinity samples. So the Chatham Sound salinity sampling is not useful for calibration purposes. There is no sign of any overall problems with either the CTD or sampling.

For calibration purposes the study was limited to the Line P section of the cruise. The comparison had quite a lot of scatter even after cases with noisy CTD data (Std Dev  $>0.001$ psu) were excluded. Excluding bottles above 200db improved the fit (the only shallow sampling was right at the surface). When plotted against pressure the fits were both reasonably flat (especially the secondary) with the primary salinity low by an average of 0.0024psu and the secondary high by 0.0036psu. A fit against time (using file pairs as time proxy) had fairly flat fits as well but they were of opposite sign so that differences between sensors appeared to be growing slightly. While differences appear to grow from about 0.005psu to 0.007psu the pressure range varies with time and there is a lot of scatter in the comparison.

While the Chatham Inlet samples were run within 41 to 69 days, those from Line P were analyzed 72 to 84 days after collection. Using the estimates from Alexander and Hinrichsen (1986), bottle values might be high by about 0.003psu after 84 days due to desorption of glass particles into the samples and any evaporation of sample would also lead to high bottle salinity but randomly through the cruise. The cases where the CTD looks lowest compared to bottles may be ones with significant evaporation. If those bottles were left out the comparison the primary salinity would be low by ~0.002psu and the secondary high by ~0.004psu. If we assume desorption errors ~0.003psu then the primary would be very close to the bottles and the secondary high by ~0.006psu. There may also be some error due to incomplete flushing but that is expected to be fairly small for Line P. The primary salinity is likely good to  $\pm 0.002$ psu.

During 2021-020 which preceded this cruise the 2 salinity channels were very close early in the cruise but the differences started to grow later until they were about 0.0025psu. Those data were also delayed in analysis and visited a variety of regions including fjords. There appears to be have been a drifting apart of these sensors between 2021-020 in April and while on the shelf between that cruise and this one.

For full details for the COMPARE run see file 2021-006-sal-comp1.xls.

#### Dissolved Oxygen

COMPARE was run with pressure as the reference channel.

The comparison was divided into 2 parts – Line P and Chatham Inlet.

The fit for Line P when only 5 outliers were removed was remarkably tight:

$$\text{CTD DO Corrected} = \text{CTD DO} * 1.0515 - 0.0131 \quad R^2 = 0.98 \quad (\text{Line P})$$

For Chatham Inlet no fit was convincing, because all CTD DO values were between 4 and 7mL/L, but when forced through the origin and removing a few outliers the fit was:

$$\text{CTD DO Corrected} = \text{CTD DO} * 1.0439 \quad R^2 = 0.61 \quad (\text{Chatham Inlet})$$

The lower slope is to be expected due to incomplete flushing of bottles.

Major outliers were examined:

- Event 10, Sample 5 – The bottle DO is lower than any recorded by the CTD even allowing for the those values being low by 5%. The CTD DO was very noisy during this cast with many spikes and significant gaps that are all spikes. A connection problem was resolved after cast #15. No problems were noted in the analysis. There is some doubt here but the CTD data are suspicious. The shallower bottles and all bottles during Event 11 looks ok so it does not seem to be a matter of the CTD data being unreliable in general.
- Event 20, Sample 74 - This was a surface sample and there were reversals nearby. This sample is only slightly out of line in COMPARE so neither CTD nor bottle value are suspicious. No flag is recommended.
- Event 64, Sample 338 – The CTD data are noisy and there was a nearby reversal so the bottle value is likely fine. No flag is recommended.
- Event 64, Sample 340 – The CTD data are very noisy and the local gradient high. No flag is recommended.
- Event 77, Sample 435 – The CTD data are noisy and the local gradient very high. No flag is recommended.

All outliers from Chatham Inlet came from the bottom of casts. Since these samples are from close to the bottom the Niskin contents are likely affected by larger flushing errors and ones of opposite sign to those of other bottles. The analysis values likely do represent the bottle contents accurately, but not ambient waters.

A hysteresis check was run on the Line P casts excluding outliers. Above 1000db the fit was:

$$\text{CTD DO Corrected} = \text{CTD DO} * 1.0509 - 0.0099 \text{ (Above 2000db)}$$

$$\text{CTD DO Corrected} = \text{CTD DO} * 1.0492 - 0.0165 \text{ (Below 2000db)}$$

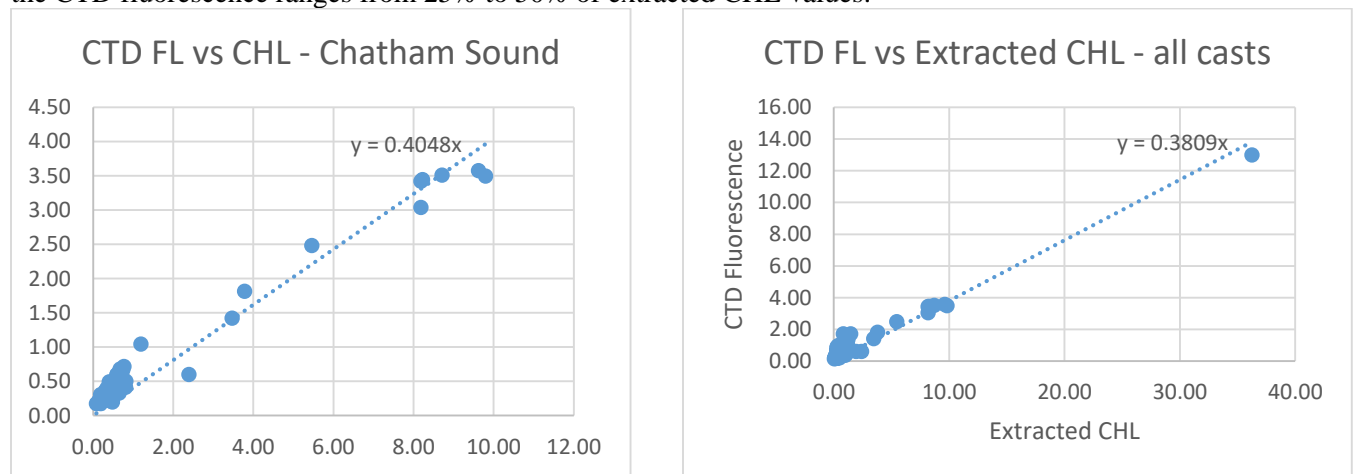
There is a slight difference between the two sets but too small to justify changing the configuration parameter E given the variability.

For full details for the COMPARE run see file 2021-006-dox-comp1.xls.

### Fluorescence

COMPARE was run with extracted chlorophyll and CTD Fluorescence using pressure as the reference variable.

Almost all the samples from Line P had very low chlorophyll values, the exception being a very high value at station P1. At low CHL levels the SBE fluorometers tend to read high so most of the points fall above the trendline that is forced through the origin. The 2 values >1.5ug/L have CTD Fluorescence ~35% of extracted CHL. In Chatham Sound there were more bottles with high CHL values. For CHL>2 the CTD fluorescence ranges from 25% to 50% of extracted CHL values.



Overall, the fluorescence is lower than expected compared to extracted chlorophyll.

For full details for the COMPARE run see file 2021-006-fl-chl-comp1.xls.

### **5. Conversion of Full Files from Raw Data**

File 2021-006-ctd.xmlcon was used to convert all files.

The Tau function and the hysteresis function were selected since there was deep sampling. Depth was included in the conversion.

A few casts were examined and all expected channels are present. The descent rate was often extremely noisy offshore but steady inshore. The T and C pairs were reasonably close during downcasts but there were quite a few spikes in the secondary temperature. Upcasts are noisy. The Green transmissivity was much too high when test casts were sent from sea but it was found that the slope/offset values were wrong. Once corrected the values looked fine with the "Green" transmissometer generally higher than the "Red"; the 2 profiles had similar shapes. The altimetry looked ok even though the signal was sometimes noisy at the bottom of casts. Dissolved oxygen and fluorescence traces had unusual spikes from events #1 to 15. Before cast #16 the Y-cable for the DO and Fluorometer were changed and the noise disappeared.

## 6. WILDEDIT

Program WILDEDIT was run to remove spikes from the pressure, depth, 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.

Test runs to remove spikes from the fluorescence and dissolved oxygen for casts #1 to 15 were not successful. An IOS SHELL routine will be tried later in processing.

## 7. ALIGN DO

A few casts were examined; both temperature channels were noisy during upcasts so the tests were not easy to interpret, but using +2.5s certainly improves the alignment and overall looks like a good choice for both sensors. That setting has worked well for many SBE DO sensors in recent years.

ALIGNCTD was run on all casts using +2.5s.

## 8. CELLTM

The noise in the upcast data makes tests for the best parameters for this routine very difficult to interpret. In the past when upcast data were not so noisy, the default setting of ( $\alpha = 0.0245$ ,  $\beta=9.5$ ) was generally found to be the best choice. A few casts were checked for this cruise and the default setting does improve the data. CELLTM was run using ( $\alpha = 0.0245$ ,  $\beta=9.5$ ) 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 3 of the deeper casts to find the differences between the pairs of temperature, conductivity and salinity channels.

Cast #	Press	T1-T0	C1-C0	S1-S0	Descent Rate
2021-020-0037	320	-0.0002	~	+0.0002	High, F.Steady
2021-020-0082	350	+0.0001	+0.00017	+0.0015	
2021-020-0117	375	+0.0004	+0.00022	+0.0021	High, Noisy
2021-006-0020	375	+0.0004	+0.00044	+0.0043	High, Noisy
	1200	+0.0002	+0.00042	+0.0050	“
2021-006-0039	1200	0	+0.00042	+0.0049	High, XNoisy
“	2000	-0.0002	+0.00044	+0.0055	“
“	3000	-0.0003	+0.00044	+0.0057	“
2020-001-0052	1200	0	+0.00043	+0.0057	High, XNoisy
“	2000	-0.0005	+0.00042	+0.0056	“
“	3000	-0.0005	+0.00044	+0.0060	“
2021-001-0077	1200	-0.0005	+0.00042	+0.0059	High XNoisy
	2000	-0.0007	+0.00044	+0.0063	“
	3000	-0.0006	+0.00045	+0.0062	“

The conductivity differences were all small and very noisy with no sign of drift. Temperature differences have a little drift that accounts for a slight drift in salinity.

The casts in inlets did not have a 10m soak. Typically acquisition started immediately with a stop at about 1m for between 15s and 2 minutes with pumps off. The CTD was then lowered to about 2.5m with pumps on where there was a stop of 75s to 145s with 100s being most common. A number of casts were checked at the end of the soak time and the 2 temperature and salinity channels still differed significantly.



For the cast with the longest soak period (145s) the differences between salinity channels was large until the CTD was at about 17m depth. The secondary system seemed to be the one that was slow to equilibrate in this case and a few others in the same area, so there may have been a pump problem. Nonetheless, waiting longer is likely to clear any issues in the plumbing.

The longer the wait the better, but at least 3 minutes soaking is likely necessary to get good data.

## 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.

A few casts had to be treated separately at this point:

- Event #70 was interrupted by a computer crash at about 1000m. File 2021-006-0070.ios was renamed as \*.iosa and 2021-006-0071.ios was renamed as \*.iosb. There is a small overlap of data so a text editor was used to remove 265 initial records from the 2<sup>nd</sup> file. JOIN was then run to combine the iosa and iosb files. CLEAN was run on file 2021-006-0070.ios.
- Event #89 had pumps off until the CTD was at about 100m. The CTD was returned to the surface and a full cast run. CLIP was run to remove 14871 records. CLEAN was rerun on the CLIP file.

## 11. Checking Headers

- The cross-reference check and header check were run. No problems were found.
- Surface check was run in 2 parts as the deployment method varied. For the offshore casts the average surface value was 3.4db, which is reasonable for an off-shore Tully cruise.
- For the northern, inshore group the average was 1.1db which makes sense given the deployment method that started acquisition right at the surface for most casts. The lowest value recorded was +0.9db.
- Cruise tracks were plotted and added to the end of this report.

The altimeter and water depth readings from the headers of the CLN files were exported to a spreadsheet. A check value was calculated by subtracting water depth from maximum depth sampled plus altimetry header). Where that number was > 4 or <-4 plots of the altimetry were checked. Some casts didn't get near the bottom so there are no altimetry headers and for most the check value was small.

Changes needed to be made to the following CLN files:

- There was no depth entry for 4 casts (32, 43, 55, 64) so the value entered in the log book was added to the headers.
- For event #2 the altimetry header is clearly wrong as the cast did not get near the bottom, so the header entry was removed.
- For casts 10 and 15, 20 and 77 the water depth was changed to match the log entry.
- For casts 20 and 77 the depth was changed to match the log entry for another cast at the same site.
- For cast 96 the water depth was changed to match the log entry. The check value is still ~6m but the altimetry was noisy and there may be shoaling

Changes were also applied to the SAMAVG files (except casts #2 and #15 which were not rosette casts).

At this stage tests were run using a DESPIKE routine to improve the fluorescence and dissolved oxygen profiles for casts 1-15. No improvement could be made to the 1-sided spikes in fluorescence; they contained variable numbers of points. For fluorescence there appears to be a "Good" trace and roughly equal length spikes so that there is an apparent "Ghost" trace with higher values. Simple Despik removed as many good points as bad. Binning these data are likely to lead to values that are too high. The spikes largely disappear during stops for bottles so the issue is likely related to winch speed. Fluorescence should be removed from the downcast files for casts 1-15.

The spikes in dissolved oxygen are a little different – smaller spikes and not one-sided, so bin averaging definitely helps. De-spiking was not successful. The DO signal was not very spiky during bottle stops.

## **12. Shift**

### Fluorescence

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

### 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 a few casts to assess what settings are best to align conductivity with temperature (as judged by the effect on salinity as seen in T-S space). The best settings overall were -0.8 records for both the primary and the secondary channels, with the primary looking better than the secondary.

SHIFT was run twice on all SBE911 casts using -0.8 records for both conductivity channels. Salinity was recalculated for both channels.

## **13. Clip – Events 91-141**

Because the casts in Chatham Sound had acquisition start as soon as the CTD entered the water, CLIP was run to remove all records with pumps off, so that DELETE will not choose those records. There remains the fact that DELETE may pick records for which the pumps have just come on, but given the wait at the surface in most cases the feature to remove records to the last pressure minimum will generally lead to the selection of more appropriate data. The graphical editing feature will catch some obviously bad surface data as well. (Cast #89 was put through CLIP earlier.)

This approach occasionally fails due to pumps going off later in a cast, so surface check was rerun to ensure too many records were not removed. For event #98 the pumps were turned off towards the end of the upcast so too many records were removed. A text editor was run to remove from the SHFC1 file the initial records with pumps off.

## **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**

### Experience with these sensors since last factory service –

The pressure, temperature, and conductivity sensors were used during only 1 cruise since the last factory visit:

- 2021-020 – The salinity channels started out being close and gradually drifted apart. Based on information from the Line P section of cruise 2021-006 it appeared that the primary salinity did not drift much. The drift in secondary salinity appears to have been fairly sudden and then settled down. Dissolved oxygen was recalibrated using slope/offset = 1.0515/-0.0131 based on cruise

2021-001. This correction seemed high since it was first use since previous factory calibration. Pressure looked ok.

Historic ranges – Profile plots were made with 3-standard deviation climatology ranges of T and S superimposed. There were some excursions. Temperature was below the range minimum between 80 and 120db at 2 stations in Dixon Entrance. Salinity was frequently below the climatology minimum at the base of the halocline offshore and in the top 10 to 15m in Chatham Sound. Low salinity has been reported frequently in recent years. None of these excursions suggest calibration drift.

Post-Cruise Calibration – None available.

Repeat Casts – There were no repeat casts deep enough to expect a good comparison, but casts at P25 and P35 taken about 4.5 hours and 50 km apart were compared around 1500db and differences in temperature were  $\sim 0.005\text{C}^\circ$  and in salinity  $\sim 0.0005\text{psu}$  along lines of constant density. This is good repeatability.

## 16. DETAILED EDITING

The primary channels were chosen for editing because the salinity was found to be more accurate in the bottle comparison and problems were noted in secondary temperature and salinity near the surface in some of the inlet casts.

All DEL files were copied to \*.EDT.

CTDEDIT was used to remove records that appear to be corrupted by shed wakes. Salinity was cleaned to remove spikes that appear to be due to small misalignment or instrumental noise. All files required some editing. Notes about editing applied were added to the files.

For Chatham Sound editing was mostly limited to the surface and bottom of casts.

The edited files were copied to \*.EDT.

After editing, T-S plots were examined for all casts. Some small unstable features remain in some casts but come from areas where such features may well be real. No further editing was done.

## 17. Corrections to Pressure, Salinity and Dissolved Oxygen Concentration

Pressure and salinity do not need recalibration. The Dissolved Oxygen fit based on the Line P casts was selected for correction of all files.

File 2021-006-recal.ccf was prepared to apply the following correction to channel Oxygen:Dissolved:

$$\text{CTD DO Corrected} = \text{CTD DO} * 1.0515 - 0.0131$$

This correction was first applied to the SAM and MRGCLN2 files.

COMPARE was rerun for dissolved oxygen and shows that the correction was applied properly. When data are excluded based on using the same points as in the original fit the average is 0.00003mL/L, with a standard deviation of 0.018mL/L. See file 2021-006-DO-comp2.xls for details.

CALIBRATE was then run on the EDT files using the same recalibration file.

## 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 delayed response 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.

For the Line P casts, the CTD DO was higher than the titrated samples by an average of ~0.026mL/L but the standard deviation was high, at 0.21mL/L. When a few outliers based on residuals were excluded the average difference was similar at 0.022mL/L but the standard deviation was much lower at 0.08mL/L. The outliers all came from the 100-200db range where gradients were highest for most casts. However, for the shallow casts at P1 and P2 there were no outliers which may indicate that the longer waits before firing bottles was effective where vertical DO gradients were high. The conclusion is that longer waits are likely most useful in the part of the cast with the highest DO vertical gradients.

For the Chatham Sound casts there was a lot of scatter in the CTD DO during stops for bottles and also in the downcast data at bottle stop levels. So it is not a surprise that there is a lot of variability in the comparison of bottles with downcast CTD DO. Such data would not usually be included in a bottle comparison. However, noisy as it is, the differences are all within 0.025mL/L with an average of 0.012mL/L and standard deviation of 0.10mL/L. The bottles were all fired at levels with low vertical gradients of DO and there were 60s waits for most of them, so flushing errors are likely low. When 4 cases where the CTD variability was very high were excluded the CTD was higher than bottles by an average of 0.026mL/L and standard deviation was 0.07mL/L. Except at the bottom of the casts we expect the CTD to read a little higher than bottles due to flushing errors and/or slow response in the DO during the downcast.

A plot of differences versus pressure showed a lot of scatter. In most cases the differences are within 3%, except in areas of large vertical DO gradients. For this cruise the largest gradients were between 100db and 300db for stations P4 to P26. At P1 and P2 there were larger gradients near the surface but errors were still fairly small, perhaps due to longer waits before firing near-surface bottles. In Chatham Sound the vertical gradients were fairly low and there were 60s waits for most bottle firings, so it is not surprising that differences are also mostly <3%. For the header comments the following statement will be used:

Based on a comparison with titrated dissolved oxygen samples, the accuracy of data in channel Oxygen:Dissolved:SBE in the downcast files is considered, very roughly, to be  $\pm 3\%$ , except in areas of very large DO gradients, especially at the base of the mixed layer.

For more detail see file 2021-006-dox-comp3.xls.

## **19. Fluorescence Processing**

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 T-S plots were examined.

Profile plots were examined. No problems were noted.

## **21. Final CTD File Steps (REMOVE and HEADEDIT)**

For all casts REMOVE was run to remove the following channels:

Scan\_Number, Temperature:Secondary, Conductivity:Secondary, Oxygen:Voltage:SBE, Descent\_Rate, Status:Pump, Altimeter, Salinity:T1:C1 and Flag.

PAR was removed for casts #39, 52, 64, 77.

Fluorescence was removed from casts 1-15.

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 comments about processing.

The Standards Check routine was run and no problems were found.  
The Header Check was run; no problems were found.  
Profile and T-S plots were examined. No problems were found.  
The sensor history was updated.

## **22. Dissolved Oxygen Study**

As a final check of dissolved oxygen data, % saturation was calculated and plotted. Values at 2 to 3m ranged between ~70% to 130%. From P10 to P26 values were quite tight between 102% and 104% which is typical for this area. The lowest values were in Haro Strait and the highest at P1 and Saanich Inlet. The values in Chatham Sound varied with most between 95% and 105%. These values look reasonable and do not suggest any problem with DO calibration.

## **23. Final Bottle Files**

SORT was run to arrange casts in pressure order.

For all casts REMOVE was run to remove the following channels:

Scan\_Number, Temperature:Primary, Conductivity:Primary, Oxygen:Voltage:SBE, Descent\_Rate, Status:Pump, Altimeter, Salinity:T0:C0 and Flag.

PAR was removed for casts #39, 52, 64, 77.

Fluorescence and Dissolved Oxygen data from casts 1-15 look ok when the CTD was stopped so they were not removed from the bottle files.

A second SBE DO channel with mass units was added for both the CTD DO and titrated DO and REORDER was run to get the pairs of DO channels together.

EDIT HEADERS was run to fix formats and channel names and to add comments about analyses and CTD processing.

Data were exported from the CHE files to file 2021-006-bottles-final.xlsx. The entries were compared with the rosette log sheets and many problems were found:

- Analysis results were missing from 3 casts because the cast # was wrong due to a plan change: 42, 118, 124 should be 43, 119, 127. The analysis results were renamed and the merges rerun.
- A number of chlorophyll data were missing – in one case the sample number was wrong and many were missing that were duplicates from late in the cruise.
- 3 nutrient samples were missing with no flag or comment (659, 660, 936).
- The DO samples from cast 107 did not match the rosette log – samples 641 and 642 should be 642 and 643.

The problems were reported to analysts and all were resolved.

Standards check and a header check were run. No problems were found.

The track plot looks ok.

Plots of each file were examined and no problems were found.

A cross-reference listing and header check were produced for the CHE files.

## **24. Thermosalinograph Data**

An IOS TSG45 was used for this cruise and data were saved in 2 files.

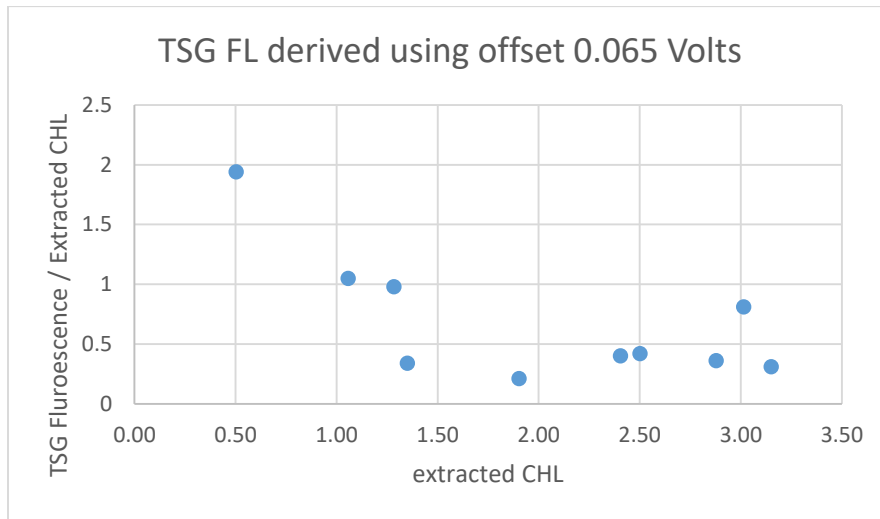
The IOS SBE TSG45 files were opened in EXCEL.

The files have extensions RAW but are in csv format, so the files were opened in EXCEL and combined in a single CSV file. (In opening use DELIMITED, deselect TAB, select COMMA and OTHER (\*).

It is necessary to choose TEXT for the time on the 2<sup>nd</sup> page of the text import wizard.)

The spreadsheets were adjusted as follows:

- 2 lines of headers were added – channel names and units.
- A column with pressure was added with all values set to 4.5 (to enable derivation of salinity).
- A temperature difference column was added (Lab-Intake).
- The fluorescence channel is in volts. It was moved to column M. Then a concentration value was calculated in column F using scale 14.6 as determined in the most recent recalibration of the fluorometer. No clean water offset value was available. A study was made comparing some CHL samples taken during CTD casts to see what offset should be used. This type of fluorometer tends to read too high for very low values of CHL and low for high values of CHL. So we don't expect a good match through the whole range. Picking an offset  $<0.05\text{ug/L}$  led to the TSG fluorescence looking too high offshore and an offset of  $0.1\text{ug/L}$  led to negative fluorescence offshore. The fit that looks most like what we expect is  $0.065\text{ug/L}$ , so that will be used; the range of reasonable fits were  $0.05$  to  $0.08\text{ug/L}$ , so the error in picking a suitable offset is likely  $\sim 0.15\text{V} * 14.6\text{ ug/L/V}$ , or roughly  $\pm 0.2\text{ug/L}$ . The plot below shows the ratio of TSG FL / CHL using that setting and it looks similar to the sort of fits we get comparing CTD fluorescence to CHL.



See TSG\_Fluorescence\_offset\_study.xlsx for more detail.

- A file break column was filled with the cruise #-data/time info from the original file name.
- The TSG was running for several hours before leaving the dock. For 1.5 hours there was no flow. The first 1016 records were removed as there was no flow or it was just being established.
- The flow to the fluorometer was turned off at 13:30 for cleaning. The flow rate channel shows occasional flow but was mostly 0 until 13:50. Fluorescence data were padded for that 20-minute section.
- Time and Date formats are a problem – when converting from RAW choose TEXT but once opened in EXCEL set Time Format to HH:MM:SS and save the file again.
- The file break column was completed so that new files would be created at the beginning of each day by assigned file names like 20200210-000000 except for the first file which has a time later than 000000.

The file was then converted to IOS Header format with header info added. There are 15 IOS files, one for each day.

CLEAN was run to reset the number of records, min and max values, set the start and end times, and latitude and longitude limits.

ADD TIME CHANNEL was used to add Julian dates – i.e. Decimal Year. A record number was also added to enable averaging (for use in comparison to CTD files). Time zero was set to 31 December 2020 0:00:00. (Note that this step leads to problems plotting until REORDER is run.)

DERIVED QUANTITIES was run twice, first to derive salinity using the lab temperature and again to derive sigma-T.

REORDER was run to move the Julian date to after the Time/Date channels and to put salinity and fluorescence after the lab temperature. Also the record # was moved to the end.

#### a.) Plots

A track plot was produced and added to the end of this report.

Time-series plots were produced.

- The salinity and fluorescence traces have spikes in the westward part of the cruise, but very few after the ship reached Station Papa.
- The loop flow rate was generally steady for hours at a time but the rate varied from 0.8 to 1.1. Heating in the loop decreased as the flow rate increased, as expected.
- The flow rate to the fluorometer was mostly steady but there were a few spikes to high and/or low values, but they had no obvious effect on fluorescence. There was a section starting at 13:30 on May 11<sup>th</sup> when the flow was stopped for about 20 minutes to clean the fluorometer; the affected fluorescence data were padded.

#### b.) Checking Time Channel

The CTD files were thinned to reduce the files to a single point from the downcast at or within 0.5db of 4.5db. These were exported to a spreadsheet which was saved as 2021-006-tsg-ctd-loop-rosette-comp.xlsx. All CTD casts overlapped with TSG records but 1 occurred before flow was turned on, so there are 87 records for comparison.

The TSG files were averaged over 24 records (2 minutes) on record number to reduce the noise and file size. Standard deviations were included. Then required records (times, positions, temperatures with standard dev, salinity with standard dev, fluorescence with standard dev, flow rate) were exported to a spreadsheet and that file was thinned to the closest times of CTDs and added to file 2021-006-ctd-tsg-loop-rosette-comp.xlsx.. The same file was thinned to the closest times to loop files and added to the TSG-Loop comparison. (Note the time in the log for Loop 73 is wrong; it makes sense only if it is PDT rather than UTC, so 7 hours were added to the log time.)

Comparisons were made of positions to check for good matches. The differences in positions are expected to be small despite the averaging because the ship was stopped at these times. The average differences were 0.0000° for latitude and 0.0002° longitude. There were 4 differences > 0.001° in latitude and 9 >0.001° in longitude. The times were checked and the matches are good. They all came from early in the cruise in areas where ship drift may have been a factor given the differences in time between the start of the CTD acquisition and sampling at 4.5m. There were no differences in latitude or longitude >0.0005° in Chatham Sound.

#### c.) Comparisons

The comparisons will be difficult to interpret because of highly variable near-surface vertical gradients. The offshore casts are better mixed near the surface than those in Chatham Sound especially for salinity. Fluorescence varies greatly from area to another, even within each of Line P and Chatham Sound. There was also no 10m soak in Chatham Sound so the salinity data may not be fully equilibrated, while ship movement is larger offshore due to wind.

- Comparison of T, S and Fluorescence from TSG and CTD data

The initial comparison between TSG and CTD data using all casts includes some large outliers.

All Casts	TSG (int) - CTD Temp	TSG Sal- CTD Sal	TSG FL/ CTD FL
max	0.8023	7.9907	2.98
min	-1.5260	-1.1257	0.45
avg	-0.0169	0.6088	1.56
median	0.0070	0.1856	1.45
stdev	0.3126	1.1187	0.49

The comparison was then run separately for the 2 different parts of the cruise.

Offshore	TSG (int) – CTD Temp	TSG Sal- CTD Sal	TSG FL/ CTD FL
max	0.2555	-0.1081	2.84
min	-0.4020	-0.1994	1.22
avg	-0.0003	-0.1824	1.79
median	0.0070	-0.1837	1.64
stdev	0.0778	0.0124	0.43

Chatham Sound	TSG (int) - CTD Temp	TSG Sal- CTD Sal	TSG FL/ CTD FL
max	0.8023	1.1257	2.98
min	-1.5260	-7.9907	0.45
avg	-0.0415	-1.0868	1.42
median	-0.0173	-0.9588	1.39
stdev	0.4494	1.4992	0.47

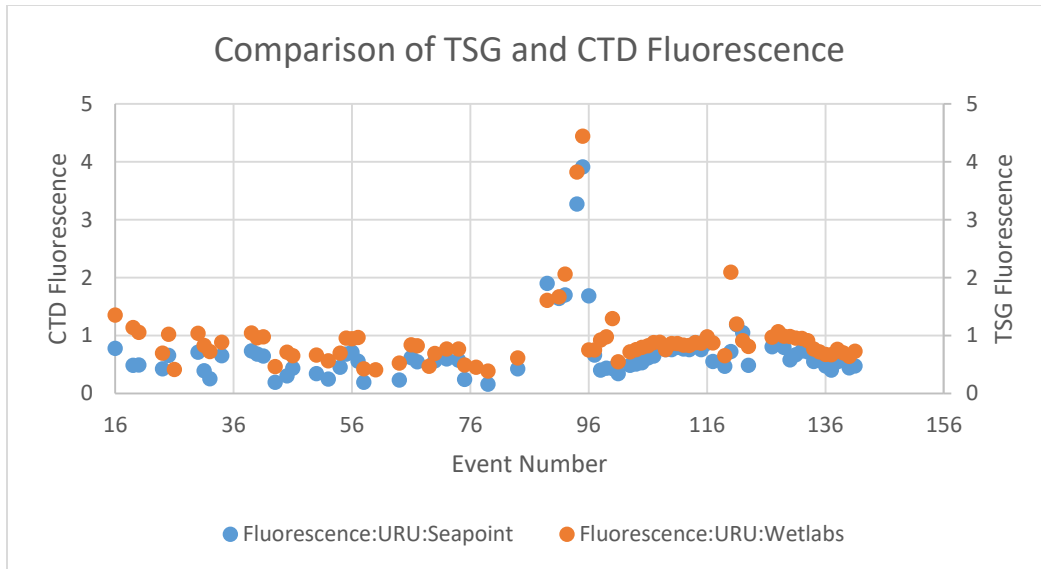
There is a significant difference between the two regions that is likely due mainly to larger vertical gradients in Chatham Sound so that exact matches in depth of sampling matters more. There is also a possible effect on salinity differences due to inadequate soak times in Chatham Sound and high local vertical and temporal variability in that area. The high standard deviations in Chatham Sound make the comparison less useful for calibration checks.

The offshore comparison indicates that the intake temperature is higher than the CTD by 0.007 with a standard deviation of 0.078psu. A comparison was done by choosing the 27 casts with standard deviation in the TSG intake temperature over the 2-minute averaging period <0.003C°. The median difference between the intake temperature and TSG temperature was 0.0098C° and the standard deviation 0.0381C°.

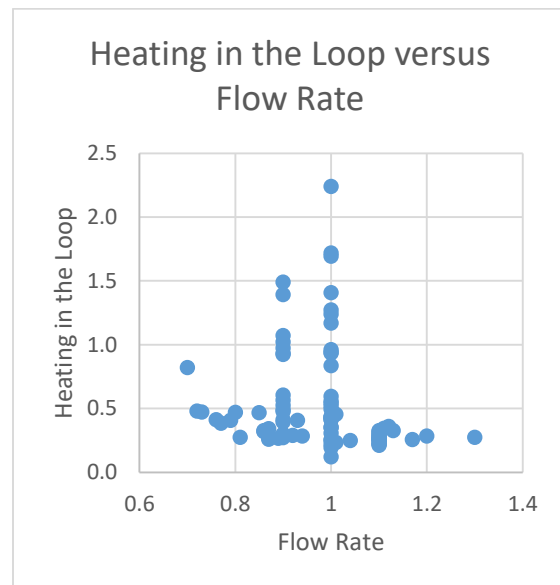
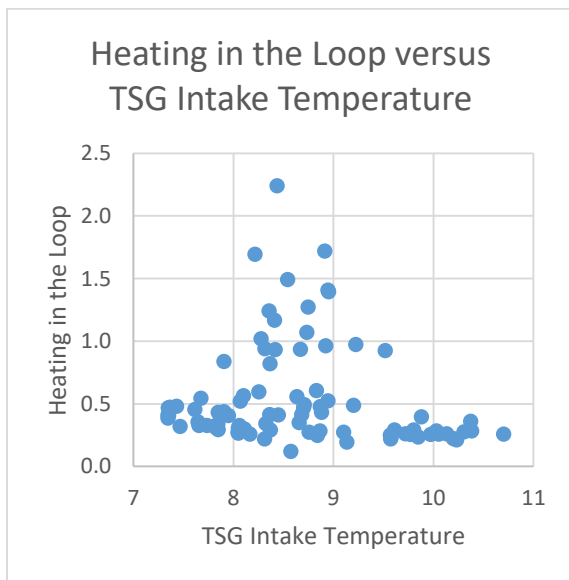
The offshore comparison indicates that the TSG salinity is lower than the CTD by 0.184psu (standard deviation 0.012psu). A comparison was done by choosing the 33 casts with standard deviation in the TSG salinity over the 2-minute averaging period <0.0007psu. The median difference between the TSG salinity and the CTD salinity was 0.183 (standard deviation 0.0026). This result is remarkably close to the result using all casts. There is a slight hint that the differences might be increasing with time in the offshore, but the evidence is weak.

The TSG fluorescence is higher than the CTD fluorescence by about 50% in most cases, but the traces track each other well. This is a much better correspondence than noted during 2021-001.

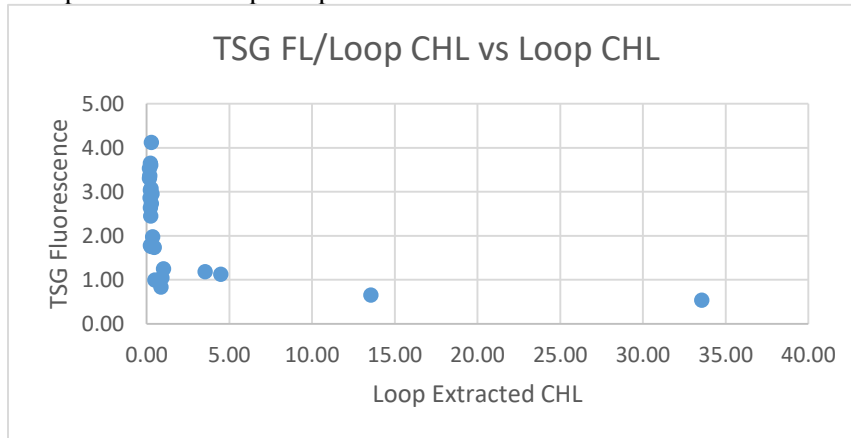




Heating in the loop (Lab Temperature – Intake Temperature) was plotted against intake temperature. There is a lot of scatter that all comes from Chatham Sound casts. But the basic trend shows that heating varied from 0.5 C° for the coldest intake water to 0.3 C° for the warmest. This is the usual pattern found. There was a slight hint that heating decreased as flow rate increased, but geographic variations make this weak evidence. This study can provide guidance for any Tully cruise with no intake temperature available.



- Comparisons of Loop samples and TSG data



There were 25 loop Salinity and Chlorophyll samples of which 8 were taken while stopped and the rest while underway. Only 7 samples had chlorophyll >0.5ug/L and only 2 were >5ug/L. The loops were compared with TSG data. As is usually the case, TSG fluorescence was higher than Extracted CHL by up to a factor of 4 for the samples with CHL < 0.5ug/L. Fluorescence was close to loops between 0.9 and 5ug/L. Above that the fluorescence readings were 65% and 54% of the loop samples. The highest CHL values came from underway samples so there is no way to estimate the vertical CHL gradient.

The TSG salinity was lower than loop samples by a median 0.1872psu using all available data, and by 0.1877psu using only offshore samples, 0.1881psu while stopped and 0.1857psu when underway.

- Comparison of 5m Rosette samples and Loop samples

There were 8 salinity and extracted chlorophyll loop samples taken during rosette casts. Salinity values were very close with the loops lower by a median of 0.0008psu (std. dev. 0.036psu). There was a clear bias in the chlorophyll comparison with 7 of the loop samples lower than those from the rosette and 1 was higher by 0.01ug/L. The loop samples were lower by a median 0.03ug/L (std. dev. 0.03ug/L); they were low by a median of 14%. The maximum rosette CHL value was 0.49ug/L.

Event Number	Sample Number	Station	Loop data		Rosette Data		Loop-Rosette		% diff	
			Salinity :Bottle	Chlorophyll :Extracted	Salinity :Bottle	Chlorophyll :Extracted	Salinity	CHL		
24	5024	P5	32.0172	0.23	32.013	0.25	0.0043	-0.02	-6.10	
31	5031	P9	32.0577	0.46	32.056	0.49	0.0018	-0.03	-6.12	
43	5042	P13	32.3162	0.20	32.316	0.23	0.0002	-0.03	-13.04	
46	5046	P14	32.3324	0.17	32.334	0.20	-0.0020	-0.03	-15.00	
55	5055	P17	32.3808	0.32	32.383	0.38	-0.0018	-0.06	-15.79	
57	5057	P19	32.3696	0.36	32.373	0.35	-0.0035	0.01	2.86	
66	5066	P21	32.3728	0.22	32.365	0.27	0.0075	-0.05	-18.52	
72	5072	P25	32.4446	0.26	32.443	0.34	0.0013	-0.08	-23.53	
							average	0.0010	-0.04	-11.91
							median	0.0008	-0.03	-14.02
							stdev	0.0036	0.03	8.37

Since the rosette samples likely came from a little lower in the water column we might expect the loop to have lower salinity than the rosette samples, but near-surface salinity was very well-mixed during these casts and there was a 60s wait before firing, so this is not likely to be a significant factor. Some of the fluorescence profiles suggest the rosette samples might have a tendency to read slightly higher if flushing is incomplete. Overall the results show good correspondence.

#### d.) Calibration History

- The TSG and fluorometer were recalibrated shortly before cruise 2021-001.
- During 2021-001 the TSG salinity was found to be lower than CTD salinity by a median of 0.178psu, and lower than loops by 0.181psu with no significant difference between underway and stopped samples. There was no evidence of drift through the cast. The TSG intake temperature was higher than the CTD temperature by  $\sim 0.02\text{C}^\circ$  offshore but if only casts with a low standard deviation in the intake temperature are included it is high by a median of  $0.009\text{C}^\circ$ . No recalibration was applied as the differences were reasonably small given some differences in depth and time between the 2 data sets. The TSG fluorescence values were about 32% of fluorescence from the CTD and 74% of the loop CHL samples. Loop and rosette salinity samples compared very well, while the loop chlorophyll was about 75% of that from the rosette.

#### e.) Conclusions re TSG

1. The TSG clock worked well and position information was available and reliable.
2. The flow rate as recorded by the meter was generally high and steady for hours at a time though it varied from about 0.8 to 1.1L/min. While stopped the average was 1 L/min. There were occasional spikes to high or low values.
3. The flow rate to the fluorometer was mostly steady but there were a few spikes to high and/or low values, but they had no obvious effect on fluorescence. Mid-cruise the flow to the fluorometer was stopped for about 20 minutes to enable cleaning; fluorescence values were padded for that section.
4. The TSG salinity was found to be lower than CTD salinity by a median of 0.184psu in the offshore section or by 0.183psu for the offshore casts with lowest standard deviation in the TSG data. Compared to loops it was low by 0.188psu while stopped and 0.186psu when underway. During 2021-001 it was low by 0.178psu compared to CTDs and 0.181 compared to loops. These results are all remarkably close, suggesting little drift since February. While there is a slight hint of increasing differences with time in the offshore the evidence is weak. Salinity will be recalibrated by adding 0.183psu.
5. Why did TSG salinity read low immediately after factory service and then stay relatively steady? Any explanation that involves incomplete equilibration in the TSG system as lab temperature varies should lead to a random error. The water in the loop compared well with rosette samples. That leaves bubbles as the most likely cause. Large spikes will be removed in editing, but there are likely small bubbles present all the time that don't affect loop samples because they disappear before analysis is done. Recalibration will remove the net effect of that.
6. The TSG intake temperature was higher than the CTD temperature by about  $0.01\text{C}^\circ$ . No recalibration is justified as differences are small given some differences in depth and time between the 2 data sets.
6. The TSG fluorescence values are about 50% higher than those from the CTD and higher than loop CHL samples by 50 to 300%. For the cases where the CHL was in the range 0.49 to 5.0ug/L, the TSG fluorescence was higher than loop samples by 8%. This is typical of how the CTD fluorometer works with much higher readings than CHL when CHL is very low.
7. Loop and rosette salinity samples compared very well, while the loop chlorophyll was about 86% of that from the rosette.

#### g.) Editing

Time-series plots were examined. The only significant salinity spikes were in the files for days May 6 to May 11. CTDEDIT was used to remove a few spikes from those files.

#### h.) Preparing Final Files

REMOVE was used to remove channel Pressure, Temperature:Difference , and record #.

#### i.) Calibrate

CALIBRATE was used to add 0.183psu to channel Salinity

HEADER EDIT was used to change the DATA DESCRIPTION to THERMOSALINOGRAPH and add the depth of sampling to the header and to change channel names to standard names and formats and to add comments.

A cross-reference list was prepared.

The TSG sensor history was updated.

As a final check plots were made of the cruise track and time-series and all looks fine.

### **25. Loop File**

The Chief Scientist provided file 2021-0006 Loop log.xlsx which included event numbers, sample numbers and what was sampled. Earlier in the processing the loop samples were used to study the TSG calibration. Times were added based on the log entries. For loops taken at the same time as 5m rosettes, the times were set to the ends of casts. The data were copied to file 2021-006-tsg-ctd-loop-rosette-comp.xlsx.

A 6-line header spreadsheet was prepared using a template from previous cruises.

The sampling method column was added and filled with USW.

The columns in the loop-data file were arranged in the order required for the 6-line header used to prepare the loop file.

Date and Time were found in the Loop file in the TSG comparison.

Positions were added based on log entries or for those done during a CTD cast taken from the CTD headers.

Next data from near-surface rosettes were obtained.

The CHE files were put through program DERIVE to obtain sigma-t. (\*.dqt)

Clip was run to choose only data between 0db and 7db. (\*.clip)

Data from those files were exported to file 2021-006-ros.csv. The Oxygen:Dissolved and Oxygen:Dissolved:SBE channel in mass units were included and Draw Temperature.

The Start Time was used to fill the DATE column and format was set to date (style 2021-05-04).

The times in the files are start times and the samples were actually taken near the end of the cast, so the End Times were calculated from the full files (\*.CLN) and exported to a spreadsheet.

Those times were entered in the spreadsheet – note that there were several records for many casts, so this required some manipulation.

A sample method column was added. ROS was entered for the method.

That data were then added to the 6-line header, sorted on event number, sampling method and pressure.

That file was saved as 2021-006-surface-6linehdr.csv.

The file break column was filled with value 1 so all data will be in a single file when converted.

CONVERT was run to produce an IOS Header file.

CLEAN was run to get start and stop times and positions and to add flag 0 to empty flag cells.

A comment file was prepared which was essentially the same as the one used in preparing CHE files but including a description of the loop system and comments on the CTD data processing.

Header Edit was used to correct channel names and formats and to add comments. The final file was renamed as 2021-006-surface.loop. The track plots look reasonable and plots of temperature and salinity versus event numbers, latitude and longitude look reasonable.

### **Particulars - Notes from Daily Science Log and Sampling Notes**

PAR off: 39, 52, 64, 77

Casts with bottle fired out of order: 3, 6, 10, 26, 32, 34, 57, 66, 67, 72, 96, 124. Cast 137 was not out of order but a few bottles were skipped.

Casts with no Niskin closed: 1, 15, 42, 70 (computer crash – bottles in file 71).

Casts with bottles closed but not sampled: 2 (all), 137 (bottles 3,4,5), 140 (bottle 3)

Wrong depth in headers: 32, 43, 46, 55, 64. (All fixed.)

Deployment schemes:

1-84 – Down to 10m, 30s wait, up to surface, 30s wait, then cast began.

89-end - No 10m dip – acquisition started at beginning of cast.

For depths deeper than, and including, 125 db, we would wait 30 seconds before closing a bottle. For depths shallower than, and including, 100 db, we would wait 60 seconds before closing a bottle.

1-15. DO and fluorescence traces full of spikes

2. Test cast all bottles closed, no sampling – not processed.

15. No bottles closed

16. Y-cable replaced for DO and Fluorometer. No more spikes

20. Stop at 400m for 15 min for grey water release.

28. Ship released grey water while rosette was at 200m on way down.

29. File name should be 30. Fixed.

42. Pumps off. Delete

43. Replacement for file 42

64. Stop at 3800db upcast to check winch noise

67. Bottle 11 integrity failed. Top end cap failed to seal. Bot 20 HPLC sampled before TOC.

70. Split cast. Seasave stopped at 1000db on way down.

71. Completion of file 70 – all bottle data in #71. Bottle file renamed as #70.

~1300, May 11 - TSG stop flow to fluorometer to clean. New file started.

73. Loop time in log obviously wrong. Assume was local time, not UTC.

89. Forgot to turn pumps on, returned to surface from 100m.

112. Bottle 2 - LARS overshot depth then went down – Let soak 1.25 min allow mixed water to settle.

124. Abort at 20m due to hydraulic leak on LARS head. – do not process – have 127 for CH19

125. Test cast near CH19 – log says NET – do not process.

126. Test cast near CH19 to flush rosette – do not process – have 127 for CH19

127. Cast to use for CH19

131. Small leak at boom.

137 – Shallower than planned, bottles 3, 4, 5 not used.

140 – bottle 3 closed too early – skipped – use bottles 4 to 10 instead.

2021-006

CTD#	Make	Model	Serial#	Used with Rosette?	CTD Calibration Sheet Completed?		
1	SEABIRD	911+	0443	Yes	Yes		
<b>Calibration Information - 0506</b>							
Sensor				Pre-Cruise		Post Cruise	
Name	S/N	Date	Location	Date	Location		
Temperature	4700	12Dec2020	Factory				
Conductivity	3531	06Jan2021	Factory				
Secondary Temp.	4888	12Dec2020	Factory				
Secondary Cond.	4513	18Dec2020	Factory				
Transmissometer	1185DR	28Apr2021	Factory				
Transmissometer	1883DG	28Apr2021	Factory				
SBE 43 DO sensor	3791	22Dec2020	Factory				
PAR sensor	70613	24Feb2021	Factory				
SeaPoint Fluor.	3950						
Pressure Sensor	0443	07Jan2021	Factory				
Altimeter	75321		Factory				

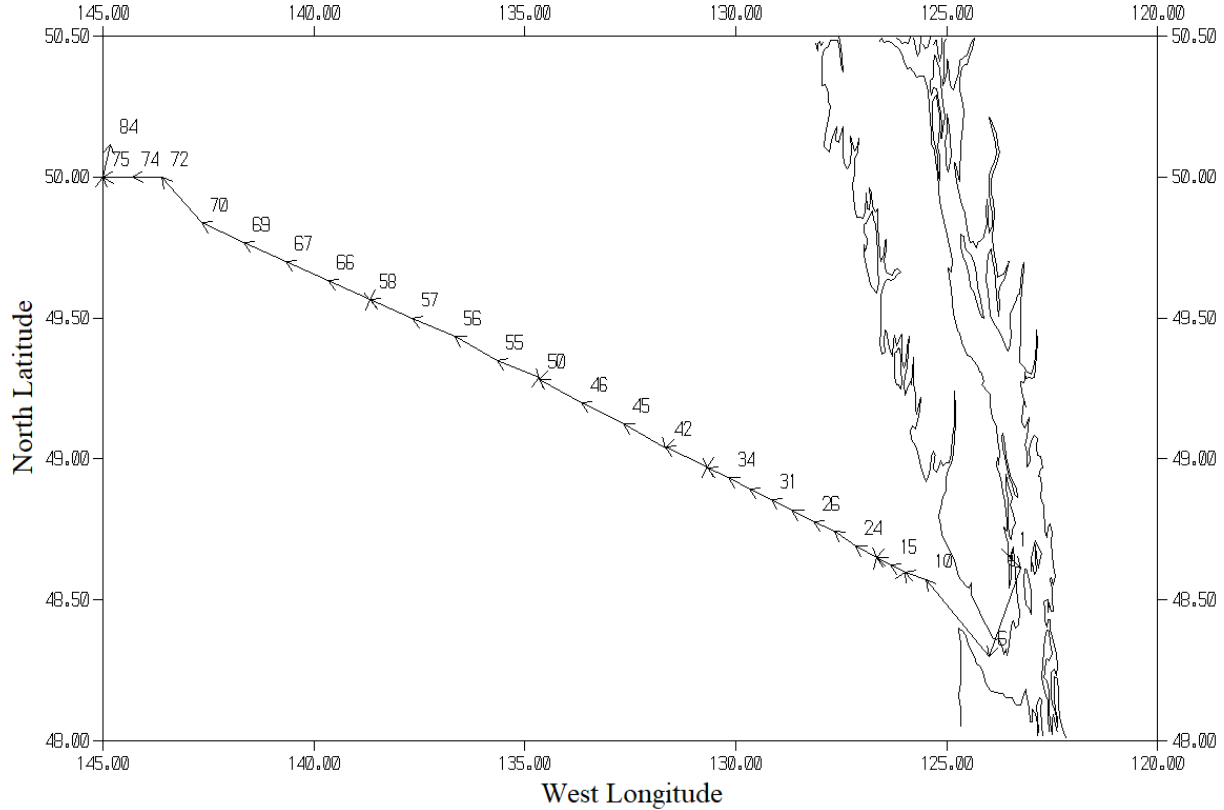
**CRUISE SUMMARY – CTD**

TSG Make/Model/Serial#: SEABIRD/45/0620

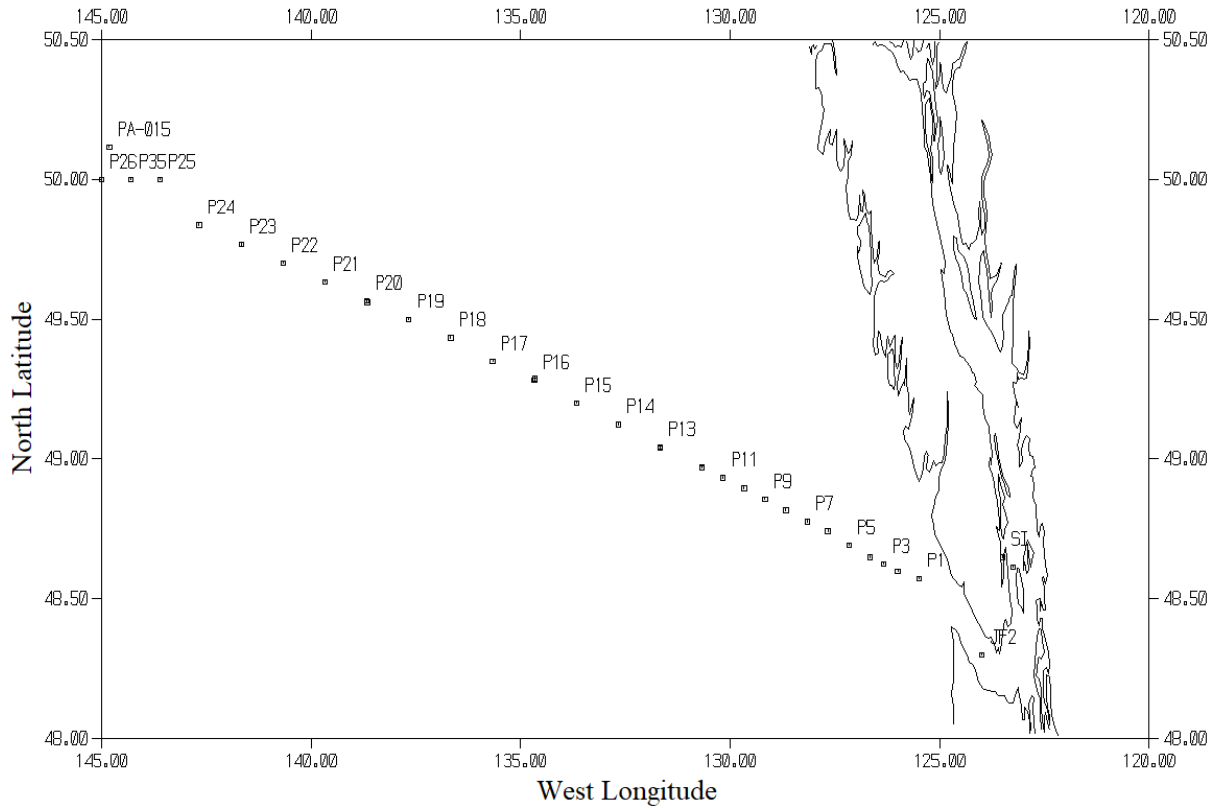
<b>Calibration Information</b>							
Sensor				Pre-Cruise		Post Cruise	
Name	S/N	Date	Location	Date	Location		
Temperature	0620	21Jan20	Factory				
Conductivity	0620	21Jan20	Factory				
Wetlabs WETStar Fluor.	1656	12Mar2021	Factory				

# LINE P SECTION

2021-006 Event #

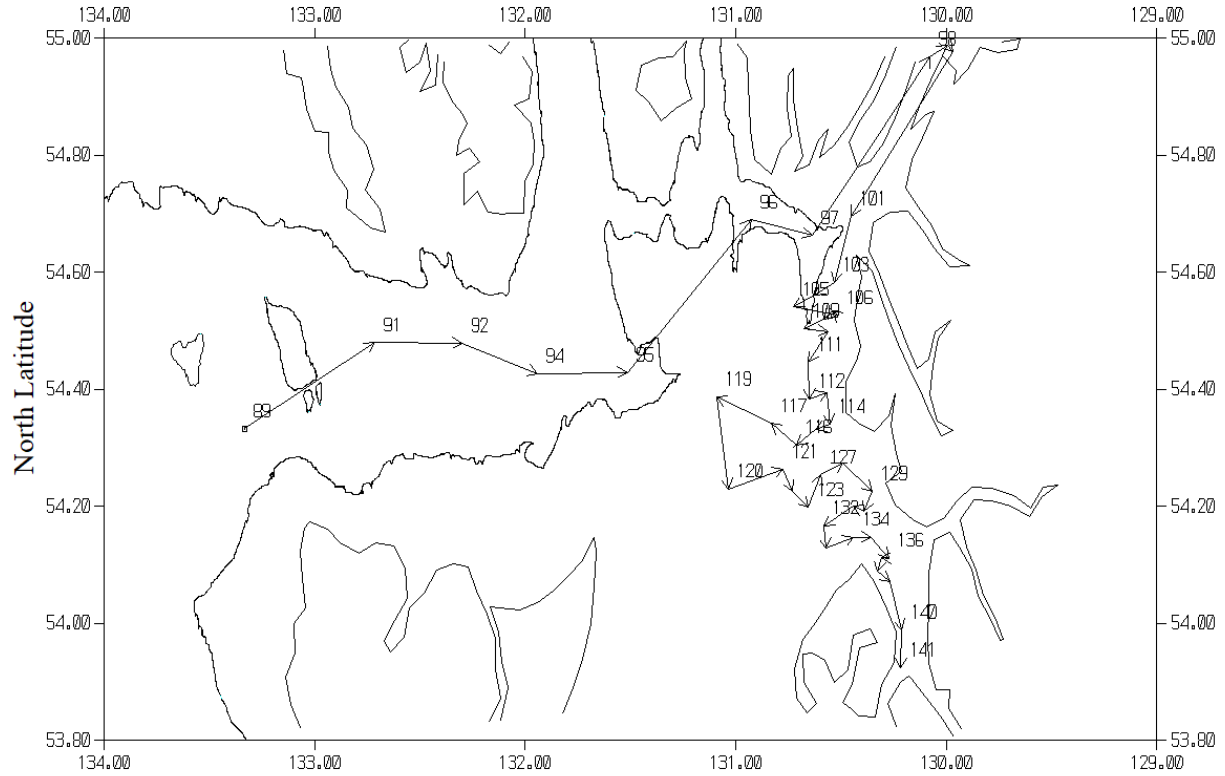


2021-006 Stn Names

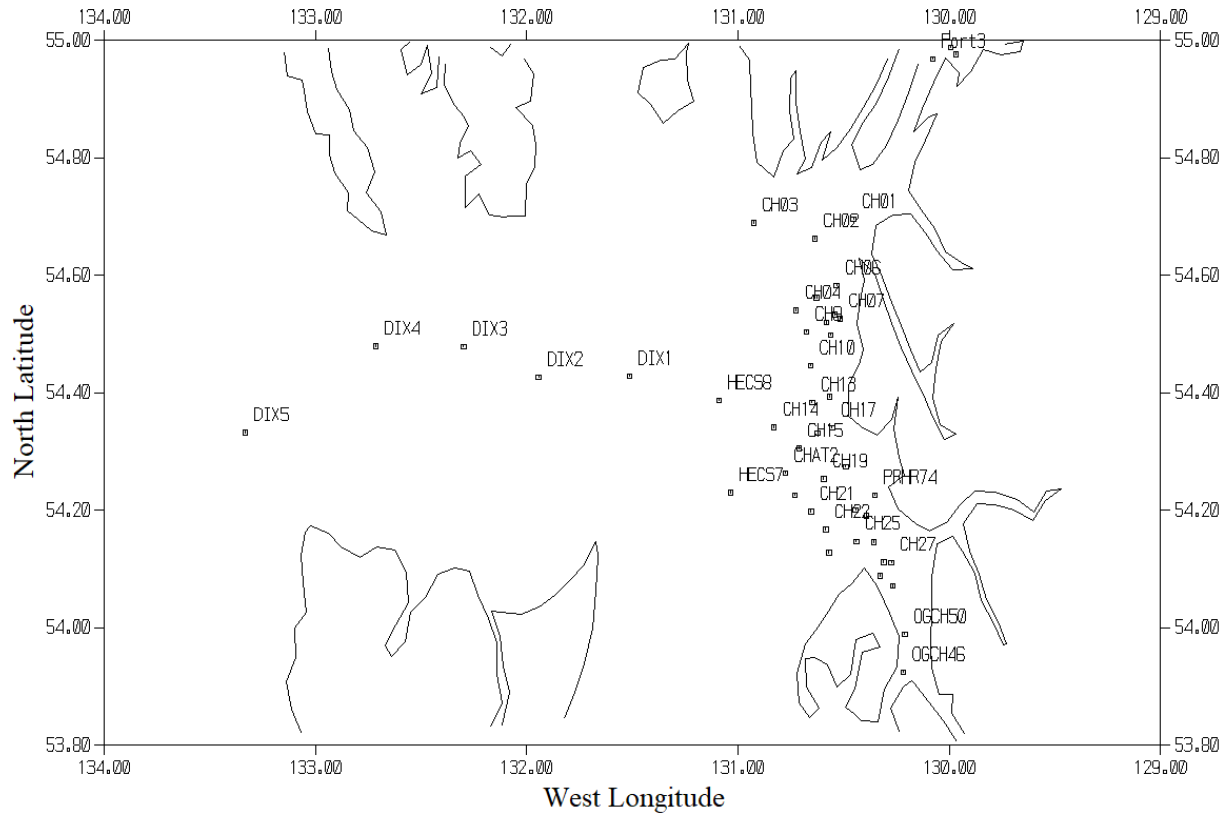


# CHATHAM SOUND SECTION

## 2021-006 Event #



## 2021-006 Stn Names





2021-006 TSG

