## REVISION NOTICE TABLE

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| DATE | DESCRIPTION OF REVISION |
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## PROCESSING NOTES

Cruise: 2023-022

Agency: IOS, Ocean Sciences Division, Sidney BC

Chief Scientist: Young K. Platform: Neocaligus

Location: Strait of Georgia Project: Strait of Georgia Plankton

Date: 30 May 2023 –4 June 2023

Processed by: Germaine Gatien

Date of Processing: 20 July 2023 – 15 September 2023

Number of original HEX files: 29 (including 3 files from Chito casts & 1 Test of new CTD)

Number of CTD files: 25 Number of BOT files: 13

##### INSTRUMENT SUMMARY

A SeaBird Model SBE-25 CTD (s/n 0456) was used with temperature sensor #6566, conductivity sensor #5046, WetLabs ECO Fluorometer #2216, dissolved oxygen sensor #3779, PAR sensor (4565) and pressure sensor # 0573. The data acquisition program was SBE SeaTerm version 1.59.

The data logging computer was an Acer WP-14.

A 2nd CTD, SeaBird Model SBE-25+ CTD (s/n 1255) was used for event #11 only for comparison purposes and the data were not intended to go to the IOS Data Archive.

# SUMMARY OF QUALITY AND CONCERNS

There was a digital log with positions and notes about sampling and a digital sampling log. Header information was entered in the raw files in a format that enabled easy conversion into IOS Header format.

As noted in the log and found in previous uses of this equipment, time was wrong in all files. This was corrected by adding 88.53 hours.

CTD casts were run at 24 sites; there were 3 sites which also had a separate CTD cast to enable Chito sampling. The Chito full casts were not prepared for the archive due to frequent stops during downcasts; there was a standard CTD cast at each of those sites.

Surface bottles were fired at 13 sites during the soak period of regular CTD casts. 3 surface samples were also taken during Chito casts but were not added to the bottle files since there was a surface sample from the associated regular CTD cast. During 2 regular CTD casts and 3 Chito CTD casts salinity and nutrient samples were taken at the bottom of the cast using a Niskin mounted ~3m above the CTD. CTD data were extracted from the Chito casts for the bottles fired at the bottom of casts. The files prepared for the archive will contain only 1 BOT file per site with the event number matching the regular CTD cast.

No data will be archived from channels Salinity:T0:C0 and Conductivity:Primary due to salinity values being much higher than bottle samples and well above the local climatology. The problem first arose during 2023-003 and was also seen during 2023-020, 2023-021 and 2023-053. During the cruise CTD salinity gradually grew a little closer to expected values but not close enough to archive. No objective method was found to correct salinity. A new problem also appeared during this cruise with random spikes and strange offset features in many of the salinity profiles.

For details, see document “Study of CTD0456.docx” and associated documents:

CTD456\_vs\_Bottles.xlsx – Comparison of CTD salinity and bottles from 4 cruises

 CTD456\_vs\_CTD1255.xlsx – Comparison of 2 CTDs from cruise 2023-022

The study also examined data from the SBE Dissolved Oxygen sensor. While there were problems seen in 2022-003, particularly at the bottom of casts and during upcasts, none were noted during 2021-020 or 2021-021. For this cruise the oxygen sensor behaved much like it did during 2022-003 with the first cast looking normal, the rest needing a higher alignment correction and later casts having very poor upcast data and suspicious downcast data.

Oxygen:Dissolved:SBE data were removed from CTD casts 32 to 48.

The waits at the surface after the 10m soak period were occasionally less than 10s; longer waits, preferably 30s, should allow near-surface waters to recover from the stirring caused by the CTD rising.

The fluorescence compared with extracted CHL in the normal way except that there were 2 CHL samples from the bottom of casts; at those levels fluorescence was about 0.65ug/L and chlorophyll near zero. Applying an offset of that size to fluorescence led to poor comparisons at the surface.

Cast #11 was run as a test of a new CTD. It was shallow and there was a full cast (#9) at the same site, so it will not be archived. A comparison was done between the 2 casts and is reported on in document CTD456\_vs\_CTD1255.xlsx. At 35m the newer CTD had a slightly higher temperature, much lower conductivity and salinity, lower fluorescence and dissolved oxygen. The lower conductivity and salinity is to be expected since both were clearly reading much too high from the older CTD. Dissolved oxygen data from the older CTD also had some problems, so that comparison is not reliable either. The minimum value from the older fluorometer seemed a little high though that is hard to judge in the Strait of Georgia. So the comparison was not as useful as hoped due to malfunction in the older system.

# PROCESSING SUMMARY

Based on results of cruise 2023-003 a study was made of all 2023 cruises that used this CTD using preliminary data. Document “Study of CTD0456.docx” compared the performance of this equipment during the following cruises which were all in the Strait of Georgia:

2023-002 – Feb

2023-003 – March

2023-020 – April

2023-021 – Early May

2023-022 - May/June

2023-053 – mid-June

##### 1. Seasave

This step was completed at sea.

##### 2. Preliminary Steps

A digital daily log was obtained as well as a sampling log.

The cruise summary sheet was completed.

Deep samples were taken during 3 CHITO casts; those casts will be used to obtain CTD data to go with the samples, but no CTD files are needed.

Surface samples were taken while the CTD was soaking. There were also surface samples during Chito casts but those will be included in the BOT files.

##### 3. Conversion of Raw Data

The configuration file used at sea was correct, but during the previous use of this equipment a pressure offset of 0.7db was found more appropriate. A test conversion was done using a 0.7db offset and starting and ending pressures were very close to 0.

The file used at sea, with the adjusted pressure offset, was saved as 2023-022-ctd.xmlcon and used to convert all HEX files.

Plots were made of a few casts and all expected variables were present.

Fluorescence dark value at depth is ~0.6ug/L with no values <0; while rather high, values do not usually get close to 0 in the Strait of Georgia; this will be studied further when chlorophyll samples are available.

The pressure has steps but no reversals were noted.

The dissolved oxygen profiles look odd, more like 2023-003 than those seen during 2023-020 and 2023-021. The first cast looks normal but after that it appears that alignment is different. For casts #3-#24 downcast and upcast profiles are similar, but further apart vertically. After cast #24 the correspondence is poor, with some odd low values at the bottom of casts and more small-scale variability than normally seen. Downcasts may be ok but upcasts are definitely not.

Waits at the surface were sometimes shorter than 10s. A 30s wait at the top is recommended to allow surface waters to settle from the mixing caused in raising the CTD.

##### 4. WILDEDIT

The only spikes noted in the data occurred at the beginning or end of the casts or included many points, and will be removed in the normal course of editing. So WILDEDIT was not run.

##### 5. FILTER

Program FILTER was used to apply a low-pass filter with a time constant of 0.5s to pressure and depth. The results were excellent with pressure steps disappearing.

Next the temperature and conductivity were examined and the usual approach of applying a cosine filter, size 8, in routine WFILTER did a good job of removing small reversals.

In the past running WFILTER without the previous pressure filter did not produce as good results.

##### 6. ALIGNCTD

Generally, a setting of +2.5s is found suitable for this equipment, so ALIGNCTD was run with that setting on all casts, Plots were examined after this step and the results look good for only the first cast. This differs from the 2023-020 and 2023-021 cruises when +2.5s looked good throughout, but it is similar to 2023-003 when the same sensor was used and most casts required a much higher setting, +6s. When that setting was tried for these data the results were much better. However, spikes begin to appear after event 15, and from cast #32 to the end there is more small-scale noise, unusual shifts and spikes than normally seen in SBE oxygen data. It looks like casts #1 to #31 are probably good enough to archive but not #32-48. Further tests will be done later.

ALIGNCTD was run with a setting of +2.5s for cast #1 and #11 (new CTD) and +6s for casts #2 to #48.

##### 7. CELLTM

CELLTM was run on all casts using the SeaBird recommended parameters, (α, 1/β) = (0.04, 8).

##### 8. DERIVE

Program DERIVE was run to calculate salinity and dissolved oxygen concentration (tau correction included). Plots were examined and confirmed that steps 5, 6 and 7 had improved the data.

Test cast #11 (new CTD) was shallow so it is hard to judge dissolved oxygen alignment, but it looked reasonably good when a +2.5s setting was used.

##### 9. Conversion to IOS Headers

The IOSSHELL routine was used to convert the CNV files to IOS Headers.

CLEAN was run to add event numbers and replace pad values in the pressure channel with interpolated values.

##### 10. Checking Headers

Track plots looked ok and were added to the end of this report.

All start times for CTD #0456 are off by about 88.53 hours as was the case for the past 2 cruises that used this CTD. Cast #11 from CTD #1255 was 9 hours behind.

ADD TIME CHANNEL was used to advance the time channel by 88.53 hours except for cast #11 that was advanced by 9 hours.

The IOS files for events 3 and 14 had their file names changed at this point by adding a leading 9 to the event numbers; these are the CHITO casts which are not intended to be archived but will be processed.

A cross-reference list after this step showed good results with times close to the log entries.

Surface Check was run on the CLN files and the average was +0.1db, so using 0.7db as pressure offset in conversion was appropriate.

##### 11. CLIP

The next step is to remove the data collected during soaks at 10m. Plots were examined to see how many records should be removed from each cast. File clip.csv was prepared with 2 columns containing event # and # of records to removed. CLIP was run and output plots examined until all looked appropriate.

The surface check was then run on CLIP files and the average was 1.1db.

##### 12. SHIFT

Conductivity

This step was skipped since the conductivity data are not to be archived..

Fluorescence

The fluorometer was not pumped, so a shift in alignment is expected to be small or unnecessary. Profile plots of temperature and fluorescence were examined and no significant mis-alignment was noted. Shift was not run on fluorescence.

Dissolved Oxygen

This channel was aligned earlier, but checks were made by examining plots of temperature and dissolved oxygen. No further adjustment was made.

##### 13. DELETE

DELETE was run on all casts using the following parameters:

Surface Record Removal: Last Press Min. Surface Swell Pressure Tolerance: 1.0

Swells deleted. Warning message if pressure difference of 2.00

Drop rates < 0.3m/s (calculated over 5 points) was deleted from 10db to 10db above the maximum pressure.

COMMENTS ON WARNINGS: There were no warnings

##### 14. DETAILED EDITING

All DEL files were copied to \*.EDT so there will be a complete set of files even if some need no editing.

CTDEDIT was used to remove some data corrupted by shed wakes near the bottom of 18 casts.

Notes of editing details were made in the headers.

##### 15. Initial Bottle Data Steps

There was no rosette available for this cruise. There were surface bottles fired at 13 sites, not including surface samples from Chito casts which will not be included in BOT files. At 5 sites there was also a Niskin mounted 3m above the CTD to collect near-bottom samples. This included 3 deep samples from Chito casts which will be added to BOT files.

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 2023-022-bot-hdr.txt which will be updated as needed during processing.

File 2023-022-bottles\_plus\_CTD\_6linehdr. csv was created. A 6-line header was included and analysis data from the QF worksheets were added Space was included for the addition of CTD data.

CTD data were bin-averaged in 0.5m bins. Data were then extracted from the shallowest data available below 0.5db and the sampling level for the 5 casts with deep bottles.

Workbook 2023-022-Bottle-comparison.xlsx was prepared to do a comparison of CTD and bottle data for salinity and fluorescence.

##### 16. Compare

Salinity Comparison

There were 10 bottle samples, 5 from the surface and 5 near the bottom.

CTD Salinity is higher than bottles by an average of 0.76psu using all points of comparison, but note the higher standard deviation near the surface.

|  |
| --- |
| CTD Salinity - Bottle Salinity |
|  |  | Median | Std Dev |
| All samples | 0.76 | 0.59 |
| Surface samples | 0.74 | 0.84 |
| Deep samples | 0.78 | 0.07 |

As noted during the previous 3 cruises using this equipment, the CTD salinity is reading too high, but the difference from bottle samples is smaller than during the previous cruises.

See file 2023-022-CTD-bottle-comparison.xlsx for more detail on this cruise.

A study of how CTD salinity varied through a series of cruises in 2023 using CTD #0456 showed that it continued to be much higher than bottle samples, but that the differences gradually decreased with time until the mid-June cruise when conductivity, salinity and dissolved oxygen data were full of spikes. The CTD was sent for service after that cruise.

The CTD salinity is clearly bad; no method was found to enable recalibration. Conductivity and salinity channels will be removed from files to be placed in the OSD Data Archive.

For more information see 2023-022\_CTD\_Bottle\_comparisons.xlsx and CTD456\_vs\_Bottles.xlsx.

Fluorescence

There were 14 CHL samples but 2 deep ones are not shown in the Bottle\_Summary. Surface samples from 3 Chito casts were not included since the fluorescence data are very noisy, there was no soak period and surface data are available for the 3 sites from other casts. Two samples were deep which is unusual but it was interesting to see how fluorescence compared to CHL in deep water.

The two deep bottles had values 0.01 and 0.06ug/L while the fluorescence values were 0.64 and 0.65ug/L. This could be due to an offset in fluorescence or due to the nature of fluorometers. When those 2 samples were left out of the fit of fluorescence versus extracted CHL that it made little difference to the fits:

CTD FL = 0.548 \* CHL + 0.730 (without deep samples)

CTD FL = 0.576 \* CHL + 0.675 (with deep samples)

When no offset was applied, and deep samples excluded, the fit of CTD Fluorescence/CHL versus CHL looks typical of this type of fluorometer. We expect the ratio to be >1 for CHL<1 with the ratio then dropping until it is about 0.5 for high CHL.

When all fluorescence values had 0.6 subtracted, the fit does not look like those normally seen by a number of different fluorometers. Tests of different offsets suggest 0.3ug/L might be reasonable, but there are too few samples and the range is fairly small, so this is very weak evidence and does not justify applying any offset.

The CTD fluorescence data comes from about 1m, slightly lower in the water column than the chlorophyll samples, so some difference is expected and it could have either sign depending on where the maximum CHL is.

To get a better picture, the data from 20223-00, 2023-020, 2023-021 and 2023-023 were combined. The usual pattern of FL/CHL being high for low CHL is seen and FL being ~30% to 40% of CHL for CHL>1.5ug/L. This is a very rough comparison given variable near-surface CHL gradients and few data. The 2023-022 data do not show up as outliers.

See 2023-022-CTD-bottle-comparison.xlsx for more detail.

##### 17. Other calibration checks

Sensor History –

* 2023-002: The sensors were all used during 2023-002 and data looked good. Pressure was found to be low by 0.7db. Salinity data were in reasonable agreement with the few bottles collected and all salinity profiles fell within local climatology. Some temperature profiles were occasionally outside the climatology but the variations looked real and certainly did not look like evidence of calibration drift. There was no dissolved oxygen sampling but profiles looked reasonable..
* 2023-003: Pressure was converted with 0.7db offset and looked accurate. Conductivity data were bad, producing salinity higher than bottles by as much as 4psu and well above climatology maxima. There was no dissolved oxygen sampling. Temperatures were mostly within the climatology except for some low temperatures in deep water in south-central Strait of Georgia.
* 2023-020: Pressure was converted with 0.7db offset and looked accurate. Conductivity data were bad, producing salinity higher than bottles by 3.7psu early in the cruise and gradually dropping to 1.3psu at the end.; all were well above climatology maxima. There was no dissolved oxygen sampling, but profiles looked good. Temperatures were mostly within the climatology except for some low temperatures in deep water in south-central Strait of Georgia.
* 2023-021: Pressure was converted with 0.7db offset and looked accurate. Conductivity data were bad, producing salinity higher than bottles by an average of 1.3psu when one outlier was excluded; all salinity were well above climatology maxima. There was no dissolved oxygen sampling, but profiles looked good. Temperatures were mostly within the climatology except for some low temperatures below 250db.

Historic Ranges – Most salinity data were above the historic ranges except for a few near-surface values where the ranges were very wide and the casts in Baynes Sound and Cowichan Bay. Starting at cast #19 spikes and odd offset features begin to appear randomly. Temperatures were within the climatology except for some slightly low values at mid-depths to the north and some low values below about 200db at station 42. In previous cruises there were low temperatures in deep water that moved from south to central parts of the Strait over time. These features do not suggest calibration drift as they are not systematic and this is a region of high variability.

Post-cruise calibrations – None were available.

##### 18 CALIBRATE

Pressure looks good.

Salinity cannot be corrected and will not be archived.

There was no dissolved oxygen calibration sampling during this cruise or any other cruise since the sensor was last calibrated.

Dissolved oxygen was derived in mass units. For cruises 2023-003, -020 and -021 that channel was not included in the files to be archived due to very large errors in salinity. But for this cruise the salinity error is smaller, and the effect on the conversion to mass units is only weakly dependent on salinity, so the mass units will be archived for casts #1 to #31. See section 22 for error analysis.

Surface saturation of dissolved oxygen was derived for casts #1-31 and ranged from 110-135%. All those casts were from the central and northern part of the cruise. From the bottle files similar results were found in the north but lower ones to the south. Values tend to vary widely in this area, so the only conclusion is that dissolved oxygen values are reasonable, with no obviously unbelievable values.

The results look close to those observed in July 2021 in this region including higher values to the north and a low value near the Gulf Islands. This suggests that downcast DO is reasonable at the surface for all casts, but towards the end of the cruise the profiles look bad through most of the casts.

No recalibration will be applied to CTD cast files.

##### 19. Fluorescence Filter

The fluorescence data did not require filtering.

**20. Bin Average, Remove, Derive DO in mass units, Reorder**

The files were bin averaged using 1db bins.

Reorder was run to get the 2 DO channels together.

REMOVE was run to remove Scan\_Number, Conductivity, Salinity:T0:C0, Oxygen:Voltage, Descent Rate and Flag channels. Oxygen:Dissolved:SBE data were removed from CTD casts 32 to 48.

##### 21. HEADER EDIT and final checks of CTD files.

Header Edit was used to fix headers, fix formats and to add comments about processing.

A cross-reference listing was produced.

A header check and standards check were run on the CTD files and no errors were found.

The sensor history was updated.

Plots of CTD casts were examined and no problems were found.

##### 2. Final BOT file preparation

For 3 sites, there were 2 CTD casts, a regular cast and a CHITO cast. The CHITO casts have no 10m soak and multiple stops during both the downcast and the upcasts, so no CTD file was prepared for those.

A single bottle file will also be produced for each site with a CHITO cast, with event # matching the regular casts.

There were surface bottles fired when the regular cast began. During the CHITO cast bottles were fired at the surface and at the bottom of the cast. The only sampling in the surface bottles from the CHITO casts was extracted chlorophyll. Those data will not be included in the bottle files since the CTD data collected at that time is not of good quality with pumps not yet on and fluorescence not yet equilibrated, and we have chlorophyll data from the surface of the regular casts. The salinity samples from the bottom of the CHITO cast are useful as there was a sufficient wait before firing and CTD data look ok, so those will be included in the BOT files.

Workbook 2023-022-bottles\_plus\_CTD\_6linehdr. csv was adjusted to change the event # of the CHITO bottom bottle records to match that of the regular cast.

Although CTD salinity will be removed later, it is needed in order to derive dissolved oxygen in mass units and to correct channel Silicate where salinity is <25psu. So the values in the spreadsheet were adjusted by subtracting 0.75psu based on the comparison with bottles; the errors in the corrections are not expected to be large.

That file was converted to IOS Header files for each cast.

The time and date are present as channels as these cannot be converted directly into header entries.

CLEAN was run to add START and END time to the headers. The END TIME is identical so the START time so it will be removed later. CLEAN was also used to enter 0 flags where the flag channels are empty.

Change Units was run to get the dissolved oxygen data in mass units. (Output \*.UNT)

DERIVED Quantities was run to derive dissolved oxygen saturation. The saturation near the surface varied from ~80% to 130%, with values all >115% in the central and northern Strait of Georgia. The lowest value was at station 56 and highest at station 9. The temperature values are not from the same depth and the salinity is an estimate, so this is a rough estimate. It only demonstrates that oxygen values are not extremely out of line, as values often vary widely in the Strait of Georgia. The saturation channel will not be archived.

CALIBRATE was run on all \*.unt files using file 2023-022-sil.ccf and selecting CTD salinity values which were earlier reduced by 0.75psu based on the comparison with bottles.

A test was run on one cast with CTD salinity 21.7754psu and bottle salinity 21.7396psu.

* When silicate was originally 24.22, the corrected value was 23.48 using the CTD salinity and 23.47 using the bottle salinity. So errors in the estimated CTD salinity of ~0.036psu led to an error in silicate of 0.01 umol/L or 0.04%.
* For dissolved oxygen a comparison was made between calculating mass units using corrected or uncorrected Salinity:T0:C0 and no difference was found. Even a test using a very large difference in CTD salinity produced only a small effect on DO in mass units.

So for both silicate correction and DO derivation in mass units, using a rough estimate of salinity produces good results. Dissolved oxygen is weakly dependent on salinity.

REORDER was run to get the 2 DO channels together.

REMOVE was run to remove Date, Time, Salinity:T0:C0 and Conductivity channels.

Header Edit was run to add comments and to remove END TIME (same as START TIME) and TIME ZERO.

The final files have extensions BOT.

The standards check was run and no errors were found.

A cross-reference list and header check were run on the BOT files and no errors were found.

A track plot looked fine.

Plots were made of all BOT casts. With just 1 or 2 levels these were not very useful.

Finally, all data from BOT files were extracted to a spreadsheet and compared to the original spreadsheet; no problems were found.

PARTICULARS – Notes from log

Surface bottle snapped during CTD soak.

Shallow bottles from Chito casts NOT included in BOT files.

Deep bottles from Chito casts included with standard cast at same station; Chito event / Standard event: 3/1, 16/15, 36/34.

Deep bottles from standard casts #20 and #26.

For deep samples bottle mounted 3m above CTD.

1. Longer soak which winch counter batteries changed.

3. Chito cast. Sample #2 deep bottle used for BOT file for event #1

11. Test of new CTD – compare with event #9. Not for archival.

16. Chito cast – Sample #14 deep bottle used for BOT file for event #15

36. Chito cast – Sample #27 deep bottle used for BOT file for event #34

**CRUISE SUMMARY**

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| --- |
| Cruise ID#: 2023-022 |
| Dates: Start: 30 May 2023 End: 4 June 2023 |
| Location: Strait of Georgia Plankton |
| Chief Scientist: Young K. |
| **CTD#** | **Make** | **Model** | **Serial#** | **Used with Rosette?** | **CTD Calibration Sheet Competed?** |
| 1 | SEABIRD | 25 | 456 | No | Yes |
| 2 | SEABRID | 25+ | 1255 | No | Yes |

**CTD CALIBRATION INFORMATION**

**Make/Model/Serial#: SEABIRD/SBE25/0456 Cruise ID#: 2022-003**

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| **Calibration Information** |
| **Sensor** | **Pre-Cruise** | **Post Cruise** |
| **Name** | **S/N** | **Date** | **Location** | **Date** | **Location** |
| **Temperature** | **6566** | **30Mar2021** | **Factory** |  |  |
| **Conductivity** | **5046** | **30Mar2021** | **Factory** |  |  |
| **ECO Fluorometer** | **2216** | **8Mar2017** | **Factory** |  |  |
| **SBE43 Oxygen** | **3779** | **15Oct2021** | **Factory** |  |  |
| **QSP BiosphericalPAR** | **4565** | **24Feb2021** | **Factory** |  |  |
| **Pressure****D:\Te****lewo****rk\2022-0** **28\Process****ing\ios\** | **573** | **4Feb****2022** | **Factory** |  |  |

**Make/Model/Serial#: SEABIRD/SBE25/1255 Cruise ID#: 2022-022**

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| **Calibration Information** |
| **Sensor** | **Pre-Cruise** | **Post Cruise** |
| **Name** | **S/N** | **Date** | **Location** | **Date** | **Location** |
| **Temperature** | **6448** | **4Feb2023** | **Factory** |  |  |
| **Conductivity** | **6147** | **18Jan2023** | **Factory** |  |  |
| **ECO Fluorometer** | **8046** | **21Apr2023** | **Factory** |  |  |
| **SBE43 Oxygen** | **4378** | **28Mar2023** | **Factory** |  |  |
| **QSP BiosphericalPAR** | **2274** | **25Jan2023** | **Factory** |  |  |
| **Pressure****D:\Te****lewo****rk\2022-0** **28\Process****ing\ios\** | **1255** | **13Feb2023****2022** | **Factory** |  |  |



