CTD Calibration Report
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Cruise summary

Ship: USCGC *Healy*
Project Name: HLY2401
Dates: 1 July – 1 August, 2024
Ports: Dutch Harbor, AK – Kugluktuk, NWT

Data files included as part of this distribution

HLY2401_CTD_Calibration_Report.pdf
This document in pdf format

HLY2401_*.cdn and .cup (downcast and upcast SBE .cnv format)***
1 dB pressure-averaged downcast and upcast file per station following SeaBird Electronics' standard cnv format (human readable ASCII file) for translated CTD data. Files contain primary and secondary sensor, temperature, salinity, oxygen, pressure, fluorescence, beam transmission, and altimeter data. CTD sensor data have been scaled with pre-cruise calibrations from the sensor manufacturer. Primary and secondary temperatures, conductivities, and derived salinities have been spike-edited.

CTD configuration

General

156 casts were performed using a SeaBird 911plus CTD and deck unit configured to measure pressure, temperature, conductivity, oxygen, beam transmission, and fluorescence. Data from the CTD were acquired at 24 Hz. The CTD data were acquired by an SBE Model 11 plus V2 CTD Deck Unit providing demodulated data to a personal computer running SEASAVE (SeaBird). Bottom approach was controlled by real time altimeter data and ship provided ocean depth information. For each cast, water samples were collected at up to 24 discrete intervals and analyzed for salinity. A rosette frame holding 24 10 L Niskin bottles was used for collecting water samples.

CTD calibrations

Calibrations for CTD sensors were performed by the manufacturer before the cruise. A listing of sensors and calibration dates are presented in the following table. The configuration report file for the SBE 911plus containing sensor calibration coefficients can be found in appendix A.

CTD sensor calibration dates

Sensor Name	Serial Num	Cal Date
Temperature	1367	21-Feb-24
Conductivity	1029	15-Mar-24
Pressure, Digiquartz with TC	0777	20-Mar-24
Temperature, 2	2945	24-Feb-24
Conductivity, 2	2568	15-Mar-24
Oxygen, SBE 43	0458	29-Mar-24
Fluorometer, WET Labs ECO-AFL/FL	FLRTD-074	20-Dec-23
Transmissometer, WET Labs C-Star	CST-1032DR	09-Apr-24
Altimeter	65378	17-May-18
Fluorometer, WET Labs ECO CDOM	FLCDRTD	23 April 2024

SeaBird processing

As per manufacturer recommendations, CTD data were processed using SeaBird data processing software (ver. 7.22.0). The raw CTD data were converted from HEX to ASCII, lag corrected, edited for large spikes, smoothed according to sensor, and pressure averaged into 1 dB bins for final data quality control and analysis. Given that HLY2401 took place in a region with strong vertical gradients in both temperature and salinity, special care was taken to choose the best values for the ALIGNCTD module so as to minimize unphysical spikes in derived salinity values. In addition, special care was taken to cut out data prior to and during the surface soak in the DATCNV module. This together with LOOPEDIT ensures that only data from the CTD once equilibrated to the ocean temperature and salinity was included in the final pressure binned data. The following table summarizes the processing routines used together with SeaBird-recommended parameters for the sensor configuration used. Additional information regarding SeaBird processing can be found in the lengthy header of each .cdn downcast file.

SeaBird processing routines

SeaBird Module	Description (SeaBird, Version 7.22.0)
DATCNV	Convert the raw data to pressure, temperature, conductivity, and dissolved oxygen
BOTTLESUM	Writes out a summary of the bottle data to a file with a .btl extension
ALIGNCTD	Delaying conductivity by 0.05 seconds relative to pressure minimized salinity spikes through sharp gradients. Advancing oxygen by 8 seconds.
WILDEDIT	Checks for and marks 'wild' data points: first pass 2.0 standard deviations; second pass 20 standard deviations
CELLTM	Conductivity cell thermal mass correction alpha = 0.03 and 1/beta = 7.0
FILTER	Low pass filter pressure and depth with a time constant of 0.15 seconds to increase pressure resolution for LOOPEDIT
LOOPEDIT	Mark scans where the CTD is moving less than the minimum velocity (0.1 m/s) or traveling backwards due to ship roll
DERIVE	Compute salinity and oxygen using corrected parameters
BINAVG	Average data into the 1 dbar pressure bins
SPLIT	Split .cnv file into upcast and downcast files

CTD performance

General events and notes:

Stations 1 – 156

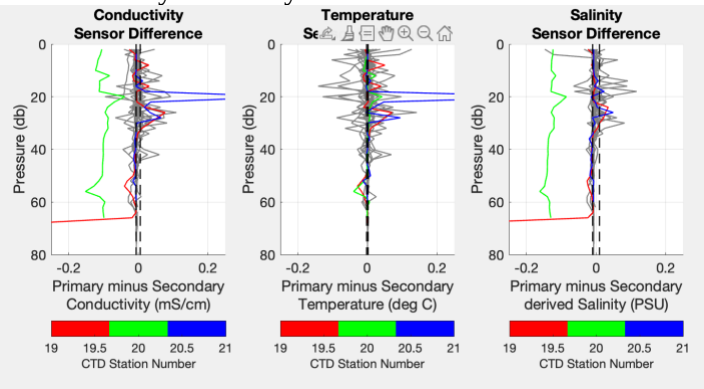
All CTD casts for HLY2401 had the SBE43 oxygen sensor s/n 0458 plumbed into the secondary ducting (where the secondary temperature and conductivity were plumbed) instead of the primary path. When calculating dissolved oxygen, the SeaBird Software automatically uses primary values for oxygen, temperature, and conductivity. The resulting error is likely small given the objectives for the cruise.

Stations 14 – 156

UVP was installed between stations 13 and 14.

Station 19, 20, 21

Biofouling in the primary temperature and conductivity ducting. Primary data overwritten by secondary.

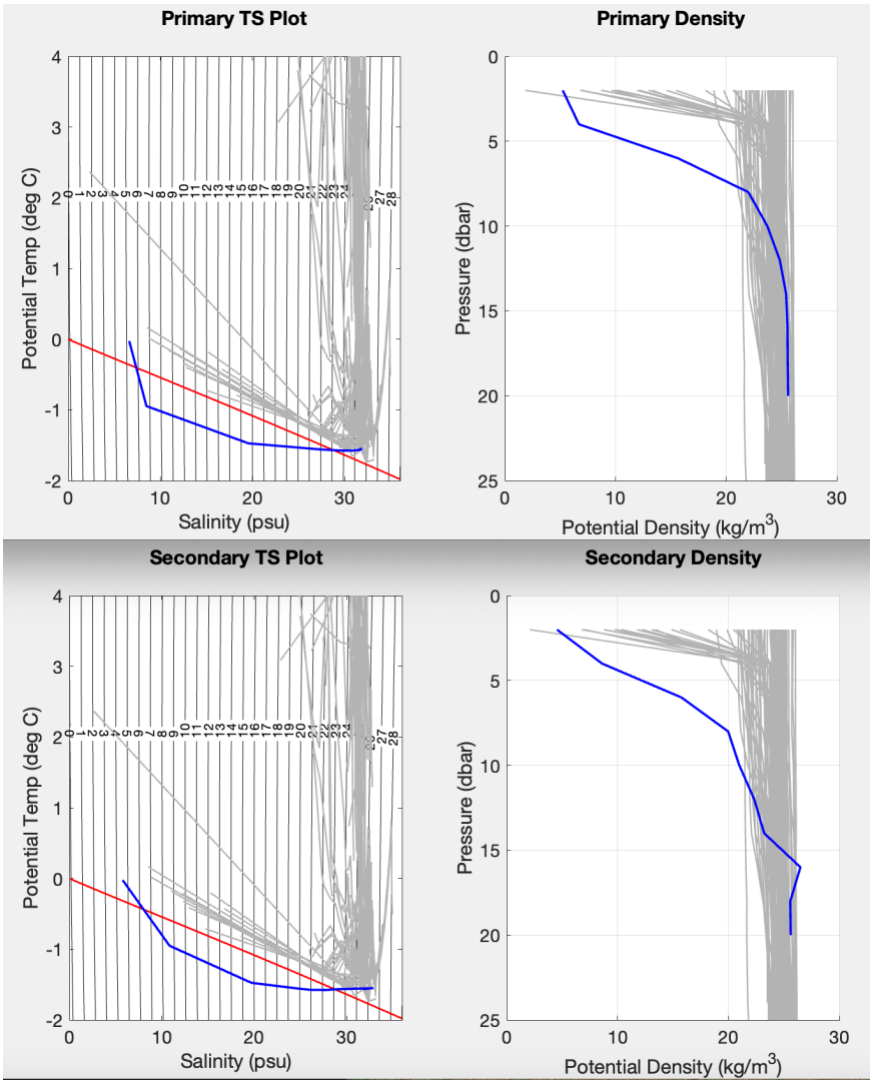


Station 81

At the bottom of station 81 communications were lost with the CTD. The unit was restarted, and a new cast was started to record data during the upcast. The resulting downcast and upcast files from this were merged and renamed to ‘HLY2401_081’.

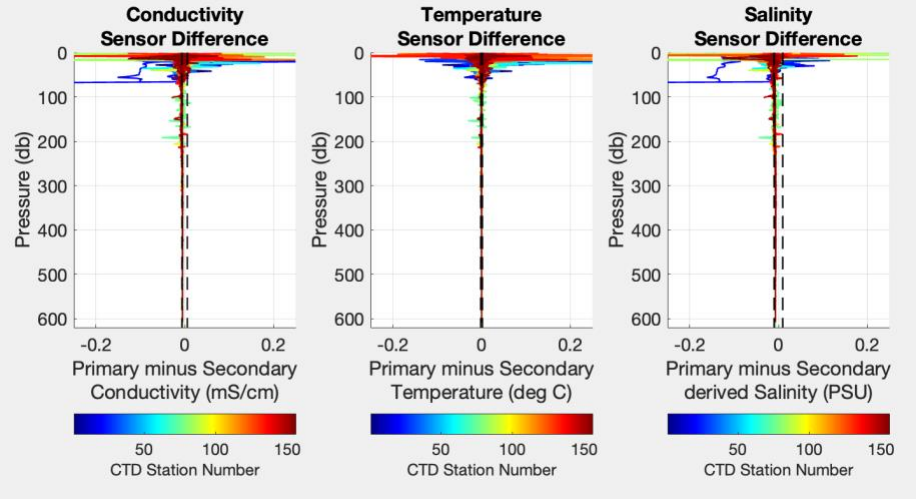
Station 84

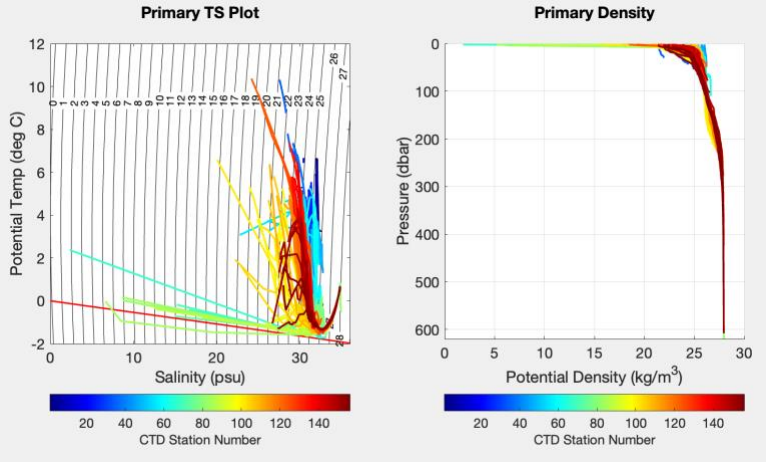
Unphysical t-s properties observed in the upper 5 bins of data in both primary and secondary sensors. Ice was likely caught in the ducting and melted/flushed after the cast began. Data from cast were manually edited, but caution should be used when working with data from the station.



Temperature and conductivity notes:

CTD performance was generally good. Sensor QC plots blow indicate no major calibration drifts throughout the cruise. Below are summary figures comparing primary and secondary sensors together with the resulting impact on derived salinity. Each panel includes vertical dashed lines indicating expected manufacturer agreement ranges. The values shown are, ±(2 x 0.001 ºC) and ±(2 x 0.003 uS/cm) for temperature and conductivity sensors respectively (note that 0.003 uS/cm is close to 0.003 psu for reasonable temperature ranges). In general, sensor differences should fall within, or very close to, this range when calibrated by the manufacturer within the past year (the rule can be relaxed in the upper water column).





Manual data edits:

Upon completion of Seabird processing, each CTD profile was assessed for quality of data. Using primary and secondary temperature and conductivity data, density was calculated and inspected for spikes and inversions with respect to pressure. Temperature and conductivity data that resulted in density inversions of magnitude larger than 0.02 kg/m^3 were interpolated as a function of pressure.

Conductivity sensor performance:

HLY2401 took place in a region with very shallow bottom depths, strong vertical gradients in both temperature and salinity, and large spatial variability in both temperature and salinity. During the cruise salinity bottles were collected during the deepest station on the cruise, station 80. The salinity samples were then analyzed by an ODF tech during the following cruise. About half of the samples were either incorrectly drawn or properly prepared for preservation prior to running. However, physically consistent bottle samples show an offset of salinity less than 0.01 psu for both primary and secondary sensors in water deeper than 400 db. Summary figures can be found in Appendix C.

In order to quantify CTD conductivity performance for the HLY2401 cruise, the primary and secondary conductivity sensors have been regressed against one another. Figures 1-2 in Appendix B. summarize the regression and general performance of sensors. The final slope, bias, standard deviations, and percent error are reported in the table below. The standard deviations reported are defined by the scatter about the line of best fit and are meant to be an estimate of relative sensor precision. In addition, a calculation of percent error, defined as [(fit – CTD values)/fit] * 100, is given as a relative estimate of sensor accuracy. Overall, a slope of 0.9988 and bias of 0.03947 relate the two conductivity sensors. The standard deviation about this fit is 0.0126 with an average absolute value in percent error of 0.0129%.

Conductivity 2 vs. Conductivity 1 Regression

Slope	Bias	Standard deviation about fit	Standard deviation when pressure < 400 dB	Standard deviation when pressure > 400 dB
0.9988	0.03947	0.0126 (using 12785 data points)	0.01424 (using 9958 data points)	0.00028 (using 2827 data points)

Conductivity 2 vs. Conductivity 1 Percent Error

Average absolute value of percent error	Average absolute value of percent error when pressure < 400 dB	Average absolute value of percent error when pressure > 400 dB
0.0129% (using 12785 data points)	0.0153% (using 9958 data points)	0.00437% (using 2827 data points)

References

Millard, R.C. and K. Yang. 1993. CTD Calibration and Processing Methods used at Woods Hole Oceanographic Institute. WHOI Technical Report, WHOI-93-44, 96 pp. OCE-91-14465.

McTaggart K.E., G.C. Johnson, M.C. Johnson, F.M. Delahoyde, and J.H. Swift. 2010. The GO-SHIP Repeat Hydrography Manual: A collection of Expert Reports and Guidelines, Notes on CTD/O2 data acquisition and processing using Sea-Bird hardware and software. IOCCP Report No. 14, ICPO Publication Series No. 134, Version 1, 2010.

Knapp, G.P., M. Stalcup, and R.J. Stanley. 1990. Automated Oxygen Titration and Salinity Determination. WHOI Technical Report, WHOI-90-35, 25 pp.

Appendix A.

Date: 01/06/2025

Instrument configuration file:
Z:\Documents\Work\Data\ctd\HLY2401\raw\HLY2401_001.XMLCON

Configuration report for SBE 911plus/917plus CTD

Frequency channels suppressed : 0
Voltage words suppressed : 0
Computer interface : RS-232C
Deck unit : SBE11plus Firmware Version >= 5.0
Scans to average : 1
NMEA position data added : Yes
NMEA depth data added : No
NMEA time added : No
NMEA device connected to : PC
Surface PAR voltage added : No
Scan time added : No

1) Frequency 0, Temperature

Serial number : 1367
Calibrated on : 21-Feb-24
G : 4.39240639e-003
H : 6.42474254e-004
I : 2.26762485e-005
J : 2.03659927e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

2) Frequency 1, Conductivity

Serial number : 1029
Calibrated on : 15-Mar-24
G : -3.98768892e+000
H : 5.40719485e-001
I : -1.65355744e-004
J : 3.84304410e-005
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

3) Frequency 2, Pressure, Digiquartz with TC

Serial number : 0777
Calibrated on : 20-Mar-24

C1 : -4.516594e+004
C2 : -7.999805e-001
C3 : 1.213820e-002
D1 : 3.780300e-002
D2 : 0.000000e+000
T1 : 3.041153e+001
T2 : -4.897913e-004
T3 : 3.959850e-006
T4 : 1.708160e-009
T5 : 0.000000e+000
Slope : 0.99996316
Offset : 1.90832
AD590M : 1.280490e-002
AD590B : -9.096340e+000

4) Frequency 3, Temperature, 2

Serial number : 2945
Calibrated on : 24-Feb-24
G : 4.32066052e-003
H : 6.32297269e-004
I : 2.18600140e-005
J : 2.15236899e-006
F0 : 1000.000
Slope : 1.00000000
Offset : 0.0000

5) Frequency 4, Conductivity, 2

Serial number : 2568
Calibrated on : 15-Mar-24
G : -9.83407685e+000
H : 1.50872509e+000
I : -2.67481047e-003
J : 2.98614934e-004
CTcor : 3.2500e-006
CPcor : -9.57000000e-008
Slope : 1.00000000
Offset : 0.00000

6) A/D voltage 0, Oxygen, SBE 43

Serial number : 0458
Calibrated on : 29-Mar-24
Equation : Sea-Bird
Soc : 5.01630e-001
Offset : -4.96300e-001
A : -3.23800e-003
B : 1.12460e-004
C : -1.89490e-006
E : 3.60000e-002

Tau20 : 1.24000e+000
D1 : 1.92634e-004
D2 : -4.64803e-002
H1 : -3.30000e-002
H2 : 5.00000e+003
H3 : 1.45000e+003

7) A/D voltage 1, Free

8) A/D voltage 2, Fluorometer, WET Labs ECO-AFL/FL

Serial number : FLRTD-074
Calibrated on : 20-Dec-23
Dark output : 0.0180
Scale factor : 2.60000000e+001

9) A/D voltage 3, Transmissometer, WET Labs C-Star

Serial number : CST-1032DR
Calibrated on : 09-Apr-24
M : 20.7639
B : -0.1017
Path length : 0.250

10) A/D voltage 4, Altimeter

Serial number : 65378
Calibrated on : 17-May-18
Scale factor : 15.000
Offset : 0.000

11) A/D voltage 5, Free

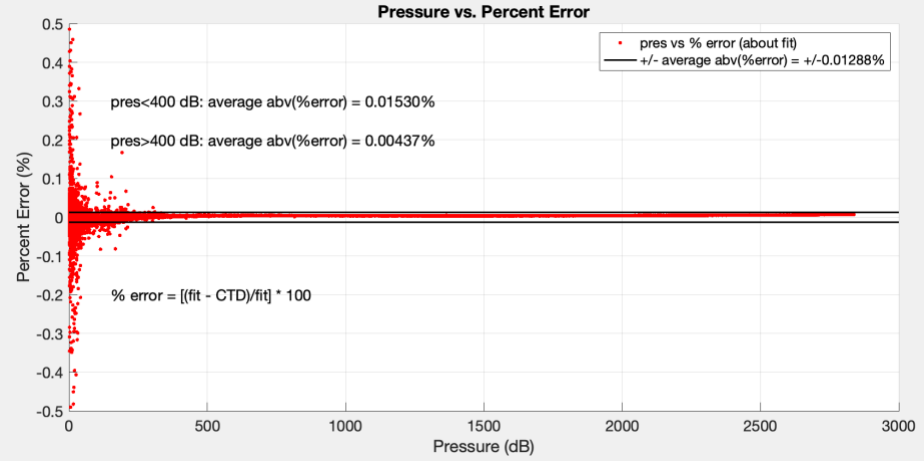
12) A/D voltage 6, Fluorometer, WET Labs ECO CDOM

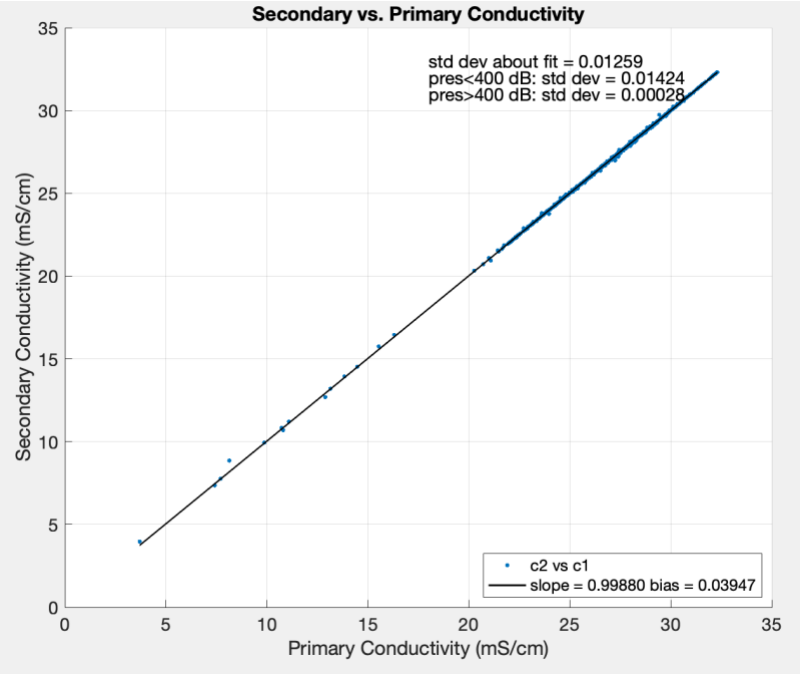
Serial number : FLCDRTD
Calibrated on : 23 April 2024
Dark output : 0.024
Scale factor : 100.000

13) A/D voltage 7, Free

Scan length : 37

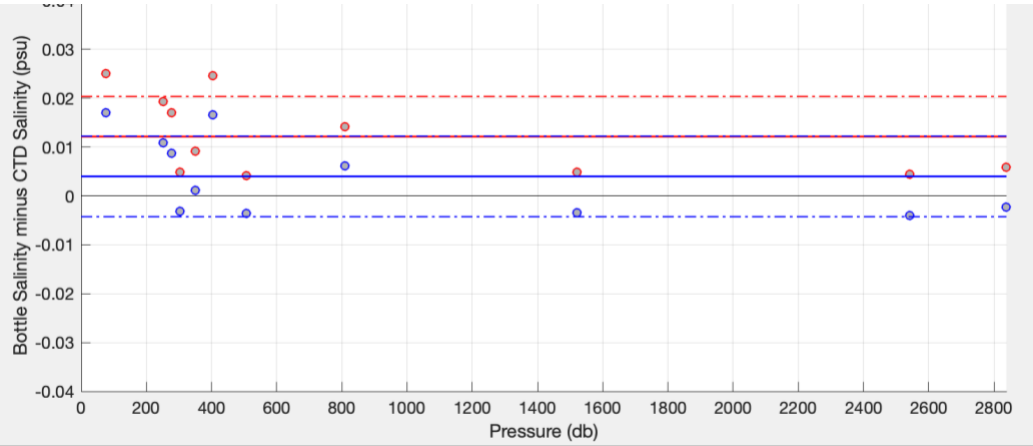
Appendix B.


Pressure vs. Percent Error
pres vs % error (about fit)
+/- average abv(%error) = +/-0.01288%
pres<400 dB: average abv(%error) = 0.01530%
pres>400 dB: average abv(%error) = 0.00437%
% error = [(fit - CTD)/fit] * 100
Percent Error (%)
Pressure (dB)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
0
500
1000
1500
2000
2500
3000


Secondary vs. Primary Conductivity
std dev about fit = 0.01259
pres<400 dB: std dev = 0.01424
pres>400 dB: std dev = 0.00028
c2 vs c1
slope = 0.99880 bias = 0.03947
Secondary Conductivity (mS/cm)
Primary Conductivity (mS/cm)
35
30
25
20
15
10
5
0
0
5
10
15
20
25
30
35

Appendix C.

CTD salinity minus bottle sample salinity as a function of pressure. Red and blue shown indicate primary and secondary sensor comparison, respectively. The solid lines indicates the average offset and dashed lines indicate ±2*(standard deviation). Salinometer accuracy is generally better than 0.002 psu when correctly setup and operated.



Bottle data for station 80 shown in temperature-salinity space.

