ODF Cruise Report of the 2023-24 occupation of GP17-ANT

ODF

Jan 28, 2024

CONTENTS:

CHAPTER

ONE

ODF CRUISE SUMMARY

1.1 ODF team

PIs

- Susan Becker
- Todd Martz

Sailing Technicians

- Andrew Barna (Sailing lead, oxygen analysis, ODF database maintinence)
- Aaron Mau (CTDO data processing)
- Kelcey Chung (Nutrient analysis)
- Gabriel Matthias (Salinity analysis and rosette maintinence) (*UNOLS* tech pool/*RVTEC*)

Port Technicians

- Megan Roadman (Mobilization)

All individuals are members of *SIO ODF* unless otherwise noted.

1.2 Overview

GEOTRACES is an international study of marine biogeochemical cycles, specific to trace elements and isotopes. GP17-ANT was led by chief scientist Peter Sedwick, supported by co-chiefs Phoebe Lam and Robert Sherell. GP17-ANT was conducted aboard the RVIB Nathaniel B. Palmer from November 29, 2023 to January 28, 2024. The Palmer was mobilized in Punta Arenas, Chile and following the conclusion of the cruise, demobilization concluded in Lyttelton, New Zealand.

ODF sent two techs in advance of the rest of the science party to set up for the cruise at the beginning of mobilization on November 18, 2023. The ship departure was delayed until November 29, 2023 in port due to high winds and difficulties loading equipment.

The first station was undertaken on December 2nd, with the intention of soaking *GTC* bottles and testing equipment, designated as a "soak" station. The second station was on December 5th and acted as a true mock station, where multiple groups acquired samples and sensors were tested on the ODF rosette. This was designated as the "test" station. The first non-testing station was on December 7th, overlapping with station 29 of GP17-OCE.

Science operations concluded on January 14, 2024. The rosette was disassembled, ODF container repacked, and data were finalized before making port on January 28, 2024. Demobilization concluded on January 30, 2024, including a shipment for the ODF 20-ft container and seperate air shipment for sensors.

A total of 29 stations were occupied, involving 60 ODF casts. ODF provided support for the rosette, which had 39 casts for a total of 99 CTD casts on GP17-ANT.

CHAPTER

TWO

CTD AND ROSETTE SETUP

For GP17-ANT a *SIO STS* 36-place yellow rosette and bottles were used. The rosette was loaded on RVIB Nathaniel B. Palmer from the ODF shipping container in mid-November 2023. The rosette and bottles were built before the assembly of a new 36-place rosette in 2017. This rosette is commonly brought aboard *GO-SHIP* cruises as a backup.

Beginning shortly after November 18, 2023, the rosette bottles were inspected. New non-baked buna o-rings were placed on the bottle spigots, vents, and endcaps. Bottle lanyards were also replaced as needed with premade lanyards from *STS* in San Diego. Bottle lanyards were made from 300-pound monofilament. Springs within the Bullister-style Niskin bottles were electropolished stainless steel or teflon-coated steel. No sample contamination has been noticed by the change in o-rings and springs.

The package used on GP17-ANT weighs roughly 1100 lbs in air without water and 1900 lbs in air with water. The package used on GP17-ANT weighs roughly 900 lbs in water.

In addition to the standard *CTDO* package on *GO-SHIP* cruises, a *WHOI UVP* and *UW* turbidity sensor were mounted on the rosette. Y-cables for the UVP and turbidity sensors were provided by their respective research institutions.

During the cruise we encountered a handful of problems. We describe all of the above in more detail in the sections below.

2.1 Underwater Sampling Package

ODF rosette casts were performed with a package consisting of a 36 bottle rosette frame, a 36-place carousel and 36 Bullister style Niskin bottles with an absolute volume of 10.6 L. The carousel was provided by the *NOAA PMEL*. Underwater electronic components primarily consisted of a SeaBird Electronics (*SBE*) housing unit with Paroscientific pressure sensor with dual plumbed lines where each line has a pump, temperature sensor, conductivity sensor, and exhaust line. A SeaBird Electronics membrane oxygen sensor was mounted on the "primary" line. A SBE reference thermometer (SBE35), JFE-Advantech RINKO oxygen optode, WetLABS transmissometer and chlorophyll-a fluorometer, and Valeport VA500 altimeter were also mounted on the rosette. UVP, and turbidity instruments were deployed with the CTD/rosette package and their use is outlined in sections of this document specific to their titled analysis. A monocore system was mounted below the ODF sampling package during select casts.

CTD and cage were horizontally mounted at the bottom of the rosette frame, located below the carousel for all stations. The CTD was mounted diagonal to the rosette bars to reduce influence of turbulence of the frame on the plumbed lines. The temperature, conductivity, dissolved oxygen, respective pumps and exhaust tubing was mounted to the CTD and cage housing as recommended by SBE. The reference temperature sensor was mounted between the primary and secondary temperature sensors at the same level as the intakes for the pumped temperature sensors. The transmissometer was mounted horizontally on the rosette frame with hose clamps, avoiding shiny metal inside that would introduce noise in the signal. The hose clamps for the transmissometer were covered in black electrical tape. The oxygen optode, fluorometer, and altimeter were mounted vertically inside the bottom ring of the rosette frames, with nothing obstructing their line of sight. The UVP was mounted on the inside of the rosette frame below the bottles and facing the CTD, away from any optical sensors that it could possibly have an influence on. The turbidity sensor was mounted on the inside middle ring of the rosette frame, below the bottles.

Equipment	Model	S/N	Cal Date	Stations	Group
Rosette	36-place	Yellow	–	1-29	*STS*/*ODF*
CTD	SBE9+	0569	–	1-29	*STS*/*ODF*
Pressure Sensor	Digiquartz		07-Dec-2021	1-29	*STS*/*ODF*
Primary Temperature	SBE3+	6140	03-Oct-2023	1-29	*STS*/*ODF*
Primary Conductivity	SBE4C	4537	24-Aug-2023	1-29	*STS*/*ODF*
Primary Pump	SBE5	2567	–	1-29	*STS*/*ODF*
Secondary Temperature	SBE3+	5046	03-Oct-2023	1-3	*STS*/*ODF*
Secondary Temperature	SBE3+	2309	03-Oct-2023	3-29	*STS*/*ODF*
Secondary Conductivity	SBE4C	6130	15-Sep-2023	1-29	*STS*/*ODF*
Secondary Pump	SBE5	2559	–	1-29	*STS*/*ODF*
Transmissometer	Cstar	1874DR	03-Aug-2023	1-20	*ODF*
Transmissometer	Cstar	1873DR	02-Aug-2023	20-29	*ODF*
Fluorometer Chlorophyll	WetLabs ECO-FL-RTD	8223	11-May-2023	1-29	*ODF*
Dissolved Oxygen	SBE43	4339	03-Aug-2023	1-29	*STS*/*ODF*
Oxygen Optode	JFE Advantech Rinko-III	0297	24-Aug-2022	1-29	*ODF*
Reference Temperature	SBE35	0035	04-Oct-2023	1-29	*ODF*
Carousel	SBE32	0641	–	1-29	*PMEL*
Altimeter	Valeport VA500	84324	–	1-29	*STS*/*ODF*
UVP6	HF	000161	–	1-29	*WHOI*
Turbidity	Seapoint	11961	–	1-29	*UW*
Starmon Compass	STAR-ODDI	SCL0009	–	Sub 3000 m casts	*USAP*/*ASC*

2.2 Winch and Deployment

All ODF casts were undertaken from the Baltic room aboard the Palmer. The rosette system was suspended from a UNOLS-standard three-conductor 0.322” electro-mechanical sea cable. The sea cable was terminated with a Guy Grip (primary) and a poured termination (secondary).

No electrical issues occurred on GP17-ANT.

The ODF rosette team prepared the rosette 10-45 minutes prior to each cast. The bottles were cocked and all valves, vents, and lanyards were checked for proper orientation.

The Baltic room was cleared of non-essential personnel and the Palmer’s *MTs* lifted the rosette into the air. When the rosette was outside of the ship, the CTD was powered on and allowed to hang for 30 seconds to get an approximation of deck pressure. At this point, the data file would begin to be written to using *SBE* SeaSave software. The rosette would then be lowered to 20 m to soak, allowing the pumps and UVP to power on. This soak depth would later be increased to 30 m to make it easier to trigger the UVP power sequence.

Recovering the package at the end of the deployment was the reverse of launching. Once the CTD was lowered down inside the Baltic room, a tugger would be used to move it away from the door. The carousel was rinsed and sensors were cleaned after every cast, and then samplers were allowed to begin collecting water. Any biofouling noted was cleaned off the outside of the rosette before the next cast, and the inside of the bottles were checked for biofouling and periodically sprayed down.

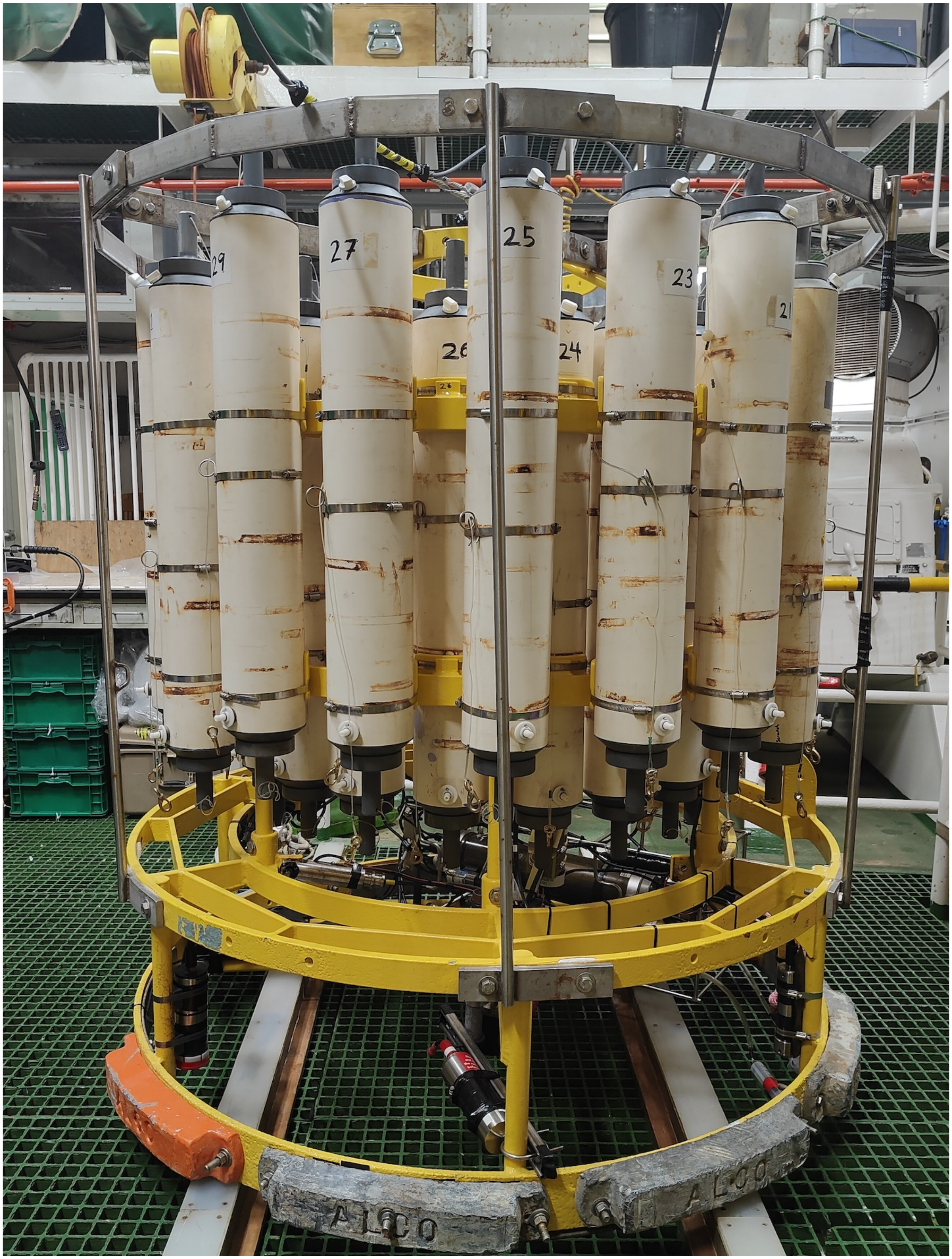


Fig. 1: Package sensor setup from the starboard side.

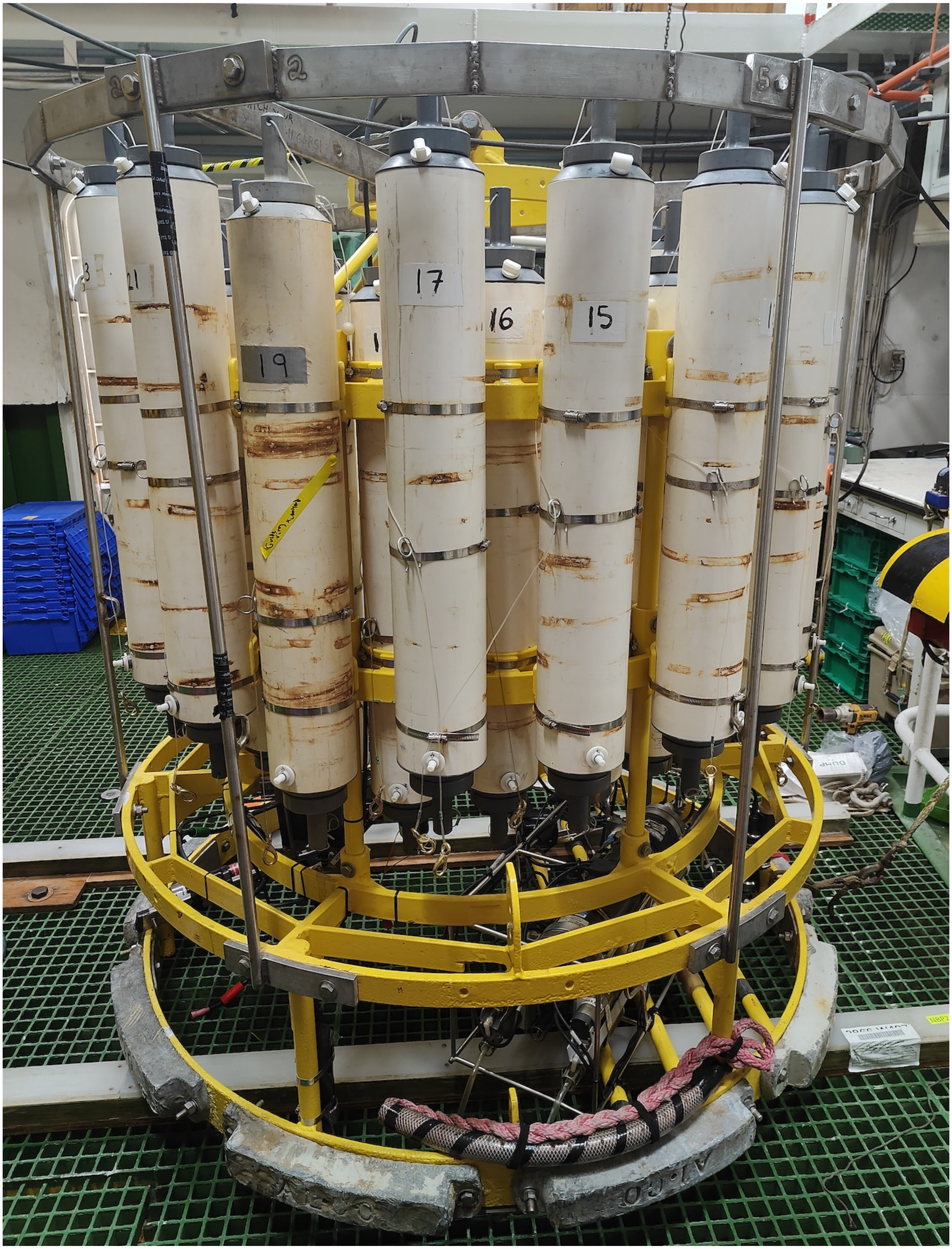


Fig. 2: Package sensor setup from the forward side.

Fig. 3: Package sensor setup from the aft side.

Fig. 4: Package sensor setup, seen from above.

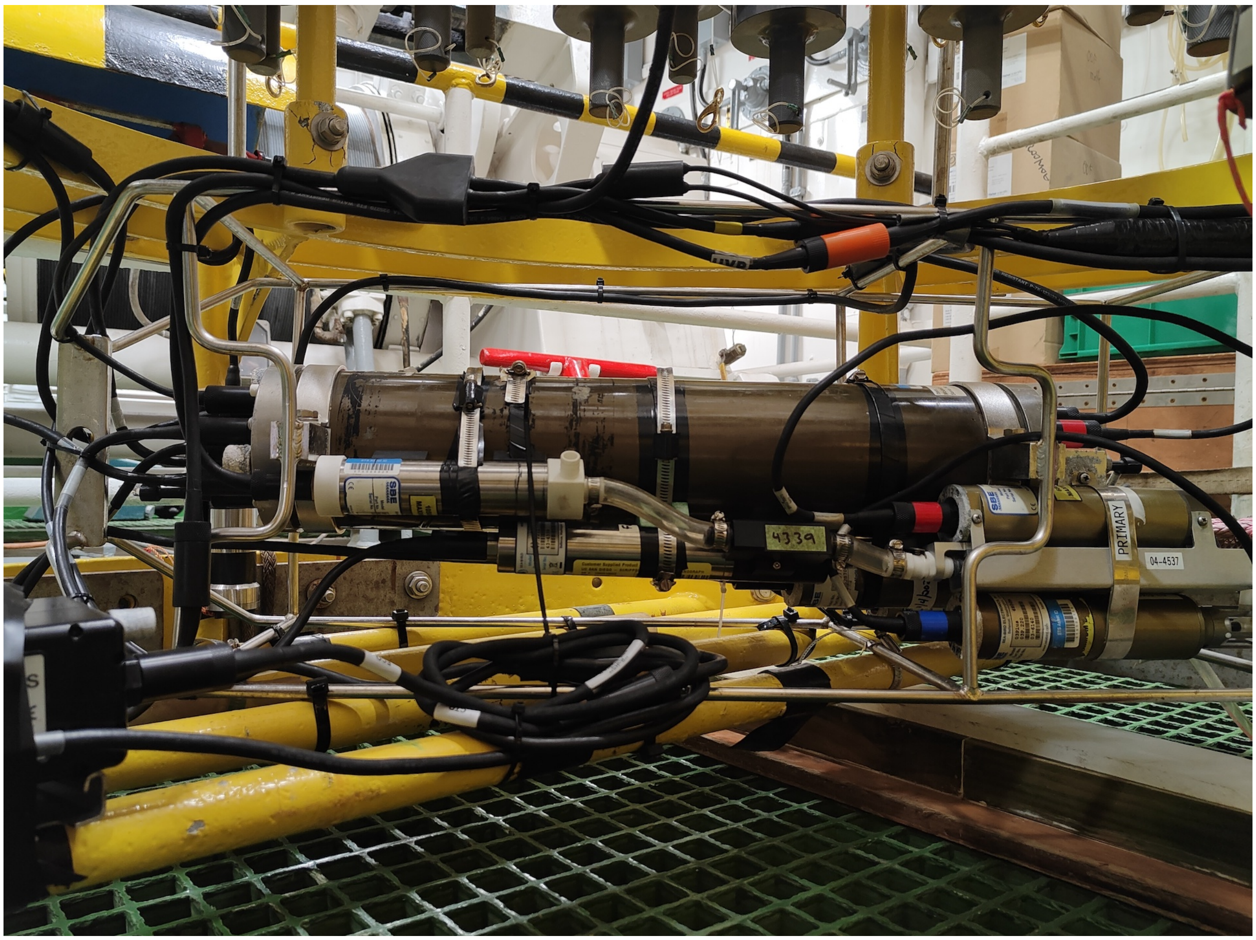


Fig. 5: ODF CTD package mounted below the Niskin bottles.

Fig. 6: ODF altimeter mounting position.

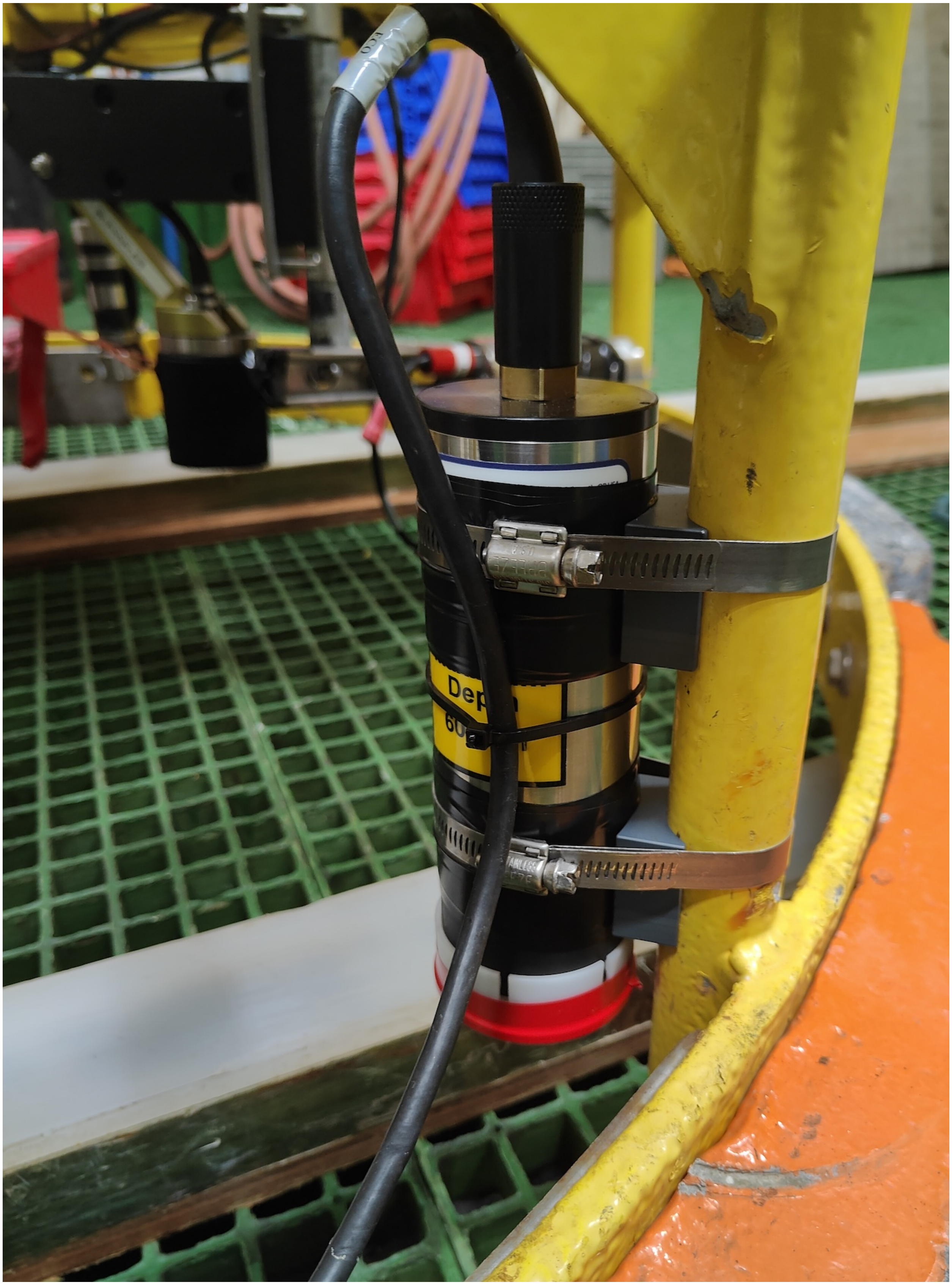


Fig. 7: ODF ECO fluorometer mounting position.

Fig. 8: ODF RINKO sensor mounting position, away from the *WHOI UVP*.

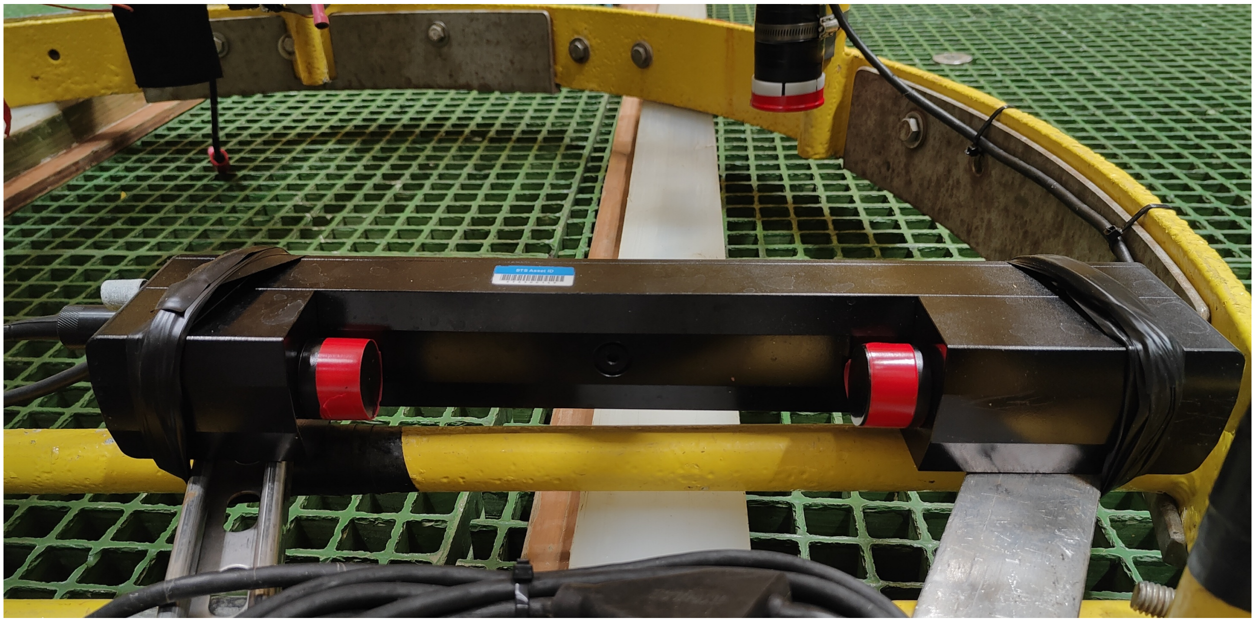


Fig. 9: ODF transmissometer, mounted on bottom rosette bars.

Fig. 10: Guy grip primary termination, located above the rosette package.

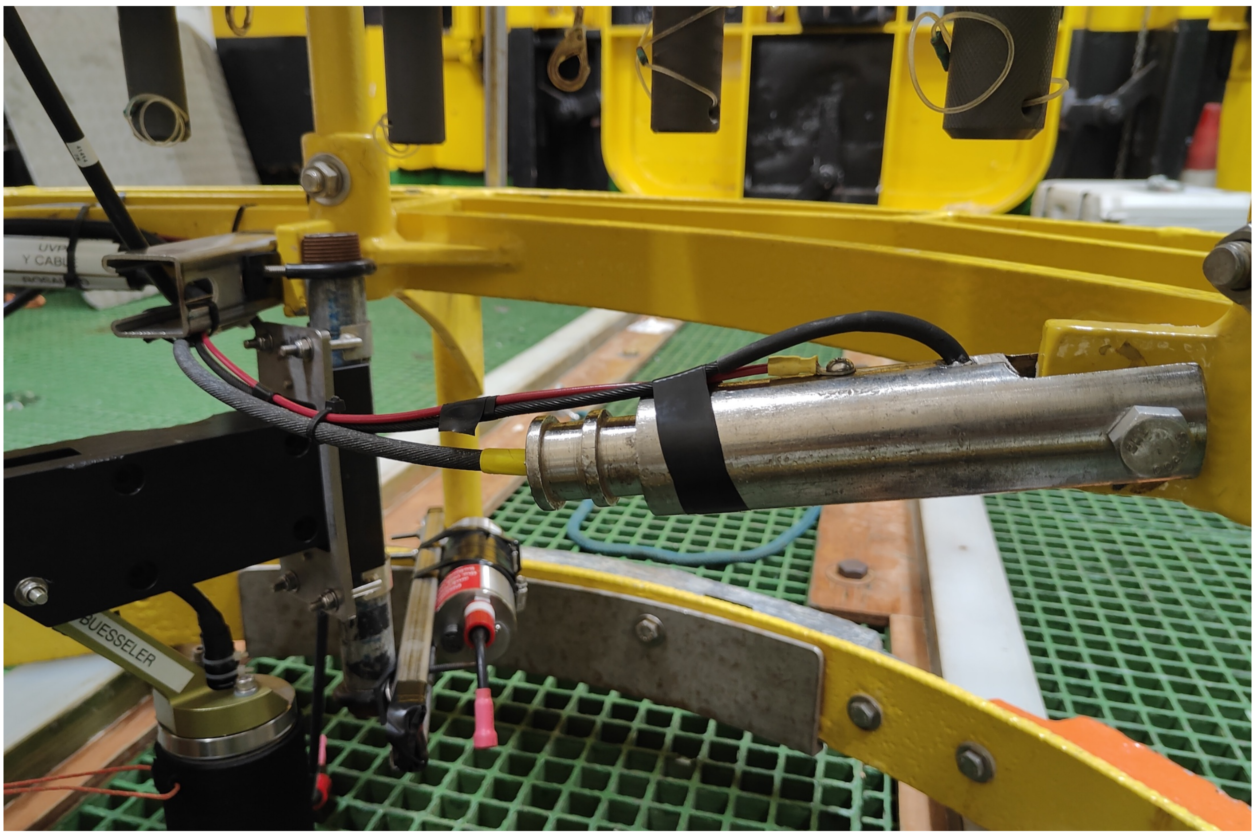


Fig. 11: Poured secondary termination, bolted to the rosette frame below the Niskin bottles.

2.3 Monocore

A monocore system was provided by *LDEO* for GP17-ANT. It was mounted approximately 25 meters below the ODF rosette to collect seafloor sediment on most deep ODF casts using a nylon line. This was not deployed with a "shielding cone", something done on previous GEOTRACES cruises to mask the monocore from the rosette altimeter. The justification was that the shielding cone could cause erratic positioning during the downcast. During GP17-OCE, there was one station where the monocore was on top of the rosette following a cast.

Because of this, the monocore was seen in the altimeter signal at ~28 m during the down and upcasts until the seafloor gave a better return. When the seafloor was first seen in the altimeter, the console operator would give an "all stop" command to the winch operator and the rosette would be allowed to hang for about a minute. The justification for this was to allow the monocore to straighten below the ODF rosette. After waiting, the rosette was lowered at between 20-25 m/min until the altimeter read 10 m from the bottom. Care was taken to choose sample depths not between 25-30 m off the seafloor to allow the monocore to leave the sediment cleanly.

The monocore was rinsed with fresh water after sampling during every cast where it was used.

After not collecting good cores at stations 010 and 011, the monocore spring was exchanged for another with higher tension.

The monocore collected sediment samples on 23 out of 26 casts.

Station	Cast	Monocore Notes
003	08	The monocore was not seen on the altimeter during the downcast and the cast was aborted.
003	09	The monocore was seen hanging ~27 m during the cast and a good seafloor sample was taken.
004	10	A good monocore sample was collected.
005	06	A good monocore sample was collected.
006	06	The monocore appeared to have dragged on the seafloor. A good core collected.
007	07	Descent at 25 m/min. Good core collected.
008	06	Persisting with 25 m/min monocore insertion. Short core collected.
009	06	Good monocore sample collected.
010	06	No core - the monocore did not fire at the bottom. Same procedure as before.
011	06	No core - the monocore fired but the caps did not cover the sample and it was lost at the surface.
012	06	A short monocore sample collected.
013	06	Good monocore sample collected.
014	07	Good monocore sample collected.
015	06	Good monocore sample collected.
016	06	Good monocore sample collected.
017	07	Good monocore sample collected.
018	05	A short monocore sample collected. Monocore not seen on the altimeter.
019	05	Descended at 16 m/min. Short monocore sample collected.
020	06	The monocore was deployed on a slope and rocks prevented the caps from covering the sample.
021	06	Good monocore sample collected.
022	06	Good monocore sample collected. Mechanism had to be closed manually at surface.
023	06	Good monocore sample collected.
024	06	Good monocore sample collected.
025	01	Good monocore sample collected.
026	06	Good monocore sample collected.
027	06	Good monocore sample collected.
028	06	Good monocore sample collected.
029	07	No core - the monocore fired but sediment on top suggest it was not oriented vertically.

Fig. 12: Monocore, for hanging below the ODF rosette.

2.4 UVP

A Hydroptic underwater vision profiler (*UVP*) was supplied by *WHOI* and mounted on the inside of the ODF rosette below the carousel for all casts. The UVP has a built-in pressure sensor and was set to "CTD mode" for all deployments. This setting means the sensor powers on when it reads approximately 20 m in the water. While it is on, it photographs particles in the water column using a red-laser diode and saves them to the device memory. When the pressure sensor detects a pressure difference of approximately 30 m during the upcast, the sensor powers off and data acquisition is halted until the power is reset on deck. The UVP was connected to the ODF CTD and a voltage was read on voltage channel 4 to see when the sensor was active.

While on deck, the UVP was kept dummy plugged and both the camera and lighting elements were kept covered. Prior to a cast, the dummy plugs were removed and the battery was reconnected to the camera and lighting elements. The sensor flashed 3 times when the battery was connected before a cast, indicating that the sensor's "autocheck" routine was successful. There were occasions where the sensor did not flash following the autocheck routine, which was attributed to the UVP sensor being too cold.

The UVP was rinsed with fresh water after niskin sampling had concluded. The battery was recharged every 48 hours. Whenever possible, the UVP was warmed using heaters in the Baltic room.

Data were downloaded off the sensor at the end of the cruise.

2.5 Compass & TDRs

The Palmer *ETs* (*USAP ASC*) provided a Starmon Compass model "STAR-ODDI" (S/N SCL0009) for the ODF rosette. The compass records heading, tilt, temperature, and depth. It was secured to the rosette with two hose clamps, facing down, near the transmissometer. It is rated to 3000 m, so it was not used during ODF deep casts at locations where more than 3000 m of wire out was expected. Following a cast or series of casts, the ETs would remove the compass and download the data to assess rosette spin and tilt.

In addition to the compass, the Palmer ETs attached two temperature depth recorders (TDRs, model DST centi-TD) during casts 02203 and 02507. These sensors are typically attached to the cable during a McLane pump cast, recording depth and temperature which can be extracted later. They were attached for calibration using the ODF CTD.

2.6 Cruise Maintenance and Calibrations

During GP17-ANT, routine maintenance was done to the rosette and sensor package to ensure quality of the science done. All electrical instruments and terminations on the rosette were rinsed with fresh water following every cast. Special attention was paid to the SBE32 mechanisms to prevent triggers from sticking.

The rosette and sensor package were inspected and thoroughly cleaned of possible biofouling during transit between stations 025 and 026.

Rosette and Niskins

Integrity checks on the rosette, such as checking lanyard angles, o-ring and lanyard replacement, and spigot movement were performed during fueling before transit to test station. All bottles were filled and leak-tested. Many had previous damage on the sealing surfaces, some had been ssanded previously with moderate success. No sanding was attempted on GP17-ANT as a plentiful supply of bottles from the Palmer were available. Of the rosette configuration that was originally shipped, 7 niskin bottles were changed out during GP17-ANT. 4 of which were prior to the first station.

In routine operations of the RVIB Nathaniel B. Palmer and with approval from the chief scientists, the rosette and CTD were rinsed by Palmer marine technicians prior to sampling. Rosette Niskin hoseclamps and lanyard guide rings were routinely inspected and adjusted as needed. Guide rings were repositioned to ensure that bottle lanyards had appropriate tension. The rosette was routinely examined for valve and o-ring leaks, which were maintained as needed. Care was taken not to rinse spigots and other parts of the bottle that might be touched by samplers in order to not contaminate the samples.

Sensor Package

After each cast, Palmer tubing of fresh, filtered water was connected to the CTD's plumbed lines to rinse the sensors and allow them to soak between casts. SBE35RT temperature data was routinely downloaded each day.

The transmissometer was calibrated before the start and after the end of science operations.

Date	Serial Number	Vair	Vdark	Notes
2023-11-19	1874	4.8011	0.0040	In port
2023-12-30	1873	4.7421	0.0012	Initial replacement
2024-01-14	1873	4.8117	0.0037	End of cruise

2.7 Logs

A running ODF log notebook was kept for recording modifications, adjustments, or events related to the rosette or CTD package. Repeat instances of events such as leaky bottles were used to describe and diagnose problems during different casts.

ODF rosette logs are available in the *appendicies*.

CHAPTER

THREE

BOTTLE DATABASE

PIs

- Todd Martz
- Susan Becker

Technicians

- Andrew Barna

3.1 Equipment and Setup

For GP17-ANT, a cruise database was set up to store and visualize *ODF* and *GTC* data. The database was set up on a Mac Mini running Sonoma 14.1, granted a domain name for members of the science party to access while on the RVIB Nathaniel B. Palmer's "NBPCORE" network. The database was set up with Flask, an open-source Python web development tool, and the package SQLAlchemy to handle data sequestration and queries.

A schema specific to the cruise was set up, wherein cruise parameters were able to be initialized. Users can navigate prepared HTML pages which visualize the samples taken for each station and cast entered by ODF.

The database was run with the following dependencies:

- Click == 7.1.2
- Flask == 1.1.2
- Flask-SQLAlchemy == 2.4.4
- itsdangerous == 1.1.0
- Jinja2 == 2.11.3
- MarkupSafe == 1.1.1
- SQLalchemy == 1.3.23
- Werkzeug == 1.0.1

Data are then available for visualization using Ocean Data View (ODV), a program developed by Reiner Schlitzer at the Alfred Wegner Institute (AWI) for Polar and Marine Research (Bremerhaven, Germany). ODV allows users to plot, calculate, and save physiochemical properties of seawater.

A Docker image was created to host a pre-configured version of DevDocs.io, providing access to extensive coding documentation without an internet connection.

3.2 Narrative

Cast parameters were initialized at the beginning of the cruise and were appended to as needed to track the samples and sampling groups that were involved in the rosette sampling routine.

Data were updated daily by ODF during GP17-ANT. Station and cast lists were updated as console, hydrocast, and sample logs became available following a deployment. This was for all ODF and GTC casts. ODF samples for salinity or nutrients taken from the towfish, beryllium and radium pumps, and multicorer and McLane niskins were added to the database.

Following the conclusion of science on January 14, 2024, the bottle database was finalized and the data products were exported for the science party.

CHAPTER

FOUR

CTDO AND HYDROGRAPHIC ANALYSIS

Technicians

- Aaron Mau

4.1 CTDO and Bottle Data Acquisition

The CTD data acquisition system consisted of an SBE-11+ (V1) deck unit and a networked generic PC workstation running Windows 10. SBE SeaSave7 v.7.26.7.121 software was used for data acquisition and to close bottles on the rosette.

CTD deployments were initiated by the console watch operator (CWO) after the ship had stopped on station. The watch maintained a CTD cast log for each attempted cast containing a description of each deployment event and any problems encountered.

Once the deck watch had deployed the rosette, the winch operator would lower it to 20 meters (30 meters at later stations). The CTD sensor pumps were configured to start 10 seconds after the primary conductivity cell reports salt water in the cell. The UVP was configured to start recording after it had descended to 20 meters. The CWO checked the CTD data for proper sensor operation, waited for sensors to stabilize, and then instructed the winch operator to bring the package to the surface. The winch was then instructed to lower the package to the initial target wire-out at no more than 60 m/min after 100 m depending on depth, sea-cable tension, and the sea state.

The CWO monitored the progress of the deployment and quality of the CTD data through interactive graphics and operational displays. The altimeter channel, CTD pressure, wire-out and center multi-beam depth were all monitored to determine the distance of the package from the bottom. The winch was directed to slow decent rate to 30 m/min 100 m from the bottom. The bottom of the CTD cast was usually to 10 meters above the bottom, as determined by the altimeter. During deep casts with the monocorer attached, the final approach was done at 20 m/min after a short delay for the monocorer to level out. For each full upcast, the winch operator was directed to stop the winch at up to ~12 predetermined sampling depths, dependent on the cast type. The CTD CWO waited a minimum of 30 seconds prior to tripping sample bottles, to ensure package had shed its wake [Paver2020] (the effect of bottle stop time is discussed further at the end of Conductivity Analysis). An additional 15 seconds elapsed before moving to the next consecutive trip depth, which allowed for the SBE35RT to record bottle trip temperature averaged from 13 samples.

After the last bottle was closed, the CWO directed winch to recover the rosette. Once the rosette was out of the water and on deck, the CWO terminated the data acquisition, turned off the deck unit and assisted with rosette sampling.

Additionally, the watch created a sample log for the deployment which recorded the depths bottles were tripped and correspondence between rosette bottles and analytical samples drawn.

The CTD sensors were rinsed after every cast using fresh water connected to Tygon tubing available in the ship's Baltic room. The tubing was left on the CTD between casts, with the temperature and conductivity sensors immersed in fresh water.

Each bottle on the rosette had a unique serial number, independent of the bottle position on the rosette. Sampling for specific programs were outlined on sample log sheets prior to cast recovery or at the time of collection. The bottles and rosette were examined before samples were drawn. Any abnormalities were noted on the sample log and stored in the cruise database using the appropriate WOCE bottle flag.

4.2 CTDO Data Processing

Shipboard CTD data processing was performed after deployment using SIO/ODF CTD processing software "ctdcal" v. 0.1.4b. CTD acquisition data were copied onto a OS X system, and then processed. CTD data at bottle trips were extracted, and a 2-decibar downcast pressure series created. The pressure series data set was submitted for CTD data distribution after corrections outlined in the following sections were applied.

A total of 29 CTD stations were occupied including one "soak" and one test station.

CTD data were examined at the completion of each deployment for clean corrected sensor response and any calibration shifts. As bottle salinity and oxygen results became available, they were used to refine conductivity and oxygen sensor calibrations.

Temperature, salinity and, dissolved O_2 (*DO*) comparisons were made between down and upcasts as well as between groups of adjacent deployments. Vertical sections of measured and derived properties from sensor data were checked for consistency.

A number of issues were encountered during GP17-ANT that directly impacted CTD analysis. Issues that directly impacted bottle closures are detailed in the *ODF rosette log* section of this report. Temperature, conductivity, and oxygen analytical sensor issues are detailed in the following respective sections.

4.3 Pressure Analysis

Dates of laboratory calibration are recorded on the underway sampling package table and calibration documents are provided in the *calibration documents*.

The lab calibration coefficients provided on the calibration report were used to convert frequencies to pressure. Initial SIO pressure lab calibration slope and offsets coefficients were applied to cast data. A shipboard calibration offset was applied to the converted pressures during each cast. These offsets were determined by the pre and post-cast on-deck pressure offsets. The pressure offsets were applied per cast.

ODF CTD #0569:

	Start P (dbar)	End P (dbar)
Min	-0.21	-1.84
Max	0.67	-0.53
Average	0.18	-1.27

On-deck pressure reading varied from -0.21 to 0.67 dbar before the casts, and -1.84 to -0.53 dbar after the casts. The pressure offset varied from -2.12 to -0.90, with a mean value of -1.44 dbar.

4.4 Temperature Analysis

Laboratory calibrations of temperature sensors were performed prior to the cruise at the SIO Calibration Facility. Dates of laboratory calibration are recorded on the underway sampling package table and calibration documents are provided in the appendices.

The pre-cruise laboratory calibration coefficients were used to convert SBE3plus frequencies to ITS-90 temperature. Additional shipboard calibrations were performed to correct systematic sensor bias. Two independent metrics of calibration accuracy were used to determine sensor bias. At each bottle closure, the primary and secondary temperature were compared with each other and with a SBE35RT reference temperature sensor.

The SBE35RT Digital Reversing Thermometer is an internally-recording temperature sensor that operates independently of the CTD. The SBE35RT was located equidistant between the two SBE3plus temperature sensors. The SBE35RT is triggered by the SBE32 carousel in response to a bottle closure. According to the manufacturer's specifications, the typical stability is 0.001 °C/year. The SBE35RT was set to internally average over 13 samples, approximately a 15 second period.

A functioning SBE3plus sensor typically exhibit a consistent predictable well-modeled response. The response model is second-order with respect to pressure and second-order with respect to temperature:

The *GTC* rosette did not have a SBE35RT mounted, so temperature fitting was omitted from GTC routines.

$$T_{cor} = T + cp_2 P^2 + cp_1 P + ct_2 T^2 + ct_1 T + c_0$$

Fit coefficients are shown in the following tables.

Table 1: Primary temperature (T1) coefficients.

Station	cp_2	cp_1	ct_2	ct_1	c_0
3	2.228e-11	-7.3078e-8	0.0	0.0	-6.1073e-4
4-29	-1.2993e-10	3.6118e-7	0.0	0.0	-1.8939e-4

Table 2: Secondary temperature (T2) coefficients.

Station	cp_2	cp_1	ct_2	ct_1	c_0
3	-9.3324e-11	6.6308e-8	0.0	0.0	-7.7646e-4
4-29	-1.1552e-10	2.4207e-7	0.0	0.0	-6.1971e-4

Corrected temperature differences are shown in the following figures.

The 95% confidence limits for the mean low-gradient (values -0.002 °C $\leq$ T1-T2 $\leq$ 0.002 °C) differences are $\pm$0.00414 °C for SBE35RT-T1, $\pm$0.00405 °C for SBE35RT-T2 and $\pm$0.00133 °C for T1-T2. The 95% confidence limits for the deep temperature residuals (where pressure $\geq$ 2000 dbar) are $\pm$0.00049 °C for SBE35RT-T1, $\pm$0.00056 °C for SBE35RT-T2 and $\pm$0.00037 °C for T1-T2.

Following station 3, the secondary temperature sensor was removed as the pins appeared loose and gave NaN values during upcasts. Otherwise, no problems affected primary or secondary temperature sensor (SBE3) data or the reference temperature sensor (SBE35) data during GP17-ANT.

The resulting affected sections of data have been coded and documented in the quality code appendices.

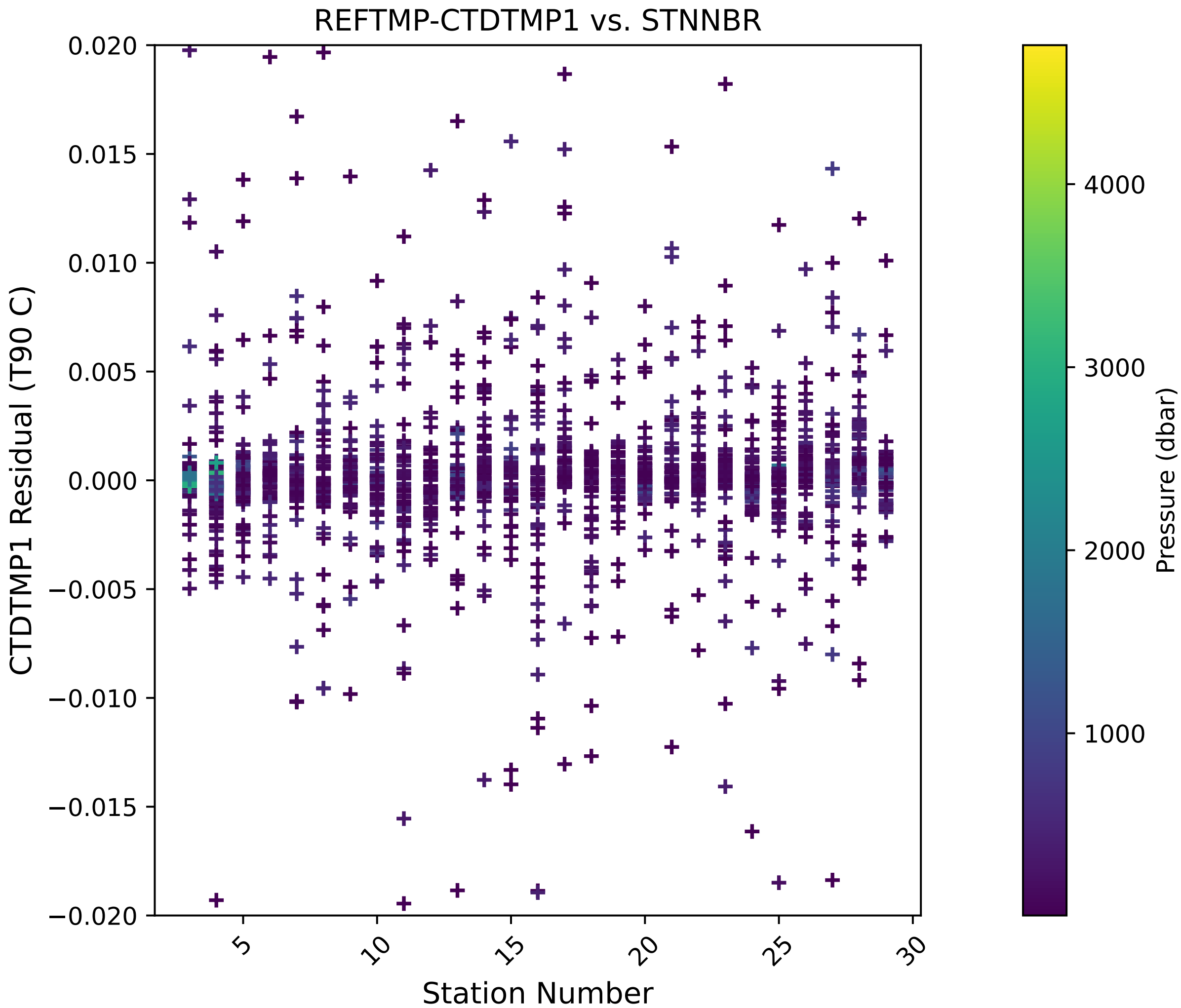


Fig. 1: SBE35RT-T1 versus station.

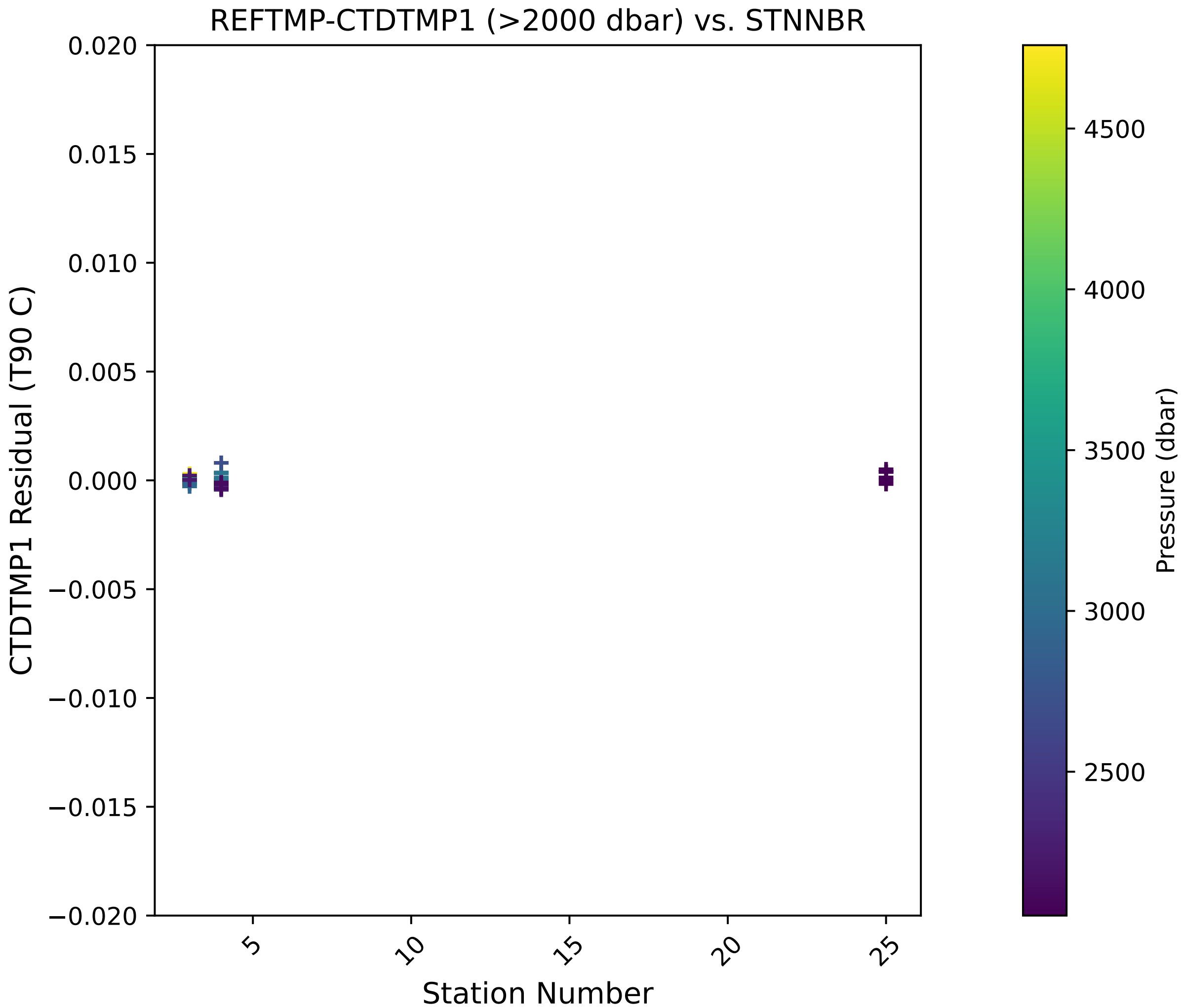


Fig. 2: Deep SBE35RT-T1 by station (Pressure ≥ 2000dbar).

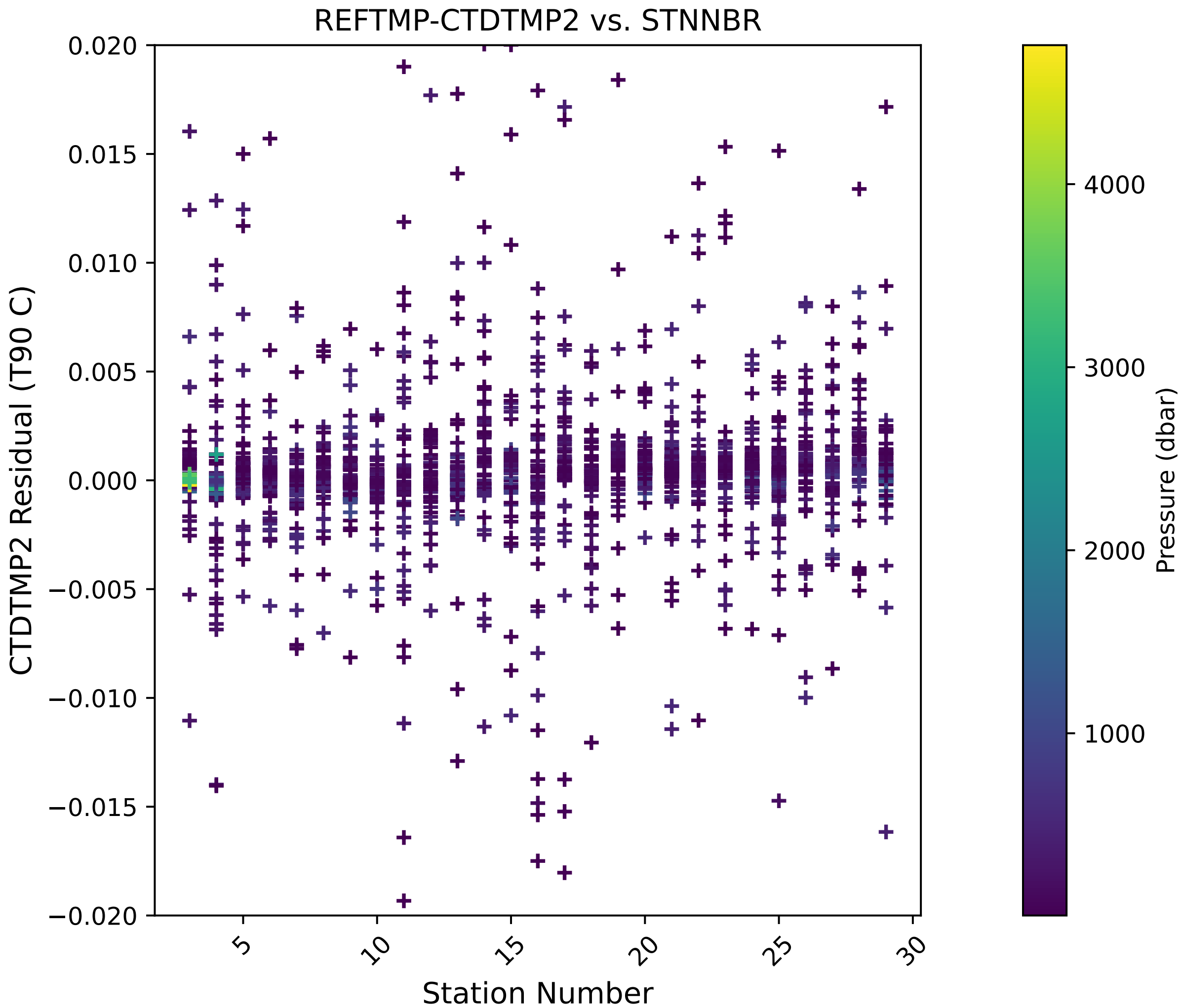


Fig. 3: SBE35RT-T2 versus station.

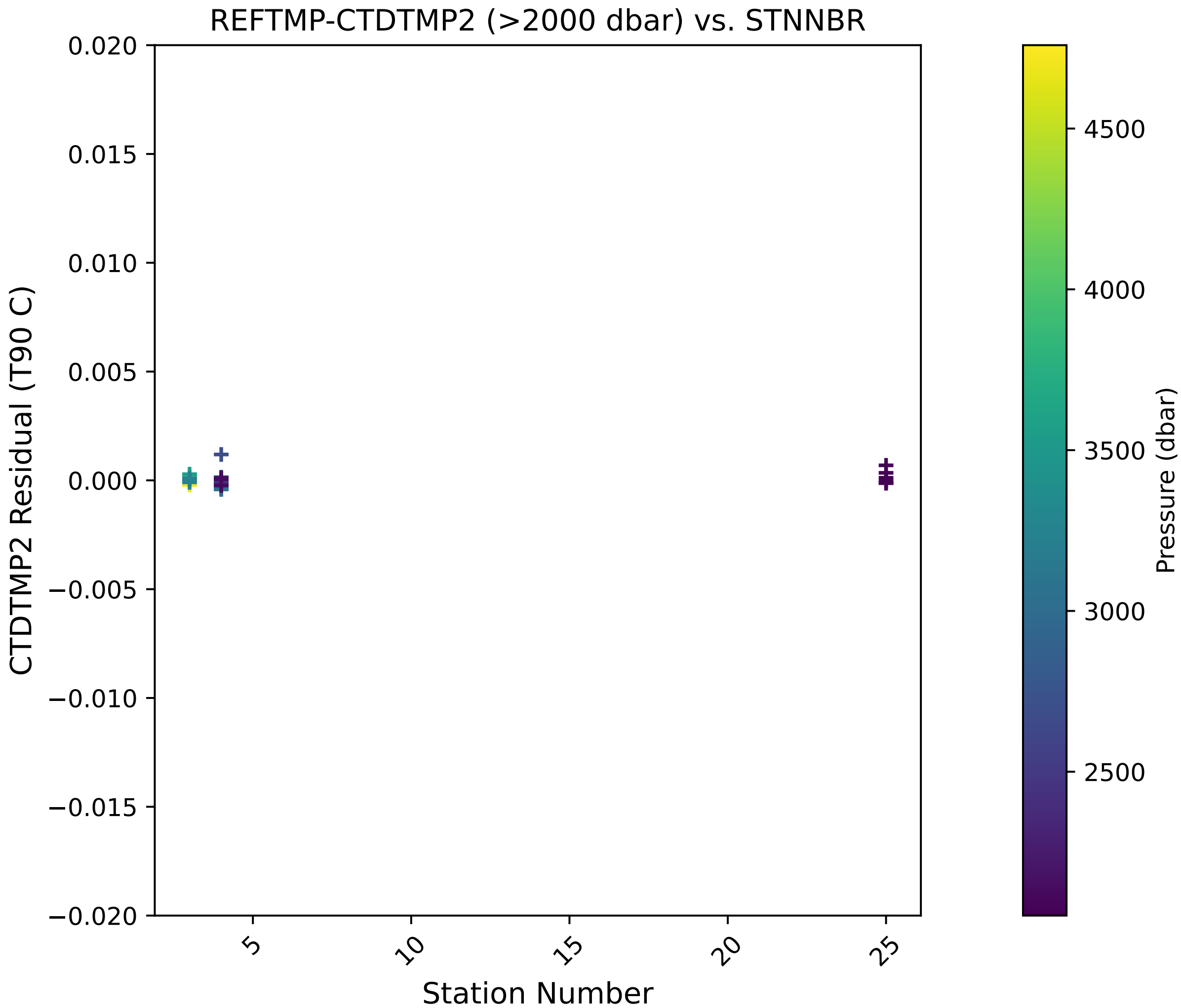


Fig. 4: Deep SBE35RT-T2 by station (Pressure ≥ 2000dbar).

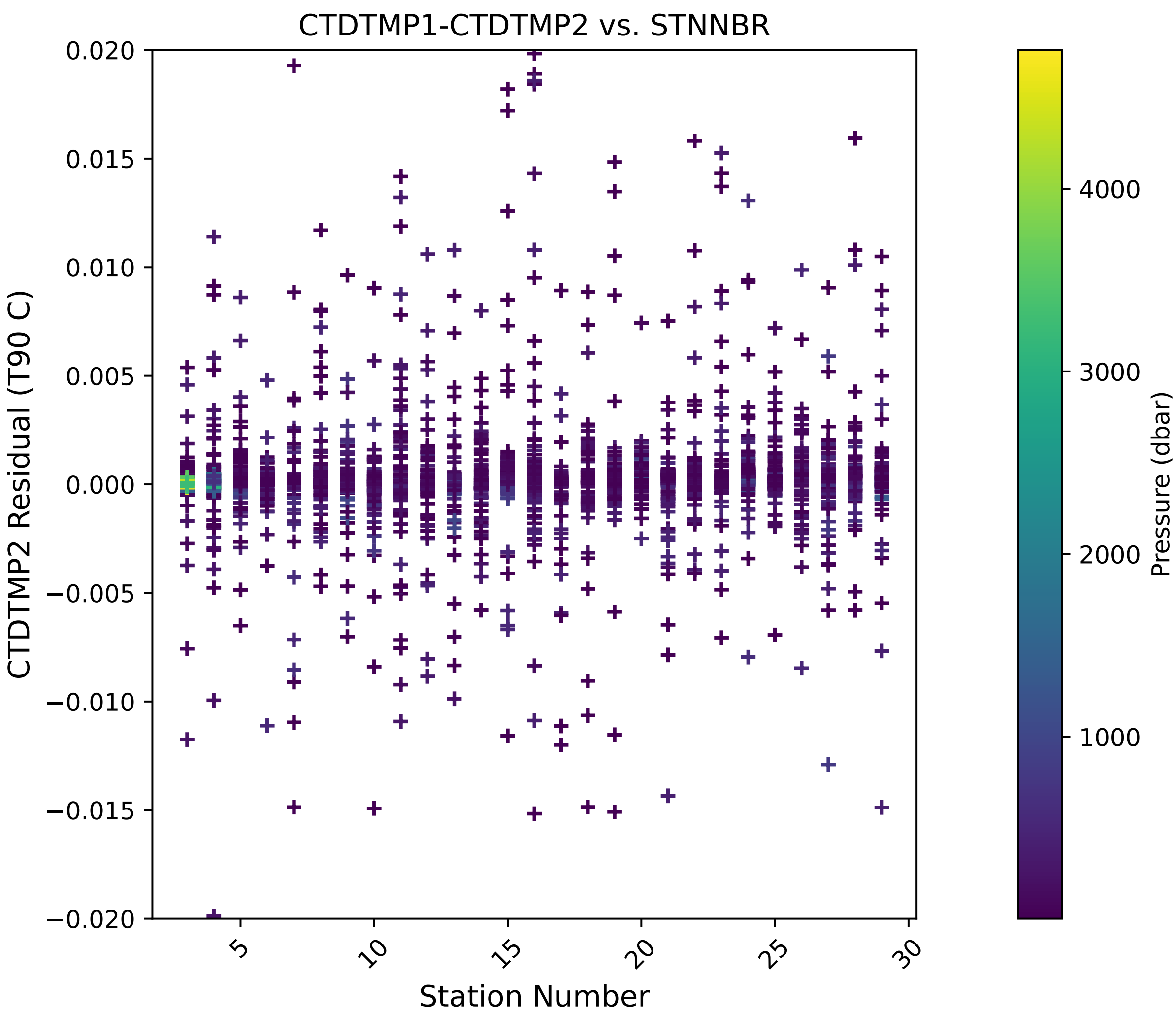


Fig. 5: T1-T2 versus station.

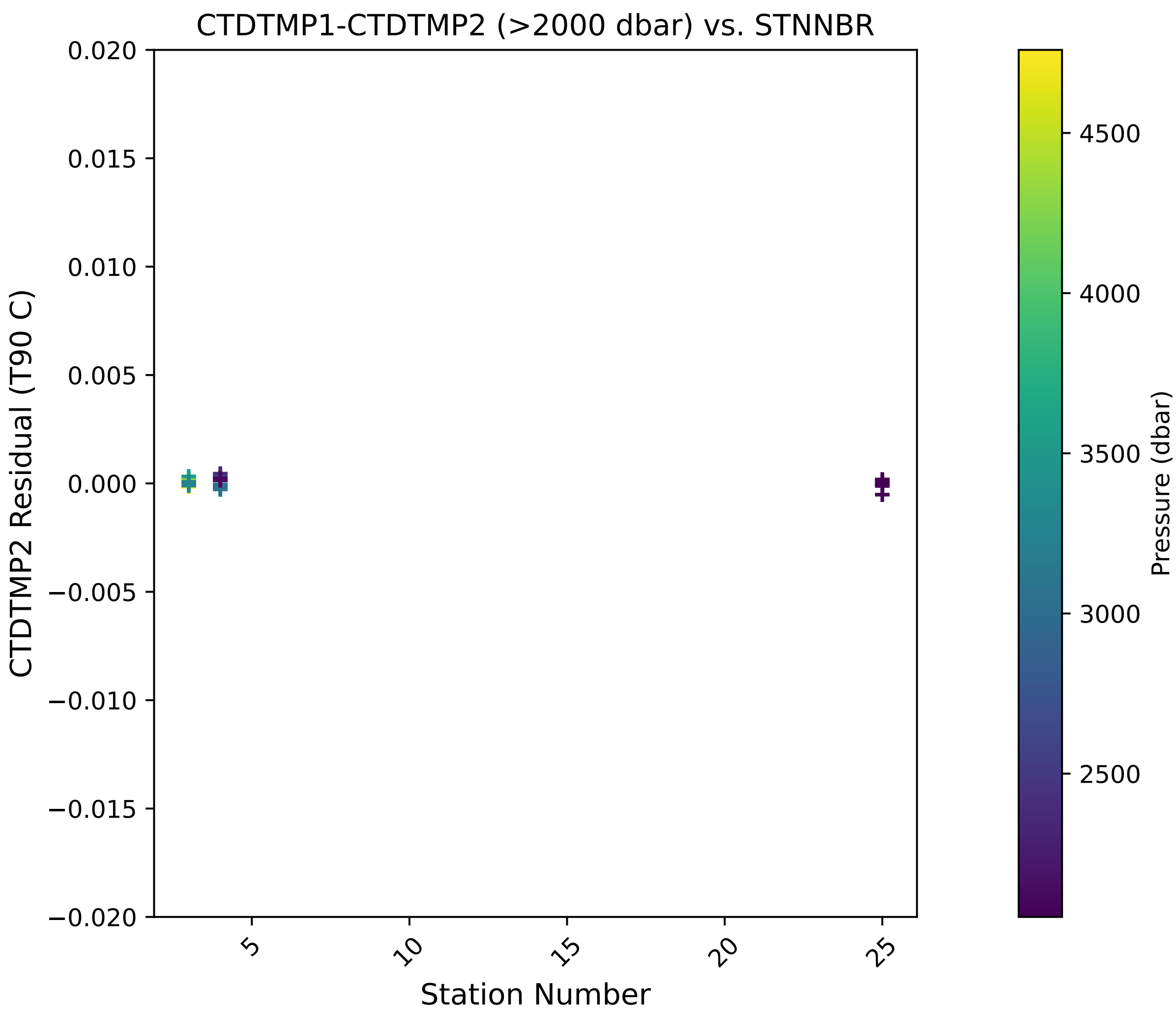


Fig. 6: Deep T1-T2 versus station (Pressure $\geq$ 2000dbar).

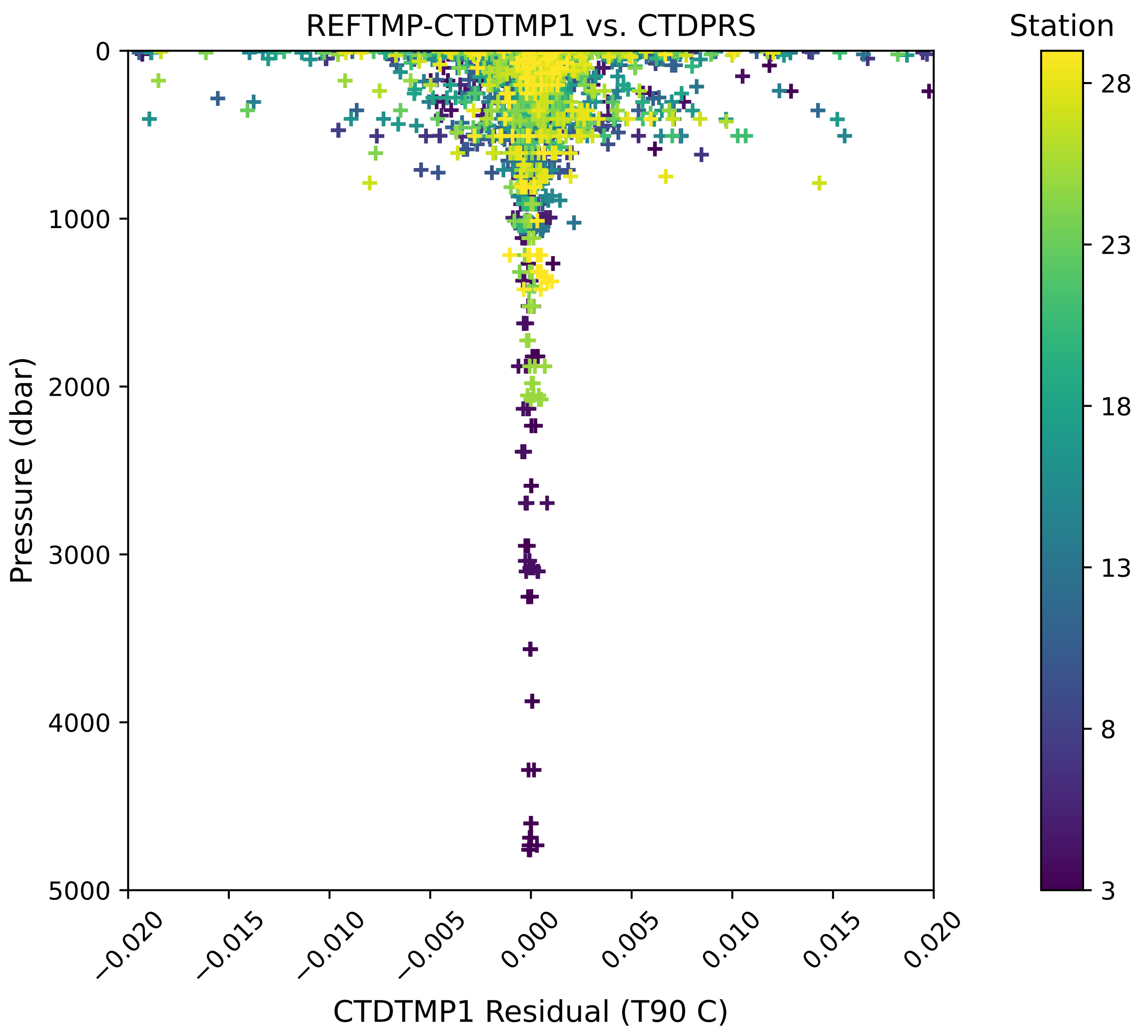


Fig. 7: SBE35RT-T1 versus pressure.

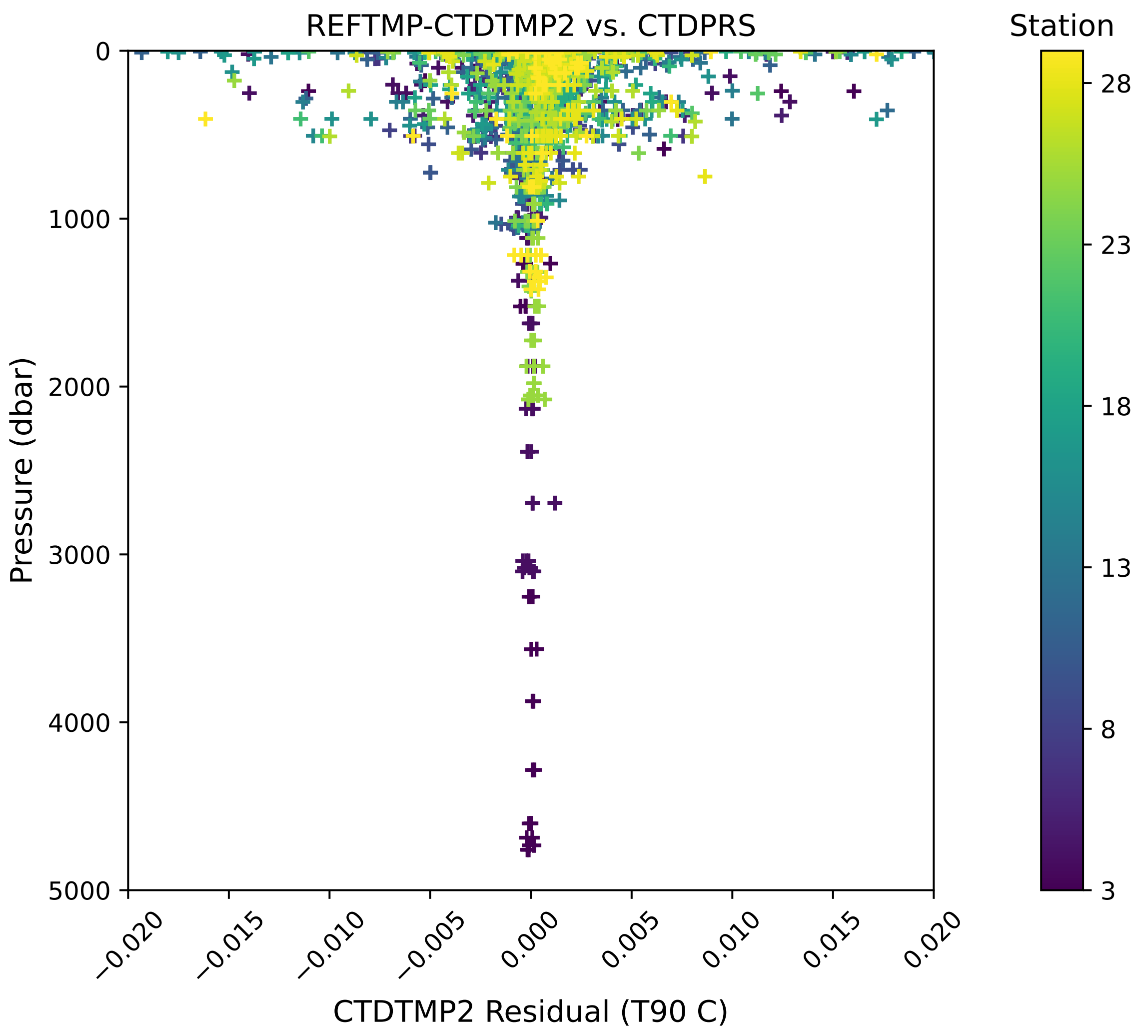


Fig. 8: SBE35RT-T2 versus pressure.

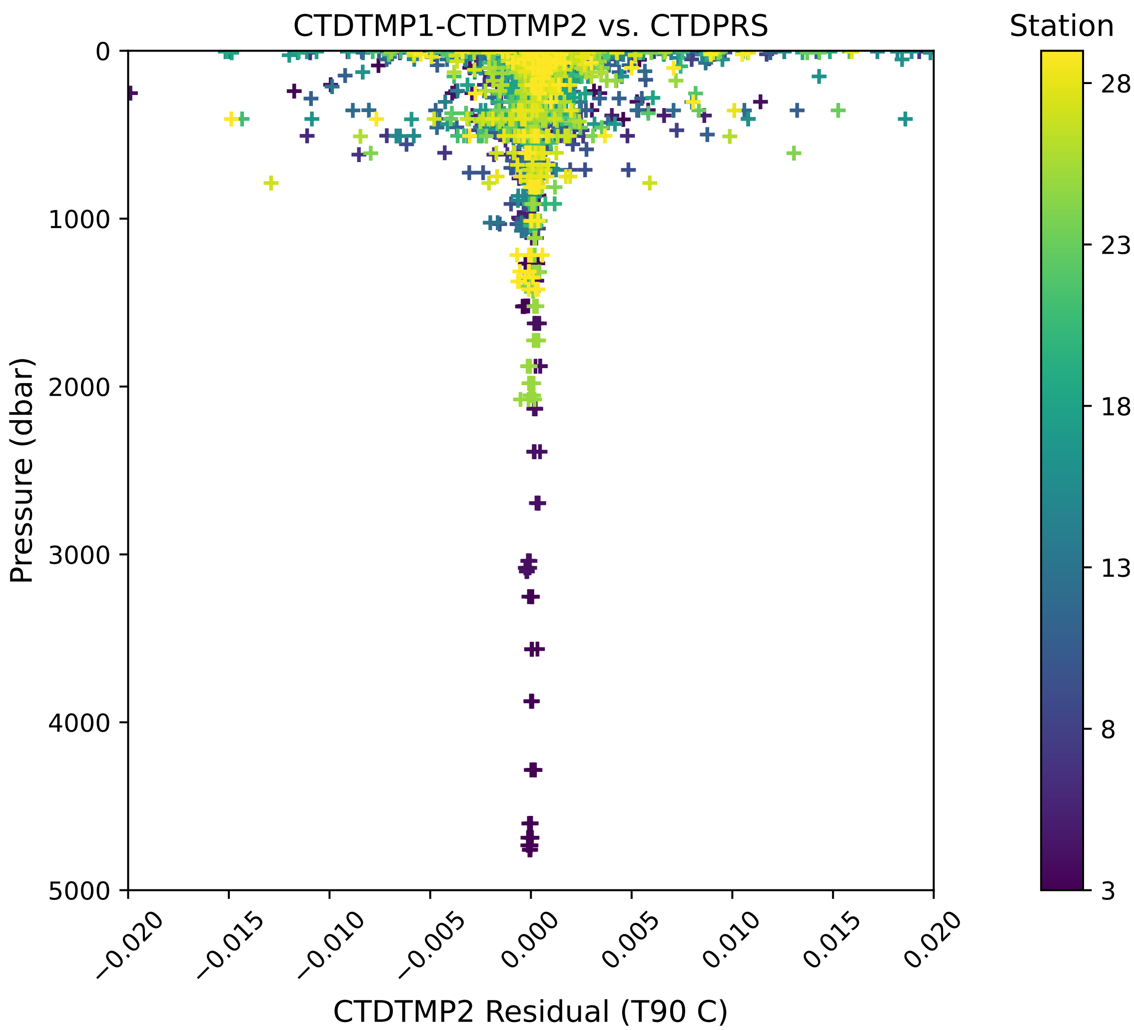


Fig. 9: T1-T2 versus pressure.

4.5 Conductivity Analysis

Laboratory calibrations of conductivity sensors were performed prior to the cruise at the Sea-Bird Calibration Facility. Dates of laboratory calibration are recorded on the underway sampling package table and calibration documents are provided in the appendices.

The pre-cruise laboratory calibration coefficients were used to convert SBE4C frequencies to mS/cm conductivity values. Additional shipboard calibrations were performed to correct sensor bias. Corrections for both pressure and temperature sensors were finalized before analyzing conductivity differences. Two independent metrics of calibration accuracy were examined. At each bottle closure, the primary and secondary conductivity were compared with each other. Each sensor was also compared to conductivity calculated from check sample salinities using CTD pressure and temperature.

The differences between primary and secondary temperature sensors were used as filtering criteria to reduce the contamination of conductivity comparisons by package wake. The coherence of this relationship is shown in the following figures.

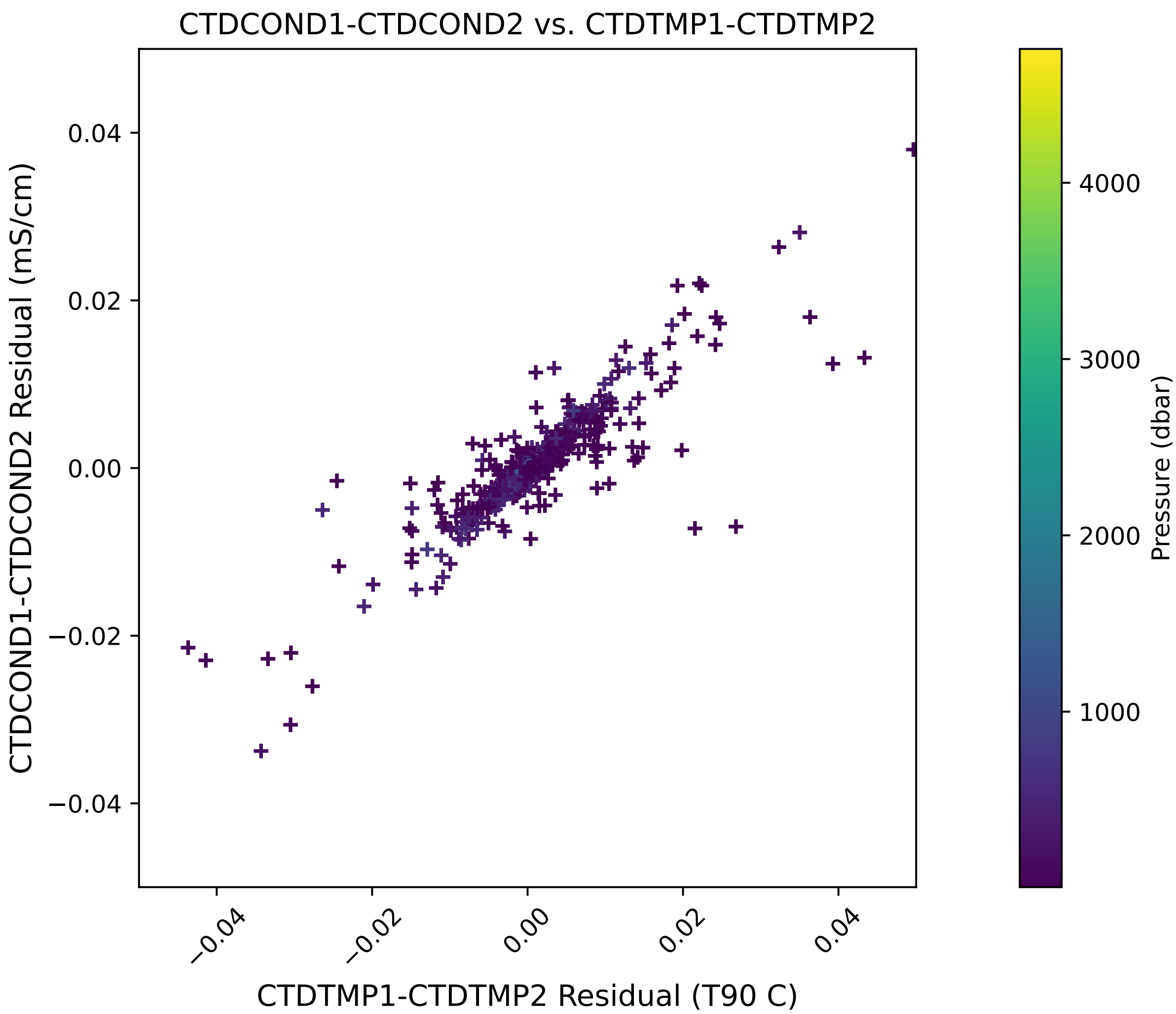


Fig. 10: Coherence of conductivity differences as a function of temperature differences.

A functioning SBE4C sensor typically exhibit a predictable modeled response. Offsets for each C sensor were deter-

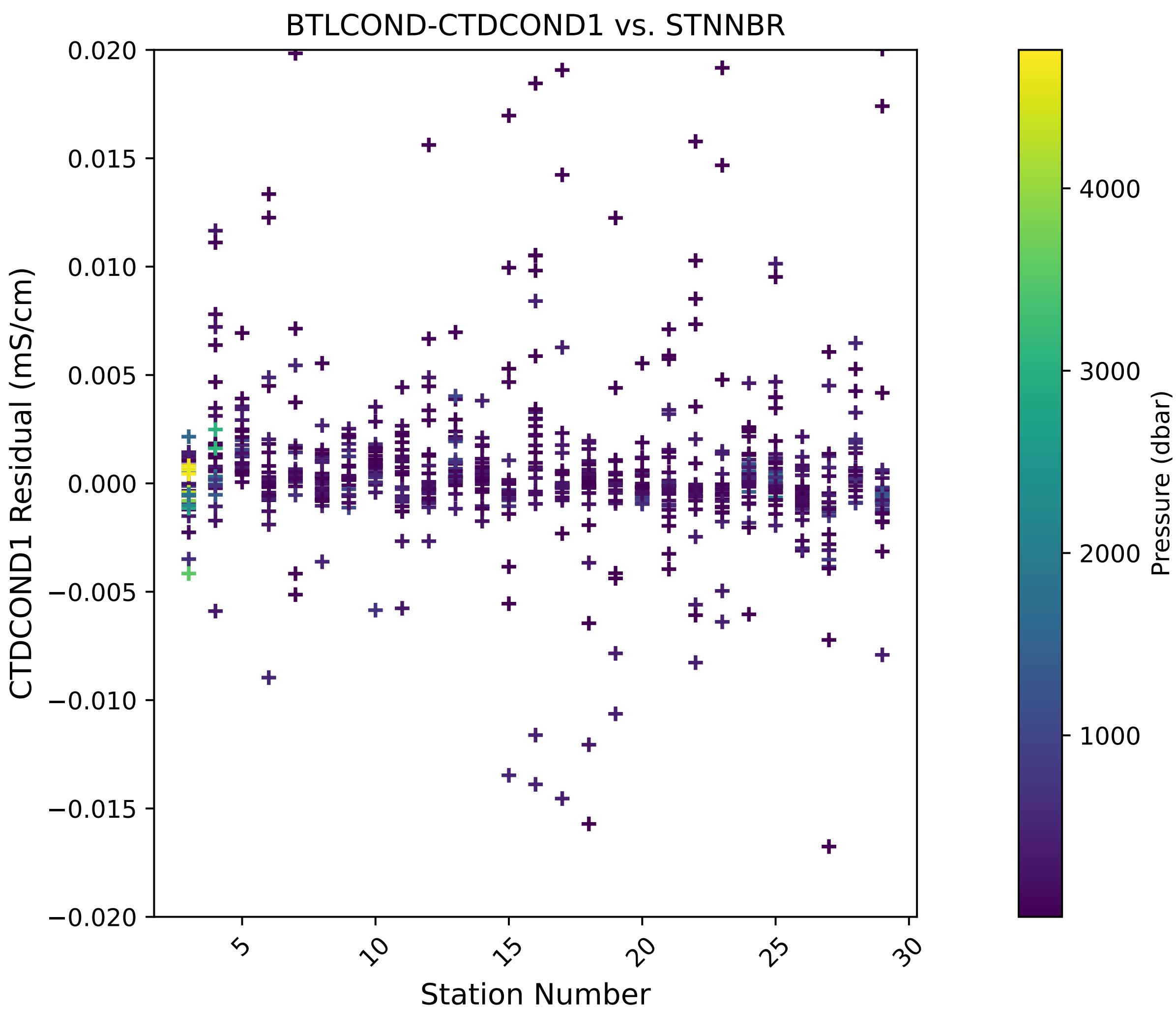


Fig. 11: Corrected C_{Bottle} - C1 versus station.

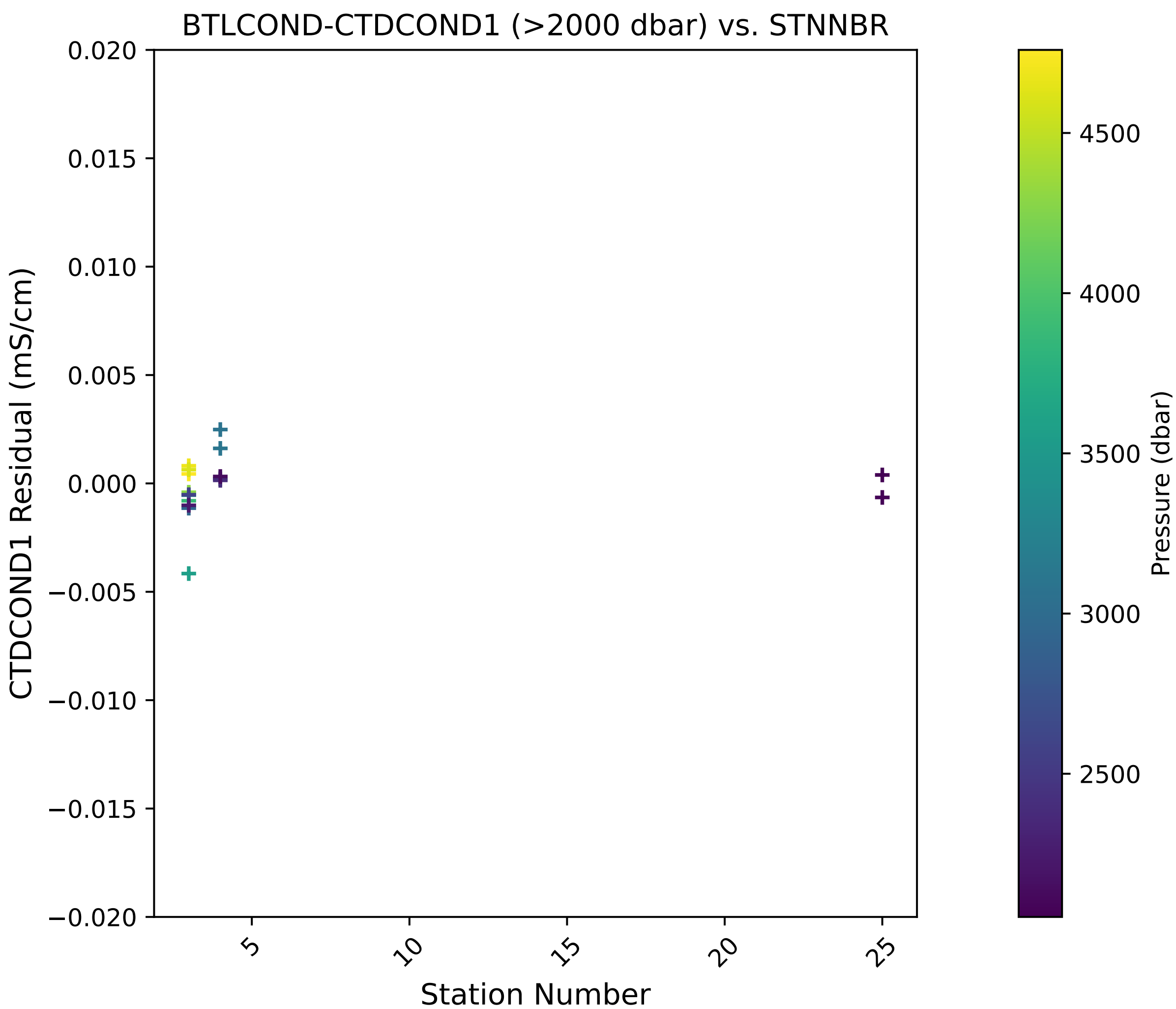


Fig. 12: Deep Corrected C_{Bottle} - C1 versus station (Pressure >= 2000dbar).

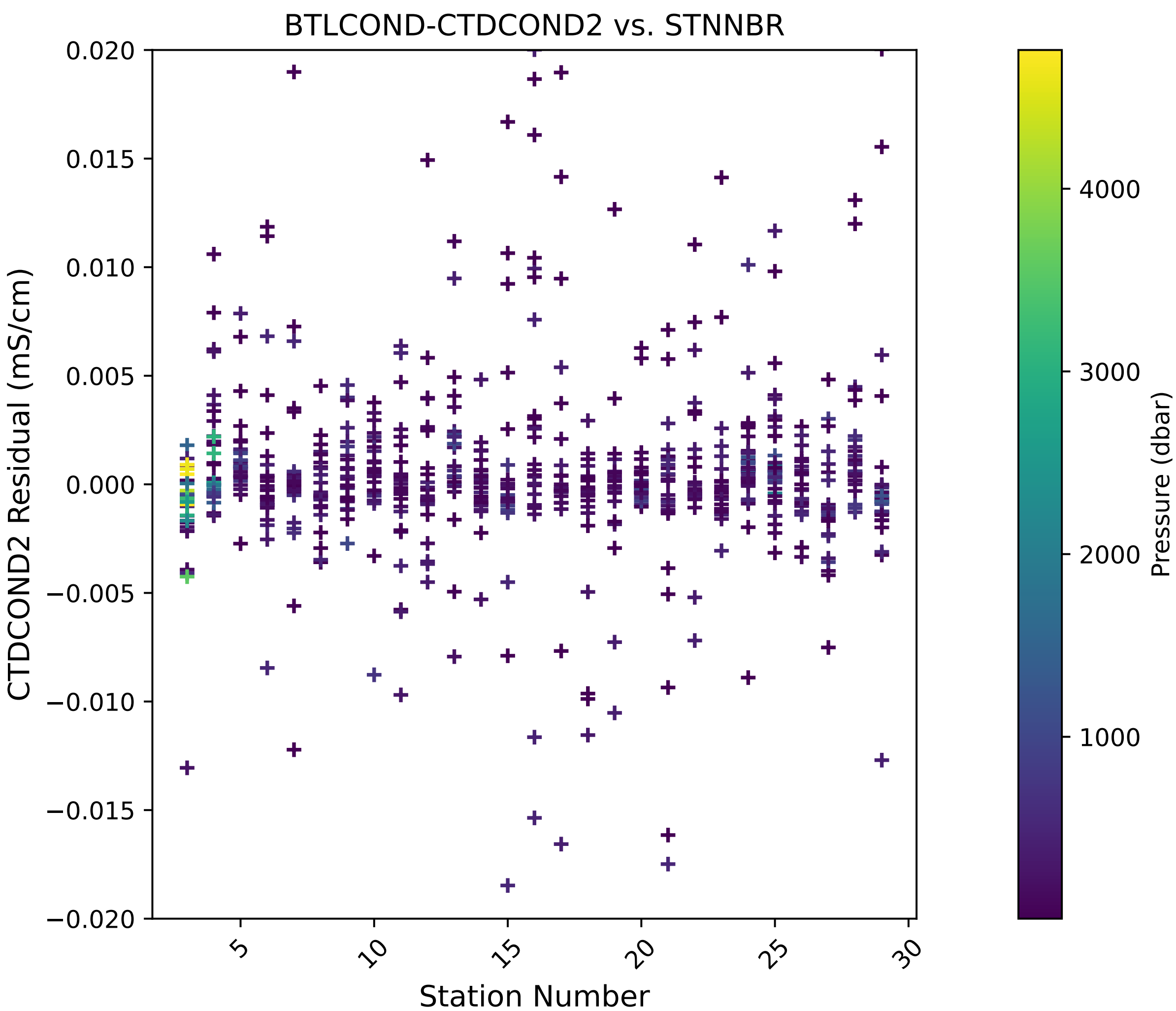


Fig. 13: Corrected C_{Bottle} - C2 versus station.

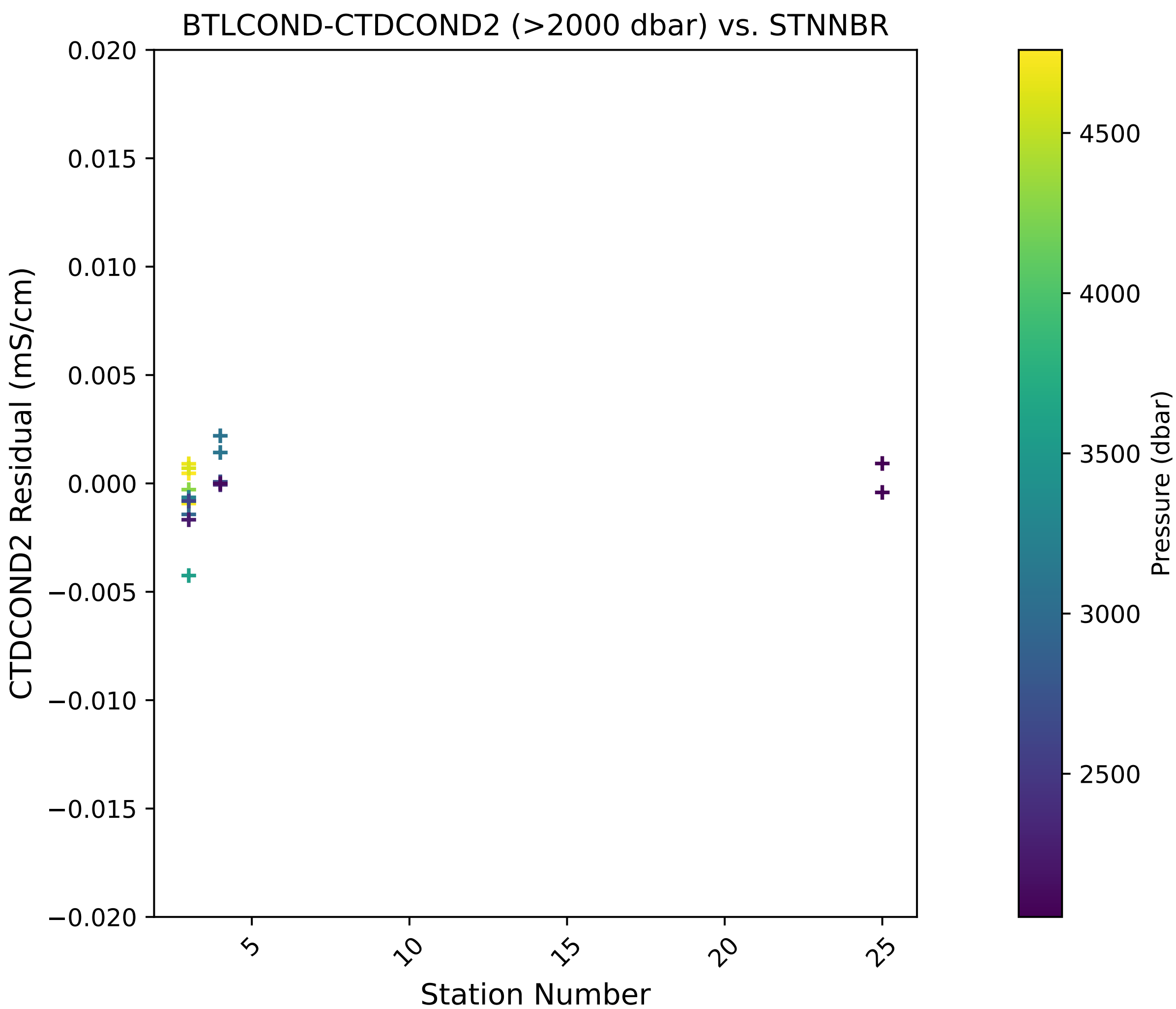


Fig. 14: Deep Corrected C_{Bottle} - C2 versus station (Pressure >= 2000dbar).

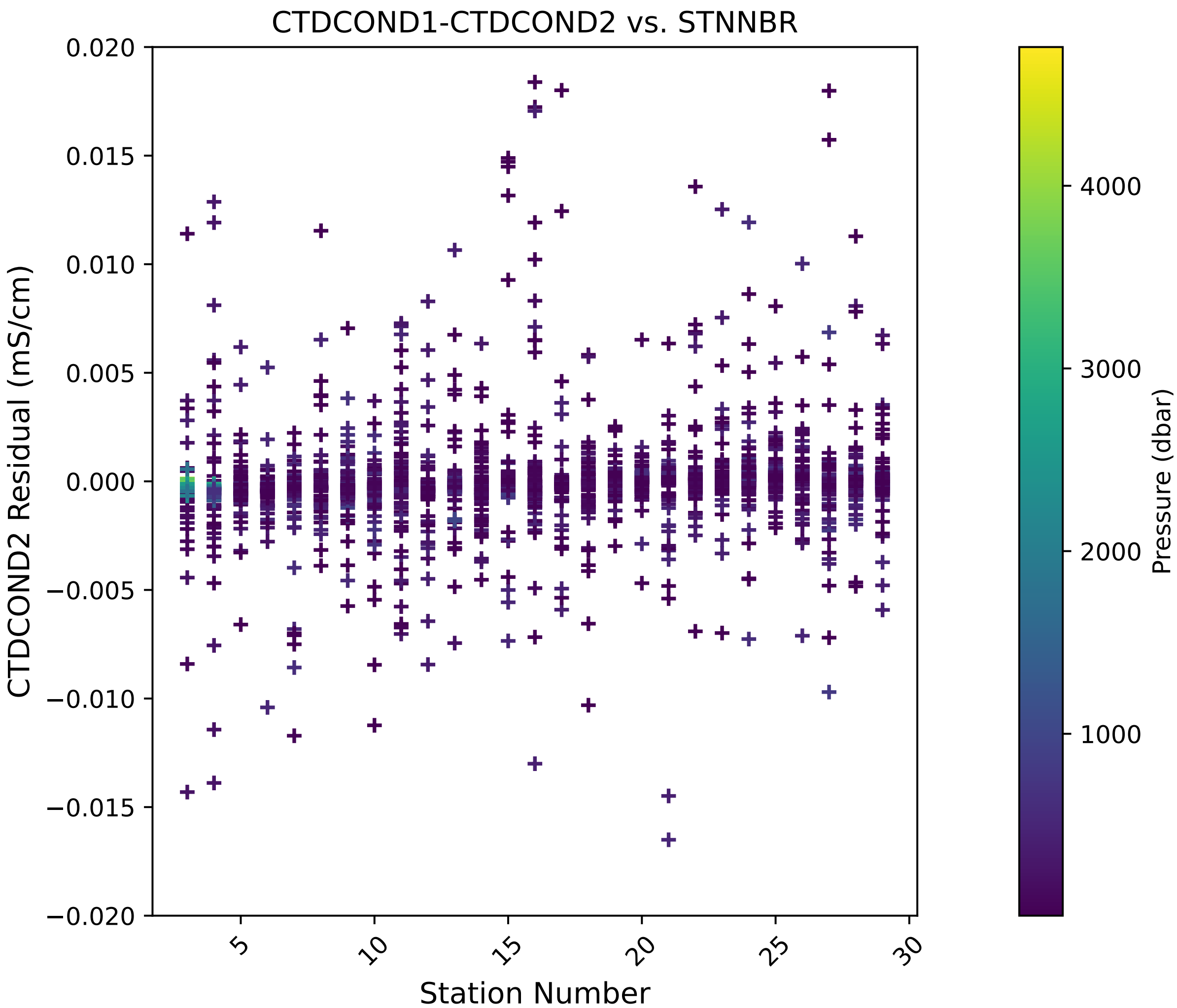


Fig. 15: Corrected C1-C2 versus station.

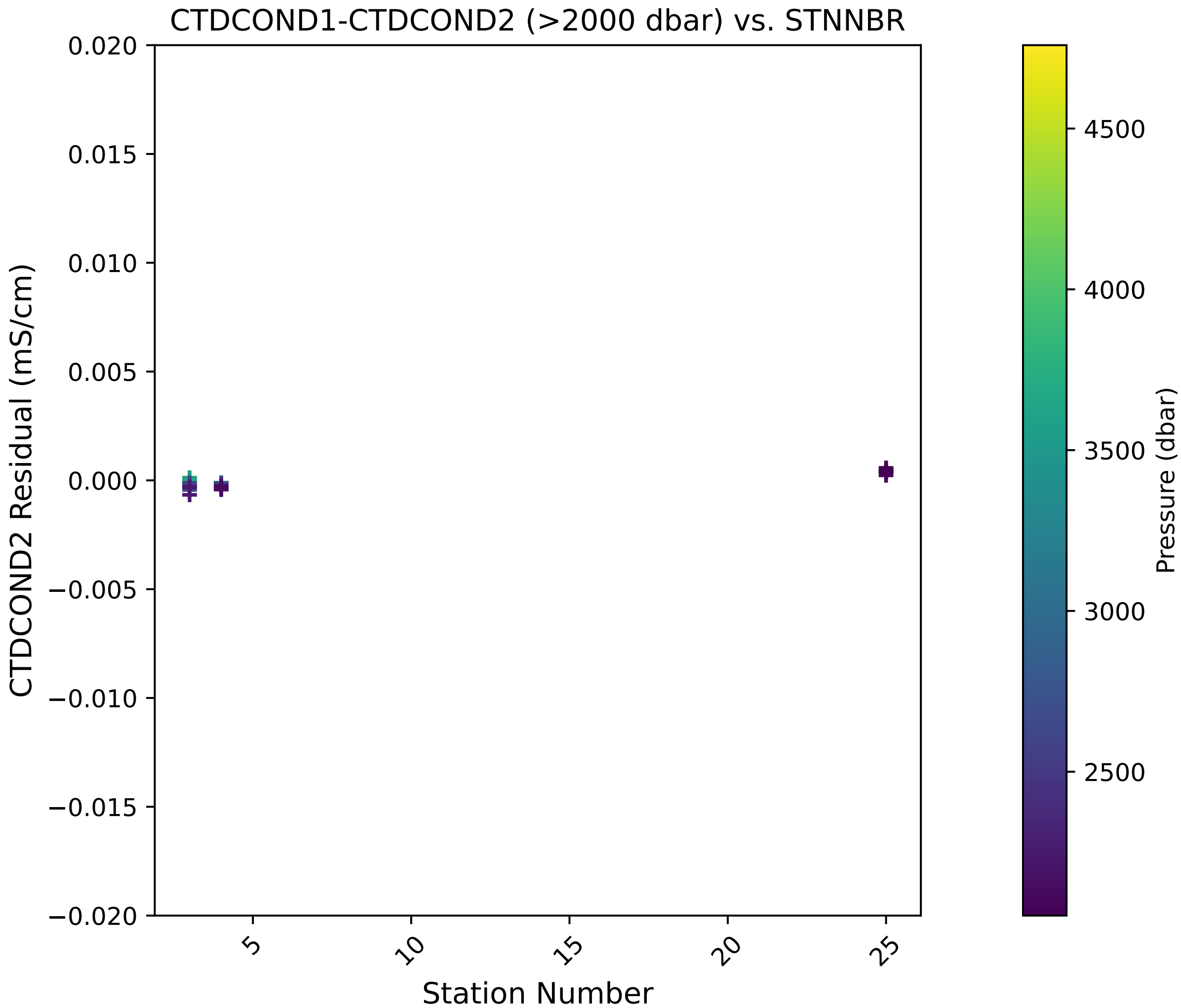


Fig. 16: Deep Corrected C1-C2 versus station (Pressure >= 2000dbar).

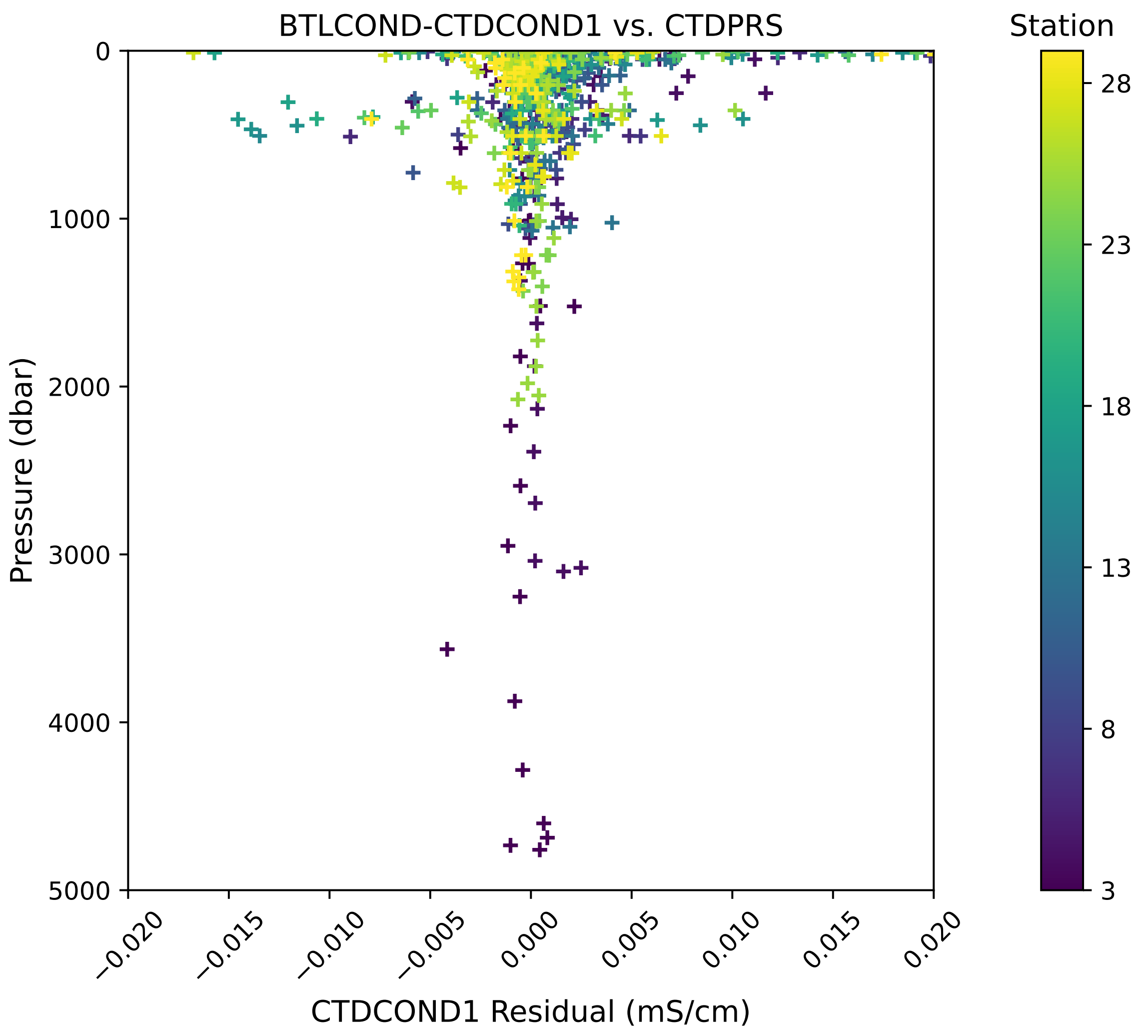


Fig. 17: Corrected C_{Bottle} - C1 versus pressure.

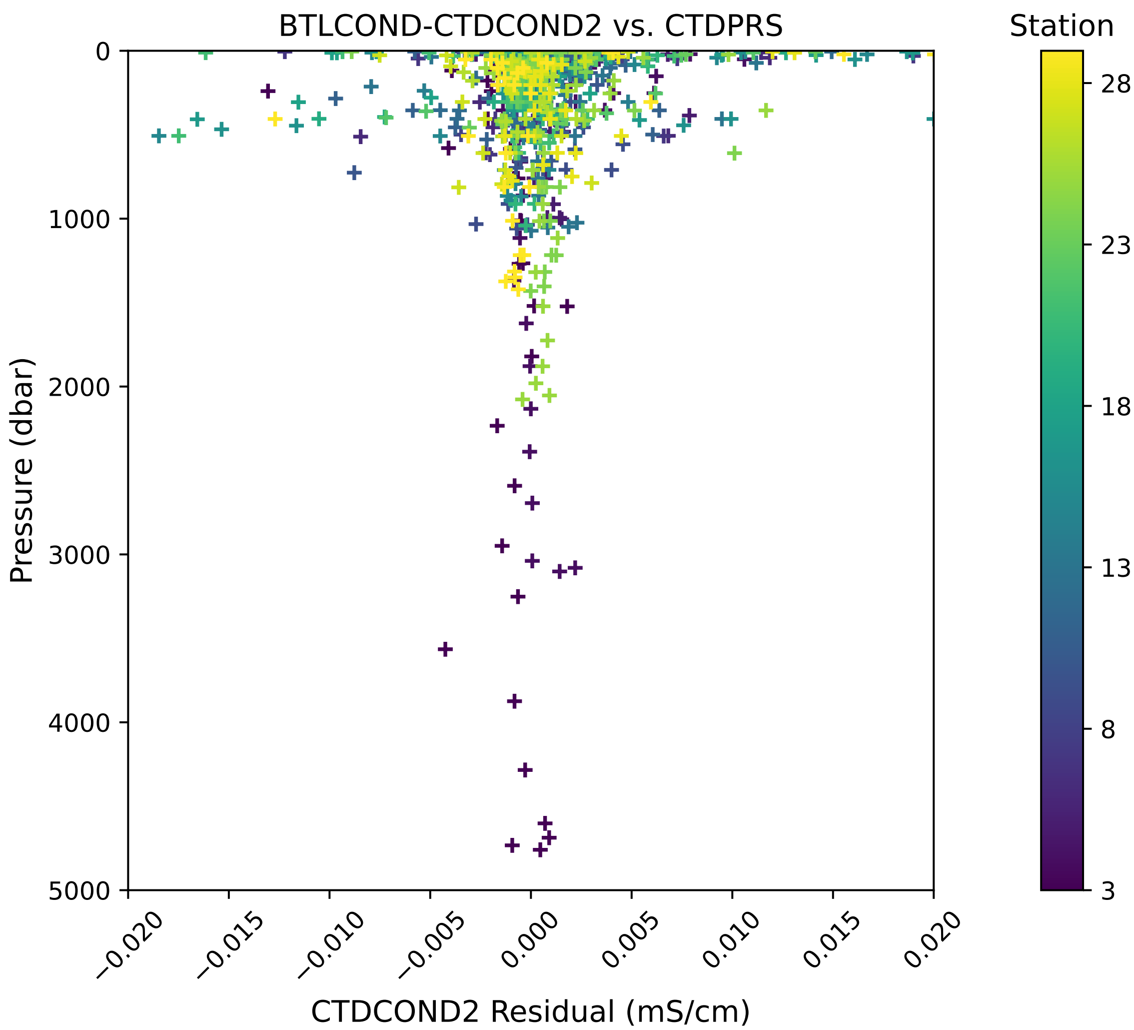


Fig. 18: Corrected C_{Bottle} - C2 versus pressure.

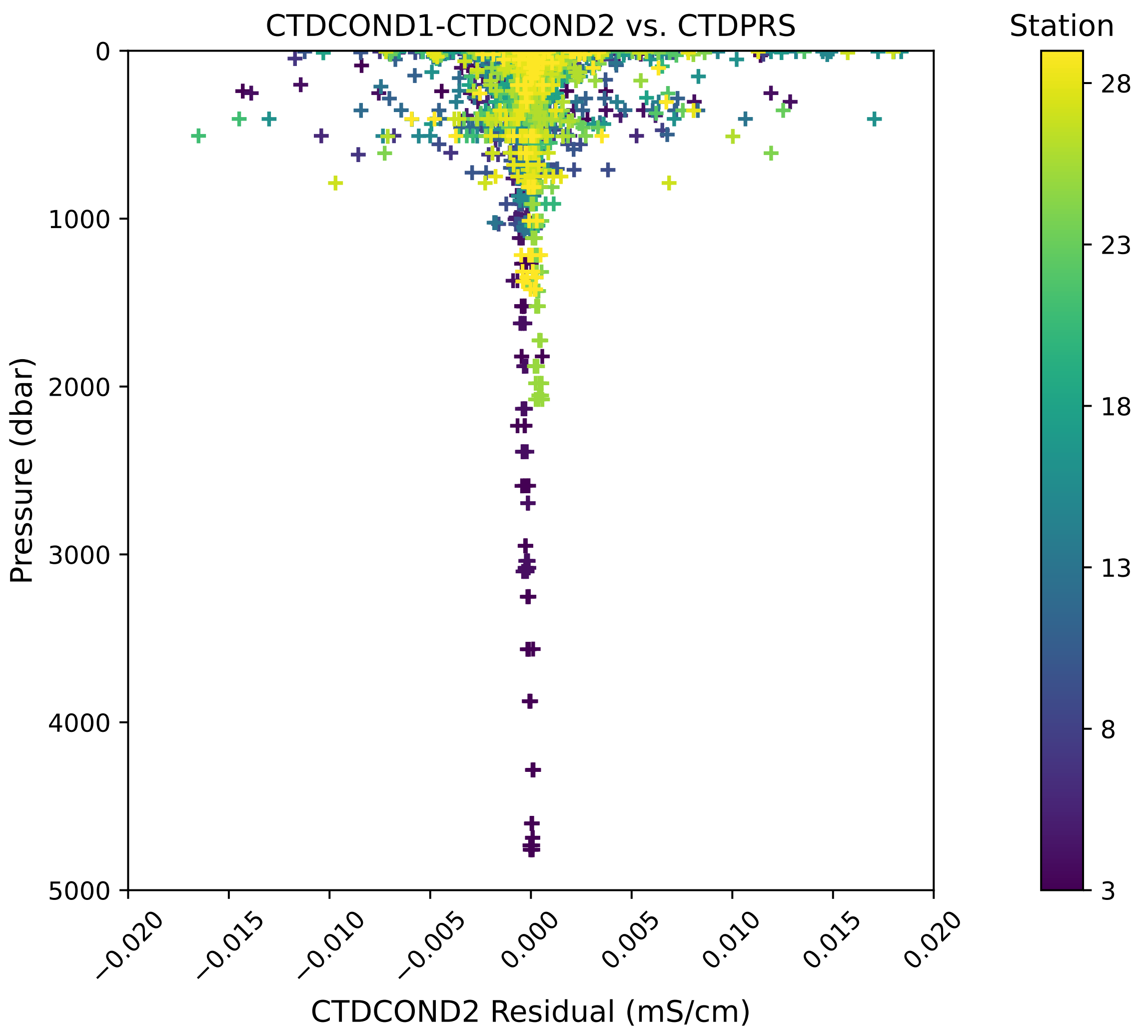


Fig. 19: Corrected C1-C2 versus pressure.

mined using C_{Bottle} - C_{CTD} differences in a deeper pressure range (500 or more dbars). After conductivity offsets were applied to all casts, response to pressure, temperature and conductivity were examined for each conductivity sensor. The response model is second-order with respect to pressure, second-order with respect to temperature, and second-order with respect to conductivity:

$$C_{cor} = C + cp_2P^2 + cp_1P + ct_2T^2 + ct_1T + cc_2C^2 + cc_1C + \text{Offset}$$

Fit coefficients for the ODF rosette are shown in the following tables.

Table 3: ODF Primary conductivity (C1) coefficients.

Station	cp_2	cp_1	ct_2	ct_1	cc_2	cc_1	c_0
3-29	-5.9364e-11	-4.0481e-7	0.0	0.0	0.0	0.0	3.3847e-3

Table 4: ODF Secondary conductivity (C2) coefficients.

Station	cp_2	cp_1	ct_2	ct_1	cc_2	cc_1	c_0
3-29	-8.5951e-11	-4.3569e-7	0.0	0.0	0.0	0.0	7.3171e-5

Fit coefficients for the GTC rosette were also generated using values from the ODF autosalinometer and are summarized in the following tables.

Table 5: GTC Primary conductivity (C1) coefficients.

Station	cp_2	cp_1	ct_2	ct_1	cc_2	cc_1	c_0
3-29	2.2117e-10	-1.6874e-6	0.0	0.0	0.0	0.0	4.3324e-3

Table 6: GTC Secondary conductivity (C2) coefficients.

Station	cp_2	cp_1	ct_2	ct_1	cc_2	cc_1	c_0
3-29	7.8292e-11	-1.3560e-6	0.0	0.0	0.0	0.0	5.9207e-3

Salinity residuals after applying shipboard P/T/C corrections are summarized in the following figures for both rosettes. Only CTD and bottle salinity data with "acceptable" quality codes are included in the differences. Quality codes and comments are published in the appendices of this report.

The 95% confidence limits for the mean low-gradient (values -0.002 ºC $\leq$ T1-T2 $\leq$ 0.002 ºC) differences are $\pm$0.01376 PSU for salinity-C1SAL. The 95% confidence limits for the deep salinity residuals (where pressure $\geq$ 2000 dbar) are $\pm$0.0033 PSU for salinity-C1SAL.

No issues affected conductivity and calculated CTD salinities during this cruise.

The resulting affected sections of data have been coded and documented in the quality code appendices.

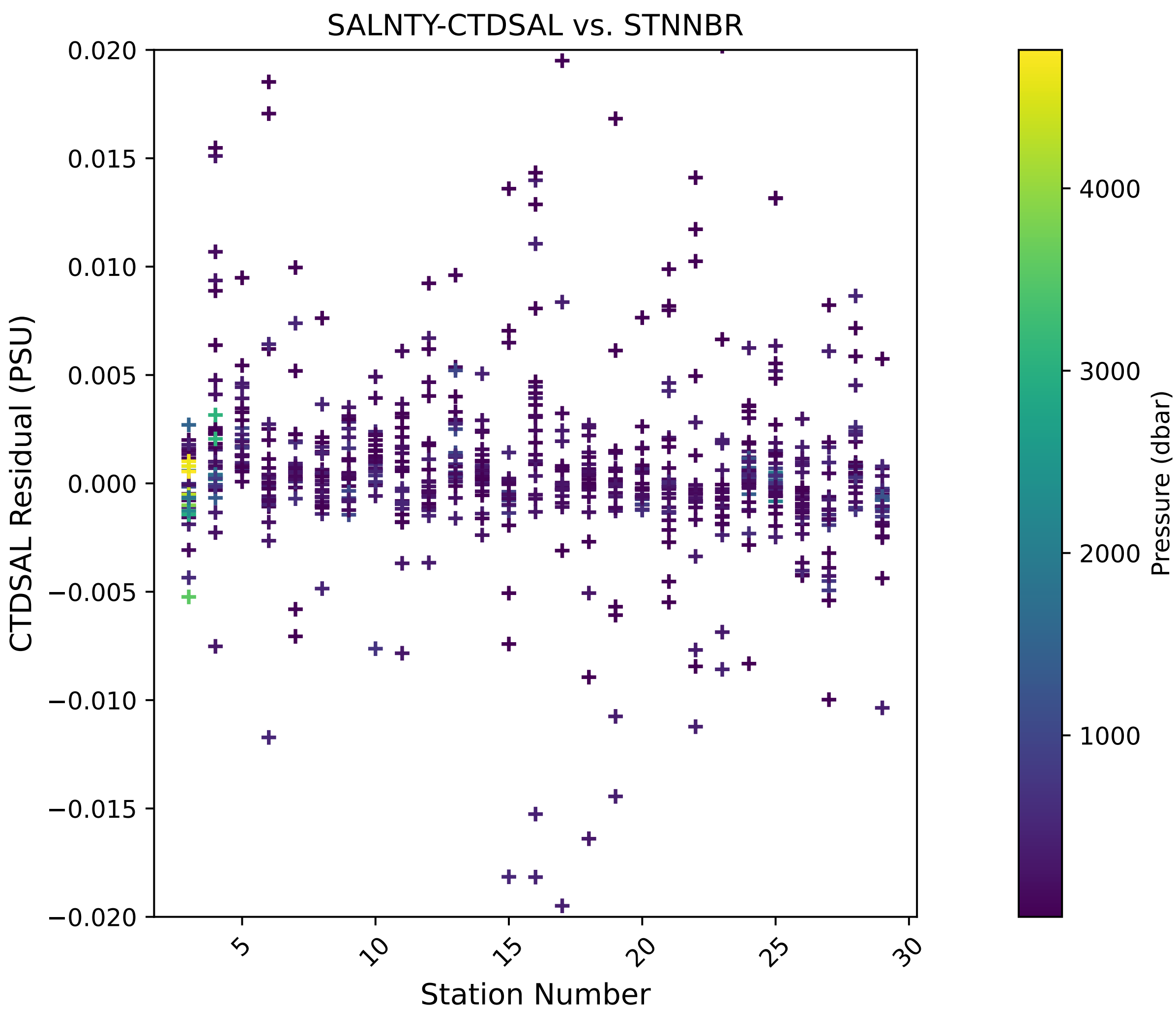


Fig. 20: Salinity residuals versus station.

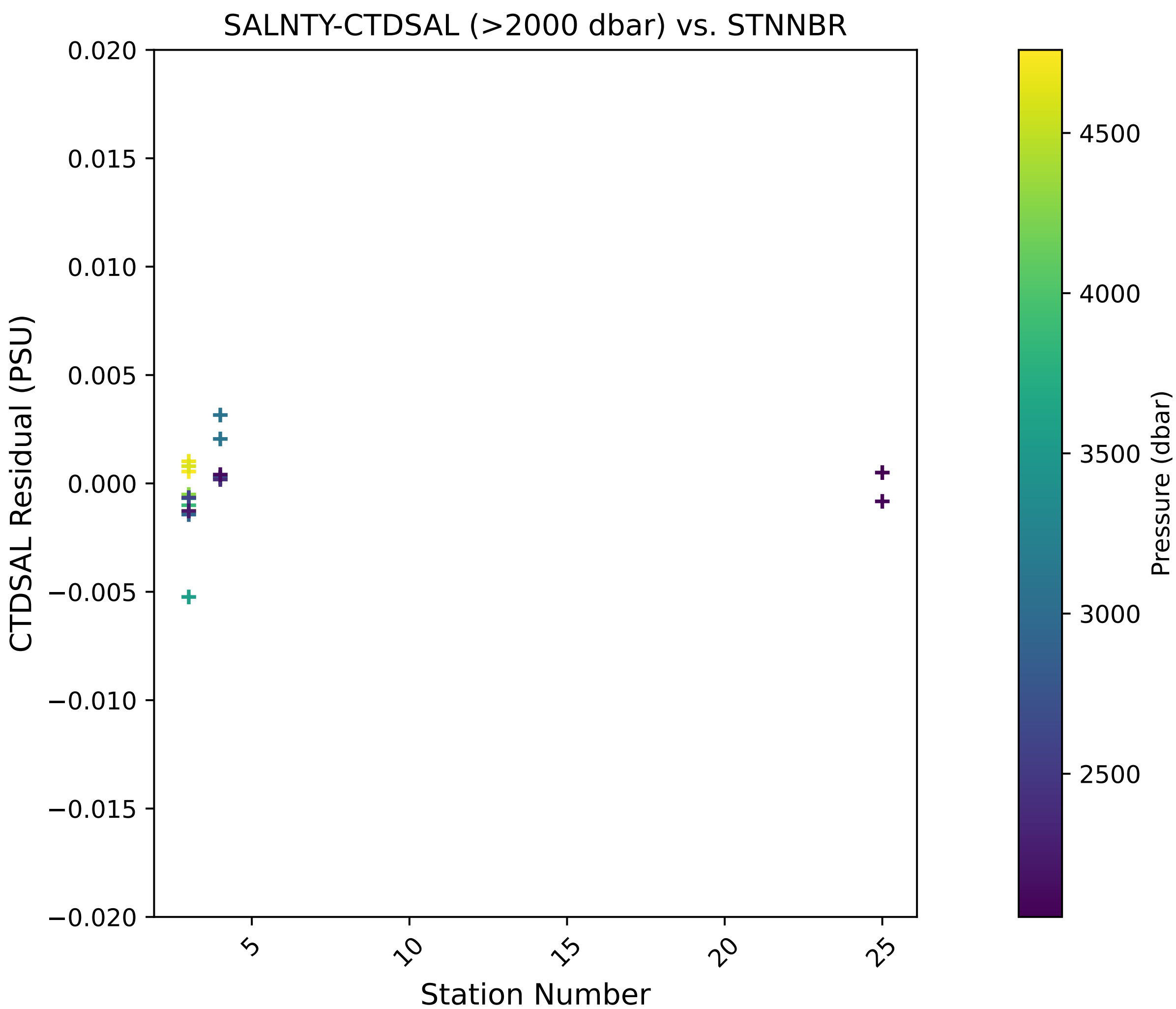


Fig. 21: Deep Salinity residuals versus station (Pressure >= 2000dbar).

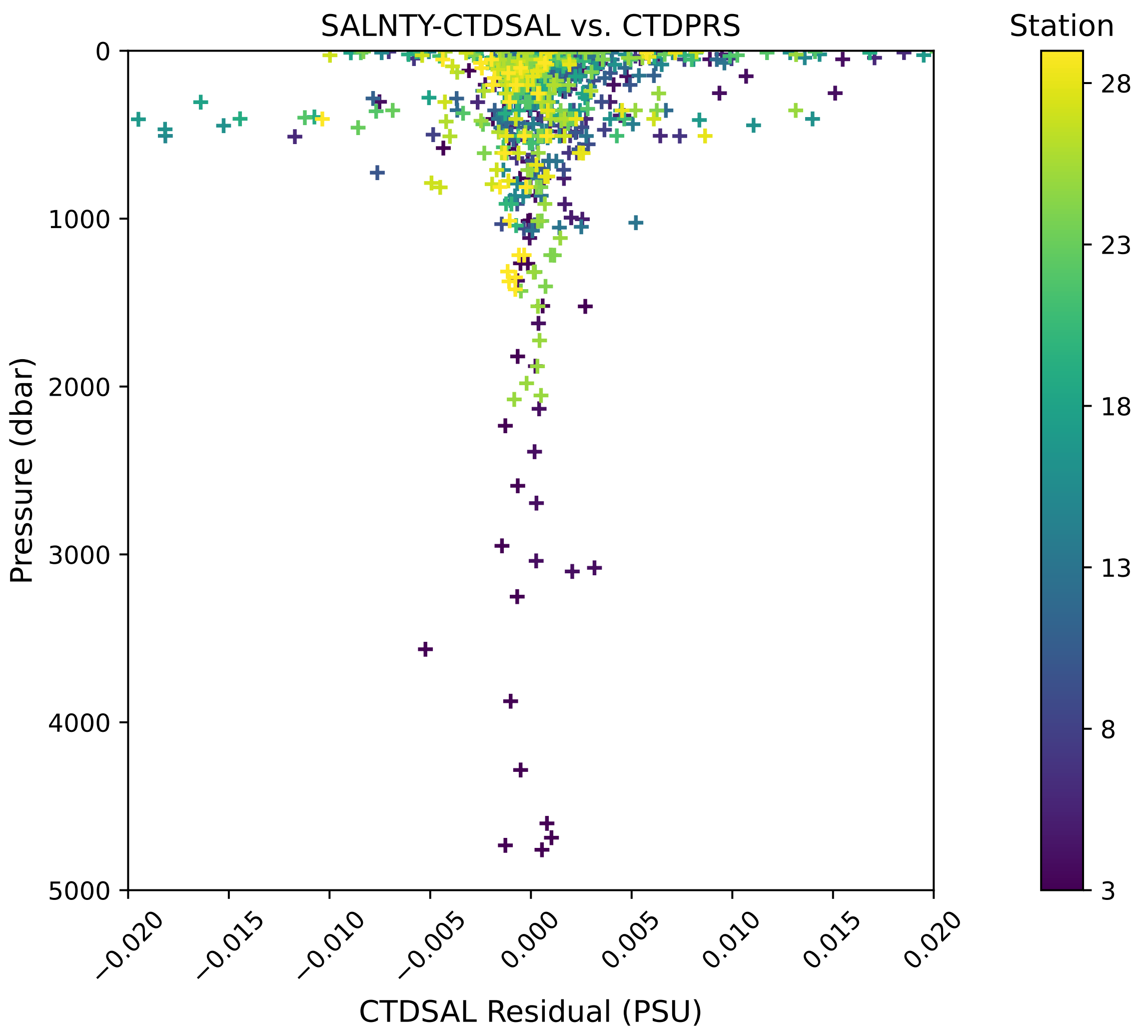


Fig. 22: Salinity residuals versus pressure.

4.6 CTD Dissolved Oxygen (SBE43)

Laboratory calibrations of the dissolved oxygen sensors were performed prior to the cruise at the SBE calibration facility. The only difference in operations between the ODF and GTC oxygen sensors was that the GTC rosette was kept outside and the oxygen sensor was removed after every cast to preserve the membrane. Dates of laboratory calibration are recorded on the underway sampling package table and calibration documents are provided in the appendices.

The pre-cruise laboratory calibration coefficients were used to convert SBE43 frequencies to µmol/kg oxygen values for acquisition only. Additional shipboard fitting were performed to correct for the sensors non-linear response. Corrections for pressure, temperature, and conductivity sensors were finalized before analyzing dissolved oxygen data. Corrections for hysteresis are applied following Sea-Bird Application Note 64-3. The SBE43 sensor data were compared to dissolved O_2 check samples taken at bottle stops by matching the downcast CTD data to the upcast trip locations along isopycnal surfaces. Unlike some other GEOTRACES cruises, 1 to 2 oxygen Winkler samples were taken for sensor fitting on GP17-ANT. CTD dissolved O_2 was then calculated using Clark Cell MPOD O_2 sensor response model for Beckman/SensorMedics and SBE43 dissolved O_2 sensors. The residual differences of bottle check value versus CTD dissolved O_2 values are minimized by optimizing the *NOAA PMEL* DO sensor response model coefficients using the *BFGS* non-linear least-squares fitting procedure.

The general form of the PMEL DO sensor response model equation for Clark cells follows Brown and Morrison [Mill82] and Owens [Owen85]. Dissolved O_2 concentration is then calculated:

$$O_2 = S_{oc} \cdot (V + V_{\text{off}} + \tau_{20} \cdot e^{(D_1 \cdot p + D_2 \cdot (T-20))} \cdot dV/dt) \cdot O_{sat} \cdot e^{T_{cor} \cdot T} \cdot e^{[(E \cdot p)/(273.15+T)]}$$

Where:

- V is oxygen voltage (V)
- D_1 and D_2 are (fixed) SBE calibration coefficients
- T is corrected CTD temperature (°C)
- p is corrected CTD pressure (dbar)
- dV/dt is the time-derivative of voltage (V/s)
- O_{sat} is oxygen saturation
- S_{oc}, V_{off}, τ_{20}, T_{cor}, and E are fit coefficients

All stations were fit together to get an initial coefficient estimate. Stations were then fit individually to refine the coefficients as the membrane does not deform the same way with each cast. If the fit of the individual cast had worse resdiuals than the group, they were reverted to the original group fit coefficients.

Table 7: ODF SBE43 group fit coefficients. Coefficients were further refined station-by-station.

Station	S_{oc}	V_{off}	tau_{20}	T_{cor}	E
3-29	4.667e-1	-4.9773e-1	3.9107e+1	-2.1329e-3	3.8353e-2

Table 8: GTC SBE43 group fit coefficients. Coefficients were further refined station-by-station.

Station	S_{oc}	V_{off}	tau_{20}	T_{cor}	E
3-29	4.7295e-1	-4.8418e-1	1.0824e+0	-2.0819e-3	3.7501e-2

CTD dissolved O_2 residuals are shown in the following figures *O2 residuals versus station.* through *Deep O2 residuals versus station (Pressure >= 2000dbar).*.

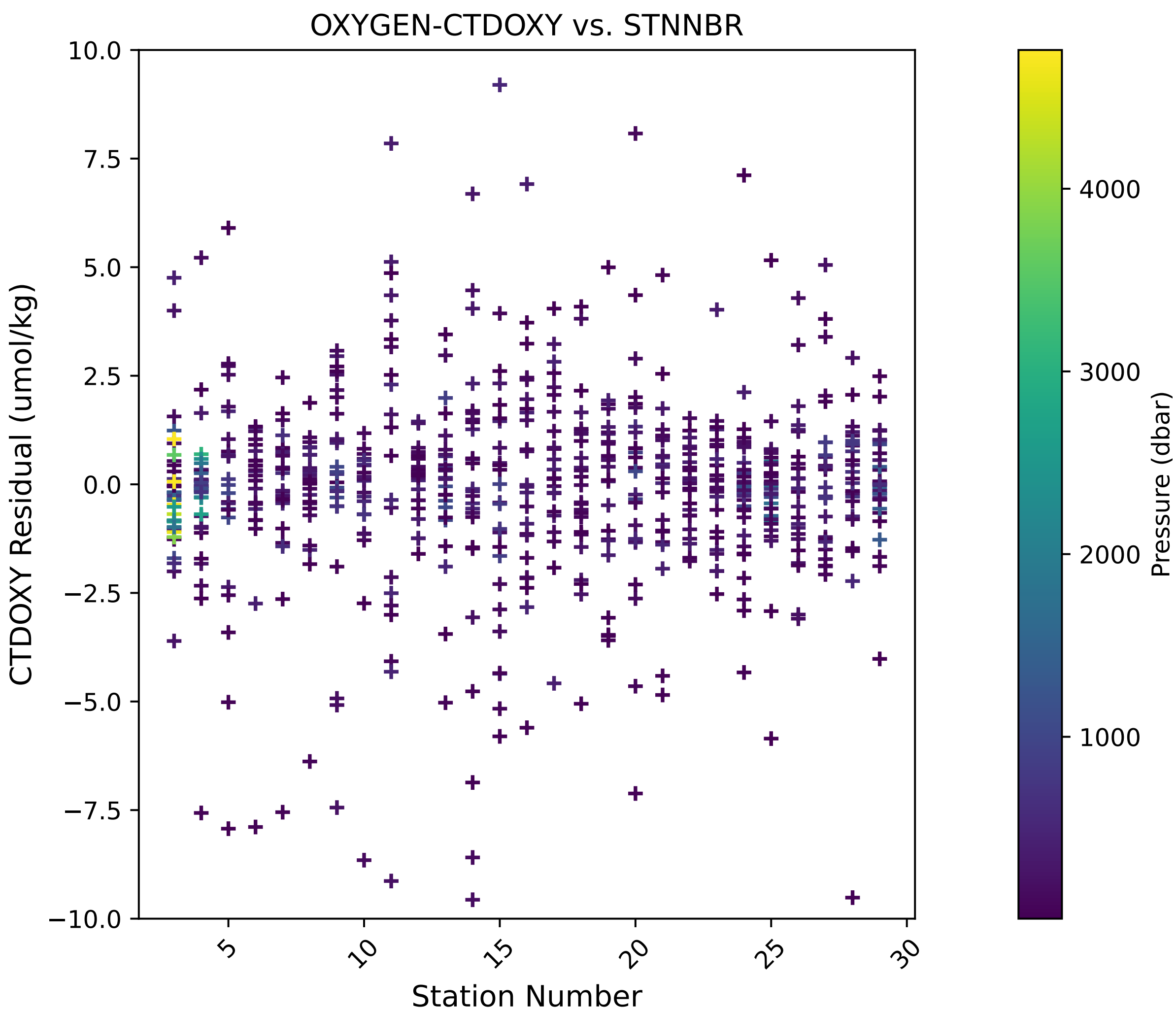


Fig. 23: O_2 residuals versus station.

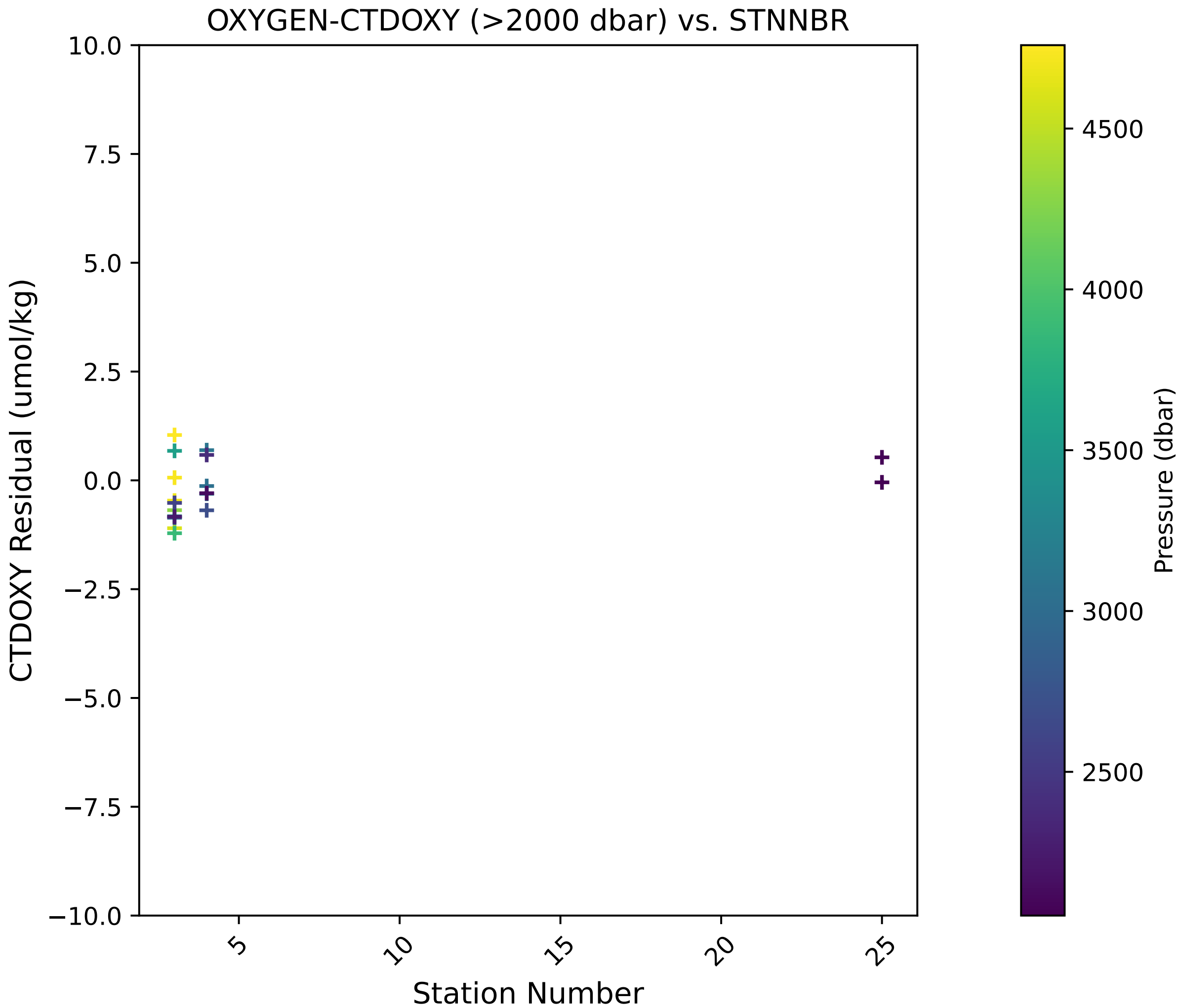


Fig. 24: Deep O_2 residuals versus station (Pressure >= 2000dbar).

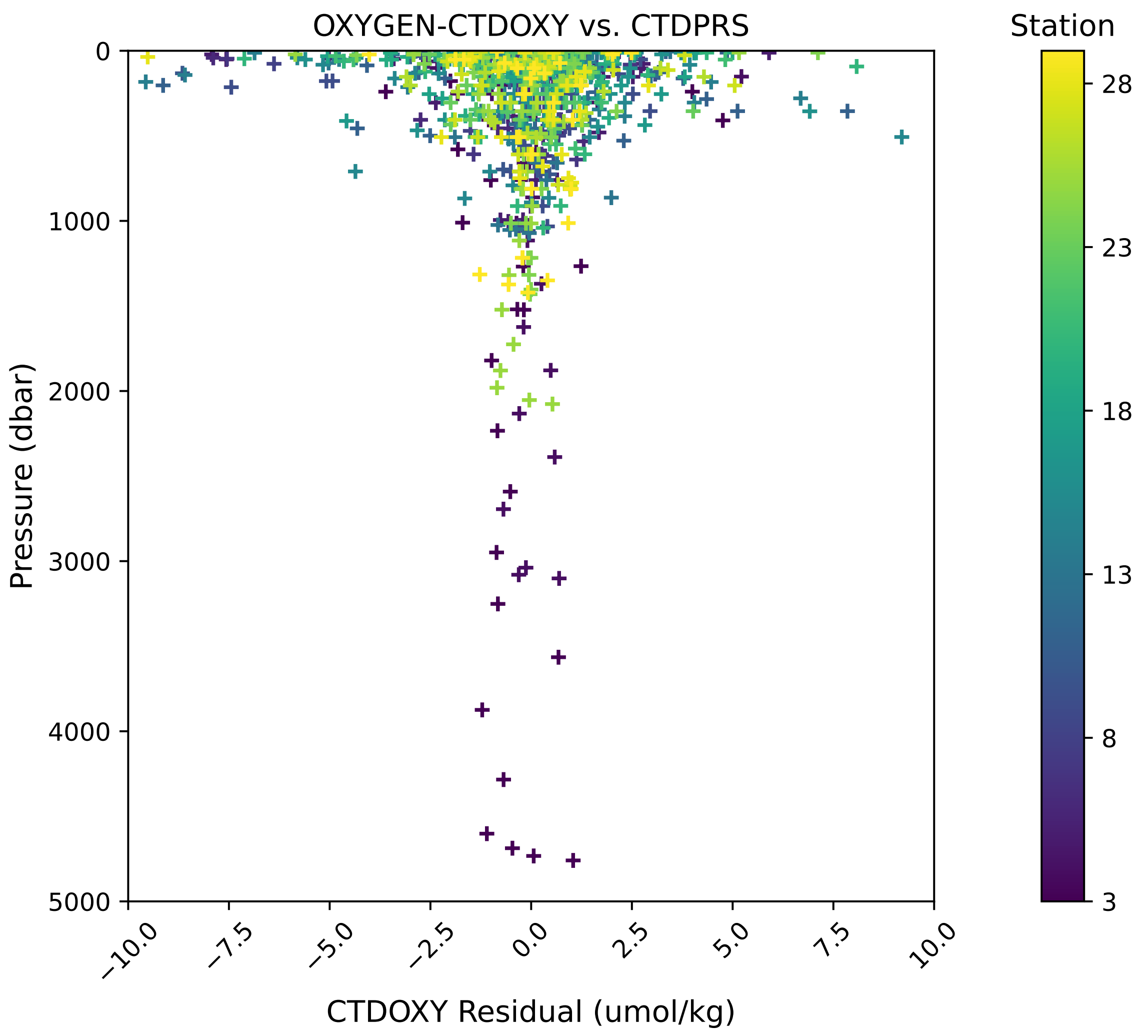


Fig. 25: O_2 residuals versus pressure.

The 95% confidence limits of 2.23 (µmol/kg) for all acceptable (flag 2) dissolved oxygen bottle data values and 1.34 (µmol/kg) for deep dissolved oxygen values are only presented as general indicators of the goodness of fit. CLIVAR GO-SHIP standards for CTD dissolved oxygen data are < 1% accuracy against on board Winkler titrated dissolved O_2 lab measurements.

No issues arose with the acquisition and processing of CTD dissolved oxygen data (SBE43).

4.7 CTD Dissolved Oxygen (RINKO)

A two-point calibration was performed prior and after deployment on the rosette. These calibrations produced sets of calibration coefficients (G and H) to adjust factory calibration of dissolved oxygen raw voltage. The calibrations also provided an assessment of foil degradation over the course of the 90 stations. As per manufacturer (JFE Advantech Co., Ltd.) recommendation, 100% saturation points were obtained via bubbling ambient air in a stirred beaker of tap water about 30 minutes, removing air stone, then submersing the powered Rinko. Zero point calibrations also followed general manufacturer recommendations, using a sodium sulfite solution (25g in 500mL deionized water). Dissolved oxygen raw voltage (DOout), atmospheric pressure, and solution temperature were recorded for calculation of new oxygen sensor coefficients (G and H).

Rinko temperature (factory coefficients) was used for pre-cruise calibration. An SBE 43 dissolved oxygen sensor was deployed simultaneously. Both oxygen sensor data sets were analyzed and quality controlled with Winkler bottle oxygen data. RinkoIII data used as primary oxygen for all stations (1-29).

RINKO data was acquired, converted from volts to oxygen saturation, and then multipled by the oxygen solubility to find values in µmol/kg. The resulting data were then fitted using the equations developed by [Uchida08]:

$$[O_2] = (V_0/V_c - 1)/K_{sv}$$

$$K_{sv} = c_0 + c_1 T + c_2 T^2, \quad V_0 = 1 + d_0 T, \quad V_c = d_1 + d_2 V_r$$

where:

- T is temperature (ºC)
- V_r is raw voltage (V)
- V_0 is voltage at zero O_2 (V)
- c_0, c_1, c_2, d_0, d_1, d_2 are calibration coefficients

Oxygen is further corrected for pressure effects:

$$[O_2]_c = [O_2](1 + c_p P/1000)^{1/3}$$

where:

- P is pressure (dbar)
- c_p is pressure compensation coefficient

Lastly, salinity corrections are applied [GarciaGordon1992]:

$$[O_2]_{sc} = [O_2]_c \exp[S(B_0 + B_1 T_S + B_2 T_S^2 + B_3 T_S^3) + C_0 S^2]$$

where:

- T_S is scaled temperature ($T_S = \ln[(298.15 - T)/(273.15 + T)]$)
- B_0, B_1, B_2, B_3, C_0 are solubility coefficients

All stations were fit together to get an initial coefficient estimate. Station were then fit in groups of similar profiles to get a further refined estimate. Individual casts were then fit to remove the noticeable time drift in coefficients. If the fit of the individual cast had worse residuals than the group, they were reverted to the original group fit coefficients. This was the case only on SSSCC 00602, where the system was underconstrained and led to unrealistic values that were 600 µmol/kg higher than other casts.

Sensor drift was most apparent between the initial transect, Dotson (*DIS*), and Getz (*GIS*) ice shelves. However, fitting casts individually was able to account for sensor drift.

Table 9: Rinko group fit coefficients. Coefficients were further refined station-by-station.

Station	c_0	c_1	c_2	d_0	d_1	d_2	c_p
3-29	2.4837e+0	1.7548e-1	-1.0020e-3	3.1672e-2	-1.8098e-1	2.685e-1	9.7101e-2

CTD dissolved O_2 residuals are shown in the following figures.

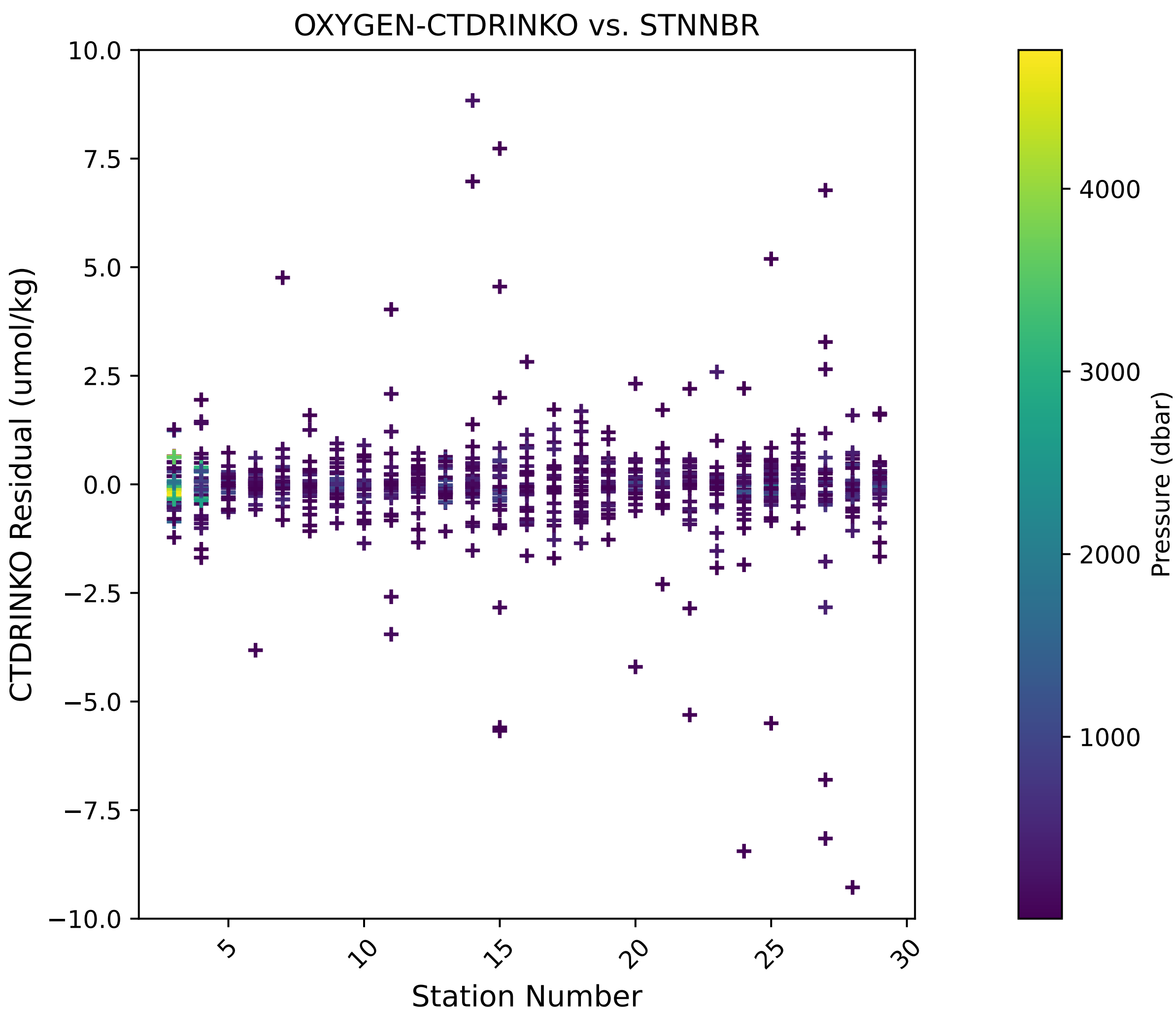


Fig. 26: O_2 residuals versus station.

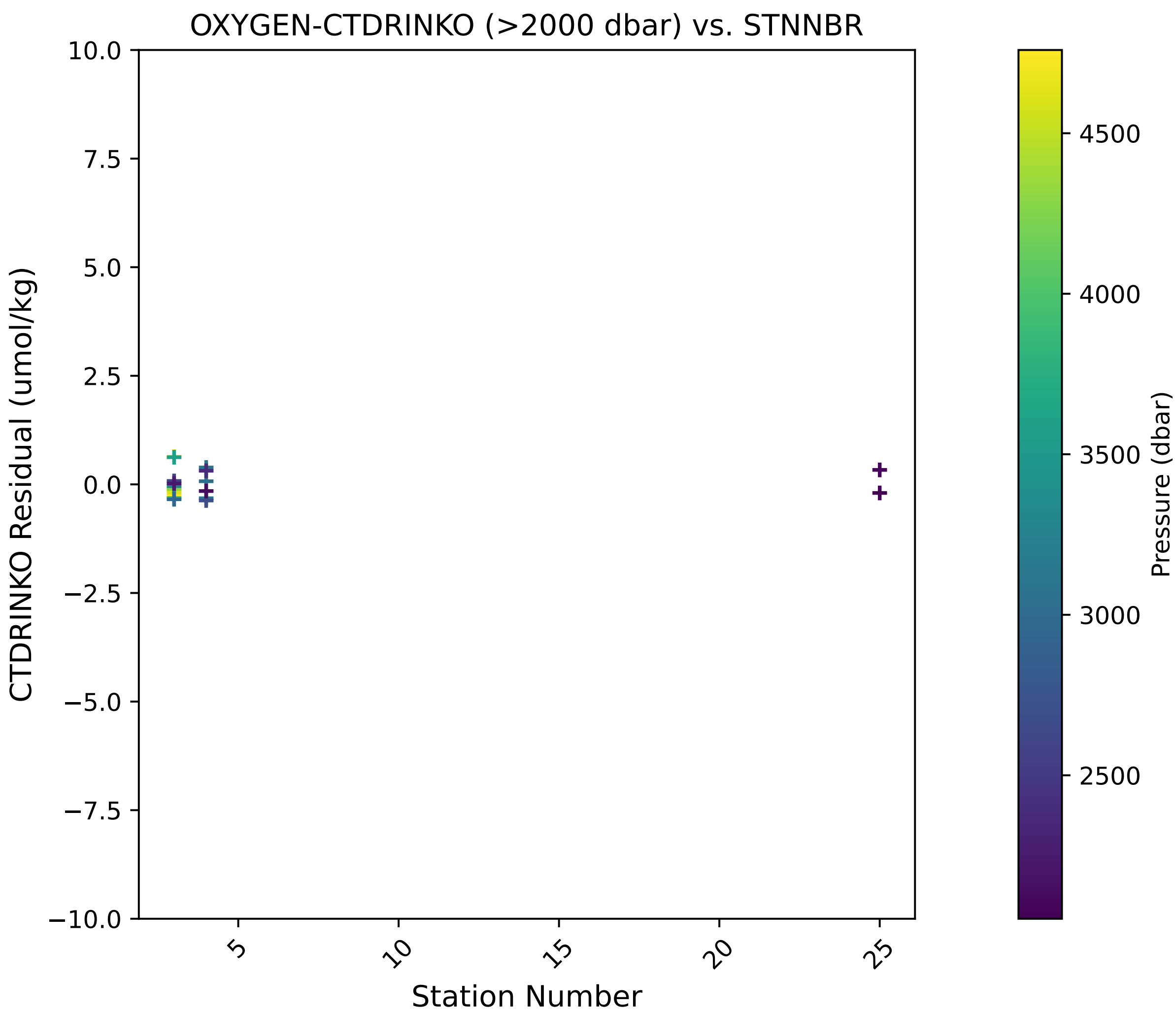


Fig. 27: Deep O_2 residuals versus station (Pressure >= 2000dbar).

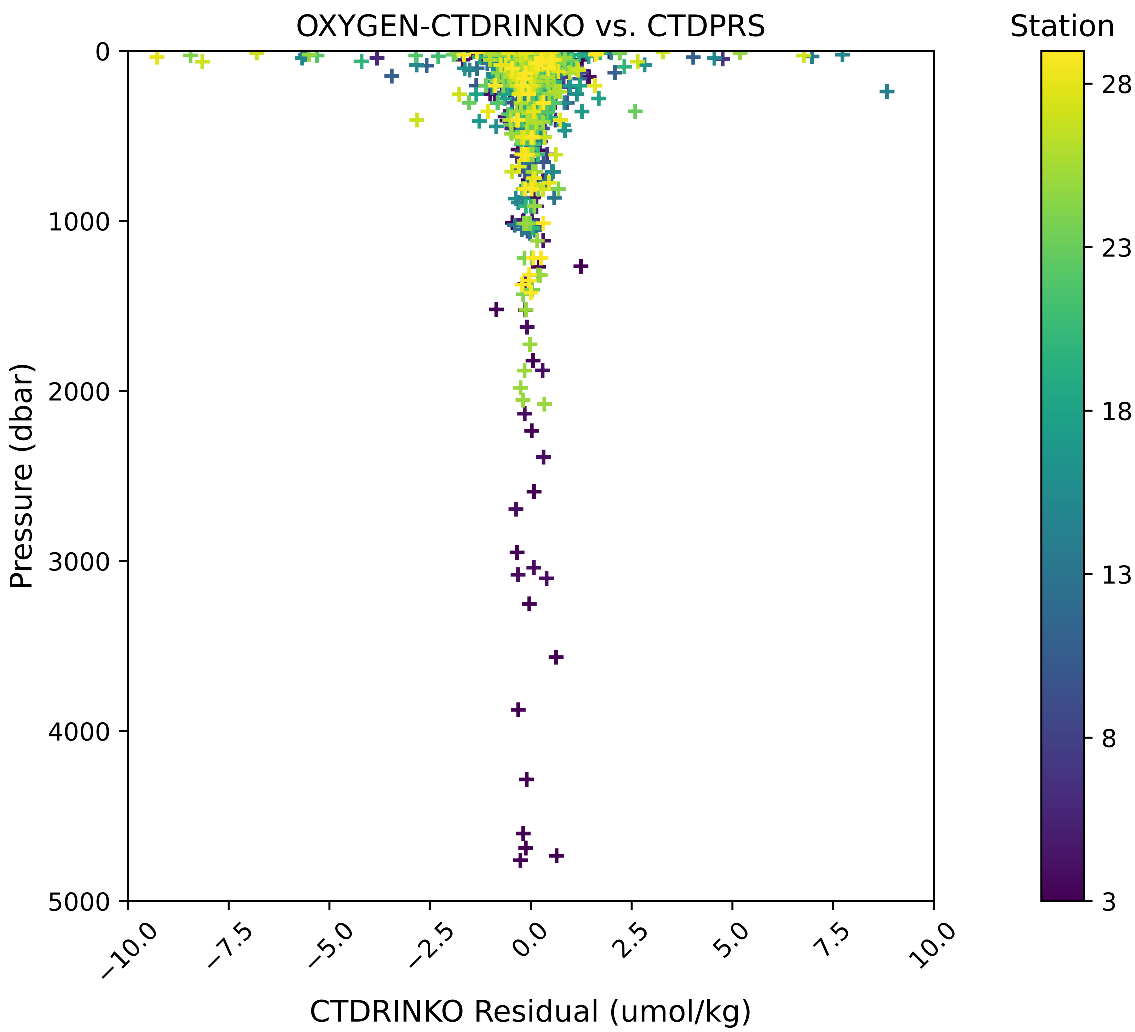


Fig. 28: O_2 residuals versus pressure.

The 95% confidence limits of 1.24 (µmol/kg) for all acceptable (flag 2) dissolved oxygen bottle data values and 0.64 (µmol/kg) for deep dissolved oxygen values are only presented as general indicators of the goodness of fit. CLIVAR GO-SHIP standards for CTD dissolved oxygen data are < 1% accuracy against on board Winkler titrated dissolved O_2 lab measurements.

No issues arose with the acquisition and processing of CTD dissolved oxygen data (RINKO).

4.8 Post-Cruise Quality Control

All casts from the ODF rosette were inspected and manually flagged using ctdcal. Bottle data were flagged as questionable (*WOCE* 3) in accordance with limits as a function of depth, as well as data which indicated a mistrip or otherwise were not believed to be accurate. Data were then reprocessed with updated flags to assess any changes to fitting residuals.

Table 10: Residual flagging limits.

Residual tolerance	Depth (m)
0.020	0-500
0.010	500-1000
0.005	1000-2000
0.002	2000-6000

The following casts were identified with major anomalies and required manual adjustments to the continuous data:

- 00707: Primary C sensor had a 3-point spike at index 12711. The issue was not present in the other sensors, but could not be remedied with a triangle filter. Hardcoded the scans to NaN.
- 01805: Issue with the pump status during the downcast. The pump status momentarily turned off during the downcast, making it difficult to detect the conclusion of the soak period. As such, the soak period was identified manually, trimming off the first ~6,500 scans from the downcast.
- 02405: Spiking behavior in T/C/O following cold gradient around 600 m depth. This was apparent in all sensors and caused iterative fitting techniques to struggle. Spikes around indices 24465 and 24770 were hardcoded to NaN and fitting coefficients were reassigned to overall group coefficients.
- 02703: The secondary T sensor spiked at index 28694. Nothing else on the secondary line suggested a clog or fouling. The scans were hardcoded to NaN and interpolated over (5 points).
- The following casts had some sort of issue writing the scan to the disk and one or more scans were manually removed:
  - 00309, 00906, 01503, 01802, 01805, 02406, 02410

CHAPTER

FIVE

SALINITY

Technicians

- Gabriel Matthias (*UNOLS* tech pool / *RVTEC*)

5.1 Sampling Equipment and Techniques

The salinity samples were collected in 200 ml Kimax high-alumina borosilicate bottles that had been rinsed at least three times with sample water prior to filling. The bottles were sealed with plastic insert thimbles and Nalgene screw caps. This assembly provides very low container dissolution and sample evaporation. Prior to sample collection, inserts were inspected for proper fit and loose inserts replaced to insure an airtight seal.

Samples were collected for the *ODF* and *GTC* rosettes, as well as for Megacore/Multicore 30 L niskins and McLane, radium, and beryllium pumps.

5.2 Analysis and Data Processing

Salinity analysis was run in the Environmental Control room, located most aft of the bio lab. The chamber temperature varied between about 20 and 21 degrees Celcius, depending on room activity. Laboratory temperature was also monitored electronically throughout the cruise. Salinity analyses were performed after samples had equilibrated to laboratory temperature of 21 °C, usually 8 hours or more after collection.

A Guildline Autosalinometer was aboard, an 8400A (S/N 526) owned by SIO and loaded into the ODF container in Port Hueneme, California, in October 2023. The Palmer had a Guildline 8410A "Portasal" aboard (S/N 71938). The Portasal was acquired by the Palmer in 2016 and was last serviced in 2020. Due to issues with the SIO-owned 8400A, the 8410A Portasal was used for salinity analysis for all stations excluding the first soak.

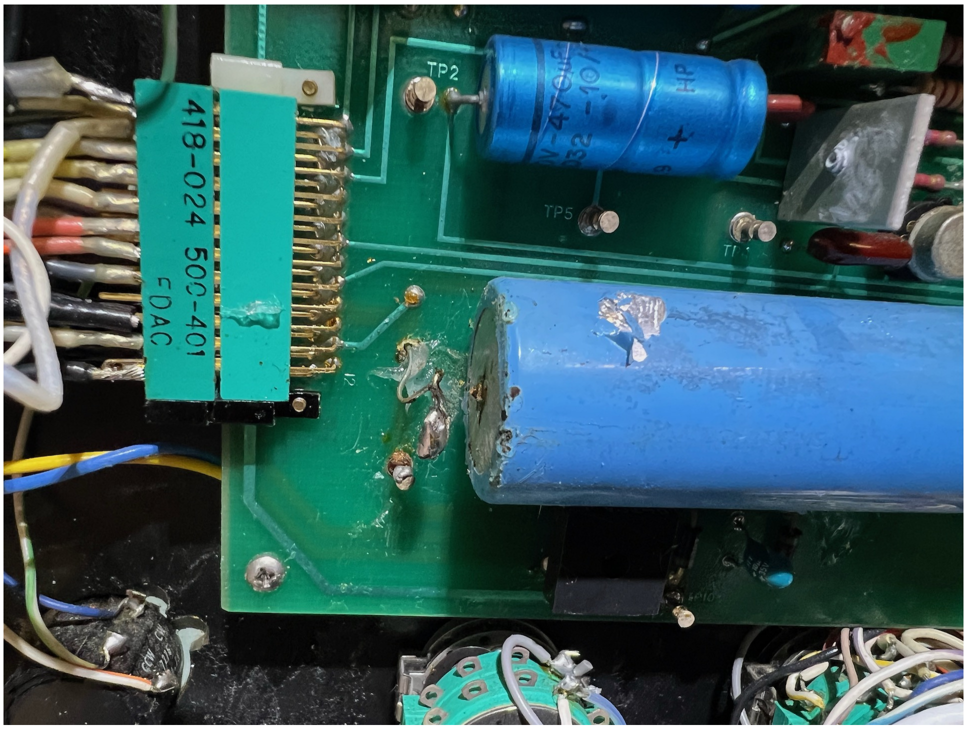
Communications with the Portasal were established using a Windows 10 workstation running Sainometer Data Logger v1.2 by Ocean Scientific International. The salinometer was standardized for each group of samples analyzed (normally 2 to 6 casts, up to ~95 samples) using two bottles of standard seawater: one at the beginning and one at the end of each set of measurements. *IAPSO* Standard Seawater Batch P-167 was used for all calibrations: K15 = 0.99988, salinity 34.994, expiration 2026-02-21. For each calibration standard and sample reading, the salinometer cell was initially flushed at least 3 times before a set of conductivity ratio readings was recorded. Between runs the water from the last standard was left in the cell. If long periods (exceeding 2 days) were taken between samples, the cell was filled with deionized water from the ship instead.

PSS-78 salinity [UNESCO1981] was calculated for each sample from the measured conductivity ratios. The offset between the initial standard seawater value and its reference value was applied to each sample. Then the difference (if any) between the initial and final vials of standard seawater was applied to each sample as a function of elapsed run time. The corrected salinity data was then incorporated into the cruise database.

5.3 Narrative

The cruise began with the SIO-owned 8400A autosal set up for salinity measurements. A LabView program (LVasal) developed by Carl Mattson was used for monitoring temperatures, logging data and prompting the operator while using the autosal 8400A.

Issues arose in port (Nov. 18th) with the 8400A where the standby and zero values were fluctuating wildly when testing an IAPSO standard. The cause was found to be that, during shipping, a connection had come undone on the 10,000 µF capacitor C101, which regulates power to the conductivity cell. This was re-soldered the next day.



During the collection of salt samples on the soak station (station 1), a large crack was found on 36-bottle sample crate "W" and was removed from circulation.

The 8400A capacitor issue persisted and had to be re-soldered again on December 4th, prior to running the samples from the soak cast at station 1. A new analysis issue arose while running the samples. Conductivity measurements were found to be consistently dropping as sampling continued. When running an IAPSO standard by itself, the conductivity CR value would climb by an excess of 0.00200 over a short time. However, the salinity of the IAPSO standard was well below what was expected. The unit was disassembled and the power supply board was taken off. The C101 capacitor, in addition to many other aspects of the board, had been modified in a way that made it difficult to keep the capacitor in the circuit.

Using materials on the ship, a more robust connection was made to the C101 capacitor and the power supply board was remounted inside the unit. Unfortunately, the issue persisted thereafter. With values continuing to climb well after flushing the cell, the 8410A Portasal was set up for primary use. The 8410A returned strange values during 00205 and it was calibrated before running salts on 00301. Values prior to 00301 have been discarded.

ODF samples were collected at test stations 1 and 2 to check ODF rosette bottles for leaks. All other ODF samples were collected with one sample at each target sampling depth unless otherwise noted. Salinity analyses were also performed for other sampling groups throughout the cruise, including all bottles of the GTC rosette for every cast to check for *GO-FLO* Niskin mistrips and calibrate the conductivity sensors.

While analyzing salts sample bottle 18 from SSSCC 01906 (niskin #13) was broken and the sample was lost.

There was some noise in the portasal readings on 2024-1-2, though the standard deviation of the conductivity ratio was still below 0.00001 per sample. Just in case, Triton-X was passed through the system to clean it out.

While sampling the salts on SSSCC 02906, salt bottle #29 was dropped and broke by the rosette. Sampling resumed using salt bottle #30.

1,682 total salinity samples were analysed over the course of the cruise.

CHAPTER

SIX

NUTRIENTS

Technicians

- Kelcey Chung

6.1 Summary of Analysis

- 1219 samples from 27 CTD stations, including samples from both Rosettes (ODF and Trace Metal), McClane pump cast, Radium surface pumps, multicore niskin, and sea ice sampling.
- The cruise started with new pump tubes and they were change once after the ODF PigRaTh cast at station 17.
- 3 sets of Primary/Secondary mixed standards and 2 sets of primary Nitrite standards were made up over the course of the cruise.
- The cadmium column efficiency was checked periodically and ranged between 90%-100%.

6.2 Equipment and Techniques

Nutrient analyses (phosphate, silicate, nitrate+nitrite, and nitrite) were performed on a Seal Analytical continuous-flow AutoAnalyzer 3 (AA3). The methods used are described by Gordon et al [Gordon1992] Hager et al. [Hager1972], and Atlas et al. [Atlas1971]. Details of modification of analytical methods used in this cruise are also compatible with the methods described in the nutrient section of the updated GO-SHIP repeat hydrography manual (Becker et al., 2019, [Becker2019]).

6.3 Nitrate/Nitrite Analysis

A modification of the Armstrong et al. (1967) [Armstrong1967] procedure was used for the analysis of nitrate and nitrite. For nitrate analysis, a seawater sample was passed through a cadmium column where the nitrate was reduced to nitrite. This nitrite was then diazotized with sulfanilamide and coupled with N-(1-naphthyl)-ethylenediamine to form a red dye. The sample was then passed through a 10mm flowcell and absorbance measured at 520nm. The procedure was the same for the nitrite analysis but without the cadmium column.

REAGENTS

Sulfanilamide

Dissolve 10g sulfamilamide in 1.2N HCl and bring to 1 liter volume. Add 1 drop of 30% Brij 35 surfactant. Store at room temperature in a dark poly bottle.

N-(1-Naphthyl)-ethylenediamine dihydrochloride (N-1-N)

Dissolve 1g N-1-N in DIW, bring to 1 liter volume. Add 1 drop of 30% Brij 35 surfactant. Store at room temperature in a dark poly bottle. Discard if the solution turns dark reddish brown.

Imidazole Buffer

Dissolve 13.6g imidazole in ~3.8 liters DIW. Stir for at least 30 minutes to completely dissolve. Add 1 drop of CuSO4 (see below). Add 1 drop of 30% Brij 35 surfactant. Let sit overnight before proceeding. Using a calibrated pH meter, adjust to pH of 7.83-7.85 with 10% (1.2N) HCl (about 10 ml of acid, depending on exact strength). Bring final solution to 4L with DIW. Store at room temperature.

$CuSO_4$

Dissolve 2g cupric sulfate in DIW, bring to 100 mL volume (2%).

6.4 Phosphate Analysis

Ortho-Phosphate was analyzed using a modification of the Bernhardt and Wilhelms (1967) [Bernhardt1967] method. Acidified ammonium molybdate was added to a seawater sample to produce phosphomolybdic acid, which was then reduced to phosphomolybdous acid (a blue compound) following the addition of dihydrazine sulfate. The sample was passed through a 10mm flowcell and absorbance measured at 820nm.

REAGENTS

Ammonium Molybdate H_2SO_4 sol'n

Pour 420 ml of DIW into a 2 liter Ehrlenmeyer flask or beaker, place this flask or beaker into an ice bath. SLOWLY add 330 ml of conc H_2SO_4. This solution gets VERY HOT!! Cool in the ice bath. Make up as much as necessary in the above proportions.

Dissolve 27g ammonium molybdate in 250ml of DIW. Bring to 1 liter volume with the cooled sulfuric acid sol'n. Add 3 drops of 15% DDS surfactant. Store in a dark poly bottle.

Dihydrazine Sulfate

Dissolve 6.4g dihydazine sulfate in DIW, bring to 1 liter volume and refrigerate.

6.5 Silicate Analysis

Silicate was analyzed using the basic method of Armstrong et al. (1967). Acidified ammonium molybdate was added to a seawater sample to produce silicomolybdic acid which was then reduced to silicomolybdous acid (a blue compound) following the addition of stannous chloride. The sample was passed through a 10mm flowcell and measured at 660nm.

REAGENTS

Tartaric Acid

Dissolve 200g tartaric acid in DW and bring to 1 liter volume. Store at room temperature in a poly bottle.

Ammonium Molybdate

Dissolve 10.8g Ammonium Molybdate Tetrahydrate in 1000ml dilute H_2SO_4. (Dilute H_2SO_4 = 2.8ml conc H_2SO_4 or 6.4ml of H_2SO_4 diluted for PO_4 moly per liter DW) (dissolve powder, then add H_2SO_4) Add 3-5 drops 15% SDS surfactant per liter of solution.

Stannous Chloride

stock: (as needed)

Dissolve 40g of stannous chloride in 100 ml 5N HCl. Refrigerate in a poly bottle.

NOTE: Minimize oxygen introduction by swirling rather than shaking the solution. Discard if a white solution (oxychloride) forms.

working: (every 24 hours) Bring 5 ml of stannous chloride stock to 200 ml final volume with 1.2N HCl. Make up daily - refrigerate when not in use in a dark poly bottle.

6.6 Sampling

Nutrient samples were drawn into 30 ml polypropylene screw-capped centrifuge tubes. The tubes and caps were cleaned with 10% HCl and rinsed 2-3 times with sample before filling. Samples were analyzed within 1-24 hours after sample collection, allowing sufficient time for all samples to reach room temperature. The centrifuge tubes fit directly onto the sampler.

6.7 Data Collection and Processing

Data collection and processing was done with the software provided with the instrument from Seal Analytical (AACE). After each run, the charts were reviewed for any problems during the run, any blank was subtracted, and final concentrations (micro moles/liter) were calculated, based on a linear curve fit. Once the run was reviewed and concentrations calculated a text file was created. That text file was reviewed for possible problems and then converted to another text file with only sample identifiers and nutrient concentrations that was merged with other bottle data.

6.8 Standards and Glassware Calibration

Primary standards for silicate (Na_2SiF_6), nitrate (KNO_3), nitrite ($NaNO_2$), and phosphate (KH_2PO_4) were obtained from Johnson Matthey Chemical Co. and/or Fisher Scientific. The supplier reports purities of >98%, 99.999%, 97%, and 99.999 respectively.

All glass volumetric flasks and pipettes were gravimetrically calibrated prior to the cruise. The primary standards were dried and weighed out to 0.1mg prior to the cruise. The exact weight was noted for future reference. When primary standards were made, the flask volume at 20C, the weight of the powder, and the temperature of the solution were used to buoyancy-correct the weight, calculate the exact concentration of the solution, and determine how much of the primary was needed for the desired concentrations of secondary standard. The new standards were compared to the old before use.

All the reagent solutions, primary and secondary standards were made with fresh distilled deionized water (DIW).

Standardizations were performed at the beginning of each group of analyses with working standards prepared every 12-16 hours from a secondary. Working standards were made up in low nutrient seawater (LNSW). Two batches of LNSW were used on the cruise. All batches of LNSW were treated in the lab. The water was re-circulated for ~8 hours through a 0.2 micron filter, passed a UV lamp and through a second 0.2 micron filter. The actual concentration of nutrients in this water was empirically determined during the standardization calculations.

The concentrations in micro-moles per liter of the working standards used were:

-	N+N (uM)	PO_4 (uM)	SIL (uM)	NO_2 (uM)
0	0.0	0.0	0.0	0.0
1	15.50	1.2	60	0.50
2	31.00	2.4	120	1.00
2	46.50	3.6	180	1.50

6.9 Quality Control

All final data was reported in micro-moles/kg. NO_3, PO_4, and NO_2 were reported to two decimals places and SIL to one. Accuracy is based on the quality of the standards the levels are:

NO_3	0.05 µM (micro moles/Liter)
PO_4	0.004 µM
SIL	2-4 µM
NO_2	0.05 µM

The deep check sample (99) was collected on the first soak station and was analyzed on every station.

Reference materials for nutrients in seawater (RMNS) were used as a check sample run with every station. The RMNS preparation, verification, and suggested protocol for use of the material are described by [Aoyama2006] [Aoyama2007], [Aoyama2008], Sato [Sato2010] and Becker et al. [Becker2019] . RMNS batch CM was used on this cruise, with each bottle being used for all runs in one day before being discarded and a new one opened. Data are tabulated below.

Parameter	Concentration	stddev	assigned conc
-	(µmol/kg)	-	(µmol/kg)
NO_3	33.12	0.18	33.2
PO_4	2.39	0.02	2.38
Sil	100.8	1.0	100.5
NO_2	0.025	0.005	0.02

6.10 Analytical Problems

For the first four stations, cadmium columns were not lasting longer than 2 days and were changed frequently before column efficiency dropped below 90%. The issue was eventually tracked down to bad cadmium granules, so cadmium granules were treated and columns were re-packed. The problem was resolved before station 7. There were some issues with the intersample bubble causing the phosphate baseline not to be stable during a run, it did not affect the samples or the data produced. Samples taken at stations with high fluorescence occasionally clogged nitrite and phosphate flow cells, and caused noisy baselines across all channels, but was quickly fixed with deep cleaning of pump tubes and did not affect the data produced.

CHAPTER

SEVEN

OXYGEN ANALYSIS

Technicians

- Andrew Barna

7.1 Equipment and Techniques

Dissolved oxygen analyses were performed with an SIO/ODF-designed automated oxygen titrator using photometric end-point detection based on the absorption of 365nm wavelength ultra-violet light. The titration of the samples and the data logging were controlled by PC LabView software. Thiosulfate was dispensed by a Dosimat 665 buret driver fitted with a 1.0 ml burette.

ODF used a whole-bottle modified-Winkler titration following the technique of Carpenter [Carpenter1965] with modifications by [Culberson1991] but with higher concentrations of potassium iodate standard (~0.012 N), and thiosulfate solution (~55 g/L).

Pre-made liquid potassium iodate standards and reagent/distilled water blanks were run every day (approximately every 3-4 stations), with samples analyzed within 24 hours of the last standard.

7.2 Sampling and Data Processing

A total of 799 oxygen measurements were made, all of which were niskin samples. Niskin samples were collected soon after the rosette was secured on deck, either from fresh niskins or immediately following CFC sampling.

Nominal 125 mL volume-calibrated biological oxygen demand (BOD) flasks were rinsed 3 times with minimal agitation using a silicone draw tube, then filled and allowed to overflow for at least 3 flask volumes, ensuring no bubbles remained. Pickling reagents $MnCl_2$ and NaI/NaOH (1 mL of each) were added via bottle-top dispensers to fix samples before stoppering. Flasks were shaken twice (10-12 inversions) to assure thorough dispersion of the precipitate - once immediately after drawing and then again after 30-60 minutes.

Sample draw temperatures, measured with an electronic resistance temperature detector (RTD) embedded in the draw tube, were used to calculate umol/kg concentrations, and as a diagnostic check of bottle integrity.

Niskin samples were analyzed within 2-24 hours of collection, and the data incorporated into the cruise database.

Thiosulfate normalities were calculated for each standardization and corrected to 20°C. The 20°C thiosulfate normalities and blanks were plotted versus time and were reviewed for possible problems, and were subsequently determined to be stable enough that no smoothing was required.

7.3 Volumetric Calibration

Oxygen flask volumes were determined gravimetrically with degassed deionized water to determine flask volumes at ODF's chemistry laboratory. This is done once before using flasks for the first time and periodically thereafter when a suspect volume is detected. The 10 mL Dosimat buret used to dispense standard iodate solution was calibrated using the same method.

7.4 Standards

Liquid potassium iodate standards were prepared in 6 L batches and bottled in sterile glass bottles at ODF's chemistry laboratory prior to the expedition. The normality of the liquid standard was determined by calculation from weight. The standard was supplied by Alfa Aesar and has a reported purity of 99.4-100.4%. All other reagents were "reagent grade" and were tested for levels of oxidizing and reducing impurities prior to use.

7.5 Narrative

Setup of the ODF oxygen rig occurred in the bio lab of the R/V Palmer, aft of the outboard sink. Only 1 liter batches of reagents were made due to the restrictions of the ship. The first standards were not run until after the crossing of the Drake Passage.

Around station 3, the UV pen lamp started to take several attempts to get it to turn on. A UV LED lamp was swapped in and functioned normally the rest of the expedition.

4 samples were lost during the expedition. One sample had left over or dry iodide in the bottom that dissolved when acid was added, preventing the finding of the end point. Two samples were lost due to the computer program freezing when the 1ml thiosulfate burette needed to refil due to super saturated oxygen values. A final sample was lost due to some sort of contamination on the outside of the flask that prevented the end point from being found.

High surface oxygen values were being seen. With a little under 150% calculated saturation being the maximum. Due to the limited amount of thiosulfate pre weighs and these high oxygens, the sample boxes were reordered so that the smallest flasks would be used at the surface.

CHAPTER

EIGHT

APPENDICES AND TABLES

- genindex
- modindex
- search

8.1 Abbreviations

AACC
Antarctic Circumpolar Current, or ACC

ABW
Antarctic Bottom Water

ASC
Antarctic Support Contract

ASPIRE
Amundsen Sea Polynya International Research Expedition

BFGS
Broyden-Fletcher-Goldfarb-Shanno algorithm

BNL
Benthic Nepheloid Layer

CDW
Circumpolar Deep Water - *mCDW*

CTDO
Conductivity Temperature Depth Oxygen, relating to CTD data and acquisition package

DCM
Deep Chlorophyll Max

DIS
Dotson Ice Shelf

DO
Dissolved Oxygen

ECO
Edison Chouest Offshore

ETs
Electronics Technicians

GIS
Getz Ice Shelf

GO-FLO
General Oceanics FLOw sampling bottles designed for minimal trace metal contamination

GO-SHIP
Global Ocean Ship-based Hydrographic Investigations Program

GTC
GEOTRACES Carousel - pertaining to the GEOTRACES trace-metal rosette

IAPSO
International Association for the Physical Sciences of the Oceans

LDEO
Lamont-Doherty Earth Observatory - Columbia University

mCDW
Modified Circumpolar Deep Water - *CDW*

ML
Surface Mixed Layer

MTs
Marine Technicians

NOAA
National Oceanographic Atmospheric Administration

NSF
National Science Foundation

ODF
Oceanographic Data Facility - *SIO*

PMEL
Pacific Marine Environmental Laboratory

PPZ
Primary Production Zone

REE
Rare Earth Elements

RVDAS
Research Vessel Data Acquisition System

RVTEC
Research Vessel Technical Enhancement Committee - *UNOLS* tech pool

SBE
SeaBird Electronics

SIO
Scripps Institution of Oceanography

STS
Shipboard Technical Support - *SIO*

TEI
Trace Element and Isotope parameter

UCSD
University of California San Diego

UNOLS
University-National Oceanographic Laboratory System

USAP
United States Antarctic Program

UVP
Underwater Vision Profiler

UW
University of Washington

WHOI
Woods Hole Oceanographic Institution

WOCE
World Ocean Circulation Experiment

WW
Winter Water

8.2 ODF CTD and Rosette Log

Below is the log of inspections, adjustments, and maintinence for the ODF rosette on GP17-ANT.

2023-11-19

O-ring inspection of ODF rosette. Starting with the vents:

- B7 O-ring crumbled, replaced
- B33 O-ring was chipped, replaced
- B15 vent cap broke at threads, replaced

Spigot O-ring check:

- Outside-most O-ring (at nozzle) were replaced for 1, 2, 4, 5, 8, 9, 15, 16, 18, 19, 20, 22, 23, 29, 36

Bottle chip (where spring O-rings seal) check:

- B7 bottom looks suspect
- B15 chip on top, should be ok
- B18 chip on top, should be ok
- B34 top has a long scratch that almost goes to O-ring, should be ok
- B35 bottom looks scratched, should be ok

Wet test:

- B4, B10, B11, B12, B18, B19 slow leak bottom endcap

2023-11-21

O-ring replacements:

- B4, 11, 12, 18 (had a hair), 26 botton O-rings all looked new but were replaced anyway

While doing O-ring replacements, B10 and B19 were identified as having deep scratches over the bottom cap and the entire bottle was replaced with one from ODF spares. Issues with bottles were noted and stored updstairs on the 01 catwalk. B29 also had the top spring lanyard replaced.

2023-12-02

- 00102

Soak cast of the ODF rosette before the test station. Goal of letting the GTC rosette bottles soak, with the ODF rosette collecting water at 1000 m to test the seals on the bottles.

During the console operations, in demonstrating that bottles can be fired from the deck unit, the “Home/Arm” button was triggered before closing bottle 6. This reset the carousel index to 1 on bottle 6 and, due to the 36-bottle configuration in the SeaSave configuration, did not allow bottles 32-36 to fire. B32-36 were not fired when the rosette was recovered. For all future stations, we will not be using the deck unit to fire the bottles.

Wet test results:

- B2 vent is hard to close and get a good seal - it must be closed very tightly. Bottle was labeled and some grease was applied to make it seal better.
- B17 was leaking from the spigot.
- B29 has a sticky pylon latch. Removed the latch, cleaned it with soapy water, and reassemnled. The cause was likely an overtightened screw on the trigger mechanism.

ODF salts took samples from all available bottles to check for leaks or mistrips (B1-31). Sample crate “W” was cracked at the handle while sampling and was removed from circulation thereafter. ODF nutrients took samples on B1, B3.

2023-12-05

- 00202

Applied high vaccuum o-ring grease to bottles B2 and B17 before test station cast 00202. Prior to the cast, bottles 16 and 18 were noted as tight or difficult to cock. Sampling bottles B2 and B17 was fine following the cast. No other bottles were identified as leaking.

A *LDEO* monocore was mounted on the ODF rosette to emulate a deep cast procedure. The monocore was not seen by the altimeter, which appeared to be static to 5V.

2023-12-07

- 00302

Bottles 22 and 30 were difficult to cock and it it became immediately obvious that they were cocked on the hose clamps prior to 00302. Uncocked bottles, adjusted the lanyards, and recocked them with no issues.

Bottles 8 and 18 were particularly tight before deployment.

Following recovery, bottles B1 and 9 leaked from the bottom cap when the petock and vent were opened, respectively. O-rings were changed on Bottles B7 and 9 for the top and bottom caps. Hose clamps were tightened, as they were loose. Some hose clamps took 1-2 whole turns. .. index:: USAP, ASC, ETs

In testing the altimeter, the CTD Y cable for the altimeter and UVP sensor was removed (returning previous Y cable to UVP operator Wokil Bam) and replaced with an alternative Y cable provided by the Palmer. The sensor is inventoried by the Palmer’s *ETs*. A STAR-ODDI TDR Compass was mounted by the transmissometer for casts 00302 and 00305, as 00309 would be too deep (over 4000 m).

- 00305

UVP was not flashing before deployment of 00305. Charged it for an additional 20 minutes while the rest of the cast preparations were done. A heat gun was used on the UVP to warm the photographing element - which has been sensitive to low temperatures on previous GEOTRACES cruises.

Though the UVP still did not flash before the CTD was lowered into the water, the dedicated voltage channel indicated that it did turn on at around 20 m.

Following the cast, the Palmer compass was taken off the rosette.

Niskin bottle 3 came up empty due to a mistrip, so all sampling was moved to bottle 4.

Bottle 16 was realigned after sampling. Adjusted hose clamp heights on bottles 21, 23. Tightened all hose clamps prior to giving the rosette a final rinse, most by 1/8 of a turn.

2023-12-08

- 00308

Because the rosette would be lowered to 10 m above the bottom with a monocore sample on 00308, it was essential that the altimeter pick up the monocore hanging below the rosette. For this reason, 00308 was deployed but the cast was aborted due to a static 5 V being read from the altimeter voltage channel. Once on deck, the altimeter was serviced using the Valeport setup utility and it was identified that the settings remained unchanged from factory defaults. This meant the maximum depth that the altimeter could read was 10 m - too short to see the monocore hanging about 27 m below the rosette.

However, the voltage was still static following reconfiguration and during bucket tests. From there, a second Valeport VA500 from the Palmer was mounted to see if the issue persisted. The ship VA500 was known to work, but was also static at 5 V. At that time it was found that the 6-pin cable connecting the altimeter to the UVP Y-cable was for a SBE32 carousel, not for an altimeter. The cable was swapped with one belonging to the Palmer and voltages were no longer static during a bucket test.

- 00309

During 00309 the VA500 was detecting the monocore at 27 m below the rosette during both the downcast and the upcast. There were no issues with the altimeter during the cast.

The secondary temperature sensor (S/N 5046) was static at 99 ºC during approximately 2,900 - 200 m during the upcast. When removed after the cast, 2 of the connector pins on 5046 were no longer rigid, able to be moved or spun by hand. The sensor was replaced with S/N 2309 following the cast.

Bottle 21 on the rosette was leaky during sampling of 00309 and, due to previous issues with the bottle, was replaced after sampling. At this point there were no reliable ODF spare bottles (4 spares were brought), so a spare 10 L niskin was mounted from the Palmer's spares. The bottle is also a Bullister-style niskin, so the ODF endcaps were transferred to the new bottle. The bottle was leak tested prior to use on the next cast and is referred to as bottle 37 in the bottle database.

2023-12-12

- 00403

The STAR-ODDI compass was mounted prior to the deployment of the ODF rosette on cast 00403.

While cocking bottles, bottle 2 seemed like the lanyard was a little loose but otherwise there were no issues. B11 had a very slow leak from the bottom endcap during sampling, but B2 was fine.

2023-12-13

Upon inspection of B11 following sampling, the surface looked like it had a small crack. Rather than sand the surface down, the bottle was replaced with another Palmer spare. The old B11 endcaps, with their lanyards, were installed on the new bottle. The new B11 was filled with fresh water for leak testing prior to the upcoming ODF PigRaTh cast. This bottle is referred to as bottle 38 in the cruise database.

- 00407

No issues with rosette preparations or sampling. All bottle hoseclamps were tightened following sampling.

2023-12-14

- 00410

No issues noted.

- 00503

The STAR-ODDI was mounted prior to 00503. Bottle 15 felt a little loose when cocked. The bottle did not leak during sampling of 00503.

Bottle 29 didn't close during 00503. The latch felt a little sticky. Inspecting the latch and magnet did not diagnose the problem. The bottle was raised as high as possible to minimize the angle required for the latch to swing freely.

2023-12-15

- 00506

The STAR-ODDI was taken off after sampling of 00506. From here on out, the STAR-ODDI was mounted and taken off every cast or two to assess rosette spin. No bottles leaked during sampling. The lanyard guide rings for bottles 15, 18, 20 were adjusted to improve the angle of the bottom cap while cocked. All bottle hoseclamps were tightened following sampling.

2023-12-16

- 00603

No issues noted.

- 00606

Btl 29 appeared leaky from bottom end cap during sampling, but could not be reproduced. The bottle was filled with fresh water and leak tested with different orientations of the top and bottom end caps.

2023-12-17

- 00703

No issues noted.

- 00707

Changed procedure with monocore to approach the seafloor at a rate of 25 m/min until the altimeter reads 10 m off the bottom. The theory is to add additional velocity to when the core is driven in. Recovered a decent core.

2023-12-18

- 00803

No issues noted.

- 00806

Top lanyard for bottle 28 closed inside of the top of bottle 30, just barely breaking the seal on 30. When the spigot was pushed in, water came gushing out even when the air vent was closed. Lanyard for 28 was not damaged. No obvious scratching on bottle 30. Sampling from bottle 30 was moved to bottle 29, which fired at the same depth level.

2023-12-19

- 00903

No issues noted.

- 00906

Bottle 32 leaking profusely when air vent opened. Leaking from bottom endcap. Appeared to be good seal otherwise, sampling continued. Stopped leaking after less than 1 L of sample had been removed. After sampling, the bottle was completely filled with fresh water in an attempt to recreate the issue. There was no success in reproducing the issue. Passed info along to other shift, where they did not observe B32 leaking.

2023-12-20

- 01003

No issues noted.

- 01006

No change in routine, though the monocore was not successful at getting a core. It had not fired at the bottom. The hypothesis is that it could have sank into sediments and not lost sufficient tension in the line to close.

While sampling the rosette after 01006, the air vent on B34 was found open. It may not have been closed prior to the deployment of 01006. Sampling was moved to B35 for this cast.

All hose clamps were tightened after sampling. B4 was raised and realigned, such that the spigot was pointing straight out.

2023-12-21

- 01103

Following reports of tight lanyards and difficulty cocking bottles, lanyards on bottles 14, 18, and 34 were loosened as best as possible without cutting new lanyards prior to 01103. After sampling of 01103, a new lanyard was put on the top of bottle 1 to make it easier to fit over the latch.

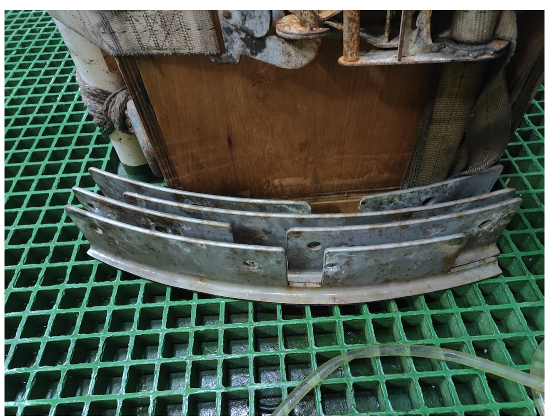
- 01106

There were no issues in cocking bottles or sampling. However, the monocore came up without a sample. It had fired at the bottom and carried sediment up the water column, though the endcaps didn't close completely and the sample was lost in the splash zone. Members of *LDEO* and Palmer *MTs* inspected and disassembled the monocore following sampling of 01106.

2023-12-22

- 01203

ODF metal plate skids were removed to preserve the plastic tracks in the Palmer baltic room prior to the deployment of the ODF rosette. These stainless steel plates have been historically used by ODF to prevent paint from being sanded off on textured surfaces, but have recently been gauging and scratching the recovery tracks.



There were no problems with the deployment or recovery on cast 01203.

- 01206

No issues noted.

2023-12-23

- 01303

No issues noted.

- 01306

No issues noted.

2023-12-23

- 01403

Abnormal sampling procedure led to new groups sampling on bottles 11 and 21, which have a different nozzle type from the others on the ODF rosette. Bottles 11 and 21 are spares from the Palmer and are not normally sampled by these groups. Some tygon tubing was found that fit bottle 11, but not on bottle 21. Because of the spigot type, sampling was moved from 21 to 22, which was fired at the same depth.

During sampling, the spigot of bottle 4 would leak when the air vent was open and the nozzle was pushed up towards the air vent. Because the spigot did not leak when the air vent was closed, sampling resumed as normal and no contamination was inferred. The leakage, however, was not reproducible when the bottle was filled with fresh water.

- 01407

No issues noted.

2023-12-24

- 01503

A new spigot was put on bottle 4 prior to the deployment of the rosette.

Bottle 29 was leaky from the bottom endcap for the first 1L of sampling. Thereafter, leaking ceased. Will keep an eye on the bottle.

2023-12-25

- 01506

No issues noted.

2023-12-26

- 01603

No issues noted.

2023-12-27

- 01606

Bottle 29 was leaky from the bottom endcap again and the o-rings were replaced.

- 01703

Bottle 29 was leaking profusely from the bottom endcap (with new o-rings) when the air vent was opened. Another Bullister-style bottle was procured from the Palmer's spares and prepared as a substitute, though it is not preferred as it has not been used since February 2010. Other Bullister Niskins that could be used would require the removal of the bottle handle, which the *MTs* are not keen on removing.

However, it was found that the lanyard of B29 had caught on the top hose clamp for B30. This added tension to the line on the bottom endcap. When the tension was released, the bottle dripped but not as profusely.

Bottles 29, 30, and 31 were removed to adjust the hose clamp position for B30 so it will not catch on future casts. This modification in mind, B29 will not be sampled for any volatiles on the next cast and as such will be a good test to see if the issue with 29 is resolved.

2023-12-28

- 01707

Bottle 29 leaked during sampling of 01707, prompting the bottle to be changed out with the Palmer spare from the day before. The end caps and springs (including the new o-rings) were transferred to the new bottle and leak tested with fresh water. The new bottle 29 will be referred to as bottle 39 in the ODF database.

- 01802

The spigot of bottle 7 was open prior to sampling. Sampling was able to continue and preliminary bottle temeperatures didn't suggest excessive contamination.

- 01805

No issues noted.

2023-12-29

- 01903

Following 01903, the following bottles had their lanyard guide rings adjusted to get a better angle while cocked.

B4, 5, 7, 13, 16, 17, 19, 23, 31, 32, 35.

By "better angle", this means the bottom endcap could make a 90º angle with the bottom of the bottle while cocked, rather than an acute angle which would cause the inside spring lanyard to rub on the edge of the bottle. By not having the lanyards rub, it is possible to extend the life of the lanyards.

During the bottom endcap inspection, it was discovered that bottle 29's top lanyard had not been threaded correctly. It was corrected and did not require adjustment thereafter.

All hoseclamps were tighened following the adjustment. During tightening, it was discovered that bottles B4, 29, and 31 were loose (requiring a half turn or more) and tightening reaffixed the bottles tightly to the rosette.

2023-12-30

- 01906

No issues noted.

- 02003

Following 02003, the primary transmissometer was replaced with serial number 1873DR. This was because, when compared to the GTC transmissometer, the voltage on the downcast was not the same as that of the upcast. These signals should be a little noisier and identical during either half of the cast. A deck test was done to acquire the voltages (V_a, V_d) required for input coefficients M and B.

The configuration was updated prior to the deployment of the next cast.

2023-12-31

- 02006

Transmissometer SN 1873 had a matching up and downcast for 02006 and the cable is not a concern.

During sampling bottle 9 leaked from the bottom cap. The bottom cap was re-greased and the internal lanyards were tightened for more tension on the spring. The bottle was leak-tested prior to the next cast.

- 02102

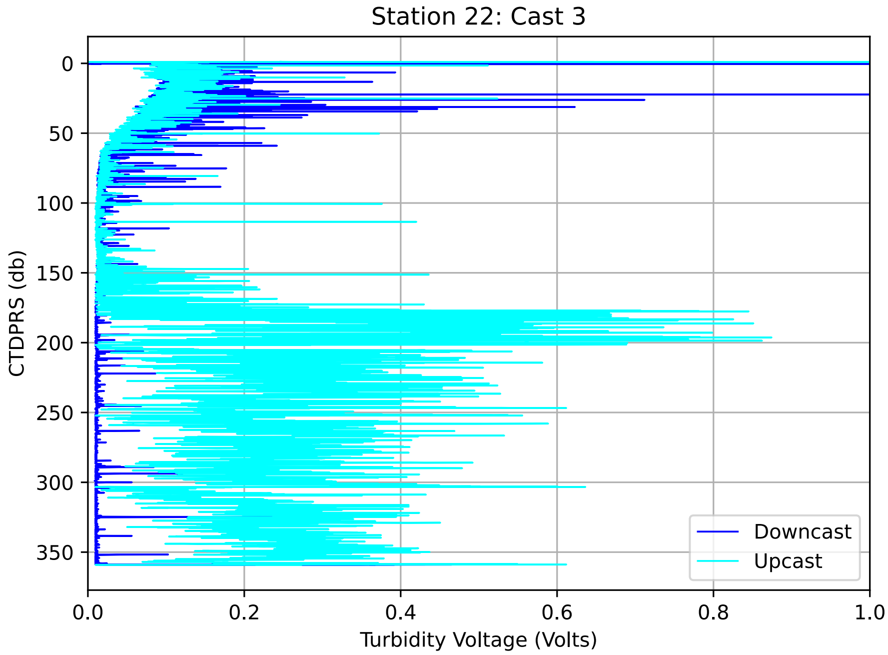
No issues noted.

2024-01-01

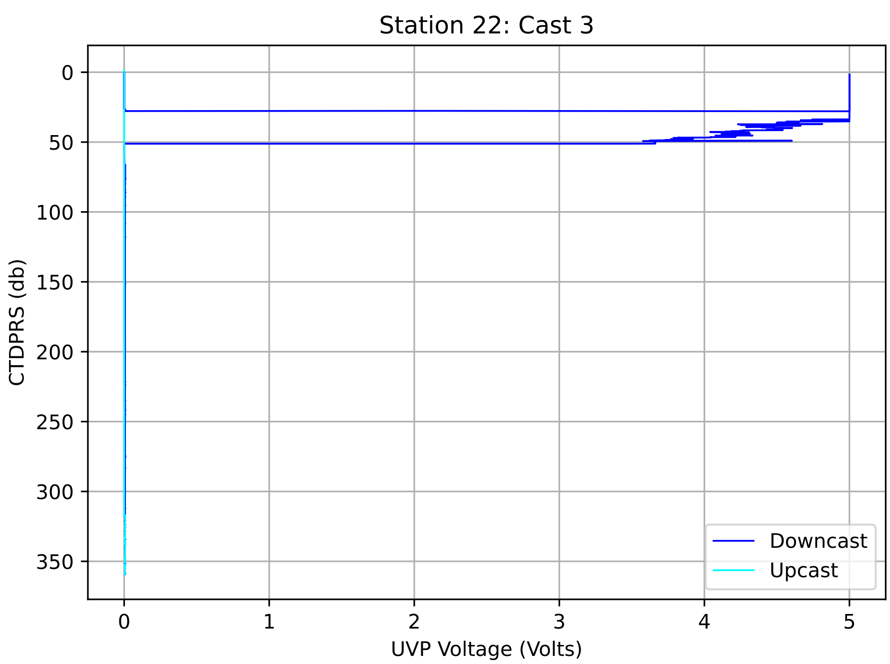
- 02203

Prior to the cast, two Palmer temperature/depth loggers were installed next to the compass. These TDRs are commonly used with the GP17-ANT McLane pumps, recording physical parameters in a small form-factor. There were no issues with the TDRs during or after the cast.

The turbidity sensor was noisy during the upcast on 02203. Following the cast the sensor face was wiped with soapy water and a kim wipe. The connection between the sensor and the y-cable was checked for corrosion but looked ok.



The UVP sensor powered off at 50 m during the downcast of 02203. Following the cast the connections were cleaned and re-greased. The battery was left to recharge and the Baltic room heater was turned on.



For the new transmissometer on the rosette, previous casts had beam transmission exceed 100%. The coefficients were modified to reduce the beam transmission such that it no longer exceeded 100%.

2024-01-02

- 02206

No issues noted.

- 02303

The bottom of bottle 9 leaked when the air vent was opened. The O-rings were regreased and were not an issue on the following cast.

- 02306

No issues noted.

2024-01-03

- 02405

No issues noted.

- 02506

No issues noted. All hose clamps were tightened after sampling.

2024-01-04

- 02501

When the rosette was recovered for sampling, the bottom cap of bottle 3 was poorly seated and had a slight leak.

- 02502

No issues noted.

- 02507

Prior to the cast, the TDR sensors from 02203 were remounted. They had been calibrated since their previous deployment and were remounted identically to before to compare their calibrations to those of the CTD.

2024-01-06

- 02410

Prior to sampling, the bottom cap o-ring of B33 was not seated correctly and all sampling was moved to B34.

During transit to station 026, the rosette was inspected and cleaned.

2024-01-09

- 02603

The rosette was thoroughly rinsed with fresh water prior to the deployment of 02603.

O-rings had been pressed tightly against the tops of the bottles for serveral days and the O-ring on the top of bottle 21 popped out of its groove when the bottle was cocked. This O-ring was pressed back into the groove and did not leak while sampling on 02603.

- 02606

No issues noted.

2024-01-10

- 02703

While cocking bottle 18, the bottom endcap felt much tighter than normal. Bottle 18 was raised to alleviate some tension on the outside lanyard while cocked and make future preparations easier.

All hose clamps were tightened following sampling on 02703.

- 02706

No issues noted.

2024-01-11

- 02803

Niskin bottle 12 was reported as leaking on the bottom endcap during large-volume sampling. Prior to dumping the bottle, it was refilled with fresh ship water and leak tested. The issue was not able to be reproduced and the bottle will be monitored on the next cast.

- 02806

No issues noted.

2024-01-12

- 02903

No issues noted.

- 02906

No issues noted.

2024-01-14

The rosette and sensors were hosed down thoroughly during transit and were disassembled for shipping.

8.3 Bottle Quality Comments

The following is a list of bottles or sampling systems where the sample quality was noted as suspect. Quality codes follow *WOCE* protocol described by [Swift2010].

Flag	Comments
2	No problems noted
3	Leaking
4	Did not close/trip correctly

It should be noted that these bottle quality flags differ from those of data quality flags, applied to specific analyses or data streams. Bottle flags should be considered prior to data quality flags, given scenarios where analyses can give correct readings from bottles that do not match metadata. Bottles with bottle ID beginning with "GF" indicate *GO-FLO* bottles, mounted on the GTC rosette for collecting *REE* and *TEI* samples. Bottle IDs beginning with "GSNIS" indicate *GO-SHIP* Bullister-style niskins, mounted on the ODF rosette.

STNNBR	CASTNO	SAMPNO	BTLNBR	BTLNBR_FLAG_W	GEOTRC_SAMPNO
1	1	5	GF-18	3	N/A
1	1	20	GF-15	3	N/A
1	2	17	GSNIS-17	3	N/A
1	2	29	GSNIS-29	4	N/A
1	3	6	GF-41	3	N/A
1	3	11	GF-12	3	N/A
1	3	17	GF-37	3	N/A
2	1	5	GF-18	3	18791
2	5	4	GF-32	3	18812
2	5	21	GF-39	3	18801

continues on next page

Table 1 – continued from previous page

STNNBR	CASTNO	SAMPNO	BTLNBR	BTLNBR_FLAG_W	GEOTRC_SAMPNO
3	1	11	GF-31	3	18838
3	1	23	GF-24	3	18826
3	5	3	GSNIS-3	4	18884
3	7	11	GF-33	3	18899
3	9	7	GSNIS-7	3	18925
3	9	21	GSNIS-21	3	18921
4	3	11	GSNIS-11	3	18972
4	4	21	GF-4	4	18943
4	4	22	GF-14	4	18942
4	8	17	GF-48	4	19007
5	3	29	GSNIS-29	4	19076
6	2	21	GF-4	3	19157
7	2	21	GF-22	3	19218
7	6	13	GF-11	4	19263
7	6	15	GF-1	4	19261
8	6	30	GSNIS-30	4	19350
9	2	24	GF-42	3	19363
9	6	32	GSNIS-32	3	19411
10	2	1	GF-19	4	19455
10	2	2	GF-27	4	19454
10	6	34	GSNIS-34	4	19479
11	2	12	GF-49	3	19522
11	2	20	GF-15	3	19514
12	2	10	GF-17	3	19587
12	2	23	GF-4	3	19574
12	2	24	GF-42	3	19573
13	2	11	GF-11	3	19683
13	2	12	GF-49	3	19682
14	2	16	GF-35	3	19740
14	2	17	GF-49	3	19739
14	6	22	GF-15	4	19785
14	6	23	GF-21	4	19784
14	6	24	GF-2	4	19783
16	6	29	GSNIS-29	3	19968
17	3	29	GSNIS-29	3	20000
17	7	29	GSNIS-29	3	20042
18	2	7	GSNIS-7	4	20099
20	6	9	GSNIS-9	3	20248
22	2	12	GF-49	3	20360
24	10	33	GSNIS-33	4	20707
25	1	3	GSNIS-3	3	20553
25	8	7	GF-36	4	20634
25	8	9	GF-22	4	20632
26	2	12	GF-49	3	20761
27	2	12	GF-49	3	20830

Of these flags, the following bottles were identified as mistrips through salinity measurements. These were bottles that closed, but did not resemble bottle salinities from other bottles at the same depth or differed greatly from the CTD sensor trace.

GT_SAMPNO	STNNBR	CASTNO	SAMPNO	BTLNBR	Comment
19007	4	8	17	GF-48	Bottle salty
19785	14	6	22	GF-15	Bottle salty with value similar to 300m
19784	14	6	23	GF-21	Same as above
19783	14	6	24	GF-2	Same as above
20206	20	2	9	GF-22	Bottle salty after gradient or possibly missampled
20634	25	8	7	GF-36	Bottle salt does not agree with 8 or CTD trace
20632	25	8	9	GF-22	Bottle salt does not agree with 10 or CTD trace

During *CTDO* analysis, a number of bottles were found to be closed on or in the near vicinity to steep physiochemical gradients. This was often near the mixed layer (*ML*) or benthic nepheloid layer (*BNL*). These bottles were omitted from consideration for CTD calibration, as bottle temperature, salinity, and oxygen could be highly variable depending on ship movement. These bottle entries may not be indicative of the sample from that depth, when the displacement between the niskins and CTDO sensor package are taken into consideration.

GT_SAMPNO	STNNBR	CASTNO	SAMPNO	BTLNBR
18860	3	2	34	GSNIS-34
18878	3	5	19	GSNIS-19
18955	4	4	9	GF-36
18950	4	4	14	GF-40
18949	4	4	15	GF-15
18943	4	4	21	GF-4
18942	4	4	22	GF-14
19159	6	2	19	GF-35
19190	6	3	1	GSNIS-1
19236	7	3	28	GSNIS-28
19597	12	3	33	GSNIS-33
19836	15	2	23	GF-4
19836	15	2	24	GF-31
19862	15	3	29	GSNIS-29
19912	16	2	23	GF-4
19911	16	2	24	GF-31
19967	16	6	33	GSNIS-33
19982	17	2	21	GF-35
19981	17	2	22	GF-49
19999	17	3	31	GSNIS-31
19998	17	3	34	GSNIS-34
20051	17	7	1	GSNIS-1
20042	17	7	28	GSNIS-28
20041	17	7	31	GSNIS-31
20040	17	7	34	GSNIS-34
20090	18	2	31	GSNIS-31
20089	18	2	33	GSNIS-33
20131	19	2	21	GF-35
20130	19	2	22	GF-14
20153	19	3	31	GSNIS-31
20177	19	6	31	GSNIS-31
20193	20	2	22	GF-14
20218	20	3	26	GSNIS-26
20216	23	3	31	GSNIS-31

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Table 2 – continued from previous page

GT_SAMPNO	STNNBR	CASTNO	SAMPNO	BTLNBR
20463	23	6	31	GSNIS-31
20462	23	6	34	GSNIS-34
20478	24	2	23	GF-21
20477	24	2	24	GF-33
20503	24	5	28	GSNIS-28
20709	24	10	28	GSNIS-28
20708	24	10	31	GSNIS-31
20556	25	2	31	GSNIS-31
20571	25	4	21	GF-35
20570	25	4	22	GF-14
20840	27	2	2	GF-1
20834	27	2	8	GF-51
20843	27	3	31	GSNIS-31
20898	28	2	21	GF-35
20921	28	3	28	GSNIS-28
20981	29	3	30	GSNIS-30
20980	29	3	33	GSNIS-33
21006	29	6	19	GF-49
21005	29	6	20	GF-7
21020	29	7	29	GSNIS-39

8.4 Calibration Documents

Pressure Calibration Report
STS Calibration Facility

SENSOR SERIAL NUMBER: 0569
CALIBRATION DATE: 07-DEC-2021
Mfg: SEABIRD Model: 09P CTD Prs s/n: 75672

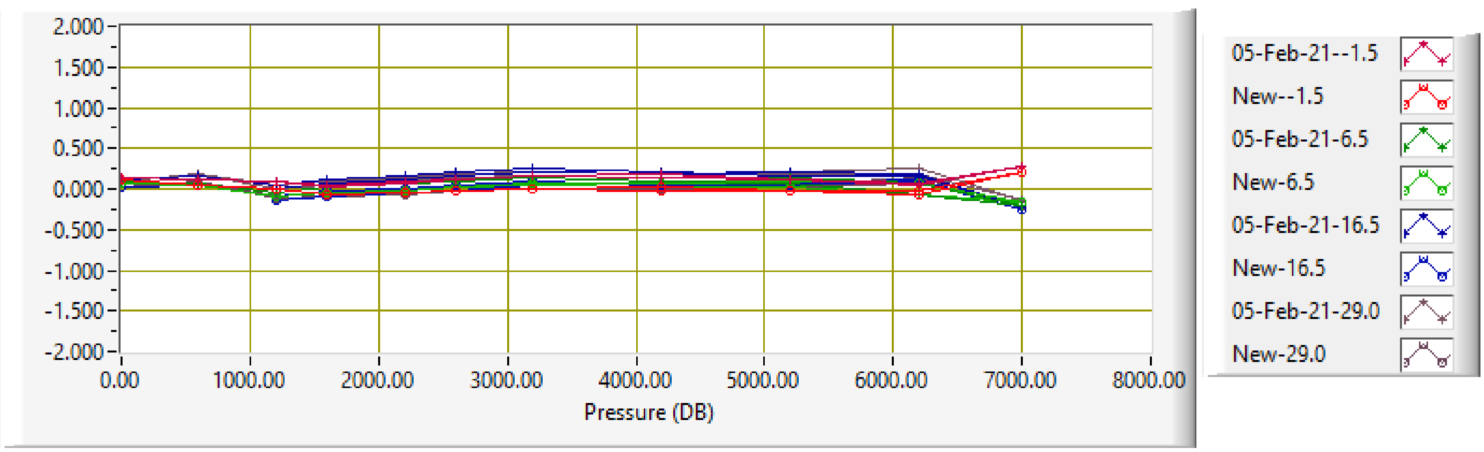
C1= -4.261473E+4
C2= -1.007365E-1
C3= 7.514018E-3
D1= 3.786680E-2
D2= 0.000000E+0
T1= 3.044517E+1
T2= -4.160351E-4
T3= 4.704882E-6
T4= -1.557303E-8
T5= 0.000000E+0
AD590M= 1.28617E-2
AD590B= -8.28826E+0
Slope = 1.00000000E+0
Offset = 0.00000000E+0

Calibration Standard: Mfg: FLUKE   Model: P3125   s/n: 70856
t0=t1+t2*td+t3*td*td+t4*td*td*td
w = 1-t0*t0*f*f
Pressure = (0.6894759*((c1+c2*td+c3*td*td)*w*(1-(d1+d2*td)*w)-14.7)

Sensor Output	DWT	Sensor New_Coefs	DWT-Sensor Prev_Coefs	DWT-Sensor NEW_Coefs	PT-DegC	Bath_Temp
32851.539	0.27	0.16	0.13	0.11	-0.33	-1.522
33184.957	600.32	600.27	0.11	0.05	-0.31	-1.523
33514.522	1200.35	1200.34	0.10	0.01	-0.31	-1.523
33732.191	1600.37	1600.43	0.05	-0.06	-0.31	-1.523
34055.605	2200.40	2200.44	0.10	-0.04	-0.31	-1.523
34269.244	2600.41	2600.44	0.12	-0.02	-0.31	-1.523
34586.849	3200.48	3200.48	0.15	-0.00	-0.31	-1.523
35108.738	4200.53	4200.51	0.18	0.02	-0.30	-1.523
35621.723	5200.59	5200.61	0.12	-0.02	-0.31	-1.523
36126.138	6200.60	6200.63	0.07	-0.03	-0.30	-1.523
36523.627	7000.60	7000.39	0.27	0.21	-0.30	-1.522
36126.137	6200.57	6200.64	0.04	-0.07	-0.31	-1.522
35621.712	5200.56	5200.59	0.11	-0.03	-0.31	-1.522
35108.748	4200.53	4200.54	0.14	-0.01	-0.32	-1.522
34586.852	3200.49	3200.49	0.16	0.00	-0.31	-1.522
34269.262	2600.45	2600.48	0.11	-0.03	-0.33	-1.522
34055.619	2200.42	2200.47	0.08	-0.05	-0.33	-1.522
33732.202	1600.38	1600.46	0.03	-0.08	-0.33	-1.522

Sensor Output	DWT	Sensor New_Coefs	DWT-Sensor Prev_Coefs	DWT-Sensor NEW_Coefs	PT-DegC	Bath_Temp
33514.522	1200.35	1200.35	0.10	0.01	-0.33	-1.523
33184.953	600.32	600.27	0.11	0.05	-0.33	-1.523
32854.870	0.27	0.19	0.08	0.08	7.71	6.485
33188.304	600.32	600.28	0.07	0.04	7.71	6.485
33517.954	1200.35	1200.45	-0.04	-0.09	7.71	6.485
33735.574	1600.37	1600.41	0.03	-0.04	7.71	6.485
34059.018	2200.41	2200.42	0.07	-0.02	7.71	6.484
34272.668	2600.42	2600.41	0.10	0.01	7.71	6.484
34590.279	3200.45	3200.40	0.13	0.04	7.71	6.484
35112.215	4200.46	4200.44	0.10	0.02	7.71	6.484
35625.206	5200.46	5200.45	0.06	0.01	7.71	6.484
36129.706	6200.48	6200.55	-0.07	-0.07	7.72	6.484
36527.416	7000.51	7000.68	-0.21	-0.16	7.72	6.484
36129.681	6200.57	6200.51	0.06	0.06	7.71	6.485
35625.231	5200.59	5200.50	0.15	0.09	7.71	6.485
35112.246	4200.57	4200.50	0.15	0.07	7.71	6.485
34590.300	3200.51	3200.44	0.16	0.07	7.71	6.485
34272.691	2600.46	2600.45	0.10	0.01	7.71	6.485
34059.034	2200.44	2200.45	0.07	-0.02	7.71	6.485
33735.589	1600.39	1600.44	0.02	-0.05	7.71	6.485
33517.961	1200.36	1200.46	-0.04	-0.10	7.71	6.485
33188.297	600.32	600.27	0.09	0.05	7.71	6.485
32858.199	0.27	0.23	0.12	0.03	17.77	16.491
33191.648	600.33	600.28	0.16	0.05	17.78	16.493
33521.344	1200.36	1200.46	0.05	-0.09	17.78	16.492
33738.990	1600.39	1600.42	0.12	-0.03	17.78	16.492
34062.469	2200.43	2200.42	0.17	0.00	17.78	16.492
34276.146	2600.44	2600.40	0.21	0.04	17.79	16.492
34593.787	3200.47	3200.38	0.26	0.09	17.79	16.491
35115.795	4200.48	4200.43	0.21	0.05	17.80	16.491
35628.853	5200.49	5200.45	0.17	0.04	17.80	16.491
36133.354	6200.53	6200.44	0.17	0.09	17.80	16.491
36531.228	7000.54	7000.80	-0.23	-0.26	17.80	16.491
36133.363	6200.57	6200.46	0.19	0.11	17.79	16.491
35628.873	5200.57	5200.50	0.20	0.07	17.78	16.492
35115.829	4200.52	4200.51	0.18	0.02	17.78	16.492
34593.819	3200.49	3200.45	0.21	0.04	17.78	16.492
34276.176	2600.45	2600.47	0.15	-0.02	17.77	16.492
34062.493	2200.42	2200.47	0.12	-0.05	17.78	16.492
33739.012	1600.38	1600.47	0.07	-0.09	17.77	16.491
33521.359	1200.35	1200.49	0.00	-0.14	17.77	16.491
33191.647	600.32	600.28	0.16	0.04	17.77	16.491
32861.152	0.27	0.23	0.08	0.03	30.36	29.003
33194.625	600.33	600.22	0.19	0.10	30.37	29.002
33524.401	1200.36	1200.45	0.03	-0.08	30.37	29.002
33742.094	1600.39	1600.43	0.09	-0.04	30.37	29.002

Sensor Output	DWT	Sensor New_Coefs	DWT-Sensor Prev_Coefs	DWT-Sensor NEW_Coefs	PT-DegC	Bath_Temp
34065.628	2200.43	2200.43	0.15	-0.01	30.37	29.002
34279.342	2600.44	2600.42	0.18	0.02	30.37	29.002
34597.053	3200.48	3200.44	0.20	0.04	30.37	29.002
35119.131	4200.49	4200.47	0.19	0.02	30.37	29.002
35632.257	5200.48	5200.46	0.18	0.03	30.37	29.001
36136.828	6200.49	6200.43	0.17	0.06	30.37	29.000
36534.721	7000.49	7000.69	-0.13	-0.20	30.37	29.001
36136.810	6200.52	6200.39	0.24	0.13	30.37	29.001
35632.277	5200.55	5200.50	0.20	0.05	30.37	29.002
35119.158	4200.53	4200.52	0.18	0.01	30.37	29.003
34597.082	3200.49	3200.50	0.16	-0.01	30.36	29.002
34279.371	2600.45	2600.48	0.13	-0.03	30.36	29.002
34065.652	2200.42	2200.48	0.09	-0.06	30.37	29.001
33742.113	1600.38	1600.47	0.04	-0.09	30.36	29.001
33524.416	1200.35	1200.48	-0.01	-0.12	30.36	29.002
33194.627	600.32	600.23	0.18	0.09	30.36	29.001
32861.142	0.27	0.22	0.10	0.05	30.36	29.000



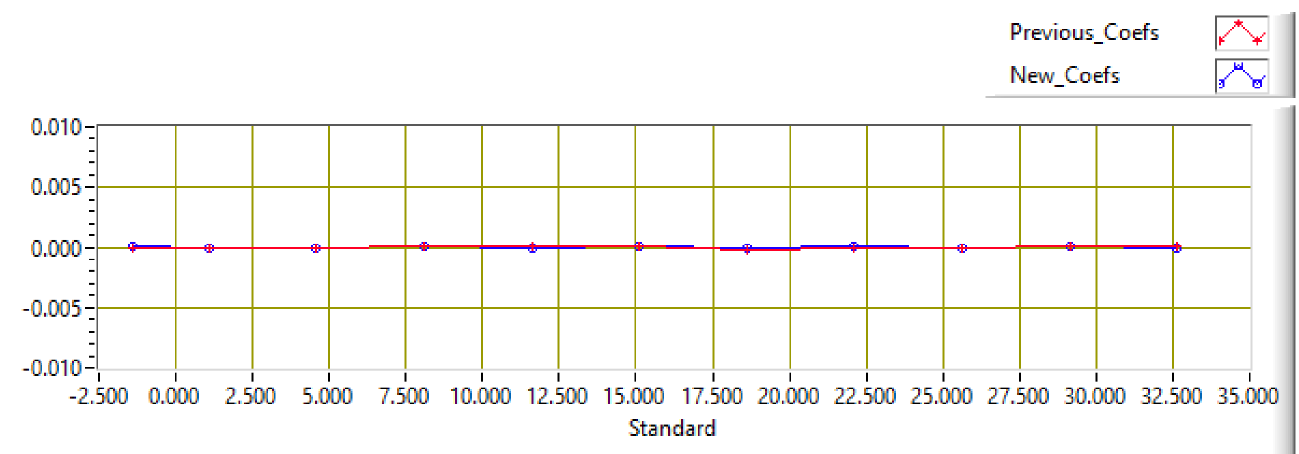
Temperature Calibration Report
STS Calibration Facility

SENSOR SERIAL NUMBER: 2309
CALIBRATION DATE: 03-Oct-2023
Mfg: SEABIRD   Model: 03
Previous cal: 31-May-23
Calibration Tech: CAL

ITS-90_COEFFICIENTS	IPTS-68_COEFFICIENTS ITS-T90	
g = 4.35775230E-3	a = 4.35795053E-3	
h = 6.45014103E-4	b = 6.45225471E-4	
i = 2.42532057E-5	c = 2.42859661E-5	
j = 2.34703352E-6	d = 2.34862900E-6	
f0 = 1000.0	Slope = 1.0	Offset = 0.0

Calibration Standard: Mfg: Isotech   Model: MicroK100   s/n: 291088-2
Temperature ITS-90 = 1/{g+h[ln(f0/f)]+i[ln2(f0/f)]+j[ln3(f0/f)]} - 273.15 (°C)
Temperature IPTS-68 = 1/{a+b[ln(f0/f)]+c[ln2(f0/f)]+d[ln3(f0/f)]} - 273.15 (°C)
T68 = 1.00024 * T90 (-2 to -35 Deg C)

SBE3 Freq	SPRT ITS-T90	SBE3 ITS-T90	SPRT-SBE3 OLD_Coefs	SPRT-SBE3 NEW_Coefs
2975.1438	-1.4320	-1.4321	-0.00009	0.00003
3146.6661	1.0720	1.0720	-0.00007	-0.00004
3398.7690	4.5786	4.5787	-0.00002	-0.00005
3665.2158	8.0866	8.0865	0.00013	0.00009
3946.4643	11.5961	11.5961	0.00003	0.00000
4242.0567	15.0978	15.0977	0.00003	0.00005
4553.9817	18.6101	18.6102	-0.00018	-0.00012
4881.4491	22.1201	22.1201	-0.00008	0.00001
5225.2504	25.6322	25.6322	-0.00010	-0.00002
5585.1723	29.1413	29.1412	0.00006	0.00010
5962.1048	32.6525	32.6526	0.00003	-0.00005



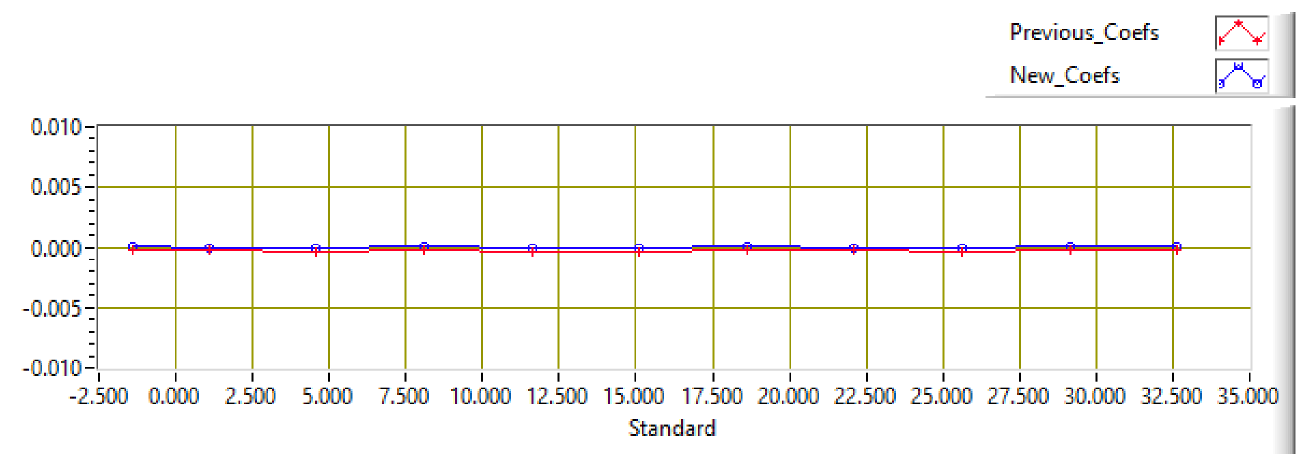
Temperature Calibration Report
STS Calibration Facility

SENSOR SERIAL NUMBER: 5046
CALIBRATION DATE: 03-Oct-2023
Mfg: SEABIRD   Model: 03
Previous cal: 23-Aug-23
Calibration Tech: CAL

ITS-90_COEFFICIENTS	IPTS-68_COEFFICIENTS ITS-T90	
g = 4.41649683E-3	a = 4.41671462E-3	
h = 6.44461073E-4	b = 6.44677004E-4	
i = 2.28009619E-5	c = 2.28333156E-5	
j = 2.10982815E-6	d = 2.11129129E-6	
f0 = 1000.0	Slope = 1.0	Offset = 0.0

Calibration Standard: Mfg: Isotech   Model: MicroK100   s/n: 291088-2
Temperature ITS-90 = 1/{g+h[ln(f0/f)]+i[ln2(f0/f)]+j[ln3(f0/f)]} - 273.15 (°C)
Temperature IPTS-68 = 1/{a+b[ln(f0/f)]+c[ln2(f0/f)]+d[ln3(f0/f)]} - 273.15 (°C)
T68 = 1.00024 * T90 (-2 to -35 Deg C)

SBE3 Freq	SPRT ITS-T90	SBE3 ITS-T90	SPRT-SBE3 OLD_Coefs	SPRT-SBE3 NEW_Coefs
3276.3147	-1.4320	-1.4321	-0.00026	0.00003
3465.5779	1.0720	1.0720	-0.00030	-0.00002
3743.7215	4.5786	4.5787	-0.00035	-0.00006
4037.6354	8.0866	8.0865	-0.00020	0.00009
4347.8242	11.5961	11.5962	-0.00033	-0.00004
4673.7731	15.0978	15.0978	-0.00035	-0.00005
5017.6251	18.6101	18.6100	-0.00018	0.00011
5378.5981	22.1201	22.1201	-0.00029	-0.00000
5757.4803	25.6322	25.6323	-0.00036	-0.00008
6154.0449	29.1413	29.1413	-0.00023	0.00002
6569.2482	32.6525	32.6525	-0.00019	0.00001



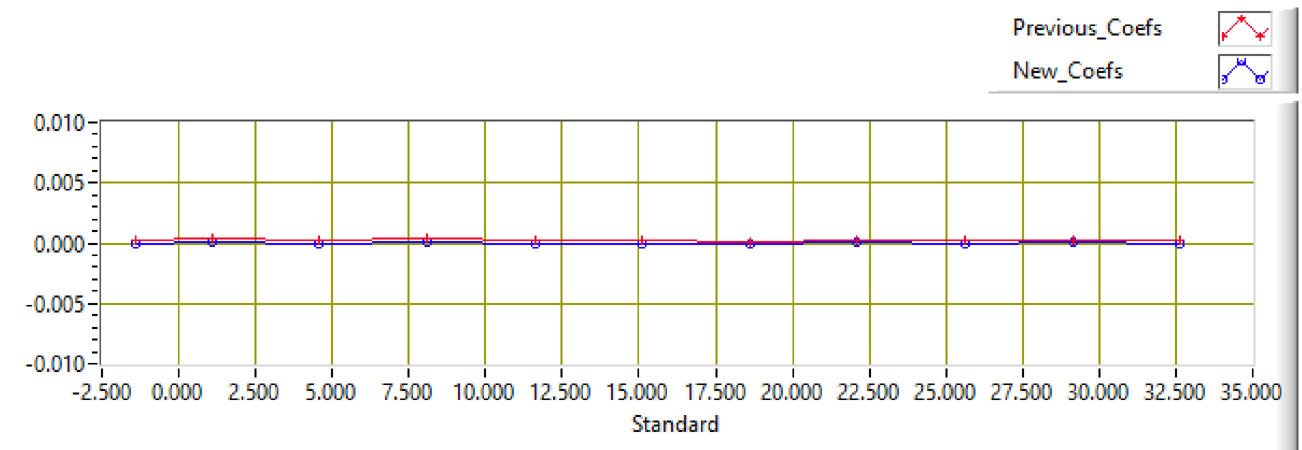
Temperature Calibration Report
STS Calibration Facility

SENSOR SERIAL NUMBER: 6140
CALIBRATION DATE: 03-Oct-2023
Mfg: SEABIRD   Model: 03
Previous cal: 23-Aug-23
Calibration Tech: CAL

ITS-90_COEFFICIENTS	IPTS-68_COEFFICIENTS ITS-T90	
g = 4.31726085E-3	a = 4.31744598E-3	
h = 6.36346974E-4	b = 6.36552608E-4	
i = 2.19418980E-5	c = 2.19735280E-5	
j = 2.07529430E-6	d = 2.07676467E-6	
f0 = 1000.0	Slope = 1.0	Offset = 0.0

Calibration Standard: Mfg: Isotech   Model: MicroK100   s/n: 291088-2
Temperature ITS-90 = 1/{g+h[ln(f0/f)]+i[ln2(f0/f)]+j[ln3(f0/f)]} - 273.15 (°C)
Temperature IPTS-68 = 1/{a+b[ln(f0/f)]+c[ln2(f0/f)]+d[ln3(f0/f)]} - 273.15 (°C)
T68 = 1.00024 * T90 (-2 to -35 Deg C)

SBE3 Freq	SPRT ITS-T90	SBE3 ITS-T90	SPRT-SBE3 OLD_Coefs	SPRT-SBE3 NEW_Coefs
2813.0305	-1.4320	-1.4320	0.00026	-0.00003
2975.9873	1.0720	1.0719	0.00032	0.00003
3215.5421	4.5786	4.5786	0.00026	-0.00003
3468.7574	8.0866	8.0865	0.00035	0.00008
3736.0712	11.5961	11.5962	0.00020	-0.00004
4017.0475	15.0978	15.0978	0.00021	-0.00001
4313.5693	18.6101	18.6101	0.00013	-0.00006
4624.9145	22.1201	22.1201	0.00019	0.00001
4951.8183	25.6322	25.6322	0.00016	-0.00002
5294.0837	29.1413	29.1412	0.00031	0.00011
5652.5670	32.6525	32.6526	0.00018	-0.00006



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SENSOR SERIAL NUMBER: 4537
CALIBRATION DATE: 24-Aug-23

SBE 4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:
g = -1.02645469e+001
h = 1.26300353e+000
i = -1.74170263e-003
j = 1.75254805e-004

CPcor = -9.5700e-008 (nominal)
CTcor = 3.2500e-006 (nominal)

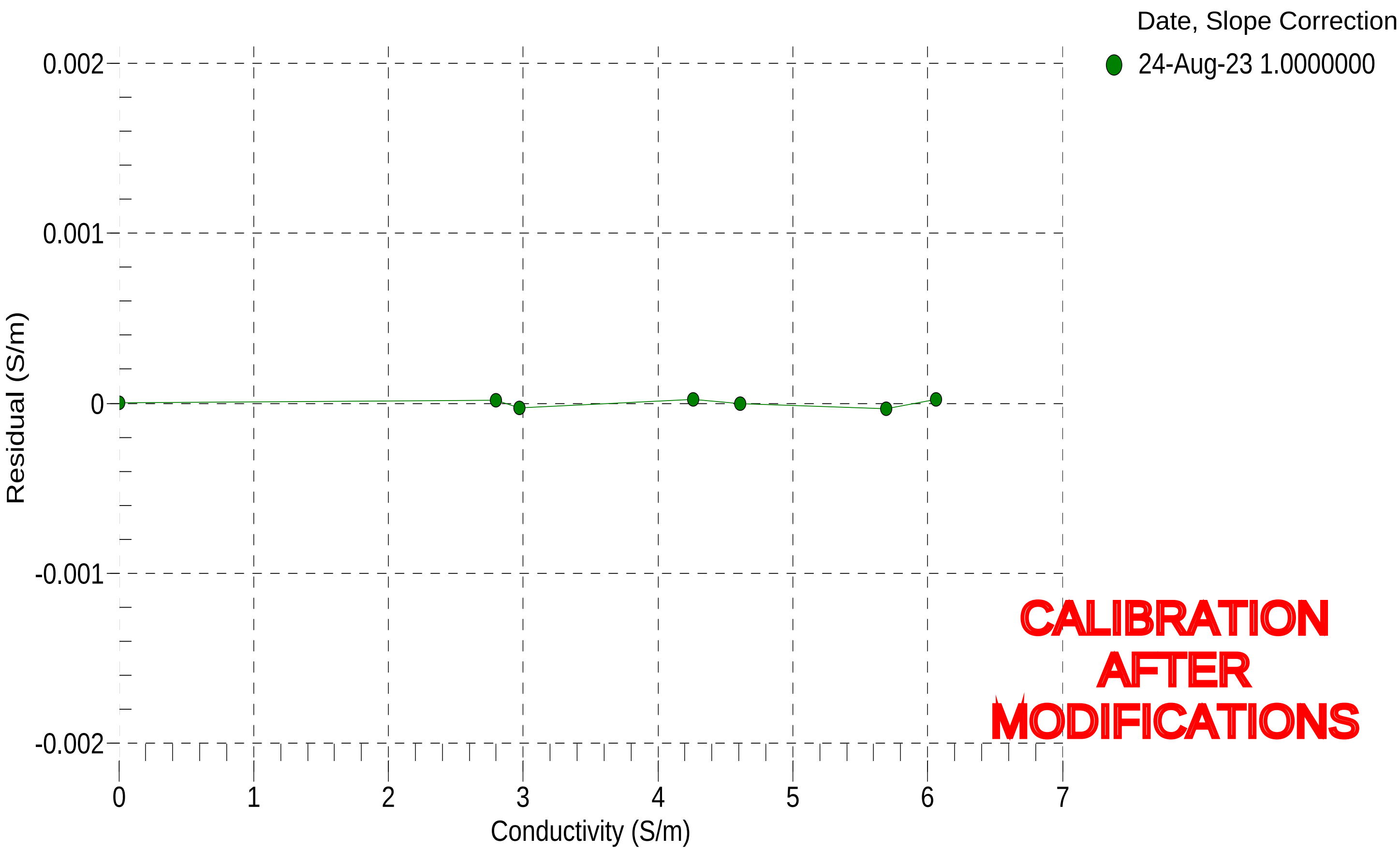
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.85481	0.00000	0.00000
-1.0000	34.7301	2.79828	5.51233	2.79830	0.00002
0.9999	34.7315	2.96940	5.63422	2.96937	-0.00003
15.0000	34.7322	4.26239	6.48132	4.26241	0.00002
18.4999	34.7328	4.60848	6.68973	4.60847	-0.00000
28.9999	34.7305	5.68983	7.30230	5.68980	-0.00003
32.4999	34.7200	6.06108	7.50097	6.06110	0.00002

f = Instrument Output (kHz)

t = temperature (°C); p = pressure (decibars); δ = CTcor; ε = CPcor;

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) /10 (1 + \delta * t + \varepsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



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SENSOR SERIAL NUMBER: 6130
CALIBRATION DATE: 15-Sep-23

SBE 4 CONDUCTIVITY CALIBRATION DATA
PSS 1978: C(35,15,0) = 4.2914 Siemens/meter

COEFFICIENTS:

```
g =  -1.01148309e+001
h =   1.43047423e+000
i =  -3.37110823e-003
j =   3.13098316e-004

CPcor = -9.5700e-008 (nominal)
CTcor =  3.2500e-006 (nominal)
```

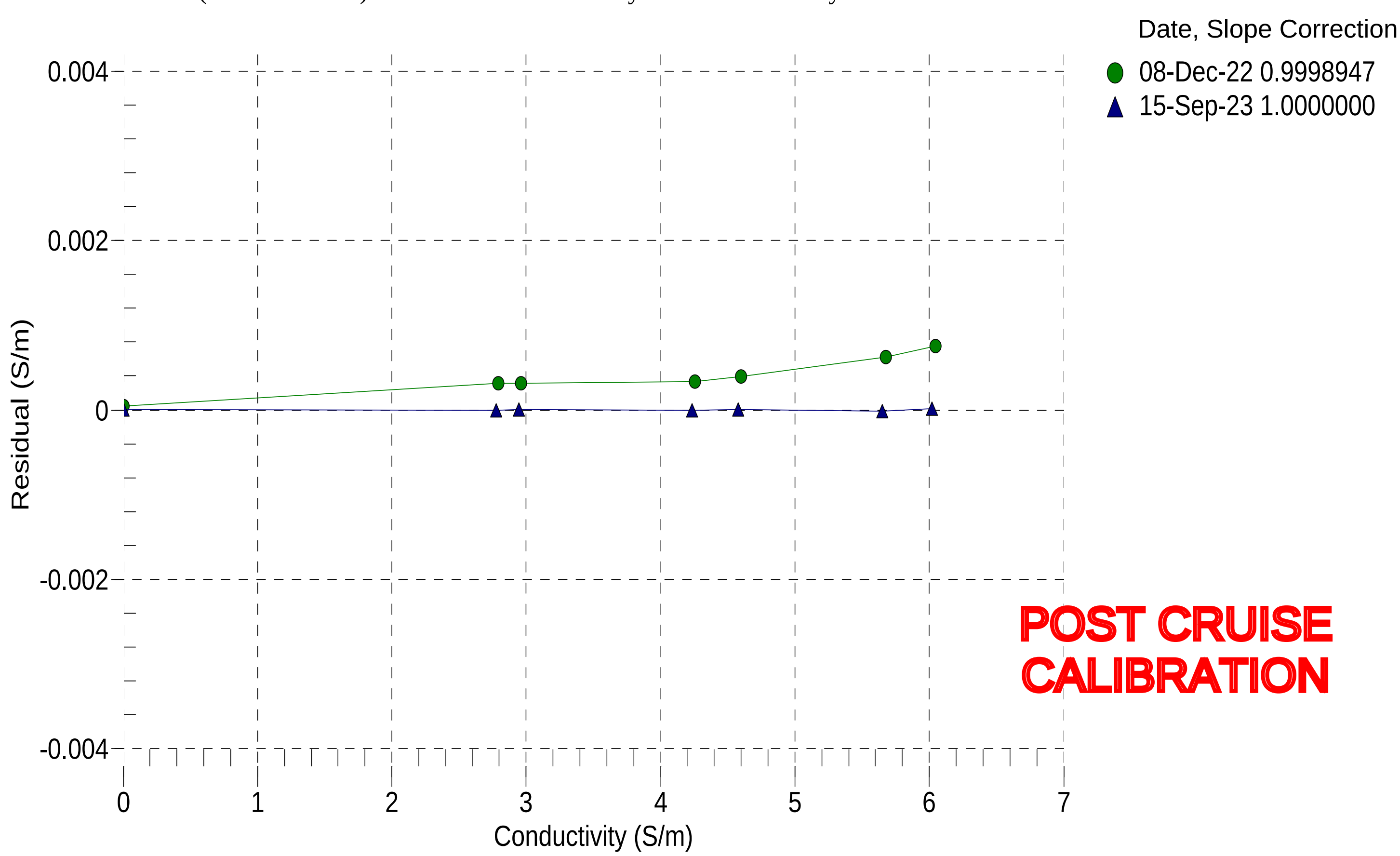
BATH TEMP (° C)	BATH SAL (PSU)	BATH COND (S/m)	INSTRUMENT OUTPUT (kHz)	INSTRUMENT COND (S/m)	RESIDUAL (S/m)
0.0000	0.0000	0.00000	2.66544	0.00000	0.00000
-0.9999	34.4525	2.77799	5.16331	2.77799	-0.00001
0.9999	34.4539	2.94791	5.27784	2.94792	0.00000
15.0000	34.4541	4.23185	6.07339	4.23185	-0.00000
18.4999	34.4536	4.57540	6.26903	4.57541	0.00001
29.0000	34.4494	5.64895	6.84396	5.64893	-0.00002
32.4999	34.4377	6.01738	7.03031	6.01739	0.00001

f = Instrument Output (kHz)

t = temperature (°C); p = pressure (decibars); δ = CTcor; ε = CPcor;

Conductivity (S/m) = $(g + h * f^2 + i * f^3 + j * f^4) / 10 (1 + \delta * t + \varepsilon * p)$

Residual (Siemens/meter) = instrument conductivity - bath conductivity



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Pressure Test Certificate

Test Date: **2023-08-16**

Description: **SBE-5T Submersible Pump**

Sensor Information:

Replaced the main piston "O"-Rings.

Model Number: **SBE-5T**

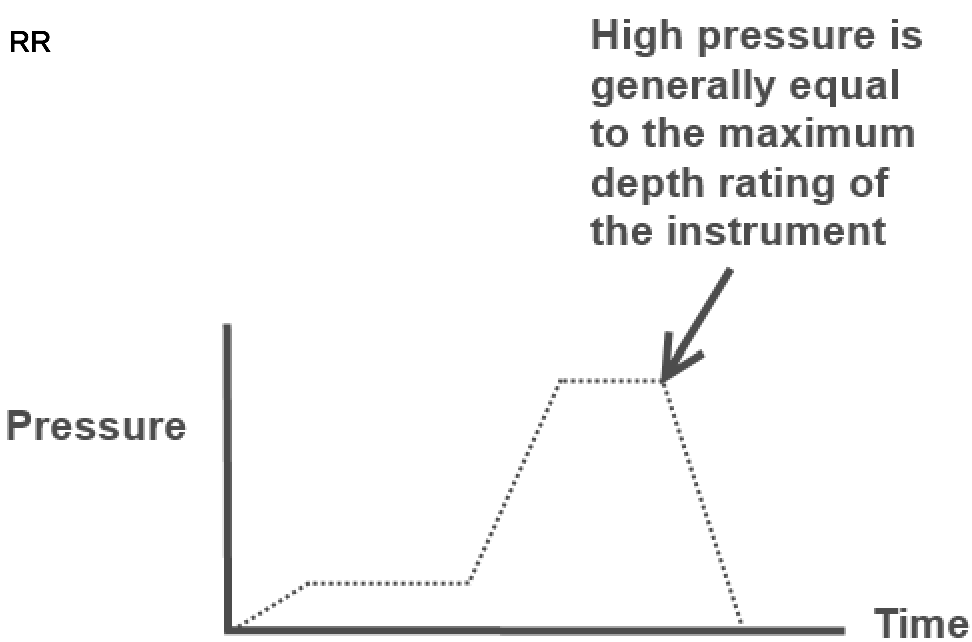
Serial Number: **5T-2559**

Pressure Test Protocol:

Low Pressure Test:	**40**	PSI	Held For:	**15**	Minutes
High Pressure Test:	**10000**	PSI	Held For:	**15**	Minutes

Passed Test: **True**

Tested By: **RR**



Typical Test Profile

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Pressure Test Certificate

Test Date: **2023-06-22**

Description: **SBE-5T Submersible Pump**

Sensor Information:

Replaced the main piston "O"-Rings.

Model Number: **SBE-5T**

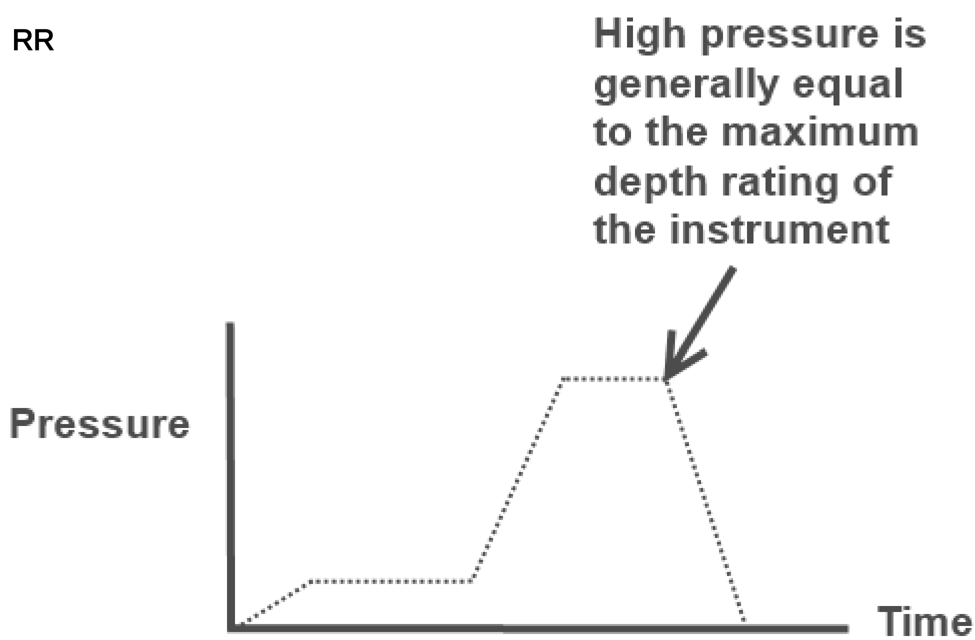
Serial Number: **5T-2567**

Pressure Test Protocol:

Low Pressure Test:	**40**	PSI	Held For:	**15**	Minutes
High Pressure Test:	**10000**	PSI	Held For:	**15**	Minutes

Passed Test: **True**

Tested By: **RR**



Typical Test Profile

Temperature Calibration Report
STS Calibration Facility

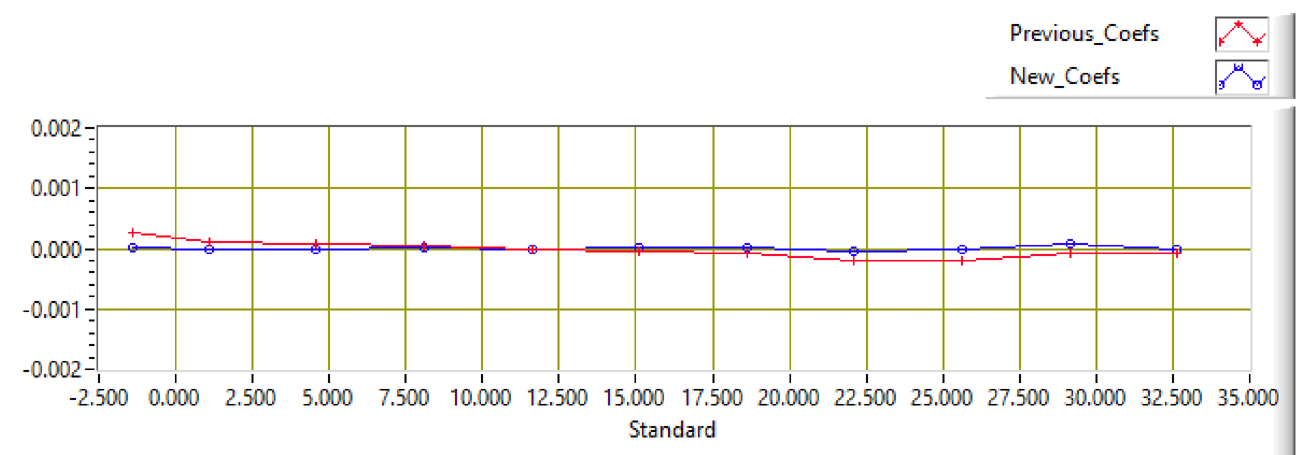
SENSOR SERIAL NUMBER: 0035
CALIBRATION DATE: 04-Oct-2023
Mfg: SEABIRD   Model: 35
Previous cal: 06-Jul-23
Calibration Tech: CAL

ITS-90_COEFFICIENTS
a0 = 3.914354549E-3
a1 = -1.032862732E-3
a2 = 1.628972809E-4
a3 = -9.154874617E-6
a4 = 1.980499186E-7
Slope = 1.000000 Offset = 0.000000
Calibration Standard: Mfg: Isotech   Model: MicroK100   s/n: 291088-2

Calibration Standard: Mfg: Isotech   Model: MicroK100   s/n: 291088-2

Temperature ITS-90 = 1/{a0+a1[ln(f)]+a2[ln2(f)]+a3[ln3(f)]+a4[ln4(f)} - 273.15 (°C)

SBE35 Count	SPRT ITS-T90	SBE35 ITS-T90	SPRT-SBE35 OLD_Coefs	SPRT-SBE35 NEW_Coefs
656926.0818	-1.4328	-1.4329	0.00025	0.00002
588677.4278	1.0713	1.0714	0.00011	-0.00003
506035.9443	4.5780	4.5780	0.00007	-0.00001
436155.0774	8.0862	8.0861	0.00006	0.00003
376923.5133	11.5958	11.5958	-0.00001	-0.00000
326727.5914	15.0971	15.0971	-0.00005	0.00001
283845.5006	18.6097	18.6097	-0.00009	0.00002
247269.3309	22.1197	22.1198	-0.00021	-0.00006
215951.8468	25.6318	25.6318	-0.00019	-0.00002
189106.2737	29.1409	29.1408	-0.00008	0.00007
165993.5236	32.6529	32.6530	-0.00007	-0.00003



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SENSOR SERIAL NUMBER: 4339
CALIBRATION DATE: 03-Aug-23

SBE 43 OXYGEN CALIBRATION DATA

COEFFICIENTS:
Soc = 0.4750
Voffset = -0.5006
Tau20 = 1.53

A = -3.9553e-003
B = 1.9815e-004
C = -2.7094e-006
E nominal = 0.036

NOMINAL DYNAMIC COEFFICIENTS
D1 = 1.92634e-4
D2 = -4.64803e-2

H1 = -3.300000e-2
H2 = 5.00000e+3
H3 = 1.45000e+3

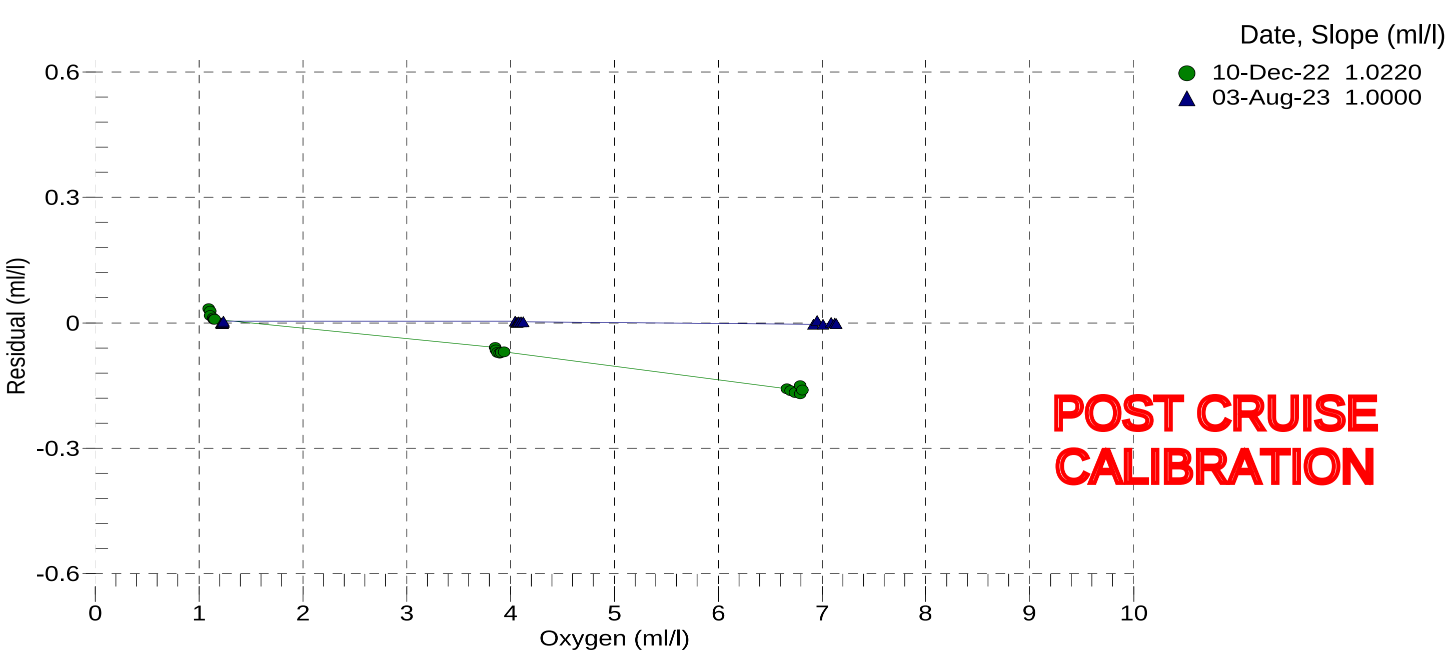
BATH OXYGEN (ml/l)	BATH TEMPERATURE (° C)	BATH SALINITY (PSU)	INSTRUMENT OUTPUT (volts)	INSTRUMENT OXYGEN (ml/l)	RESIDUAL (ml/l)
1.22	12.00	0.00	0.848	1.22	-0.00
1.22	2.00	0.00	0.768	1.22	-0.00
1.23	6.00	0.00	0.802	1.23	-0.00
1.23	20.00	0.00	0.916	1.23	-0.00
1.24	26.00	0.00	0.967	1.24	0.00
1.24	30.00	0.00	1.003	1.24	0.00
4.05	2.00	0.00	1.388	4.05	0.00
4.06	6.00	0.00	1.500	4.06	0.00
4.06	12.00	0.00	1.663	4.06	0.00
4.08	20.00	0.00	1.883	4.09	0.00
4.10	26.00	0.00	2.047	4.10	0.00
4.12	30.00	0.00	2.165	4.12	0.00
6.92	2.00	0.00	2.016	6.92	-0.00
6.95	6.00	0.00	2.212	6.96	0.01
7.01	12.00	0.00	2.505	7.01	-0.00
7.09	20.00	0.00	2.897	7.09	0.00
7.12	26.00	0.00	3.186	7.12	-0.00
7.14	30.00	0.00	3.380	7.13	-0.00

V = instrument output (volts); T = temperature (°C); S = salinity (PSU); K = temperature (°K)

Oxsol(T,S) = oxygen saturation (ml/l); P = pressure (dbar)

Oxygen (ml/l) = Soc * (V + Voffset) * $(1.0 + A * T + B * T^2 + C * T^3)$ * Oxsol(T,S) * exp(E * P / K)

Residual (ml/l) = instrument oxygen - bath oxygen



POST CRUISE CALIBRATION

PO Box 518
620 Applegate St.
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Fax (541) 929-5277
www.sea-birdscientific.com

C-Star Calibration

Date August 2, 2023 S/N# CST-1873DR Pathlength 25cm

	Analog output	Digital output
V_d	0.014 V	0 counts
V_{air}	4.820 V	15783 counts
V_{ref}	4.702 V	15397 counts

Temperature of calibration water	23.5	°C
Ambient temperature during calibration	22.6	°C

Relationship of transmittance (Tr) to beam attenuation coefficient (c), and pathlength (x, in meters): $\mathbf{Tr = e^{-cx}}$

To determine beam transmittance: $\mathbf{Tr = (V_{sig} - V_{dark}) / (V_{ref} - V_{dark})}$

To determine beam attenuation coefficient: $\mathbf{c = -1/x * \ln (Tr)}$

V_d Meter output with the beam blocked. This is the offset.
V_{air} Meter output in air with a clear beam path.
V_{ref} Meter output with clean water in the path.
Temperature of calibration water: temperature of clean water used to obtain V_{ref}.
Ambient temperature: meter temperature in air during the calibration.
V_{sig} Measured signal output of meter.

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C-Star Calibration

Date	August 3, 2023	S/N#	CST-1874DR	Pathlength	25cm

	Analog output	Digital output
V_d	0.018 V	0 counts
V_{air}	4.807 V	15719 counts
V_{ref}	4.702 V	15373 counts

Temperature of calibration water	24.6	°C
Ambient temperature during calibration	22.2	°C

Relationship of transmittance (Tr) to beam attenuation coefficient (c), and pathlength (x, in meters): $\mathbf{Tr = e^{-cx}}$

To determine beam transmittance: $\mathbf{Tr = (V_{sig} - V_{dark}) / (V_{ref} - V_{dark})}$

To determine beam attenuation coefficient: $\mathbf{c = -1/x * \ln (Tr)}$

V_d Meter output with the beam blocked. This is the offset.
V_{air} Meter output in air with a clear beam path.
V_{ref} Meter output with clean water in the path.
Temperature of calibration water: temperature of clean water used to obtain V_{ref}.
Ambient temperature: meter temperature in air during the calibration.
V_{sig} Measured signal output of meter.

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WET Labs

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www.wetlabs.com

ECO Chlorophyll Fluorometer Characterization Sheet

Date: 5/11/2023 S/N: FLRTD-8223

Chlorophyll concentration expressed in µg/l can be derived using the equation:

CHL (µg/l) = Scale Factor * (Output - Dark Counts)

	Analog Range 1	Analog Range 2	Analog Range 4 (default)		Digital	
Dark Counts	0.078	0.047	0.032	V	51	counts
Scale Factor (SF)	6	13	25	µg/l/V	0.0077	µg/l/count
Maximum Output	5.01	5.01	5.01	V	16380	counts
Resolution	0.6	0.6	0.6	mV	0.9	counts

Ambient temperature during characterization 21.0 °C

Analog Range: 1 (most sensitive, 0–4,000 counts), 2 (midrange, 0–8,000 counts), 4 (entire range, 0–16,000 counts).

Dark Counts: Signal output of the meter in clean water with black tape over detector.

SF: Determined using the following equation: SF = x ÷ (output - dark counts), where x is the concentration of the solution used during instrument characterization. SF is used to derive instrument output concentration from the raw signal output of the fluorometer.

Maximum Output: Maximum signal output the fluorometer is capable of.

Resolution: Standard deviation of 1 minute of collected data.

The relationship between fluorescence and chlorophyll-a concentrations *in-situ* is highly variable. The scale factor listed on this document was determined using a mono-culture of phytoplankton (*Thalassiosira weissflogii*). The population was assumed to be reasonably healthy and the concentration was determined by using the absorption method. To accurately determine chlorophyll concentration using a fluorometer, you must perform secondary measurements on the populations of interest. This is typically done using extraction-based measurement techniques on discrete samples. For additional information on determining chlorophyll concentration see "Standard Methods for the Examination of Water and Wastewater" part 10200 H, published jointly by the American Public Health Association, American Water Works Association, and the Water Environment Federation.

CALIBRATION CERTIFICATE

NAME	:	RINKO Ⅲ
MODEL	:	ARO-CAV
SERIAL No.	:	0297
Parameter	:	Temperature Dissolved Oxygen

JFE

JFE Advantech Co., Ltd.

Temperature Calibration Certificate

Model	:	ARO-CAV
Serial No.	:	0297
Date	:	August 24, 2022
Location	:	Production Section
Method	:	Calibration equation is determined from third order regression of samples of the reference temperature against instrument voltages. Samples are taken at approximately 3, 10, 17, 24, and 31 ℃.

1. Equation

Instrument temperature[℃] = $A+B\times V+C\times V^2+D\times V^3$ V: Instrument voltage[V]

2. Coefficients

A = −5.282776e+00

B = +1.671875e+01

C = −2.186949e+00

D = +4.688863e−01

3. Calibration results

Reference temperature [℃]	Instrument voltage [V]	Instrument temperature [℃]	Residual error [℃]	Acceptance [℃]	OK/NG
2.819	0.51556	2.820	0.001	±0.020	OK
9.859	1.01007	9.856	−0.003	±0.020	OK
16.798	1.52588	16.802	0.004	±0.020	OK
23.737	2.04230	23.734	−0.003	±0.020	OK
30.871	2.54779	30.872	0.001	±0.020	OK

4. Verification

Criteria of judgement : Residual error of the instrument temperature at arbitrary point is within the acceptance value.

Reference temperature [℃]	Instrument temperature [℃]	Residual error [℃]	Acceptance [℃]	Judgement
20.688	20.698	0.010	±0.020	Passed

Examined H. Shimotsu

Approved M. Ujinaki

JFE Advantech Co., Ltd.

Dissolved Oxygen Calibration Certificate

Model	:	ARO-CAV
Serial No.	:	0297
Date	:	August 25, 2022
Location	:	Production Section
Method	:	Calibration is performed with the nitrogen gas (zero) and the oxygen saturated water (span) kept by air bubbling.
Film No.	:	220245BA

1. Equation

DO[%] =G+H×P'

Here, P'[%] consists of the coefficients A–F determined by the initial calibration.

2. Coefficients

A =	−4.367428e+01	E =	+4.300000e−03
B =	+1.376636e+02	F =	+6.810000e−05
C =	−3.647983e−01	G =	+0.000000e+00
D =	+1.044300e−02	H =	+1.000000e+00

3. Verification

Criteria of judgement : Residual error of the instrument DO at arbitrary point is within the acceptance value. The test is performed 3 times.

Acceptance: ±0.5% of full scale

Test for DO 0 %

	Test condition		Instrument DO [%]	Residual error [%]	Acceptance [%]	Judgement
	Atm. pressure [hPa]	Reference DO [%]				
1st	1003.9	0.00	−0.05	−0.05	±1.00	Passed
2nd	1003.8	0.00	−0.06	−0.06	±1.00	Passed
3rd	1003.7	0.00	−0.06	−0.06	±1.00	Passed

Test for DO 100 %

	Test condition			Instrument DO [%]	Residual error [%]	Acceptance [%]	Judgement
	Water T. [℃]	Atm. pressure [hPa]	Reference DO [%]				
1st	25.2	1003.5	99.01	99.09	0.08	±1.00	Passed
2nd	25.1	1003.5	99.01	99.04	0.03	±1.00	Passed
3rd	25.1	1003.4	99.00	98.95	−0.05	±1.00	Passed

Examined M. FUJITA

Approved M. Ujinaki

JFE Advantech Co., Ltd.

CALIBRATION CERTIFICATE

This document certifies that the instrument detailed below has been calibrated according to Valeport Limited's Standard Procedures, using equipment with calibrations traceable to UKAS or National Standards.

Instrument

Instrument Serial Number

Calibrated By

Certificate Number

Date

Signed

This summary certificate should be kept with the instrument.

Altimeter Build and Calibration Record

© Valeport Limited

Instrument type	Altimeter
Serial number	84324
Baud rate set ex factory	9600

Calibration History:	Certificate	Date
	75142	19/12/2022

System Components	Original Manufacture				Modification				Modification				Modification			
	Part (Blank=Not Fitted)	Iss	Serial Number	Range / Firmware	Part (Blank=Not Fitted)	Iss	Serial Number	Range / Firmware	Part (Blank=Not Fitted)	Iss	Serial Number	Range / Firmware	Part (Blank=Not Fitted)	Iss	Serial Number	Range / Firmware
PSU board	0430502	D1	1042352													
Micro board	0430501	E0	1042244	ACTEL 0430707												
				ATMEL 0430704A16												
Transducer Assembly	500kHz		46828	100m												
Pressure sensor	PAA - 10LX		N/A	N/A												

Name K. Bovey	Name	Name	Name
Date 19/12/2022	Date	Date	Date
Signed K.A Bovey.	Signed	Signed	Signed

Calibrated to Valeport's procedures using test equipment with calibrations traceable to UKAS or national standards

Instrument Serial Number	**84324**
Sensor Type	**500kHz**
Altimeter Range (m)	**100m**
Certificate Number	**75142**

Stage 1

Test the assembled altimeter in a body of water to ensure a signal is recieved at the minimum range. Taking direct readings from the unit immerse the head till it is roughly 0.1m from the bottom, readings should come through - if not then the signal is being saturated and there is a problem

To inhibit spurious readings set using: **#226;40**

	Pass/Fail
Bench Test Min Range <0.1m	Pass

Stage 2
Using a mini SVS or similar, measure the average sound velocity for the water in the tow tank and input the value in the cell below.

Enter the SOS	1472.859

Input SOS value to the altimeter using: **#830;1472.8590**

Stage 3
Fit the altimeter into the calibration fixture and lower the assembly into the tank till it is about 0.5m down facing the far end of the tow tank and clamp in place. Using the distance markers on the wall align the front edge of the trolley with the datum line to set the front of the altimeter at stated distance from the wall.

To determine the Range Offset		
Distance m	**Measured Range m**	**Measured Offset m**
1	1.018	-0.018

Stage 4: Enter the Offset Correction
#828;-0.0180

Stage 5 - Range Check after Offset Correction			
Distance m	**Measured Range m**	**Measured Offset m**	**Pass/Fail**
1	1	0	Pass
5	4.999	0.001	Pass

Stage 6: Reset the SOS
#830;1500

Stage 7: Reset maximum range to 105m		**Stage 8: Reset spurious range**
#823;105	(500kHz units)	**#226;0**

Calibrated by:	S.Court	Date:	19/12/2022
	S. [signature]		

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