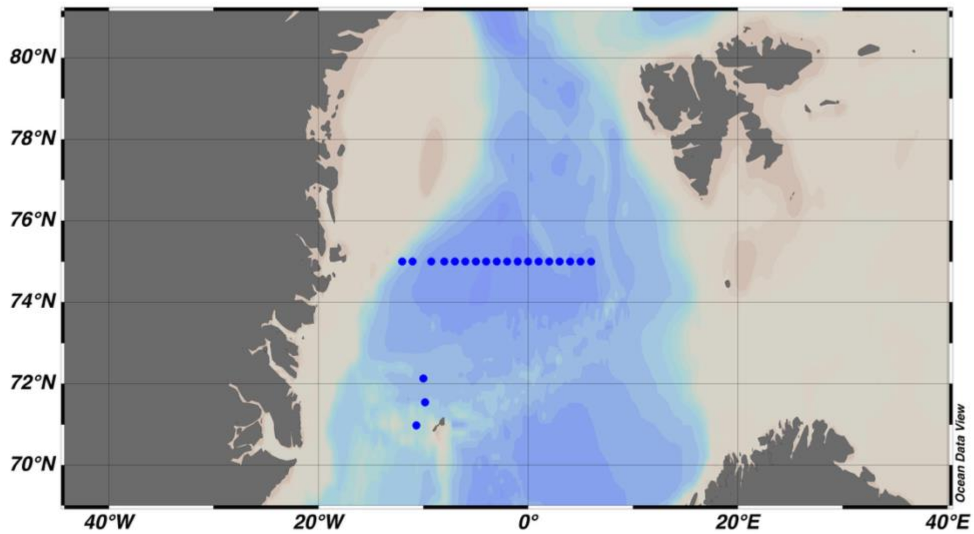
CRUISE REPORT: GOS2016111



Highlights

Cruise Summary Information

Section Designation	75N
Expedition Designation (ExpoCode)	**58GS20160802**
Chief Scientist	**Emil Jeansson**
Dates	August 2 – August 12, 2016
Ship	R/V G.O. Sars
Ports of Call	Tromso, Norway to Reykjavik, Norway
Geographic Boundaries	75° ”N 12° 05”W 6° ”E 70° 98”N
Stations	22
Floats and Drifters Deployed	0
Moorings Deployed and Recovered	0

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Report assembled by Savannah Lewis

Cruise report

58GS20160802
(a.k.a. GOS2016111, Ventilate CRUISE)

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Contents

1. Introduction and Background

The cruise was conducted on the Norwegian research vessel R/V G. O. Sars, as part of the Norwegian funded research project VENTILATE (Ventilation age and remineralisation rates in polar and sub-polar regions as an indicator for climate change). The project focuses on the link between ventilation processes and the oceanic carbon cycle, and how this connection is affected by the anthropogenic climate change. The sample program was planned with a few main goals in mind:

i) to study the present state of ventilation and related amount of anthropogenic carbon in the Greenland Sea (along the repeat section 75°N; especially since there were some problems on the last cruise in 2013)
ii) to detect water possibly transported directly from the Greenland and the Iceland Seas, in an opening in the Jan Mayen Fracture Zone, just west of Jan Mayen, and,
iii) to get status of the ventilation state in the Iceland Sea, which, together with the Greenland Sea would describe the summer situation before the 2017 winter, when a large cruise was planned to be conducted in the area.

At most stations we planned to take water samples for transient tracers (chlorofluorocarbon-12; CFC-12, and sulphur hexafluoride; SF_6), oxygen, dissolved inorganic carbon (DIC), total alkalinity (TA), $\delta^{13}C$ of DIC, nutrients, and salinity. Except the carbon isotope and nutrient samples, all samples were analysed on-board; more details below. The C-13 and nutrient samples were brought home and analysed in different labs in Bergen; more details below.

Along the 75°N section we planned water sampling at every full degree, while for every half degree a CTD cast was planned. This to give some time for the chemical analyses to be finished/well underway, since it easily builds up a large backlog, at the same time as gathering some useful hydrographic data, increasing the resolution in temperature and salinity (and oxygen, from the CTD sensor).

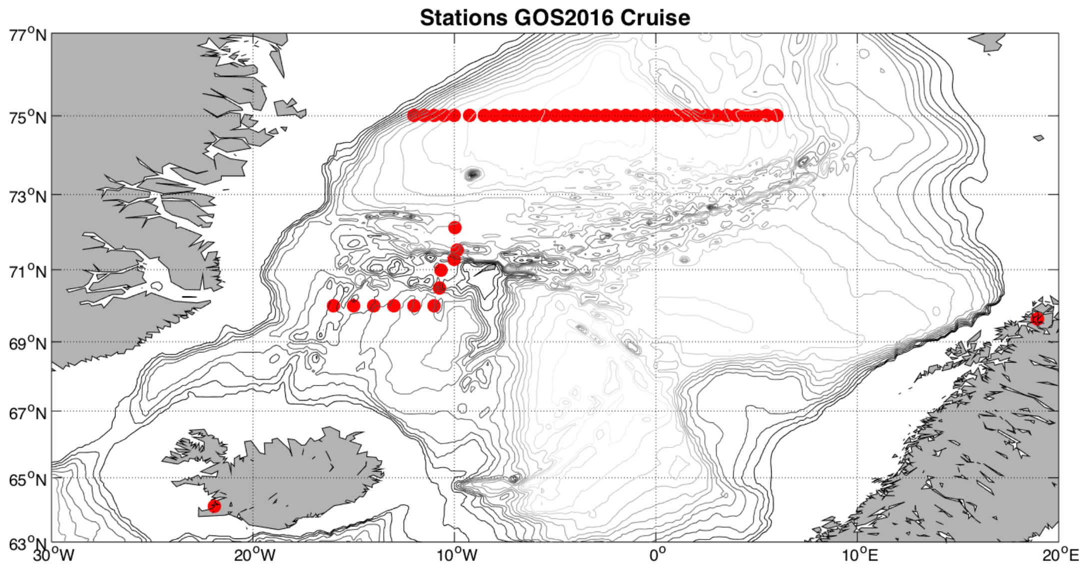

Fig. 1. Planned sampling locations for 58GS20160802.

2. Participants & responsibilities

Ailin Brakstad	Bottle salinity sampling and analysis
Are Olsen	Cruise leader
Balamuralli Rajasakaren	CFC-12 & SF_6
Camilla Landa	Bottle salinity sampling and analysis
Emil Jeansson	Chief Scientist, CFC-12 & SF_6 (PI) and underway O_2/Ar (PI)
Julia S. Villalba	DIC & TA
Kristin Jackson	Winkler oxygen, sampling and analysis (PI).
Martin Dahl	CTD, instrument chief
Ole Sverre Fossheim	CTD, instrument
Salma Elageed	Winkler oxygen sampling and analysis
Samuel Lindsay	DIC & TA
Siv Lauvset	DIC & TA (PI)
Tor de Lange	DIC & TA
Tore Onarheim	$\delta^{13}C$ sampling
Yanchun He	$\delta^{13}C$ sampling

3. WATCH LIST

Who	**When**	**What**
Ailin Brakstad	1200-2400	Salinity
Are Olsen	0800-2000	Cruise leader
Balamuralli Rajasakaren	0000-1200	CFC-12 & SF6
Camilla Landa	0000-1200	Salinity
Emil Jeansson	1200-2400	CFC-12 & SF6; O_2/Ar; Chief Scientist
Julia S. Villalba	0000-1200	DIC, TA
Kristin Jackson	0000-1200	Oxygen
Martin Dahl	0600-1200 & 1800-2400	CTD
Ole Sverre Fossheim	0000-0600 & 1200-1800	CTD
Salma Elageed	1200-2400	Oxygen
Samuel Lindsay	1200-2400	DIC, TA
Siv Lauvset	0000-1200	DIC, TA
Tor de Lange	1200-2400	DIC, TA
Tore Onarheim	0000-1200	$\delta^{13}C$ sampling
Yanchun He	1200-2400	$\delta^{13}C$ sampling

4. SAMPLING and INSTRUMENTS

4. 1 Water profile sampling

We used a 24-bottle rosette equipped with 10 l Niskin bottles from General Oceanics.

All water sampling was carried out following GO-SHIP protocols. The sampling order was: (1) CFC-12 & SF_6, in one syringe (2) Oxygen (3) DIC & AT, in one bottle (4) $\delta^{13}C$ (5) nutrients (6) salinity.

CTD

Seabird 911+ with two sets of temperature (SBE 3, serial numbers: primary 4340; secondary 5884, both calibrated 6. Oct 2015) and conductivity sensors (SBE 4, serial numbers: primary 3012, secondary 1827, calibrated 6. and 16. Oct. 2015) and a SBE 43 dissolved oxygen sensor (serial number 3090, calibrated 20. March 2015). The pressure sensor had serial number 0510, last calibrated 6. Apr. 2006. The CTD also carried a Chelsea Aqua3 sensor for fluorescence, serial number 088-251, last calibrated 3. Feb. 2012

Conductivity sensor 2 seems to have had issues throughout duration of cruise, dropouts and frequent low readings. Do not use.

Temperature sensor 2 seems to be more unstable than sensor 1, more spikes. Do not use.

The oxygen sensor also showed good behaviour over the cruise, reporting values that were typically around 15 μmol/l less than those obtained by Winkler titration of water samples.

Both CTD salinity and oxygen values that will be reported in our final data set will be corrected for offsets with respect to the values obtained by analysis of water samples.

CFC-12 and SF_6 analyses

Samples for analysis of CFC-12 and SF_6 were collected on all stations throughout the cruise. The samples were taken from the Niskin bottles in 250-ml glass syringes, which were stored immersed in cold seawater and analysis took place within six hours after sampling. The analysis is based on purge-and-trap work-up of the water samples followed by gas chromatographic separation and electron capture detection of the different compounds; the analytical technique is described by Bullister et al. (2008) and Stöven and Tanhua (2014).
The standardisation was achieved by calibration gas prepared at Deuste Steininger GmbH, Mühlhausen, Germany, and cross-calibrated against gas prepared at Scripps Institute of Oceanography. The standard gases were calibrated against the SIO-05 scale.

Winkler oxygen

Oxygen concentrations in water samples, which were sampled from every Niskin were determined using Winkler titration on an instrument designed and built at Scripps Institute of Oceanography. The instrument functioned seamlessly at the cruise.

Carbon chemistry

Analysis of the DIC and TA in water samples followed standard operating procedures as described in Dickson et al. (2007) by using two instruments built by MARIANDA in Kiel, VINDTA. The DIC is determined through coulometric titration of the gas stream from an acidified water sample of known volume following Johnson et al. (1985). The TA is determined using potentiometric titration of a water sample with HCl with a known concentration and a curve-fitting routine.

The collected samples were first brought to the desired measurement temperatures (20°C) and analysed first for DIC and then for TA (after heating further to 25°C). The heating of the samples were carried out by storing them in the lab, under a dark plastic sheet to minimise possible primary production.

All samples were analysed within approximately 12 hours of collection, and there was no need of conserving these with mercury chloride. All sampling bottles had been thoroughly cleaned and baked prior to the cruise.

The accuracy of the DIC and TA measurement systems was kept under control by frequent measurements of Certified Reference Material (CRM) supplied by Andrew Dickson (Scripps Institute of Oceanography, USA). Typical offsets were 4 - 6 μmol kg^{-1} for both, these offsets are corrected for in our final data file.

δ^{13}C

The δ^{13}C samples were drawn from every Niskin into 250 ml serum vials and transferred into exitainers preflushed with helium and that contained an aliquot of phosphoric acid. The seawater from each sampling depth was injected into three exitainers, 1 ml in each, using a new syringe for each sample, and making sure there were no air bubbles in the syringe when injecting the water into the exitainers. The three exitainers were taken from separate flushing batches, for analysis in duplicate at the mass spectrometer at Department of Earth Sciences at University of Bergen. If the duplicates show poor correspondence then the third replicate will be measured. At the ship the exitainers were stored cold and in the dark.

Nutrients

Samples for analysis of concentration of phosphate, nitrate and silicate were drawn from each Niskin into 24 ml scintillation vials and preserved with 0.2 ml chloroform. These will be analysed on shore by IMR using an auto analyser. At the ship the samples were stored cold and in the dark.

Salinity

Salinity was determined on board in bottle samples drawn from every Niskin on the rosette at each station, following GO-SHIP recommended practises. The samples were allowed to reach recommended analysis temperature by storing them in the climate controlled room on board, before analysing them using a Guildline Portasal. This was also installed in the climate controlled room. The stated accuracy of this instrument is 0.006.

4.2 Surface Sampling

Surface sampling for the following parameters:

Temperature and Salinity
Using the ships TSG, SBE21 from start until end of cruise.

Chlorophyll
Using ships fluorometer, Wet Labs Wet Star from start until end of cruise.

pCO_2
An underway pCO_2 system from General Oceanics, connected to the intake on the keel, approx. 6 m depth, measured surface ocean partial pressure of CO_2 every 2 minutes. This was running all the time and used three certified standard gasses from NOAA for calibration of the Licor.

Oxygen
An Anderaa optode was hooked up to the underway pCO_2 system, and was running all the time of the cruise.

Oxygen/Argon
Underway measurements of the ion current ratio between oxygen and argon (O_2/Ar) are performed by means of equilibrator inlet mass spectrometry using the EIMS system (Cassar et al. 2009). Both physical and biological processes influence the concentration of oxygen in the surface ocean. As O_2 and Ar have very similar physical properties (e.g. solubility and temperature dependence), measuring the ratio allows the removal of the physically driven part of the oxygen flux, and thus determination of the biologically driven contribution.

$$\Delta O_2/Ar = ([O_2]_{meas}/[Ar]_{meas})/([O_2]_{sat}/[Ar]_{sat})-1 \quad (1)$$

This "biological O_2 supersaturation" reflects the net metabolic balance between photosynthesis and respiration (Cassar et al. 2009), hence the net community production (NCP):

$$NCP=k*(\Delta O_2/Ar) *[O_2]_{sat}*\rho \quad (2)$$

where k is the gas exchange coefficient for O_2 (m d^{-1}) , $[O_2]_{sat}$ is the equilibrium concentration of O_2 in the mixed layer (μmol kg^{-1}) and ρ is the mixed layer density [kg m^{-3}].

5. PRELIMINARY RESULTS

5.1 Water profile sampling

The generally good weather and few technical issues made it possible to complete the planned 75°N section; one test station (#526, where all Niskins were closed at the same depth, ~300 m), 18 stations (#527-561) with full chemistry (typically every full longitude degree), and a total of 35 CTD stations (some being double casts) (typically every 0.5 degree). However, due to a wrong winch speed used for the pre-cruise time calculations, the actual time at hand was somewhat less than planned, and in addition, due to an approaching low pressure, we had to cancel the last stations across the Jan Mayen Ridge, and all in the Iceland Sea. Three stations were completed west of Jan Mayen (#562-565; one was a double cast), all with full chemistry.

The hydrographic data (Fig. 2) clearly show the some high-saline Atlantic Water (AW) in the upper layers in the eastern part, while the stations furthest west, close to the Greenland slope, captured some cold and fresh Polar Surface Water in the surface, with some re-circulated AW below. The salinity in the central Greenland Sea all have values above 34.91, with values around 34.92 are frequent. There is a layer between 1000 and 2000 m with somewhat lower salinity, although the values are clearly higher than traditional Arctic Intermediate Water.

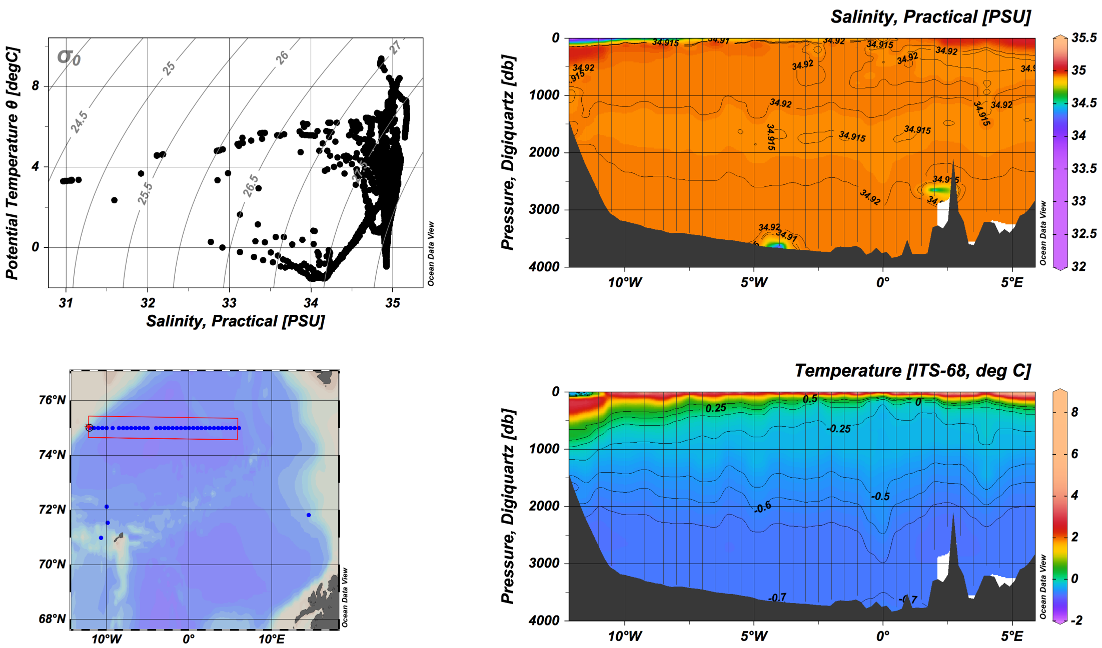

Fig. 2. Section plot of the Greenland Sea (75°N) of potential temperature and salinity (from CTD); uncorrected data.

The bottle data of oxygen and transient tracers (Fig. 3) clearly illustrate the difference in ventilation between the convectively active upper and intermediate layers, and the older deep waters. There is also a rather clear difference, especially in oxygen, between the stations located in the East Greenland Current in the west, dominated by waters of Arctic origin, and the more recently ventilated waters of the Greenland Sea Gyre. Figure 3 also shows an eddy, located at 0°E, with high concentrations of oxygen and transient tracers down to well below 2000 m. This is also seen in the temperature distribution, where isotherms below 1500 m drop down, and isotherms above 1000 m shoals, at this location.

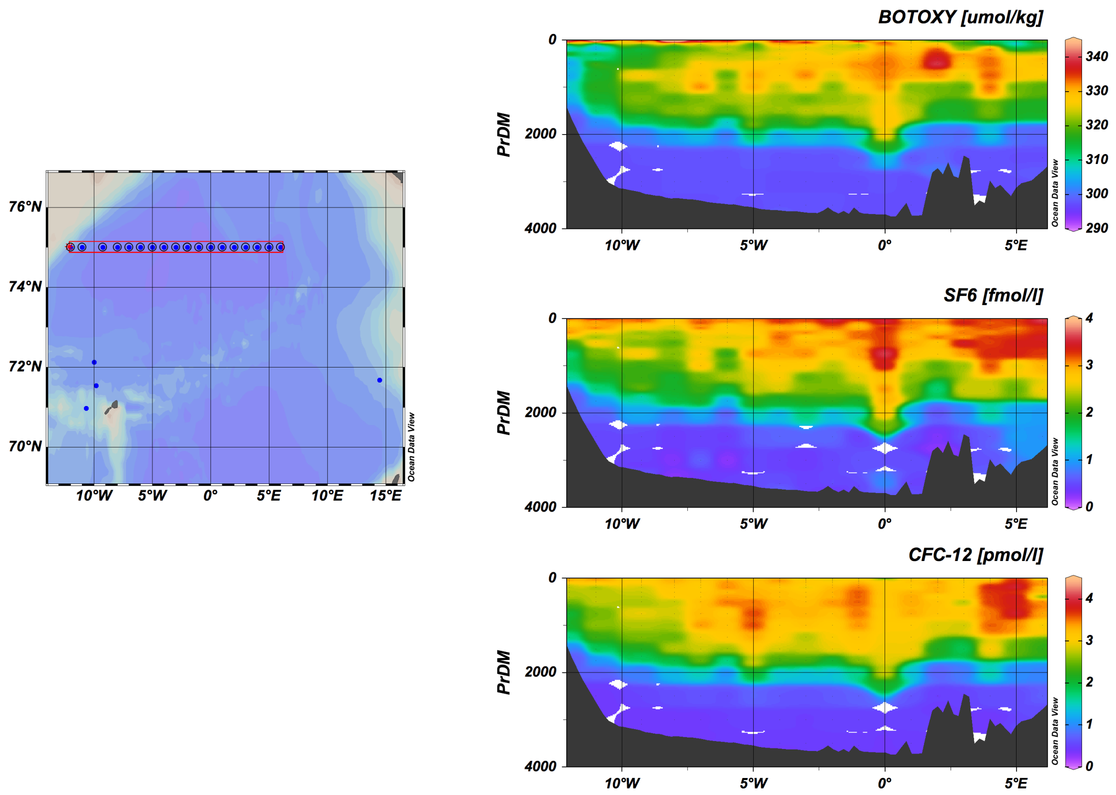

Fig. 3. Section plot of the Greenland Sea (75°N) of dissolved oxygen, CFC-12, and SF_6, uncorrected bottle data.

Three stations were sampled close to Jan Mayen (~71-72°N, 10°W), over the Jan Mayen Fracture Zone. The Θ/S properties show a rather clear difference between the two stations in the southern Greenland Sea, and the station closer to the northern Iceland Sea (Fig. 4), with the former two having much fresher water in the upper layers. The southern station has a clear Atlantic-derived salinity maximum at ~100 m, and a deeper salinity minimum of Arctic Intermediate Water at ~700 m.

Bottle data of oxygen and transient tracers (Fig. 5) show a gradual concentration increase southwards at intermediate depths (~250–1000 m), indicating higher degree of ventilation. The station located furthest south across the JMFZ, has a rather homogeneous and recently ventilated layer that is associated with the salinity minimum, suggesting AIW formed in the Greenland Sea.

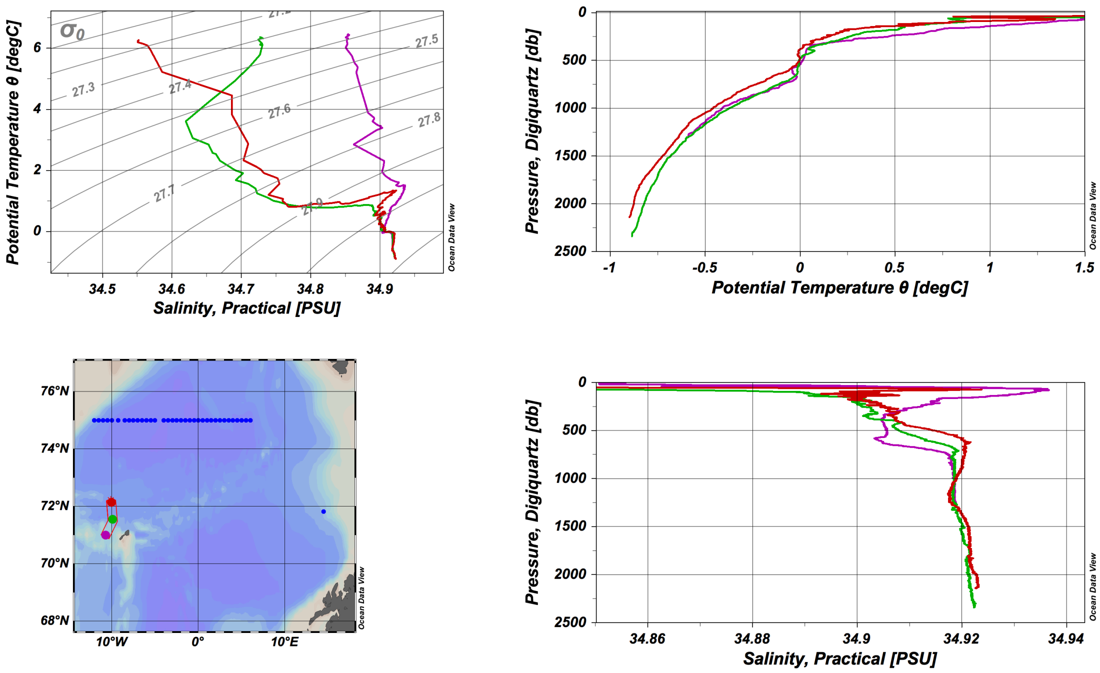

Fig. 4. Stations sampled across the Jan Mayen Fracture Zone; uncorrected CTD data.

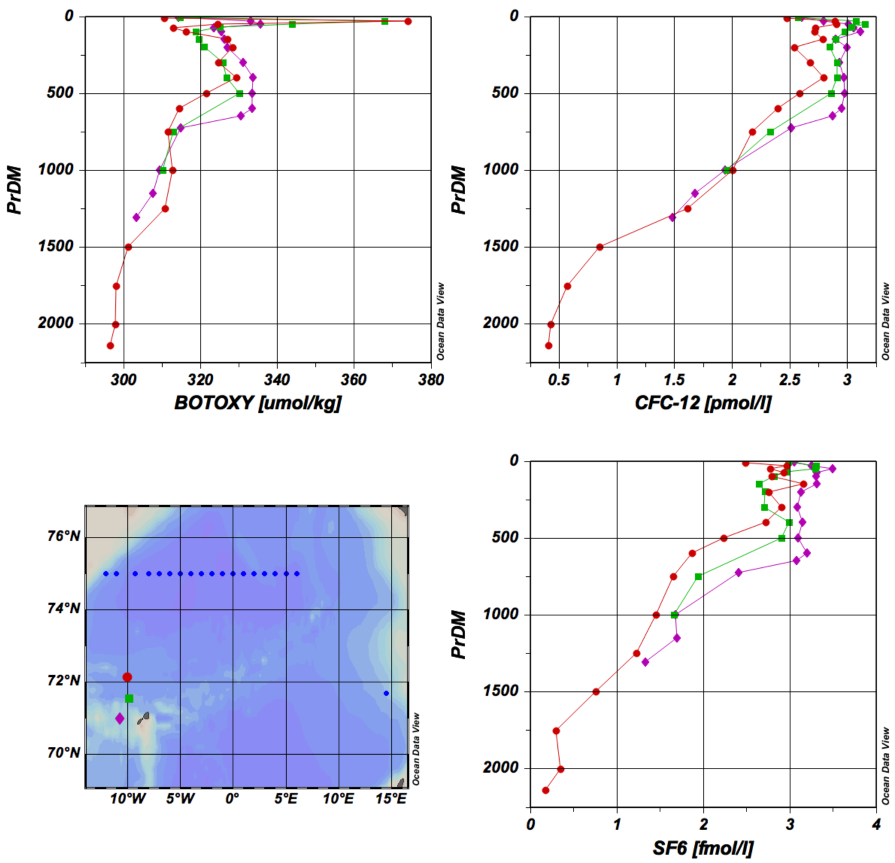

Fig. 5. Stations sampled across the Jan Mayen Fracture Zone; dissolved oxygen (upper left), CFC-12 (upper right), and SF_6 (lower right).

5.2 Surface water sampling

O_2/Ar

The O_2/Ar measurements worked well during the cruise (Fig. 6). Positive values dominated, indicating biological production, while the negative values indicate a net flux of oxygen into the sea surface (net respiration). Combined with TSG and wind data this will give estimates of net community production. Due to a non-working meteorological station on the ship during the cruise a wind data product has to be extracted from NCEP (or similar).

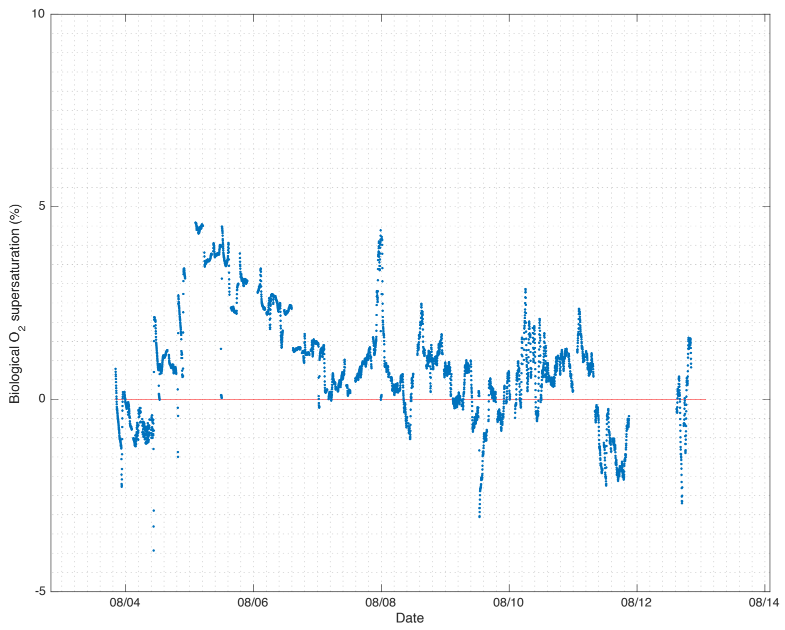

Fig. 6. Biological supersaturation, from raw data of the O2/Ar measurements during the 58GS20160802 cruise.

6. DIARY

All timestamps are Norwegian time zone, two hours after UTC (which is the timestamps for CTD).

2 Aug

All instruments installed and secured

1540: left Tromsø port to fill fuel.

2000: left bunker station

2015: Test cast in fjord to check CTD and rosette, everything fine.

3 Aug

Station 526
Approx 1300
Internal precision test cast. Sample all 24 bottles well below mixed layer, all closed, valve at Niskin 7 a little hard to pull out. See if we can replace this. Anyhow, comparing salinometer salinities and Winkler oxygen with the ones from the CTD, no consistent offsets of the two are found at any bottles. Winkler O_2 is abnormally high compared to CTDOXY at bottle 7. But salinity did not show abnormal bias and at later stations bottle 7 did not show abnormal bias in neither O_2 or salinity, so I do not think this is taking in water after being tripped.

4. Aug
Station 527
Approx. 1215, arrived at first real station at 75N, 6E. Station conducted without peculiarities. Bottle 7 seem to leak (water drips out when upper valve is opened). Oxygen and salinity data indicates no issues.

Station 528
1530, arrive next station. Sampling of previous not complete when we arrive. Station start approx. 1610. O2 sensor acting up at 2200 m downcast and 500 m on way up. Seems to jump completely, and then slowly revert to initial values. Only CTD, i.e., no water samples taken. We will stick to this schedule throughout most of the 75N section, water sampling at every full degree and only CTD at every half, this allows carbon measurements to keep track with the sampling pace.

DIC instrument: pipette won't drain into stripper. Valve 7, directing flow of gas to stripper or top-of-pipette doesn't seem to switch. Tee-d off N_2 gas from main supply line to top of pipette as makeshift solution.

Station 529
1900, arrive station.
Still problems with oxygen sensor. Also one peak in salinity, but this jumped right back to initial values.
Sample for all parameters. Emil complains on bottle 7, water coming out from lower cap when sampling. Otherwise OK.

Station 530
Spike in oxygen at about 500 m, otherwise fine.

5. Aug.
Plug for oxygen and altimeter cleaned during the night.

Station 531
Oxygen very bad at downcast, but nice on up-cast. This is the first station after having taken apart and cleaned the plug. So it may have been loose and then closed shut at bottom. If anything, use up-cast CTD values for this station.

Station 532
3.5 deg east at 0535

Only CTD. Still Atlantic water on top. Oxygen sensors and all of the others seem fine now.

Station 533
3 deg east at 0846
Oxygen sensor acting up again, at ca. 1450 dbar on the way down and 500 dbar on way up.

Station 534
2.5 deg east at ~1253
Only CTD. A few minor blips on the oxygen curve.

> Actually, until now (in time, not analysis of stations) the DIC instrument has not been stable. We are still working on it.

Station 535
Arriving at station Martin and Ole Sverre services all plugs on CTD-sonde.
Rosette in water 1330

DIC instrument: By now we seemed to have fixed the DIC system and starts analyses again at samples from bottle 8 at station 531. So data from before btl 8 sta 531 are likely questionable, but those from after are likely good. The system had been somewhat unstable since tee-ing off carrier gas to drain the pipette. Measured DIC values tended to be low. Using an analogue flow meter we found that it did not shut completely. So we added an on/off valve, and turned off the gas to the pipette whenever valve 7 would be shut. This gave higher and more stable values.

Oxygen works fine, until 500 dbar on way up, then we get a disturbance.

13C: Yanchun informs me that the exitainers for 13C have not been placed sequentially back in the boxes after sampling, remember to notify Pål Tore before analysis. This applies to the first set of boxes, Yanchun will coordinate with Tore for the next ones)

Aug 6
The night has been uneventful, I when woke up we were at station 539, 2 deg W. There had been some glitches in the CTDOXY, but no catastrophic failures. Siv informed me that they had been having trouble with the DIC instrument during the night, but that it was analysing now.

Sta 540
Arrive at station 1030. Martin replaces bottle 7. Uneventful CTD. Oxygen sensor seemed well behaved

Sta 541

Freons: 1600 Emil reports issues with CFC instrument. Has to service it a bit, may take a few hours. Later in the evening the system is up and running

The rest of the day passes without any issues.

7. Aug
Wakes up at Sta 545, water sampling station at 3 deg W. Night has passed without issues. Station completed without issues.

Sta 546
CTD station, uneventful

Sta 547
CTD display freezes once we start to take up the CTD from the deepest level. Take up CTD and restart. Repeat carried out without issues

Skip the CTD station at -4.5 to catch up.

Sta 548
At 5 degrees west. , uneventful

8. Aug
Reports states that operations during night were carried out without issues.

I wake up for sampling of Sta 550.

Sta. 551
CTD station. Carried out without incidents.

Sta 552
Water sampling, carried out without issues.

9 Aug
Wake up at station 557, Martin reports no issues from during the night.

Rest of 75N section completed today, without any problems. Sampled quite a few replicates at the two last water sampling stations, i.e., 559 and 561

10. Aug
Been steaming to section west of Jan Mayen. First station, 561 at 1400. No problems

Next station, number: 563 at about 2000.
At 1000, up-cast, waiting to trip the Niskin CTD software crashed, had to repeat cast down to 1000 m to get samples from above this depth.

11. Aug
At 0700 we decide to steam to Reykjavik.

References

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Post-Cruise CTD and Oxygen Data Correction

VENTILATE - GO.Sars 2016

In total, 41 stations (numbered 525–565) were taken during the cruise. The geographical positions are shown in Figure 1. Water samples from Niskin bottles were collected at 23 stations (indicated in red in the figure). Station 525 and 526 were test stations (525 was taken in a Norwegian fjord just after the ship left port in Tromsø and is not visible on the map). Station 563 and 564 are the same station, they could have been marked cast 1 and 2 (this is not done in the current

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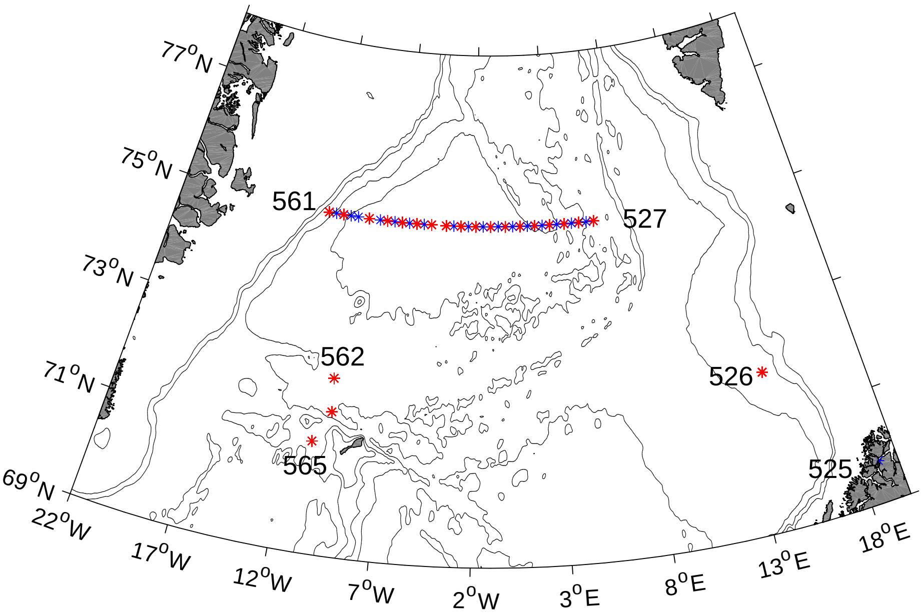


Figure 1: Map showing the position of the cruise stations. Red indicate stations including water samples. The first station (number 525) was taken in a Norwegian fjord just outside of Tromsø on the 2nd of August 2016, while the last station (565) was taken west of Jan Mayen the 11th of August 2016.

manual.

Pressure and temperature

No additional pressure and temperature sensor corrections were applied.

Conductivity

Uncorrected CTD conductivity from the primary sensor - bottle conductivity residuals are shown in Figure 2. The top panel shows uncorrected residuals with station number (time) and the lower panel shows the residuals versus pressure. The residuals are generally small with no clear pattern, except a few outliers which appear to be related to measurements close to the surface.

Calibration of the conductivity sensor was performed using a non-linear least-squares fitting procedure that minimize the residuals. The employed calibration equation was obtained from the GO-SHIP manual (McTaggart et al., 2010):

$$C_{corr} = C + cp2 * P^2 + cp1 * P + c2 * C^2 + c1 * C + c0 \tag{1}$$

where C_{corr} and C is the corrected and measured CTD conductivity, respectively. P is pressure and $cp2, cp1, c2, c1,$ and $c0$ are regression coefficients. The coefficients were calculated for each station based on the residuals between the bottle conductivity and the uncorrected CTD conductivity from the primary sensor. That is, the regression coefficients for each station including water samples (shown in Table 1) were determined by applying equation 1 to the bottle conductivity.

The corrected residuals, after calibration, are shown in Figure 3 with the according mean and standard deviation. The mean residual is closer to zero and the spread is smaller.

In order to correct the whole dataset (including stations without water samples) we estimated the mean of each calibration coefficient. This was done after excluding outliers ($> \pm 1$ standard deviation). Outliers and the mean calibration coefficients are indicated in red and bold, respectively, in Table 1.

Oxygen

Calibration of the SBE-43 oxygen sensor on the CTD was performed using a non-linear least-squares fitting procedure that minimize the residuals between the measured CTD oxygen and the dissolved O_2 bottle samples. Bottle oxygen was determined by Winkler titration. The resulting values given in ml/l were converted to $\mu mol/kg$ seawater. This was done by multiplication with 44.66 $\mu mol/l$ (reverse of molar volume of real oxygen) and by division with density of seawater which was calculated at standard pressure and bottle draw temperature.

The uncorrected CTD oxygen - bottle oxygen residuals are shown in Figure 4. There are some outliers related to one specific station (537). These were excluded during the calibration. Uncorrected residuals without these outliers are shown in Figure 5.

The employed calibration equation was obtained from the GO-SHIP manual (Uchida et al., 2010):

$$\begin{aligned} O_2 = S_{oc} * \left(V + V_{off} + \tau_{20} * e^{(D_1 * p + D_2 * (T-20))} * \frac{dV}{dt}\right) \\ * O_{sat} * (1 + A * T + B * T^2 + C * T^3) * e^{((E*P)/(273+T))} \end{aligned} \tag{2}$$

where O_2 is oxygen (in $\mu mol/kg$), V is the measured CTD oxygen voltage, and dV/dt is the temporal gradient of the oxygen voltage in Vs^{-1}. T and P are the temperature and pressure, respectively, and S_{oc}, V_{off}, τ_{20}, D_1, D_2, A, B, C, and E are calibration coefficients provided by the SBE company for the specific sensor. For each station S_{oc}, V_{off}, τ_{20}, and dV/dt were determined by non-linear least squares fits to in situ water sample oxygen data. That is, equation 2 was solved for each station for the bottle data in order to determine these four coefficients. Saturated oxygen concentration (O_{sat}) was determined at in situ pressure and temperature via sw_satO2.m and potential density (σ_0).

After the four coefficients were estimated for each station (shown in Table 2) the corrected CTD oxygen was calculated using equation 2. Figure 6 shows the corrected residuals with station number and pressure. The mean residual is closer to zero (~ -0.0036 $\mu mol/kg$) and the spread is smaller.

In order to correct the whole dataset (including stations without water samples) we estimated the mean of each calibration coefficient following a similar procedure as for the conductivity (ref. Table 2). Outliers ($> \pm 2$ standard deviations) are marked red in the table.

During the cruise we had some problems with the CTD oxygen sensor. We observed several spikes and shifts in the measured oxygen. Spikes (as in station 528, 530, 531, and 533) are not removed/smoothed in the current dataset. Station number 529 and 537 had several spikes/shifts in the profile. Since these two stations also differ a lot from the bottle oxygen/ the calibration coefficients were considered outliers, they are flagged as questionable (=3) in the dataset. All other stations are flagged 2 (no noted problems).

Table 1: Regression coefficients for conductivity determined by solving equation 1 for each station including water samples. Red values (> ±1 standard deviation) are not included in the mean at the bottom of the table (bold).

Station	cp2	cp1	c2	c1	c0
526	5,98E-04	-3,76E-01	-1,39835	95,51721	-1571,99329
527	-6,61E-11	-1,73E-08	-0,00006	0,00398	-0,06976
529	-6,03E-10	1,24E-06	-0,00049	0,03060	-0,48159
531	-4,93E-12	-4,13E-07	-0,00020	0,01212	-0,18969
533	3,20E-10	-1,06E-06	0,00029	-0,01844	0,29011
535	-1,20E-09	2,58E-06	-0,00024	0,01695	-0,29143
537	9,56E-10	-3,01E-06	0,00039	-0,02859	0,49799
539	1,44E-11	-2,31E-07	0,00015	-0,00949	0,14486
541	-6,67E-10	1,89E-06	-0,00014	0,00859	-0,13946
543	3,98E-10	-1,30E-06	0,00007	-0,00474	0,07277
545	-6,67E-12	-2,51E-07	0,00005	-0,00326	0,04707
547	1,67E-10	-8,76E-07	-0,00002	0,00126	-0,01869
548	-3,03E-10	2,36E-07	-0,00247	0,14835	-2,22965
550	-2,14E-10	-1,56E-08	-0,00020	0,01291	-0,21254
552	6,77E-10	-2,92E-06	-0,00049	0,02708	-0,37236
554	3,77E-10	-1,98E-06	-0,00118	0,06852	-0,99721
556	-8,48E-11	-3,54E-07	-0,00033	0,01912	-0,28084
559	4,97E-09	-1,79E-05	0,00050	-0,03577	0,63095
561	-1,67E-08	3,81E-05	0,00212	-0,12574	1,84499
562	-1,52E-10	-9,01E-08	-0,00016	0,01045	-0,17183
563	4,13E-08	-1,12E-04	-0,36841	21,35097	-309,26532
564	4,12E-09	-6,93E-06	0,00054	-0,03460	0,55322
565	3,78E-09	-7,54E-06	0,00064	-0,04128	0,65921
MEAN	**-2,03E-10**	**-3,93E-08**	**-0,00006**	**0,00276**	**-0,03400**

Table 2: Regression coefficients for oxygen determined by solving equation 2 for each station including water samples. Red values (> ±2 standard deviations) are not included in the mean at the bottom of the table (bold).

Station	S_{oc}	V_{off}	τ_{20}	dV/dt
526	0,57192	-0,57609	0,17917	1,60E-05
527	0,53125	-0,46992	3,24000	0,00032
529	0,58760	-0,63524	0,16200	1,60E-05
531	0,57031	-0,58284	0,16200	1,60E-05
533	0,54722	-0,53246	0,16200	1,60E-05
535	0,51983	-0,42831	0,16200	1,60E-05
537	0,53418	-0,47464	3,24000	0,00032
539	0,54233	-0,49304	3,24000	0,00032
541	0,53824	-0,48404	3,24000	0,00032
543	0,53984	-0,48841	3,24000	0,00032
545	0,53609	-0,47497	0,16200	1,60E-05
547	0,54986	-0,50657	3,24000	0,00032
548	0,53952	-0,48697	3,24000	0,00032
550	0,54330	-0,49565	3,24000	0,00032
552	0,53472	-0,46906	0,16200	1,60E-05
554	0,54600	-0,49988	3,24000	0,00032
556	0,52416	-0,44892	0,16206	1,60E-05
559	0,53680	-0,47515	0,16209	1,60E-05
561	0,54497	-0,49137	0,18694	1,86E-05
562	0,54133	-0,49156	3,24000	0,00032
563	0,51872	-0,43545	3,24000	0,00032
564	0,53739	-0,48401	3,24000	0,00032
565	0,53636	-0,47518	0,16200	1,60E-05
MEAN	**0,54020**	**-0,48929**	**1,84283**	**0,00018**

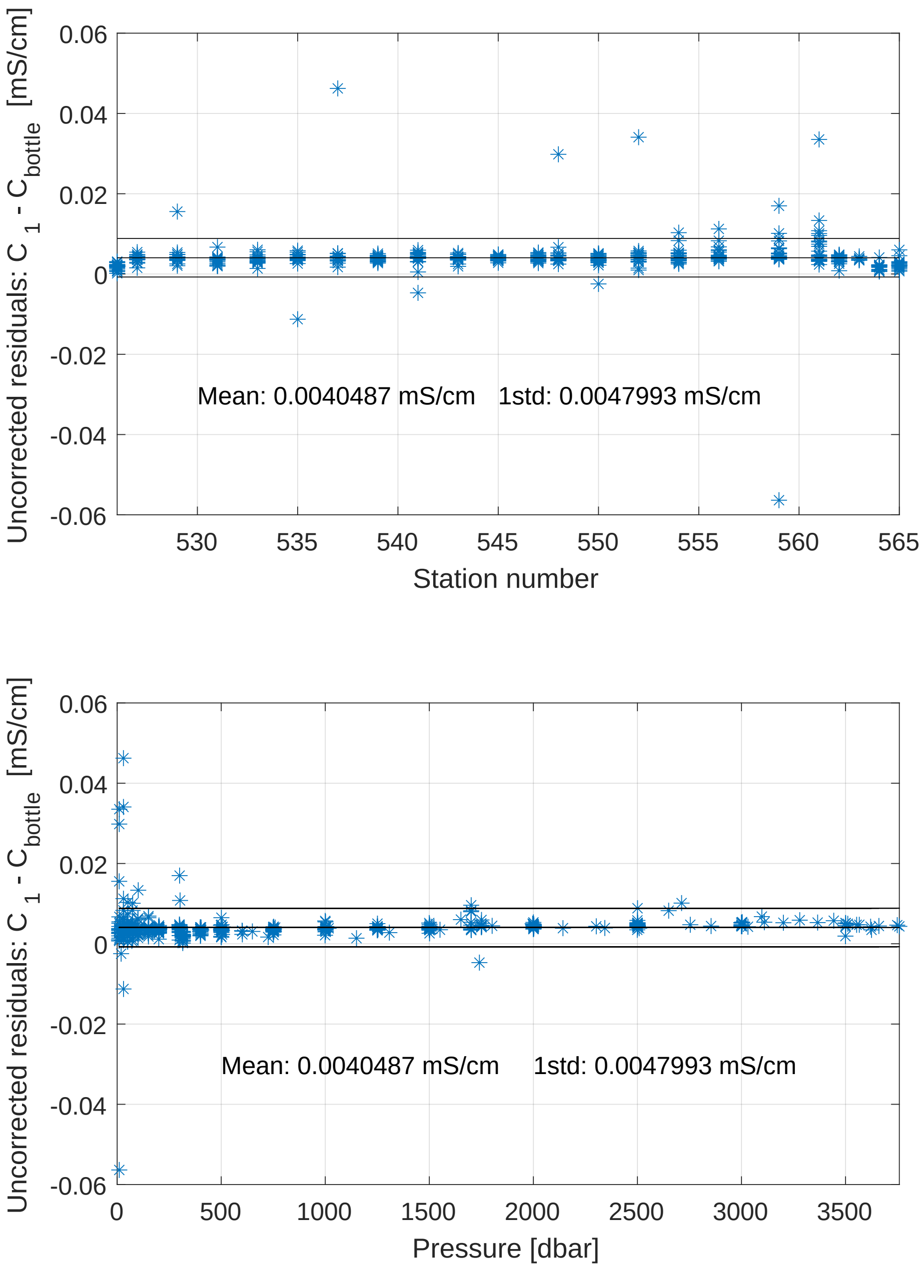


Figure 2: Uncorrected residuals: CTD conductivity from the primary sensor (C_1) - bottle conductivity (C_{bottle}) versus station number (top) and pressure (bottom). The mean residual and $\pm$ 1 standard deviation are indicated by the black lines.

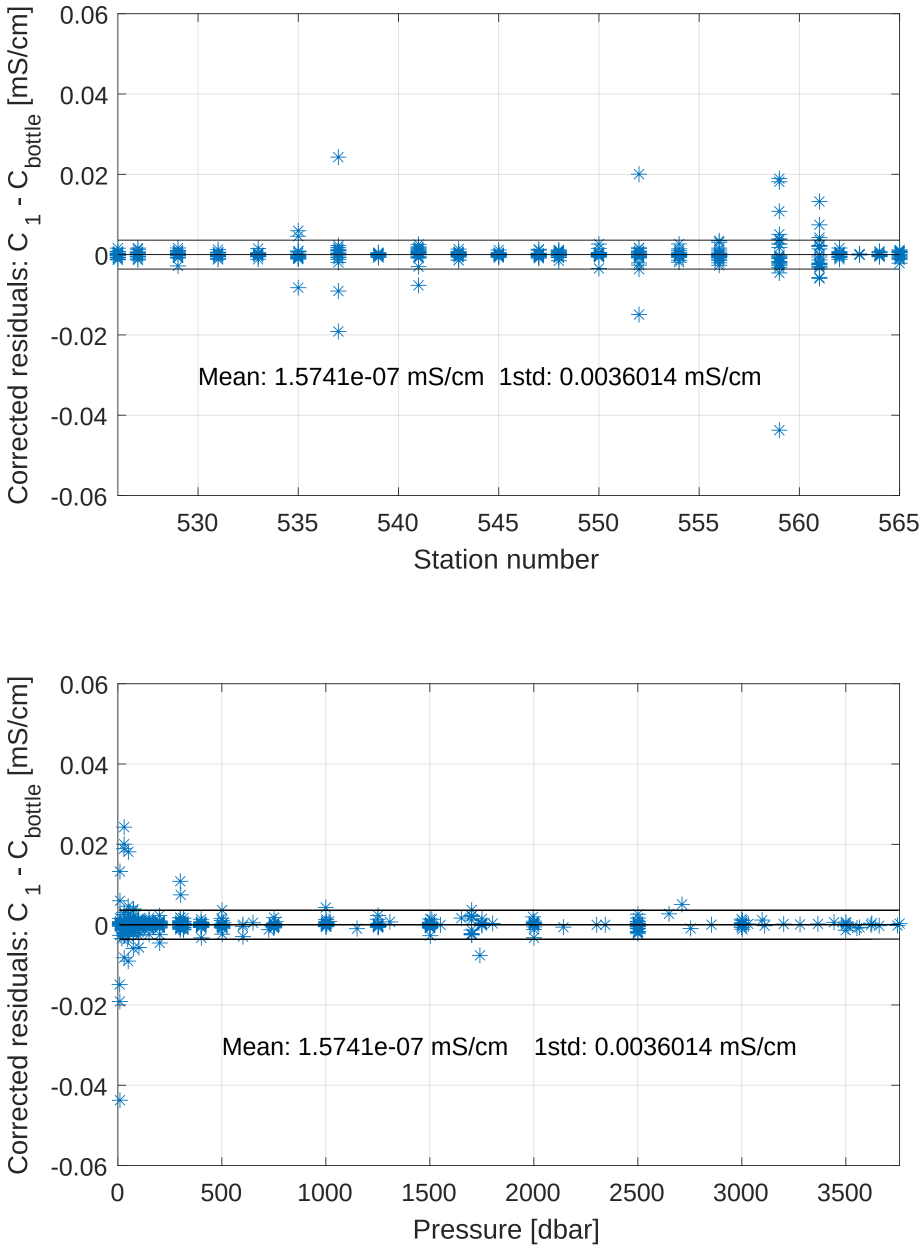


Figure 3: Corrected residuals: Corrected CTD conductivity (C_1) - bottle conductivity (C_{bottle}) versus station number (top) and pressure (bottom). The mean residual and ± 1 standard deviation are indicated by the black lines.

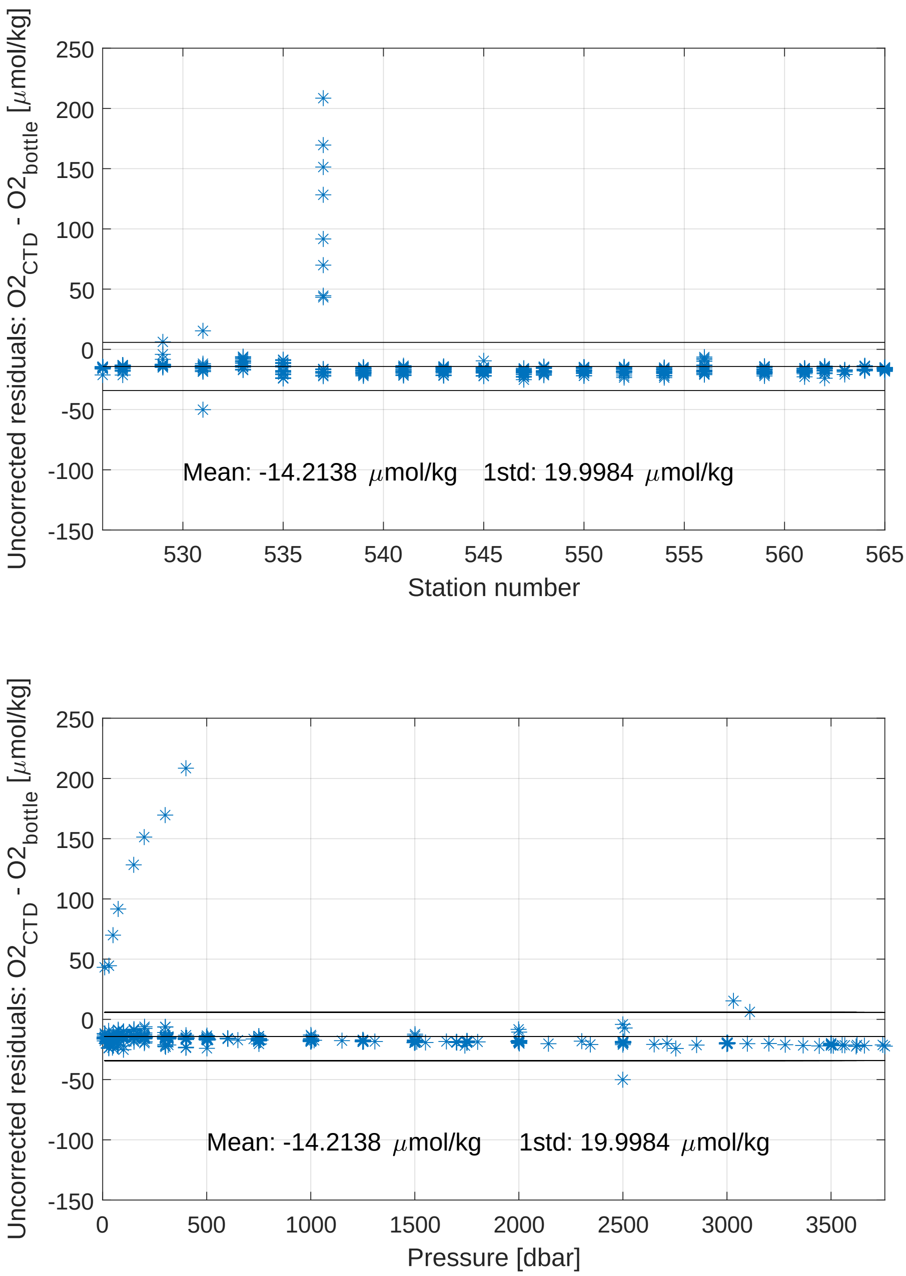
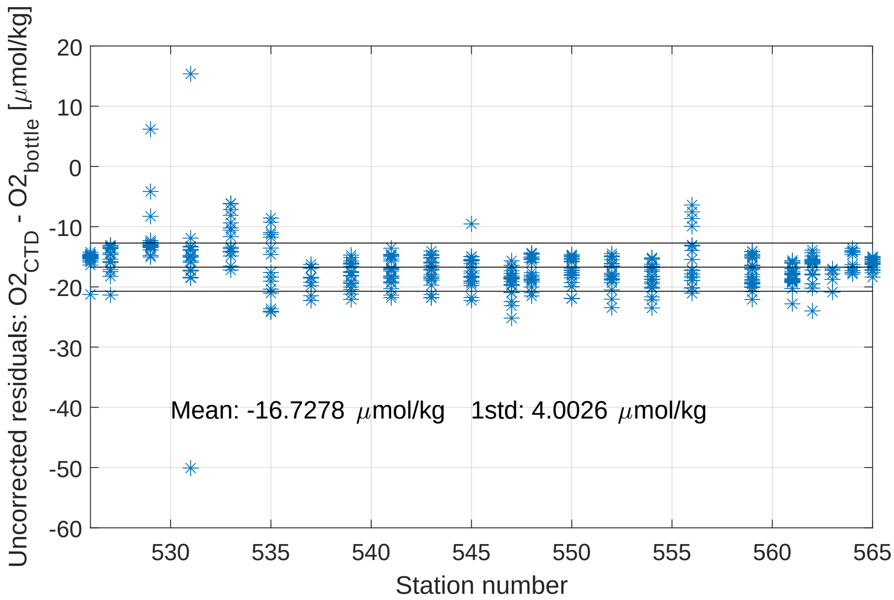


Figure 4: Uncorrected residuals: CTD oxygen - bottle oxygen versus station number (top) and pressure (bottom). The mean residual and ± 1 standard deviation are indicated by the black lines.



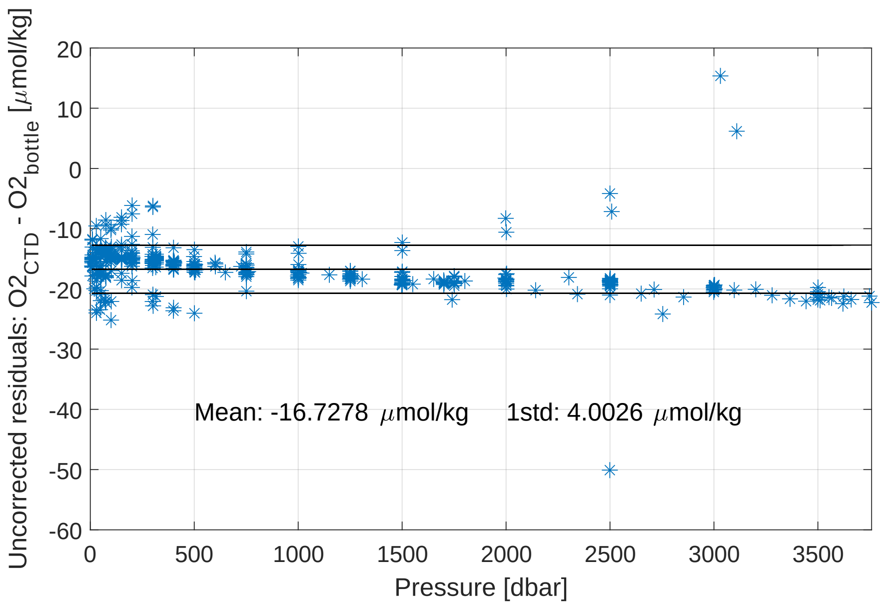


Figure 5: Uncorrected residuals: CTD oxygen - bottle oxygen versus station number (top) and pressure (bottom). Outliers from station 537 are removed (compare with Figure 4). The mean residual and ± 1 standard deviation are indicated by the black lines.

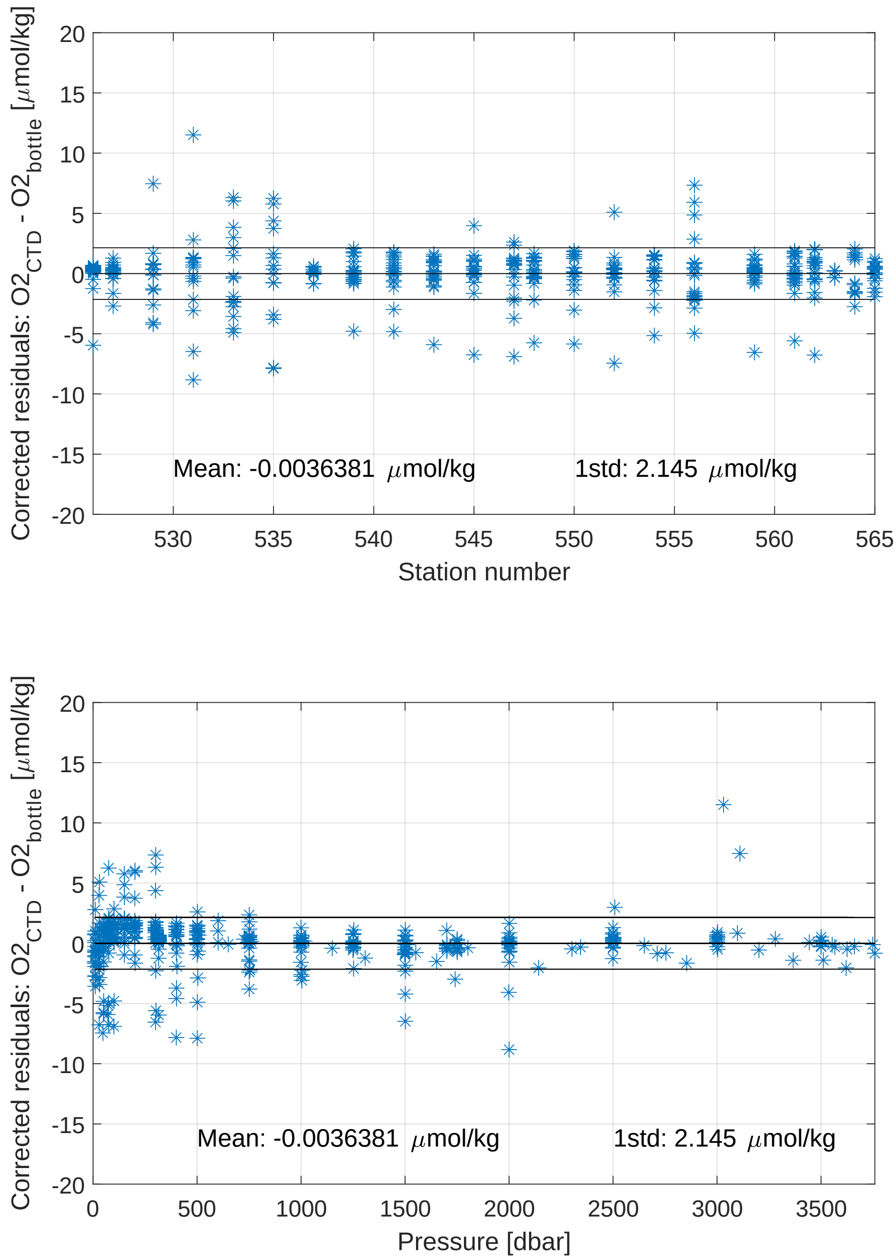


Figure 6: Corrected residuals: CTD oxygen - bottle oxygen versus station number (top) and pressure (bottom). The mean residual and $\pm$ 1 standard deviation are indicated by the black lines.