UNIVERSITY OF BERGEN

Geophysical Institute

FINAL REPORT

A Study of the Osterøy and Masfjord Region

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Spring 2021

"I have not failed. I have successfully found 10 000 ways that won't work."

Thomas A. Edison

Acknowledgement

We would like to thank the following people for all their help during the course and the execution of this report!

- Dr. Kjersti Birkeland Daae
- Dr. Harald Sodemann
- Christiane Duscha
- Jakob Simon Dörr
- Tor De Lange
- The Crew of R.V. Kristine Bonnevie

The GEOF232 Students

Contents

Chapter 1

Introduction

This report is the output of GEOF232: Practical Meteorology and Oceanography. To compile this report, we set out on two separate field excursions: one to set up meteorological instrumentation and one on a multi-day cruise.

Meteorological instrumentations, including two automatic weather stations (AWS), were set up on Osterøy on February 18th, 2021. The instrumentation was taken down on March 12th, 2021.

The cruise and oceanographic data collection took place between February 24th and March 2nd, 2021 on the R.V. Kristine Bonnevie. The main study sites for this survey were the Osterøy area and Masfjorden.

The following reports were produced using this data to analyze a variety of climate variables around the western region of Norway.

Chapter 2

Oceanographic Survey

2.1 Participants

Table 2.1: Participants

Last name	**First name**	**Role**	**Time onboard**
Rinde	Birgit	GEOF337	24. feb – 2. mars
Stallemo	Astrid	GEOF337	24. feb – 2. mars
Andriani	Glykofridi	GEOF337	24. feb – 2. mars
Astrid	Bergland	GEOF337	24. feb – 2. mars
Dung	Nguyen	GEOF337/232	24. feb – 2. mars
Reppert	Valerie	GEOF232	24. feb – 2. mars
Rønning	Emili Carin	GEOF232	24. feb – 2. mars
Staudinger	Ilga	GEOF232	24. feb – 2. mars
Kavaliauskas	Paulius	GEOF232	24. feb – 2. mars
Sælemyr	Ingrid	GEOF232	24. feb – 2. mars
Dörr	Jakob	Instructor	24. feb – 2. mars
Daae	Kjersti B.	Cruise leader	24. feb – 2. mars
Jackson-Misje	Kristin	Chemical engineer	24.feb
Peterson	Algot	Engineer	26. feb

2.2 Cruise overview

The cruise on board the Research Vessel Kristine Bonnevie was undertaken as a part of the GEOF232 and GEOF337 courses offered at the Geophysical Institute (GFI), University of Bergen. During the cruise, we collected data in the fjords around Osterøy (Osterfjorden and Sørfjorden), and also Masfjorden, Fensfjorden, Lurefjorden, and the open coast outside Fensfjord. We will use the data to address the processes related to tides and mixing in Masfjord and Lurefjord, ocean-fjord exchange mechanisms, the observed deoxygenation of the inner basis, and the various forcing mechanisms that affect the surface layer. The students become familiar with typical and state-of-the-art measurement systems. The students participate in all parts of the cruise, including the planning phase, the data collection onboard, and writing the cruise report.

In total, 2 moorings were deployed in Masfjorden, consisting of current meters, current profilers, and temperature, salinity, oxygen and pressure loggers, which will collect data for one-year duration. During the cruise, the students collected data primarily by using the ship's CTD and vessel-mounted current profiling system, drifters, and a small CTD probe. The students also collected water samples for measurements of CO2, nutrients, isotopes, and oxygen, and titrated the oxygen samples.

2.3 Environmental conditions

2.3.1 Weather observations from the dayshift

24.02: A little rain in the evening, overcast and windy during the day.

25.02: A little drizzle in the morning, cloudy but some peaks of sun. Some more rain in the afternoon, very windy and a lot of waves.

26.02: Cloudy but calm in the morning, nice of the sun to show itself a little bit. Light drizzle in the evening

27.02: Overcast and grey in the morning and it continued out through the day and evening.

28.02: Overcast and cloudy, some small peaks of the sun, making the sunrise in the morning quite beautiful. There was little wind.

01.03: Overcast and raining, during the morning and it quit around 13(UTC), overcast and calm during the evening. Strong currents in Lyrefjorden in the morning.

02.03: The weather was calm, and the sky was mostly overcast.

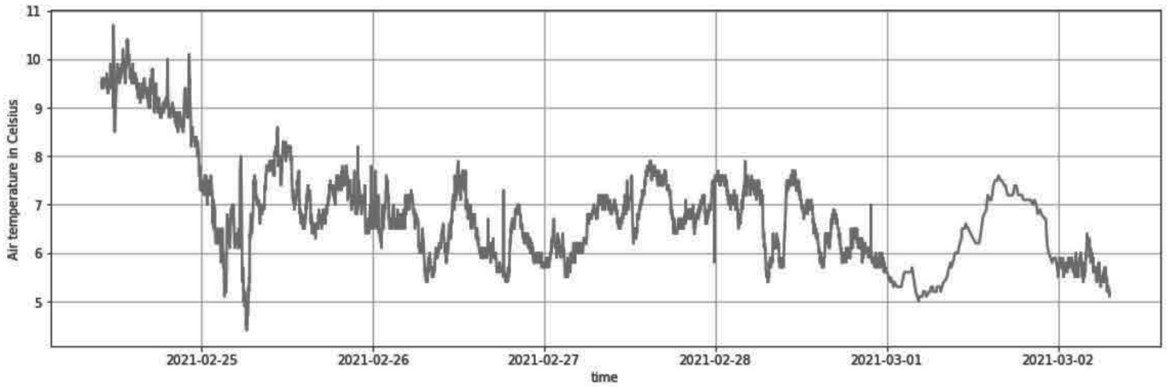

Figure 2.1: Temperature on ship

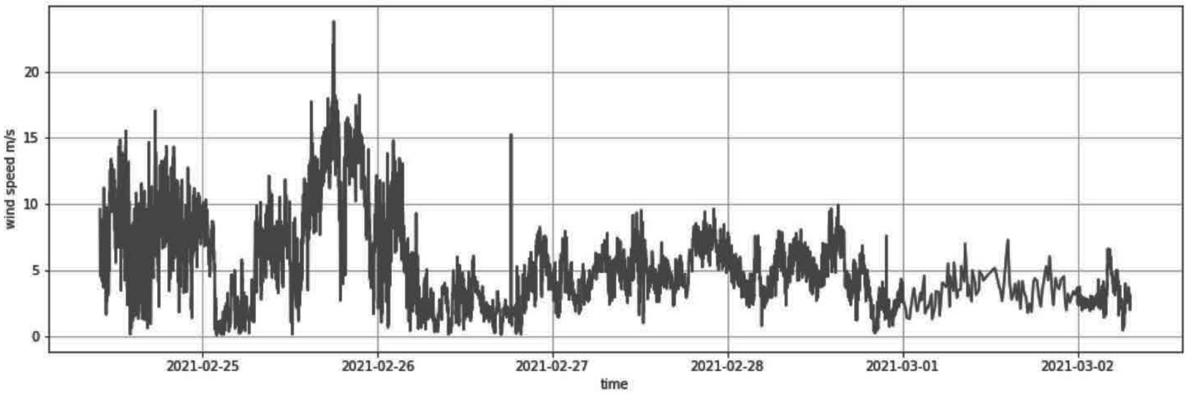

Figure 2.2: Windspeed from ship

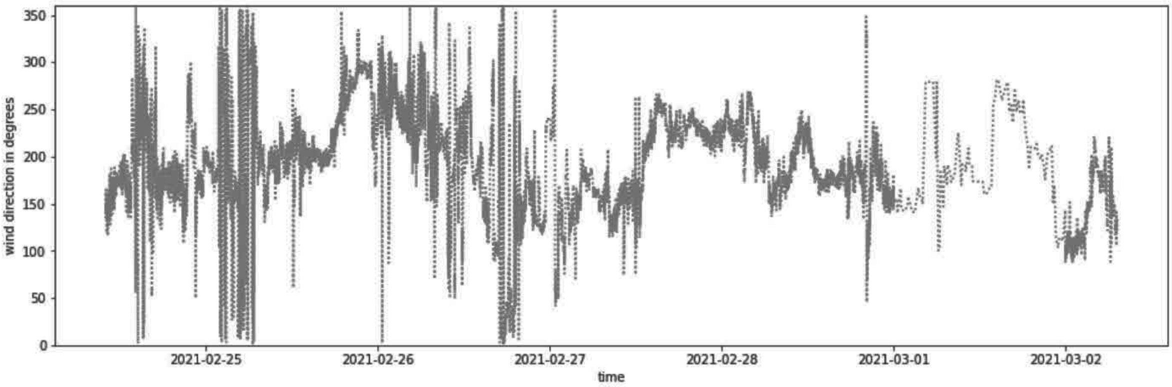

Figure 2.3: Winddirection from ship

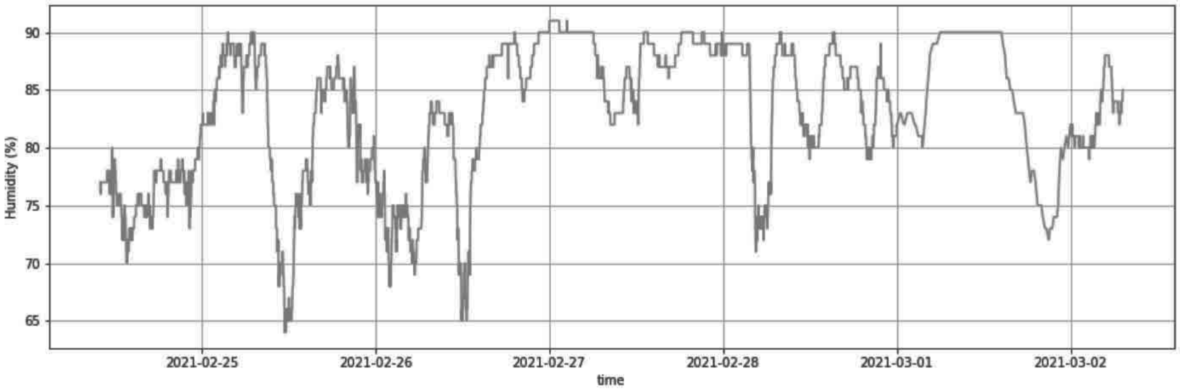

Figure 2.4: Humidity from ship

2.3.2 Tides

Estimated tidal prediction and sea level forecast for Lurefjorden, using data from Bergen, adjusted with 10 min, height factor of 1.03 and observed weather contributions from Bergen:

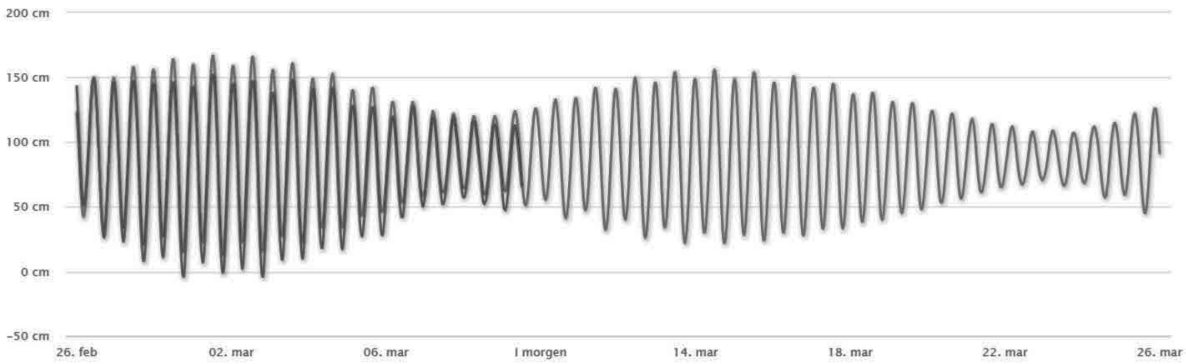

Figure 2.5: Tidal predictions (red) and observed water level (blue) for Lurefjorden from 26th of February to 26th of March, chart datum reference level. Figure from kartverket.no.

Estimated tidal prediction and sea level forecast for Lurefjorden, using data from Bergen, adjusted with 10 min, height factor of 1.03 and observed weather contributions from Bergen:

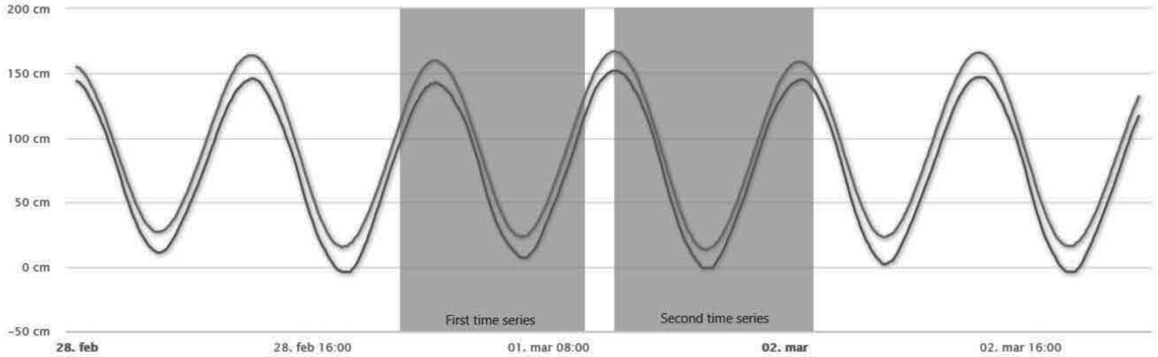

Figure 2.6: Tidal predictions (red) and observed water level (blue) for Lurefjorden from 28th of February to 2nd of March, chart datum reference level. Grey areas show the duration of the first time series at the sill and the second time series at the head of Lurefjorden. Figure from kartverket.no.

2.4 Oceanographic instrumentation

2.4.1 Moorings

he moorings at Masfjorden sill and at its inner basin deployed during KB2020603 (March 2020), were recovered by L. asplin from IMR a few weeks before the cruise. Therefore, we only redeployed new moorings at the sill and the inner basin of the Masfjorden during KB2021605 (February 2021). We started to assemble the instruments on board on 26/02 08:15, which we set them in the water at 09:45.

The table 2.2 below shows when and where the moorings were redeployed. We first started with the Masfjorden sill, which we released the instrument in the water at 09:45. In addition, the Masfjorden inner basin was released at 13:00.

Table 2.2: Mooring deployment details

Mooring Deployment		
	Masfjorden sill	Masfjorden inner basin
Position	60 48.231N / 005 17.875E	60 52.193N / 005 22.042E
Time	26.02.2021 09:45	26.02.2021 13:00
Echodepth		
CTD station		
Acoustic release	AR2500 s/n: 1222 ARM: 0899 REL : ARM + 0855	Oceano R5 s/n: 0001 ARM: 3502 REL : ARM + 3555

In appendix E, we present the mooring design at the sill and the inner basin which were recovered and deployed.

At 26.02.2021 19:45 UTC, we tried to triangulate the sill mooring from various locations, by using echosounder. However, the release did not answer. We tried again the next day with echo sounders turned off and better weather conditions. This time we succeeded to triangulate the sill mooring. Below we describe the process of triangulation at 27.02.2021.

Triangulation: 27.02.2021 11:30 UTC
1st try, unsuccessful (26.02.2021 19:45)
2n try, success (turned off echosounder because of possible interference):
Position 1: Latitude 60° 48.159 N, longitude 005° 17.663 E. 209.3 m from mooring.
Position 2: Latitude 60° 48.271 N, longitude 005° 17.706 E. 144.3 m from mooring.
Position 3: Latitude 60° 48.316 N, longitude 005° 18.008 E. 243.3 m from mooring.

2.4.2 CTD Profiling

The CTD-instrument measures Conductivity, Temperature and Depth, as the name CTD already indicates. The depth is converted from a pressure sensor while Salinity is resulting from the conductivity. The instrument is mounted together with twelve bottles (“Niskin-bottles”), which are sorted in a Rosette. We can lower it into the sea by a winch, so that we can stop in every depth. First, we lower it all the way to 10m above seafloor, where we fire the first bottle. That means, that we close one of the bottles to take a sample from the deep water. Make sure to always wait for 30 seconds before firing. Depending on the profile we want to retrieve from a station, we can stop the CTD on its way up at a certain depth and fire a bottle. During the whole process the cruise boat‘s computer records and displays profiles of salinity, temperature, density and oxygen.

After the CTD is pulled up, we take a salinity sample from the lowest depth at which a bottle was fired. This sample can help us calibrating the salinity profile and finding an offset. When interested in oxygen samples, we need to take this samples first from the bottles, as oxygen exchanges very fast with the surrounding milieu. We also took samples for nutrients, Carbon and isotopes.

Having taken all necessary samples, we rinse the whole equipment both from the outside and inside. If the CTD is resting on deck for a longer time we also need to use soap and chlorine.

While working with the CTD, we encounterd some problems. A major issue is that the salinity pump does not turn on if there is very strong freshwater input into the surface layer. Therefore, we had to pull the CTD up and down to trigger the salinity pump. After turning on, we lowered the CTD slowly, but still one profile (M35) seems to be strange. Furthermore, we have to be sure to close the taps of the Niskin-bottles after every CTD-water sampling. Otherwise, the water from the bottle is already spilling while pulling the CTD up. It also happens that the data from the logging computer is not synchronizing, so that we have to start a new CTD-program.

During our cruise we make eight transects in seven fjords: Sørfjorden, Veafjorden and Osterfjorden (circling the island Osterøy O1-O23), Fensfjorden (+cross section), Masfjorden, Haugsværfjorden and Lurefjorden. In addition, we have taken eleven CTD-stations in the nearby coastal region.

Because our time management has been very good, we are also able to take two 12-hours-timeseries in two spots of Lurefjorden. For these timeseries we stay for 12 hours at the same CTD station lowering every 30 minutes the CTD down to the seafloor. We can therefore analyse a whole tidal cycle.

All in all, we run 109 CTD stations (without the timeseries), where we take different profiles. Five of them are full stations, this means that we fire all twelve Niskin bottles and sample oxygen (and temperature), total carbon, nutrients and salinity. We fill out a data sheet for every station, which contains the information of station number, coordinates, date, depth at which the bottles are fired, and the sample code of the different chemical constituents that were measured. Moreover, we log every CTD station in a Word-document and an Excel sheet. Please find a list of all CTD stations in Appendix B.

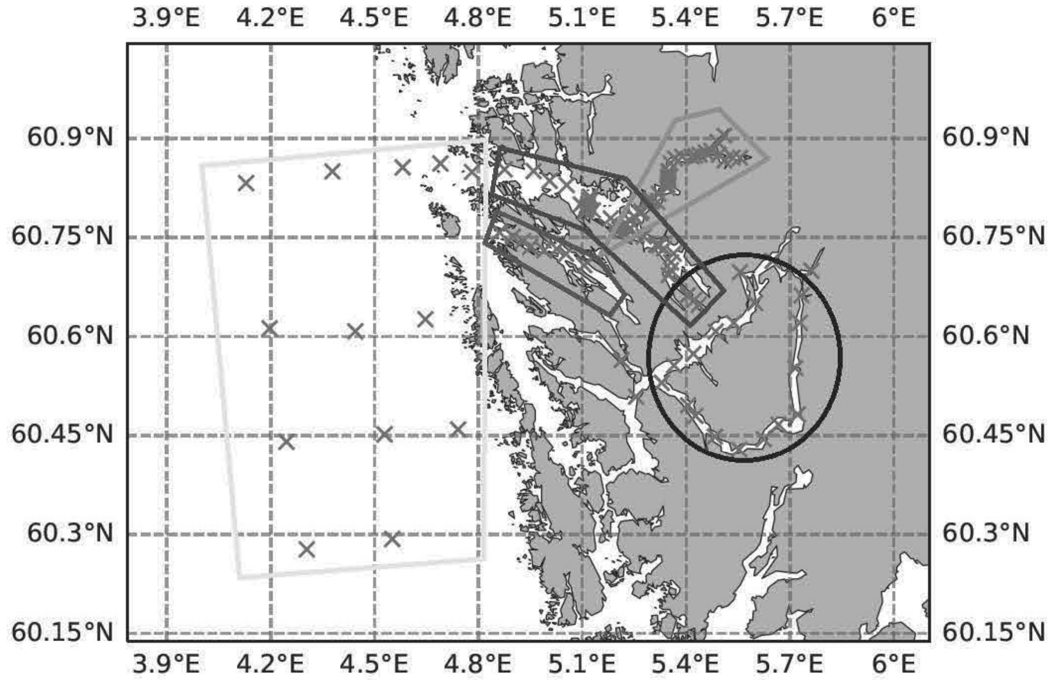

Figure 2.7: Overview over all sections

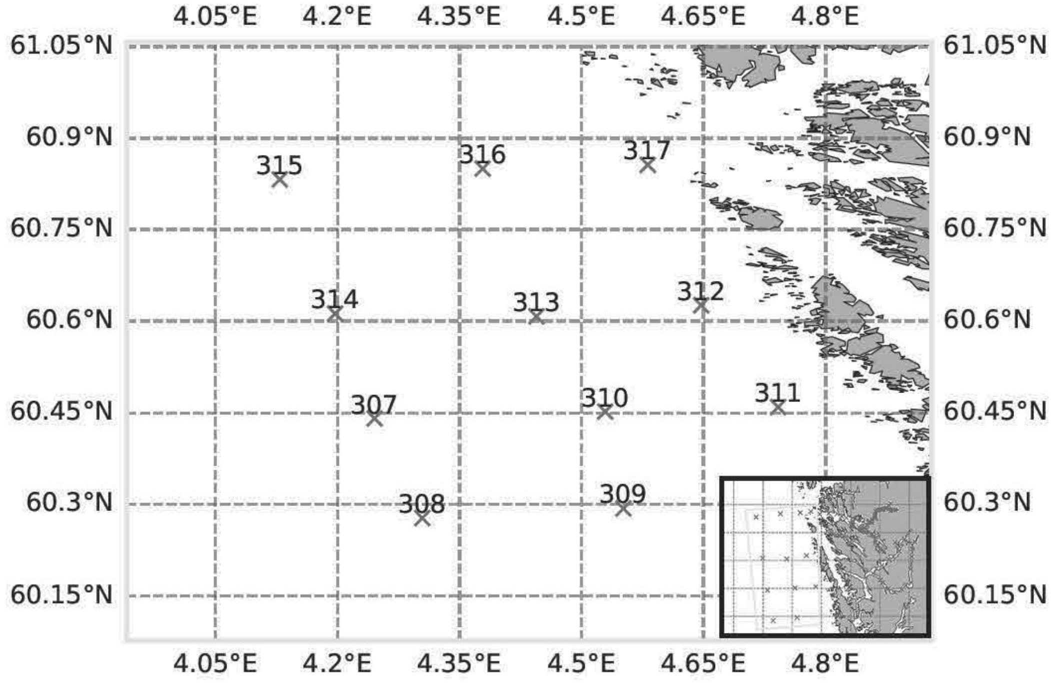

Figure 2.8: Zoom: coastal stations

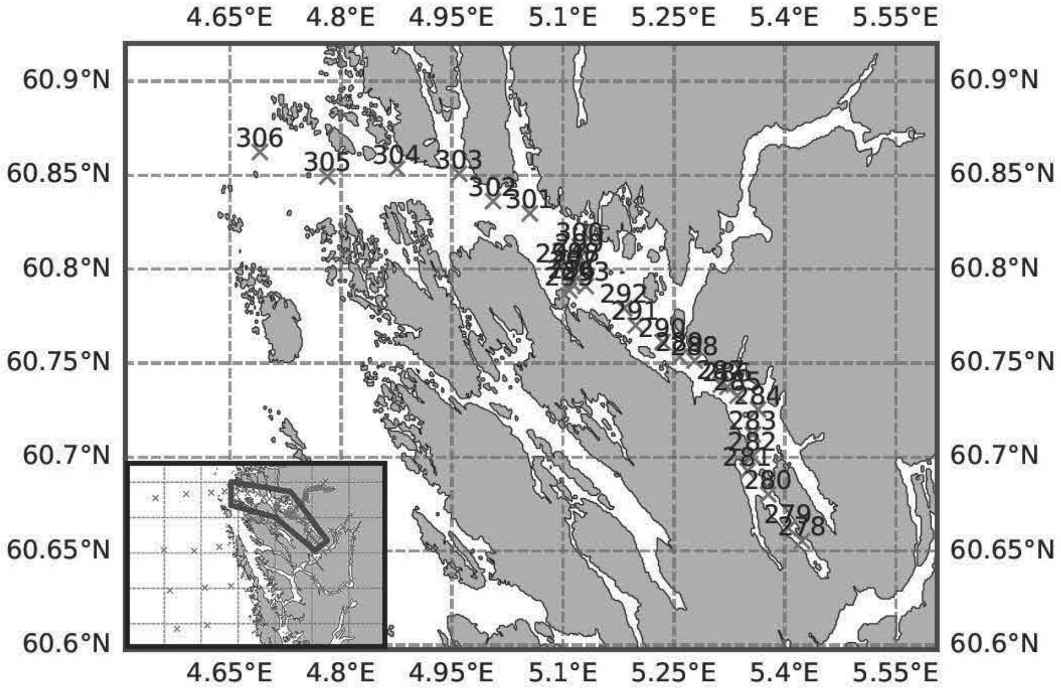

Figure 2.9: Zoom: Fensfjorden

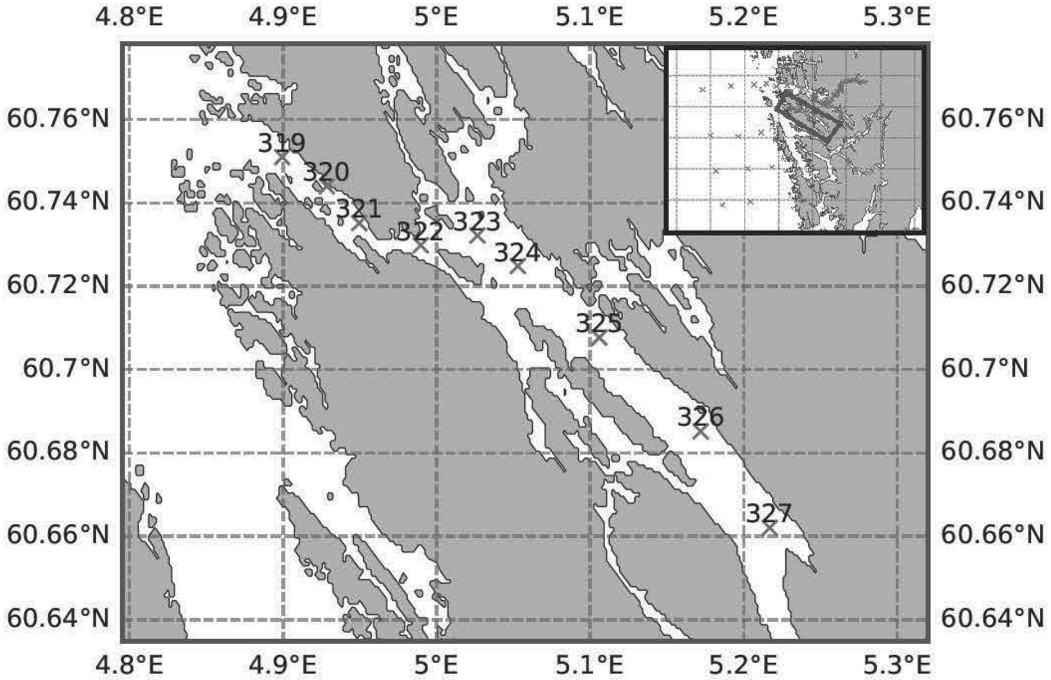

Figure 2.10: Zoom: Lurefjorden

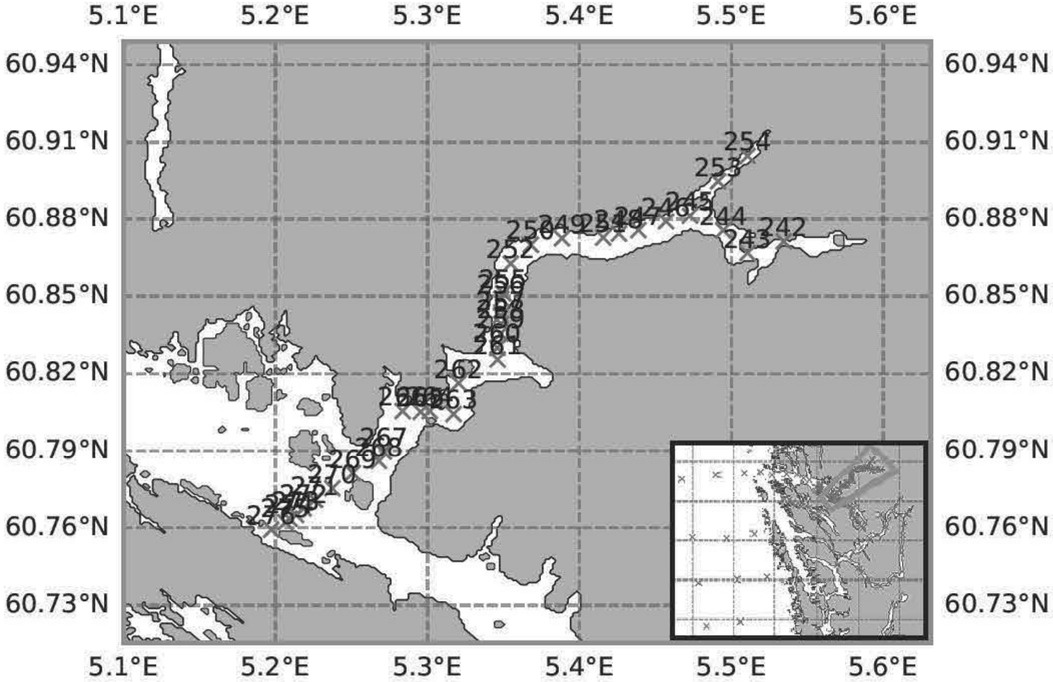

Figure 2.11: Zoom: Masfjorden

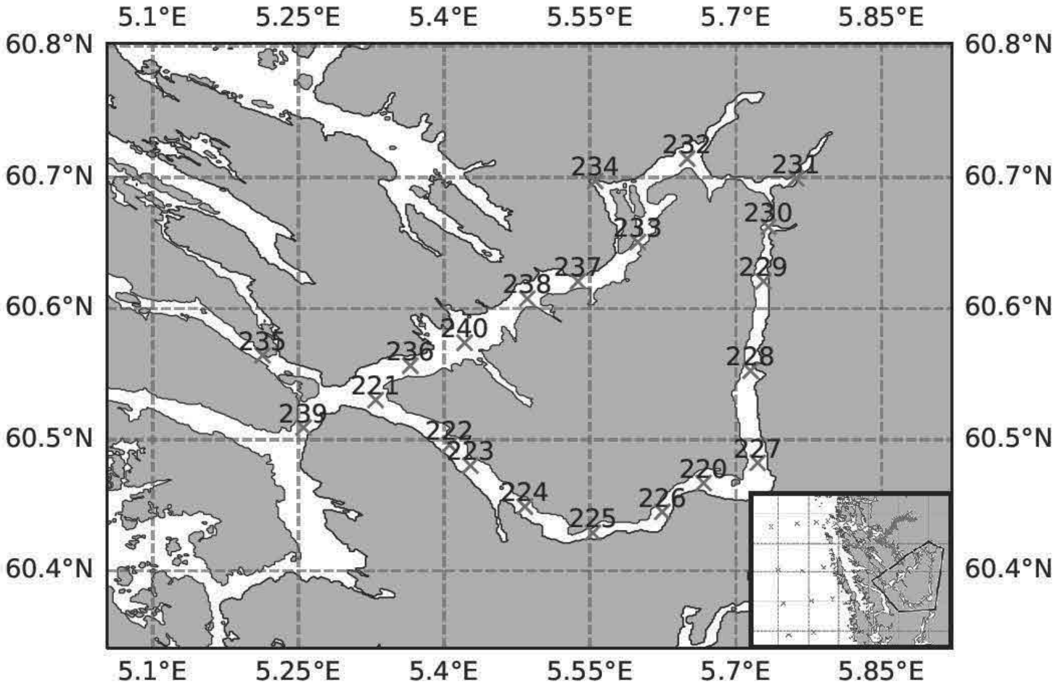

Figure 2.12: Zoom: Osterøy

Table 2.3: sensors and calibration date

Sensor	**Serial number**	**Last calibration**
Primary temperature	6102	10th march 2020
Secondary temperature	6498	10th march 2020
Primary conductivity	4974	11th march 2020
Secondary conductivity	4387	30th June 2020
Oxygen	3648	27th February 2020
Pressure	70766-0510	24th October 2019

Table 2.4: sections, when they were occupied

Section	**Date occupied**	**Number of stations**
Osterøy (O)	24.2.-25.2	21 (skipped O14 & O12)
Masfjorden (M)	26.2-27.2	34 (skipped M30)
Haugsværfjorden (H)	26.2	2
Fensfjorden (F)	27.2	25 (skipped F11)
Fensfjord-Crosssection (fx)	27.2	6
Coastal region (VK)	28.2	11
Lurefjorden (L)	28.2	7
La, Lb, Lc	28.2	3

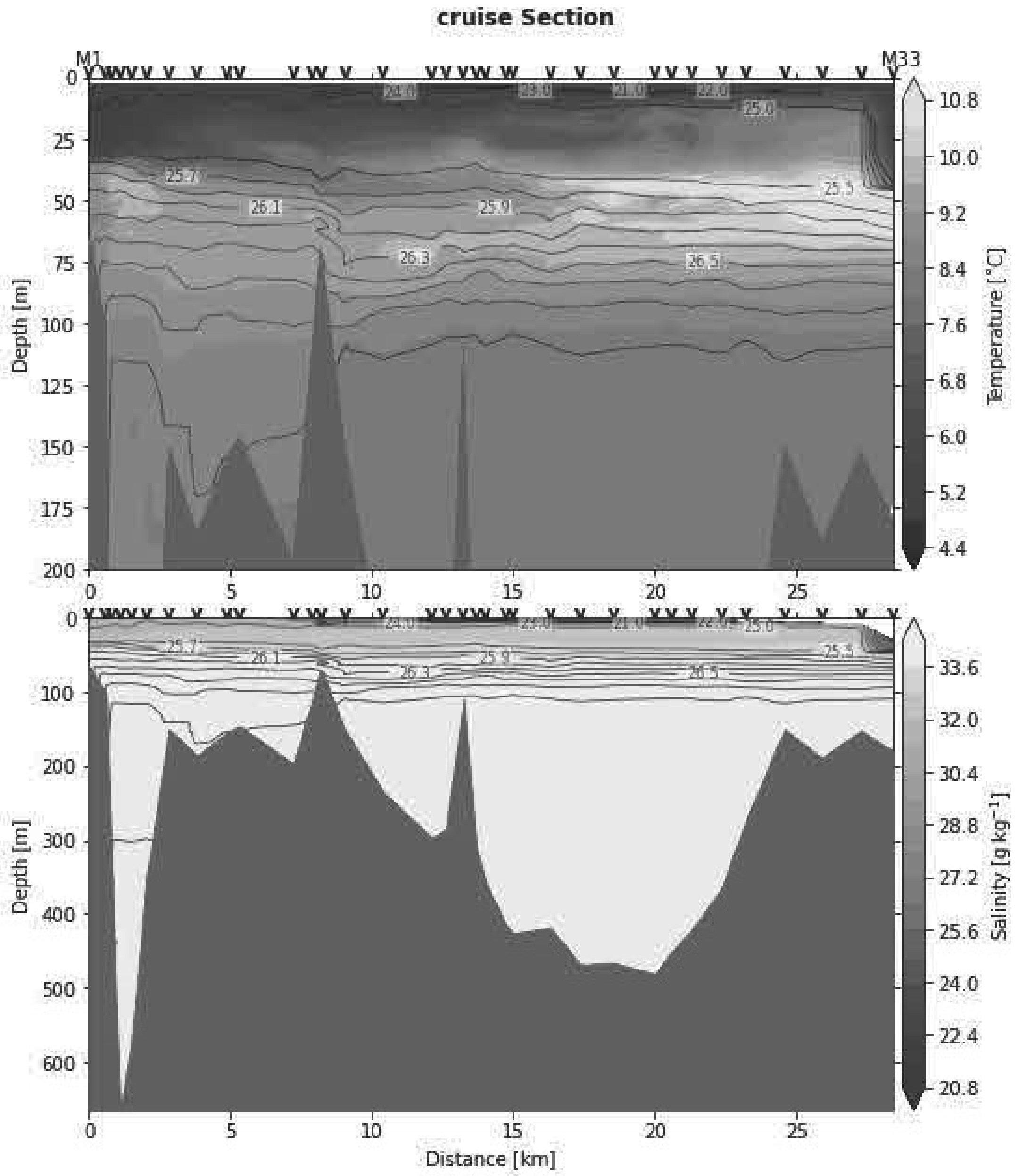

Figure 2.13: Temperature and Salinity-section along Masfjorden

Salt calibration

During the ship cruise we took 170 water samples from the CTD in different depths for the salinity calibration later in the laboratory. Before we filled the water into the bottle we rinsed the bottle 3 times. Later in the laboratory we measured the salinity with the salinometer. Therefore we took 3 measurements of each sample to find an average and rinsed the measuring instrument 3 times between each sample.

For the calibration we calculated the conductivity difference between the conductivity from the CTD and the samples. Then we determined the average $\overline{\Delta C}$ and standard deviation σ from the conductivity difference ΔC. All ΔC values not in between the interval $(\overline{\Delta C} - 2 * \sigma, \overline{\Delta C} + 2 * \sigma)$ were removed. 16 outliers were found and removed from the data set. The conductivity from the CTD and from the water samples are stronly correlated as illustrated in 2.14. The linear regression line is: $C_{sample} = 1 * C_{CTD} + 0$ The mean average difference between C_{sample} and C_{CTD} 0.01 $S\ m^{-1}$ was added to the whole data set as an offset and then converted into salinity. The comparison between the calibrated and not corrected data set for stations 220, 251, 306 and 326 is shown in figure 2.15.

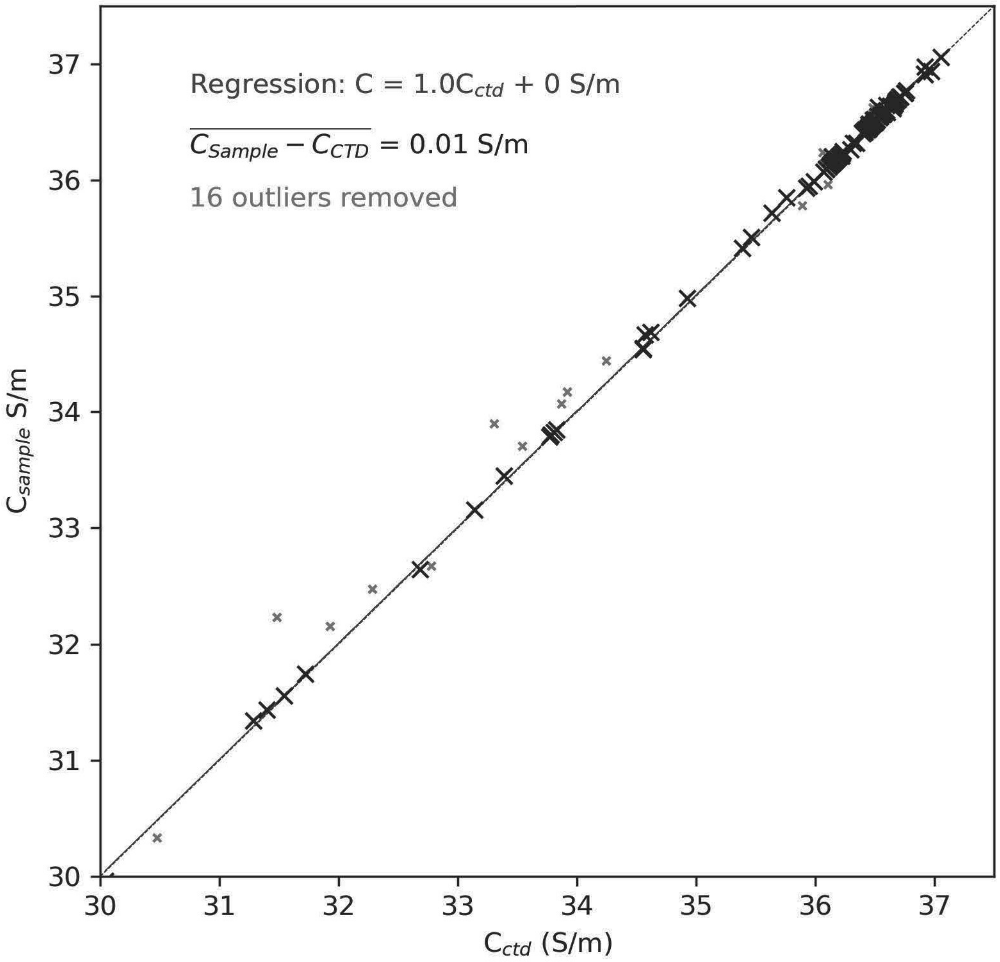

Figure 2.14: Conductivity from the water samples in dependency of the conductivity values from the CTD stations, the 16 removed outliers are shown in red.

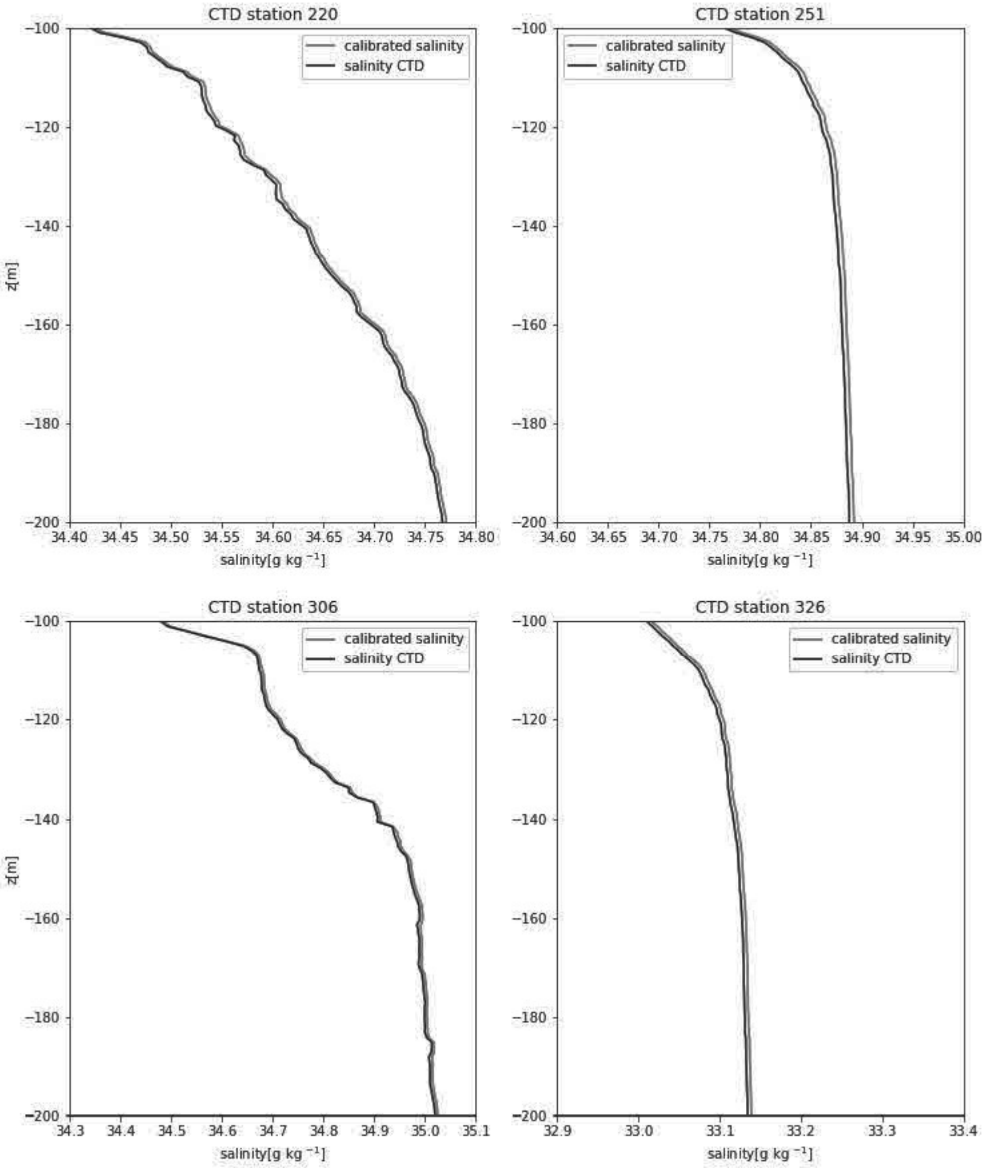

Figure 2.15: Salinity profile from 100-200m, calibrated salinity data and CTD compared for station 220, 251, 306 and 326.

Oxygen calibration

163 oxygen samples were collected from 53 different stations. The samples were taken at various depths in order to ensure a wide spread of values. We sampled duplicates at some of the deeper stations to include more deep-water samples.

Calibration was carried out using linear regression, where the CTD values were set as the predictor and the values from Winkler titration the predictand. We tested several methods of outlier removal. Removing outliers from the whole dataset resulted in an offset of 0.129 ml/l, whilst removing outliers from oxygen levels above a certain threshold resulted in offsets in the range 0.42-1.02 ml/l for thresholds in the range 4-6 ml/l. The best fit was found by removing all the values from samples taken above 100 m. This is due to the large gradient often found in the upper part of the water column. 60 points were removed by excluding those taken above (and at) 100 m. Outliers were then removed by assessing the mean and standard deviation of the difference between the CTD values and the titration values. This way, any points with a difference outside the mean ± 2*(standard deviation) were removed. The process was repeated until there were no more outliers. 4 outliers were removed using two removal rounds. In total 64 points were removed. The resulting regression line is shown in 2.16, and has the formula $y = 0.071 + 1.016x$. Thus, the final calibration offset is 0.071.

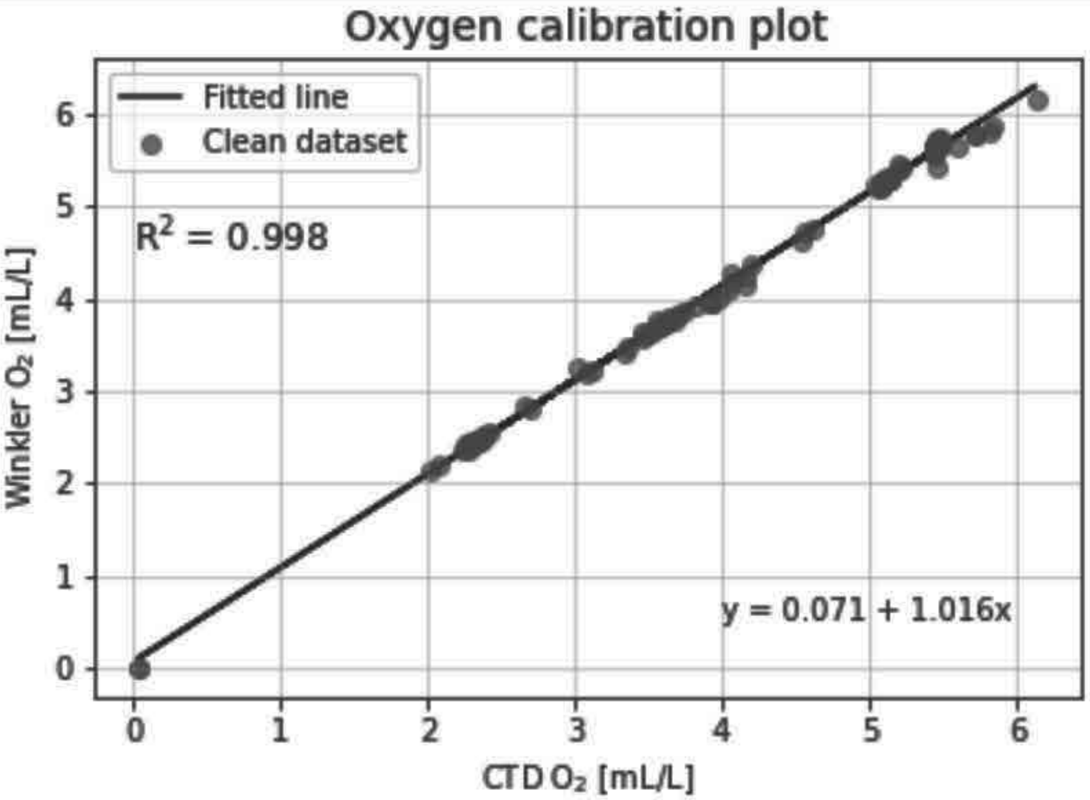

Figure 2.16: Oxygen values from the CTD plotted against oxygen values obtained from Winkler titration after outliers and points measured at 100 m and above have been removed. The regression line is plotted in black

To ensure the calibration fits the data, it was tested on 4 of the full stations as these have the most oxygen samples to compare with. In the figure below, the original CTD profiles, corrected CTD profiles and Winkler titration values are plotted for comparison.

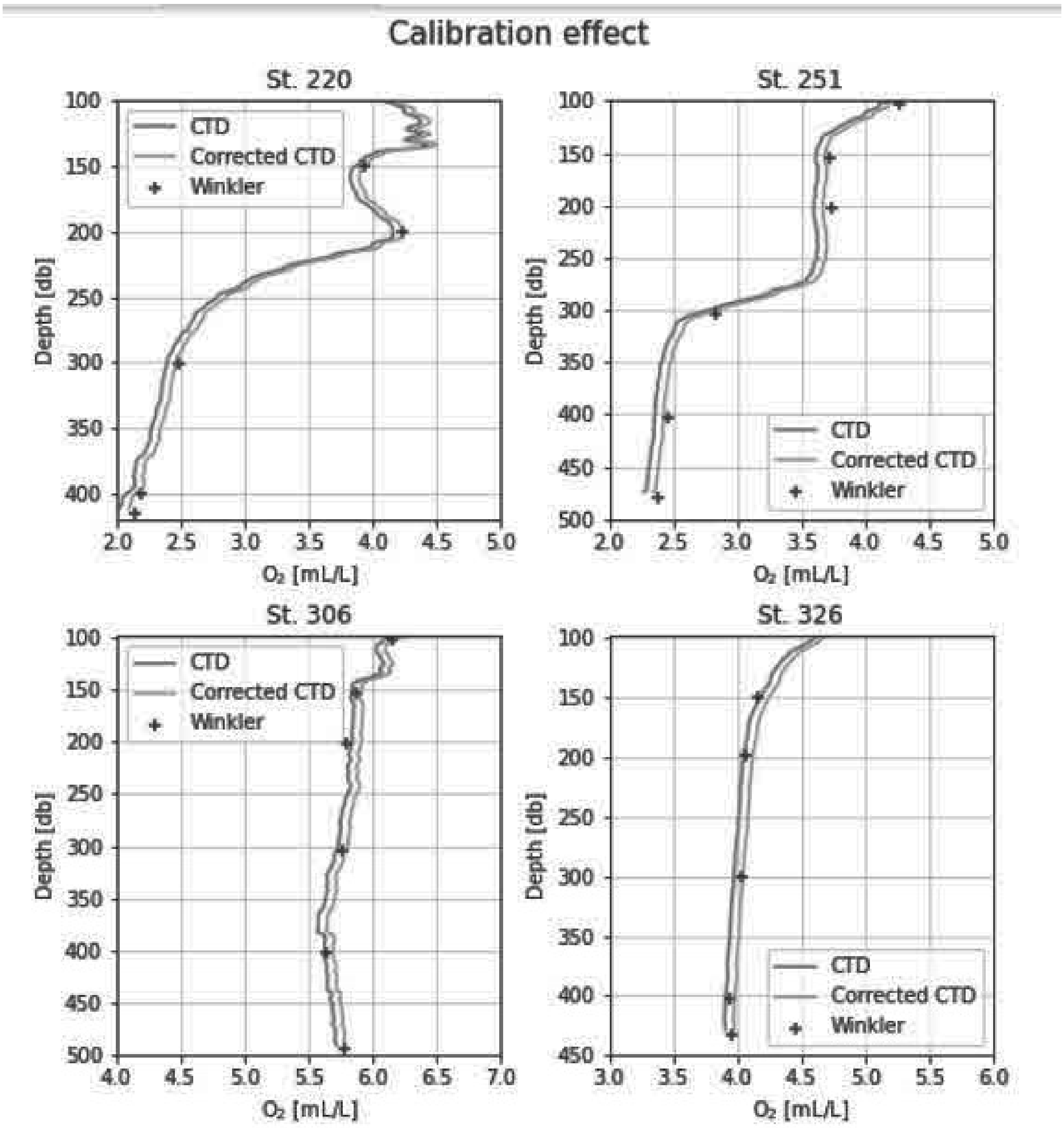

Figure 2.17: Oxygen profiles from CTD measurements (blue), corrected oxygen profiles (orange) and Winkler titration measurements (black +) for 4 of the full stations.

From figure 2.17 we see that the correction fits very well for station 220 and 251. These are located in Sørfjorden by Osterøy and the deep part of Masfjorden respectively. The correction also fits reasonably well with stations 306 and 326 as well, though less so. These stations are located at the mouth of Fensfjorden and in Lurefjorden respectively. The correction may fit the fjord stations better than those with water masses more influenced by coastal water.

2.4.3 Oxygen sampling

We collected a total of 163 oxygen samples from 53 stations for calibration (see Appendix F for full list of water samples). The samples were taken at various depths to ensure a good range of values. We analysed the samples continuously onboard via Winkler titration.

In order to avoid contamination of the samples, care had to be taken. First, we attached a sampling tube to the Niskin bottle and squeezed this lightly while the water was running to ensure there were no air bubbles. The bottle, cap and tube were then rinsed three times. Next, we let the water overflow twice or three times while measuring the temperature, while the tube was touching the bottom of the bottle. The bottle was removed carefully while the water was still flowing. With the bottle full to the brim, we added 1 mL NaOH + NaI (4M) and 1 mL MnCl2 (3M). A precipitate should form, with a brownish colour for oxygen rich samples, and a whiteish colour for samples poor in oxygen. After checking for bubbles, the bottle was carefully stoppered with the cap at an angle. We then shook the bottle for 20 seconds, making sure there was both horizontal and vertical motion as the vacuum in the bottle inhibits mixing. The samples were checked for air bubbles throughout the sampling process and any contaminated samples were discarded.

Winkler titration was carried out according to the manual provided in the lab. The precipitate formed under the sampling process was dissolved by adding 1 mL sulfuric acid (H2SO4, 5M). A stirring magnet was carefully slid into the solution. The first titration was then started by adding thiosulfate in 1 mL doses until the sample became a pale yellow. The thiosulfate volume used was recorded as Dose A before adding 3-4 drops of starch. The solution became purple. This allowed us to observe a colour change in the second titration where thiosulfate was added in 0.01 mL doses until the sample changed from purple to colourless. The volume of thiosulfate used was recorded as Dose B.

We analysed 2-4 standards and blanks approximately once every 24 hours. ‘Standards’ refer to the concentration of the thiosulfate used. The standards were determined by titration of a potassium iodate standard solution in which the iodate reacted with acid and iodide to form a triiodide complex. This was then titrated with the thiosulfate. ‘Blanks’ are determined in order to eliminate effects of other species present. They were determined by titrating one dose of iodate, adding a second dose and continuing the titration. The blank was calculated by taking the difference in the volume of thiosulfate used to titrate the first and the second dose.

By the end of the cruise, two batches of thiosulfate had been used. In calculating the oxygen concentrations, the standards and blanks were averaged for each batch rather than using the daily averages. The standards and blanks for 24th-26th were considered one batch, and those for 27th and 28th of February the other.

We used the calculated oxygen concentrations to calibrate the CTD values. See section 1.4.2 for more information.

2.4.4 Other biological sampling

In addition to salinity and oxygen, dissolved inorganic carbon (DIC) and nutrients samples were taken. We used standard depth tables to choose the sampling depths. The table below shows where and when the samples were taken. A complete list of water samples can be found in Appendix F.

Table 2.5

Station	Longitude	Latitude	Date
220/O16	5 40.007	60 28.014	24.02.2021
251/M26	5 24.94	60 52.37	26.02.2021
254/H3	5 30.642	60 54.281	26.02.2021
261/M16	5 20.775	60 49.531	26.02.2021
306/F1	4 41.461	60 51.729	27.02.2021
326/L6	5 10.363	60 41.106	28.02.2021

Sampling procedures and sample analysis for DIC and nutrients are explained in the following two subsections.

DIC

We collected dissolved inorganic carbon (DIC) at each of the 6 full stations. At the final full station, L6, there were only enough bottles for 4 of the 12 depths sampled. This led to a total of 60 samples. DIC is a measure of the amount of carbonate present in the water and is useful for determining biological activity and acidification.

As for the oxygen samples, we used a sampling tube to extract water from the Niskin bottles into the sample bottles. The tube was squeezed while the water was running to remove any bubbles. The bottle, tube and cap were rinsed three times before inserting the tube to the bottom of the bottle and letting the water overflow twice. The caps had a layer of grease which was distributed around the bottle neck when closing the bottles by twisting it lightly.

Once the samples were bottled, we poisoned them using one drop of $HgCl_2$ per bottle. They were then turned upside down two-three times and stored in a dark, cool environment. The DIC samples were analysed using coulometric titration at the university lab by the university chemical engineer.

Coulometric titration exploits electric currents and redox reactions to determine the CO_2 content. Once a background sample has been taken to correct for CO_2 not pertaining to the sample, acid is added to a stripper. The acid reacts with the inorganic carbon components and force these to convert to CO_2 gas. A cooler then causes water to condense whilst the CO_2 is forced into an electrical cell in the coulometer using N_2 gas. In the coulometer the amount of CO_2 is determined using electrical currents. The cathode contains blue dye through which light transmission is measured. As CO_2 is added, the solution becomes more and more acidic until it is colorless, i.e. transmission is 100%. The system then uses electrical currents to dissolve the silver anode and electrolyze the water. The electrolysis produces basic OH- ions which counter the acidic H+, bringing the system back to its original state. Thus, the titration is complete once the light transmission of the cathode solution is the same as it was before adding CO_2. At this point the amount of current that was applied during titration is proportional to the amount of CO_2 in the sample, allowing the system to determine this value for us.

Nutrients

A total of 61 nutrient samples were collected from the 6 full stations. At the final full station, L6, there were only enough bottles for 5 of the 12 depths sampled. We used 20 mL polyethylene scintill bottles to collect the nutrient samples from the Niskins. The bottles were rinsed twice, then filled to the neck.

Once all the samples were taken, we poisoned them with 0.2 mL chloroform. The samples were stored in the fridge. Nutrient analysis was carried out by the Institute of Marine Research (IMR) via gas segmented continuous flow analysis.

2.4.5 Isotopes

For our isotope project, we collected samples from different depths with 6 CTD stations and 9 surface samples with a small boat on the 25.02.2021.

We took the surface samples with a small boat going to the coordinates where we assumed to find freshwater input by land runoff with the help of a syringe. To make sure that there is no water from a previous sample (last time the vial was used) we rinsed the syringe 3 times before we filled the surface water into the vials (1.5 ml). At this position we also lowered the mini-CTD. Due to a technical error the data from the mini CTD was not reliable and so it will not be used for further analysis.

For the CTD-samples, we fired the Niskin bottle whenever we were interested in a certain depth. In general, we were studying the surface layer, so we took samples at about 20m, 5m and 0m depth (O3, O5, O8, O7). For the samples at the surface, we used a bucket and for the 5m and 20m sample the CTD Niskin bottles. In order to have a complete transect overview, we took two deep profiles close at both ends of the fjord (O8, O2). In addition, we took also extra salinity samples from the CTD for our isotope project. Figure 1 shows an overview of all stations.

2.4.6 Current profiling using Vessel-mounted ADCP (VMADCP)

The vessel-mounted Acoustic Doppler Current Profiler was used for current measurements in the water column. The VMADCP transmits acoustic signals that are backscattered by particles in the water. The VMADCP calculates current velocity in 3 dimensions (forward, sideways, and up.) by using the Doppler shift between the transmitted signal and the reflected signal.

The VMADCP was running throughout the cruise using standard settings: narrowband mode, with 50 bins of length 8.0 m and blanking distance 4.0 m. Narrowband mode causes a long range for the measurements, but with lower resolution. Sampling rate was set to 1.10 seconds. Default modes were chosen for robustness and measurement precision. The VMADCP was using 150 kHz frequency which gives a nominal profiling range of 400 meters. Since echo from a hard surface such as sea surface is much stronger than the echo from scatterers in the water that it can overwhelm the side lobe suppression of the transducer, we should reject data from too close to the surface - in our case first 20m sea surface layer (figure 2.21).

Processing of data is done automatically by the ADCP-system on board. It uses CODAS (Common Ocean Data Access System) to calculate ocean velocities from ADCP measured velocities, positions, and heading.

During the cruise we had three dedicated ADCP sections two sections at costal area (figure 2.18) and one at Masfjorden (figure 2.19). During the ADCP sections ship had constant speed around 11 knots to get robust data.

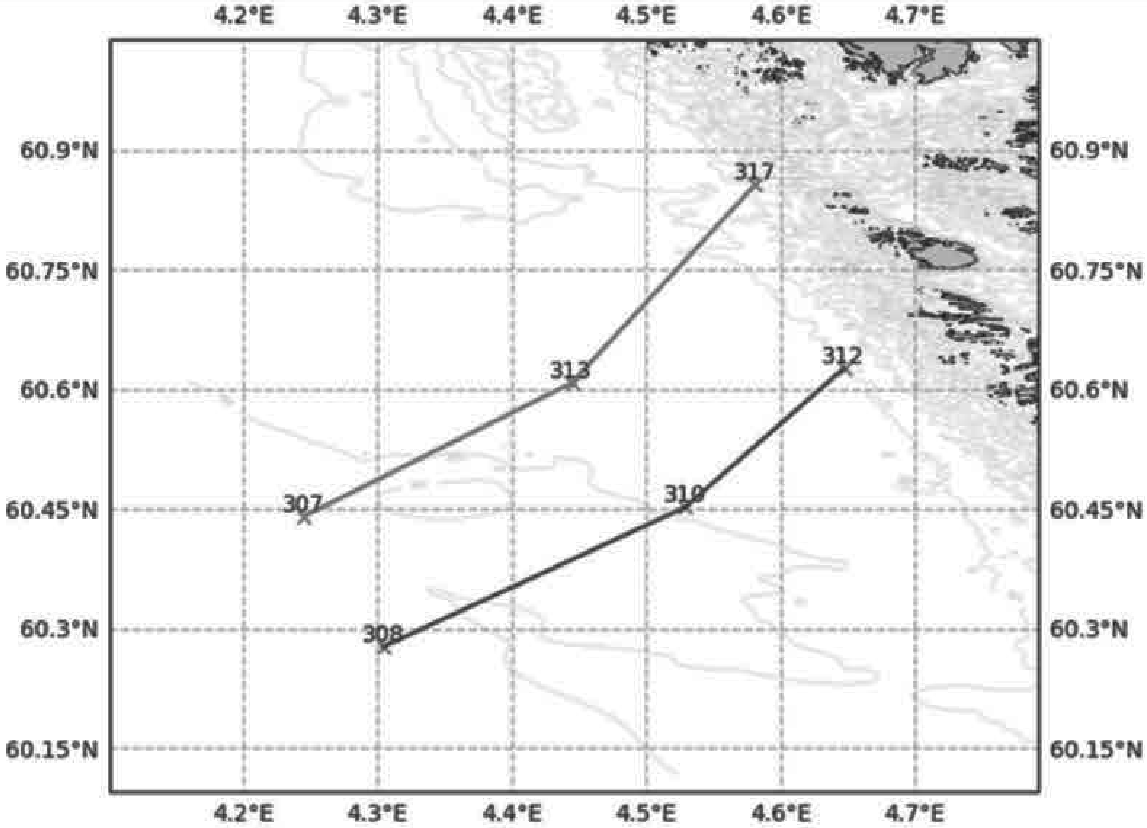

Figure 2.18: Two ADCP sections at costal area between stations 317-307 and 308-312

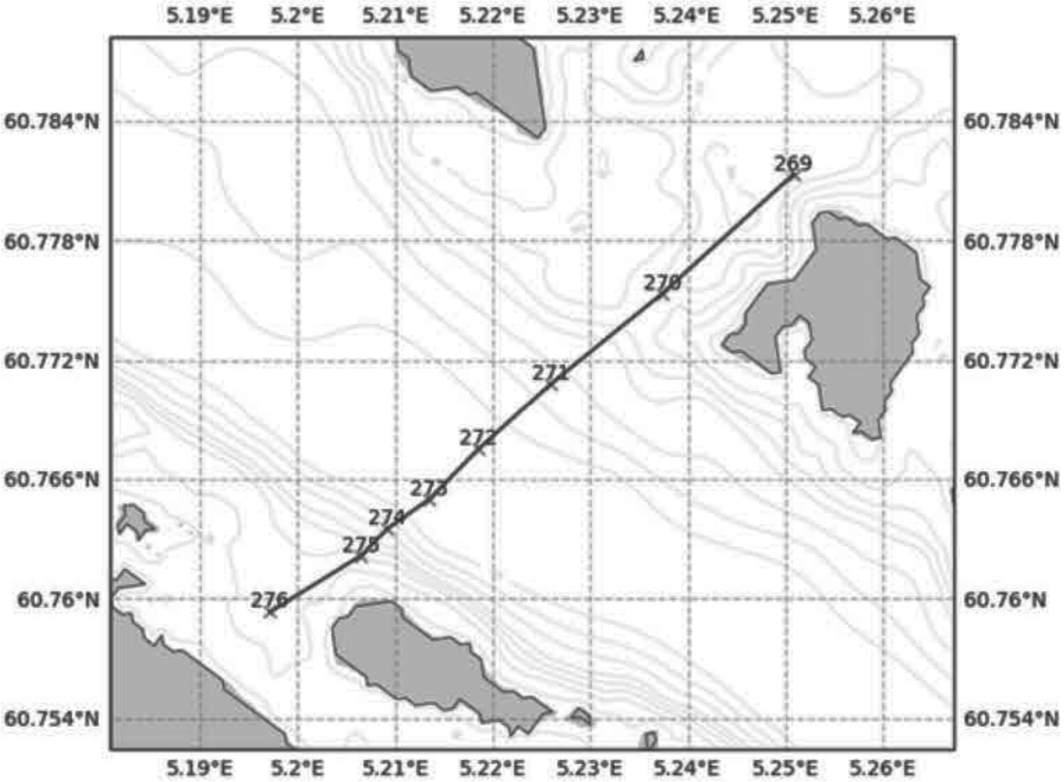

Figure 2.19: ADCP section at Masfjorden between 269 and 276 stations

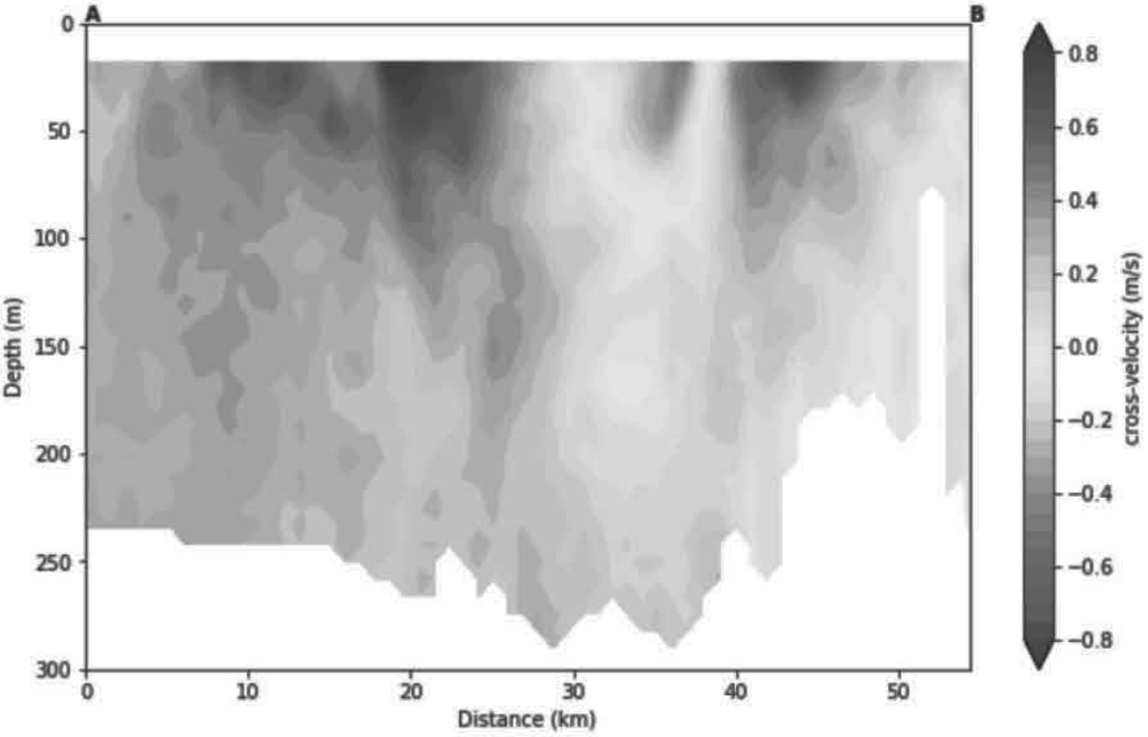

Figure 2.20: ADCP data section between station 317 and 307. 2021.02.27 21:30(UTC) - 2021.02.28 00:40(UTC).

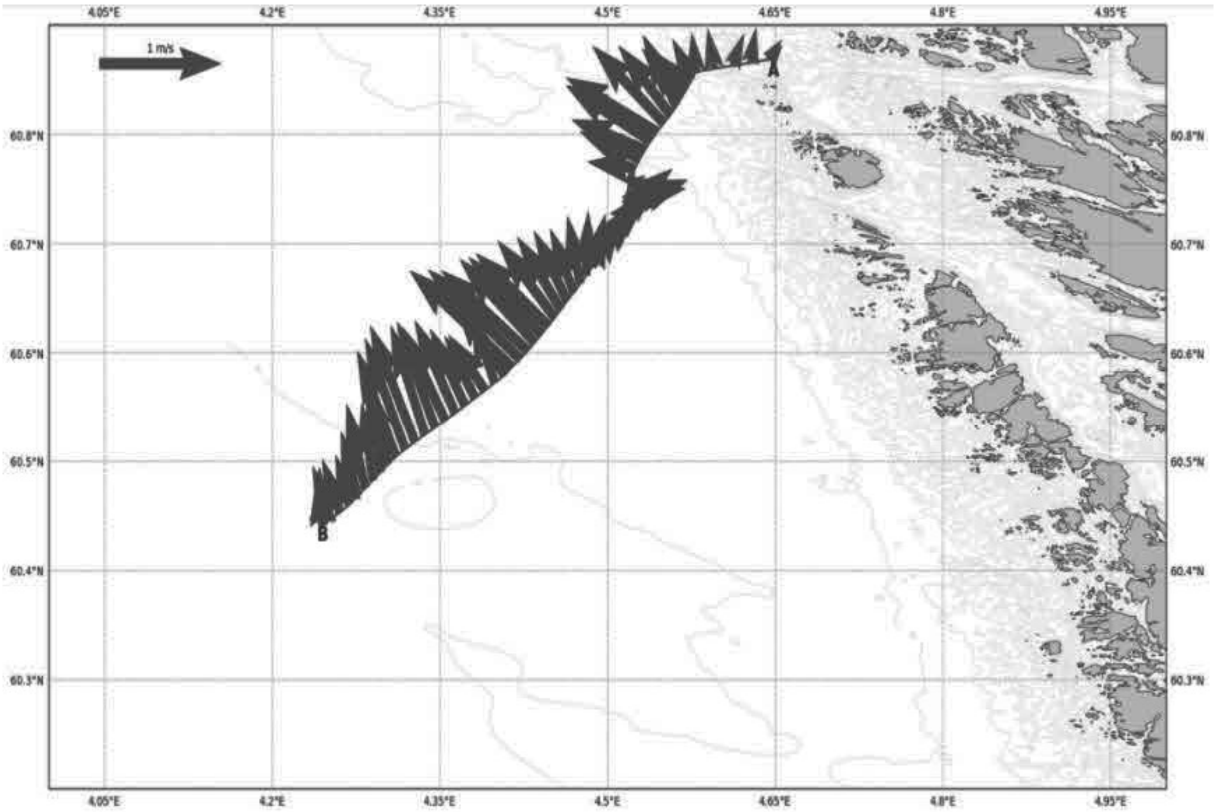

Figure 2.21: Current velocity and direction at first 17.98 measured meters (37.98m under surface level) between 317(A) and 307(B) stations. 2021.02.27 21:30(UTC) - 2021.02.28 00:40(UTC)

2.4.7 Drifters

We use drifters when we want to look at the currents. A drifter drifts along the surface following the wind, the tides, or the inner ocean circulation. Our drifters are home made with a GPS tracker. We can follow the drifters online/on an app to see where they are. This makes it easier to find them and see when they are stuck.

We use three surface drifters and one drifter that is at 10m depth. Here we can compare how for example the weather, i.e. the wind affects the surface drifters and how for example the fjord circulation or the tides affect the 10m differently than the surface ones.

Drifter project in Osterfjorden
We deployed drifters in the Osterfjord to look at how they move, and if the wind or the current is affecting them the most. We deployed three drifters at the surface and one drifter at 10m depth. On the 24th, we deployed the drifters at position 60 32.008 N and 5 18.459 E, at 12:37(UTC). We chose this location because we wanted to look at which fjord opening the drifters would choose, the northern or the southern opening. There was

a strong wind from south. We let the drifters stay out for the night and recovered them in the morning.

The drifters at the surface had all ended up in the same area close to land. While the 10m one had ended up further away.

We found the drifters on the morning of the 25th and redeployed them. Due to the strong wind and yesterday's observations, we deployed the drifters a bit more south compared with the first drifter experiment. We put all out at the same time at 60 33.352 N and 5 22.933 E at 08:27(UTC). Shown in table 2.6 and 2.7.

During the day we lost contact with the 10m drifter and we could not find it. We looked for it, but it got too dark to continue.

The three surface drifters ended up in the same area, and we took them back to the ship, shown in figures 2.22 and 2.23.

Table 2.6: deploy nr. 1

Drifter	**Time of deployment**	**Location of deployment**	**Drifter depth**	**Time of recovery (UTC**	**Location of recovery**
1	12:37 (24.02)	60 32.008 N 5 18.459E	Surface	07:49	60 32.670 N 5 17.952 E
2			Surface	07:53	60 33.252 N 5 18.594 E
3			10 m	08:11	60 33.270 N 5 15.774 E
4			Surface	07:54	60 32.826 N 5 18.102

Table 2.7: deploy nr. 2

Drifter	**Time of deployment**	**Location of deployment**	**Drifter depth**	**Time of recovery (UTC)**	**Location of recovery**
1	08:27(25.02)	60 33.352N 5 22.933 E	Surface	15:30	60 31.974 N 5 15.762 E
2			Surface	15:30	60 31.956 N 5 15.714 E
3			10 m	N/A	N/A
4			Surface	15:30	60 31.998 N 5 16.762 E

The goal of my project is to look at how the wind affects the surface currents, or if the tides will affect them or if the fjord circulation affects them.

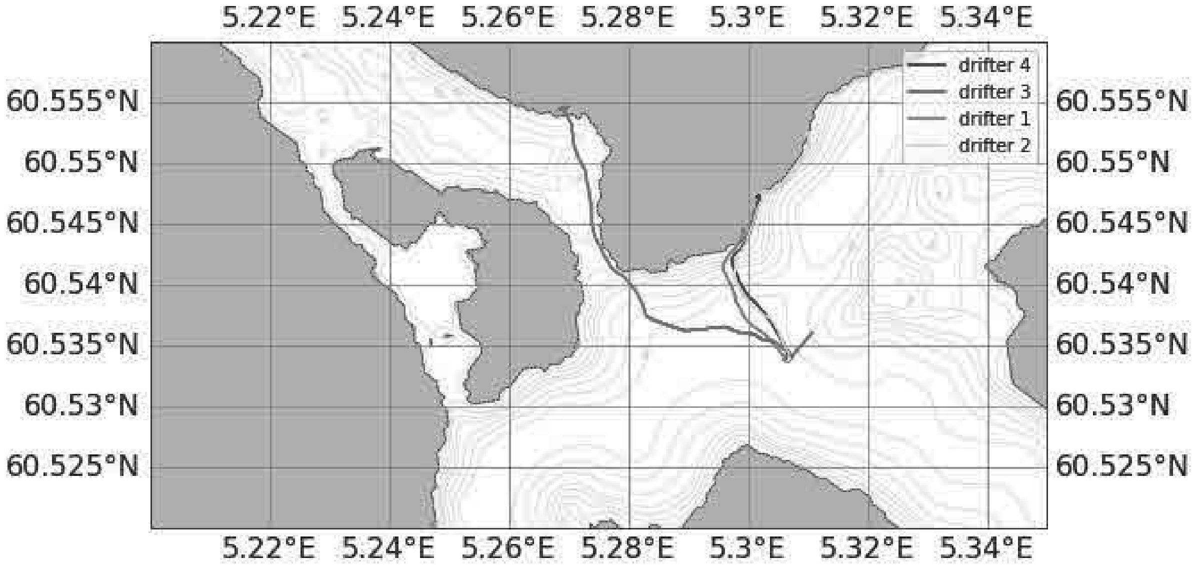

Figure 2.22: shows the paths of the drifters after the first deploy

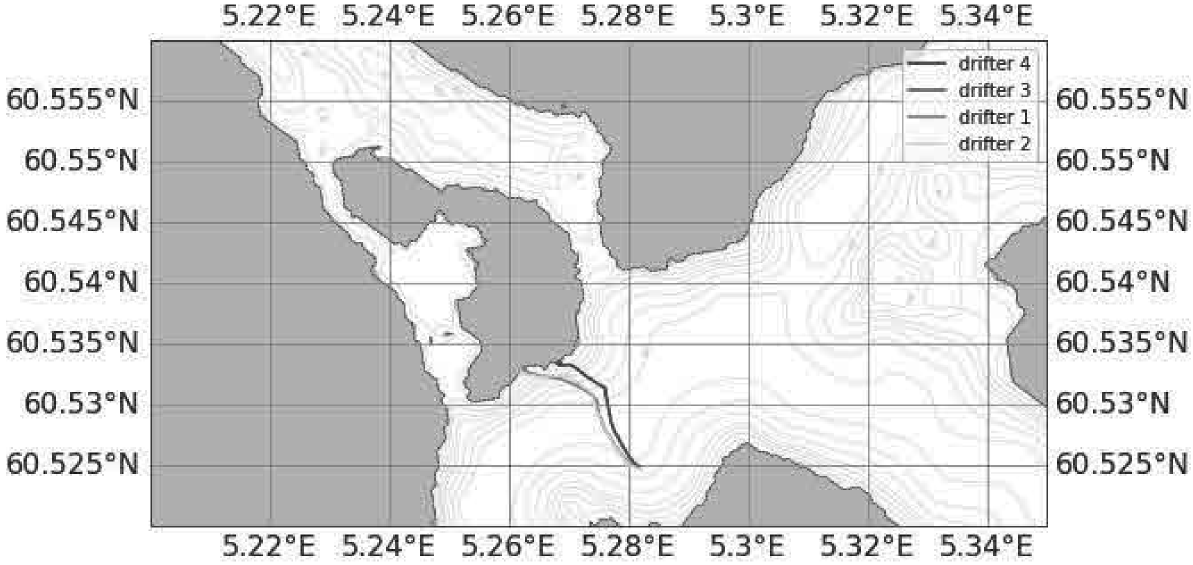

Figure 2.23: shows the paths of the drifters after the second deploy

From figure 2.22 and 2.23 we can see that all the surface drifters followed mostly the same path. Sadly, we lost the 10m depth drifter so it cannot show the path it took from the second deploy. But we can see from the first deploy that it drifted a little different than the other drifters. They all went northward, probably following the wind. It was quite windy. So to further analyse we can look at the wind data in this period.

Wind data from Kristine Bonnevie:

This is the wind data over the period in which the drifters were deployed, shown in figure 2.24.

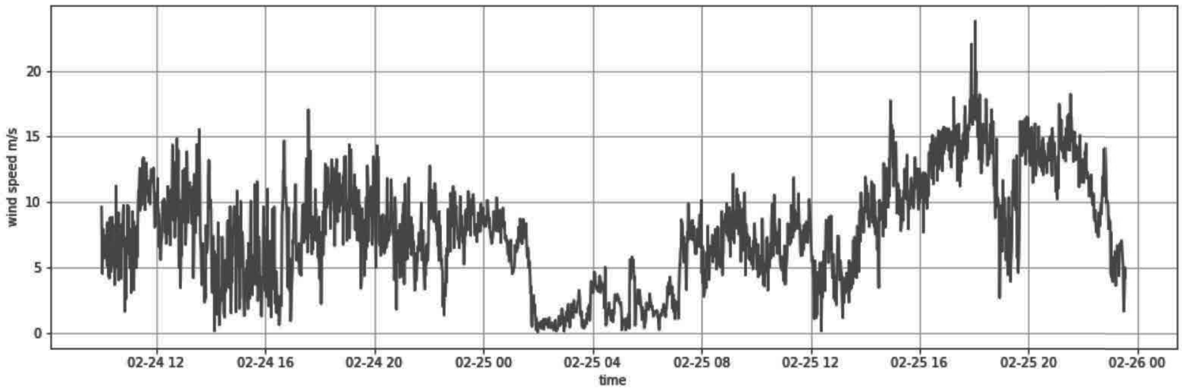

Figure 2.24: shows the wind speed in m/s

From figure 2.25 we can see that the wind was shifting very much, but this is with the time interval of 1 minute.

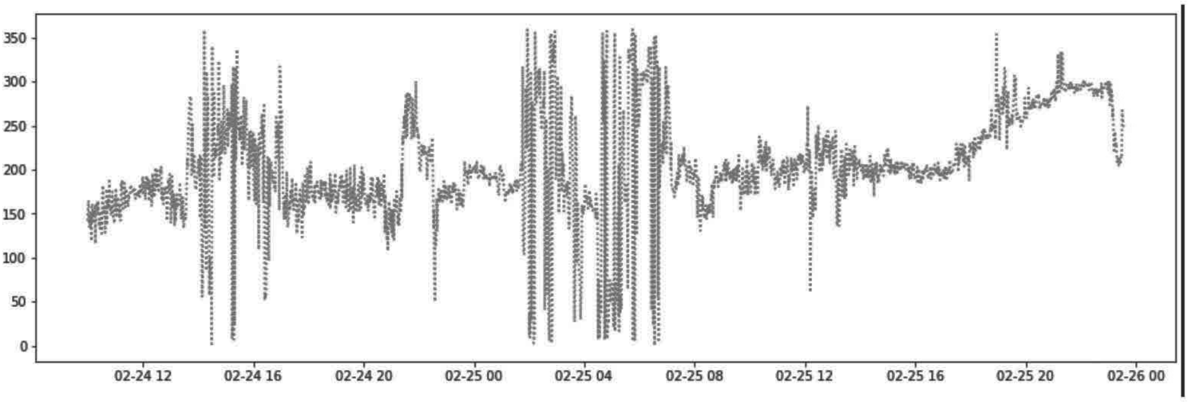

Figure 2.25: shows the wind direction

Drifter project in Masfjorden:

One of our goals for the GEOF337 project is to observe the surface circulation at Masfjorden. More specifically, we wanted to investigate the surface current here due to the influence of local wind and the fresh water. Our first idea was to set up drifters at different positions at the middle of the fjord since we wanted to investigate the impact of the river at the surface current. However, it was a risk to deploy them in the head of the fjord due to being surrounded by mountains, and possible to lose the signal of the drifters. For this purpose, we set up three drifters on 26th February at the same position in the outer part of Masfjorden. In the first experiment, we deployed them at latitude 60o81.1632 N and longitude 5o32.2337 E at 14:30 (UTC). By seeing their position on an app, we noticed that they moved close to the coastline. After a few hours they got stuck here, and they were not able to move. Therefore, at 16:23 (UTC) we picked them up and redeployed them again at the position 60° 48.205 N, 5°17.183 E. During the recovery and the deployment, there was calm weather conditions, and it did not rain much. The drifters were recovered the next day and were out in roughly 11 hours. At the table 2.8, we present a short description of the location and the time of drifters' deployment and recovery. From the figure 2.26, the path of drifters is shown. The drifters followed the same direction, moving outside the fjord. Only the drifter 4 stopped earlier, due to sticking to the coastline, while we found the drifter 1 and 2 close during the recovery.

Table 2.8: Time and Position of the deployment and recovery of Drifters

	Deployment				**Recovery**			
Drifter	Date	Time (UTC)	Latitude	Longitude	Date	Time (UTC)	Latitude	Longitude
1	26.02.2021	17:22	60°80,371 N	5°28,686 E	27.02.2021	02:22	60°81,764 N	5°13,928 E
2	26.02.2021	17:22	60°80,372 N	5°28,729 E	27.02.2021	02:23	60°81,676 N	5°13,825 E
4	26.02.2021	17:22	60°80,370 N	5°28,683 E	27.02.2021	02:24	60°79,527 N	5°26,378 E

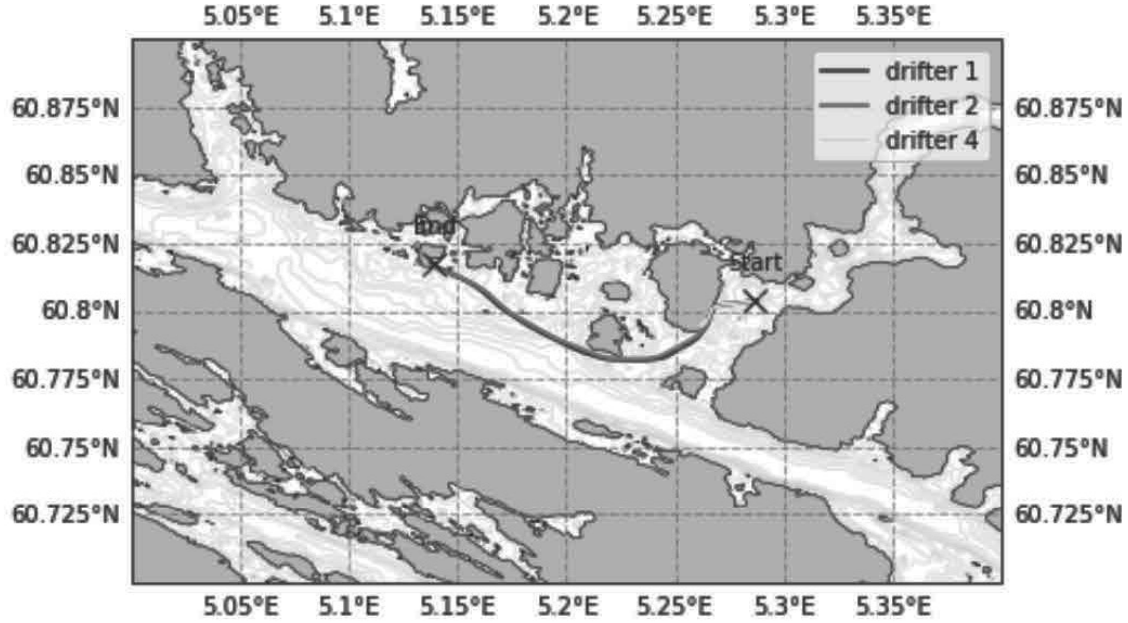

Figure 2.26: The paths of drifters (drifter 1 with the blue color, drifter 2 with the red and drifter 4 with the yellow one).