CRUISE REPORT

Cruise KB 2019602

with R.V. Kristine Bonnevie

1 – 4 Feb 2019

Working Areas:

Masfjorden, Fensfjorden

Geophysical Institute, University of Bergen

Compiled from inputs of GEOF337 students, spring 2019

Version: 1 February 2019

1. Background

The cruise on board the Research Vessel Kristine Bonnevie was undertaken as a part of the GEOF337, Physical Oceanography of Fjords course offered at the Geophysical Institute (GFI), University of Bergen. The site of study was Masfjorden and Fensfjorden. The data set collected aimed to address the processes related tides and mixing processes in Masfjorden, ocean-fjord exchange mechanisms and the observed deoxygenation of the inner basis. The students become familiar with typical and state-of-the-art measurement systems, including ship-based measurements (CTD, thermosalinograph and Ship-ADCP) as well as moored instruments, turbulence measurements (MSS) and measurements of oxygen concentrations in collected water samples. The students are also encouraged to participate in planning of the cruise and sampling, and contributed substantially to the cruise report.

In total, 4 moorings were deployed consisting of current meters, current profilers, and temperature, salinity, oxygen and pressure loggers, which will collect data for one month or one year duration. During the cruise, data collection was primarily by using the ship's CTD and vessel-mounted current profiling system and GFI's microstructure profiler.

2. Cruise participants

Table 1: Cruise participants

	Name	Institute	Responsibility
Scientists	Elin Darelius, elin@gfi.uib.no	UIB	Cruise leader
	Mirjam Glessmer	UIB	Watch leader
Assistants	Stefanie Semper	UIB	Watch leader
	Nadine Steiger	UIB	Moorings
Students	Roy Andreas Nilsen	UIB	
	Jori Neteland-Kyte	UIB	
	Øystein Breiteig	UIB	
	Aleksander Dürr Libæk	UIB	
	Sonja Wahl	UIB	
	Evangelina Efstathiou	UIB	
	Helene Asbjørnsen	UiB	
	Julie T. Kvalheim	UiB	
Technical personnel	Kristin Jackson	UIB	Chemistry
	Algot Peterson	UIB	Moorings, MSS

	Benjamin Marum	IMR	Instrument chief

3. Cruise Overview (Elin)

During cruise KB2019602 to Masfjorden we deployed 4 moorings, made 65 CTD-stations and 54 MSS-cast. The moorings, MF_sill and MF_inner were deployed to monitor the exchange of water across the main sill of Masfjorden (79 m) and the evolution of hydrography and oxygen in the deep inner basin respectively. These moorings will be in the water for a year. The two small "mini-moorings", measuring only pressure and temperature are placed on either side of the sill to monitor sea level (tides) until the next student cruise (KB2019604) that will take place end of February, 2019. Along fjord CTD-section were taken a) along Masfjorden (Section A) and along Fensfjorden (Section C) and across Masfjorden (Section B), Fensfjorden (Section D &E) and across Byfjorden (Section F) . MSS-section was taken along Section A (extending across Fensfjorden) and a 12h time series was occupied in the sill area.

The inner, northern branch of Masfjorden (Haugsværfjorden) was covered with sea ice preventing access to that part of the fjord.

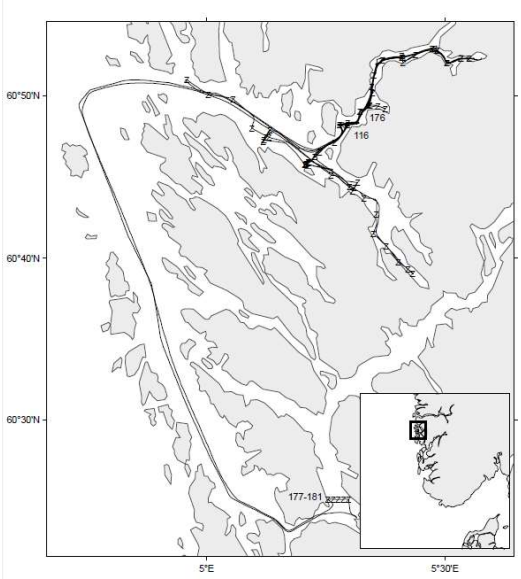
Water samples for calibration of the oxygen sensors of the CTD were taken at 8 stations, and these were analyzed on board. In addition to the one bottle that HI takes at the bottom of each station, we took 36 water bottles for calibration of the conductivity sonde. These bottles were analyzed at the Geophysical Institute by Kristin and the students a few days after the cruise.

The cruise track is shown in Figure 1.

The thermosalinograph, the shipADCP and the weatherstation run continuously throughout the cruise.

A detailed cruise narrative is given in Appendix A.

Figure 1: Cruise track



4. Environmental conditions

The weather was calm with relatively low winds and low temperatures during the entire cruise (Figure 2). The tidal predictions obtained from www.kartverket.no are shown in Figure 3. Tidal amplitudes are expected to be about 80-100 cm.

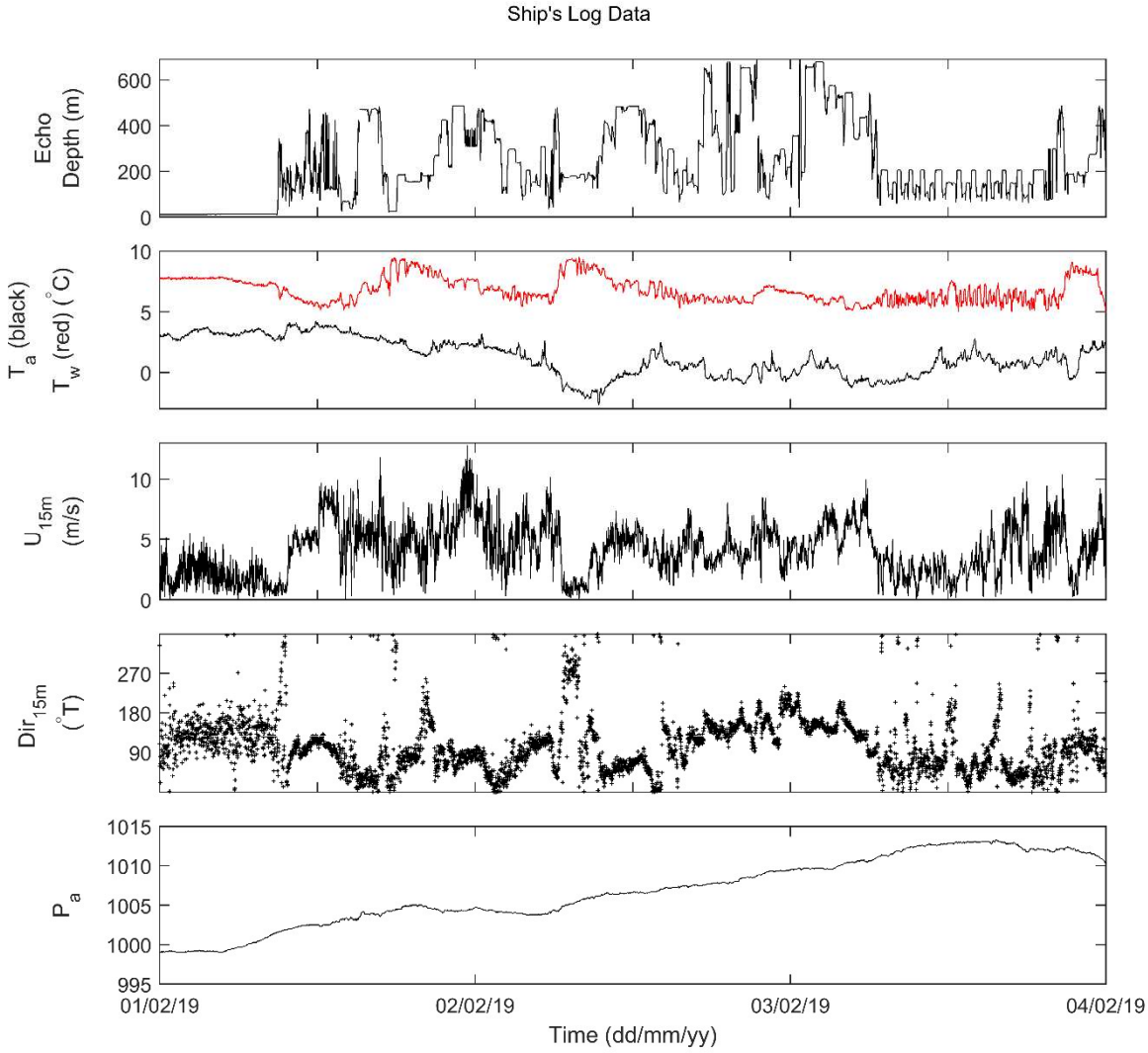


Figure 2: a) Echo depth b) air (red) and water (black) temperature, wind c) strength and d) direction and e) pressure logged by the ship.

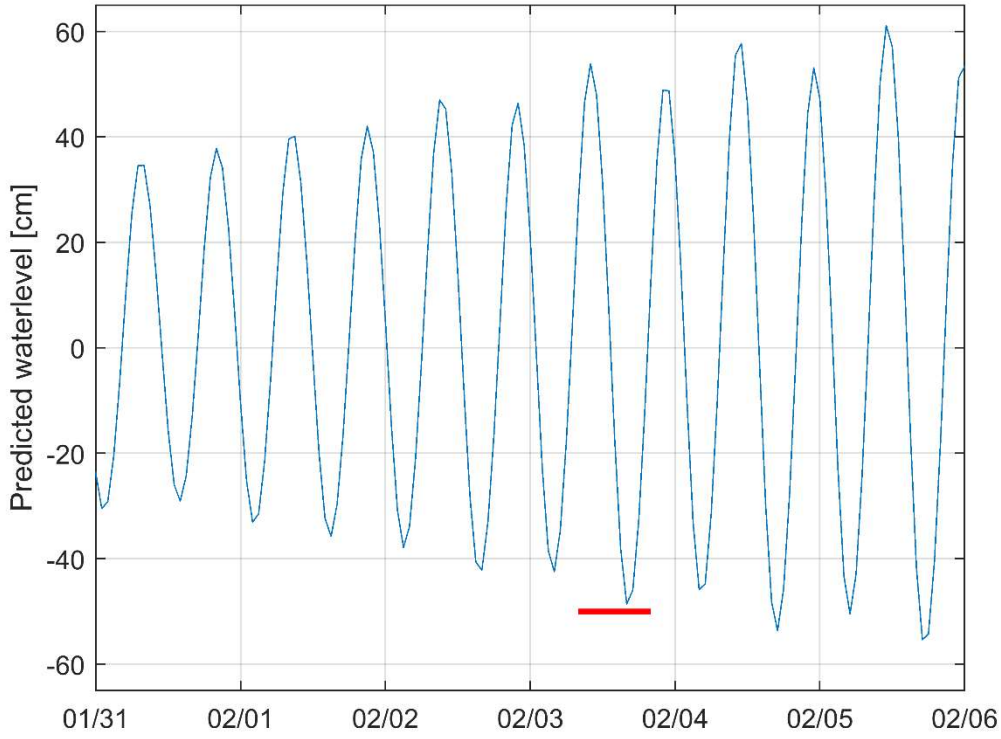


Figure 4: Tidal predictions for Masfjorden (local times). The red line shows the duration of the MSS-time series. (data from www.kartverket.no)

5. Moorings

Two full moorings – MF_sill and MF_inner were deployed during the cruise, see Fig 1 for location. Drawings of the moorings are shown in appendix D, deployment details are given in Table 1 and instrumentation details in Table 2. Results from mooring triangulation is shown in appendix E.

	MF_sill	MF_inner
Position:	60° 48.213'N 5° 17.875'E	60° 52.213'N 5° 22.100'E
Time of deployment	1 Feb 2019, 13:47 UTC	1 Feb 2019, 16:30 UTC
Echodepth:	70 m	466 m
Acoustic release	Sn: 1224 Arm: 089B	Sn: 2424 Arm: 2424

Table 1: Instrument details mooring MF_inner.

Depth (m)	Height (m)	Instrument	Serial #	Sampling interval (min)	Comments
200	260	SBE37ODO	12340		
275	185	SBE37 CTD	8974		
350	110	SBE37ODO	12338		
450	10	SBE37ODO	12339		
455	5	AR	2424		ARM: 1BDD REL: ARM + OA55

Table 2: Instrument details mooring MF_outer.

Depth (m)	Height (m)	Instrument	Serial #	Sampling interval (min)	Comments
15	55	Seaguard	1050		
25	45	SBE56	1946	5	
45	25	SBE37	5446		
65	5	RDCP600	229		
66	4	SBE37	8975		
67	3	AR	1224		ARM: 089B ARM+0A55

Triangulation

The moorings were triangulated using the deck-unit of the acoustic release, and the results are shown in Appendix E.

«Mini-moorings»

During the cruise it was deployed two mini-moorings. They were positioned on both sides of the shallowest sill in Masfjorden. The moorings were made with a buoy that is floating in the ocean surface. The buoy is attached to a rope that is roughly 10 meters, which is attached to a tire with weights. The mooring were deployed in shallow water because of the short length of the rope, where the tire is located on the bottom. To the tire there was attached an instrument, called SBE-39, that measures temperature and pressure. The setup of the mooring in shown in figure 5.

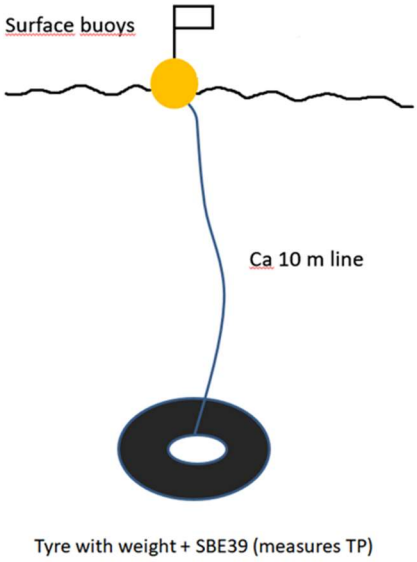


Figure 5: Drawing of the mini-moorings.

The positions of the mini-moorings are shown in the table below:

Mooring	**Serial number**	**Position [lat]**	**Position [lon]**	**Date [dd.mm.yy]**	**Time of deployment [hh:mm]**
SBE-39 (orange tire)	6149	60.820375 °N	005.314952 °E	04.02.19	09:29 UTC
SBE-39 (black tire)	3282	60.796876 °N	005.279792 °E	04.02.19	12:28 UTC

6. Thermosalinograph

The ships thermosalinograph (Sea-Bird SBE21 serial number: 2135836-3238 Sea-Bird SBE21) was running throughout the cruise recording temperature and salinity of the surface water. The instrument was last calibrated in January, 2006.

7. CTD profiling

From a CTD you can get information about the physical quantities of sea water such as conductivity, temperature and depth. The conductivity tells us something about how much salt there is in the water, temperature is temperature and the depth is measured by pressure. These parameters are constantly

measured when the CTD moves through the water column. A CTD operator gets information in real time on a computer about the parameters the CTD measures. At the bottom of every station, we take a water sample. This is done in order to calibrate the conductivity sensor. We can also take water samples on different depths when the CTD is ascending to get information on oxygen, nutrients, etc. The operator can fire the Niskin bottles from the computer.

The CTD used on this cruise is a model SBE9 plus with serial number 09P1258. Mounted on the CTD is a Niskin Bottle rosette with model name SBE 32 and serial number 32-1109. Table 5 shows the other types of sensors that are mounted on the CTD. Also in this table is serial number for every sensor and when the sensor was last calibrated.

A total of 65 CTD stations were done on this cruise. Section A, B and F were done in Masfjorden whereas section C, D and E were done in Fensfjorden.

Listed in appendix B is a complete list of all of the CTD stations on the cruise and Appendix F lists the water samples obtained. Figure 6 shows a map of all of the CTD stations occupied. This map also includes the positions of the two moorings we deployed, and show where we did oxygen sampling. We also collected water for salinity sampling at the same places as oxygen measurements, see . The salinity measurements were done at GFI when we got back from the cruise. In Figure 7 is a cross section of Masfjorden (section A) displaying temperature in the upper panel and salinity in the lower panel.

On our way back to Bergen, we had a special request from an Msc student on land to make a cross section in Byfjorden. We did 5 stations and in the CTD log these stations are noted as BF1-5.

Problems encountered with the CTD

The CTD worked perfectly for almost every position. On one station we had to fire all of the bottles because we had a suspicion that one of the bottles were leaking. We identified the leaking bottle and we could therefore replace it with a new one. Also, at one station, two of the bottles wouldn't close. This happened only one time during the cruise.

On section D, we planned to do 4 measurements (D1-D4). However, we did just 3 measurements on this section (D2-D4). We decided together with the captain to skip D1 because of safety reasons due to strong winds, snow reducing the visibility, and the fact that we were already pretty close to land at night time on station D2.

Table 5: Types of sensor mounted on the CTD with its serial number and when it was last calibrated.

Sensor	S/N	Last calibrated
Primary temp. sensor	03-5884	19. October 2017
Secondary temp. sensor	03-4306	19. October 2017
Primary conductivity sensor	04-4386	14. December 2017

Secondary conductivity sensor	04-2860	14. November 2017
Pressure sensor	134950	17. November 2015
Submersible pump	05-8402	N/A
Oxygen sensor	43-0633	31. October 2017
Fluormeter, Wet Labs ECO-AFL/FL	FLRTD-4131	2. October 2015
PAR sensor, Biospherical QCP2300-HP	70656	13. January 2017
SPAR sensor, Biospherical QCR-2200	20539	13. January 2017

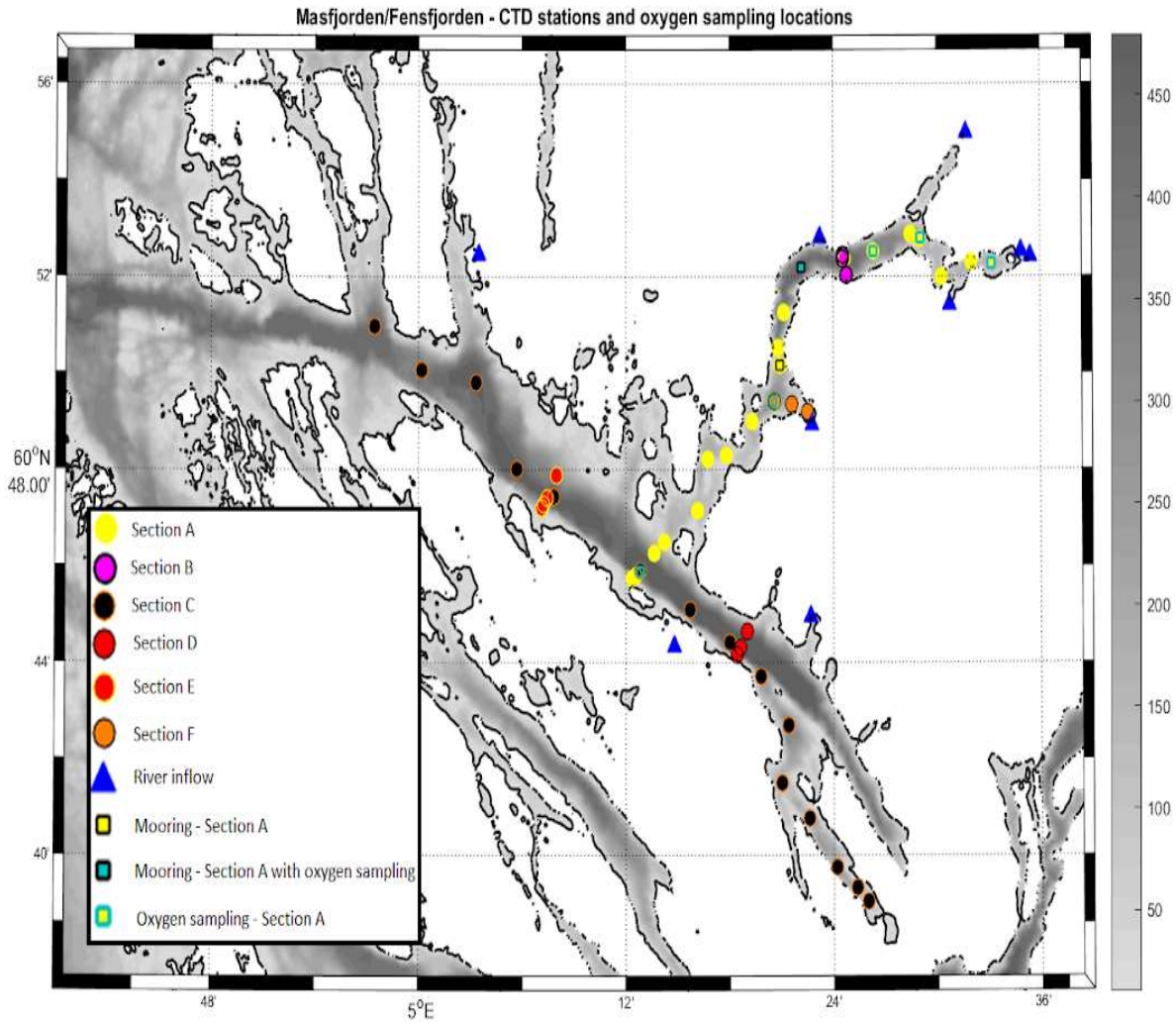
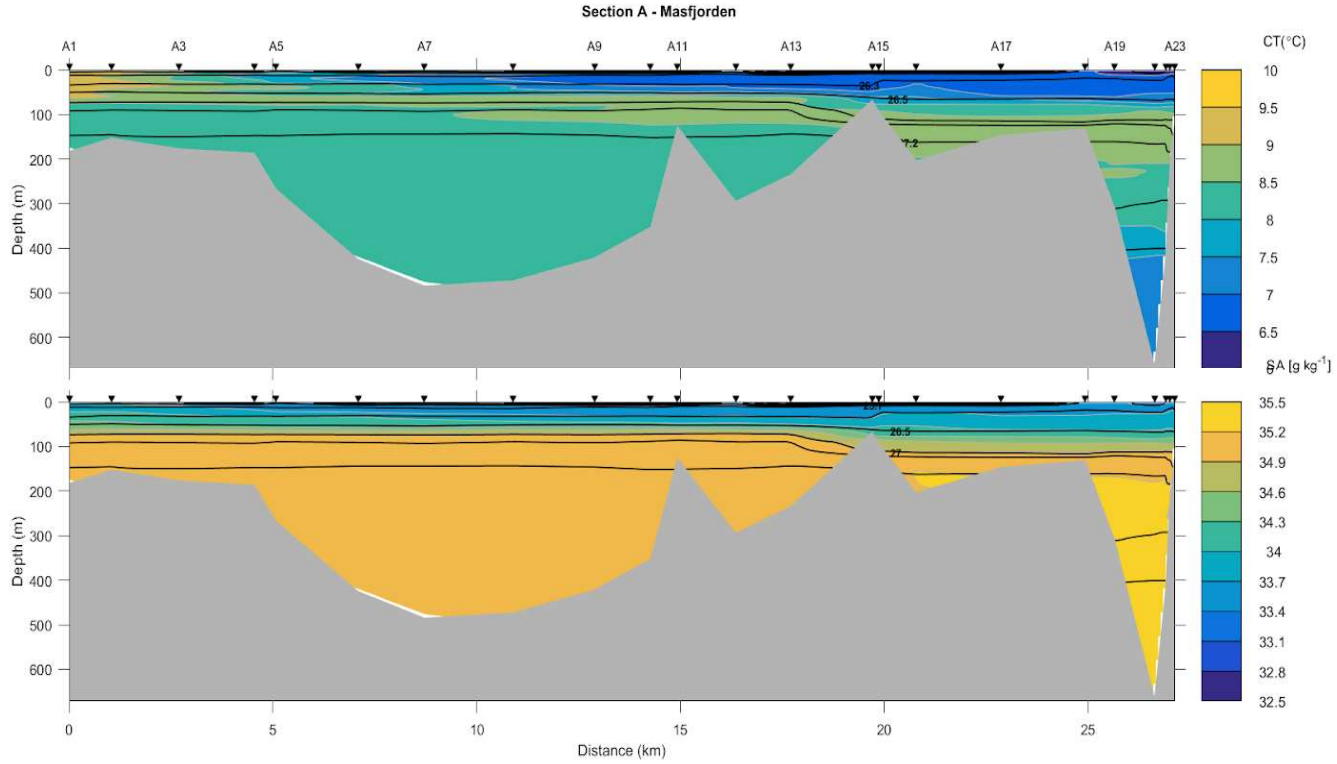


Figure 6: CTD-stations occupied in Mas and Fens fjorden during KB2019604.



Figur 7: Section A in Masfjorden, with a cross section of Fensfjorden on the right side of the panels. The top panel shows temperature and the lower panel shows salt content in the water. Isopycnals are shown in both panels.

7.1 Calibration of the conductivity sensor

Water samples for calibration of the conductivity cell were collected a) at the bottom of every station for HI and b) at selected stations for UiB. Due to a misunderstanding, many of the UiB samples were filled on HI bottles and had to be emptied.

UIB samples: In total there were 14 UiB samples that were analysed by the students upon return. The median difference in conductivity (CTD-water bottle) was 0.008 and the mean 0.01 mS/cm.

HI samples: In total there were 57 HI samples that were analysed at HI. The results are show in Figure 7.1. The difference is larger for shallower depths, presumably because these samples were obtained in more stratified water. The data suggest a correction of -0.011 mS/cm. The correction has been applied to the data in the matlab structure. Data in the cnv-files are uncorrected.

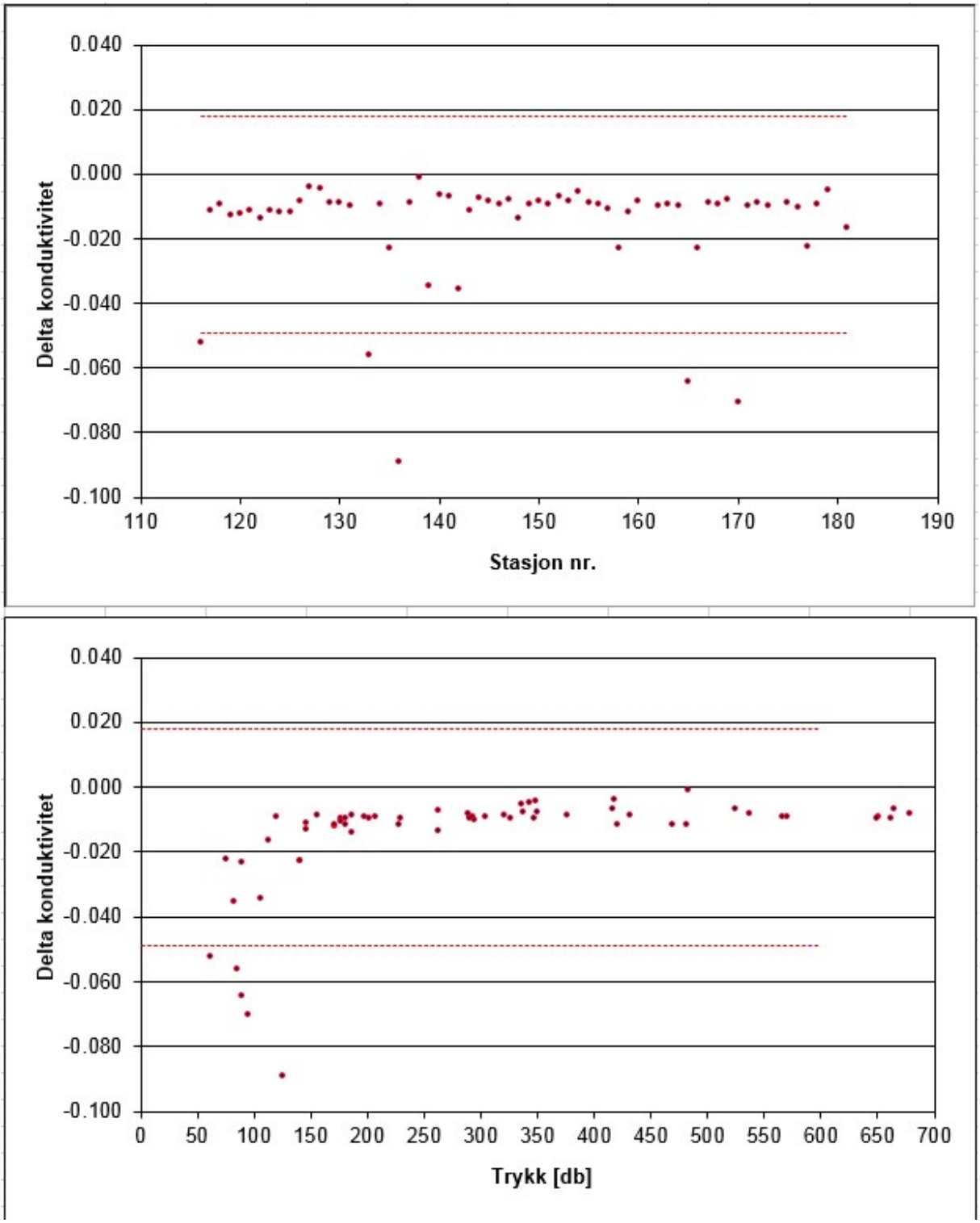


Figure 7.1: Results from the HI-samples. Difference (bottle - CTD) in conductivity as a function of station number (upper panel) and as afunction of bottom depth (lower panel).

8. Current Profiling using Vessel-mounted ADCP (VMADCP)

The vessel-mounted Acoustic Doppler Current Profiler 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.

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.

9. Microstructure Profiling

For measuring the ocean structure, we used an instrument called MSS90. The instrument is manufactured by Sea & Sun Technology and the different sensors that are attached is listed in table 6. The depth range for the MSS is down to 500 meters depth. The instrument is a free-fall instrument, which means when it is deployed it will go down the water column in free-fall.

Table 6 - Overview over the different sensors.

Instrument/sensor	Type	Serial number	Dimension	Last calibrated
MSS90	-	MSS047	-	20.05.2010
Temperature NTCHP	NTC FP07	-	Celsius	12.05.2010
Shear1	PNS6	067	-	20.05.2010
Shear2	PNS6	068	-	20.05.2010
Pressure	PA7-50	-	dbar	18.05.2010
Temperature	PT100	-	Celsius	12.05.2010
Conductivity	Small	-	mS/cm	18.05.2010
Acceleration	-	-	m/s^2	10.05.2010
Temperature NTC	NTC FP07	-	Celsius	12.05.2010

Acceleration in X	ADXL 203	-	G	10.05.2010
Acceleration in Y	ADXL 203	-	G	10.05.2010

During the cruise to Masfjorden, we did MSS measurements on two of the days. On the first day we took MSS stations along the CTD section A. In figure 8 we can see the position of the 23 casts we took the first day. The MSS casts are shown as blue stars. In the figure is also the CTD stations shown, so that we can compare the positions between the stations. The depth ranges on the section casts varied between 86 and 500 meters. On the second day we took MSS measurements on three positions over time, so we have then ended with a time series for the three different positions. The positions for the second day are shown in figure # as dark red stars. For the time series stations, we took one station before the sill, one on the sill and the last one on the other side of the sill. Started with number 1, then number 2 and thereafter number 3, before we started at number 1 again. In total we ended up with 10 laps, as described over. The depth ranges for the lap stations varied between 83 and 187 meters. More details about the positions and depths, can be read in the MSS log, in the appendix G.

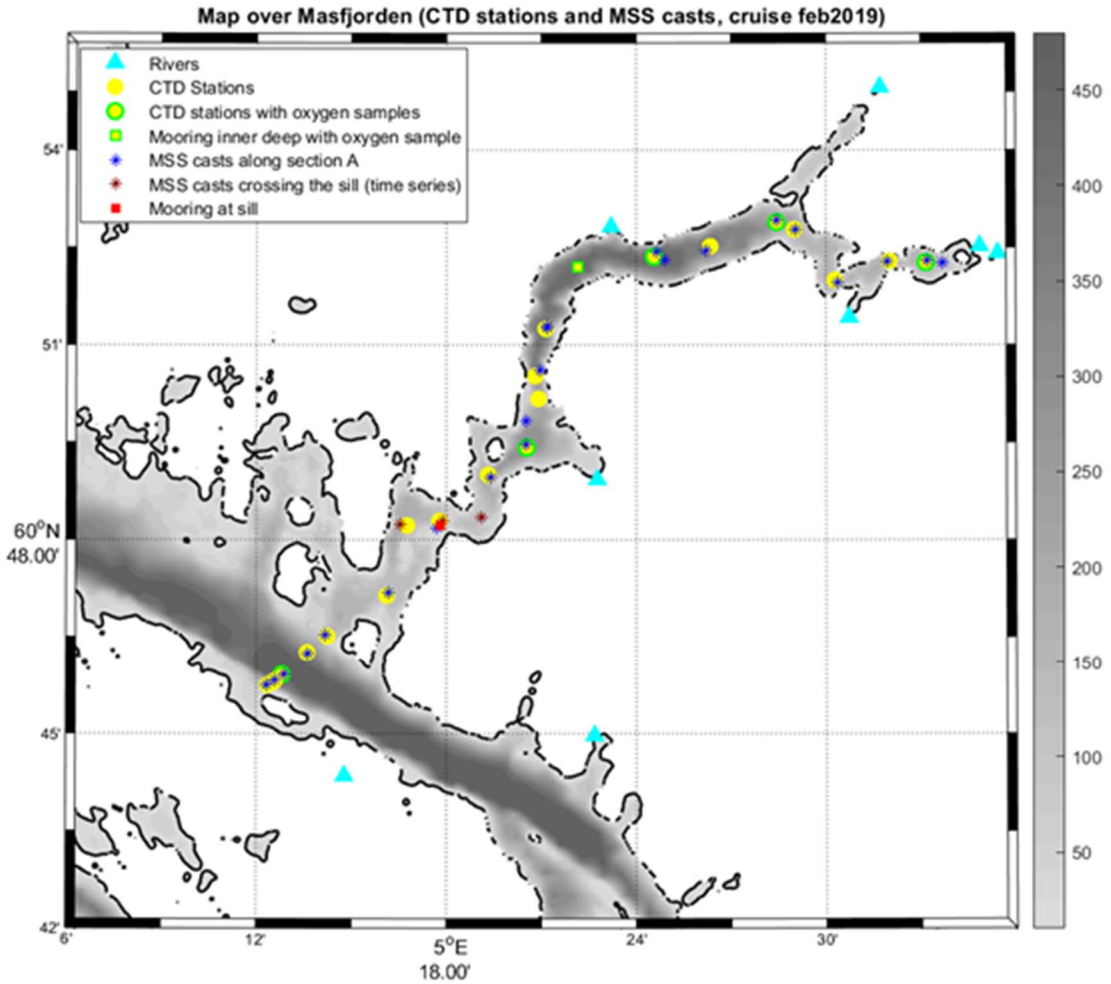


Figure 8 - Map over Masfjorden and the MSS casts/CTD stations along section A.

The data collected with the MSS are processed in Matlab and we can end up with figures and plots such as this turbulence plot shown in figure 8. The figure below shows the turbulence from Cast 15, for the depth between 20 and 40 meters.

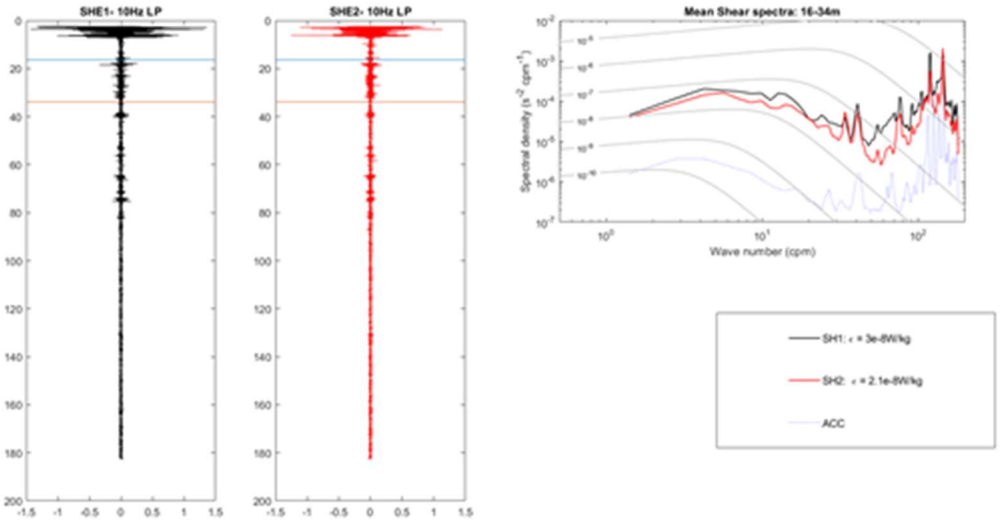


Figure 9 - Turbulence from the measured shear in the ocean.

Set-up of the MSS and data processing

The MSS was lower from the starboard of the ship by a winch with cable. The operator of the winch paid out slack on the cable such that the MSS was able to sink unhindered. The ideal vertical speed of the MSS is 0.6-0.7 m/s. From the MSS we received data on a laptop in the other room. We had two persons monitoring the depth of the MSS because the operator didn't have access to the monitor. There was a signal system between the different rooms and was used to tell the operator to stop giving out slack on the cable or to start reel in the cable, to avoid it hitting the bottom.

On the computer it was recorded RAW data from the MSS by using the Standard Data Acquisition program (SDA). The program showed pressure, acceleration and the tilt during the measurement. After the recording we processed the data and started analysis using Matlab. From the shear sensors obtained data for calculating the dissipation rate. The right side of the turbulence plots, showed in figure 9, is usually not considered due to noise. The left side of the data shows more the dissipation rate where it is following the Nasmyth spectrum.

Problems encountered with MSS during the cruise

During the cruise we got some issues during the usage of the MSS. In the beginning we had some problem with getting the instrument to fall with the right speed, so we used the five first casts to change a bit about the weight and buoyancy on the MSS. After we removed three floating elements and three metal rings, we ended up with 9 floating elements and five metal rings. After this the instrument was going with the right speed. Further on we had some problem with the connection between the instrument and the logging program, so we had to reset the program several times during the measurements. Sometimes it stopped recording on the way up, and sometimes it wouldn't record at all in the beginning. We also had to change the blue box which gives the logging program on the computer the signal from the MSS. Strong current we also experienced on a couple of the casts, and then we lost the connection.

The issues with the connection was usually solved by turning off the blue box before we closed the logging program on the computer. Then we turned on the box again and then opened the logging program.

10. Oxygen sampling

During the cruise, 96 water samples were taken at 8 CTD stations (Figure 6) for analyzing dissolved oxygen concentration in several depths. The oxygen samples are used to study ocean ventilation and the movement of water masses. CTD section-A with uncalibrated dissolved oxygen data is shown in Figure 10.

Of the 96 samples, 23 duplicates are included in the analysis. The dissolved oxygen is determined by using the colorimetric titration of discrete water samples developed by Winkler in 1888. Each day, 4 blanks and 4 standards based on standard potassium iodate were measured. Two of the 96 samples got over-titrated. The measurement uncertainty depends on the thermal expansion of bottle volume, varying drop size of thiosulfate, recording of the amount of thiosulfate added regarding a 25 mL burette, and recording of when the solution becomes colorless. The estimate of the uncertainty was set to 0.02 ml L^{-1}.

The dissolved oxygen from the colorimetric titration has a significantly different concentration compared to the CTD dissolved oxygen sensor (Figure 11). The upper panel of the figure shows a decreasing offset with depth compared with the stippled line. The maximum offset from the regression line in the lower panel of Figure 11 is 0.29 ml L^{-1}, and the average offset from the stippled zero-line is 0.30 ml L^{-1}. Both values lie outside of the measurement uncertainty of 0.02ml L^{-1} indicated by blue stippled lines. The number of values within the measurement uncertainty (blue stippled lines) is 8, while the rest 88 samples lie outside of the interval. To be sure there is a decreasing error with depth, there need to be more oxygen samples in the deeper part of the fjords.

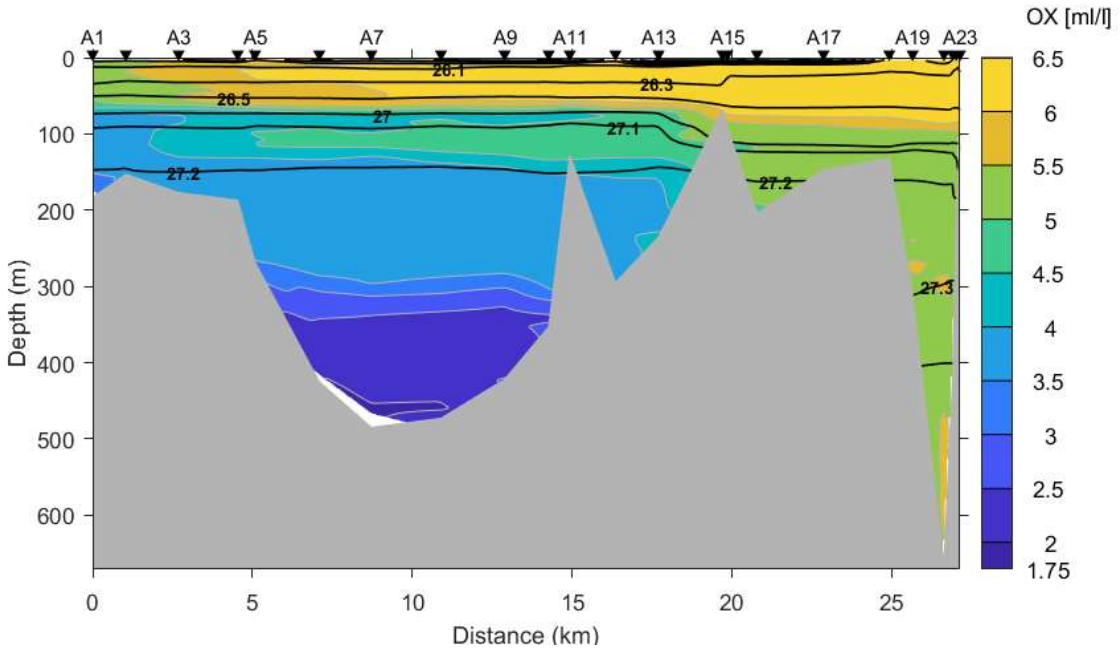


Figure 10: Contours of oxygen concentration for section-A. Potential density anomaly contours are shown in black. Station A1 is the innermost station in Masfjorden, and A23 is the outermost station lying in Fensfjorden. Section A is shown on map in Figure 6. The data shown are not corrected.

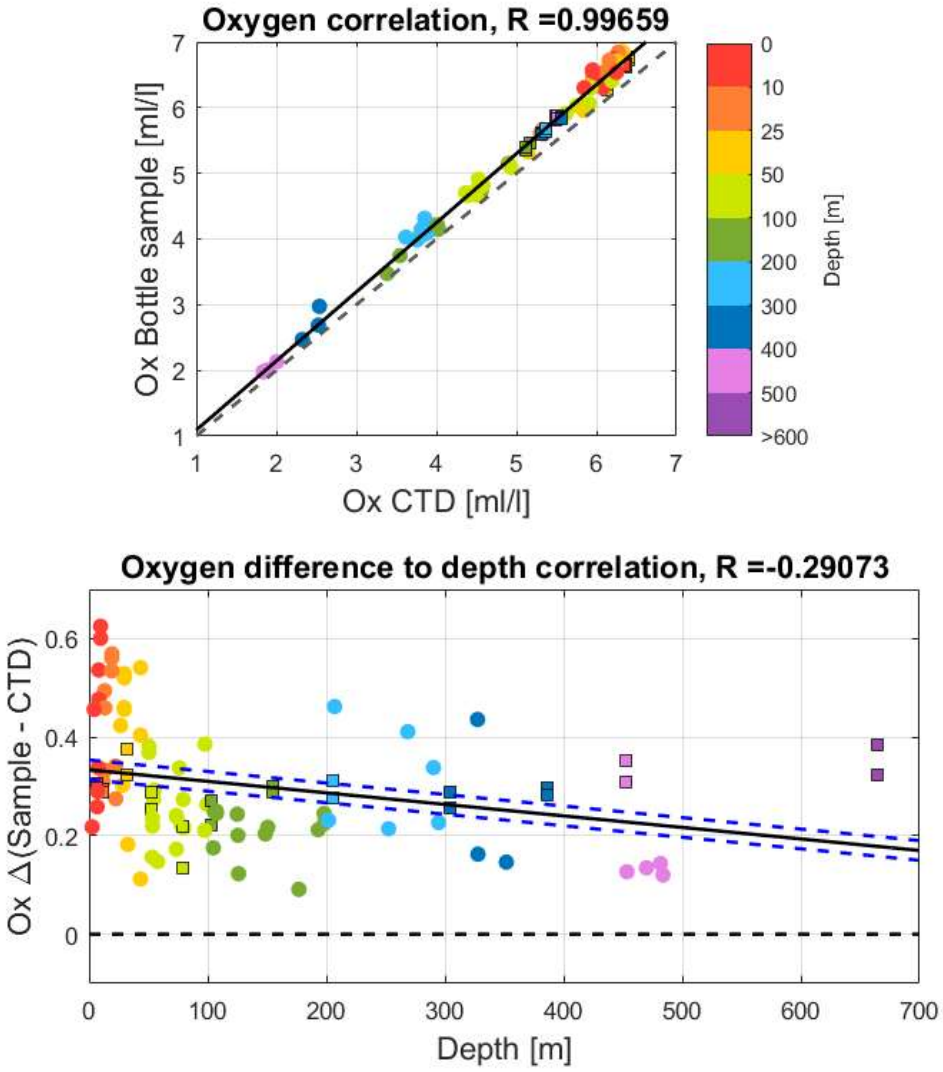


Figure 11: (upper panel) Scatter plot of dissolved oxygen samples compared to oxygen measured by CTD with color according to depth. A regression line for the scatter points is drawn in black, and a stippled line in gray to indicate an offset between the CTD-measured and the sampled dissolved oxygen. The round and square markers are data from Masfjorden and Fensfjorden, respectively. (lower panel) Difference in oxygen concentration between sampled and CTD-measured compared with depth. The measurement uncertainty of 0.02 ml L^{-1} is shown by the blue stippled line parallel to the black regression line.

Appendix A: Cruise Narrative

1 February

09:00 Left Bergen

14:10 CTD-station 116 at mooring position. "Grey box" from bridge did not appear – so weather information not to be trusted. HI water sample only.

13:47 Mooring "Masfjorden sill" was deployed at 5 17.875 60 48.231 in 70 m deep water.

15:20 CTD-station 117 at mooring position.

16:30 Mooring "Masfjorden inner" was deployed at 5 22.100 60 52.213

18:00 Put Nadine ashore

18:13 Started section A (Along Masfjorden), station: A1 – A6

22:01 Started transect section B (across the fjord), station: B1 → B2/A7 (middle station, where the name are the same station) → B3

2 February

01:05 Continued on transect A (along Masfjorden), station: A8-A17

05:20 started to steam back to head of the fjord

07:50 Started MSS with Section A, from inner Masfjorden.

Cast 1: Removed 2 floating elements before cast. Limit of 50 meter above bottom.

Cast 2: Removed 1 floating element before cast. Limit of 50 meter above bottom.

Cast 3: Removed 1 metal ring before cast. Limit of 50 meter above bottom.

Cast 4: Removed 2 metal rings before cast, limit of 70 meter above bottom

Cast 5: We have in total 9 floating elements (including all) and 5 metal rings before cast. Limit of 50 meter above, stopped 30 meter above bottom

Cast 6: No changes. Limit of 70 meter above bottom.

Cast 7: No changes. Limit of 100 meter above the bottom.

Struggles with the logging program. Restarted the program and tried to restart the computer as well.

Lesson learnt: Turn on/off the blue box before opening/closing the software.

Did not take the 2 CTD's in the northern arm of Masfjorden (Haugværfjorden), because of sea ice.

10:32 On our way to transect B, to take MSS for section B. Starts at B1.

12:00 - 18:00:

Casts with MSS along transect A (8-18), replaced the blue (logger) box due to failing communication

At 12:50 CTD with oxygen samples, nutrient samples, salinity samples and Carbon samples taken at B2/A7.

Oxygen sample analysis of CTD water samples of 01.02.19

18:00 – 24:00

MSS at cast 19 - 23, replaced the blue (logger) box at last station due to failing communication.

Finished oxygen sample analysis of CTD water samples from 01.02.19.

Finishing the last three stations at section A with CTD: starting with A21, ending at A19.

A21: We fire all bottles at one depth to check the niskin bottles for leakage. Bottle on position #4 did not close, the string was tightened to fix it.

Starting section C, time 22:10

3 February

23:00 – 05:00 UTC Outreach plan: strategy

And CTD along Transect C

05:45 UTC Start steaming back into Masfjorden
07:10 UTC Started MSS measurements around the sill
Programmed SBE39 for use in the small moorings
18.30 UTC Stopped MSS measurements.
19:15 UTC start CTD repeat stations on transect A (A12 & A1-A5), took oxygen samples at A12 and A5
23:15 UTC end repeat stations on transect A

4 February
01:51 UTC start transect D (Fensfjorden across, inner part)
03:48 UTC start transect E (Fensfjorden across, outer part)
05.50 UTC start transect A (Fensfjorden across, towards Masfjorden).
06:03 UTC Changed name of old A21 to A22, because we have added another station in between old A21 and A20.
08:00 UTC prepare mini-moorings and triangulation
11:00-17:00 UTC
CTD with water samples at station F3/A12 (salinity at all depths)
Deployed the mini-moorings and did triangulation of deep mooring
Learned how to splice a rope
cleaning of labs etc.
more oxygen sample titrations
17:39 Started with CTD stations in Byfjorden, section BF1-BF5.
19:06 Finished with the last CTD station!

Appendix B: List of CTD stations

Vessel Kristine Bonnevie
KB 2019
Cruise 602

St.name	CTD File Name	Date		UTC		Depth	Latitude/ N		Longitude/ E		W. Samples
		year	mon	day	hh:mm	m	deg	min	deg	min	y/n
A14*	116	2019	2	1	14:10	69	60	48.21	5	17.81	n
A8**	117	2019	2	1	15:20	470	60	52.21	5	22.18	y
A1	118	2019	2	1	18:13	186	60	52.27	5	33.17	y
A2	119	2019	2	1	19:32	144	60	52.29	5	32.01	n
A3	120	2019	2	1	19:03	189	60	52.00	5	30.28	n
A4	121	2019	2	1	20:39	183	60	52.78	5	29.00	n
A5	122	2019	2	1	20:58	269	60	52.89	5	28.44	n
A6	123	2019	2	1	21:29	425	60	52.52	5	26.34	n
B1	124	2019	2	1	22:01	217	60	52.03	5	24.76	n
B2 / A7	125	2019	2	1	22:21	485	60	52.36	5	24.56	y
B3	126	2019	2	1	23:47	376	60	52.28	5	24.34	n
A9	127	2019	2	2	00:49	405	60	51.15	5	21.80	n
A10	128	2019	2	2	01:37	344	60	50.32	5	20.49	n
A11	129	2019	2	2	02:13	120	60	50.10	5	20.55	n
A12/F3	130	2019	2	2	02:42	290	60	49.26	5	20.33	n
A13	131	2019	2	2	03:21	225	60	49.1	5	19.20	n
A14	133	2019	2	2	03:44	95	60	48.29	5	17.78	n
A15	134	2019	2	2	04:00	198	60	48.30	5	16.46	n
A16	135	2019	2	2	04:20	139	60	47.9	5	16.80	n
A17	136	2019	2	2	04:50	124	60	46.31	5	14.14	n
A18	137	2019	2	2	05:03	309	60	46.26	5	13.62	n
B2/A7	138	2019	2	2	11:50	478	60	52.22	5	24.41	y
A22	139	2019	2	2	19:31	115	60	45.75	5	12.363	n
A20	140	2019	2	2	19:48	446	60	45.82	5	12.58	n
A19/C10	141	2019	2	2	20:18	654	60	45.92	5	12.81	y
C1	142	2019	2	2	22:12	87	60	39.04	5	25.99	n
C2	143	2019	2	2	22.32	157	60	39.32	5	25.36	n
C3	144	2019	2	2	22:44	272	60	39.74	5	24.17	n
C4	145	2019	2	2	23:20	289	60	40.50	5	22.27	n
C5	146	2019	2	2	23:50	207	60	41.31	5	21.1	n
C6	147	2019	2	3	00:19	347	60	42.42	5	21.23	n
C7	148	2019	2	3	00:55	185	60	43.42	5	19.49	n
C8	149	2019	2	3	01:20	643	60	44.26	5	18.1	n
C9	150	2019	2	3	02:00	671	60	45.70	5	15.43	n
C11	151	2019	2	3	02:58	564	60	47.27	5	07.51	n
C12	152	2019	2	3	03:40	525	60	48.1	5	5.41	n
C13	153	2019	2	3	04:20	538	60	49.48	5	3.19	n
C14	154	2019	2	3	04:52	335	60	50.07	5	0.21	n
C15	155	2019	2	3	05:33	435	60	50.97	4	57.48	n
A12/F3	156	2019	2	3	19:14	299	60	49.41	5	20.50	Y
A1	157	2019	2	3	21:14	187	60	52.28	5	33.10	n
A2	158	2019	2	3	21:38	153	60	52.28	5	32.08	n

A3	159	2019	2	3	22:01	181	60	51.98	5	30.32	n
A4	160	2019	2	3	22:27	197	60	52.80	5	29.04	n
A5	161	2019	2	3	22:48	273	60	52.90	5	28.41	y
D4	162	2019	2	4	01:51	344	60	44.67	5	19.01	n
C8/D3	163	2019	2	4	02:15	642	60	44.32	5	18.61	n
D2	164	2019	2	4	02:45	181	60	44.15	5	18.43	n
D1	x	x	x	x	x	x	x	x	x	x	x
E1	165	2019	2	4	03:48	89	60	47.21	5	07.16	n
E2	166	2019	2	4	03:58	89	60	47.28	5	07.24	n
C11/E3	167	2019	2	4	04:13	566	60	47.42	5	07.46	n
E4	168	2019	2	4	04:43	325	60	47.87	5	08.01	n
E2	169	2019	2	4	05:10	328	60	47.28	5	07.24	n
A22	170	2019	2	4	05:50	100	60	45.74	5	12.39	n
A21	171	2019	2	4	06:03	245	60	45.78	5	12.49	n
A20	172	2019	2	4	06:20	278	60	45.80	5	12.57	n
A19	173	2019	2	4	06:55	668	60	45.89	5	12.82	y
F1	174	2019	2	4	09:55	82	60	49.21	5	22.50	n
F2	175	2019	2	4	10:10	168	60	49.35	5	21.58	n
F3/A12	176	2019	2	4	10:29	299	60	49.39	5	20.57	y
BF1	177	2019	2	4	17:39	84	60	25.06	5	15.28	n
BF2	178	2019	2	4	17:54	298	60	25.08	5	15.93	n
BF3	179	2019	2	4	18:14	350	60	25.05	5	16.59	n
BF4	180	2019	2	4	18:36	283	60	25.08	5	17.28	n
BF5	181	2019	2	4	18:55	110	60	25.07	5	17.88	n

Comments:

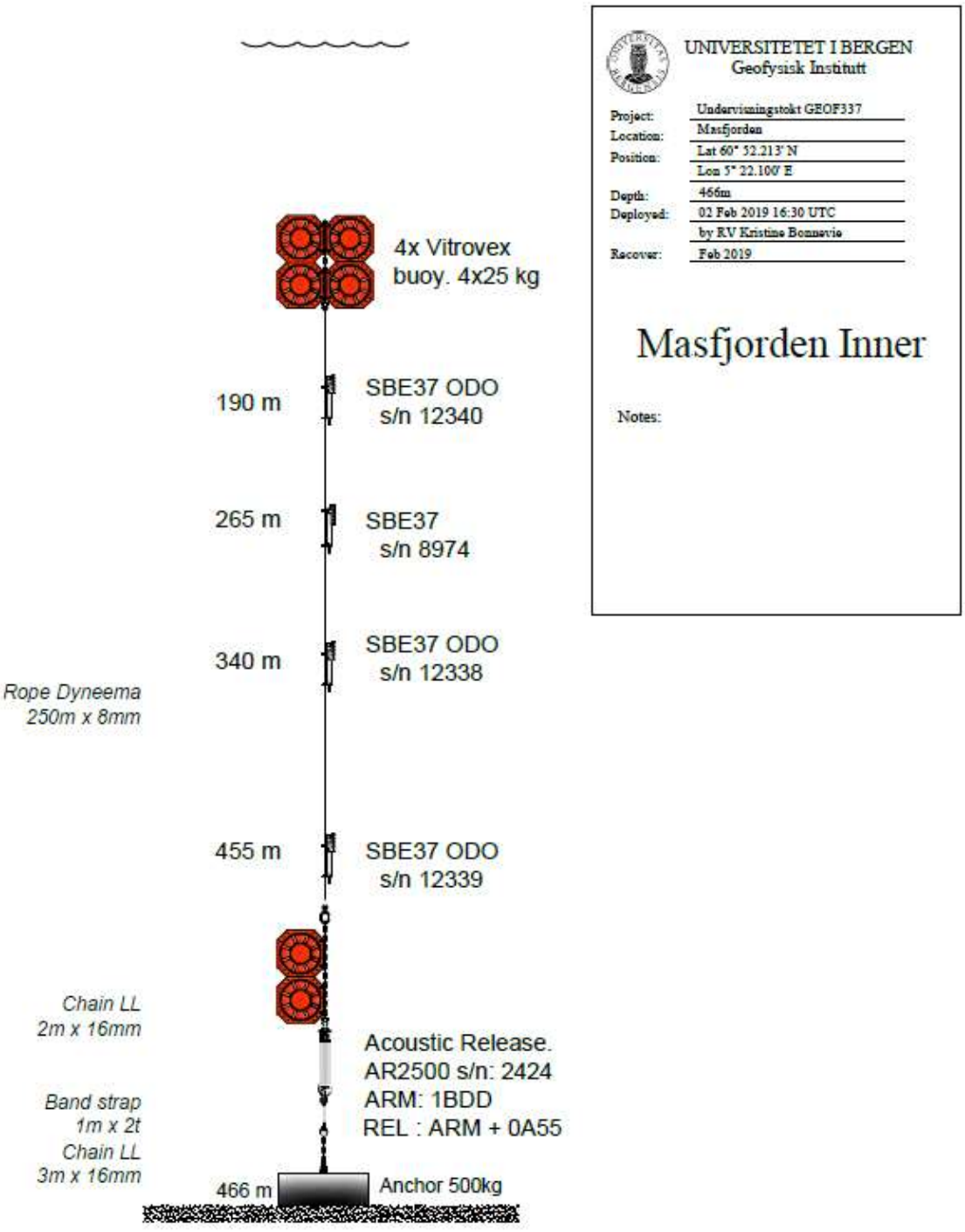
HI water bottle samples were taken at the bottom at almost all stations. The last column indicate water bottle samples (Oxygen, Salinity, Carbon, Nutrients) taken for UiB.

116 BF_sill, mooring deployment
117 BF_inner, mooring deployment
126 stopped data aquisition early on the upcast / altimeter did not kick in so we used echosounding and unsure about the final distance between sampling and ground
127 strange foam in salinity bottle
139 fired all the bottles to check for the bottle with leak.
148 CTD sent down before completeing session. Started recording at 50m
166 probably too shallow cast because of instrument mismatch
170 Changed name because we have added another new station inbetween old A21 and A20.
172 We don't know the depth (echosounder shows CTD below bottom (but shallower than depth where we began the station), altimeter shows ca. 45m where we stopped, but the slope is very steep).
173 Salinity samples, bottle 3 and 7 didn't close

Appendix C: Mooring instrumentation set up

Instrument	S/N	Nye batteri	Service	Programmert	Interval (min)	Start logging	Gjort av
SBE37 ODO	12338	x	x	x	30	02.02.2018 12:00 UTC	Algot
	12339	x	x	x			
	12340	x	x	x			
SBE37 SM CTD	8975	x	x	x	5	02.02.2018 12:00 UTC	Algot
	5446	x	x	x			
	8974	x	x	x			
	7224	x	x	x			
SBE 56	1946	x	x	x	5	02.02.2018 12:00 UTC	Nadine
SBE39	6149 TP	x	x	x	20s	04.02.2019 10:00 UTC	Elin & Students
	3282 TP	x	x	x		04.02.2019 10:00 UTC	Elin & Students
Sea Guard	1050	x	x	x	60	02.02.2018 12:00 UTC	Algot
RDCP 600	229	x	x	x	120	02.02.2018 12:00 UTC	Stefanie & Nadine

Appendix D: Mooring drawings



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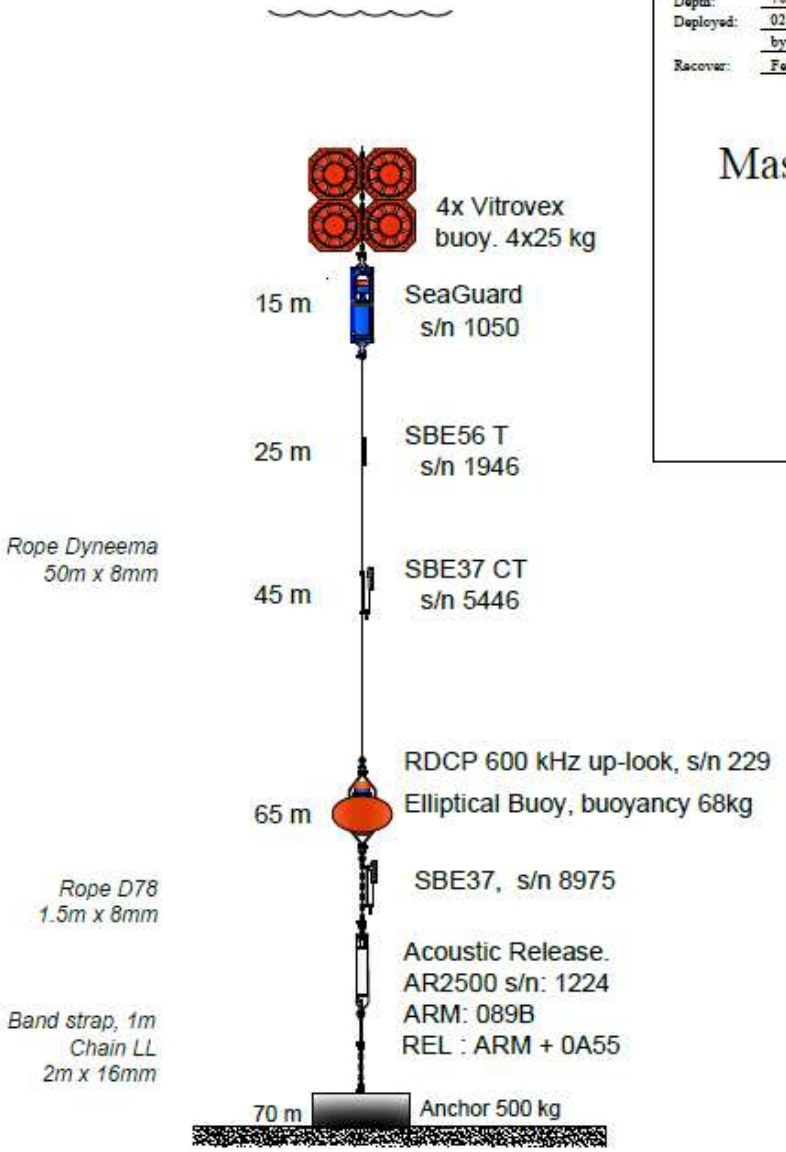
Geofysisk Institutt

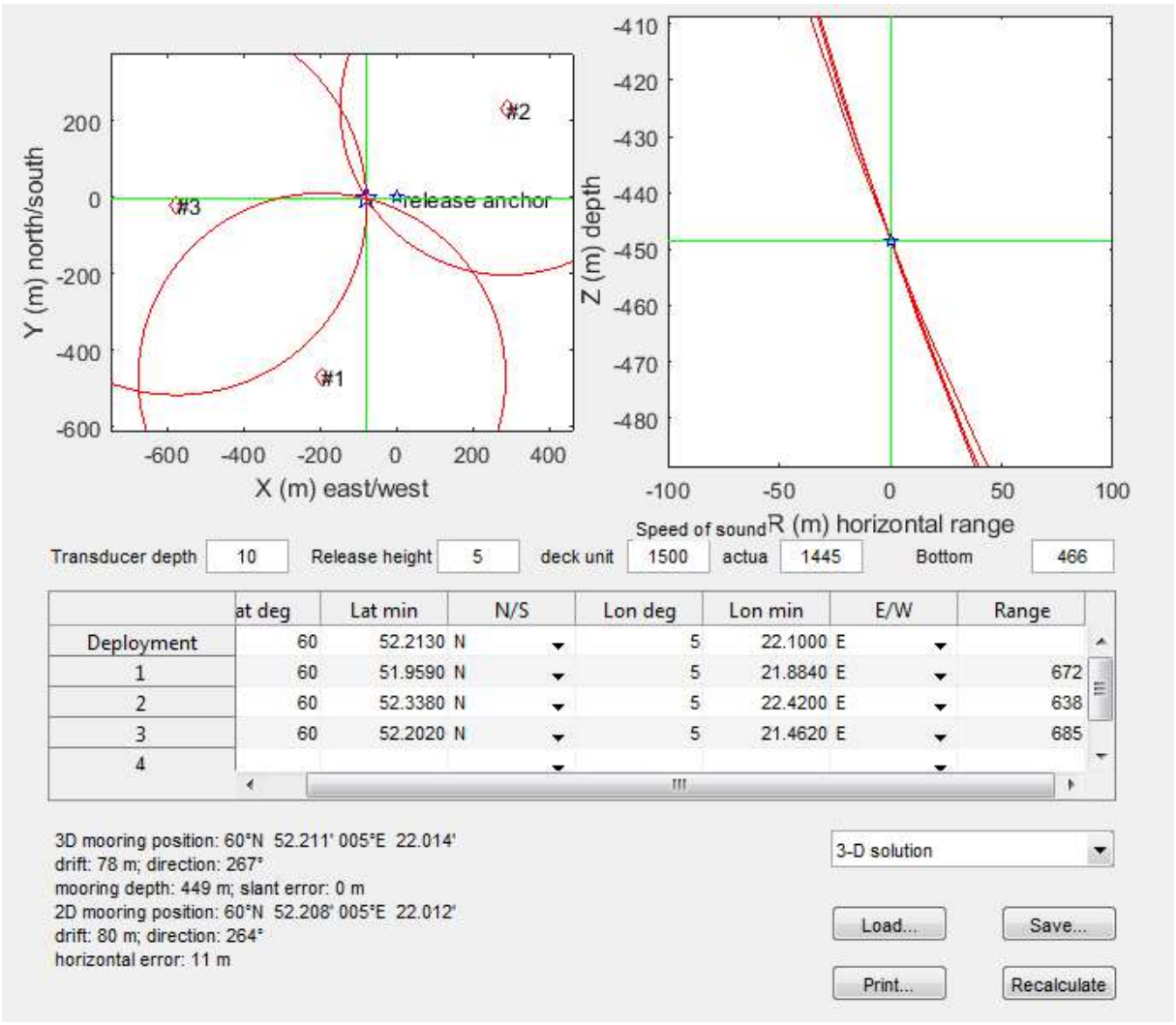
Project:	Undervisningstokt GEOF337
Location:	Masfjorden
Position:	Lat 60° 48.231' N
	Lon 5° 17.875' E
Depth:	70m
Deployed:	02 Feb 2019 13:47 UTC
	by RV Kristine Bonnevie
Recover:	Feb 2019

Masfjorden sill

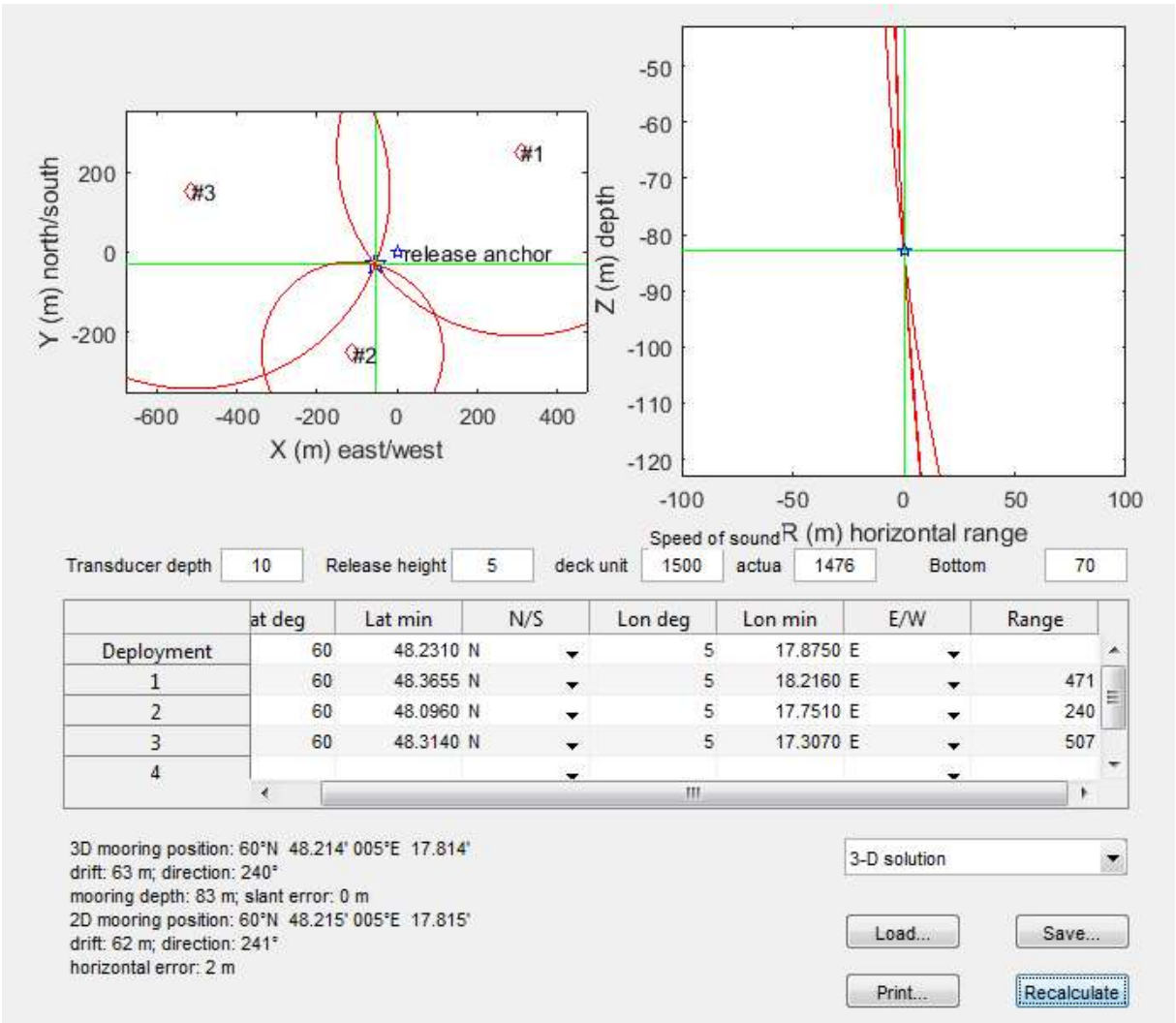


Appendix E: Mooring Triangulation

MF_inner



MF_sill


#1
#3
#2
release anchor
Y (m) north/south
X (m) east/west
Z (m) depth
R (m) horizontal range
Speed of sound
Transducer depth 10
Release height 5
deck unit 1500
actua 1476
Bottom 70
at deg | Lat min | N/S | Lon deg | Lon min | E/W | Range
Deployment 60 48.2310 N 5 17.8750 E
1 60 48.3655 N 5 18.2160 E 471
2 60 48.0960 N 5 17.7510 E 240
3 60 48.3140 N 5 17.3070 E 507
4
3D mooring position: 60°N 48.214' 005°E 17.814'
drift: 63 m; direction: 240°
mooring depth: 83 m; slant error: 0 m
2D mooring position: 60°N 48.215' 005°E 17.815'
drift: 62 m; direction: 241°
horizontal error: 2 m
3-D solution
Load...
Save...
Print...
Recalculate

Appendix F: Bottle information

Station Name	Depth	Niskin bottle	Oxygen	Salinity	CT	Nutrients	HI
			Bottle	Bottle	Bottle	Bottle	Bottle
116	65	1		14			53:1399
117	470	1	10				53:1400
	448	2	11				
	448	3					
	448	4	14				
	350	5	12				
	350	6	16				
	350	7	17				
	350	8	18				
	190	9	13				
	190	10	19				
	190	11					
	190	12					
118	175	1	20				53:1401
	125	2	21				
	100	3	23				
	75	4	25				
	50	5	26				
	30	6	27				
	20	7	28/29				
	10	8	30				
	5	9	31				
119	140	1					53:1402
120	169	1					53:1403
121	181	1					53:1404
122	260	1					53:1405
123	420	1					53:1406
124	225	1					53:1407
125	476	1	32				53:1409
	324	2	33				
	280	3					
	196	4	34				
	124	5	35				
	103	6	05				

	78	7	07	
	54	8	14	
	43	9	08/18	
	28	10	09	
	13	11	16	
	8	12	17	
126	376	1		53:1413
127	405	1		53:1414
128	345	1		53:1415
129	120	1		53:1416
130	290	1		53:1417
131	225	1		53:1418
133	95	1		53:1419
134	198	1		26:1735
135	139	1		26:1736
136	124	1		26:1737
137	301	1		26:1738
138	478	1	25	26:1739
	324	2	19	
	280	3		
	196	4	29	
	124	5	12	
	104	6	27	
	79	7	20	
	54	8	30	
	43	9	31	
	26	10	26	
	13	11	23	
	8	12	28	
139	100	1		26:1742
140	417	1		26:1743
141	656	1	05/07	26:1744
	448	2	08/09	
	382	3	10/11	
	300	4	12/13	
	204	5	14/16	
	153	6	17/18	
	102	7	19/20	
	78	8	21/23	

	51	9	25/26	
	32	10	27/28	
	11	11	29/30	
	7	12	31/32	
142	81	1		26:1747
143	157	1		26:1748
144	272	1		26:1749
145	289	1		26:1750
146	207	1		26:1751
147	347	1		26:1752
148	185	1		26:1753
149	643	1		26:1754
150	671	1		26:1755
151	564	1		83:2032
152	525	1		83:2033
153	538	1		83:2034
154	335	1		83:2035
155	435	1		83:2036
156	299	1	5	83:2037
	250	2	7	
	200	3	8	
	149	4	9	
	106	5	10/11	
	73	6	12	
	57	7	13	
	29	8	14/17	
	19	9	16	
	8	10	18	
	3	11	19	
157	175	1		83:2041
158	139	1		83:2042
159	181	1		83:2043
160	197	1		83:2044
161	273	1	21	161-1
	207	2	23	161-2
	155	3	x	x
	97	4	25	161-4
	76	5	26	161-5
	50	6	27/30	161-6

	29	7	28/31	161-7
	19	8	29/33	161-8
	9.50	9	32/35	161-9
	4	10	34	161-10
162	344	1		83:2045
163	642	1		83:2046
164	181	1		83:2047
165	89	1		83:2048
166	89	1		83:2049
167	566	1		83:2050
168	325	1		83:2051
169	334	1		83:2052
170	95	1		83:2053
171	199	1		83:2054
172	318	1		83:2055
173	655	1		70:1273 / 173-1
	502	2		173-2
	375	3		
	249	4		173-4
	137	5		173-5
	71	6		173-6
	10	7		
174	68	1		70:1274
175	154	1		70:1275
176	291	1	5	70:1276 / 176-1
	147	2	7	176-2
	147	3		
	96	4	8	176-3
	96	5		
	70	6	9/12	176-4
	70	7		
	50	8	10/13	176-5
	50	9		
	5	10	11	176-6
	5	11		
177	75	1		70:1277
178	291	1		70:1278

179	340	1	70:1279
180	275	1	
181	112	1	70:1280

Appendix G: MSS Log sheet

MSS LOG-SHEET

Vessel Kristine Bonnevie
KB 2019

Cruise 602
1-4 Feb

Date 2019

castXXX	Date/UTC			Time/UTC		E. Depth	Latitude/ N		Longitude/ E		Start	End	
	year	mon	dd	hh	min	m	deg	min	deg	min	m	m	
1	2019	2	2	7	50	170	60	52.27	5	33.70	1	136	Removed 2 floating elements before cas
2	2019	2	2	8	6	187	60	52.30	5	33.20	8	170	Removed 1 floating element
3	2019	2	2	8	25	164	60	52.29	5	31.92	8	151	Removed 1 metal ring
4	2019	2	2	8	44	183	60	51.97	5	30.36	8	185	Removed 2 metal rings
5	2019	2	2	9	6	172	60	52.78	5	29.02	8	139	We have in total 9 floating elements (inc
6	2019	2	2	9	28	268	60	52.93	5	28.44	8	273	
7	2019	2	2	10	6	405	60	52.45	5	26.22	9	360	Issues with getting the logging program
8	2019	2	2	10	52	482	60	52.31	5	24.92	8	470	
9	2019	2	2	11	24	465	60	52.44	5	24.65	2	463	
10	2019	2	2	13	15	406	60	51.297	5	21.196	5	108	Strong current, lost connection
11	2019	2	2	13	20	410	60	51.268	5	21.182	1	244	lost connection, changed the blue box
12	2019	2	2	13	53	343	60	50.485	5	21.786	2	322	
13	2019	2	2	14	27	103	60	49.834	5	20.523	1	86	
14	2019	2	2	14	47	297	60	49.46	5	20.52	2	283	
15	2019	2	2	15	12	194	60	48.96	5	19.40	2	181	
16	2019	2	2	15	38	101	60	48.29	5	17.89	2	88	
17	2019	2	2	15	51	205	60	48.19	5	17.71	2	187	
18	2019	2	2	16	18	152	60	47.18	5	16.19	2	143	
19	2019	2	2	16	52	138	60	46.524	5	14.172	2	122	
20	2019	2	2	17	6	322	60	46.242	5	13.639	8	320	Lost connection on the way up.
21	2019	2	2	17	31	650	60	45.924	5	12.897	2	557	The pressure censor stopped recording 500m.
22	2019	2	2	18	5	385	60	45.82	5	12.584	2	367	Lost connection on the way up.
23	2019	2	2	18	57	104	60	45.75	5	12.342	2	94	Lost connection 2 times on way down. T
24	2019	2	3	7	10	205	60	48.24	5	16.55	1	187	Start time series
25	2019	2	3	7	33	98	60	48.29	5	17.90	1	87	
26	2019	2	3	7	52	154	60	48.34	5	19.10	1	138	
27	2019	2	3	8	11	205	60	48.25	5	16.55	1	187	New lap, periods with low fall speed
28	2019	2	3	8	32	108	60	48.312	5	17.869	1	92	
29	2019	2	3	8	45	146	60	48.369	5	19.079	1	132	
30	2019	2	3	9	6	205	60	48.23	5	16.52	1	187	New lap
31	2019	2	3	9	24	97	60	48.33	5	17.96	1	83	
32	2019	2	3	9	38	137	60	48.38	5	19.16	1	123	
33	2019	2	3	9	58	206	60	48.211	5	16.535	1	185	New lap
34	2019	2	3	10	19	105	60	48.30	5	17.89	1	89	
35	2019	2	3	10	42	140	60	48.35	5	19.11	1	134	
36	2019	2	3	11	21	205	60	48.222	5	16.588	1	187	
37	2019	2	3	11	40	97	60	48.297	5	17.837	1	86	
38	2019	2	3	11	58	153	60	48.347	5	19.124	1	135	Programme crashed, started cast over.
39	2019	2	3	12	47	205	60	48.288	5	16.617	1	186	
40	2019	2	3	13	9	101	60	48.305	5	17.830	1	85	
41	2019	2	3	13	30	150	60	48.325	5	19.051	1	136	
42	2019	2	3	13	53	205	60	48.027	5	17.805	1	185	Stopped recording a bit late - stopped at
43	2019	2	3	14	19	90	60	48.284	5	17.786	1	80	
44	2019	2	3	14	43	129	60	48.376	5	19.113	1	114	
45	2019	2	3	15	2	205	60	48.234	5	16.635	1	186	

46	2019	2	3	15	22	84	60	48.268	5	17.787	1	66	
47	2019	2	3	15	38	150	60	48.355	5	19.170	1	141	
48	2019	2	3	16	10	205	60	48.221	5	16.664	1	187	
49	2019	2	3	16	32	108	60	48.323	5	17.883	1	96	
50	2019	2	3	16	45	150	60	48.349	5	19.071	1	133	
51	2019	2	3	17	23	205	60	48.22	5	16.63	1	185	
52	2019	2	3	17	43	99	60	48.28	5	17.88	1	84	
53	2019	2	3	18	13	148	60	48.35	5	19.13	1	132	
54	2019	2	3	18	32	205	60	48.23	5	16.58	1	187	