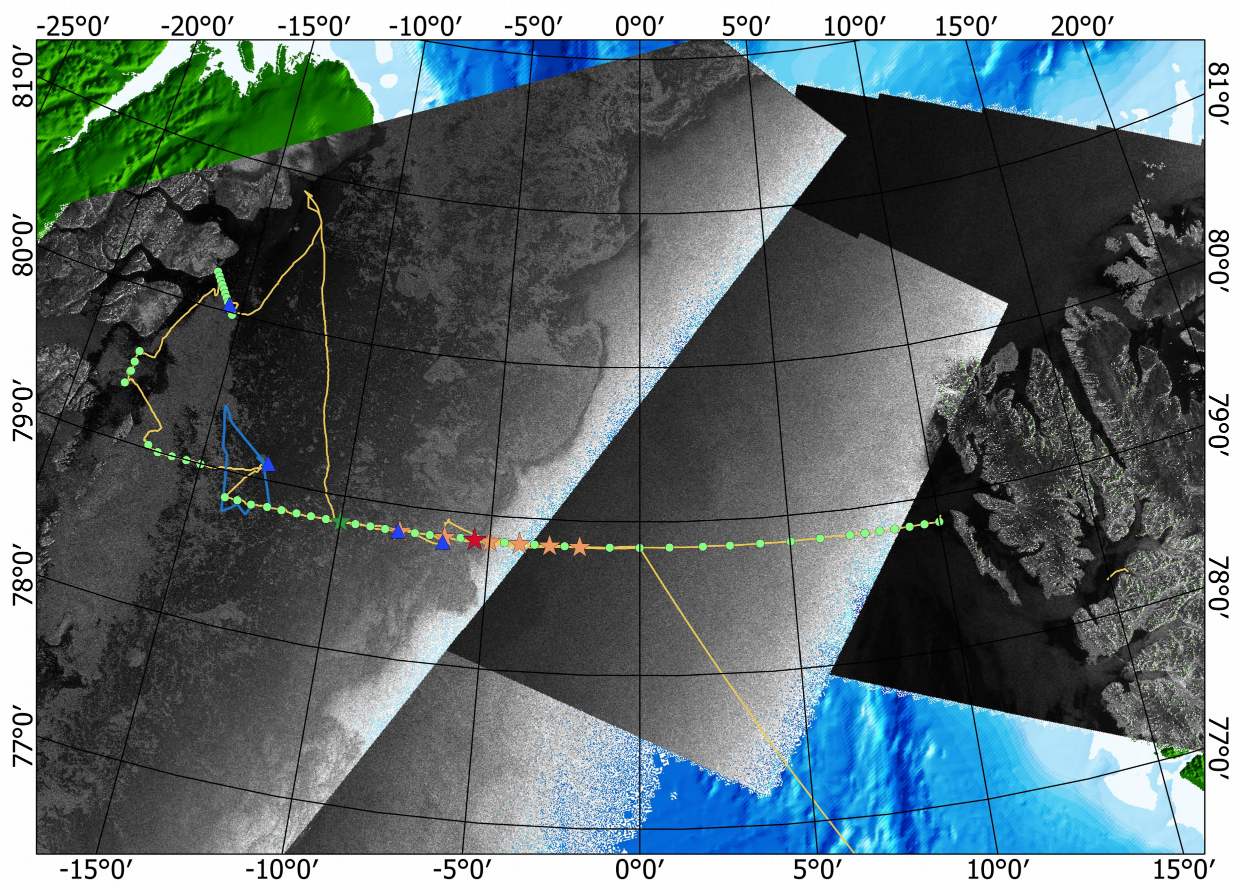
Fram Strait Cruise Report

24 August – 13 September 2020

Cruise no. 2020709



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1. Cruise Overview

The objective of the annual cruise of the Norwegian Polar Institute to Fram Strait is to service the Arctic Outflow Observatory in the western Fram Strait. The purpose of this observing system is to monitor the properties of the Arctic freshwater, sea ice, and returning Atlantic water, as well as the state of ocean acidification, CDOM and nutrients in the East Greenland Current.

The main priority was to recover and redeploy seven NPI moorings across the East Greenland Current at 78°50' N, and to carry out the CTD/LADCP section including extensive water sampling for various tracers across the whole Fram Strait along the 78°50'N line. This time, we could do the main section all the way to the coast of Greenland, however, continued at 79°N as of the Belgica Bank. In addition, one CTD/LADCP section across the Westwind trough on the northwestern part of the east Greenland shelf, was carried out.

Sea ice physics work was carried out across the East Greenland Current and shelf. This included in-situ work on some selected sea ice floes as well as on a very small remaining piece of land-fast ice. In addition, two helicopter flight with EM-bird were carried out. There was again, a limited amount of sea ice in the EGC and on the shelf this year which appears to be continuing trend. It was hard to find sufficient size of floes from which to work on. The land-fast ice region on Belgica bank had again shrunk relative to 2019 and was nearly completely deteriorated in August. There were only two identifiable chunks of land-fast ice left seen on satellite images, and we carried out one sea ice station on it.

Similar to 2018 and 2019, there was a whale research programme deploying satellite transmitters on large whales, mainly bowhead whales, and tracking their movements in the following year, as well as collecting skin biopsies for genetic analyses. These tasks were conducted from a helicopter (Ecureuil 350) based on KPH.

Prioritization and timing of mooring operations, CTDs and flights were guided by sea ice images (Sentinel) send to the ship by the data management group at NPI.

The cruise was challenged by COVID-19 pandemic in the sense that foreign collaborators and non-NPI employees could not attend the cruise. Hence there were fewer participants than originally planned and the workload around CTD water sampling was particularly challenging with the reduced number of people. The 7 planned participants from the (EU) ARICE project NoTAC from DTU Aqua, Denmark, could not partake but partial sampling for that project was carried out by NPI participants. The other change in the cruise was that the cruise had to depart from Tromsø instead of Longyearbyen and hence the transit time to reach the main CTD and mooring section in Fram Strait was longer than usual.

The glider deployment that was planned as part of NorEMSO (NFR infrastructure project) could not be carried out this year due to COVID-19.

2. Participants

Due to COVID-19, there were only NPI employees and Airlift helicopter pilot and engineer allowed on the cruise. There were 18 single cabins available for NPI participants, since there were two extra cabins taken up by IMR personnel (one extra AB, one extra IMR instrument technician).

Organisation
1. Laura de Steur (Cruise leader, mooring coordination)
2. Paul A. Dodd (Cruise deputy, CTD coordination)

Sea ice
3. Dmitry Divine
4. Hiroshi Sumata
5. Anca Cristea

CTD/tracer/water sampling (together with Paul, Tristan and sea ice team:
6. Amalia Keck
7. Amalie Ask
8. Thodoris Karpouzoglou

Optical work:
9. Tristan Petit

Whale research:
10. Christian Lydersen
11. Kit Kovacs
12. Eirik Grønningsæter

Technical Support:
13. Kristen Fossan
14. Marius Bratrein
15. Jan Are Jacobsen

Airlift helicopter crew:
16. Rolf Grindstuen - Helicopter pilot Airlift
17. Luigino Visintini - Helicopter technician Airlift

Initially planned but cancelled: O.A. Misund (NPI director)

3. Sailing log

Monday 24.08.2020	Participants check in on RV Kronprins Haakon between 8-9am in Breivika, Tromsø. Loading, unpacking and installing in to labs and cabins. Departure from Tromsø at 19:30 local time.
Tuesday 25.08.2020	All day steaming toward 0°W, 78°50'N. Use day for presentations of the cruise plan, HMS and risk assessment.
Wednesday 26.08.2020	All day steaming toward 0°W, 78°50'N. Use the day for instrument preparations.
Thursday 27.08.2020	Arrival at first CTD at 0°W at 16:35 local time. Optical cast and a shallow and deep cast for water. Start up problems with sensors, have to change DO sensor and do some tests. Optical cast and CTDs at 1°W, slightly more delayed. Steam to F10.
Friday 28.08.2020	Arrival at F10 at 06:15 local time (04:15 UTC). Open water and only slightly windy conditions. Cloudy but good visibility. Release F10 at 04:33 UTC (takes 35 min before last floats come up to surface). Optical cast and CTD at 2°W, CTD at 2.5°W. Steam to F11 and recover in late afternoon. CTD and optical cast at 3°W. CTD at 3.5°W. Steam to 4.5°W but no CTD taken since too much ice drift due to storm.
Saturday 29.08.2020	Strong winds cause ice drift of 3 knots. All operations postponed until later in the day. Winds weakens late afternoon. Steam back to F12 position and release at 16:45 local time. CTD and optical cast at 4°W, CTD at 4.5°W in the night through moonpool
Sunday 30.08.2020	7:00 am CTD at 6°W (shifted CTD to outside again), takes long time to do 2 casts and optics. Steam back to 5.5°W for F13B. Recovery F13B at 11:15 am. CTD at 5.5°W. Steam to 5°W. Recover F13 followed by CTD in moonpool, no optical cast. Steam to 7°W.
Monday 31.08.2020	Very early am: CTD cast and optical station at 7°W. CTD at 6.5°W and recovery of mooring F14 at 7:15 local time. Sea ice station after breakfast. Freezing fog so no flying weather yet. Recovery of mooring F17 at 14:45 local time, followed by CTDs, optical casts. Continue eve+night on the main CTD section toward 14°W
Tuesday 01.09.2020	Continue all day on the main CTD section toward 14°W. Optical cast every whole degree. Two flights for whales. One flight with EM bird.
Wednesday 02.09.2020	Finish main CTD section at nearly 14°W at 4am. Steam to small remains of land-fast ice at 79°6'N, 12°46'W. Not possible to moor the ship to the ice. Use small boat instead. 2x2 groups on the ice: first 2 groups (EM31+thickness cores and tracer cores) at the time working for ~ 3 hrs, second 2 groups (ADCP and optics) working for ~ 2 hrs on ice. Ready by 17:30 local time. Start steaming in evening to 79°N, 15°W to pick up CTD section there to the west across Norske trough.
Thursday 03.09.2020	Continue CTDs westward on 79°N, 15°W through 17°15'W. Two optical cast2. Section aborted at about 16.8W because of too heavy ice. Veer off to the north to head out to 79.5 glacier and try to pick up AWI 79N2-2 mooring there next morning.

Friday 04.09.2020	Early after midnight, decided to not continue into the bay in front of 79.5N glacier. Too many icebergs, large area of heavy ice melange and not accurate enough charts to navigate around it. Instead plan for 6 CTDs north-south at about 18°W. Only 4 could be carried out until lunch. Head to the northeast for Westwind section. Morning and evening flights for whales. Evening flight is disrupted by engine problems and helicopter had to land on an ice floe. After contacting Airlift mechanic on KPH and diagnosing the problem, they could return to the vessel. Message from land that the flight OA Misund was supposed to have from LYB to Station Nord on Saturday was postponed until Sunday.
Saturday 05.09.2020	Repeat Westwind (1) CTD section with twice as many stations as in 2018. After breakfast, break in CTDs to carry out an ice station. Weather changes from cloudy but excellent visibility to more cloudy and low clouds. Helicopter gets maintenance. Ice station between 10 am and 13:00 local time. Continue with 3 more CTDs on Westwind until latest 20:00. Turn to the northeast to be in Antarctic Bukt in NE Greenland in the morning of Sunday to arrange pick up of Misund who aims to fly to Station Nord on 6 Sept at 9 am.
Sunday 06.09.2020	Very bad visibility, fog when in Antarctic Bukt. Even close to shore, hardly land in sight. Contact ~8:10 am with Misund. Discuss situation. Flight from Longyearbyen is also postponed to later. Contact again at 9 am, 12:45 and 14:10. Finally, it is decided to cancel the operation since it is too risky considering the KPH / Airlift situation: fog, snow, and bad visibility. At 14:15, KPH heads south to go to the main section, target mooring site F20 at ~ 10.5°W. About 20 hrs steaming.
Monday 07.09.2020	Steaming to 78°50'N, 10°10'W. Arrival around 13:00. Check for correct depth, take CTD and deploy F20. Steam to F17. Quite a lot of ice so it goes slow. Flight for whales in evening, afterwards, deploy F17. Sea ice station in late eve using small boat, start around 23:00. After 2 hrs, a quite fast polar bear approach, nearing vessel steadily from 500m, so immediate evacuation around 01:15. Some gear left on floe. Wait until polar bear has left and is far out of sight, then 3pax pick up the left gear on the floe. All back on ship by 02:45. Steam to 7°W where there is a lot of ice, to wait here until morning to do an EM bird flight.
Tuesday 08.09.2020	Both planned flights (EM bird and whales) cancelled in morning due to fog/visibility away from the ship. Steam to F14 and deploy at 09:45 loca time. Steam slightly north to find a floe for a last ice station. Once found and ready to go with 2 groups, the small boat is not in good shape and needs to be fixed. Cooling problem already during last half of last night's ice station. Attempt to fix boat but no spare parts, we start heading to F13. Cancel all further ice work. EM bird and whale flights also cancelled. Deploy F13 at 20:22 local time (in ice floes). Spooling on kevlar for F12. Steam to F12 and wait there most of the night.
Wednesday 09.09.2020	Deploy F12 at 10:20 local time. Open water and substantial waves. Steam to F11. Wind has picked up, more so than forecasted. Too big sea to deploy, postpone until 3pm, 6pm and 8pm, and finally, to the next day 4 am.
Thursday 10.09.2020	4 am: Inspect waves and wind situation, still too much. Postpone to 6 am.

	Calmer seas, start deploying F11 at 6:30. Deployed by 08:30 local time. Likely too deep, since the total amount of kevlar was less than last year. Spooling and prep for F10. Deploy F10 after lunch. Little delayed due to discussion on water depth and kevlar lengths. The current is strong and drags the mooring sideways. Need to give out more wire than we thought would be the correct mooring length. Stay conservative with adding wire since we have an IceCAT here. IceCAT wire cut to 30 m. Hopefully it is at about 25-30 m depth. Deployed by 14:30 local time. Steam to 1°E CTD and continue the main section again here around 18:30 local time.
Friday 11.09.2020	Continue CTDs and optical casts on the main section eastward to Svalbard
Saturday 12.09.2020	Finish CTD section and sampling in early morning. Continue back slightly west and then south to look for whales to tag for the rest of the day until ±10pm. No luck however, and no sufficient flying conditions either. Head to Longyearbyen.
Sunday 13.09.2020	Arrival in LYB around breakfast. Packing, cleaning and offloading.

4. Mooring operations during FS2020

The main Fram Strait Arctic Outflow Observatory moorings F11, F12, F13, F14, and F17 were recovered in good shape. The limited edition of mooring F10 (an attempt to continue this after AWI discontinued it in 2016) and the additional pilot mooring F13B targetted for IceCAT data were also recovered. The moorings F10, F11, F12, F13, F14, and F17 were deployed in the same positions.

Since the mooring F13B has only been limited successful in collecting near-surface T and S data (IceCATs, IM) at 5.5°W, it was decided to move this small (pilot) mooring to the shelf, with the purpose of trying to capture the Greenland shelf jet at about 10°W. This mooring was called F20.

The moorings F20, F17 and F10 were all equipped with IceCATs. Continuation of F10 is made possible through the NorEMSO project, an NFR infrastructure project led by I. Fer (UiB). Due to delayed delivery times related with COVID-19, however, not all intended instrumentation for F10 like pH and pCO2 sensors could be purchased in 2020 and this is postponed to 2021.

4.1 Moorings recovered during FS2020

Mooring	Position	Depth (m)	Date and time (UTC)	Instrument	Serial #	Instrument depth (m)
F10-15	N 78° 49.623' W 01° 57.036'	2663 m (EK80 likely 10 m off, top is 50 m below surface)	Deployed: 13 Sept 2019, 19:34 UTC Recovered: 28 Aug 2020, 04:33 UTC	ADCP	18070 (dir only)	50
				RCM9	1175	52
				SBE37	**7059**	**55**
				RCM7	9464	251
				SBE37	**14099**	**253**
				SBE37	**8226**	**2642**
				Nortek Aquadopp*	930	2645
				AR861	506	2647
F11-21	N 78° 49.121' W 03° 3.072'	2474 m added 10 m kevlar (EK80 likely 10 m off, IPS is just 43 m under surface)	Deployed: 13 Sept 2019, 13:48 UTC Recovered: 28 Aug 2020, 14:32 UTC	**IPS5**	**51062**	**55**
				SBE37	**3492**	**58**
				ADCP	17462	60
				SBE37	**3996**	**276**
				RCM9	1049	273
				SBE37	**7061**	**1540**
				RCM11	538	1542
				SBE37 (re-used)	**8821**	**2442**
				RCM Seaguard	834	2445
				AR861	499	2450
F12-21	N 78° 49.274' W 04° 1.332'	1851 m (EK80 is likely 12 m off, top is ~ 64 m below surface)	Deployed: 12 Sept 2019, 16:31 UTC Recovered: 29 Aug 2020, 14:45 UTC	**IPS5**	**51167**	**53**
				SBE37	**7055**	**55**
				ADCP	20021	60
				SBE37	**3994**	**276**
				RCM9	836	283
				SBE37	**13505**	**1488**
				RCM11	556	1490
				SBE37	**10294**	**1830**
				RCM11	117	1832
				AR861	500	1835

F13-21	N 78° 50.346' W 04° 59.959'	1027 m	Deployed: 11 Sept 2019, 15:33 UTC Recovered: 30 Aug 2020, 13:09 UTC	**IPS** **SBE16** ADCP AURAL **SBE37** **SBE37** RCM9 **SBE37** RCM Seaguard AR861	**51140** **7253** 18151 n/a **3995** **7060** 1326 **13504** 345 743	**50** **58** 50 82 **165** **270** 273 **1018** 1020 1025
F13B-6	N 78° 50.213' W 05° 30.149'	534 m	Deployed: 11 Sept 2019, 09:40 UTC Recovered: 30 Aug 2020, 09:22 UTC	**SBE37-IM weak link** RCM Seaguard ICEBOX **SBE37** **SBE37** AR661	**21029** 883 n/a **9853** **9852** 410	**Not at 25, but 50m....!** 50 58 **60** **102** 520
F14-21	N 78° 48.884' W 06° 30.001'	269	Deployed: 10 Sept 2019, 14:34 UTC Recovered: 31 Aug 2020, 04:48 UTC	**IPS** **SBE37** ADCP **SBE37 (re-used)** **SBE56** **SBE37** RCM9 AR861	**51138** **7058** 17461 7054 **3943** **7057** 1325 568	**58** **62** 65 **106** **209** **259** 261 265
F17-16	N 78° 50.180' W 08° 4.798'	225	Deployed: 10 Sept 2019, 07:06 UTC Recovered: 31 Aug 2020, 12:45 UTC	**SBE37-IM weak link** **SBE16** **SBE37** ADCP **SBE16** **SBE56** **SBE37 (re-used)** AR661	**21024** **7212** **13525** 24518 **7339** **3942** **14098** 501	**30** **55** **75** 105 **108** **190** **213** 218

Table: *Moorings recovered during FS2020*
(Full SN of Nortek Aquadopp: 42836-1-930)*

Notes:

SBE37 that were redeployed in 2019 without factory calibration:
--> Redeployed SN 14098 (from F14-20) on F17-16
--> Redeployed SN 7054 (from F12-20) on F14-21
--> Redeployed SN 8821 (from F11-20) on F11-21

in 2019, calibration cast on CTD down to 1820m were done for:
--> SN 8227 (F10 bottom)
--> SN 8821 (F11 bottom)
--> SN 8822 (F12 bottom)

in 2020, first data processing shows a drift of the bottom Microcats at F10 and F11.
We did a calibration CTD # 57 with them at 4°W with three 5-minute stops at bottom, 1500m and 1000m.
--> SN 8226 (F10 bottom)
--> SN 8821 (F11 bottom)

in 2020, a cross-calibration CTD cast # 82 was done with the two recovered SBE16 SeaCATs from F17 and the two RBR+CDOM to be deployed, with three 5-minute stops at bottom, 100m and 75m.

Instrument notes, failures/early stop:

- F13B-6: IceCAT was recovered. It was deployed too deep at ~ 50m. Full year data.
- F17-21: IceCAT was lost. It was deployed at ~ 20 m. Data until ~ Dec. 2019
- SBE37 SN 3492 on F11, 39 m, stopped in Oct. 2019
- RCM SN 117 on F12, bottom, stopped early Nov. 2019.

Mooring depths based on recovery of instruments:

1. F10 top Microcat was at ~ 62 m (instead of target 55 m) = acceptable.
2. F11 top Microcat was at ~39 m (instead of target 58 m) = is 20 m too shallow.
3. F13B top IceCAT was at 50 m (instead of target 25 m) = 25 m too deep.

4.2 Moorings deployed during FS2020

Mooring	Position	Depth (m)	Date and time (UTC)	Instrument	Serial #	Instrument depth (m)
F10-16	N 78° 49.624' W 01° 57.041'	2666 m	Deployed: 10 Sept 2020, 12:32 UTC	**SBE37-IM weak link** ADCP AQD* **RBR +ODO** **SBE37** AQD* **SBE37** AQD* AR861	**22258** 16831 665 **205002** **20789** 666 **22261** 667 2879	**30** 57 58 **59** **254** 257 **2645** 2650 2653
F11-22	N 78° 49.121' W 03° 03.065'	2474 m (instru-ments at 60 / 270m likely deeper..)	Deployed: 9 Sept 2020, 06:35 UTC	**IPS5** **SBE37** ADCP **SBE37** RCM9 **SBE37** RCM11 **SBE37** RCM8 AR861	**51062** **3490** 24830 **4702** 1324 **3552** 494 **8227** 10071 287	**55** **58** 60 **270** 273 **1496** 1500 **2452** 2455 2460
F12-22	N 78°49.116' W 04° 01.294'	1848 m (EK80 depth about 17 m too much?)	Deployed: 9 Sept 2020, 08:22 UTC	**IPS5** **SBE37** ADCP **SBE37** **SBE37** RCM Seaguard **SBE37** RCM11 **SBE37** RCM11 AR861	**51167** **3489** 16876 **14100** **4837** 884 **3554** 556 **8822** 228 182	**52** **54** 65 **114** **264** 267 **1471** 1474 **1814** 1817 1820

F13-22	N 78° 50.346' W 04° 59.959'	1026 m	Deployed: 8 Sept 2020; 18:22 UTC	**IPS** **SBE37** ADCP AURAL **SBE37** **SBE37** **SBE37** RCM9 **SBE37** RCM11 AR861	**51140** **7056** 18151 n/a **12234** **12232** **3993** 1327 **3551** 561 053	**50** **52** 56 81 **104** **154** **255** 258 **1008** 1012 1015
F14-22	N 78° 48.848' W 06° 30.130'	270	Deployed: 8 Sept 2020, 07:49 UTC	**IPS** **SBE37** ADCP **SBE37** **SBE56** **SBE56** **SBE37** RCM9 AR861	**51138** **14097** 24518 **13253** **10330** **10331** **3992** 1046 409	**50** **54** **58** **99** **203** **228** **253** 257 265
F17-17	N 78° 50.185' W 08° 4.845'	224	Deployed: 7 Sept 2020, 20:45 UTC	**SBE37-IM weak link** **RBR CDOM** **SBE37** ADCP **RBR CDOM** **SBE56** **SBE56** **SBE37** RCM7 AR661	**22260** **204799** **13525** 24385 **204800** **3942** **3943** **9650** 12733 1424	**25** **56** **96** 107 **109** **170** **196** **216** 218 219
F20-1	N 78° 50.100' W 10° 08.814'	326	Deployed: 7 Sept 2020, 12:47 UTC	**SBE37-IM weak link** **SBE37** ADCP **SBE37** RCM7 AR661	**21029** **12233** 727 **10295** 7718 291	**25** **51** 102 **106** 314 316

***Table:** Moorings deployed during FS2020*
AQD - Nortek Aquadopp*

Notes:

! IceCAT deployed on F20-1 was recovered from F13B-5 during FS2020
! New IceCATS on F17-17 and F10-16
! Struggle with kevlar lengths, mooring lengths, target depths of upper instruments and target bottom depths for F11-22 and F10-16. Kevlar lengths changes each year and sometimes pieces are added or removed; compare the exact lengths, and compare the target depths with actual measured depths from recovered Microcats.
! One IM SBE37 was left in Tromsø. Keep this one for 2021.

Cross-calibration:

! A cross-calibration CTD cast was taken on CTD # 82 with recovered Seacats SBE16 SN 7212 and SN 7339 from F17-16 together with the RBR CTD+ CDOM instruments that were deployed on F17-17.

Funding:

- F10-16 financed by NorEMSO funding (NFR infrastructure). This covered the F10 instruments SBE37, RDI ACDP, Nortek Aquadopp, RBR CTD+ ODO, and IceCAT + data logger. In 2021, pCO2 and pH sensors will be added.
- Two IceCATs on F20-1 and F17-17 funded by FreshARC (NFR FRINATEK).
- Two RBR CTD+ CDOM instruments for F17 were financed by the Polar Ocean Program, NPI.

4.3 ADCP calibrations FS2020

- 5 ADCPs calibrated in Tromsø (17/6/2020)
- 2 ADCPs calibrated on ice land-fast ice 79°06'N, 12°46'W (FS2020, 2/9/2020)

Two ACDPs were left with a relatively large compass error of 7.6°. Lookup tables of true heading vs ADCP heading were created with the rotating table compass calibration and should be used for a correction of the direction measured by these two ACDPs (on F14 and F10) in the data processing after recovery.

Deployment plan:

F20 @ 100m	**F17** @ 100m	**F14**	**F13**	**F12**	**F11**	**F10**
Calibrated in Tromsø	Calibrated in Tromsø	Calibrated on ice (2/9)	Calibrated on ice (2/9)	Calibrated in Tromsø	Calibrated in Tromsø	Calibrated in Tromsø
Error after cal: 1.1	Error after cal: 2.9°	Error after cal: 7.6°	Error after cal: 0.6°	Error after cal: 1.5°	Error after cal: 5.4°	Error after cal: 7.6°
Alkaline	Lithium	Lithium	3x alkaline	Lithium	Lithium	Lithium
N/A	ICE track	BTM track	BTM track	ICE track	BTM track	ICE track
SN 727	SN 24385	SN 24518	SN 18151	SN 16876	SN 24830	SN 16831

5. CTD Measurements

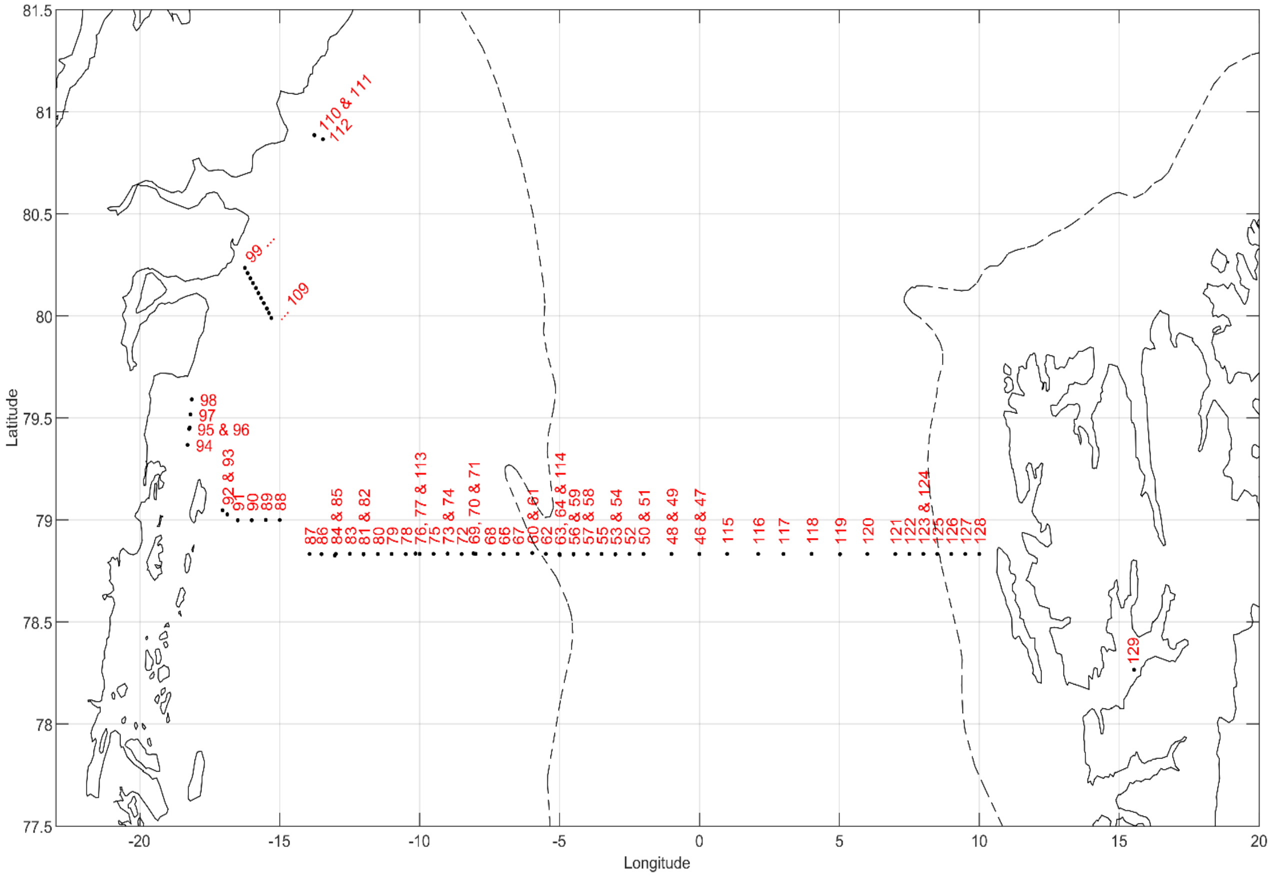


Figure 5.1. CTD stations completed during FS2020. Where two stations occur at the same location, the number of the second station is offset for readability.

5.1 General Approach

The CTD used was an SBE911+ unit. The T, S and O_2 ducts were flushed with Triton-X and freshwater between stations, which was blown out by mouth just before deployment, to avoid problems with icing. At the beginning of stations, the CTD was lowered to 10 dbar and allowed to soak until the pump started and sensors stabilised. The CTD was then brought to the surface and then lowered to within 10 m of seabed as determined using the altimeter. Data acquisition was generally initiated just before deployment with the CTD on deck and allowed to run until the CTD was back on deck at the end of the cast.

Where possible the CTD was lowered over the side of the ship in the conventional way. Due to dense ice along the Westwind section the CTD was lowered though a moon pool. The lower aperture of the moon pool was 10 m below the surface, so the upper 10 m of these profiles describes water trapped in the moon pool rather than the natural environment. Niskin bottles were closed using the bottle fire command within the Sea-Bird acquisition software so that a .bl file was created for each deployment when bottles were fired. NMEA time and position information was fed to the acquisition computer and added to each scan line of the data files. Cast positions and starting times were also automatically added to the header of all data files.

Note that the first station completed during Fram Strait 2020 has the number 046 and not 001. The vessel operators specify numbers assigned to CTD stations. The first cast each year has the number 1 and subsequently casts are numbered sequentially.

5.2 CTD Package Configuration

Channel	Sensor	Serial Number	Last Calibration
Frequency	Temperature 1	4535	20-Feb-2020
Frequency	Conductivity 1	4386	28-Jan-20
Frequency	Pressure	141612	19-Dec-17
Frequency	Temperature 2	4306	28-Jan-20
Frequency	Conductivity 2	2799	28-Jan-20
A/D Voltage 0	SBE43 Oxygen 1*	3115	03-Dec-19
A/D Voltage 1	Altimeter	73084	24-Dec-2017
A/D Voltage 2	SBE43 Oxygen 2*	3483	30-Aug-19
A/D Voltage 3	(FREE)	N/A	25-Jul-2019
A/D Voltage 4	Transmissometer	CST-2003DR	01-Oct-2019
A/D Voltage 5	Chl. Fluorometer	FLRTD-1547	01-Apr-2016
A/D Voltage 6	(PAR)	70736	29-Oct-2018
A/D Voltage 7	(CDOM Fluorometer)	FLCDRTD-1930	25-Jul-2019

*Table 5.1: CTD package configuration during FS2020. CDOM fluorometer FLRCTD1930 has an internal gain setting (AsV) which can be varied between 1, 2 and 4. AsV was set to 1 during FS2020 (maximum gain, smallest range). On Fram Strait cruises before 2019 the AsV was probably set to 2. *A freezing accident occurred at station 87 when the CTD was deployed with the ducts full of fresh water. The primary and secondary oxygen sensors were both affected by this event and did not provide reliable data for subsequent stations. No reliable replacement oxygen sensors were available.*

5.3 CTD Sections

Open drift ice conditions on the East Greenland Shelf allowed the vessel to move along two sections and to complete a few stations in front of the 79N Glacier during the cruise (Figure 5.1). Station times and the types of samples collected are summarized in Table 5.3:

- Main Fram Strait Section (Figure 5.2): An east-west section along the Fram Strait mooring array line at 78º 50 N, which is repeated annually. During Fram Strait 2020, stations were completed between 010°E and 014°W. Station spacing was 20 km for most of the section and 10 km in the cores of the inflow and outflow and over the East Greenland Shelf.

- Westwind Trough Section (Figure 5.3): A high-resolution section across the Westwind Trough on the East Greenland continental shelf. Due to heavy ice moving in rapidly from the south and time constraints, the section was aborted about halfway across the trough.

5.4 Salinity Sensor Validation

Water samples for laboratory salinity measurement were collected along the main Fram Strait stations and at selected stations along the Îsle de France section. At stations where tracer samples were collected, salinity samples were collected at standard depths of 1, 5, 15, 25, 50, 75, 100, 150, 200, 250 and 400 dbar, plus one sample from the bottom of the water column.
Salinity samples were analysed on broad using Guildline Portasal portable salinometer (serial number 70177), which was standardised after every 24 measurements using IAPSO P-series standard seawater from batch 163.

Comparison of laboratory salinity measurements and CTD-salinity measurements revealed an offsets of -0.002 practical salinity units for the primary and -0.004 for the secondary sensor groups (Figure X.4). During this cruise the histogram of CTD offsets was not normally distributed, but exhibited a long tail on the negative side of the peak. The mean and median offsets are therefore slightly different here we focus on the median values. The median difference between both the primary and secondary sensor group and the laboratory measurements was, similar to the precision of laboratory salinity measurements (+/- 0.003) so no correction is made here.

Moreover, as the difference between the mean and median offsets (ca 0.002) is insignificant relative to the CTD and salinometer precision the shape of the distribution is not investigated further here. However, this it is noted as indicative of a potential problem, as in all previous Fram Strait cruises these histograms have been normally distributed

Both sets of CTD sensors performed fairly during the cruise. The offsets determined relative to the laboratory salinity measurements and fair agreement between primary and secondary senor groups reflects the relatively long interval since calibration of the conductivity sensors. Freshly calibrated primary and secondary sensor sets deployed during the 2017 Fram Strait cruise showed much smaller mean offsets of +0.0007 and +0.0008 practical salinity units. Sensors deployed during the 2020 Fram Strait cruise, which had been used for some time without calibration showed larger offsets, and are approaching the level where post-calibration would be necessary.

5.5 Dissolved Oxygen Sensor Validation

Profiles of water samples for laboratory oxygen measurement were collected at selected stations along the main section. Samples were collected in triplicate in volume-calibrated glass bottles, with an angled glass stopper. A silicon tube was attached to the spigots of the Niskin bottles and inserted to the bottom of the sampling bottles, which were filled slowly to minimise exposure to the atmosphere. Winkler re-agents 1 and 2 were added to the samples immediately after sampling and samples were then stored under water, and allowed to reach room temperature to allow volumetric consistency with reagents added during analysis.

Analysis followed standard protocol using a Metrohm Ti-Touch potentiometric titrator, with a 2 ml dosing unit filled with 0.1M thiosulphate. Samples were run in 7 batches of 3 to 30 samples. Sets of 4 blanks were run before and after each batch of samples and 4 measurements of an internal iodate standard (0.01M, prepared at NPI in Tromsø on 19-June-2019) were run before each batch of samples.

Comparison of laboratory oxygen measurements and CTD-oxygen measurements revealed an offset of -23 umol l^{-1} for the primary sensor and an offset of -19 umol l^{-1} for the secondary sensor (Figure 5.4). The sensors had not been serviced / calibrated for more than 8 months before the cruise and this may be the reason for the large difference with laboratory measurements and the abnormal shape of the sensor/laboratory histograms. The CTD was flushed with freshwater between casts – a risky practise when deploying the CTD into freezing water – at station 87 the CTD technicians forgot to empty the CTD of freshwater before deployment. Both oxygen sensors were damaged by the resulting freezing incident. No further oxygen measurements could be collected due to a lack of space sensors.

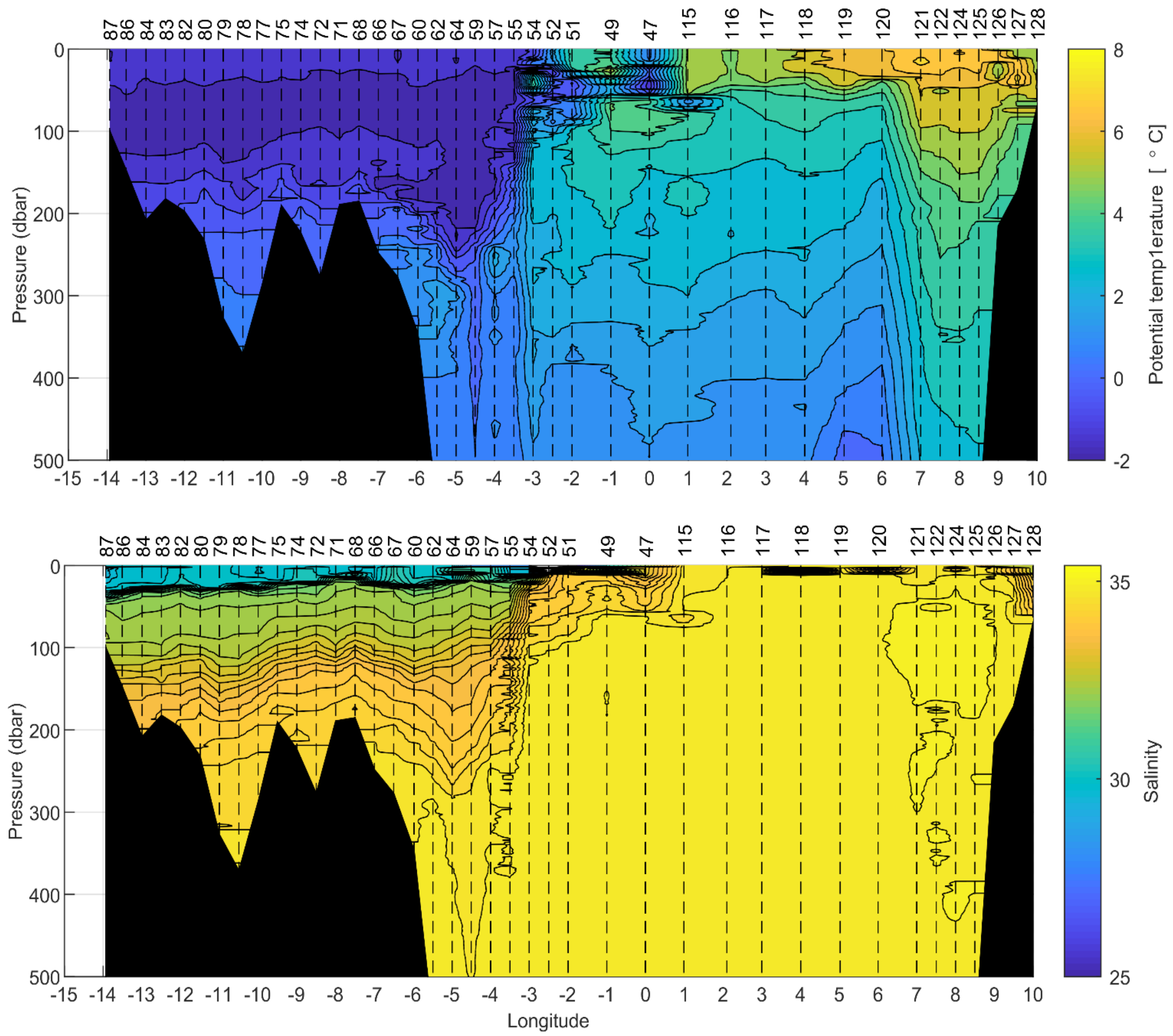


Figure 5.2: CTD measurements along the main Fram Strait section; Measurements from the primary temperature (top panel) and salinity (bottom panel) sensors. Station numbers are indicated above sections.

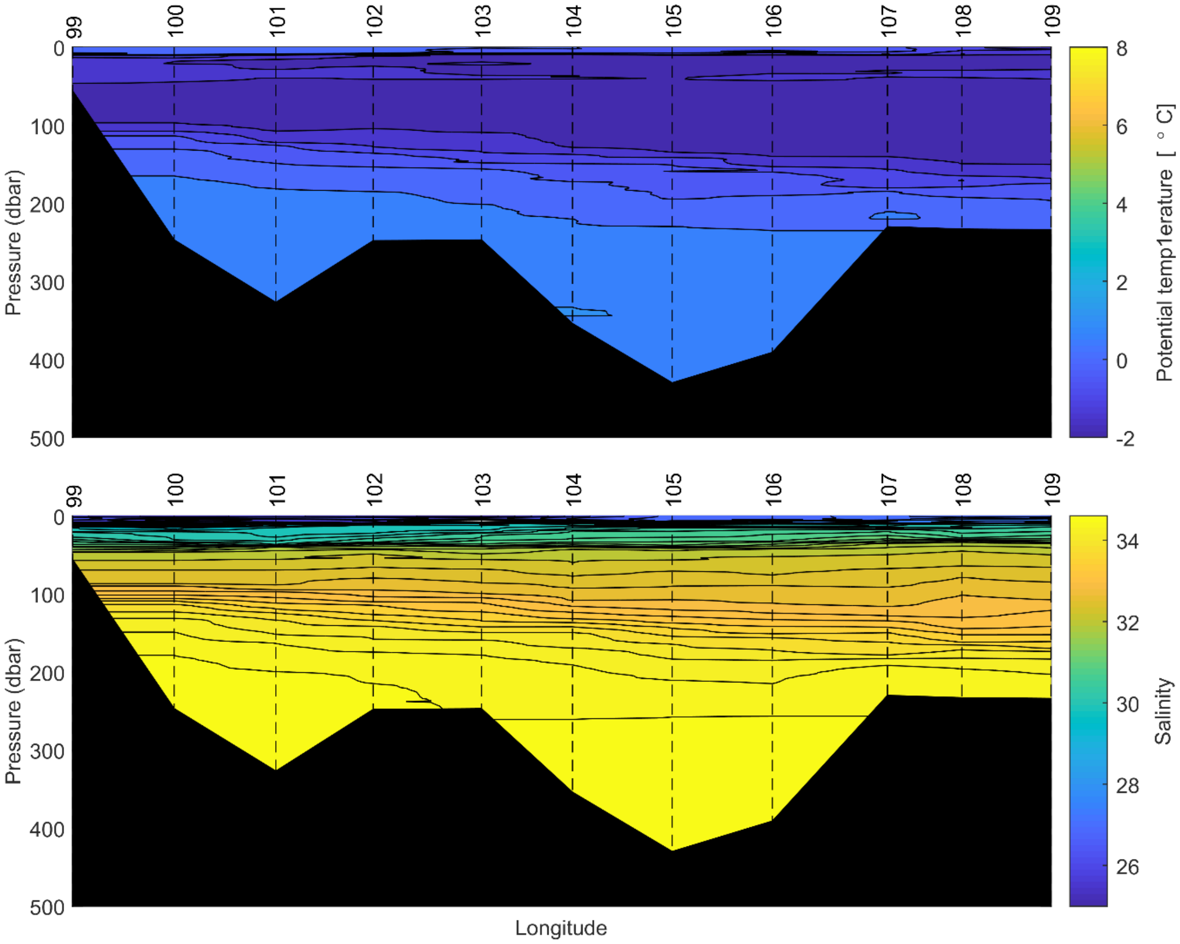


Figure 5.3: CTD measurements along the Westwind section; Measurements from the primary temperature (top panel) and salinity (bottom panel) sensors. Station numbers are indicated above sections.

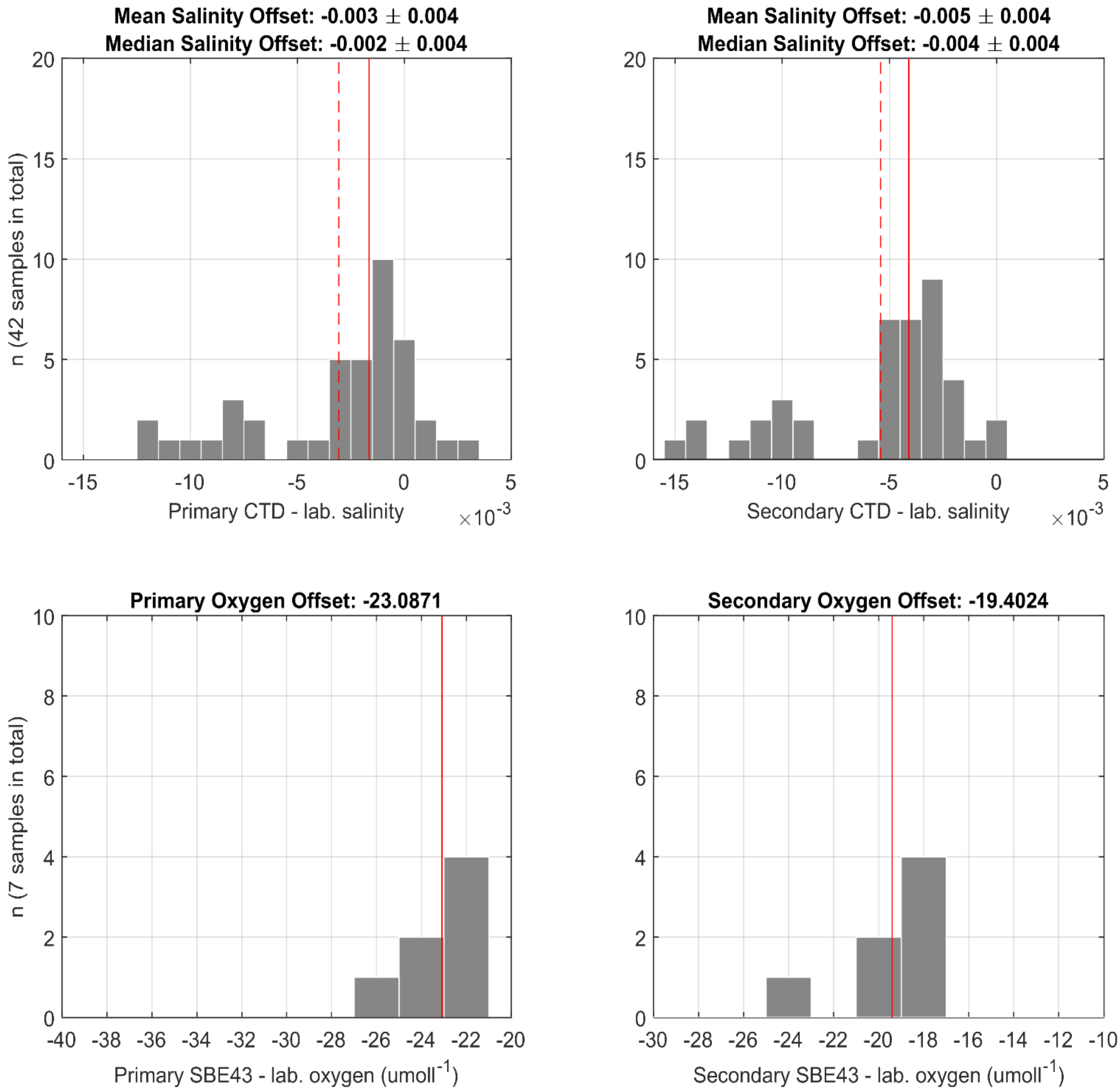


Figure 5.4: Histograms showing the difference between the primary (left hand panels) and secondary (right hand panels) sensor groups on the CTD and laboratory salinity and dissolved oxygen measurements. Only points deeper than 400 m are considered for salinity validation, due to step salinity gradients close to the surface.

6. Biogeochemical Program

Table 6.2 lists sample types that were collected from Niskin bottles and melted sea ice cores. Samples marked with an asterisk were analysed onboard, other samples will be analysed ashore.

Sample type	**Description**
Laboratory Salinity*	Used to validate and (if necessary) calibrate conductivity sensors on the CTD. Required to obtain representative salinity values for Niskin bottles closed in steep salinity gradients, where CTD salinity values are unsuitable.
Dissolved Oxygen*	Used to validate and (if necessary) calibrate dissolved oxygen sensors on the CTD. Dissolved oxygen is a basic parameter, which can be used to estimate water mass ages, interpret how non-conservative parameters have been affected by biological interactions and to trace Pacific water in combination with dissolved nitrate measurements.
Dissolved Inorganic Carbon (DIC) & Total Alkalinity (A_T)	Used to investigate the carbonate system, including estimation of carbon fluxes and monitoring of the ocean acidification state.
Dissolved Organic Carbon (DOC)	Used to investigate the carbonate system, including estimation of carbon fluxes.
Nitrate, Nitrite, Phosphate & Silicate	Used to investigate nutrient cycling in Arctic Ocean, to trace Pacific Water NB: On this cruise Nutrient samples were filtered though a GF/F XXX filter prior to freezing.
Coloured Dissolved Organic Matter (CDOM)	Used to trace fresh water masses in the Arctic Ocean, to investigate the optical properties of the water column and to help interpret carbonate system measurements. CDOM samples are used to calibrate the CDOM fluorometer on the CTD, which measures continuous profiles of CDOM, which responds to a single excitation wavelength.
Stable Nitrogen & Silicon Isotopes	Used to map the isoscape in Fram Strait – the isoscape is used to interpret isotope ratio measurements in organisms from the perspective of describing food webs. Also used to validate nutrient and nutrient-oxygen ratios employed to trace Pacific and Shelf waters, which are affected by nitrifying and de-nitrifying organisms.
Stable Oxygen Isotopes ($\delta^{18}O$)	Used to separate sea ice meltwater from river input & precipitation. Combined with CDOM and/or total alkalinity measurements $\delta^{18}O$ is also be used to identify freshwater from precipitation.
^{129}I	Used to trace Atlantic-derived water masses circulating in the Arctic Ocean basin. Also used to study the fate of anthropogenic radionuclides released by fuel reprocessing.
^{236}U	Combined with ^{129}I, ^{236}U provides more information about the age and pathways followed by Atlantic-derived water masses.
Nitrous Oxide (N_2O)	TBC

Table 6.2 – Parameters measured from water samples collected during FS2020

6.1 Samples collected from the water column

Table 6.3 lists the water samples collected at each CTD station. During the cruise a paper log sheet was completed at each CTD station listing the depths at which bottles were fired and the samples taken from each bottle. Times, depths and positions manually recorded on log sheets are indented as a backup in the case of a problem with the data acquisition, not a replacement for electronically logged time and position data. There were no problems with time or position data during the cruise.

Station	Salinity	Winkler	CDOM + FDOM	D18O + Nutrients	AT CT	d15N	129I	233U	N20
46	-	-	-	-	-	-	-	14	-
47	19	7	12	12	12	-	8	6	12
48	-	-	-	-	-	-	-	14	-
49	16	-	12	12	12	-	8	6	-
50	-	-	-	-	-	-	-	14	-
51	12	-	12	12	12	12	8	12	-
52	16	-	16	16	-	-	-	-	-
53	-	-	-	-	-	-	-	14	-
54	15	-	-	12	12	12	8	12	10
55	-	6	-	12	-	-	-	-	-
56	-	-	-	-	-	-	-	-	-
57	12	8	12	12	12	12	8	12	-
58	-	-	-	-	-	-	-	12	-
59	12	-	10	-	-	-	-	-	-
60	11	-	11	11	11	11	8	3	-
61	-	-	-	-	-	-	-	14	-
62	12	-	12	12	-	-	-	-	12
63	-	-	-	-	-	-	-	14	-
64	10	-	10	10	10	10	7	6	-
65	-	-	-	-	-	-	-	14	-
66	10	-	10	10	10	10	7	3	-
67	11	-	11	11	-	-	-	-	-
68	-	-	-	-	-	-	-	-	-
69	-	-	-	-	-	-	-	-	-
70	-	-	-	-	-	-	-	21	-
71	9	-	9	9	9	9	6	-	-
72	-	-	-	-	-	-	-	-	-
73	-	-	-	-	-	-	-	24	-
74	10	-	10	10	10	10	7	-	-
75	-	-	-	-	-	-	-	-	-
76	-	-	-	-	-	-	-	21	-
77	11	-	11	11	11	11	7	3	-
78	-	-	-	-	-	-	-	-	-
79	11	-	11	11	11	11	8	-	-
80	-	-	-	-	-	-	-	-	-
81	-	-	-	-	-	-	-	21	-
82	9	-	9	9	9	9	7	-	-
83	-	-	-	-	-	-	-	-	-
84	-	-	-	-	-	-	-	18	-
85	9	-	9	9	9	-	-	3	-

86	-	-	-	-	-	-	-	-	-
87	7	-	7	7	7	7	-	-	-
88	-	-	-	-	-	-	-	-	-
89	-	-	-	-	-	-	-	-	-
90	-	-	-	-	-	-	-	-	-
91	-	-	-	-	-	-	-	-	-
92	10	-	10	10	10	10	-	-	-
93	-	-	-	-	-	-	-	-	-
94	-	-	-	-	-	-	-	-	-
95	-	-	-	-	-	-	-	-	-
96	10	-	10	10	10	-	-	-	-
97	10	-	10	10	10	-	-	-	-
98	10	-	10	10	10	-	-	-	-
99	-	-	-	-	-	-	-	-	-
100	-	-	-	-	-	-	-	-	-
101	-	-	-	-	-	-	-	-	-
102	-	-	-	-	-	-	-	-	-
103	-	-	-	-	-	-	-	-	-
104	-	-	-	-	-	-	-	-	-
105	-	-	-	-	-	-	-	-	-
206	-	-	-	-	-	-	-	-	-
207	-	-	-	-	-	-	-	-	-
108	-	-	-	-	-	-	-	-	-
109	-	-	-	-	-	-	-	-	-
110	5	-	6	6	-	-	-	-	-
111	-	-	-	-	-	-	-	-	-
112	-	-	-	-	-	-	-	-	-
113	-	-	-	-	-	-	-	-	-
114	-	-	-	-	-	-	-	-	-
115	21	-	12	12	12	-	-	-	-
116	21	-	12	12	12	-	8	-	-
117	21	-	12	12	-	-	-	-	-
118	21	-	12	12	12	-	-	-	-
119	18	-	12	12	-	-	-	-	-
120	17	-	11	11	11	-	-	-	-
121	16	-	12	12	12	12	6	-	12
122	12	-	12	12	-	-	-	-	-
123	-	-	-	-	-	-	-	21	-
124	12	-	12	12	12	12	8	3	12
125	12	-	12	12	-	-	-	-	-
126	9	-	9	9	9	-	-	-	-
127	9	-	9	9	-	-	-	-	-
128	6	-	6	6	6	-	-	-	-
129	-	-	-	-	-	-	-	-	-

Table 6.3 Number of each type of water sample collected at each CTD station. N.B. Samples taken in duplicate/triplicate from the same depth are counted as one sample.

6.2 Samples collected from melted sea ice cores

Sea ice cores for biogeochemical analysis were collected from sea ice at the locations shown in Figure 6.5. Whole cores were melted onboard in a single container and meltwater samples were collected for the following analyses:

! Laboratory Salinity
! Stable Oxygen Isotopes ($\delta^{18}O$)
! Nitrate, Nitrite, Phosphate & Silicate
! Coloured Dissolved Organic Matter (CDOM)
! Total Alkalinity (A_T)

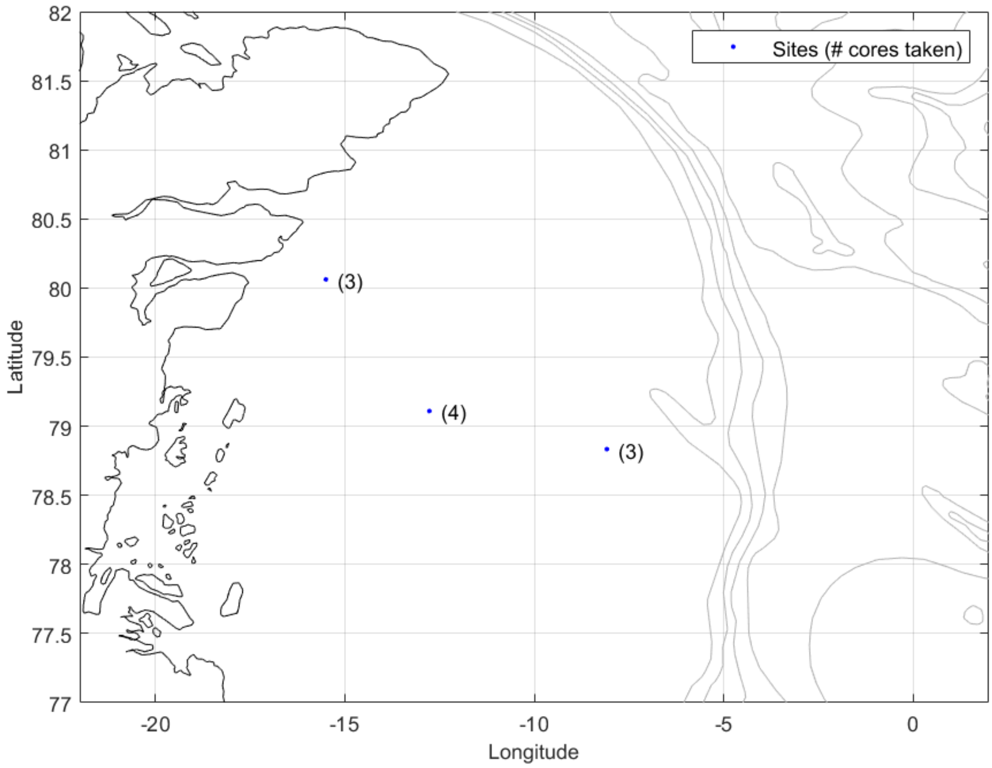


Figure 6.5 Locations where sea ice cores were collected for biogeochmical sampling.

7. VMADCP and LADCP measurements

During the cruise, both hull-mounted Vessel Mounted Acoustic Doppler Current Profilers (VMADCP) (38 kHz and 150 kHz) were used on the main transect across the Fram Strait to provide continuous measurements of ocean velocity. This meant it was turned when reaching the Prime Meridian at 78°50'N and stopped when reaching Isfjorden on Svalbard. It was decided to not use the drop-keel VMADCPs as the sampling would be interrupted too much when meeting sea ice implying that they would need to be stopped and lifted into the hull.

Lowered Acoustic Doppler Current Profiler (LADCP) data were collected at all CTD stations. The set up consisted of a double-head LADCP system (one downward looking (master) and one upward looking (slave) ADCP) with external battery case on the large, 24-bottle CTD rosette. The data were processed using the LDEO processing package (Version IX.7 – IX.10) and detided with the barotropic tidal model (TMD2.03/DATA/Model_tpxo6.2). The script files to program and start the LADCP are given in Appendix C.

8. Optics

8.1 General

The main goal of the optics work was to collect Inherent Optical Properties (IOP) of the sea water and track their variability as function of depth and location. Two main IOPs are the absorption and scattering properties of the particulate and dissolved materials present in the water. IOPs are, by definition, independent of the characteristics of the light field occurring at time of data collection (as opposed to Apparent Optical Properties like downwelling irradiance). They can thus be used as proxies of several biophysical properties of the sea water. In the western part of the Fram Strait, the amount of Coloured Dissolved Organic Matter (CDOM) is used to track the Arctic-like water leaving the Arctic with the East Greenland Current. In the eastern part of the strait, IOPs related to particles give information about the algal biomass linked to the warmer and nutrients-richer Atlantic water. This work was conducted in part to provide similar observations supposed to be conducted by the ARICE project (EU) that could not be onboard due to COVID-19. The work was carried out by Tristan Petit (NPI).

8.2 Data collection

First part of the measurements was conducted in-situ thanks to an optics cast deployed most of the time from the side of the ship for performing high-resolution vertical profiles. A second part of the work involved water sampling and filtration for further analysis in lab of the samples taken at discrete depths along the in-situ vertical profiles. A total of 33 optics casts were performed (+ 2 test deployments from an ice floe) and concomitant water samples could be collected for 30 of them. The work done at each station is represented by blue boxes in Table 8.1 (from 0°W longitude toward the west) and Table 8.2 (from 2°E longitude toward the east).

8.3 In-situ

In-situ data collection was performed thanks to an instrument package (Figure 8.1) consisting of:

- A Wetlabs ac-s sensor capturing the absorption and attenuation (sum of absorption and scattering) of light by the sea water at 81 different narrow spectral channels in the visible range and with a sampling frequency of 4Hz. The ac-s used (s/n 311) has a 25cm optical path length making it suitable for clear water surveys.
- A Wetlabs WETstar FDOM sensor (s/n 003) measuring the fluorescence by dissolved organic matter at 3 channels (different emission/excitation pairs) with a sampling frequency of 1Hz (this sensor was provided by the IOPAN group part of the ARICE project).
- A Seabird SBE37SMP CTD (model with internal pump) measuring temperature, salinity and depth at a sampling frequency of ~0.6Hz.
- A Seabird 5T 3000RPM pump assuring the water flow through the ac-s and FDOM sensors.
- A 51Ah 15V battery pack
- A Wetlabs DH-4 data logger powered by the battery pack. It was used for powering all the other components, collecting the data from the different sensors and storing them along a single time reference.

For each profile, the cast was first immersed and kept at 20m depth for 3 minutes to make sure all bubbles were removed from the plumbing. It was then brought back to subsurface before performing the profile at a constant vertical speed of 0.4 m/s. The profiles were done between 0-200m depth when possible or by keeping a ~10% safety margin to the bottom when shallower.
The main plumbing and the CTD cells were rinsed with fresh water after each cast. After noticing on 4th September problems with the conductivity cell giving for stations 93 and 98 erroneous values for the beginning of the cast, the CTD plumbing was flushed with air after being rinsed with freshwater. The problem did not reappear.

The Ac-s optics and chambers were cleaned successively with soap, ethanol and Milli-Q water once a day. Ac-s blanks were measured 3 times during cruise with Milli-Q water alternatively injected inside each chamber thanks to a Peristaltic pump.

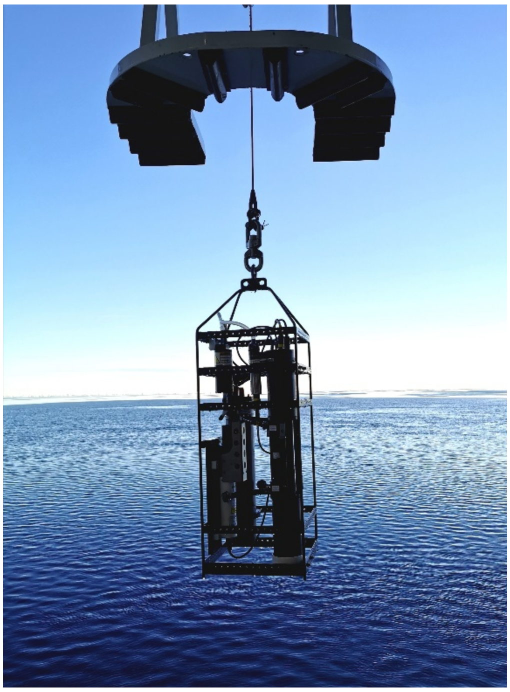


Figure 8.1 - Deployment of the optics cast from the CTD hangar of RV Kronprins Haakon

8.4 Discrete samples

Three different kind of water samples were collected at 5 standard depths 5, 15, 25, 50 and 100m:

- Chlorophyll-a (Chl-a) samples were filtered onto 25mm GF/F filters. Pigments were directly extracted within methanol during 12-24h (samples stored in cold and dark during that time) and then analysed before and after acidification using a Turner Trilogy fluorometer.
- Total/algal/mineral particulate absorption samples were filtered onto 25mm GF/F filters. Sample volume was adjusted between 350-1300ml depending on particle load for obtaining some slight coloration on the filter (requirement for the spectrometric technique to be used). However, for many stations, it was difficult to obtain visually perceptible coloration on the filters due to the very low particle content of the water. The filters were flash frozen into liquid nitrogen before being placed into a -80°C freezer. These samples are meant to be analysed inside an integrating cavity at HZG (Germany) with the help of Dr. Rüdiger Röttgers.
- Total Suspended Matter (TSM) were filtered onto pre-burnt and pre-weighted 47mm GF/F filters and stored directly into a -20°C freezer. This parameter was sampled only for longitudes > 5°E due to logistics constraints and the fact that significant particle load was expected only for this part of the transect.

Table 8.1 - Optics work done at each station from 0°W longitude and westward in the western part of the strait. Achieved work is represented by boxes filled in blue.

Stat. no		47	49	51	54	57	60	65	66	71	74	77	79	82	85	87	88	93	97	98	100	107	110
Lat N	D °	78	78	78	78	78	78	78	78	78	78	78	78	78	78	78	79	79	79	79	80	80	80
	M '	50	50	50	50	50	50	50	50	50	50	50	50	50	50	50	00	03	31	33	13	02	53
Lon W	D °	00	01	02	03	04	06	05	07	08	09	10	11	12	13	14	15	17	18	18	16	15	15
	M '	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	03	12	09	09	28	46

Optics Cast	■	■	■	■	■	■		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Chl-a	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■
A_p	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■		■	■	■	■	■	■
TSM																						

Table 8.2 - Optics work done at each station from 2°E longitude and eastward in the eastern part of the strait. Achieved work is represented by boxes filled in blue.

Stat. no		**116**	**118**	**119**	**120**	**121**	**122**	**124**	**125**	**126**	**127**
Lat	**D °**	78	78	78	78	78	78	78	78	78	78
N	**M '**	50	50	50	50	50	50	50	50	50	50
Lon	**D °**	02	04	05	06	07	07	08	08	09	09
E	**M '**	00	00	00	00	00	30	00	30	00	30
Optics Cast		■	■	■	■	■	■	■	■	■	■
Chl-a		■	■	■	■	■	■	■		■	
A_p		■	■	■	■	■	■	■		■	
TSM					■	■	■	■		■	

8.5 Preliminary results

At time of writing this report, a first version of the processed data from the optics casts has been produced for each station but only the chl-a concentration is available from the water samples. Vertical profiles from the optics cast are presented in Figure 8.2 for the stations located at 7°W (representative of Polar Water) and 7°E (representative of Atlantic Water) respectively. Low scattering (assessed from the difference between attenuation and absorption) can be observed at 7°W while scattering is highly present in the first 30-40m water depth at 7°E. This traduces the higher (resp. lower) presence of particles in the East (resp. West) part of the strait. Conversely, the fluorescence from dissolved organic matter, as quantified by the FDOM sensor, shows very low values at 7°E compared to 7°W where a strong and constant signal can be observed in the first 70m of the water column, followed by a gradual decrease down to 175m where optical properties seem to get stabilized. This is very likely to be linked to the East Greenland Current carrying Polar Water which contains a lot of dissolved organic matter originating mainly originating from the river discharge in Siberia. These findings are consistent with optics work done during previous Fram Strait cruises at the same time of year.

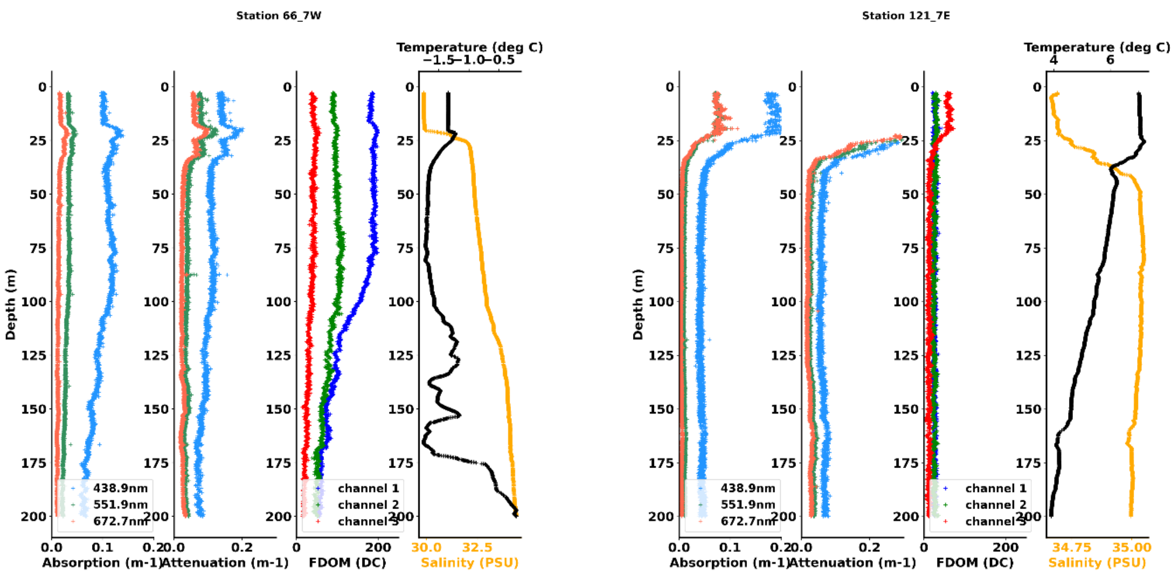


Figure 8.2 - Preliminary results from the Optics cast for the station 66 located at 7°W longitude (left) and the station 121 located at 7°E longitude (right).

9. Sea ice work on Fram Strait 2020 cruise

9.1 General

The sea ice work on Fram Strait 2020 cruise was conducted by Dmitry V. Divine, Hiroshi Sumata and Anca Cristea with support from Paul A. Dodd, Tristan Petit, Amalie Ask, Amalia Keck, Jan Are Jakobsen and Marius Bratrein.

As in the previous years, the sea ice cover in Fram Strait this time of the year at the transect latitude was mainly represented by open to very open pack ice (ice concentrations 0.1-0.3) west of 5W in the core of the ECG and open water to very open drft ice almost between 6- 12°W. More solid ice pack was present between 12 and 18 W; see the cruise charts for details on changing ice conditions during the cruise.

Altogether the sea ice group conducted five sea ice stations (see Table 1) that include four regular ice stations on drift ice/fast ice and one thin ice sampling. A majority of sea ice observed outside fast ice area during the cruise was a thick second year/multiyear ice, often ridged and deformed with a thickness from visual observations exceeding 2 – 4 m. Thinner, around 1 - 1.5 m thick first year ice was mainly found in the core of the EGC, closer to the ice edge, with generally small ice floes.

The floe sizes were preferentially small in the range of 20-60 m. Fast ice area next to Greenland on Belgica bank has further shrunk compared with the previous years with only two smaller areas detected of about 4 by 6 and 8 by 7 km of fast ice left anchored to the grounded icebergs.

Regular sea ice observations using ASSIST protocol were also made by D.V. Divine, H. Sumata and A. Cristea while RV KPH was in the ice covered waters.

9.2 Helicopter-borne sea ice thickness measurements (HEM-surveys) of ice thickness in the East Greenland Current around 79°N

Through collaboration with the whale research team (C. Lydersen, K. Kovacs) we conducted an aerial regional scale sea ice survey in the area of two remaining pieces of fast ice and drift ice in between. During a one hour and 45-minute-long flight about 120 km of sea ice covered area along the flight track was studied using a helicopter-borne electromagnetic instrument EM-bird (Figure 1). The ICE camera have experienced a failure yet corroborated the EM bird operation with a high quality GPS+INS data. Interpretation of the derived data including a conversion to the actual sea ice thickness will be carried out back at NPI.

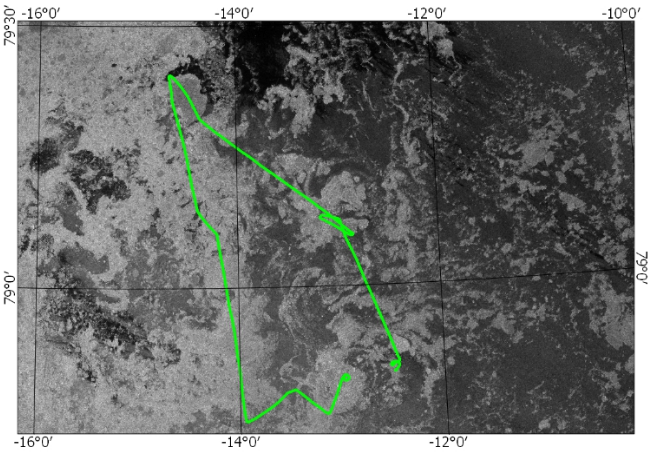


Figure 9.1. HEM-survey flight track on 01.09.2020.

9.3 Sea ice stations

On four main sea ice stations (S1, S2, S3, S5) we collected ice cores for salinity and temperature analysis, chemical analyses, optics, archive storage and later analysis of the microstructure. Station 4 was a station on thin ice. On stations S2, S3 and S5, three tracer cores were additionally collected by Paul Dodd and his team. Stations positions are found in Table 1, and also shown in the main map for the cruise.

On stations S2 on fast ice and S3, sea ice thickness of the floe was additionally surveyed directly by thickness drilling and indirectly using a Geonics EM31-MK2 short (EM31SH). The EM31 is placed on a sledge and pulled over the ice; the data including GPS position is logged at a frequency of 0.5 Hz to an Archer II field computer. Thickness drillings were done on selected spots for calibration and validation, and ice thickness and freeboard were measured with a Kovacs thickness gauge. The example of the derived data is shown Figure 2.

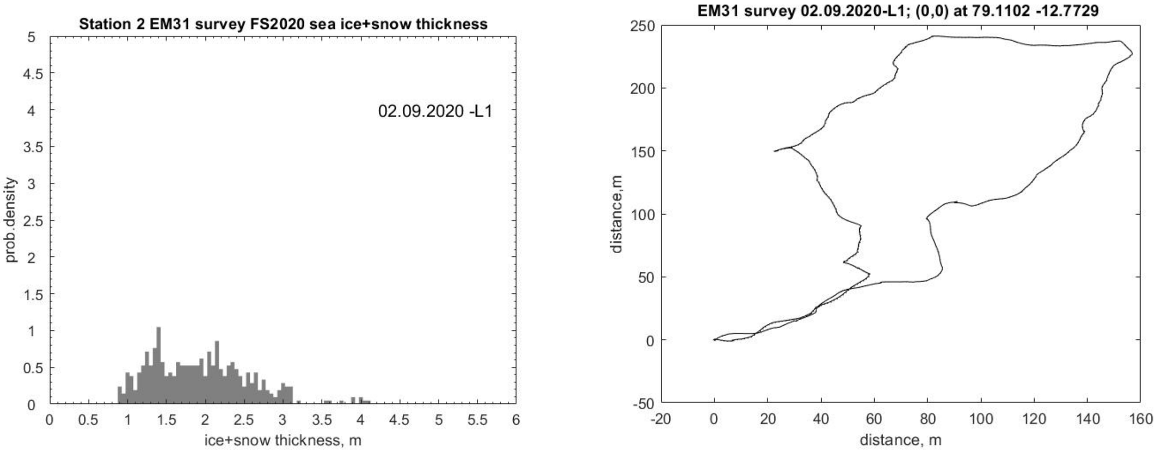


Figure 9.2. Left panel: Sea ice total thickness (ice + snow/scatter layer) probability density for fast ice on sea ice Station 2; Right panel: EM31SH survey track.

All four main stations featured rather thick (2-3 m) and fresh ice according to salinity measurements; suggesting the ice floes surveyed were second- or multiyear ice. Due to limited snow cover (0-2 cm thick crust/scattering layer) and no significant precipitation events throughout the cruise, we did not use Magna Probe for measuring snow thickness. Instead, the scatter layer thickness was manually logged during the EM31SH transects/ coring.

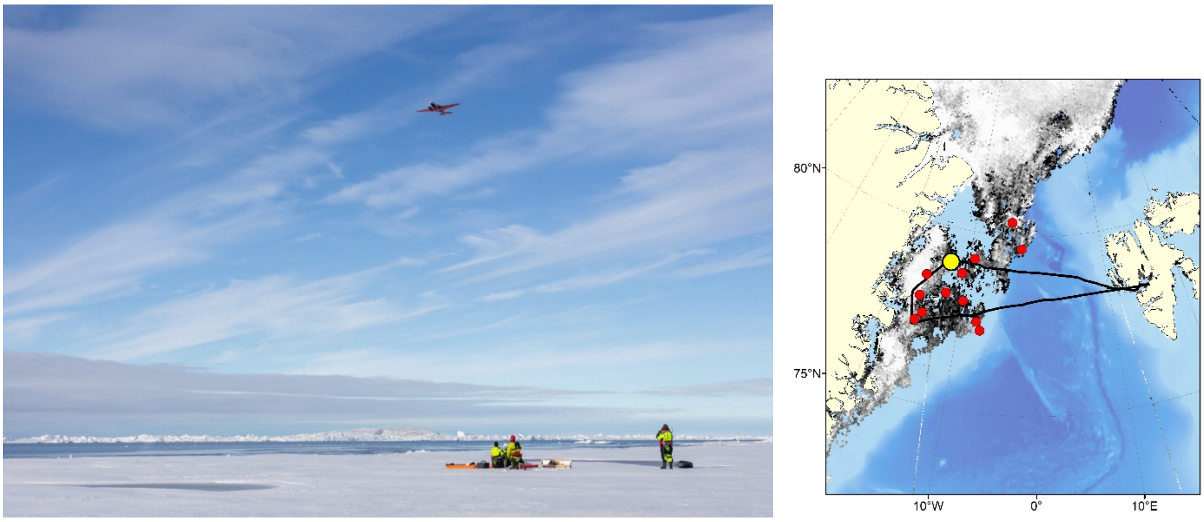


Figure 9.3: Right panel: sea ice station S2 on the remaining segment of multiyear fast ice east of Greenland. The picture depicts the AWI research aircraft Polar-6 on its overflight over fast ice. Photo: Paul Dodd. Right panel: track of Polar 6 aircraft with a yellow dot showing a location of ice station S2.

On the 02.09.2020, while working on sea ice station S2, we had an overflight of the AWI research aircraft Basler Polar 6 (Figure 9.3). This aircraft is equipped with a number of instruments for sea ice research including EM-bird, airborne laser scanner, high resolution DLR and multi-spectral cameras.

9.4 Thin ice sampling

The thin ice samples were collected on Station 3 from the edge of the floe (see Figure 9.4). Temperatures, salinity, thickness, and visual information were collected. New ice formation whenever observed, was also registered in ASSIST.

Figure 9.4: Sea ice station 4; thin ice sampling procedure from the floe edge, 05.09.2020

9.5 High resolution SAR satellite acquisitions

As a part of the program on sea ice remote sensing a number of higher resolution SAR scenes from various satellites were ordered. It included:

- Radarsat-2: 7 scenes
- TerraSAR X: 10 scenes
- Cosmo-Sky-Med: 13 scenes
- ALOS: 3 scenes

The major goal of the activity was to acquire a combined data set with sea ice properties inferred from in situ work (ice stations and bridge based observations), aerial (EM-bird) and satellite observations. For at least one station S2 on fast ice this goal was successfully achieved; the resulted dataset is to be analyzed in the near future.

9.6 Ice service for the cruise

In order to ensure efficient implementation of the cruise plan during operation/steaming in ice covered waters, sea ice group was responsible for providing satellite-based sea ice charts. The ice charts for the cruise were made on a regular, daily to twice-daily basis depending on the planned activities and the focus area. In total 98 Sentinel-1 low resolution SAR scenes/scene fragments were ordered using the dedicated expedition data service provided by the NPI data section. The sea ice group onboard have compiled 32 ice charts for the 15 cruise days; example and application is shown in Figure 9.5.

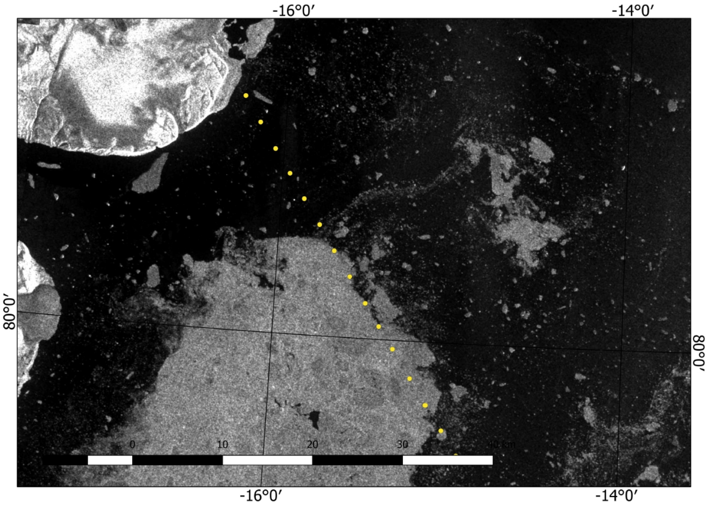


Figure 9.5: Ice chart from 04.09.2020 showing ice conditions along the West Wind oceanographic transect. The chart was used for optimizing the oceanographic work on 05.09.2020 and conducting sea ice Station 3. Radar image Sentinel-1.

9.7 Ice observations from the bridge (ASSIST)

Sea ice conditions were observed every one to three hours, except for the night time between midnight and 07:00, from the observation deck of RV KPH. Various sea ice parameters including sea ice types, floe sizes, snow cover, ridges, rafting etc. were recorded along with ship data (position, speed, and heading) and meteorological data (air and water temperature, air pressure, wind speed and direction, and humidity). Digital photos were taken with each observation (3 photos, looking out towards port, bow, and starboard. In total 114 observations were made during the cruise while RV KPH was in or in proximity to sea ice covered area.

9.8 Iceberg observations

During the cruise the sea ice group registered about 70 icebergs all together, both as alone standing or within iceberg groups. Iceberg log included ship positions and water depth at a time of the observation or, whenever possible, iceberg ice-radar based coordinates. The observation was complemented with an image of the ice radar that can later be used for the analysis of iceberg dimensions.

9.9 Daily activities during the cruise

A detailed description of ice station activities with station logs and photos is available in the cruise data collection, see folder "Sea Ice". Table 1 below shows a brief overview of FS2020 daily activities related to the sea ice work.

Table 9.1: An overview of all visited stations including tasks/activities.

Date	Day	#	time (UTC)	lat (start)	lon (start)	Task/activities
24.08.2020	1		09:00			Cargo work; departure TOS 19:00;
25.08.2020	2					Transit - Instrument maintenance;
26.08.2020	3					Transit to the Greenland Sea; planning SAR acquisitions

27.08.2020	4					Transit to the Greenland Sea; EM-bird and ICE camera assembly
28.08.2020	5					On transect; CTD shifts, ASSIST starts
29.08.2020	6					On transect; bad weather conditions. SAR/Polar 5 overflight planning.
30.08.2020	7					CTD shifts
31.08.2020	8	S1	07:13	N 78° 48’	W 6° 33’	Station 1 on drift ice; maintenance, data work.
01.09.2020	9					CTD shifts; EM-bird/ICE camera flight to fast ice, maintenance, SAR planning
02.09.2020	10	S2	10:33	N 79° 6.6’	W 12° 46’	Station 2 on fast ice: coring, thickness drilling, EM31 surveys, optics, Polar 6 overflight
03.09.2020	11					Lab and data work, maintenance, SAR planning.
04.09.2020	12					Lab and data work, maintenance, SAR planning.
05.09.2020	13	S3 S4	08:10	N 80° 03’	W 15° 30’	Station 3 on drift ice: coring, EM31; Station 4 on thin ice; ice lab; data work
06.09.2020	14					Lab and data work, SAR planning
07.09.2020	15	S5	21:30	78° 50’	W 8° 04’	Station 5 on drift ice: coring, optics. Station aborted due to bear appearance.
08.09.2020	16					Station on drift ice cancelled due to boat failure. EM-bird flight cancelled due to poor weather and sea ice conditions
09.09.2020	17					Equipment maintenance, lab work, core repacking, report writing.
10.09.2020	18					CTD shifts
11.09.2020	19					CTD shifts, Packing EM-bird, report writing
12.09.2020	20					CTD shifts, equipment maintenance and packing, report writing
13.09.2020	21					Arrival LYR; unloading KPH

10. Whale program

The purpose of the whale project on the Framstredet 2020 cruise was to deploy satellite tags and collect biopsies from bowhead whales and narwhals in the ice-covered waters in the western Fram Strait and to do similar deployments and collections on blue whales on the coastal shelf of Svalbard in the final days of the return trip. The satellite tags provide information on distribution and movements of these whales and the biopsies are used for studies of genetics, diet and pollution. A novel element of the study this year is that the satellite tags destined to be used also provide information on diving and thus information that can be used to make correction factors for animals available at the surface in future aerial surveys for estimating population size(s). Three bowhead whales were tagged, and biopsies were taken from one of these individuals. In addition, a biopsy was taken from a male narwhal. Very few bowhead whales were seen (only 4), while narwhales were seen on multiple occasions but getting close enough to tags or collect biopsies proved to be difficult. This may be related to the fact that most animals observed were females and calves and juveniles; our experience is that these groups are much more skittish and dive on longer distances from the helicopter compared to adult males. Another major issue related to the few target species/animals seen was that we flew ~30 h due to the fact that only 5000 liters of helicopter fuel were put onboard for this expedition (for reasons unknown to us), which was most definitely detrimental to the success of this project this year.

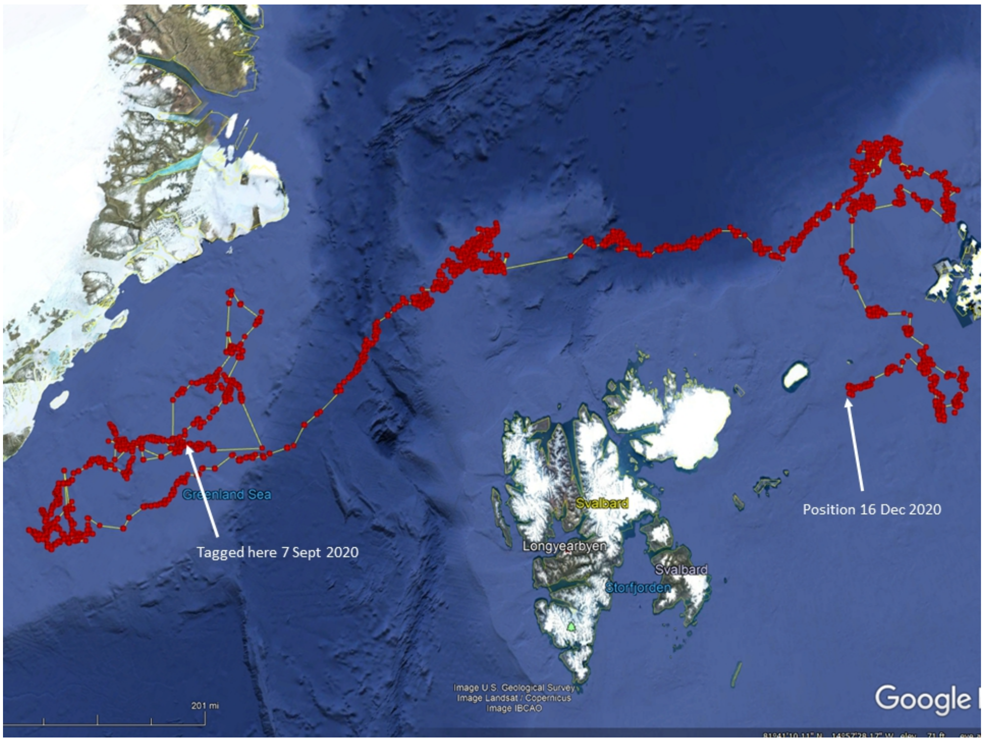


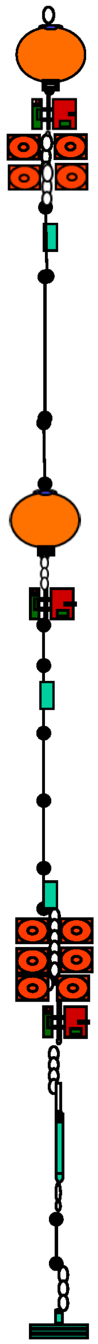
Figure 10.1: GPS track of a bowhead whale tagged during FS2020.

11. Outreach

We reported weekly to our home base at NPI to post on the oceanseaicenpi instagram account:
https://www.instagram.com/oceanseaicenpi/?hl=en

Appendix A: Diagrams of moorings recovered

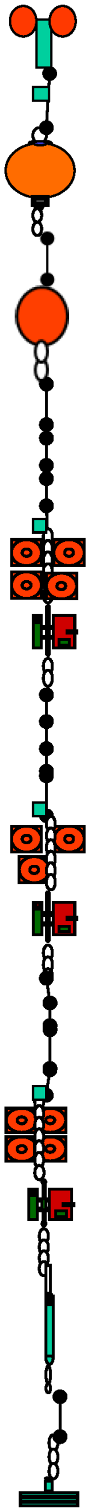
Rigg F10-15 78 49,623N
Satt ut 13 Sep 2019 , kl 19:34 001 57,036W



		Dyp:	Fra bunn:	Ned i vann:
ADCP/IPS-ram 300	SNR: 18070	50	2591	19:30
RCM9	SNR. 1175	52	2589	19:30
SBE37	SNR.7059	54	2585	19:30
100 (102) m Kevlar				
20 m Kevlar				
Stålkule Med svivel. 1 m Kjetting Galv.				
RCM 7	SNR. 9464	180	2414	18:24
0,5 m Kjetting Syrefast 0,5 m Kjetting Galv.				
SBE37	SNR. 14099	222	2417	18:24
4 x 500 (538,40,20,198,197,506,506) m Kevlar				
200(204) m Kevlar 100 (101 m Kevlar 100 (101) m Kevlar				
5 m Kevlar (totalt 2412)				
SBE37	SNR. 8226	2634	16	17:48
6 Glasskuler 3 m Kjetting Galv.				
Nortek	SNR. 42836-1-930	2639	11	17:48
Svivel				
AR861	SNR. 506			
5 m Kevlar				
3 m Kjetting				
ANKER	1200/(1000) kg	2650 (2663)	0	

Rigg F11-21

Satt ut 13 Sep 2019 kl 13:48 — 78 49,121N 003 03,072W



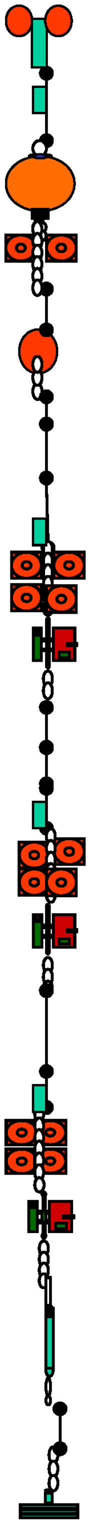
		Dyp:	Fra bunn:	Ut:
IPS	SNR. 51062	44	2409	13:42
SBE37	SNR. 3492	46	2407	13:42
5 m Kevlar				
ADCP300	SNR: 17462	50	2403	13:42
0,5 m Kjetting galvanisert				
10 m Kevlar				
Stålkule (gul)		72	2381	
Svivel				
1 m Kjetting galvanisert				
100 m Kevlar				
50 m Kevlar				
50 m Kevlar				
SBE37	SNR. 3996	273	2180	13:27
4 Glasskuler (2 gule og 2 oransje)				
2 m Kjetting galvanisert				
RCM9	SNR.1049	276	2177	13:27
0,5 m Kjetting galv				
200(199) m Kevlar				
500(510) m Kevlar				
500(510) m Kevlar				
20 m Kevlar				
10 m Kevlar				
SBE37	SNR. 7061	1526	927	13:08
3 Glasskuler (gule)				
2 m Kjetting galvanisert				
RCM11	SNR.538	1529	924	13:08
0,5 m Kjetting galv				
500(511) m Kevlar				
200 m Kevlar				
200 m Kevlar				
SBE37	SNR. 8821	2439	14	12:52
4 Glasskuler (gule)				
2 m Kjetting galvanisert				
Seaguard	SNR.834	2442	11	12:52
0,5 m Kjetting rustfri				
Svivel				
AR861	SNR. 499			
5 m Kevlar				
3 m Kjetting galvanisert				
ANKER	1230/(980) kg	2453(2474?)	0	

Rigg F12-21

Satt ut 12/9-19 kl 17:25

Tatt opp

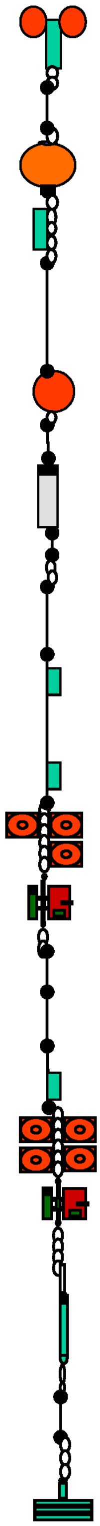
78 49,274N
004 01,332W



		Dyp:	Fra bunn:	Ut:
IPS	SNR. 51167	60	1770	17:22
SBE37	SNR.7055	62	1768	17:22
5 m Kevlar				
ADCP300	SNR: 20021	66	1764	17:22
2 Glasskuler				
1,0 m Kjetting galvanisert				
0,5 m Kjetting galv				
10 m Kevlar				
Stålkule 37	SNR.	78	1752	
1,0 m Kjetting galvanisert				
0,5 m Kjetting galv				
200(199) m Kevlar				
SBE37	SNR.3994	278	1552	17:10
3 Glasskuler				
2 m Kjetting galvanisert				
RCM9	SNR. 836	282	1548	17:10
0,5 m Kjetting galv				
500(498) m Kevlar				
500(497) m Kevlar				
200(205) m Kevlar				
SBE37	SNR.13505	1482	348	16:53
3 Glasskuler				
2 m Kjetting galvanisert				
RCM11	SNR.556	1486	344	16:53
0,5 m Kjetting galv				
200(207) m Kevlar				
100(101) m Kevlar				
20 m Kevlar				
SBE37	SNR. 10294	1816	14	16:42
4 Glasskuler				
2 m Kjetting galvanisert				
RCM11	SNR.117	1819	11	16:42
0,5 m Kjetting rustfri				
Svivel				
AR861	SNR. 500			
5 m Kevlar				
2 m Kjetting galvanisert				
ANKER	1190/(960) kg	1830 (1851)	0	

Rigg F13-21 78 50.346N

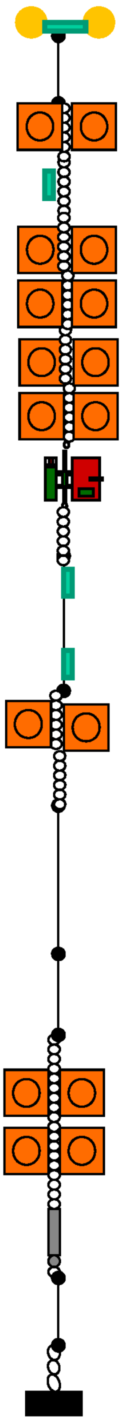
Satt ut 11/9-19 kl 15:34 004 59.959W



		Dyp:	Fra bunn:	Ned i vann:
IPS5	SNR. 51140	50	962	15:32
5 m Kevlar				
ADCP300	SNR: 18151	56	956	15:32
1,5 m Kjetting galv				
SEACAT SBE16	SNR. 7253	59	953	15:32
0,5 m Kjetting galv.				
10 m Kevlar				
Stålkule 37		69	943	
2 m Kevlar				
Hvallydopptaker		72	940	15:25
2 m Kevlar				
0,5 m Kjetting galv.				
20 m Kevlar				
Merke for instrument		95		
50 m Kevlar				
SBE37	SNR. 3995	147	865	15:18
100 m Kevlar				
SBE37	SNR.7060	245	767	15:16
3 Glasskuler				
2 m Kjetting galv.				
RCM9	SNR.1326	248	764	15:16
0,5 m Kjetting galv				
500(497) m Kevlar				
100 m Kevlar				
100 m Kevlar				
50 m Kevlar				
SBE37	SNR. 13504	996	16	15:02
4 Glasskuler				
2 m Kjetting galv.				
SEAGUARD	SNR. 345	1000	12	15:02
0,5 m Kjetting rustfri				
Svivel				
AR861	SNR. 743			
5 m Kevlar				
3 m Kjetting galvanisert				
ANKER	1100/(880) kg	1012(1027)	0	

Rigg F13B-6 78 50.213 N Dyp: Fra bunn: Ut:

Satt ut 11/9-19 , kl 09:40 005 30.149W

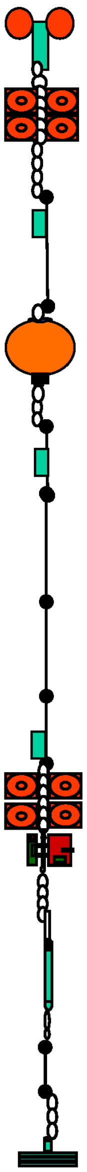


		Dyp	Fra bunn	Ut
ICECat	SNR. 21029	34	490	09:40
25 m Wire				
Weak link				
1 m Kjetting galv.				
2 Glasskuler				
ICECAT modem				
4 m Kjetting galv.				
4 Glasskuler				
SEAGUARD	SNR. 883	65	459	09:35
0,5 m Kjetting galv.				
SBE37	SNR. 9853	67	457	09:30
41 m Kevlar				
SBE37	SNR. 9852	106	418	09:27
1 m Kjetting galv.				
2 Glasskuler				
0,5 m Kjetting galv.				
200(199) m Kevlar				
Merket 50 m ned		204		
205 m Kevlar				
Merket 100 m over kuler		413		
2 m Kjetting galv.				
4 GLASSKULER		513	11	09:20
AR661	SNR. 410			
5 m Kevlar.				
3 m Kjetting galv.				
ANKER	820/(640)kg	524(534)	0	

Rigg F14-21

Satt ut 10/9-19, kl 14: 33

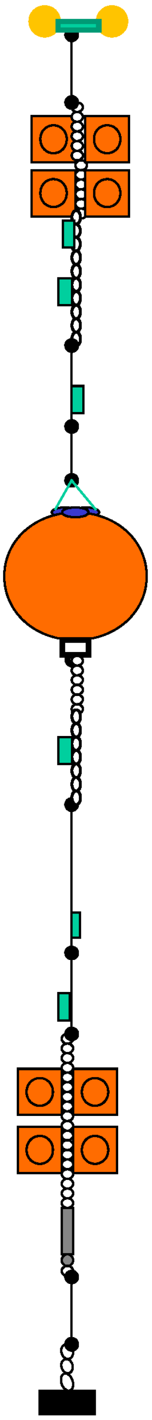
78 48,884N
006 30,001W



		Dyp:	Fra bunn:	Ned i vann:
IPS	SNR. 51138	46	224	14:30
4 Glasskuler				
2 m Kjetting galv.				
SBE37	SNR: 7058	52	218	14:28
5 m Kevlar				
ADCP 300	SNR: 17461	56	214	14:25
1 m Kjetting Galv.				
0,5 m Kjetting Galv.				
100 m Kevlar				
SBE37	SNR. 7054	100	170	14:18
50 m Kevlar				
SBE56	SNR: 3943	207	63	14:14
40 m Kevlar				
SBE37	SNR.7057	257	13	14:07
4 Glasskuler				
2 m Kjetting Galv.				
RCM9	SNR. 1325	260	10	14:07
Svivel				
AR861	SNR. 568			
3,5 m Kevlar				
2,5 m Kjetting				
ANKER 900/(740) kg		270 (269)	0	

Rigg F17-16 78 50. 180 N

Satt ut 10/9-19 , kl 07:05 008 04.798W



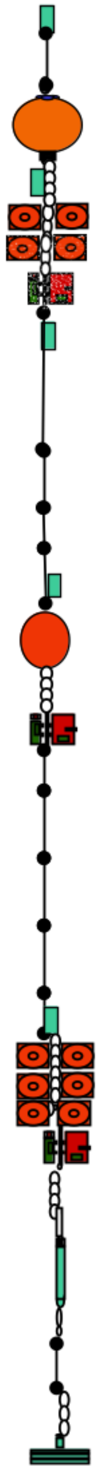
		Dyp:	Fra bunn:	Ut:
ICECAT	SNR.21024	25	201	07:05
3 m Kjetting galv.		52	174	07:05
4 Glasskuler				
Datalogger				
SBE16	SNR.7212	54	172	07:05
0,5 m Kjetting				
51 m Kevlar				
SBE37 Merket	SNR.13252	94	132	06:53
ADCP	SNR.24518	105	121	06:50
2 m Kjetting galv.				
SBE16	SNR.7339	108	118	06:50
0,5 m Kjetting				
99 m Kevlar				
SBE56	SNR.3942	180	36	06:44
5 m Kevlar				
SBE37	SNR.14098	214	12	06:42
2 m Kjetting galv.				
4 GLASSKULER		215	11	
AR861CS	SNR. 501			
5 m Kevlar.				
2 m Kjetting galv.				
ANKER	800/(700)kg	226	0	

Appendix B: Diagrams of moorings deployed

Rigg F10-16

Satt ut 10 Sep 2020, kl 12:32

78 49,624N
001 57,048W

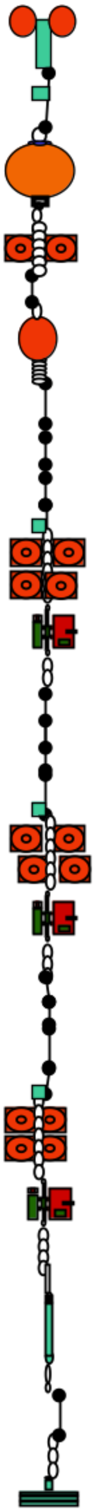


		Dyp:	Fra bunn:	Ned i vann:
SBE37IM	SNR. 22258	25	2602	11:37
30 m Vaier				
ADCP 300	SNR: 16831	56	2571	11:37
DATALOGGER	SNR.	58	2569	11:37
4 glasskuler 3 m Kjetting Galv.				
AQUADOPP	SNR. 665	61	2566	11:37
RBR ODO	SNR. 205002	63	2564	11:37
100 (102) m Kevlar				
40 m Kevlar				
20 (17)m Kevlar				
10 m Kevlar				
SBE37	SNR. 20789	230	2397	11:25
Plastkule 40'' Oransje Svivel 1 m Kjetting Galv.				
AQUADOPP	SNR. 666	234	2393	11:25
0,5 m Kjetting Galv. Med svivel.				
4 x 500 (497,498,498,498) m Kevlar				
208 m Kevlar 100 m Kevlar 40 m Kevlar				
40 m Kevlar				
SBE37	SNR. 22261	2612	15	10:54
6 Glasskuler 3 m Kjetting Galv.				
AQUADOPP	SNR. 667	2616	11	10:54
Svivel				
AR861	SNR. 2879			
5 m Kevlar				
2 m Kjetting				
ANKER	1000/(850) kg	2627(Ekko 2667)	0	

Rigg F11-22

Satt ut 10 SEP 2020 kl 06:35

78 49,121N
003 03,294W



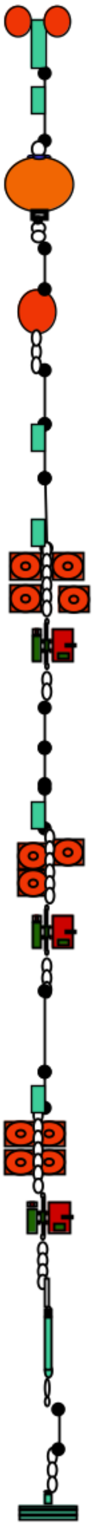
		Dyp:	Fra bunn:	Ut:
IPS	SNR. 51062	54	2369	06:27
SBE37	SNR. 3490	56	2367	06:27
5 m Kevlar				
ADCP300	SNR: 24830	60	2363	06:27
2 Glasskuler				
1 m Kjetting galvanisert				
5 m Kevlar				
Stålkule 37 McLane		69	2354	
0,5 m Kjetting galvanisert				
100 m Kevlar				
50 m Kevlar				
20 m Kevlar				
5 m Kevlar				
SBE37	SNR. 4702	244	2179	05:51
4 Glasskuler (gule)				
2 m Kjetting galvanisert				
RCM9	SNR.1324	247	2176	05:51
0,5 m Kjetting galv				
200(208) m Kevlar				
500(498) m Kevlar				
500(502) m Kevlar				
40 (41) m Kevlar				
SBE37	SNR. 3552	1496	927	05:10
4 Glasskuler				
2 m Kjetting galvanisert				
RCM11	SNR.494	1499	924	05:10
0,5 m Kjetting galv				
500 m Kevlar				
200 (201)m Kevlar				
200 (209)m Kevlar				
SBE37	SNR. 8227	2409	14	04:39
4 Glasskuler (gule)				
2 m Kjetting galvanisert				
RCM8	SNR.10071	2413	10	04:39
0,5 m Kjetting rustfri				
Svivel				
AR861	SNR. 287			
5 m Kevlar				
2 m Kjetting galvanisert				
ANKER	1220/(980) kg	2423(Ekko 2474)	0	

Rigg F12-22

Settes ut 9 SEP 2020 kl 08:22

78 49,116N

004 01.294W



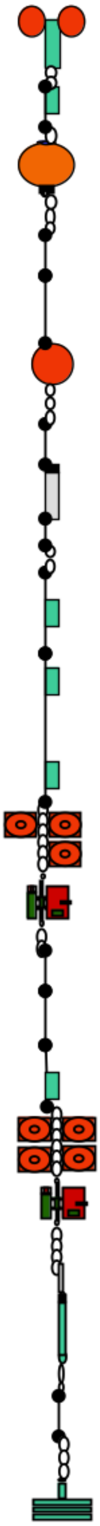
		Dyp:	Fra bunn:	Ut:
IPS	SNR. 51167	50	1778	08:20
SBE37	SNR.3489	52	1776	08:20
5 m Kevlar				
ADCP300	SNR: 16876	56	1772	08:20
0,5m Kjetting galvanisert				
5 m Kevlar				
Stålkule 37 Gul		62	1766	
0,5 m Kjetting galvanisert				
SBE37	SNR. 14100	114	1714	07:54
200 m Kevlar				
SBE37	SNR.4837	264	1564	07:49
4 Glasskuler				
2 m Kjetting galvanisert				
SEAGUARD	SNR. 884	267	1561	07:49
0,5 m Kjetting galv				
498 m Kevlar				
501 m Kevlar				
200m Kevlar				
SBE37	SNR.3554	1471	357	07:13
3 Glasskuler				
2 m Kjetting galvanisert				
RCM11	SNR.235	1474	354	07:13
0,5 m Kjetting galv				
199 m Kevlar				
99 m Kevlar				
40 m Kevlar				
SBE37	SNR. 8822	1814	14	07:05
4 Glasskuler				
2 m Kjetting galvanisert				
RCM11	SNR.228	1817	11	07:05
0,5 m Kjetting rustfri				
Svivel				
AR861	SNR. 182			
3 m Kevlar				
3 m Kjetting galvanisert				
ANKER	1120/(940) kg	1828 (Ekko1848)	0	

Rigg F13-22

Settes ut 8 SEP 2020 , kl 18:22

78 50.346N

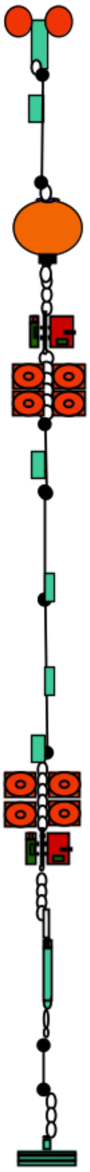
004 59.959W



		Dyp:	Fra bunn:	Ned i vann:
IPS5	SNR. 51064	50	971	18:18
SBE37	SNR: 7056	52	969	18:18
5 m Kevlar				
ADCP300	SNR: 18151	56	965	18:18
1,5 m Kjetting galv				
5 m Kevlar				
10 m Kevlar				
Plastkule 37 Oransje		73	948	
1,5 m Kjetting galv.				
2 m Kevlar				
Hvallydopptaker M3	SNR. 304	78	943	18:11
2 m Kevlar				
0,5 m Kjetting galv.				
50 + 20 m Kevlar				
SBE37	SNR. 12234	102	919	17:56
SBE37	SNR. 12232	152	869	17:54
100 (103) m Kevlar				
SBE37	SNR.3993	253	768	17:48
3 Glasskuler				
2 m Kjetting galv.				
RCM9	SNR.1327	257	764	17:48
0,5 m Kjetting galv				
500 m Kevlar K				
200 m Kevlar				
50 m Kevlar				
SBE37	SNR.3551	1007	14	17:20
4 Glasskuler				
2 m Kjetting galv.				
RCM11	SNR. 561	1011	10	17:20
0,5 m Kjetting rustfri				
Svivel				
AR861	SNR. 053			
5 m Kevlar				
2 m Kjetting galvanisert				
ANKER	1110/(880) kg	1021 (Ekko 1026)	0	

Rigg F14-22
Satt ut 8 SEP 2020, kl 07:45

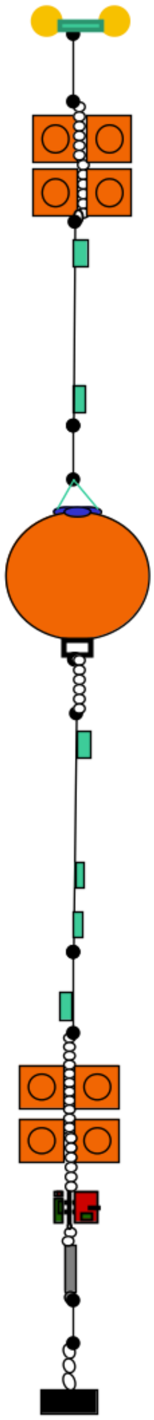
78 48,848N
006 30,130W



			Dyp:	Fra bunn:	Ned i vann:
IPS	SNR. 51138		50	217	08:31
SBE37	SNR: 14097		54	213	08:31
5 m Kevlar					
ADCP 300	SNR: 24518		58	209	08:30
0,5 m Kjetting Galv.					
AQUADOPP	SNR: 930		58	209	08:30
4 Glasskuler					
2 m Kjetting Galv.					
40 m Kevlar					
SBE37	SNR: 13253		99	168	08:21
100 (103) m Kevlar					
SBE56	SNR.10330	(25 m over 56)	203	64	08:16
SBE56	SNR.10331	(25 m over 37)	228	39	08:12
50 (51) m Kevlar					
SBE37	SNR.3992		253	14	08:03
4 Glasskuler					
2 m Kjetting Galv.					
RCM9	SNR. 1046		257	10	08:01
Svivel					
AR861	SNR. 1220				
3,5 m Kevlar					
2,5 m Kjetting					
ANKER 920/(740) kg			267 (Ekko 270)		0

Rigg F17-17 78 50. 185 N

Satt ut 7 SEP 2020, kl 20:45 : 008 04.845W



			Dyp:	Fra bunn:	Ut:
SBE37	SNR. 22260		32	196	14:02
23 m Kevlar Weak link o/u					
3 m Kjetting galv. 4 Glasskuler					
RBR CDOM	SNR.204799		56	172	14:02
0,5 m Kjetting galv.					
40 m Kevlar					
SBE37	SNR. 9651		96	132	13:52
10 m Kevlar					
ADCP	SNR.24385		107	121	13:48
1,5 m Kjetting galv.					
RBR CDOM	SNR.204800		109	119	13:48
0,5 m Kjetting galv.					
102 m Kevlar					
SBE56	SNR. 3942	(25 m over 56)	170	32	13:38
SBE56	SNR. 3943	(20 m over 37)	196	32	13:38
5 m Kevlar					
SBE37	SNR. 9650		216	12	13:34
2 m Kjetting galv.					
4 GLASSKULER			217	11	
RCM8	SNR. 12733		219	9	13:34
AR861Li	SNR. 1424				
3 m Kevlar. 2 m Kjetting galv.					
ANKER	815/(700)kg		228 (Ekko 225)	0	

Rigg F20-1
Satt ut 7 SEP 2020 , kl 12:47

78 50.100 N
010 08.814W

		Dyp:	Fra bunn:	Ut:
ICECat	SNR. 21029	28	298	12:46
25 m Wire Weak link				
3 m Kjetting galv. 4 Glasskuler				
ICECAT modem				
SBE37	SNR. 12233	56	270	12:42
51 m Kevlar				
ADCP	SNR.727	106	220	12:47
1 m Kjetting galv.				
SBE37	SNR. 10295	109	217	12:30
206 m Kevlar (Merke på ca 50 m ned)				
4 GLASSKULER		314	12	
2 m Kjetting galv.				
RCM7	SNR. 7718	316	10	12:15
AR661	SNR. 291			
5 m Kevlar.				
2 m Kjetting galv.				
ANKER	800/(620)kg	326(Ekko 326)	0	

Appendix C: Script files for Master and Slave LADCP programming and starting:

```
; Append command to the log file
$LC:\KH2020709\LADCP\Mladcp_log.txt
$P *************************************************************************
$P ************** LADCP Master. Looking down (firmware v16.3) *************
$P ************* Master and Slave will ping at the same time ***************
$P ************ staggered single-ping ensembles every 0.8/1.2 s *************
$P *************************************************************************
; Send ADCP a BREAK
$B
; Wait for command prompt (sent after each command)
$W62
; Display real time clock setting
tt?
$W62
; Set to factory defaults
CR1
$W62
; use WM15 for firmware 16.3
; activates LADCP mode (BT from WT pings)
WM15
$W62
; Rename data file prior to new CTD station and use CTD station nr
RN M047_
; Flow control (Record data internally):
; - automatic ensemble cycling (next ens when ready)
; - automatic ping cycling (ping when ready)
; - binary data output
; - disable serial output
; - enable data recorder
CF11101
$W62
; coordinate transformation:
; - radial beam coordinates (2 bits)
; - use pitch/roll (not used for beam coords?)
; - no 3-beam solutions
; - no bin mapping
EX00100
$W62
; Sensor source:
; - manual speed of sound (EC)
; - manual depth of transducer (ED = 0 [dm])
; - measured heading (EH)
; - measured pitch (EP)
; - measured roll (ER)
; - manual salinity (ES = 35 [psu])
; - measured temperature (ET)
EZ0011101
$W62
;
```

```
; - configure staggered ping-cycle
; ensembles per burst
TC2
$W62
; pings per ensemble
WP1
$W62
; time per burst
TB 00:00:01.20
$W62
; time per ensemble
TE 00:00:00.80
$W62
; time between pings
TP 00:00.00
$W62
;
; - configure no. of bins, length, blank
; number of bins
WN015
$W62
; bin length [cm]
WS0800
$W62
; blank after transmit [cm]
WF0000
$W62
; ambiguity velocity [cm]
WV250
$W62
; amplitude and correlation thresholds for bottom detection
LZ30,220
$W62
; Set ADCP to narrow bandwidth and extend range by 10%
LW1
$W62
;
; SET AS MASTER ADCP
SM1
$W62
;+ TRANSMITS SYNCHRONIZING PULSE BEFORE EACH ENSEMBLE
SA011
$W62
; WAIT .55 s after sending sync pulse
SW05500
$W62
; SYNCHRONIZING PULSE SENT ON EVERY PING
SI0
$W62
; keep params as user defaults (across power failures)
CK
$W62
```

```
; echo configuration
T?
$W62
W?
$W62
; start Pinging
CS
; Delay 3 seconds
$D3
$p **************************************************************************
$P Please disconnect the ADCP from the computer.
$P **************************************************************************
; Close the log file
$L
```

```
; Append command to the log file
$LC:\KH2020709\LADCP\Sladcp_log.txt
$P
************************************************************************
$P ************** LADCP SLAVE. Looking UP (firmware v16.30) *************
$P ************* Master and Slave will ping at the same time ***************
$P ************ staggered single-ping ensembles every 0.8/1.2 s ************
$P
************************************************************************
; Send ADCP a BREAK
$B
% Wait for the command prompt; BBTalk needs this before each command
$W62
; Display real time clock setting
tt?
$W62
; Set to factory defaults
CR1
$W62
; use WM15 for firmware 16.3
; activates LADCP mode (BT from WT pings)
WM15
$W62
; Rename data file prior to new CTD station and use CTD station nr
RN S047_
$W62
; Flow control (Record data internally):
; - automatic ensemble cycling (next ens when ready)
; - automatic ping cycling (ping when ready)
; - binary data output
; - disable serial output
; - enable data recorder
CF11101
$W62
; coordinate transformation:
; - radial beam coordinates (2 bits)
; - use pitch/roll (not used for beam coords?)
; - no 3-beam solutions
; - no bin mapping
EX00100
$W62
; Sensor source:
; - manual speed of sound (EC)
; - manual depth of transducer (ED = 0 [dm])
; - measured heading (EH)
; - measured pitch (EP)
; - measured roll (ER)
; - manual salinity (ES = 35 [psu])
```

```
; - measured temperature (ET)
EZ0011101
$W62
; - configure staggered ping-cycle
; ensembles per burst
TC2
$W62
; pings per ensemble
WP1
$W62
; time per burst
TB 00:00:01.20
$W62
; time per ensemble
TE 00:00:00.80
$W62
; time between pings
TP 00:00.00
$W62
;
; - configure no. of bins, length, blank
; number of bins
WN015
$W62
; bin length [cm]
WS0800
$W62
; blank after transmit [cm]
WF0000
$W62
; ambiguity velocity [cm]
WV250
$W62
; amplitude and correlation thresholds for bottom detection
LZ30,220
$W62
; Set ADCP to narrow bandwidth and extend range by 10%
LW1
$W62
;
; SET AS SLAVE ADCP
SM2
$W62
; TRANSMITS SYNCHRONIZING PULSE BEFORE EACH ENSEMBLE
SA011
$W62
; don't sleep
SS0
```

```
$W62
; WAIT UP TO 300 SECONDS FOR SYNCHRONIZING PULSE
ST0300
$W62
; keep params as user defaults (across power failures)
CK
$W62
; echo configuration
T?
$W62
W?
$W62
; start Pinging
CS
; Delay 3 seconds
$D3
$p
********************************************************************************
$P Please disconnect the ADCP from the computer.
$P
********************************************************************************
; Close the log file
$L
```