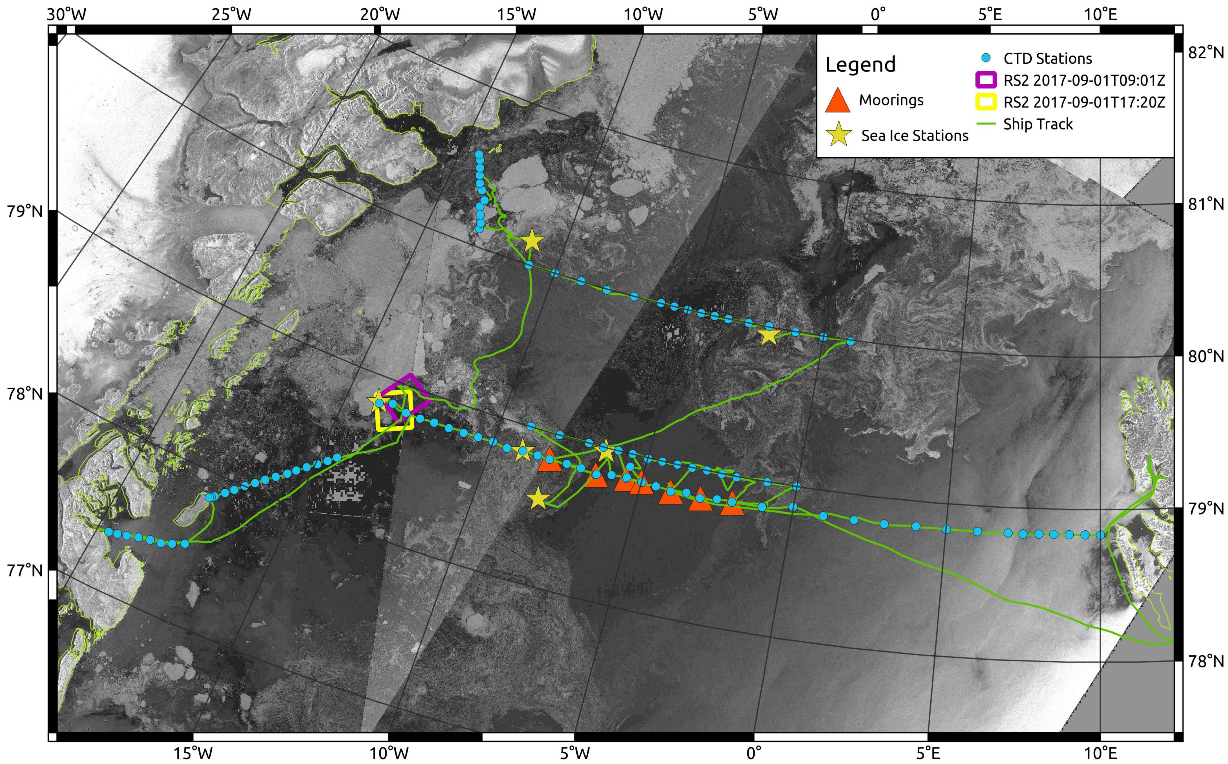
Fram Strait Cruise Report

24th August – 13th September 2017



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1. Participants

Principle Investigators
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3. Colin Stedmon (Danish Technical Univ., Denmark)

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4. John Guthrie (Polar Science Centre, University of Washington, USA)
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6. Signe Melbye Hansen (Danish Technical Univ., Denmark)
7. Per Anton Almgren (Danish Technical Univ., Denmark)
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9. Margot Debyser (Univ. of Edinbrugh, UK)
10. Elina Nystedt (NPI)

Moorings
11. Kristen Fossan (NPI)
12. Marius Bratrein (NPI)

Sea Ice
13. Micha Itkin (NPI)
14. Rob Graham (NPI)

2. Sailing log

Date	Activities
Tue 22/8	Participants arrive in Longyearbyen Collect equipment sent to Longyearbyen from NPI or Bring 19:00 Joint dinner in town at Kroa
Wed 23/8	All participants meet at Svalbard Science Centre (UNIS) 09:00 local time for safety training (polar bear theory, shooting). Afternoon: Pick up equipment (clothing) and gear at NPI logistics at UNIS Start setting up equipment on Lance
Thu 24/8	At 9 am participants move into cabins on Lance Loading equipment, setting up equipment in labs ADCP & LADCP compass calibrations. The LADCP turned out to be the wrong one, so no calibration of the actual LADCP to be used on Lance. Safety briefing on Lance Lance departs Longyearbyen at 15:00 local time. Science briefing on Lance Start sailing towards 78 52'N 000° 00'E (~180 nm, 18 hrs)
Fri 25/8	CTD at 0E at 9:30 UTC Radiosonde launch at 11:20 UTC CTD at 1W at 14:30 UTC, continue with CTDs at 2W and 2.5W during night. Passing a very narrow (N-S), very low concentration sea ice band around 1.5W.
Sat 26/8	Arrival at F11 at 5 UTC, open water as far as one can see. Recovery of F11 after breakfast followed by a CTD at the F11 site. Radiosonde launch at 11:00 UTC. Recovery of F12 at 13:00 UTC followed by a CTD at the F12 site. CTDs at 3.5W and 4.5W, done by midnight. All day no sea ice.

Sun 27/8	Recovery of F13 after breakfast at 06:24 UTC followed by a CTD on the F13 site. Open water, 100% ice free. Steam to F13B, recovered at 10:28 UTC. CTD at 5.5W the F13B site. Bottle failed so another CTD for water (no LADCP). Radiosonde launch at 11 UTC. CTD at 6W. Moving a bit northward into an E-W band of sea ice to look for a floe for sea ice work. Sea ice station (5p) after dinner (2.5 hours) with MOB. Coring only. No CTDs at night, steam to F14.
Mon 28/8	Recovery of F14 after breakfast, followed by CTD at 6.5W, 7W and 7.5W. Finally some sea ice, thick compressed small ice floes, low concentration still. Recovery of F17 at 12:36 UTC followed by CTDs at 8, 8.5, 9W. Sea ice station with MOB, 2 groups between 17:00 and 20:20 UTC. Continue with CTDs on the ain section until Tuesday morning.
Tue 29/8	Continue with CTDs until nearly 14W where we meet 'fast' ice (done by 9 UTC). Moor ship to land fast ice for sea ice work after lunch. Sea ice work (2 groups), drone test flying and 3 ADCP calibrations in the evening. Leave ice floe at 21 UTC
Wed 30/8	Start IdF CTD section at 05:05 UTC, finish at 18? UTC. Steam towards SW of IdF and start fjord section around 21:20 UTC.
Thu 31/8	CTDs fjord section southwest of IdF. After that steam northward to the main section for a sea ice station at ~13W 78 55'N on Friday morning where satellite image will be obtained from.
Fri 1/9	Cancelled regular sea ice station because of fog/bad visibility. Taking thin ice samples ~13W. After it clears photography of thin ice with drone. Drone crashes. ICING! Stupid we did not think of it. Steam to Westwind 2 (moved slightly eastward because of ice). Transit is slow because of a lot of ice underway, stuck after the thin ice sampling for a while near main section at 13.5W towards 79N. Continued north but a lot of thick ice after 79.5N. Hard to navigate, finally find a way after 4 am to Westwind 2.
Sat 2/9	Start CTD section Westwind 2 (moved ~0.5° to the east to avoid heavy ice) at ~6:15 UTC Visibility gets bad, fog. Section finished by 1800 UTC. Sea ice station=cancelled because of weather. Steam to 80N, 11W overnight.
Sun 3/9	Sea ice station at ~80N, 11W between 7:00 and 10:30 UTC, moored to large ice floe After lunch start CTD section E-W at 80N between 11W and 2W.
Mon 4/9	Finish CTD section at 80N until 2W. Afternoon: sea ice station with ship moored to ice floe between 11 and 15 UTC Evening: Three more CTDs at 80N at 1W, 0, and 1E: only down to 750 m. Midnight: Steam to 78°50'N, 8W.
Tues 5/9	Arrival at F17 at 78°50'N, 8W at noon, F17 deployed at 10:57 UTC. No sea ice. Steam to 78°50'N, 6.5W. Deploy F14 at 13:47 UTC. No sea ice. After dinner: sea ice station south of the mooring line moored to a floe. Work for about 2.5 hours but cancelled because of fog getting more heavy. The visibility is too bad to see polar bear. Station abandoned earlier. Cores not finished since it was very thick (>5 m) ice. Night: steam to 79N, and start <u>CTDs at 79N</u> at 9W, 8W, 7W, 6.5W and 6W
Wed 6/9	Morning: finish <u>CTDs at 79N</u> at 9W, 8W, 7W, 6.5W and 6W Deploy F13B at 78°50'N, 5.5W at 09:43 UTC. No sea ice. Deploy F13 at 78°50'N, 5W at 13:45 UTC. No sea ice. Evening: <u>CTDs at 79N</u> at 5.5W, 5 W, 4.5W and 4W (down to 1000 m only)
Thu 7/9	Cancelled: sea ice station near 79N, 2.5W. Too much swell and too little sea ice. No more options to do sea ice work, there iare no good size floes to work on. Only some left over thick chunks, small but thick and mostly flooded by waves. Morning: get last mooring equipment from the hold (3 anchors and kevlar) Storm picking up, no deployment possible. Cancelled all CTD and mooring operations during the day because of bad weather and too much wind, swell and waves until at least 10 pm
Fri 8/9	Morning: repeat CTD (nr 3) at 78°50'N, 2W (F10 site). No sea ice Deploy F10 at 12:23 UTC, no sea ice Repeat deep CTD at 78°50'N, 1°W (repeat of stn 2) Evening/night: CTDs at 79N at 0W, 1, 2, 2.5, 3, and 3.5W (down to 1000 m only)
	CTDs at 79N finished at 4:30 UTC

Sat 9/9	Steam to 78°50'N, 4W for F12 deployment. No sea ice, very calm. Deploy F12 at 09:05 UTC Steam to F11 site, calm weather, no sea ice Start deploying F11 around 1340 UTC at 78°50'N, 3W. All goes well until we are adding the top section, trying to lift the last bit in one go under and angle which does not make it with the crane, kevlar that holds the top release breaks because of too much strain and IPS, SBE37, ADCP and yellow buoy fall on deck from ~10m. No one gets hurt luckily. The steel float, IPS frame and the SBE37 are destroyed. We wait until after dinner to continue and look for back-up solutions: re-use an SBE37 from last year, the ADCP is still working, change IPS frame and put in 8 benthos floats to replace the big one. F11 gets finally deployed at18:42 UTC. Steam to the main CTD section to pick up the line at 1E, start CTDs around 23.30 UTC.
Sun 10/9	All day: continue CTD section at 78°50'N, 1E, 2E, etc. towards Svalbard. No sea ice. Winds picking up and more waves but still good enough to do all CTDs
Mon 11/9	Finish the main CTD section at 78°50'N at 10°E at 5:20 UTC. Steam eastward into Krossfjorden and Lilliehookfjorden and Lilliehookbreen for sightseeing there most of the day. Short landing on Camp Zoo. End of cruise dinner. 1800 UTC start steaming to LYR.
Tue 12/9	8 am arrival and disembarking in Longyearbyen Packing gear & off loading
Wed 13/9	Flights from Longyearbyen
Thu 14/9	Flights from Longyearbyen

3. Mooring operations during FS2017

The 5 standard moorings from the Fram Strait Arctic Outflow Observatory moorings were serviced and the additional mooring F13B at 5.5°W for enhanced near-surface measurements. In addition, NPI aims to fill in the gap left at 2°W after AWI has removed their moorings in the central Fram Strait. F10 at 2°W is at the eastern edge of the EGC and is required to obtain the full transport of the EGC/RAC system. NPI deployed mooring F10 with relatively few instruments, however, aiming to improve on that in coming years by getting external funding. The instruments were programmed to go for two years since there may be a risk with next year's cruise (or cruise time) if the new research vessel is not in full operation yet in 2018. The two IceCATs that were deployed in 2016 on F17 and F13B were torn off very early in the deployment already (10 days), but one of them was still hanging on the mooring with 2 weak links and may be deployed next year after service with Seabird. All other instruments were recovered. Some SBE37s showed bad data quality. Both recoveries and deployments went extremely smooth since there was no sea ice at all in the EGC.

3.1 Moorings recovered

Mooring	Position	Depth (m)	Date and time (UTC)	Instrument	Serial #	Instrument depth (m)
F11-18	N 78° 48.998' W 03° 01.559'	2465	Deployed: 10 Sept 2016, 09:20 Recovered: 26 Aug 2017, 06:41	IPS **SBE37** ADCP **SBE37** RCM9 **SBE37** RCM11 **SBE37** RCM8 AR861	**51062** **3490** 17461 **4702** 1324 **3552** 494 **8821** 10071 287	55 **57** 59 **270** 273 **1551** 1554 **2454** 2455 2458

F12-18	N 78° 49.156' W 04° 00.427	1849	Deployed: 9 Sept 2016, 13:29 Recovered: 26 Aug 2017, 13:00	**IPS4** **SBE37** ADCP **SBE37 (new)** **SBE37** RCM Seaguard **SBE37** RCM11 **SBE37** RCM11 AR861	**1047** **3489** 17462 **14097** **4837** 884 **3554** 235 **8822** 228 182	**60** **62** 66 **~150** **280** 283 **1488** 1490 **1832** 1835 1839
F13-18	N 78° 50.283' W 04°59.191'	1036 (too deep)	Deployed: 8 Sept 2016, 17:20 Recovered: 27 Aug 2017, 06:24	**IPS** **SBE37** ADCP AURAL **SBE37** **SBE37** RCM9 **SBE37** RCM11 AR861	**51064** **7056** 16831 n/a **12232** **3993** 1327 **3551** 561 053	**65** **70** 75 100 **172** **272** 252 **1024** 1026 1030
F13B-3	N 78° 50.266' W 05° 30.873'	526	Deployed: 8 Sept 2016, 09:06 Recovered: 27 Aug 2017, 10:28	**SBE37-IM** weak link ICEBOX ADCP **SBE37** **SBE37** RCM7 **SBE37** AR661	**13506** 11435 727 **12234** **12233** 9464 **10295** 291	**26** 58 60 **63** **102** 104 **154** 519
F14-18	N 78° 48.861' W 06° 30.074'	271	Deployed: 7 Sept 2016 13:23 Recovered 28 Aug 2017, 06:18	**IPS** **SBE37** ADCP **SBE37 (new)** **SBE56 (new)** **SBE56 (new)** **SBE37** RCM9 AR861	**51127** **3492** 16876 **14098** **3943** **3942** **3992** 1046 506	**58** **62** 66 **102** **197** **227** **257** 261 265
F17-13	N 78° 50.179' W 08° 04.913'	225	Deployed: 7 Sept. 2016 09:08 Recovered 28 Aug 2017, 12:36	**SBE37-IM** weak link **SBE16** **SBE37** ADCP ICEBOX **SBE16** **SBE56 (new)** **SBE37** AR661	**13507** **6693** **2962** 7636 n/a **6694** **3944** **7062** 110	**25** **55** **75** 106 108 **110** **190** **210** 218

Table 2: *Moorings recovered during FS2017.*

3.1.1 Notes on instrument failures or errors in data recovery

- **<u>IceCat at F13B</u>** survived by having 2 weak links to it, and 1 weak link to the float. But since it was at ~9 m depth, deployed too shallow (!) it only measured there for only 10 days until the top float was broken off and it dropped to a depth of ~60 dbar for the rest of the deployment. At least it was saved and may be used again next year. Since the P data appeared corrupted after some months the P sensor is broken --> it need to be send for repair and calibration to SBE

- **<u>IceCAT at F17</u>** was lost. Just like the one at F13B it only had near surface data for ~ 11 days before it broke off. Data files appeared weird: there were .dat and .imm files (like there should be) but also .daz and .imz (zipped). Not clear why those were saved -> data logger?

- **<u>SBE37 SN 8821</u> (F11, bottom)** had a <u>drift and offset in S</u>. Bad C cell. A post-calibration dip on the CTD was done at CTD station 101with 10 three-minute stops at depths between 2100 and 15 m.

- **<u>SBE37 SN 14097</u> (F12, 150 m)** had a <u>bad P sensor, needs repair.</u> Pressure derived from the upper Microcat at 60 m.

- **<u>SBE37 SN 12234</u> (F13B, 50 m)** had <u>bad S data for some weeks in July</u>. C sensor likely got clogged. Removed this period with bad S from processed data file.

3.2 Moorings deployed during FS2017

Mooring	Position	Depth (m)	Date and time (UTC)	Instrument	Serial #	Instrument depth (m)
F10-14	N 78° 49.624' W 01° 57'.048	2650	Deployed: 8 Sept 2017, 12:23 UTC	ADCP RCM7 **SBE37** RCM Seaguard **SBE37** **SBE37** RCM8 AR861	16831 1175 **13253** 1846 **14100** 8227 12733 1424	50 52 **55** 251 **253** **2642** 2645 2647
F11-19	N 78° 49.147' W 03° 3.189'	2453	Deployed: 9 Sept 2017, 18:42 UTC	IPS **SBE37** ADCP **SBE37** RCM9 **SBE37** RCM11 **SBE37** RCM Seaguard AR861	**51062** **3492*** 18070 **3996** 1049 **7061** 538 **8226** 834 499	55 **57** 59 **270** 273 **1540** 1542 **2442** 2445 2450
F12-19	N 78° 49.283' W 04° 01.373	1842	Deployed: 9 Sept 2017, 09:05 UTC	**IPS5** **SBE37** ADCP **SBE37** RCM9 **SBE37** RCM11 **SBE37** RCM11 AR861	**51167** **7055** 18151 **3994** 836 **13505** 556 **10294** 117 500	**60** **62** 66 **280** 283 **1488** 1490 **1830** 1832 1835

13-19	N 78° 50.324' W 05°00.146'	1022	Deployed: 6 Sept 2017, 13:45 UTC	**IPS** ADCP **SBE16** AURAL **SBE37** **SBE37** RCM9 **SBE37** RCM Seaguard AR861	**51064** 20021 **7253** N/A **3995** **7060** 1326 **13504** 345 743	**52** 55 **58** 75 **145** **245** 252 **997** 1000 1010
F13B-4	N 78° 50.260' W 05° 30.926'	524 m	Deployed: 6 Sept. 2017, 09:43 UTC	**SBE37-IM weak link** ICEBOX ADCP **SBE37** **SBE37** RCM Seaguard **SBE37** AR661	**15910** n/a 17462 **9853** **9852** 883 **7059** 410	**25** 58 60 **63** **102** 104 **160** 510
F14-19	N 78° 48.848' W 06° 30.058'	273	Deployed: 5 Sept 2017, 13:47 UTC	**IPS** **SBE37** ADCP **SBE56** **SBE56** **SBE37** RCM9 AR861	**51127** **7058** 24385 **3943** **3942** **7057** 1325 568	**58** **62** 66 **197** **227** **257** 261 265
F17-14	N 78° 50.186' W 08° 4.892'	226	Deployed: 5 Sept 2017, 10:26 UTC	**SBE16** **SBE37** ADCP **SBE16** **SBE56** **SBE37** AR661	**7212** **13252** 17461 **7339** 3944 **14099** 501	**55** **75** 100 **105** **190** **210** 218

Table 2: *Moorings deployed during FS2017.*

**** Note: SBE37 sn 3492 was redeployed after 2016-2017 (i.e. not calibrated in 2017)***

3.2.1 ADCP calibrations

The ADCPs that were deployed on the moorings in 2017 were all calibrated prior to deployment. That was done either on land (in Tromsø in June) or on land-fast ice during the cruise. This was the first time that all were fully and successfully calibrated prior to deployment since there were more ADCPs to change out and since there was time and good land-fast ice during the cruise to do the remaining ADCPs during the cruise.

F17	F14	F13B	F13	F12	F11	F10
SN 17461	SN 24385	SN 17462	SN 20021	SN 18151	SN 18070	SN 16831
Recovered on FS2017. Land fast ice calibration	New ADCP (lithium) Calibration in Longyear ICE TRACK*	Recovered on FS2017. Land fast ice calibration	ADCP Ex Statoil (3xalkaline) Calibration in Tromsø BOTTOM TRACK	ADCP Ex Statoil (3xalkaline) Calibration in Tromsø BOTTOM TRACK	ADCP Ex Statoil (3xalkaline) Calibration in Tromsø BOTTOM TRACK	Recovered on FS2017. Land fast ice calibration Added RCM since error > 5°
error after cal: 2.9°	error after cal: 2.3°	error after cal: 3.2°	error after cal: 2.5°	error after cal: 1.1°	error after cal: 2.2°	error after cal: 5.8°

* Programming of BT track did not work on board to start despite the newly purchased & installed firmware.

4. CTD Measurements

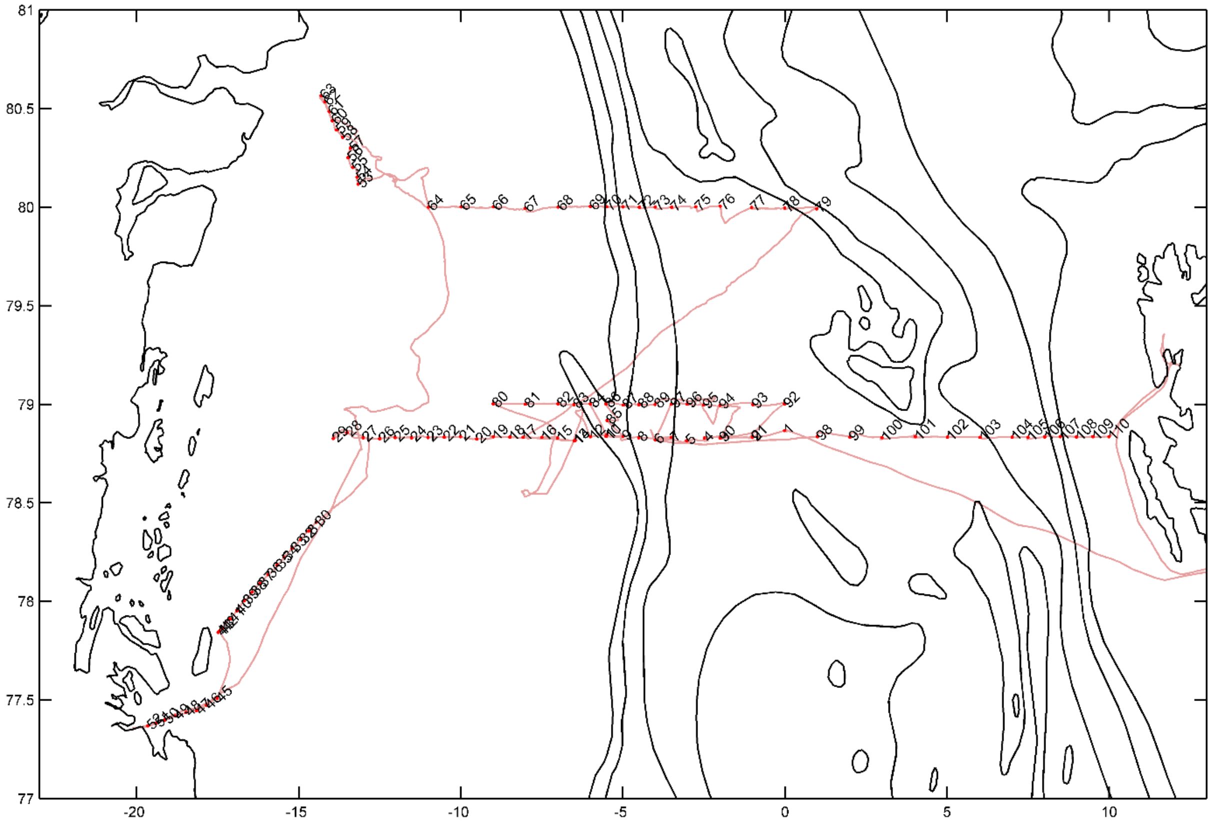


Figure 4.1 *CTD stations during FS2017*

4.1 General Approach

The CTD used was an SBE911+ unit. 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 starting times were automatically added to the header of all data files.

A paper log sheet was completed at each CTD station. Log sheets list the depths at which bottles were fired and the samples taken from each bottle. Times 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 logged time and position data. There were no problems with navigation data during the cruise.

4.2 CTD Package Configuration

Channel	Sensor	Serial Number	Last Calibration
Frequency	Temperature	2400	11-Apr-17
Frequency	Conductivity	3234	12Apr-17
Frequency	Pressure	0972	20-Feb-14
Frequency	Temperature 2	4052	31-Mar-17
Frequency	Conductivity 2	3447	12-Apr-17

A/D Voltage 0	SBE43 Oxygen	3483* 1740 (stns 17-end)	01-Dec-16 (stns 0-17) 27-Apr-17 (stns 17-end)
A/D Voltage 1	SBE43 Oxygen 2	3481*	01-Dec-16
A/D Voltage 2	Transmissometer	CST-1306DR	18-Dec-15
A/D Voltage 3	Flourometer (Chlorophyll)	FLRTD-1547	4-Jan-16
A/D Voltage 4	Fluorometer (CDOM)	FLCDRTD-1930	3-Des-2015
A/D Voltage 6	Altimeter	48701	08-Jan-2010
Spar Voltage	SPAR	20349	12-9-2015

* TRIMODAL oxygen sensors

The primary oxygen sensor was replaced between stations 017 and 018 because it had begun to drift. Other than this, the package configuration was not altered during the cruise.

4.3 CTD sections

Very open drift ice conditions on the East Greenland Shelf allowed Lance to move along six sections during the cruise (Figure 4.1). Station times and the types of samples collected are summarized in Table 4.1:

1.
2. **Main Fram Strait Section (Figure 4.2):** An east-west section along the Fram Strait mooring array line at 78º 50 N, which is repeated annually. During Fram Strait 2017, stations were completed between 009 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. Figure 4.2 shows hydrographic measurements collected along the Main Fram Strait Section.

3. **Isle de France Section (Figure 4.3):** A high-resolution section across the Belgica-Norske Trough on the East Greenland continental shelf close to Isle de France. This section begins at the tip of Isle de France and crosses the complete trough. The section was completed in 2013, 2014, 2015 and 2016 as well as during FS2017.

4. **Skjaerfjord Section (Figure 4.4):** A section along the axis of Skaerfjord. 2017 is the first year data have been collected from skjaerfjord during a Fram Strait cruise. Figure 4.4 shows the data collected along the Skjaerfjord section.

5. **Westwind Trough Section (Figure 4.5):** A high-resolution section across the northern part of the Belgica-Norske Trough on the East Greenland continental shelf. This section is in a similar location to sections completed in 2011 and 2015. Heavy ice in the region prevented an exact repeat.

6. **80N section (Figure 4.6):** An east-west section across Fram Strait at 80 N, permitted by exceptionally open ice conditions.

7. **79N section (Figure 4.7):** An east-west section across Fram Strait at 79 N. Comparison of 78 50'N, 79 N and 80 N sections will be used to estimate the impact of completing the CTD section at different latitudes in different years.

Station	Date (UTC)	Time (UTC)	Depth	Lab sal	d18O	Nuts	AT-CT	CDOM	Winkler	Lig nin	127I	129I	d15N	dSi
1	25-Aug-2017	08:40	2605 m	11	11	11	11	11	-	8	9	7	11	11
2	25-Aug-2017	14:38	2635 m	11	11	11	-	-	-	-	9	7	-	-
3	25-Aug-2017	19:14	2708 m	11	11	11	11	11	-	-	9	7	11	-
4	25-Aug-2017	23:23	2640 m	11	11	11	-	-	-	-	-	-	-	-
5	26-Aug-2017	08:32	2526 m	11	11	11	11	11	-	-	9	7	11	11
6	26-Aug-2017	14:28	1893 m	10	11	11	11	10	-	7	8	6	10	-
7	26-Aug-2017	16:59	2288 m	11	11	11	-	-	-	-	-	-	11	-
8	26-Aug-2017	20:23	1475 m	11	11	11	-	-	-	-	-	-	-	-
9	27-Aug-2017	07:37	1045 m	11	11	11	11	11	-	-	10	7	11	11
10	27-Aug-2017	11:25	535 m	10	10	10	-	10	10	-	-	-	10	-
11	27-Aug-2017	12:39	535 m	1	1	1	-	1	1	-	-	-	1	2
12	27-Aug-2017	13:33	347 m	10	10	10	10	10	-	7	8	7	10	-

13	28-Aug-2017	07:09	273 m	-	-	-	-	-	-	-	-	-	-	-
14	28-Aug-2017	07:47	276 m	10	10	10	-	-	-	-	-	-	-	-
15	28-Aug-2017	09:31	242 m	9	9	9	9	9	-	-	8	6	9	9
16	28-Aug-2017	10:57	188 m	-	-	-	-	-	-	-	-	-	-	-
17	28-Aug-2017	13:20	228 m	9	9	9	9	9	-	8	8	6	-	-
18	28-Aug-2017	14:21	271 m	-	-	-	-	-	-	-	-	-	-	-
19	28-Aug-2017	15:38	235 m	9	9	9	9	9	-	-	8	5	9	-
20	28-Aug-2017	21:43	189 m	-	-	-	-	-	-	-	-	-	-	-
21	28-Aug-2017	22:50	275 m	10	10	10	10	10	-	8	9	6	10	10
22	29-Aug-2017	00:02	364 m	-	-	-	-	-	-	-	-	-	-	-
23	29-Aug-2017	01:16	326 m	9	9	9	9	9	-	-	8	5	-	-
24	29-Aug-2017	02:28	225 m	-	-	-	-	-	-	-	-	-	-	-
25	29-Aug-2017	03:28	194 m	8	8	8	8	8	-	8	7	4	8	8
26	29-	04:40	186 m	-	-	-	-	-	-	-	-	-	-	-

	Aug-2017													
27	29-Aug-2017	06:03	200 m	8	8	8	8	8	-	-	7	3	-	-
28	29-Aug-2017	07:27	134 m	-	-	-	-	-	-	-	-	-	-	-
29	29-Aug-2017	08:51	86 m	-	5	5	5	5	-	-	-	2	5	-
30	30-Aug-2017	05:13	104 m	-	-	-	-	-	-	-	-	-	-	-
31	30-Aug-2017	06:19	131 m	-	-	-	-	-	-	-	-	-	-	-
32	30-Aug-2017	07:20	85 m	5	5	5	5	5	-	-	-	-	5	-
33	30-Aug-2017	08:14	122 m	-	-	-	-	-	-	-	-	-	-	-
34	30-Aug-2017	09:02	224 m	-	-	-	-	-	-	-	-	-	-	-
35	30-Aug-2017	09:54	341 m	10	10	10	-	10	-	-	-	-	-	-
36	30-Aug-2017	10:57	424 m	-	-	-	1	-	-	-	-	-	-	-
37	30-Aug-2017	12:01	479 m	-	-	-	-	-	-	-	-	-	-	-
38	30-Aug-2017	12:58	-	11	11	11	11	11	-	-	-	-	11	11
39	30-Aug-	14:11	476 m	-	-	-	-	-	-	-	-	-	-	-

	2017													
40	30-Aug-2017	15:07	398 m	10	10	10	10	10	-	-	-	-	10	-
41	30-Aug-2017	16:20	331 m	-	-	-	-	-	-	-	-	-	-	-
42	30-Aug-2017	17:19	274 m	-	-	-	-	-	-	-	-	-	-	-
43	30-Aug-2017	17:56	256 m	-	-	-	-	-	-	-	-	-	-	-
44	30-Aug-2017	18:26	141 m	7	7	7	7	7	-	-	-	-	7	7
45	30-Aug-2017	21:18	366 m	-	-	-	-	-	-	-	-	-	-	-
46	30-Aug-2017	22:25	312 m	-	-	-	-	-	-	-	-	-	-	-
47	30-Aug-2017	23:18	215 m	-	-	-	-	-	-	-	-	-	-	-
48	31-Aug-2017	00:13	209 m	-	-	-	-	-	-	-	-	-	-	-
49	31-Aug-2017	01:06	191 m	-	-	-	-	-	-	-	-	-	-	-
50	31-Aug-2017	02:57	109 m	-	-	-	-	-	-	-	-	-	-	-
51	31-Aug-2017	03:40	118 m	-	-	-	-	-	-	-	-	-	-	-
52	31-Aug-2017	04:47	-	9	9	9	9	9	-	-	-	-	-	-

53	02-Sep-2017	06:09	69 m	-	-	-	-	-	-	-	-	-	-	-
54	02-Sep-2017	06:45	133 m	-	-	-	-	-	-	-	-	-	-	-
55	02-Sep-2017	08:02	168 m	-	-	-	-	-	-	-	-	-	-	-
56	02-Sep-2017	08:49	171 m	-	-	-	-	-	-	-	-	-	-	-
57	02-Sep-2017	10:42	239 m	9	9	9	9	9	-	-	9	1	9	-
58	02-Sep-2017	13:04	296 m	10	10	10	-	-	-	-	-	-	-	-
59	02-Sep-2017	14:21	288 m	10	10	10	10	10	-	-	10	1	10	-
60	02-Sep-2017	15:17	337 m	10	10	10	-	-	-	-	-	-	-	-
61	02-Sep-2017	16:06	294 m	10	10	10	10	10	-	-	10	1	10	-
62	02-Sep-2017	17:03	181 m	8	8	8	-	-	-	-	-	-	-	-
63	02-Sep-2017	17:49	178 m	-	-	-	-	-	-	-	-	-	-	-
64	03-Sep-2017	11:10	112 m	-	-	-	-	-	-	-	-	-	-	-
65	03-Sep-2017	12:32	96 m	-	-	-	-	-	-	-	-	-	-	-
66	03-	13:46	296 m	-	-	-	-	-	-	-	-	-	-	-

	Sep-2017													
67	03-Sep-2017	15:39	208 m	-	-	-	-	-	-	-	-	-	-	-
68	03-Sep-2017	17:29	313 m	-	-	-	-	-	-	-	-	-	-	-
69	03-Sep-2017	18:51	329 m	-	-	-	-	-	-	-	-	-	-	-
70	03-Sep-2017	19:43	760 m	-	-	-	-	-	-	-	-	-	-	-
71	03-Sep-2017	21:02	1263 m	-	-	-	-	-	-	-	-	-	-	-
72	03-Sep-2017	22:42	1708 m	-	-	-	-	-	-	-	-	-	-	-
73	04-Sep-2017	00:32	2090 m	-	-	-	-	-	-	-	-	-	-	-
74	04-Sep-2017	02:33	2348 m	-	-	-	-	-	4	-	-	-	-	-
75	04-Sep-2017	05:42	2630 m	-	-	-	-	-	-	-	-	-	-	-
76	04-Sep-2017	08:41	2783 m	-	-	-	-	-	4	-	-	-	-	-
77	04-Sep-2017	16:48	-	-	-	-	-	-	-	-	-	-	-	-
78	04-Sep-2017	18:31	-	-	-	-	-	-	-	-	-	-	-	-
79	04-Sep-	20:21	-	-	-	-	-	-	-	-	-	-	-	-

	2017													
80	06-Sep-2017	02:13	262 m	-	-	-	-	5	-	-	-	-	-	-
81	06-Sep-2017	03:37	189 m	-	-	-	-	-	-	-	-	-	-	-
82	06-Sep-2017	05:10	255 m	-	-	-	-	-	-	-	-	-	-	-
83	06-Sep-2017	06:06	291 m	-	-	-	-	-	-	-	-	-	-	-
84	06-Sep-2017	07:03	564 m	-	-	-	-	-	-	-	-	-	-	-
85	06-Sep-2017	15:02	799 m	-	-	-	-	-	-	-	-	-	-	-
86	06-Sep-2017	17:04	941 m	-	-	-	-	-	-	-	-	-	-	-
87	06-Sep-2017	19:02	-	-	-	-	-	-	-	-	-	-	-	-
88	06-Sep-2017	21:12	-	-	-	-	-	-	-	-	-	-	-	-
89	06-Sep-2017	23:11	-	-	-	-	-	-	-	-	-	-	-	-
90	08-Sep-2017	06:10	2705 m	-	-	-	-	-	-	-	-	-	-	-
91	08-Sep-2017	13:59	2469 m	-	-	-	-	-	-	-	-	-	-	-
92	08-Sep-2017	17:19	-	-	-	-	-	-	-	-	-	-	-	-

93	08-Sep-2017	19:08	-	-	-	-	-	-	-	-	-	-	-	-
94	08-Sep-2017	21:05	-	-	-	-	-	-	-	-	-	-	-	-
95	08-Sep-2017	22:43	-	-	-	-	-	-	-	-	-	-	-	-
96	09-Sep-2017	00:07	-	-	-	-	-	-	-	-	-	-	-	-
97	09-Sep-2017	01:33	-	-	-	-	-	-	-	-	-	-	-	-
98	09-Sep-2017	23:26	2494 m	11	11	11	-	-	-	-	9	7	-	-
99	10-Sep-2017	02:34	2538 m	11	11	11	11	11	-	8	9	9	11	-
100	10-Sep-2017	05:51	2457 m	11	11	11	-	-	5	-	-	-	-	-
101	10-Sep-2017	09:05	2332 m	11	11	11	11	11	-	-	-	-	11	11
102	10-Sep-2017	13:20	2692 m	11	11	11	-	-	-	-	-	-	-	-
103	10-Sep-2017	17:06	2440 m	11	11	11	11	11	-	-	9	-	11	-
104	10-Sep-2017	20:17	1423 m	11	11	11	11	11	-	-	-	-	11	11
105	10-Sep-2017	22:10	1156 m	11	11	11	-	-	-	-	-	-	11	11
106	11-	00:11	1017	11	11	11	11	11	-	-	9	-	11	-

	Sep-2017		m											
107	11-Sep-2017	01:53	591 m	11	11	11	-	-	-	-	-	-	-	-
108	11-Sep-2017	03:08	211 m	8	8	8	8	8	-	-	6	-	8	8
109	11-Sep-2017	04:09	174 m	8	8	8	8	8	-	-	-	-	-	-
110	11-Sep-2017	05:03	66 m	5	5	5	5	5	-	-	5	-	5	5
Total	**-**	**-**	**-**	**431**	**437**	**437**	**280**	**304**	**24**	**54**	**193**	**104**	**268**	**126**

Table 4.1 *Samples collected at each CTD station. N. B. Corrected depths are only available when profiles reached the bottom of the water column.*

4.4 Salinity Sensor Calibration

Water samples for laboratory salinity measurement were collected at most CTD stations. At stations where tracer samples were collected, salinity samples were collected at standard depths of 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 Lance using a Guildline Portasal portable salinometer which was standardised after every 24 measurements using IAPSO P-series standard seawater.

Comparison of laboratory salinity measurements and CTD-salinity measurements revealed an offset of < 0.0007 practical salinity units for the primary sensor group (Figure X). The mean offset between the primary sensor group and the laboratory measurements is, smaller then the precision of laboratory salinity measurements (+/- 0.003) and no correction is made here.

Comparison of laboratory salinity measurements and CTD-salinity measurements revealed an offset of around < 0.0008 practical salinity units for the secondary sensor group (Figure X). The mean offset between the primary sensor group and the laboratory measurements is, smaller then the precision of laboratory salinity measurements (+/- 0.003) and no correction is made here.

Both sets of CTD sensors performed exceptionally well during the cruise. The offsets determined relative to the laboratory salinity measurements are two of the smallest offsets ever determined during a Fram Strait cruise, very small offsets were also determined in 2016.

Dissolved Oxygen Sensor

The secondary oxygen sensor attached to the CTD collected good measurements throughout the cruise. The primary sensor began to behave erratically after station 015, this may be because it was connected with convoluted tubing, which trapped air bubbles. The tubing was straitened after station 015, but this did not rectify the problem, perhaps because the sensor had been affected by highly compress air bubbles in contact with the membrane? The primary sensor was therefore replaced after station 016, with another sensor which collected good data for the remainder of the cruise.

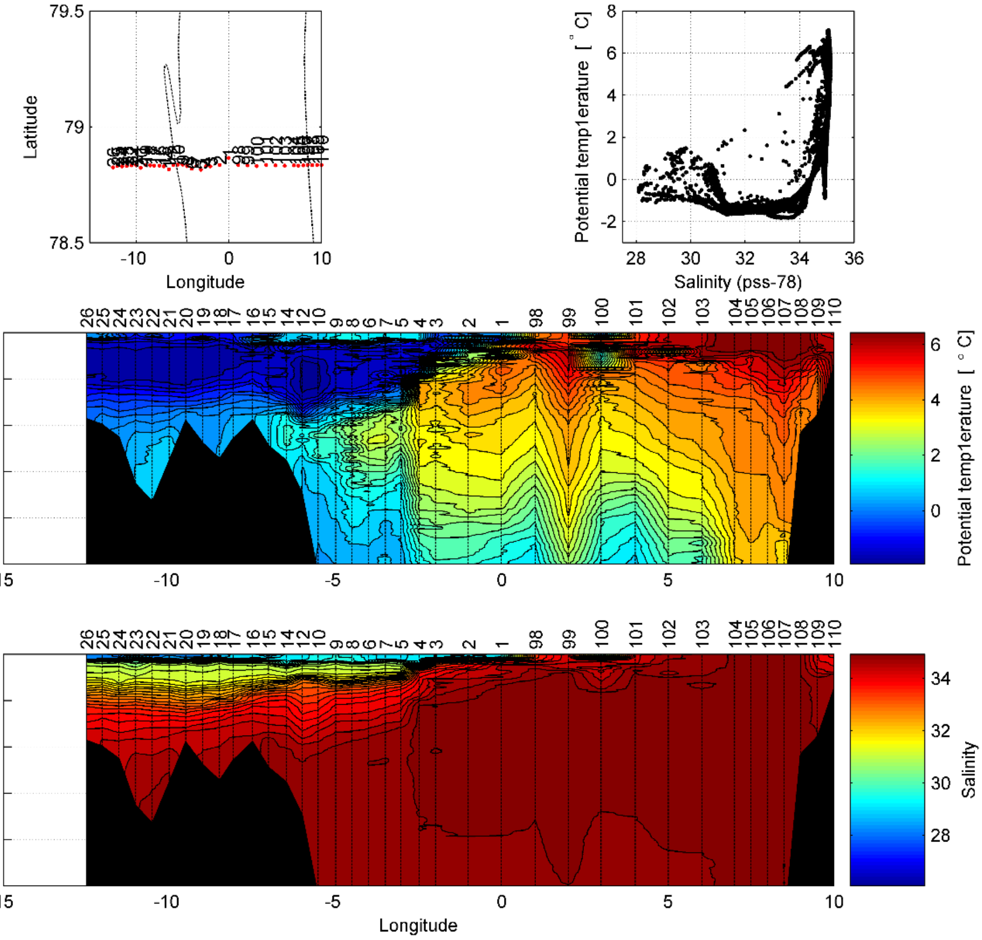


Figure 4.2: *Map showing the locations of CTD stations along the* ***Main Fram Strait Section*** *(top left panel); Measurements from the primary temperature and salinity sensors in θ-S space (top right panel); and sections of potential temperature and salinity (lower 2 panels). Station numbers are indicated above sections.*

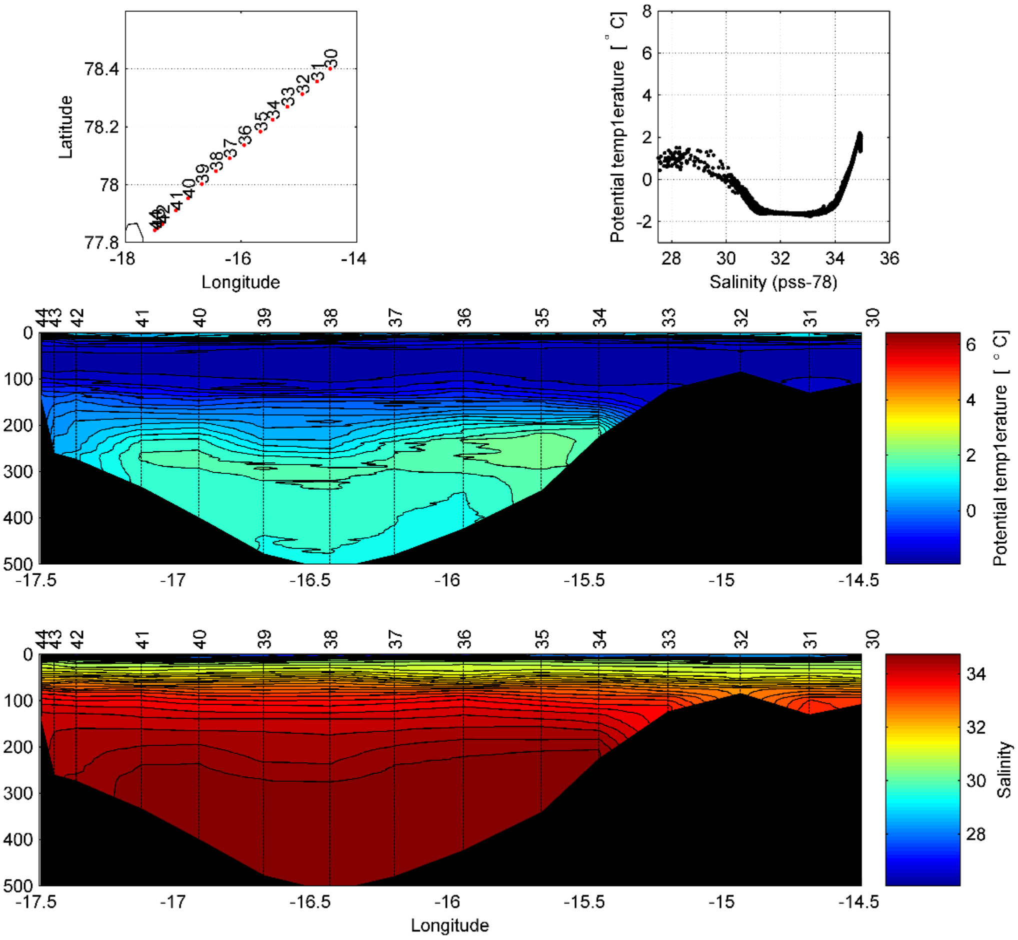


Figure 4.3: *Map showing the location of CTD stations along the **Îsle de France Section** (top left panel); (top left panel); Measurements from the primary temperature and salinity sensors in θ-S space (top right panel); and sections of potential temperature and salinity (lower 2 panels). Station numbers are indicated above sections.*

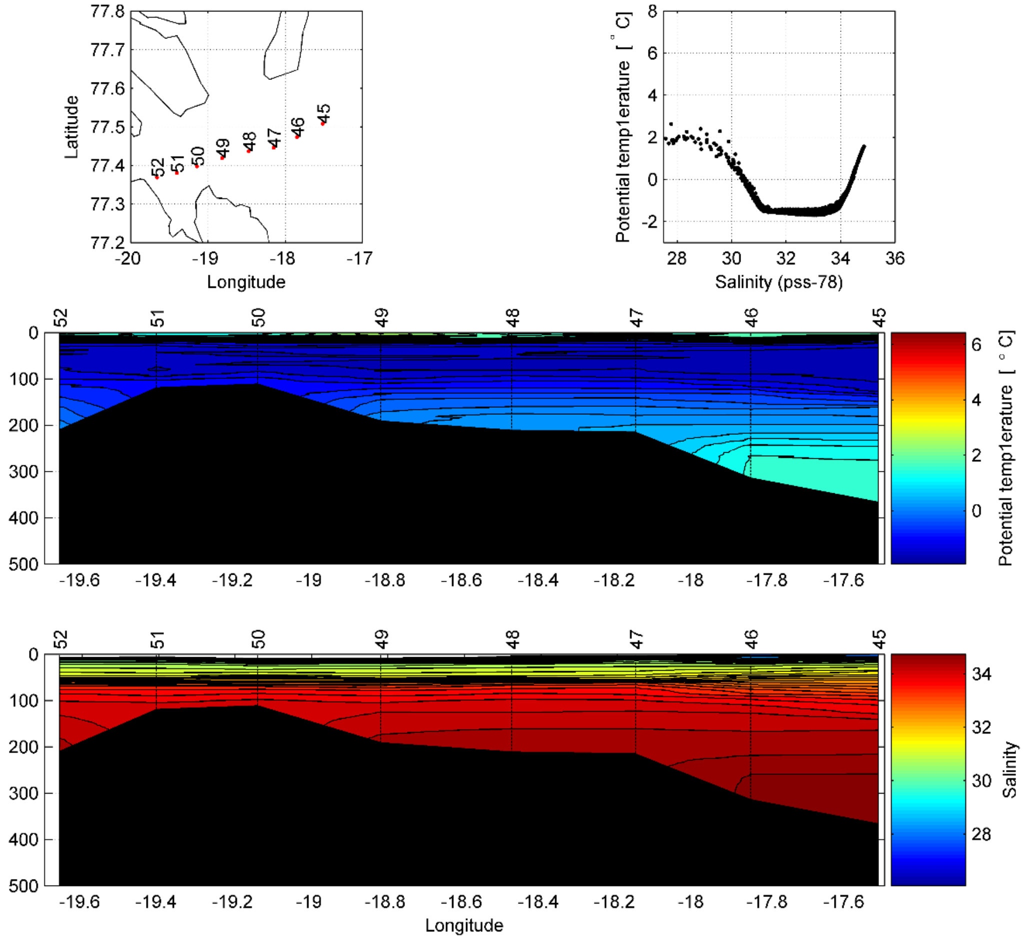


Figure 4.4: *Map showing the location of CTD stations along the* ***Skjaerfjord Section****(top left panel); Measurements from the primary temperature and salinity sensors in θ-S space (top right panel); and sections of potential temperature and salinity (lower 2 panels). Station numbers are indicated above sections.*

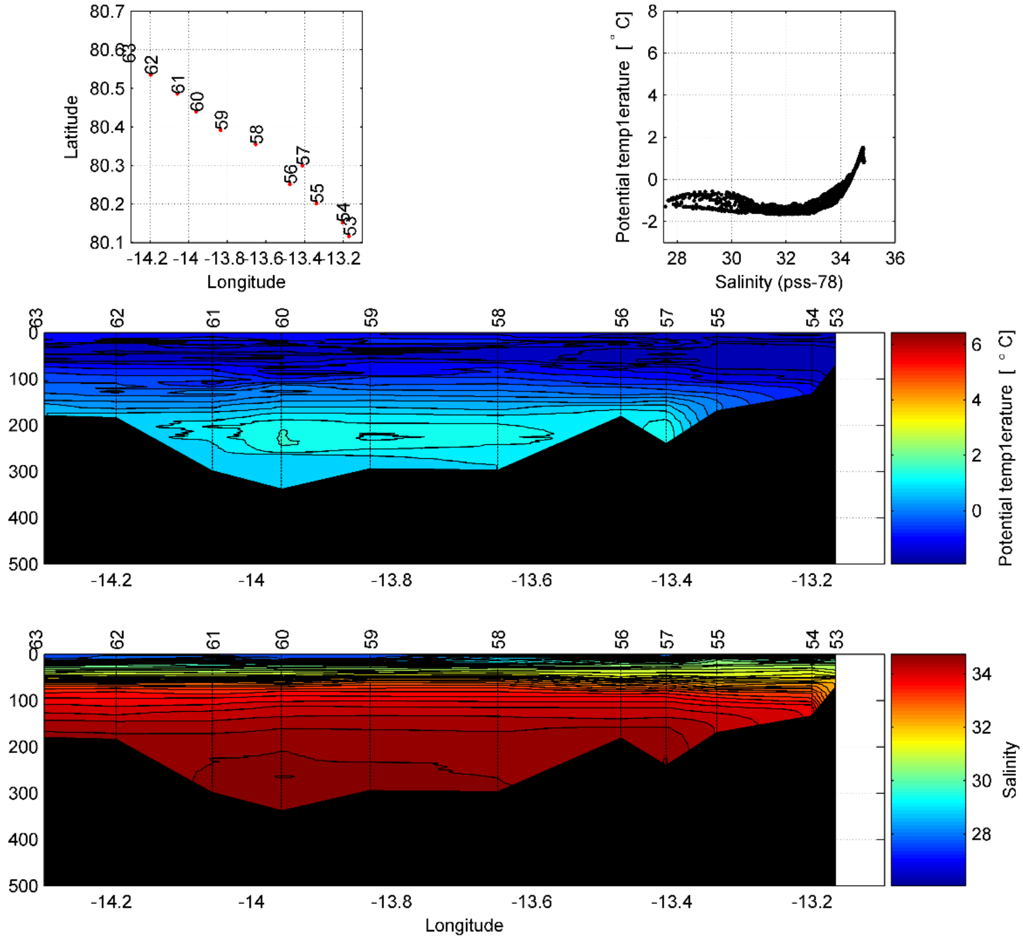


Figure 4.5: *Map showing the location of CTD stations along the* ***Westwind Trough Section****(top left panel); Measurements from the primary temperature and salinity sensors in θ-S space (top right panel); and sections of potential temperature and salinity (lower 2 panels). Station numbers are indicated above sections.*

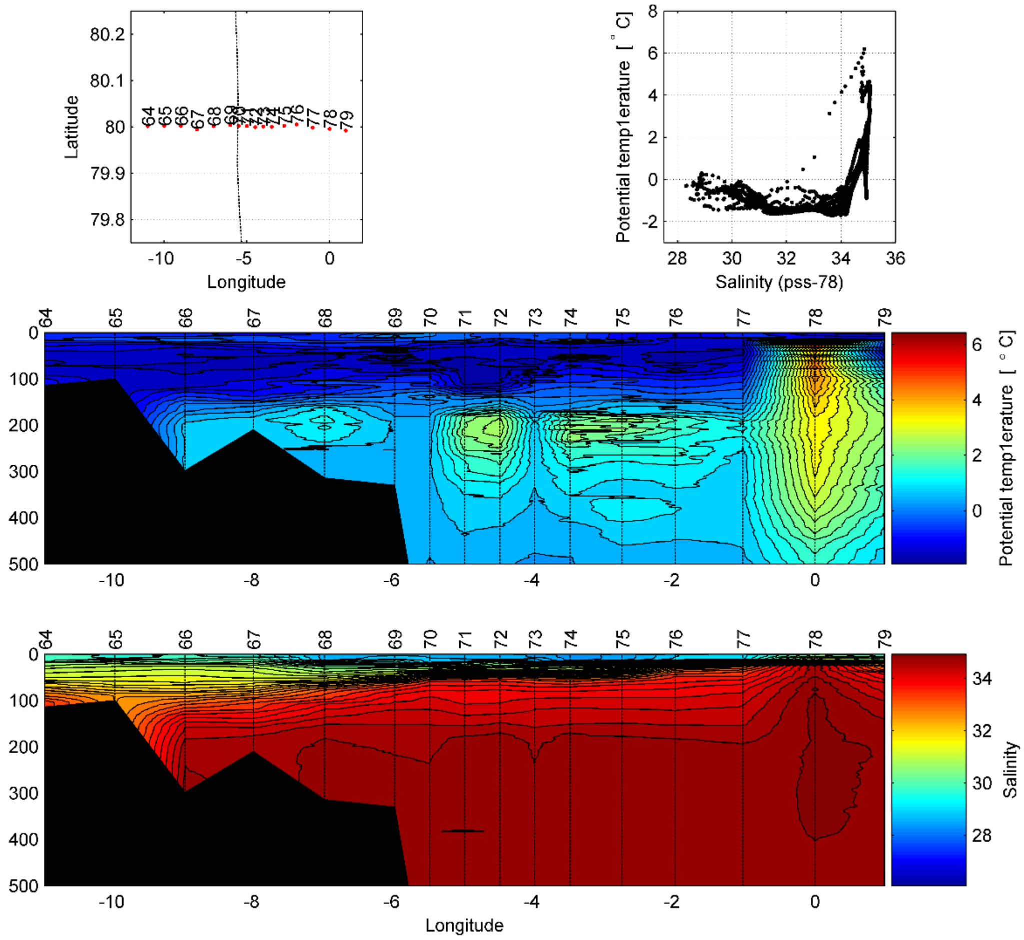


Figure 4.6: *Map showing the location of CTD stations along the* ***80°N section****(top left panel); Measurements from the primary temperature and salinity sensors in θ-S space (top right panel); and sections of potential temperature and salinity (lower 2 panels). Station numbers are indicated above sections.*

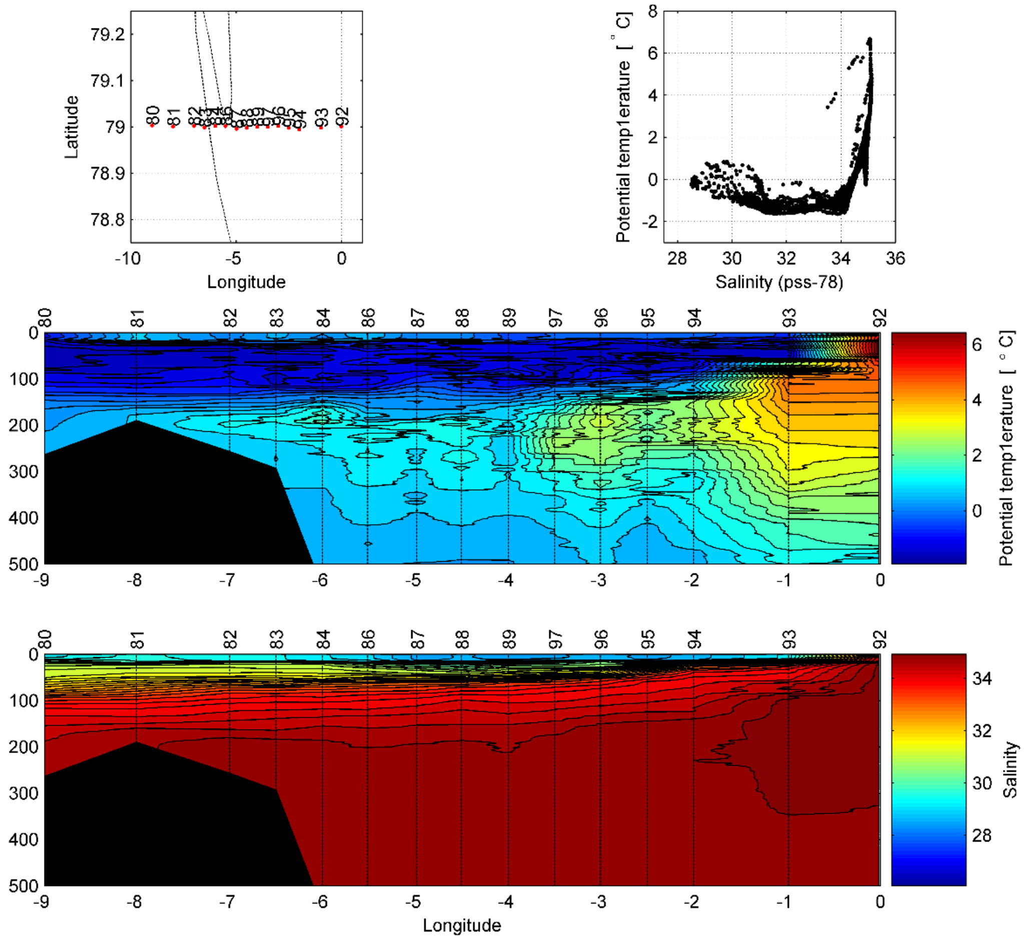


Figure 4.7: *Map showing the location of CTD stations along the* ***79°N section****(top left panel); Measurements from the primary temperature and salinity sensors in θ-S space (top right panel); and sections of potential temperature and salinity (lower 2 panels). Station numbers are indicated above sections.*

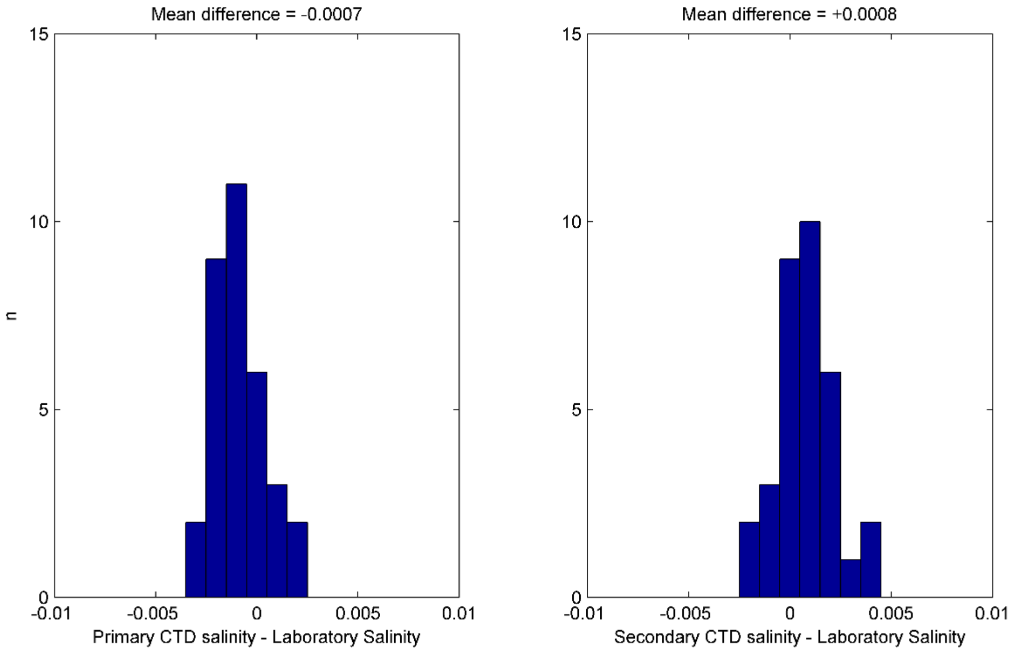


Figure 4.8: *Histograms showing the difference between the primary (left hand panels) and secondary (right hand panels) sensor groups on the CTD and laboratory salinity measurements. Only points deeper than 400 m are considered, due to step salinity gradients close to the surface.*

5. Biogeochemical Sampling

Water samples were collected at standard pressures of 5, 15, 25, 50, 75, 100, 150, 200, 250, 400 dbar and at the bottom of each cast along the main Fram Strait section and at selected stations along the Îsle de France and Westwind Trough sections. The samples collected at each CTD station are listed in table 4.1. Samples were collected in the following order:

1. Dissolved oxygen
2. DIC & Total alkalinity
3. CDOM (Filtered)
4. $\delta^{15}N$ & $\delta^{x}Si$ (Filtered)
5. Iodine speciation (Filtered)
6. $\delta^{18}O$
7. Nutrients
8. Salinity
9. ^{129}I

Dissolved Oxygen: Winkler samples were collected at selected stations to calibrate the SBE 43 dissolved oxygen sensor on the CTD. Samples were always collected in triplicate so that the precision of analysis could be evaluated.

Total alkalinity and dissolved inorganic carbon (A_T & DIC): Samples for $\delta^{18}O$ isotope ratio analysis and dissolved nutrient analysis were always collected when Total Alkalinity and Dissolved Inorganic Carbon samples were collected.

Coloured dissolved organic matter (CDOM): Samples for $\delta^{18}O$ isotope ratio analysis and dissolved nutrient analysis were always collected when CDOM samples were collected.

$\delta^{15}N$ & $\delta^{x}Si$: Samples were collected at selected locations targeting polar and shelf watermasses.

Oxygen isotope ratio analysis and dissolved nutrient analysis: Samples for $\delta^{18}O$ isotope ratio analysis and dissolved nutrient analysis were always collected concurrently.

Laboratory salinity analysis: Samples for laboratory salinity analysis were collected from all Niskin bottles. When the surface of the water column is strongly stratified, the salinity of water trapped in Niskin bottles can be significantly different from that measured by the conductivity sensor at the bottom of the CTD package, which is approximately 1 meter deeper then the top of the Niskin bottles. Independent laboratory salinity measurements give salinity measurements which correspond exactly to the other tracer measurements made from Niskin bottles. Laboratory measurements were made with a Guildline Portasal 8400b salinometer, which was standardized every 24 samples using P-series seawater supplied by OSIL.

^{129}I & iodine speciation: samples were collected at selected locations targeting Atlantic and re-cicrulationg Atlantic water

Niskin bottle operations: The rubber bands which hold the Niskin bottles closed were in good condition at the beginning on the cruise and required no attention during the cruise. The rubber o-rings retaining the taps of several Niskin bottles remained in good working order throughout the cruise.

Tracer samples of sea ice: Ice cores for tracer analysis were collected at most sea ice stations. Cores were collected in duplicate or triplicate so as to allow some assessment of the variability of properties at each site sampled. Loose surface snow was removed before coring. Cores were stored in evacuated air-tight bags and melted within 48 hours of collection, after which the melt water was sub-sampled. Cores were handled with latex or nitrile gloves and an all-plastic syringe was used to extract water from buckets for CDOM sampling. Figure 5.1 shows the location of sites where ice cores for tracer analysis were collected.

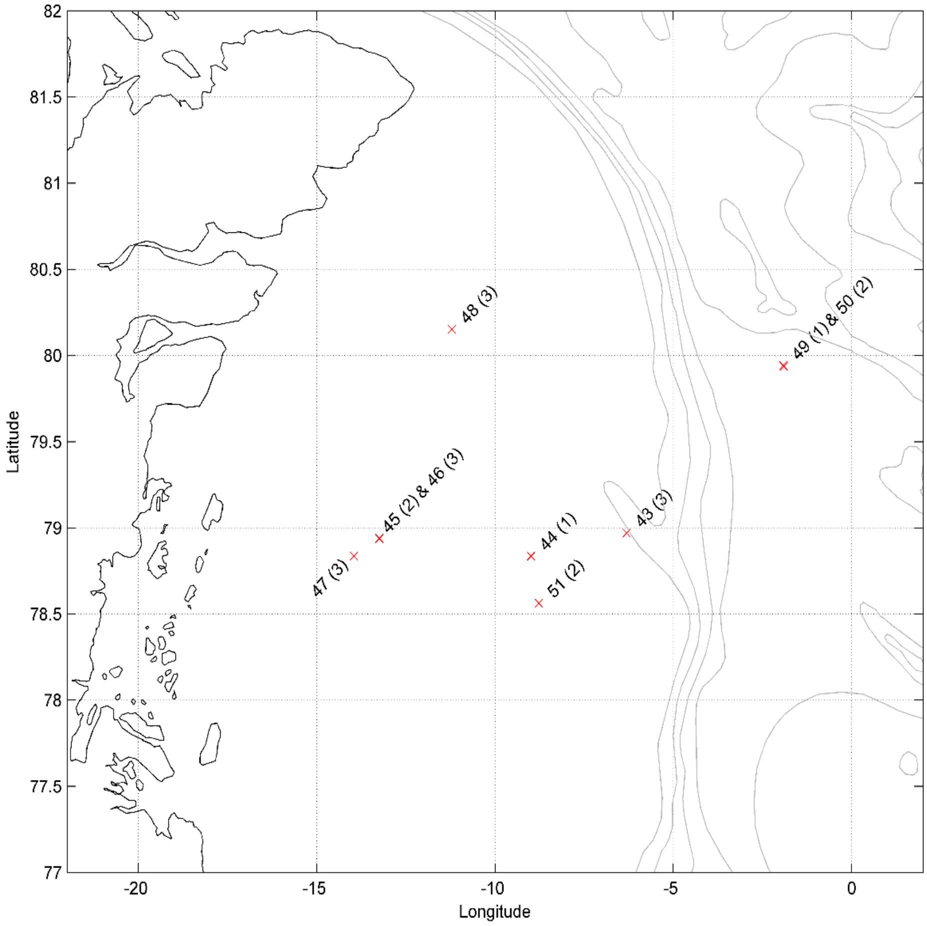


***Figure 5.1**: Locations of sea ice floes where cores were collected for tracer analysis. The first number is a serial number assigned to ice floes from which tracer measurements have been collected. i.e.: tracer measurements have been collected from 51 ice floes in Fram Strait since sampling began in 2013. Numbers in brackets indicate the number of cores collected per floe.*

6. Sea ice observations

Sea ice work on FS2017 was coordinated by Paul Dodd (NPI). Additional team members included Marius Bratrein (NPI), Mikhail Itkin (NPI), and Robert Graham (NPI). In total 7 ice stations were conducted, including one thin ice station. Additional scientists from the CTD watches assisted with on ice operations at each ice station.

6.1 General

Sea ice conditions were unusually low during FS2017. In particular, there was almost no sea ice present in the East Greenland Current, along the main CTD and mooring transect at 78°50'N, on both the outward and return journeys (Figure 6.1). As a result, there were limited opportunities for sea ice stations.

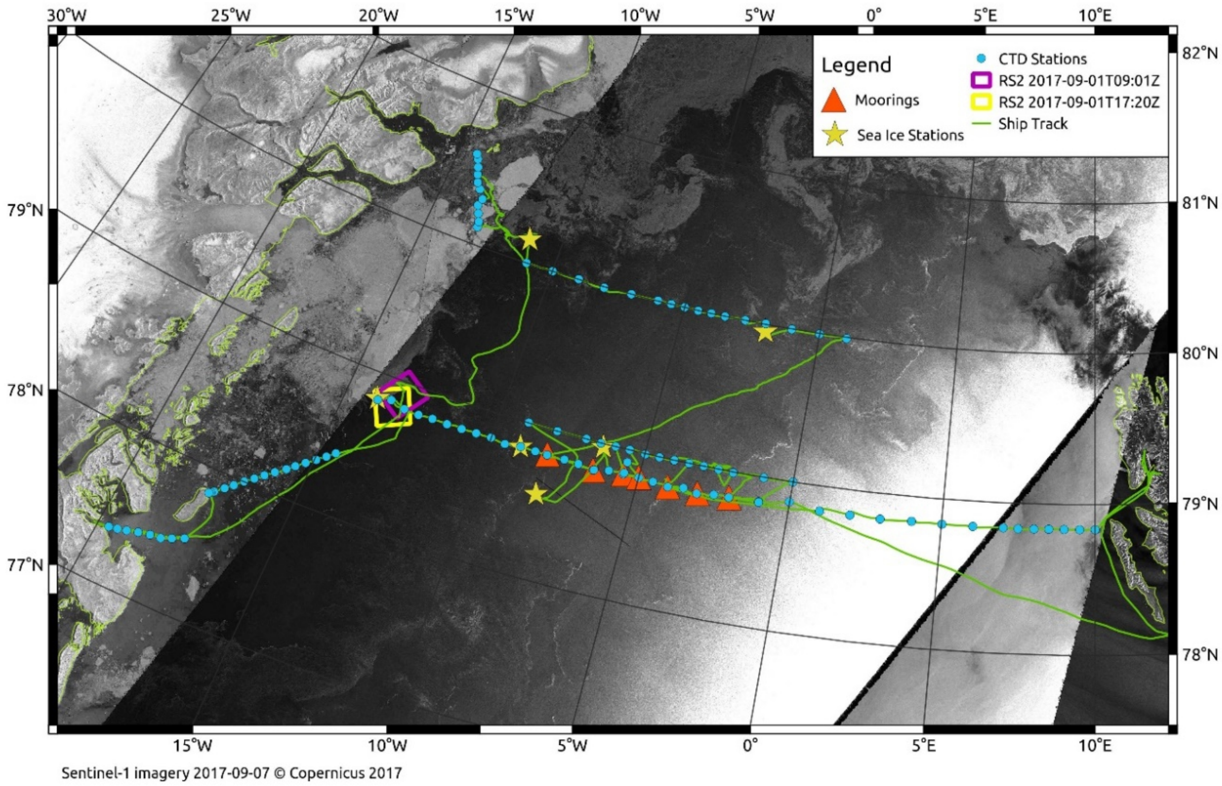


Figure 6.1*: Station map showing the sea ice stations with yellow stars.*

The majority of sea ice observed during the cruise was heavily ridged and deformed multiyear ice. This ice was typically very thick (2 – 4 m) and mainly of small floe sizes (< 100 m). We interpret from this pattern of observations that all of the thinner level ice and first year ice had melted out over the course of the summer. All that remained was these old, broken, thick and deformed pieces of ice.

Very little evidence of surface ice melt was observed for the majority of the cruise. We also did not observe any rotten ice floes. However, there were many small floes of broken ice and brash. Most of the melt ponds we observed were refrozen, and many were covered with fresh snow. A snow layer was observed on all of the floes where ice stations were conducted. On 1/9/2017 there was a significant snowfall event. The modal snow thickness measured with the magnaprobe on Station 3 (29/08/17, 78,50 N / 13,57 W) and Station 4 (02/09/17, 80,09 N / 11,11 W) increased from 4 to 11 cm (Figure 6.2).

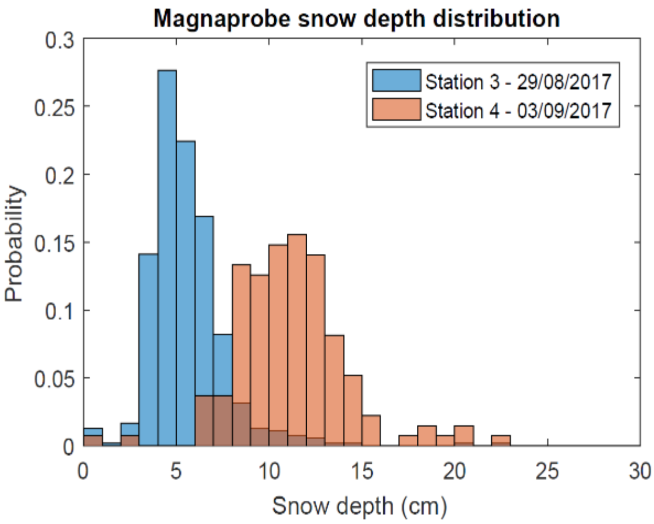


Figure 6.2: *Snow depth distribution*

Air temperatures were below freezing for several days while on the East Greenland Shelf. Associated with these freezing conditions, newly formed thin ice was observed at several locations from 29/08/2017 – 4/09/17. High resolution satellite images were ordered for 1/9/2017 to study this thin ice (Fig 1). In association with these images, in-situ thin ice observations were then conducted using the Man Over Board boat. Visual thin ice observations from the bridge were also recorded every 15 minutes, and a GoPro camera together with GPS were installed on the rear of the ship. Vast sheets of new ice < 5 cm thick were also observed on 2/9/2017 on the Westwind 2 section.

On 7/9/2017 we experienced a substantial storm in the vicinity of our mooring sites. This storm was associated with sustained surface winds above 20 knots for more than 24 hours, and a peak near surface temperature of approximately 5˚C. During this storm, we passed through an area of high ice concentration, seen from the most recent satellite image. The mean floe size in this area was small (~ 20 m) with very thick and deformed ice. Significant melt and erosion from waves was obvious at the surface of these floes with major undercutting on the edges of the floes at the sea level. This created interesting erosional features.

6.2 Ice observations from the bridge (ASSIST)

Sea ice conditions were observed every three hours from the bridge of RV Lance. 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 (visibility, air and water temperature, air pressure, wind speed and direction, and humidity). Digital photos were taken with each observation (3 photos, looking out port, bow, and starboard side).

6.3 Sea ice stations

We conducted 6 ice stations during the cruise. On each of these floes, the ice thickness and freeboard were measured directly by thickness drilling using a Kovacs thickness gauge. The combined ice and snow thickness was also surveyed indirectly using a Geonics EM31-MK2 short. The EM31 was placed on a sledge and pulled over the ice (Photo 1). The data including GPS position was logged at a frequency of 0.5 Hz on an ArcherII field computer. In total there were 21 thickness drillings performed along the EM31 survey line that were used for calibration and validation of these measurements (Figures 6.3 and 6.4).

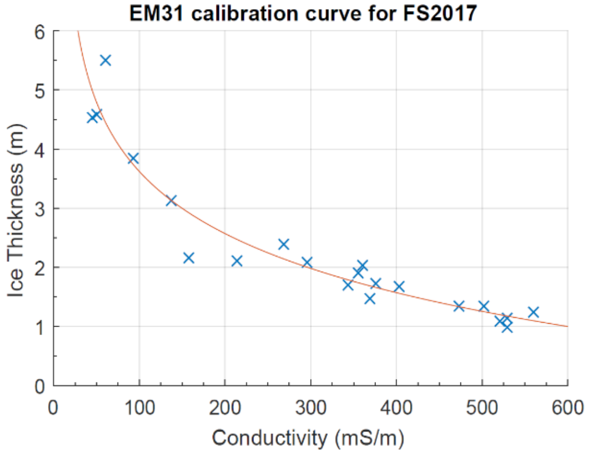


Figure 6.3:*EM31 Calibration curve*

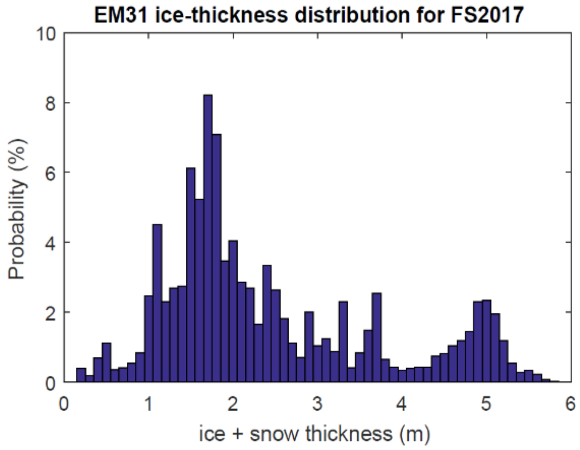


Figure 6.4: *EM31 Thickness distribution*

Together with the EM31 measurements, we measured snow depth along the survey line using a Magnaprobe (Figure 6.5). This consists of a snow probe and GPS and directly records the snow depth and GPS position when prompted by the observer pressing a button. These measurements were recorded approximately every two meters.

Figure 6.5: *Use of the Magnaprobe*

In addition to the ice and snow thickness surveys, multiple ice cores were drilled from a representative site of each floe. These included two cores to measure the temperature and salinity profiles of the ice; one core to be kept for analyses of the ice microstructure; one core bottom for to analyse the sea ice biomarker IP25. One chemistry core to be cut in to 20 cm sections for analyses of salinity, oxygen isotopes, nutrient measurements, carbonate system, and CDOM; and one to three mean tracer cores drilled from different sites across the floe (Table 6.1).

Unfortunately, we were not able to complete the full program of observations at stations 2 and 6 (Table 6.1). On Station 2, the core barrel jammed. This prevented us from drilling a temperature core and collecting a core bottom for the IP25 analyses. On station 6 heavy fog closed in around the ship and the ice station had to be abandoned for safety reasons. Therefore, we were unable to collect an archive core, core bottom for IP25 analyses and a temperature profile.

Station	Date	Time (UCT)	Lat °N	Lon °W	T	S	Chem	Tracer	Archive	IP25	Thickness holes	EM31	Magna probe
1	27/08/17	17:00	78.58	6.23	X	X	X	2	X	X	4		
2	28/08/17	15:32	78.5	9.04		X	X	3	X		6	X	
3	29/08/17	13:00	78.5	13.57	X	X	X	3	X	X	5	X	X
4	03/09/17	07:22	80.09	11.11	X	X	X	3	X	X	5	X	X
5	04/09/17	11:58	79.57	1.57	X	X	X	3	X	X	5	X	X
6	05/09/17	18:05	78.33	8.02		X	X	1			2	X	X

Table 6.1: *Overview of sea ice stations and parameters taken*

6.4 Thin ice observations

In association with the freezing weather conditions observed during long sections of the cruise, areas of newly forming thin ice were observed. Following these observations, UiT ordered two RISAT images for 1/9/2-17 in the region close to our Fast ice station (Station 3) that was made on 29/08/2017. Over the 8 hour window covering the timing of these satellite images ice visual observations were made from the bridge every 15 minutes, paying particular attention to areas of newly formed ice. A GoPro camera and GPS were also installed on the rear of the ship for later reference. Unfortunately, the areal extent of these bridge-based observations were limited by heavy fog and low visibility. Six thin ice stations were also performed in the vicinity of RV Lance using the man over board boat (Figure 6.6). At these stations observations were made of the air, surface and water temperature, sea ice thickness, sea ice salinity and surface water salinity.

Figure 6.6: *thin ice sampling*

6.5 Satellite maps

To assist navigation and planning sea ice stations near real time satellite maps have been produced in a semi-automatic manner. The system consists of several modules that automatically search and deliver compressed and mosaicked satellite scenes via Iridium connection on-board Lance. The observations have been sent twice daily. After delivering the satellite image to Lance a map is produced manually using QGIS software. The system relies on the availability of the Sentinel-1 imagery distributed either via the Copernicus Scihub satellite portal (https://scihub.copernicus.eu) or the national satellite hub (https://colhub.met.no). For the specific dates 10 Radarsat-2 ScanSar Wide scenes have been ordered, processed and sent to Lance by Are Bjørdal. This was done in case no Sentinel-1 observations would have been available. All satellite observations for the previous 12 hour period have been aggregated and resampled to the regular spatial grid that covers Fram Strait area at 150 meters resolution. The resulting images were JPEG compressed to reduce the size of the transferred files to 2 MB or less. The core component of the system that performs satellite imagery search and delivery can be obtained at: https://github.com/npolar/satmaps.git

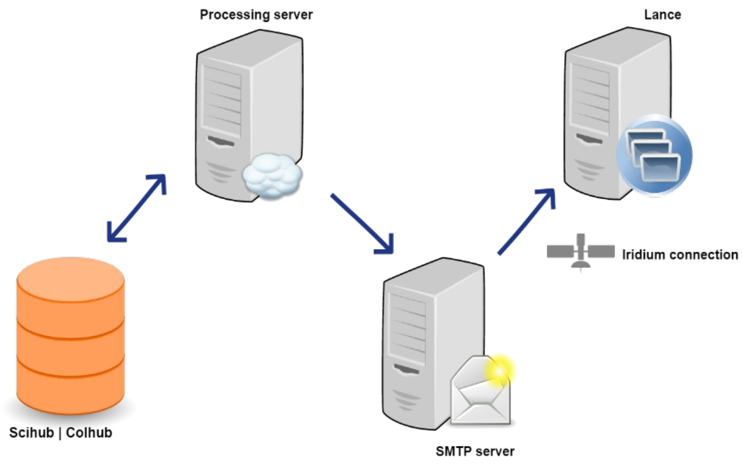


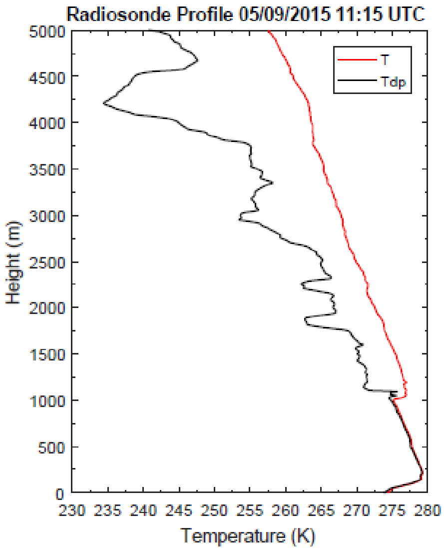
Figure 6.7: *The workflow of the satellite sea-ice map production process*

7. Radiosondes

2017 was the first year that we have launched radiosondes during the Fram Strait cruise. In total, we launched 28 radiosondes. These collected atmospheric observations of temperature, humidity, pressure, wind speed and direction, up to a maximum altitude of 28 km. In accordance with directions from the World Meteorological Organisation, the weather balloons were released daily from the ship at 11:00 UCT, such that the ascent was completed at 12:00 UCT. During the middle phase of the cruise, while closer to Greenland and in heavier ice conditions, a second radiosonde was released each day at 23:00 ECT.

The launching of radiosondes during Fram Strait was coordinated by Robert Graham (NPI). Data from the radiosondes was sent back to the ship and retrieved via a GPS and radio antenna. This Vaisala receiving system was on the helideck of Lance (Photo 1), by Marius Bratrein (NPI) and Robert Graham, on the afternoon prior to departure from Longyearbyen. The receiving system was connected to a laptop at the rear of the bridge. Data was logged on this laptop using the Viasala program Digicora. The Vaisala receiving system was loaned from the AWI-PEV station in Ny Ålesund. This was coordinated by Stephen Hudson (NPI) and Marion Maturilli (AWI).

The radiosondes we have used are the RS92-SGPL product from Vaisala. These were attached to a 350 g helium filled Totex weather balloon. In total we have used 28 radiosondes, 31 weather balloons and 3 x 300 dB canisters of helium. Each radiosonde launch took approximately 30 minutes, and was conducted by Robert Graham with the assistance of a second crew member or scientist. The balloons were launched from the ship's helideck (Photo 2). This area of the ship was chosen because it is a large open space, away from any sharp edges that may damage the balloon. Typically, radiosonde data are transmitted in near real time from the ground station to be incorporated in to GTS. This allows the data to be used for the initialization of weather forecast models, and assimilated in to reanalyses products. However, for this campaign we have kept the radiosonde observations as an independent data set. We will use these data to evaluate the performance of the new atmospheric reanalyses ERA-5.



Historically, reanalyses products have performed relatively poorly in Arctic environments in comparison to the mid latitudes. In particular, they struggle to reproduce the observed strength and thickness of stable boundary layer inversions. These inversions form by cooling at the surface due to the cold water temperatures and/or presence of sea ice, such that the atmospheric temperature increases with height (Fig. 1). Typically, reanalyses underestimate the strength of these inversions. We will investigate if there are improvements in ERA-5, over the older ERA-Interim, in the representation of stable boundary layer inversions. We will also investigate how improvements in resolution of topography around Greenland in ERA-5, may have improved the simulation of wind fields.

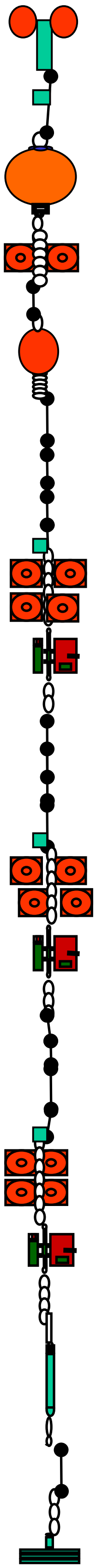
Appendix 1: moorings recovered

Rigg F11-18

78 48,998N
03 01,559W

Satt ut 10 SEP 2016, 09:20UTC

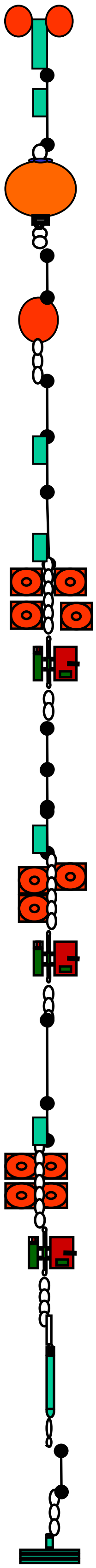
Tatt opp AUG kl



		Dyp:	Fra bunn:	Ut:
IPS	SNR. 51062	58	2390	09:09
SBE37	SNR. 3490	60	2388	09:09
5 m Kevlar				
ADCP300	SNR: 17461	64	2384	09:09
2 Glasskuler				
1 m Kjetting galvanisert				
10 m Kevlar				
Stålkule 37 McLane		76	2372	
1,0 m Kjetting galvanisert				
100 m Kevlar				
50 (49)m Kevlar				
50 m Kevlar				
5 m Kevlar				
SBE37	SNR. 4702	281	2167	08:54
4 Glasskuler (gule)				
2 m Kjetting galvanisert				
RCM9	SNR.1324	284	2164	08:54
0,5 m Kjetting galv				
200(204) m Kevlar K				
500(495) m Kevlar				
500(498) m Kevlar				
50 m Kevlar				
SBE37	SNR. 3552	1532	916	08:36
4 Glasskuler				
2 m Kjetting galvanisert				
RCM11	SNR.494	1535	913	08:36
0,5 m Kjetting galv				
500(498) m Kevlar K				
200 (198)m Kevlar				
200 (205)m Kevlar				
SBE37	SNR. 8821	2435	13	08:20
4 Glasskuler (gule)				
2 m Kjetting galvanisert				
Seaguard	SNR.10071	2438	10	08:20
0,5 m Kjetting rustfri				
Svivel				
AR861	SNR. 287			
3,5 m Kevlar				
3 m Kjetting galvanisert				
ANKER 1220/(980) kg		2448	0	

Rigg F12-18

Settes ut 9 SEP 2016 kl 13:29 — 78 49,156N, 004 00,427W

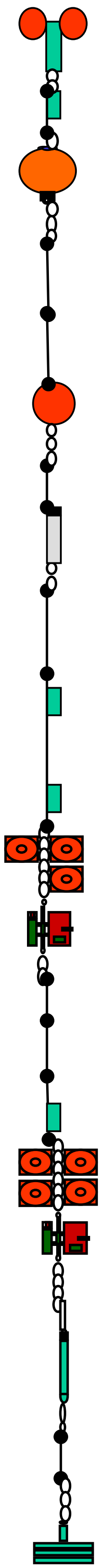


		Dyp:	Fra bunn:	Ut:
IPS	SNR. 1047	57	1778	11:55
SBE37	SNR.3489	59	1776	11:55
5 m Kevlar				
ADCP300	SNR: 17462	63	1772	11:27
0,5m Kjetting galvanisert				
2 x 10 m Kevlar				
Stålkule 37	SNR. 596	85	1750	
1,5 m Kjetting galvanisert				
SBE37	SNR. 14097	151	1684	11:57
200 m Kevlar				
SBE37	SNR.4837	276	1569	11:52
4 Glasskuler				
2 m Kjetting galvanisert				
RCM9	SNR. 884	279	1566	11:52
0,5 m Kjetting galv				
500 m Kevlar				
500 m Kevlar				
200 m Kevlar				
SBE37	SNR.3554	1479	366	11:25
3 Glasskuler				
2 m Kjetting galvanisert				
RCM11	SNR.235	1482	353	11:25
0,5 m Kjetting galv				
200 m Kevlar				
100 m Kevlar				
40 m Kevlar				
SBE37	SNR. 8822	1822	13	11:10
4 Glasskuler				
2 m Kjetting galvanisert				
RCM11	SNR.228	1825	10	11:13
0,5 m Kjetting rustfri				
Svivel				
AR861	SNR. 182			
3,5 m Kevlar				
3 m Kjetting galvanisert				
ANKER	1120/(940) kg	1835		

Rigg F13-18

Settes ut 8 SEP 2016, kl 17:20

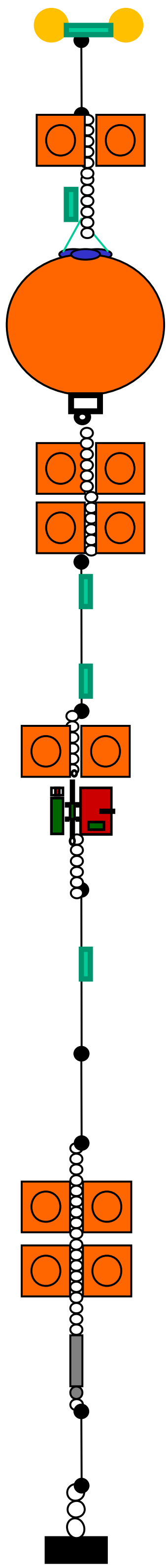
78 50.283N
04 59.191W



Komponent	SNR	Dyp:	Fra bunn:	Ned i vann:
IPS4	SNR. 51064	54	964	17:15
SBE37	SNR: 7056	56	962	17:15
5 m Kevlar				
ADCP300	SNR: 16831	60	958	17:15
1,5 m Kjetting galv				
5 m Kevlar				
10 m Kevlar				
Stålkule 37		77	941	
1,5 m Kjetting galv.				
5 m Kevlar				
Hvallydopptaker		84	934	17:07
0,5 m Kjetting galv.				
50 + 20 m Kevlar				
SBE37	SNR. 12232	155	863	15:00
100 (103) m Kevlar				
SBE37	SNR.3993	256	762	16:57
3 Glasskuler				
2 m Kjetting galv.				
RCM9	SNR.1327	259	759	16:57
0,5 m Kjetting galv				
500 (498)m Kevlar K				
200 (198)m Kevlar				
50 m Kevlar				
SBE37	SNR.3551	1005	13	16:36
4 Glasskuler				
2 m Kjetting galv.				
RCM11	SNR. 561	1008	10	16:36
0,5 m Kjetting rustfri				
Svivel				
AR861	SNR. 053			
3,5 m Kevlar				
3 m Kjetting galvanisert				
ANKER 1110/(880) kg		1018	0	

Rigg F13B-3 78 50.266 N

Satt ut 8 SEP 2016 , kl 09:08 005 30.873W

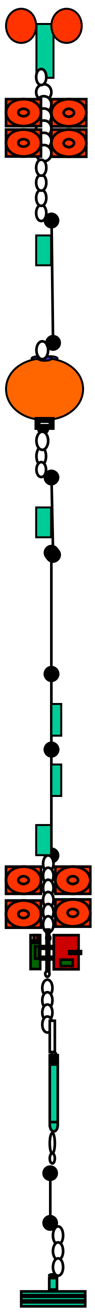


		Dyp:	Fra bunn:	Ut:
ICECat	SNR. 13506	22	505	09:06
25 m Wire				
Weak link				
1 m Kjetting galv.				
2 Glasskuler				
ICECAT modem				
ADCP	SNR.727	60	467	09:05
3 m Kjetting galv.				
4 Glasskuler				
SBE37	SNR. 12234	65	462	08:33
50 m Kevlar				
SBE37	SNR. 12233	113	414	08:25
1 m Kjetting galv.				
2 Glasskuler				
RCM7	SNR. 9464	115	412	08:25
200 m Kevlar				
SBE37	SNR. 10295	166	361	08:16
200 m Kevlar				
2 m Kjetting galv.				
4 GLASSKULER		516	11	
AR661	SNR. 291			
5 m Kevlar.				
2 m Kjetting galv.				
ANKER	800/(620)kg	527	0	

Rigg F14-18

Satt ut 7 SEP 2016 , kl 13:23

78 48,861N
006 30,09W

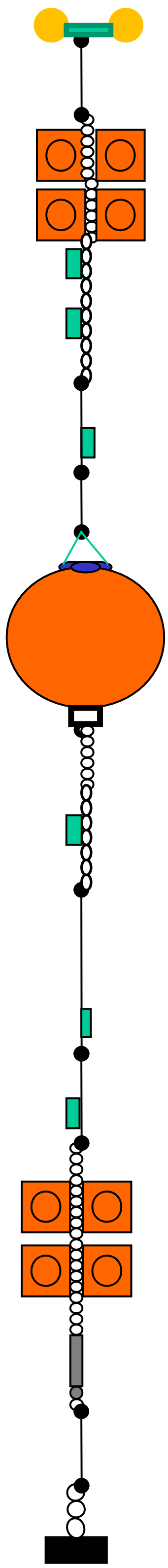


		Dyp:	Fra bunn:	Ned i vann:
IPS	SNR. 51127	57	215	13:07
4 Glasskuler				
2 m Kjetting galv.				
SBE37	SNR: 3492	61	211	13:07
5 m Kevlar				
ADCP 300	SNR: 16876	65	207	13:07
1 m Kjetting Galv.				
0,5 m Kjetting Galv.				
40 m Kevlar				
SBE37	SNR: 14098	106	166	12:58
100 (102) m Kevlar				
50 (51) m Kevlar				
SBE56	SNR.3943	259	63	12:47
SBE56	SNR.3942	234	38	12:42
SBE37	SNR.3992	259	13	12:38
4 Glasskuler				
2 m Kjetting Galv.				
RCM9	SNR. 1046	262	10	12:38
Svivel				
AR861	SNR. 506			
3,5 m Kevlar				
2,5 m Kjetting				
ANKER 920/(740) kg		272	0	

Rigg F17-13

Satt ut 7 SEP 2016 , kl 09:08

78 50. 179 N
008 04.913W

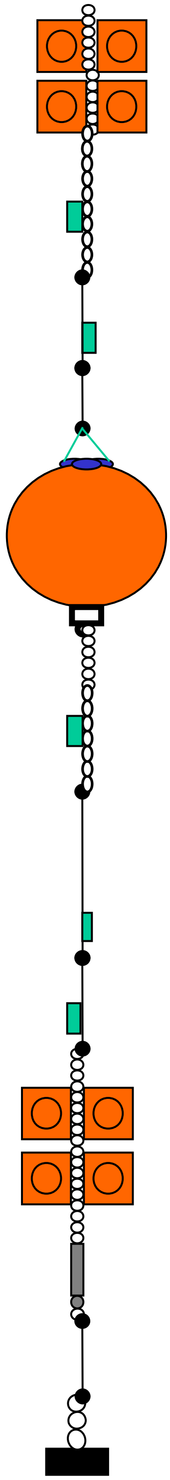


		Dyp:	Fra bunn:	Ut:
ICECat	SNR. 13507	27	198	09:08
25 m Wire				
Weak link				
3 m Kjetting galv.				
4 Glasskuler				
ICECAT Modem				
SBE16	SNR.6693	55	170	09:03
40 m Kevlar				
SBE37	SNR.2962	75	130	08:54
10 m Kevlar				
ADCP	SNR.7636	106	119	08:48
2 m Kjetting galv.				
SBE16	SNR.6694	108	117	08:48
100 m Kevlar				
SBE56	SNR.3944	187	38	08:38
5 m Kevlar				
SBE37	SNR.7062	213	12	08:34
2 m Kjetting galv.				
4 GLASSKULER		214	11	
AR661	SNR. 110			
5 m Kevlar.				
2 m Kjetting galv.				
ANKER	815/(700)kg	225	0	

Appendix 2: moorings deployed

Rigg F17-14 78 50. 186 N

Satt ut 5 Sep 2017 , kl 10:26 UTC 008 04.892W

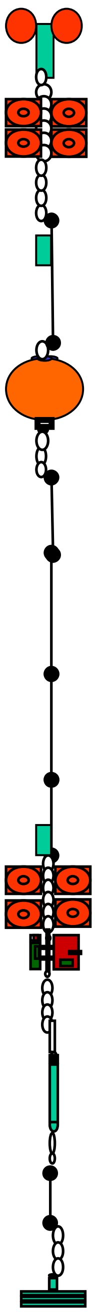


		Dyp:	Fra bunn:	Ut:
3 m Kjetting galv. 4 Glasskuler		52	174	09:03
SBE16	SNR.7212	54	172	09:03
0,5 m Kjetting 51 m Kevlar				
SBE37	SNR. 13252	94	132	08:54
ADCP	SNR.17461	105	121	08:48
2 m Kjetting galv.				
SBE16	SNR.7339	108	118	08:48
0,5 m Kjetting				
99 m Kevlar				
SBE56	SNR.3944	188	38	08:38
5 m Kevlar				
SBE37	SNR.14099	214	12	08:34
2 m Kjetting galv.				
4 GLASSKULER		215	11	
AR861CS	SNR. 501			
5 m Kevlar.				
2 m Kjetting galv.				
ANKER	800/(700)kg	226	0	

Rigg F14-19

Satt ut 5 Sep 2017, kl 13:47 UTC

78 48,848N
006 30,058W

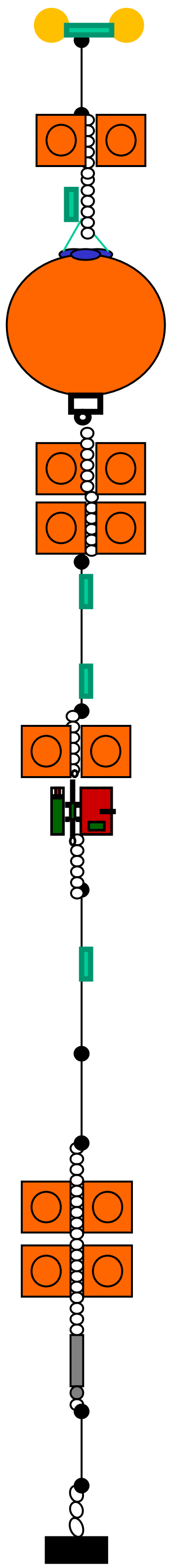


		Dyp:	Fra bunn:	Ned i vann:
IPS	SNR. 51127	54	219	13:45
4 Glasskuler 2 m Kjetting galv.				
SBE37	SNR: 7058	60	213	13:45
5 m Kevlar				
ADCP 300	SNR: 24385	64	209	13:45
1 m Kjetting Galv. 0,5 m Kjetting Galv.				
100 m Kevlar				
50 m Kevlar				
SBE56	SNR: 3943	210	63	13:35
40 m Kevlar				
SBE56	SNR: 3942	235	38	13:30
SBE37	SNR.7057	260	13	13:18
4 Glasskuler 2 m Kjetting Galv.				
RCM9	SNR. 1325	263	10	13:18
Svivel				
AR861	SNR. 568			
3,5 m Kevlar				
2,5 m Kjetting				
ANKER 900/(740) kg		273	0	

Rigg F13B-4

Satt ut 6 Sep 2017 , kl 09:43 UTC

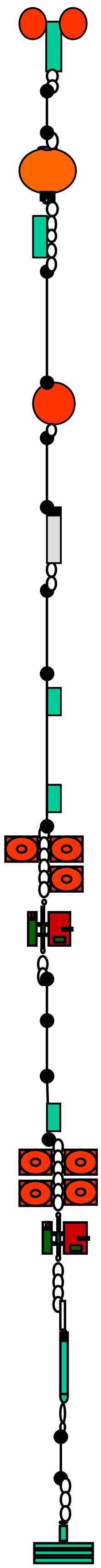
78 50.260 N
005 30.926W



		Dyp:	Fra bunn:	Ut:
ICECat	SNR. 15910	30	494	09:40
25 m Wire				
Weak link				
1 m Kjetting galv.				
2 Glasskuler				
ICECAT modem				
ADCP	SNR.17462	57	467	09:35
2 m Kjetting galv.				
4 Glasskuler				
0,5 m Kjetting galv.				
SBE37	SNR. 9853	61	463	09:30
41 m Kevlar				
SBE37	SNR. 9852	101	423	09:27
1 m Kjetting galv.				
2 Glasskuler				
SEAGUARD	SNR. 883	103	421	09:27
0,5 m Kjetting galv.				
200(199) m Kevlar				
SBE37	SNR. 7059 Merket	154	370	09:15
205 m Kevlar				
2 m Kjetting galv.				
4 GLASSKULER		513	11	
AR661	SNR. 410			
5 m Kevlar.				
2 m Kjetting galv.				
ANKER	800/(620)kg	524	0	

Rigg F13-19

78 50.324N
Satt ut 6 Sep 2017, kl 13:48 UTC 005 00.146W

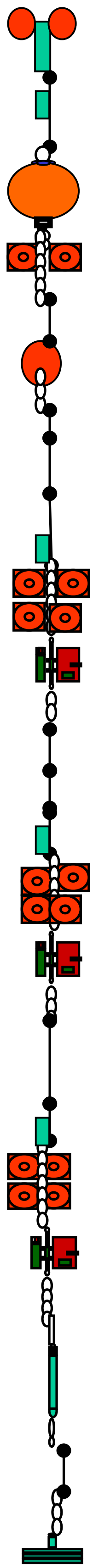


		Dyp:	Fra bunn:	Ned i vann:
IPS5	SNR. 51064	49	961	13:45
5 m Kevlar				
ADCP300	SNR: 20021	54	956	13:45
1,5 m Kjetting galv				
SEACAT SBE16	SNR. 7253	55	957	13:45
0,5 m Kjetting galv.				
10 m Kevlar				
Stålkule 37		65	947	
5 m Kevlar				
Hvallydopptaker		71	941	13:35
0,5 m Kjetting galv.				
20 m Kevlar				
50 m Kevlar				
SBE37	SNR. 3995	139	873	13:16
100 m Kevlar				
SBE37	SNR.7060	239	773	13:11
3 Glasskuler				
2 m Kjetting galv.				
RCM9	SNR.1326	242	770	13:11
0,5 m Kjetting galv				
500(497) m Kevlar				
100 m Kevlar				
100 m Kevlar				
50 m Kevlar				
SBE37	SNR. 13504	1007	15	12:56
4 Glasskuler				
2 m Kjetting galv.				
SEAGUARD	SNR. 345	1010	12	12:56
0,5 m Kjetting rustfri				
Svivel				
AR861	SNR. 743			
5 m Kevlar				
3 m Kjetting galvanisert				
ANKER	1100/(880) kg	1022	0	

Rigg F12-19

Satt ut 8 Sep 2017 09:05 UTC:

78 49,283N
004 01,373W

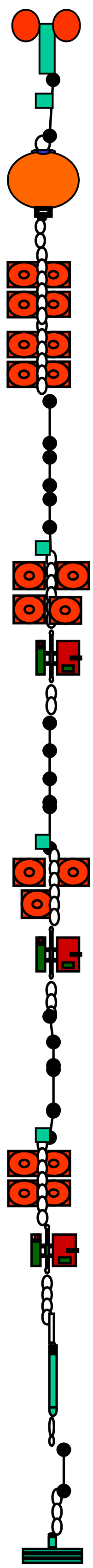


		Dyp:	Fra bunn:	Ut:
IPS	SNR. 51167	59	1783	09:02
SBE37	SNR.7055	61	1781	09:02
5 m Kevlar				
ADCP300	SNR: 18151	65	1777	09:04
2 Glasskuler				
1,0 m Kjetting galvanisert				
0,5 m Kjetting galv				
10 m Kevlar				
Stålkule 37	SNR.	77	1765	
1,0 m Kjetting galvanisert				
0,5 m Kjetting galv				
200(199) m Kevlar				
SBE37	SNR.3994	278	1564	08:42
3 Glasskuler				
2 m Kjetting galvanisert				
RCM9	SNR. 836	281	1561	08:42
0,5 m Kjetting galv				
500(498) m Kevlar				
500(497) m Kevlar				
200(205) m Kevlar				
SBE37	SNR.13505	1494	348	08:22
3 Glasskuler				
2 m Kjetting galvanisert				
RCM11	SNR.556	1497	345	08:22
0,5 m Kjetting galv				
200(207) m Kevlar				
100(101) m Kevlar				
20 m Kevlar				
SBE37	SNR. 10294	1827	15	08:13
4 Glasskuler				
2 m Kjetting galvanisert				
RCM11	SNR.117	1830	12	08:13
0,5 m Kjetting rustfri				
Svivel				
AR861	SNR. 500			
5 m Kevlar				
3 m Kjetting galvanisert				
ANKER	1190/(960) kg	1842	0	

Rigg F11-19

Satt ut 9 Sep 2017, 18:42 UTC

78 49,147N
003 03,189W

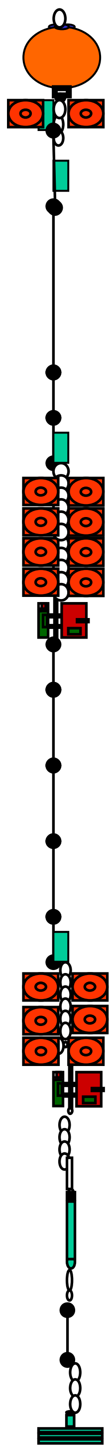


		Dyp:	Fra bunn:	Ut:
IPS	SNR. 51062	57	2396	18:35
SBE37	SNR. 3492	59	2394	18:35
5 m Kevlar				
ADCP300	SNR: 18070	63	2390	18:35
0,5 m Kjetting galvanisert				
8 Glasskuler (gule)		65	2388	
3 m Kjetting galvanisert				
100 m Kevlar				
50 m Kevlar				
50 m Kevlar				
SBE37	SNR. 3996	270	2183	14:39
4 Glasskuler (2 gule og 2 oransje)				
2 m Kjetting galvanisert				
RCM9	SNR.1049	274	2179	14:39
0,5 m Kjetting galv				
200(199) m Kevlar				
500(510) m Kevlar				
500(510) m Kevlar				
20 m Kevlar				
SBE37	SNR. 7061	1517	936	14:18
3 Glasskuler (gule)				
2 m Kjetting galvanisert				
RCM11	SNR.538	1520	933	14:18
0,5 m Kjetting galv				
500(511) m Kevlar				
200 m Kevlar				
200 m Kevlar				
SBE37	SNR. 8226	2440	13	13:58
4 Glasskuler (gule)				
2 m Kjetting galvanisert				
Seaguard	SNR.834	2442	11	13:58
0,5 m Kjetting rustfri				
Svivel				
AR861	SNR. 499			
5 m Kevlar				
3 m Kjetting galvanisert				
ANKER	1230/(980) kg	2453	0	

Rigg F10-14

Satt ut 8 Sep 2017, 12:23 UTC

78 49,624N
001 57,048W



		Dyp:	Fra bunn:	Ned i vann:
ADCP 300	SNR: 16831	59	2591	11:37
RCM9	SNR. 1175	61	2589	11:37
SBE37	SNR.13253	63	2587	11:37
100 (101) m Kevlar				
40 m Kevlar				
20 m Kevlar				
10 m Kevlar				
SBE37	SNR.14100	233	2417	11:25
8 glasskuler 3 m Kjetting Galv.				
SEAGUARD	SNR. 1846	236	2414	11:25
0,5 m Kjetting Galv. Med svivel.				
4 x 500 (495,496,496,496) m Kevlar				
200 m Kevlar				
100 m Kevlar				
100 (98) m Kevlar				
5 m Kevlar				
SBE37	SNR.8227	2635	16	10:54
6 Glasskuler 3 m Kjetting Galv.				
RCM8	SNR. 12733	2639	11	10:54
Svivel				
AR861	SNR. 1424			
5 m Kevlar				
2,5 m Kjetting				
ANKER	1000/(850) kg	2650	0	