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Cruise report CAGE 16-7

Deployment of observatories and water column survey in the Barents Sea and offshore Svalbard

Tromsø – Tromsø 16-10-16 to 25-10-16

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Contents

1. Introduction and objectives

The cruise was conducted from October 16th to 25th 2016 as part of the Centre of Excellence for Arctic Gas Hydrate, Environment and Climate (CAGE) at UiT – The Arctic University of Norway.

The main goal of the cruise was to deploy two observatories in the pingo-crater area ("Yin Yang") in the Barents Sea, and offshore Svalbard at the same location where OS2 was deployed in June 2015 and recovered in May 2016 (OS2: 78 33.6765N 10 08.5356E). The exact targeted location was determined according to multibeam analysis in order to deploy in the vicinity of bubble streams.

The previously K-Landers called OS1 (black) and OS2 (grey) are now called K-Lander 1 and K-Lander 2. They contain a CH_4 sensor, a CO_2 sensor, a CTD, a pH meter, and a hydrophone. K-Lander 1 contains in addition a DVS (Doppler volume sampler) as the broken ADCP did not arrive on time for the deployment. K-Lander 2 contains in addition an ADCP, a transmissometer (for turbidity measurement) and an M3 (Multibeam echosounder).

The present cruise also aimed at investigating an area of extensive flares western Svalbard, particularly the shallow shelf and shelf edge. The addressed scientific topics include quantification of methane concentration in the water column, temperature and salinity (via CTD casts), echosounder and multibeam signals and current (amplitude and direction).

2. Participant list

- Bénédicte Ferré – Chief scientist, CAGE, IG, UiT, benedicte.ferre@uit.no
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- Carsten Frank – Kongsberg, Carsten.Frank@km.kongsberg.com

3. Study areas and deployments

Figure 1 shows the overall of the CTD stations (left), inside the yin-yang crater (zoom in the inlet of the left picture) and offshore Prins Karls Forland (right). Part of the 90m grid was repeated, as well as 5 stations across the "MASOX" area.

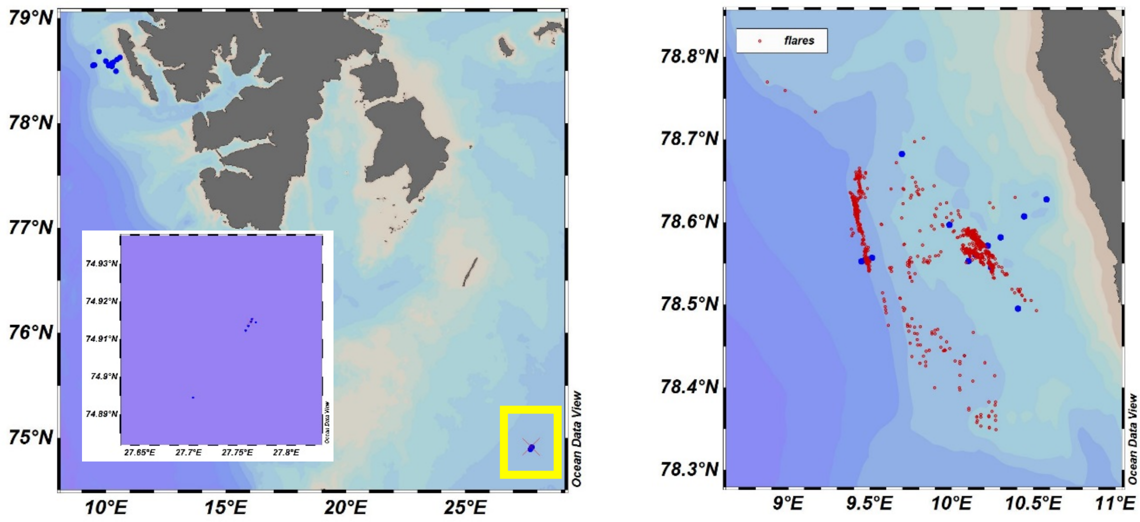

Figure 1. Maps of the areas with CTD stations (blue dots): Overall area (left); "Yin-Yang" pingo-crater (inlet) and Prins Karls Forland (right). Known flares locations offshore Prins Karls Forland are represented in red dots offshore Prins Karls Forland (right).

➢ Yin-Yang crater in the Barents Sea

The crater part of the Yin-Yang pingo-crater is centered near 27 45'N / 74 54'E where a flare was located with the multibeam (figure 2). These coordinates are the target for K-Lander 1. One of the hypothesis for the craters formation is that retreating ice sheet triggered explosive release of gas from dissociating gas hydrates, due to changing pressure/temperature conditions.

We performed three multibeam lines in order to locate the flares and chose the location. After a short toolbox meeting on the bridge with people involved in the deployment, we dropped the anchor and deployed the K-Lander 1 (Figure 2 left) close to the flare (Figure 2 right) at 08:02 UTC on October 18^{th}.

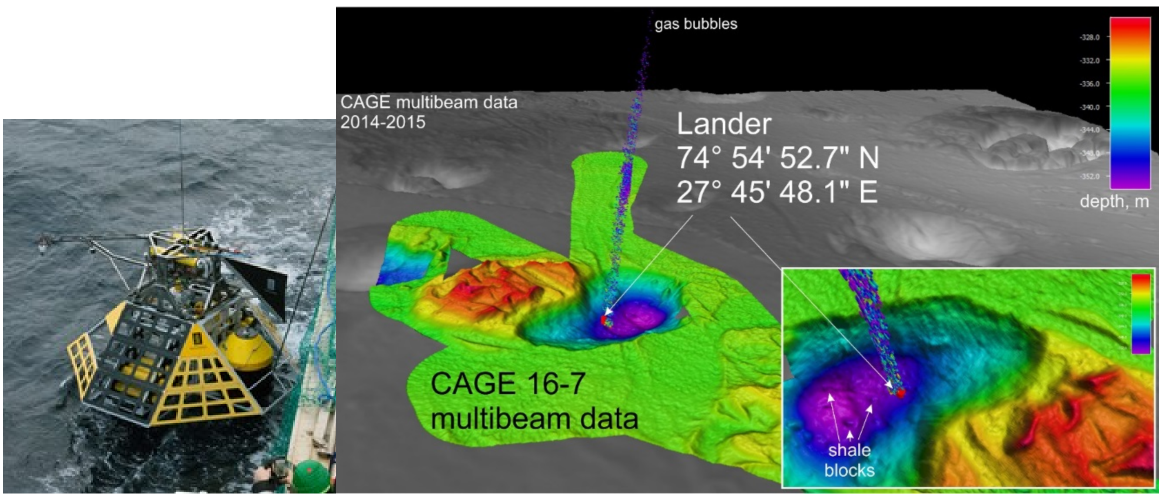

Figure 2. Lander deployment (left) and location (right, red dot) inside the crater, along with multibeam bathymetry (colored scale). Purple circles show the bubbles.

➢ OFFSHORE PRINS KARLS FORLAND

The survey included the 14 km wide and 30 km long relatively shallow shelf area close to Prins Karls Forland (cf. Figure 1). Here, the depth is ~100 m on average and the seabed morphology is diverse with ridges and depressions distributed all over the shelf.

We performed one multibeam line in order to locate the flares and chose a location for the K-lander. After anchoring the ship, the K-Lander 2 was deployed (Figure 3) at 22:20 UTC on October 19th.

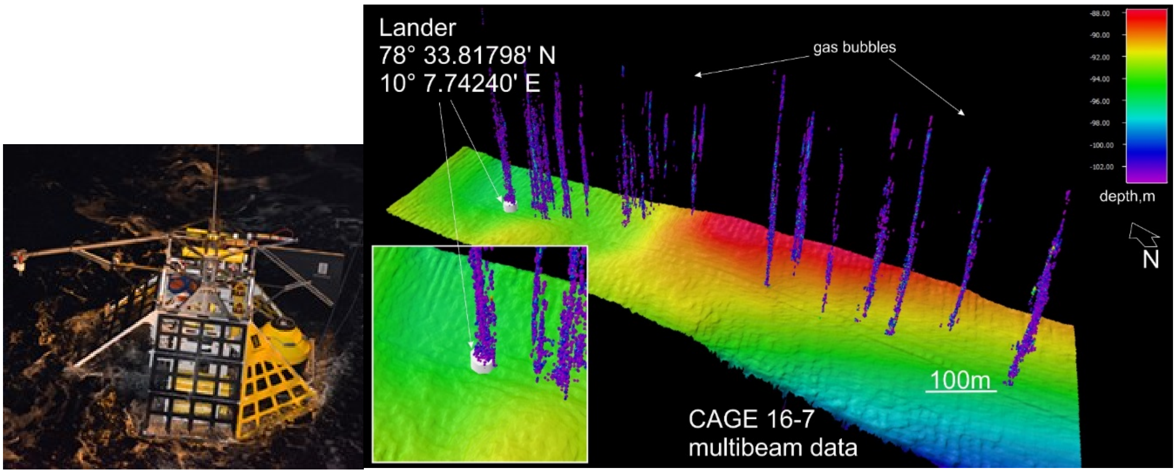

Figure 3. Deployment (left) and location (right) of the K-lander 2 offshore Prins Karls Forland (white spot) and multibeam bathymetry (colored scale). Purple circles show bubbles stream.

4. METHODS AND PRELIMINARY RESULTS

➢ ECHOSOUNDER EK60 FOR FLARE OBSERVATION

Single beam echo sounders are common among all types of ships with the main purpose of detecting fish. Here, the Simrad EK60 scientific echosounder system was used at 18 KHz, 38 KHz and 120 KHz to identify active seeps. In a single beam echo sounder, the transducer projects a sound pulse through water in a controlled direction and the reflected wave is received. The depth is calculated from the travel time of the sound pulse.

The echosounder was on during the entire cruise. The new data was used to identify active flares, expand the CAGE flares data set and compare with previous flares activity.

➢ ADCP

The ship is equipped with a traditional "Ocean Surveyor" Acoustic Doppler Current Profiler (ADCP) from Teledyne RD, operating at 75 kHz. The setup consists of an ADCP transducer / receiver mounted on the lowered keel, 7 meters below the sea surface, a deck unit, communicating with the device and a standard PC in the Instrument room. The ADCP provides current amplitude and direction, as well as backscatter information. Current amplitude during CTD sampling in the crater area and offshore Prins Karls Forland are shown in Figure 4 and 5 respectively.

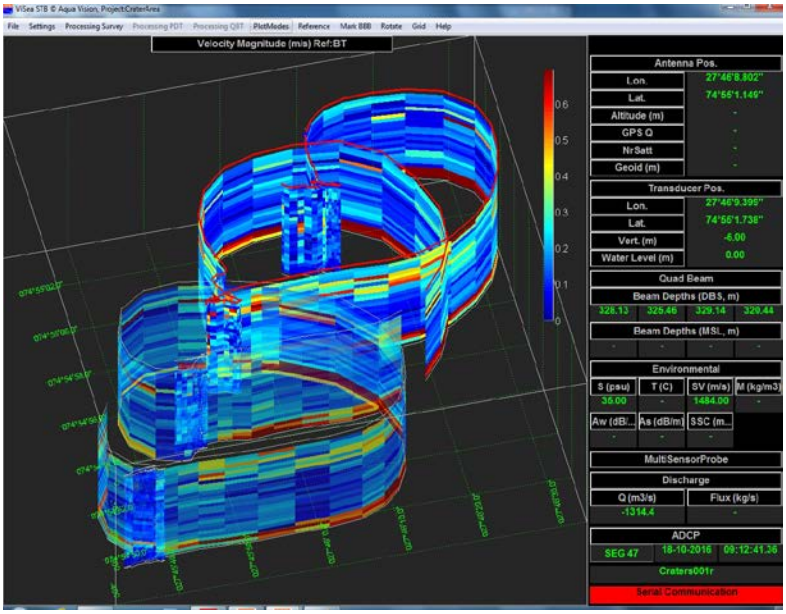

Figure 4. Current amplitude from the mounted ADCP during CTD casts in the Yin-Yang crater

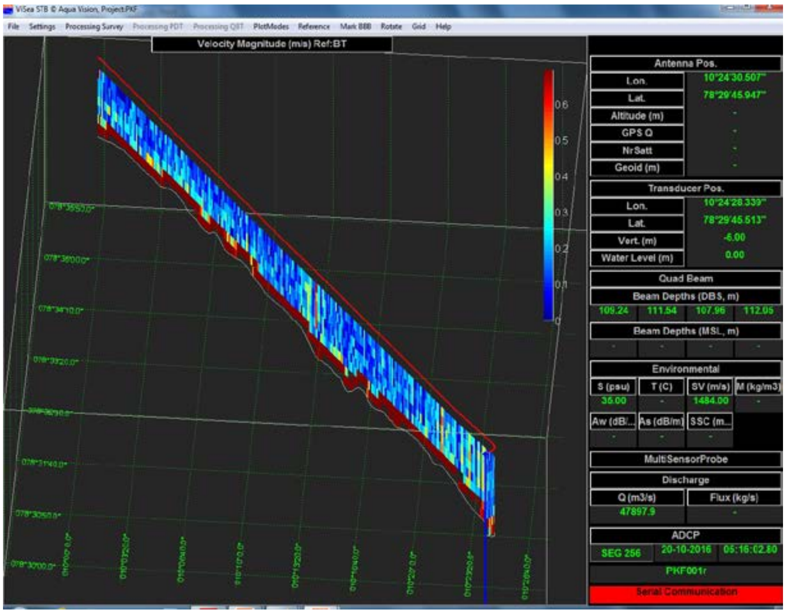

Figure 5. Current amplitude during CTD sampling offshore Prins Karls Forland (~90m depth)

- **CTD**

CTD (Conductivity, Temperature, Depth) sensors measure the physical properties of seawater. In addition to measuring the conductivity, temperature and pressure (from which depth is calculated), the CTD sensors can measure or calculate salinity of seawater, density, P-wave velocity, turbidity, fluorescence/chlorophyll, and oxygen content.

R/V Helmer Hanssen uses SBE 911plus CTD to produce vertical profiles of seawater properties. A winch is used to lower the CTD system into the water at 1 m/s. The CTD sensors record data at a rate of 24 samples per second.

A total of 12 × 5-liters Niskin bottles are attached to the CTD instrument set up to collect water samples from chosen depth. A single conductor cable supplies power to the system and transmits data from and to the CTD system in real time.

We collected CTD data and water sampling at 14 stations during the cruise and water samples from 8 discrete depths for methane concentration (see water sampling section for details).

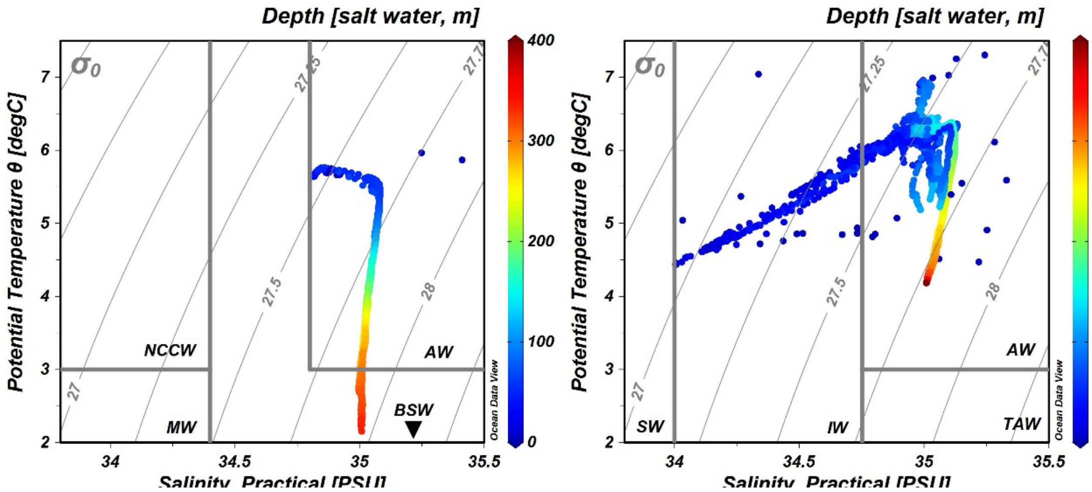

Figure 6. Temperature –Salinity diagram showing the different water masses in the crater area (left, water masses classification from Oziel et al. 2016) and offshore Prins Karls Forland (right, water masses classification from Cottier et al., 2005). Acronyms stands for: NCCW: Norwegian coastal current water; MW: Melt water; AW: Atlantic Water; BSW: Barents Sea water (colder than 2degrees); SW: Surface water; IW: Intermediate water; TAW: Transformed water

Water masses in both sites are dominated by Atlantic water (~35 psu). Bottom waters are influenced by Barents Sea Water in the crater area and surface water up to 100m depth are influenced by less salty intermediate water.

➢ WATER SAMPLING FOR METHANE AT CTD LOCATION

To prepare water samples for measurements of methane concentrations we applied the conventional headspace gas extraction technique. Water samples were collected bubble free into 120 mL crimp seal bottles, and poisoned with 1 mL NaOH solution. We injected 5 ml of nitrogen through the rubber septa into with simultaneous removal of 5 mL of sample. By shaking the bottle for two minutes the headspace nitrogen equilibrated with the in situ water sample gas. Bottles were kept in the fridge (5 degrees C) until analysis back in Tromsø with the GC.

➢ BOX CORE

We performed a box core ~800m depth as requested by Giuliana Panieri. The chosen coordinates were 75 44.034N; 13 50.283E.

5. DEVIATION FROM INITIAL PLAN

The departure from Tromsø was delayed 8 hours due to technical issues (cf cruise narrative for details) with the landers that were easier to treat at the bunkerdepot. We left Tromsø at 16:00 on October 16th and had to fuel so we left for the Barents Sea around 19:30.

The wind became too strong on Oct. 20th to continue the multi-beam and echosounder survey offshore Prins Karls Forland and we found shelter in Kongsfjorden until Oct. 22nd in the morning.

We also could not finish the planned echousounder survey on Oct. 22nd because of another storm coming, and had to start our trip back to Tromsø.

6. CRUISE NARRATIVE

Date	*Time (TOS, UTC+2)*	
10.10.	evening	Lander in Tromsø.
11.10.		Main structure assembled. One battery frame broken, new one sent from Germany.
		Missing screws for batteries. New ones sent from Germany. We are not sure yet whether we will receive these on time
12.10.		Missing batteries for the c-nodes. Sent from Horten immediately.
		Launcher assembled
	12:10	hydrophones delivered
13.10.		DVS cables delivered. CTD installed along with the fluorimeters.
		Problem with launcher that we had to open up. Camera working
14.10.		Because of the delay in delivery, we bought stainless steel screws for the batteries, and installed longer ones where there are no titanium to make sure there won't be any corrosion.
		M3 communicating but no data. DVS working, pH sensors checked
		Test for launcher. No room for launcher because of the ADCP, we have to change the angle and lower the ADCP.
		c-node batteries arrived.
		note: 80 and 83 c-nodes need battery
15.10.	~18:00	Sensors finished to be assembled for both landers
16.10.	08:00	Talk to the captain at 8am. Problem with DPU in lander 2 (with ADCP) because it takes too much power.
	16:00	departure from Frøya (8hours delay)
	16:45	start fueling until 19:15.
	19:30	Leaving for Kjosen for test.
	20:10	Test, no visibility because of bad lighting. 20:35
	20:35	Testing again with Barents Sea setting. Good visibility
	21:00	Departure towards Crater Area. Estimated arrival Tuesday morning.
17.10.	all day	cruising towards yin-yang
18.10.	06:30	CTD to calibrate multibeam
	06:50	start of mutlibeam survey (3) to find best location for K-Lander
	07:00	check up of lander and launcher
	08:00	tool box meeting
	08:30	drop the anchor after exact position has been estimated from multibeam survey

	09:27	Lander 1 underwater
	10:02	Lander 1 released 27 45.803'N / 74 54.879'E in the Yin Yang pingo-crater
	10:30	retrieve anchor to perform CTDs.
	10:45	First CTD in Yin Yang
	13:05	Last CTD in Ying Yang. Departure for PKF
19.10.	22:32	CTD for calibration of multibeam
	23:08	start multibeam survey
20.10.	00:20	lander 2 released 78 33.817 / 10 7.742
	01:00	start CTD
	11:26	last CTD. Start of echosounder and multi-beam survey
	14:00	Towards Kongsfjorden for shelter
21.10.	All day	at Ny Ålesund for shelter
22.10.	15:20	Start echosounder survey along the ridge
23.10.		End echosound survey because of the coming storm. Start heading to box core location
24.10.	03:15	Box core (75 44.034N; 13 50.283E)
		Head home
25.10.		Arrival in tromsø

ACKNOWLEDGEMENTS

We thank all the engineers (Roy Sorensen, Bjørn Runar Ølsen and Steinar Iversen), the captain and his crew of R/V Helmer Hanssen of the University of Tromsø for their excellent support before and during the oceanographic survey and the deployment of the landers. This part of the cruise was conducted under the framework of the Centre of Excellence on Gas Hydrates, Environment and Climate (CAGE) (Norwegian Research Council (NFR) project number 223259/F5 at the University of Tromsø.

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Oziel, L., Sirven, J. and Gascard, J. C. (2016). "The Barents Sea frontal zones and water masses variability (1980–2011)." Ocean Sci. 12(1): 169-184.

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Appendix 1: Stasjonslapper

CruiseNr	Date (UTC)	Time (UTC)	Logg (nm)	Stasjonstype	StNr	Kommentar	Speed	Latitude	Longitude	Depth (m)	Water Temp (°C)	Wind Speed (m/s)	Humidity (%)	Wind dir (deg)	Sea	Weather	Clouds	Ice	Light	Scanmar DP1	Scanmar DP2
8102016	18.10.2016	04:17:51	6080.34	CTD uten vann START	1734		0.5	7453.667507 N	02742.270613 E	342.61	6	9.3	88	261							
8102016	18.10.2016	04:33:46	6080.46	CTD uten vann STOPP	1734		0.2	7453.568147 N	02742.402514 E	343.44	6.1	7.34	87	265							
16102016	18.10.2016	04:50:25	6082.04	Multibeam survey START	1735		4.5	7454.876095 N	02745.218047 E	337.4	5.9	9.05	87	275							
16102016	18.10.2016	04:54:29	6082.32	Multibeam survey STOPP	1735		4	7455.035422 N	02746.114467 E	327.9	5.9	7.84	87	270							
16102016	18.10.2016	05:20:38	6083.78	Multibeam survey START	1736		3.4	7454.713447 N	02746.138514 E	338.26	5.8	8.72	87	271							
16102016	18.10.2016	05:25:59	6084.09	Multibeam survey STOPP	1736		3.5	7454.988030 N	02745.570124 E	341.03	5.9	10.1	87	271							
16102016	18.10.2016	08:25:19	6089.3	Annen stasjon	1737	Lander 18.	1.3	7454.793526 N	02746.551672 E	336.61	6	6.83	88	267							
16102016	18.10.2016	08:45:45	6090.05	CTD med vannhenter START	1738		0.6	7455.008104 N	02746.163348 E	330.21	5.7	8.49	89	273							
16102016	18.10.2016	09:06:34	6090.13	CTD med vannhenter STOPP	1738		0.3	7454.990224 N	02746.173986 E	330.15	5.9	9.31	89	266	1	1	6	0	5	0.63	
16102016	18.10.2016	09:18:47	6090.52	CTD med vannhenter START	1739		1.2	7454.927912 N	02745.947897 E	334.74	5.8	8.03	90	268	1	1	6	0	5	398.31	
16102016	18.10.2016	09:39:23	6090.61	CTD med vannhenter STOPP	1739		0.1	7454.933870 N	02745.924788 E	330.1	5.8	7.91	90	261	1	1	6	0	5	390.25	
16102016	18.10.2016	09:50:09	6091.04	CTD med vannhenter START	1740		1.2	7454.887315 N	02745.861891 E	346.95	5.8	8.83	90	270	1	1	6	0	5	-3.25	
16102016	18.10.2016	10:08:14	6091.1	CTD med vannhenter STOPP	1740		0.2	7454.878945 N	02745.808868 E	347.48	5.9	8.29	90	266	1	1	6	0	5	1173.5	
16102016	18.10.2016	10:19:08	6091.56	CTD med vannhenter START	1741		1.4	7454.812501 N	02745.721032 E	344.55	5.9	6.83	90	260	1	1	6	0	5		
16102016	18.10.2016	10:38:47	6091.64	CTD med vannhenter STOPP	1741		0.3	7454.812116 N	02745.656655 E	342	6.1	7.32	90	258	1	1	6	0	5	0.25	
16102016	18.10.2016	10:47:52	6092.02	CTD med vannhenter START	1742		1.3	7454.746143 N	02745.533966 E	334.37	5.9	7.73	90	256	1	1	6	0	5		
16102016	18.10.2016	11:05:37	6092.07	CTD med vannhenter STOPP	1742		0.2	7454.752167 N	02745.436702 E	334.92	5.9	6.63	91	267	1	1	6	0	5		
16102016	19.10.2016	20:32:48	6440.79	CTD uten vann START	1743		1.2	7832.717264 N	01014.301064 E	105.09	4.7	8.25	93	205	1	1	6	0	5		
16102016	19.10.2016	20:40:17	6440.92	CTD uten vann STOPP	1743		0.7	7832.834465 N	01014.296227 E	95.43	4.6	9.15	94	210	1	1	6	0	5		
16102016	19.10.2016	22:39:21	6444.79	Annen stasjon	1744	Multibeam	2.1	7833.822003 N	01008.223239 E	93.36	4.9	9.6	94	200	1	1	6	0	5		
16102016	19.10.2016	22:41:56	6444.88	Annen stasjon	1745	Lander ut	1.7	7833.830664 N	01007.832514 E	93.94	4.9	9.73	94	198	1	1	6	0	5		
16102016	19.10.2016	23:27:18	6447.23	CTD med vannhenter START	1746		0.5	7833.228504 N	01006.150645 E	111.42	5.6	9.62	94	199	1	1	6	0	5		
16102016	19.10.2016	23:36:11	6447.27	CTD med vannhenter STOPP	1746		0.3	7833.203037 N	01006.203858 E	110.18	5.7	10.34	94	196	1	1	6	0	5		
16102016	19.10.2016	23:53:45	6448.4	CTD med vannhenter START	1747		1.3	7833.689434 N	01008.595403 E	89.7	5.1	10.08	94	194	1	1	6	0	5		
16102016	20.10.2016	00:01:55	6448.45	CTD med vannhenter STOPP	1747		0.2	7833.656216 N	01008.608735 E	90.43	5.1	10.21	94	194	1	1	6	0	5		
16102016	20.10.2016	00:24:35	6449.98	CTD med vannhenter START	1748		0.7	7834.323326 N	01013.151061 E	147.56	5	10.32	94	196	1	1	6	0	5		
16102016	20.10.2016	00:33:43	6450.04	CTD med vannhenter STOPP	1748		0.7	7834.326233 N	01013.186452 E	148.64	5	10.35	94	195	1	1	6	0	5		
16102016	20.10.2016	00:50:45	6451.63	CTD med vannhenter START	1749		1	7834.929413 N	01017.908536 E	123.56	4.9	9.74	95	197	1	1	6	0	5		
16102016	20.10.2016	00:58:49	6451.69	CTD med vannhenter STOPP	1749		0.4	7834.901643 N	01018.080869 E	127.02	4.8	10.1	95	195	1	1	6	0	5		
16102016	20.10.2016	01:24:01	6454.52	CTD med vannhenter START	1750		0.6	7836.465016 N	01026.540317 E	117.95	4.8	8.68	95	195	1	1	6	0	5		
16102016	20.10.2016	01:31:54	6454.56	CTD med vannhenter STOPP	1750		0.5	7836.475544 N	01026.555311 E	118.97	4.9	9.68	95	202	1	1	6	0	5		
16102016	20.10.2016	01:54:00	6457.06	CTD med vannhenter START	1751		0.9	7837.675971 N	01034.767518 E	77.9	4.8	8.7	96	200	1	1	6	0	5		
16102016	20.10.2016	01:59:56	6457.11	CTD med vannhenter STOPP	1751		0.3	7837.645781 N	01034.890955 E	77.28	5	8.1	96	197	1	1	6	0	5		
16102016	20.10.2016	03:13:43	6468.27	CTD med vannhenter START	1752		0.3	7840.949809 N	00941.549001 E	131.97	4.9	11.34	96	219	1	1	6	0	5		
16102016	20.10.2016	03:23:06	6468.35	CTD med vannhenter STOPP	1752		0.3	7840.982541 N	00941.622550 E	127.71	4.9	10.58	96	224	1	1	6	0	5		
16102016	20.10.2016	04:08:48	6474.82	CTD med vannhenter START	1753		0.6	7835.829121 N	00959.207703 E	112.93	5.6	10.1	96	223	1	1	6	0	5		
16102016	20.10.2016	04:17:18	6474.93	CTD med vannhenter STOPP	1753		0.7	7835.896896 N	00959.533554 E	111.26	5.5	8.74	96	223	1	1	6	0	5		
16102016	20.10.2016	05:15:56	6483.06	CTD med vannhenter START	1754		0.3	7829.743021 N	01024.376889 E	107.12	4.7	8.33	96	231	1	1	6	0	5	388.56	
16102016	20.10.2016	05:24:15	6483.1	CTD med vannhenter STOPP	1754		0.3	7829.751409 N	01024.297336 E	106.47	4.7	7.12	96	227	1	1	6	0	5	392	
16102016	20.10.2016	06:37:35	6494.68	CTD med vannhenter START	1755		1.4	7833.476326 N	00930.694547 E	365.72	7	10.82	95	237	1	1	6	0	5	1176.13	
16102016	20.10.2016	06:58:43	6494.89	CTD med vannhenter STOPP	1755		0.6	7833.484009 N	00930.623455 E	366.99	7.1	8.76	95	230	1	1	6	0	5	-1.25	
16102016	20.10.2016	07:10:24	6495.26	CTD med vannhenter START	1756		1.6	7833.373738 N	00929.503495 E	384.13	7.1	10.93	95	224	1	1	6	0	5	-0.63	
16102016	20.10.2016	07:31:58	6495.43	CTD med vannhenter STOPP	1756		0.8	7833.333438 N	00929.347717 E	386.5	7	8.5	94	226	1	1	6	0	5	0	
16102016	20.10.2016	07:48:07	6496.04	CTD med vannhenter START	1757		0.8	7833.341218 N	00928.810939 E	389.1	7	10	95	216	1	1	6	0	5		
16102016	20.10.2016	08:08:13	6496.12	CTD med vannhenter STOPP	1757		0.4	7833.345602 N	00928.700397 E	388.08	7.2	10.79	95	218	1	1	6	0	5	-0.25	
16102016	20.10.2016	08:24:47	6496.79	CTD med vannhenter START	1758		1.5	7833.284210 N	00928.186489 E	391.13	7	11.72	96	218	1	1	6	0	5	0	
16102016	20.10.2016	08:47:44	6496.88	CTD med vannhenter STOPP	1758		0.7	7833.299723 N	00928.203730 E	390.64	7.1	6.9	96	227	1	1	6	0	5		
16102016	20.10.2016	08:57:25	6497.23	CTD med vannhenter START	1759		1.7	7833.212328 N	00926.910486 E	403.28	7	8.03	96	225	1	1	6	0	5	394.06	
16102016	20.10.2016	09:25:58	6498.11	CTD med vannhenter STOPP	1759		9.7	7832.381000 N	00926.960052 E	426.96	7.1	8.28	96	209	1	1	6	0	5	392.38	
16102016	20.10.2016	09:35:52	6499.76	Annen stasjon	1760	lin jekjørin	10	7832.076466 N	00929.835725 E	398.15	7	7.65	96	223	1	1	6	0	5		
16102016	22.10.2016	13:50:17	6645.94	Annen stasjon	1761	linjekjøring	5.3	7838.401086 N	00924.730723 E	268.29	6.7	5.32	82	20	1	1	6	0	5		
16102016	24.10.2016	01:14:45	6939.16	Box core (BC)	1762		0.5	7544.042873 N	01350.271731 E	802.93	7.6	7.4	75	175	1	1	6	0	5		

Appendix 2: Summary of CTDs

CTD#	UTC	Lat	Lon	depth
1734	Oct 18 2016 04:19:30	74.89448	27.70432	342.61
1738	Oct 18 2016 08:49:18	74.91678	27.7689	330.21
1739	Oct 18 2016 09:21:26	74.91532	27.76482	334.74
1740	Oct 18 2016 09:50:54	74.91466	27.76382	346.95
1741	Oct 18 2016 10:19:48	74.9135	27.76116	344.55
1742	Oct 18 2016 10:48:17	74.91232	27.75832	334.37
1743	Oct 19 2016 20:34:25	78.54566	10.23866	105.09
1746	Oct 19 2016 23:27:31	78.55366	10.10232	111.42
1747	Oct 19 2016 23:54:44	78.56116	10.14282	89.7
1748	Oct 20 2016 00:24:24	78.572	10.21916	147.56
1749	Oct 20 2016 00:50:41	78.58216	10.2985	123.56
1750	Oct 20 2016 01:23:46	78.60766	10.44232	117.95
1751	Oct 20 2016 01:54:01	78.62782	10.57932	77.9
1752	Oct 20 2016 03:12:20	78.68266	9.69382	131.97
1753	Oct 20 2016 04:08:44	78.59698	9.98666	112.93
1754	Oct 20 2016 05:15:47	78.49566	10.406	107.12
1755	Oct 20 2016 06:40:09	78.55754	9.51148	365.72
1756	Oct 20 2016 07:12:33	78.55566	9.49	384.13
1757	Oct 20 2016 07:48:57	78.55548	9.4795	389.1
1758	Oct 20 2016 08:25:45	78.5545	9.46882	391.13
1759	Oct 20 2016 08:59:01	78.55282	9.4465	403.28