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CAGE 15-6

Cruise Report
FF Helmer Hanssen
Arctic gas hydrate studies

Storfjordrenna – Vestnesa & Svyatogor Ridge –Fram Strait - Yermak Plateau – Sofia Basin

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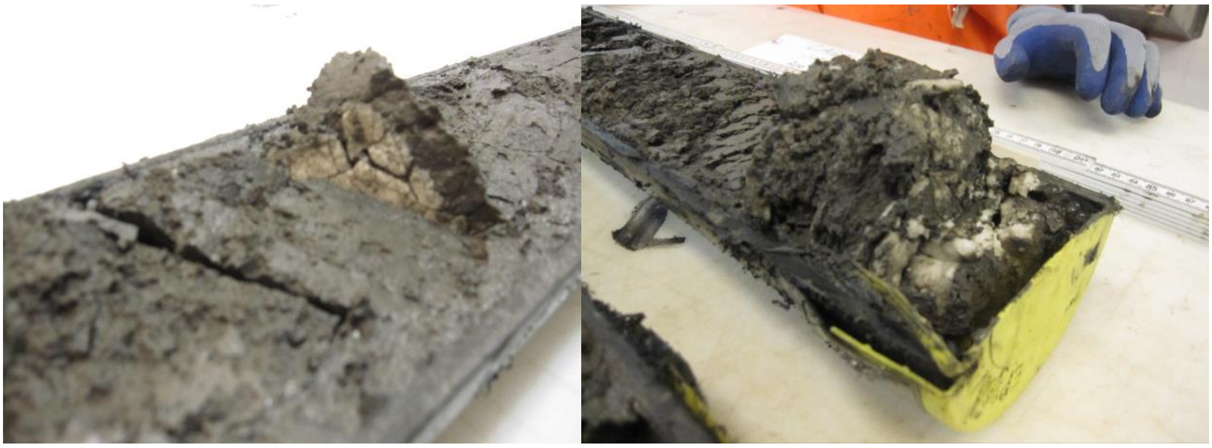
With contributions by: Leg 1 Tromsø – Longyearbyen (07.10. - 20.10.) Weil-Li Hong, Pår Jansson, Kate Alyse Waghorn, Malin Waage, Sunny Singhroha, Giacomo Osti, Haoyi Yao, Steinar Iversen, Bjørn Runar Olsen, Karianne Heimdal, Suchada Krokmyrdal, Rowan Romeyn. **Leg 2** Longyearbyen – Tromsø (20.10. - 27.10.) Pår Jansson, Kate Alyse Waghorn, Malin Waage, Steinar Iversen, Bjørn Runar Olsen, Jack Triest, Roberto Grilli, Rowan Romeyn.

RV Helmer Hanssen, 07 October 2015 – 27 October 2015

Gas Hydrate



Sediment gravity cores from Storfjordrenna showing gas hydrate

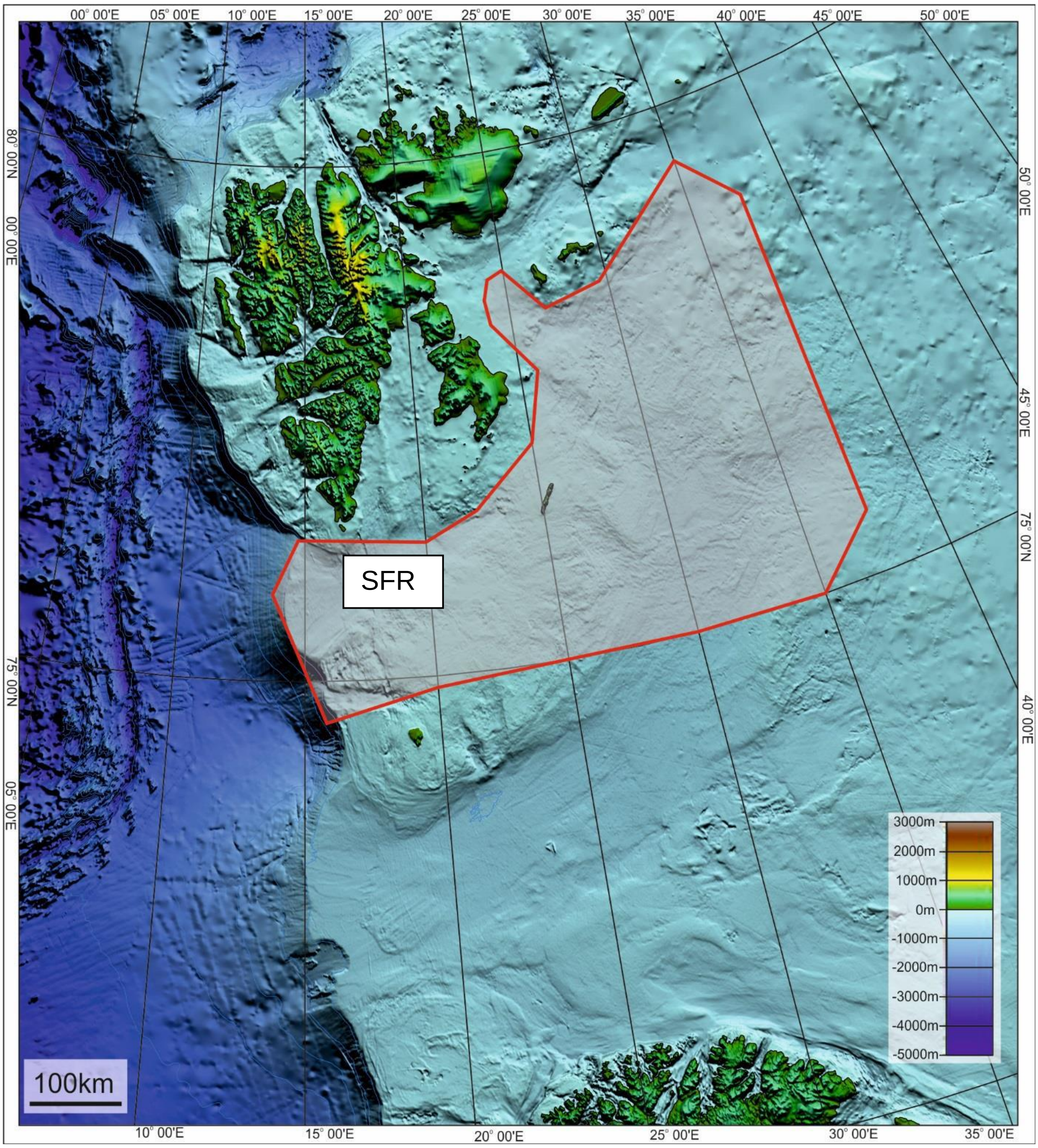


Figure 1 a: Overview map showing the overall working area (Figs. 1 a,b: grey shaded) and more specifically Storfjordrenna (SFR). Cruise CAGE 15-6 started from Tromsø (TOS), on 07-10-2015 and finished in Tromsø on 27-10-2015. The work concentrated on (1) gas hydrate and bio-geochemistry in sediments, and methane in the water column at Storfjordrenna (SFR); (2) gas release activity and methane in the water column at Vestnesa Ridge (VR), (3) gas hydrate, sediment geochemistry and methane in the water column at Svyatogor Ridge (SR) and (4) gas hydrate and submarine slides at Yermak Plateau (YP), Sofia Basin (SF) and gas release at Prins Karls Forland see Fig. 1b.

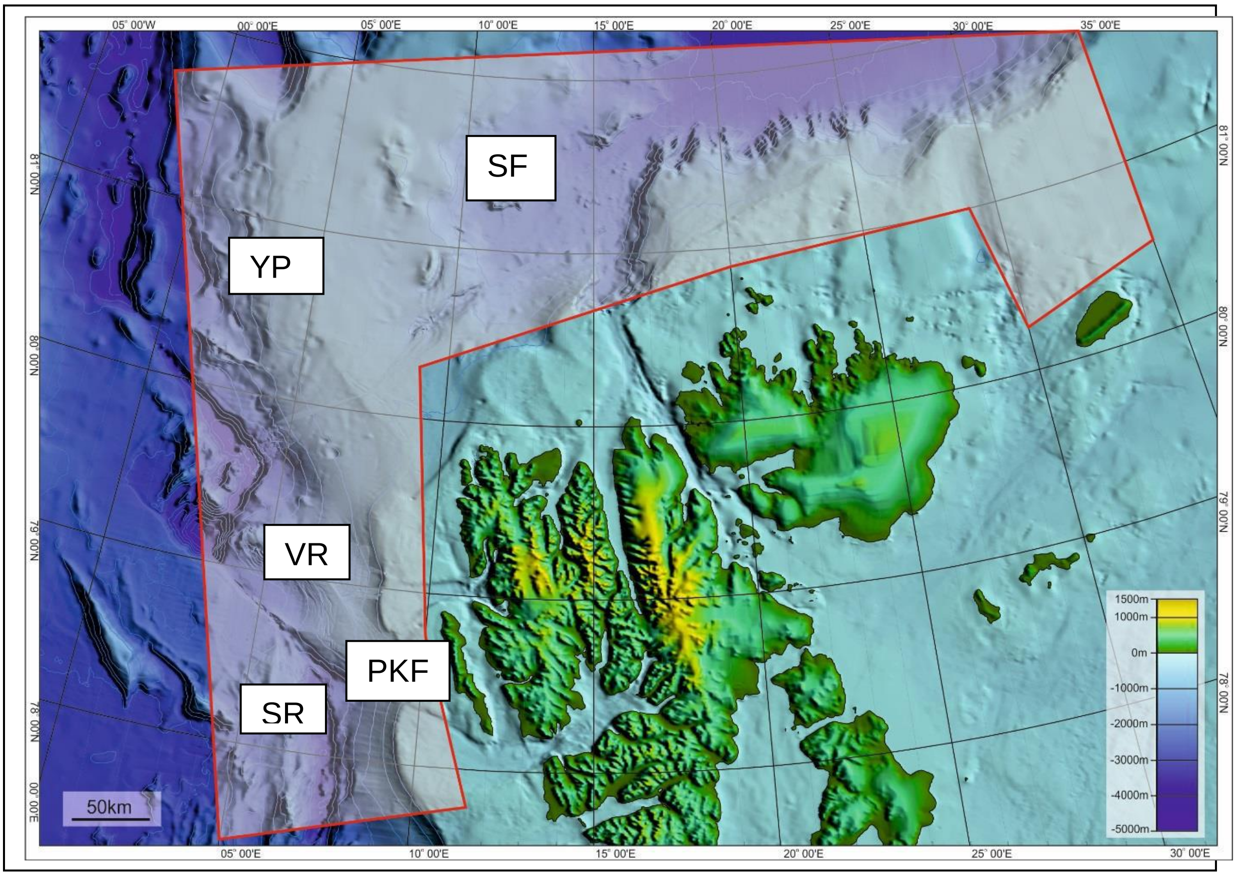


Figure 1 b: Overview map showing the five northern working areas Svyatogor Ridge (SR) , Prins Karls Forland (PKF), Vestnesa Ridge (VR), Yermak Plateau (YP) and Sofia Basin (SF).

1 Summary

RV Helmer Hanssen is the only vessel operating so far north (81 N) in October. One of the research questions addressed during this cruise is: Where do gas hydrate exist in the seabed and how much methane does it actually release? The CAGE 15-6 cruise explored potential gas hydrate charged sub-seabed environments and gas release zones at Storfjordrenna, Vestnesa and Svyatogor Ridge, Yermak Plateau, Sofia Basin and west of Prins Karls Foreland (Fig. 1a, b). Our route was traceable by www.sailwx.com. The weather forecasts from www.windyty.com were used to prepare and adjust our cruise activities. In these Barents Sea-Arctic areas we carried out seismic profiling (mini GI 15/45 in3 and large GI 45/105 in3) and 6m long gravity coring for detecting gas hydrate, acoustic profiling (18, 38 and 120 kHz) for detecting gas flares in the water column, and CTD water sampling for gas analyses. Multibeam bathymetry mapping (EM300) data was collected on route for the entire cruise. We also ran echosounder profiles along the NW Svalbard margin, across Yermak Plateau from west to east into the Sofia Basin and upslope towards the northern Svalbard margin. We reached the upper gas hydrate stability (GHSZ) theoretical outcrop zone but no acoustic evidence for extended gas release activity was found along the GHSZ outcrop zone at Yermak Plateau.

2 Participants and Affiliations

2.1 Participants Leg 1* and Leg 2^

1. Jürgen Mienert*^	Chief scientist	UiT_CAGE
2. Malin Waage *^	Seismics (PhD)	UiT_CAGE
3. Kate Alyse Waghorn*^	Seismics (PhD)	UiT_CAGE
4. Sunny Singhroha*	Seismics (PhD)	UiT_CAGE
5. Suchada Krokmyrdal*	MS student	UiT_CAGE
6. Rowan Romeyn*^	MS student	UiT_CAGE
7. Giacomo Osti*	Sedimentology (PhD)	UiT_CAGE
8. Karianne Heimdal*	MS student	UiT_CAGE
9. Weil-Li Hong *	Geochemistry (Postdoc)	UiT_CAGE
10. Haoyi Yao*	Geochemistry (PhD)	UiT_CAGE
11. Pår Jansson*^	Ocean chemistry (PhD)	UiT_CAGE
12. Steinar Iversen*^	Engineer	UiT
13. Bjørn Runar Olsen*^	Engineer	UiT
14. Jackie Peter Alien Triest^	Scientist	CNRS, France
15. Roberto Grilli^	Scientist	CNRS, France

2.2 Affiliations

UiT_CAGE	UiT - The Arctic University of Norway, CAGE - Centre of Arctic Gas Hydrate, Environment and Climate, Department of Geology, N-9037 Tromsø
CNRS	Centre National de Recherche Scientific, Laboratoire de glaciologie et géophysique de l'environnement, 25 avenue des Martyrs BP 166 CR 38042 Grenoble Cedex, France

3 Research program

3.1 Introduction

Gas hydrates form ice-like crystals occurring in the pore space of sediments in continental margins at high pressure and low temperature. Gas hydrates consists mainly of methane and water and therefore one often called methane hydrates. Methane hydrates may also form in pan-arctic permafrost areas from land to ocean (Sloan Jr., 1998). The stability of hydrates in both continental margins and permafrost is mainly governed by temperature variations. Hence, hydrate stability will be affected by future warming of the Earth's ocean and land masses.

Large uncertainties exist when estimating the total amount of carbon stored in gas hydrates and the free gas reservoirs beneath it. Values for gas hydrates range from 500 to 5000 Gt of carbon (e.g. Buffett and Archer, 2004; Milkov, 2004; Kvenvolden & Rogers, 2005) but free gas reservoirs may add approximately 1800 Gt of organic carbon (Buffett and Archer, 2004). The total carbon reservoirs are enormous and comprise almost half of the Earth's organic carbon. If these carbon stores entered the atmosphere, they would affect climate – leading to a greenhouse world'

The long- and short-term dynamics of this carbon reservoir need to be better understood to improve understanding of the carbon reservoirs and its flux rates. One could envision a rapid release of methane that would have recognisable effects on climate as most of this methane (as carbon) is a 25-35 times more effective greenhouse gas than CO_2 (Harvey and Huang, 1995; Shindell et al., 2009). A change in ocean temperature of 3°C would for example release globally ~4000 Gt of carbon into the ocean and atmosphere, but again large uncertainties from 500 (Biastoch et al., 2011) – 4000 Gt (Archer and Buffett, 2005) exist regarding such predictions.

Climate models do not yet include the dynamical behaviour of carbon fluxes from the seafloor via the overlying water column to the atmosphere. Models assume that the present amounts of released carbon from the seafloor are small. The assumption is based on a situation where methane does not reach the atmosphere as methane gets oxidised in the water column. However, more evidence accumulates that even at the present time there are significant variations and the amount of methane venting from the seabed through shallow seas of large Arctic shelf regions may become larger (Shakova et al.; Portnov et al. 2013). Evidence exists also from deep water areas from which methane may reach the atmosphere (Dimitrov, 2002; Kennett et al., 2003; Kastner et al., 2005, Smith et al., 2013).

Triggering of submarine landslides on glaciated continental margins may be at least partly related to dissociation of gas hydrate and migrating fluids leading to overpressure build up (e.g. Mienert et al., 2005; Mienert, 2009). The part of the gas hydrate system that is most strongly affected by bottom-water warming is the zone where the base of the gas hydrate stability zone (BGHSZ) intersects the seabed, which is at the extreme upper continental margin (Jung and Vogt, 2004; Mienert et al., 2005, Westbrook et al, Ferre et al., Graves et al., 2015). In the Arctic this zone is at approximately 350 m water depth. Because most, if not all, of the investigated submarine slides are retrogressive (Solheim et al., 2005; Vanneste et al., 2006; Hogan et al., 2013) the instability starts at the toe and not at the upper end of the slope. However, gas hydrate dissociation triggered by ocean warming would start at the top of the slope leading most likely to a progressive and not a retrogressive slope failure.

The Centre of Excellence CAGE – Centre for Arctic Gas Hydrate, Environment and Climate aims to understand how the gas hydrate reservoirs and methane production and uptake systems will react to future increases in bottom-water temperature, which might trigger a sudden release of large amounts of methane leading to changes in the ocean environment and climate.

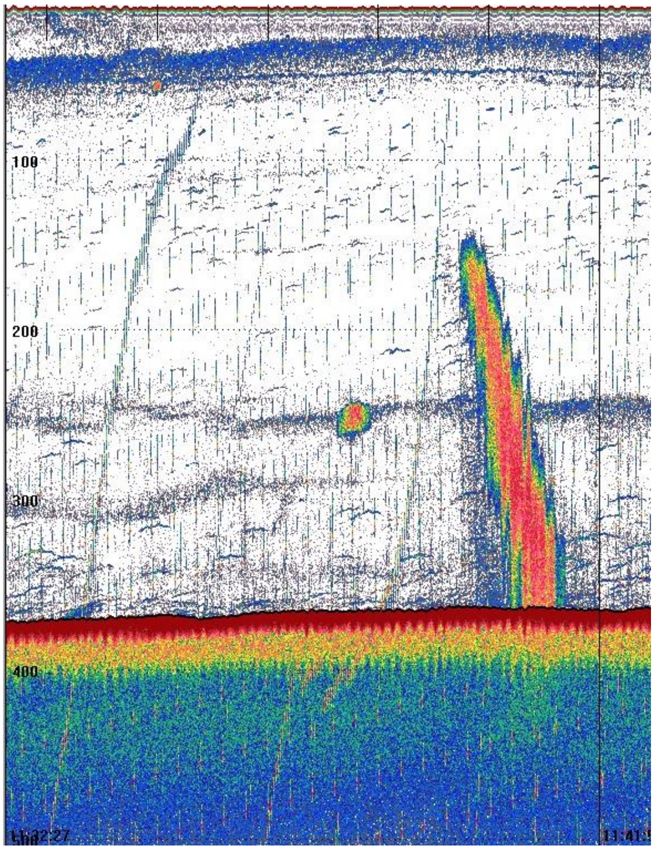


Fig. 2: Flare at Storfjordrenna at approx. 363 m water depth.

3.2 Cruise activities

The main activities during the cruise included:

- A total of 57 CTD stations. 9 CTD stations (Stnr 1511-1519) at Storfjordrenna at ~380 m water depth, and 11 CTD stations at Vestnesa Ridge (Stnr 1541-1551) at ~1200 m water depth for measurements of ocean water masses for water/gas changes across methane seeps. In addition CTD stations were taken for EM300 speed of sound calibrations (Stnr 1504 and 1527). CTD stations 1617-1626 were taken for water/geochemistry analysis in the spectrometer profiling area offshore PKF at ~400m water depth (see CNRS report).

- One Plankton Net station (Stnr 1524) for seasonal studies of foraminifera distribution and ocean acidification incl. one CTD station (Stnr 1636). (for Kasia Zamelzyk)

- A total of 21 gravity cores were taken during the cruise to study shallow sediments with respect to stratigraphy, microbiology, micropaleontology and geochemistry. Core locations are at Storfjordrenna (Stnr 1520-1523), Svyatogor Ridge (Stnr 1520-1523) at the Spitsbergen Transform Fault, and Sofia Basin (Stnr 1568-1569). Sediment samples were taken from up to 4 m long cores. One of the aims of the gravity coring is to study the age of sediment mass movement events along the slope of Yermak Plateau in Fram Strait close to the Spitsbergen Transform Fault. (PhD student Giacomo Osti et al.)

- Gravity cores collected during the cruise were split, sampled and described. On land they will be investigated further to determine methane fluxes and decouple methane-related diagenesis, detailed geochemical and microbiological analysis to investigate the microbial communities responsible for organic matter degradation, and the generation and consumption of methane in sediments (Postdoc Weili Hong and PhD Haoyi Hao).

- Subsampling of some of the gravity cores through GC.. was completed for geochemical analyses on board (see report Weili and Haoyi). These measurements will help to characterize down core variations in detrital and diagenetic products within the sediments from methane and non-methane rich core sites.
- 18 and 38 kHz single echo sounder profiling for gas bubble detection and release mapping. The multi-frequency echosounder allows flare imaging, which in turn helps to identify active seeps and variations in their activity pinpointing the best locations for CTD stations.. (PhD Pår Jansson, see report)
- 20 seismic lines were used to investigate the potential for the existence of gas hydrate and free gas for all working areas (PhD Savel Pavrov, Giacomo Osti, Kate Alyse Waghorn, Master student Suchada Krokmyrdal, see report Kate and Malin)
- 5 Ocean bottom seismometer deployments including short 2D seismic lines across (see report Kate and Malin)
- 2 Ocean observatory communication tests (see report Pår Jansson)

3.3 Deviations from the intended cruise schedule

The cruise followed the intended schedule as planned. The sea was relatively calm and no major downtime occurred for equipment.

3.4 Compliance with the regulations for responsible marine research

We complied with the regulations for responsible marine research. The cruise activities were outside of the Svalbard National Park boundaries. During the cruise the ship was operated in clean ship mode except for disposal of sediments after sampling.

3.5. Results

3.5.1. CTD - Water Mass Analyses; Ocean Observatories (Pår Jansson et al.)

Water mass sampling

We collected CTD data at 33 stations during the first leg of the cruise. Water samples were taken from 28 of these. The number of bottles at each station is listed in Table 1 and the locations indicated in Figures 3 and 4.
Water samples will be analysed for methane concentrations at the institute after arrival in Tromsø, using headspace chromatography. We also collected samples for planned nutrient analysis. An example of salinity and temperature profiles an water masses is shown in figures 3 and 4.

Area	Station	CTD	Station depth	Date_time	Lon	Lat	Bottles
No name	1504	1	380	2015-10-09 04:49	16.139	76.070	0
Pingo Area	1511	2	390	2015-10-09 20:11	16.055	76.097	9
Pingo Area	1512	3	385	2015-10-09 20:52	16.027	76.104	8
Pingo Area	1513	4	385	2015-10-09 21:26	16.003	76.104	8
Pingo Area	1514	5	381	2015-10-09 21:59	15.992	76.110	8
Pingo Area	1515	6	380	2015-10-09 22:31	15.946	76.108	8
Pingo Area	1516	7	383	2015-10-09 23:06	15.986	76.098	8
Pingo Area	1517	8	382	2015-10-09 23:42	15.959	76.113	8
Pingo Area	1518	9	366	2015-10-10 0:21	15.935	76.123	8
Pingo Area	1519	10	359	2015-10-10 0:50	15.907	76.131	8
Bjørnøyrenna west	1526	11	210	2015-10-10 11:36	12.912	76.396	0
No name	1527	12	1203	2015-10-11 4:33	07.026	78.959	12
Vestnesa	1541	13	1198	2015-10-11 16:22	06.950	78.999	12
Vestnesa	1542	14	1208	2015-10-11 17:29	06.925	79.004	12
Vestnesa	1543	15	1208	2015-10-11 18:34	06.904	79.007	12
Vestnesa	1544	16	1208	2015-10-11 19:43	06.884	79.010	12
Vestnesa	1545	17	1214	2015-10-11 20:57	06.858	79.015	10
Vestnesa	1546	18	1203	2015-10-11 22:09	06.866	79.005	10
Vestnesa	1547	19	1212	2015-10-11 23:59	06.890	79.003	10
Vestnesa	1548	20	1206	2015-10-12 0:57	06.906	79.000	10
Vestnesa	1549	21	1219	2015-10-12 2:01	06.950	79.008	10
Vestnesa	1550	22	1228	2015-10-12 3:00	06.928	79.0132	10
Vestnesa	1551	23	1222	2015-10-12 4:33	06.914	79.0143	10
No name	1565	24	812	2015-10-14 13:03	07.889	80.452	0
No name	1570	25	1488	2015-10-16 02:11	10.480	80.751	0
No name	1584	26	2675	2015-10-18 20:59	04.339	79.751	0
Prins Karls Forland	1586	27	118	2015-10-19 10:30	10.294	78.581	7
Prins Karls Forland	1587	28	161	2015-10-19 10:55	10.278	78.579	7
Prins Karls Forland	1588	29	101	2015-10-19 11:18	10.232	78.572	7
Prins Karls Forland	1589	30	81	2015-10-19 11:54	10.183	78.567	7
Prins Karls	1590	31	101	2015-10-19 12:17	10.180	78.564	7

Forland							
Prins Karls Forland	1591	32	113	2015-10-19 12:33	10.099	78.554	7
Prins Karls Forland	1592	33	84	2015-10-19 12:54	10.089	78.557	7

Tab.1: CTD stations Storfjordrenna (Pingos), Vestnesa and PKF.

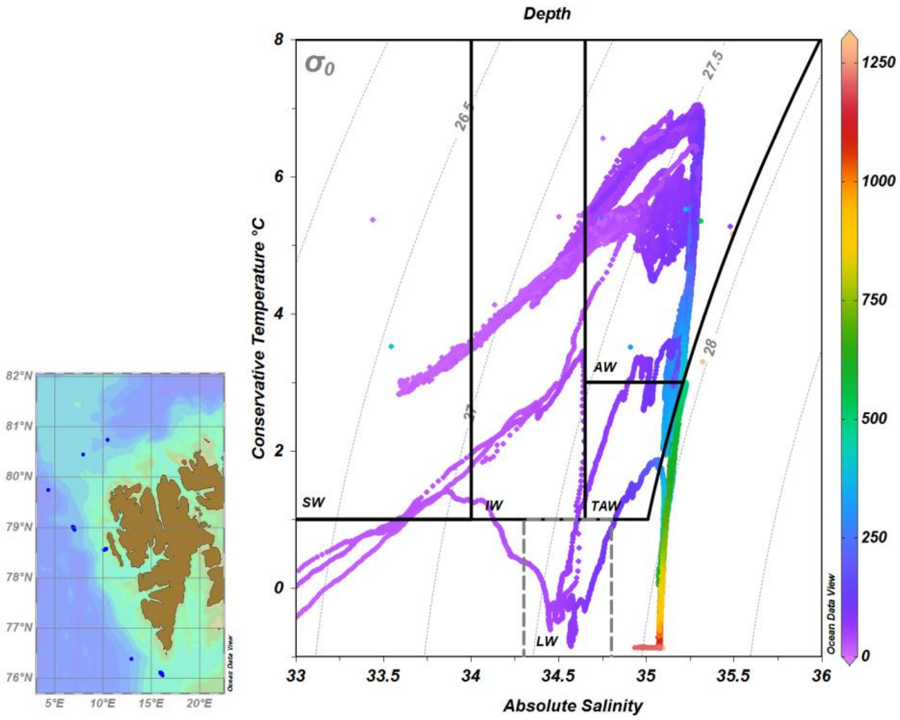


Figure 3: Map of the CTD stations (left), and T-S (temperature and salinity) diagram of the continuous CTD profiles (right). Water mass definitions are redrawn from Svendsen et al., 2002. We see surface water (SW) and Atlantic water (AW) and also some ice influenced local water (LW) in the northernmost stations. The deepest water is dominated by Nordic sea deep water with densities higher than 1027.9 kg m^{-3}, not labelled in the diagram.

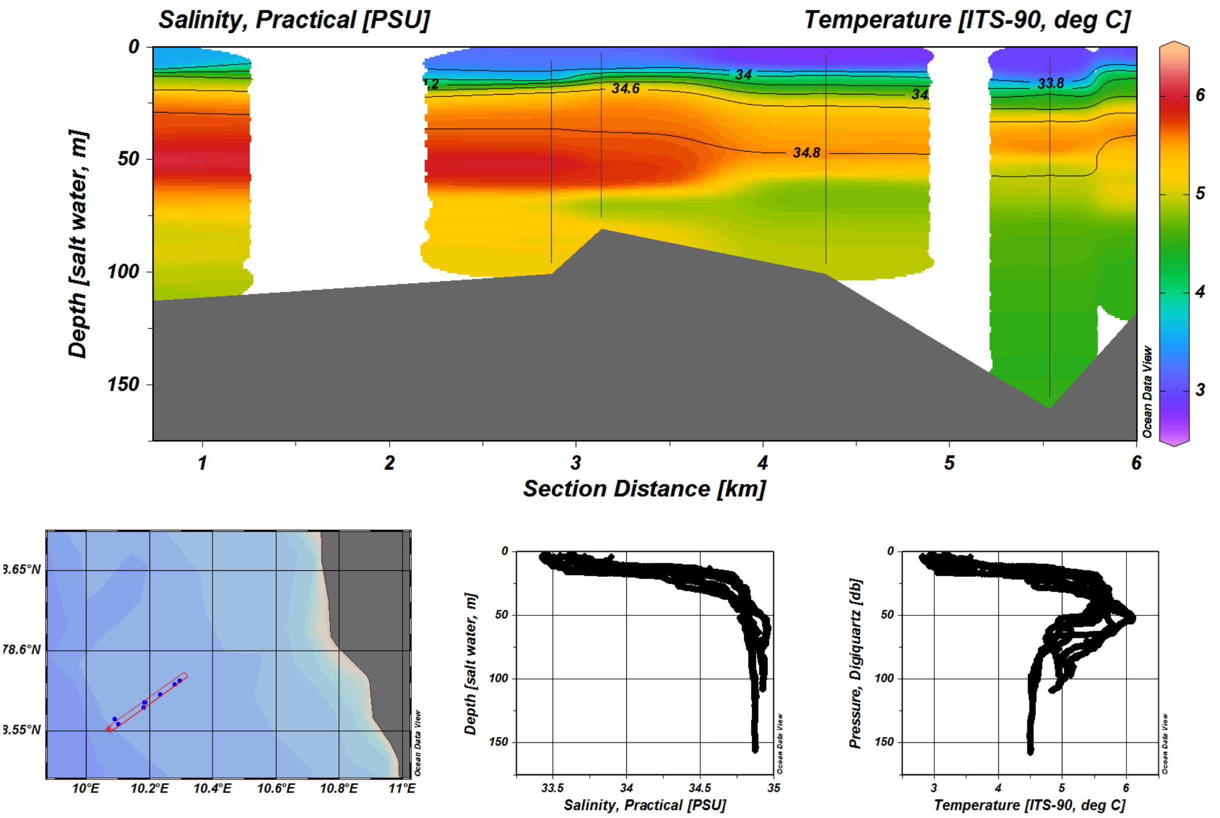


Figure 4: Transect of 6 CTD profiles at Prins Karls Forland. We see horizontally homogenous water masses with a clear pycnocline governed by both salinity and temperature. Some cooling of surface waters exists with residual warmer water immediately underlying the surface water. The area is dominated by Atlantic water below 50 meters water depth.

CTD Number	Station Nr.	Position (END) Longitude/Latitude	Number of Bottles
CAGE 15-6_HH_CTD	1504	76°04.135N16°08.045E	0 (depth 386m)
CAGE 15-6_HH_CTD	1511	76°06.237N16°02.427E	(depth 390m)
CAGE 15-6_HH_CTD	1512	76°06.215N16°03.193E	(depth 388m)
CAGE 15-6_HH_CTD	1513	76°06.546N16°00.001E	(depth 393m)
CAGE 15-6_HH_CTD	1514	76°06.537N15°57.602E	(depth 390m)
CAGE 15-6_HH_CTD	1515	76°06.525N15°55.063E	(depth 386m)
CAGE 15-6_HH_CTD	1516	76°05.791N15°59.607E	(depth 387m)
CAGE 15-6_HH_CTD	1517	76°07.060N15°57.189E	(depth 385m)
CAGE 15-6_HH_CTD	1518	76°07.697N15°55.863E	(depth 370m)
CAGE 15-6_HH_CTD	1519	76°06.260N15°58.643E	(depth 386m)
CAGE 15-6_HH_CTD	1526	76°24.063N12°52.747E	(depth 1565m)
CAGE 15-6_HH_CTD	1527	79°00.548N06°53.416E	(depth 1208m)
CAGE 15-6_HH_CTD	1541	78°59.951N06°57.275E	(depth 1197m)
CAGE 15-6_HH_CTD	1542	79°00.301N06°55.062E	(depth 1202m)
CAGE 15-6_HH_CTD	1543	79°00.532N06°54.043E	(depth 1208m)
CAGE 15-6_HH_CTD	1544	79°00.762N06°53.177E	(depth 1208m)
CAGE 15-6_HH_CTD	1545	79°01.167N06°51.491E	(depth 1215m)
CAGE 15-6_HH_CTD	1546	79°00.757N06°52.032E	(depth 1207m)
CAGE 15-6_HH_CTD	1547	79°00.018N06°54.386E	(depth 1208m)

CAGE 15-6_HH_CTD	1548	79°00.237N06°56.101E	(depth 1212m)
CAGE 15-6_HH_CTD	1549	79°00.228N06°58.141E	(depth 1218m)
CAGE 15-6_HH_CTD	1550	79°00.598N06°56.236E	(depth 1222m)
CAGE 15-6_HH_CTD	1551	79°00.324N06°53.394E	(depth 1207m)
CAGE 15-6_HH_CTD	1563	78°27.939N09°36.790E	(depth 406m)
CAGE 15-6_HH_CTD	1565	80°27.703N07°49.765E	(depth 707m)
CAGE 15-6_HH_CTD	1570	80°45.127N01°28.520E	(depth 1468m)
CAGE 15-6_HH_CTD	1584	79°44.569N04°11.413E	(depth 2650m)
CAGE 15-6_HH_CTD	1586	78°34.883N10°18.046E	(depth 126m)
CAGE 15-6_HH_CTD	1587	78°34.564N10°15.025E	(depth 160m)
CAGE 15-6_HH_CTD	1588	78°34.107N10°11.575E	(depth 90m)
CAGE 15-6_HH_CTD	1589	78°33.928N10°11.035E	(depth 80m)
CAGE 15-6_HH_CTD	1590	78°33.498N10°07.370E	(depth 101m)
CAGE 15-6_HH_CTD	1591	78°33.258N10°05.994E	(depth 114m)
CAGE 15-6_HH_CTD	1592	78°33.716N10°08.499E	(depth 89m)
CAGE 15-6_HH_OS 1	1585 talk	78°39.313N09°25.870E	(depth 243m)
CAGE 15-6_HH_OS 2	1593 talk	78°33.656N10°08.679E	(depth 92m)
CAGE 15-6_HH_CTD	1597	78°38.055N07°23.320E	(depth 1379m)
CAGE 15-6_HH_CTD	1598*	78°38.793N07°40.091E	(depth 1130m)
CAGE 15-6_HH_CTD	1599	78°38.886N07°58.044E	(depth 1031m)
CAGE 15-6_HH_CTD	1600	78°38.966N08°17.460E	(depth 899m)
CAGE 15-6_HH_CTD	1601	78°38.750N08°37.351E	(depth 766m)
CAGE 15-6_HH_CTD	1602*	78°38.859N08°57.296E	(depth 587m)
CAGE 15-6_HH_CTD	1603	78°39.041N09°07.032E	(depth 488m)
CAGE 15-6_HH_CTD	1604*	78°39.115N09°20.629E	(depth 411m)
CAGE 15-6_HH_CTD	1605*	78°39.408N09°25.499E	(depth 246m)
CAGE 15-6_HH_CTD	1606	78°39.425N09°41.124E	(depth 156m)
CAGE 15-6_HH_CTD	1607	78°39.385N09°41.101E	(depth 158m)
CAGE 15-6_HH_CTD	1608	78°39.478N09°50.519E	(depth 131m)
CAGE 15-6_HH_CTD	1609*	78°39.638N10°08.137E	(depth 142m)
CAGE 15-6_HH_CTD	1610	78°39.893N10°18.121E	(depth 76m)
CAGE 15-6_HH_CTD	1611	78°40.017N10°26.925E	(depth 70m)
CAGE 15-6_HH_CTD	1617*	78°34.537N09°26.858E	(depth 398m)
CAGE 15-6_HH_CTD	1618*	78°34.290N09°27.441E	(depth 397m)
CAGE 15-6_HH_CTD	1619*	78°33.927N09°27.356E	(depth 397m)
CAGE 15-6_HH_CTD	1620*	78°33.540N09°27.733E	(depth 393m)
CAGE 15-6_HH_CTD	1621*	78°33.243N09°28.683E	(depth 391m)
CAGE 15-6_HH_CTD	1622*	78°32.819N09°29.312E	(depth 394m)
CAGE 15-6_HH_CTD	1623*	78°32.303N09°30.024E	(depth 306m)
CAGE 15-6_HH_CTD	1624*	78°33.531N09°25.912E	(depth 410m)
CAGE 15-6_HH_CTD	1625*	78°33.536N09°28.614E	(depth 387m)
CAGE 15-6_HH_CTD	1626*	78°33.519N09°32.043E	(depth 347m)
CAGE 15-6_HH_CTD	1635	77°56.217N12°57.058E	(depth 3452m)
CAGE 15-6_HH_CTD	1636	76°23.496N12°58.345E	(depth 152m)
Note: CTD stations 1617-1626 and ADCP lines 1-7 are for the spectrometer data quality control and interpretations.	Talk 1 and 2 communicated with CAGE OS1 and 2		

Ocean Spectrometer (OSP)			
CAGE 15-6_HH_OSP	1594 (VP)	78°34.031N09°31.470E	(depth 342m)
CAGE 15-6_HH_ OSP	1595 (line1)	78°34.110N09°31.460E	(depth 339m)
CAGE 15-6_HH_ OSP	1596 (line2)	78°31.731N09°27.349E	(depth 431m)
CAGE 15-6_HH_ OSP	1612 (line3)	78°34.162N09°27.086E	(depth 400m)
CAGE 15-6_HH_ OSP	1613 (line4)	78°31.941N09°29.822E	(depth 403m)
CAGE 15-6_HH_ OSP	1614 (line4)	78°34.136N09°27.196E	(depth 399m)
CAGE 15-6_HH_ OSP	1615 (line4)	78°31.874N09°31.049E	(depth 391m)
CAGE 15-6_HH_ OSP	1616 (VP)	78°31.941N09°29.822E	(depth 396m)
CAGE 15-6_HH_ OSP	1628	78°32.005N09°31.878E	(depth 381m)
CAGE 15-6_HH_ OSP	1629	78°34.177N09°27.334E	(depth 399m)
CAGE 15-6_HH_ OSP	1630	78°31.904N09°32.686E	(depth 372m)
CAGE 15-6_HH_ OSP	1631	78°34.302N09°28.292E	(depth 386m)
CAGE 15-6_HH_ OSP	1632	78°34.093N09°28.874E	(depth 381m)
CAGE 15-6_HH_ OSP	1633	78°34.065N09°28.743E	(depth 383m)
CAGE 15-6_HH_ OSP	1634	78°33.508N09°28.167E	(depth 390m)
ADCP 7 lines			
CAGE 15-6_HH_ ADCP	1627	78°31.813N09°16.455E	(depth 482m)

Table 2. All CTD station numbers and locations (***with water samples**).**Pår Check water samples!** Ocean Spectrometer (see CNRS report) vertical profiles (VSP) and horizontal profiles 1-5. OSP profiles were run at 10, 50, 150 and ~340m above seabed to observe changes across flare and/or no flare areas. See appendix 2 for additional CTD information.

3.5.2 CAGE Ocean Observatories tests (Pår Jansson)

Cnode / Cpap test

On 19.10.2015 we conducted two communication tests with CAGE observatories OS 1 (black) and OS 2 (grey). In preparation for deployment of the landers Pär Jansson (CAGE) was trained by Kongsberg staff in communication procedures, and took notes and photographed the lander assembly. He compiled a list of serial numbers of Cnodes and channels for each lander, respectively. The landers were deployed on June 30th (Black lander) and July 2nd (Grey lander) 2015.

The information derived from photos taken during the assembly turned out to be different if compared with notes written down during the 1st deployment of the landers in June and July 2015. We believe this discrepancy is due to a change of the Codes from the grey (OS1) to the black lander (OS2), without notifying CAGE staff.

Finally, tests were fortunately successful when we used the following Cnodes for the tests. Table 3 shows which Cnodes responded in the respective positions.

Note that the information in the Cnode table should be used in the future to communicate with the landers.

14080 mounted on 2 lander

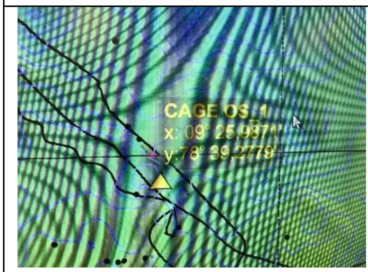
14083 on lander 2

14082 on lander 1

14081 on lander 1


Lander 1 deployed June 30th 2015


At 240 m water depth



First lander at 240 m

Second lander at 90 m

Figure 5. Photographs showing lander and release configuration.

Lander **OS 1**	**Black**	240 m depth			
Serial #	Channel	Longitude	Latitude	Response	Comment
14083	M27	9°26'	78°39'	Yes	Autonomous
14082	M26	9°26'	78°39'	No	Main battery
Lander **OS 2**	**Grey**	90 m depth			
Serial #	Channel	Longitude	Latitude	Response	Comment
14081	M25	10°8'	78°34'	Yes	Autonomous
14080	M24	10°8'	78°34'	Yes	Main battery. Battery used 18Ah

Tab. 3: Correct Cnodes responding to interrogation during CAGE_15-6 October 19th

3.5.3. Sediment cores – Facies Description (*Giacomo Osti* et al.)

Sedimentology

21 gravity cores (Table 4) have been recovered during the cruise, in four study areas: Storfjordrenna, Svyatogor Ridge, Sofia Basin (Yermak Plateau) and Spitsbergen Transform Fault (SFZS) Slides (Fig. 1)

Date	Time (UTC)		Station number	Latitude		Longitude		Water depth (m)
Pingo Like Features								
10.10.2015	01:40:04	5187.21	1520	7606.341927	N	1557.96406	E	386.21
10.10.2015	05:00:55	5191.43	1521	7606.361264	N	1557.82788	E	386.49
10.10.2015	06:05:13	5192.77	1522	7606.42657	N	1557.47377	E	387.78
Svyatogor								
12.10.2015	19:31:01	5564.23	1553	7816.477098	N	556.404998	E	1660.43
12.10.2015	21:03:06	5566.45	1554	7815.835699	N	550.335931	E	1524.61
12.10.2015	22:14:09	5567.29	1555	7815.849745	N	551.096132	E	1536.72
12.10.2015	23:27:37	5568.03	1556	7815.683456	N	551.561378	E	1538.71
13.10.2015	00:52:46	5568.99	1557	7815.48177	N	551.570563	E	1534.94
13.10.2015	02:06:56	5569.97	1558	7815.788038	N	552.835451	E	1548.95
13.10.2015	04:03:42	5575.02	1559	7819.540456	N	545.61196	E	1597.97
13.10.2015	07:00:24	5585.92	1560	7828.594881	N	540.868745	E	1687.58
Yermak Plateau channel								
15.10.2015	23:29:04	5970.35	1568	8044.868205	N	1025.06404	E	1384.16
16.10.2015	01:46:58	5972.4	1569	8045.034213	N	1028.82263	E	1469.54
SFZS								
18.10.2015	05:52:01	6247.79	1576	7933.139485	N	453.400295	E	2860.71
18.10.2015	07:39:36	6249.08	1577	7933.926236	N	455.366515	E	2895.23
18.10.2015	09:23:38	6250.84	1578	7934.70799	N	458.168947	E	2850.4
18.10.2015	12:59:46	6265.18	1579	7947.544324	N	446.636112	E	2041.24
18.10.2015	14:16:02	6266.62	1580	7948.526618	N	449.275829	E	1810.43
18.10.2015	16:40:32	6269.81	1581	7946.917304	N	447.186589	E	2211.54
18.10.2015	18:37:56	6274.27	1582	7944.032279	N	432.656262	E	2716.19
18.10.2015	20:19:51	6276.97	1583	7945.092754	N	421.8751	E	2621.5

Tab. 4: All gravity core stations at the four working areas (Fig.1).

Storfjordrenna PLF

Station number: 1520, 1521 and 1522

Three gravity cores were recovered from the Pingo like features (PLF) area in Storfjordrenna. Core number 1520 and 1521 have been recovered on top of one of the pingos at a water depth of 386 m whereas core number 1522 has been taken as a control core at a water depth of 388 m. The two cores that penetrated the pingo (1520 and 1521) recovered gas hydrates.

Core CAGE 15-6 1520 GC:
The total length of the core is 359 cm but the sediment recovery is 309 cm as between 171 cm and 227 cm, a 55 cm long void is observed, probably generated by the overpressure in the sediments caused by the dissociation of gas hydrates during the recovery of the core. After the core was split, gas hydrates were observed within the sediment at a depth of ~235 cm and ~350 cm (at the bottom of the core). The sedimentary column is composed mainly of dark grey mud presenting cracks and a "mousse-like" texture probably due to the porosity generated by the dissociation of gas hydrate. Authigenic carbonate crusts occur throughout the entire sedimentary column, with a high concentration of different size carbonate clasts at a depth of ~105 cm. Two dark layers and a strong smell of H_2S characterize the top 17 cm of the sediment column.

Core CAGE 15-6 1521 GC:
The core presents a length of 80 cm. Gas hydrates were observed both during the recovery operation and after it was split, at the bottom of the core. At this depth, the sediments are characterized by a "mousse-like" texture probably due to the porosity generated by the dissociation of gas hydrate. The sediment column presents a homogeneous dark grey muddy composition. A soupy appearance characterizes the upper 5 cm of the sediment column and authigenic carbonate clasts have been observed at 35 cm, 45 cm and 55 cm depth.

Core CAGE 15-6 1522 GC:
The core is 329 cm long and characterized by dark gray mud. No hydrates were observed in the sedimentary column and the texture of the sediment is less porous than the previous cores, suggesting that gas hydrates have not formed within the sediments. A clast of authigenic carbonate was observed at a depth of 50 cm whereas at 250 cm and 300 cm two brighter layers of carbonate mud differs from the homogeneous composition of the rest of the sediment column. The core is characterized by the regular occurrence of black patches and it is highly bioturbated.

Svyatogor
Station number: from 1553 to 1560
Eight cores were recovered from the Svyatogor Ridge. One of them is a control core. Three have been recovered from pockmarks above faults and the rest have been recovered from what has been interpreted as paleo-pockmarks. A 3-D seismic cube previously acquired in the area shows that the faults observed have a deep penetration, terminating at depths where serpentinization processes may occur. The main goal of coring was to extract pore water from sediments in order to understand whether pore fluids originate at deep crustal levels. Pore-water samples were extracted from the cores recovered on paleo-pockmark. Further studies will show whether there is a correlation between the origin and the chemistry of the pore fluids in the different areas.

Sofia Basin Channel
Station number: 1568 and 1569
The location of the two cores recovered in Sofia Basin has been based on a seismic profile acquired in the area, showing the occurrence of a channel-like feature that may act as a sediment transportation path from the continental shelf to Sofia Basin. Stratigraphy of the channel (core 1569) will be analyzed and compared with stratigraphy on the levee (core 1568) in order to determine the timing of sediment transport activation.

Spitsbergen Transform Fault Slides

Station number: from 1576 to 1583

Core 1576, 1577 and 1578 were recovered along a fault. On a seismic profile crossing the area the strong amplitude anomalies are observed along the fault, which might indicate gas accumulation. Gas and pore water samples were extracted from the sediments in order to detect the potential occurrence of gas and investigate it's chemical composition and origin. The remaining sediment cores were recovered from within the slide scars that are well imaged in the bathymetric data. Here, we observe a headwall morphology, which may indicate recent failure events. The main goal is to date the slide events and correlate the time of failures to glacial or interglacial periods, or changes in the ocean circulation and physical properties of palaeo water masses, in order to identify potential triggering mechanisms.

Sediment Core Number	Station Nr.	Position (END) Longitude/Latitude	Water depth (m)
CAGE 15-6_HH_GC	1520*	76°06.341N15°57.964E	0 (depth 386m)
CAGE 15-6_HH_GC	1521*	76°06.361N15°57.827E	(depth 386m)
CAGE 15-6_HH_GC	1522*	76°06.426N15°57.473E	(depth 387m)
CAGE 15-6_HH_GC	1553*	78°16.477N05°56.404E	(depth 1660m)
CAGE 15-6_HH_GC	1554	78°15.835N05°50.335E	(depth 1524m)
CAGE 15-6_HH_GC	1555	78°15.849N05°51.096E	(depth 1536m)
CAGE 15-6_HH_GC	1556	78°15.683N05°51.561E	(depth 1538m)
CAGE 15-6_HH_GC	1557	78°15.481N05°51.570E	(depth 1534m)
CAGE 15-6_HH_GC	1558	78°15.788N05°52.835E	(depth 1548m)
CAGE 15-6_HH_GC	1559	78°19.540N05°45.611E	(depth 1597m)
CAGE 15-6_HH_GC	1561	78°28.594N05°40.868E	(depth 1687m)
CAGE 15-6_HH_GC	1568*	80°44.868N10°25.064E	(depth 1384m)
CAGE 15-6_HH_GC	1569*	80°45.034N10°28.822E	(depth 1469m)
CAGE 15-6_HH_GC	1576*	79°33.139N04°53.400E	(depth 2860m)
CAGE 15-6_HH_GC	1577*	79°33.926N04°55.366E	(depth 2895m)
CAGE 15-6_HH_GC	1578*	79°34.707N04°58.168E	(depth 2850m)
CAGE 15-6_HH_GC	1579	79°47.544N04°46.636E	(depth 2041m)
CAGE 15-6_HH_GC	1580	79°48.526N04°49.275E	(depth 1810m)
CAGE 15-6_HH_GC	1581	79°46.917N04°47.186E	(depth 2211m)
CAGE 15-6_HH_GC	1582	79°44.032N04°32.656E	(depth 2716m)
CAGE 15-6_HH_GC	1583	79°45.092N04°21.875E	(depth 2621m)

Table 5: Sediment core station numbers marked with * for pore-water geochemistry analyses on gravity cores (see report Wei-Li Hong and Haoyi Hao).

3.5.4. Sediment cores – Porewater Geochemistry (*Wei-Li Hong and Haoyi Hao*)

Introduction and motivation

Geochemistry of pore fluid provide essential information about fluid source and its dynamic. By analyzing the concentration and isotopic composition of target species in the pore fluid, we are able to both identify the biogeochemical processes and quantitatively estimate the fluxes of key solutes from sub-bottom to seafloor. During the CAGE 15-6 cruise, we have two motivations for the porewater geochemistry program. We first intend to confirm the shallow gas hydrate reservoir (~1 mbsf) and the non-steady state porewater system in the sediments of the mouth of Storfjordrenna. This area was surveyed and sampled during CAGE 15-2 cruise in May 2015. Five Pingo-like features (PLF) were identified and sampled for geochemical investigation. At the south rim of PLF#3, gas hydrates were recovered from the shallow sediments (> 1mbsf). The porewater profiles indicate non-steady state condition that was hypothesized as the consequence of a recent increase in methane supply from gas hydrate dissociation. We therefore planned two gravity cores at the location where gas hydrate was recovered and one background core to confirm the observations made during CAGE 15-2 cruise. The second motivation for the geochemistry program during CAGE15-6 is to explore new areas, Yermak plateau, Svyatogor Ridge, and Spitsbergen Transform Fault Zone slides (SFZS). We conducted pore water sampling and analyzed time-sensitive items on board to identify trace of fluid originating from deep subsea floor. Water samples for strontium isotopes and/or other trace cations (cation fraction in Table 6) are planned to detect the presence of fluid from great depth. The sampling locations were chosen based on the seismic survey done in these regions during the cruise. We summarize the samples and analyses taken during CAGE 15-6 in Table 6.

Method

In Figure 6, we summarize the porewater sampling protocol. We did not always recover sufficient pore water for all subsampling. The porewater for onboard analyses (Tab. 5 & 6), sulfate and cation samples (for Sr isotopes) received the highest priority.

Alkalinity titration

Total alkalinity was determined with a pH-controlled titration to a pH just under 4 using a Metrohm 917 Ti-Touch titrator, within 3 hours from core recovery. The pH electrode was calibrated against pH 4, 7 and 10 Metrohm Instrument buffers. We used 12M reagent grade HCl (Sigma-Aldrich Prod. #: 84415) diluted with MilliQ water to 0.012M, which was calibrated on a daily basis by titrating a reference seawater sample and a 0.01M Borax standard. Samples (2ml) were diluted with 15 ml of 0.7M KCl solution before titration. The amount of acid and pH was manually recorded during each addition. Alkalinity was calculated from the Gran function plots using 8 to 10 points from pH 4.7 to 3.9. From the repeated measurements of standards (n=7), the uncertainty is around 1.(Weili include units)

Fe^{2+} concentration through spectrophotometric method

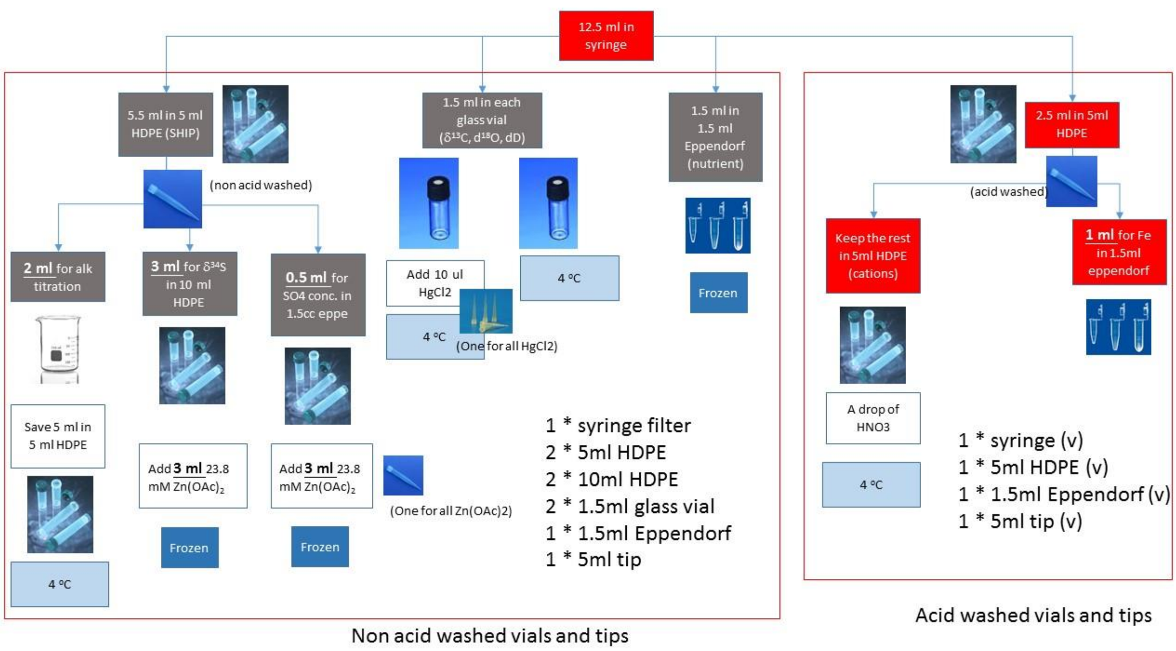
We measured the concentration of dissolved Fe^{+2} by spectrophotometric method with Shimadzu UV1280 spectrophotometer under wavelength 565 nm. We weigh all chemicals (iron sulfate heptahydrate, ascorbic acid, and Ferrospectral) needed onshore and preserved them in dark containers. To make standard solutions and color complexation reagent, we prepared anoxic 0.7M KCl solution and MilliQ water onshore.

This was done by autoclaving KCl solution and MilliQ water under 121°C for 20 minutes. We bubbled them with N_2 gas for 15 minutes before the temperature drops to room temperature. The anoxic solution was extracted onboard by applying a positive N_2 atmosphere. For the calibration curve, we made 10 calibration points with 1.1 to 16.7 μM $FeSO_4 \cdot 7H_2O$ standards (Sigma-Aldrich prod. #: 215422) and 2 background check with our anoxic MilliQ and KCl solution. This was done daily before measuring our porewater samples. After adding 50 ml of 9.72 mM Ferrospectral solution (Merck prod. #: 111613) in each 1 ml of pore water sample, the sample vials were stored in dark for 5-10 minutes to complete the reaction. Proper dilution of samples was made before adding Ferrospectral solution.

	Alk	Fe^{2+}	SO_4/ HS	$\delta^{18}O$	$\delta^{13}C$	Nutrient	Cations	Sed. Geochem	Biomarker /foram	MBio	CH4	poro
1520GC	22	15	21	18	18	18	19	0	72	1	17	11
1521GC	10	5	9	6	6	6	9	36	0	1	5	2
1522GC	3	0	6	0	0	6	6	0	33	0	11	0
1553GC	3	4	6	0	0	0	6	0	0	0	0	0
1554GC	3	4	7	0	0	0	5	0	0	0	0	0
1555GC	3	2	6	0	0	0	4	0	0	0	0	0
1556GC	3	6	7	0	0	0	7	0	0	0	0	0
1557GC	3	6	6	0	0	0	6	0	0	0	0	0
1558GC	3	7	7	0	0	0	7	0	0	0	0	0
1559GC	3	4	5	0	0	0	4	0	0	0	0	0
1560GC	3	5	7	0	0	0	5	0	0	0	0	0
1568GC	3	0	9	0	0	0	9	0	0	0	0	0
1569GC	5	0	6	0	0	0	6	0	0	0	0	0
1576GC	3	0	6	0	0	0	5	0	0	0	2	1
1577GC	4	0	7	0	0	0	6	0	0	0	2	1
1578GC	6	0	9	0	0	0	8	0	0	0	2	1

Table 6: Summary of geochemical samples and analyses during CAGE15-6

Figure 6: Summary of porewater sampling protocol during CAGE 15-6



Preliminary results

We successfully recovered gas hydrate from 1520GC and 1521GC taken from the PLF area. For 1520GC, the alkalinity profile above the depth where hydrates were recovered exhibit clear non-steady state condition. At 1521GC the profile seems to be smoother (Figure 7). Based on the alkalinity profiles, the depth of sulfate-methane-transition-zone (SMTZ) should be around 90 and 64 cmbsf for 1520GC and 1521GC, respectively. For 1522GC, alkalinity increases from 4.9 mM at 182.5 cmbsf to 8.1 mM at the 299 cmbsf indicating SMTZ depth greater than 3 mbsf. Fe^{2+} is soon depleted within the first 25 to 50 cm at 1520GC and 1521GC indicating very strong hydrogen sulfide flux towards seafloor which confines iron reduction zone to the very top of the cores.

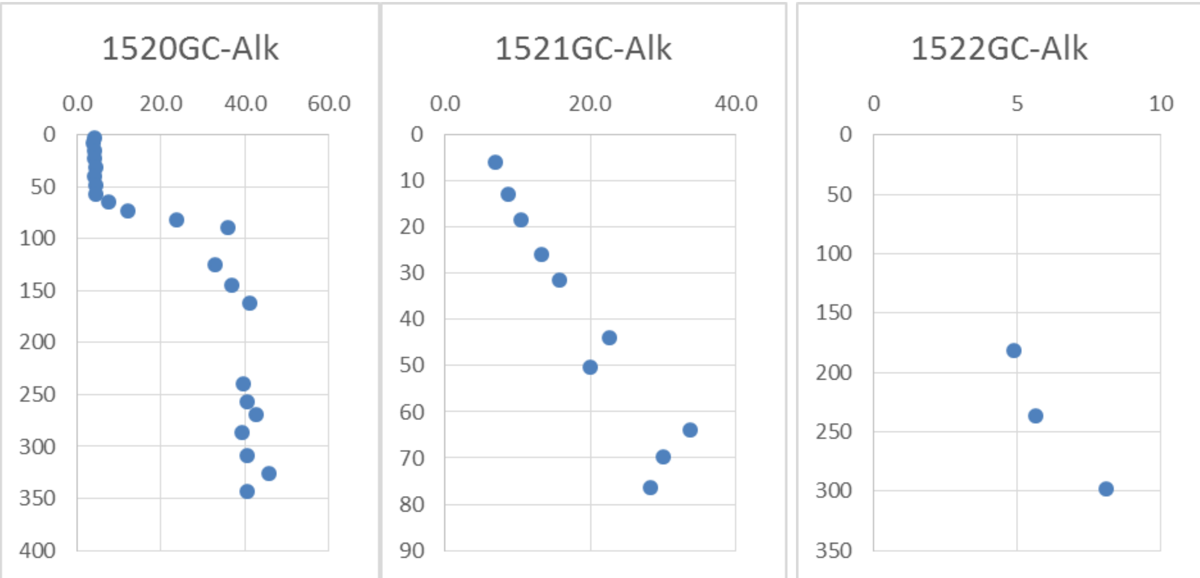


Figure 7: Alkalinity profiles of the three gravity cores taken from the PLF#3 during the CAGE15-6 cruise. Notice the different scale of the three cores.

For the eight cores (1553GC to 1560GC) taken from the Svyatogor ridge, none of the cores penetrated the sulfate reduction zone as alkalinity at the bottom of the core is no higher than 7.7 mM. Abundant Fe^{2+} was still detected in the porewater suggesting very weak sulfide flux in the sediments. Based on the shipboard alkalinity and Fe^{2+} analyses, 1557GC has the highest potential to detect deep fluid from later shore-based analyses. The two cores taken from Yermak Plateau (1568GC and 1569GC) show only very weak geochemical signal related to methane as alkalinity at the bottom of these two cores is no higher than 4 mM. For the three cores taken from SFZS (1576GC to 1578GC), we detect up to 7.2 mM nd 8.5 mM alkalinity at 1577GC and 1578GC, respectively. Such alkalinity values, although still low comparing to other very active area such as PLF, suggest these two sites have higher chance to detect deep fluid than 1576GC.

3.5.5. Seismic (Kate Alyse Waghorn and Malin Waage)

2D Reflection Seismic

2D seismic lines during CAGE15-6 were collected in five study sites, Storfjordrenna, Vestnesa, Svyagator Ridge, Yermak Plateau and at Fram Strait Slides Complex (FSSC) (Tab. 7). 2D reflection seismic is widely used to study the deeper subsurface. Here, acoustic energy is reflected by various lithological and fluid interfaces to obtain an image of the subsurface geology, to then be interpreted stratigraphically and structurally. A reflection seismic survey typically involves generating sound waves (shots) which penetrate the subsurface, and at some point are reflected back up to a streamer, which records the reflected waves using receivers. The receivers record the seismic events and convert to electrical voltage that is then digitally recorded.

Source: During 2D seismic acquisition, two types of source were used depending on the seismic target; mini GI and GI air guns. The mini GI air guns have an injector and generator volume of 30/30 and 15/15 in^3 and the GI guns have an injector and generator volume of 45/105 and 105/105 in^3, respectively. Mini GI airguns generate higher frequency signal, which is suitable for studying the shallow subsurface in detail, while GI air guns have a lower frequency spectrum, and therefore potential for deeper penetration. The air gun generates seismic waves by releasing compressed air into the water. A compressor supplies air at a pressure of 170 bar to the air gun. See table 7 for specific details at the different sites.

Streamer: The streamer used during 2D data acquisition is 100 m long with 32 channels separated by 3.125 m. The streamer is composed of four 25 m long solid state sections.

Operation: The streamer is towed behind the ship at a distance of 70 m from an arm offset laterally ~7 m from the centre line of the boat. The air gun is towed at a distance of 33 m behind the ship at a depth of approximately 2-4 mbsl. See figure 8 for geometry of the survey.

	Storfjord renna	Storfjord renna	Vestnesa	Svaytogor	Yermak Platau	FSSC	FSSC
Source (in³)	30/30 & 15/15	45/105 & 105/105	30/30 & 15/15	45/105 & 105/105	30/30 & 15/15	30/30 & 15/15	45/105 & 105/105
Shot rate (s)	5	14	5	14	5	5	14
Sample rate (ms)	0.250	0.5	0.25	0.5	0.5	0.5	0.5
Recording length (s)	1.5	1.5	3	5	4.5	4.8	6
Line Numbers	Line 001-005	Line 006	Line 007-011	Line 012 -13	Line 14 - 16	Line 17	Line 18-20
Streamer length (m)	100	100	100	100	100	100	100
Number of channels	32	32	32	32	32	32	32
Channel Offset (m)	3.125	3.125	3.125	3.125	3.125	3.125	3.15
Source-Receiver x-offset (m)	6	7	7	7	7	7	7
Source-Receiver y-offset (m)	37	37	37	37	37	37	37
Gun depth (m)	2	4	2	4	2	2	4

Table 7: Acquisition parameters at the different study areas (Fig.1).

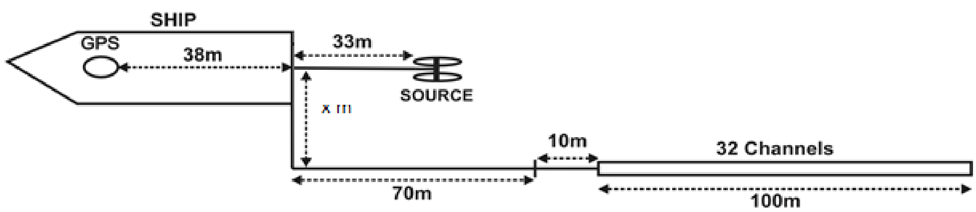


Figure 8: Geometry of the 2D seismic survey during CAGE15-5 expedition.

Ship-Board Processing

Lines are numbered as CAGE15-6-001,002 etc. On-board data processing used Radex Pro for data quality control. Seg-y files were imported to Petrel for further quality control. On board processing included:

1. *Navigation Files:* Seatrack GPS positioning from the gun raft and stern of the ship is used. These are checked for gaps and interpolated if necessary
2. *Read SegD Files into RadEx Pro*
3. *Single channel display for quality control*
4. *Geometry assignment (Fig. 8)*
5. *CDP Binning (3.125 x 3.125 m bin size)*
6. *Bandpass filtering using 10-20-300-400 Hz*
7. *Amplitude Correction (spherical divergence and time-variant gain)*
8. *NMO Correction (1500 m/s)*
9. *Stacking*
10. *Migration using a Kirchhoff Time Migration*
11. *Seg-y Output*

Results of Ship-Board Processing

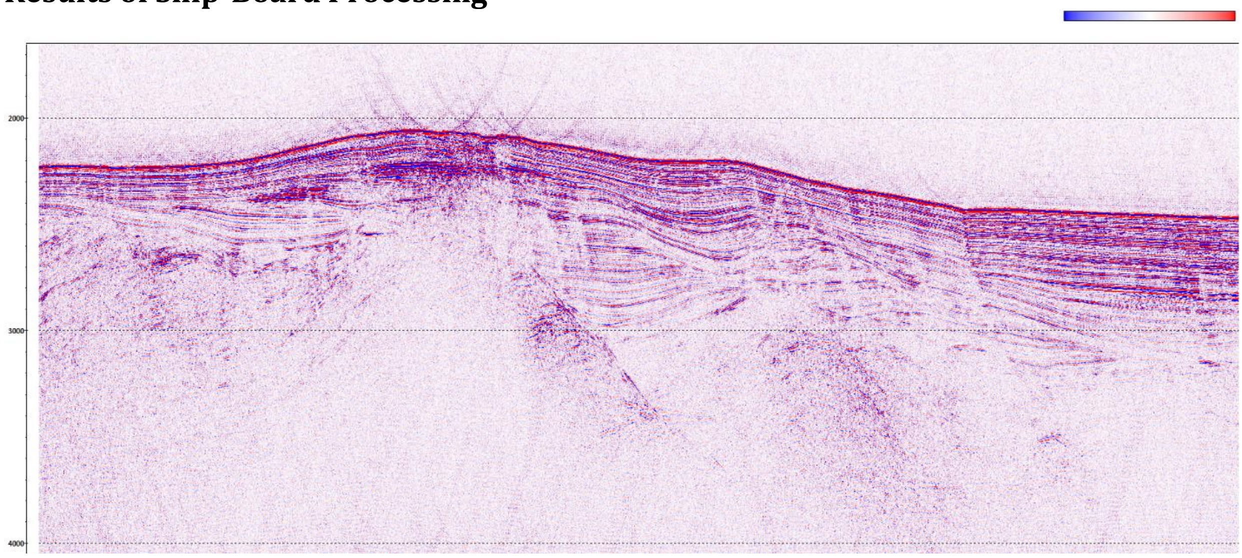


Figure 9: CAGE15-6-013 (Svyatogor Ridge) final processing outcome. Acquisition using 45/105 and 105/105 in^3 air gun.

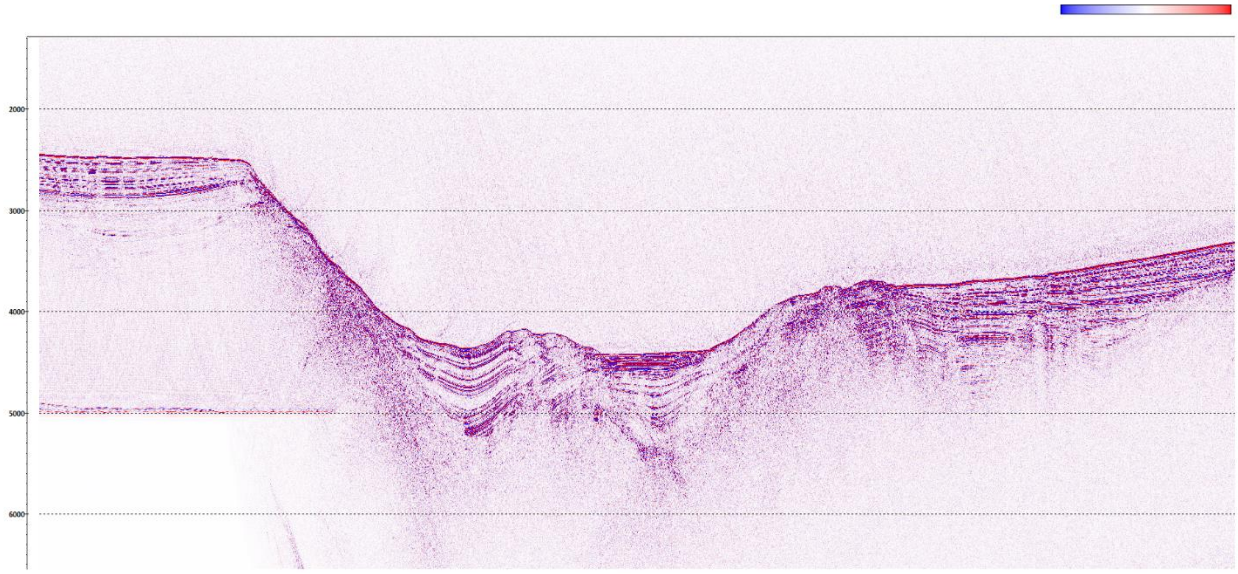


Figure 10: CAGE15-6-013 (Svyatogor rRdge) ship-board processing outcome. Line acquired using 105/105 & 45/105 in^3 air guns.

Figures 9 and 10 show the processed line CAGE15-6-13 (Svyatogor Ridge). A Stolt migration was applied to both these lines with a migration velocity of 1500 m/s. In this case, the sediment packages are almost as thick as the level of penetration so a constant velocity assumption for ship board processing is acceptable. As can be seen in both figures 9 and 10, the penetration of signal extends to the acoustic basement and even gives details of structures in the basement such as faults.

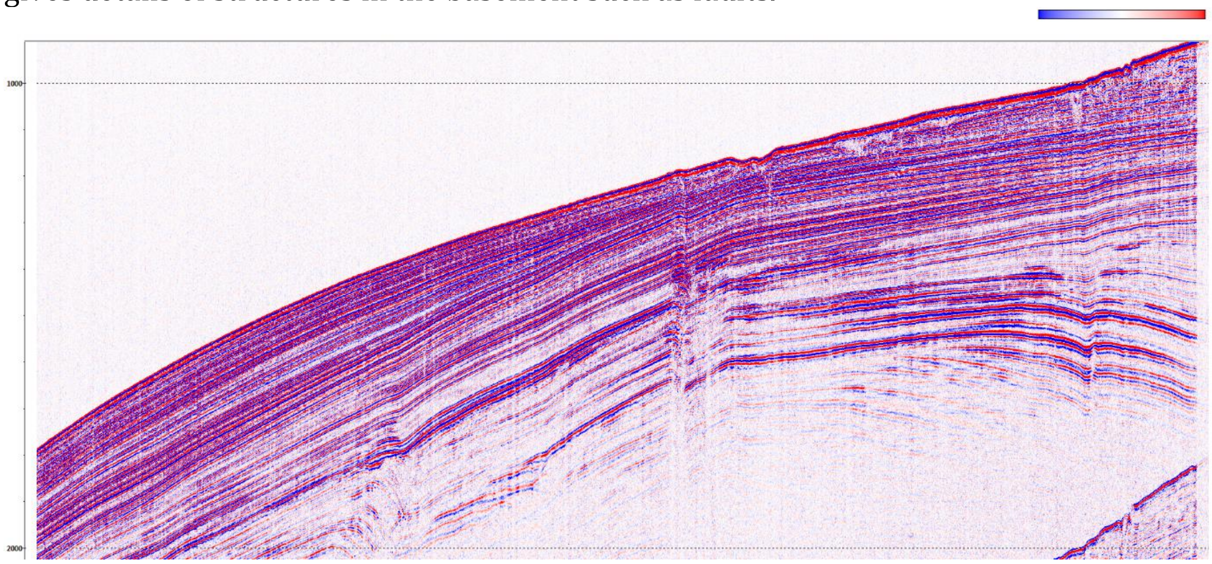


Figure 11: CAGE15-6-017 (Fram Strait Slides Complex) ship board processing outcome. Line acquired using 15/15 & 30/30 in^3 air guns.

Figure 11 shows the processing outcome of Line 017 (FSSC). Here, the smaller airguns (30 in^3 total and 60in^3 total) are used and the higher frequency signals produces excellent vertical resolution as can be clearly seen below the seafloor, details are well captured. Despite the high frequency, due to the thickly-sedimented nature of the area, the seismic signal is still penetrating below the multiple. For the Yermak Plateau and FSSC lines, a migration velocity of 1500 m/s (constant) is employed under the assumption that compaction is limited in the shallow subsurface and therefore velocities remain similar. This assumption appears valid. Figure 12 shows an overview of all the seismic line locations and Table 8 provides line details.

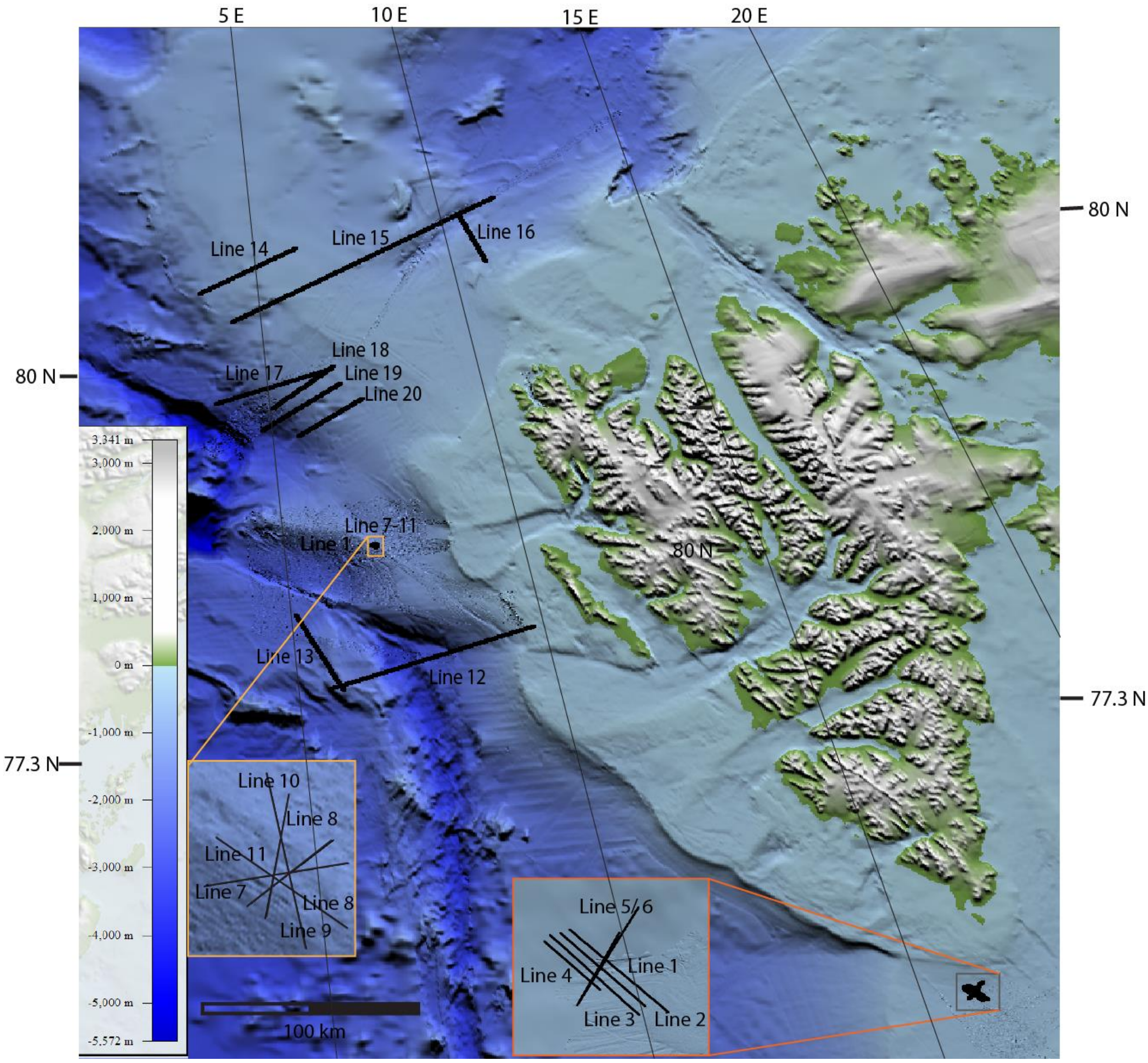


Figure 12: Location of seismic lines in the four working areas (Fig.1a and b).

Line Name	Station Number	Date	Location	Start (UTC)	Start shot number	Start Lat degree	Start Lat decmin	Start Long	Start Long decmin	End (UTC)	End Shot Number	End Lat	End Lat decmin	End Long	End Long decmin	Shot rate	Ship spe	Comments
Line 001	1505	9.10.	Storfjordrenna	07:17:00	311	76	03.374	16	10.279	08:48:00	1400	76	09.268	15	56.072	5s	4	Shot s 0- xx are test shots. Channel 32 disabled. 5s shooting rate, 1.5s rec len. 0.250ms sample interval. Gun 1 30/30 cubic inch, gun 2 15/15 cubic inch
Line 002	1506	9.10.	Storfjordrenna	09:05:00	1401	76	09.189	15	54.004	10:21:48	2314	76	04.026	16	06.108	5s	4	Sailing SE. Windspeed: SSE, 10 m/s. ~ 2.5 m waves.
Line 003	1507	9.10.	Storfjordrenna	10:36:39	2315	76	03.629	16	04.360	11:56:00	3271	76	09.229	15	51.870	5s	4	Sailing NW. Windspeed: SSE, 8 m/s. ~ 2.5 m waves.
Line 004	1508	9.10.	Storfjordrenna	12:07:00	3272	76	08.969	15	50.303	13:02:00	3921	76	05.529	15	58.195	5s	4	Sailing SE. Windspeed: SSE, 10 m/s. ~ 2.5 m waves.
Line 005	1509	9.10.	Storfjordrenna	15:28:00	3922	76	05.088	15	53.035	14:31:14	4641	76	08.407	16	05.779	5s	4	Sailing NNE. Windspeed: SSE, 8 m/s. ~ 1 m waves.
Line 006	1510	9.10.	Storfjordrenna	16:51:00	4763	76	09.528	16	11.276	18:14:00	5118	76	05.0030	15	52.639	14s	4	Airgun changed to 45/105, test shots 4642-4763. Sailing SW, windspeed SSE, 10 m/s.
Line 007(001)	1536	11.10.	Vestnesa	12:55:00	469	79	00.389	6	50.309	13:15:00	708	79	00.424	6	57.564	5s	4	Line 001 Vestnesa. Airguns 15/15 30/30. Sailing E, windspeed 11 m/s from EES. Channel 32 disabled. Sample rate 0.250ms rec length 3s.
Line 008(002)	1537	11.10.	Vestnesa	13:31:00	709	78	59.740	6	55.014	13:49:00	928	79	01.287	6	54.022	5s	4	Sailing NNW. Windspeed 10 m/s from EES.
Line 009(004)	1538	11.10.	Vestnesa	13:54:00	929	79	01.083	6	54.999	14:12:33	1148	79	00.044	6	53.145	5s	4	Sailing S. Windspeed 10m/s from E. Gas flare approx middle of line
Line 010	1539	11.10.	Vestnesa	14:18:58	1149	79	00.171	6	52.317	14:31:24	1298	79	00.639	6	56.939	5s	4	Sailing ENE. Windspeed 10m/s from ESE. Gas flare approx middle of line
Line 011	1540	11.10.	Vestnesa	14:44:50	1299	78	59.876	6	57.140	15:01:51	1504	79	00.797	6	51.176	5s	4	Sailing NW. Windspeed 8m/s from E. small flares at shot 1349, 1407
Line 012	1552	12.10.	Svaytogor	11:38:00	88	78	39.713	4	59.908	17:42:00	1648	78	14.127	5	48.945	14s	4	Channel 32 disabled. 0.50ms sample rate 5s recording length. Sailing SE, wind 5 m/s from 260 degrees. Minimal swell.
Line 013	1562	13.10.	Svaytogor	09:40:00	1683	78	14.747	5	32.838	21:32:41	4732	78	28.222	9	55.488	14s	4	Sailing ENE, Windspeed 7 m/s from W/NW. 105/45 and 105/105 air guns. Channel 32 disabled. 0.5s sample rate, 5 sec rec length. Rec length changed to 8s at shot 2453. CHAN 1 sometimes a little noisy.. (shot 3180 ->)
Line 014	1566	14.10.	Yermak Plateau	16:02:00	159	80	39.597	6	05.910	22:24:17	4731	80	27.022	3	31.97606	5s	4	Wind from ESE, 11 m/s. Sailing SSW. Shot s 0-159 are test shots. Channel 32 disabled. 5s shooting rate, 4.5s rec len. 0.50ms sample interval. Gun 1 30/30 cubic inch, gun 2 15/15 cubic inch, Gun2 froze around shot number 4448, ship encountered sea ice and started turning at shot number 4600
Line014_2	1566	14.10.	Yermak Plateau	22:30:00	4732	80	26.40	3	32.67	02:17:20	5491	80	19.700	3	48.288	5s	4	Few shots after ship turned after encountering sea ice, Gun frozen at shot number 4766, recording stoped, system taken out of water. Gun 2 frozen at shot number 5347
Line015	1567	15.10.	Yermak Plateau	01:55:00	5492	80	16.800	4	15.800	20:54:52	17865	80	48.7388	11	25.1816	5s	4	Wind 150 deg., 7 m/s. Sailing NE. Channel 32 disabled. 5s shooting rate, 4.5s rec len. 0.50ms sample interval. Gun 1 30/30 cubic inch, gun 2 15/15 cubic inch, 5548 shot number: overdriven channels, 6249: gun 2 frozen, recording stopped at shot no. 6822, ship turned around and gun 2 again started in shot number 6833, 6853:overdriven channels, shot number:7243:gun 2 frozen, Gun 2 again started working at 7374. shot 7934-8254: Gun 15/15 frozed and was not working. Defreezed at shot 8254. 9538:overdrivern channels. Chirp crashed at 09:00. Gun 2 frozen at around 10376. Defrozen at shot 10544. small Air gun two off at 12540, bacl at 12606. Air gun frozen at shot
Line016	1571	16.10.2015	Yermak Plateau	03:43:51	17866	80	45.715954	10	22.924008	07:41:32	20713	80	28.331	10	49.110	5s	4	Wind 331 deg., 15 m/s. Sailing NE. Channel 32 disabled. 5s shooting rate, 4.5s rec len. 0.50ms sample interval. Gun 1 30/30 cubic inch, gun 2 15/15 cubic inch, Recording started when ship was on start-up line, ship on line at shot number 18094, channel 1, 25 noisy. Indications of fluid leakage around SHOT no 20116, 832 m depth, everything is good in aqcusition, guns working well.
Line 017	1572	16.10.2015	SFSZ Slide	18:48:00	20714	79	50.504	3	41.869	02:27:31	26210	80	,	6	32.4576	5s	4	Line starts at shot 20748. Channel 32 is disabled. Record length set to 4.8s. Sample interval is 0.500ms. Continuing all other survey parameters from Yermak Plateau survey. Sailing directions is ENE. Wind sensor is broken. Slight swell. Guns frozen at shot number 26119. Line ended at shot number 26210 and guns taken out.
Line 018	1573	17.10.2015	SFSZ Slide	09:44:00	26234	79	59.826	6	36.715	14:44:00	27521	79	47.658	5	02.260	14s	4	Shots 26211 - 26234 are tests. Sailing WSW. Wind speed about 10m/s from 253 degrees. Channel 32 is disabled. Rec length is 6s. Sample rate is 0.500 ms. Guns are 105/105 45/45. At shot number 27367 course changes to S (180 degrees).
Line 019	1574	17.10.2015	SFSZ Slide	16:09:00	27522	79	40.791	4	42.772	21:39:51	28935	79	54.2470	6	42.0783	14s	4	Sailing ESE wind speed 6 m/s from SSW. Same paramenters as line 017
Line 020	1575	17.10.2015	SFSZ Slide	23:11:54	28936	79	48.6104	7	09.443255	03:32:00	30051	79	38.271	5	32.999	14s	4.5	Sailing SW wind speed 7 m/s from 238. Same paramenters as line 019, crossed SOL point at shot number 29020, acquisition stopped at 03:33 due to sea ice.

Table 8: All seismic lines incl. acquisition conditions, shot points and start and of line.

Ocean Bottom Seismometer stations

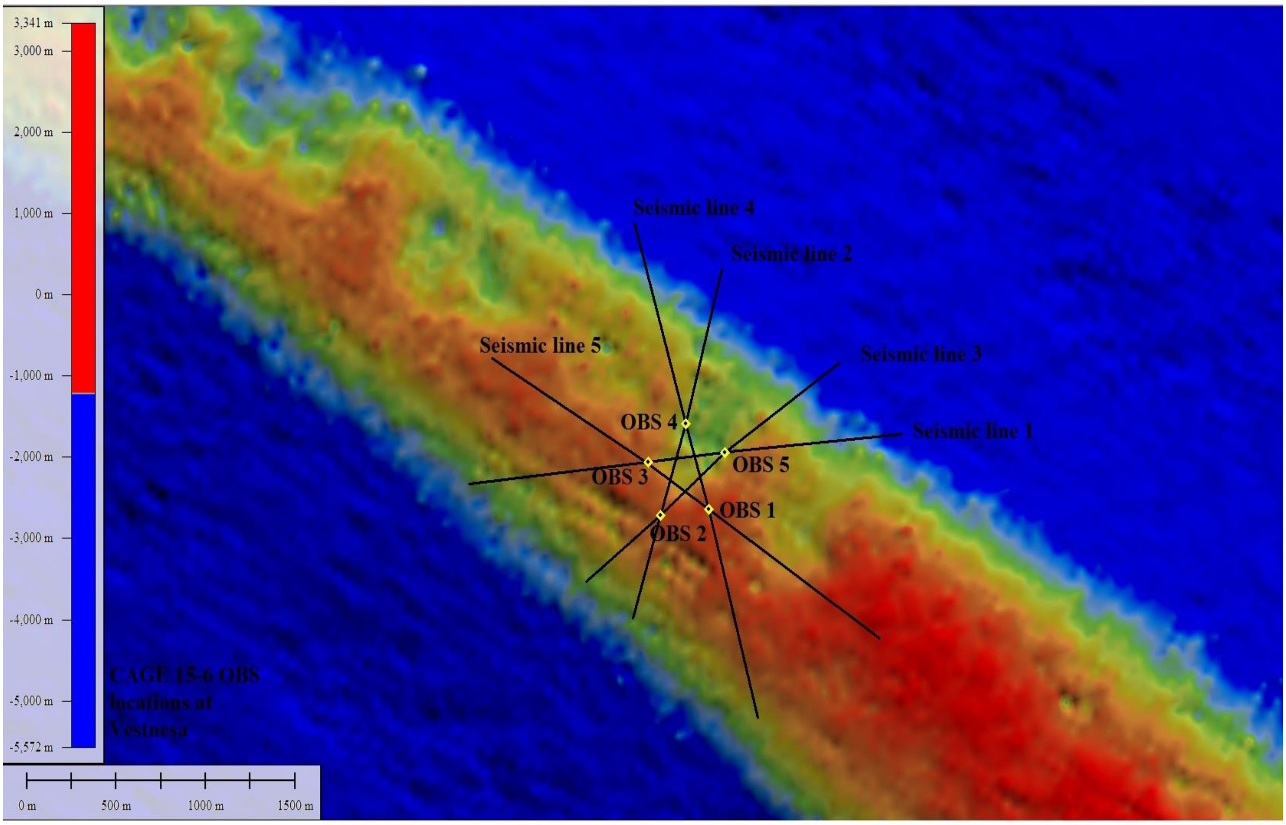


Figure 13: Position of the five deployed OBS on Lume pockmark on Vestnesa Ridge (Longitude/Latitude). 6 54 29.3714E/79 00 17.8639N OBS 2;6 53 43.4734E/79 00 17.9469N OBS 1;6 53 36.9112E/79 00 26.5558N OBS 5;6 54 16.6609E/79 00 31.8348 N OBS 4**;** 6 54 50.6944E/79 00 26.4973N OBS 3. Short seismic lines were shot across the OBS stations.

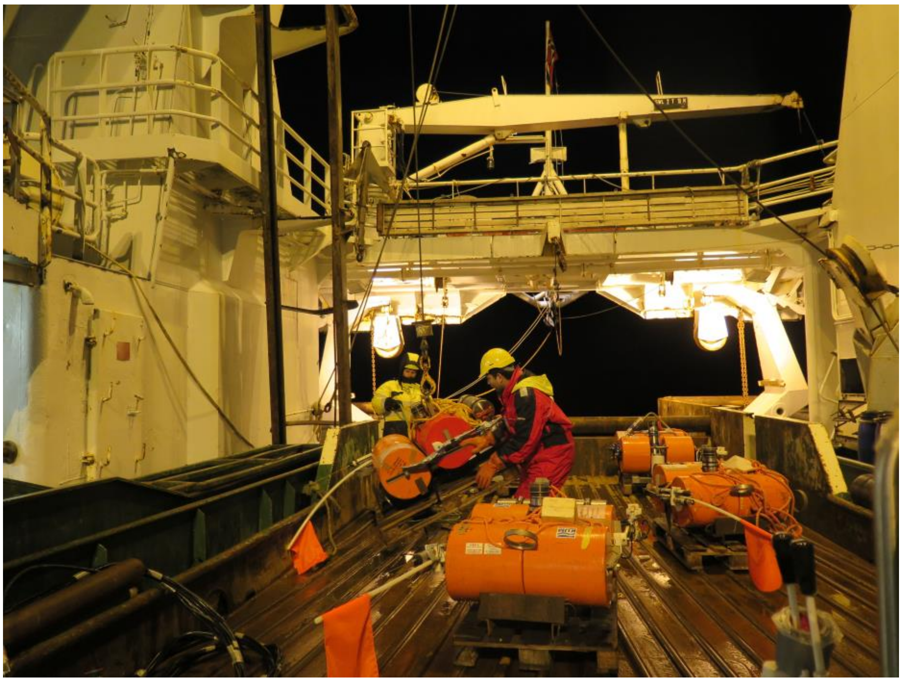


Figure 14: Five Ocean Bottom Seismometers were deployed on Vestnesa Ridge.

3.5.6. Ocean Spectrometer (Jack Triest and Roberto Grilli, CNRS/LGGE)

Motivation

At LGGE/CNRS there are currently two joined projects (SubGlacior, ANR, O. Alemany + Ice&Lasers, ERC, J.Chappellaz) to develop a probe with the aim to drill down through the Antarctic icesheet and determine the age of the ice down to bedrock. Measurements of ice-age indicators, such as water-isotopes and methane, will be performed on sample melted water in-situ and in real-time whilst drilling down. A specifically re-designed OFCEAS (Optical Feedback Cavity Enhanced Absorption Spectroscopy) spectrometer (Grilli et al., Rev. Sci. Instrum., 85 (111301) 1-7, 2014) is embedded in this drill to make the measurements. In July 2014, the laser spectrometer was used in the Mediterranean sea for testing its mechanical and thermal stability. This test proved that dissolved methane in the seawater could also be measured accurately at high resolution. In July 2015 funding was obtained through the SATT (Innovation Fast Track Incubator) in Grenoble to build a demonstrator/prototype and evaluate the commercial potential for such an oceanographic instrument. A key aim for this start-up incubator project, called SubOcean, was to join this cruise on the RV Helmer Hanssen to take measurements on a previously surveyed area in order to compare with previous results, highlight the added benefits of the instrument compared to existing methods and learn about aspects that may require further development.

Objectives and Methods

Our objectives for the cruise (Figure13 a,b,c, Tab. 9):

O1: evaluate the quality of the measurements, repeatability and response time of the SubOcean demonstrator prototype.

O2: compare the SubOcean measurements to Niskin bottle water samples from CTD stations (Pår Jansson).

O3: compare the instrument to a calibrated Contros HISEM instrument.

O4: evaluate the potential user-needs and constraints to steer the further developments of the instrument.

O5: use the obtained data for scientific publication in close collaboration with UiT and NILU

M1: The SubOcean instrument was connected to the winch cable and lowered and/or pulled behind the ship at the required depths. See Fig 1 and 2 for the profiles and trajectories. The SubOcean instrument was deployed with a CTD, oxygen sensor and a Contros HISEM methane sensor attached. The instrument was deployed at daytime; 5hrs on the 21st, 10hrs on the 22nd and 10hrs on the 23rd.

M2: A Contros HISEM sensor was attached to the SubOcean instrument at all times for direct comparison of the measured methane concentrations.

M3: Discreet water sample bottles were collected for comparison by running the 10 vertical CTD profiles (two shallow, two deep & two intermediate samples/run). See section 3.5.1 for CTD station details.

M4: the current SubOcean instrument is a prototype designed to show the potential of the technology. It is relatively large to allow for ease of modifications and future developments. Deployment was straightforward but would be easier with a smaller instrument. The system performed exceptionally well for three days after initial bugs due to transportation and cold (<-4°C) temperatures were resolved.

M5: all the obtained data is stored at 1 sec intervals. The system calibration appears to be correct and will be verified with further lab testing. Both vertical and horizontal profiles have been measured. We have a total of about 25hrs of data at various depths.

Results

R1: Repeat vertical profiles showed excellent repeatability and a response time of seconds (compared to 1 hour for the commercial instrument).

R2: The methane concentration levels are in very good accordance with the (calibrated) Contros data.

R3: Results will be compared once the water samples have been analysed in the lab. Note that because the CTD and SubOcean instrument were deployed at different times, possible variations in the results could be explained by uncertainty in ship position, different cable lengths, current flows, etc.

R4: The SubOcean instrument would be best deployed at the same time as, or attached to, the CTD for vertical profiles. To make best use of the instrument, its battery life should be extended to cover 24hrs a day without the need to wait for recharging. The instrument could be made heavier, or have ballast added, to be less sensitive to the ships speed (it rose up with an increase of the ship's speed)

R5: The data will be interpreted in close association with Acoustic Doppler Current Profiler (ADCP, 7 lines), echo-sounding data (continuous), seafloor bathymetry (existing) and atmospheric data (measured continuously by NILU) for a detailed understanding of the interactions.

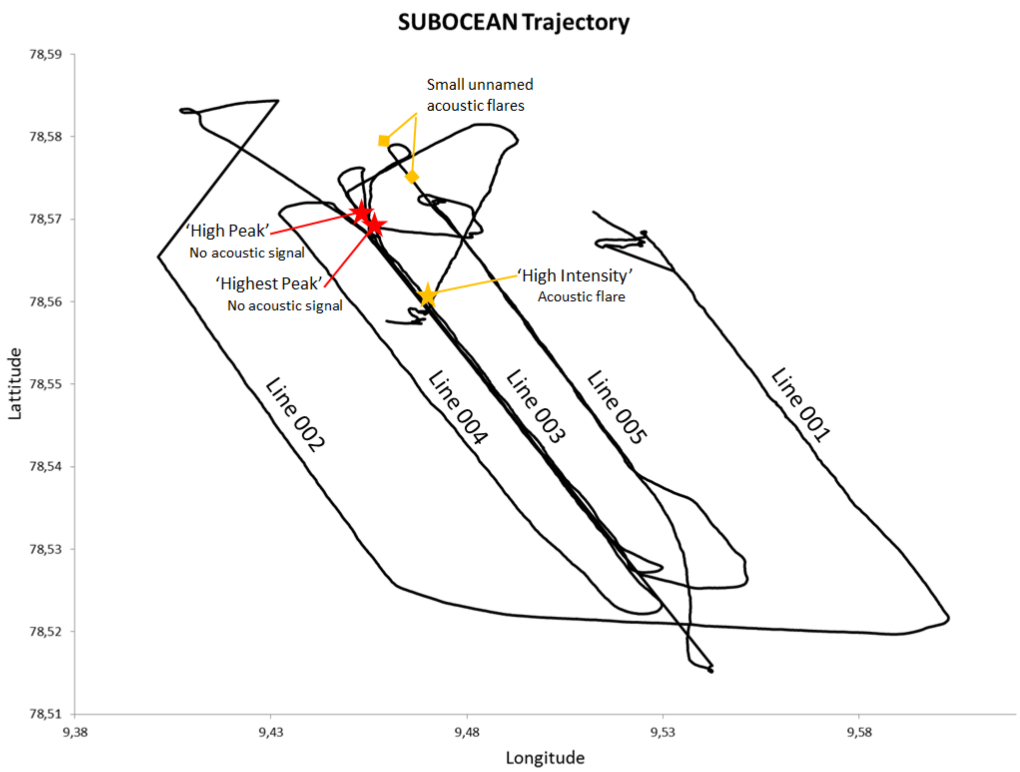


Fig 15a. *SubOcean Trajectory for 21-22—23 October 2015*

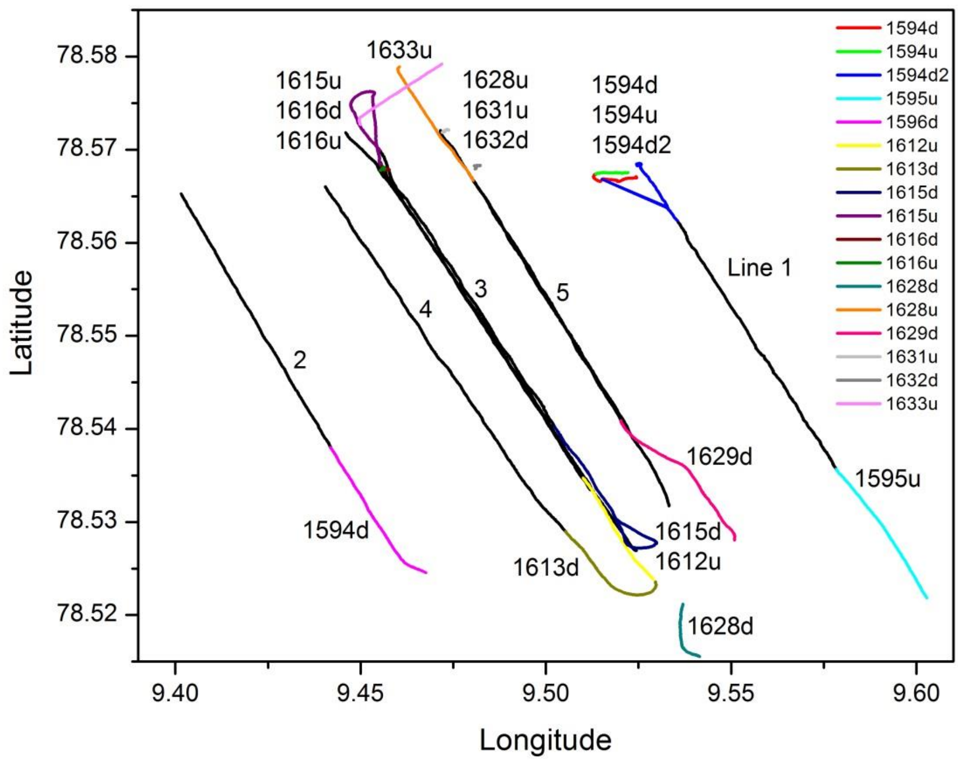


Fig 15b. *SubOcean trajectory breakdown by coordinates per day using the ships UWLS station numbers. In colored, the coordinates of vertical profiles are shown.*

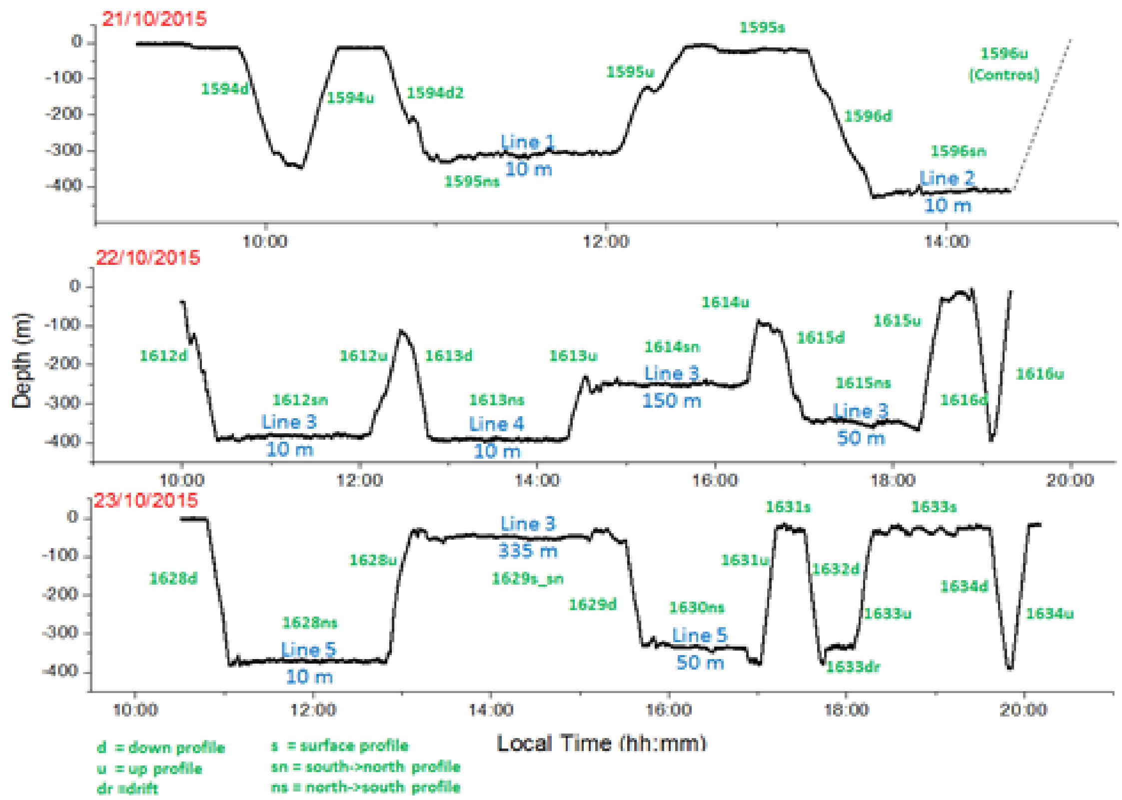


Fig 2. SubOcean trajectory breakdown by depth per day using UWLS station numbers

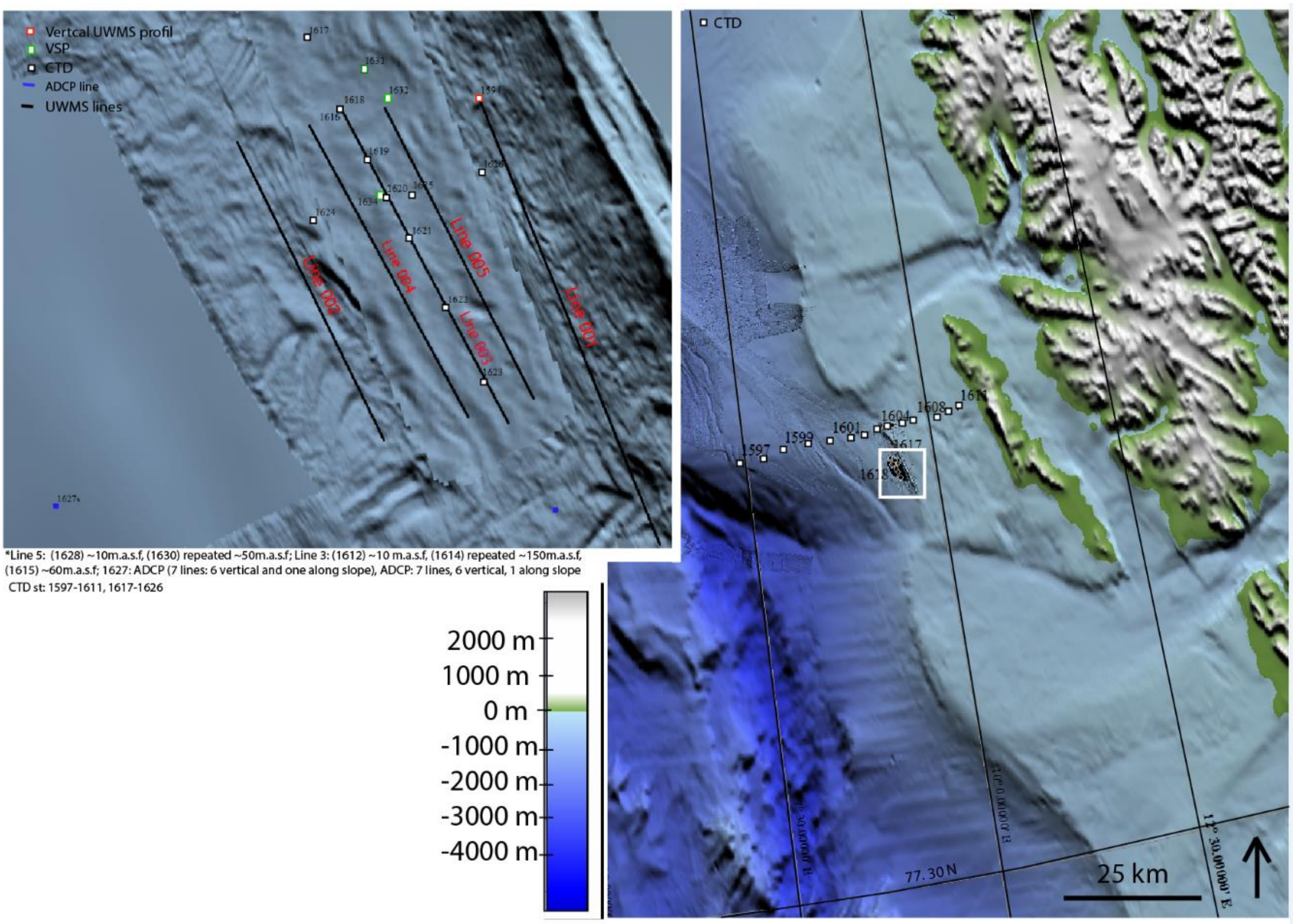


Figure 15c: Location of spectrometer profiles and CTD stations at PKF (~400m water depth)

		UWS	Water depth	Above seabed	Depth from surface	Start Coordinates		End Coordinates		Start	End	Elapsed	
Station	Key	Line	[m]	[m]	[m]	78°N	9°E	78°N	9°E	Time	Time	Time	Date
1594	d		342			34,0248	31,4574	34,0434	30,8142	9:49	10:12	0:22	21/10/2015
1594	u		342			34,0428	30,8136	34,0518	31,3278	10:12	10:25	0:13	21/10/2015
1594	d2		342			34,0956	31,488	33,7428	32,1282	10:40	10:59	0:19	21/10/2015
1595	ns	001	339	10	330	33,8262	31,9572	32,121	34,7364	10:56	12:03	1:07	21/10/2015
1595	u		339			32,142	34,7016	31,3116	36,165	12:02	12:28	0:25	21/10/2015
1595	s		339			31,3716	36,0756	31,4868	27,9858	12:26	13:10	0:43	21/10/2015
1596	d		431			31,4748	28,0554	32,2812	26,514	13:10	13:34	0:24	21/10/2015
1596	sn	002	431	10	420	32,2452	26,5728	33,9144	24,0948	13:33	14:21	0:48	21/10/2015
1596	u		431			-	-	-	-	14:22	14:59	0:37	21/10/2015
1612	d		400			34,9758	24,4752	34,3944	26,3784	9:55	10:21	0:26	22/10/2015
1612	ns	003	400	10	390	34,0926	27,2712	31,9782	30,795	10:39	12:06	1:27	22/10/2015
1612	u		400			32,0826	30,606	31,4328	31,7364	12:02	12:27	0:25	22/10/2015
1613	d		403			31,413	31,773	31,7388	30,3198	12:28	12:50	0:21	22/10/2015
1613	sn	004	403	10	390	31,6638	30,4986	33,96	26,4306	12:46	14:20	1:33	22/10/2015
1613	u		403			33,864	26,601	34,2564	25,9482	14:16	14:32	0:16	22/10/2015
1614	ns	003	399	150	250	34,3092	26,76	32,0088	30,7182	14:40	16:19	1:38	22/10/2015
1614	u		399			32,0598	30,6414	31,8024	31,1946	16:19	16:29	0:10	22/10/2015
1615	d		391			31,8156	31,1556	32,415	30,1368	16:29	17:06	0:37	22/10/2015
1615	sn	003	391	50	340	32,2326	30,4704	34,233	27,2352	17:00	18:17	1:16	22/10/2015
1615	u		391			34,1958	27,3096	34,0926	27,3456	18:17	18:52	0:35	22/10/2015
1616	d		396			34,0944	27,3402	34,0824	27,378	18:52	19:05	0:12	22/10/2015
1616	u		396			34,0824	27,3762	34,0662	27,3192	19:06	19:19	0:13	22/10/2015
1628	d		381			30,9336	32,4882	31,269	32,2194	10:47	11:03	0:16	23/10/2015
1628	sn	005	381	10	370	31,8642	32,031	34,0278	28,788	11:27	12:49	1:21	23/10/2015
1628	u		381			34,0014	28,8246	34,7334	27,6294	12:49	13:09	0:20	23/10/2015
1629	s_ns	003	399	330	60	34,1178	27,3246	31,6152	31,461	13:31	15:05	1:33	23/10/2015
1629	d		399			31,6836	33,0516	32,4516	31,2138	15:20	15:43	0:23	23/10/2015
1630	sn	005	372	50	320	32,3814	31,3314	34,3218	28,2942	15:43	16:52	1:09	23/10/2015
1631	u		372			34,3296	28,413	34,3128	28,3218	17:01	17:13	0:11	23/10/2015
1631	s		386			34,3134	28,3416	34,098	28,9182	17:13	17:31	0:18	23/10/2015
1632	d		381			34,0962	28,932	34,0764	28,8498	17:31	17:44	0:13	23/10/2015
1633	dr		383			34,0734	28,8636	34,3962	26,9784	17:45	18:05	0:19	23/10/2015
1633	u		383			34,3626	26,9946	34,7508	28,3116	18:05	18:18	0:13	23/10/2015
1633	s		383			34,7256	28,2132	33,4746	28,1256	18:18	19:36	1:18	23/10/2015
1634	d		390			33,4746	28,1226	33,456	27,9822	19:36	19:51	0:14	23/10/2015
1634	u		390			33,456	27,9948	33,444	27,9612	19:51	20:03	0:12	23/10/2015

Table 9. *SubOcean trajectory breakdown. Times are expressed in Local Time using the ships UWLS station numbers*

4. Cruise narrative

Wednesday 07.10.2015
On 07.10.2015 we left Tromsø at 17:00 (19:00 UTC) local time heading northwest towards Storfjordrenna. Echosounder and multibeam profiles were running while en route to the first working area.

Thursday 08.10.2015
Transit

Friday 09.10.2015
We reached our first working area Storfjordrenna at 04:50 UTC and started with a CTD station (stnr 1504) for calibrating the EM 300 using an updated speed of sound profile. Afterwards we surveyed a "GH Pingo" area at ~380 m water depth with seismic profiling (stnr 1505-1510) using the small airgun array (15/15 in3, 30/30 in3) including echosounder profiles (120, 38 and 18 kHz, and chirp). At the end of this seismic survey, one seismic line (stnr 1510) using the large GI gun array (45/45 in3, 105/105 in3) acquired deeper penetration but lower resolution data. CTD stations (stnr 1511-1518) and water sampling (stnr 1513-1518) allows for ocean water mass identification and chemistry analysis. Our 12 hrs watch started at 0800 local time. Water surface temperature lies between 4.2 and ~5.6 degrees Celsius and wind speed varies from 7,8 to 12,8 m/s. Sea is relatively calm.

Saturday 10.10.2015
We finished the last CTD stations (stnr 1518 and 1519) successfully at ~ 01:31 UTC and took three gravity cores(stnr 1520 and 1522), two within and one outside the GH Pingo area. The recovery was low (< 1m) in the gas-hydrated Pingo at 365 and 369 m water depth. One of these cores was 3 m long but outside the pingos at 387 m water depth. Water surface temperature lies between 4.2 and ~6.8 degrees Celsius and wind speed varies from 7,6 to 11,7 m/s. Plankton net (stnr 1523-1525) was taken for Kasia Zamelzyk at a relatively calm sea, and a CTD station (stnr 1526) at 1565 m water depth.

Sunday 11.10.2015
We reached Vestnesa Ridge at ~ 03:43 UTC and started with a CTD station (stnr 1527) at 1208 m water depth. Afterwards, four (from GEOMAR) and afterwards two (from UiT) ocean bottom seismometers (OBS) were deployed (Stnr 1528- 1531 and 1534-1535) at an active pockmark called Lunde (Fig. 13). The two OBS from UiT had too low weight on the steel frame so that additional weight has to be put on by our engineers and the ship crew. A multibeam (Stnr 1532 – 1533) and seismic survey (Stnr 1536 – 1540) across the OBS stations finalised the OBS deployment. CTD stations (stnr 1541-1547) and water sampling allows for ocean water mass and ocean chemistry analysis above the Vestnesa Ridge gas release area. Water surface temperature lies between 5.2 and ~6.2 degrees Celsius and wind speed varies from 2,9 to 13,0 m/s. Sea is relatively calm.

Monday 12.10.2015
CTD stations (stnr 1547-1551) and water sampling continued and allow for detailed local ocean water mass and ocean chemistry analysis above the active Vestnesa Ridge gas release area. We sailed to our next working area Svyatogor Ridge and started shooting a long seismic line (Stnr 1552) (14 sec shot rate) with the large GI guns (45/45 and 105/105 in3) to get a tie line for seismic stratigraphy. Also an IODP bore hole (IODP

912A) may be useful for correlation. Gravity coring (Stnr 1553-1556) and afterwards porefluid sampling provided first insights into the not so active Svyatogor Ridge pockmarks.

Tuesday 13.10.2015

Gravity coring at Svyatogor Ridge pockmarks continued (Stnr 1557-1559) followed by a short flare mapping survey. No obvious flares were detectable at the Svyatogor Ridge pockmarks. One more gravity core was taken in a pockmark area (Stnr 1561). Afterwards, a seismic line (Stnr 1562) was accomplished starting at the ridge and running eastward crossing the Molloy Transform Fault and ending on the shelf edge west of Prins Karls Foreland. Before we started flare mapping on the shelf-edge (Stnr 1564) a CTD station was done at 23:00 UTC (Stnr 1563). Water surface temperature varies between 2.4 and ~ 5 degrees Celsius and wind speed varies from 4,3 to 8,5 m/s. Sea is relatively calm.

Wednesday 14.10.2015

Flare mapping without any major new discoveries stopped at 13:00 UTC followed by a CTD station for EM300 calibration (Stnr 1565). We encountered sea ice on a seismic line (Str 1566) running westward from the Yermak Plateau at ~ 80 16.56 N, 04 07.152 E and stopped the line. Fortunately, a long eastward running seismic line crossing the Yermak Plateau into the Sofia Basin (1567) did not encounter sea ice. In a large incision valley running into the Sofia Basin the seismic line showed distinct onlap structures and we decided to gravity core the valley slope and fill. Water surface temperature lies between -0.8 and -1.5 degrees Celsius and wind speed varies from 2,0 to 11,0 m/s. Sea is relatively calm.

Thursday 15.10.2015

The seismic line ended at 21:00 UTC in Sofia Basin at 1614 m water depth. The first core was taken at 23:30 UTC on the slope outside the valley (Stnr 1568).

Friday 16.10.2015

In the large incision valley at southern Sofia Basin we took a gravity core from within the valley (Stnr 1569), which showed sandy layers suggesting turbidity currents. A CTD station (Stnr 1570) in Sofia Basin and a seismic line (Stnr 1571) from Sofia Basin westward accomplished our investigations in the region of the Arctic without encountering much sea-ice. We have had calm sea conditions throughout. From Sofia Basin, we sailed westward towards Fram Strait. Here, weather conditions deteriorated (Bft 6-7). Therefore only multibeam mapping towards the northern extend of Fram Slides complex (Osti et al. submitted) was done. The profiling was stopped at 79^{o} 56.654, 03^{o} 28.215E because we encountered sea ice towards southeast. The interruption was also caused several times due to gun freezing despite the fact that we injected alcohol into the pipe. A seismic line with the small gun array (15/15; 30/30 in3) (Stnr 1573) started (sea – 1.2 ^{o}C, air – 5.3 ^{o}C) running eastward towards the Yermak Plateau. This seismic line passed IOPD hole 912A (~1000m water depth), which will be used for seismic stratigraphy and sediment facies analysis of the region.

Saturday 17.10.2015

Seismic line (Stnr 1573) stopped at 14:42 UTC. The water temperature was +5.2 degrees Celsius at the start and – 0.9 degrees Celsius at the end of the line towards the west. Seismic lines (Stnr 1574 and 1575) were also within the Fram slides complex showing evidence for BSRs beneath glide planes of submarine failures. The water depth was about 850 m.

Sunday 18.10.2015
After we finished seismic line (Stnr 1575) at 2005 m water depth gravity coring started in partly sea ice covered regions. Sea ice extentalso determined the length of the western seismic lines. However, RV Helmer Hanssen can sail into sea ice and accomplish sediment coring. Gravity cores (Stnr 1576 – 1583) reached a sediment recovery from 0,5 to 4.5 m at individual core stations in water depth between 1810 and 2893 m. Water temperature varied between -0.3 to -1.5 in these sea-ice covered areas. At the end of the coring activities we took one CTD station at 2650 m water depth for oceanographic studies (Stnr 1584).

Monday 19.10.2015
We reached the area of Prins Karls Forland at 09:53 UTC and started CAGE ocean observatory OS1 communication procedures, which worked after a short time period (Stnr 1585). The delay of the process was caused by a mix up of the code documentation during the previous cruise with lander deployment. We identified the problem soon and clarified the use of the codes. During seven CTD stations (Stnr 1586-1592) we took water samples from shallow water depth (70 – 118 m). Water temperatures varied between 2.9 and 3.4 degrees Celsius. Water samples allow for ocean chemistry studies above methane plumes. Before we departed from the last CTD station we communicated with CAGE ocean lander 2 (1593) without problems. Therefore, we interpreted that both ocean observatories are working well and recording data continuously. We left the working area at 15:15 in continuously fair weather conditions, steamed towards Longyearbyen and arrived here at 23:00 local time the same day in LYR.

Tuesday 20.10.2015
During the day the team from CNRS, Jack and Roberto assembled the ocean spectrometer. UNIS was very helpful in accommodating the CNRS equipment and transporting it to the ship. We departed from Longyearbyen at 21:00 local time and arrived at our working area offshore Prins Karls Foreland during the next morning. During transit the software problem was solved and all spectrometer components worked well. Writing of reports and seismic data processing continued on transit to and from Longyearbyen.

Wednesday 21.10.2015
Shortly after our arrival at Prins Karls Forland at Stnr 1594 we started with a vertical spectrometer profile at 342 m water depth and carried on with profiles (Stnr 1595 and 1596) along a 2nm long line at 339 and at 431 m water depth, respectively. The spectrometer worked well for 5 hours and then the battery was already empty, which stopped the computer and data recording. The instrument was brought on deck and we decided to recharge the batteries overnight. CTD stations and water sampling started a new depth transect from 1379m to 70m water depth (Stnr 1597-1611).

Thursday 22.10.2015
We repeated CTD stations on this transect along the previous year 2013 transect (Pår please check). Water depth ranges from 1379 to 70 m and ocean surface temperatures vary between 2.4 and 6.2 degrees Celsius. We accomplished CTD Stnr 1602 to 1611

including some water sampling profiles. Spectrometer profiles started (Stnr 1612, line 3 at 10 m above seabed) at ~08:35 UTC at a calm sea providing optimum conditions for launch, recovery and profiling of the equipment. We continued spectrometer profiling (Stnr 1613; line 4 at 10m above seabed; Stnr 1614, line 3 at 150m above seabed; Stnr1615 line 3 at 50 m above seabed) A vertical spectrometer profile (Stnr 1616 at 396 m water depth) completed the survey for the day. CTD stations (Stnr 1617-1626) incl. water samples for methane measurements allowed us to complete the research work successfully at 23:37UTC.

Friday 23.10.2015
The ADCP ocean current velocity profiling (Stnr 1627) started at 00:01 UTC consisting of 7 lines, 6 in E-W and W-E direction and one along slope. Spectrometer line Stnr 1628 (line 5, 10 m above seabed), Stnr 1629 (line 3 ~330 m above seabed) and Stnr 1630 (Line 5, 50 m above seabed) finalised the horizontal profiles in the water column. Vertical spectrometer profiling (VSP) became more difficult due to strong currents causing a drift of the vessel. Stnr 1631 and 1632 were vertical profiles, Stnr 1633 a drift profile, and Stnr 1634 is again a vertical profile. The battery was still functioning at 10 hrs! We successfully finished our station work at PKF (Fig. 1) and sailed to the Knipovich off-axis ridge volcanoes, called "Helmer Hanssen Volcanoes" at 77º 56.054N; 07 º 34.362E at ¨3316 m water depth at the ridge axis.

Saturday 24.10.2015
Multibeam, chirp and echosounder profiles completed a bathymetry map of the Svyatogor Ridge at the western flank of Knipovich Ridge, i.e. on the American plate. Leaving working area at 21:00 UTC and heading for CTD station (Kasia) at Storfjordrenna.

Sunday 25.10.2015
Transit, cleaning up of laboratories, processing data and writing the cruise report. Changed to winter time (1 hour back).

Monday 26.10.2015
Transit Continued

Tuesday 27.10.2015
FF Helmer Hanssen arrived in Tromsø at 0700 UTC

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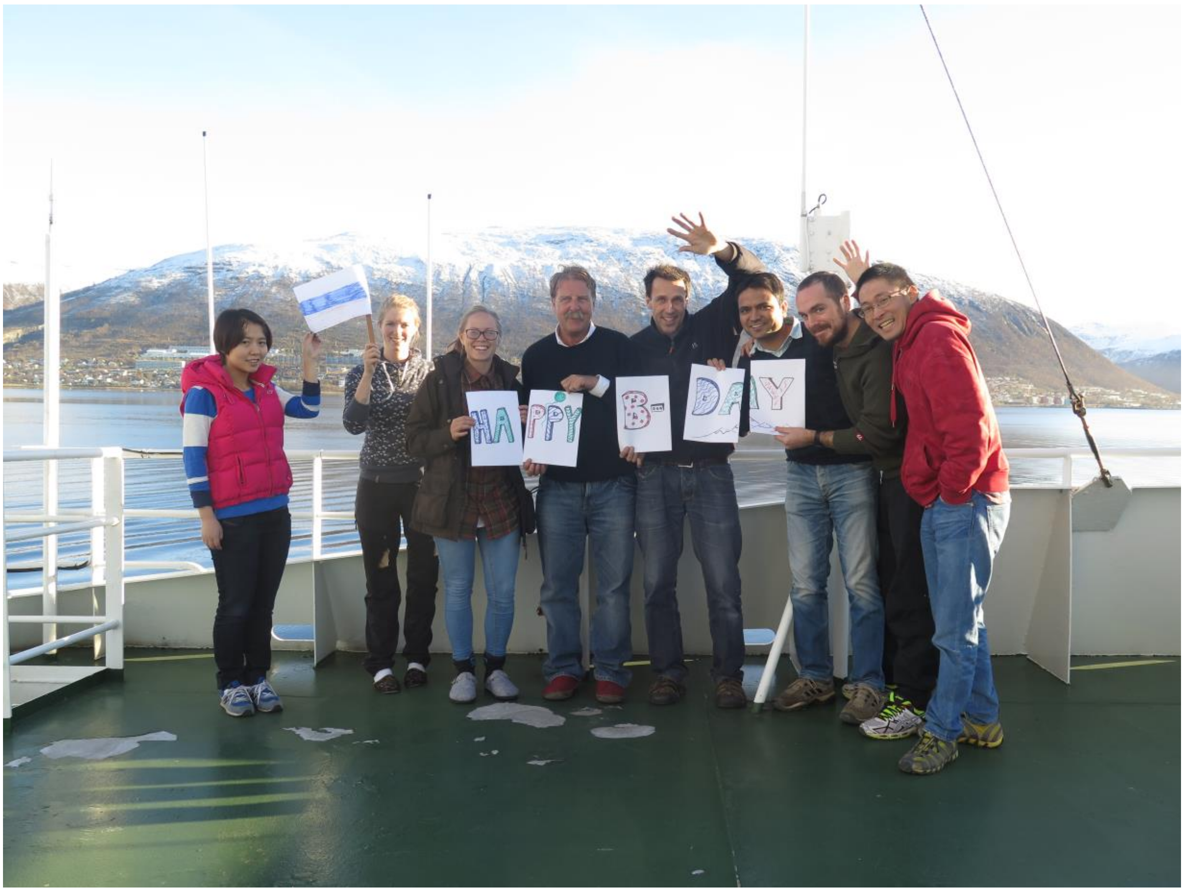

Hope to see you next year in October 2016

7. Appendix 1

Stasjonslapper CAGE 15-6 på FF Helmer Hanssen UWLS = Underwater Laser Spectroscope; VSP = Vertical Spectroscope Profile; OSP Ocean Spectroscope Profile (horizontal)

Station type	Cruise	Date	Time UTC	Station number	Log n.miles	Latitude	Longitude	Depth meter	Heading	Speed knot	Water temp	Wind m/s	Wind dir	Air temp	Air pressure
Seismisk profil START	Cage 15-6	09.10.2015	07:31:13	1505	5114.46	7604.186118 N	01608.380854 E	385.48	319.97	4.3	5.6	11.41	174	4.9	1026.2
Seismisk profil STOPP	Cage 15-6	09.10.2015	09:02:23	1505	5121.47	7609.416487 N	01554.109877 E	351.81	204.90	4.3	4.5	9.54	152	5.0	1025.7
Seismisk profil START	Cage 15-6	09.10.2015	09:07:24	1506	5121.85	7609.052007 N	01554.151484 E	352.06	159.39	4.9	4.5	10.01	158	5.0	1025.8
Seismisk profil STOPP	Cage 15-6	09.10.2015	10:25:30	1506	5127.93	7603.812480 N	01606.642401 E	388.05	151.54	4.5	5.6	8.32	153	5.1	1025.6
Seismisk profil START	Cage 15-6	09.10.2015	10:39:04	1507	5129.06	7603.819787 N	01604.122530 E	393.01	333.04	5.4	5.6	9.04	150	5.3	1025.5
Seismisk profil STOPP	Cage 15-6	09.10.2015	11:52:21	1507	5134.88	7608.900842 N	01552.563510 E	353.84	326.48	5.7	4.7	8.32	148	5.6	1025.2
Seismisk profil START	Cage 15-6	09.10.2015	12:09:00	1508	5136.05	7608.885751 N	01550.481923 E	362.65	160.16	4.5	4.8	9.80	152	5.4	1024.7
Seismisk profil STOPP	Cage 15-6	09.10.2015	13:02:28	1508	5139.90	7605.522607 N	01558.214764 E	386.01	151.47	4.8	5.6	11.03	155	5.5	1024.6
Seismisk profil START	Cage 15-6	09.10.2015	13:28:20	1509	5141.85	7604.874132 N	01552.836723 E	381.35	14.12	4.6	5.3	7.34	152	5.4	1024.7
Seismisk profil STOPP	Cage 15-6	09.10.2015	14:36:30	1509	5146.78	7608.539100 N	01606.316659 E	355.47	42.65	2.4	5.2	8.26	148	5.4	1024.7
Seismisk profil START	Cage 15-6	09.10.2015	17:12:40	1510	5162.18	7608.520823 N	01606.278942 E	355.83	225.72	4.4	4.7	8.79	163	5.4	1024.1
Seismisk profil STOPP	Cage 15-6	09.10.2015	18:12:43	1510	5166.85	7605.118250 N	01553.119127 E	378.84	223.01	4.8	4.9	10.13	167	5.4	1023.8
CTD uten vann START	Cage 15-6	09.10.2015	19:50:09	1511	5173.95	7606.303394 N	01605.549570 E	390.59	132.61	0.8	5.0	8.41	168	5.4	1023.9
CTD uten vann STOPP	Cage 15-6	09.10.2015	20:30:16	1511	5175.89	7606.237869 N	01602.427397 E	388.46	103.88	4.4	4.6	9.19	165	5.5	1023.6
CTD uten vann START	Cage 15-6	09.10.2015	20:30:18	1512	5175.90	7606.237553 N	01602.437322 E	388.17	104.93	4.3	4.6	8.88	164	5.5	1023.6
CTD uten vann STOPP	Cage 15-6	09.10.2015	20:54:49	1512	5176.12	7606.215819 N	01603.193263 E	388.60	172.25	0.9	4.8	8.84	159	5.4	1023.7
CTD med vannhenter START	Cage 15-6	09.10.2015	21:02:21	1513	5176.93	7606.302484 N	01600.200915 E	387.48	144.38	1.3	4.7	9.30	165	5.4	1023.6
CTD med vannhenter STOPP	Cage 15-6	09.10.2015	21:27:33	1513	5177.20	7606.546194 N	01600.001672 E	393.82	53.84	0.4	4.3	7.71	156	5.3	1023.5

CTD med vannhenter START	Cage 15-6	09.10.2015	21:36:04	1514	5178.02	7606.325728 N	01557.803053 E	387.50	117.39	1.4	4.5	7.97	167	5.5	1023.5
CTD med vannhenter STOPP	Cage 15-6	09.10.2015	22:02:22	1514	5178.34	7606.537964 N	01557.602519 E	390.70	54.13	1.2	4.4	7.37	178	5.5	1023.3
CTD med vannhenter START	Cage 15-6	09.10.2015	22:12:21	1515	5179.13	7606.404117 N	01555.409109 E	385.70	116.79	1.1	4.3	8.44	171	5.5	1023.3
CTD med vannhenter STOPP	Cage 15-6	09.10.2015	22:34:58	1515	5179.34	7606.525510 N	01555.063534 E	386.71	38.68	1.5	4.3	7.51	158	5.4	1023.1
CTD med vannhenter START	Cage 15-6	09.10.2015	22:50:28	1516	5180.90	7605.685759 N	01600.060506 E	387.07	156.76	1.1	4.4	7.70	164	5.6	1023.0
CTD med vannhenter STOPP	Cage 15-6	09.10.2015	23:09:56	1516	5181.10	7605.791403 N	01559.607200 E	387.79	50.06	1.1	4.9	7.62	168	5.5	1023.0
CTD med vannhenter START	Cage 15-6	09.10.2015	23:24:09	1517	5182.83	7606.910808 N	01556.909298 E	388.26	129.36	3.8	4.4	8.86	163	5.4	1022.8
CTD med vannhenter STOPP	Cage 15-6	09.10.2015	23:44:16	1517	5183.06	7607.060364 N	01557.189324 E	385.70	83.05	1.2	4.4	7.92	172	5.6	1022.8
CTD med vannhenter START	Cage 15-6	09.10.2015	23:54:04	1518	5183.71	7607.497415 N	01555.893966 E	372.86	59.38	0.3	4.2	7.60	174	5.3	1022.9
CTD med vannhenter STOPP	Cage 15-6	10.10.2015	00:19:22	1518	5183.93	7607.697899 N	01555.863288 E	369.90	63.40	0.3	4.3	7.76	177	5.4	1022.7
CTD med vannhenter START	Cage 15-6	10.10.2015	00:36:13	1519	5184.45	7607.890524 N	01554.378332 E	365.03	55.51	0.4	4.4	8.18	175	5.4	1022.6
CTD med vannhenter STOPP	Cage 15-6	10.10.2015	01:31:09	1519	5186.95	7606.260060 N	01558.643019 E	386.37	260.47	3.3	4.2	9.91	174	5.4	1022.2
Gravity core (GC)	Cage 15-6	10.10.2015	01:40:04	1520	5187.21	7606.341927 N	01557.964063 E	386.21	53.06	1.0	4.3	7.75	177	5.5	1022.3
Gravity core (GC)	Cage 15-6	10.10.2015	05:00:55	1521	5191.43	7606.361264 N	01557.827880 E	386.49	72.66	0.7	4.4	7.72	170	5.4	1020.9
Gravity core (GC)	Cage 15-6	10.10.2015	06:05:13	1522	5192.77	7606.426570 N	01557.473765 E	387.78	191.37	0.4	4.3	8.20	177	5.5	1020.5
Håv WP2 START	Cage 15-6	10.10.2015	10:39:56	1523	5239.19	7623.603463 N	01258.227826 E	1523.31	187.40	2.5	6.7	11.74	182	6.9	1017.1
Håv WP2 STOPP	Cage 15-6	10.10.2015	11:08:19	1523	5239.70	7623.598523 N	01256.520688 E	1534.81	135.73	1.0	6.7	11.42	185	6.8	1016.8
Håv WP2 START	Cage 15-6	10.10.2015	11:14:10	1524	5239.77	7623.591704 N	01256.326130 E	1535.60	178.15	1.0	6.8	10.31	179	6.7	1016.7
Håv WP2 STOPP	Cage 15-6	10.10.2015	11:24:32	1524	5239.95	7623.661301 N	01255.647815 E	1540.77	192.72	1.7	6.8	8.63	175	6.8	1016.6
Håv WP2 START	Cage 15-6	10.10.2015	11:28:11	1525	5240.03	7623.687373 N	01255.336022 E	1542.82	194.47	1.6	6.7	10.01	175	6.7	1016.5
Håv WP2 STOPP	Cage 15-	10.10.2015	11:34:33	1525	5240.16	7623.727945	01254.874396	1546.42	176.30	0.9	6.6	10.16	180	6.7	1016.6

	6					N	E								
CTD med vannhenter START	Cage 15-6	10.10.2015	11:35:33	1526	5240.17	7623.739928 N	01254.820268 E	1547.45	176.83	1.5	6.7	8.67	182	6.7	1016.6
CTD med vannhenter STOPP	Cage 15-6	10.10.2015	11:52:18	1526	5240.88	7624.063853 N	01252.747020 E	1565.03	341.07	10.2	6.6	10.84	181	6.7	1016.5
CTD med vannhenter START	Cage 15-6	11.10.2015	03:43:24	1527	5415.63	7900.299065 N	00654.682884 E	1205.02	63.98	0.4	5.9	8.55	139	5.5	1005.6
CTD med vannhenter STOPP	Cage 15-6	11.10.2015	04:36:21	1527	5416.07	7900.548682 N	00653.416126 E	1208.79	46.78	0.4	5.4	6.38	140	5.5	1005.3
Annen stasjon(pockmark)	Cage 15-6	11.10.2015	05:00:07	1528	5416.86	7900.441683 N	00654.779448 E	1208.42	164.17	1.5	5.4	8.91	137	5.4	1005.1
Annen stasjon(pockmark)	Cage 15-6	11.10.2015	05:16:10	1529	5417.49	7900.530285 N	00654.213326 E	1210.25	136.08	1.4	5.4	8.41	131	5.4	1005.0
Annen stasjon(pockmark)	Cage 15-6	11.10.2015	05:28:31	1530	5418.02	7900.436851 N	00653.508914 E	1202.31	114.37	1.7	5.4	7.65	128	5.5	1004.9
Annen stasjon(pockmark)	Cage 15-6	11.10.2015	05:41:27	1531	5418.56	7900.298662 N	00653.685493 E	1201.89	143.03	0.3	5.5	8.81	115	5.5	1004.9
Multibeam survey START	Cage 15-6	11.10.2015	08:01:13	1532	5431.33	7853.334644 N	00728.185808 E	1133.99	314.35	9.4	6.2	9.70	125	5.0	1004.4
Multibeam survey STOPP	Cage 15-6	11.10.2015	09:55:43	1532	5449.15	7904.976887 N	00625.604573 E	1215.57	118.96	7.0	5.9	13.07	124	5.2	1004.1
Multibeam survey START	Cage 15-6	11.10.2015	09:55:46	1533	5449.15	7904.973887 N	00625.628851 E	1214.19	119.55	6.5	5.9	11.64	126	5.2	1004.1
Multibeam survey STOPP	Cage 15-6	11.10.2015	10:58:40	1533	5457.92	7859.753490 N	00659.196665 E	1202.88	297.20	9.0	5.5	10.09	125	5.1	1003.6
Annen stasjon(pockmark)	Cage 15-6	11.10.2015	11:20:50	1534	5459.38	7900.317735 N	00653.655190 E	1203.29	83.81	1.6	5.3	11.06	134	5.0	1003.8
Annen stasjon(pockmark)	Cage 15-6	11.10.2015	11:28:43	1535	5459.65	7900.289208 N	00654.513032 E	1202.75	142.26	0.7	5.3	11.94	122	4.8	1003.8
Seismisk profil START	Cage 15-6	11.10.2015	13:10:19	1536	5464.91	7900.430252 N	00655.634364 E	1207.12	93.96	4.3	5.3	11.33	120	4.5	1003.5
Seismisk profil STOPP	Cage 15-6	11.10.2015	13:52:46	1536	5467.97	7901.124416 N	00654.763309 E	1234.02	116.68	3.4	5.3	9.20	92	4.4	1003.4
Seismisk profil START	Cage 15-6	11.10.2015	13:31:20	1537	5468.13	7859.740000 N	00655.014000 E	1229.41	177.07	3.2	5.4	9.19	94	4.5	1003.5
Seismisk profil STOPP	Cage 15-6	11.10.2015	13:49:22	1537	5468.13	7901.287000 N	00654.022000 E	1229.13	177.04	2.6	5.4	8.86	85	4.5	1003.5
Seismisk profil START	Cage 15-6	11.10.2015	13:57:25	1538	5468.18	7900.941842 N	00655.046293 E	1226.29	178.44	3.0	5.4	9.76	90	4.5	1003.4
Seismisk profil START	Cage 15-6	11.10.2015	14:41:56	1539	5471.37	7859.946762 N	00657.923249 E	1198.75	218.94	4.4	5.4	9.38	107	4.2	1003.4

Seismisk profil STOPP	Cage 15-6	11.10.2015	14:42:01	1539	5471.38	7859.941744 N	00657.901902 E	1198.27	218.02	4.7	5.4	8.96	109	4.2	1003.4
Seismisk profil START	Cage 15-6	11.10.2015	14:44:11	1540	5471.55	7859.866905 N	00657.257731 E	1197.00	296.00	4.1	5.2	6.97	105	4.1	1003.5
Seismisk profil STOPP	Cage 15-6	11.10.2015	15:00:46	1540	5472.98	7900.740690 N	00651.548205 E	1202.25	306.81	5.3	5.4	8.98	93	4.5	1003.7
CTD med vannhenter START	Cage 15-6	11.10.2015	15:37:08	1541	5474.70	7859.956792 N	00657.030246 E	1198.23	124.19	0.2	5.4	7.68	92	4.5	1003.6
CTD med vannhenter STOPP	Cage 15-6	11.10.2015	16:24:06	1541	5475.20	7859.951403 N	00657.275336 E	1197.12	57.96	0.7	5.4	6.97	83	4.5	1003.6
CTD med vannhenter START	Cage 15-6	11.10.2015	16:42:20	1542	5475.79	7900.242198 N	00655.480859 E	1208.12	89.51	0.7	5.5	7.30	62	4.5	1003.6
CTD med vannhenter STOPP	Cage 15-6	11.10.2015	17:31:28	1542	5476.13	7900.301837 N	00655.062715 E	1202.91	36.66	0.5	5.4	4.67	51	4.5	1003.8
CTD med vannhenter START	Cage 15-6	11.10.2015	17:37:54	1543	5476.30	7900.429165 N	00654.518520 E	1209.95	338.31	1.4	5.4	5.38	53	4.4	1003.8
CTD med vannhenter STOPP	Cage 15-6	11.10.2015	18:36:36	1543	5476.84	7900.532979 N	00654.043077 E	1208.68	103.46	0.5	5.5	5.04	41	4.2	1004.0
CTD med vannhenter START	Cage 15-6	11.10.2015	18:56:27	1544	5477.22	7900.653819 N	00653.059283 E	1207.55	93.89	0.4	5.6	5.76	30	4.2	1004.0
CTD med vannhenter STOPP	Cage 15-6	11.10.2015	19:45:39	1544	5477.67	7900.762199 N	00653.177439 E	1208.89	45.34	1.3	5.6	4.58	358	4.0	1004.1
CTD med vannhenter START	Cage 15-6	11.10.2015	19:58:13	1545	5478.10	7900.943985 N	00651.462294 E	1215.73	61.25	0.9	5.5	4.77	347	3.9	1004.2
CTD med vannhenter STOPP	Cage 15-6	11.10.2015	20:59:10	1545	5478.77	7901.167417 N	00651.491097 E	1215.38	45.63	0.9	5.2	2.97	324	3.6	1004.4
CTD med vannhenter START	Cage 15-6	11.10.2015	21:11:51	1546	5479.76	7900.362941 N	00651.999773 E	1212.02	141.46	1.5	5.2	2.56	292	3.6	1004.5
CTD med vannhenter STOPP	Cage 15-6	11.10.2015	22:11:47	1546	5480.54	7900.757245 N	00652.032116 E	1207.43	233.27	0.4	5.6	5.67	316	4.2	1004.4
CTD med vannhenter START	Cage 15-6	11.10.2015	22:30:11	1547	5481.30	7900.205342 N	00653.388244 E	1208.57	96.50	0.6	5.6	7.06	9	4.5	1004.4
CTD med vannhenter STOPP	Cage 15-6	12.10.2015	00:14:02	1547	5483.00	7900.018291 N	00654.386324 E	1208.97	238.57	0.2	5.3	6.21	357	4.5	1004.9
CTD med vannhenter START	Cage 15-6	12.10.2015	00:14:05	1548	5483.00	7900.018650 N	00654.387654 E	1208.47	238.94	0.7	5.3	7.20	2	4.5	1004.9
CTD med vannhenter STOPP	Cage 15-6	12.10.2015	01:08:37	1548	5483.79	7900.237038 N	00656.101247 E	1212.51	34.08	3.9	5.2	6.89	339	4.1	1005.4
CTD med vannhenter START	Cage 15-6	12.10.2015	01:15:44	1549	5484.15	7900.495258 N	00656.984092 E	1224.18	270.75	0.8	5.1	6.72	342	3.8	1005.2
CTD med vannhenter STOPP	Cage 15-	12.10.2015	02:04:36	1549	5484.58	7900.228234	00658.141869	1218.33	246.24	1.4	5.2	5.94	339	2.8	1005.7

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CTD med vannhenter START	Cage 15-6	12.10.2015	02:16:22	1550	5485.38	7900.793815 N	00655.718931 E	1234.39	278.79	0.7	5.4	6.90	343	3.0	1005.6
CTD med vannhenter STOPP	Cage 15-6	12.10.2015	03:05:57	1550	5485.93	7900.598511 N	00656.236515 E	1222.15	317.74	4.0	5.6	7.54	342	3.0	1005.8
CTD med vannhenter START	Cage 15-6	12.10.2015	03:17:23	1551	5486.53	7900.997903 N	00654.294828 E	1226.04	229.76	0.8	5.4	5.35	340	2.8	1006.0
CTD med vannhenter STOPP	Cage 15-6	12.10.2015	04:41:08	1551	5487.85	7900.324134 N	00653.394937 E	1207.66	224.31	9.5	5.5	7.47	326	1.6	1006.7
Seismisk profil START	Cage 15-6	12.10.2015	12:02:58	1552	5531.99	7838.096562 N	00505.111148 E	2299.19	138.86	4.5	5.9	6.36	275	0.2	1008.3
Seismisk profil STOPP	Cage 15-6	12.10.2015	18:05:09	1552	5559.26	7812.619003 N	00551.171382 E	1639.92	163.65	4.5	4.4	7.62	281	-1.1	1009.4
Gravity core (GC)	Cage 15-6	12.10.2015	19:31:01	1553	5564.23	7816.477098 N	00556.404998 E	1660.43	328.72	0.6	4.3	5.78	274	-1.7	1009.3
Gravity core (GC)	Cage 15-6	12.10.2015	21:03:06	1554	5566.45	7815.835699 N	00550.335931 E	1524.61	246.42	2.1	5.0	7.34	303	-1.5	1009.3
Gravity core (GC)	Cage 15-6	12.10.2015	22:14:09	1555	5567.29	7815.849745 N	00551.096132 E	1536.72	332.85	0.7	4.6	8.04	308	-1.3	1009.3
Gravity core (GC)	Cage 15-6	12.10.2015	23:27:37	1556	5568.03	7815.683456 N	00551.561378 E	1538.71	226.86	0.5	4.4	6.72	285	-1.4	1009.4
Gravity core (GC)	Cage 15-6	13.10.2015	00:52:46	1557	5568.99	7815.481770 N	00551.570563 E	1534.94	257.06	0.4	4.4	7.48	289	-1.7	1009.5
Gravity core (GC)	Cage 15-6	13.10.2015	02:06:56	1558	5569.97	7815.788038 N	00552.835451 E	1548.95	278.80	0.5	4.5	7.66	288	-1.8	1009.6
Gravity core (GC)	Cage 15-6	13.10.2015	04:03:42	1559	5575.02	7819.540456 N	00545.611960 E	1597.97	300.69	0.4	4.9	8.42	306	-2.2	1009.8
Multibeam survey START	Cage 15-6	13.10.2015	06:27:08	1560	5585.36	7828.712836 N	00542.424381 E	1675.31	227.23	5.5	4.8	8.58	312	-2.3	1010.1
Multibeam survey STOPP	Cage 15-6	13.10.2015	06:27:10	1560	5585.37	7828.710683 N	00542.413788 E	1675.31	225.60	5.5	4.8	8.13	312	-2.3	1010.1
Gravity core (GC)	Cage 15-6	13.10.2015	07:00:24	1561	5585.92	7828.594881 N	00540.868745 E	1687.58	327.22	0.5	5.0	6.78	310	-2.1	1010.0
Seismisk profil START	Cage 15-6	13.10.2015	10:01:53	1562	5604.04	7815.077980 N	00540.643919 E	1648.53	69.87	4.4	4.7	5.49	295	-0.7	1011.0
Seismisk profil STOPP	Cage 15-6	13.10.2015	21:32:31	1562	5657.37	7828.218298 N	00955.401174 E	167.68	80.60	4.1	2.5	4.37	81	-0.0	1011.8
CTD med vannhenter START	Cage 15-6	13.10.2015	22:25:50	1563	5662.70	7828.004770 N	00938.118704 E	389.87	315.27	4.4	2.4	5.48	106	0.1	1011.8
CTD med vannhenter STOPP	Cage 15-6	13.10.2015	23:00:15	1563	5663.03	7827.939865 N	00936.799384 E	406.15	356.29	0.5	3.1	7.42	114	0.0	1011.5

Multibeam survey START	Cage 15-6	13.10.2015	23:00:27	1564	5663.03	7827.939734 N	00936.790303 E	405.84	356.06	0.7	3.1	7.82	118	0.0	1011.5
Multibeam survey STOPP	Cage 15-6	14.10.2015	13:03:56	1564	5804.83	8027.153786 N	00753.354313 E	810.54	57.68	1.1	-1.1	7.89	106	-0.2	1002.2
CTD med vannhenter START	Cage 15-6	14.10.2015	13:04:07	1565	5804.83	8027.155511 N	00753.335679 E	810.25	56.93	1.2	-1.1	8.86	107	-0.2	1002.2
CTD med vannhenter STOPP	Cage 15-6	14.10.2015	13:38:57	1565	5805.65	8027.703609 N	00749.765815 E	797.67	301.75	9.8	-0.8	7.52	91	-0.3	1001.8
Seismisk profil START	Cage 15-6	14.10.2015	15:58:36	1566	5826.23	8039.394117 N	00608.071182 E	731.60	270.38	4.9	-1.6	8.59	118	-0.5	999.3
Seismisk profil STOPP	Cage 15-6	15.10.2015	01:30:13	1566	5868.13	8016.569856 N	00407.162274 E	0.00	91.67	5.1	-1.5	9.38	96	0.3	997.5
Seismisk profil START	Cage 15-6	15.10.2015	21:01:38	1567	5953.90	8048.939026 N	01128.300514 E	1614.43	66.84	3.5	-1.3	8.23	349	-1.4	986.4
Seismisk profil STOPP	Cage 15-6	15.10.2015	21:01:39	1567	5953.90	8048.939442 N	01128.306687 E	1614.43	66.73	4.1	-1.3	2.05	247	-1.4	986.4
Gravity core (GC)	Cage 15-6	15.10.2015	23:29:04	1568	5970.35	8044.868205 N	01025.064040 E	1384.16	226.95	0.7	-1.2	11.07	354	-1.5	985.2
Gravity core (GC)	Cage 15-6	16.10.2015	01:46:58	1569	5972.40	8045.034213 N	01028.822625 E	1469.54	56.59	0.1	-1.3	0.01	56	-1.1	984.3
CTD uten vann START	Cage 15-6	16.10.2015	02:12:43	1570	5972.56	8045.057206 N	01028.835526 E	1470.59	56.11	0.2	-1.3	0.01	56	-1.2	984.1
CTD uten vann STOPP	Cage 15-6	16.10.2015	03:13:53	1570	5972.80	8045.127581 N	01028.520494 E	1468.56	55.06	0.3	-1.4	0.01	55	-1.1	983.8
Seismisk profil START	Cage 15-6	16.10.2015	04:01:20	1571	5975.64	8044.428439 N	01024.707933 E	1465.88	148.47	4.7	-1.3	2.05	328	-1.0	983.8
Seismisk profil STOPP	Cage 15-6	16.10.2015	07:43:55	1571	5992.50	8028.193418 N	01049.353706 E	722.39	167.77	3.6	0.2	1.53	348	-0.3	984.1
Seismisk profil START	Cage 15-6	16.10.2015	18:34:56	1572	6086.40	7950.011792 N	00337.056866 E	2485.96	59.93	5.0	-1.4	2.56	240	-5.8	995.4
Seismisk profil STOPP	Cage 15-6	17.10.2015	02:30:12	1572	6121.96	8007.584436 N	00633.466433 E	638.16	58.09	4.7	1.6	6.37	210	-2.1	997.3
Seismisk profil START	Cage 15-6	17.10.2015	10:05:24	1573	6151.83	7959.216313 N	00628.665265 E	800.57	249.73	4.5	5.2	12.26	301	-4.3	1000.0
Seismisk profil STOPP	Cage 15-6	17.10.2015	14:42:52	1573	6172.65	7947.757068 N	00501.889391 E	1669.24	147.41	4.1	-0.9	5.71	227	-6.3	1003.3
Seismisk profil START	Cage 15-6	17.10.2015	16:13:06	1574	6182.21	7940.774386 N	00443.807656 E	0.00	58.00	4.5	-0.1	4.93	216	-6.2	1003.7
Seismisk profil STOPP	Cage 15-6	17.10.2015	21:33:29	1574	6206.97	7954.073601 N	00640.309777 E	834.42	49.46	4.2	2.9	6.02	239	-2.9	1004.1
Seismisk profil START	Cage 15-	17.10.2015	23:27:15	1575	6218.60	7948.078263	00704.171320	828.83	247.26	4.5	5.2	7.31	216	-1.8	1004.0

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Seismisk profil STOPP	Cage 15-6	18.10.2015	03:38:16	1575	6237.59	7938.185434 N	00534.077509 E	2005.90	195.69	2.1	3.9	4.12	248	-4.7	1004.4
Gravity core (GC)	Cage 15-6	18.10.2015	05:52:01	1576	6247.79	7933.139485 N	00453.400295 E	2860.71	180.81	0.2	-0.3	1.42	205	-5.1	1004.0
Gravity core (GC)	Cage 15-6	18.10.2015	07:39:36	1577	6249.08	7933.926236 N	00455.366515 E	2895.23	295.40	0.7	-0.8	2.21	188	-3.5	1003.5
Gravity core (GC)	Cage 15-6	18.10.2015	09:23:38	1578	6250.84	7934.707990 N	00458.168947 E	2850.40	54.18	1.1	-0.0	2.23	206	-2.3	1002.8
Gravity core (GC)	Cage 15-6	18.10.2015	12:59:46	1579	6265.18	7947.544324 N	00446.636112 E	2041.24	0.24	0.3	-1.4	3.15	78	-2.6	1000.4
Gravity core (GC)	Cage 15-6	18.10.2015	14:16:02	1580	6266.62	7948.526618 N	00449.275829 E	1810.43	29.08	0.3	-1.5	5.30	56	-2.9	999.6
Gravity core (GC)	Cage 15-6	18.10.2015	16:40:32	1581	6269.81	7946.917304 N	00447.186589 E	2211.54	80.09	0.4	-1.3	6.28	27	-1.4	997.4
Gravity core (GC)	Cage 15-6	18.10.2015	18:37:56	1582	6274.27	7944.032279 N	00432.656262 E	2716.19	279.64	0.6	-1.1	7.83	46	-1.2	995.8
Gravity core (GC)	Cage 15-6	18.10.2015	20:19:51	1583	6276.97	7945.092754 N	00421.875100 E	2621.50	66.46	0.3	-0.8	10.13	9	-1.1	995.5
CTD uten vann START	Cage 15-6	18.10.2015	21:08:32	1584	6277.52	7944.988999 N	00419.891621 E	2635.18	264.70	0.8	-0.7	9.63	5	-1.1	995.4
CTD uten vann STOPP	Cage 15-6	18.10.2015	22:31:07	1584	6279.11	7944.569861 N	00411.413548 E	2650.00	274.93	1.7	-0.2	12.31	6	-1.2	994.9
Annen stasjon	Cage 15-6	19.10.2015	07:53:00	1585	6372.07	7839.313888 N	00925.870369 E	243.63	137.75	0.6	2.8	4.88	218	2.2	990.9
CTD med vannhenter START	Cage 15-6	19.10.2015	10:23:34	1586	6384.21	7834.885795 N	01017.654316 E	118.00	217.77	0.5	3.1	10.96	233	2.7	991.5
CTD med vannhenter STOPP	Cage 15-6	19.10.2015	10:33:35	1586	6384.32	7834.883102 N	01018.046372 E	126.50	175.32	0.4	3.0	11.65	232	2.7	991.4
CTD med vannhenter START	Cage 15-6	19.10.2015	10:47:28	1587	6385.04	7834.651421 N	01014.948412 E	157.08	196.77	1.0	2.9	11.13	230	2.5	991.5
CTD med vannhenter STOPP	Cage 15-6	19.10.2015	10:56:53	1587	6385.15	7834.564526 N	01015.025553 E	160.07	182.09	0.6	3.0	10.17	236	2.5	991.4
CTD med vannhenter START	Cage 15-6	19.10.2015	11:14:09	1588	6385.99	7834.185867 N	01012.024327 E	106.08	218.74	0.3	3.0	12.87	225	2.7	991.5
CTD med vannhenter STOPP	Cage 15-6	19.10.2015	11:22:19	1588	6386.12	7834.107181 N	01011.575717 E	90.30	218.92	1.0	3.1	13.27	231	2.7	991.5
CTD med vannhenter START	Cage 15-6	19.10.2015	11:52:00	1589	6386.48	7833.937854 N	01010.899062 E	80.06	185.84	0.5	3.0	13.46	241	2.5	991.5
CTD med vannhenter STOPP	Cage 15-6	19.10.2015	11:54:30	1589	6386.52	7833.928467 N	01011.035587 E	80.57	201.44	0.8	3.1	13.83	227	2.4	991.5

CTD med vannhenter START	Cage 15-6	19.10.2015	12:12:09	1590	6387.53	7833.495068 N	01007.082015 E	0.00	181.02	0.5	3.2	13.10	227	2.5	991.1
CTD med vannhenter STOPP	Cage 15-6	19.10.2015	12:18:01	1590	6387.60	7833.498946 N	01007.370977 E	0.00	203.32	1.0	3.3	11.24	218	2.6	991.1
CTD med vannhenter START	Cage 15-6	19.10.2015	12:27:36	1591	6387.98	7833.264489 N	01005.967070 E	114.76	207.52	0.4	3.4	11.54	221	2.8	990.7
CTD med vannhenter STOPP	Cage 15-6	19.10.2015	12:32:33	1591	6388.03	7833.258584 N	01005.994811 E	114.29	216.20	0.6	3.4	15.51	222	2.8	990.7
CTD med vannhenter START	Cage 15-6	19.10.2015	12:48:54	1592	6389.10	7833.721351 N	01008.491099 E	89.16	202.63	0.2	3.4	15.19	227	3.0	991.3
CTD med vannhenter STOPP	Cage 15-6	19.10.2015	12:54:26	1592	6389.16	7833.716318 N	01008.499538 E	89.75	203.23	0.7	3.3	13.54	234	3.2	990.8
Annen stasjon (OS2 pinging)	Cage 15-6	19.10.2015	13:07:21	1593	6389.33	7833.656888 N	01008.679972 E	91.92	192.33	0.7	3.3	13.04	234	3.3	990.8
Annen stasjon (UWLS)	Cage 15-6	21.10.2015	07:29:30	1594	6576.82	7834.031961 N	00931.470805 E	342.79	141.99	0.4	3.3	0.24	266	-3.3	1002.5
Annen stasjon (UWLS)	Cage 15-6	21.10.2015	08:42:07	1595	6577.33	7834.110758 N	00931.460732 E	339.24	95.52	0.4	3.3	2.62	96	-3.1	1002.1
Annen stasjon (UWLS)	Cage 15-6	21.10.2015	11:18:13	1596	6582.32	7831.731452 N	00927.349668 E	431.82	350.56	2.5	3.4	6.48	113	-3.2	1001.3
CTD uten vann START	Cage 15-6	21.10.2015	18:04:00	1597	6612.97	7837.390752 N	00723.752515 E	1379.97	37.54	0.9	5.1	3.89	119	-2.3	998.5
CTD uten vann STOPP	Cage 15-6	21.10.2015	18:45:07	1597	6613.67	7838.055060 N	00723.320798 E	1329.53	30.49	1.1	5.2	4.31	84	-2.3	998.5
CTD med vannhenter START	Cage 15-6	21.10.2015	19:12:07	1598	6617.54	7837.706079 N	00742.431410 E	1161.15	81.32	2.8	5.6	3.08	83	-2.7	998.5
CTD med vannhenter STOPP	Cage 15-6	21.10.2015	20:09:15	1598	6618.81	7838.793713 N	00740.091291 E	1130.93	20.47	1.4	6.0	3.48	97	-2.8	998.1
CTD uten vann START	Cage 15-6	21.10.2015	20:36:07	1599	6622.86	7838.263220 N	00759.826431 E	1035.60	59.01	4.4	6.2	2.99	61	-2.7	997.9
CTD uten vann STOPP	Cage 15-6	21.10.2015	21:19:22	1599	6623.64	7838.886896 N	00758.044803 E	1031.03	300.76	1.0	6.2	2.62	65	-2.6	997.9
CTD uten vann START	Cage 15-6	21.10.2015	21:49:12	1600	6628.08	7838.638013 N	00819.533854 E	891.59	38.30	3.5	4.9	2.60	81	-2.4	997.6
CTD uten vann STOPP	Cage 15-6	21.10.2015	22:32:04	1600	6628.78	7838.966729 N	00817.460717 E	899.77	293.68	2.3	5.0	3.33	32	-1.8	997.4
CTD uten vann START	Cage 15-6	21.10.2015	23:02:49	1601	6633.28	7838.651507 N	00839.350928 E	746.69	94.59	2.2	4.1	4.31	20	-2.1	997.1
CTD uten vann STOPP	Cage 15-6	21.10.2015	23:34:14	1601	6633.75	7838.750943 N	00837.351231 E	766.88	281.87	1.2	4.0	4.24	38	-1.6	996.9
CTD med vannhenter START	Cage 15-	22.10.2015	00:03:21	1602	6638.03	7838.756224	00857.983239	578.87	43.92	2.2	3.6	4.18	29	-1.9	996.7

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CTD med vannhenter STOPP	Cage 15-6	22.10.2015	00:25:33	1602	6638.22	7838.859468 N	00857.296141 E	587.93	287.08	0.4	3.8	5.52	26	-2.0	996.5
CTD uten vann START	Cage 15-6	22.10.2015	00:46:44	1603	6640.44	7838.963538 N	00907.720307 E	484.53	160.91	0.1	3.5	4.72	55	-1.9	996.3
CTD uten vann STOPP	Cage 15-6	22.10.2015	00:59:36	1603	6640.60	7839.041469 N	00907.032166 E	488.83	168.67	0.8	3.3	5.64	43	-2.0	996.3
CTD med vannhenter START	Cage 15-6	22.10.2015	01:31:16	1604	6643.67	7839.085925 N	00921.055298 E	402.46	293.79	0.2	3.0	3.91	48	-2.1	995.9
CTD med vannhenter STOPP	Cage 15-6	22.10.2015	01:48:13	1604	6643.77	7839.115876 N	00920.629189 E	411.72	294.98	0.2	3.1	4.80	67	-1.8	995.9
CTD med vannhenter START	Cage 15-6	22.10.2015	02:02:33	1605	6644.97	7839.317989 N	00926.134027 E	243.27	345.92	0.3	3.0	4.67	72	-2.0	995.8
CTD med vannhenter STOPP	Cage 15-6	22.10.2015	02:18:05	1605	6645.18	7839.408933 N	00925.499701 E	246.28	88.63	3.8	3.0	6.31	66	-2.0	995.7
CTD uten vann START	Cage 15-6	22.10.2015	02:27:35	1606	6646.51	7839.351336 N	00932.216720 E	217.82	67.74	4.6	2.9	4.58	59	-2.1	995.7
CTD uten vann STOPP	Cage 15-6	22.10.2015	02:57:51	1606	6648.58	7839.425433 N	00941.124619 E	156.95	327.28	0.1	2.8	3.65	71	-2.1	995.5
CTD uten vann START	Cage 15-6	22.10.2015	02:57:53	1607	6648.58	7839.425335 N	00941.124729 E	156.91	325.99	0.2	2.8	3.61	69	-2.1	995.5
CTD uten vann STOPP	Cage 15-6	22.10.2015	03:07:53	1607	6648.64	7839.385686 N	00941.101876 E	158.41	353.81	2.3	3.1	2.63	74	-2.0	995.5
CTD uten vann START	Cage 15-6	22.10.2015	03:21:09	1608	6650.51	7839.465144 N	00950.441205 E	131.66	44.31	2.9	3.3	3.19	77	-2.2	995.5
CTD uten vann STOPP	Cage 15-6	22.10.2015	03:27:07	1608	6650.55	7839.478276 N	00950.519070 E	131.74	295.65	0.1	3.5	1.84	68	-2.2	995.5
CTD med vannhenter START	Cage 15-6	22.10.2015	03:53:07	1609	6654.09	7839.624540 N	01008.103332 E	143.07	53.39	3.4	3.3	0.99	78	-2.4	995.5
CTD med vannhenter STOPP	Cage 15-6	22.10.2015	04:05:08	1609	6654.17	7839.638878 N	01008.137911 E	142.78	60.02	3.1	2.7	1.29	51	-2.5	995.4
CTD uten vann START	Cage 15-6	22.10.2015	04:20:53	1610	6656.12	7839.865451 N	01017.750804 E	77.96	236.36	0.6	2.5	1.68	8	-2.6	995.3
CTD uten vann STOPP	Cage 15-6	22.10.2015	04:28:22	1610	6656.20	7839.893592 N	01018.121437 E	76.24	273.49	0.7	2.6	3.36	26	-2.4	995.3
CTD uten vann START	Cage 15-6	22.10.2015	04:44:20	1611	6658.05	7840.027534 N	01026.784508 E	69.29	349.42	0.4	2.5	3.05	51	-2.4	995.1
CTD uten vann STOPP	Cage 15-6	22.10.2015	04:48:07	1611	6658.10	7840.017727 N	01026.925180 E	69.50	322.08	0.8	2.4	2.96	42	-2.3	995.1
Annen stasjon (UWLS)	Cage 15-6	22.10.2015	08:35:51	1612	6674.33	7834.162814 N	00927.086450 E	400.70	136.80	1.4	3.5	5.59	48	-2.1	994.6

Annen stasjon (UWLS)	Cage 15-6	22.10.2015	10:58:42	1613	6678.09	7831.941699 N	00929.822581 E	403.80	359.57	1.4	3.8	5.58	44	-1.6	994.5
Annen stasjon (UWLS)	Cage 15-6	22.10.2015	12:47:35	1614	6680.94	7834.136038 N	00927.196696 E	399.68	148.34	1.5	3.5	4.31	87	-1.7	994.6
Annen stasjon (UWLS)	Cage 15-6	22.10.2015	14:48:31	1615	6683.98	7831.874980 N	00931.049234 E	391.77	339.82	2.3	3.2	6.20	88	-0.6	994.2
Annen stasjon (UWLS)	Cage 15-6	22.10.2015	16:54:31	1616	6687.39	7834.079826 N	00927.441692 E	396.97	130.70	0.9	3.9	6.97	99	-0.3	994.2
CTD med vannhenter START	Cage 15-6	22.10.2015	18:13:55	1617	6688.29	7834.537165 N	00926.858838 E	395.16	328.49	1.1	4.0	8.98	105	-0.3	994.4
CTD med vannhenter STOPP	Cage 15-6	22.10.2015	18:33:58	1617	6688.50	7834.680610 N	00926.122415 E	398.29	32.54	1.7	4.1	9.79	98	-0.2	994.2
CTD med vannhenter START	Cage 15-6	22.10.2015	18:47:49	1618	6689.32	7834.073106 N	00927.324070 E	398.85	25.86	0.9	4.0	9.40	92	-0.3	994.1
CTD med vannhenter STOPP	Cage 15-6	22.10.2015	19:03:43	1618	6689.55	7834.290882 N	00927.032204 E	397.81	35.48	1.5	4.1	8.10	113	-0.4	994.2
CTD med vannhenter START	Cage 15-6	22.10.2015	19:17:20	1619	6690.35	7833.615098 N	00928.001416 E	391.87	83.76	0.8	3.9	7.87	81	-0.4	994.1
CTD med vannhenter STOPP	Cage 15-6	22.10.2015	19:39:30	1619	6690.71	7833.927961 N	00927.356386 E	397.17	61.39	1.0	4.1	8.09	94	-0.3	994.2
CTD med vannhenter START	Cage 15-6	22.10.2015	19:56:54	1620	6691.41	7833.380724 N	00928.573133 E	388.07	115.10	1.5	4.1	7.78	95	-0.5	994.1
CTD med vannhenter STOPP	Cage 15-6	22.10.2015	20:17:12	1620	6691.67	7833.540793 N	00927.733604 E	393.76	22.01	0.8	4.1	7.88	108	-0.3	994.3
CTD med vannhenter START	Cage 15-6	22.10.2015	20:31:00	1621	6692.36	7833.091814 N	00929.310531 E	392.04	111.12	1.8	3.8	8.82	89	-0.6	994.2
CTD med vannhenter STOPP	Cage 15-6	22.10.2015	20:47:52	1621	6692.58	7833.243958 N	00928.683665 E	391.26	6.38	1.1	3.7	6.36	83	-0.3	994.2
CTD med vannhenter START	Cage 15-6	22.10.2015	21:06:53	1622	6693.37	7832.619782 N	00929.932120 E	390.54	99.26	1.4	3.5	6.14	82	-0.6	994.2
CTD med vannhenter STOPP	Cage 15-6	22.10.2015	21:24:25	1622	6693.62	7832.819587 N	00929.312837 E	394.50	30.85	1.8	3.5	7.04	98	-0.5	994.2
CTD med vannhenter START	Cage 15-6	22.10.2015	21:41:41	1623	6694.47	7832.102285 N	00930.676091 E	391.62	84.42	1.0	3.5	4.05	95	-0.5	994.2
CTD med vannhenter STOPP	Cage 15-6	22.10.2015	22:00:27	1623	6694.73	7832.303680 N	00930.024022 E	396.43	359.75	1.2	3.6	2.17	82	-0.2	994.1
CTD med vannhenter START	Cage 15-6	22.10.2015	22:14:18	1624	6696.01	7833.331308 N	00926.253270 E	408.56	348.26	1.1	3.6	0.76	70	-0.6	994.1
CTD med vannhenter STOPP	Cage 15-6	22.10.2015	22:34:46	1624	6696.26	7833.531095 N	00925.912850 E	410.56	57.92	0.9	3.9	2.80	345	-0.5	994.1
CTD med vannhenter START	Cage 15-	22.10.2015	22:47:01	1625	6696.92	7833.418879	00929.018239	387.89	71.02	1.5	3.7	4.89	23	-0.2	994.1

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CTD med vannhenter STOPP	Cage 15-6	22.10.2015	23:03:47	1625	6697.08	7833.536402 N	00928.614125 E	387.95	123.10	1.3	3.5	5.24	12	-0.5	994.1
CTD med vannhenter START	Cage 15-6	22.10.2015	23:16:15	1626	6697.74	7833.462120 N	00931.809253 E	351.35	140.27	0.9	3.4	3.27	47	-0.5	994.1
CTD med vannhenter STOPP	Cage 15-6	22.10.2015	23:30:17	1626	6697.87	7833.519474 N	00932.043306 E	347.21	44.62	0.8	3.4	3.82	31	-0.6	994.0
Annen stasjon (ADCP)	Cage 15-6	23.10.2015	00:01:24	1627	6701.57	7831.813562 N	00916.455819 E	482.09	148.02	5.2	5.0	5.36	27	-0.5	994.1
Annen stasjon (UWLS)	Cage 15-6	23.10.2015	09:30:43	1628	6741.86	7832.005975 N	00931.878481 E	381.96	356.87	1.9	4.6	3.00	40	-0.5	994.5
Annen stasjon (UWLS)	Cage 15-6	23.10.2015	11:29:28	1629	6745.39	7834.177306 N	00927.334791 E	399.23	163.53	1.4	4.0	2.48	110	-1.2	994.9
Annen stasjon (UWLS)	Cage 15-6	23.10.2015	13:22:52	1630	6748.80	7831.904244 N	00932.686611 E	372.05	358.14	2.0	4.1	7.01	28	-1.9	994.6
Annen stasjon (UWLS)	Cage 15-6	23.10.2015	15:14:42	1631	6751.56	7834.302765 N	00928.292350 E	386.03	281.61	0.1	3.8	7.16	35	-1.3	994.3
Annen stasjon (UWLS)	Cage 15-6	23.10.2015	15:34:08	1632	6752.08	7834.093306 N	00928.874910 E	381.17	252.88	0.5	3.9	7.10	23	-1.3	994.2
Annen stasjon (UWLS)	Cage 15-6	23.10.2015	15:48:35	1633	6752.16	7834.065343 N	00928.743954 E	383.18	294.29	1.9	3.8	6.61	30	-1.4	994.1
Annen stasjon	Cage 15-6	23.10.2015	17:15:03	1634	6754.85	7833.508045 N	00928.167161 E	390.13	225.89	0.5	3.7	7.07	50	-1.3	993.6
CTD med vannhenter START	Cage 15-6	23.10.2015	23:00:30	1635	6801.24	7755.912904 N	00734.814234 E	3156.00	334.47	3.7	5.7	8.77	310	0.1	993.2
CTD med vannhenter STOPP	Cage 15-6	24.10.2015	01:39:49	1635	6803.30	7756.217406 N	00730.315445 E	3452.39	277.91	8.7	5.7	7.83	304	-0.0	992.6
CTD uten vann START	Cage 15-6	25.10.2015	09:10:34	1636	7110.65	7624.073296 N	01257.058657 E	1538.27	239.08	0.2	6.1	5.36	339	1.6	979.9
CTD uten vann STOPP	Cage 15-6	25.10.2015	10:17:30	1636	7111.46	7623.496428 N	01258.345129 E	1521.95	209.89	0.8	6.1	10.34	313	3.5	980.0