CAGE - Centre for Arctic Gas Hydrate Environment and Climate Report Series, Volume 4 (2016)

To be cited as: Bünz, S. (2023). CAGE16-6 Cruise Report: Cruise CAGE16-6. *CAGE - Centre for Arctic Gas Hydrate Environment and Climate Report Series, Volume 4.* https://doi.org/10.7557/cage.6929
Additional info at: https://septentrio.uit.no/index.php/cage/database

ISSN: 2703-9625
Publisher: Septentrio Academic Publishing Tromsø Norway

FACULTY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF GEOLOGY

Date: September 30, 2016

UNIVERSITY OF TROMSØ cruise report

Longyearbyen – Longyearbyen 05-07-16 to 18-07-16

R/V Helmer Hanssen

Cruise CAGE16-6

Centre for Arctic Gas Hydrate, Environment and Climate (CAGE))

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INTRODUCTION AND OBJECTIVES

Cruise CAGE16-6 with UiT's research vessel Helmer Hanssen is the 6th of several cruises in 2016 that is carried out to collect cross-disciplinary data for addressing the objectives of the Norwegian Centre of Excellence for Arctic Gas Hydrate, Environment and Climate, CAGE.

The overall goal of cruise CAGE 16-6 is to collect seismic, multibeam and water column data on the W-Svalbard margin and in the outer parts of the Storfjord Trough (Fig. 1). The objectives associated with the overall goal are to better understand the occurrence of gas hydrates and fluid leakage, the source of the gas in these systems, and seafloor expressions of fluid seepage. In order to address these objectives we plan to carry out (Fig. 2):

- P-Cable 3D seismic acquisition over gas hydrate and fluid flow areas with potential abiogenic gas sources;
- P-Cable 3D seismic acquisition over gas-hydrated pingo structures in the Storfjorden Trough;
- Recovery of 5 OBS stations that were deployed at the Lunde pockmark in October last year for long-term monitoring of microseismicity;
- Acquisition of additional OBS seismic data to fill gaps in existing data on the eastern segment of the Vestnesa Ridge;
- 2D multi-channel seismic for reconnaissance and stratigraphic correlation;
- Multibeam mapping to fill in gaps and improve resolution of existing data using the upgraded EM302 system on R/V Helmer Hanssen;
- Water column mapping of gas flaring on the Vestnesa Ridge using the upgraded EM302 system on R/V Helmer Hanssen;

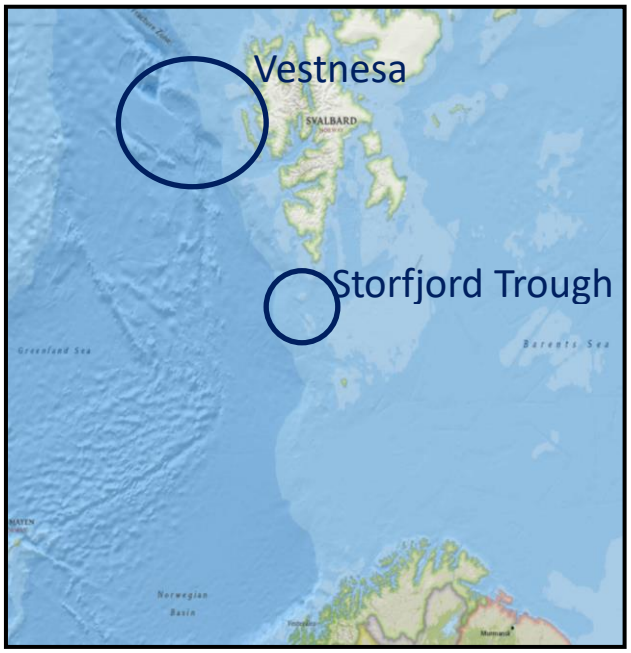


Figure 1: Location of the study areas on the W-Svalbard margin and the outer trough of the Storfjord.

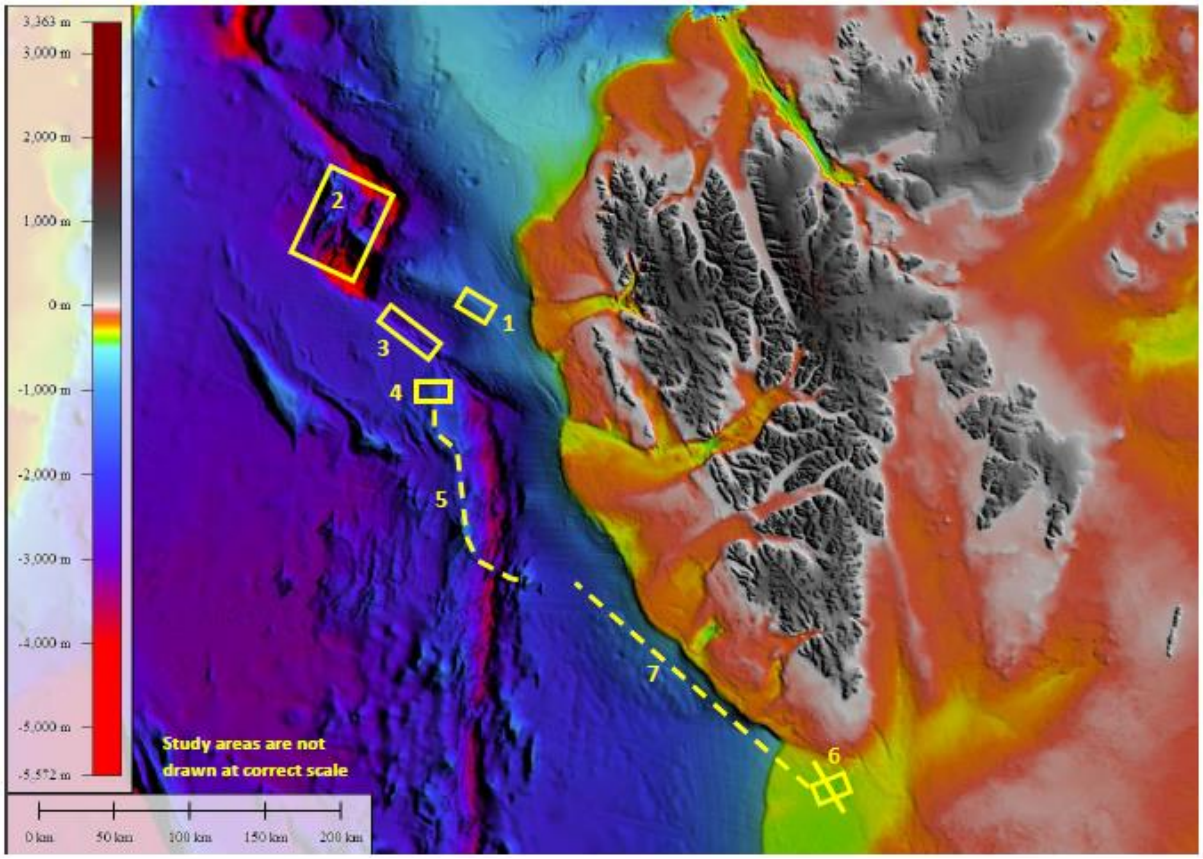


Figure 2: Figure 2 – Overview map of study areas and activities completed during the CAGE16-6 cruise (numbered) plotted on IBCAO V3 bathymetry (500m gridded).

1. Vestnesa Ridge: OBS retrieval, 2D seismic and OBS redeployment for active source experiment, multibeam bathymetry and flare mapping.
2. Western flank of Molloy Ridge: multibeam bathymetric mapping
3. Molloy transform: 2D seismic lines and multibeam mapping
4. Svyatogor ridge: acquisition of new 3D seismic volume
5. Western flank of Knipovich Ridge: multibeam bathymetric mapping
6. Storfjordrenna pingos area: acquisition of new 3D seismic volume followed by acquisition of an extended narrow 3D seismic "corridor"
7. Continental slope SW Svalbard: 2D seismic and multibeam transect

METHODS

Seismic methods

The high-resolution P-Cable 3D seismic system was used together with a Granzow high-pressure (210bar) compressor and one mini-GI gun (15/15 in^3) or one GI gun (45/45 in^3). Onboard seismic processing and QC of P-Cable seismic data provided preliminary 3D cubes and migrated 2D seismic sections for quality assessment and geofluid interpretations.

During this cruise we used the upgraded SIMRAD EM302 high-resolution multibeam system. The new EM302 improves seabed resolution greatly by increasing the number of beams from 135 to a possible maximum of 864 beams. In addition, the system allows mapping the water column in order to detect gas flares over active pockmarks.

Other acquisition systems that were partly used include SIMRAD EK 60 38 and 18 kHz echosounder, the Edgetech Discover penetration sub-bottom profiler and a CTD to extract

information about different (T, S) properties of water masses to calculate the speed of sound for calibrating the EM302.

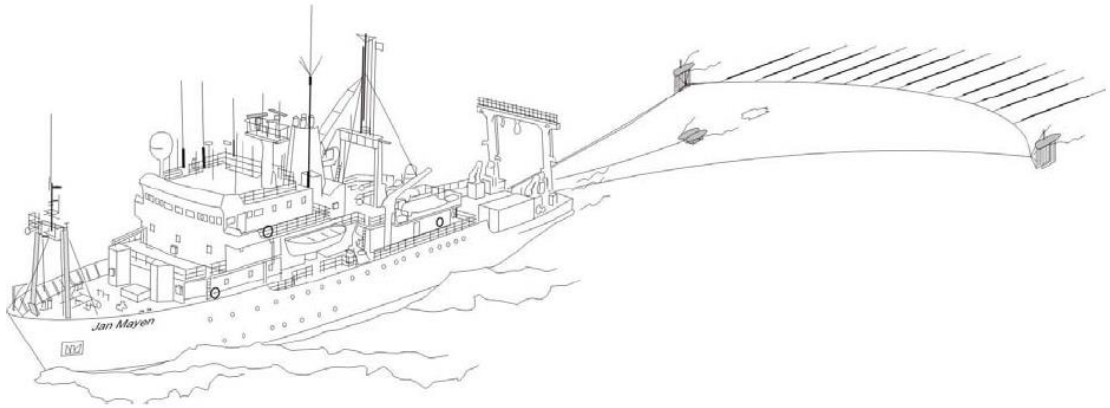
The P-Cable 3D (2D) seismic system

The P-Cable 3D high-resolution seismic system consists of a seismic cable towed perpendicular (cross cable) to the vessel's steaming direction (Figure 3 and 4). An array of multi-channel streamers is used to acquire many seismic lines simultaneously, thus covering a large area with close in-line spacing in a cost efficient way. The cross cable consists of two 62,5-m long and one 87,5-m long section with a total of 14 streamers attached to it. Including lead-in cables, the cross cable has a total length of 233 m between paravanes (doors) (Figure 2). The cross-cable is spread by two paravanes that due to their deflectors attempt to move away from the ship. The paravanes itself are towed using R/V Helmer Hanssen's large trawl winches. The spacing between the streamers is 12.5 m but due to curvature of the cross-cable, the effective spacing between the streamers may be shortened in cross line direction to about 6-12 m. Each digital streamer is 25 meters long and consists of an A/D-module and 8 channels. New Geometrics solid state streamers are used that are much less affected by sea swell and hence provide data with significantly less noise. The A/D-module converts the analogical signal from the channels to digital signals. The group spacing of channels along the streamer is of 3.125 m.

A 300-m long signal cable is run off the P-Cable winch and connects to the starboard termination of the cross cable (Figure 3). It contains wiring for power and data transmission. The data is transferred via Ethernet protocol. Ethernet-to-Coax switches at the ends of the signal cable allow data transmission over long distances. The digital data is recorded using Geometrics GeoEel software.

The P-Cable system can be reconfigured to a multi-channel 2D seismic streamer. During this cruise we used 6 streamer sections for a 150 m long active hydrophone cable with 48 channels at a receiver spacing of 3,25 m (Figure 5). The cable was towed approximately 80 m behind the vessel.

Details on the acquisition parameters like recording length, sampling rates, etc. can be found in the seismic line log in the Appendix of this report.



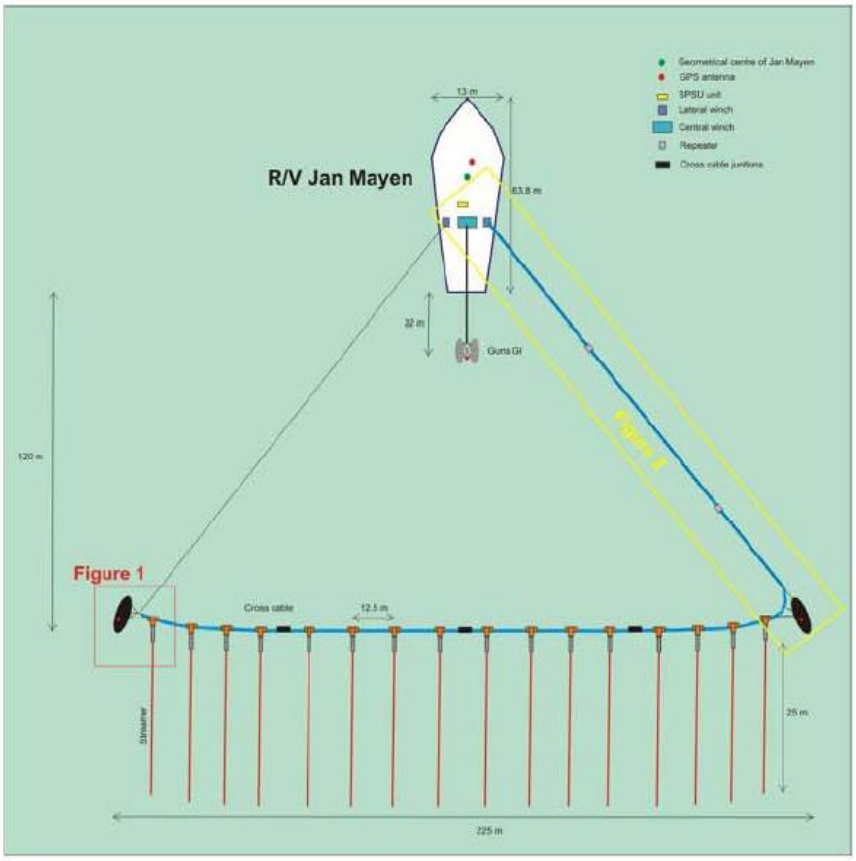


Figure 3: Schematic sketch (top) and technical drawing (bottom) of the P-Cable high-resolution 3D seismic system.

Figure 4: Images of the P-Cable system during deployment and recovery. Top left: the cross cable is being deployed, streamer sections are connected during deployment; top and bottom right: The cross cable is recovered and spooled back on the winch while streamers as disconnected from the cross cable. The small winch next to the cross cable holds the signal cable; bottom left: inspection of cross cable junction boxes during deployment and recover.

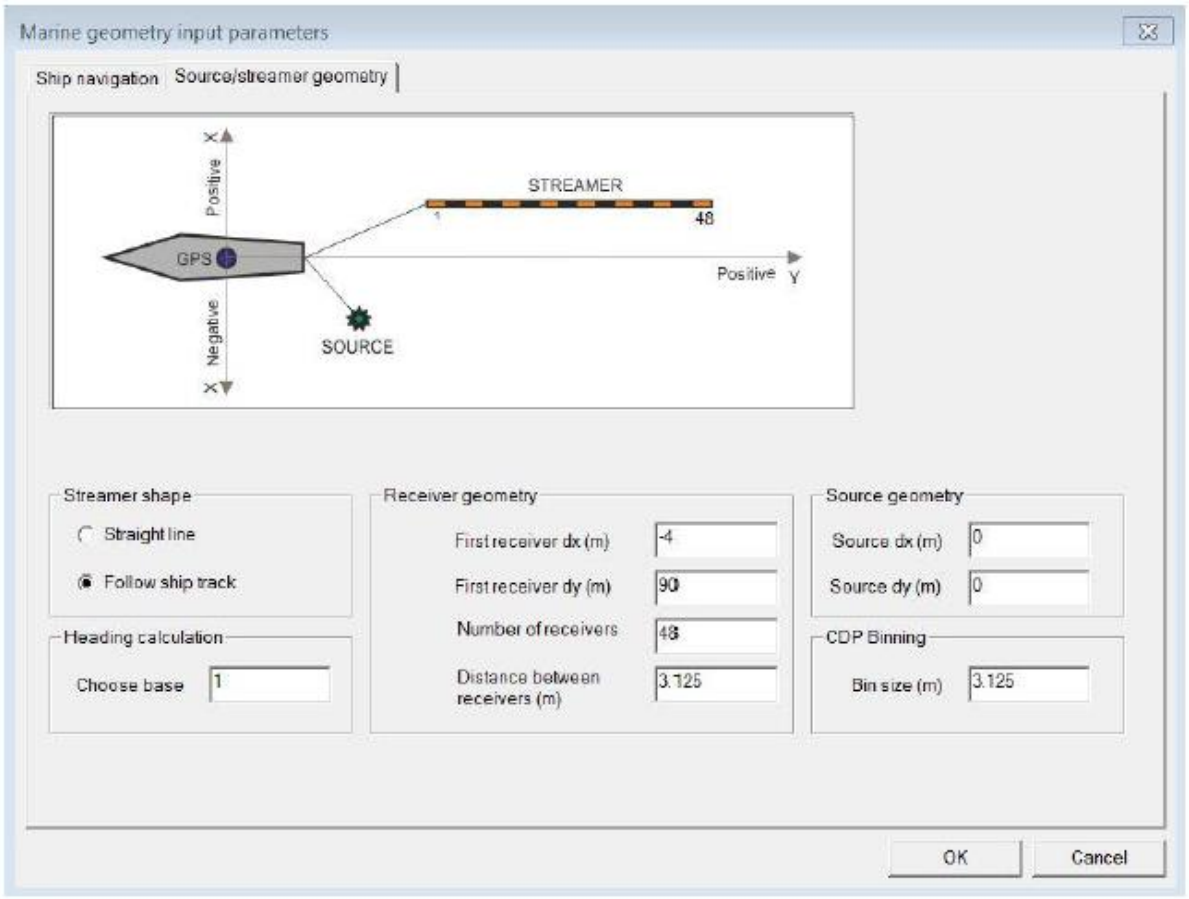


Figure 5: Figure 7 – Typical parameters used to describe the 2D seismic acquisition system as defined during shipboard processing in RadexPro 2016.2.

Multi-component ocean bottom seismometer (OBS)

Multi-component Ocean Bottom Seismometer (OBS) were deployed to record compressional and shear wave velocities. On cruise CAGE15-6 in October 2015, 5 OBS systems were

deployed around the Lunde pockmark on the Vestnesa Ridge. These 5 OBS recorded microseismicity associated with the leakage of fluids from the subsurface. They also generally record earthquake seismic events in this region and other acoustic signals possibly also from marine mammals. All 5 OBS systems were successfully recovered. Subsequent to that, 2 OBS were prepared for an active source seismic experiment on the Vestnesa Ridge.

The OBS systems used represent two design types that serve the same purpose (Figure 6). They are autonomous sea floor recording platforms, designed to record both, compressional and shear waves reflected and refracted through the sediments. It consists of a titanium frame with buoyancy made of syntactic foam, a KUMQUAT acoustic release system, and a digital data recorder in a separate pressure case[1]. A hydrophone and a 3-component geophone are used to record the seismic wavefield. The Tromsø OBS has a 4.5 Hz geophone attached. While the hydrophone is fixed to the frame of the OBS, the geophone is detached from it. This design insures that the geophone is mechanically decoupled from the frame, to avoid noise generated by the frame being recorded by the geophone. The whole system is rated for a water depth of up to 6000 m.

The OBS is attached to a ground weight via the acoustic release system, to make it sink to the sea floor after deployment. When the seismic experiment is completed, the OBS is released from its ground weight by sending an acoustic code and it rises to the sea surface by its buoyancy.

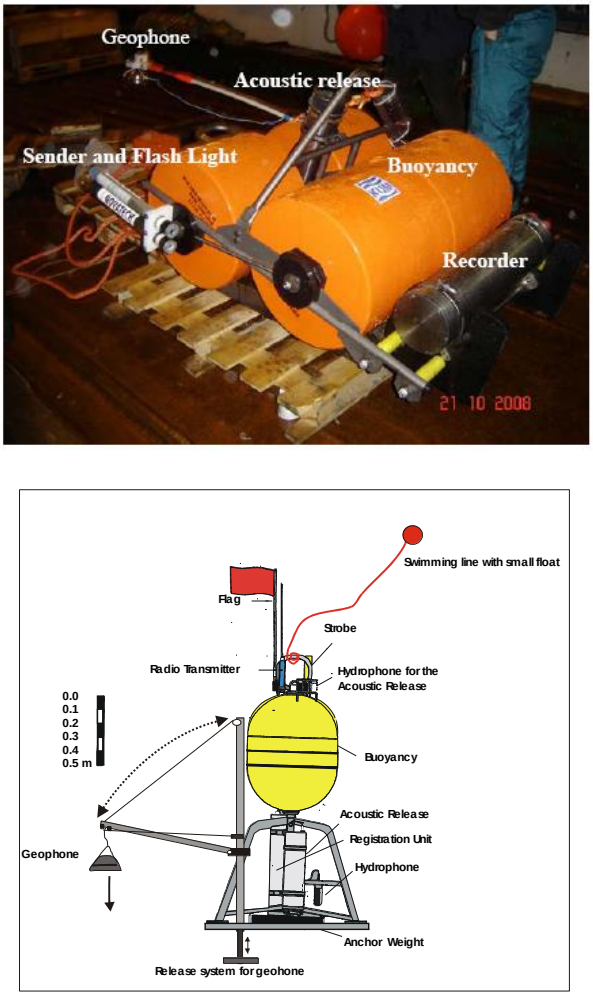


Figure 6: The old (bottom) and the new (top) Ocean Bottom Seismometer (OBS) system (UiT).

During the cruise the OBS's were retrieved (Figure 3) which had been stationed around an actively leaking pockmark at Vestnesa since October 2015 to monitor passive seismicity with aim of quantifying the gas release. Two OBS's were then re-deployed to conduct an active source experiment whereby the ship sailed several lines across the area firing the airgun. This data will be processed to investigate the acoustic velocity structure of the subsurface.

The OBS systems were prepared and programmed prior to deployment. The first channel records the hydrophone data, while channel two, three and four are connected to horizontal and vertical components of the geophone. The locations were selected based on seismic anomalies in the 3D seismic data and previously acquired OBS data. The station list is given in the appendix.

NARRATIVE OF THE CRUISE

Times in this report are given in local time (local time -2 hrs = UTC), seismic data are logged in UTC time and ship logs are given in UTC time. Weather conditions throughout the cruise were mostly good with sea state and wave heights not significantly above 1 m and only few periods with slightly more deteriorated weather. Air temperatures were between 1 ◦C and 8 ◦C. We started to prepare the cruise in Longyearbyen on July 5 with assembling of the equipment.

Tuesday, 05.07.
Most of the scientific crew arrived at 10:00 and a three more crew arrived by plane from Tromsø in the afternoon. We started to prepare lab areas and to assemble the equipment. RV Helmer Hanssen left Longyearbyen at 20:30 heading towards the first working area on the Vestnesa Ridge. A multibeam line was planned to run along the crest of the Vestnesa Ridge using R/V Helmer Hanssen's upgraded EM302 system with improved resolution and water column imaging.

Wednesday, 06.07
The multibeam and water column mapping continues along the crest of the Vestnesa Ridge until approximately 15:00. A CTD station is taken at 1500 m water depth at 08:30 ofr calibration of sound speed in the multibeam and echosounder systems. Then Helmer Hanssen turns to go to the Lunde pockmark where 5 OBS have been deployed in October 2015 for long-term monitoring. We use the acoustic release systems on each OBS to firstly triangulate the position of the OBS on the seafloor and then release it. Triangulation using the release system gives better accuracy than using seismic waves as OBS instruments have low sampling rates designed for long-term monitoring. OBS1 and 2 are successfully located and recovered. OBS3 does not respond to the acoustic release system initially. OBS4 is then released but floats up to the surface with the pressure housing off its mounting point and hanging only by the subconn data cable connection. The stainless steel clamps have rusted and broken off. We need to deploy a small rubberboat to successfully secure the pressure housing while the OBS is still in the sea.

Thursday, 07.07.

OBS5 is successfully recovered. We return to OBS3 position and outright send release commands skipping over the triangulation. The communication with the acoustic release unit is almost dead except for a slim sign. However, the release unit had received the release command and is coming up in the water column as we receive successful response at shallow water depth (<300 m). OBS3 surfaces with the same problem as OBS4 with the pressure housing by a thread on the data cables. We again can successfully secure the housing with the rubberboat and OBS3 is recovered. However, the stainless steel clamps of the release unit have also failed and the unit is lost to the sea during its ascend. The planned 2D seismic lines that were supposed to be run during the rest of the night have to be cancelled as both mini-GI guns are leaking air. Instead we do further multibeam surveying in the area. In the morning two CTD stations are taken with water samples at the seafloor and slightly above. Following that, the repair of one of the mini-GI guns with help from the chief engineer was successful and we acquire 3 2D seismic lines. In the meantime, 2 OBS systems are prepared for an active seismic source experiment. The 2 OBS are deployed on the Vestnesa Ridge shortly before midnight.

Friday, 08.07.
The planned seismic acquisition over the OBS has to be cancelled shortly after the start of the first line due to failing mini-GI guns. The streamer and gun systems are recovered at 03:00 and the work is called off for the night. At 08:00 the our engineer and the chief engineer try to repair the mini-GI gun. However, several tests are unsuccessful and we decide to proceed with the larger GI gun systems. The assembly of the GI gun takes another three hours, but at 17:00 we are finally ready and deploy the gun system and 2D seismic streamer. Three seismic lines cross both OBS systems. In addition, one of the OBS has 4 circular seismic lines around it at varying distance.

Saturday, 09.07.
The fourth and final circle line finishes shortly after midnight. Subsequently both OBS are successfully recovered. At about 03:00 we head away from this area continuing the multibeam survey along the crest of the Vestnesa Ridge towards its western end with the upgraded EM302 system. The multibeam survey then continues into the Molloy Ridge area. At 14:00 a CTD station is conducted for calibrating the EM302 system. The multibeam survey continues and finishes north of the Molloy Transform close to the Molloy Deep shortly before midnight.

Sunday, 10.07.
The 2D seismic systems is deployed and we acquire four 2D seismic lines across the Molloy Transform, an area where a BSR has been observed but data coverage so far is sparse. The four seismic lines conclude at 14:00 and we steam south-westward to the Svyatogor Ridge for the 3D seismic experiment. On the transit, the P-Cable 3D seismic system is prepared on deck. The deployment of the 3D systems starts at 17:30 and takes approximately one hour. Initial test show no leakage on the system. However, the Geoeel software does not detect all digitizers. Further testing and detection attempts are unsuccessful and we have to bring the system back on deck for inspection. The connections of the first two streamers are thoroughly checked but testing and detection does still not provide a clear solution. After some cleaning and reconnections the first two digitizers can be successfully detected multiple times. At about 22:00 the system is deployed again. Initial test are fine and detection after 6 digitizers is also successful. The

whole system is back in the water at 23:00 and after several tries all digitizers are detetcted.

Monday, 11.07.
Shortly after midnight, we start our warm-up program for the 3D seismic survey at Svyatogor. The 3D seismic system works well and the data quality is very good. The survey starts on 3D seismic line 1 at about 03:30. At the end of the day, the P-Cable system is still working well and we are on 3D seismic line 10.

Tuesday, 12.07.
The P-Cable system is still working well and at the end of the day we have already acquired a total of 19 3D seismic lines.

Wednesday, 13.07.
At 22:00 we conclude the 3D seismic acquisition at Svyatogor Ridge with a total of 31 acquisition lines. After recovering the gun system, we found that the gun frame broke at two locations and that the back gun was only hanging by one chain. It should not have taken much longer before we would have lost parts of the frame and potentially one GI gun. At 23:30 we head southward to the working area at the pingos in Storfjordrenna.

Thursday, 14.07.2016
We arrive at outer Storfjorden at about 20:00 and immediately start to deploy the P-Cable system. The airgun frame has been repaired during the transit. At about 22:30 the system is in the water and we start on our pre-survey warm-up program. 3D seismic acquisition line 1 starts shortly before midnight.

Friday, 15.07.2016
The P-Cable acquisition system stull shows full leakage but as all systems seem to work fine with no errors showing we continue to survey. At the end of the day, we are about to finish line 18 of the Pingo 3D seismic survey.

Saturday, 16.07.2016
We get individual “serial string” error messages towards the end of the survey on lines 30-32 but not yet in an abundance that we would stop the survey and troubleshoot the failure. The survey concludes with line 32 at about 19:00. We then decide to shoot a 3D seismic corridor connecting the previous block with gas seepage structure on the flanks and almost outside of the trough. In total, 4 corridor lines are acquired until shortly before midnight.

Sunday, 17.07.2016
We recover the P-Cable system and reconfigure it for 2D seismic. At about 04:00 we start to shout a 2D seismic line outbound from the Trough to the continental slope and then turning northbound following approximately the 1000 m isobaths. This line will provide important stratigraphic links between existing lines in the Barents Sea and Western Svalbard. The 2D seismic line has to finish at about 19:30 as we have to steam back to Longyearbyen.

Monday, 18.07.2016
08:00: Arrival in Longyearbyen. End of cruise.

ACKNOWLEDGEMENT

We thank the captain and his crew of R/V Helmer Hanssen of the University of Tromsø for their excellent support during the 3D and multicomponent seismic survey. This part of the cruise was conducted under the framework of the Centre of Excellence on Gas Hydrates, Environment and Climate (CAGE) (Norwegian Research Council (NFR) project number 223259/F5 at the University of Tromsø.

APPENDIX

OBS Stations

OBS Locations

OBS	X	Y	Z	Vw	Lat	Long
OBS1	452176	8774133	1202	1466	79° 01' 44.3911''	6 ° 44 ' 54.4495 ''
OBS2	453264	8772955	1196	1468	79° 01' 07.706''	6° 48 ' 06.1880''

Coordinates in UTM zone 32.

3D seismic line log Svyatogor

Expedition: Helmer Hanssen July 2016 Survey: Svyatogor Ridge 11.07 – 13.07 Sheet #: 1 - 9

Survey configuration Svyatogor: see end of document STREAMER DEPTH CALIBRATION IS ON THE LAST PAGE
Times are UTC

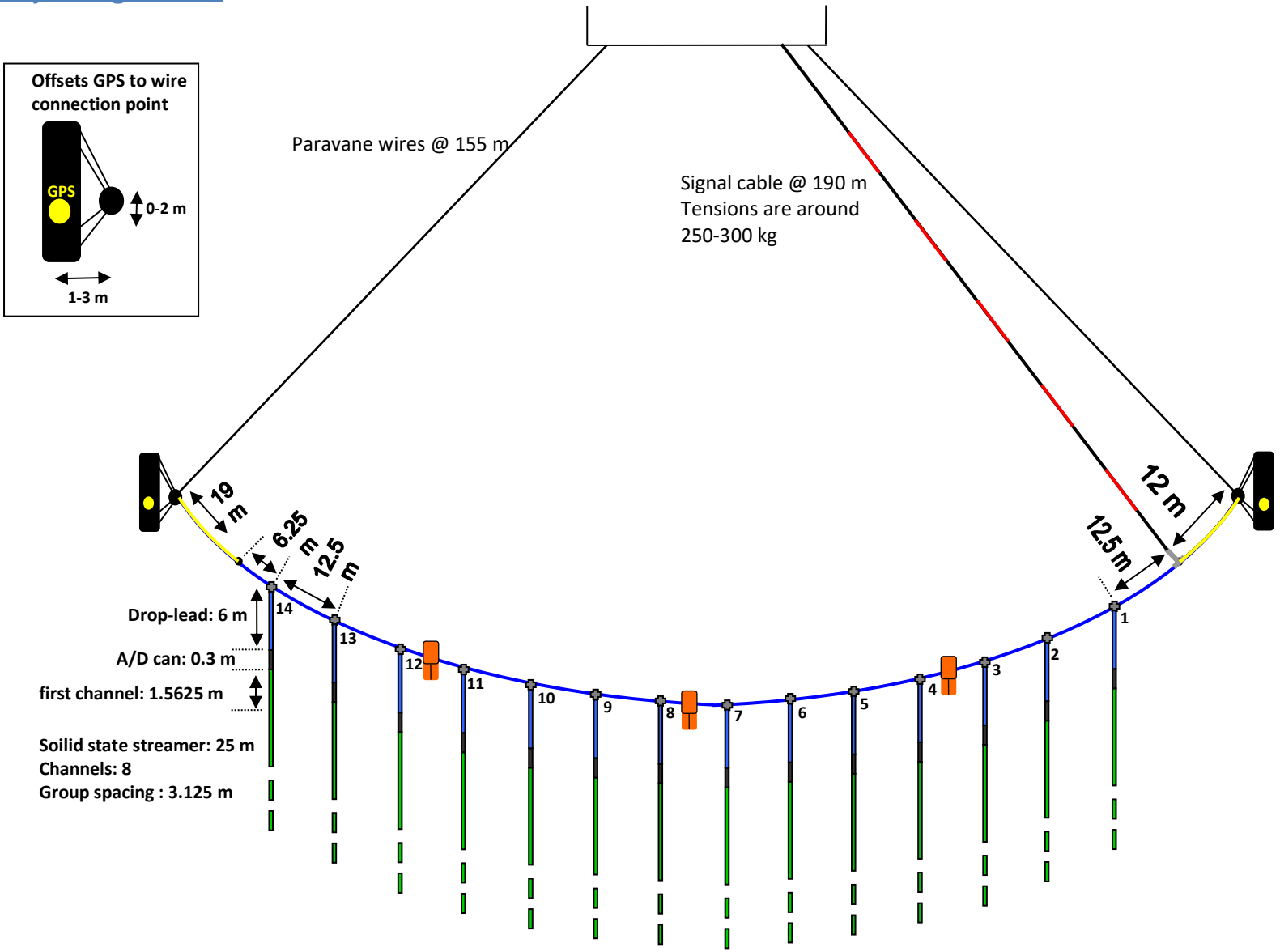
3D line number:	Date: Start - end	Time (UTC): Start - end	Shot point number First - last	Shot point number when crossing planned start and end of line	Comments (sailing direction, ship speed, depth sensor, wind speed, etc.)
0	10.07-11.07	23:56:25 – 00:57:49	169 - 781		Sailing E, ship speed 4 kn, wind speed 10 m/s, wind direction NNE deg Disabled chan 23, 16, 14, 57, 8, 67. Noise on chan 65.
1	11.07- 11.07	01:39:49 -03:23.12	782 - 1816	800 - 1812	Sailing E, ship speed 4 kn, wind speed 10 m/s, wind direction NNE deg Swell ~ 1 m
2	11.07-11.07	03:46:18 – 05:30:48	1817 - 2862	1837 - 2853	Sailing W, ship speed 4 kn, wind speed 10 m/s, wind direction NNE deg Swell ~ 1 m
3	11.07-11.07	06:15:42-07:56:06	2863 -3872	2904-3862	Sailing E, ship speed 4 kn, wind speed 10 m/s, wind direction NNE deg Swell ~ 1 m. Sea temp. 8.1-8.5 degrees
4	11.07-11.07	08:23:48-10:00:00	3873-4835	3887-4750	Sailing W, ship speed 4 kn, wind speed 7 m/s, , wind direction N (3deg). Swell ~ 1 m. sailing approx. 10m to left of line (S) to shot 3928. Sea temp. 8.1-8.2 degrees

5	11.07-11.07	10:35:12-12:27:18	4836-5957	4928-5925	Sailing E, ship speed 4 kn, wind speed 6.5-1.2 m/s, , wind direction N (10deg). Swell ~ 0.75 m. sailing approx. 10m to left of line (S) to shot 3928. Sea temp. 8.5-8.2 degrees
6	11.07-11.07	12:49:54-14:41:30	5958-7092	6013-7063	Sailing W, ship speed 4 kn, wind speed 1.9-1.5 m/s wind direction W (214deg). Swell ~ 0.50 m. Sea temp. 8.5-8.6 degrees. 15m left of line (S) shot 6225 (10-15min period off line) due to effect of current from the North on autopilot. 8m left of line shot 6455-6465.
7	11.07-11.07	15:14:00-17:18:00	7093-8322	7230-8286	Sailing E, ship speed 4 kn, wind speed 5 m/s wind direction NW (340deg). Swell ~ 0.50 m. Sea temp. 8.7 degrees, 18 m South from line in beginning (20m at shot 7356). Bad channel: 28
8	11.07-11.07	17:31:30-19:21:41	8323-9425	8417-9415	Sailing W, ship speed 4 kn, wind speed 4.5 m/s wind direction NW (340deg). Swell ~ 0.50 m. Sea temp. 8.4 degrees. Start of line-20 m South from the planned line
9	11.07-11.07	19:59:29-21:50:34	9426-10537	9546-10523	Sailing E, ship speed 4 kn, wind speed 4.2 m/s wind direction N (350-20deg). Swell ~ 0.50 m. Sea temp. 8.6 degrees. 9535
10	11.07-11.07	22:16:04-23:57:10	10538-11550	10561-1153	Sailing W, ship speed 4 kn, wind speed 4.0 m/s wind direction NNE (20deg). Swell ~ 0.40 m. Sea temp. 9.2 degrees Serial string not detected, Incomplete data on shot 10922, missing section 4.
11	12.07-12.07	00:34:46-02:22:22	11551-12627	11606-12625	Sailing E, ship speed 4 kn, wind speed 2.3 m/s wind direction NNE (20deg). Swell ~ 0.20 m. Sea temp. 9.4 degrees
12	12.07-12.07	02:51:34-04:36:58	12628-13682	12671-13672	Sailing W, ship speed 4 kn, wind speed 3.4 m/s wind direction SSE (170deg). Swell ~ 0.40 m. Sea temp. 9.4 degrees
13	12.07-12.07	05:10:34-07:03:58	13683-14821	13726-14756	Sailing E, ship speed 4 kn, wind speed 3.4 m/s wind direction S. Swell ~ 0.40 m. Sea temp. 8.7 degrees 14150 shot 14151,14152,14158,14158,14160,14161

					Incomplete data on shot
14	12.07-12.07	07:27:58-09:16:46	14822-15920	14859-15830	Sailing W, ship speed 4 kn, wind speed 5.3 m/s wind direction S. Swell ~ 0.40 m. Sea temp. 9.4 degrees. Slight mess up due to operator incompetence (SSH): a few shots from the beginning of line 15 are recorded with line 14 (shots 15921-15929).
15	12.07-12.07	09:45:16-11:39	15930-17072	16029-16993	Sailing E, ship speed 4 kn, wind 6.6-7.9 m/s from south. Swell 0.4m, Sea temp 8.5-9.3 deg. Geometry seems nice, maybe current has dropped off.
16	12.07-12.07	11:56:58-13:47:22	17073-18177	17138-18162	Sailing W, ship speed 4kn, wind 4 m/s from the SE. Swell ~ 0.3 m. Sea temp 8.9 C. Shot 17613: serial string not detected.
17	12.07-12.07	14:12:52-16:01:16	18178-19262	18230-19220	Sailing E, ship speed 4kn, wind 4 m/s from the SE. Swell ~ 0.3 m. Sea temp 8.9 C. SOL: ~15 m south of line.
18	12.07-12.07	16:21:04-18:07:59	19263-20332	19319-20323	Sailing W, at 4kn. Wind from NE at about 2 m/s. Sea temp about 9-9.3 C. Swell about 0.3 m. Quite far south of line at start (worse before the actual start of the line, got it down to about 20m then overshot to north…)
19	12.07-12.07	18:35:29-20:14:05	20333 - 21320	20363 - 21307	Sailing E, at 4kn. Wind from NE at about 4 m/s. Sea temp about 8.3 C. Swell about 0.3 m.
20	12.07-12.07	20:31:59 -22:09:17	21321 - 22294	21349 - 22284	Sailing W, at 4kn. Wind from N at about 4.5 m/s. Sea temp about 8.8 C. Swell about 0.3 m.
21	12.07-13.07	22:33:23-00:16:35	22295 - 23328	22321-23320	Sailing E, at 4kn. Wind from N at about 3 m/s. Sea temp about 8.1 C. Swell about 0.3 m.
22	13.07-13.07	00:35:29-02:16:17	23329-24337	23354-24328	Sailing W, at 4kn. Wind from NNW at about 4.5 m/s. Sea temp about 9.5 C. Swell about 0.10 m.

23	13.07-13.07	02:37:23-04:18:29	24338-25349	24379-25347	Sailing E, at 4kn. Wind from N at about 4.5 m/s. Sea temp about 8.4 C. Swell about 0.10 m.
24	13.07-13.07	04:42:05-06:25:35	25350-26385	25381-26338	Sailing W, at 4kn. Wind from NNW at about 4.5 m/s. Sea temp about 9.3 C. Swell about 0.10 m.
25	13:07-13:07	06:43:53-08:26:23	26386-27413	26422-27400	Sailing E at 4kn. Wind from NW at 4 m/s. Sea temp about 8.5. Swell about 0.2 m.
26	13:07-13:07	08:43:40-10:27:40	27414-28454	27450-28413	Sailing W at 4kn. Wind from NW at 4-6 m/s. Sea temp about 9.5-8.5. Swell about 0.1 m. Ship off start mark by 43 meters. Ship back on track at shot 27504. NAVIGATION FOR Line 26 saved in Line 25 file.
27	13:07-13:07	10:43:46-12:29:22	28455-29511	28514-29490	Sailing E at 4kn. Wind from NW at 4-6 m/s. Sea temp about 9.5-8.5. Swell about 0.25 m.
28	13.07-13.07	12:49:46-14:35:58	29512-30574	29545-30518	Sailing W at 4kn. Wind from NW at 4-6 m/s. Sea temp about 9.5. Swell about 0.25 m.
29	13.07-13.07	14:52:04-16:39:00	30575-31645	30635-31605	Sailing E at 4kn. Wind from NW at 4-6 m/s. Sea temp about 9.0. Swell about 0.10 m. Channel 37 is noisy today, channel 28 which was noisy the previous day now seems ok.
30	13.07-13.07	16:52:00-18:41:09	31646-32733	31720-32726	Sailing W at 4kn. Wind from NW at 4-6 m/s. Sea temp about 9.4. Swell about 0.20 m. Channel 37 is noisy today.
31	13.07-13.07	19:04:03-20:46:03	32734-33754	32780-33754	Channel 37 is noisy today. Around shot no 33098, seatrack stopped working, but in about a few seconds we had it up and running again (~21:40)
~~End~~					

Survey configuration:



Observed spread of paravanes: 168 m
Observed distance between gun and paravanes: 98 – 113 m, deviations between distances to both paravanes up to 5 m

Ship's speed: 4 kn ± 0,3 kn
Gun system: GI (45/105 in^3)
Shooting pressure: ~150-160 bar
Shooting interval: 6 sec
Recording window: 4 sec
Recording delay: 0 sec
Sampling interval: 0.5 ms
Streamer depth: 1.5 m

Switch no	6013	6014	6031	6016	6017	6028	6011	6030	6023	6034	6025	6026	6022	6019
Depth reading on deck after survey (m)														

Yellow: kind of okay
Red: Wrong. Recalibration required

Survey configuration Storfjord: see end of document STREAMER DEPTH CALIBRATION IS ON THE LAST PAGE
Times are UTC

3D line number:	Date: Start - end	Time (UTC): Start - end	Shot point number First - last	Shot point number when crossing planned start and end of line	Comments (sailing direction, ship speed, depth sensor, wind speed, etc.)
0	14.07-14.07	20:54-21:46	167-625	167-652	Sailing E, ship speed 4 kn, wind speed 11 m/s, wind direction NNE deg chan 8,14,16,23,57,67 enabled at shot 249, channels 14,16 re-disabled at shot 420. At approx. shot 511 (21:35) utm zone changes from 32 to 33. Some shots before 583 may not have correct port paravane coordinates due to waves washing over the paravane gps. Some shots at end of line will have the wrong time stamp
1	14.07-14.07	21:47-22:50	626-1263	670-	Sailing 55 degrees, ship speed 4 kn, wind speed 10 m/s, wind direction ~30 degrees. 0.5m swell.
2	14.07 – 15.07	23:13-00:14	1264-1873	1297-1852	Sailing 232 degrees, ship speed 4 kn, wind speed 8 m/s, wind directions ~25 degrees. 0.1 m swell. Leakage 1373
3	15.07-15.07	00:30-01:33	1874-2506	1908-2492	Sailing 57 degrees, ship speed 4 kn, wind speed 8 m/s, wind direction ~36 degrees. Geometry off by few milliseconds(direct wave arrives at streamer 1 before 14) most of the line
4	15.07-15.07	02:00-03:04	2507-3149	2557-3126	Sailing 241 degrees, ship speed 4 kn, wind speed 8 m/s, wind directions ~36 degrees.
5	15.07-15.07	03:21-04:38	3150-3924	3185-3784	Sailing 61 degrees, ship speed 4 kn, wind speed 7 m/s, wind direction ~40 degrees. Geometry off by

					few milliseconds(direct wave arrives at streamer 1 before 14) most of the line
6	15.07-15.07	04:48-05:51	3925-4550	3962-4525	Sailing 241 degrees, ship speed 4 kn, wind speed 7 m/s, wind direction ~40 degrees.
7	15.07-15.07	06:07:08-07:14:02	4551-5226	4591-5183	Sailing ENE, ship speed 4kn, wind speed 6 m/s from the NNE. Water temp 6.7 C. Serial string missing for shot 5104.
8	15.07-15.07	07:28:08-08:33:50	5227-5928	5309-5906	Sailing WSW at 4kn. Wind speed 7-8 m-s from NE. Water temp 7 C. Started recording pretty far before the waypoint, but the ship is going straight and the geology is interesting. Serial string missing for shot 5331 and 5333. Bunch of missing strings roughly 5654 to 5691. Bunch more missing strings, a couple more big groups. -5871
9	15.07-15.07	08:50:20-09:56:32	5929-6608	5992-6580	Sailing ENE at 4kn. Wind speed 7-8 m-s from NE. Water temp 7 C. Chan 57 Is disabled Serial string and missing data, incomplete data file messages (check log) Serial string and missing data, sect 1-14 lost (shot ~6309) check log Serial string and missing data, sect 1-14 lost (shot ~6373) check log
10	15.07-15.07	10:13:50-11:23:05	6609-7301	6640-7250	Sailing WSW at 4kn. Wind speed 5-6 m-s from NE. Water temp 6,8 C. Bad channel: 37

11	15.07-15.07	11:32:00-12:43:38	7302-8015	7359-7945	Sailing ENE at 4kn. Wind speed 5 m-s from NE. Water temp 7 C. Bad channel: 37 (relatively better than earlier lines)
12	15.07-15.07	12:52:20-14:00:44	8016-8700	8116-8677	Slight (10-15m) deviation from the line at SOL Sailing WSW at 4kn. Wind speed 4 m-s from NE. Water temp 6.8 C. Bad channel: 37
13	15.07-15.07	14:14:02-15:24:19	8701-9404	8761-9335	Sailing ENE at 4kn. Wind speed 4 m-s from NE. Water temp 6.8 C. Bad channel: 37
14	15.07-15.07	15:33:07-16:43:07	9405-10105	9506-10074	Sailing WSW at 4kn. Wind speed 2.5 m-s from 10-20 deg. Water temp 6.7 C. Bad channel: 37
15	15.07-15.07	16:55:13-17:58:30	10106-10739	10157-10729	Sailing ENE at 4kn. Wind speed 1.5 m-s from NW. Water temp 6.7 C. Bad channel: 37
16	15.07-15.07	18:18:48-19:17:21	10740 – 11327	10750-11313	Sailing WSW at 4kn. Wind speed 2.5 m-s from NW. Water temp 6.9 C. channel 37 is better
17	15.07-15.07	19:33:27 – 20:44:15	11328- 12036	11398 - 11984	Sailing ENE at 3.6kn. Wind speed 4 m-s from WSW. Water temp 6.8 C. channel 37 is better (relatively bad signal every third/forth shot). 0,2-0,3m swell. Generally more noise on ch 97 compared to rest
18	15.07-15.07	21:01:03 – 22:01:03	12037-12643	12059 - 12623	Sailing WSW at 3.6kn. Wind speed 5 m-s from WSW. Water temp 6.8 C.

					channel 37 is better (relatively bad signal every third/forth shot). 0,1-0,2m swell. Generally more noise on ch 97 compared to rest. 23:51:47 Serial String not detected! Incomplete data 12541-49
19	15.07 – 15.07	22:21:03-23:23:57	12644 - 13292	12664-13256	Sailing ENE at 4 kn. Wind speed 5.5 m-s from WNW. Water temp 6.9 C. channel 37 is better (relatively bad signal every third/forth shot). 0,1-0,2m swell. Generally more noise on ch 97 compared to rest 00:23:52 (pc time, not UTC) Serial String not detected! Incomplete data on files 12669-77 00:29:59 Serial String not detected! Incomplete data 12735-12742 Channels 37 and 97 deactivated 00:37:59 Serial String not detected!! Incomplete data 12817-12827 00:59:04 Serial String not detected!! Incomplete data 13037-13042
20	15.07-16.07	23:40:45-00:47:57	13293-14024	13352-13998	Sailing WSW at 3.8kn. Wind speed 7 m-s from WNW. Water temp 6.8 C. 0,1-0,26m swell. 01:44:05 Serial String not detected!! Incomplete data 13322-13332 01:44:35 Serial String not detected!! Incomplete data 13337-13345 01:50:59 Serial String not detected!! Incomplete data 13406-13415 01:52:22 Serial String not detected!! Incomplete data 13427-13432 02:37:22 Serial String not detected!! Incomplete data 13880-13885 02:44:55 Serial String not detected!! Incomplete data 13950-13981

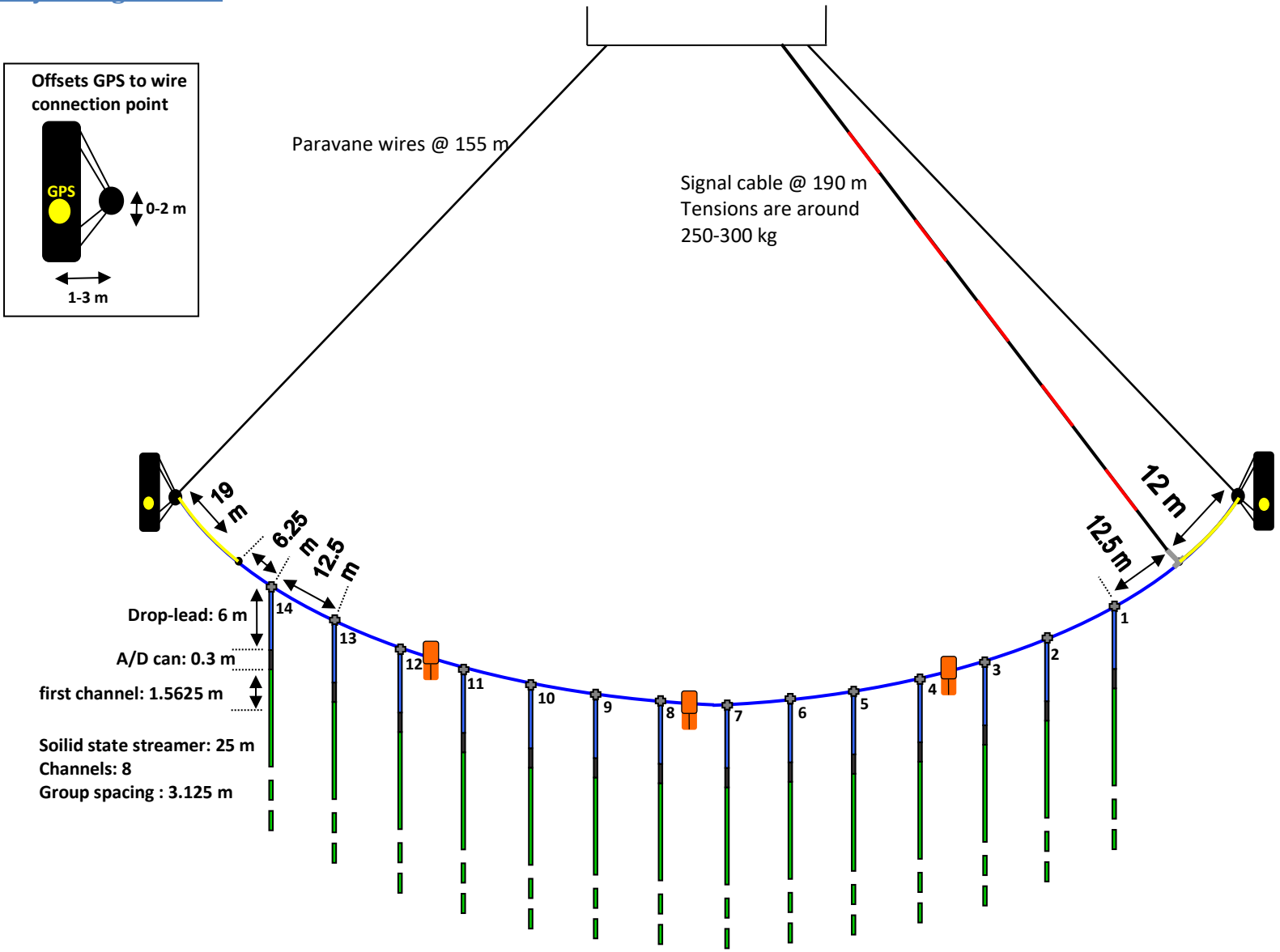
					02:46:47 Serial String not detected!! Incomplete data 14002-14011
21	16.07-16.07	01:06:15-02:06:21	14025-14635	14062-14617	Sailing ENE at 4 kn. Wind speed 6 m-s from WNW. Water temp 6.8 C 0,1-0,2m swell. 03:08:16 Serial String not detected!! Incomplete data 14044-14050 03:26:53 Serial String not detected!! Incomplete data 14232-14239
22	16.07-16.07	02:27:39-03:31:57	14636-15279	14684-15263	Sailing WSW at 3.8 kn. Wind speed 8 m-s from WNW. Water temp 6.8 C. 0,1m swell.
23	16.07-16.07	03:50:33-04:51:57	15280-15894	15311-15858	Sailing ENE at 4 kn. Wind speed 7 m-s from WNW. Water temp 6.2 C 0,1-0,2m swell.
24	16.07-16.07	05:06:51-06:11:20	15895-16540	15939-16503	Sailing WSW at 4 kn. Wind speed 8.5 m-s from WNW. Water temp 6.8 C. 0,1m swell.
25	16.07-16.07	06:29:26-07:34:38	16541-17193	16565-17165	Sailing ENE at 4 kn. Wind speed 7 m-s from WNW. Water temp 6.7. Swell 0.1 m. Starting line 50 m to the left/north.
26	16.07-16.07	07:54:02-08:55:56	17194-17813	17237-17797	Sailing WSW at 4 kn. Wind speed 8.4 m-s from WNW. Water temp 6.9 C. 0.15 m swell.
27	16.07-16.07	09:17:20-10:19:38	17814-18437	17864-18421	Sailing ENE at 4 kn. Wind speed 8 m/s from WNW. Water temp 6.9 C. 0.2m swell. Starting line 10 m to the north of the line
28	16.07-16.07	10:39:02-11:43:32	18438-19083	18476-19070	Sailing WSW at 4 kn. Wind speed 8 m-s from WNW. Water temp 6.9 C. 0.2 m swell.
29	16.07-16.07	12:03:38-13:08:02	19084-19736	19138-19723	Sailing ENE at 4 kn. Wind speed 7 m-s from WNW. Water temp 6.9 C. 0.5 m swell.

					~15:01:10 Serial string not detected. Incomplete data chan. 19657-19668. Check log file.
30	16.07-16.07	13:29:02-14:33:38	19737-20419	19770-20398	Sailing WNW at 4 kn. Wind speed 9.5 m-s from WNW. Water temp 6.9 C. 0.5 m swell. 15:37:11 Serial string not detected. Incomplete data chan. 19818-19826. Check log file. 15:42:20 Serial string not detected. Incomplete data chan. 19874-19879. Check log file. 16:05:51 Serial string not detected. Incomplete data chan. 20111-20120. Check log file. 16:09:21 Serial string not detected. Incomplete data chan. 20155-20160. Check log file. 16:12:09 Serial string not detected. Incomplete data chan. 20188-20193. Check log file. 16:24:16 Serial string not detected. Incomplete data chan. 20312-20319. Check log file. 16:32:26 Serial string not detected. Incomplete data chan. 20398-20407. Check log file.
31	16.07-16.07	14:39:02-15:28:26	204120-20979	204120-20979	Transit line to start of the corridor 16:53:21 Serial string not detected. Incomplete data chan. 20561-20568. Check log file. 16:58:11 Serial string not detected. Incomplete data chan. 20594-20637. Check log file. 16:58:21 Serial string not detected. Incomplete data chan. 20649-20652. Check log file. 17:04:33 Serial string not detected. Incomplete data chan. 20712-20718. Check log file. 17:26:51 Serial string not detected. Incomplete data chan. 20936-20963. Check log file.

32	16.07-16.07	15:37:44-16:48-32	20980-21800	20980-21800	3D corridor for Pingos. Sailing SE at 4 kn. Wind speed 8 m-s from NW. Water temp 6.9 C. 17:47:09 Serial string not detected. Incomplete data chan. 21071-21080. Check log file. 17:49:33 Serial string not detected. Incomplete data chan. 21103-21105. Check log file. ~17:54:00 Serial string not detected. Incomplete data chan. 21140-21179. Check log file. 17:54:52 Serial string not detected. Incomplete data chan. 21185-21193. Check log file. 17:58:14 Serial string not detected. Incomplete data chan. 21223-21230. Check log file. 18:00:00 Serial string not detected. Incomplete data chan. 21248-21256. Check log file. 18:10:33 Serial string not detected. Incomplete data chan. 21359-21366. Check log file. 18:23:15 Serial string not detected. Incomplete data chan. 21491-21498. Check log file. 18:25:23 Serial string not detected. Incomplete data chan. 21530-21540. Check log file. 18:26:09 Serial string not detected. Incomplete data chan. 21551-21556. Check log file. 18:38:57 Serial string not detected. Incomplete data chan. ~21679-21705. Check log file.
33	16.07-16.07	17:05:56-18:11:14	21801-22454	21870-22445	3D corridor for Pingos. Sailing NW at 4 kn. Wind speed 8.5 m-s from NW. Water temp 6.9 C.
34	16.07-16.07	18:33:50-19:38:08	22455-23098	22502-23085	3D corridor for Pingos. Sailing SE at 4 kn. Wind speed 8 m-s from NW. Water temp 6.8 C.
35	16.07-16.07	19:56:50-20:57:38	23099-23707	23129-23694	3D corridor for Pingos. Sailing NW at 4 kn. Wind speed 7.8 m-s from NW. Water temp 6.7 C.
36	16.07-16.07	21:20:38-22:24:50	23708-24352	23767-24349	3D corridor for Pingos. Sailing SE at 4 kn. Wind speed 6.9 m-s from NW. Water temp 6.9 C.

~~End~~

Survey configuration:



Observed spread of paravanes: 168 m
Observed distance between gun and paravanes: 98 – 113 m, deviations between distances to both paravanes up to 5 m

Ship's speed: 4 kn ± 0,3 kn
Gun system: GI (45/45 in^3)
Shooting pressure: ~150-160 bar
Shooting interval: 6 sec
Recording window: 2 sec
Recording delay: 0 sec
Sampling interval: 0.5 ms
Streamer depth: 1.5 m

Switch no	6013	6014	6031	6016	6017	6028	6011	6030	6023	6034	6025	6026	6022	6019
Depth reading on deck after survey (m)														

Yellow: kind of okay
Red: Wrong. Recalibration required

2D seismic line log for CAGE16-6

GUN: 30/30 in3, 33 m behind ship, pressure 165 bar. 6 streamer configuration 8 channels per streamer = 48 channels spaced 3.125m. Streamer is 4 m to the port of the ship, the first channel is ~90 m behind Ship. (THINGS TO NOTE IN COMMENTS: rec length, sampling rate, delay, weather conditions, disabled channels, noise in traces etc.)

Line name	Date	Location	Start (UTC)	Start shot number	Start Lat degree	Start Lat decmin	Start Long degree	Start Long decmin	End (UTC)	End Shot Number	End Lat degree	End Lat decmin	End Long degree	End Long decmin	Shot rate	Ship speed [kn]	Comments
CAGE16-6_001	07.07.2016	Vestnesa	########	794	79	0,450	7	7,933	15:34:06	3160	79	0,379	5	41,391	5s	5kn	Test shots: 0-793. Shooting interval 5 s, recording length 4 s, sampling rate 0.25 ms. Wind 6.52m/s from N. Sea calm. Channels 14, 16 deactivated. Start time not exact
CAGE16-6_002	07.07.2016	Vestnesa	########	3201	78	59,038	5	48,522	18:08:56	4628	79	8,930	6	1,873	5s	5kn	Shooting interval 5 s, recording length 4 s, sampling rate 0.25 ms. Wind 6.7m/s from NNE. A little bit of swell. Channels 14, 16 deactivated
CAGE16-6_003	07.07.2016	Vestnesa	########	4629	79	9,143	6	13,017	20:36:56	5939	79	0,042	6	1,604	5s	5kn	Shooting interval 5 s, recording length 4 s, sampling rate 0.25 ms. Wind 6.7m/s from NNE. A tiny bit of swell. Channels 14, 16 deactivated
CAGE16-6_004	08.07.2016	Vestnesa	########	6166	79	0,407	6	52,360	00:26:56	6391	79	2,373	6	41,529	5s	5kn	Shooting interval 5 s, recording length 4 s, sampling rate 0.25 ms. Wind 3.8 m/s. No shot 4629-6165 are test shots. Disarmed 00:26:56 due to airgun 6385 and to 6391 (one more test),
CAGE16-6_005	08.07.2016	Vestnesa	########	6878	78	59,893	6	54,699	16:56:00	7463	79	3,168	6	37,200	6s	5kn	Usable shots start at 6470 (line 004a) Gun changed to GI, shooting interval 6s. Windspeed 5.7 m/s from NNE. Sea calm, slight swell. Channels 14 and 16 disabled. Preamp gain changed to 8dB. Rec length, sampling rate are still the same.
CAGE16-6_006	08.07.2016	Vestnesa	########	7464	79	0,884	6	39,091	18:10:13	7733	79	2,390	6	48,149	6s	5kn	shooting interval 6s. Windspeed 9 m/s from NNE. Sea calm, slight swell. Channels 14 and 16 disabled. Preamp gain changed to 8dB. Rec length, sampling rate are still the same.
CAGE16-6_007	08.07.2016	Vestnesa	########	7734	79	1,821	6	51,599	18:50:12	7953	79	0,478	6	44,823	6s	5kn	CHAN 24 is spiking. Maybe remove it while processing.
CAGE16-6_008	08.07.2016	Vestnesa	########	7954	79	0,682	6	50,955	20:07:00	8516	79	0,134	6	51,000	6s	5kn	First circle.
CAGE16-6_009	08.07.2016	Vestnesa	########	8517	79	1,156	6	51,086	20:51:24	8937	79	1,100	6	51,109	6s	5kn	Second Circle

CAGE16-6_010	08.07.2016	Vestnesa	########	8938	79	1,440	6	49,587	21:35:18	9313	79	1,411	6	49,768	6s	4kn	Third circle. Boat speed changed to 4 knots
CAGE16-6_011	08.07.2016	Vestnesa	########	9314	79	1,215	6	47,200	22:01:00	9493	79	1,215	6	47,200	6s	4kn	Fourth circle.
CAGE16-6_012	09.07.2016	Molloy Transform	########	9566	79	4,786	3	31,713	02:32:36	11564	78	53,397	4	50,009	7s	5kn	shooting interval at line start: 7 sec; reco.length: 5.5 sec; sampling rate: 0,5 sec; all shots prior to 9566 are test shots; 12 m/s from NNE, ~2m swell. CHAN 24 is making a lot of noise. 11990: CHAN 24 is idsabled. More noise at 12095..
CAGE16-6_013	10.07.2016	Molloy Transform	########	11565	78	54,254	4	48,944	05:31:54	12864	78	43,677	4	8,283	7s	5kn	wind 10 m/s from NNE, 1 - 1,5 m swell; changed to 5 sec rec.length from shot 9732; lot of noise on data.
CAGE16-6_014	10.07.2016	Molloy Transform	########	12864	78	43,661	4	10,780	07:27:03	13687	78	48,364	3	35,192	7s	5kn	Windspeed 10.60 m/s NNE, swell 1-1.5 m, All parameters are the same as previous lines. Warning at 06:08: cycle program. Running again approximately 130 meters later, 5 minutes.
CAGE16-6_015	10.07.2016	Molloy Transform	########	13718	78	47,960	3	36,246	11:08:00	15233	78	58,860	4	18,919	7s	5kn	Windspeed 12.1m/s NNE, swell 1-1.5m. Gun 45cu in harmonic, 160bar pressure. Not on line before shot 13718. Shot 14131 guns pulled back 2 m (towards ship) because they have slipped back.
CAGE16-6_016	17.07.2016	Storfjordrenna-slope-fan-northbound (curved line)	########	15423	76	9,248	15	58,050	19:34:50	25909	77	2,957	11	13,399	6s	5kn	Wind 7-8 m/s NNW, swell 0,5-1 m. GI gun 45/45 cu in3, 160 bar, shooting rate 6 sec, rec.window 2.5 sec. Stratigraphic line from Storfjordrenna to the upper slope and following approx the 1000m isobath northover. All shots before shot number 15423 are warm-up. CH1 with very strong DC bias, disabled. Ship turns towards STB on shot 15728, geometry might be affected. Turn finished and ship straight at approx. shot no. 15780. Ch 16 show relatively more noise compared to rest