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R/V Helmer Hanssen
29-06-19 to 08-07-19
Longyearbyen – Longyearbyen

CAGE-19-1Cruise Report

Passive and active ocean-bottom seismic surveys at Vestnesa Ridge, west-Svalbard margin within the framework of the SEAMSTRESS project

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With contributions by cruise participants

DOI:

Key words: gas hydrates, chimney, fluid flow, Vestnesa, OBS

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Table of Contents

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INTRODUCTION AND OBJECTIVES

Cruise CAGE19-1 with UiT's research vessel R/V Helmer Hanssen is the 1st of several cruises in 2019 that is carried out to collect cross-disciplinary data for addressing the objectives of the SEAMSTRESS project (Tectonic stress effects on Arctic methane seepage) and the Norwegian Centre of Excellence for Arctic Gas Hydrate, Environment and Climate, CAGE.

The overall goal of cruise CAGE19-1 is to conduct a large-scale ocean-bottom seismic experiment on the eastern segment of the Vestnesa Ridge (Figure 1). Other data that will be acquired on this cruise are multibeam and water column hydro-acoustic data. The ocean-bottom seismic experiment is designed to better understand the internal structure of a chimney that actively seeps gas into the water column, and to deploy long-term ocean-bottom seismic stations to monitor microseismic activity along the Vestnesa Ridge. In the first experiment, a dense network of 23 ocean-bottom seismometers (OBS) will be deployed over the Lunde pockmark. Seismic shooting over these OBS will provide data for a tomographic inversion of travel times in order to obtain the velocity structure of the chimney beneath the Lunde pockmark. In the second experiment, 7 OBS will be deployed long-term until summer 2020 and measure seismic events related to the tectonics and seepage from the pockmarks on along the eastern segment of Vestnesa Ridge

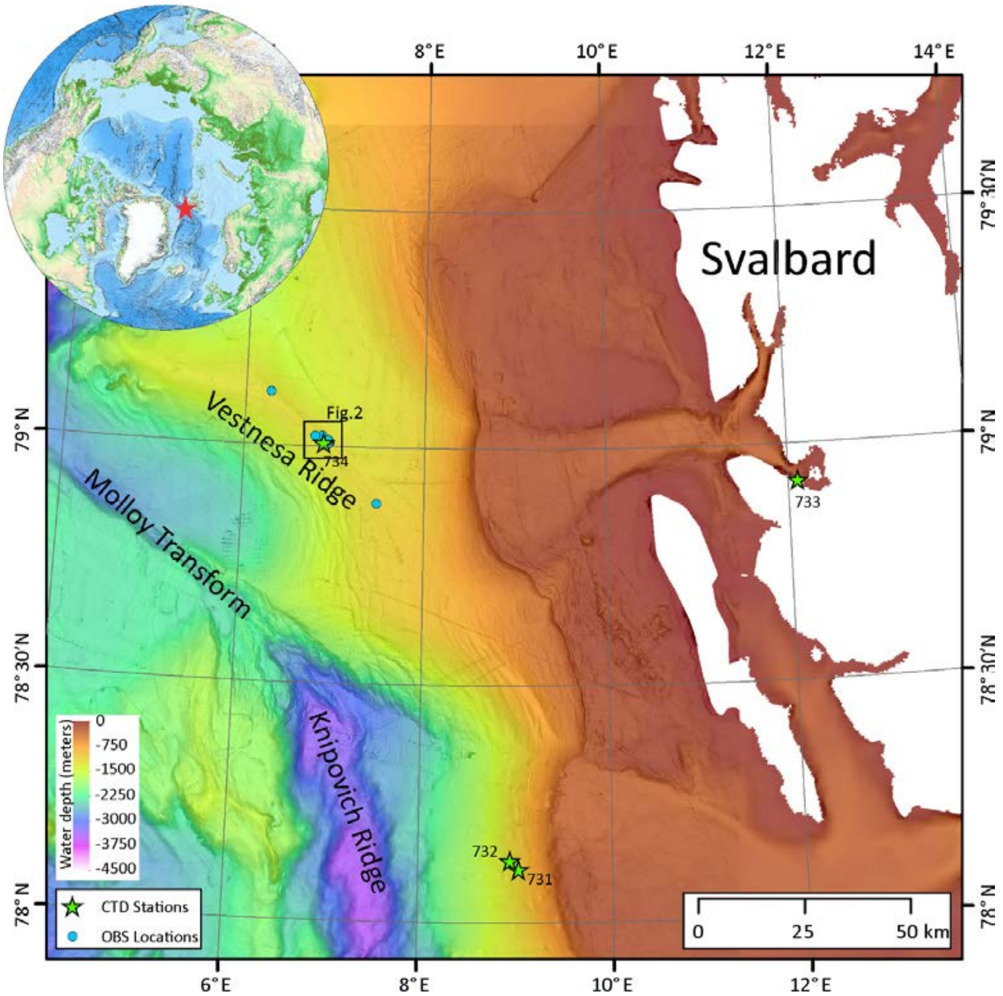

Figure 1: Location of the study area on the W-Svalbard margin showing also some of the locations where long-term OBS were deployed for recording microseismic activity.

METHODS

Seismic methods

The high-resolution P-Cable 3D seismic system was used together with a Granzow high-pressure (210bar) compressor and mini-GI or GI guns. 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 SIMRAD EM302 high-resolution multibeam system. The EM302 provides excellent seabed resolution with a 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 2). 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. 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 4 streamer sections for a 100 m long active hydrophone cable with 32 channels at a receiver spacing of 3,25 m. The lead-in cable to the active streamer had a length of 70 m behind the ship. The streamer cable was towed at a depth of approximately 2 m.

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.

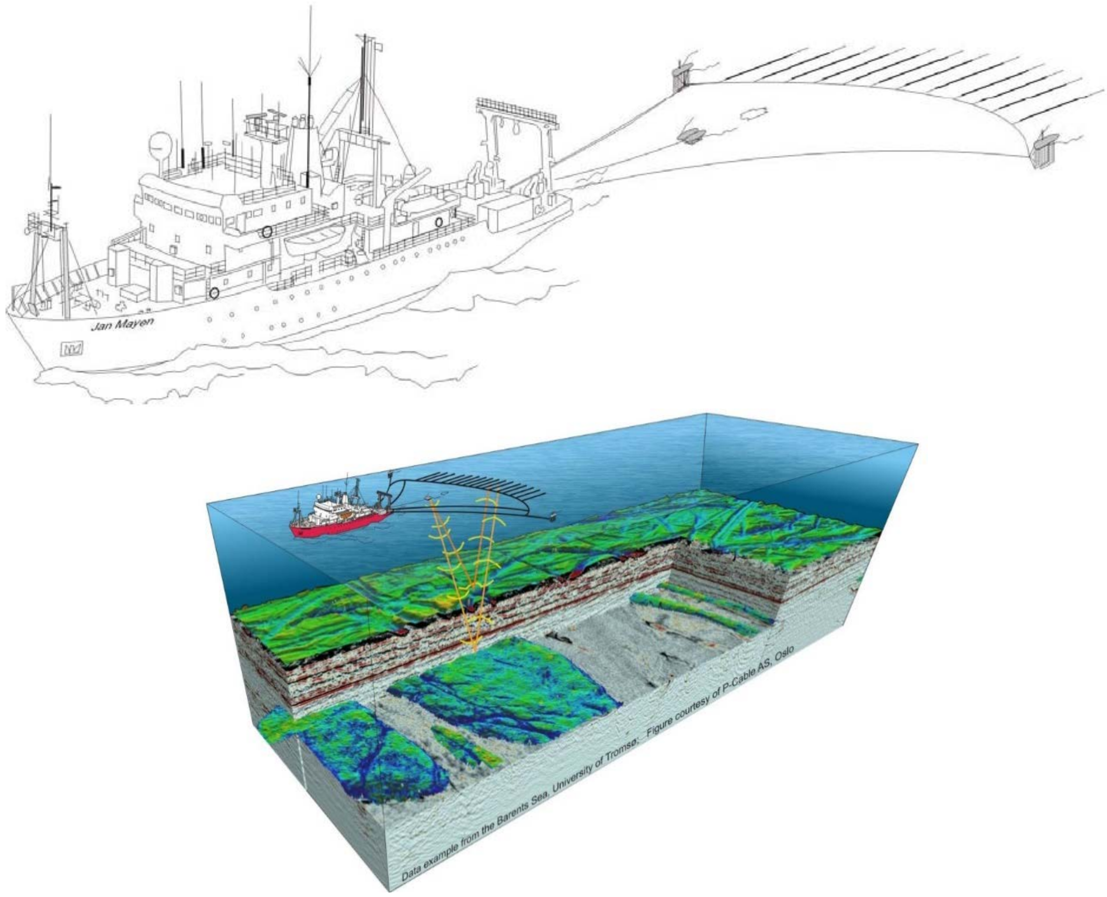

Figure 2: Schematic sketch an acquisition principle of the P-Cable high-resolution 3D seismic system.

Multi-component ocean bottom seismometer (OBS)

Multi-component Ocean Bottom Seismometer (OBS) were deployed to (1) record compressional and shear waves in an active source experiment, and (2) record microseismic activity during a year-long deployment.
The OBS systems used represent two design types that serve the same purpose (Figure 3). 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.

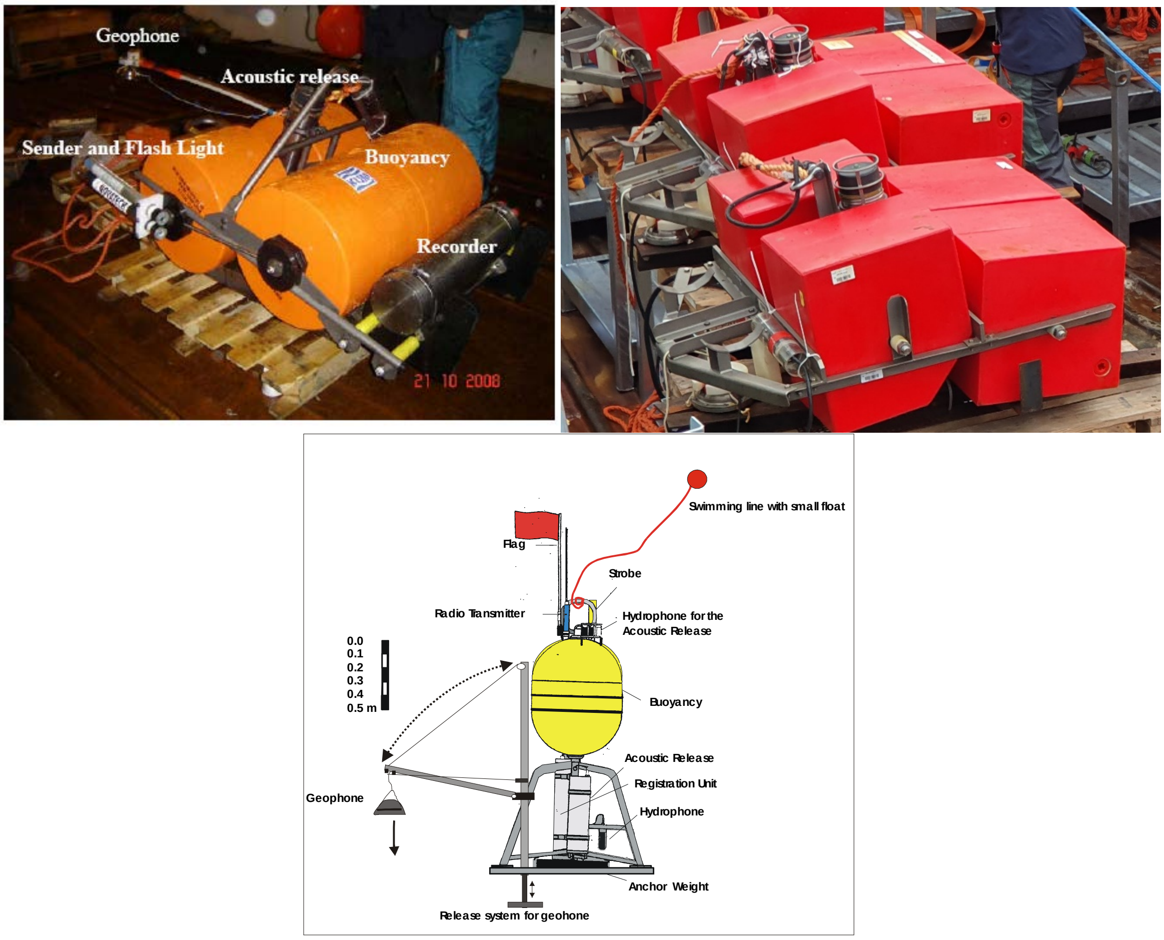

Figure 3: The old (bottom) and the new Ocean Bottom Seismometer (OBS) system from UiT (top left) and Geomar (top right).

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 at Svalbard was very poor in the beginning of the cruise and delayed the start of the experiments by 2-3 days. After that, weather conditions were mostly very good with sea state and wave heights below 1 m. Air temperatures were between 1 °C and 8 °C. We started to prepare the cruise in Longyearbyen on June 29 with assembly of the equipment.

Saturday, 29.06.2019
The scientific personnel arrived by flight at 01:00 early in the morning. We started to prepare lab areas and to assemble the equipment after breakfast. The preparation of 23 OBS systems and the seismic source and streamer systems constitutes a significant amount of work that will take some time.

Sunday, 30.06.2019
Assembly of the seismic equipment continued. Weather forecast for the working area are poor predicting wave heights of about 3 m over the next days. Due to a sick crew member, a substitute was supposed to arrive at 01:00 but missed his flight in Oslo, which further delayed our departure from Longyearbyen. The engineer arrived at 14:00 and we finally left Longyearbyen for our working area on the Vestnesa Ridge. A light storm lingered on the horizon and we only went briefly into the deep water for a test of all acoustic release systems which were mounted in two batches on the CTD frame. After that we went into Kongsfjord to wait out the storm.

Monday, 01.07.2019
Within Kongsfjorden we had time to test and calibrate the USBL system that we intended to use for OBS deployment. Meanwhile, we continued to set up OBS systems. Weather outside the fjord shelter is still very bad and would not allow us to work.

Tuesday, 02.07.2019

We continued to prepare experiments. Weather forecasts in the afternoon predict calmer conditions for the next days in the working area on Vestnesa Ridge. We leave Kongsfjorden in the evening to sail out to the working area overnight.

Wednesday, 03.07.2019
We arrived at Vestnesa early in the morning. With 23 OBS, we had to organize the onboard space and organize deployment. We conducted a CTD stationat 15:00 to calibrate acoustic systems. At 18:00 we start to deploy OBS on a wire with releaser and USBL transponder. Unfortunately, the work with the USBL release system to deploy OBS on planned positions did not work out well. The ship cannot hold position well enough but worse is that the OBS on the wire with USBL and acoustic release is too light and quickly drifts off. After three tries, we gave up deployment using USBL and deploy OBS directly from the ship. OBS 7 is deployed shortly before midnight.

Thursday, 04.07.2019
The last OBS 23 has been deployed shortly before 05:00 early morning. Due to the weather downtime, we do not have enough time left to conduct a 3D seismic survey across OBS stations. Therefore, we set out a line plan for 50 2D seismic lines. Due to problems with one of the mini-GI guns, shooting did not start before 12:20 and guns even had to recovered again after the first line, when he decided to only shoot the survey with one mini-GI at 30/30 cu.in. FTB signals showing error as well so Geoeel source output is sent as trigger capture for OBS. Starting shooting with one gun (30/30). Shot rate at 5 sec. Record length 3 sec, sampling interval 0.25ms. Seismic line 9 is finished shortly before the end of the day.

Friday, 05.07.2019
Seismic shooting continued in very good weather conditions.

Saturday, 06.07.2019
The last 2D seismic line no. 50 was completed at 12:00. We immediately started to recover OBS systems. As weather conditions were excellent with almost no waves, the working boat was put to sea to snatch OBS at the sea surface, tow them to the ship and hook them into the crane. As we were able to release 3-4 OBS simultaneously, the whole recovery operation only lasted about 5 hours. At 23:00 we started to shoot 6 2D seismic reconnaissance lines as many OBS were disassembled and 7 of them prepared for a long-term deployment.

Sunday, 07.07.2019
6 2D reconnaissance seismic lines were completed at about 13:00. Shortly after we started to deploy long-term OBS stations, each one of those were followed by 2 short crossing lines with only the airgun deployed. Those shots are important to later relocate the exact OBS position at the ocean floor.

Monday, 08.07.2019
The 7th OBS was deployed shortly before 03:00 and the last shot line finished at 04:00. All work completed and heading back to Longyearbyen. Arrival in Longyearbyen at 12:00. Demobilizing.

Preliminary results

OBS deployments at Vestnesa Ridge

23 OBS were prepared and deployed over the Lunde pockmark, an actively gas-seeping structure on the eastern segment of the Vestnesa Ridge (Figure 4 and 5). The OBS array was designed to provide arrival times for a tomographic analysis of P- and S-wave velocities and for analysis of shear-wave splitting and anisotropy. Source signals were provided by a mini-GI airgun on 50 2D seismic acquisition lines (Figure 6).

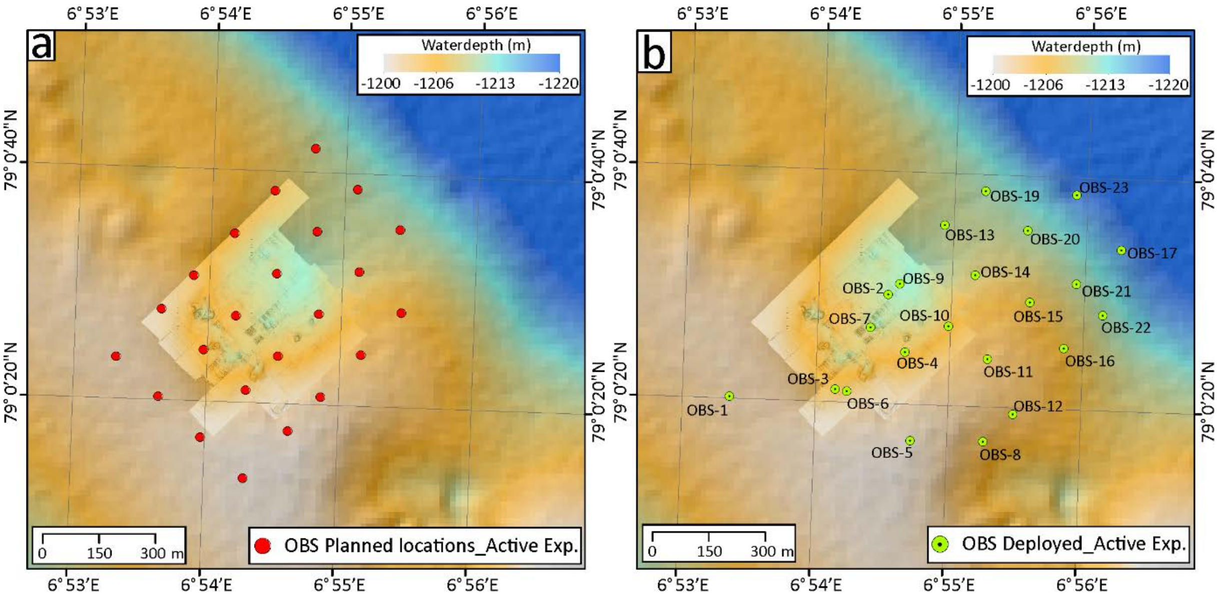

Figure 4: Overview map showing the planned (left) and actual drop positions for 23 OBS deployed over the Lunde pockmark at Vestnesa Ridge for an active source experiment. Drop locations were planned to be ca 200 m off to the SE due as NW bound currents would take them towards their intended position.

Figure 5: top left: OBS spread out over the Helmer Hanssen deck; bottom left: weather conditions allowed to use the working boat to snatch OBS from the water and tow them to the ship; right: OBS on the hook of the crane being recovered.

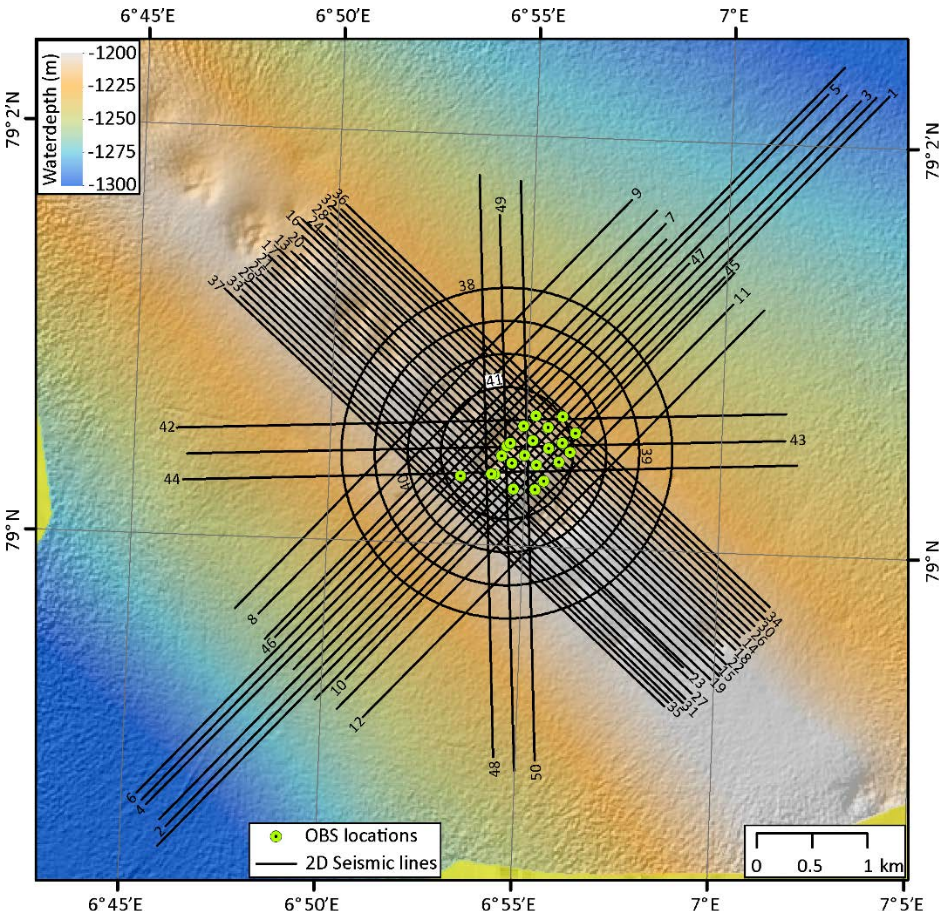

Figure 6: 50 2D seismic lines were acquired across the OBS array to provide active sources for the tomographic experiment.

Following the active source experiment, 7 of the OBS were prepared for long-term deployment in order to record microseismic activity related to tectonics and seepage. The 7 OBS were deployed along the actively-seeping, eastern segment of the Vestnesa Ridge, with 5 of those close to the active pockmarks and the 2 others offset at the end of the ridge segment (Figure 7). OBS will be recovered during a cruise in 2020. Short crossing lines with the airgun system were conducted across the OBS station in order to provide seismic sources with exact position for relocation of OBS systems.

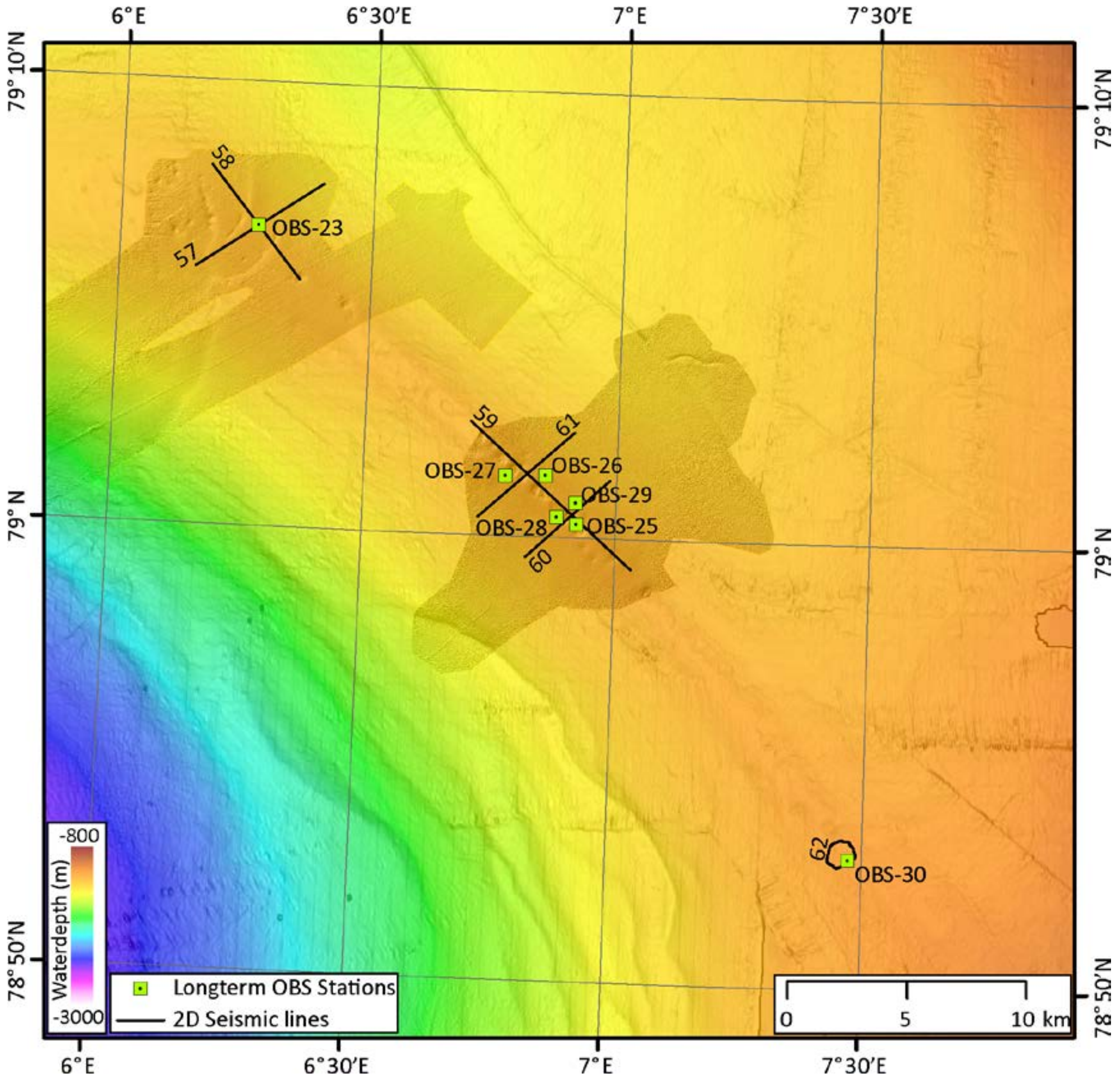

Figure 7: Locations of the 7 long-term OBS stations. Short shot lines were run across the OBS in order to allow exact relocation of the OBS systems.

2D seismic acquisition at Vestnesa Ridge

Six 2D seismic lines were acquired on the Vestnesa Ridge on the western Svalbard Margin (Figure 8) in order to acquire site survey data for an IODP proposal and to fill in gaps in seismic coverage and more closely investigate the cause of sliding on the southern flank of the Vestnesa

Ridge. The multi-channel seismic streamer was configured with 4- 25 m long Geoeel solid state sections, providing a total of 32 channels with 3,125 m receiver group spacing. For a detailed list of survey parameters and survey configuration, refer to the Table and Figure below (Table 1, Figure 9).

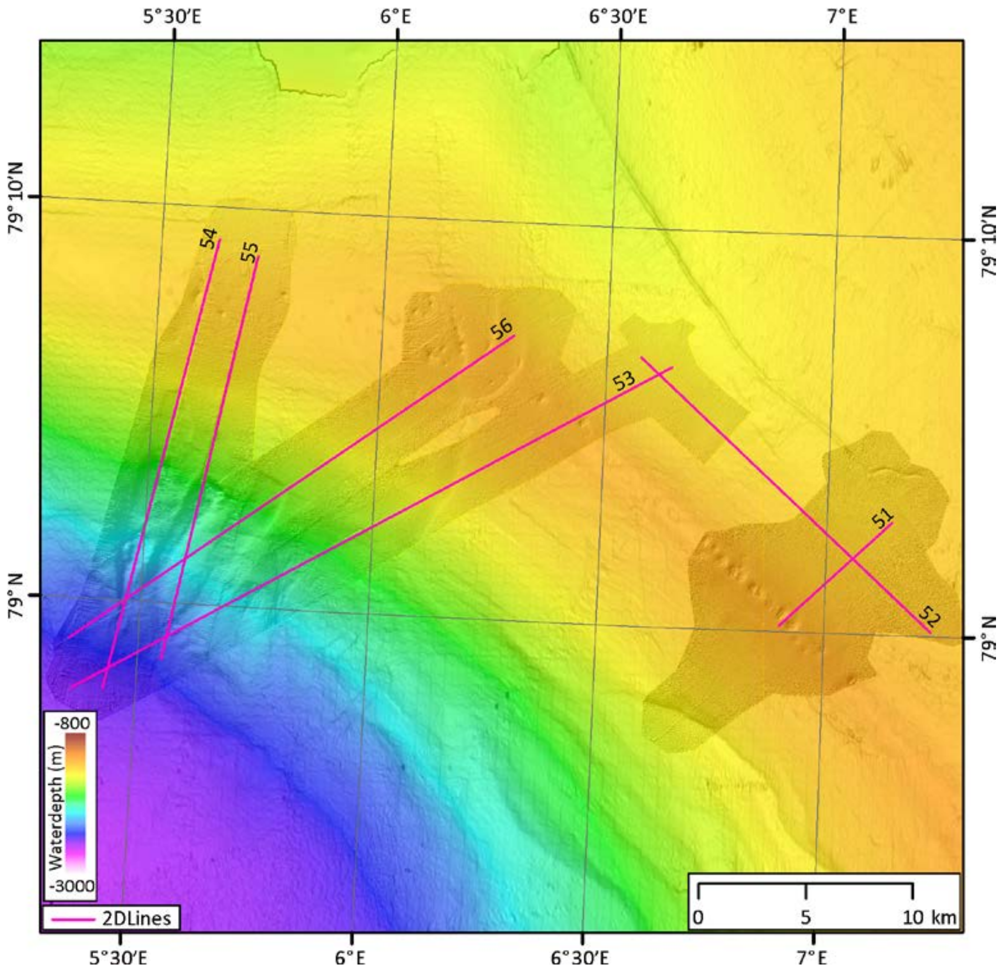

Figure 8: Overview of 2D seismic data acquired during cruise CAGE19-1.

Table 1: The detailed survey parameters for this survey are given in the table below:

Survey parameters	
Deployment / recovery	0,5 h
Survey speed	5 kt
Turn time	-
Source	1 mini GI 30/30 in^3
Shooting rate	5 s
Shooting pressure	170 bar
Source towing depth	2 m
Dominant frequency (bandwidth)	100-150 Hz (20-400 Hz)

Positioning	GPS transponder on gun raft
Streamer length	100 m
Active section	-
Number of channels	32
Receiver group spacing	3.125 m
Streamer towing depth	2-3 m
Sampling rate / interval	4000 Hz / 0.25 ms
Recording length	3-4 s

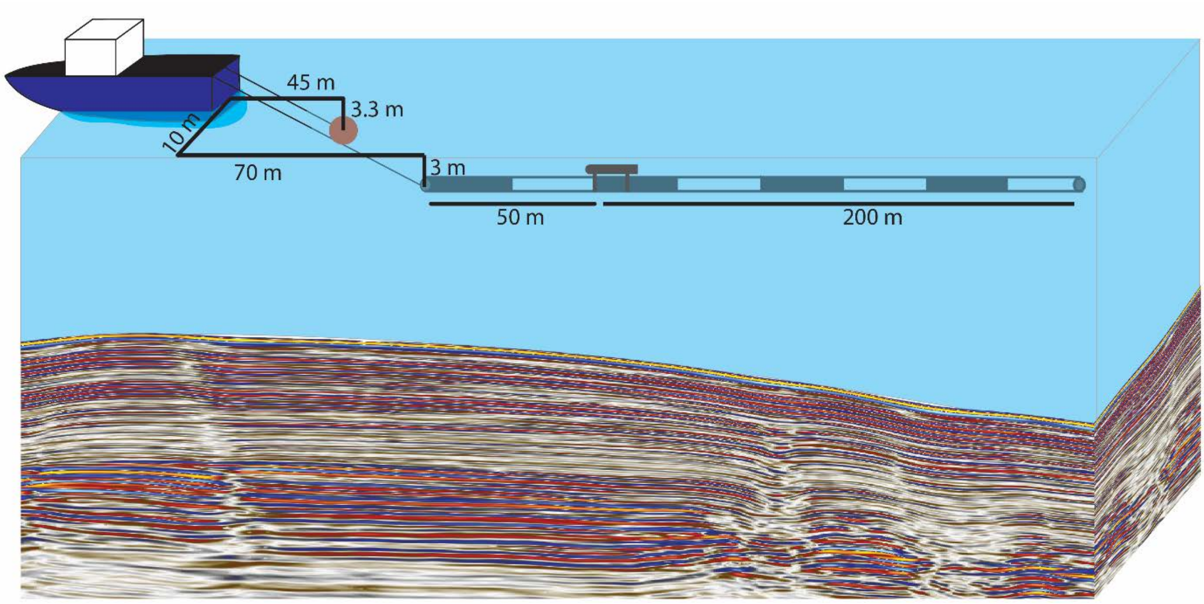

Figure 9: Acquisition geometry of the 2D multi-channel seismic streamer. Notice that in this cruise we used only 4 streamer. Hence, the active section was 100 m instead of 200 m.

The raw data was processed using the RadexPro Professional 2019.1 software. The 2D seismic lines were binned to 3.125 m. This binning generated a nominal fold of ca. 8-12 traces. The seismic processing flow consists sequentially of: geometry assignment (after processing navigation files using Python code) initial filtering to improve signal-to-noise ratio and spherical divergence correction (band pass, burst, f-k), de-ghosting (alternative), f-x (alternative) NMO correction, stacking and Stolt or Kirchhoff migration. Onboard processing will be refined post-cruise.

ACKNOWLEDGEMENT

We thank the captain and his crew of R/V Helmer Hanssen of UiT the Arctic University of Norway for their excellent support during the scientific surveys. This 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 and the SEAMSTRESS project (Tectonic stress effects on Arctic methane seepage) supported by the Tromsø Research Foundation (TFS) and the Research Council of Norway (RCN-Frinatek) through two starting grants awarded to Andreia Plaza-Faverola.

APPENDIX

2D seismic log CAGE19-1

Line Id	Date (UTC)	Time (UTC)	Start Shot	Latitude		Longitude		End Time (UTC)	End Shot	Latitude (end)		Longitude (end)	
CAGE19-1-HH-001-2D	04.07.2019	10:21:00	733	79 02.256	N	07 3.986	E	11:23:00	1483	78 58.4809	N	6 45.9734	E
CAGE19-1-HH-002-2D	04.07.2019	12:46:00	1528	79 58.577	N	06 46.168	E	13:44:00	2233	79 02.236	N	07 03.819	E
CAGE19-1-HH-003-2D	04.07.2019	14:02:00	2245	79 02.231	N	07 03.258	E	15:00:00	2946	78 58.609	N	06 46.004	E
CAGE19-1-HH-004-2D	04.07.2019	15:11:00	2947	78 58.680	N	06 45.649	E	16:08:00	3629	79 02.257	N	07 02.887	E
CAGE19-1-HH-005-2D	04.07.2019	16:26:00	3630	79 02.257	N	07 02.421	E	17:22:00	4303	78 58.700	N	06 45.527	E
CAGE19-1-HH-006-2D	04.07.2019	17:35:00	4304	78 58.737	N	06 45.397	E	18:35:00	5010	79 02.391	N	07 02.823	E
CAGE19-1-HH-007-2D	04.07.2019	19:27:00	5011	79 01.60	N	06 58.37	E	20:01:00	5421	78 59.508	N	06 48.521	E
CAGE19-1-HH-008-2D	04.07.2019	20:19:00	5422	78 59.63	N	06 48.33	E	20:50:00	5804	79 01.663	N	06 58.132	E
CAGE19-1-HH-009-2D	04.07.2019	21:05:00	5805	79 01.7104	N	06 57.4843	E	21:38:00	6197	78 59.6534	N	06 47.7281	E
CAGE19-1-HH-010-2D	04.07.2019	21:55:00	6198	78 59.3281	N	06 50.6097	E	22:28:00	6597	79 01.3700	N	07 00.1659	E
CAGE19-1-HH-011-2D	04.07.2019	22:40:00	6598	79 01.2180	N	07 00.1722	E	23:13:00	6991	78 59.1812	N	06 50.4162	E
CAGE19-1-HH-012-2D	04.07.2019	23:28:00	6992	78 59.1451	N	06 51.0827	E	00:01:00	7397	79 01.1931	N	07 00.9584	E
CAGE19-1-HH-013-2D	05.07.2019	00:40:00	7398	78 59.464	N	07 00.292	E	01:14:00	7810	79 01.400	N	06 48.817	E
CAGE19-1-HH-014-2D	05.07.2019	01:27:00	7818	78 59.464	N	07 00.291	E	02:04:00	8247	78 59.599	N	07 00.626	E
CAGE19-1-HH-015-2D	05.07.2019	02:20:00	7398	78 59.464	N	07 00.291	E	02:54:00	8662	79 01.406	N	06 48.515	E
CAGE19-1-HH-016-2D	05.07.2019	03:06:00	8663	79 01.535	N	06 48.998	E	03:41:00	9075	78 59.558	N	07 00.636	E
CAGE19-1-HH-017-2D	05.07.2019	03:54:00	9076	78 59.405	N	07 00.130	E	04:29:00	9490	79 01.377	N	06 48.482	E
CAGE19-1-HH-018-2D	05.07.2019	04:41:00	9491	79 01.479	N	06 49.075	E	05:16:00	9903	78 59.537	N	07 00.522	E
CAGE19-1-HH-019-2D	05.07.2019	05:29:00	9904	78 59.387	N	06 59.915	E	06:02:00	10311	79 01.377	N	06 48.231	E
CAGE19-1-HH-020-2D	05.07.2019	06:15:00	10312	79 01.428	N	6 49.110	E	06:49:00	10709	78 59.552	N	7 00.191	E
CAGE19-1-HH-021-2D	05.07.2019	07:05:00	10710	78 59.414	N	06 59.481	E	07:38:00	11106	79 01.317	N	6 48.348	E
CAGE19-1-HH-022-2D	05.07.2019	07:55:00	11107	79 01.387	N	06 49.060	E	08:28:00	11512	78 59.51	N	7 00.207	E
CAGE19-1-HH-023-2D	05.07.2019	08:47:00	11513	78 59.444	N	06 59.194	E	09:19:00	11900	79 01.301	N	6 48.242	E
CAGE19-1-HH-024-2D	05.07.2019	09:38:00	11901	79 01.503	N	06 49.534	E	10:11:00	12298	78 59.618	N	7 00.730	E
CAGE19-1-HH-025-2D	05.07.2019	10:28:00	12299	78 59.3905	N	06 59.3396	E	11:03:00	12716	79 01.281	N	6 48.102	E
CAGE19-1-HH-026-2D	05.07.2019	11:23:00	12717	79 01.528	N	6 49.688	E	11:57:00	13117	78 59.634	N	07 00.879	E
CAGE19-1-HH-027-2D	05.07.2019	12:10:00	13118	78 59.315	N	06 59.454	E	12:43:00	13528	79 01.266	N	06 47.964	E
CAGE19-1-HH-028-2D	05.07.2019	13:04:00	13529	79 01.572	N	06 49.680	E	13:37:00	13926	78 59.656	N	07 00.983	E
CAGE19-1-HH-029-2D	05.07.2019	13:51:00	13927	78 59.289	N	06 59.295	E	14:26:00	14336	79 01.246	N	06 47.833	E

CAGE19-1-HH-030-2D	05.07.2019	14:48:00	14337	79 01.594	N	06 49.797	E	15:22:00	14751	78 59.684	N	07 01.073	E
CAGE19-1-HH-031-2D	05.07.2019	15:36:00	14752	78 59.269	N	06 59.235	E	16:11:00	15180	79 01.240	N	06 47.665	E
CAGE19-1-HH-032-2D	05.07.2019	16:31:00	15181	79 01.623	N	06 49.839	E	17:06:00	15606	78 59.690	N	07 01.244	E
CAGE19-1-HH-033-2D	05.07.2019	17:21:00	15607	78 59.278	N	06 58.949	E	17:57:00	16035	79 01.205	N	06 47.606	E
CAGE19-1-HH-034-2D	05.07.2019	18:21:00	16036	79 01.615	N	6 50.060	E	18:54:00	16439	78 59.729	N	07 01.251	E
CAGE19-1-HH-035-2D	05.07.2019	19:14:00	16440	78 59.269	N	6 58.860	E	19:48:00	16843	79 01.172	N	06 47.568	E
CAGE19-1-HH-036-2D	05.07.2019	20:12:00	16844	79 01.639	N	06 50.174	E	20:46:00	17248	78 59.751	N	07 01.356	E
CAGE19-1-HH-037-2D	05.07.2019	21:05:00	17249	78 59.250	N	06 58.762	E	21:39:00	17660	79 01.207	N	06 47.151	E
CAGE19-1-HH-038-2D	05.07.2019	21:56:00	17661	79 01.193	N	06 52.413	E	23:03:00	18465	79 01.24	N	06 54.191	E
CAGE19-1-HH-039-2D	05.07.2019	23:11:00	18466	79 01.016	N	06 56.265	E	00:07:00	19138	79 00.963	N	06 56.497	E
CAGE19-1-HH-040-2D	06.07.2019	00:15:00	19139	79 00.505	N	06 57.009	E	01:07:00	19762	79 00.429	N	06 56.938	E
CAGE19-1-HH-041-2D	06.07.2019	01:22:00	19763	79 00.183	N	06 53.906	E	02:01:00	20238	79 00.242	N	06 53.658	E
CAGE19-1-HH-042-2D	06.07.2019	02:39:00	20239	79 00.522	N	06 46.065	E	03:13:00	20644	79 00.692	N	07 01.610	E
CAGE19-1-HH-043-2D	06.07.2019	03:32:00	20645	79 00.562	N	07 01.611	E	04:05:00	21042	79 00.397	N	06 46.350	E
CAGE19-1-HH-044-2D	06.07.2019	04:23:00	21043	79 00.269	N	06 46.275	E	04:57:00	21462	79 00.445	N	07 01.931	E
CAGE19-1-HH-045-2D	06.07.2019	05:20:00	21463	79 01.349	N	06 59.914	E	05:56:00	21888	78 59.222	N	06 49.848	E
CAGE19-1-HH-046-2D	06.07.2019	06:12:00	21889	78 59.520	N	06 48.779	E	06:43:00	22269	79 01.524	N	6 58.397	E
CAGE19-1-HH-047-2D	06.07.2019	06:56:00	22270	79 01.423	N	06 58.916	E	07:29:00	22667	78 59.366	N	06 49.286	E
CAGE19-1-HH-048-2D	06.07.2019	07:54:00	22668	78 58.973	N	06 54.441	E	08:27:00	23066	79 01.805	N	06 53.568	E
CAGE19-1-HH-049-2D	06.07.2019	08:44:00	23067	79 01.613	N	06 54.119	E	09:17:00	23461	78 58.908	N	06 54.991	E
CAGE19-1-HH-050-2D	06.07.2019	09:32:00	23462	78 58.963	N	06 55.498	E	10:05:00	23874	79 01.784	N	6 54.621	E
CAGE19-1-HH-051-2D	06.07.2019	20:53:00	24096	79 0.1717	N	06 54.1109	E	21:39:00	24646	79 02.839	N	07 08.593	E
CAGE19-1-HH-052-2D	06.07.2019	22:42:00	24652	79 00.12	N	07 14.09	E	00:41:00	26081	79 06.765	N	06 34.542	E
CAGE19-1-HH-053-2D	07.07.2019	01:07:00	26082	79 06.551	N	06 38.646	E	04:32:00	28542	78 57.758	N	05 21.635	E
CAGE19-1-HH-054-2D	07.07.2019	04:49:00	28543	78 57.792	N	05 25.689	E	07:01:00	30127	79 09.202	N	05 37.637	E
CAGE19-1-HH-055-2D	07.07.2019	08:38:00	30224	79 08.827	N	05 42.894	E	10:41:00	31681	78 58.593	N	05 33.07	E
CAGE19-1-HH-056-2D	07.07.2019	11:20:00	31682	78 58.989	N	05 20.807	E	13:50:00	33481	79 07.172	N	06 17.480	E
CAGE19-1-HH-057-2D	07.07.2019	15:30:00	33515	79 07.753	N	6 23.8756	E	16:12:00	34013	79 05.8031	N	06 09.1044	E
CAGE19-1-HH-058-2D	07.07.2019	16:44:00	34014	79 08.08997	N	06 10.4481	E	17:26:00	34511	79 05.5798	N	06 21.5525	E
CAGE19-1-HH-059-2D	07.07.2019	20:35:00		79 02.557	N	06 42.552	E	21:31:00		78 59.336	N	07 01.947	E
CAGE19-1-HH-060-2D	07.07.2019	22:05:00		79 01.32	N	06 59.2	E	22:35:00		78 59.546	N	06 49.460	E
CAGE19-1-HH-061-2D	07.07.2019	22:55:00		79 00.423	N	06 43.723	E	23:29:00		79 02.378	N	6 54.800	E
CAGE19-1-HH-062-2D	08.07.2019	01:14:00		78 52.864	N	07 28.278	E	01:44:00		78 52.226	N	7 29.011	E

OBS deployments

Station Id	Date (UTC)	Time (UTC)	Latitude		Longitude		Water Depth [m]	Notes
CAGE19-1-HH-OBS1-OBSdeployment	03.07.2019	17:02	79 00.336	N	6 53.354	E	1204	
CAGE19-1-HH-OBS6-OBSdeployment	03.07.2019	21:36	79 00.349	N	6 54.236	E	1204	
CAGE19-1-HH-OBS2-OBSdeployment	03.07.2019	18:39	79 00.490	N	6 54.521	E	1216	
CAGE19-1-HH-OBS5-OBSdeployment	03.07.2019	21:27	79 00.281	N	6 54.725	E	1202	
CAGE19-1-HH-OBS3-OBSdeployment	03.07.2019	19:58	79 00.351	N	6 54.146	E	1204	
CAGE19-1-HH-OBS7-OBSdeployment	03.07.2019	21:48	79 00.442	N	6 54.395	E	1209	
CAGE19-1-HH-OBS4-OBSdeployment	03.07.2019	20:30	79 00.408	N	6 54.664	E	1208	
CAGE19-1-HH-OBS8-OBSdeployment	03.07.2019	21:59	79 00.284	N	6 55.272	E	1205	
CAGE19-1-HH-OBS9-OBSdeployment	03.07.2019	22:59	79 00.506	N	6 54.605	E	1213	
CAGE19-1-HH-OBS10-OBSdeployment	03.07.2019	23:59	79 00.447	N	6 54.980	E	1208	
CAGE19-1-HH-OBS11-OBSdeployment	03.07.2019	00:59	79 00.402	N	6 55.284	E	1210	
CAGE19-1-HH-OBS12-OBSdeployment	03.07.2019	01:59	79 00.324	N	6 55.490	E	1205	
CAGE19-1-HH-OBS13-OBSdeployment	03.07.2019	02:59	79 00.592	N	6 54.930	E	1211	
CAGE19-1-HH-OBS14-OBSdeployment	03.07.2019	03:59	79 00.522	N	6 55.172	E	1208	
CAGE19-1-HH-OBS15-OBSdeployment	04.07.2019	04:59	79 00.485	N	6 55.588	E	1207	
CAGE19-1-HH-OBS16-OBSdeployment	04.07.2019	05:59	79 00.421	N	6 55.854	E	1212	
CAGE19-1-HH-OBS19-OBSdeployment	04.07.2019	01:15	79 00.643	N	6 55.230	E	1211	
CAGE19-1-HH-OBS20-OBSdeployment	04.07.2019	01:48	79 00.588	N	6 55.553	E	1210	
CAGE19-1-HH-OBS21-OBSdeployment	04.07.2019	02:12	79 00.514	N	6 55.934	E	1210	
CAGE19-1-HH-OBS22-OBSdeployment	04.07.2019	02:32	79 00.470	N	6 56.140	E	1211	
CAGE19-1-HH-OBS23-OBSdeployment	04.07.2019	02:40	79 00.642	N	6 55.912	E	1218	
CAGE19-1-HH-OBS17-OBSdeployment	04.07.2019	02:47	79 00.565	N	6 56.261	E	1216	
CAGE19-1-HH-OBS24-OBSdeployment	07.07.2019	14:46	79 06.772	N	06 16.310	E	1234	Long-term OBS
CAGE19-1-HH-OBS25-OBSdeployment	07.07.2019	18:49	79 00.315	N	6 55.327	E	1204	Long-term OBS
CAGE19-1-HH-OBS26-OBSdeployment	07.07.2019	19:26	79 01.406	N	6 51.513	E	1224	Long-term OBS

CAGE19-1-HH-OBS27-OBSdeployment	07.07.2019	19:39	79 01.361	N	6 46.786	E	1206	Long-term OBS
CAGE19-1-HH-OBS28-OBSdeployment	07.07.2019	19:00	79 00.474	N	6 53.013	E	1202	Long-term OBS
CAGE19-1-HH-OBS29-OBSdeployment	07.07.2019	19:11	79 00.796	N	6 55.197	E	1220	Long-term OBS
CAGE19-1-HH-OBS30-OBSdeployment	08.07.2019	00:53	78 52.934	N	7 28.374	E	1130	Long-term OBS

CTD stations

Ship Station	**Station Id**	**Date (UTC)**	**Time (UTC)**	**Latitude**		**Longitude**		**Water Depth [m]**	**Notes**
731	CAGE19-1-HH-731-CTD	30.06.2019	21:42	78 06.811165'	N	9 01.901609'	E	1080	10 KUMQuat releaser on rosette for testing
732	CAGE19-1-HH-732-CTD	30.06.2019	23:18	78 07.925782'	N	8 56.527838'	E	1166	9 KUMQuat releaser on rosette for testing
733	CAGE19-1-HH-733-CTD	01.07.2019	14:34	78 55.36991'	N	12 06.368876'	E	134	Calibration of USBL system
734	CAGE19-1-HH-734-CTD	03.07.2019	15:49	79 00.474	N	6 52.761	E	1187	Calibration of USBL system and multibeam