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CRUISE REPORT

Marine Geological Cruise to Storfjordrenna, Bjørnøyrenna and Thor Iversenbanken

R/V Helmer Hanssen 11th July – 23rd July, 2015

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N-9037 Tromsø, Norway

1. Introduction and scientific objectives

The cruise was a part of the Centre of Excellence for Gas Hydrate, Environment and Climate (CAGE) at UiT - The Arctic University of Norway.

The cruise aimed at investigating areas with gas venting from the seabed in central Bjørnøyrenna and outer Storfjordrenna, as well as subglacial meltwater systems in Thor Iversenbanken, central Barents Sea. More specific objectives were:

- Acquisiton of a P-cable 3D seismic survey over part of a large crater and pingo field in central Bjørnøyrenna
- Sampling gas in water, sediments and air in areas of gas venting within the crater and pingo field
- Acquisiton of gravity cores for identification of palaeo-subglacial lakes in Thor Iversenbanken
- Acquisiton of 2D seismic across subglacial meltwater systems in Thor Iversenbanken
- Acqusition of 2D seismic across pingos identified in Storfjordrenna
- Sampling of gas in air in the area where pingos have been identified in Storfjordrenna.

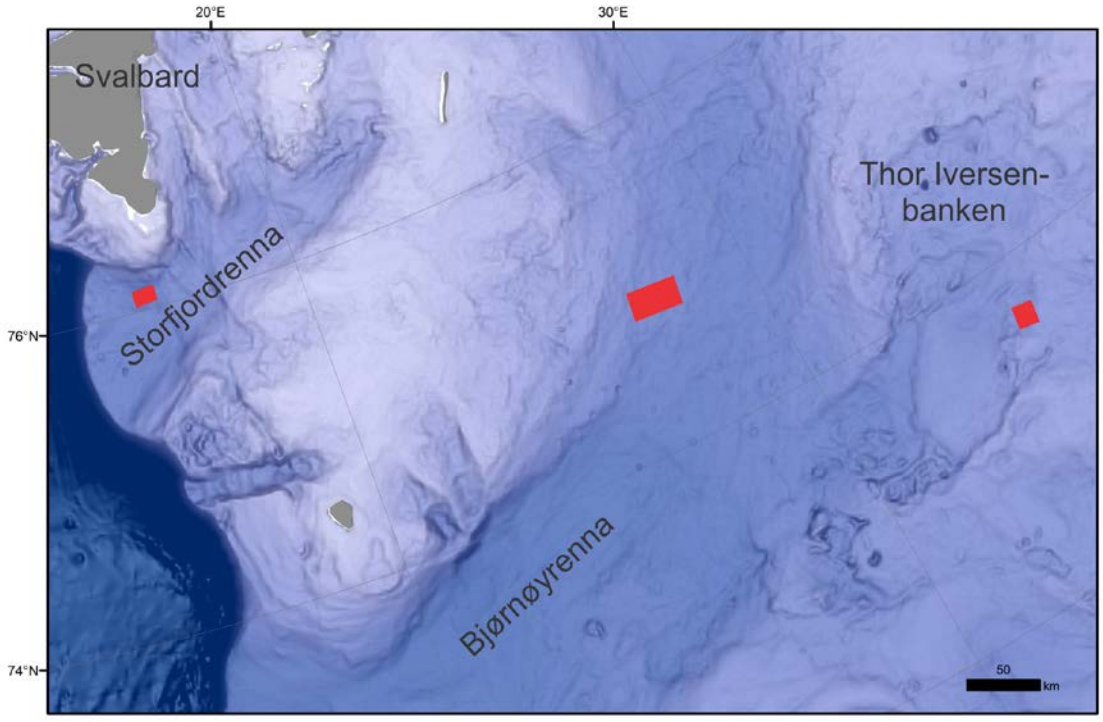


Figure 1. Map of the three study areas (red boxes) for cruise CAGE 15-5: pingos in Storfjordrenna, crater area in Upper Bjørnøyrenna and potential subglacial lake basins in Thor Iversenbanken.

2. Cruise participants

Shift	Cabin	Name
1/open	505	Karin Andreassen
1	411	Monica Winsborrow
2	215	Pär Jansson
1	322	Pavel Serov
2	212	Mariana da S Ramos Esteves
2	212	Calvin Shackleton
1	211	Henry Patton
1/open	323	Kamila Sztybor
open	404	Sunil Vadakkepuliyambatta
2	209	Malin Waage
1	209	Kate Waghorn
open	213	Ove Hermansen
1	214	Anastasia Sevenova
1	215	Warren Smith
1	214	Alisa Ianchevskaia
2	216	Julia Beznosikova
2	216	Nataliia Egorova
open	210	Steinar Iversen
Shift1: 08:00-14:00. 20:00-02:00; Shift2: 14:00-20:00. 02:00-08:00		
Breakfast: 07:30-08:30; Lunch: 13:30-14:30; ; Supper: 19:30-20:30		

3. Equipment

3.1 Subbottom Profiler (Chirp)

A X-STAR Full Spectrum Sonar is a versatile wideband FM sub-bottom profiler that generates cross-sectional images of the seabed and collects digital normal incidence reflection data over many frequency ranges. X-STAR transmits an FM pulse that is linearly swept over a full spectrum frequency range (also called “chirp pulse”).

The chirp system comprises of a hull-mounted 4 x 4 transducer array operated at an energy level of 4 kW and at a shot rate of 1 s. The signal lasts 40 ms, starts at 1.5 kHz and end at 9 kHz. The system can operate in up to 8000 m of water. The penetration depth depends on the sediment type/thickness, it can be up to 80 m in soft clay.

During this cruise, we image the morphology of the ocean floor and its shallow sub-bottom sedimentary layers and structures using the subbottom profiler. This can be used for deciding the location from where to extract the gravity cores.

3.2 Multibeam Echosounder

In the hull of R/V Helmer Hansen has been installed a Kongsberg Simrad EM 300 multi-beam echo sounder. The multi-beam system measures the two-way travel time that a sound wave initiated by a transmitter needs to reach the sea floor and come back. These waves have a frequency of 30 kHz, which is too high to penetrate the seafloor sediments, but gives a high resolution for a bathymetric map.

A number of piezo-electric transmitters, mounted in the hull, transmit 135 beams producing a fan arc, perpendicular to the ship track. Each beam has a width as narrow as one vertical degree by one horizontal degree.

The swath width, dependent on seabed sediments, in shallow water (<500 m) is typically 4 times the water depth. Down to 2000 m, a swath width of 4-5 km is common. The maximum width is 5000 m. The swath width, dependent on seabed sediments, in shallow water (<500 m) is typically 4 times the water depth. Down to 2000 m, a swath width of 4-5 km is common. The maximum width is 5000 m. The multibeam system has been used to map the seafloor morphology and its acoustic backscatter.

We have to take into account that the amplitudes recorded are slightly attenuated (~6 dB) because of protective housing installed around the hardware to avoid damage of ice contact. The outer beams of the EM300 swath can be of low quality, due to speed and signal reception errors because of the great travel distance, large propagation angle and low angle of reflection. That is why we usually have an overlap of 7-25% between the connecting lines. Ship turns also produce unevenly spaced swaths and so, data logging is normally paused during turns.

Once data have been acquired, we used programs such as, Neptune, Fledermaus and ArcGIS to visualize, clean, filter and process them.

3.3 CTD

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

R/V Helmer Hanssen uses SBE 911plus CTD for producing vertical profiles of seawater properties (Fig. 3.3.1). A winch is used to lower the CTD system into the water. The SBE 911plus CTD can measure physical properties of the seawater from up to eight auxiliary sensors, in marine or fresh-water environments at depths up to 6000 meters. However, the winch wire length limits CTD measurements to approximately 3200 meters. The CTD sensors record data at a rate of 24 samples per second. The 911plus system uses the modular SBE 3plus temperature sensor, SBE 4C conductivity sensor, SBE 5T submersible pump, and TC duct. The submersible pump pumps water along the sensor to measure the conductivity. The TC duct makes sure that temperature and conductivity are measured on the same parcel of water. If required, 12 water bottles can be attached to the CTD instrument set up to collect the water samples from any depth. A single conductor cable supplies the power to the system and transmits data from and to the CTD system real time.

During our cruise, we used the sound velocity profiles from different CTD stations to calibrate depth calculations in the swath bathymetry data.

We collected CTD data at 20 stations during the cruise and water samples from ten discrete depths for further analysis (see gas in water).

3.4 2D Reflection Seismic

2D seismic lines during CAGE15-5 are collected in two study sites, the Crater Area and Storfjordrenna. 2D reflection seismic is widely used to study deeper subsurface. Here, acoustic energy is reflected by various lithological 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 mini GI (Generator-Injector) air guns are used as the seismic source. Mini GI airguns are especially suited for high resolution surveys. The air gun generates seismic waves by releasing compressed air into the water. During the Crater Area 2D seismic acquisition, the total volume of the gun is 60 in^3, and operates in harmonic mode, where the generator and injector volumes are the same (30 in^3 each). During

Storfjordrenna 2D survey, every line was repeated, once with 60 in^3 (total) air gun volume, and again with 30 in^3 (15 in^3 each) air gun volume. This generates a high frequency signal, which is suitable for studying the shallow subsurface in detail. A compressor supplies air at a pressure of 170 bar to the air gun. Shooting rate was 3 s and sampling rate 0.25 ms.

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 P-Cable Sections (see 3D seismic chapter).

Operation: The streamer is towed behind the ship at a distance of 80 m from an arm at ~13 m from the centre of the boat. The air gun is towed at a distance of 33 m behind the ships at a depth of approximately 2 mbsl. See figure 2 for geometry of the survey.

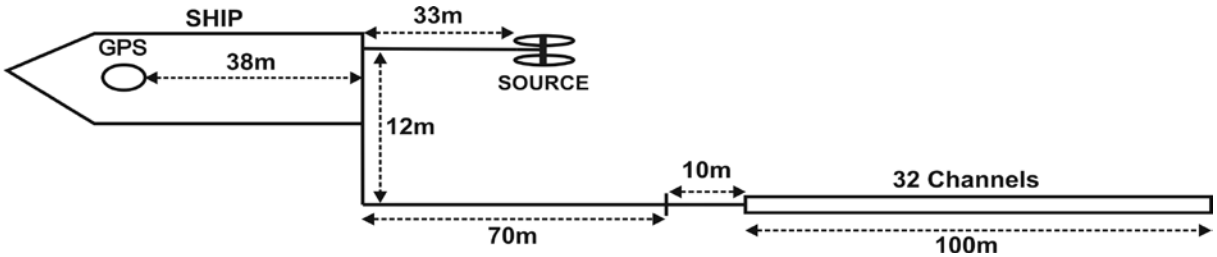


Figure 2. Geometry of the 2D seismic survey during CAGE15-5 expedition.

3.4.1 Ship-Board Processing

During the period 18.07-22.07, 8 lines were collected in two study sites, the Crater Area and Storfjordrenna. Lines are numbered as CAGE15-5-001,002 etc. On-board data processing used Radex Pro for data quality control. Seg-y files were imported to Petrel for 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. 3.4.1)*
5. *CDP Binning (3.125 x 3.125 m bin size)*
6. *Bandpass filtering using 10-20-350-450 Hz*
7. *Amplitude Correction (spherical divergence and time-variant gain)*
8. *NMO Correction (2200 m/s)*

9. *Stacking*
10. *Migration using a Kirchhoff Time Migration*
11. *Seg-y Output*

3.4.2 Results of Ship-Board Processing

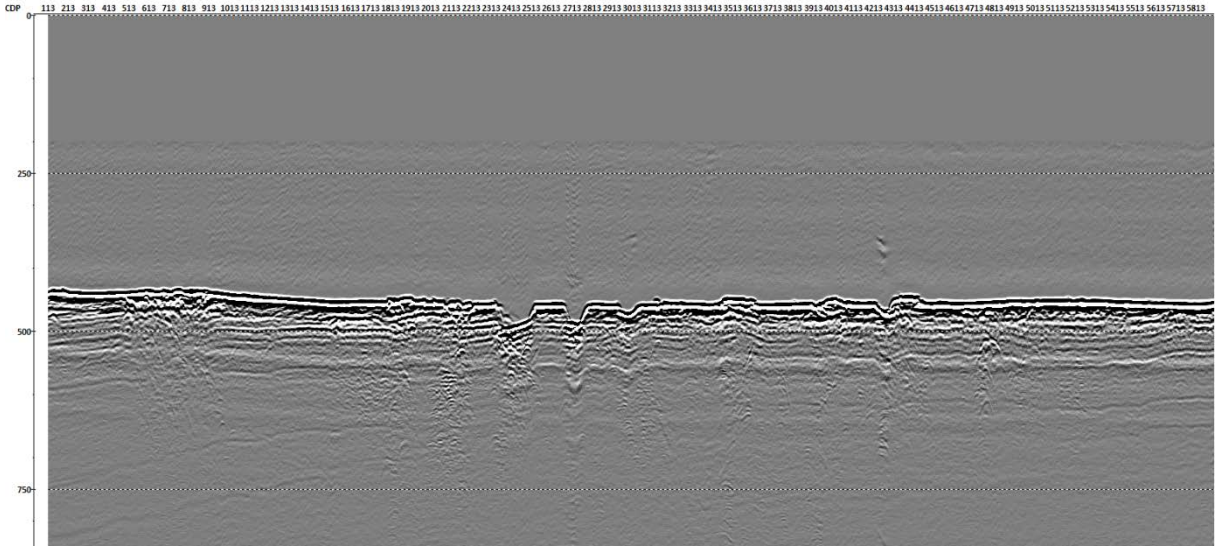


Figure 3. Showing the final output of CAGE15-5-001 (Crater Area) before importing into Petrel.

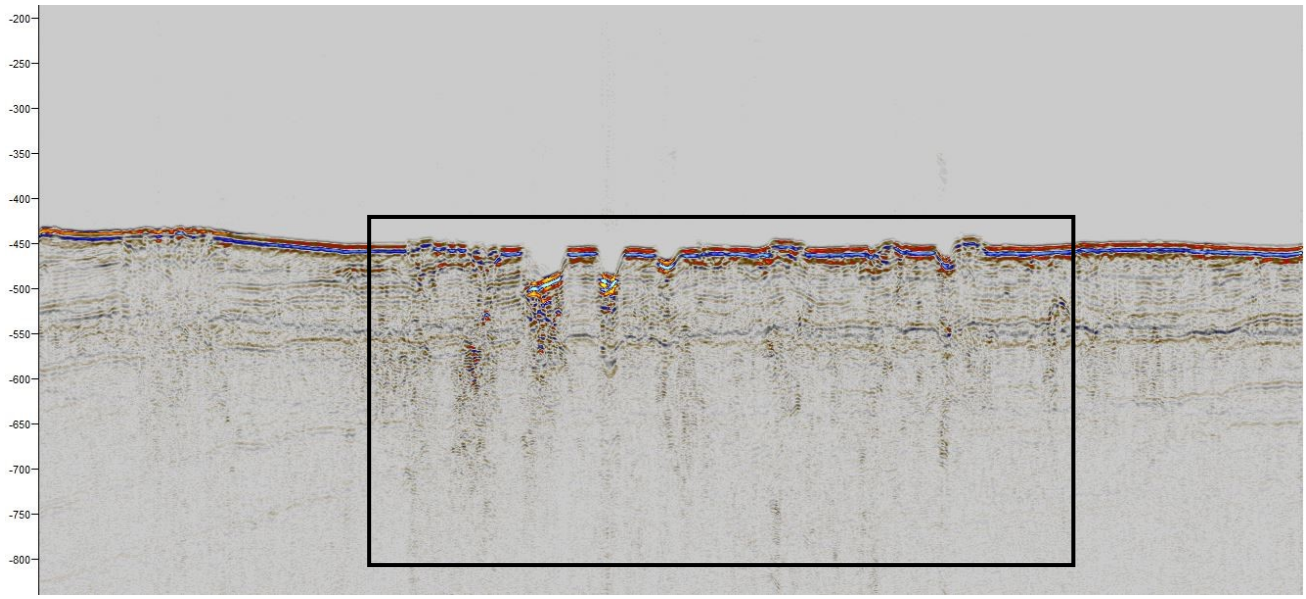


Figure 4. The result of Ship-Board processing of line CAGE15-5-001 (Crater Area) after importing into petrel. Inset box is shown in figure 5.

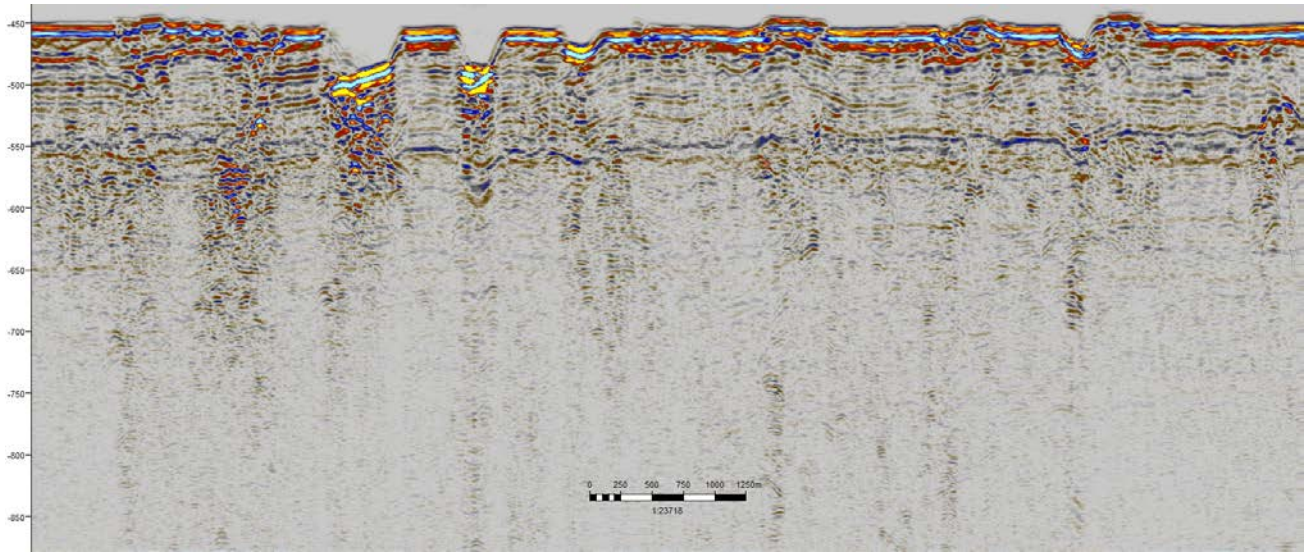


Figure 5. CAGE15-5-001 (Crater Area) showing a zoomed section of the dataset.

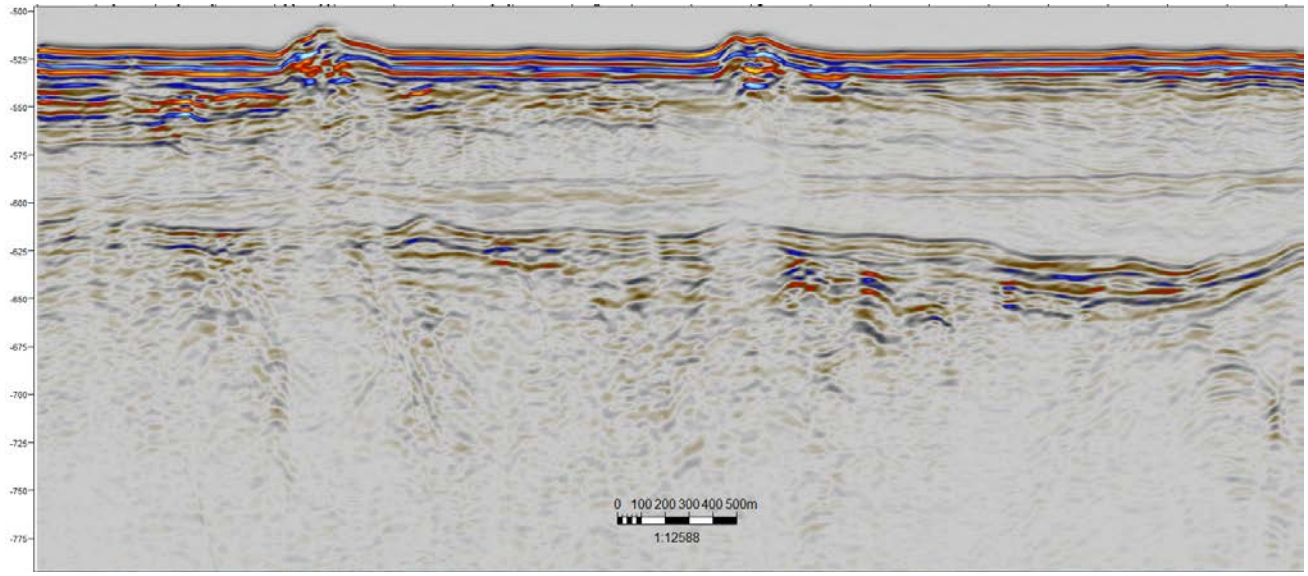


Figure 6. CAGE15-5-002 (Storfjordrenna) final processing outcome. Acquisition using 30/30 in^3 air gun.

Figure 3, 4 and 5 show the processed line CAGE15-5-001 (Crater Area). Migration velocities are time variable, using 2000 m/s for the seafloor arrival, and 2500-3000 m/s for the lower strata. Time variant gain was also applied so that lower amplitudes are not washed out by the dense seafloor. Figure 6 shows the outcome of processing for line CAGE15-5-002 (Storfjordrenna). Here, the 60 in^3 (total) air gun is used, compared to the same line (Fig. 7) with the 30 in^3 (total) air gun. Migration velocities are again time variable, in Storfjordrenna 300-400 ms is migrated at a velocity of 1500 m/s, while below 400 ms, 2500 m/s is the migration velocity used. Note that there are still some localized diffractions below 400 ms in some places. This indicates the need for a lateral and depth variable velocity model.

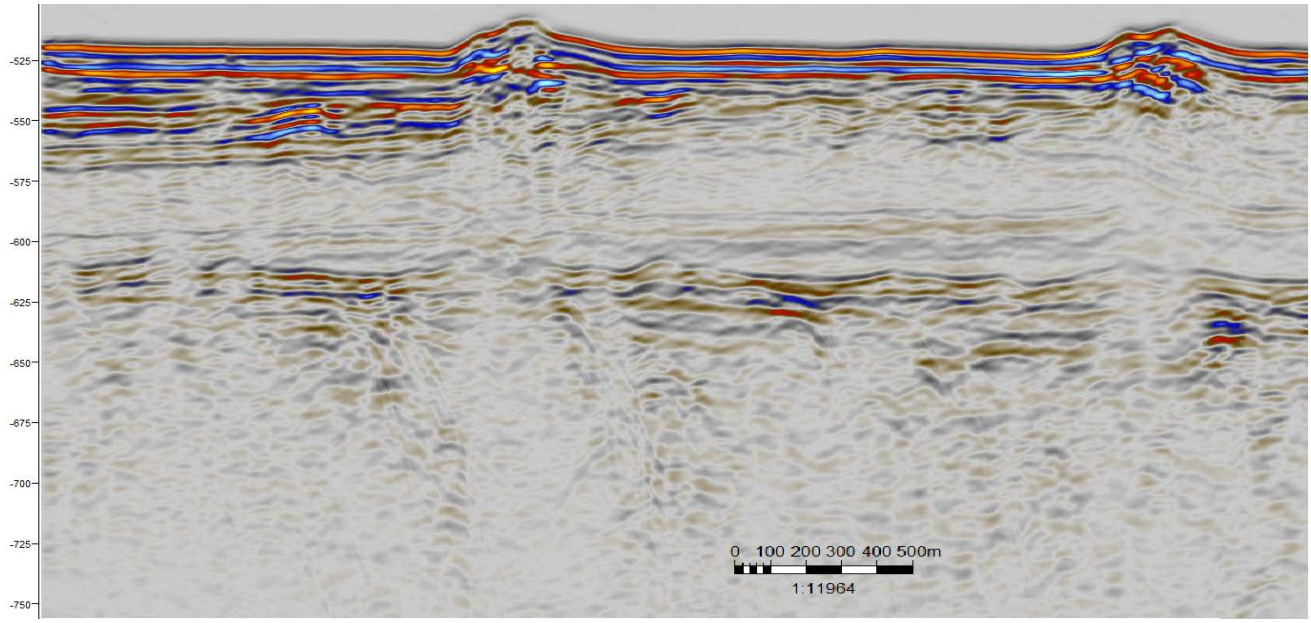


Figure 7. CAGE15-5-005 (Storfjordrenna) final processing outcome. Line is acquired on the same sailing line as CAGE15-5-002, this line is acquired with 15/15 in^3 air gun.

3.5 3D Seismic

The 3D seismic survey during the expedition CAGE15-5 aims to acquire P-Cable high-resolution data over an area where craters and pingos are identified in previous studies. The theory behind 3D seismic is essentially the same as 2D, where sound waves penetrating the surface are recording lithological changes in the subsurface. 3D surveys, however, allow the user to identify lateral (dis)continuity of features in the subsurface. The 3D seismic survey intends to image deeper structure and stratigraphy related to these seafloor features. Onboard seismic processing and QC of P-Cable data provided preliminary 3D cubes for quality assessment and initial interpretations.

3.5.1 The P-Cable 3D 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 (Fig. 8). An array of 14 streamers is used to acquire many seismic lines simultaneously, thus covering a large area with close inline spacing. Including lead-in cables, the cross cable has a total length of 212 m between paravanes (doors) (Fig. 8). 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. Each streamer is 25 meters long and consists of an A/D-module and 8 channels. Solid state streamers are used because they are less affected by sea swell and hence provide

data with significantly less noise. The A/D-module converts the analogue signal from the channels to digital signals. 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. Digital data is recorded using Geometrics GeoEel software.

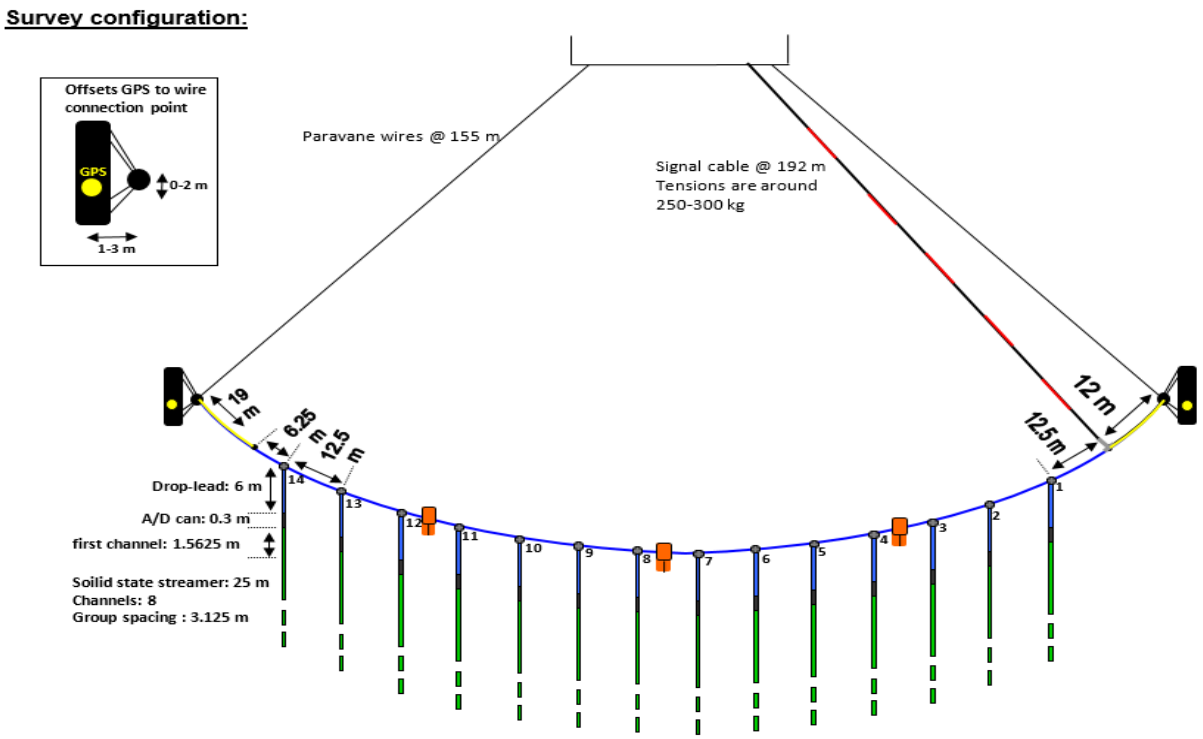


Figure 8. Geometry of the P-Cable 3D seismic system. 14 Streamers, spaced 12.5 m apart contain 8 channels each and are connected to a crosscable between two paravanes.

Source: The source used during the 3D seismic data acquisition was a 45/105 in^3 air gun. The total volume of the gun is 150 in^3 operated in true GI mode, so 45 in^3 for the generator and 105 in^3 for the injector. This gun is configuration is used to get reasonable depth penetration while still maintaining dense coverage of shot-receiver positions in a 6.25 x 6.25 m grid. A compressor is used to supply air at a pressure of 160 bar to the air gun. Shooting rate during this survey is 6 s and the sampling rate is 0.50 ms.

Streamer: During this survey, we used 14, 25 m long solid state streamers, spaced 12.5 m apart on the cross cable (Fig. 8). Each streamer is proceeded by an A/D converter (0.3 m), and a lead-in cable (6 m). The first receiver position in each streamer is located after 1.5625 m, giving a total distance from cross-cable to first receiver of 7.7625 m. Channel spacing is 3.125 m, with 112 channels in total.

Operation: The paravanes are towed at a distance of 155-153 m at an angle from the aft corners of the ship. The observed spread of the paravanes is 160-165m. The air gun is towed 65 m from the centre aft of the ship. See figure 8 for the geometry of the survey.

3.5.2 Ship-Board Processing

During the period 13.07-17.07, 46 lines were collected as the basis of the 3D data cube in the Crater Area. All lines are numbered sequentially from 0001. On-Board data processing was undertaken in Radex-Pro for quality control. The following summarizes the data processing steps during line based, Ship-Board Processing:

1. *Navigation Files:* The port and starboard paravanes, gun and ship GPS positions are all necessary for geometry assignment to the data set. SeaTrack records GPS positions of all four points every second, and these files are used during data processing. Gaps in positions are interpolated in MatLab.
2. *Read SegD Files into RadEx Pro*
3. *Single channel display for quality control*
4. *Geometry assignment (Fig. 3.5.1.1)*
5. *Geometry Quality Control:* Here, we check to see if the geometry parameters we assign fit with the data. There is always some uncertainty with how the P-Cable system is placed in the water. For example, often in strong currents the distance between the port paravane and consequent streamer is different to the starboard side. During geometry assignment we assume the cross-cable is a symmetric shape, however this is not always accurate. To check this, we calculate the offset of all the receiver positions, create a pick of where the first-break should be based on the offset and velocity of sound through water. Major deviations between the calculated and actual direct waves mean we must change the geometry configuration.

After all lines are collected, and geometry assigned and checked, the dataset is merged into a 3D cube. The processing steps for the merged data-set were:

6. *CDP Binning (6.25 x 6.25 m bin size)*
7. *Bandpass filtering using 10-20-350-500 Hz*
8. *Amplitude Correction (spherical divergence and trace variance)*
9. *NMO Correction (2300 m/s)*

10. *Stacking*
11. *Seg-y Output*

Additionally, three 2D lines (Inline 160,260 and 310) were extracted from the 3D data set to test migrations before applying to the whole dataset. The migration used a Kirchhoff Time migration using the following CDP's, times and velocities: Every 30 CDP; 0-429:1.5, 430-480.9:3,481-1000:3.5.

3.5.3 Results of Ship-Board Processing

Coverage of the 3D area is outlined in figure 9. Some gaps were filled before the end of the survey, so minor gaps are all that remain.

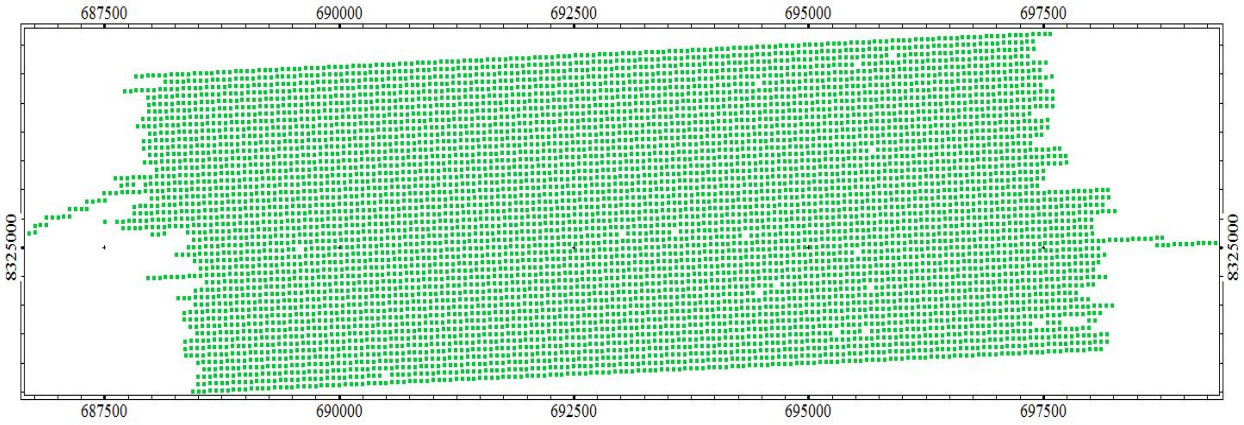
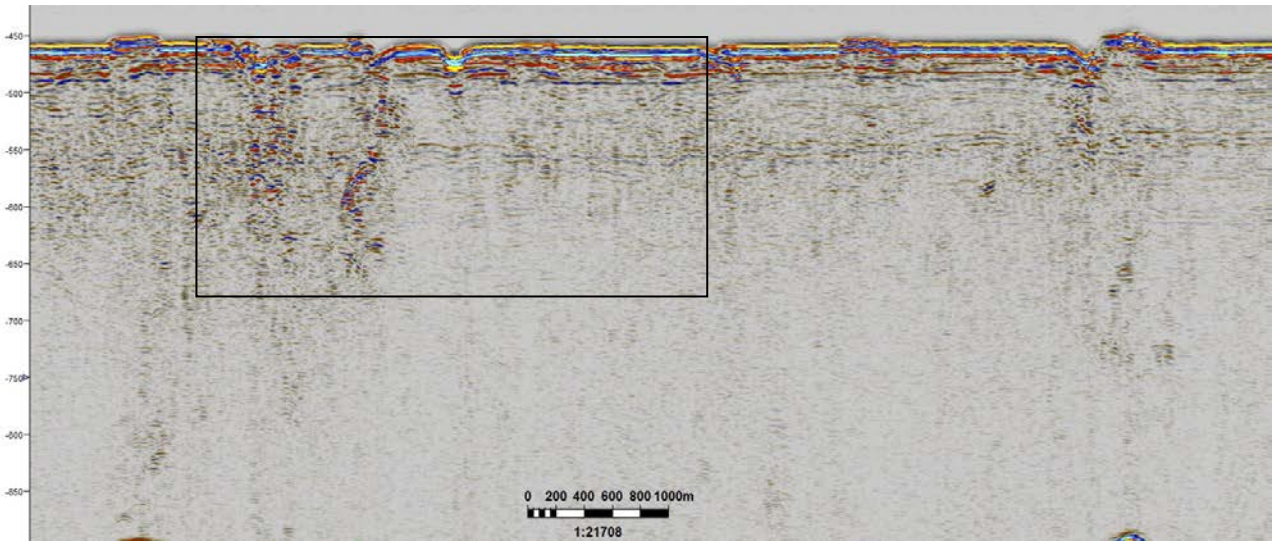


Figure 9. Map of the area covered by 3D seismic shots (green squares indicate CDP bins). Some gaps remain due to occasional missing shots, however the more problematic gaps were filled prior to the survey ending.



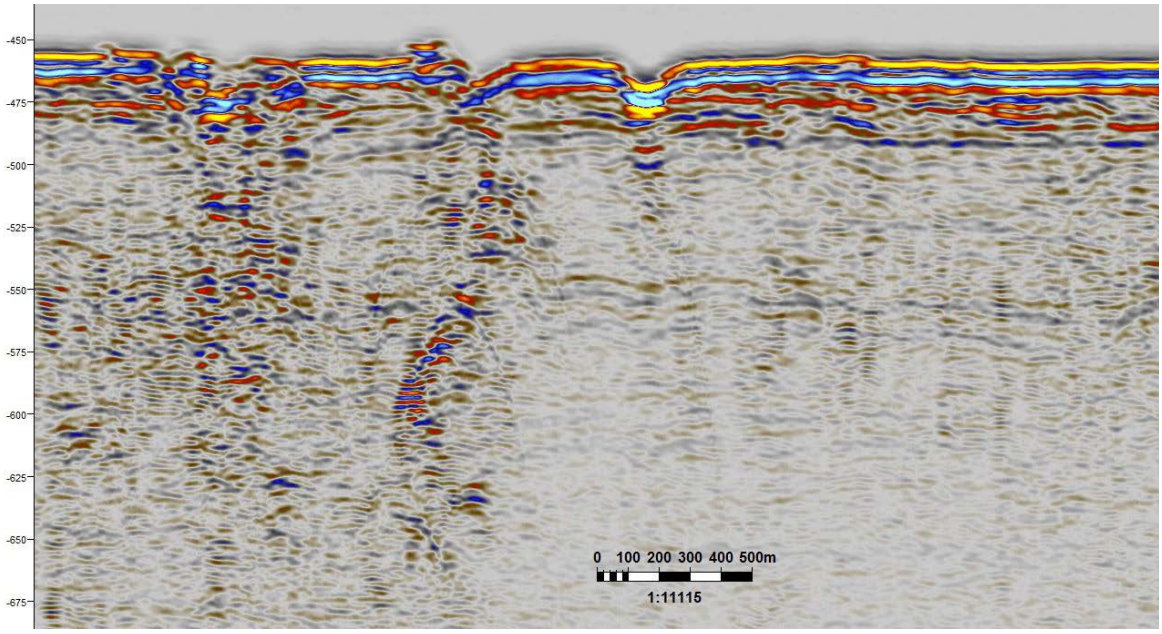


Figure 10. CAGE15-5 Crater area, 2D line of 3D seismic cube (Inline260) after simple on-board migration.

3.6 Single Beam Echo sounder

Single beam echo sounders are common among all types of ships. Their primary purpose is to estimate the depth of the seafloor. In a single beam echo sounder, the transducer projects a sound pulse through water in a controlled direction and the reflected wave is received. The depth is calculated from the travel time of the sound pulse. R/V Helmer Hanssen has a keel-mounted Simrad EK 60 single beam echo sounder with transducers at three different frequencies, 18 KHz, 38 KHz and 120 KHz. The 18 KHz transducer can be used for depths up to 10 km whereas 38 KHz and 120 KHz can only be used for depths up to 2 km and 500m respectively.

The single beam echo sounder can also be used for detecting gas leakages from the seafloor using 18KHz and 38KHz transducers.

3.7 Sediment coring

Coring is the primary tool for ground truthing, studying sediment types, paleontology, and paleo-climate. R/V Helmer Hanssen has a piston corer, box corer, multi corer and a gravity corer. During our cruise we used the multi corer and gravity corer for sampling sediments.

The gravity corer onboard Helmer Hanssen consists of a 3m and 6m long iron barrel with iron weights attached on top of it. The whole apparatus weighs close to 2 tons. The gravity corer has an inner diameter of 11cm. A plastic liner with outer diameter of 11cm and inner diameter of 10.2 cm is inserted in to the iron barrel. During the coring operation, a core catcher

and core cutter is attached to the lower end of the gravity corer. Core catcher keeps the sediments from falling out of the core, whereas core cutter helps the penetration of the core in to the sediments.

The gravity corer lies on a rail, which, during operation, is lifted vertically and the gravity corer is lowered to around 20m away from the seabed using a winch. When at the chosen core location the gravity corer is then dropped. The winch has a wire length of 2900 meters. When the gravity corer is lifted from the seabed and is brought to deck, the core catcher and core cutter are sampled first, if there are sediments present in them. Then, the plastic liner is taken out, cleaned, cut to 1 meter sections, labeled and stored in a cold room.

Five of the gravity cores obtained in Thor Iversen Banken were opened, split, logged and sampled for biomarkers and reactive metal and sulphur at 10cm and 5cm intervals respectively, following the normal subsampling procedures. The rest of the gravity cores from this area will be further analysed at the department of geology, Tromsø.

Box corer was used to subsample for geochemistry in areas within the crater area where it was not possible to obtain gravity cores.

3.8 Gas in bottom sediments

For compositional analyses of hydrocarbon gas (C_1-C_5) conventional headspace sampling preparation technique was applied. Bulk sediments (5ml) were subsamples with a 5 ml cut-off plastic syringe. The sediments were transferred into 20 ml headspace glass vials, containing 5 ml of 1-molar NaOH solution and 2 glass beads. The vials were immediately capped with rubber septa, sealed with aluminum crimp caps and shaken afterwards. All samples were stored in a fridge with a temperature of +2 C.

For gas analyses we used ThermoScientific Trace 1310 gas chromatograph equipped with a flame-ionization detector (GC-FID) and ThermoScientific TG-BOND alumina (Na_2SO_4) 30m x 0,53mm x 10µm column. Instrument method for our sequence of samples:

- constant column flow (H_2): 30 ml/min
- split ratio 1
- injection volume 100µl
- injector temperature: 150 C
- detector temperature: 180 C

- oven temperature program: 40 C (0-5 min); temperature ramp 10 C/min (5-11 min); 100 C (11-16min); temperature ramp 10 C/min (16-19 min); 130 C (19-25 min)
- air flow: 350 ml/min
- makeup gas (N2) flow: 35 ml/min
- hydrogen flow: 40 ml/min

In order to estimate headspace gas concentrations in ppm (particles per million) we applied 6 calibration levels for methane (5ppm, 10ppm, 50ppm, 100ppm, 4400ppm, 8800ppm) and 3 calibration levels for various C2-C5 hydrocarbon gas (2ppm, 5ppm, 10ppm). We also collected samples for sediment porosity tests, which is necessary for converting our GC-FID results from ppm to nmol.

Chromeleon 7 software was used for the instrument control and processing of chromatograms.

3.9 Gas in water

We collected water samples from 20 stations (see CTD) and 10 discrete depths at each station. Water samples were analyzed with a Gas Chromatograph equipped with a FID. The chromatograms allow for detection of hydrocarbon gases such as methane, ethane, ethylene and propane.

Headspace gas extraction method was applied for sample preparation for subsequent GC-FID gas analyses. Water samples from Niskin bottles were placed into 100ml glass vials, sealed with rubber septa and crimped. Subsequently we added 5ml of instrument nitrogen gas into each of the bottles and shake them to equilibrate gas dissolved in a water sample and headspace gas. Samples were stored in the fridge (+2 C) and analyzed within 0.5-2 hours after the sampling.

For gas analyses we used ThermoScientific Trace 1300 GC-FID with the same hardware configurations. Instrument method for our sequence of samples:

- constant column flow (H_2): 10 ml/min
- splitless injection
- injection volume 100µl
- injector temperature: 170 C
- detector temperature: 180 C

- oven temperature: 40 C
- air flow: 350 ml/min
- makeup gas (N2) flow: 35 ml/min
- hydrogen flow: 40 ml/min

We used 5ppm, 10ppm, 25ppm, 50ppm and 100ppm methane calibration levels and 5ppm and 10ppm calibration levels for different C_2-C_5 hydrocarbon gas. However, we did not detect any methane homologs in our water samples. For subsequent ppm to nmol/L data conversion we continuously measured temperature of the samples and atmospheric pressure in the laboratory. Salinity data for was taken from SBE 19 CTD.

A first look at the water column chromatograms show very small (below detection limit) for all hydrocarbons heavier than methane and small (relative to other seep areas) concentrations of methane. Further processing will be made based on the resulting chromatograms and CTD data (temperature, salinity and depth) to calculate the dissolved gas concentrations in the water column.

3.10 Plankton net

Plankton net samples were collected using a WP-2 net with 63um mesh size. Samples were collected from four stations within the crater area in central Bjørnøyrenna, along a transect from west to east. At each station four casts were performed, each cast dividing the water column into the following depths intervals: bottom-200m, 200-100m, 100-50m and 50-surface.

The contents of each cast were sieved on 500 um and 63 um sieves and placed in separate bottles, resulting in 32 bottles in total. Samples were preserved in “Absolutt alcohol” (ethanol) with Rose Bengal and buffered with Disodium Hydrogen Phosphate and Sodium Hydrogen Phosphate. Planktonic foraminifera will be studied from the collected samples, in particular the condition of their shells (CaCO3). The relatively small mesh size and covering of the entire water column means that the same samples can be used for analyses of other zooplankton groups (e.g. copepoda, ostracoda),which can provide additional information about water masses in the crater area.

3.11 Gas in air

Methane is monitored at the Zeppelin mountain station and on board RV Helmer Hanssen using a Picarro Cavity Ring Down spectrometer (CRDS), model G2401. Both are connected to a

heated main sample inlet line with excess air flow. The sample air is dried using a nafion drier to minimise any water correction error in the instrument. A multiport valve on the instrument inlet enables switching between sample air and control samples/working standards. Working standards are calibrated against reference standards from NOAA-CMDL (CH4 scale NOAA2004). The central inlet line is connected to the top of the mast on RV Helmer Hanssen (xx m asl) and on top of a 15 m mast at the Zeppelin station (490 m asl). Sample residence time in the sample line is about 10 secs.

Ethane and propane is monitored at the Zeppelin station by the use of a semi continuous GC-MS system (the Medusa system ref. xxx) sampling every two hours, using the same main sample line as the CRDS system. On board RV Helmer Hanssen, air samples are collected on SUMMA canisters, also using the same sample line as the CRDS system. The canisters are sent to the laboratory at NILU where they are analysed on a Medusa system, similar to the system at Zeppelin. Both instruments are calibrated against AGAGE reference standards (AGAGE scale). The Medusa systems measure a range of hydrocarbons and halogenated trace gases in addition to ethane and propane.

Air samples for analysis of isotopes in methane are sampled on steel and aluminium canisters, daily at the Zeppelin station and at the same time as the hydrocarbon canisters on RV Helmer Hanssen.

Figure 11. Setup of Picarro sampling station on RV Helmer Hanssen

4. Ship tracks and study areas

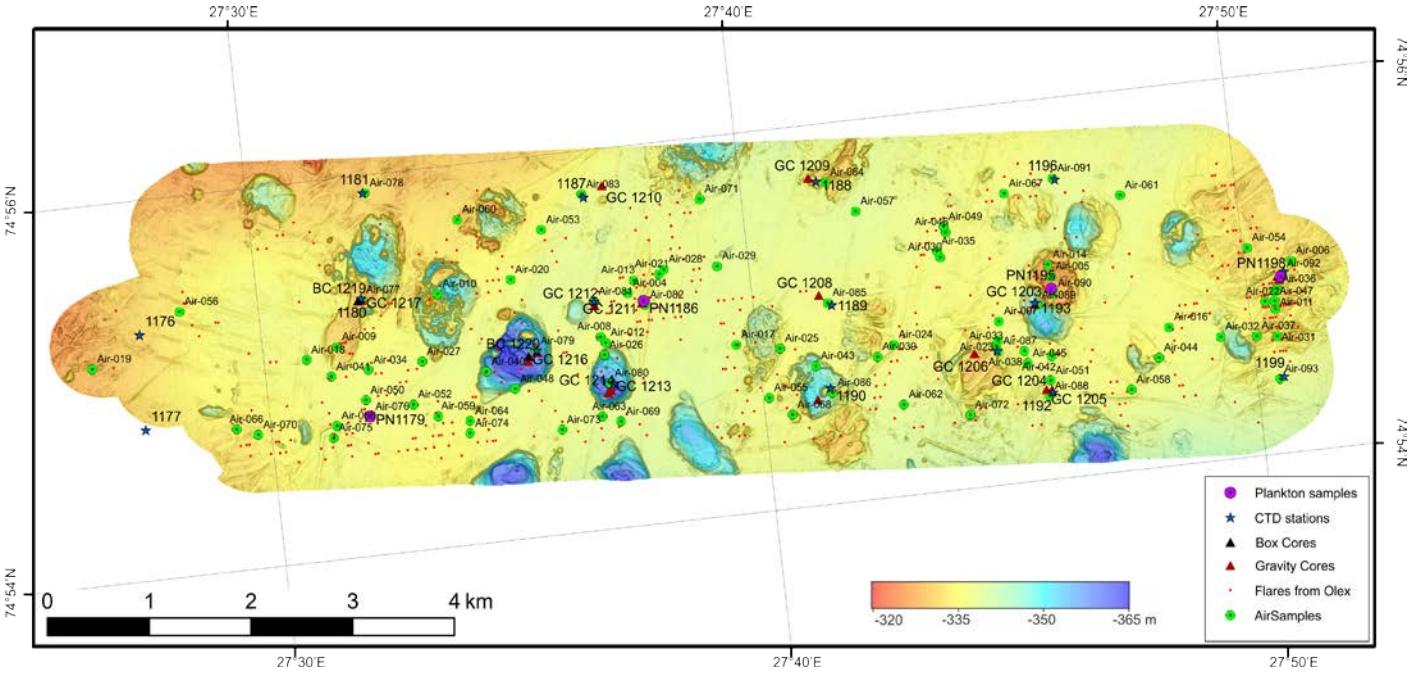


Figure 12. Location of sampling stations within the crater area in Upper Bjørnøyrenna.

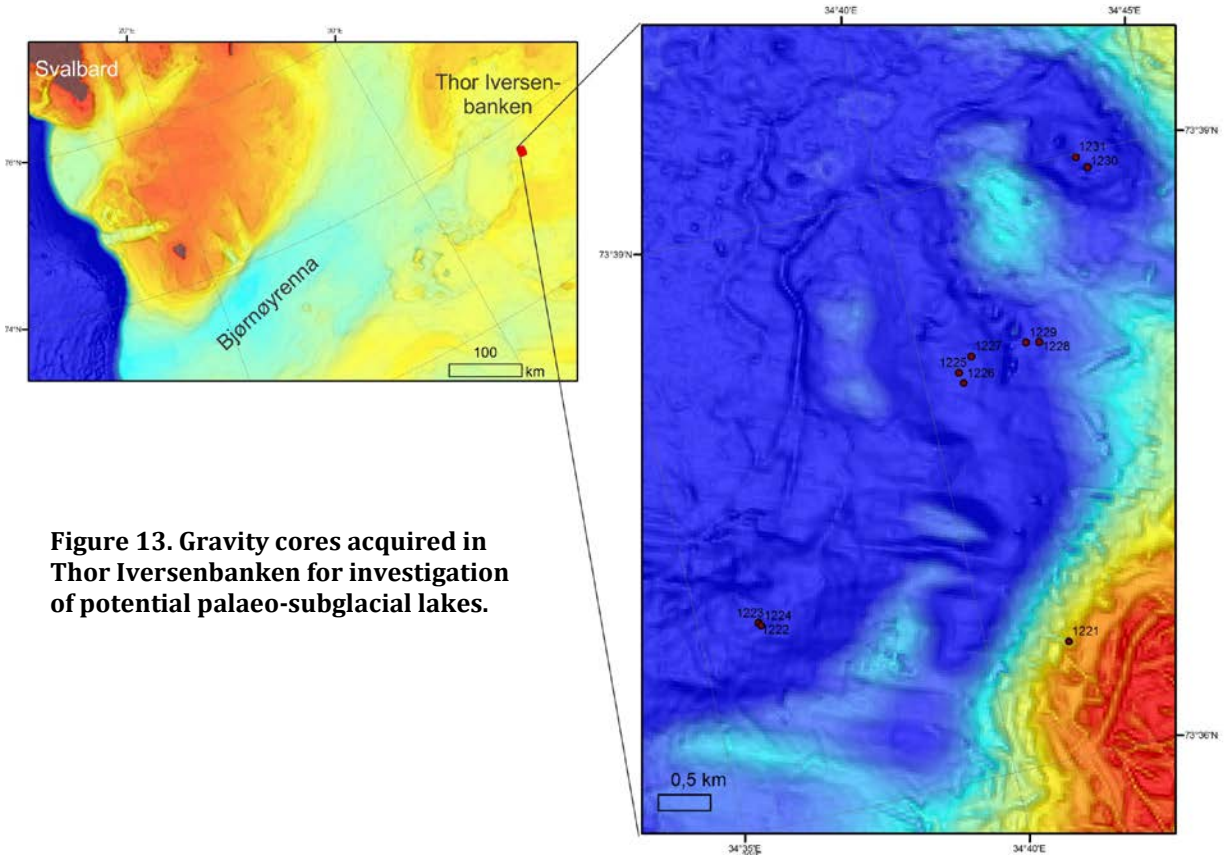


Figure 13. Gravity cores acquired in Thor Iversenbanken for investigation of potential palaeo-subglacial lakes.

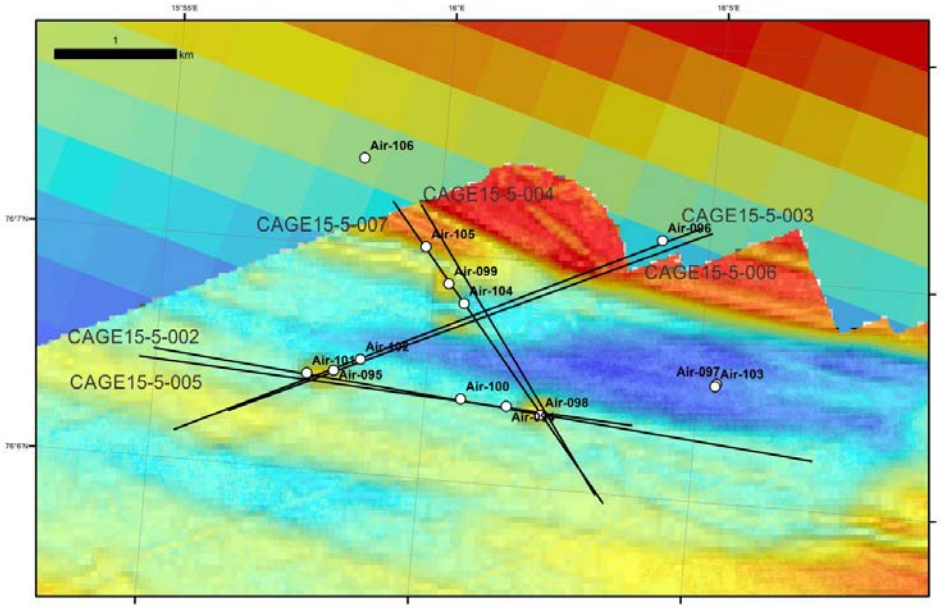


Figure 14. Location of air samples and 2D seismic datasets in Storfjordrenna.

5. Logs

5.1. Event log

Date	UTC	Position	Event
11/07	Ca 15:00		Departure from Longyearbyen, heading for Ny Ålesund to pick up 6 boxes with pressure bottles for sampling for gas
12/07	Ca 02:15		Transit Ny Ålesund to Crater area
12/07			Air Station 001.
12/07	17:31:42		Start SB line 173142
13/07	20:07		3D seismic acquisition started
13/07	20:32	74 56.009 27 25.138	Flare on test line 0
13/07	20:51		Start 3D seismic line 0001
14/07	20:45		Problems with streamer 2 channels, stops shooting after line 15 and takes streamers up on deck.
			Deck cable damaged.
15/07	00:48		Restart 3D seismic
17/07	09:22	74 55.031 27 32.894	End 3D seismic (Line12a – line filling gaps). 46 lines acquired + 2 half lines filling gaps. 61.5 hours of 3D seismic.
18/07	18:53	74 56.487 27 24.5544	Starting 2D seismic (Line 000, test shots)
18/07	21:39	74 56.323 27 55.200	Ending 2D seismic in crater area (1 line, 2 hrs 46 minutes)
18/07	21:39	74 56.323 27 55.200	Transit to Thor Iversenbanken
19/07	10:30	73 40.384 34 12.757	Start chirp survey in Thor Iversenbanken

19/07	14:00	73 37.359 34 43.970	Finish chirp survey in Thor Iversenbanken
19/07	14:29	73 36.589 34 41.446	First gravity core, corer bent due to strong sediments. Crew replacing the corer.
19/07	16:07	73 37.0424 34 36.0707	Gravity coring resumed
19/07	20:41	73 38,9830 34 43,5591	End of gravity coring in Thor Iversenbanken
19/07	21:32	73 39,519759 34 45,135718	Beginning 2D seismic in Thor Iversen Banken
19/07	21:41		Ending 2D seismic due to interference from other seismic ships, running chirp over planned seismic lines instead
19/07	21:41		Start of chirp survey in Thor Iversenbanken
20/07	00:14		End of chirp survey in Thor Iversenbanken
20/07	00:14		Start of chirp survey during the transit from Thor Iversenbanken to the Crater area
20/07	12:55	74 57.85 27 55.64	Continue multibeam and chirp survey crater area. Chirp file number 47 - 63
21/07	06:21	74 45.16 27 27.48	End of multibeam and chirp survey in crater area
21/7	06:55	74 47.83 27 42.97	Start CTD
21/7	07:13	74 47.98 27 43.01	Stop CTD
21/7	07:35		Start transit Crater-Storfordrenna Chirp og Multibeam
22/7	03:00		Starting 2D seismic survey in Storfjordrenna
22/7	07:50		Stopped seismic survey at Storfjordrenna
22/7	07:50		Transit to Longyearbyen via Hornsund

5.2. Station log

Type: GC (Gravity core), PC (Piston core), MC (Multicore), BC (Box core), GRAB (Van Veen Grab), SCRATE, PN (Plankton net), Air (Air Sample)

Area	Cruise	Station	Type	Lat decdeg	Long decdeg	Lat degrees	Lat decmin	Long degrees	Long decmin	Date	Time (UTC)	Recovery (m)	Water Depth (m)	Comment
Helmer Hanssen	CAGE15-5	Air-001	Air	76,818071	14,653275	76	49,084271	14	39,196523	12.7.	18:23:00			Innerluft
	CAGE15-5	1175	CTD	74,892499	27,477309	74	53,549929	27	28,638534					
Hornsund	CAGE15-5	Air-002	Air	76,763596	14,777564	76	45,815763	14	46,653862	12.7.	18:45:09			
Spitsbergenban	CAGE15-5	Air-003	Air	75,251131	25,023555	75	15,067886	25	1,413313	13.7.	12:21:01			
Crater Area	CAGE15-5	Air-004	Air	74,920591	27,624957	74	55,235458	27	37,497405	14.7.	06:59:44			Sample over ridge
Crater East	CAGE15-5	Air-005	Air	74,917826	27,767897	74	55,069566	27	46,073817	14.7.	07:34:22			On pingo
Eastern Turn	CAGE15-5	Air-006	Air	74,916792	27,849213	74	55,007509	27	50,952751	14.7.	07:54:04			On Eastern turn crater area.
Eastern Line 8	CAGE15-5	Air-007	Air	74,914442	27,748673	74	54,866513	27	44,920373	14.7.	08:21:00			Line 8
Western Line 8	CAGE15-5	Air-008	Air	74,917041	27,614035	74	55,022475	27	36,842124	14.7.	08:52:48			Line 8
W End line 8	CAGE15-5	Air-009	Air	74,918721	27,525100	74	55,123252	27	31,505995	14.7.	09:14:42			End of line 8
Line 9 Crater	CAGE15-5	Air-010	Air	74,922382	27,560893	74	55,342894	27	33,653604	14.7.	09:54:34			Middle line 9
End Line 9	CAGE15-5	Air-011	Air	74,912732	27,842094	74	54,763904	27	50,525628	14.7.	11:03:42			Eastern turn crater area
N central crater	CAGE15-5	Air-012	Air	74,916467	27,615640	74	54,988036	27	36,938406	14.7.	11:55:55			North of central crater
N central crater	CAGE15-5	Air-013	Air	74,921640	27,627367	74	55,298425	27	37,642016	14.7.	13:07:28			
End line 11	CAGE15-5	Air-014	Air	74,918907	27,767268	74	55,134399	27	46,036107	14.7.	13:38:27			
Between 11 and 12	CAGE15-5	Air-015	Air	74,914303	27,842444	74	54,858191	27	50,546655	14.7.	13:57:37			
Start of line 12	CAGE15-5	Air-016	Air	74,912228	27,805737	74	54,733704	27	48,34424	14.7.	14:08:30			
S main flare area	CAGE15-5	Air-017	Air	74,915015	27,659456	74	54,900892	27	39,567358	14.7.	14:41:04			

End of line 12	CAGE15-5	Air-018	Air	74,917878	27,514276	74	55,072707	27	30,856554	14.7.	15:13:58			
Between line 12 + 13	CAGE15-5	Air-019	Air	74,919099	27,441828	74	55,145958	27	26,509702	14.7.	15:35:27			
Start of line 13	CAGE15-5	Air-020	Air	74,922906	27,585911	74	55,374369	27	35,154667	14.7.	16:12:46			
N of central crater	CAGE15-5	Air-021	Air	74,921941	27,636088	74	55,316473	27	38,165283	14.7.	16:26:14			
Start line 14	CAGE15-5	Air-022	Air	74,913503	27,838975	74	54,810167	27	50,338529	14.7.	17:21:02			
S central crater	CAGE15-5	Air-023	Air	74,912815	27,747639	74	54,768916	27	44,858333	14.7.	17:46:16			
Line 14	CAGE15-5	Air-024	Air	74,913442	27,712522	74	54,806501	27	42,751326	14.7.	17:55:37			
Line 14	CAGE15-5	Air-025	Air	74,914250	27,674070	74	54,855001	27	40,444173	14.7.	18:05:41			
Line 14	CAGE15-5	Air-026	Air	74,915404	27,614689	74	54,92422	27	36,881329	14.7.	18:20:27			
Line 14	CAGE15-5	Air-027	Air	74,916609	27,553076	74	54,996513	27	33,184567	14.7.	18:34:50			
Line 15	CAGE15-5	Air-028	Air	74,922298	27,637842	74	55,337864	27	38,270524	14.7.	19:47:34			
Line 15	CAGE15-5	Air-029	Air	74,922066	27,655999	74	55,32393	27	39,359961	14.7.	19:51:57			
	CAGE15-5	Air-030	Air	74,920611	27,731312	74	55,236659	27	43,878729	14.7.	20:11:50			
Start line 16	CAGE15-5	Air-031	Air	74,910343	27,841586	74	54,620564	27	50,495143	15.7.	00:46:22			
Start line 16	CAGE15-5	Air-032	Air	74,910856	27,822638	74	54,651362	27	49,358283	15.7.	00:50:45			
Line 16	CAGE15-5	Air-033	Air	74,912344	27,746716	74	54,740652	27	44,802943	15.7.	01:09:53			
Line 16	CAGE15-5	Air-034	Air	74,916402	27,534740	74	54,984114	27	32,084409	15.7.	02:02:13			
Line 17	CAGE15-5	Air-035	Air	74,921176	27,730404	74	55,270586	27	43,824267	15.7.	03:25:17			
End line 17	CAGE15-5	Air-036	Air	74,914463	27,843524	74	54,86779	27	50,611433	15.7.	03:55:14			Air not open, therefore second sample #37
Start line 18	CAGE15-5	Air-037	Air	74,910568	27,834778	74	54,634074	27	50,086665	15.7.	04:00:21			
Line 18	CAGE15-5	Air-038	Air	74,911588	27,756115	74	54,695263	27	45,366905	15.7.	04:19:44			
Line 18	CAGE15-5	Air-039	Air	74,912544	27,706549	74	54,752638	27	42,392953	15.7.	04:32:02			
Line 18	CAGE15-5	Air-040	Air	74,915103	27,574414	74	54,906174	27	34,464846	15.7.	05:04:41			

Line 18	CAGE15-5	Air-041	Air	74,916164	27,522052	74	54,969837	27	31,323102	15.7.	05:16:54			
Line 20	CAGE15-5	Air-042	Air	74,910876	27,765211	74	54,652579	27	45,912663	15.7.	07:32:39			
Line 20	CAGE15-5	Air-043	Air	74,912364	27,685421	74	54,741816	27	41,12527	15.7.	07:51:37			
Line 22	CAGE15-5	Air-44	Air	74,909662	27,801184	74	54,579729	27	48,071013	15.7.	10:41:16			
Line 22	CAGE15-5	Air-45	Air	74,910488	27,756795	74	54,629274	27	45,407701	15.7.	10:51:59			
Line 23	CAGE15-5	Air-046	Air	74,922750	27,734185	74	55,365023	27	44,051094	15.7.	13:11:19			
Line 23	CAGE15-5	Air-047	Air	74,913446	27,842146	74	54,806736	27	50,528763	15.7.	13:41:05			
line24	CAGE15-5	Air-048	Air	74,913329	27,583474	74	54,799753	27	35,008439	15.7.	14:48:35			
line25	CAGE15-5	Air-049	Air	74,923276	27,733649	74	55,396556	27	44,018964	15.7.	16:27:26			
Line 26	CAGE15-5	Air-050	Air	74,913784	27,532721	74	54,827068	27	31,963237	15.7.	18:21:12			
	CAGE15-5	Air-051	Air	74,908757	27,763849	74	54,525439	27	45,830951	15.7.	20:45:00			
	CAGE15-5	Air-052	Air	74,912954	27,548545	74	54,777267	27	32,91271	15.7.	21:45:00			
	CAGE15-5	Air-053	Air	74,926963	27,598062	74	55,617752	27	35,883743	15.7.	22:45:00			
	CAGE15-5	Air-054	Air	74,918370	27,834972	74	55,102219	27	50,098344	15.7.	23:45:00			
	CAGE15-5	Air-055	Air	74,910052	27,668536	74	54,60309	27	40,11213	16.7.	00:45:00			
	CAGE15-5	Air-056	Air	74,923316	27,473311	74	55,398988	27	28,398643	16.7.	01:45:00			
	CAGE15-5	Air-057	Air	74,925474	27,704678	74	55,528424	27	42,280681	16.7.	02:45:00			
	CAGE15-5	Air-058	Air	74,907142	27,790707	74	54,428524	27	47,442449	16.7.	03:45:00			
	CAGE15-5	Air-059	Air	74,911673	27,556565	74	54,700404	27	33,393914	16.7.	04:45:00			
	CAGE15-5	Air-060	Air	74,928673	27,570303	74	55,720393	27	34,218201	16.7.	05:45:00			
	CAGE15-5	Air-061	Air	74,924231	27,794296	74	55,453867	27	47,657768	16.7.	06:45:00			
	CAGE15-5	Air-062	Air	74,908122	27,713601	74	54,487297	27	42,816061	16.7.	07:45:00			
	CAGE15-5	Air-063	Air	74,910062	27,611638	74	54,60373	27	36,698298	16.7.	08:13:05			

	CAGE15-5	Air-064	Air	74,910947	27,567082	74	54,65684	27	34,024938	16.7.	08:25:13			
	CAGE15-5	Air-065	Air	74,911824	27,522070	74	54,709413	27	31,324222	16.7.	08:37:26			
	CAGE15-5	Air-066	Air	74,912478	27,488242	74	54,748671	27	29,294507	16.7.	08:45:48			
	CAGE15-5	Air-067	Air	74,925557	27,755269	74	55,533416	27	45,31613	16.7.	10:17:07			
	CAGE15-5	Air-068	Air	74,908328	27,675736	74	54,499672	27	40,544134	16.7.	11:37:45			
	CAGE15-5	Air-069	Air	74,909446	27,617827	74	54,566781	27	37,069615	16.7.	11:54:15			
	CAGE15-5	Air-070	Air	74,911800	27,495285	74	54,707997	27	29,717117	16.7.	12:29:04			
	CAGE15-5	Air-071	Air	74,928074	27,652630	74	55,684413	27	39,157813	16.7.	13:35:14			
W 3d cube line1	CAGE15-5	1176	CTD	74,921667	27,458933	74	55,300000	27	27,536000	17.7.	10:50:09			
W 3d cube line32	CAGE15-5	1177	CTD	74,913298	27,457600	74	54,797900	27	27,456000	17.7.	11:42:08			
S 3D cube	CAGE15-5	1178	CTD	74,912338	27,533558	74	54,740256	27	32,013507	17.7.	12:21:33			
	CAGE15-5	1179	PN	74,912338	27,533558	74	54,740256	27	32,013507	17.7.	12:50:00			
	CAGE15-5	1180	CTD	74,922713	27,534791	74	55,362769	27	32,087485	17.7.	14:36:35			
	CAGE15-5	1181	CTD	74,931909	27,539345	74	55,914568	27	32,360710	17.7.	15:18:58			
	CAGE15-5	1182	CTD	74,916484	27,591998	74	54,989069	27	35,519900	17.7.	16:02:00			
	CAGE15-5	1183	CTD	74,912879	27,616636	74	54,772727	27	36,998130	17.7.	16:49:00			
	CAGE15-5	1184	CTD	74,920187	27,613277	74	55,211226	27	36,796637	17.7.	17:26:00			
	CAGE15-5	1185	CTD	74,919746	27,629905	74	55,184775	27	37,794308	17.7.	18:03:00			
	CAGE15-5	1186	PN	74,919746	27,629905	74	55,184775	27	37,794308	17.7.	19:30:00			
	CAGE15-5	1187	CTD	74,929398	27,613542	74	55,763900	27	36,812549	17.7.	20:10:00			
	CAGE15-5	1188	CTD	74,928512	27,692384	74	55,710712	27	41,543018	17.7.	20:51:00			
	CAGE15-5	1189	CTD	74,917549	27,693053	74	55,052947	27	41,583153	17.7.	21:25:00			
	CAGE15-5	1190	CTD	74,910321	27,689500	74	54,619284	27	41,370000	17.7.	21:54:00			

	CAGE15-5	1191	CTD	74,911875	27,747049	74	54,712503	27	44,822914	17.7.	22:30:00			
	CAGE15-5	1192	CTD	74,907729	27,764150	74	54,463732	27	45,848999	17.7.	23:00:00			
	CAGE15-5	1193	CTD	74,915733	27,761549	74	54,944000	27	45,692936	17.7.	23:37:00			
	CAGE15-5	1194	CTD	74,916608	27,767683	74	54,996500	27	46,060989	18.7.	00:05:00			
	CAGE15-5	1195	PN	74,916745	27,767400	74	55,004687	27	46,044021	18.7.	00:28:00			
	CAGE15-5	1196	CTD	74,926297	27,772860	74	55,577800	27	46,371600	18.7.	01:52:00			
	CAGE15-5	1197	CTD	74,915938	27,846232	74	54,956300	27	50,773900	18.7.	02:40:00			
	CAGE15-5	1198	PN	74,915503	27,845088	74	54,930187	27	50,705266	18.7.	03:13:00			
	CAGE15-5	1199	CTD	74,906765	27,842467	74	54,405900	27	50,548000	18.7.	04:44:00			
	CAGE15-5	1200	BC	74,915552	27,844163	74	54,933144	27	50,649751	18.7.	05:36:00	0,4	330	
	CAGE15-5	1201	GC	74,915242	27,844578	74	54,914500	27	50,674700	18.7.	06:17:48	0	330	Empty
	CAGE15-5	1202	GC	74,916915	27,766955	74	55,014920	27	46,017300	18.7.	07:06:34	0.7	326	
	CAGE15-5	1203	GC	74,915558	27,761374	74	54,933469	27	45,682427	18.7.	07:40:47	1,06	343	
	CAGE15-5	1204	GC	74,907947	27,763874	74	54,476813	27	45,832455	18.7.	08:09:48	0	335	Empty
	CAGE15-5	1205	GC	74,907995	27,762119	74	54,479691	27	45,727141	18.7.	09:00:39	0	336	Empty
	CAGE15-5	1206	GC	74,911863	27,739196	74	54,711763	27	44,351730	18.7.	09:27:21		331	Gas samples from sediment in core catcher
	CAGE15-5	1207	GC	74,909404	27,684893	74	54,564265	27	41,093580	18.7.	09:58:25	0	338	Empty
	CAGE15-5	1208	GC	74,918486	27,689147	74	55,109149	27	41,348800	18.7.	10:27:19	0,28	336	
	CAGE15-5	1209	GC	74,928823	27,689813	74	55,729379	27	41,388755	18.7.	10:57:28	0	331	Empty
	CAGE15-5	1210	GC	74,930211	27,620124	74	55,812655	27	37,207441	18.7.	11:34:05	0	335	Empty
	CAGE15-5	1211	GC	74,919588	27,629290	74	55,175275	27	37,757427	18.7.	12:19:27	0.8	335	Gas samples only (sediment without liner)
	CAGE15-5	1212	GC	74,919802	27,613157	74	55,188136	27	36,789418	18.7.	13:01:07	0	337	Empty
	CAGE15-5	1213	GC	74,912243	27,615659	74	54,734592	27	36,939563	18.7.	13:42:09	0	360	Empty

	CAGE15-5	1214	GC	74,912066	27,614372	74	54,723974	27	36,862308	18.7.	14:04:49	1,57	360	Slushy sediments, not filling the entire length
	CAGE15-5	1215	GC	74,916426	27,592084	74	54,985576	27	35,525062	18.7.	14:42:16	0	357	Empty
	CAGE15-5	1216	GC	74,915587	27,588738	74	54,935234	27	35,324303	18.7.	15:00:44	0	359	Empty
	CAGE15-5	1217	GC	74,922553	27,535024	74	55,353200	27	32,101442	18.7.	15:39:15	0	330	Empty
	CAGE15-5	1218	GC	74,912239	27,533256	74	54,734351	27	31,995331	18.7.	16:12:35	0,2	335	Sampled for gas
	CAGE15-5	1219	BC	74,922548	27,533821	74	55,352855	27	32,029274	18.7.	16:56:28	0	329	Rocks, not enough sediments
	CAGE15-5	1220	BC	74,916031	27,589134	74	54,961873	27	35,348052	18.7.	17:36:08	0,21	356	Filled with sediments
Thor I Bank	CAGE15-5	1221	GC	73,609829	34,690774	73	36,589760	34	41,446438	19.7.	14:29:25	0,71	253	Gravity corer bent. Change to 3m pipe
	CAGE15-5	1222	GC	73,617360	34,601096	73	37,041586	34	36,065738	19.7.	16:08:20	1,30	310	
	CAGE15-5	1223	GC	73,617320	34,600923	73	37,039217	34	36,055368	19.7.	16:40:21	0	310	Empty
	CAGE15-5	1224	GC	73,617061	34,601639	73	37,023647	34	36,098357	19.7.	17:05:04	1,28	310	
	CAGE15-5	1225	GC	73,634135	34,676870	73	38,048071	34	40,612213	19.7.	17:49:46	1,86	305	
	CAGE15-5	1226	GC	73,633171	34,677639	73	37,990287	34	40,658313	19.7.	18:15:53	0,41	304	
	CAGE15-5	1227	GC	73,635268	34,681717	73	38,116074	34	40,902990	19.7.	18:38:55	1,18	304	
	CAGE15-5	1228	GC	73,635124	34,702593	73	38,107419	34	42,155578	19.7.	19:08:26	0,94	291	
	CAGE15-5	1229	GC	73,635354	34,698684	73	38,121231	34	41,921060	19.7.	19:37:41	0,69	291	
	CAGE15-5	1230	GC	73,648626	34,728707	73	38,917587	34	43,722390	19.7.	20:14:39	1,49	300	
	CAGE15-5	1231	GC	73,649717	34,725984	73	38,983019	34	43,559060	19.7.	20:41:14	142	303	
Storfjordrenna	CAGE15-5	Air-072	Air	74,906569	27,735416	74	54,394138	27	44,124976	16.7.	15:06:11			
	CAGE15-5	Air-073	Air	74,909285	27,597685	74	54,557127	27	35,861115	16.7.	15:41:31			
	CAGE15-5	Air-074	Air	74,909895	27,566673	74	54,593712	27	34,000368	16.7.	15:48:59			
	CAGE15-5	Air-075	Air	74,910789	27,520593	74	54,647357	27	31,235552	16.7.	16:01:23			
	CAGE15-5	Air-076	Air	74,912319	27,533715	74	54,739159	27	32,022906	17.7.	12:29:15			

	CAGE15-5	Air-077	Air	74,922592	27,534979	74	55,355494	27	32,098733	17.7.	14:32:03			
	CAGE15-5	Air-078	Air	74,931885	27,540004	74	55,913111	27	32,400258	17.7.	15:21:37			
	CAGE15-5	Air-079	Air	74,916448	27,591697	74	54,986856	27	35,501793	17.7.	16:01:52			
	CAGE15-5	Air-080	Air	74,912899	27,615490	74	54,773914	27	36,929419	17.7.	16:57:31			
	CAGE15-5	Air-081	Air	74,920199	27,613070	74	55,211916	27	36,784209	17.7.	17:22:31			
	CAGE15-5	Air-082	Air	74,919373	27,630272	74	55,162373	27	37,816298	17.7.	17:54:33			
	CAGE15-5	Air-083	Air	74,929666	27,612882	74	55,779956	27	36,772903	17.7.	20:14:31			
	CAGE15-5	Air-084	Air	74,928309	27,695474	74	55,698531	27	41,728465	17.7.	20:43:38			
	CAGE15-5	Air-085	Air	74,917761	27,691787	74	55,065649	27	41,507213	17.7.	21:25:43			
	CAGE15-5	Air-086	Air	74,909855	27,690007	74	54,591286	27	41,400441	17.7.	21:47:17			
	CAGE15-5	Air-087	Air	74,911863	27,747262	74	54,711779	27	44,835717	17.7.	22:27:49			
	CAGE15-5	Air-088	Air	74,907418	27,763000	74	54,445104	27	45,780023	17.7.	22:54:53			
	CAGE15-5	Air-089	Air	74,915465	27,762110	74	54,927878	27	45,726594	17.7.	23:26:27			
	CAGE15-5	Air-090	Air	74,916346	27,767947	74	54,980789	27	46,076823	17.7.	23:59:15			
	CAGE15-5	Air-091	Air	74,926387	27,772171	74	55,583231	27	46,330271	18.7.	01:50:51			
	CAGE15-5	Air-092	Air	74,915749	27,845618	74	54,944919	27	50,737076	18.7.	02:26:37			
	CAGE15-5	Air-093	Air	74,906594	27,840939	74	54,395618	27	50,456318	18.7.	04:34:55			
	CAGE15-5	Air-094	Air	76,105873	16,025202	76	6,352397	16	1,512110	22.7.	03:39:06			
	CAGE15-5	Air-095	Air	76,107448	15,971470	76	6,446861	15	58,288196	22.7.	04:22:14			
	CAGE15-5	Air-096	Air	76,119000	16,068782	76	7,140003	16	4,126892	22.7.	04:43:46			
	CAGE15-5	Air-097	Air	76,108792	16,088928	76	6,527506	16	5,335690	22.7.	04:56:40			
	CAGE15-5	Air-098	Air	76,105438	16,035691	76	6,326257	16	2,141478	22.7.	05:17:25			
	CAGE15-5	Air-099	Air	76,114512	16,004497	76	6,870748	16	0,269825	22.7.	05:26:06			

	CAGE15-5	Air-100	Air	76,106138	16,011082	76	6,368298	16	0,664898	22.7.	06:06:47			
	CAGE15-5	Air-101	Air	76,107093	15,963379	76	6,425604	15	57,802721	22.7.	06:16:16			
	CAGE15-5	Air-102	Air	76,108424	15,979407	76	6,505416	15	58,764409	22.7.	06:44:02			
	CAGE15-5	Air-103	Air	76,108603	16,088535	76	6,516173	16	5,312117	22.7.	07:13:48			
	CAGE15-5	Air-104	Air	76,113164	16,009679	76	6,789859	16	0,580727	22.7.	07:41:49			
	CAGE15-5	Air-105	Air	76,117081	15,996555	76	7,024860	15	59,793285	22.7.	07:46:03			
	CAGE15-5	Air-106	Air	76,123216	15,975558	76	7,392930	15	58,533489	22.7.	07:54:06			
	CAGE15-5	Air-107	Air	76,291828	15,772520	76	17,509705	15	46,351229	22.7.	09:20:17			

5.3. 3D seismic line log

Expedition: Helmer Hanssen July 2015 Survey: Crater area 13.07 – 17.07 Sheet #: 1 - 9

Survey configuration: 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	13.07-13.07	20:07-20:44	31-399	N/A	TEST LINE Shot interval changed to 6 seconds due to lack of pressure. Channels 30, 57 deactivated due to high noise.
1	13.07-13.07	20:51-22:11	400-1204	467-1202	Sailing ESE, ship speed 4.0 kn, wind speed 8.1 m/s, wind direction 28 deg Gun pressure reduced to 1.60 bars **Paravane length @153m**
2	13.07-13.07	22:28-23:50	1205-2018	1262-2008	Sailing WNW, ship speed 3.7 kn, wind speed 6.4 m/s, wind direction 48 deg Channel #42 disabled due to high noise
3	14.07-14.07	00:08-01:27	2019-2770	2045-2765	Sailing ESE, ship speed 4.4 kn, wind speed 4.8 m/s, wind direction 48 deg
4	14.07-14.07	01:48-03:05	2771-3540	2815-3535	Sailing WNW, ship speed 3.9 kn, wind speed 3.5 m/s, wind direction 23 deg Incomplete datafile 3069, 3070, 3497, 3498
5	14.07-14.07	03:22-04:38	3541-4307	3586-4302	Sailing ESE, ship speed 4.3 kn, wind speed 3.0 m/s, wind direction 44 deg Incomplete datafile 3826, 4016, 4017, 4086, 4087, 4109, 4110,4151, 4152,4180,4181,4247,4248,4254,4255,4287,4288
6	14.07-14.07	04:54-6:09	4308-5082	4355-5058	Sailing WNW, ship speed 4.3 kn, wind speed 4.0 m/s, wind direction 29 deg Incomplete datasets 4453, 4455,4456 Serial string not detected at 07:07am (between shots 4455 and 4456; UTC time 05:07am) Incomplete datasets 4667,4668,4669,4670 Serial string not detected at 07:28am (UTC time 05:28am) Incomplete datasets 4895,4896, 4897, 4898 Serial string not detected at 07:50am (UTC 5:50) All incomplete datasets and serial string messages within line 5 and line 6 seem to appear at similar times to craters. Incomplete Datafiles 5060, 5061, 5069, 5070 (serial string not

					detected)
7	14.07-14.07	06:27-07:46	5083-5886	5121-5877	Sailing ESE, ship speed 3.9 kn, wind speed 5.1 m/s, wind direction 13 deg. Slight navigation deviation around 07:08 shot number 5500. Incomplete Datafile 5490, 5852
8	14.07-14.07	08:02-09:23	5887-6740	5926-6719	Sailing WNW, ship speed 4.0 kn, wind speed 5.2 m/s, wind direction 5 deg. Incomplete datafile 6032, 6033, 6035, 6036, 6262, 6263, 6265, 6266, 6307-6348 due to seagull on ship GPS. Incomplete datafile 6598, 6599, 6633, 6634, 6635
9	14.07-14.07	09:36-10:56	6741-7550	6784-7515	Sailing ESE, ship speed 4.0 kn, wind speed 5.1 m/s, wind direction 13 deg Incomplete datafiles (seagulls) 7522-7524
10	14.07-14.07	11:08-12:24	7511-8346	7581-8335	Sailing WNW, ship speed 4.0 kn, wind speed 5.50 m/s, wind direction 1 deg Incomplete datafile 7647, 7867-7885,7762,7763, 8095,8096,8097,8098 Serial string not detected 13:57
11	14.07-14.07	12:37-13:49	8347-9087	8365-9081	Sailing ESE, ship speed 4.4 kn, wind speed 4.8 m/s, wind direction 14 deg Incomplete datafile 8408,8409,8597,8598,8824,8825,8928,8929,8945, 8946,8957,8958,8985,8986,9007,9008, Serial string not detected 14:41,15:38,
12	14.07-14.07	14:04-15:34	9088-9877	9118-9871	Sailing WNW, ship speed 4.0 kn, wind speed 5.50 m/s, wind direction 450 deg Incomplete datafiles 9411-9449,9556,9557,9722-9725, 9732-35, 9759-62,9777,9778,9781,9782, 9784-9787,9790,9791, 9808, 9809,9821-24,9831-34, 9848, 9849 Trigger time threshold exceeded at 16:35,17:02, 17:03, 17:07, 17:09 (Local time) Serial string not detected 16:35, 17:02, 17:03, 17:07, 17:09, 17:12 (Local time) Channel 24 disabled eel 2 not responding, disarmed at 15:07 (UTC) and restarted immediately SPSU powered off and restarted at the end of line
13	14.07-14.07	15:42- 17:15	9878 - 10842	10006 - 10819	Sailing ESE, ship speed 4.0 kn, wind speed 5.8 m/s, wind direction 331 deg Incomplete datafiles 10098, 10099, 10125, 10126, 10352, 10353, 10367 10368, 10394, 10395, 10402 10403, 10404, 10431, 10432, 10458 10459, 10466-10470, 10502, 10504, 10521, 10522, 10534 - 10538 10554, 10555, 10557, 10558, 10626, 10628, 10637 10638, 10665, 10666, 10712 10713, 10722 10723, 10738, 10739, 10832

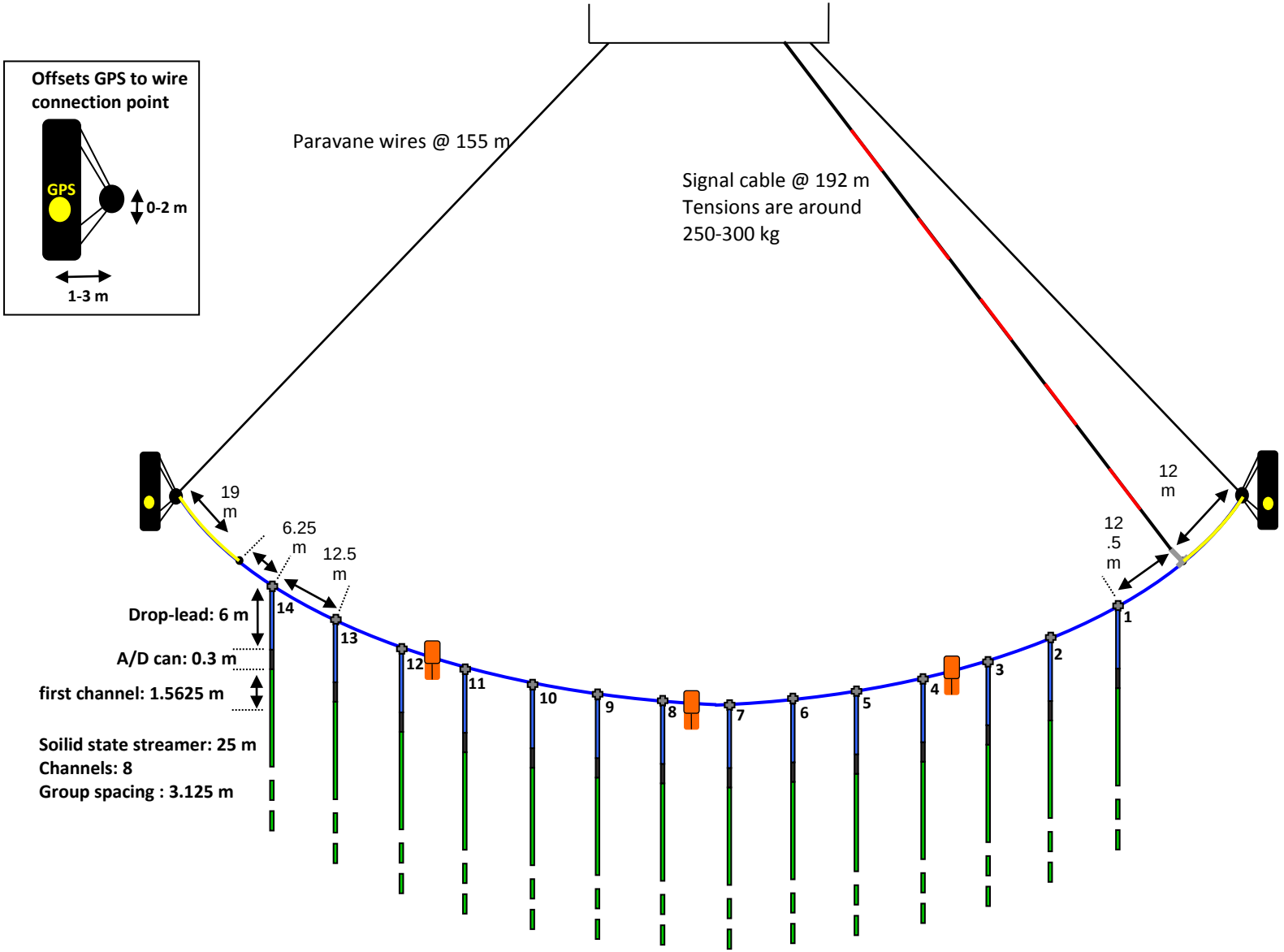
					10833 10835 10836 Serial string not detected 18:38 18:44 18:46 Trigger time threshold exceeded 18:44
14	14.07 – 14.07	17:26 – 18:54	10843 - 11747	10878 - 11703	Sailing WNW, ship speed 4.0 kn, wind speed 7.4 m/s, wind direction 330 deg Incomplete datafiles 10875, 10876, 10921 10922, 11027, 11028, 11059 11060,11159,11160,11175,11176,11197,11198,11238-41,11249-55,11259,11260,11280,11281,11292,11294,11305-08,11316-19,11345,346,11348,349,11445,446,11505,506,11521,522,11691,692 Serial string not detected. 20:00(local)
15	14.07-14.07	19:07-20:34	11748-12647	11783-12641	Sailing ESE, ship speed 4.0 kn, wind speed 7.4 m/s, wind direction 330 deg Incomplete datafiles 11748,749 11863,11864, 11866, 11869, 11897, 11898,11972,973,12183,84,87,88,89,90,91,92,93,12261-62,12317,318,12325,326,12337,38,12397-12405,12460,61,12487,488,12495 Trigger time threshold exceeded. Serial string not detected. Streamer 2 channels disabled (to test whether streamer 2 is creating the problem) @ ~12489 12571, 12572 Incomplete data file 12598, 12599 IDF Reactivated streamer 2 channels at shot 12605
System back on deck, replacing section 2 and streamer. Section 2 changed to s/n 6196. Depth sensor for 6196 not working. Deck cable damaged. SPSU on deck. Paravane length @155m					
16	15.07-15.07	00:48-02:11	12770 -13602	12837 - 13598	Sailing WNW, ship speed 4.0 kn, wind speed 6.6 m/s, wind direction 345 deg Channel 28 deactivated from 12984
17	15.07-15.07	02:28-03:47	13603-14396	13623-14380	Sailing ESE, ship speed 3.9 kn, wind speed 5.5 m/s, wind direction 328 deg
18	15.07-15.07	04:03-05:24	14397-15210	14435-15200	Sailing WNW, ship speed 4 kn, wind speed 7 m/s, wind direction 350 deg
19	15.07-15.07	05:40-07:03	15211-16032	15233-16207	Sailing ESE, ship speed 3.9 kn, wind speed 5.5 m/s, wind direction 335 deg

20	15.07-15.07	07:17-08:39	16033-16845	16075-16826	Sailing WNW, ship speed 3.7 kn, wind speed 4.9 m/s, wind direction 340 deg.
21	15.07-15.07	08:57 -10:20	16846-17680	16885-17663	Sailing ESE , ship speed 3.5 kn, wind speed 9.0 m/s, wind direction 345 deg.
22	15.07-15.07	10:35-11:59	17681- 18514	17720-18505	Sailing WNW, Ship speed 4 kn, wind speed 9 m/s, wind directions 350 deg.
23	15.07-15.07	12:17 – 13:32	18515 -19270	18535 - 19249	Sailing ESE, ship speed 3 kn, wind speed 8 m/s, wind directions 345 deg. Navigation data missing for the last shots due to lost seatrack signal, last shot with logged GPS time- 19248
24	15.07-15.07	13:48-15:11	19271-20140	19311-20126	Sailing WNW, Ship speed 4 kn, wind speed 8 m/s, wind direction 356 deg. Serial string not detected, incomplete data file 19477-84, 19574-19581,19670-77,19740-47, 19819-25,19899-909,20080,81,83-85,20092-95,97-99
25	15.07-15.07	15:27-16:50	20144-20981	20192-20960	Sailing ESE, ship speed 4 kn, wind speed 7 m/s, wind direction 356 deg Incomplete datafile 20184-20191
26	15.07-15.07	17:06-18:33	20982-21851	21017-21833	Sailing WNW, ship speed 3.4 kn, wind speed 5.7 m/s, wind direction 339 deg Serial string not detected, Incomplete datafile 21190-97
27	15.07-15.07	18:51-20:11	21856-22656	21889-22640	Sailing ESE, ship speed 3.9 kn, wind speed 4.9 m/s, wind direction 005 deg Serial string not detected 21:02, 21:03, 21:13 (local time not UTC)
28	15.07-15.07	20:27-22:01	22657-23586	22702-23576	Sailing WNW, ship speed 3.3 kn, wind speed 4.7 m/s, wind direction 340 deg. Serial string not detected 23:12 (local time not UTC)
29	15.07-15.07	22:20-23:40	23587-24388	23617-24365	Sailing ESE, ship speed 3.8 kn, wind speed 3.1 m/s, wind direction 1 deg. Serial string not detected 00:53, 01:28 (local time). Incomplete datafile 23927-30, 23932, 23933, 24284, 24285
30	16.07-16.07	00:00-01:33	24389-25320	24436-25309	Sailing WNW, ship speed 3.2 kn, wind speed 2.8 m/s, wind direction 350 deg
31	16.07-16.07	01:54-03:14	25321-26112	25358-26097	Sailing ESE, ship speed 4.2 kn, wind speed 3 m/s, wind direction 44 deg.

32	16.07-16.07	03:37- 05:01	26113- 26957	26141-26939	Sailing WNW, ship speed 3.3 kn, wind speed 2.2 m/s, wind direction 45 deg
33	16.07 – 16.07	05:25 – 06:54	26958 - 27846	26986 -27835	Sailing ESE, ship speed 3.6 kn, wind speed 4.7 m/s, wind direction 80 deg. Serial string not detected 07:49 (local time) Incomplete datafile 27213-20,
34	16.07-16.07	07:18-08:46	27847-28731	27871-28717	Sailing WNW, ship speed 3.6 kn, wind speed 4.9 m/s, wind direction 127 deg. Approx. 08:34 UTC may have a slight navigation gap.
35	16.07-16.07	09:12-10:33	28732-29537	28756-29522	Sailing ESE, ship speed 3.8 kn, wind speed 4.5 m/s, wind direction 97 deg. Serial String not detected 12:07 (local time) incomplete datafile 29287
36	16.07-16.07	10:55- 12:32	29538- 30507	29590- 30483	Sailing WNW, ship speed 3.5 kn, wind speed 4.9 m/s, wind direction 130 deg. Serial string not detected 13:30. Incomplete datafile 29909
37	16.07 – 16.07	12:59 – 14:17	30508 -31315	30532 - 31300	Sailing ESE, ship speed 3.8 kn, wind speed 5.2 m/s, wind direction 120 deg. 15 meters off track (to the left) in the beginning of this line. Serial string not detected 15:39 (local time) Incomplete datafile 30943 - 30953
38	16.07-16.07	14:43-16:08	31316-32184	31360-32172	Sailing WNW, ship speed 3.5 kn, wind speed 3 m/s, wind direction 120 deg. Incomplete datafile 31792-31806 Serial string not detected
39	16.07-16.07	16:37-17:58	32185-33005	32209-33001	Sailing ESE, ship speed 3.8 kn, wind speed 3.4 m/s, wind direction 90 deg. Incomplete datafile 32670,32671,32673,32674,32837-44 Serial string not detected 19:24,19:40
40	16.07-16.07	18:26-19:54	33006-33878	33040-33875	Sailing WNW, ship speed 3.6 kn, wind speed 1.8 m/s, wind direction 62 deg. Serial string not detected 21:31 (local time), incomplete datafile 33670
41	16.07-16.07	20:22-21:41	33879-34671	33919-34663	Sailing ESE, ship speed 3.9 kn, wind speed 2.5 m/s, wind direction 50 deg. Serial string not detected 2327 (local time), incomplete datafiles 34538-34551
42	16.07-16.07	22:08-23:53	34672-35548	34683-33543	Sailing WNW, ship speed 3.5 kn, wind speed 0.5 m/s, wind direction 310 deg Serial string not detect 00:47 (local time). Incomplete datafiles 35080-35089

43	17.07-17.07	00:04-01:17	35549-36293	35558-36271	Sailing ESE, ship speed 4.2 kn, wind speed 1.4 m/s, wind direction 295 deg.
44	17.07-17.07	01:47-03:22	36294-37229	36333-37221	Sailing WNW, ship speed 3.4 kn, wind speed 4.9 m/s, wind direction 317 deg
45	17.07-17.07	03:52-05:08	37230-37994	37264-37966	Sailing ESE, ship speed 4.2 kn, wind speed 6 m/s, wind direction 320 deg.
46	17.07 – 17.07	05:35 – 07:04	37995 - 38889	38045 - 38874	Sailing WNW, ship speed 3.4 kn, wind speed 6.8 m/s, wind direction 308 deg
15a	17.07-17.07	07:26-08:09	38890-39324	38944-39320	Filling gap between lines 15 and 17 – Sailing line is midway between 15+17. Sailing direction same as both 15+17 so azimuth for processing are the same Sailing ESE, ship speed 3.5 kn, wind speed 6.8 m/s, wind direction 310 deg. 09:37 local time serial string not detected 39012-16, 39181-39184 incomplete data files/serial string not detected
12a	17.07-17.07	08:34-09:22	329325-39804	39353-39788	Filling gap on line 12. Starting halfway through the original line 12, ending ~1200m before end of line 12. Sailing direction is the same as line 12 so azimuth for processing is the same. Sailing WNW, ship speed 3.4 kn, wind speed 5.5 m/s, wind direction 315 deg

Survey configuration:



Observed spread of paravanes: 160 -165 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: ~170-180 bar
Shooting interval: 6 sec
Recording window: 1.5 sec
Recording delay: 0 sec
Sampling interval: 0.5ms
Streamer depth: 1.5m

Switch no	6013	6196	6031	6012	6017	6028	6011	6030	6023	6034	6025	6026	6022	6019
Depth reading on deck after survey (m)	-2.10	NA	-0.58	0.15	0.11	0.04	0.36	-0.71	0.21	0.36	0.23	6.19	0.96	70.32

Yellow: kind of okay
Red: Wrong. Recalibration required

5.4. 2D line log

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
CAGE15-5-000	18.7.	Crater Area	18:36:00	1	74	56,101	27	26,672	19:13:00	445	74	56,595	27	21,057	3s	3	TEST SHOTS FOR 2D (mostly manual trigger shots). Streamer is on port side of the ship
CAGE15-5-001	18.7.	Crater Area	19:21:00	446	74	56,561	27	21,233	21:36:00	3143	74	56,260	27	54,910	3s	4	Shooting interval 3 s, recording length 1 s, sampling rate 0.25 ms, gun volume 30/30 in3, operating in harmonic mode, pressure 170 bar Preamp gain 8dB. WE ARE NOT RECORDING CHIRP DATA
CAGE15-5-002	22.7.	Storfjordrenna	03:20:00	226	76	6,224	16	7,197	04:01:10	1010	76	6,478	15	54,966	3s	4,8	Shooting interval 3 s, recording length 1 s, sampling rate 0.25 ms, gun volume 30/30 in3, operating in harmonic mode, pressure 170 bar Preamp gain 8dB.
CAGE15-5-003	22.7.	Storfjordrenna	04:11:36	1011	76	6,128	15	55,460	04:46:44	1713	76	7,203	16	4,795	3s	4,3	Shooting interval 3 s, recording length 1.5 s, sampling rate 0.25 ms, gun volume 30/30 in3, operating in harmonic mode, pressure 170 bar Preamp gain 8dB.
CAGE15-5-004	22.7.	Storfjordrenna	05:11:52	1714	76	5,997	16	3,269	05:31:26	2105	76	7,205	15	59,651	3s	4,5	Shooting interval 3 s, recording length 1.5 s, sampling rate 0.25 ms, gun volume 30/30 in3, operating in harmonic mode, pressure 170 bar Preamp gain 8dB.
CAGE15-5-005	22.7.	Storfjordrenna	05:56:51	2106	76	6,315	16	3,836	06:26:02	2689	76	6,437	15	54,713	3s	4,5	Shooting interval 3 s, recording length 1.5 s, sampling rate 0.25 ms, gun volume 15/15 in3, operating in harmonic mode,pressure 170 bar Preamp gain 8dB.
CAGE15-5-006	22.7.	Storfjordrenna	06:35:26	2690	76	6,232	15	56,428	07:04:49	3277	76	7,188	16	5,028	3s	4,7	Shooting interval 3 s, recording length 1.5 s, sampling rate 0.25 ms, gun volume 15/15 in3, operating in harmonic mode,pressure 170 bar Preamp gain 8dB.
CAGE15-5-007	22.7.	Storfjordrenna	07:27:56	3278	76	5,965	16	3,425	07:49:37	3711	76	7,211	15	59,128	3s	4,4	Shooting interval 3 s, recording length 1.5 s, sampling rate 0.25 ms, gun volume 15/15 in3,operating in harmonic mode, pressure 170 bar Preamp gain 8dB.