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R/V Helmer Hanssen

21st June -3rd July 2017

Longyearbyen – Tromsø

Cruise report CAGE 17-2 AMGG

Gas hydrate deposits and methane seepages in Storfjordrenna, Northern Flank of Olga Basin, and West Sentralbanken (Barents Sea): Biogeochemical and biological investigations

Chief Scientist: Giuliana Panieri
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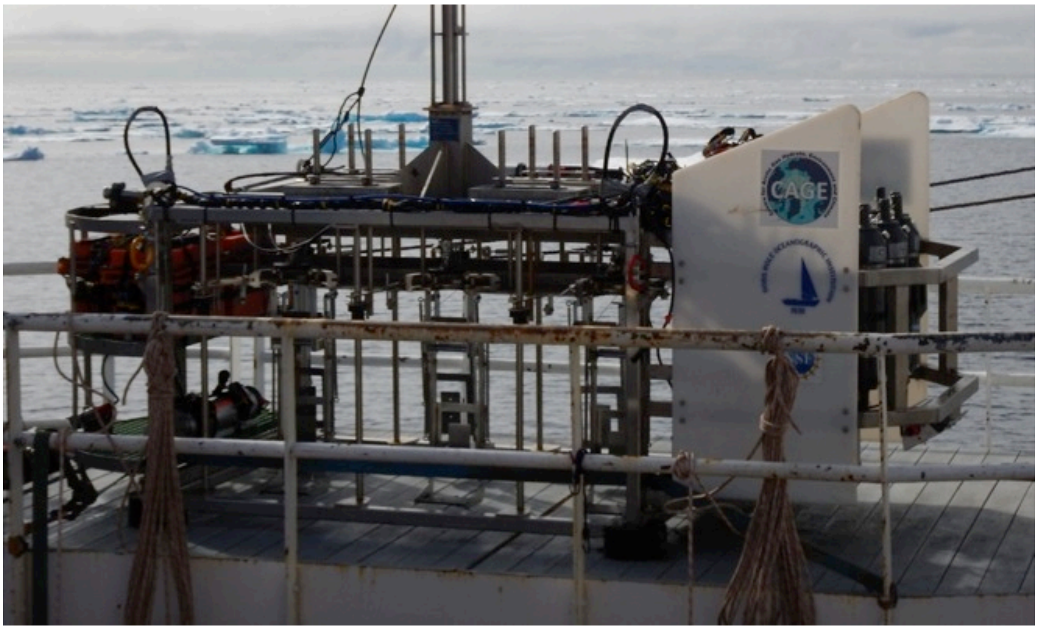

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1. Introduction and scientific objectives

The main goal of CAGE 17-2 AMGG cruise was to study the gas-hydrate-bearing system and methane emission off south and east of Spitsbergen in Storfjordrenna and the northern flank of Olga Basin (named here Olga craters) respectively, and in the West Sentralbanken.

We addressed this through a comprehensive scientific program comprising dives with the MISO-Tow Cam adapted to the multicorer frame from UiT-NPI (TowCam/Multicorer, TCM), methane measurements in sediments, water column, and in air, sediment coring (multicorer + gravity corer), water column and sediment biogeochemistry, microbiology, micropaleontology, and bathymetric mapping.

Cruise CAGE 17-2 was also hosting this year's AMGG research school cruise with masters, PhD and and post-doc students participating.

The areas investigated (Fig. 1) were:

- Storfjordrenna, Pingos site (ca 380 m water depth),
- Northern Flank of Olga Basin (ca 140 m water depth)
- West Sentralbanken (ca 200 m water depth)

We planned the following activities during the CAGE17-2 cruise:

1. EM 302 Simrad swath bathymetry mapping to identify seabed morphology
2. Mapping of flare distributions
3. CTD stations at different water depths and in different areas for measurements of i) ocean water masses characteristics, and ii) water sampling for water/gas chemistry and microbiology investigations across methane seeps.
4. TCM surveys (video-camera) to image seabed fluid flow expressions, sites of bacteria mats, crusts and gas bubbles.
5. Repeated deployments with TCM to sample surficial and shallow sediments with respect to microbiology, geochemistry, biogeochemistry, and micropaleontology.
6. Gravity corer for studying sediment biogeochemistry, biomarkers, microbiology, and foraminifera.
7. Scrape sampling to collect rocks and crusts.
8. Gas Chromatographer (GC) to measure methane concentration in the water and sediment samples.
9. Flasks Restek, Electro-Polished Miniature Canister (1000cc) for air samples.

2. Investigated areas

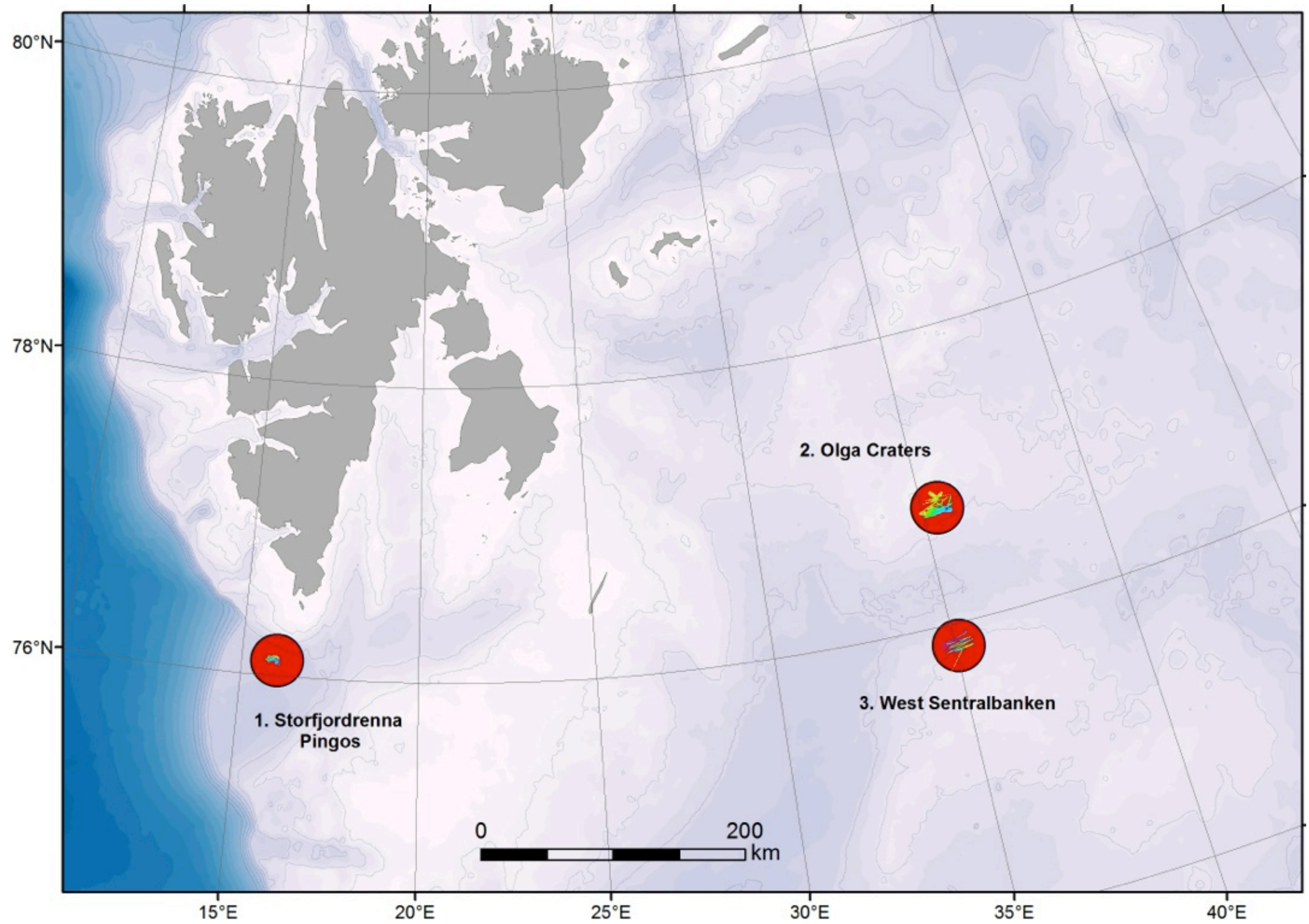


Figure 1 - Investigated area during the CAGE17-2 AMGG cruise: Storfjordrenna Pingoes (named in this cruise report Pingo site), Northern Flank of Olga Basin (named in this cruise report Olga craters), and West Sentralbanken.

3. Scientific party

Scientist	Institution
Panieri Giuliana	CAGE-UiT
Fornari Daniel John	WHOI
Kuraas Greg	Seafloor Investigations- WHOI
Alexandropoulou Nikolitsa	CAGE-UiT
Bruvik Kine Liland	CAGE-UiT
Carrier Vincent	CAGE-UiT
Dessandier Pierre-Antoine	CAGE-UiT
Dølven Knut-Olav	CAGE-UiT
Gründger Friederike	CAGE-UiT
Lindgren Matteus	CAGE-UiT
Melaniuk Katarzyna	CAGE-UiT
Ofstad Siri	CAGE-UiT
Patton Henry	CAGE-UiT
Romeyn Rowan Peter	CAGE-UiT
Sauer Simone	IFREMER-CAGE
Sen Arunima	CAGE-UiT
Sert Muhammed Fatih	CAGE-UiT
Valberg Espen	CAGE-UiT
Yao Haoyi	CAGE-UiT
Engineers	
Olsen Bjørn Runar	UiT
Holm Truls	UiT

CAGE – UiT — CAGE - Centre for Arctic Gas hydrate, Environment and climate, Department of Geosciences, UiT The Arctic University of Norway

WHOI — Woods Hole Oceanographic Institution, USA

IFREMER — Unité de Recherche Géosciences Marines, Plouzané, France.

Shift1: 8:00 -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

4. Deviations from the intended cruise schedule

The cruise followed the intended cruise schedule as planned.

5. Compliance with the regulations for responsible marine research

We complied with the regulations for responsible marine research. The cruise activities were outside of the Svalbard National Park boundaries. None of our activities affected a high percentage of occurring microorganisms in the seep areas adversely, and none of our activities left a long-term impact on the ecosystems. The entire cruise took place outside of the West Svalbard National Park boundaries. We did not take any unnecessary samples. During the cruise the ship was operated in clean ship mode except for disposal of sediments after sampling.

6. Compliance with the regulations for Work routine for bringing and storing chemicals onboard R/V Helmer Hanssen

Chemical risk assessment for each methodology that involve chemicals has been compiled and sent prior the cruise to Inger Solheim, according to the rules established at UiT, The Arctic University of Norway.

7. Equipment on board

7.1. Subbottom profiler (Chirp)

A Edge Tech Chirp Subbottom profiler 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. It 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 1.25 Hz. The signal lasts 40 ms, starts at 1.5 kHz and end at 9 kHz. The penetration depth depends on the sediment type/thickness we have observed was 20 m.

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 to locate the methane emission sites since they are characterized by blanking sediment.

7.2. 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. During CAGE 17-2 cruise, the 38 KHz and 120 KHz has been used for depths up to 2 km and 500m respectively.

7.3. Multibeam Echosounder

A Kongsberg Simrad EM 302 multi-beam echo sounder has been installed in the hull of R/V Helmer Hansen, capable of transmitting 432 beams within a 120° swath. 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. Once data have been acquired, programs such as, Qimera, Geocap, are used for cleaning, filtering and processing.
Major advantages of the newly installed EM302 multibeam system are: larger number of beams per ping, resulting in better resolution and ability to record the water column data in 3D space. This makes EM302 a perfect tool for reconnaissance and choosing the targets for sampling based on the detailed geomorphology and precise locations of gas flares in the water column.

7.4. USBL system – more information from Bjorn

The USBL (Ultra Short Base Line) is an underwater positioning system. Side-mounted USBL system, still using the mount constructed on Svalbard during the CAGE 16-2 cruise.
The USBL system was used to reveal the position of the TowCam Multicorer with respect to the vessel during a dive. For this cruise, on the ship, we interfaced to the GPS Compass and the USBL.

7.5. 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 using max 12 Niskin bottles (5 Litres).
R/V Helmer Hanssen uses SBE 9 plus CTD for producing vertical profiles of seawater properties. A winch is used to lower the CTD system into the water. The SBE 9plus 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. The CTD sensors record data at a rate of 24 samples per second. The 9plus 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. A single conductor cable supplies the power to the system and transmits data from and to the CTD system real time.
During this cruise, we used the sound velocity profiles from different CTD station to calibrate depth calculations in the swath bathymetry data.

7.6. TowCam System Configuration (D. Fornari, G. Kurras)

TCM configuration for 2017 CAGE 17-2 Cruise to the Pingo sites and Olga Basin Craters (Jun 21 – Jul 3, 2017) is documented below. The primary acquisition systems consisted of: an Ocean Imaging Systems (OIS) deep-sea digital color still camera that uses a Nikon D3300 24 megapixel camera with Nikkor 20mm lens in a 6000 m-rated Ti housing with an optically corrected dome, two 300 W-s flash strobe heads powered by a single electronics in a separate pressure housing, a Seabird19plusV2 CTD and two Valeport VA500 units; one for altitude & depth, one for forward obstacle avoidance, and two ranging green lasers spaced 20 cm apart producing 2 dots in the imagery in the middle left portion of each image. A MISO DataLink telemetry system provided real-time connectivity to various sensors for display and recording at 1 Hz. Power to the MISO systems was provided by three (3) 24VDC deep-sea batteries, each having ~40 amp/hr capacity. A power junction box provided electrical connectivity between the sensors and battery and the synch pulse between the camera and strobe system. There were a few sensor changes and sensor additions over the period of the cruise- mostly related to removal of the SBE43 dissolved O2 sensor because of danger of freezing and damaging the unit, and a switch out of the down-looking VA500P altimeter. Between TC12 and TC13 the downward looking Valeport altimeter/depth unit was changed, and a CAGE HD video camera (1080P resolution DSPL FlexLink) was installed in the front of the TCM, pointed forward and down. 24VDC power was provided by the MISO system to the CAGEcam camera. Two MISO DSPL 5150 LED deep-sea lights were installed in the front of the TCM to illuminate the video camera field of view. The lights were switched on/off using a switch device in the MISO DataLink electronics. Note that the USBL system was not used for TC01 and TC12 due to various conditions & logistics.

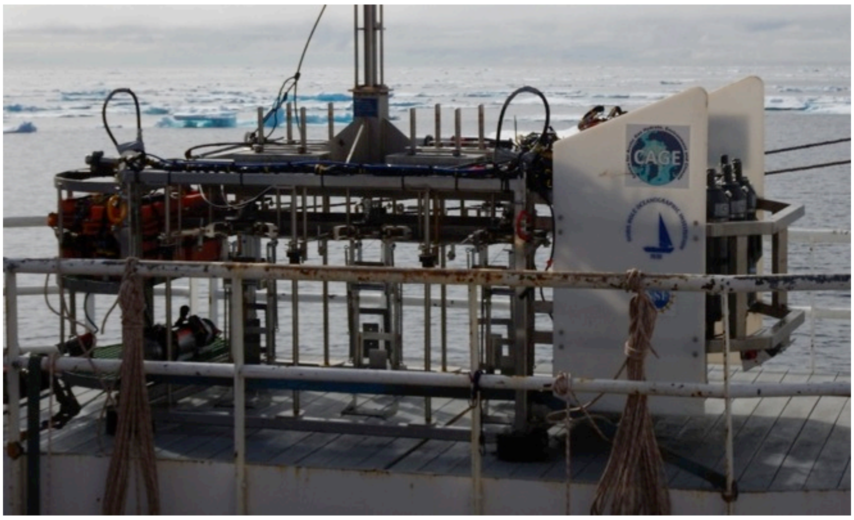


Figure 2 - TCM System CAGE17-2 in pancake ice in the western Barents Sea.

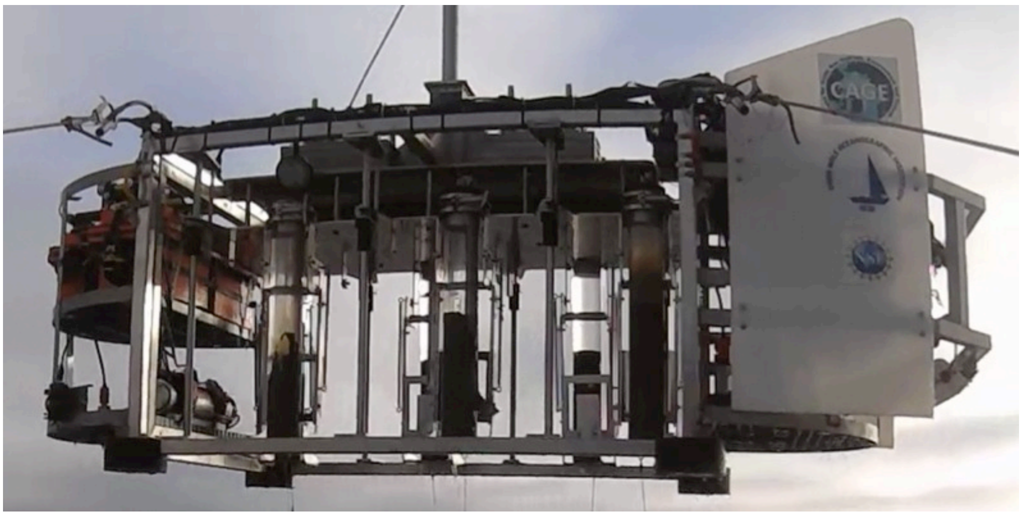


Figure 3 - TCM System CAGE17-2 retrieved with core samples.

7.7. Multicore system

The multicore sampling system is a KC Denmark DK8000 multicore acquiring 6 sample cores simultaneously.

The multicorer has been converted in a TowCam/Multicorer, TCM. The frame has been used to place the tow cam and sensors: ctd, salinity, and methane (details below). The multicore recovers six parallel 70 cm long tubes with a diameter of 10 cm from the same spot at the seafloor. The core tubes are loaded with open upper and lower ends. When the multi corer lands on the seafloor, the tubes are pushed into the soft sediment by lead weights, and closed on both ends. Up to 60 cm of sediment and the immediate overlying water can be sampled. This allows the analysis of undisturbed faunal samples within their undisturbed environment. Once on board, the core tubes filled with water end sediment. The liners were carefully taken out of the sampling device, the ends are sealed, and the cores moved, in an upright position, in the wet laboratory. Once in the lab, in racket to keep them vertical, the sampling of pore water, microbiology, micropaleontology start. To sample the cores, three extruders have been used by the different group to take samples at the same time.

In the present cruise, we were able to use real-time imaging capability to precisely guide the sampling locations of the Multicorer samples.

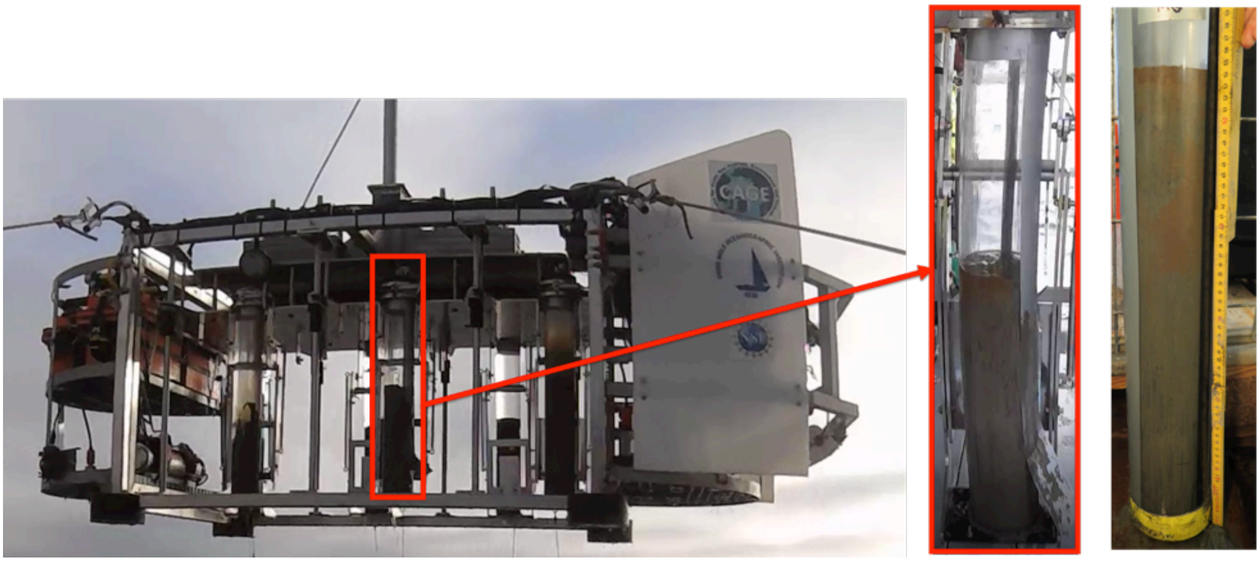


Figure 4 - The multicore sampling system is a KC Denmark DK8000 multicore acquiring 6 sample cores simultaneously.

7.8. CAGECam - **DSPL HD FlexLink Video System** (Fornari, Panieri, Olsen)

During the CAGE 17-2 cruise we test for the first time the recently acquired DSPL HD Flexlink video camera and LED lights to use for deep-sea imaging. The CAGE 17-2 cruise provided an opportunity to test part of the CAGE system and we successfully integrated the DSPL HD camera to the fiber optic cable, with power coming from the MISO deep-sea batteries on the TCM. The HD video camera was kept on for the duration of each lowering as its power consumption is low. 2 MISO LED lights (DSPL 5150, ~9000 lumens each) for illumination and provided switching of those lights from the MISO DataLink system (**Figure 3**). Switching the lights on/off was important as the lights draw ~5-6 amps, so in order not to impact other sensors on the TCM the total operational time for video lighting was restricted to ~2.5 hrs between battery charges.

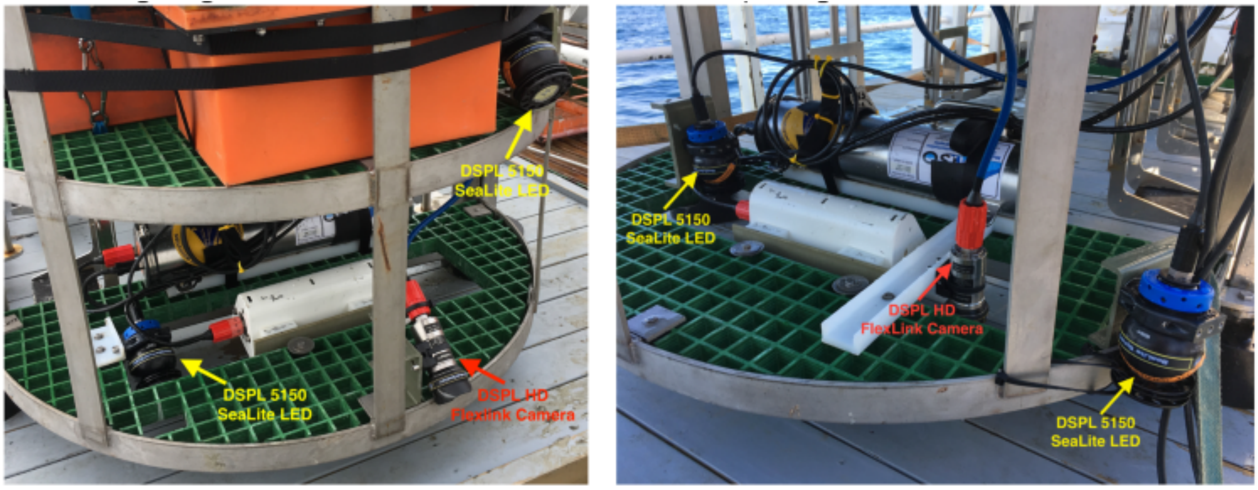


Figure 5 - Configuration of CAGECam DSPL HD Flexlink video camera.

DSPL HD Flexlink video camera and WHOI-MISO LED lights on the TCM system for the CAGE 17-2 cruise. **Figure 5**left image shows original configuration with the camera pointed approximately at a 45° angle downwards and lights also configured to fill the forward viewing image area. In **Figure 5**, right image shows the second configuration for the last few lowerings with the camera and lights pointed vertically down in the forward part of the TCM. This orientation helped with flying the TCM on the last few lowerings when the winch slip rings were not operating properly, causing connectivity to the TCM sensors to be interrupted. By placing the 2 laser dots at the bottom of the video image during real-time operations the TCM was ~2 m above the seafloor; that image was used to help fly the TCM during traverses on tows #23-26.
The videos are recorded on 256GB card. The video are usually recorded from 1.5 m altitude if not specified differently.

7.9. Sediment coring

The gravity corer onboard Helmer Hanssen consists of a 6m long iron barrel with iron weights attached on top of it. The whole apparatus weigh 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 cm is inserted in to the steel 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, and labeled. The

cores have been sampled for pore water, biogeochemistry and methane content. The cores were stored in the cold room.

7.10. Triangle Scrape

The triangle scrape is a benthic trawl that moves across the seafloor surface towed by the ship (2kts). It measures 1x1x1m and trails a net. This dredge is designed for mass collection of larger seafloor organisms in a non-quantifiable manner. In this cruise, we used this technique for collection of rocks and crusts. We ran triangle scrapes in methane seep sites and when we observed in the images or video areas with potential crusts.

7.11. Gas chromatographer

Gas measurements were done using a gas chromatograph (ThermoScientific) from CAGE-UiT, equipped with a flame ionization detector. Carrier gas (H2) brings the gas sample to the detector after passing through a capillary column (

Figure 6) that separates gas species with different molar masses and polarity in time (light gas is transported faster than heavy gas). Hence, one peak in the chromatogram corresponds to a specific gas species. To measure the gas concentration, a 0.5 ml gas sample was injected and the resulting detector peak integral corresponding to methane was calculated. The GC was calibrated with gas standards of known methane concentration.

Figure 6. Setup of Gas chromatographer on RV Helmer Hanssen.

8. Methods

8.1 Ship-Board Processing (H. Patton, R. Romein)

i) Bathymetry

At each location a CTD station was taken to measure the hydrographic parameters of the water column and adjust the sound velocity profile for the EM302. At Storfjordrenna, mulitbeam echosounder data acquisition was continuously recorded, although no lines were specifically planned for bathymetric mapping outside of the immediate Pingo area.

The acquisition of MAREANO data for the Northern Flank of Olga basin (named here Olga craters) area from 2015 meant that multibeam surveying of this area was primarily focused towards flare detection/confirmation. The large extent of the area meant a wide beam angle of 62° degrees was used during surveys in order to cover a maximum area possible. In water depths of <190 m in this area this provides a usable swath width of <600 m. The lines were typically collected at ship speeds of 4-8 knots.

57 multibeam lines were specifically surveyed at the Olga Crater site, with additional coverage coming from transits between sample sites (**Figure 9**). Some lines were extended westwards beyond the limits of the MAREANO dataset into the NPD mapped fault zone. No new craters or flares were observed in these areas. A narrow 30° beam angle was used for 3 lines surveying over the possible shipwreck site in order to obtain a higher resolution survey of this site.

8 multibeam lines were surveyed over the West Sentralbanken area, in a dispersed manner to cover as maximum an area as possible (**Figure 35**).

Multibeam echosounder data was filtered, processed, and exported as XYZ data in QPS Qimera.

ii) Flare detection

Gas flares were mapped from multi- and singlebeam echosounder water column data in FMMidwater and exported as ASCII XYZ data for filtering based on amplitude using a matlab script. Gas flares over the central crater depressions were mapped from 2015 MAREANO data prior to the cruise. These locations were used as targets to confirm flare activity in this region.

iii) USBL navigation

Precise positioning of the TCM on the seafloor was obtained by interfacing with the USBL system mounted on the port side of the ship. Absolute positioning is obtained by measuring the slant range and bearing from the USBL transponder to the TCM, then calculating a coordinate relative to the ship's on-board GPS position located on the mast. This processing is carried out in real-time using the proprietary software, Easytrack Nexus. Double logs were recorded, the first directly within Easytrack Nexus (raw data), and the second via a COM port datastream from this software to another computer (calculated). To extract the ship's GPS and the USBL-calculated TCM positions, the $GPGGA and $GPTLL data outputs were used. A python script was specifically written during the cruise to extract and convert this data into XYZ/shapefiles that could be plotted within a GIS.

The following points describe the processing workflow that was implemented with the Python script:

1. Extract $GPGGA and $GPTLL strings which represent ship and USBL positions respectively. Parse the strings to extract date/time and position information. A check is performed to ensure the ship and USBL times match for successive strings.
2. Search the extracted data for instances of duplicate time codes which were removed as they typically seemed to be associated with bad positions.
3. Apply a running median filter over a user specified sliding time window to smooth the data. The USBL positions tend to be very noisy and the median filtering proved a simple and effective means of recovering a realistic track. A filter window length of 60sec was used for the Storfjordrenna TCM dives (with water depth of approx. 370-380m). In the Olga crater area a filter length of 30sec gave the best performance of smoothing noise while preserving real turns (here the water depth was approx. 160-180m so the USBL positions were less noisy). The optimum filter parameters were determined by trialing different window lengths and visually assessing how the resulting track represents the raw, unfiltered USBL points.
4. The USBL and ship positions are interpolated to a regular 1sec sampling interval over the duration of each TCM dive using 1D linear interpolation applied independently to latitude and longitude fields.
5. The second log of USBL and ship position are written to ASCII files for each dive which are then converted to line and point shapefiles using arcpy. The shapefiles were then manually QC'd in ArcGIS for each TCM dive.

Optimum filtering window lengths for the Storfjordrenna and Olga Crater sites were decided to be 60 sec and 20 sec respectively. This difference reflects the more convoluted operations carried out at the Olga Basin, with the 60 second filter struggling to fit data along more circular tracks. Filtered tracks with 20, 30 and 60 second window lengths have been provided for all sites where there is available data. Sampling stations and image locations from the TCM were georectified from the ship's GPS position to these filtered USBL tracks based on timestamps.
Several operational issues with the USBL navigation data were encountered during the cruise:

1) The benefits of double-logging became evident when errors in the datastream recording surfaced and the TCM navigation could not be processed correctly. Easytrack Nexus allows the replaying (and thus re-recording of the datastream link) of saved raw logs. Software settings can be adjusted to modify the outputted datastream from the raw data.
2) The correct UTM zone must be specified prior to recording. At the Olga Crater area site an initial UTM zone of 33N was kept, which then inflicted a 300 m offset on the TCM's true position.

Notes on USBL corrections for the TowCam lowerings:
TC01, TC02, TC12: USBL transponder was not recording. Ship tracks extracted from the Ship's GPS datastream were used instead.
TC08: Missing data before 13:55
TC13: USBL transponder and the 1sec ship GPS log were not recording
TC14: Was recorded in the wrong UTM zone (33N). The raw log was not recorded properly in Easytrak Nexus so the file could not be replayed to correct the error as was done for other dives. The error introduced by projecting a geographic point from the study area (which is in UTM zone 36) to UTM zone 33 and then back to a geographic coordinate was measured as approx. 340m NNE by projecting back and

forth while forcing the incorrect UTM zone 33 to be used (using a UTM Python module). The towcam dive was relocated manually by back projecting along this offset vector to the true point that would map to the initial towcam location by projecting back and forth to UTM coordinates using UTM zone 33. The relocation is believed to be accurate to around the nearest meter. However, the TCM track is permanently offset in front of the ship. Ship's GPS was not recording either, though a log could be extracted from the USBL recording.

TC21: A gap in USBL recording appears around 14:55:33 until 15:07:08. Ship tracks can be extracted from the GPS log, though a couple of USBL correction gaps cannot be retrieved.

CHIRP Sub-bottom profiling

Five chirp sub-bottom profile lines were surveyed over the Olga Crater area (Figure 31). Thick sediment deposits were identified in two depressions: D1 and D2. These sites were later targeted for gravity coring. Elsewhere across the area, sediment cover is limited. The variation in sediment cover is illustrated in

Figure 7.

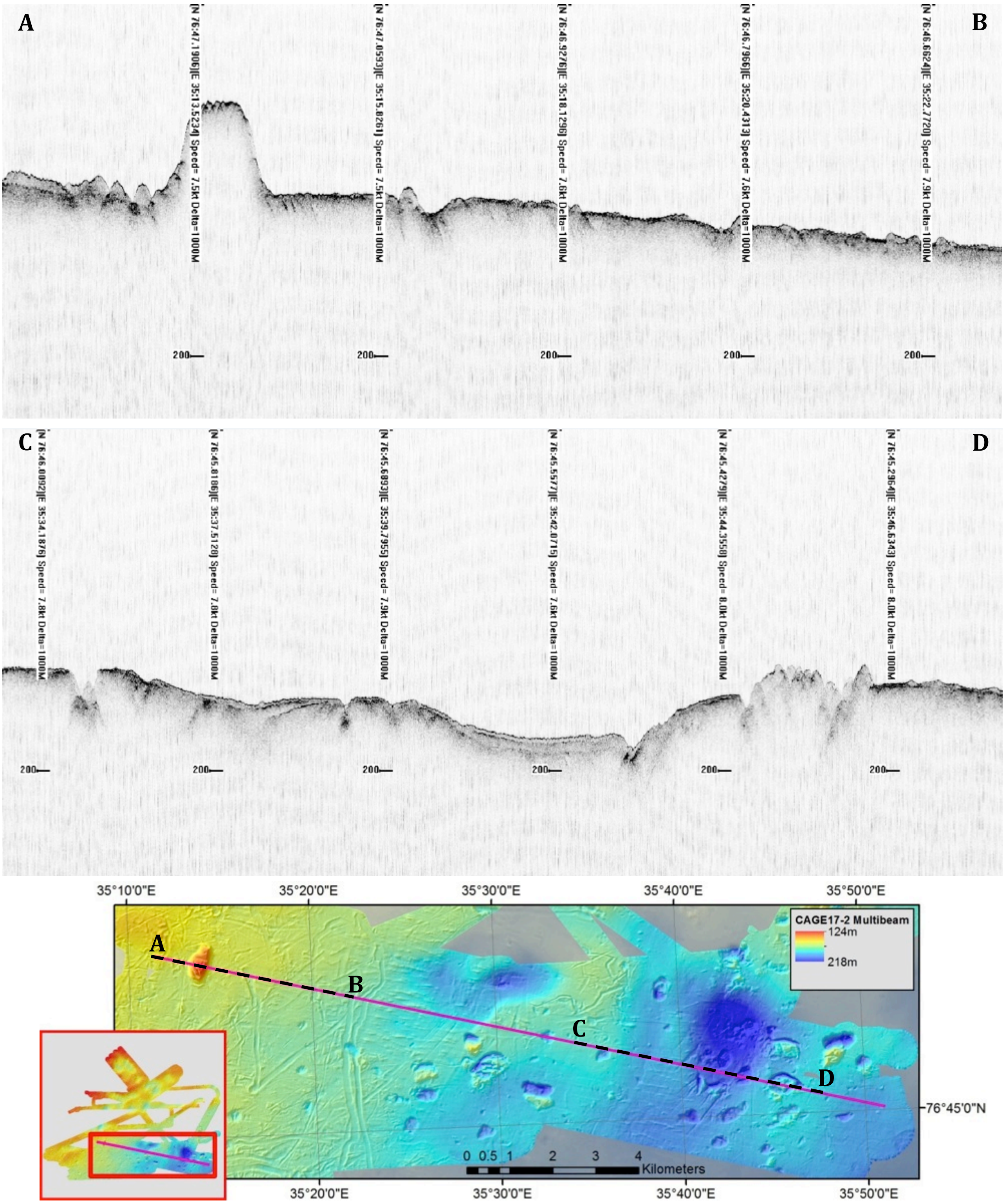


Figure 7 – Illustrative sections from a chirp sub-bottom profile across the Olga craters site. Sediments up to 15m thick were imaged within the large depression (D1) in the SE part of the surveyed area but sediment cover was limited outside of the craters. The location map (bottom) full profile is shown in pink while the black dashed lines mark the sections of the profile shown in the figure.

8.2. Acoustic surveying preliminary results (H.Patton and R.Romeyn)

Storfjordrenna Pingo Site

The multibeam bathymetry collected in the Storfjordrenna Pingos site during the CAGE 17-2 cruise is illustrated in **Figure 8**. Since multibeam mapping was not the primary focus at this site the data was collected along an irregular track, at varying speeds and during turns. Since the data was not collected along a regular survey grid it was relatively noisy.

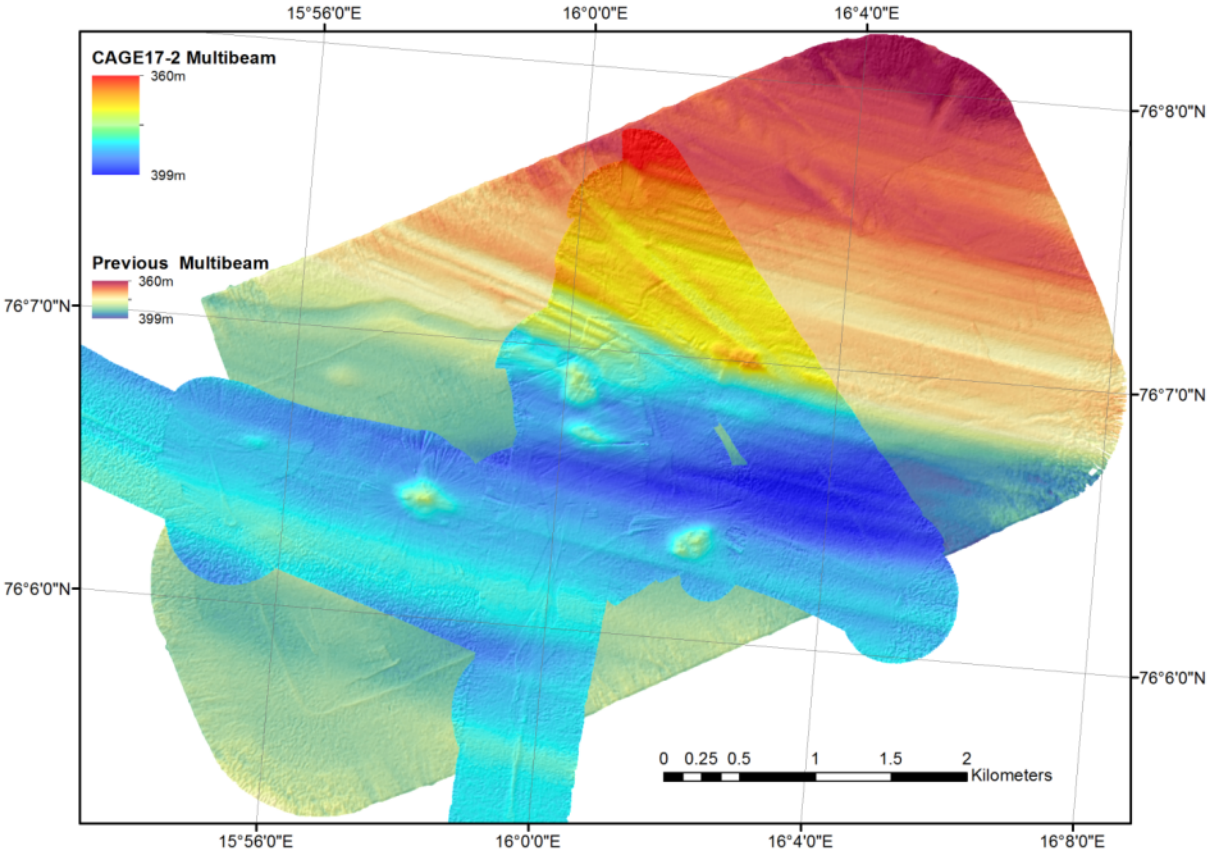


Figure 8 – overview of multibeam bathymetry collected at the Storfjordrenna Pingos site during the CAGE 17-2 cruise, gridded to 3m cell size. Previously available multibeam data (2m cell size) is shown in the background for context.

Olga Craters Site

Figure 9 shows an overview of the multibeam bathymetry collected during the CAGE17-2 survey. The multibeam surveying was primarily focused on identifying gas flares since the bathymetry of the area has already been mapped by MAREANO in 2015.

Acoustic anomalies identified as gas flares typically had a stronger response on the lower frequency (18kHz and 38kHz) singlebeam echosounder (EK60) channels (e.g. **Figure 17**). By contrast, acoustic anomalies that appear to be associated with fish/krill had a strong response at 120kHz but were much weaker at the lower frequencies (see **Figure 30**). This contrast in frequency response was used to distinguish gas flares from schools of fish during the acoustic surveying of the Olga craters site.

Table 1 is a log of the gas flares identified during preliminary shipboard interpretation of multibeam and singlebeam echosounder data and **Figure 11**-**Figure 29** illustrate these flares as they were picked using QPS

FMMidwater. **Figure 10** shows an overview of the distribution of gas flares observed in the Olga craters site. All of the flares observed during the CAGE 17-2 survey correspond with acoustic water column anomalies identified in the MAREANO 2015 dataset. The smaller acoustic anomalies from the MAREANO 2015 dataset were not observed during the CAGE 17-2 survey. Two explanations are possible: 1) the small acoustic anomalies in the MAREANO 2015 dataset may have been produced by schools of fish (such schools were abundantly observed during the CAGE 17-2 survey), 2) gas leakage has ceased through the smaller flow pathways at some point between 2015 and 2017.

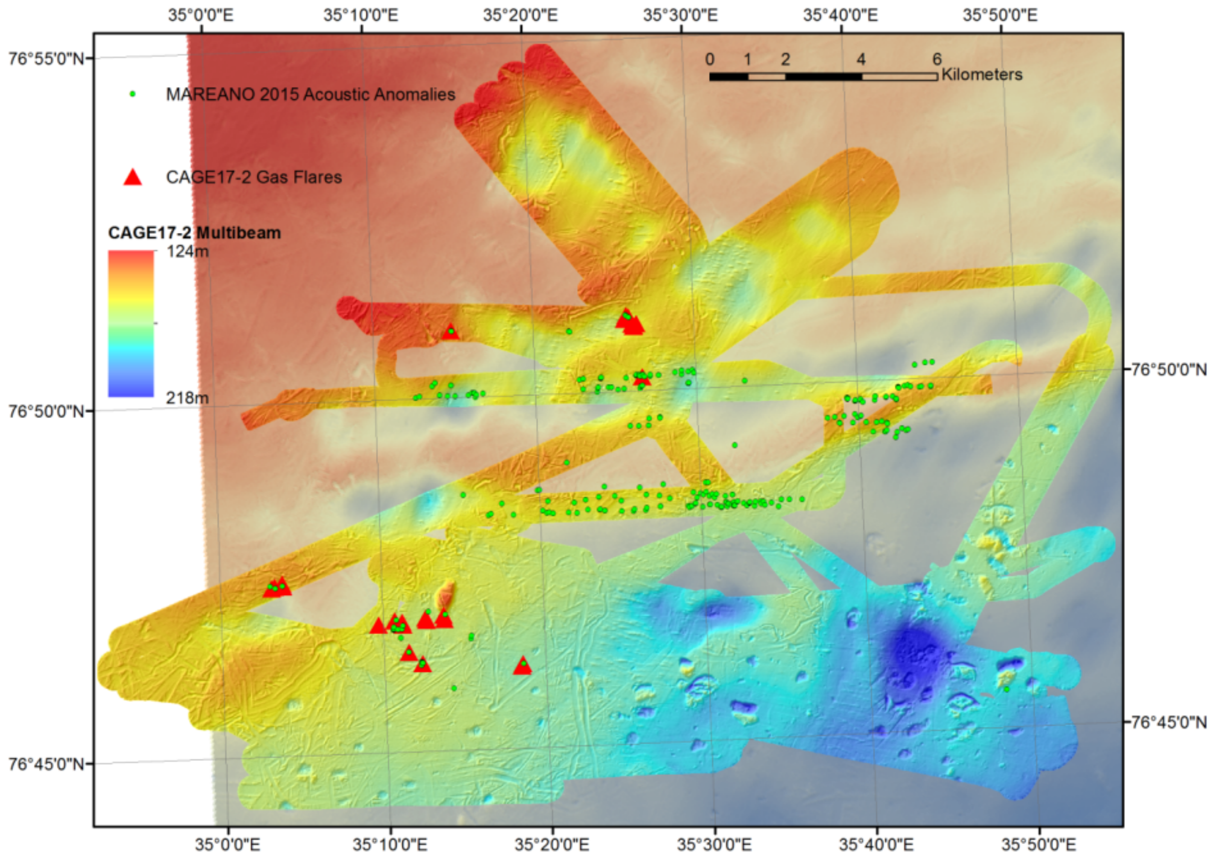


Figure 9 – overview of multibeam bathymetry collected in the Olga craters area overlaid on MAREANO 2015 bathymetry. The locations of gas flares identified during the CAGE 17-2 survey are plotted with red triangles and acoustic water column anomalies identified in the MAREANO 2015 dataset are plotted with green circles.

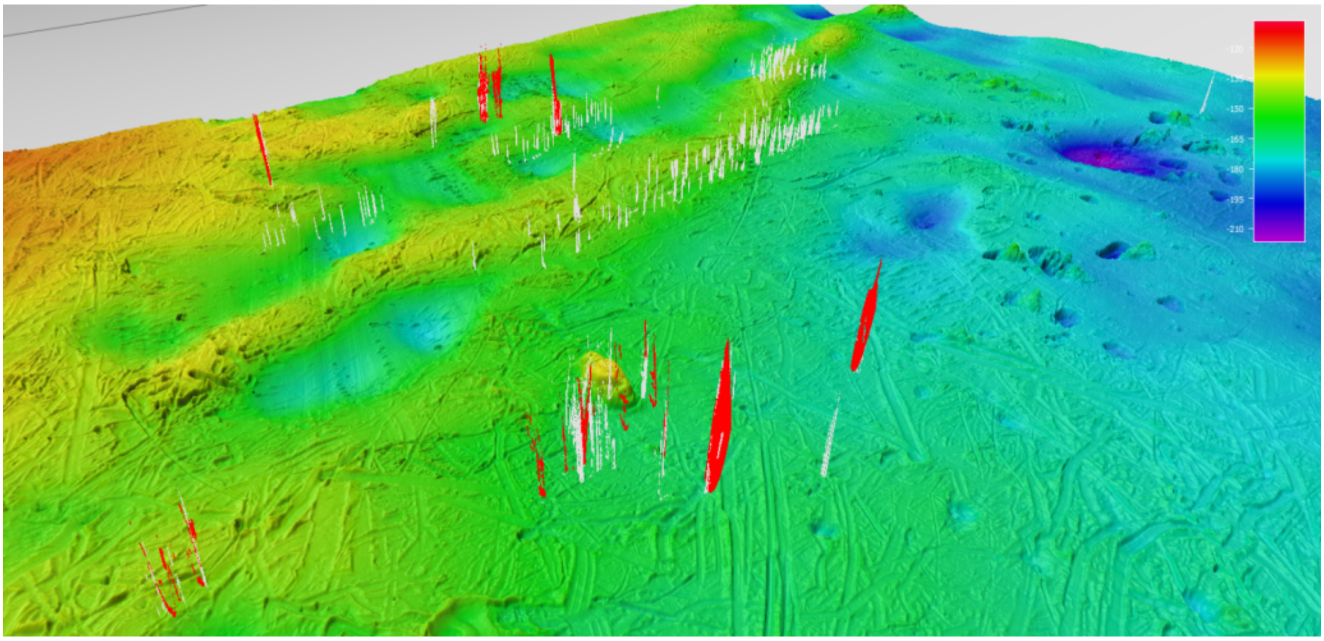


Figure 10 – Overview of acoustic anomalies identified in the Olga craters area. The flares identified during the CAGE17-2 survey are shown in red while acoustic anomalies identified in a MAREANO dataset from 2015 are shown in grey. 3D visualization in Fledermaus with bathymetry from MAREANO 2015.

Table 1 – Log of preliminary gas flare identification for the Olga craters study area

Flare ID	Instrument	Date	Time	Lat DDMMSS	Lon DDMMSS	Data File
1	EM302	26-June 2017	11:52	76 46 50.89	35 11 12.72	0026_20170626_114448_HH
2	EM302	26-June 2017	11:55	76 46 53.02	35 09 53.53	0027_20170626_115404_HH
3	EM302	27-June 2017	00:29	76 46 52.13	35 13 06.42	0054_20170627_001612_HH
4	EM302	27-June 2017	06:51	76 46 51.95	35 11 13.52	0069_20170627_063937_HH
5	EM302	27-June 2017	22:38	76 50 12.81	35 27 17.18	0093_20170627_221350_HH
5	EK60	27-June 2017	22:38	76 50 12.78	35 26 33.76	CAGE_17_1-D20170627-T222546
6	EK60	27-June 2017	23:54	76 50 57.08	35 14 30.52	CAGE_17_1-D20170627-T231829
6	EM302	27-June 2017	23:55	76 50 56.93	35 14 38.23	0098_20170627_234547_HH
7	EM302	28-June 2017	00:31	76 51 21.24	35 28 35.53	0100_20170628_002537_HH
7	EK60	28-June 2017	00:32	76 51 03.68	35 25 52.85	CAGE_17_1-D20170628-T001112

8	EM302	28-June 2017	21:20	76 47 29.05	35 04 09.48	0148_20170628_210539_HH
9	EM302	29-June 2017	21:13	76 46 16.15	35 12 24.00	0225_20170629_210554_HH
10	EM302	29-June 2017	21:32	76 46 12.86	35 18 28.20	0227_20170629_212427_HH
11	EM302	29-June 2017	23:38	76 46 21.88	35 11 43.55	0233_20170629_233254_HH

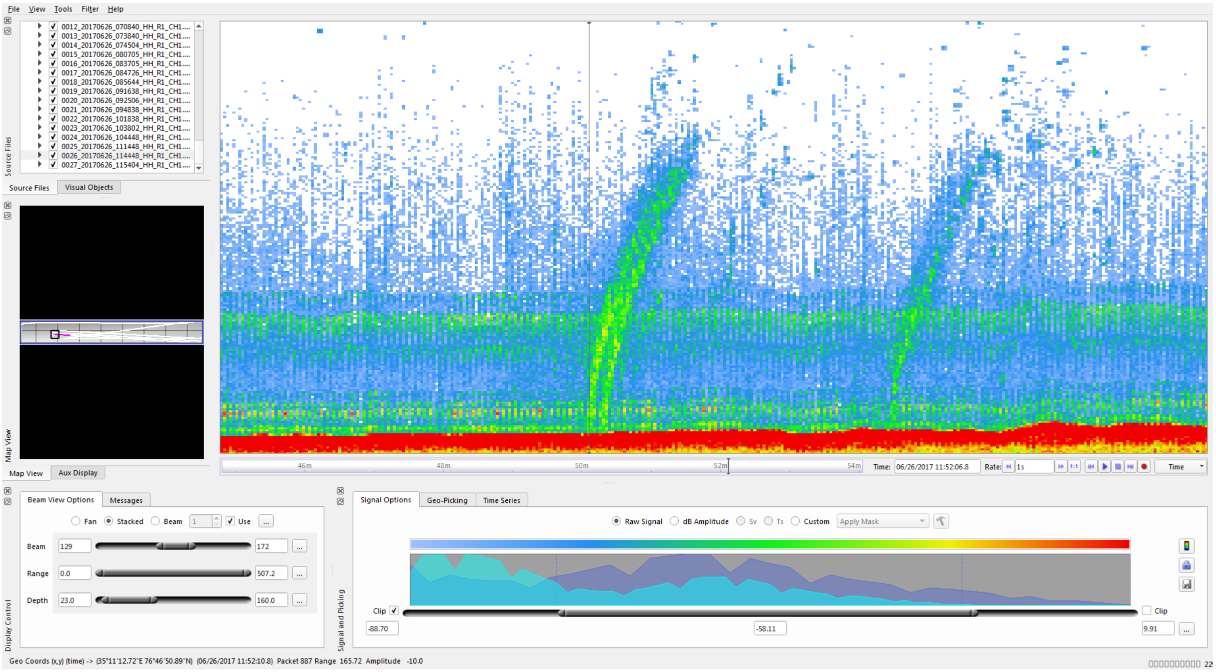


Figure 11 – Stacked multibeam profile of Flare ID 1 (see Table 1).

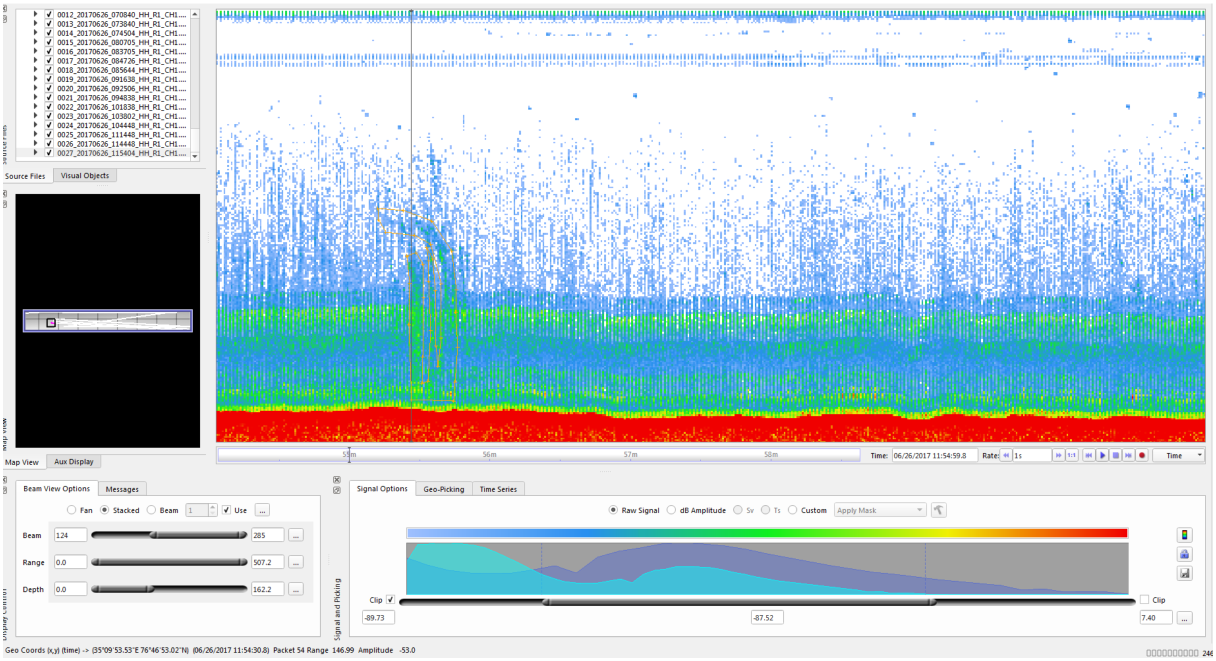


Figure 12 – Stacked multibeam profile of Flare ID 2 (see Table 1).

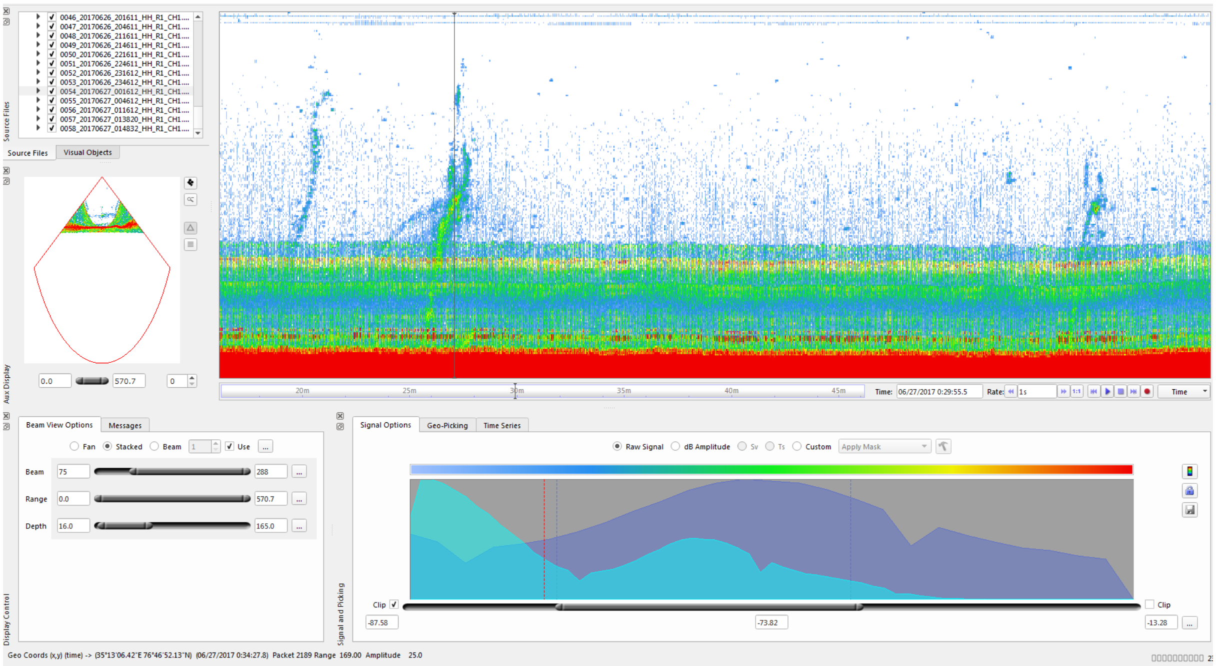


Figure 13 – Stacked multibeam profile of Flare ID 3 (see Table 1).

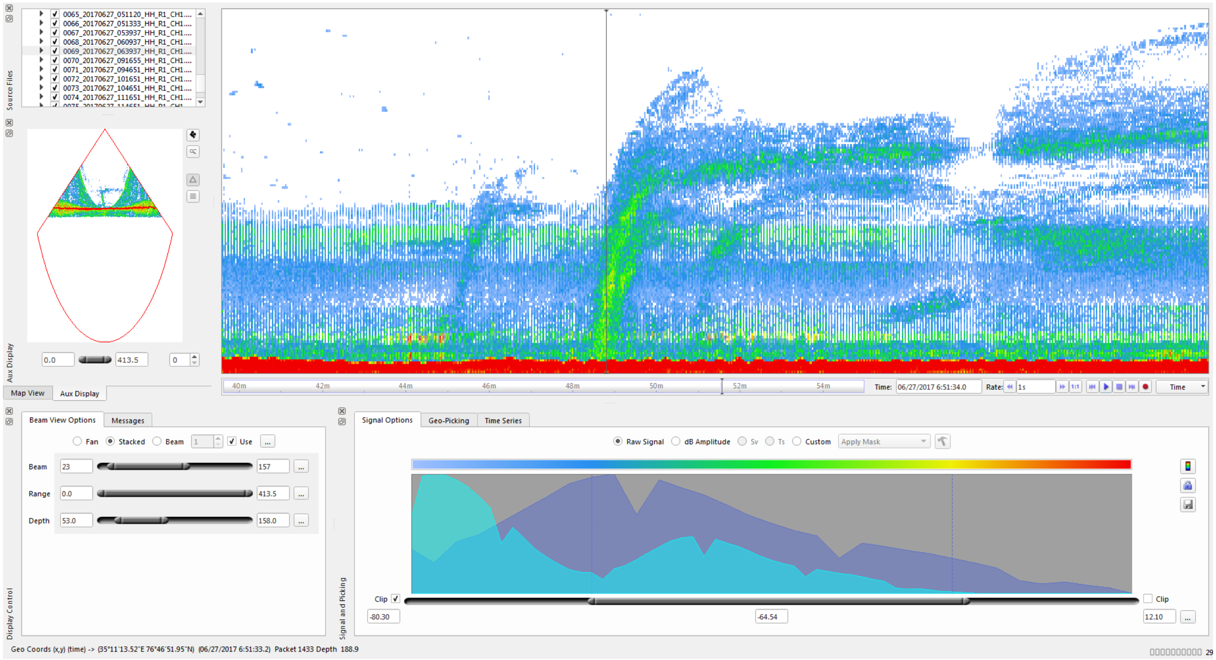


Figure 14 – Stacked multibeam profile of Flare ID 4 (see Table 1).

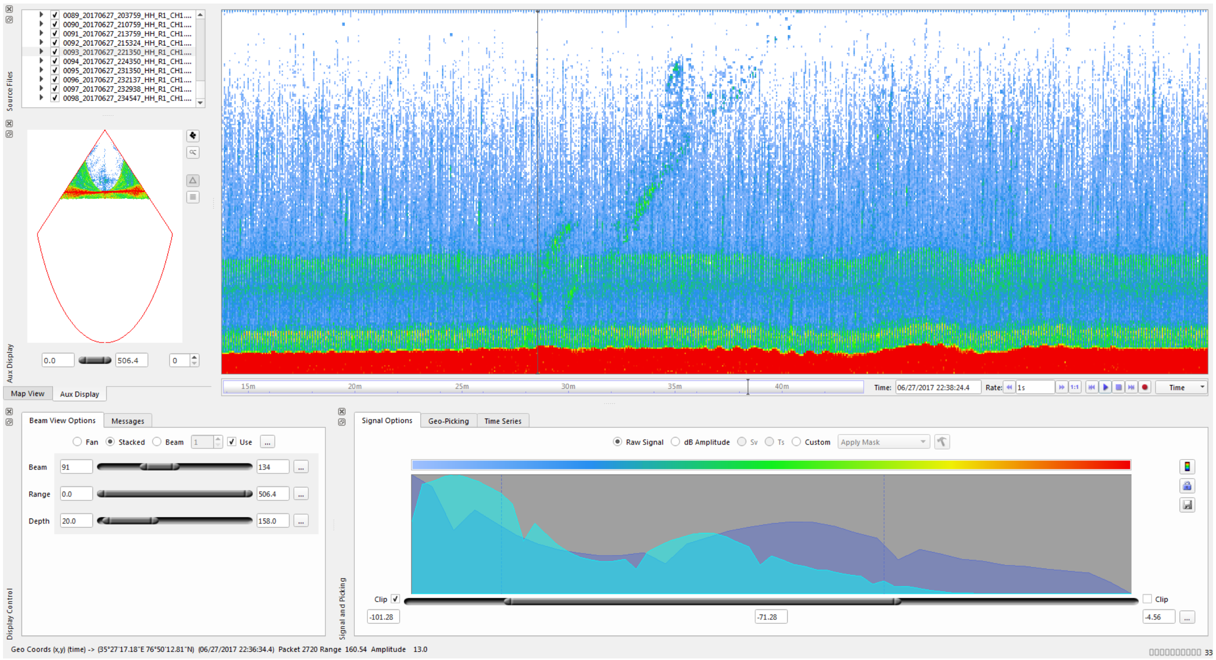


Figure 15 – Stacked multibeam profile of Flare ID 5 (see Table 1).

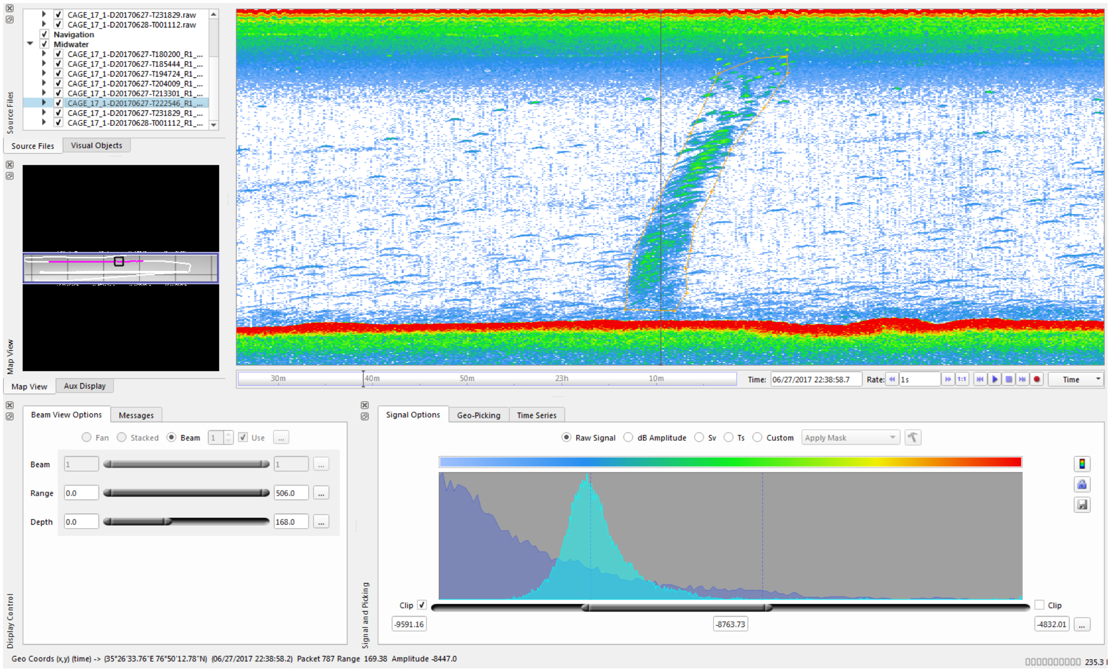


Figure 16 – Singlebeam EK60 profile of Flare ID 5 (see Table 1).

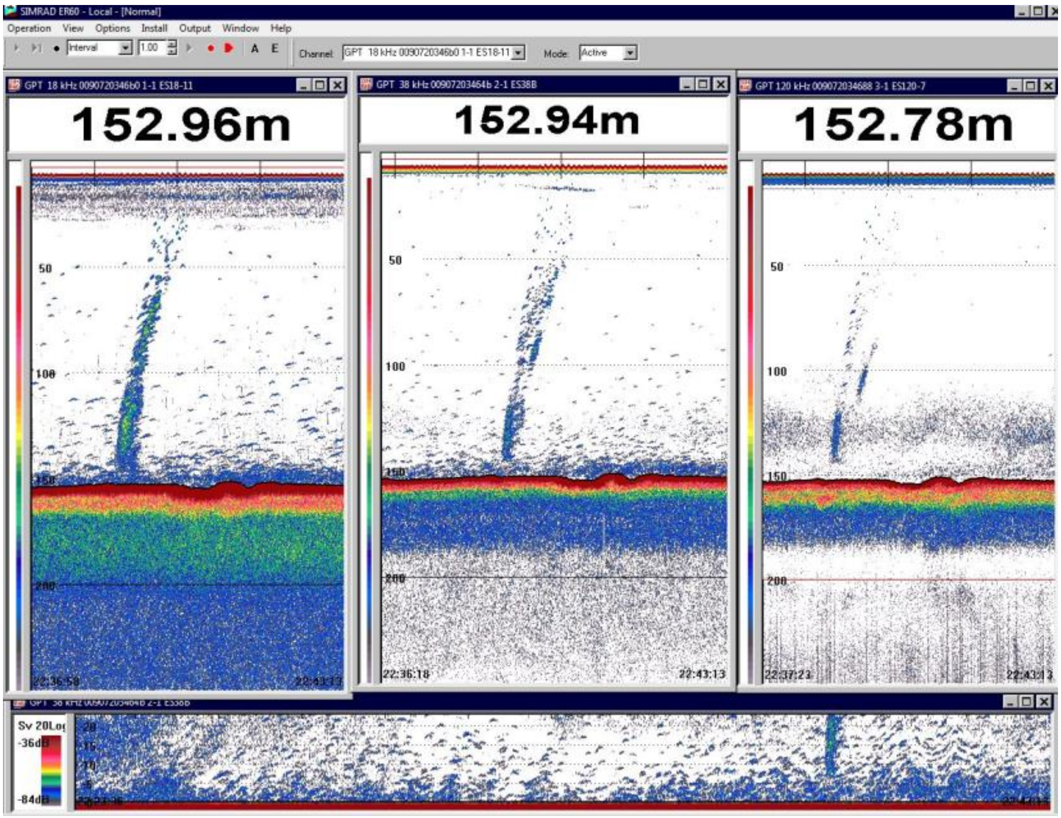


Figure 17 – Singlebeam EK60 profiles, 18kHz (left), 38kHz (middle) and 120kHz (right) of Flare ID 5 (see Table 1).

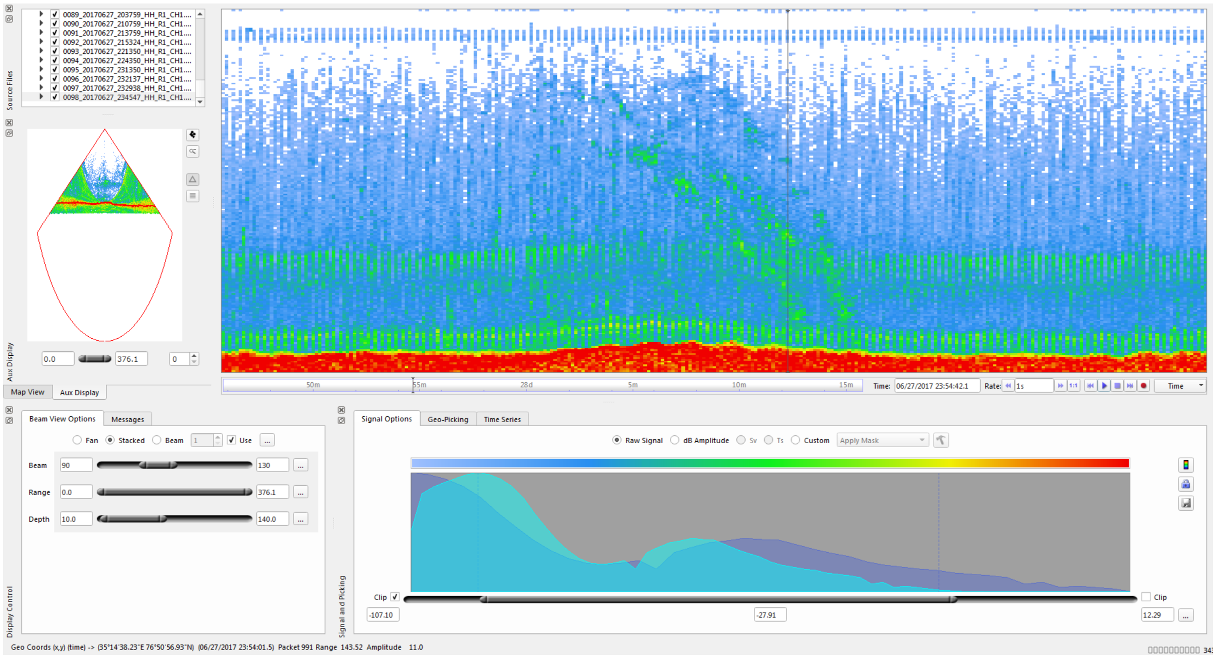


Figure 18 – Stacked multibeam profile of Flare ID 6 (see Table 1).

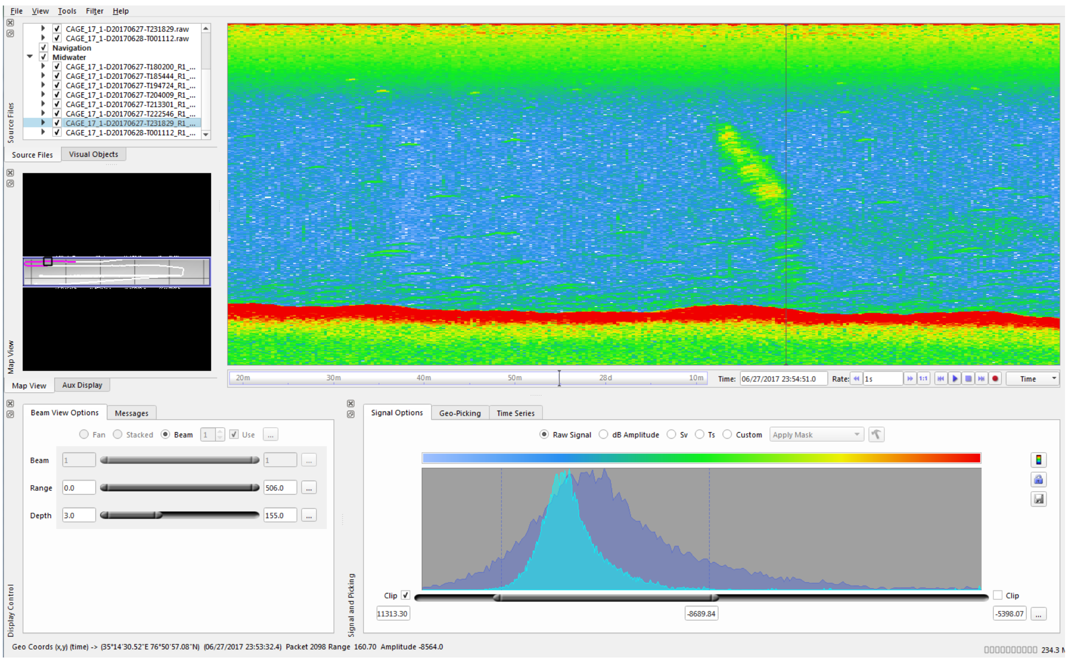


Figure 19 – Singlebeam (EK60) profile of Flare ID 6 (see Table 1).

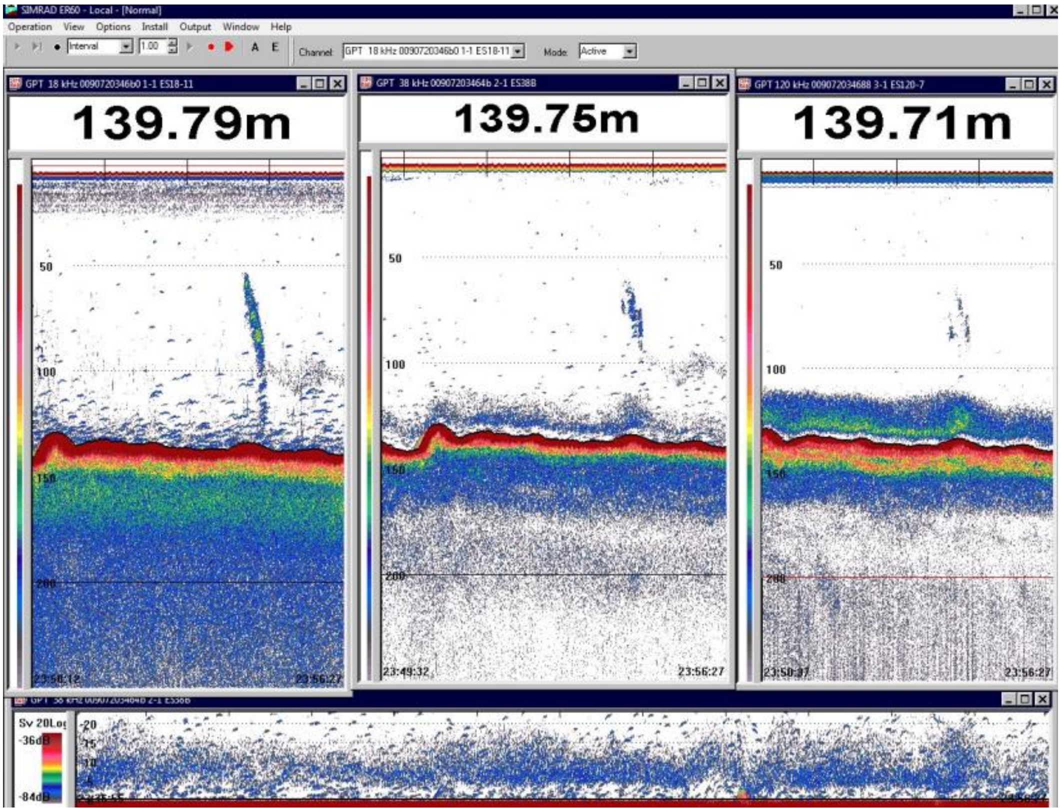


Figure 20 – Singlebeam EK60 profiles, 18kHz (left), 38kHz (middle) and 120kHz (right) of Flare ID 6 (see Table 1).

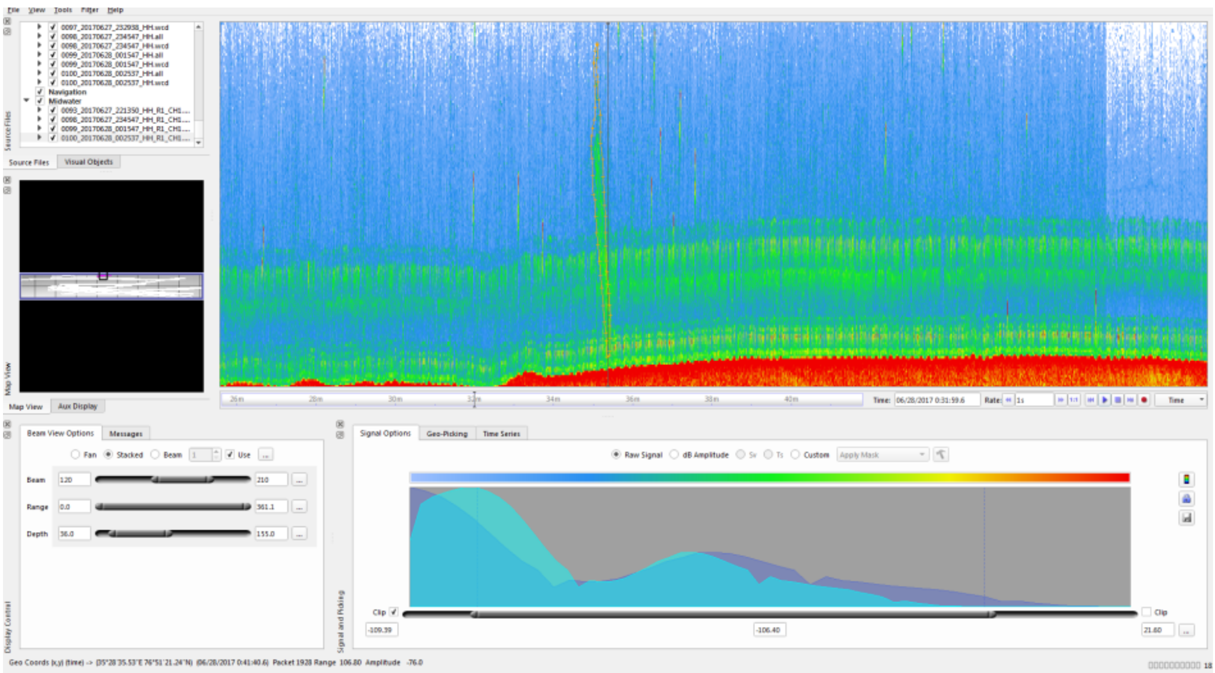


Figure 21 – Stacked multibeam profile of Flare ID 7 (see Table 1).

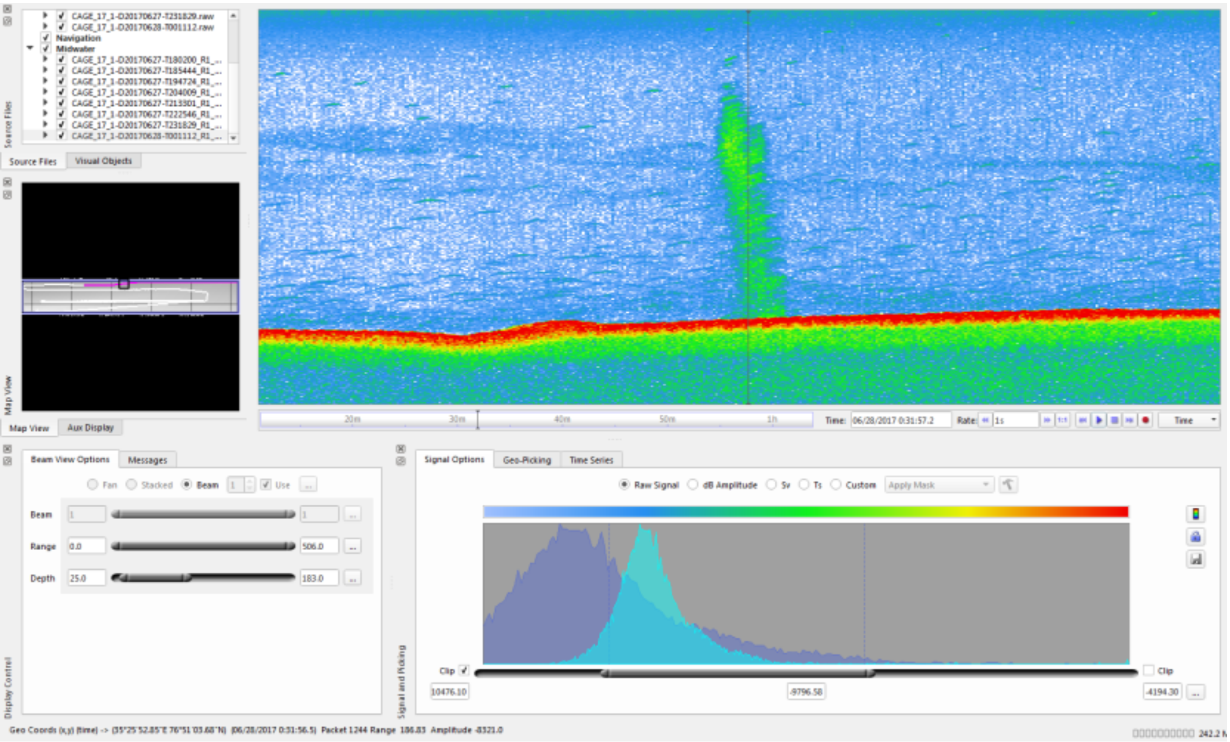


Figure 22 – Singlebeam (EK60) profile of Flare ID 7 (see Table 1).

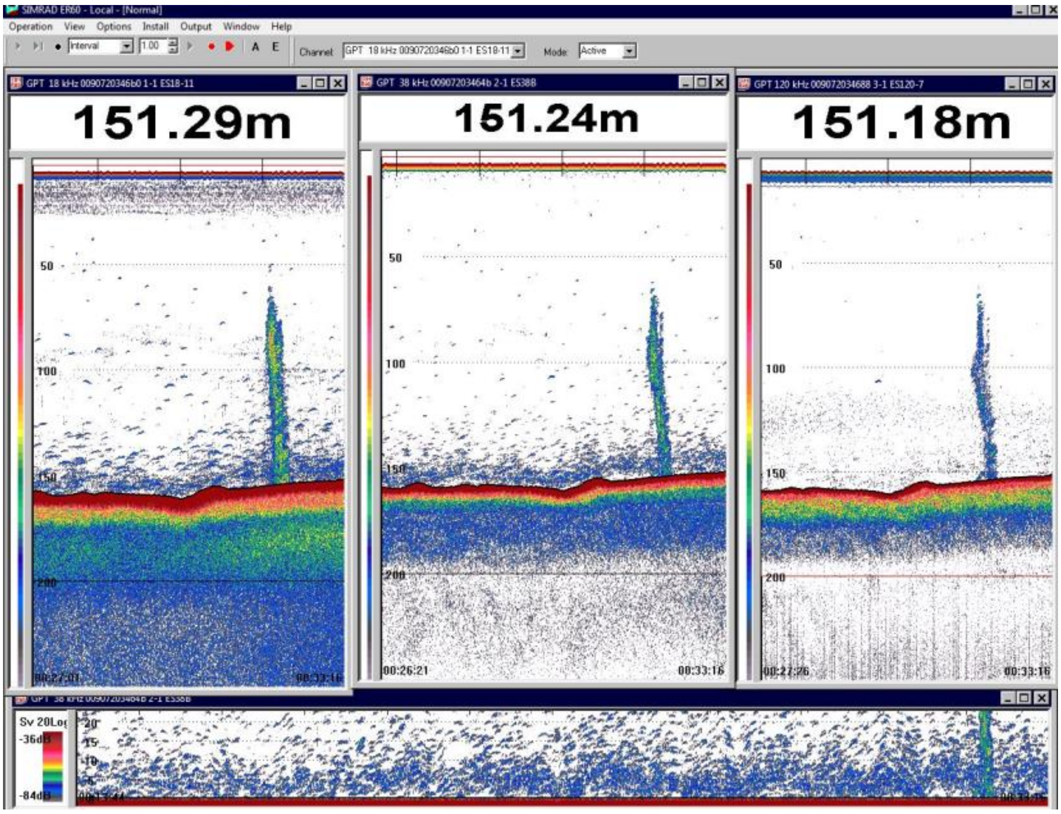


Figure 23 – Singlebeam EK60 profiles, 18kHz (left), 38kHz (middle) and 120kHz (right) of Flare ID 7 (see Table 1).

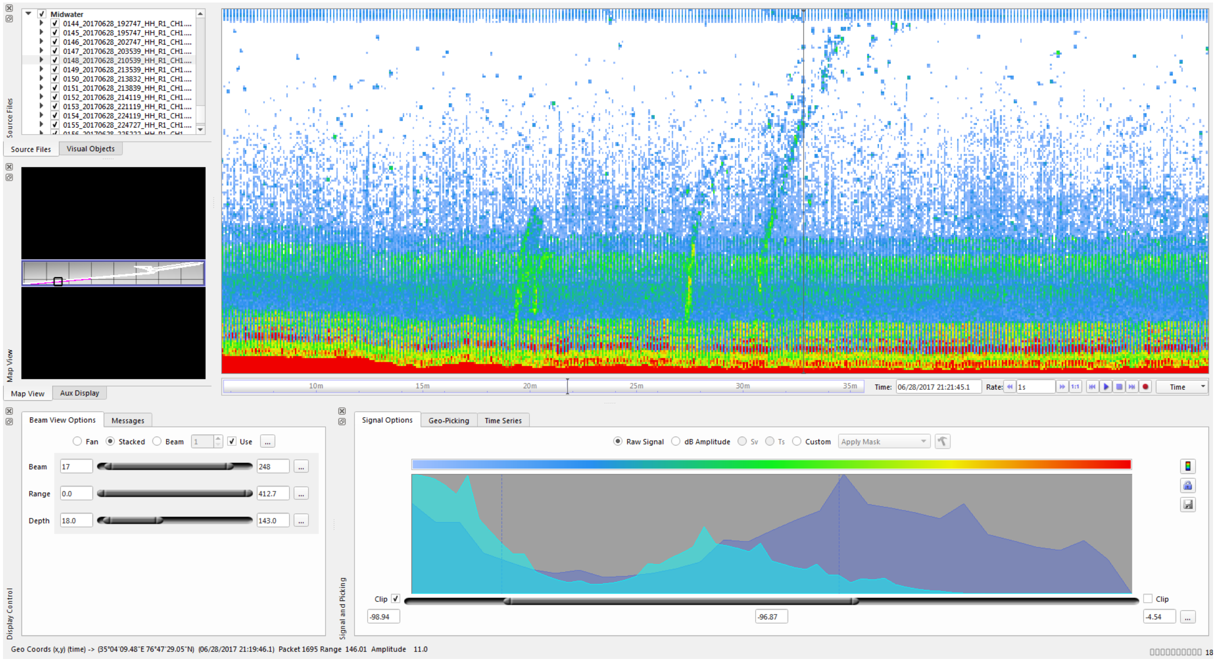


Figure 24 – Stacked multibeam profile of Flare ID 8 (see Table 1).

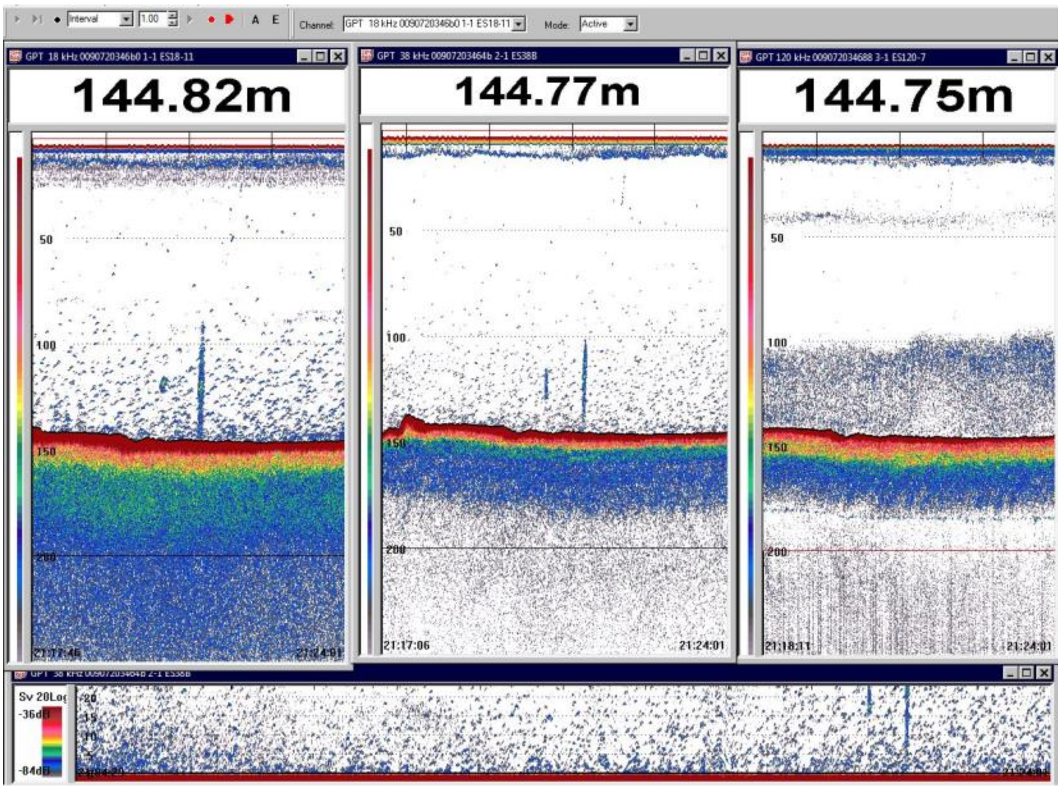


Figure 25 – Singlebeam EK60 profiles, 18kHz (left), 38kHz (middle) and 120kHz (right) of Flare ID 8 (see Table 1).

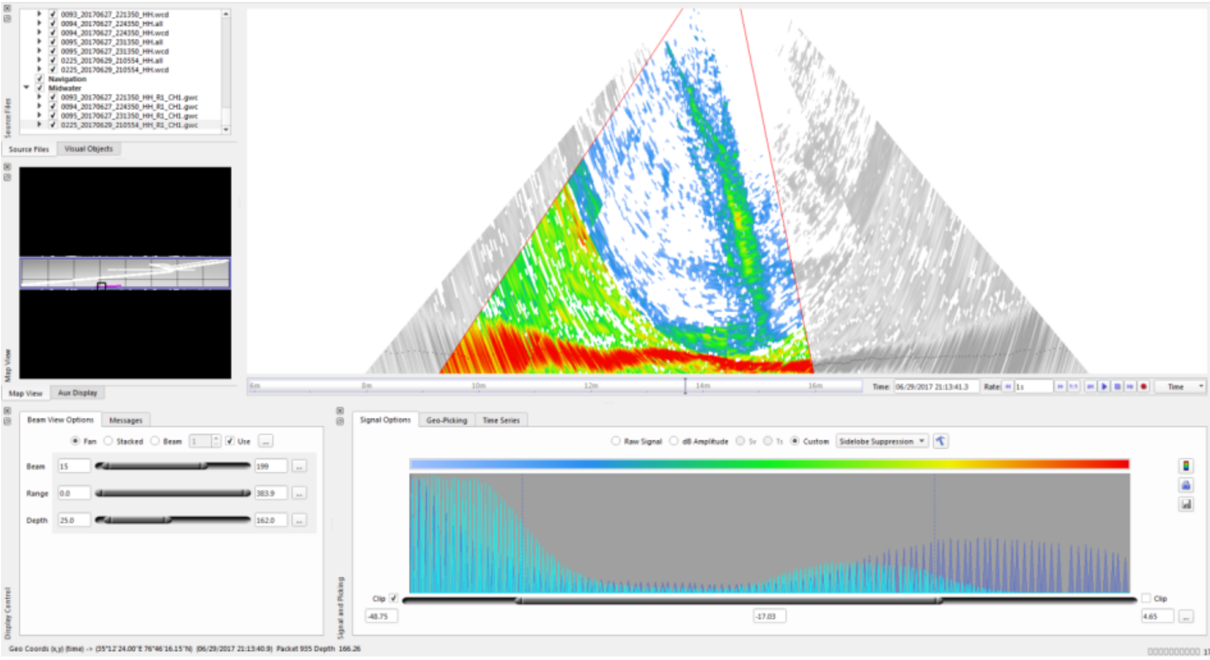


Figure 26 – Multibeam fan view of Flare ID 9 (see Table 1).

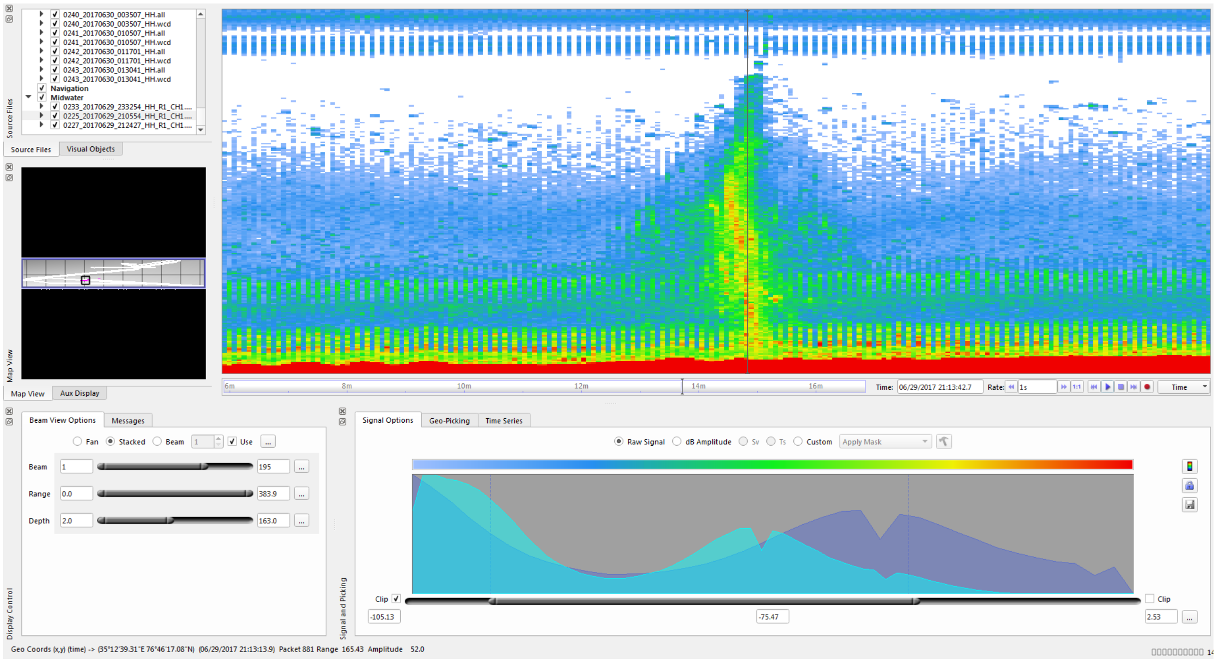


Figure 27 – Stacked multibeam profile of Flare ID 9 (see Table 1).

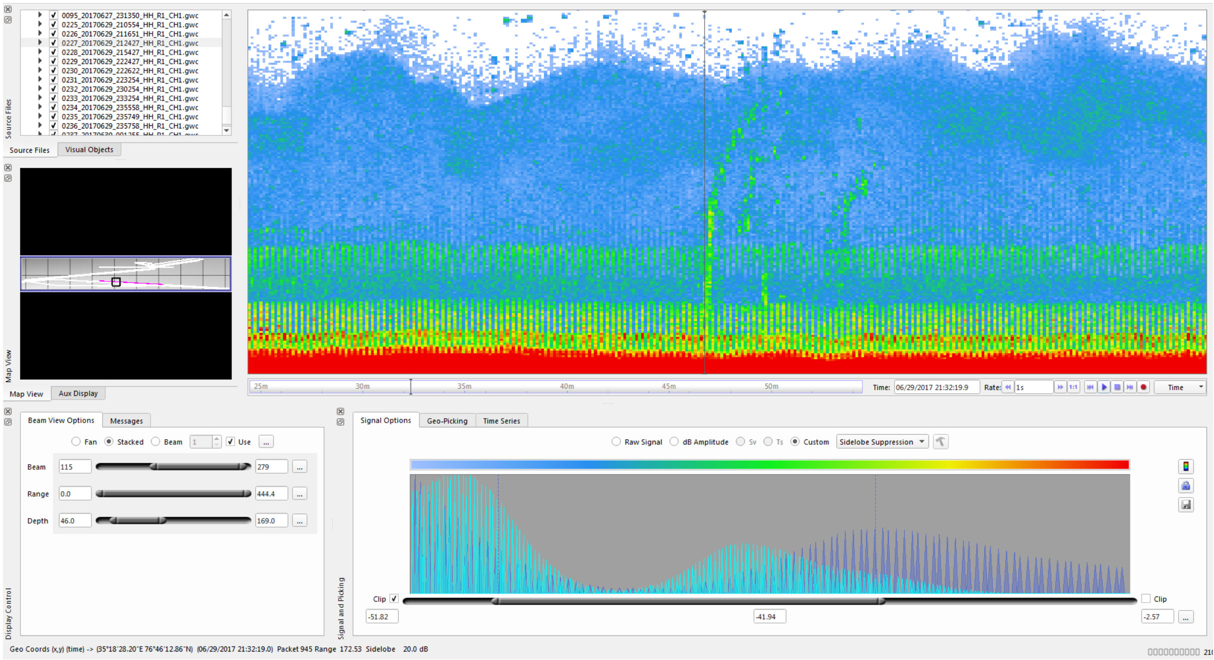


Figure 28 – Stacked multibeam profile of Flare ID 10 (see Table 1).

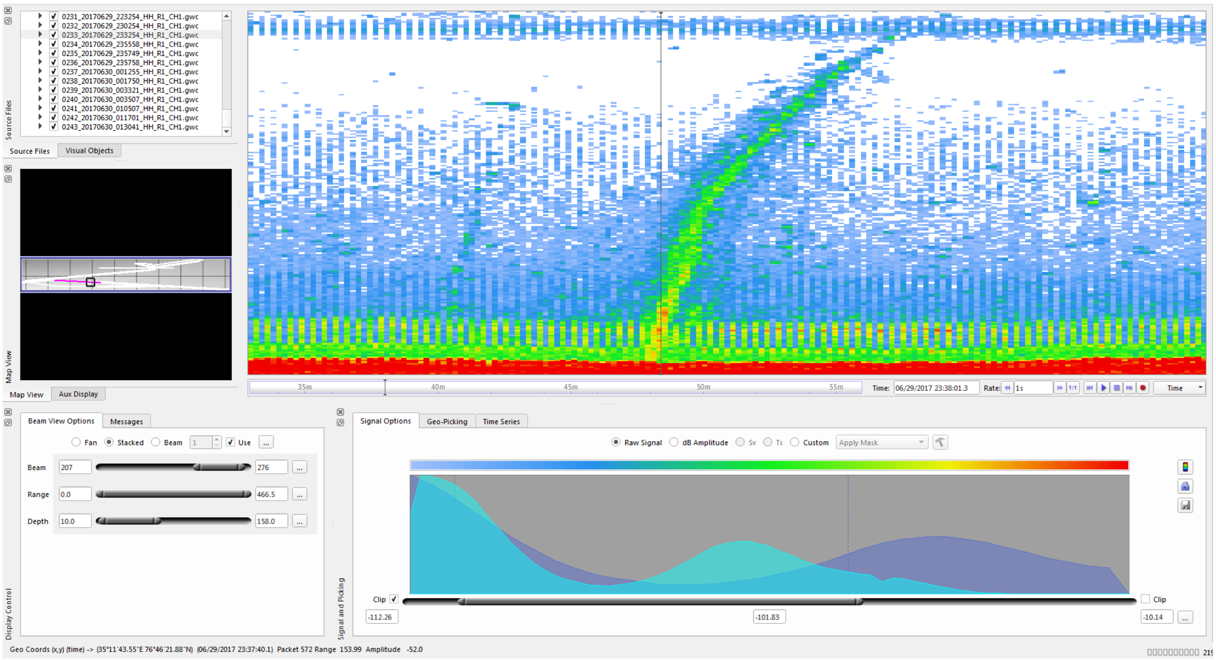


Figure 29 – Stacked multibeam profile of Flare ID 11 (see Table 1).

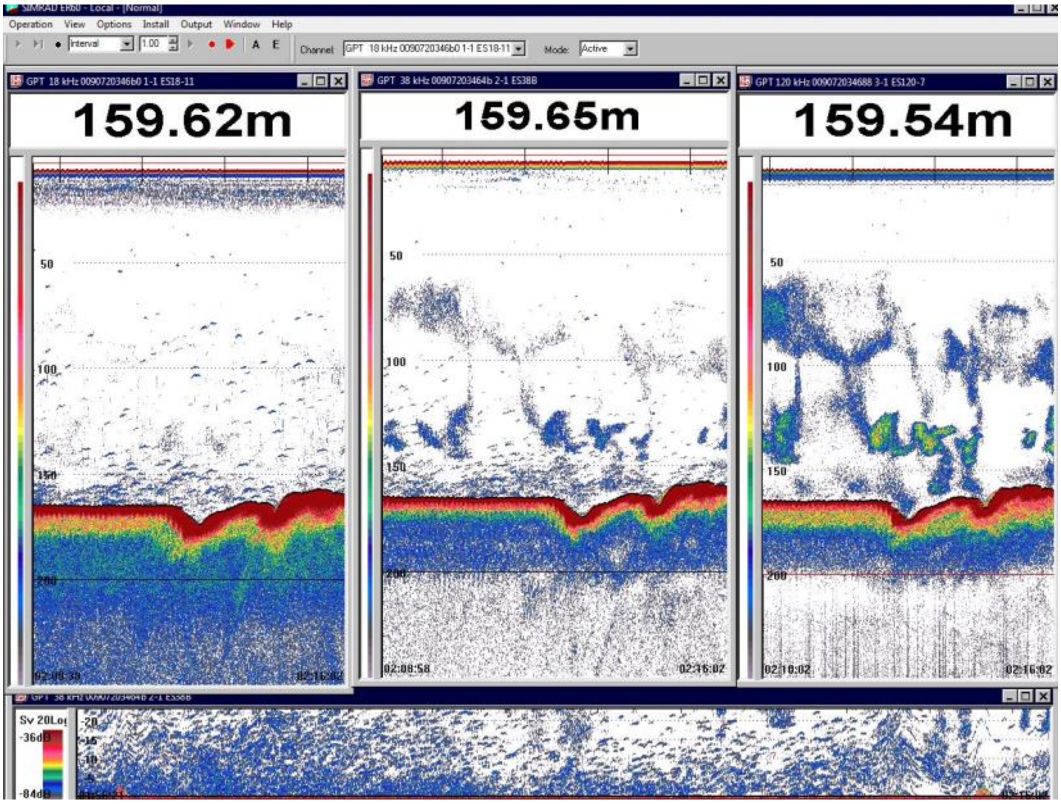


Figure 30 – Singlebeam EK60 profiles, 18kHz (left), 38kHz (middle) and 120kHz (right) demonstrating the typical acoustic response that was associated with fish/krill i.e. strong at 120kHz and almost no response at 18kHz.

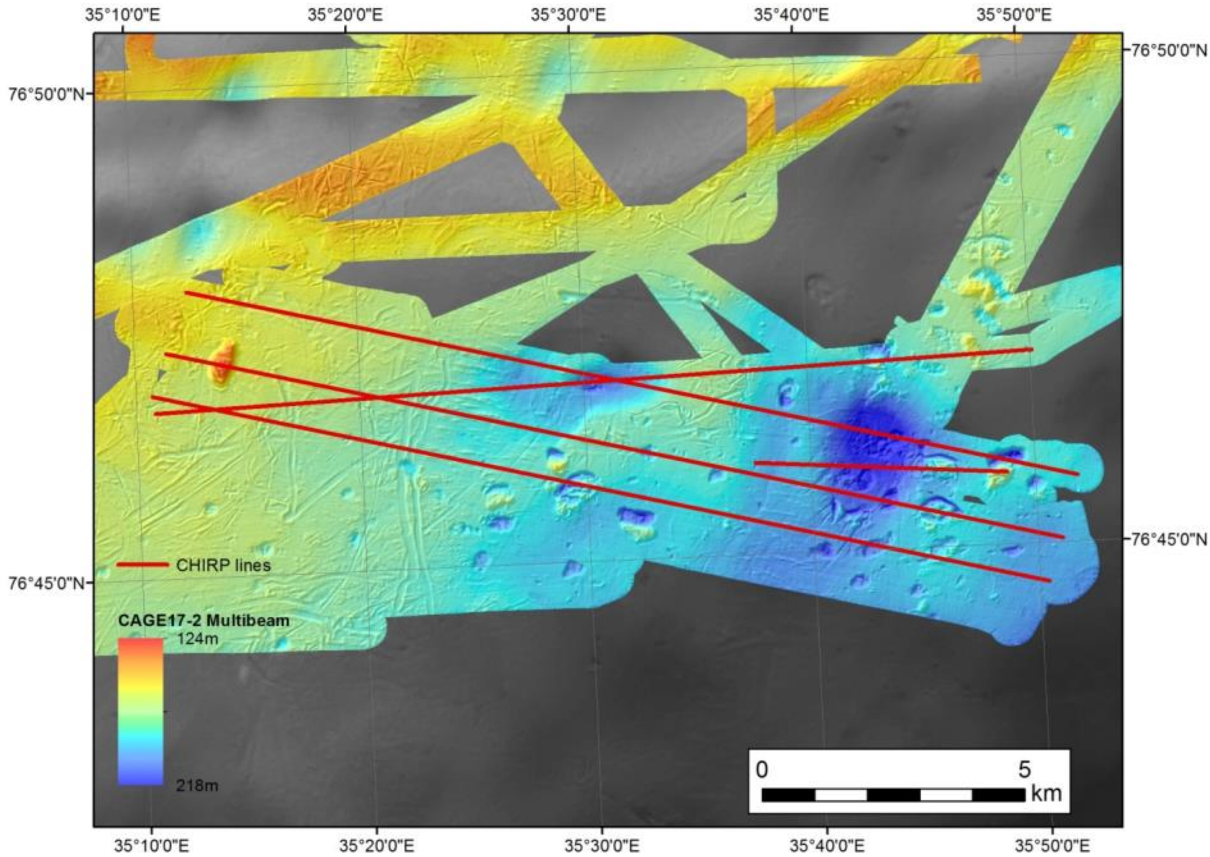


Figure 31: CHIRP lines collected over the Olga Crater site.

Identification of possible shipwreck

A seafloor topographic feature with elongate, linear morphology was observed towards the south-eastern end of the surveyed area (see **Figure 32**). This feature does not appear to be geological and was thought to represent a shipwreck based on it's dimensions of approx. 90m length, 20m breadth and 15m vertical relief above the surrounding seabed. The same feature was also visible in the MAREANO multibeam bathymetry from 2015, which suggests that it must be a real feature and not an artefact.

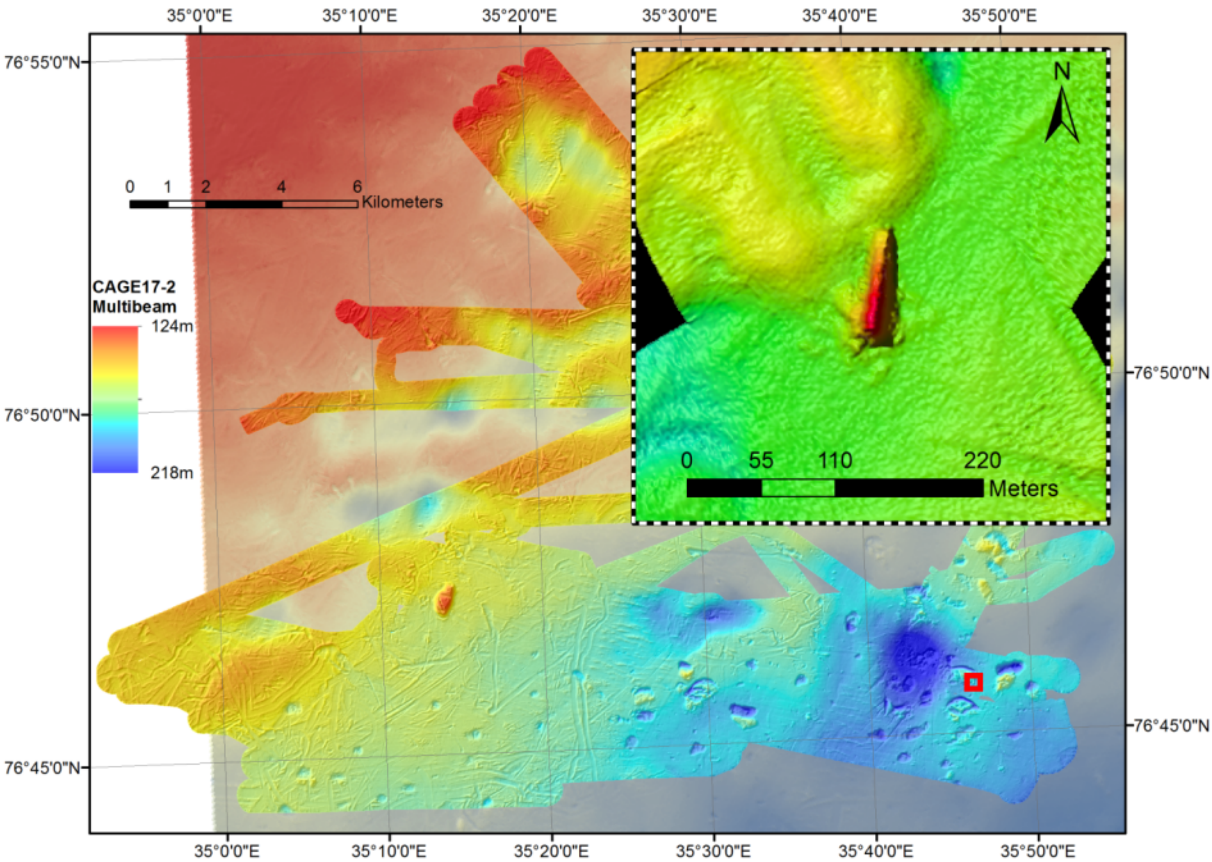


Figure 32 – Possible shipwreck was identified at 76° 45.714' latitude, 35° 46.444' longitude (WGS84). Note that colour scale of inset map does not match the regional bathymetry colour scale.

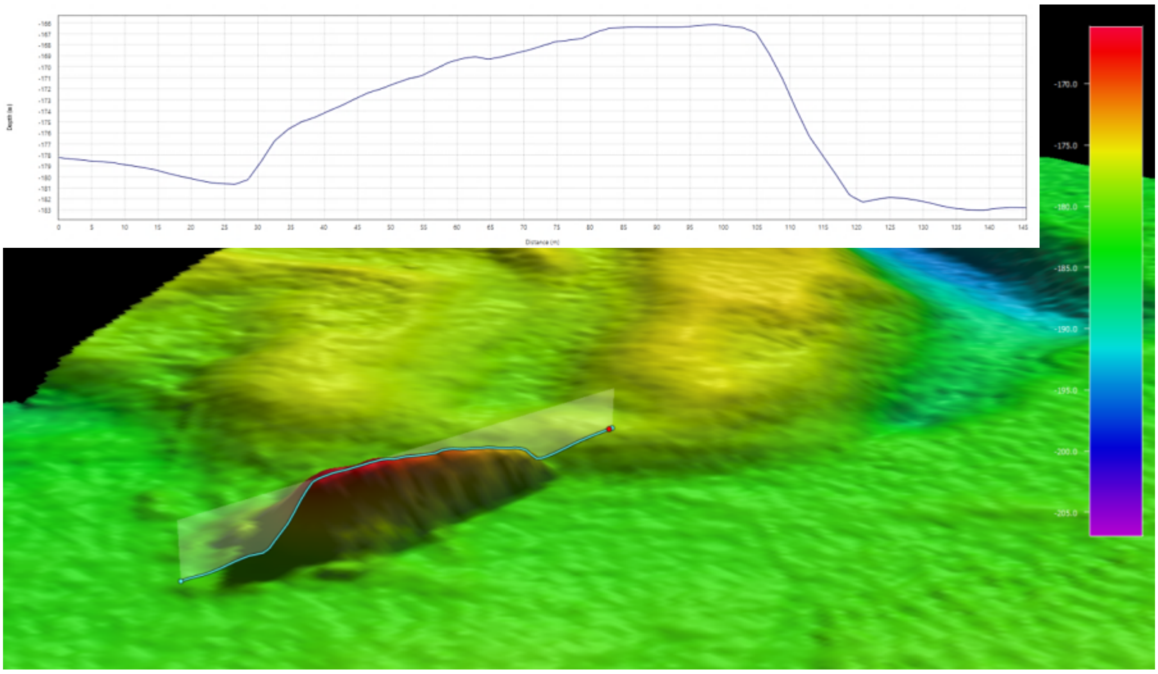


Figure 33 – Length profile across possible shipwreck (see Figure 32), it is approx. 90m long and up to 16m above the seabed.

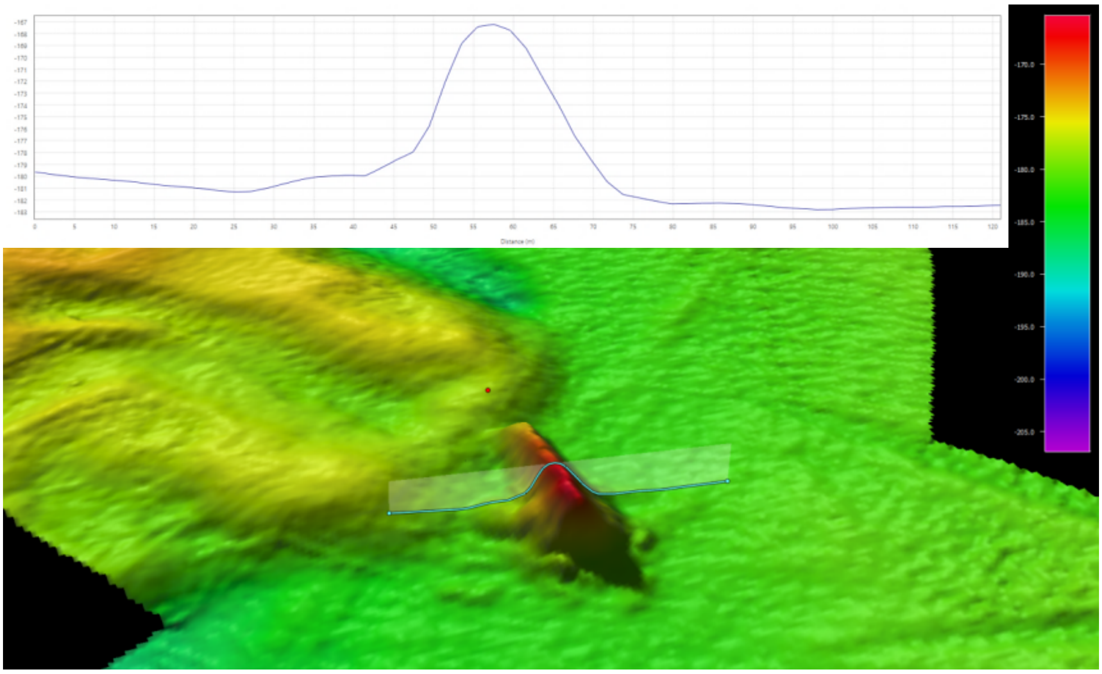


Figure 34 - Breadth profile across possible shipwreck (see Figure 32), it is approx. 20m wide with vertical relief of 15m along this profile.

West Sentralbanken

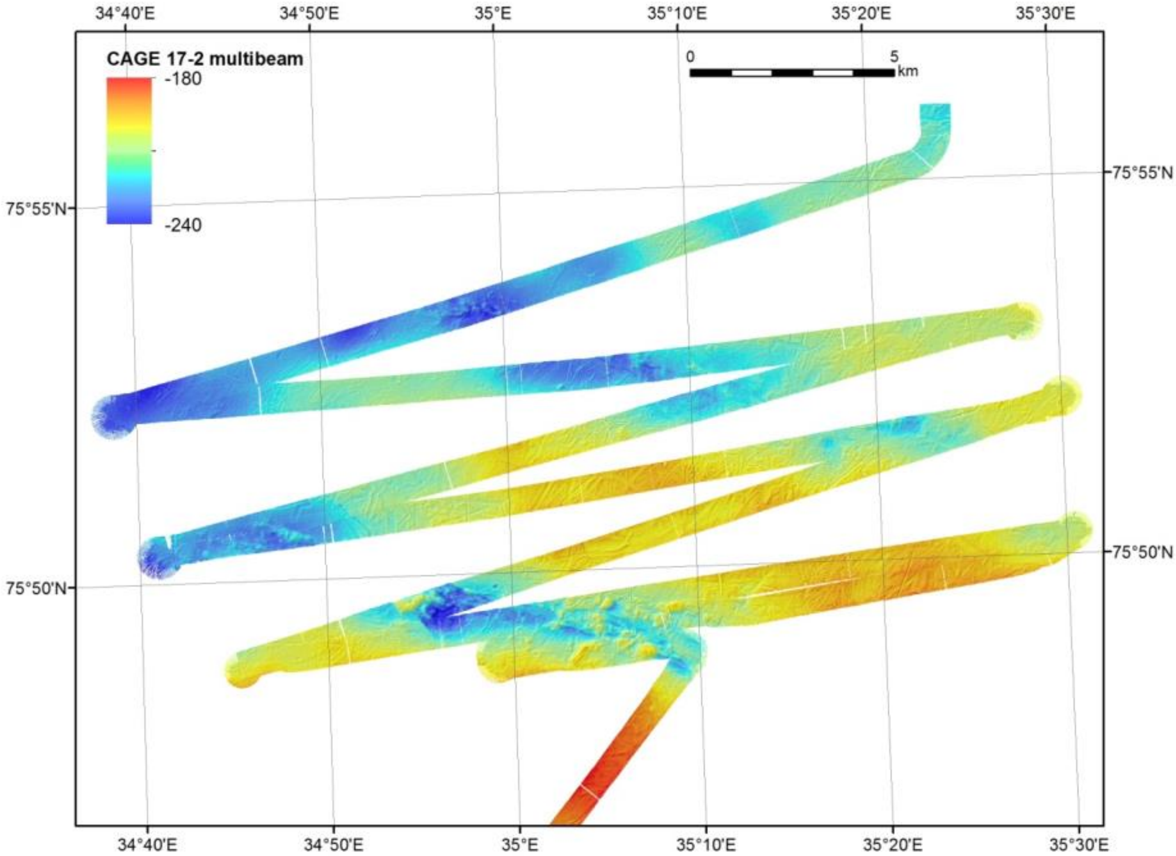


Figure 35: Overview of multibeam bathymetry collected at the West Sentralbanken site during the CAGE 17-2 cruise, gridded to 53m cell size. No flares were observed.

8.2. Water column sampling (CTD) (M.F. Sert)

Primarily, dissolved organic matter (DOM) dynamics and nutrient cycles were addressed along with the methanotrophic bacterial activity. In order to reveal compositional differences of DOM, samples for high-resolution mass spectrometry were collected at different seepage and non-seepage areas. Additionally, dissolved methane, dissolved organic carbon (DOC), stable oxygen isotope ($\delta^{18}O$), organic and inorganic nutrients and particulate organic matter were sampled for the investigation of water mass properties. Chlorophyll-a was sampled because it can to be used as indicator of primary production. Additional filtering was carried out for scanning electron microscope (SEM) samples to document the microbial diversity of the marine phytoplankton.

Water samples were taken from Niskin bottles mounted on CTD rosette system. Firstly, samples for methane concentration were collected. Then 4 L of seawater were taken to four 1 L glass bottles for filtration and subsampling. Samples were kept in +4 C cooling room if immediate filtration is not possible. Filtration of the samples was carried out by acid washed glass filtration towers. Three parallel samples were taken for particulate organic matter (POM) on GF/F filters and one liter of seawater were filtered for chlorophyll-a concentrations. Sub samples of nutrients, DOC, $\delta^{18}O$, and colored dissolved organic matter (CDOM) are taken directly from filtrate and one liter of filtrate were separated for solid phase extraction (SPE). Scanning electron microscope (SEM) samples were sampled on membrane filters.

Methodology for SPE of DOM was taken from Dittmar et al. (2008) with slight modifications. Shortly, styrene diviniyl benzene polymer type of cartridges (Bond Elut, PPL, ENV) were conditioned by 6 ml of methanol and rinsed respectively by12 ml of milliQ, 6 ml of methanol and 12 ml of pH2 milliQ water. Then, 1 liter of filtrated seawater acidified to pH 2 by 1 ml of concentrated hydrochloric acid and transferred from the conditioned cartridges. After the sample, cartridges were rinsed by 12 ml pH 2 milliQ water. 3 ml of methanol used for final elution of the sample. Samples are kept in -20C freezer until analysis date.

Table 2: Sampling CTD stations

No	**Site**	**Cruise / Station ID**	**Sampled depths**
1	Pingo site	CAGE 17-2 / 907	1, 3, 6, 8
2	Pingo site	CAGE 17-2 / 909	1, 3, 6, 8
3	Pingo site	CAGE 17-2 / 912	1, 3, 6, 8
4	Olga basin crater	CAGE 17-2 / 936	1, 3, 6, 8
5	Olga basin crater	CAGE 17-2 / 944	1, 3, 4, 5, 6, 8
6	Olga basin crater	CAGE 17-2 / 949	1, 3, 5, 6, 8

Table 3: Collected parameters in all sampling stations

No	**Parameter**	**Sample**	**volume sample**	**Analysis**	**Storage**
1	Nitrate, Phosphate, Silicate	Sea water	20 ml	Autoanalyser	-20^{o}C
2	Ammonium	Sea water	20 ml		-20^{o}C
2	Total dissolved nitrogen	Sea water	60 ml		-20^{o}C
3	Total dissolved phosphorus	Sea water	60 ml		-20^{o}C
2	Particulate organic matter	Filter (GF/F)	1 L x 3	WDXRF	Room temp.
3	Chlophyll-a	Filter (GF/F)	1 L x 1	Fluorometer	-80^{o}C
4	Dissolved organic carbon	Sea water	60 ml	TOC analyser	-20^{o}C
5	Colored dissolved organic matter	Sea water	40 ml	Fluorometer	+4^{o}C
6	Dissolved organic matter composition	Sea water	1 L	FT-ICR-MS	-20^{o}C
7	Methane	Sea water	125 ml	GC	+4^{o}C
8	Stable isotope (δ^{18}O)	Sea water	20 ml	SIL-MS	Room temp.
9	SEM	Filter (membrane)	1 L x 1	SEM	Room temp.

8.3. Pore water and gas sampling (S. Sauer and H. Yao)

During the CAGE 17_2 cruise we collected 120 pore water samples and 78 headspace sediment gas samples from multicores and gravity cores. For multicores, pore water samples were generally taken at intervals of 2 cm in the upper 10 cm's, and at intervals of 4-10 cm in the lower part of the core, depending on core length. Methane headspace samples were taken in intervals of 4-10 cm's depending on core length. We used 2 (out of 6) liners with pre-drilled holes per MC lowering, but only 1 core was used to sample pore water and headspace gas per station. For gravity cores, pore water and gas samples were taken in intervals of 20 cm.

Pore water was sampled using the rhizon technique. Rhizon samplers were inserted in the sediment cores through pre-drilled holes in the liner. 20 ml syringes were attached to the rhizons and kept open with wooden spacers to create a vacuum. Depending on the sediment properties we collected between 2 ml and 18 ml per sample. The pore water samples were split for various analyses. On board we measured alkalinity by titration and dissolved iron concentration using spectrophotometry. Following analyses will be performed on-shore: ion chromatography (SO_4^{2-}, Cl^-), ICP-OES (cations), dissolved inorganic carbon (concentration and $d^{13}C$), nutrients, Sr-isotopes.

Headspace methane samples were collected using cut off syringes to retrieve 3 ml of sediment. We filled the sediment into 20 ml serum vials containing two glass beads and 6ml NaOH (2.5%). Before closing the vials, they were flushed with N_2, shaken well, and then stored at 4°C. We will analyse methane, ethane, propane concentrations and their carbon and hydrogen isotopic composition.

Table 4: All cores from CAGE 17_2 sampled for pore water and headspace gas

Site	ID Multicores and Gravity Core	Pore water samples	CH4 headspace samples
Reference	898	1-6	1-3
GHP-1	900	6-15	4-7
	902	16-22	8-11
	916	23-26	12-14
	917	27-31	15-17
	918	32-41	18-23
	919	42-48	24-29
GHP-5	922	49-53	30-33
	923	54-57	34-37
"New Crater Area"	932-5	58-60	38-39
	933-5	61-68	40-42
	935-GC	69-74	43-47
	939-5	75-78	48-50
	948-2	79-81	52
	948-5	82-85	53-55

950-5	86-87	56
951-2	88-90	57-58
952-GC		59
957-5	91-99	60-64
959_GC		65
962-5	100-104	66-68
969-5	105-108	69-70
971-GC	109-114	71-75
972-GC	115-120	76-79

8.4 Pore water geochemistry and methane in sediments

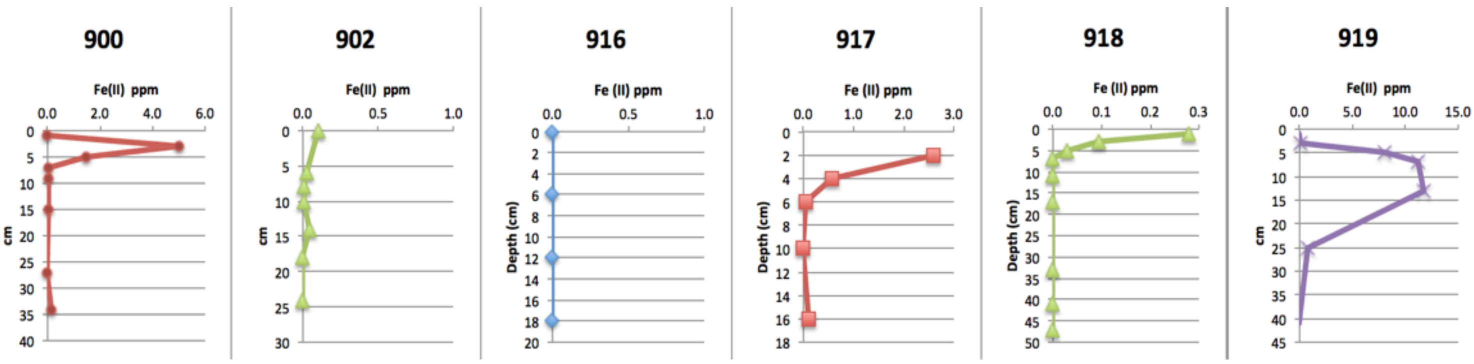
The main goal of pore water sampling and analyses is to study the influence of methane seepage on the biogeochemical reaction zones in the sediment. The primary target of sediment headspace gas sampling is to estimate concentrations and molecular composition of hydrocarbon gas as well as its isotopic composition in the investigated areas (Pingo Site and the Olga crater site) to determine the hydrocarbon gas source. Pore water and headspace gas concentrations help to constrain the depth of the SMTZ and thus provide a first estimate of methane flux strength at the respective sites.
These data are important for both microbiological studies, as well as micropaleontological studies.

8.4.1. Preliminary results

Alkalinity profiles can be used to estimate the depth of the SMTZ and the AOM activity, as HCO_3^- is formed during AOM and contributes most to alkalinity. Furthermore, HS^- is formed during AOM, which influences the dissolved Fe concentration in pore water because HS^- and Fe^{2+} react to form ironsulfides. Thus, in the cores were dissolved Fe is low or absent, we can infer higher HS^- flux which means higher sulfate turnover. In cores, where we find dissolved Fe^{2+} throughout, we can infer low sulphate turnover.

Based on Fe^{2+} concentrations from the GHP-1 transect, the sulphate turnover is highest at sites 902 and 916 (**Figure 36**). This is in agreement with the alkalinity data, which show highest alkalinity at the base of cores 902 (ca. 44 mM) and 916 (ca. 34 mM) (**Figure 37**).

At the “new crater site” almost all cores have elevated Fe^{2+} concentrations throughout the core (Figure 3), indicating the absence of HS^- and thus low sulphate turnover. Again, this is in agreement with the alkalinity measurements showing values below 5mM in all cores (**Figure 36**).



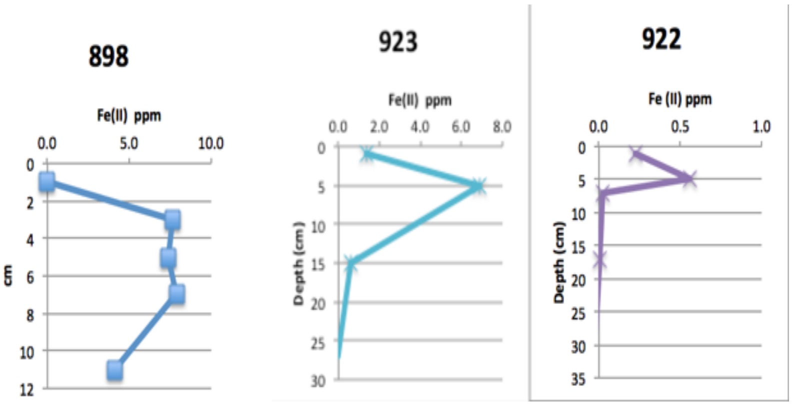


Figure 36 - Dissolved Fe2+ profiles of MC’s from the Pingo Site. Reference Site: 898

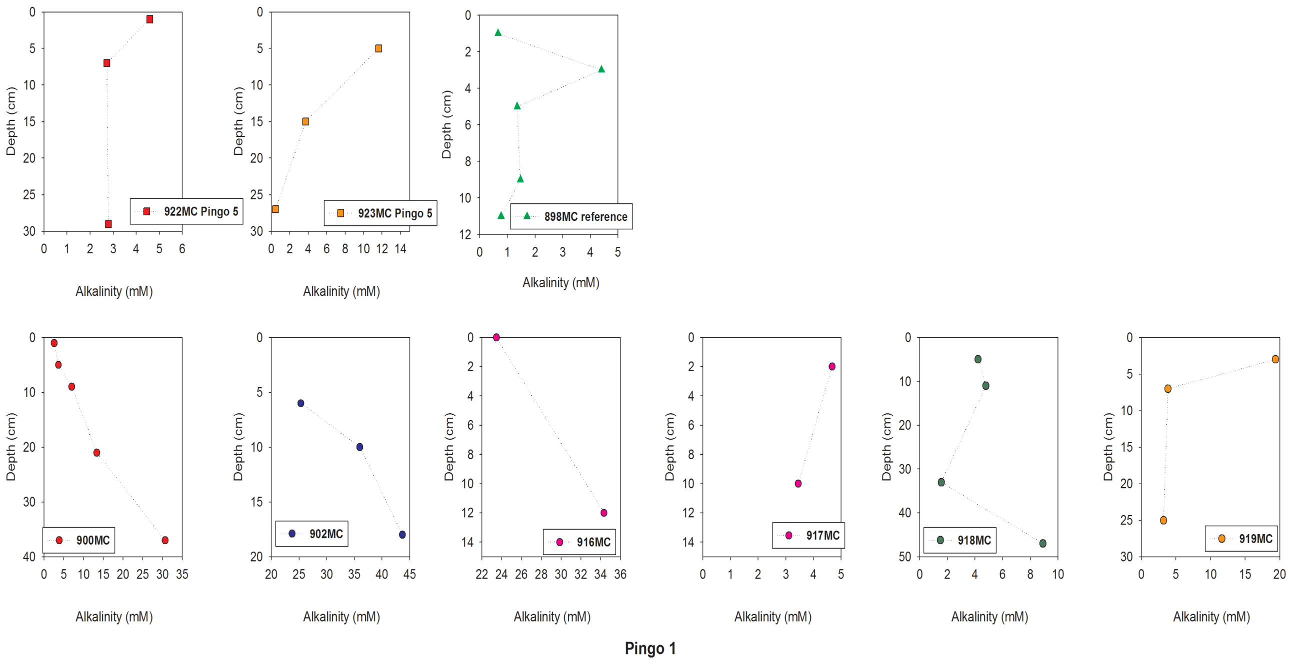


Figure 37 - Alkalinity profiles of MC's from the Pingo Site. Reference Site: 898

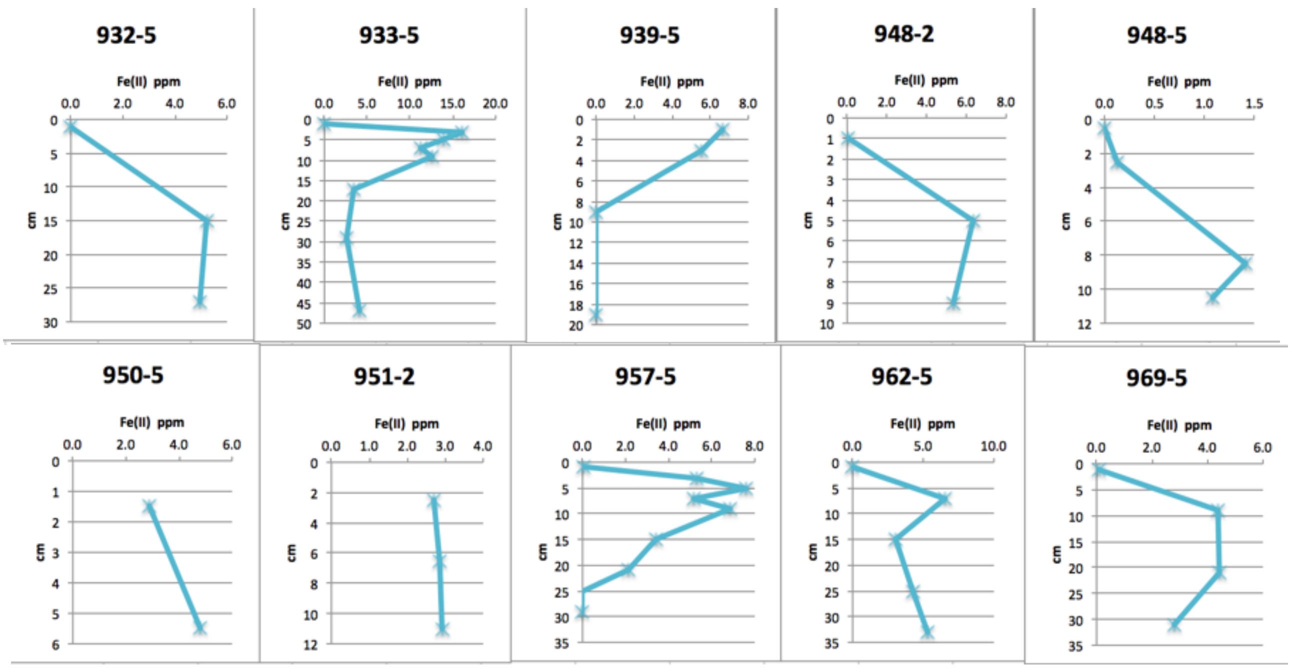


Figure 38 - Dissolved Fe^{2+} profiles of the “New Crater Site”

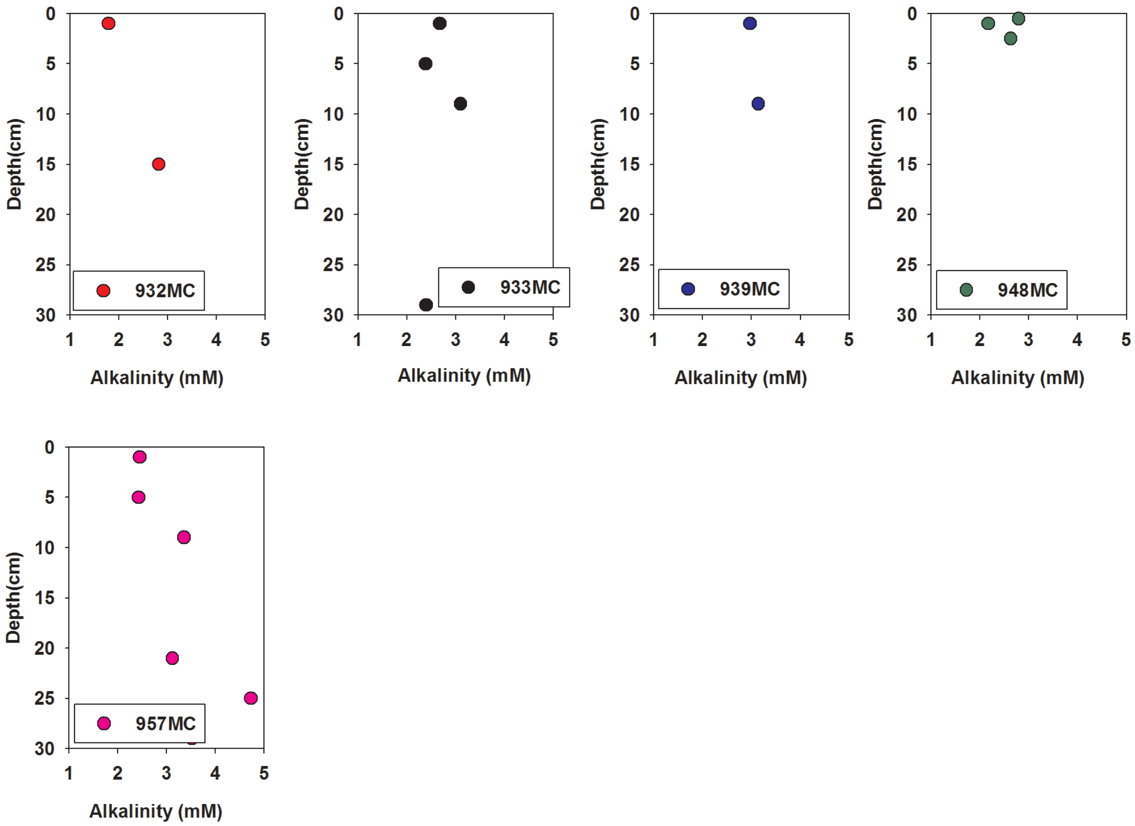


Figure 39 - Alkalinity profiles of cores from the “New Crater Site”

Methane concentration results

Preliminary methane concentration results from the GHP-1 transect indicate highest methane fluxes close to the center of the pingo (core 900, 902) with shallow SMTZ depths (**Figure 40**).

At the “new crater site” all methane measurements showed very low concentrations below ca. 10ppm CH_4 in the headspace. This suggests that sites of CH_4 escape are very local, and there is no influence of methane detectable in the sediments around the seeps.

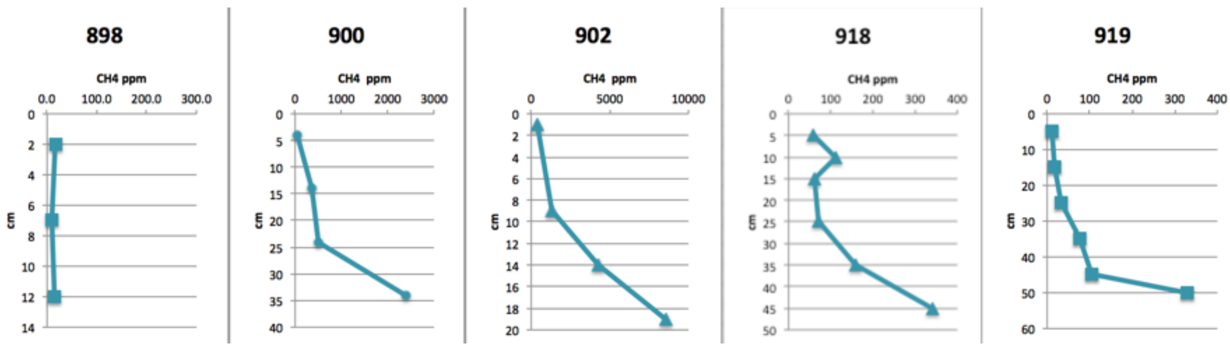


Figure 40: Methane concentrations from the reference station (898) and from cores of transect across GHP-1. The red dotted lines are estimates of SMTZ depth.

8.5 Natural Products (H. Yao)

Natural products have been a rich source of compounds for drug discovery. There is an increasingly powerful case for revisiting natural products for drug discovery. Historically, natural products from plants and animals were the source of virtually all medicinal preparations and, more recently, natural products have continued to enter clinical trials or to provide leads for compounds that have entered clinical trials, particularly as anticancer and antimicrobial agents (Harvey et al, 2015).

Drug discovery from marine natural products has enjoyed a renaissance in the past few years. Ziconotide (Prialt; Elan Pharmaceuticals), a peptide originally discovered in a tropical cone snail, was the first marine-derived compound to be approved in the United States in December 2004 for the treatment of pain. Then, in October 2007, trabectedin (Yondelis; PharmaMar) became the first marine anticancer drug to be approved in the European Union (Monlinski et al, 2009).

Samples will be analysed by Sandra Loesgen (OSU, Chemistry) for natural product/small molecules extractions. Samples for this purpose have taken duplicate.

Sediment:

A) Samples from the top 1cm (or deeper) of sediment, by a grab device, scuba etc. Use spatula sterilized. Placed in falcon tubes (15mL). 0.5 g or 1mL is needed.

Storage: Keep at fridge 0-4 C

Sediment samples (duplicate):

B) Same sample size. Add equal volume of 50% sterile glycerol/milliQ water solution to the 15mL falcon tube. (filter mixture through a 0.2um filter, solution can be stored in a fridge and used for up to 8 weeks)

Storage: 0 to 4 C or freeze -20

Water: 10-15 ml ocean water, in falcon tubes.

A) Location: We need GPS coordinates, depth, temperature, pH, salinity

Storage: 0 to 4 C (Freezer -20 as back up)

Water samples (duplicate). 5-8 ml ocean water, in falcon tubes.

B) add equal volume of 50% sterile glycerol/water solution (filter mixture through a 0.2um filter, solution can be stored in a fridge and used for up to 8 weeks).

Sample taken

Station number/Sediment (0-1cm)	Station number/Water
902	914 (#1 and 12)
917	933(#1 and 2)
918	939 (#1 and 6)
919	947 (#1 and 6)
920	949 (#1 and 12)
932	951 (#1 and 6)

933	957 (#1)
939	
940	
948	
950	

8.6 Gas in water (M. Lindgren)
Water samples were analysed 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 120ml glass vials. We added 1 ml of 1M NaOH solution for preservation. Bottles were sealed with rubber septa and crimped. Subsequently we replaced 5ml of water with instrument nitrogen gas into each of the bottles and shake them to equilibrate gas dissolved in a water sample and headspace gas. Samples were analyzed after a minimum equilibration time of 24h.

8.7 Gas in air (M. Lindgren)
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 (CH_4 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) 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.
During the CAGE17-2 cruise we have taken air samples every morning at 07:00 UTC and in sites where we observed flares in the Eco sounder. The sampling was done using the Flasks Restek, Electro-Polished Miniature Canister (1000cc).

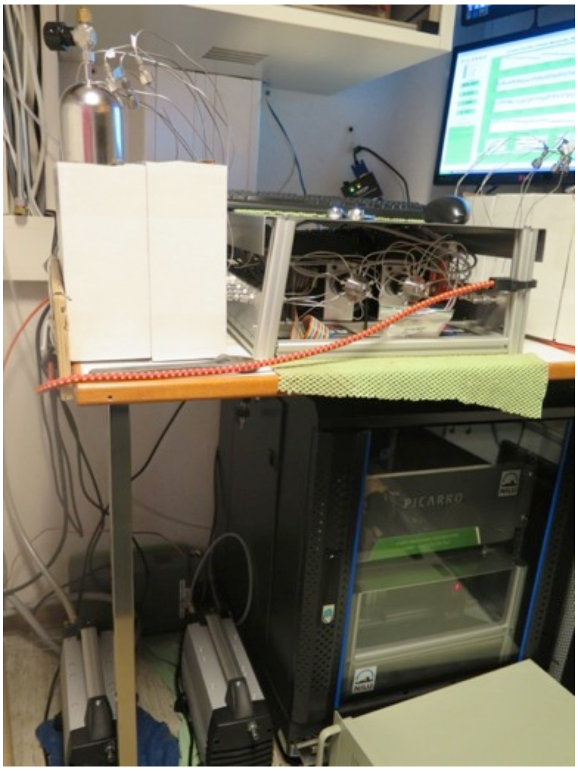


Figure 41. Setup of Picarro sampling station on RV Helmer Hanssen

8.8 . Geomicrobiology - Surveys of benthic and pelagic methanotrophic activities

(F. Gründger and V. Carrier)

Our overall aims in CAGE 17-2 were to determine the activity of methanotrophic microbes and the composition of the microbial community in the water column and in sediments at different cold seep areas of the coast of Svalbard. An overview of the different sampling locations and sample types collected are shown in tables 1 and 2. Our biogeochemical and microbiological data will be complemented with geochemical analyses of pore water constituents, methane concentration and stable isotope composition. These are essential for the interpretation of biogeochemical reactions and community composition of microbes. Geochemistry samples were collected from the same sites and depths as our sample sets.

Water column sampling

Aerobic Methane oxidation rates

Aerobic methane oxidation (MOx) is final barrier for methane before its release to the atmosphere, where it acts as a potent greenhouse gas. MOx is mediated by bacteria and proceeds according to the following net reaction:

$$CH_4 + 2\ O_2 \rightleftharpoons CO_2 + 2\ H_2O$$

For analysis of MOx rates at discrete water depths, we sampled the water column with a 12 × 5-Liter CTD/Rosette sampler at 8 different water levels. Sub-samples were taken immediately upon recovery of the sampler. Additionally, we collected bottom water samples by using 4 x 5-L Niskin bottles attached to the TOWCAM Multicore instrument. MOx rates were determined by *ex situ* incubations with trace amounts of tritium labelled methane (C^3H_4), allowing to trace the label transfer by measuring the activity of substrate (C^3H_4) and product pools (^3H_2O) after incubation (Berndt et al., 2014; Niemann et al., 2015, Steinle et al., 2015). Briefly, for each sampling depth, six 20-ml crimp-top vials were filled and closed bubble-free with PTFE coated bromobutyl stoppers (Wheaton, USA). Subsequently, each sample was amended with 5 µl gaseous C^3H_4/N_2 mixture (~5 kBq, <50 pmol CH_4, American Radiolabeled Chemicals, USA) and incubated for 3 days at *in situ* T in the dark. The incubations were terminated by unsealing one triplicate and subsampling a 10-mL aliquot of the incubation medium. This was then amended with aqueous NaCl solution (1 mL, 20%, w/v) and purged for 30 min with air to strip out the remaining methane. The activity of the produced ^3H_2O will be determined in our home laboratories by liquid scintillation counting. Similarly, the radioactivity of both, the remaining C^3H_4 and the produced ^3H_2O will be determined from the second triplicate (fixed with 0.5 mL $HgCl_2$ solution after incubation) by liquid scintillation counting in our home laboratories. MOx rates will be corrected for (most probably insubstantial) tracer turnover in killed controls (fixed with HgCl solution just after tracer amendments). MOx rates will be calculated from the fractional turnover of labelled CH_4 and water column CH_4 concentration assuming first order kinetics (Reeburgh, 2007):

$$rMOx = k \times [CH_4]$$

where k is the first-order rate constant (determined from the fractional turnover of labelled CH_4 per unit time and corrected for tracer turnover in killed controls) and $[CH_4]$ is the concentration of CH_4 at the beginning of the incubation.

Concentration of dissolved methane

For measuring the concentration of dissolved methane in the water column, seawater samples were collected from the same Niskin bottles at same water levels as the MOx samples were taken. Water samples were placed bubble-free into 160-ml glass vials. After adding 1 ml of NaOH solution (1 M) for preservation, bottles were sealed with rubber septa and crimped. Subsequently, 5 ml of nitrogen gas was added into each of the bottles to create a headspace where gasses, which are dissolved in the water can equilibrate. After shaking the water samples for several minutes, the concentration of methane in the headspace of each sample was analyzed with a gas chromatograph from Thermo scientific Trace 1310 equipped with an FID.

Microbial community composition and quantification
1 L seawater aliquots from selected water levels were collected for microbial community analyses with DNA tools (next generation sequencing, Illumina). Seawater samples were filtered through polycarbonate filters (0.2 µm pore size, Millipore) and stored at -20°C until further analyses in our laboratories.

Additional samples were collected for determining the identity and abundance of key microbial communities through fluorescence *in situ* hybridisation with catalysed reporter deposition (CARD-FISH); Pernthaler and Pernthaler, 2007). For this purpose, 300 mL of aqueous sample were fixed with 15 mL formaldehyde solution (38%) for 4 h at 4°C in the dark. Subsequently, samples were filtered through polycarbonate filters (0.2 µm pore size, Millipore) rinsed with deionised water and stored at -20°C until further analyses in our home laboratories.

MOx rates will be determined from all collected samples. The resolution of microbial community analyses (FISH, DNA) will depend on the results of rate measurements.

Table 5 -Overview of seawater and sediment samples collected during the cruise. Abbreviations: rMOx = aerobic methane oxidation rate, FISH = fluorescence in situ hybridization.

Site/Area	Ship Station	Activity	Water Depth [m]	MOx	DNA	FISH	CH_4
Gas hydrate pingos area	897	CTD	382	x	x	x	x
	900	TC		x	x	x	x
	902	TC		x	x	x	x
	906	CTD	385	x	x	x	x
	907	CTD	383	x	x	x	x
	908	CTD	385	x	x	x	x
	909	CTD	383	x	x	x	x
	910	CTD	385	x	x	x	x
	911	CTD	367	x	x	x	x
	912	CTD	382	x	x	x	x
	913	CTD	385	x	x	x	x
	914	CTD	383	x	x	x	x
Gas hydrate pingos area	918	TC			x	x	
	919	TC			x	x	
	920	TC			x	x	
	921	TC			x	x	
	922	TC			x	x	
	933	TC		x	x	x	x
New Area	936	CTD		x	x	x	x
	939	TC		x	x	x	x
	947	TC		x	x	x	x

Sediment sampling

Microbial community composition and quantification

For the characterization of the microbial community and their metatranscriptome, sediment samples were collected from multi cores (sampled in 2-cm intervals). The 2-cm slices of sediment were transferred into sterile plastic bags and frozen immediately (-80°C). From these samples DNA and RNA will be extracted in our home laboratories and analyzed by high throughput sequencing.

For quantification of different microbial groups in sediment, 0.5 mL of sediment aliquots (taken from the same intervals as DNA/RNA samples) were fixed with formaldehyde solution (4 %). After 4 h fixation at 4°C in the dark, sediment samples were washed twice with PBS buffer (pH 7.2) and stored in PBS/ethanol (1:1) solution at -20°C. Hybridization and microscopy will be conducted in our home laboratories.

Table 6 - Overall of sediments samples collected at reference sites (R), gas hydrate pingos (GHPs) and a new area (NA) during the CAGE 17-2 cruise.

	Ship Station	Depth (cm)	Nr. of layers	[CH_4]	Porosity	FISH	DNA/ RNA
R	898	23	10	X	X	X	X
	924	35	16	X	X	X	X
GHP I	900	41	19	X	X	X	X
	902	23	10	X	X	X	X
	917*	32	15	X	X	X	X
	918	45	21	X	X	X	X
	919	45	21	X	X	X	X
GHP V	920*	21	8	X	X	X	X
	921	12	4	X	X	X	X
	922*	17	18	X	X	X	X
	923	35	16	X	X	X	X
NA	939	14	6	X	X	X	X
	948	18	9	X	X	X	X

*Sediments were collected from the surface for culture.

Sediment chemistry

For measuring the concentration of methane in the sediment, conventional headspace sampling preparation technique was applied. 3 ml of bulk sediment was taken from the same intervals as DNA/RNA samples by using a 3-ml cut-off plastic syringe. The sediment sample was transferred into a 20-ml headspace glass vials, containing 7 ml of NaOH solution (1 M) and 2 glass beads. The vials were immediately capped with rubber septa, sealed with aluminum crimp caps and shaken afterwards. Samples were analyzed with a gas chromatograph from Thermo scientific Trace 1310 equipped with a FID.

For porosity measurements, 3 ml of bulk sediment was taken by using a 3-ml cut-off plastic syringe and transferred into a 15-ml centrifuge tube. Samples were stored at room temperature until processing them in the home laboratory according to Boyce, (1973).

Sulfide measurements were taken to be complimentary to the experimentation undertaken by collaborators onboard the cruise. Sampling depths are presented in Table 3. Two 2-mL Eppendorf safe-lock tubes were filled with sediments. Tubes were centrifuged at maximum speed for two minutes and the supernatant was filtered and transferred into a new safe-lock tube before being stored at -20^{o}C.

Table 7 - Overall samples collected for sulphide measurements and an approximate volume of porewater extracted for further analyses.

Ship Station	Depth (cm)	Porewater volume (mL)
902 Pingo I - II	0 - 1	0.7
	1 -2	0.4
	2 - 3	0.4
	5 - 7	1
	7 - 9	0.8
	9 - 11	0.7
	11 - 13	0.5
	13 - 15	0.2
	15 - 17	0.7
	17 - 19	0.6
	19 - 21	0.4
	21 - 23	0.6
	26 - 28	0.9
917 Pingo I - III	1 - 2	1.2
	3 - 4	1
	5 - 6	0.8
	7 - 8	0.6
	9 - 10	0.8
	10 - 11	1
918 Pingo I - IV	1 - 2	1
	3 - 4	1
	5 - 6	1
	7 - 8	1
	9 - 10	1
	10 - 11	1
919 Pingo I - V	1 - 2	1.2
	3 - 4	1.2
	5 - 6	1.2
	7 - 8	1.2
	9 - 10	1.2
	10 - 11	1.2
920 Pingo V - I	0 - 1	1
	1 - 2	0.9
	2 - 3	1

	3 - 4	0.7
	4 - 5	0.8
	0 - 1	1
	1 - 2	1
	2 - 3	1
	3 - 4	1
921 Pingo V - II	4 - 5	1.1
	5 - 6	1
	6 - 7	0.6
	7 - 8	0.7
	8 - 9	0.5
	1 - 2	1.2
	3 - 4	1.2
922 Pingo V - III	5 - 6	1
	7 - 8	0.7
	9 - 10	0.4
	10 - 11	1
	1 - 2	1
	3 - 4	1
923 Pingo V - IV	5 - 6	1
	7 - 8	1.1
	9 - 10	1
	10 - 11	1
	0 - 2	1.2
	2 - 4	1
	4 - 6	1
	6 - 8	0.4
	8 - 10	0.6
	10 - 12	0.5
	16 - 18	0.7
924	28 - 30	0.7
Reference site	34 - 36	0.5

Cultivation and isolation

For cultivation and isolation studies of methanotrophic bacteria, sediment from the sediment-water interface (~5 ml) was transferred into 100-mL glass bottles filled with 50 mL sterile filtered seawater, sealed with rubber stoppers, and the headspace was amended with 10 mL CH_4. Incubations of enrichment cultures were started on board at 4°C in the dark.

8.9. Micropalentology

Benthic foraminiferal ecology (P.-A. Dessandier)

The living benthic foraminifera will be identified in order to have a good knowledge of the dominant species in several areas in the Barents Sea. The faunal density, diversity and ecology will be investigated and linked with the methane concentration in the sediment. The faunal microhabitats of the dominant species will be determined aiming at identifying the influence of pore water chemistry on species. In order to calibrate the use of fossil assemblages of benthic foraminifera in future paleo-environmental investigations, the ecology of the dominant species will be analyzed using a large dataset or organic matter compounds and pore water analyses. The living benthic foraminifera will be used also for future isotopic measurements in methane influenced areas, to calibrate the response of isotopes in methane enriched environments using benthic foraminiferal tests. The understanding of vital effect and early diagenesis influence on isotope foraminiferal signals will be improved by the comparison of these isotopic measurements on living fauna and the species microhabitats/ecology.

Sampling of living benthic foraminifera:

At each multicore station (Table), one sediment core from the multicorer was sliced every centimeter from 0 to 5 cm depth. 2 samples from the gravity cores 969 and 970 were collected from the upper most part of the cores (~3 cm). The samples collected were stored in containers in a 2 $g.L^{-1}$ solution of Rose Bengale in 96% ethanol, in order to be preserved and to stain the living organisms.

Station number	Rose Bengal	Geochemistry	Replicates	samples
MC898	x	x	x	0-5 cm
MC900	x	x		0-5 cm
MC917	x	x		0-5 cm
MC918	x	x		0-5 cm
MC919	x	x		0-5 cm
MC920	x	x		0-5 cm
MC921	x	x		0-5 cm
MC922	x	x		0-5 cm
MC923	x	x		0-5 cm
MC932	x	x		0-5 cm
MC933	x	x		0-5 cm
MC939	x	x		0-5 cm
MC940	x	x		0-5 cm
MC948	x	x		0-5 cm
MC950	x	x		0-5 cm
MC951	x	x		0-5 cm
MC957	x	x		0-5 cm
MC962	x	x	x	0-5 cm
GC969	x	x		top (~3 cm)
GC970	x	x		top (~3 cm)

The samples have to stay at least 14 days in the solution before the analysis. All samples will be washed and sieved, the >63 and >125 µm size fraction will be analyzed. Isotopic measurement will be done on both living (stained) and dead benthic foraminifera, as well as on planktonic foraminifera. Replicates were collected in 2 stations (898 and 962) in order to evaluate the potential patchiness of the benthic foraminiferal distribution.

Geochemistry:

At each station (Table), one sediment core from the multicorer was sliced every centimeter from 0 to 5 cm depth. 2 samples from the gravity cores 969 and 970 were collected from the upper most part of the cores (~3 cm). The samples collected were stored in plastic bags directly put in -20°C freezer to avoid any photosynthetic reaction or organic matter degradation. These samples will be analyzed in laboratory to measure the Total Organic Carbon (TOC), the Total Nitrogen (TN), the $d^{13}C$ and $d^{15}N$ of the organic matter and the pigments (Chlorophyll A and B, phaeopigments). The TOC indicates the organic matter quantity, as a food source for benthic foraminifera, allowing the identification of the trophic regime of species. The TN gives information on the organic matter quality/degradation of this organic matter. The isotopes also indicate the degradation state of the organic matter as a well as its source. The pigments indicate the photosynthetic matter stock and its quality or degradation state, this photosynthetic production is well known as the major food source for benthic foraminifera.

Figure 42 - Image of the top of the multicore. The multicores

Living benthic Foraminifera (K. Melaniuk)

Sample collection

To describe living foraminiferal fauna sediment surface was collected form investigated area Storfjordrenna Pingo and Olga basin. Sampling were taken using MISO TowCam attached to multicorer from sites characterized by presence of bacterial mats, authigenic carbonates or methane flares. After recovery core for microplaentology was slice on 1cm thick layers. First two layers 0-1, 1-2 cm were labelled with **CellHunt Green (CHG).** In addition, approximately 20ml of sediment were preserved for TEM, and ok 2ml for *fluorescence in situ hybridization* (FISH) to detect methanotrophic bacteria. All samples are listed.

Staining preparation

CellHunt Green (CHG)(0-1; 1-2cm depth)

The CHG reagent solution was prepared in advance as follow: 1.4. ml of DMSO (not anhydrous) was added to 1mg of CellHunt Green (solid, stored in freeze at -20C) in a plastic vial as it came from the supplier. The CHG solution was removed from the freezer, thawed approx. 30minutes before dissolving it, and shook it to dissolved. The CHG-DMSO mixture were added to sediment samples in proportion 6µl to 10ml sample. It was mixed and stored on HPDE bottles (125ml), in 4^{o}C. After incubation time, approximately 12h, ethanol was added.

TEM- staining (0-1cm depth only)

A TEM solution of 10ml glutaraldehyde (defrosted), 25ml cacodylate buffer and 15ml distilled water was prepared ½ hour prior to sampling under the fume hood. During subsampling, approximately 20ml of sediment from 0-1 depth was transferred in 60ml HDPE bottle. And TEM solution was added until the bottle was almost full. Samples were stored in the cold room at 4^{O}C.

Station No.	CTG	TEM	FISH
MC898	X	X	X
MC900	X	X	X
MC902	X	X	X
MC917	X		X
MC918	X	X	X
MC919	X		X
MC920	X		X
MC921	X	X	X
MC922	X		X
MC923	X		X
MC932	X	X	X
MC933	X		X
MC939	X	X	X
MC940 #1	x	X	x
MC948 #6	x		X
MC950#	x		X
MC957	X	X	X
MC962	x	X	X

8.10. Image surveys and photomosaicking (A.Sen, G.Panieri)

Several image survey were conducted in the Stofrjordernna Pingo area and in the Olga basin craters. One image survey was conducted over Pingo 1 (active) and Pingo 5 (the less active pingo). Other surveys were conducted in the Olga Basin crater site.

For the Pingo site, the images from the transects, or, image surveys will be examined in order to determine whether overlap between images was achieved. In surveys with overlapping images, the images will be blended together based on common features in order to create seamless mosaics of those regions of the seafloor and complete mosaics will be georeferenced based on the navigation data and altitude. In surveys where images did not overlap, mosaics will not be possible. However, spatial extent will still be calculated, based on the navigation data and altitude associated with each image. In this case, individual images will be georeferenced and placed in space, as opposed to mosaics.

9. Cruise narrative

The date/time base for all observations and data collected during the cruise is in UTC (GMT; local time is UTC+2). The position for all the stations is from the navigation of the ship, while for the position for the multicorer is from the USBL.

Wednesday 21 June 2017

12:00 UTC - Meeting with the Captain, the Chief mate and the crew to explain the scientific objectives of the cruise, locations and the operation related to deployment of the TowCam. GP gave to the Captain the list of participants and the Next-in-Kin form.

13:00 UTC - Welcoming and safety meeting with the Chief officer and the scientific.

14:00 UTC - Scientific meeting. We discussed the scientific goals, locations, and sampling strategy.

15:00 UTC - Lecturing Arunima Sen and Pierre-Antoine Dessandier.

17:00 UTC R/V Helmer Hanssen left the harbor of Longyearbyen starting the CAGE 17-2 AMGG cruise with a group of scientists that comprise 2 WHOI Engineers, and 2 UiT Engineers. The ship was heading to the area Storfjordrenna Pingo.

18:00 UTC - The mobilization of the TCM and the lab installation was completed.

18:30 UTC - Lecturing by Friederike Grundger and Simone Sauer.

18:45 UTC - R/V Helmer Hanssen left the harbor of Longyearbien starting the AMGG CAGE 17-2 cruise with a group of scientists, master students, 2 WHOI Engineers, and 2 UiT Engineers. The ship was heading to the area Storfjordrenna Pingo.

Thursday 22 June 2017

6:30 UTC - Briefing

7:00 UTC - We took air sample for NILU (**896AIR**).

09:47 UTC - We took a CTD (**897CTD**)

10:00 UTC - Operational meeting with the Captain, First mate, UiT Engineers, WHOI Engineers: plan for the Tow Cam Multicorer (from now on TCM) lowering and recovery.

11:00 UTC - We reached our first working area

11:06 UTC - TCM in water (**898 TOW n.1**). Pictures every 10 seconds. CTD on the multicorer is not working. This is the reference station for this area. Total images taken n. 362.

11:34 UTC - TCM on bottom at 370 water depth. 6 full liners (**898 MC**)

13:00 UTC - USBL has been installed

14:00 UTC - USBL has been configured

14:55 UTC - We took air sample (**899AIR**)

14:56 UTC - TCM in water (**900 TOW n. 2**). Pictures every 10 seconds. CTD attached to the multicorer is working. This is the first station (reported as S1 in the table listing all the Tow Cam deployment) of a transect that starts at the top of the Pingo 1, moving NW. We took 6 water samples with Niskin bottles (**900 NK**). We observed trawl marks at the seafloor. The seafloor is soft mud, and we observed anemones, polychaetes, and clusters of either fish holes or bioturbations. Strong flares characterize the area and the multicores taken are characterized by very dark/black mud and a strong H2S odor. Total images taken n. 316.

15:38 UTC - TCM on bottom at 370 water depth. 4 full liners (**900MC**)

16:31 UTC - We took air sample (**901AIR**) in an area with high intensity of flares.

16:42 UTC - TCM in water (**902 TOW n. 3**). Pictures every 10 seconds. CTD attached to the TCM is working. This is the second station of a transect that starts at the top of the Pingo 1, moving NW. Samples are for Microbiology, Micropaleontology and Pore-water geochemistry group. We took 3 water samples with Niskin bottles (**902 NK**). The seafloor was strongly disturbed by trawling occurring in the area. Total images taken n. 531.

16:48 UTC –There are problems with the idrolic that control the winch. While the crew was repairing it the TCM was positioned at 20 meter below the sea surface for safety.

17:23 UTC - The problem with the idrolic is solved, and we can resume the lowering of the TCM.

17:41 UTC - TCM on bottom at 367 m water depth. 4 full liners (**902 MC**).

18:11 UTC TCM on deck.

19:47 UTC - We took a gravity core on top of Pingo 3 at 370 m water depth (**903GC**) and was empty.

20:17 UTC - We repeated the gravity core on top of Pingo 3 at 365 m water depth (**904 GC**). We recovered only concretions from the core catcher.

20:49 UTC - We repeated for the second time a gravity core on top of Pingo 3 at 367 m water depth (**905 GC**). We recovered 120 cm of sediment. The core was cut in sections (but not split) and we observed gas hydrate dissociation and bubbling for at last ca 30 minutes. The gas hydrate was from 25 to 120 cm bsf and abundant concretions (3-5 cm in diameter) in a interval from 0 to 25 cm bsf. We cut a section (156-210 cm) with gas hydrate and placed at -20 C.

21:33 UTC – We started a CTD cross transect (Planned 9 stations) in the Pingo area. We did the **906CTD**.

23:19 UTC – We did the **907CTD.**

Friday 23 June 2017

During the night we continued the CTD cross transect in the Pingo area (from **908** to **914** CTD).

6:30 UTC - Briefing on the operations done during the night, the plan for the next days.

6:56 UTC - We took air sample (**915AIR**) in an area with high intensity of flares.

07:17 UTC - TCM in water (**916 TOW n. 4**). Pictures every 10 seconds. CTD attached to the TCMC is working. This is the third station for Microbiology, Micropaleontology and Pore-water geochemistry group. The seafloor is muddy, with marks of trawls and rare biology. Rare ice-rafted debris. We took 6 water samples with Niskin bottles (**916 NK**). Total images taken n. 337.

07:48 UTC - TCM on bottom at 367 m water depth. 1 full liner (**916 MC**).

08:13 UTC - TCM on deck.

08:38 UTC - TCM in water (**917 TOW n. 5**). Pictures every 10 seconds. CTD attached to the TCM is working. We repeat the third station because in the previous the station we recovered only one full liner. The seafloor is muddy, and appears to be strongly disturbed by trawling occurring in the area. During the lowering we observed sparse ice-rafted debris, several macrofaunal organisms like anemones attached to rocks and with a diameter of ca 10 cm (when open tentacles), isolated and in patches, siboglinids, sea spider, and patches of bacterial mats. We took 2 water samples (**917NK**). Total images taken n. 297.

09:04 UTC - TCM on bottom at 367 m water depth. 6 full liners (**917 MC**) taken.

09:27 UTC - TCM on deck.

10:03 UTC - TCM in water (**918 TOW. 6**). Pictures every 10 seconds. CTD attached to the TCMC is working. This is the fourth station of the transect. The seafloor looks muddy, we observed some fish but at the seafloor less organisms than the previous lowering. We again observed trawl marks. Total images taken n. 244.

10:21 UTC - TCM on bottom at 379 m water depth. 6 full liners (**918 MC**)

10:42 UTC - TCM on deck.

11:09 UTC - TCM in water (**919 TOW n. 7**). Pictures every 10 seconds. CTD attached to the TCMC is working. We do the last station of the transect (started yesterday) on the Pingo 1. During the towing we observed fish, frenulates (Siboglinidae), bacterial mats (we took a water samples at the top of bacterial mats), IRD colonized by anemones, isolated gastropods, and concretions. In some area, the seafloor is strongly disturbed by trawling track. There are other features but difficult to explain. During the lowering at 11.49 UTC we observed the imprint of the multicorer impact (station 916 or 917). We took one water sample in a flare (bottle 1), another one (bottle2), then two water samples (bottles 3 and 4) after multicoring (**919NK**). For this reason, we might have “contaminated” the water samples with sediment reworked from the multicoring. Total images taken n. 482.

12:01 UTC - TCM on bottom at 368 m water depth. 6 full liners (**919 MC**)

12:28 UTC - TCM on deck.

13:35 UTC – TCM in water (**920 TOW n. 8**). Pictures every 10 seconds. CTD attached to the TCM is working. We start the transect from the top of Pingo 5. We observed trawl marks, patches of bacterial mats, siboglinids, anemones, sea spider, hormathia, fish, numerous IRD colonized by sessile fauna. We took one water sample with Niskin bottle few second before we took multicores (920NK). Total images taken n. 293.

13:55 UTC – TCM at bottom at 369 m. 3 full liners and one only of 10 cm (**920MC**)

14: 23 UTC - TCM on deck.

14:52 UTC - TCM in water (**921 TOW n.9**). Pictures every 10 seconds. CTD attached to the TCMC is working. We do the second station of the transect on Pingo 5. We took one water sample (921 NK) above the sampling site where we took the multicorer. Total images taken n. 290.

15:14 UTC - TCM at bottom at 370 m (921MC). 5 full liners.

16:14 UTC - TCM in water (**922 TOW n.10**). Pictures every 10 seconds. CTD attached to the TCMC is working. Based on the wind direction (from N) we did a lowering across the Pingo 5 from south to north and at the end we did the third station of the transect which is the last station in the line. We toke one water sample (**922 NK**) above the sampling site where we took the multicorer. Total images taken n. 468.

17:10 UTC - TCM at bottom at 367 m (**922 MC**). 5 full liners.

17:31 UTC - TCM on deck.

18:19 UTC - TCM in water (**923 TOW n. 11**). Pictures every 10 seconds. CTD attached to the TCMC is working. We do the fourth and last station of the transect on Pingo 5. We took one water sample (**923NK**) above the sampling station. The seafloor is muddy, with few IRD and centimetric crusts. We observed fish and anemones attached to pebbles. Total images taken n. 207.

18:35 UTC - TCM at bottom at 366 m (**923MC**). 6 full liners.

18:40 UTC - One of the students is sick and after a meeting with the Captain it has been decided to steam back to Longyearbien and disembark the student. GP communicate via email to the Administration of the Department of Geosciences the decision.

19:00 UTC - TCM on deck

20:00 UTC - The crew has pulled out the cylinder where the USBL is located. This action was taken to speed the sailing of Helmer Hanssen back to Spitsbergen.

20:36 UTC - TCM in water (**924 TOW n.12**). Pictures every 10 seconds. CTD attached to the TCMC is working. This is the reference station and the seafloor is characterized is muddy, with abundant bivalves (we see the siphon), seastar. Total images taken n. 270.

20:53 UTC – TCM at the bottom at 374 m (**924MC**). 5 full liners.

21:18 UTC - TCM on deck.

22:00 UTC – We steam back to Longyearbien to disembark the student.

Saturday 24 June 2017

06:00 UTC – We are steaming to Longyearbien.

06:55 UTC – We took an Air sample (**925 AIR**).

08:15 UTC – In a discussion on positioning, we decided that for the next area, Northern flank of Olga Basin, we will write manually the position of the multicorer station from the USBL.

10:00 UTC – The Administration of the Department of Geosciences at UiT sent the flight ticket and hotel reservation for the student that is leaving the boat.

12:00 UTC – R/V Helmer Hanssen arrived in Longyearbien where the students left the boat.

13:00 UTC – R/V Helmer Hanssen left the harbor of Longyearbyen and head to the Northern Flank of Olga Basin.

13:50 UTC – Cruise meeting. We discussed about the work done so far in the Pingo area, we did preliminary observations from the pictures taken from the TCM. We discussed about a better protocol that can be used during the operation concerning the Multicorer (rig and removal of liners, numbering the liners from 1 to 6, clean the liner before picture and use a scale) and how to better communicate between the instrument room and the deck.

During the day, UiT and WHOI engineers worked on the navigation system. They re-rand the files acquired and stored so far in a new format GPGGA. GPGGA gives ship data. GPTLL represent the location of the beacon, which is on the tow cam. Now we have the coordinates of ship station from the ship and for the tow cam multicores we use the USBL positioning.

Sunday 25 June 2017

We are steaming to North Flank of Olga basin and in the meantime the UiT and CAGE engineers are working to install the new CAGECam camera that will be tested during the next lowering. Also the USBL navigation has been adjusted and from now on the navigation for the TowCam lowering and multicores will be from the beacon of the USBL. However, the main navigation system is the one from the ship.

06:00 UTC - We are steaming to North Flank of Olga basin.

06:56 UTC – We took an Air sample (**926 AIR**).

14:00 UTC- Cruise meeting. GP informed about the plan for the next days, which survey will be done in the new area of investigation. In addition, the pore-water group explained what they did in the Pingo site, and discussed about preliminary results.

During the day Helmer Hanssen navigated with a lot of drift ice.

Monday 26 June 2017
During the night we steamed to North Flank of Olga basin.

03:40 UTC – we arrived in the position where we will start the survey of the North Flank of Olga basin.

03:40 UTC - CTD sound velocity (**927 CTD**). We noticed that at 40 m the temperature drop at -1.8 C. The temperature at the surface is 0.7º C.

04:05 UTC - we started the multibeam survey with 30Khertz 432 beams at 62 at each side of the ship (Line1-Line3). We are also recording water column data looking for flares (**928MB**).

05:25 UTC – We finished the Line 1; we did not notice any flares. Only one was suspicious.

05:28 UTC – We started the Line 2. We observed two suspicious flares.

06:35 UTC – We finished the Line 2. We observed two suspicious flares.

06:39 UTC - We start the Line 3.

06:49 UTC – We took an Air sample (**929 AIR**).

07:44 UTC - We finished the Line 3 (1 hour and 6 minutes). We did not notice any flare; only one was suspicious.

07:48 UTC – CTD station for sound velocity **(930CTD**). We noticed hat at 25 m below sea surface the temperature decreased from 0.5º C at the sea surface to -1.9º C.

08:07 UTC - We started a Multibeam and chirp survey (Lines 1-3) (**931SBP**). During the chirp we observed a depression in the middle of the investigated area where there are at least 15 m of sediment. This will be the target are for gravity coring. We observed strong flares.

13:05 UTC – we finished the survey (931SBP). During the survey we observed strong flares.

14:42 UTC - TCM in water (**932 TOW n.13**). Pictures every 10 seconds. CTD is working, dissolved oxygen sensor is not installed because the cold temperature of the water (0.8ºC). This is a reference station. During this lowering we tested our new CAGECam camera and we recorder the data from USBL. Total images taken n. 237. (Tow Cam video recorded 3 video: **932VID**)

15:04 UTC – TCM at the bottom at 171 m water depth (**932MC**). 3 full liners.

15:21 UTC - TCM on deck.

15:57 UTC - TCM in water (**933 TOW n.14**). Pictures every 10 seconds. CTD is working, dissolved oxygen sensor is not installed because the cold temperature of the water (0.8C). This lowering cross the depression (named D1) from N to S. Video and images showing abundant small organisms (krill?) in the water column, and at the seafloor abundant starfish, anemones, sponge, corals and fish. Isolated IRD. Rare trawl marks appear to be done in the past. The area does not seem to be trawled recently. 2 water sample (**933NK**). Total images taken n. 813 images (Tow Cam video recorded 7 video **933VID**).

17:57 UTC – TCM at the bottom at 211 m (**933MC**). 5 full liners

18:15 UTC - TCM on deck.

19:00 UTC – We started a multibeam and singlebeam survey (**934**) on the feature that resemble a wreck. We process the data immediately to find the origin of the feature.

22:24 UTC - Gravity core in a depression (named D2) at the center of Olga Basin crater area (**935GC**)

Tuesday 27 June 2017
00:47 UTC – CTD (**936CTD**)

01:48 UTC – we started a survey in the area where there is a mound (West of the Olga Basin crater area) (**937MB**). We observed flares in the same area where we see flares during the morning (SW from the mound).

06:58 UTC – We took an air sample (**938AIR**)

07:10 UTC – we anchor the ship for keeping the station in position and deploy the Tow Cam in the Mound site where there are flares.

07:57 UTC – TCM in water (**939TOW n. 15**). Pictures every 10 seconds. CTD is working, dissolved oxygen sensor is not installed. This lowering is done to investigate the seafloor around Mound 1 site where we observed flares in the water column data. We are trying to reach the position of flares with the tow cam while the ship is anchored. We took n. 6 water samples (**939NK**) at different altitude and we recorder a video every time we sampled the water column. We saw abundant organisms in the water column (krill?). At the station, there are abundant sea starts, patches of bacterial mats, some soft corals, insolated block (carbonate, crusts or IRD is not clear) densely colonized by sessile organisms, mostly anemones.

09.44 UTC - we decided to take off the anchor and finish the lowering without it. There is not much sediment and the anchor cannot anchor very well.

09:46 UTC - we are continuing the lowering of the TCM and trying to reach the position where we observed flares.

10:25 UTC – TCM at the bottom at 147 m (**939MC**). We took n.1 water samples close to the seafloor in the active flare. Total images taken n. 1007 images (CAGECam video recorded 13 videos **939VID**). n. 6 full liners.

12:12 UTC – TCM in water (**940 TOW n.16**). Pictures every 10 seconds. CTD is working; dissolved oxygen sensor is not installed. We took n. 5 water samples along the lowering and 1 where we saw bubbles (**940NK**). In the water column there are abundant organisms. Around the station, we observed sea starts, seaspiders, patches of bacterial mats, insolated block (crusts or IRD is not clear) densely colonized by epifauna and bubbles rising from the seafloor exactly in the middle of bacterial mats.

12:22 UTC - TCM on deck. Total images taken n. 242 images (CAGECam video recorded 7 videos **940VID**). n. 3 full liners (very low sediment recovery ca 20 cm and 1 liner was lost at deck).

12:37 UTC . TCM at the bottom (**940 MC**).

12:44 UTC - Air sample (**941 AIR**).

13:42 UTC - TCM in water (**942 TOW n.17**). Pictures every 10 seconds. CTD is working; dissolved oxygen sensor is not installed. We did a lowering from the top of the mound thorough the southern flank; we observed a peculiar biology, with abundant crinoids, and other sessile organisms. The top of the mound looks rocky. Moving down along the flank, the fauna changes and decreased in abundance. We observed sponges, isolated rocks colonized by sessile organisms. At the base of the mound we observed new flares in the multibeam and patches of bacterial mats. No water samples taken this time.

15:00 UTC - TCM on the bottom at (149m) (**942MC**).

15:17 UTC - TCM on deck. Total images taken n. 573 images (CAGECam video recorded seven video **942VID**). n. 0 full liners.

16:08 UTC – Scrape **943**. We do a scrape with the aim to collect rocks to characterize the Mound 1. We collected rocks (3-15 cm in diameter), sea stars and bivalves; many of them appear to be predated/corroded in the hinge.

17:01 UTC - **944CTD** station in the same position we did 936CTD.

19:20 UTC - **945MB**. We started a multibeam and singlebeam survey in the “flare city” area.

21:37 UTC - we are finishing the survey in the “flare city”. We haven´t seen any flares indicative of gas emissions. We believe that many of the flares indicated by Mareano data might be misleading. Because the area is extremely productive we believe that in the ecosounder fish or krill might have been interpreted as flares. During the CAGE17-2 cruise we have also observed fish ….resembling flares. We decided to steam north and survey another part of the Northern Flank of Olga Basin.

Wednesday 28 June 2017

During the night we surveyed the northern part of the Northern Flank of Olga Basin, where we observed some flares and the eastern part we did not observed flares. We decided then to steam north and do tow cam lowering in a depression that we named D3.

06:59 UTC – We took an air sample (**946AIR**)

07:29 UTC - TCM in water (**947 TOW n.18**). Pictures every 10 seconds. CTD is working; dissolved oxygen sensor is not installed. We changed the depth option of the USBL from mode manual to acoustic. We took n. 6 water samples (**947NK**) at different altitude in the flare.

08:36:22 UTC - TCM at the bottom (**947MC**) where we see several patches of bacterial mats and crusts (08:36:22). This flare was indicated by Mareano in 2015. Total images taken n. 502 images (CAGECam video recorded 5 videos **947VID**). 0 full liners.

08:52 UTC – TCM on deck. 0 full liners. One of the liners penetrated 2-3 cm but did not recover sediments. The sediment around the base of the liner was , light brown sandy mud.

09:25 UTC - TCM in water (**948 TOW n.19**). Pictures every 10 seconds. CTD is working; dissolved oxygen sensor is not installed. We are still in the D3.The winch has a problem and we do not register data from the CTD on TowCam. We did not recorded video (**948VID**) because the TCM has to fly 3-4 m altitude from the seafloor.

10:10 UTC – we start the chirp for finding an area with sediment. Unfortunately, in the area the sedimentation rate is very low.

10:18 UTC – TCM at the bottom (**948MC**) at 121.3 m water depth, at the flare location from the Mareano where we took the previous MC (**947MC**). Approaching the site we observed several patches of bacterial mats and crusts (10:04:05 and 10:10:30). Total images taken n. 422 images (CAGECam video did not record any video **948VID**). n.3 full liners with max 20 cm of sediment.

10:34 UTC - TCM on deck.

During the lunch time the crew, the UiT and WHOI engineers were working to solve the problem with the winch.

12:09 UTC . CTD station on the flare in the D3 site (**949CTD**).

13:07 UTC - TCM in water (**950 TOW n.20**). Pictures every 10 seconds. CTD is working; dissolved oxygen sensor is not installed. We are still in the D3 trying to collect samples from bacterial mats. However, the problem with the fiber optic cable of the winch has not been solved and we do tow cam lowering only on a station, but we cannot do transect. We took a water sample above bacterial mats (**950NK**).

13:21 - UTC - TCM at the bottom (**950MC**) at 143 m water depth. Towcam over some flares site area in D3 as station 947MC. Approaching the site we observed several patches of bacterial mats and crusts (13:16:25 at 76 51.1978 35 26.2316). Total images taken n. 212 images (CAGECam video recorder n.1 video **950VID**). n.2 full liners, with max 20 cm of sediments.

13:36 UTC – TCM on deck.

14:27 UTC - TCM in water (**951 TOW n.21**). Pictures every 10 seconds. CTD is working; dissolved oxygen sensor is not installed. Photo traverse the Mareano flares Mareano. We are still in the D3 trying to collect samples from bacterial mats. During the lowering we observed patches of bacterial mats and crusts, in addition to pebbles often colonized by sessile organisms. The fauna is represented mostly by sea stars; anemones and soft corals are accessory. Although the problem with the winch (slip ring) is not solved, since the relief of the area is only 50 cm, we try to do a transect crossing the flares observed by Mareano. We re-start the USBL from the bridge. We took n.2 water samples (**951NK**).

15:31 UTC - TCM at the bottom (**951 MC**) at 152 m water depth. n. 3 full liners, with max 30 cm of sediments. Total images taken n. 599 images (CAGECam video recorded n.1 video, **951VID**).

16:12 UTC – TCM on deck.

17:30 UTC – We take a gravity core from the flare (**952 GC).** The recovery was 15 cm plus the core catcher (in total 20 cm).

18:52 UTC – **953Scrape**. Along the line we covered with TCM (950 TOW n. 21). There are at least three species of sea star (brittle stars), sea cucumber, bivalves very often predated and several peddles. Most likely a small (max 5 cm) crusts.

19:47 UTC – **954 Scrape**. We repeated the scrape along the line we covered with TCM (950 TOW n. 21). There are at least three species of sea star (brittle stars), sea cucumber, bivalves very often predated and several peddles. Several crusts (the biggest max ca 30 cm).

20:37 UTC - We started a survey (**955MB**)

Thursday 29 June 2017
During the night we surveyed the northernmost part of the Northern Flank of Olga Basin, where there are 2 depressions north of D3. We did not observe any flare.

07:04 UTC – Air Sample (**956AIR)**

08:15 - TCM in water (**957 TOW n.22**). Pictures every 10 seconds. CTD is working; dissolved oxygen sensor is not installed. The CAGECam is facing down while the TowCam has still in the same position. We are in the D4 site. We took n.6 water samples (**957NK**).

10:04 UTC – TCM at the bottom (**957MC**). We took the MC very close to a small bacterial mat at 143 m water depth. n. 5 full liners. In one there is black mud.Total images taken n. 757 images (CAGECam video recorder n. 3 video, **957VID**).

10:21 UTC – TCM on deck.

We plotted all the images (Georef from USBL) with bacterial mats on the taw we did yesterday (TC 20 and TC 21). We have identified one area with several mats of bacteria and the next lowering will be done there. We gave the Captain the USBL position.

11:14 UTC - TCM in water (**958 TOW n.23**). Pictures every 10 seconds. CTD is working; dissolved oxygen sensor is not installed. The CAGECam is facing down while the TowCam has still in the same position. We moved in the D3 site in the spot where we observed several patches of bacterial mats, crusts and bubbles. We took n. 1 water sample (**958NK**) above a bacterial mat. We recorded 2 videos (**958VID**).

12:08 UTC - TCM at the bottom (**958MC**). (76 51 9846N 35 25.8369E). Crusts and bacterial mats. Liners were all empty because we might have touched the carbonate crusts. Total images taken n. 434 images

12:25 UTC - TCM on deck.

12:57 UTC – **959GC** in the same position of 958MC but was empty.

13:48 UTC - **960GC** in the same potion of 957MC and we recovered 30 cm.

15:08 UTC – We move south to the depression D1 while the batteries of the TowCam are charging and we record a multibeam (**961MB**).

18:XX UTC – We have reached the crater named C1.

18:36 UTC - TCM in water (**962 TOW n.24**). Pictures every 10 seconds. CTD is working; dissolved oxygen sensor is not installed. We are south of the crater named C1 in a Mareano flare. Muddy seafloor with rare seastars and no anemones because there are no rocks as a substrate for them.

18:46 UTC – TCM at the bottom (**962MC**) at 166 m water depth. We took the MC in a Mareano flare but we did no see the flare in the multibeam. n. 6 full liners. Total images taken n. 223 images (CAGECam video recorder n.1 video, **962VID**).

19:12 UTC – TCM on deck.

19:54 UTC - We started a survey to fill some gaps in the multibeam and survey an area further south with craters. (**963MB**)

Friday 30 June 2017

04:00 UTC - We stop the survey to take water samples and gravity on two Mareano flares that we have also observed during the night.

05:05 UTC – CTD of a flare (**964CTD**)

17:49 UTC - We took a gravity core (**965GC**) on top of the same flare of the CTD and was empty.

06:18 UTC - We took an air sample (**966AIR)** on the top of the same flare of CTD and gravity.

06:24 UTC - CTD on a flare (**967CTD**)

07:16 UTC – we took an air samples (**968 AIR**).

08:08 UTC - TCM in water (**969 TOW n.25**) in the crater C1. Pictures every 10 seconds. CTD is working;

dissolved oxygen sensor is not installed. We do a line across the eastern-most depression of C1. The seafloor is characterized by a thin veneer of soft mud; it is very different from the "old craters" area where the pavement show large slabs of rock debris surrounding the edge of the craters, and in the craters themselves. Here there are very rare isolated pebbles colonized by sponges, soft corals, anemones and other epifauna.

08:48 UTC – TCM at the bottom (**969MC**) at 204m water depth. n. 4 full liners. Total images taken n. 357 (CAGECam video recorded n. 2 video, **969VID**).

09:06 UTC – TCM on deck.

08:08 UTC - TCM in water (**970 TOW n.26**) in the crater C1. Pictures every 10 seconds. CTD is working; dissolved oxygen sensor is not installed. We do a line across the dome south of C1. At the bottom, thin veneer of soft mud, brittle stars, soft white corals, rare and isolated pebbles colonized by sponges, soft corals, anemones and other epifauna. The pebbles become more abundant at the very top of the mound. Suspicious methane-derived authigenic crusts.

11:01 UTC – TCM at the bottom (**970MC**) at 158 m water depth. n. The sample was taken at the very top of the mound. 1 full liners with 5 cm of sediment. We landed on crusts. Total images taken n. 449 (CAGECam video recorded n. 4 video, **970VID**).

12:47 UTC - We took a gravity core (**971GC**) in the southern rim of the depression D1. (Length 180 cm)

13:46 UTC - We took a gravity core (**972GC**) in the depression D1. (Length 215 cm)

15:05 UTC – We took a gravity core (**973GC**) at the top of the mound in C1 same position of 970MC. The liner was empty.

15:28 UTC - We attempted the second time (**974GC**) at the top of the mound in C1 same position of 970MC but the liner was empty.

15:46 UTC – we started a multibeam survey filling in areas to the south of the Olga craters area (**975MB**).

Saturday 1 July 2017

01:00 UTC – We started a multibeam survey in the West Centralbanken.

07:00 UTC – We took an air sample (**976AIR**)

07:05 UTC – Resume the multibeam survey (**977MB**) in the West Centralbanken.

08:33 UTC – We finished the survey in the West Sentralbanken and we started our journey to Tromsø.

Sunday 2 July 2017

07:15 UTC – We took an air sample (**978AIR**)

15:55 UTC – We took a multicorer for collecting living foraminifera (**979MC**). With this action, station work of HH cruise CAGE17-2 AMGG ended.

We continued our passage to Tromsø.

Monday 3 July 2017
06:00 UTC - We arrived in Tromsø. With the unloading of the ship in the morning cruise CAGE 17-2 AMGG ended.

10. Study areas: map and relative samples/activities

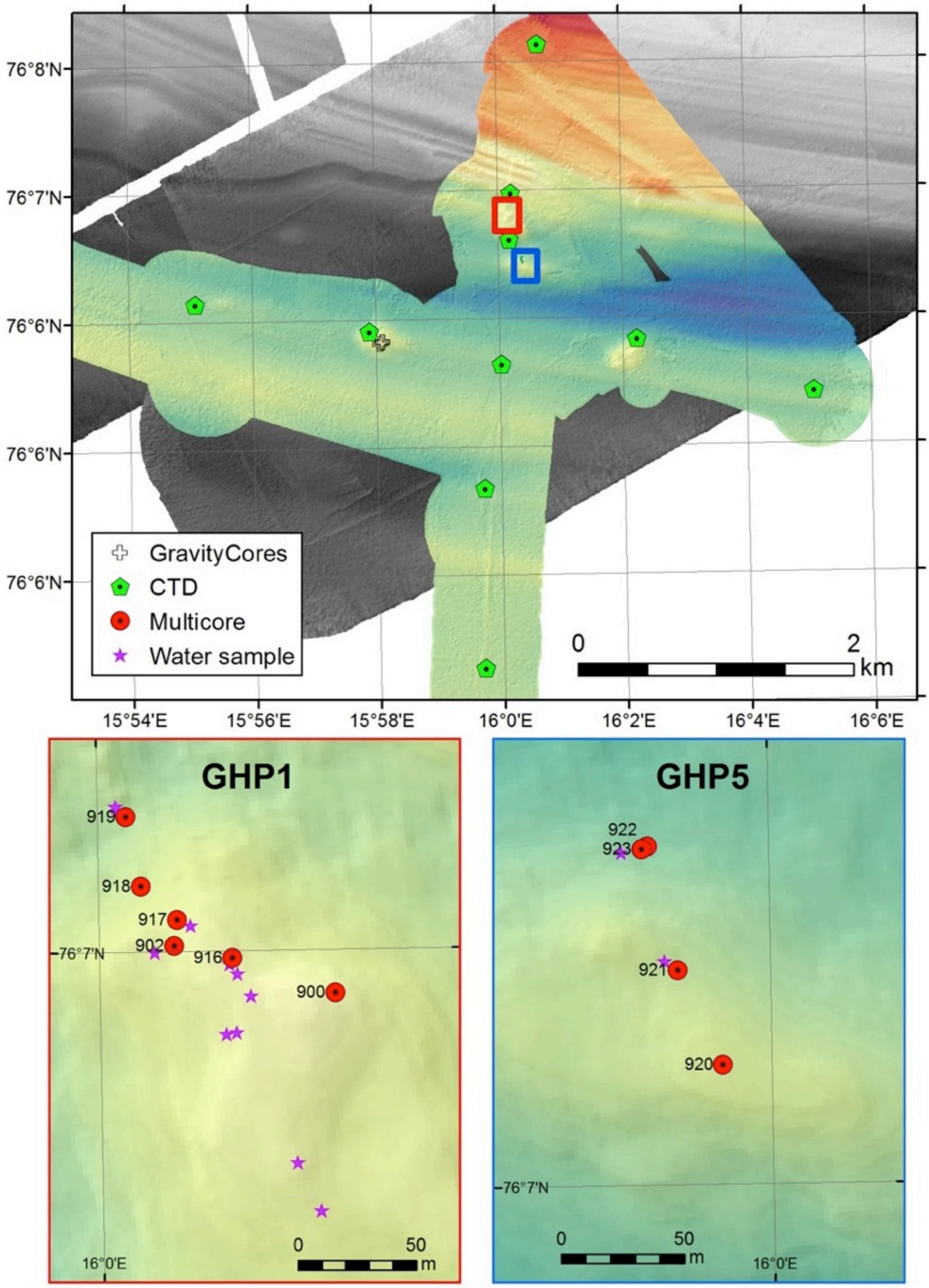


Figure 43 - Bathymetric map showing the TCM lowerings, multicorer, gravity corer, and CTD in Pingo site.

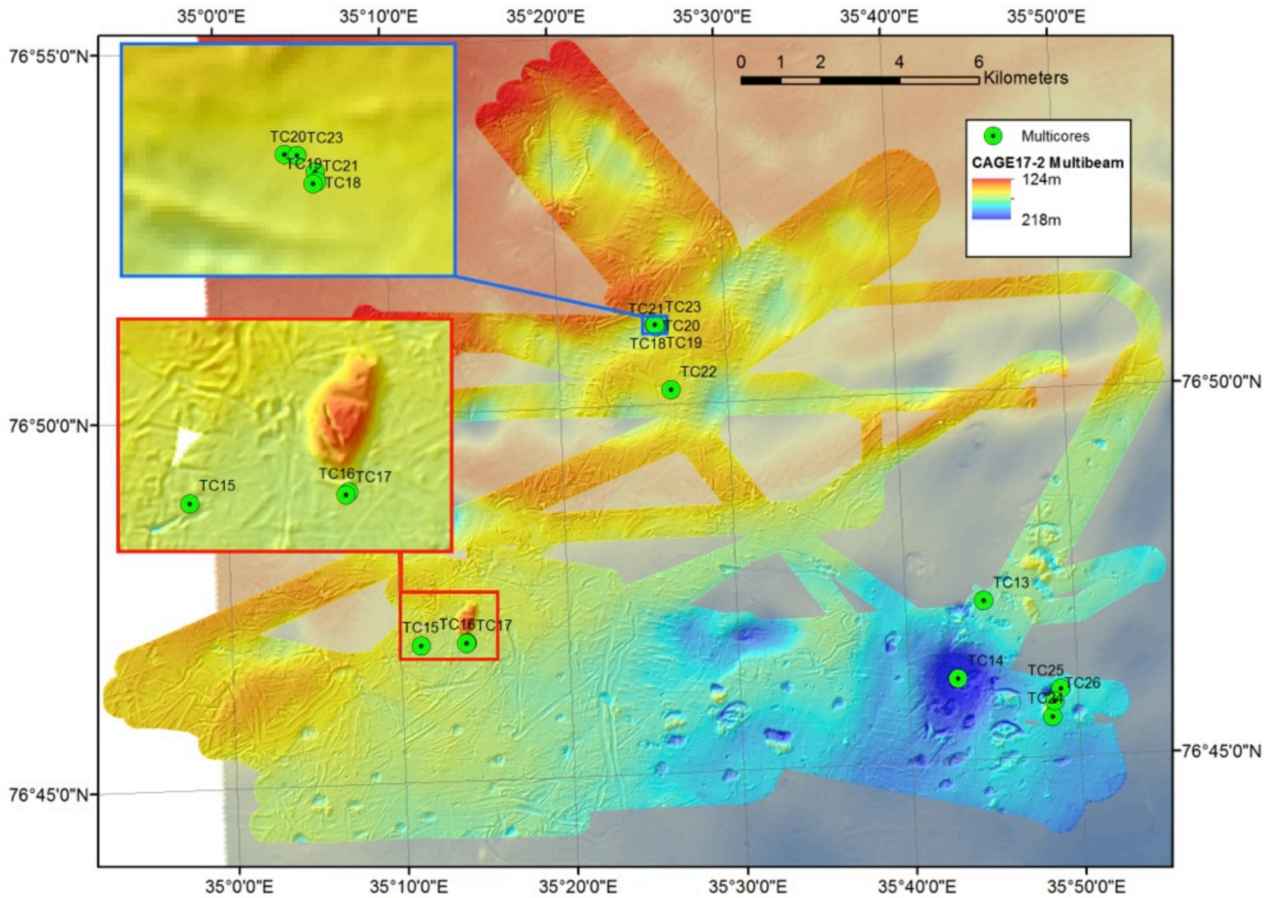


Figure 44 – Overview of multicores collected during towcam dives in the Olga craters study area.

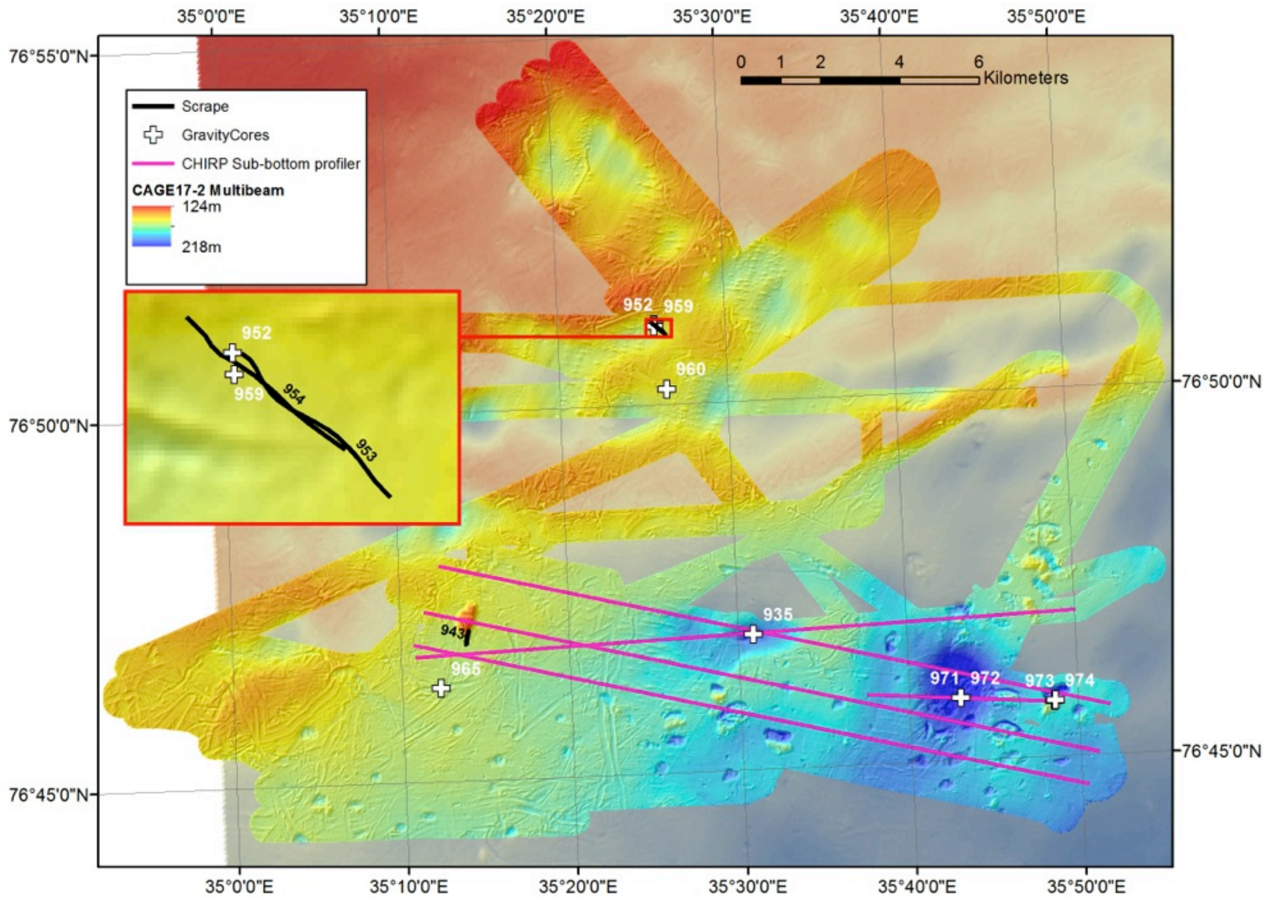


Figure 45 - Overview of scrape samples and gravity cores (annotated by station number) collected in the Olga craters study area. The locations of chirp sub-bottom profiles that were acquired to investigate variation in sedimentary thickness are also shown.

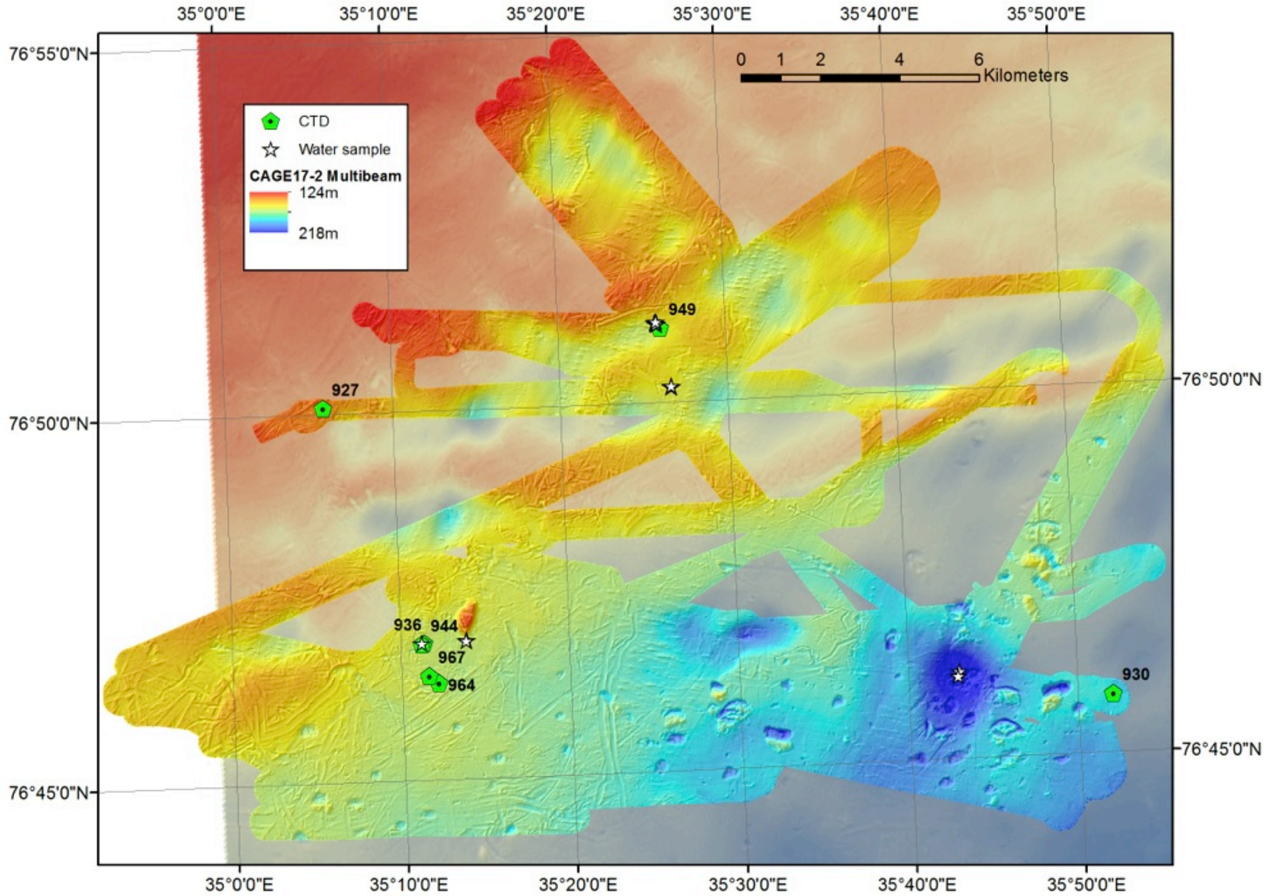


Figure 46 – Locations of CTD profiles collected n the Olga craters area. The locations of water samples collected with Niskin bottles attached to the towcam/multicorer sled are also shown.

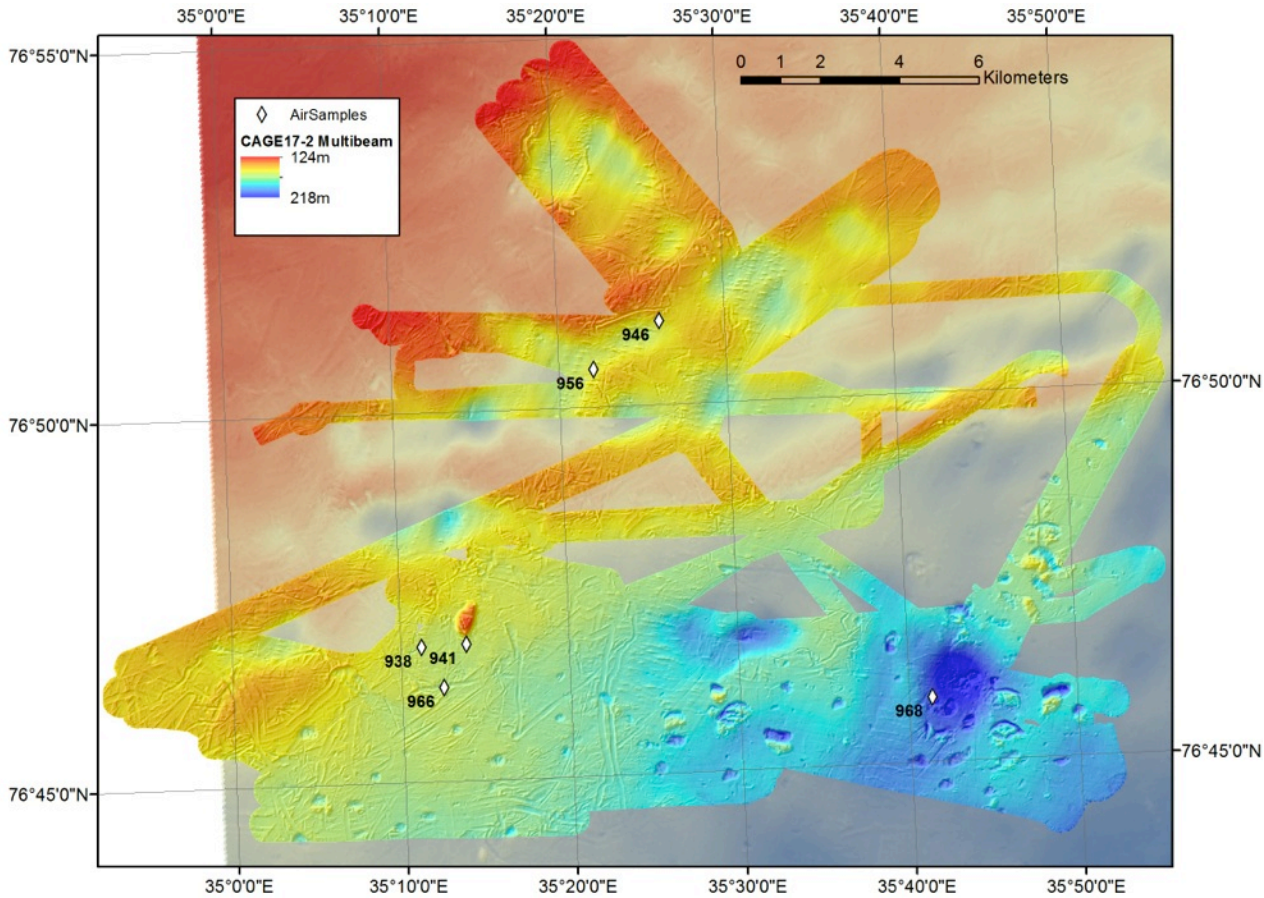


Figure 47 – Locations of air samples collected in the Olga craters area.

11. TCM Deployment Lowering Details

The TCM system was deployed a total of 26 lowerings accumulating 14 hrs 07 min of deployment time and 13 hrs 14 min of bottom time. The system accomplished 26 surveys, and acquired 10976 images, 97 cores and 55 water samples. Details of each deployment are in following section along with a summary.

Summary

A summary of key TCM deployment times (i.e. in water, on bottom, multicore sample, off bottom, on deck) are in below table and details can be found in the following pages.

Table 8 Summary of TCM Deployments

CAGE 17-2 TCM ON-OFF Bottom Summary

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
					Acc. Bot. Time	*13:13:47*		*10976*	*55*	*97*	*Sample Totals*
Ref-898	1	6/22/2017	11:06:00				Bottom Time	362	0	6	In water
	HH898	6/22/2017	11:27:00	378	76 06.924	16 00.715	0:08:04				at bottom
		6/22/2017	11:33:57	380	76 06.959	16 00.973					Multicore sample
		6/22/2017	11:35:04	380	76 06.964	16 00.057	Deployed Time				Bringing up the TCM
		6/22/2017	12:00:11				0:54:11				Secure on deck
GHP-1-S1	2	6/22/2017	14:56:03				Bottom Time	316	6	4	In water
	HH900	6/22/2017	15:14:15	371	76 06.916	16 00.220	0:14:22				at bottom
		6/22/2017	15:26:31	380	76 06.907	16 00.223					Multicore sample
		6/22/2017	15:28:37	380	76 06.908	16 00.209	Deployed Time				Bringing up the TCM
		6/22/2017	15:47:06				0:51:03				Secure on deck
GHP-1-S2	3	6/22/2017	16:42:37				Bottom Time	531	3	4	In water
	HH902	6/22/2017	17:35:30	370	76 6.920	16 00.085	0:06:12				at bottom
		6/22/2017	17:40:47	377	76 6.915	16 0.081					Multicore sample
		6/22/2017	17:41:42	377	76 6.914	16 0.090	Deployed Time				Bringing up the TCM
		6/22/2017	18:11:29				1:28:52				Secure on deck
GHP-1-S3	4	6/23/2017	7:17:09				Bottom Time	337	6	1	In water
	HH916	6/23/2017	7:34:50	375	76 06.913	16 00.083	0:15:55				at bottom
		6/23/2017	7:48:50	377	76 06.931	16 00.093					Multicore sample
		6/23/2017	7:50:45	378	76 06.931	16 00.093	Deployed Time				Bringing up the TCM
		6/23/2017	8:12:23				0:55:14				Secure on deck
GHP-1-S4	5	6/23/2017	8:38:00				Bottom Time	297	2	6	In water
	HH917	6/23/2017	8:52:03	377	76 6.930	16 00.990	0:12:12				at bottom
		6/23/2017	9:03:15	377	76 6.939	16 00.0225					Multicore sample
		6/23/2017	9:04:15		76 6.943	16 00.130	Deployed Time				Bringing up the TCM
		6/23/2017	9:27:47				0:49:47				Secure on deck
GHP-1-S4	6	6/23/2017	10:03:12				Bottom Time	244	0	6	In water
	HH918	6/23/2017	10:18:17	389	76 06.936	16 00.050	0:04:28				at bottom
		6/23/2017	10:21:00	389	76 06.940	16 00.029					Multicore sample
		6/23/2017	10:22:45		76 06.929	16 00.017	Deployed Time				Bringing up the TCM
		6/23/2017	10:43:19				0:40:07				Secure on deck
GHP-1-S5	7	6/23/2017	11:09:24				Bottom Time	482	4	6	In water
	HH919	6/23/2017	11:24:32	381	76 06.860	16 00.202	0:39:00				at bottom
		6/23/2017	12:01:40	378	76 06.962	15 59.983					Multicore sample
		6/23/2017	12:03:32		76 06.961	15 59.983	Deployed Time				Bringing up the TCM
		6/23/2017	12:28:06				1:18:42				Secure on deck
GHP-5-S1	8	6/23/2017	13:35:19				Bottom Time	293	1	3	In water

	HH920	6/23/2017	13:51:43	379	76 06.698	16 00.424	0:04:31				at bottom
		6/23/2017	13:55:48	379	76 06.708	16 00.426					Multicore sample
		6/23/2017	13:56:14	379	76 06.709	16 00.426	Deployed Time				Bringing up the TCM
		6/23/2017	14:23:25				0:48:06				Secure on deck
GHP-5-S2	9	6/23/2017	14:52:46				Bottom Time	290	1	5	In water
	HH921	6/23/2017	15:10:25	380	76 06.729	16 00.363	0:05:57				at bottom
		6/23/2017	15:14:13	380	76 06.719	16 00.399					Multicore sample
		6/23/2017	15:16:22	380	76 06.716	16 00.407	Deployed Time				Bringing up the TCM
		6/23/2017	15:40:31				0:47:45				Secure on deck
GHP-5-S4	10	6/23/2017	16:14:21				Bottom Time	468	1	5	In water
	HH922	6/23/2017	16:30:59	389	76 6.580	16 0.415	0:40:31				at bottom
		6/23/2017	17:10:16	386	76 6.745	16 0.370					Multicore sample
		6/23/2017	17:11:30	384	76 6.746	16 0.368	Deployed Time				Bringing up the TCM
		6/23/2017	17:31:00				1:16:39				Secure on deck
GHP-5-S3	11	6/23/2017	18:19:28				Bottom Time	259	1	6	In water
	HH923	6/23/2017	18:31:33	310	76 06.736	16 00.369	0:05:24				at bottom
		6/23/2017	18:35:46	376	76 06.741	16 00.461					Multicore sample
		6/23/2017	18:36:57	376	76 06.736	16 00.464	Deployed Time				Bringing up the TCM
		6/23/2017	19:00:27				0:40:59				Secure on deck
Ref-924	12	6/23/2017	20:36:27				Bottom Time	270	0	5	In water
	HH924	6/23/2017	20:50:44	380	76 06.829	15 51.199	0:03:37				at bottom
		6/23/2017	20:53:13	384	76 06.819	15 51.226					Multicore sample
		6/23/2017	20:54:21	384	76 06.813	15 51.234	Deployed Time				Bringing up the TCM
		6/23/2017	21:17:18				0:40:51				Secure on deck
Ref-932	13	6/26/2017	14:42:00				Bottom Time	237	0	3	In water
	HH932	6/26/2017	14:54:58	163	76 47.215	35 44.760	0:10:05				at bottom
		6/26/2017	15:04:12	163	76 47.172	35 44.661					Multicore sample
		6/26/2017	15:05:03		76 47.175	35 44.672	Deployed Time				Bringing up the TCM
		6/26/2017	15:21:46				0:39:46				Secure on deck
OBC-D1	14	6/26/2017	15:57:28				Bottom Time	813	2	5	In water
	HH933	6/26/2017	16:05:11	160	76 46.737	35 43.457	1:59:15				at bottom
		6/26/2017	17:57:58	221	76 46.118	35 42.921					Multicore sample
		6/26/2017	18:04:26	221	76 46.129	35 42.975	Deployed Time				Bringing up the TCM
		6/26/2017	18:14:44				2:17:16				Secure on deck
OBC-M1	15	6/27/2017	7:57:29				Bottom Time	1007	6	6	In water
	HH939	6/27/2017	8:41:56	153	76 46.840	35 11.188	1:45:14				at bottom
		6/27/2017	10:26:58	156	76 46.863	35 11.190					Multicore sample
		6/27/2017	10:27:10	156	76 46.865	35 11.174	Deployed Time				Bringing up the TCM
		6/27/2017	10:44:47				2:47:18				Secure on deck
OBC-M1	16	6/27/2017	12:12:23				Bottom Time	242	6	2	In water
	HH940	6/27/2017	12:27:05	155	76 46.8657	35 13.895	0:11:50				at bottom
		6/27/2017	12:38:23	157	76 46.865	35 13.884					Multicore sample
		6/27/2017	12:38:55	157	76 46.868	35 13.879	Deployed Time				Bringing up the TCM
		6/27/2017	12:52:11				0:39:48				Secure on deck
OBC-M1	17	6/27/2017	13:42:41				Bottom Time	573	0	0	In water
	HH942	6/27/2017	13:49:54	127	76 47.115	35 13.856	1:11:28				at bottom
		6/27/2017	15:00:00	159	76 47.855	35 13.813					Multicore sample
		6/27/2017	15:01:22	159	76 47.856	35 13.814	Deployed Time				Bringing up the TCM
		6/27/2017	15:17:35				1:34:54				Secure on deck
OBC-D3	18	6/28/2017	7:29:20				Bottom Time	502	6	0	In water
	HH947	6/28/2017	7:59:22	152	76 51.039	35 25.927	0:38:25				at bottom
		6/28/2017	8:36:25	154	76 51.045	35 25.894					Multicore sample
		6/28/2017	8:37:47	154	76 51.050	35 25.895	Deployed Time				Bringing up the TCM
		6/28/2017	8:52:09				1:22:49				Secure on deck

OBC-D3	19	6/28/2017	9:25:12				Bottom Time	422	0	3	In water
	HH948	6/28/2017	9:50:50	150	76 51.071	35 25.962	0:29:05				at bottom
		6/28/2017	10:19:25	162	76 51.465	35 25.935					Multicore sample
		6/28/2017	10:19:55	162	76 51.0429	35 25.933	Deployed Time				Bringing up the TCM
		6/28/2017	10:34:43				1:09:31				Secure on deck
OBC-D3	20	6/28/2017	13:02:21				Bottom Time	212	1	2	In water
	HH950	6/28/2017	13:13:30	147	76 51.077	35 25.839	0:10:01				at bottom
		6/28/2017	13:22:42	150	76 51.072	35 25.777					Multicore sample
		6/28/2017	13:23:31	150	76 51.072	35 25.777	Deployed Time				Bringing up the TCM
		6/28/2017	13:36:47				0:34:26				Secure on deck
OBC-D3	21	6/28/2017	14:27:52				Bottom Time	599	2	3	In water
	HH951	6/28/2017	14:40:00	149	76 51.095	35 25.905	1:14:20				at bottom
		6/28/2017	15:53:00	162	76 51.051	35 25.919					Multicore sample
		6/28/2017	15:54:20	162	76 51.053	35 25.919	Deployed Time				Bringing up the TCM
		6/28/2017	16:08:30				1:40:38				Secure on deck
OBC-D4	22	6/29/2017	8:17:55				Bottom Time	757	6	5	In water
	HH957	6/29/2017	8:43:49	150	76 50.199	35 26.594	1:21:50				at bottom
		6/29/2017	10:04:22	153	76 50.201	35 26.682					Multicore sample
		6/29/2017	10:05:39	153	76 50.203	35 26.681	Deployed Time				Bringing up the TCM
		6/29/2017	10:21:31				2:03:36				Secure on deck
OBC-D3	23	6/29/2017	11:15:00				Bottom Time	434	1	0	In water
	HH958	6/29/2017	11:26:45	151	76 51.104	35 25.893	0:43:22				at bottom
		6/29/2017	12:09:30	152	76 51.070	35 25.844					Multicore sample
		6/29/2017	12:10:07	152	76 51.073	35 25.824	Deployed Time				Bringing up the TCM
		6/29/2017	12:25:34				1:10:34				Secure on deck
OBC-C1	24	6/29/2017	18:36:31				Bottom Time	223	0	6	In water
	HH962	6/29/2017	18:46:55	170	76 45.528	35 48.522	0:08:44				at bottom
		6/29/2017	18:54:00	170	76 45.539	35 48.373					Multicore sample
		6/29/2017	18:55:39	170	76 45.540	35 48.370	Deployed Time				Bringing up the TCM
		6/29/2017	19:12:36				0:36:05				Secure on deck
OBC-C1	25	6/30/2017	8:08:32				Bottom Time	357	0	4	In water
	HH969	6/30/2017	8:20:10	174	76 45.903	35 49.492	0:29:55				at bottom
		6/30/2017	8:49:34	202	76 45.913	35 49.922					Multicore sample
		6/30/2017	8:50:05	204	76 45.911	35 49.929	Deployed Time				Bringing up the TCM
		6/30/2017	9:06:04				0:57:32				Secure on deck
OBC-C1	26	6/30/2017	10:08:20				Bottom Time	449	0	1	In water
	HH970	6/30/2017	10:17:12	168	76 45.644	35 49.079	0:53:06				at bottom
		6/30/2017	11:02:31	163	76 45.769	35 48.526					Multicore sample
		6/30/2017	11:10:18	163	76 45.776	35 48.504	Deployed Time				Bringing up the TCM
		6/30/2017	11:23:24				1:15:04				Secure on deck

Note that multicore locations as recorded within the TCM summary & TCM logs are based on ship position at the time of the bottom sample. The below table contains the multicore locations from the USBL system as matched to the time TCM stamps.

Table 9 Summary of TCM Multicore Locations (USBL)

Station	TCM Dive	Cores	Depth	usbl_lat	usbl_lon	time	date	Notes
898	TC01	6	380	76° 6.962' N	16° 1.007' E	11:33:57	6/22/2017	Reference site
900	TC02	4	380	76° 6.907' N	16° 0.223' E	15:26:31	6/22/2017	GHP1 - 1
902	TC03	4	377	76° 6.918' N	16° 0.071' E	17:40:47	6/22/2017	GHP1 - 2
916	TC04	1	377	76° 6.915' N	16° 0.126' E	7:48:50	6/23/2017	GHP1 - 3
917	TC05	6	377	76° 6.924' N	16° 0.074' E	9:03:15	6/23/2017	GHP1 - 3 (redeployed)
918	TC06	6	389	76° 6.932' N	16° 0.040' E	10:21:00	6/23/2017	GHP1 - 4
919	TC07	6	378	76° 6.948' N	16° 0.027' E	12:01:40	6/23/2017	GHP1 - 5 (transect)
920	TC08	3	379	76° 6.693' N	16° 0.455' E	13:55:48	6/23/2017	GHP5 - 1
921	TC09	5	380	76° 6.713' N	16° 0.416' E	15:14:13	6/23/2017	GHP5 - 2
922	TC10	5	386	76° 6.740' N	16° 0.390' E	17:10:16	6/23/2017	GHP5 - 4 (transect)
923	TC11	6	376	76° 6.740' N	16° 0.385' E	18:35:57	6/23/2017	GHP5 - 3
924	TC12	5	384	76° 6.821' N	15° 51.220' E	20:53:13	6/23/2017	Reference site
932	TC13	3	163	76° 47.160' N	35° 44.639' E	15:04:12	6/26/2017	Reference site (1 km north of D1)
933	TC14	5	221	76° 46.119' N	35° 42.921' E	17:57:58	6/26/2017	Within D1
939	TC15	6	156	76° 46.865' N	35° 11.194' E	10:26:58	6/27/2017	Near bacterial mats at M1
940	TC16	2	157	76° 46.888' N	35° 13.941' E	12:38:23	6/27/2017	Near flare directly south of M1
942	TC17	0	159	76° 46.877' N	35° 13.885' E	15:00:00	6/27/2017	Near bacterial mat
947	TC18	0	154	76° 51.068' N	35° 25.915' E	8:36:25	6/28/2017	Near bacterial mat in D3
948	TC19	3	162	76° 51.058' N	35° 25.921' E	10:19:25	6/28/2017	Near flare mapped in MAREANO in D3
950	TC20	2	150	76° 51.086' N	35° 25.786' E	13:22:42	6/28/2017	Slightly north of mapped MAREANO flares in D3
951	TC21	3	162	76° 51.056' N	35° 25.904' E	15:53:00	6/28/2017	Photo transect along MAREANO flares
957	TC22	5	153	76° 50.198' N	35° 26.626' E	10:04:22	6/29/2017	Onto bacterial mat around D4
958	TC23	0	152	76° 51.085' N	35° 25.840' E	12:09:30	6/29/2017	Into bacterial mats around D3
962	TC24	5	170	76° 45.548' N	35° 48.424' E	18:54:00	6/29/2017	Outside C1 near old flare
969	TC25	4	202	76° 45.920' N	35° 48.974' E	8:49:34	6/30/2017	Inside C1
970	TC26	1	163	76° 45.758' N	35° 48.583' E	11:02:31	6/30/2017	On top of pingo next to C1

HH898-TC01

Survey Summary:
TCM survey HH898-TC01, was a dangle survey along with water & multicore samples over a background reference site. The survey and sampling were conducted approximately 360 m east of site GHP-1 in a shallow flat region with water depths around 380 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
Ref-898	1	6/22/2017	11:06:00				Bottom Time	362	0	6	In water
	HH898	6/22/2017	11:27:00	378	76 06.924	16 00.715	0:08:04				at bottom
		6/22/2017	11:33:57	380	77 06.959	17 00.973					Multicore sample
		6/22/2017	11:35:04	380	77 06.964	17 00.057	Deployed Time				Bringing up the TCM
		6/22/2017	12:00:11				0:54:11				Secure on deck

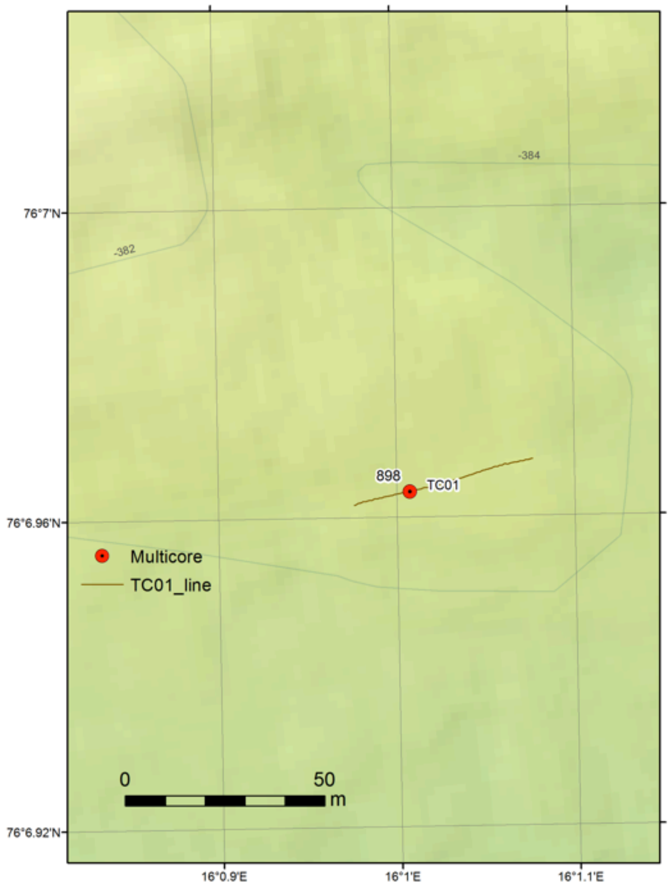


Figure 48: TCM HH898-TC01 Ship Track

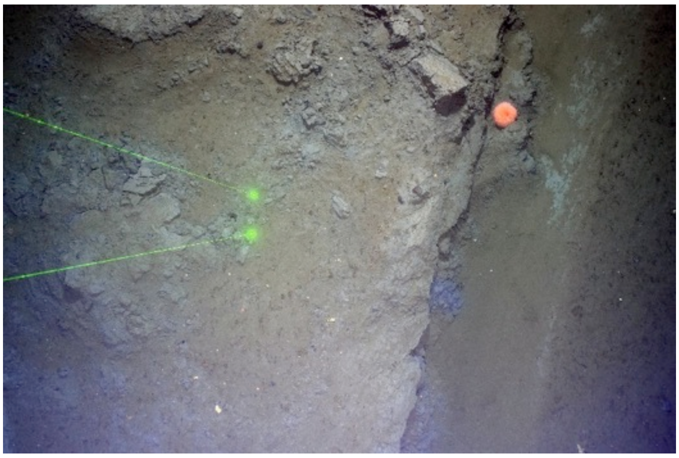


Figure 49: TCM HH898-TC01 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired	Bottle #	Time acquired / fired
1		4	
2		5	
3		6	

**No CTD Data **

Figure 50 Image HH898-TC01_20170622_113020.
Seafloor is muddy. The sediment displays extensive trawl marks.

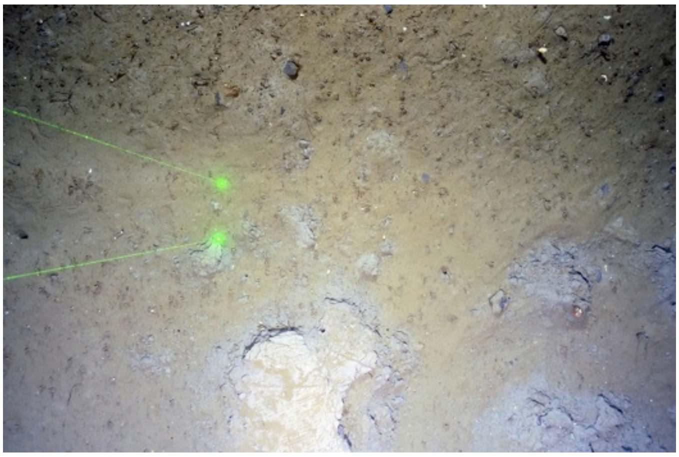


Figure 51 Image HH898-TC01_20170622_113120.
The seafloor appears disturbed with chunk of mud probably dislodged during trawling. The biology is constituted by siboglinids. Abundant holes indicate bioturbation

HH900-TC02

Survey Summary:
TCM survey HH898-TC02, was a dangle survey along with water & multicore samples over site GHP-1-S1. The survey and sampling were conducted in water depths of approximately 380 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
GHP-1-S1	2	6/22/2017	14:56:03				Bottom Time	316	6	4	In water
	HH900	6/22/2017	15:14:15	371	76 06.916	16 00.220	0:14:22				at bottom
		6/22/2017	15:26:31	380	76 06.907	16 00.223					Multicore sample
		6/22/2017	15:28:37	380	76 06.908	16 00.209	Deployed Time				Bringing up the TCM
		6/22/2017	15:47:06				0:51:03				Secure on deck

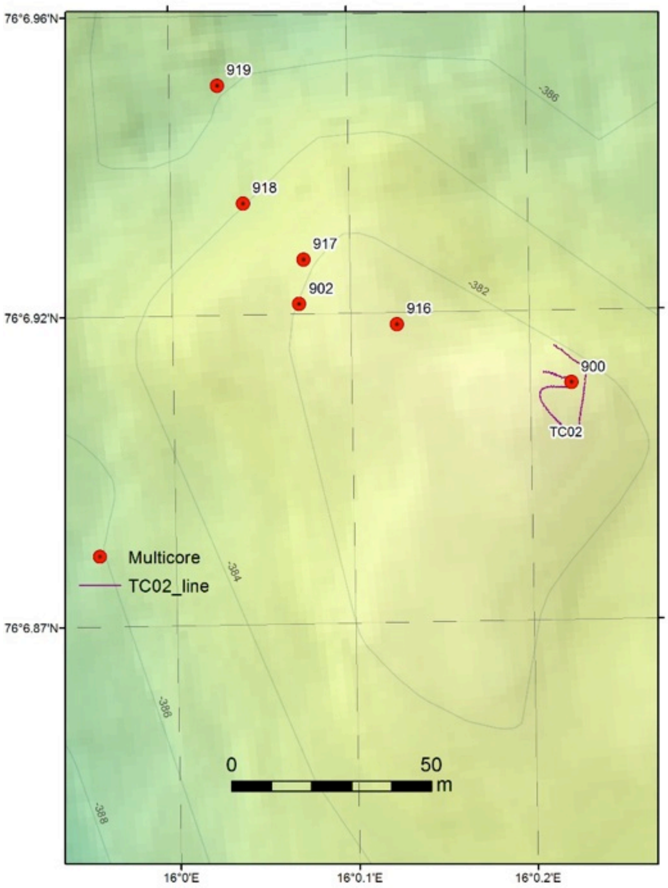


Figure 52: TCM HH900-TC02 USBL TCM Track

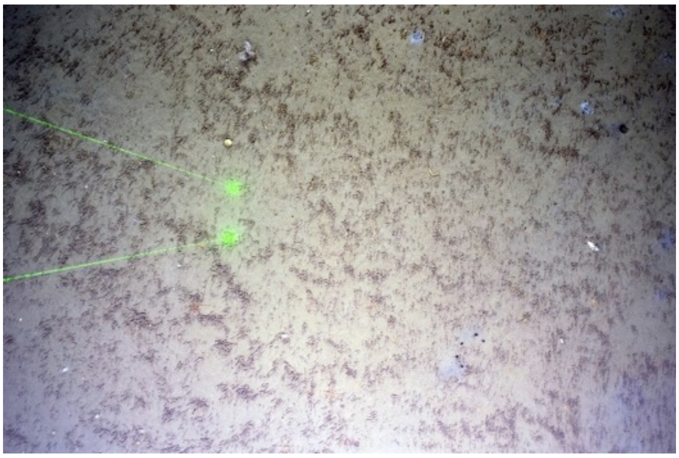


Figure 53: TCM HH900-TC02 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired
1	15:16:24
2	15:18:55
3	15:22:00

Bottle #	Time acquired / fired
4	15:22:59
5	15:23:37
6	15:24:34

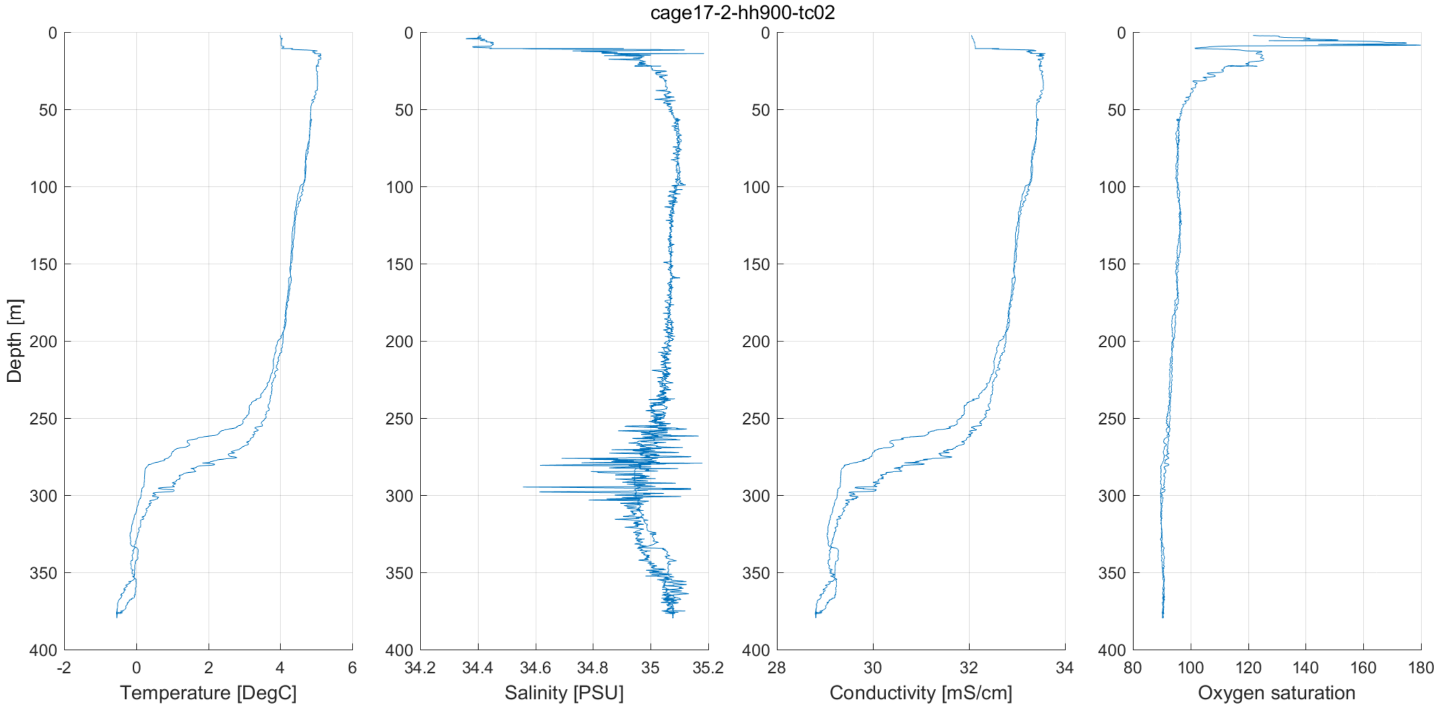


Figure 54 TCM HH900-TC02 CTD Plots

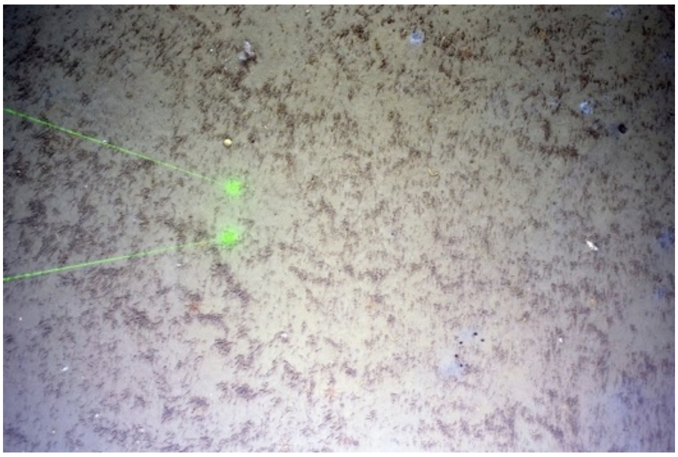


Figure 55 Image HH900-TC02_20170622_152143.
Top of Pingo 1: Typical chemosynthesis based communities with dense fields of siboglinids and patches of bacterial mats (top image). Also seen were carbonate rocks and dropstones that were colonized by anemones.

Figure 56 Image HH900-TC02_20170622_152143.
Pingo 1: Abundant anemones and sponges attached to small IRD; and other sessile and mobile organisms; numerous animal tracks.

HH902-TC03

Survey Summary:
TCM survey HH902-TC03, was a dangle survey along with water & multicore samples over site GHP-1-S2. The survey and sampling were conducted in water depths of approximately 380 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
GHP-1-S2	3	6/22/2017	16:42:37				Bottom Time	531	3	4	In water
	HH902	6/22/2017	17:35:30	370	76 6.920	16 00.085	0:06:12				at bottom
		6/22/2017	17:40:47	377	76 6.915	16 0.081					Multicore sample
		6/22/2017	17:41:42	377	76 6.914	16 0.090	Deployed Time				Bringing up the TCM
		6/22/2017	18:11:29				1:28:52				Secure on deck

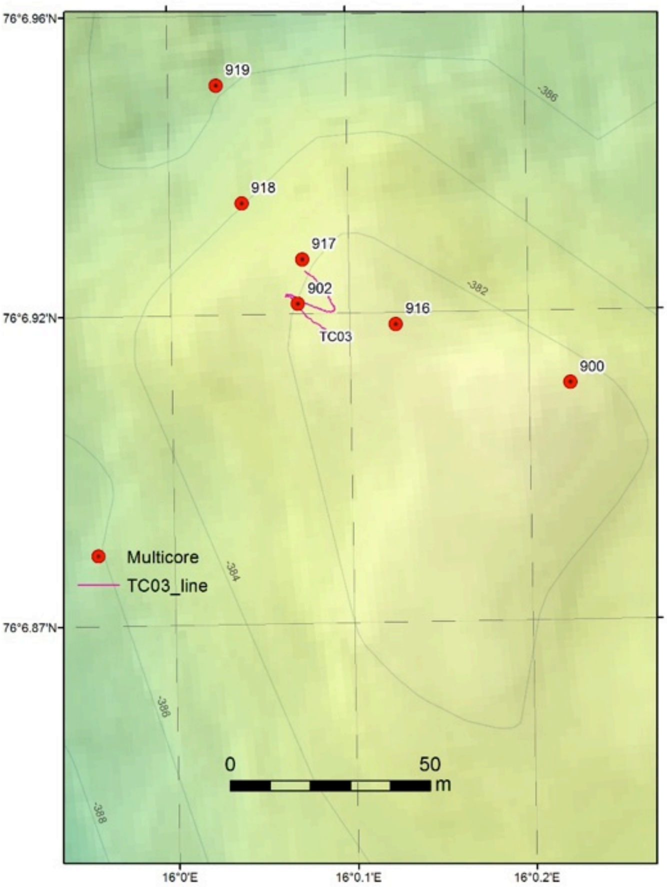


Figure 57: TCM HH902-TC03 USBL TCM Track

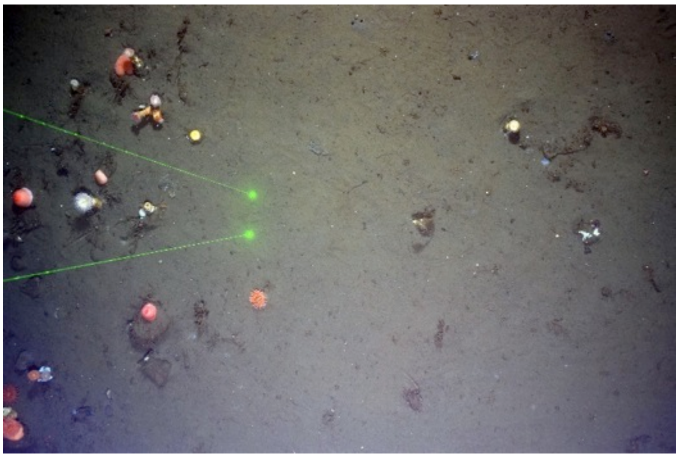


Figure 58: TCM HH902-TC03 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

1	17:36:57	4
2	17:38:33	5
3	17:39:18	6

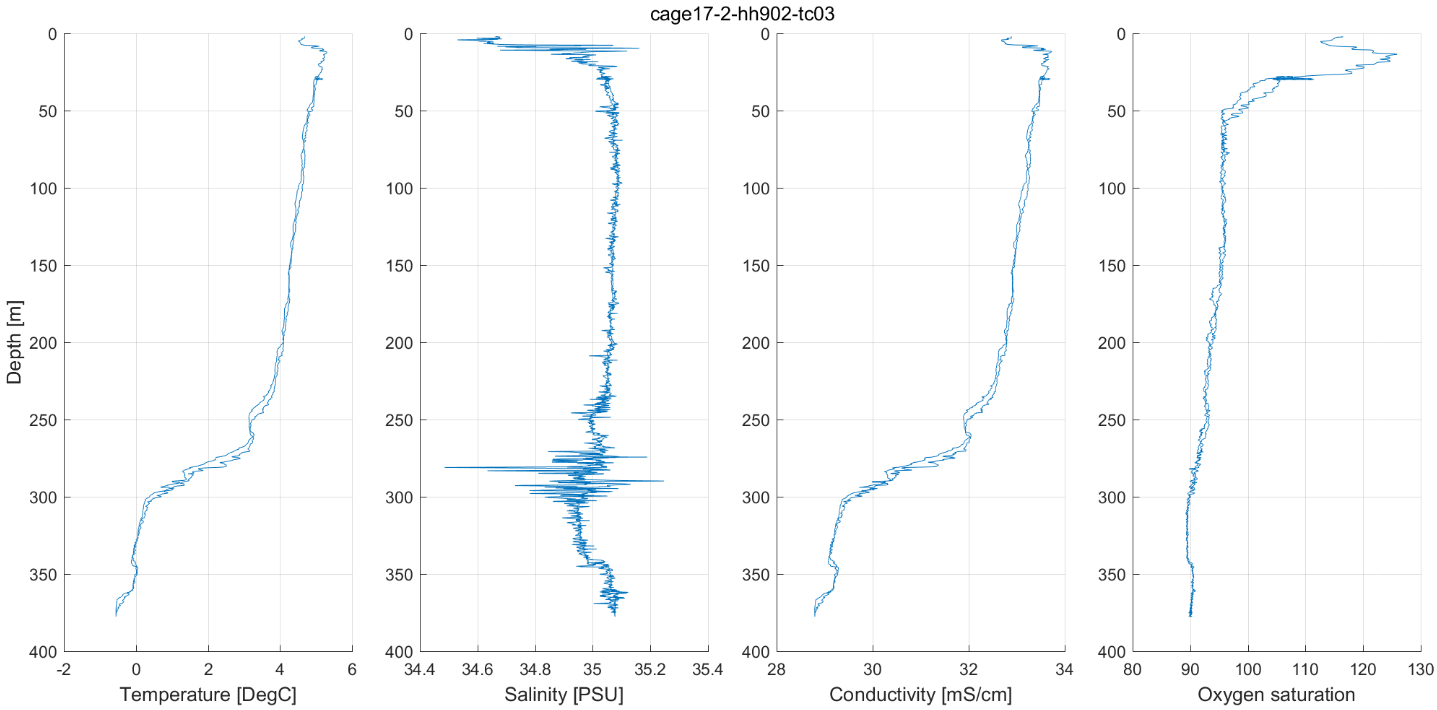


Figure 59 TCM HH902-TC03 CTD Plots

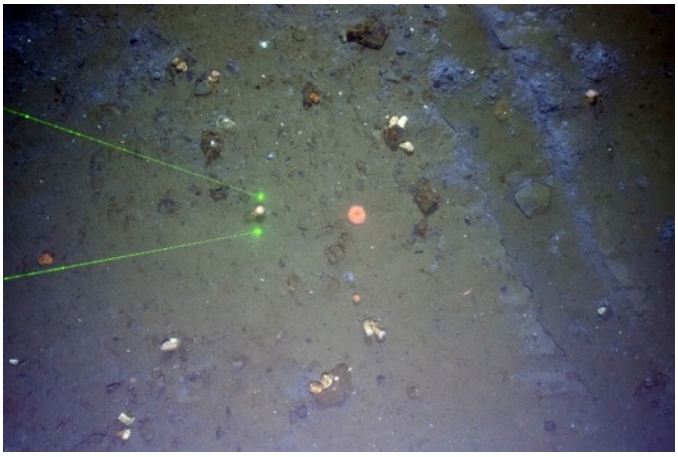


Figure 60 Image HH902-TC03_20170622_173811.
Along the flank of Pingo 1. Similar communities are seen, with siboglinid worms, bacterial mats and anemones on hard surfaces. The sediment displays extensive trawl marks.

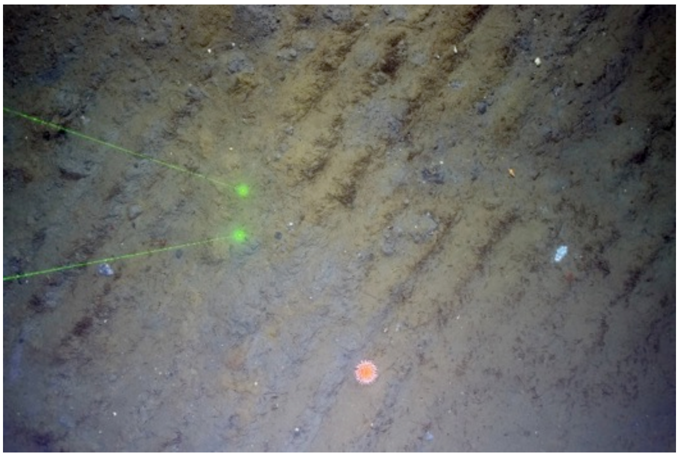


Figure 61 Image HH902-TC03_20170622_173921.
Moving down along the flank of the Pingo 1, similar communities are seen, with siboglinid worms, bacterial mats and anemones on hard surfaces. However, the sediment displays extensive trawl marks and the worms.

HH916-TC04

Survey Summary:
TCM survey HH916-TC04, was a dangle survey along with water & multicore samples over site GHP-1-S3. The survey and sampling were conducted in water depths of approximately 380 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
GHP-1-S3	4	6/23/2017	7:17:09				Bottom Time	337	6	1	In water
	HH916	6/23/2017	7:34:50	375	76 06.913	16 00.083	0:15:55				at bottom
		6/23/2017	7:48:50	377	76 06.931	16 00.093					Multicore sample
		6/23/2017	7:50:45	378	76 06.931	16 00.093	Deployed Time				Bringing up the TCM
		6/23/2017	8:12:23				0:55:14				Secure on deck

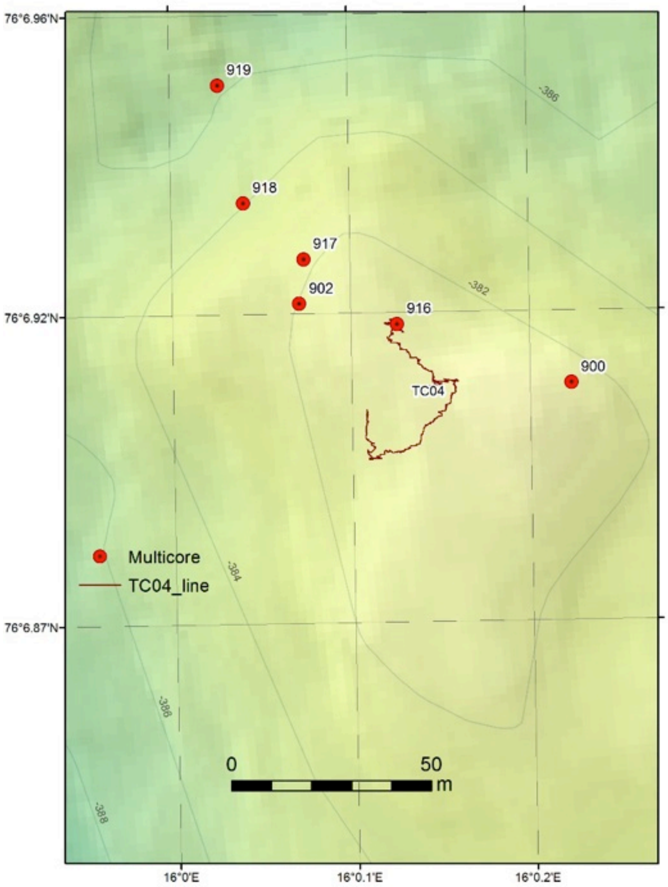


Figure 62: TCM HH916-TC04 USBL TCM Track

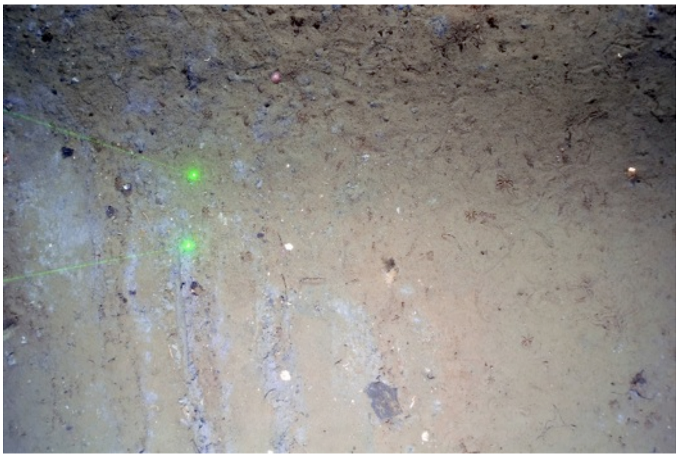


Figure 63: TCM HH916-TC04 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired	Bottle #	Time acquired / fired
1	07:36:07	4	07:45:02
2	07:37:45	5	07:46:12
3	07:42:41	6	07:46:54

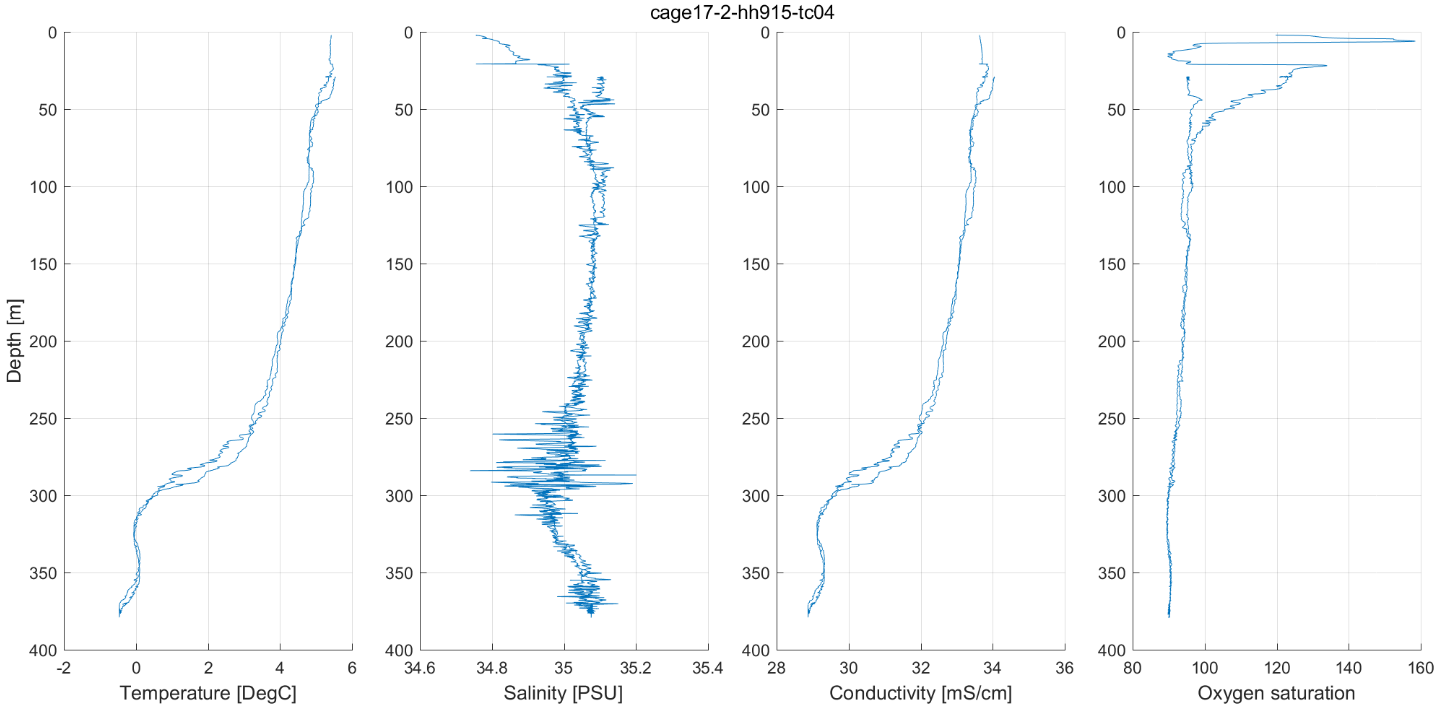


Figure 64 TCM HH916-TC04 CTD Plots

Figure 65 Image HH916-TC04_20170623_073738.
Continuing to move down the Pingo 1. Similar patterns are seen: hard surfaces colonized by anemones, siboglinids. As before, the seafloor appears to be disturbed.

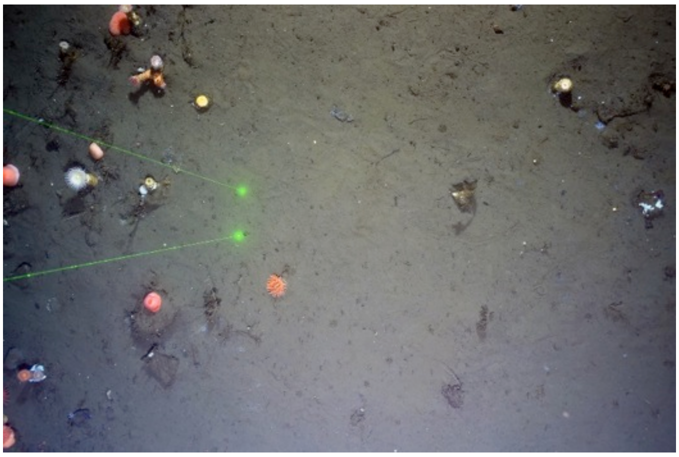


Figure 66 Image HH916-TC04_20170623_074108.
Continuing to move down the Pingo 1. Similar patterns are seen: hard surfaces colonized by anemones, siboglinids. Abundant IRD.

HH917-TC05

Survey Summary:
TCM survey HH917-TC05, was a dangle survey along with water & multicore samples over site GHP-1-S4. The survey and sampling were conducted in water depths of approximately 380 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
GHP-1-S4	5	6/23/2017	8:38:00				Bottom Time	297	2	6	In water
	HH917	6/23/2017	8:52:03	377	76 6.930	16 00.990	0:12:12				at bottom
		6/23/2017	9:03:15	377	76 6.939	16 00.0225					Multicore sample
		6/23/2017	9:04:15		76 6.943	16 00.130	Deployed Time				Bringing up the TCM
		6/23/2017	9:27:47				0:49:47				Secure on deck

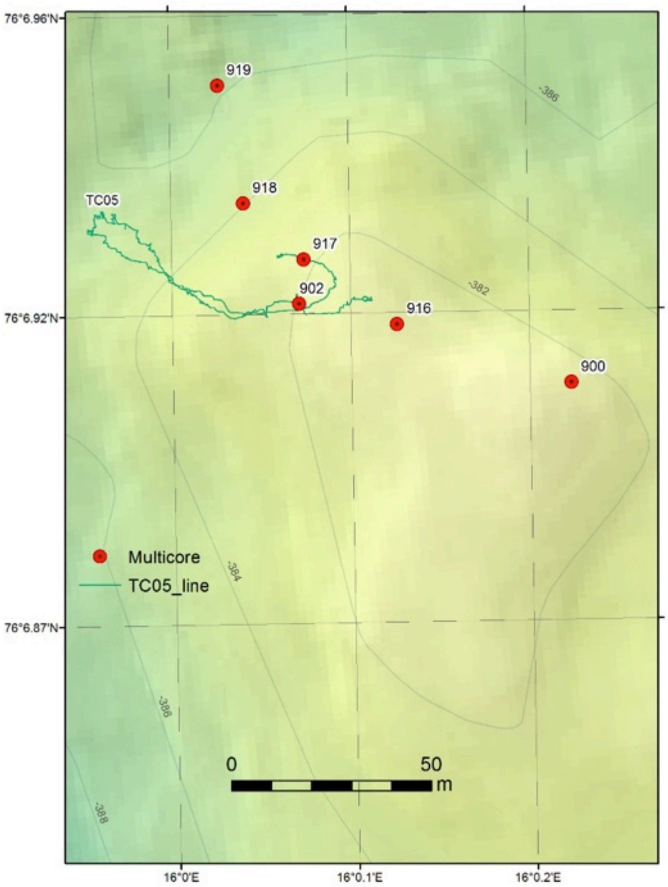


Figure 67: TCM HH917-TC05 USBL TCM Track

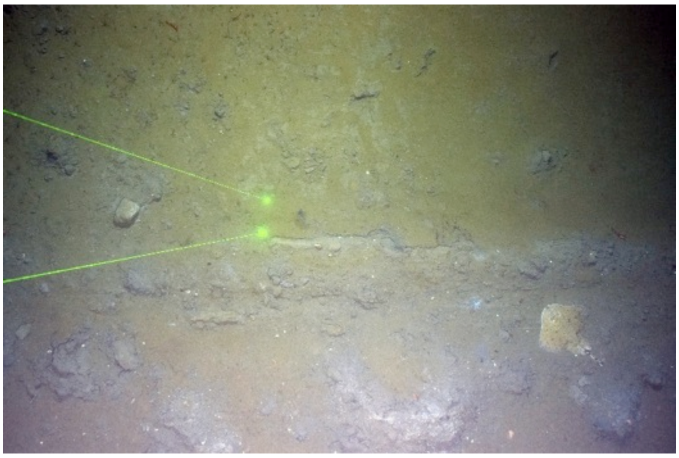


Figure 68: TCM HH917-TC05 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired	Bottle #	Time acquired / fired
1	08:53:39	4	
2	09:02:39	5	
3		6	

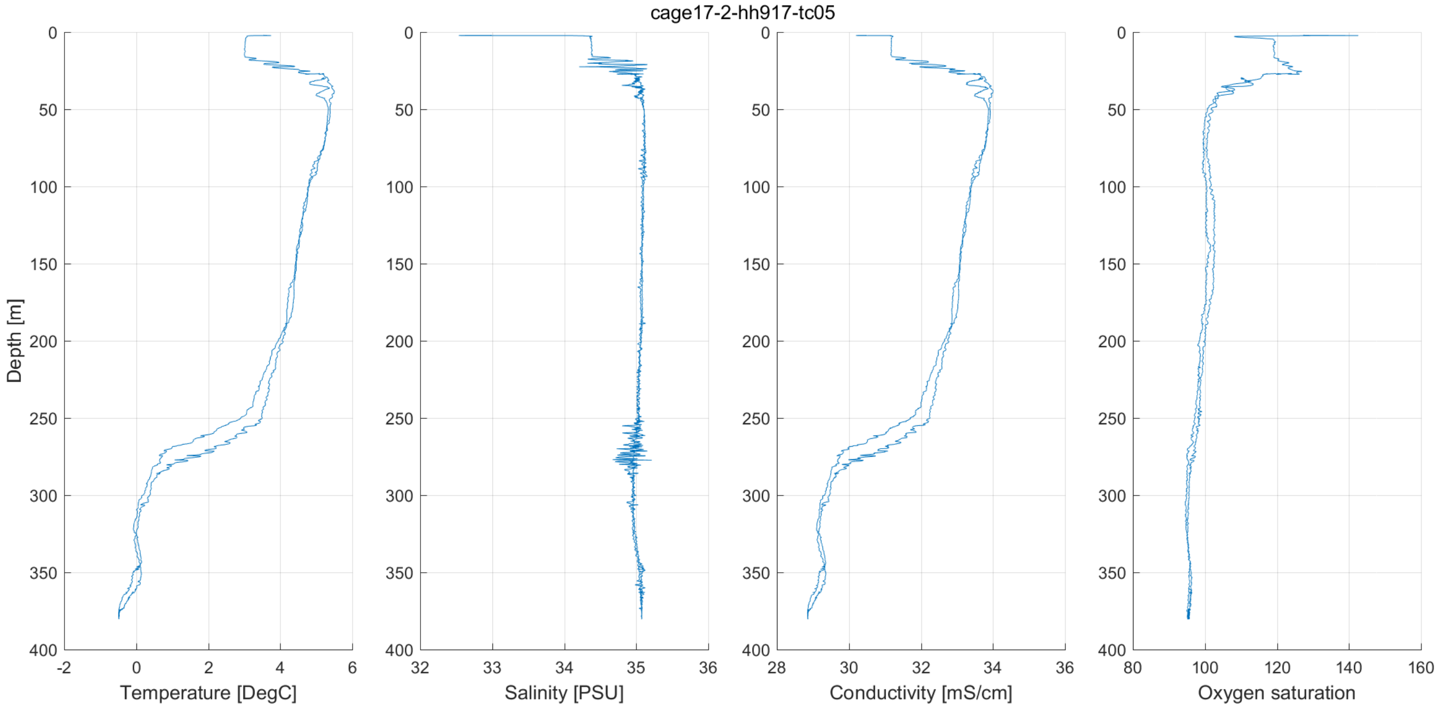


Figure 69 TCM HH917-TC05 CTD Plots

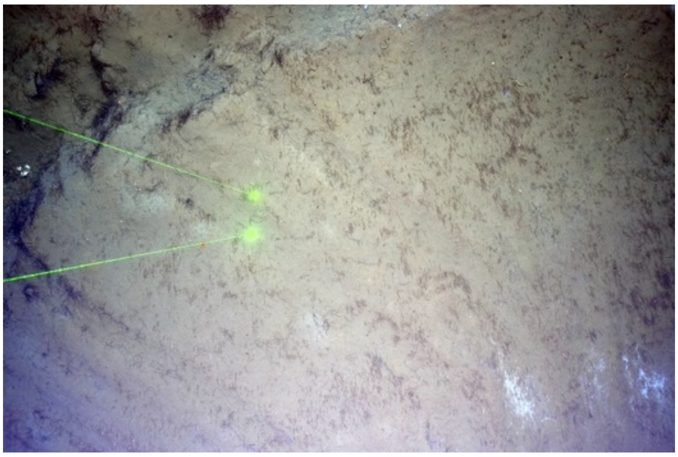


Figure 70 Image HH917-TC05_20170623_090029.
Abundant siboglinid worms and patches of bacterial mats. As before, the seafloor appears to be disturbed by trawl marks.

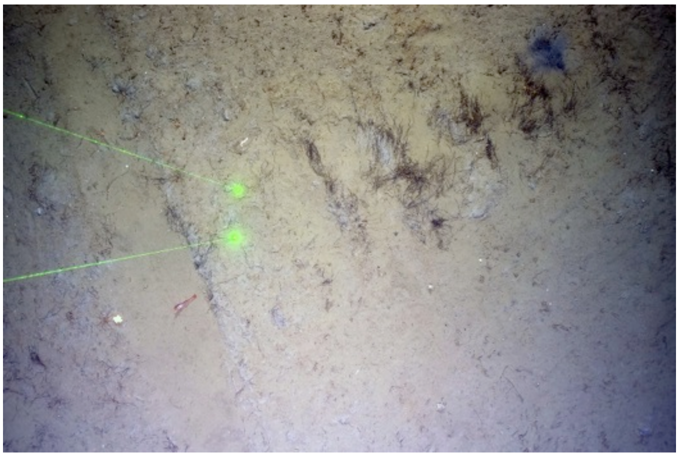


Figure 71 Image HH917-TC05_20170623_085739.
Similar communities are seen, with siboglinid worms, bacterial mats and anemones on hard surfaces. However, the sediment displays extensive trawl marks and the worms appear to be largely colonizing the crests.

HH918-TC06

Survey Summary:
TCM survey HH918-TC06, was a repeat dangle survey along with water & multicore samples over site GHP-1-S4. The survey and sampling were conducted in water depths of approximately 390 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
GHP-1-S4	6	6/23/2017	10:03:12				Bottom Time	244	0	6	In water
	HH918	6/23/2017	10:18:17	389	76 06.936	16 00.050	0:04:28				at bottom
		6/23/2017	10:21:00	389	76 06.940	16 00.029					Multicore sample
		6/23/2017	10:22:45		76 06.929	16 00.017	Deployed Time				Bringing up the TCM
		6/23/2017	10:43:19				0:40:07				Secure on deck

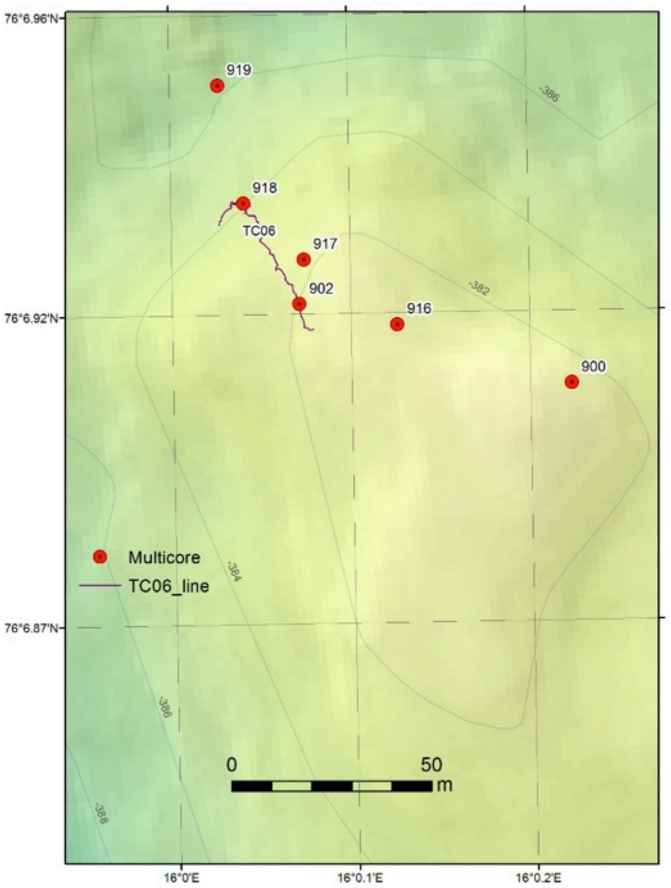


Figure 72: TCM HH918-TC06 USBL TCM Track

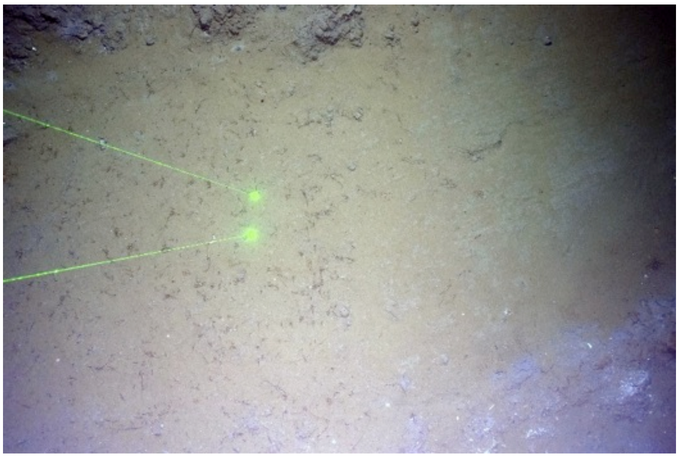


Figure 73: TCM HH918-TC06 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired
1	
2	
3	

Bottle #	Time acquired / fired
4	
5	
6	

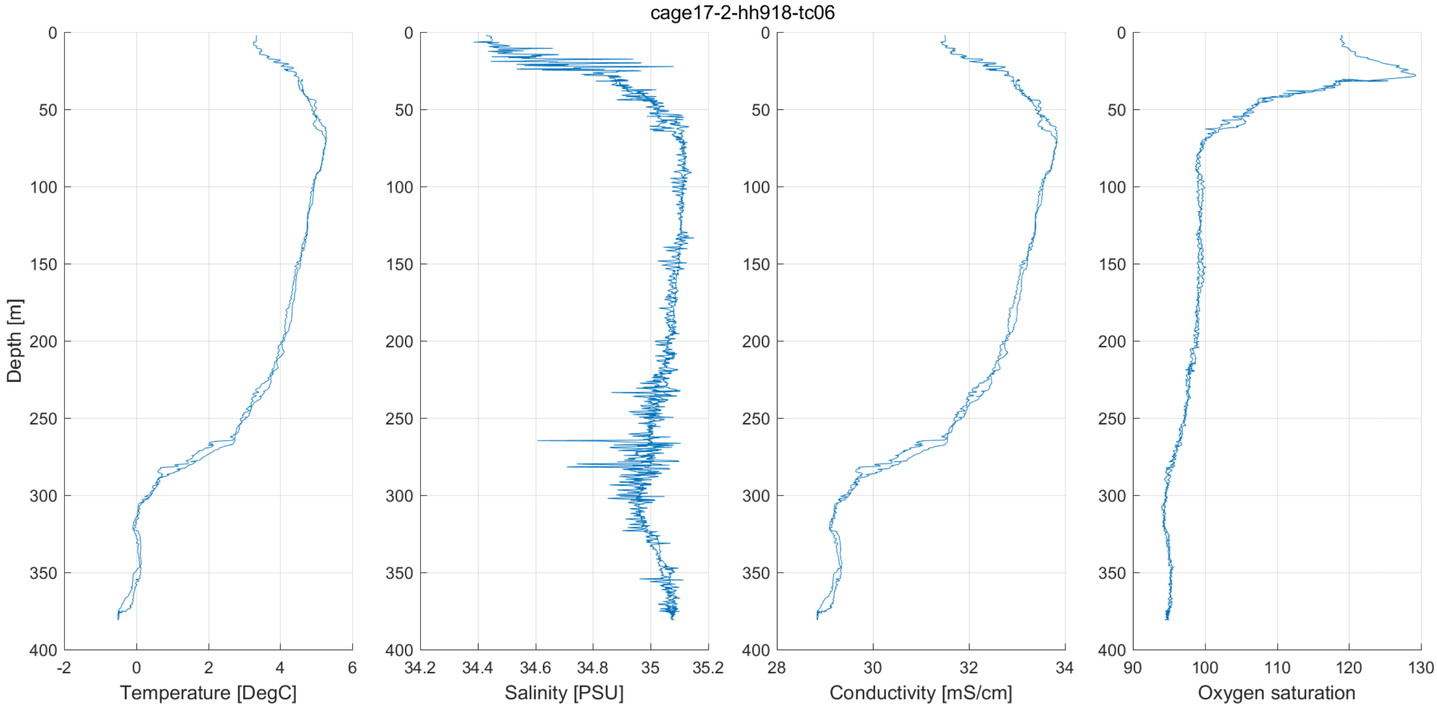


Figure 74 TCM HH918-TC06 CTD Plots

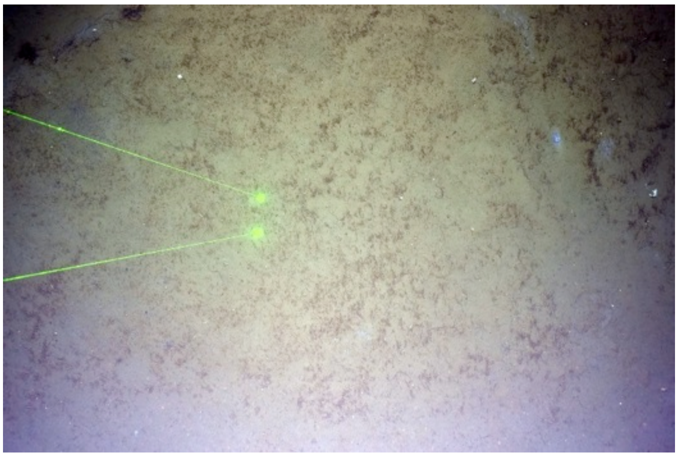


Figure 75 Image HH918-TC06_20170623_101854.
Abundant siboglinid worms.

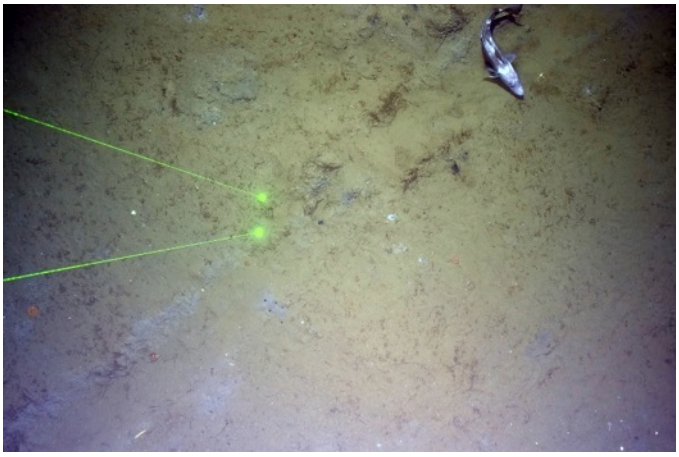


Figure 76 Image HH918-TC06_20170623_101914.
Continuing to move down the Pingo 1 the seafloor is characterized by siboglinid worms and clusters of holes. Trawl marks.

HH919-TC07

Survey Summary:
TCM survey HH919-TC07, was a dangle survey along with water & multicore samples over site GHP-1-S5. The survey and sampling were conducted in water depths of approximately 380 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
GHP-1-S5	7	6/23/2017	11:09:24				Bottom Time	482	4	6	In water
	HH919	6/23/2017	11:24:32	381	76 06.860	16 00.202	0:39:00				at bottom
		6/23/2017	12:01:40	378	76 06.962	15 59.983					Multicore sample
		6/23/2017	12:03:32		76 06.961	15 59.983	Deployed Time				Bringing up the TCM
		6/23/2017	12:28:06				1:18:42				Secure on deck

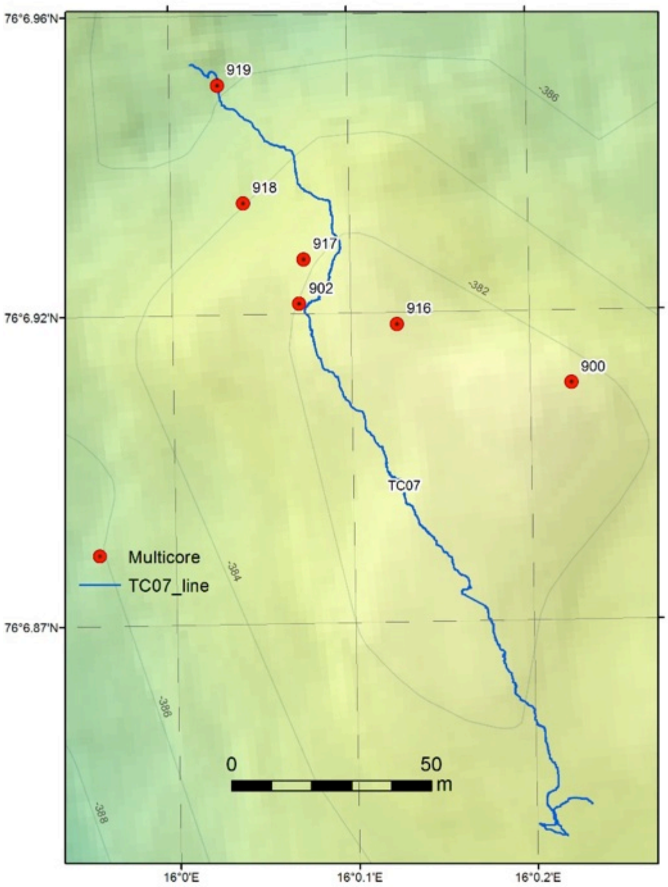


Figure 77: TCM HH919-TC07 USBL TCM Track

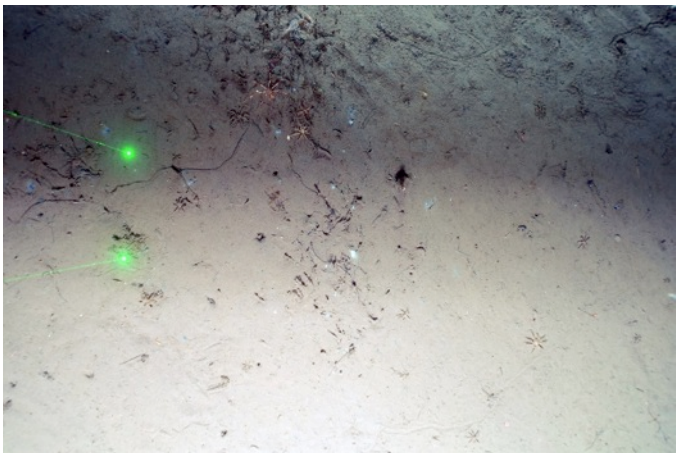


Figure 78: TCM HH919-TC07 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired
1	11:31:33
2	11:35:18
3	12:03:02
4	12:03:30
5	
6	

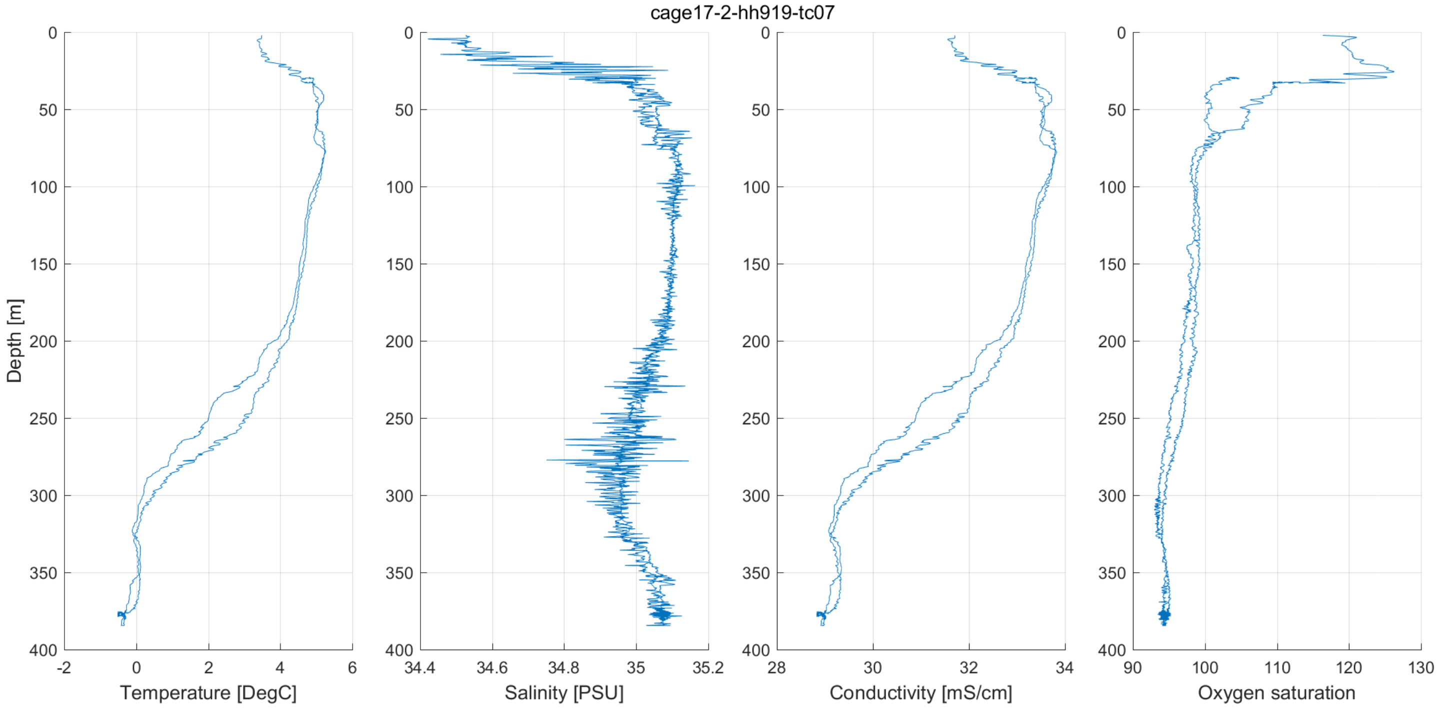


Figure 79 TCM HH919-TC07 CTD Plots

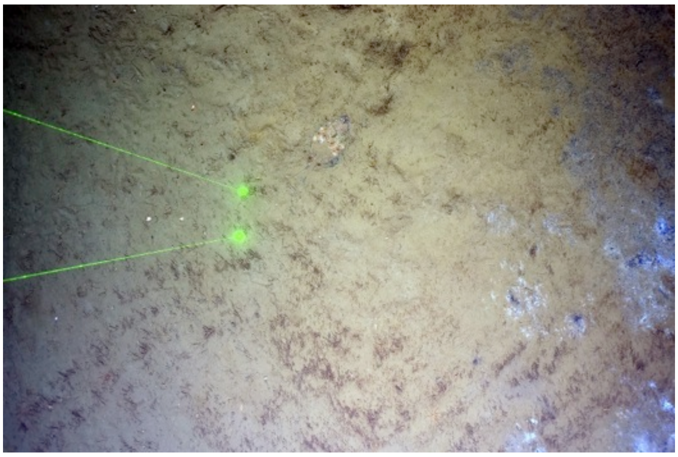


Figure 80 Image HH919-TC07_20170623_112959.
At the lower end of the flank and at the edge of the pingo, bacterial mats and siboglinids are still abundant (top picture shows a flatfish partially buried in the sediment). Hard surfaces are also still densely colonized by anemones. Sponges and corals additionally are present on the hard surfaces.

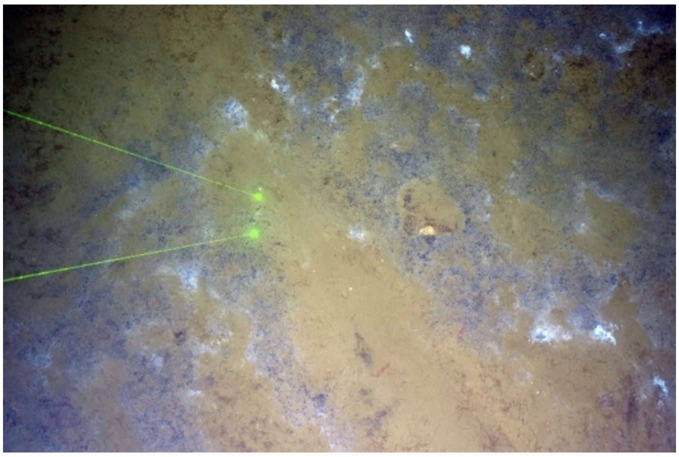


Figure 81 Image HH919-TC07_20170623_113109.
At the lower end of the flank and at the edge of the Pingo 1, bacterial mats and siboglinids are still abundant.

HH920-TC08

Survey Summary:
TCM survey HH920-TC08, was a dangle survey along with water & multicore samples over site GHP-5-S1. The survey and sampling were conducted in water depths of approximately 380 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
GHP-5-S1	8	6/23/2017	13:35:19				Bottom Time	293	1	3	In water
	HH920	6/23/2017	13:51:43	379	76 06.698	16 00.424	0:04:31				at bottom
		6/23/2017	13:55:48	379	76 06.708	16 00.426					Multicore sample
		6/23/2017	13:56:14	379	76 06.709	16 00.426	Deployed Time				Bringing up the TCM
		6/23/2017	14:23:25				0:48:06				Secure on deck

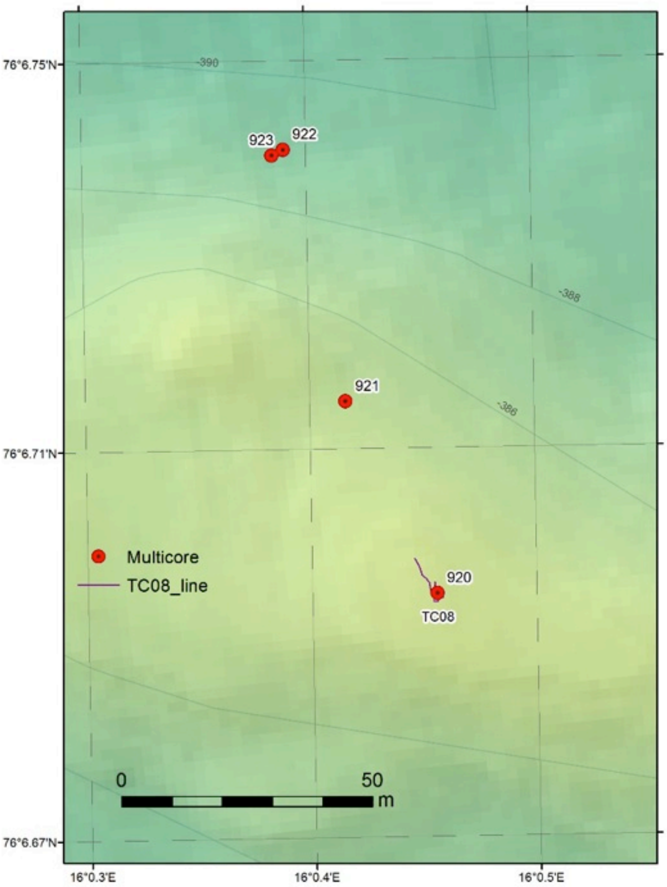


Figure 82: TCM HH920-TC08 USBL TCM Track

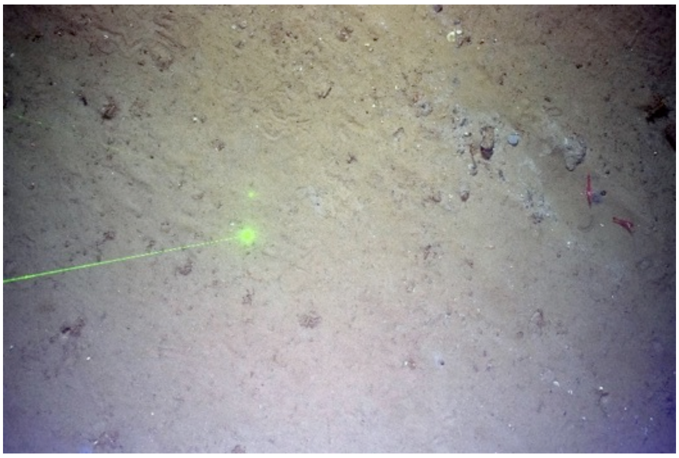


Figure 83: TCM HH920-TC08 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired	Bottle #	Time acquired / fired
1	13:54:48	4	
2		5	
3		6	

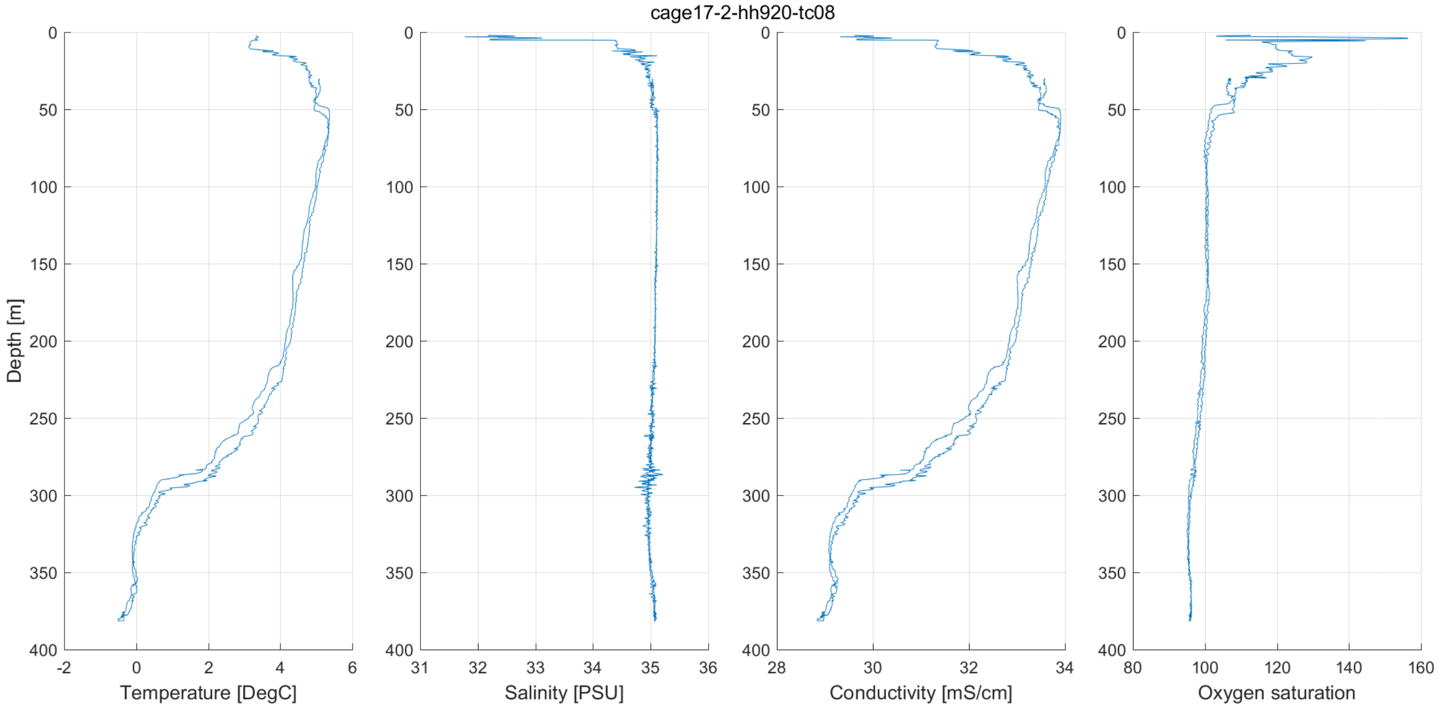


Figure 84 TCM HH900-TC02 CTD Plots

Figure 85 Image HH920-TC08_20170623_135325.
Hard surfaces are still densely colonized by anemones and sponges. IRD are abundant.

Figure 86 Image HH920-TC08_20170623_135245.
At the top of Pingo 5 still hard surfaces densely colonized by anemones and sponges and abundant IRD.

HH921-TC09

Survey Summary:
TCM survey HH921-TC09, was a dangle survey along with water & multicore samples over site GHP-5-S2. The survey and sampling were conducted in water depths of approximately 380 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
GHP-5-S2	9	6/23/2017	14:52:46				Bottom Time	290	1	5	In water
	HH921	6/23/2017	15:10:25	380	76 06.729	16 00.363	0:05:57				at bottom
		6/23/2017	15:14:13	380	76 06.719	16 00.399					Multicore sample
		6/23/2017	15:16:22	380	76 06.716	16 00.407	Deployed Time				Bringing up the TCM
		6/23/2017	15:40:31				0:47:45				Secure on deck

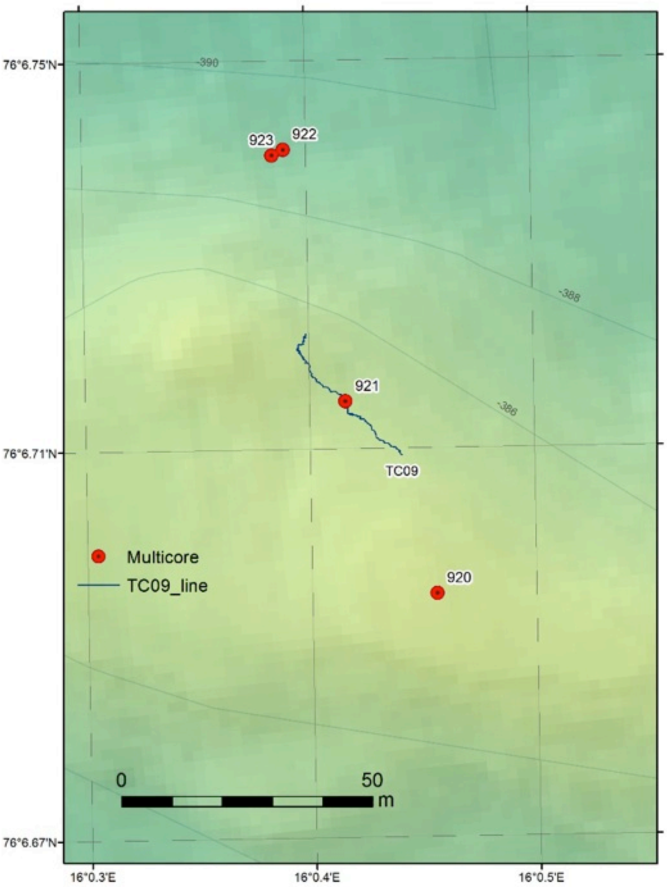


Figure 87: TCM HH921-TC09 USBL TCM Track

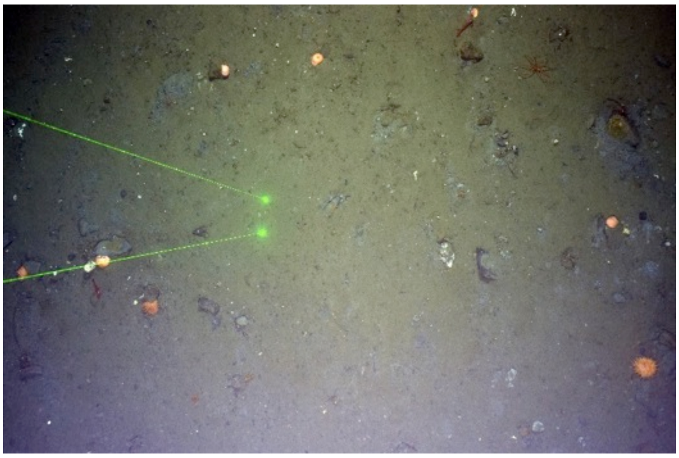


Figure 88: TCM HH921-TC09 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired	Bottle #	Time acquired / fired
1	15:13:16	4	
2		5	
3		6	

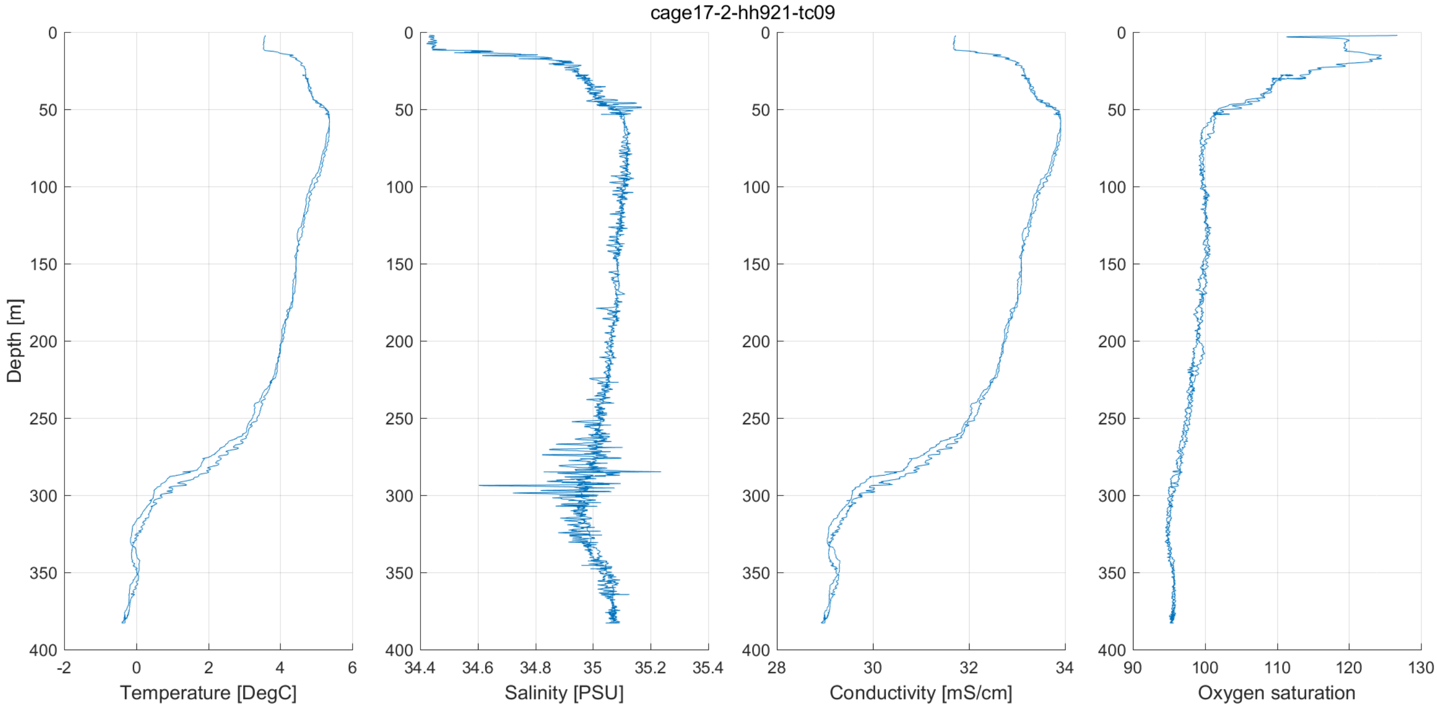


Figure 89 TCM HH921-TC09 CTD Plots

Figure 90 Image HH921-TC09_20170623_151323.
Moving down from the top of the Pingo 5 we still observe hard surfaces densely colonized by anemones and sponges and abundant IRD.

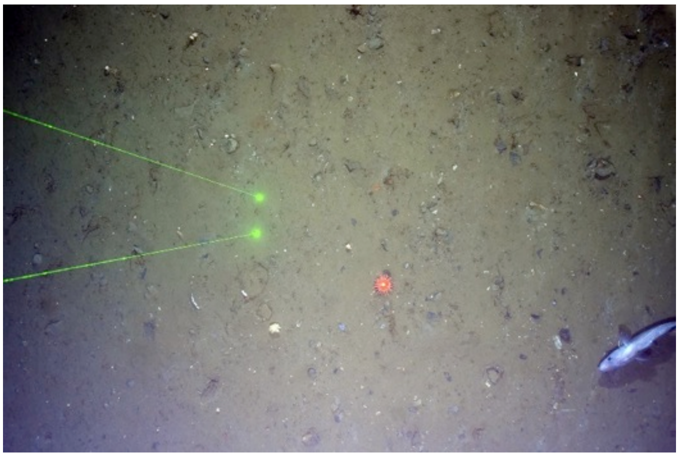


Figure 91 Image HH921-TC09_20170623_151313.
Moving down from the top of the Pingo 5 we still observe hard surfaces densely colonized by anemones and sponges and abundant IRD.

HH922-TC10

Survey Summary:
TCM survey HH922-TC10, was a survey along with water & multicore samples over site GHP-5-S4. The survey and sampling were conducted in water depths of approximately 390 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
GHP-5-S4	10	6/23/2017	16:14:21				Bottom Time	468	1	5	In water
	HH922	6/23/2017	16:30:59	389	76 6.580	16 0.415	0:40:31				at bottom
		6/23/2017	17:10:16	386	76 6.745	16 0.370					Multicore sample
		6/23/2017	17:11:30	384	76 6.746	16 0.368	Deployed Time				Bringing up the TCM
		6/23/2017	17:31:00				1:16:39				Secure on deck

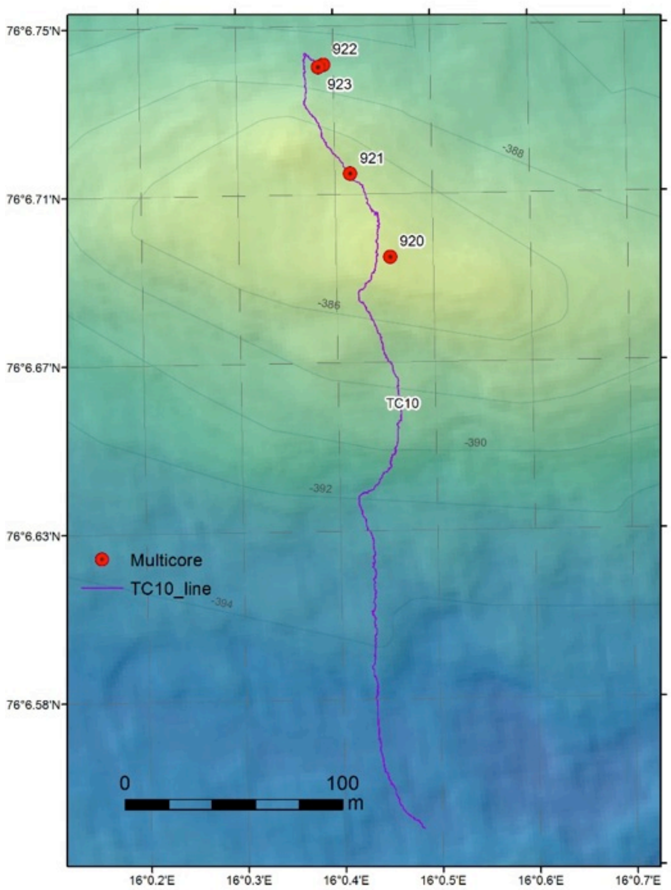


Figure 92: TCM HH922-TC10 USBL TCM Track

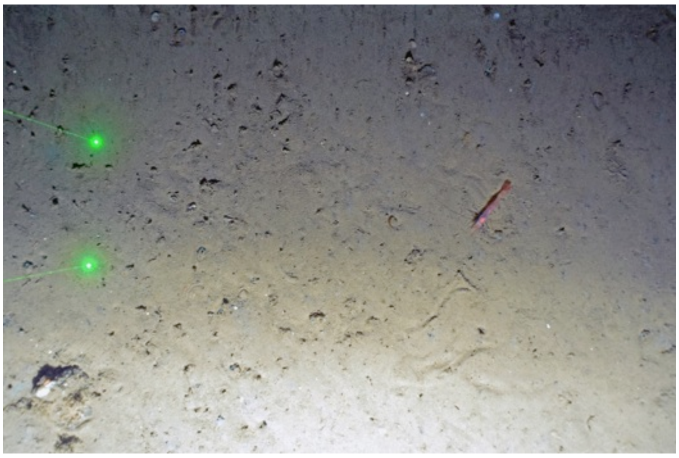


Figure 93: TCM HH922-TC10 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired	Bottle #	Time acquired / fired
1	17:09:11	4	
2		5	
3		6	

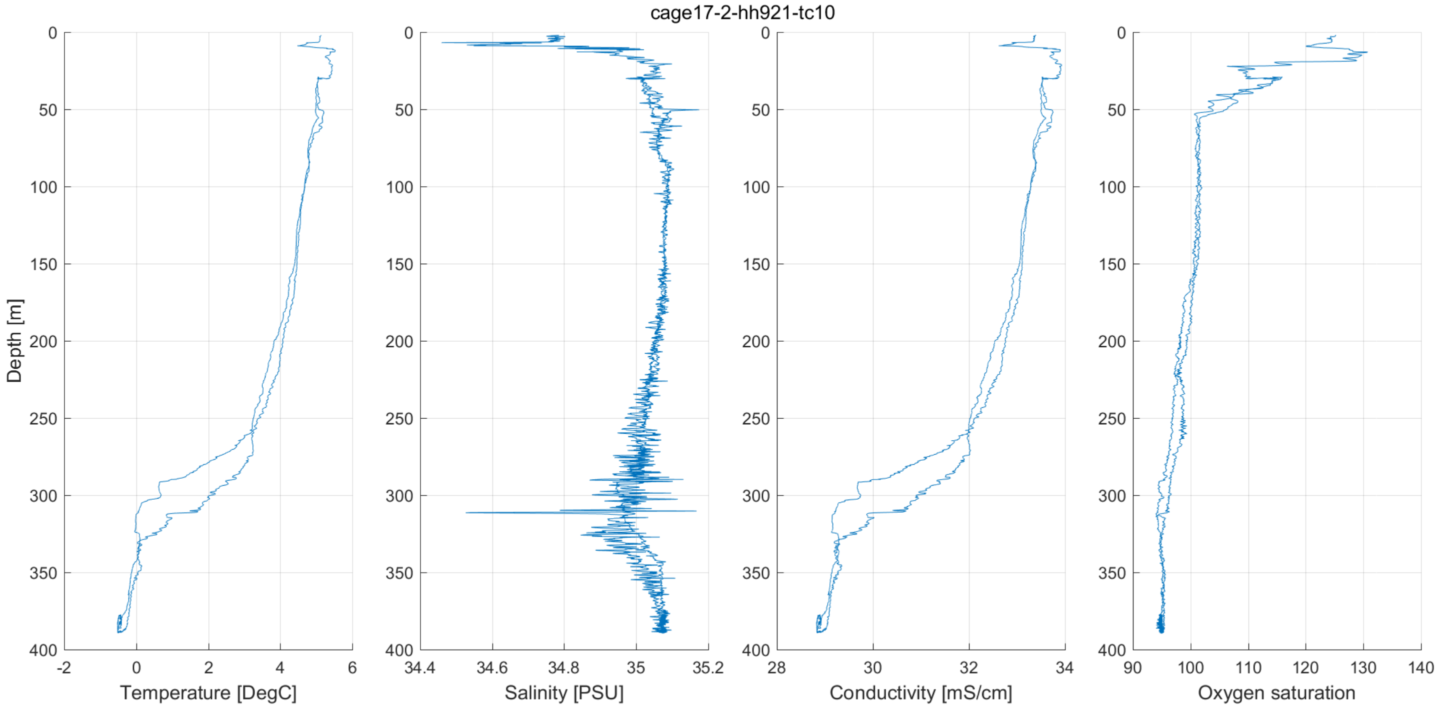


Figure 94 TCM HH921-TC10 CTD Plots

Figure 95 Image HH922-TC10_20170623_164551.
In the lower part of the Pingo 5 flank, rare IRD are colonized by anemonies and sponges. Scrimps and fish were also observed
..

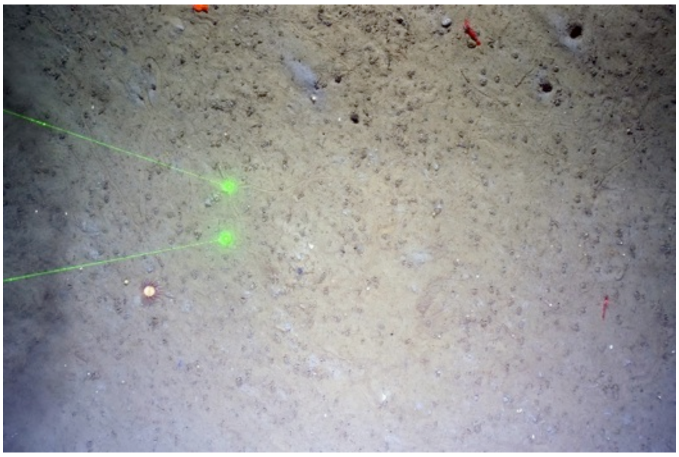


Figure 96 Image HH922-TC10_20170623_163621.
Moving down from the top of the Pingo 5 there are several bioturbations, probably fish holes and trails

HH923-TC11

Survey Summary:
TCM survey HH923-TC11, was a dangle survey along with water & multicore samples over site GHP-5-S3. The survey and sampling were conducted in water depths of approximately 375 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
GHP-5-S3	11	6/23/2017	18:19:28				Bottom Time	259	1	6	In water
	HH923	6/23/2017	18:31:33	310	76 06.736	16 00.369	0:05:24				at bottom
		6/23/2017	18:35:46	376	76 06.741	16 00.461					Multicore sample
		6/23/2017	18:36:57	376	76 06.736	16 00.464	Deployed Time				Bringing up the TCM
		6/23/2017	19:00:27				0:40:59				Secure on deck

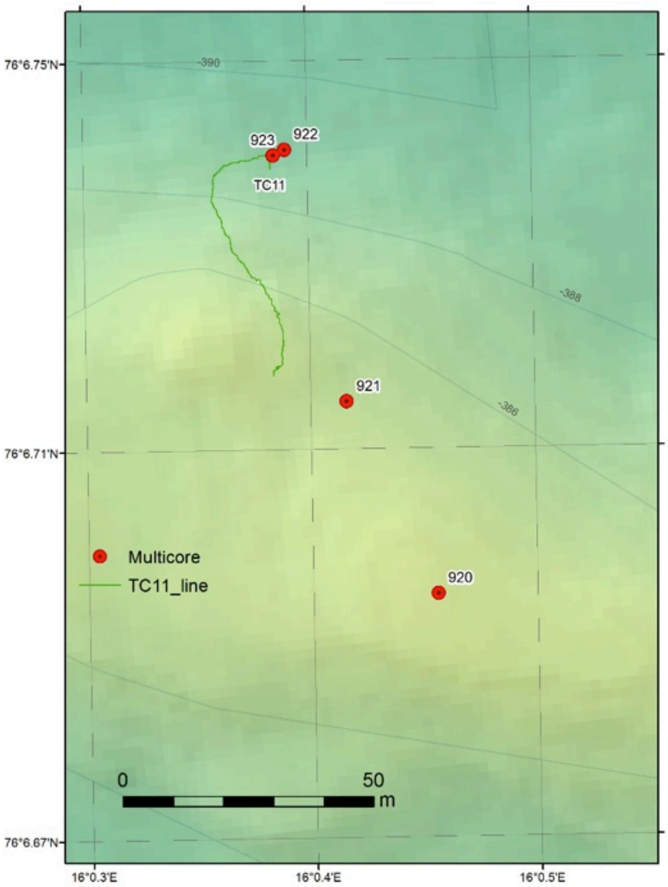


Figure 97: TCM HH923-TC11 USBL TCM Track

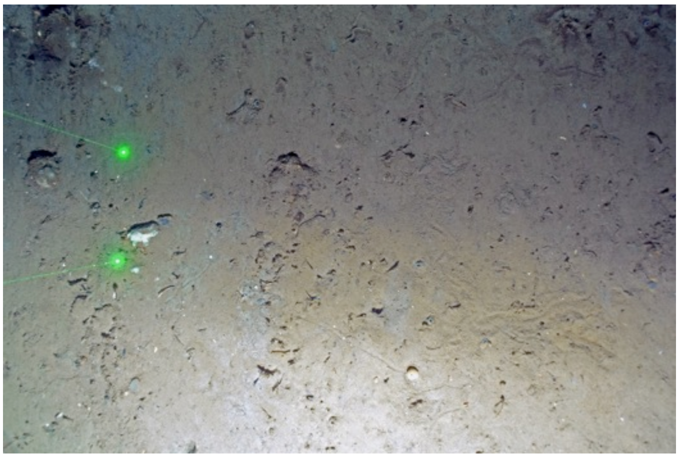


Figure 98: TCM HH923-TC11 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired	Bottle #	Time acquired / fired
1	18:35:00	4	
2		5	
3		6	

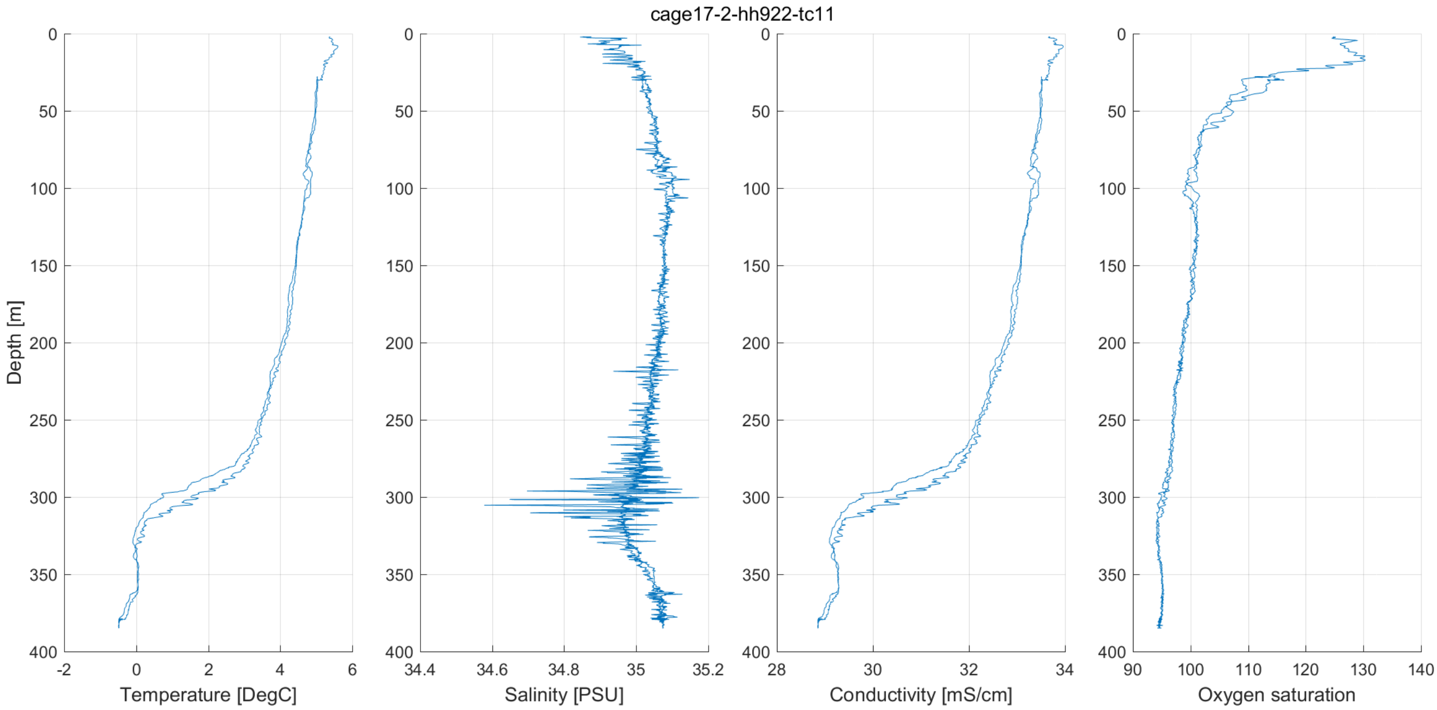


Figure 99 TCM HH922-TC11 CTD Plots

Figure 100 Image HH923-TC11_20170623_183346.
Abundant IRD colonized by anemones and sponge.

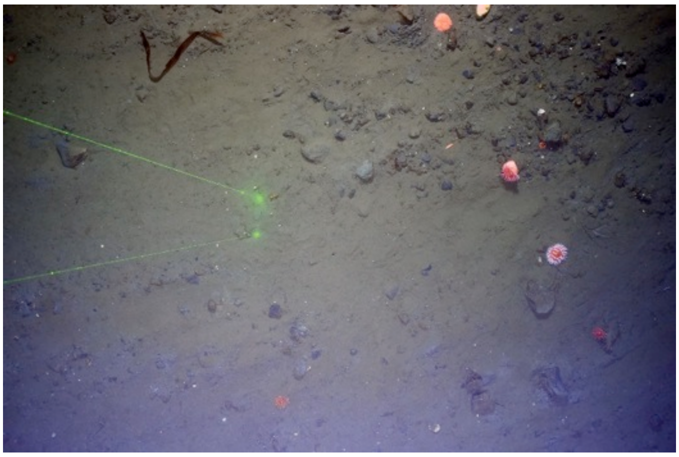


Figure 101 Image HH923-TC11_20170623_183326.
Abundant IRD colonized by anemones and sponge.

HH924-TC12

Survey Summary:
TCM survey HH924-TC12, was a dangle survey along with water & multicore samples over a background reference site. The survey and sampling were conducted approximately 4 km's west of Pingo sites in a shallow flat region with water depths around 385 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
Ref-9254	12	6/23/2017	20:36:27				Bottom Time	270	0	5	In water
	HH924	6/23/2017	20:50:44	380	76 06.829	15 51.199	0:03:37				at bottom
		6/23/2017	20:53:13	384	76 06.819	15 51.226					Multicore sample
		6/23/2017	20:54:21	384	76 06.813	15 51.234	Deployed Time				Bringing up the TCM
		6/23/2017	21:17:18				0:40:51				Secure on deck

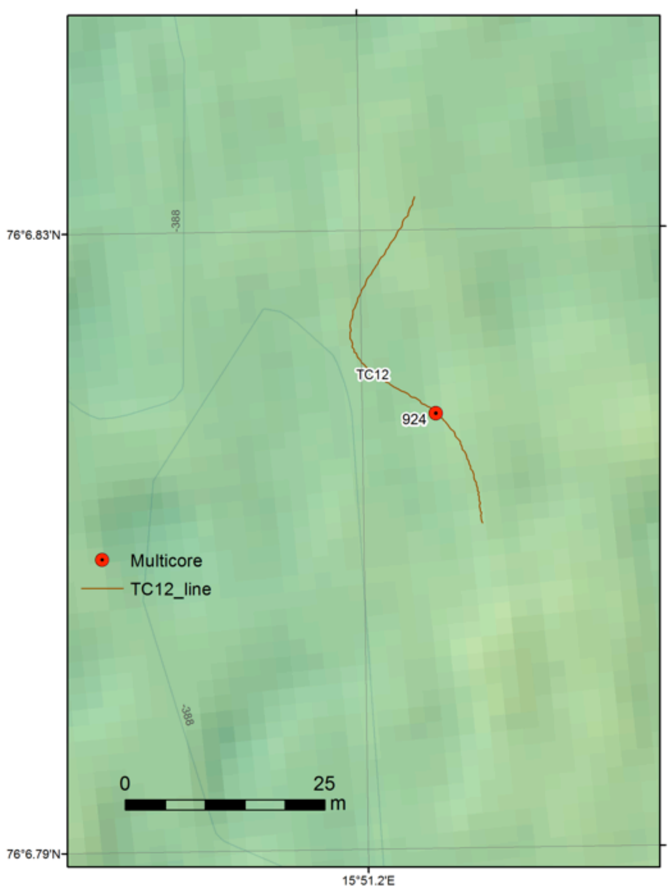


Figure 102: TCM HH924-TC12 USBL TCM Track

Figure 103: TCM HH924-TC12 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired
1	
2	
3	

Bottle #	Time acquired / fired
4	
5	
6	

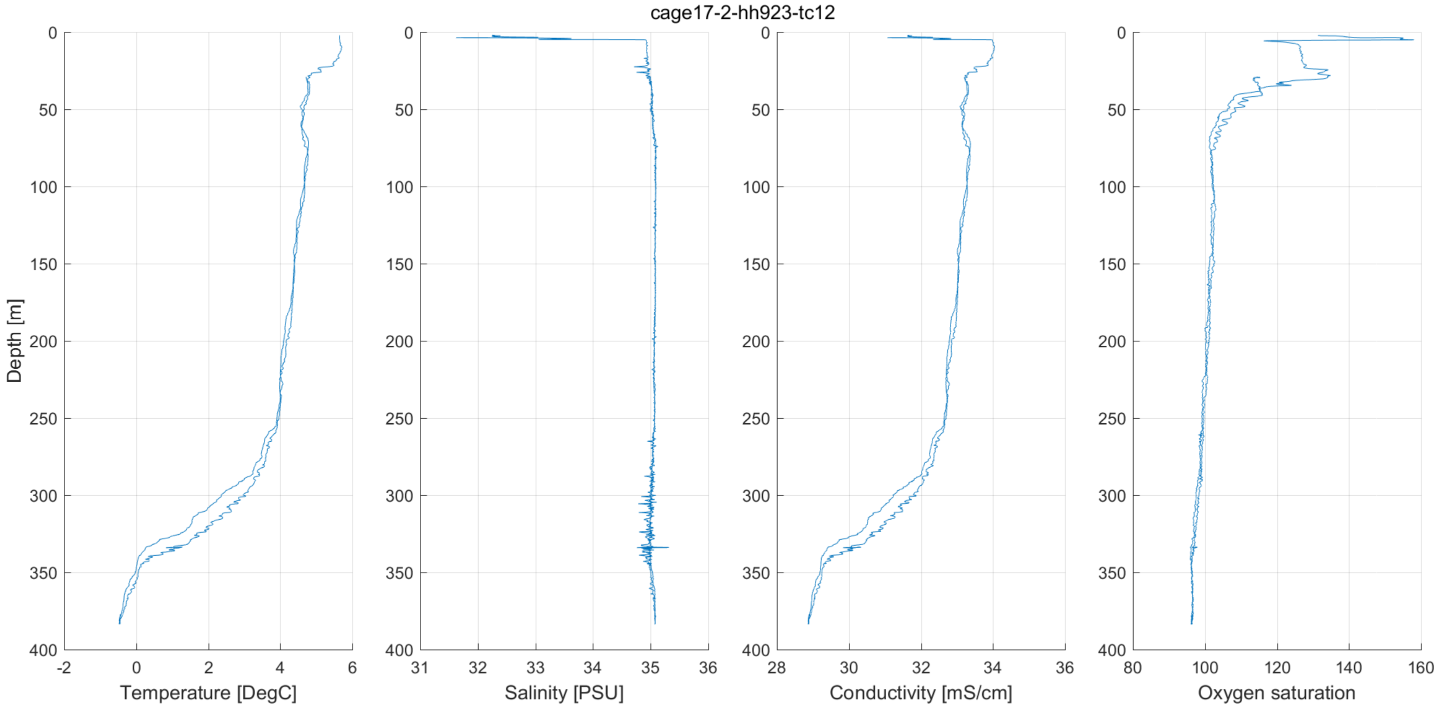


Figure 104 TCM HH923-TC12 CTD Plots

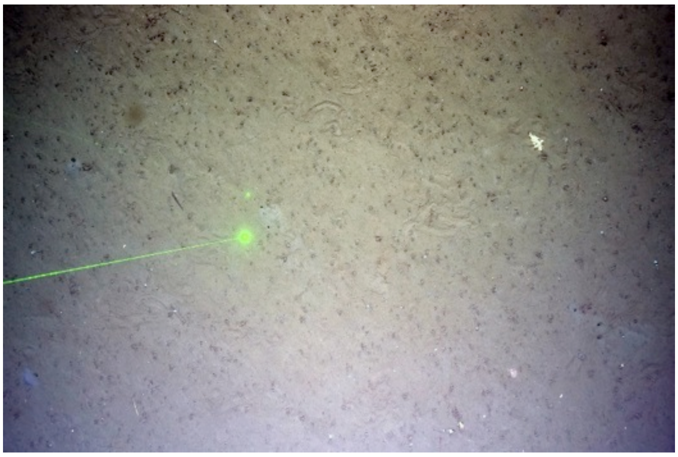


Figure 105 Image HH924-TC12_20170623_205206.
At the base of Pingo 5 the seafoor is characterized by trails and holes of worms.

HH932-TC13

Survey Summary:
TCM survey HH932-TC13, was a dangle survey along with water & multicore samples over a background reference site. The survey and sampling were conducted approximately 1 km northeast of Olga Basin Craters sites in a shallow flat region with water depths around 160 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
Ref-932	13	6/26/2017	14:42:00				Bottom Time	237	0	3	In water
	HH932	6/26/2017	14:54:58	163	76 47.215	35 44.760	0:10:05				at bottom
		6/26/2017	15:04:12		76 47.172	35 44.661					Multicore sample
		6/26/2017	15:05:03		76 47.175	35 44.672	Deployed Time				Bringing up the TCM
		6/26/2017	15:21:46				0:39:46				Secure on deck

NO NAV PLOT

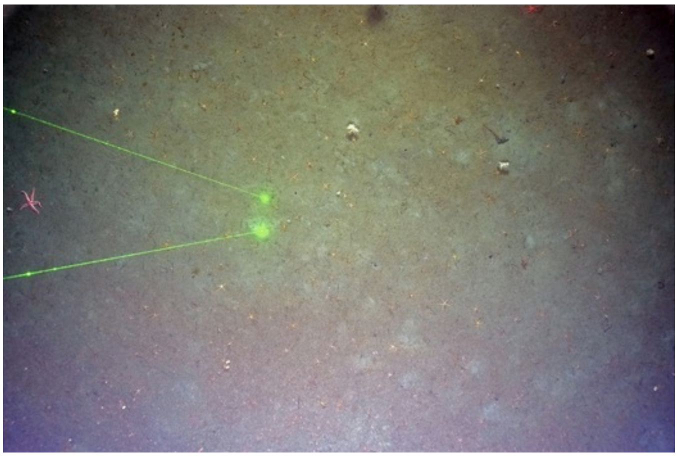


Figure 106: TCM HH932-TC13 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired	Bottle #	Time acquired / fired
1		4	
2		5	
3		6	

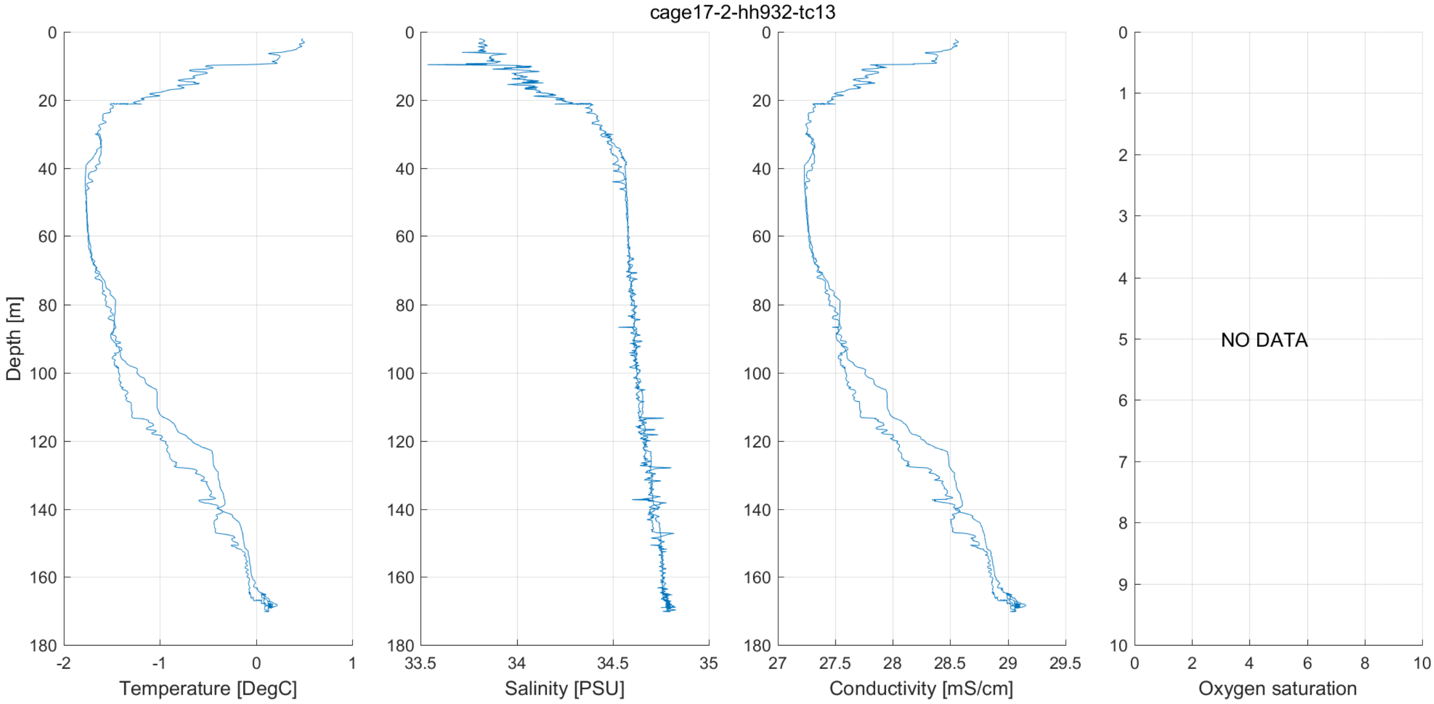


Figure 107 TCM HH932-TC13 CTD Plots

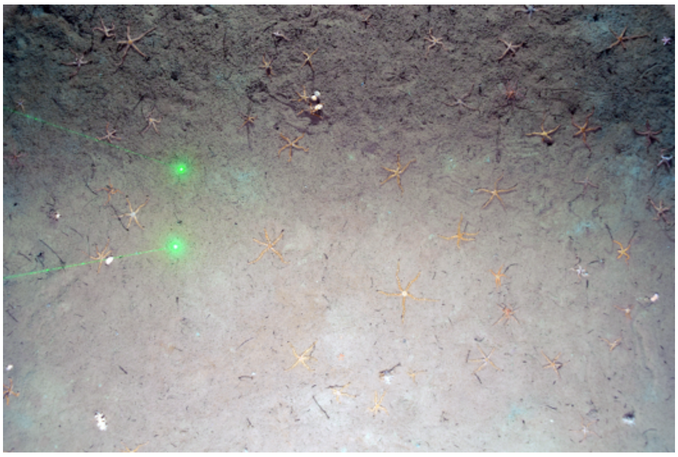


Figure 108 Image HH932-TC13_20170626_150307.
Seafloor is covered by brittle stars and starfish

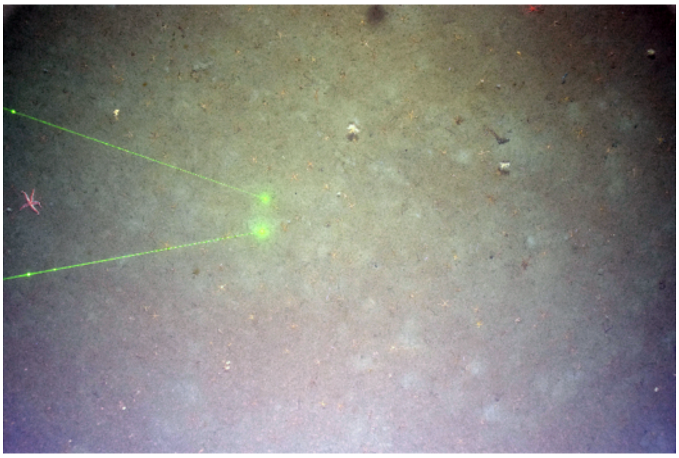


Figure 109 Image HH932-TC13_20170626_150347.
Seafloor is covered by brittle stars and starfish

HH933-TC14

Survey Summary:
TCM survey HH932-TC14, was a dangle survey along with water & multicore samples over site OBC-D1. The survey and sampling were conducted in water depths of approximately 220 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
OBC-D1	14	6/26/2017	15:57:28				Bottom Time	813	2	5	In water
	HH933	6/26/2017	16:05:11	160	76 46.737	35 43.457	1:59:15				at bottom
		6/26/2017	17:57:58	221	76 46.118	35 42.921					Multicore sample
		6/26/2017	18:04:26	221	76 46.129	35 42.975	Deployed Time				Bringing up the TCM
		6/26/2017	18:14:44				2:17:16				Secure on deck

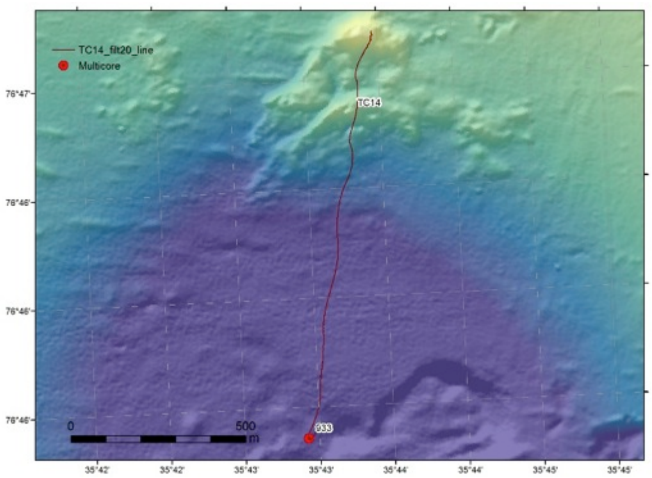


Figure 110: TCM HH933-TC14 USBL TCM Track

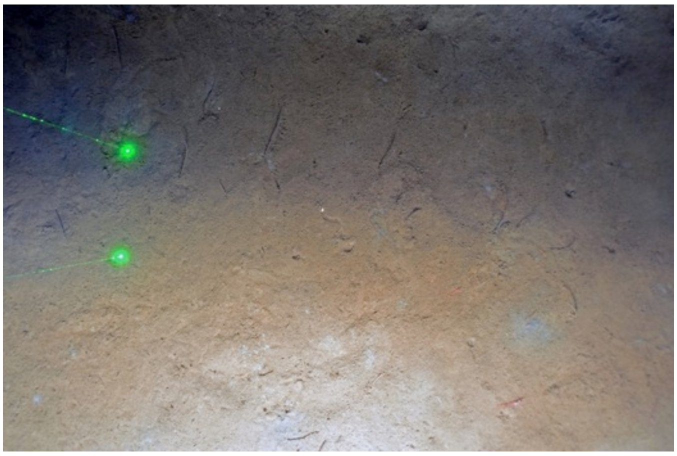


Figure 111: TCM HH933-TC14 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired	Bottle #	Time acquired / fired
1	17:44:47	4	
2	17:55:52	5	
3		6	

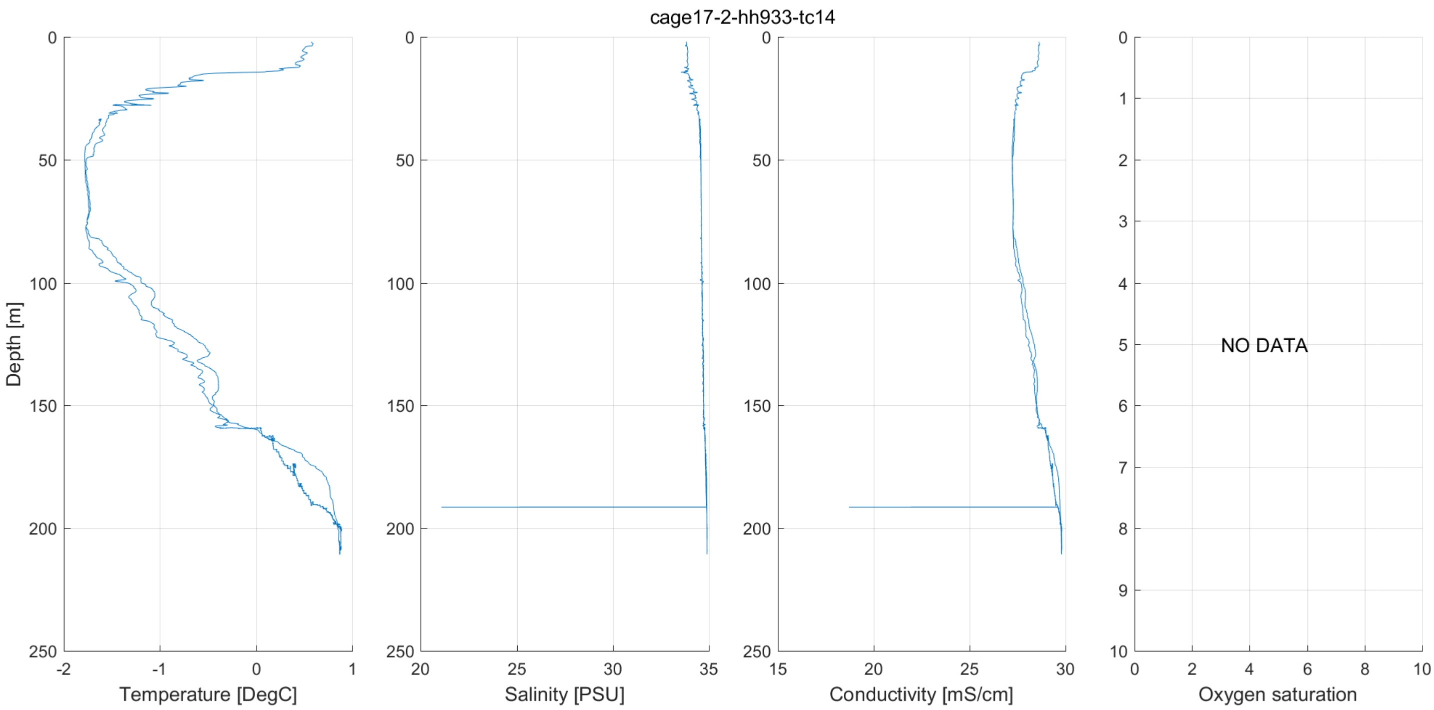


Figure 112 TCM HH933-TC14 CTD Plots

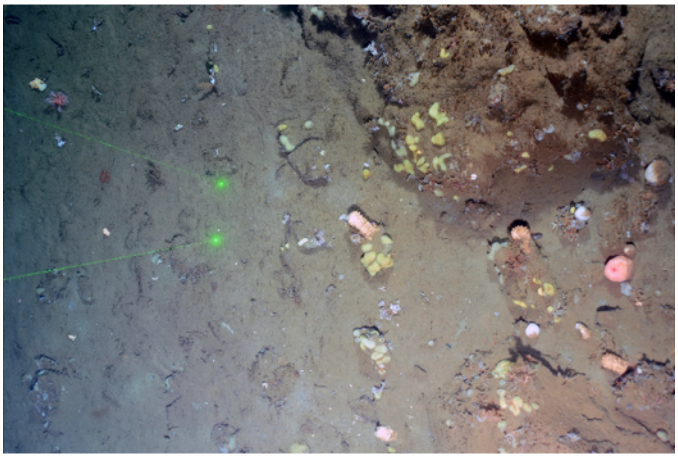


Figure 113 Image HH933-TC14_20170626_163228.
Seafloor covered by rocks and other hard substrates with anemones and sponges.

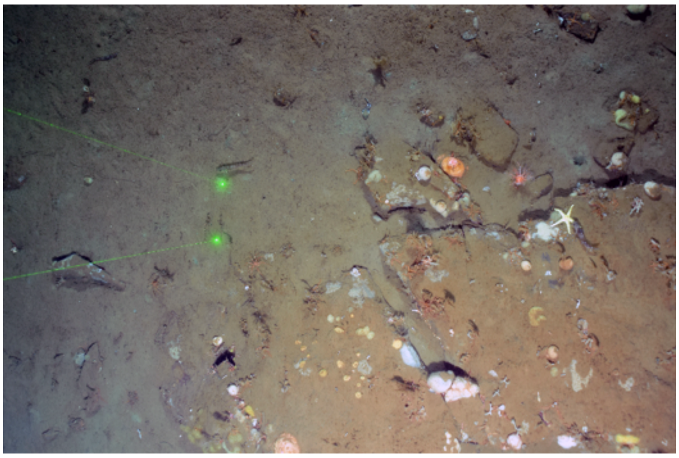


Figure 114 Image HH933-TC14_20170626_165148.
Seafloor covered by rocks and other hard substrates with anemones and sponges.

HH939-TC15

Survey Summary:
TCM survey HH939-TC15, was a dangle survey along with water & multicore samples over site OBC-M1. The survey and sampling were conducted in water depths of approximately 155 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
OBC-M1	15	6/27/2017	7:57:29				Bottom Time	1007	6		In water
	HH939	6/27/2017	8:41:56	153	76 46.840	35 11.188	1:45:14				at bottom
		6/27/2017	10:26:58	156	76 46.863	35 11.190					Multicore sample
		6/27/2017	10:27:10	156	76 46.865	35 11.174	Deployed Time				Bringing up the TCM
		6/27/2017	10:44:47				2:47:18				Secure on deck

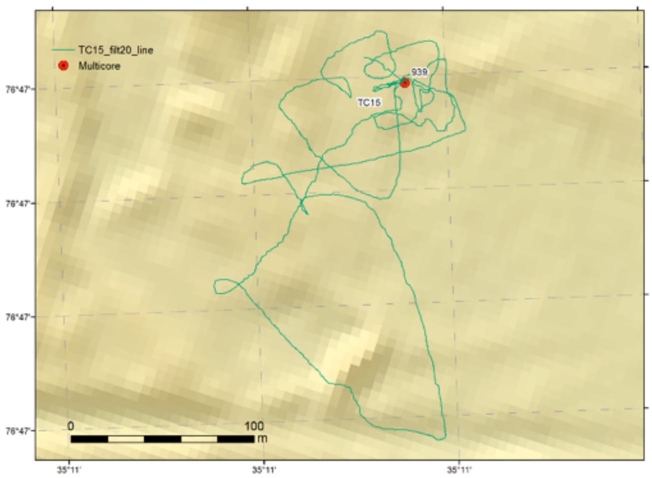


Figure 115: TCM HH9939-TC15 USBL TCM Track

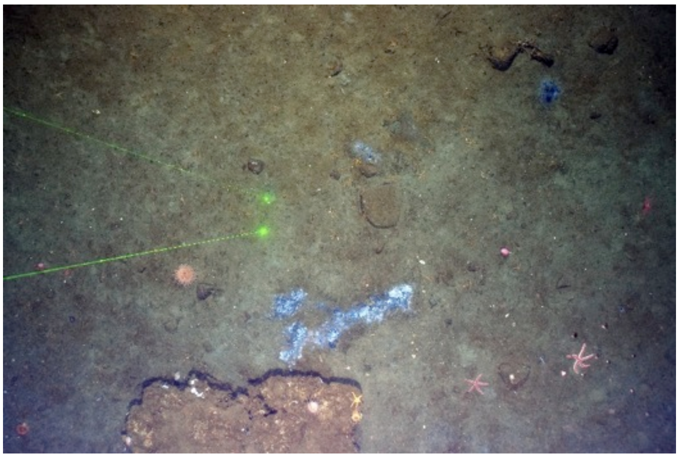


Figure 116: TCM HH939-TC15 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired	Bottle #	Time acquired / fired
1	08:29:12	4	08:38:32
2	08:32:57	5	08:40:47
3	08:36:17	6	10:25:16

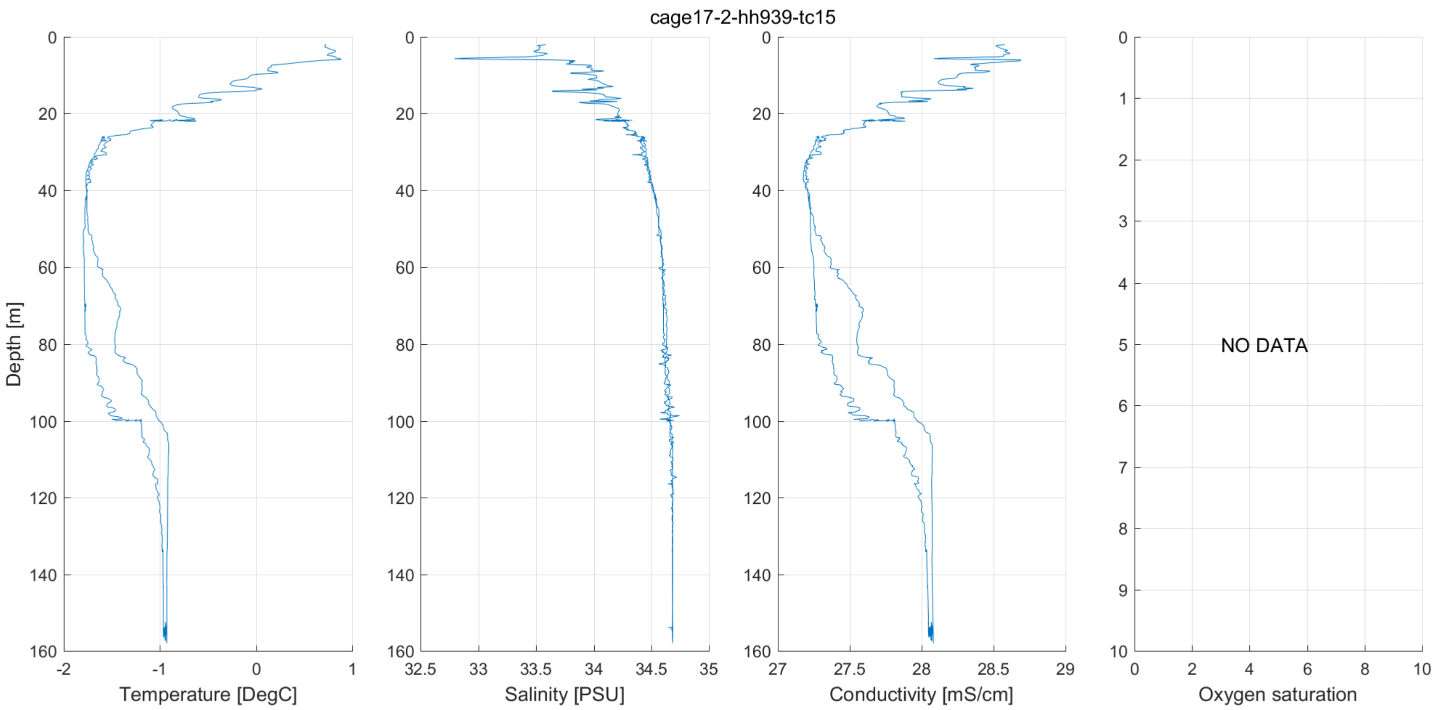


Figure 117 TCM HH939-TC15 CTD Plots

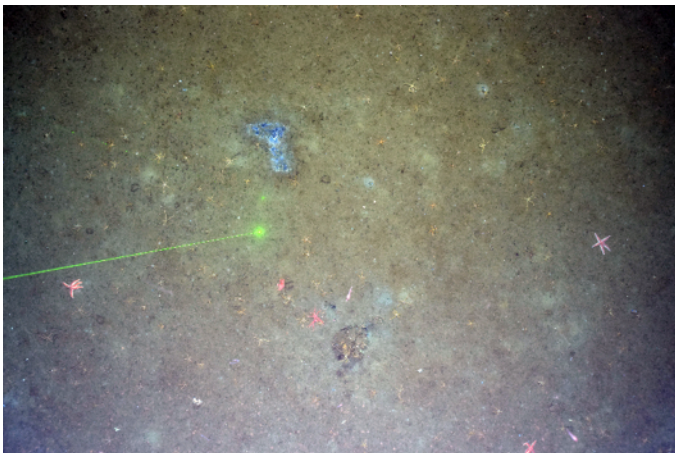


Figure 118 Image HH939-TC15_20170627_085529.
Bacterial mat visible, indicating this is a seep habitat. Surrounding sediment full of brittle stars and some starfish.

Figure 119 Image HH939-TC15_20170627_090509.
Skull of most probably, a porpoise. Anemones and starfish are also present.

HH940-TC16

Survey Summary:
TCM survey HH940-TC16, was a dangle survey along with water & multicore samples over site OBC-M1. The survey and sampling were conducted in water depths of approximately 15 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
OBC-M1	16	6/27/2017	12:12:23				Bottom Time	242	6		In water
	HH940	6/27/2017	12:27:05	155	76 46.8657	35 13.895	0:11:50				at bottom
		6/27/2017	12:38:23	157	76 46.865	35 13.884					Multicore sample
		6/27/2017	12:38:55	157	76 46.868	35 13.879	Deployed Time				Bringing up the TCM
		6/27/2017	12:52:11				0:39:48				Secure on deck

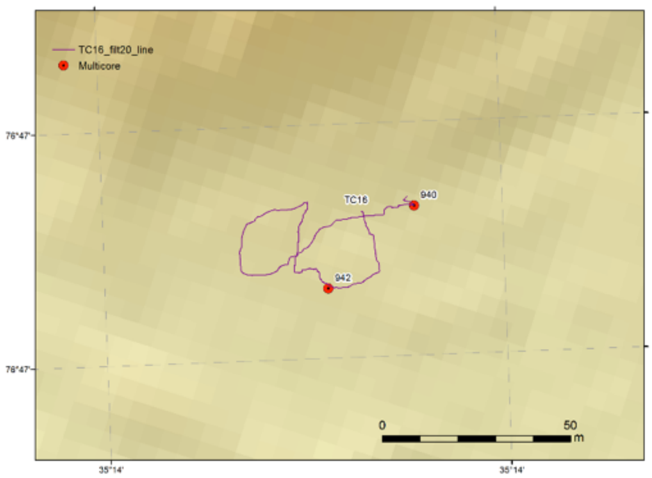


Figure 120: TCM HH940-TC16 USBL TCM Track


Figure 121: TCM HH940-TC16 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired	Bottle #	Time acquired / fired
1	12:19:46	4	12:25:58
2	12:22:02	5	12:27:44
3	12:24:30	6	12:32:10

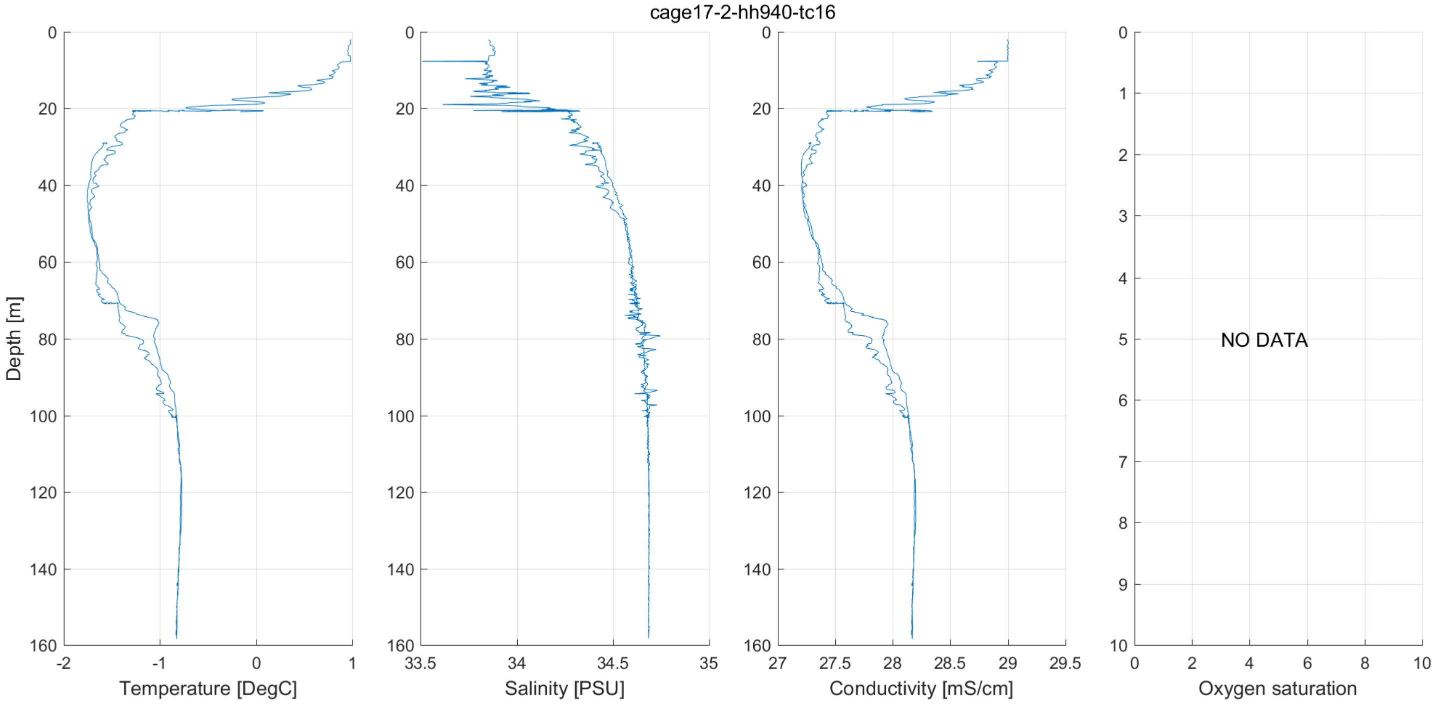


Figure 122 TCM HH940-TC16 CTD Plots

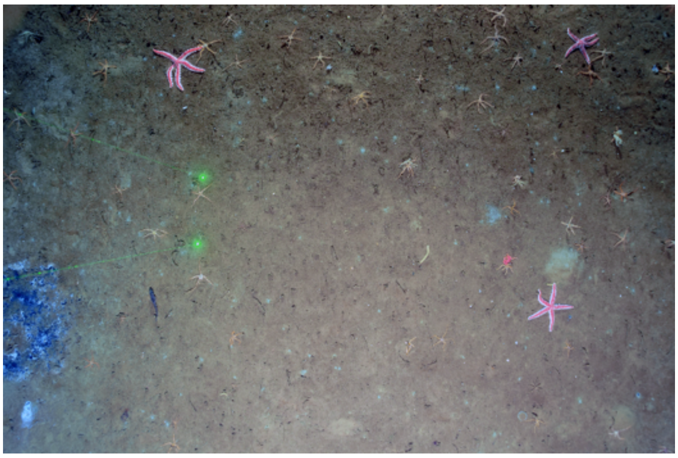


Figure 123 Image HH940-TC16_20170627_123120.
Bacterial mats, with lots of brittle stars and starfish in the sediment.

Figure 124 Image HH940-TC16_20170627_123520.
Bacterial mats, with lots of brittle stars and starfish in the sediment.

HH942-TC17

Survey Summary:
TCM survey HH942-TC17, was a towed survey along with water & multicore samples over site OBC-M1. The survey and sampling were conducted in water depths of approximately 160 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
OBC-M1	17	6/27/2017	13:42:41				Bottom Time	573	0		In water
	HH942	6/27/2017	13:49:54	127	76 47.115	35 13.856	1:11:28				at bottom
		6/27/2017	15:00:00	159	76 47.855	35 13.813					Multicore sample
		6/27/2017	15:01:22	159	76 47.856	35 13.814	Deployed Time				Bringing up the TCM
		6/27/2017	15:17:35				1:34:54				Secure on deck

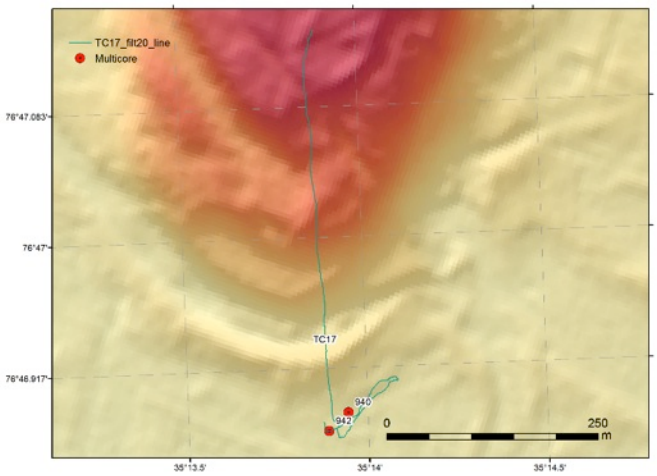


Figure 125: TCM HH942-TC17 USBL TCM Track

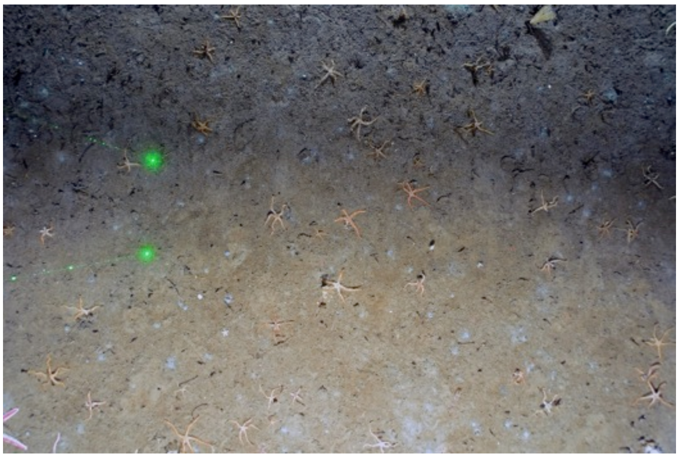


Figure 126: TCM HH942-TC17 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired	Bottle #	Time acquired / fired
1		4	
2		5	
3		6	

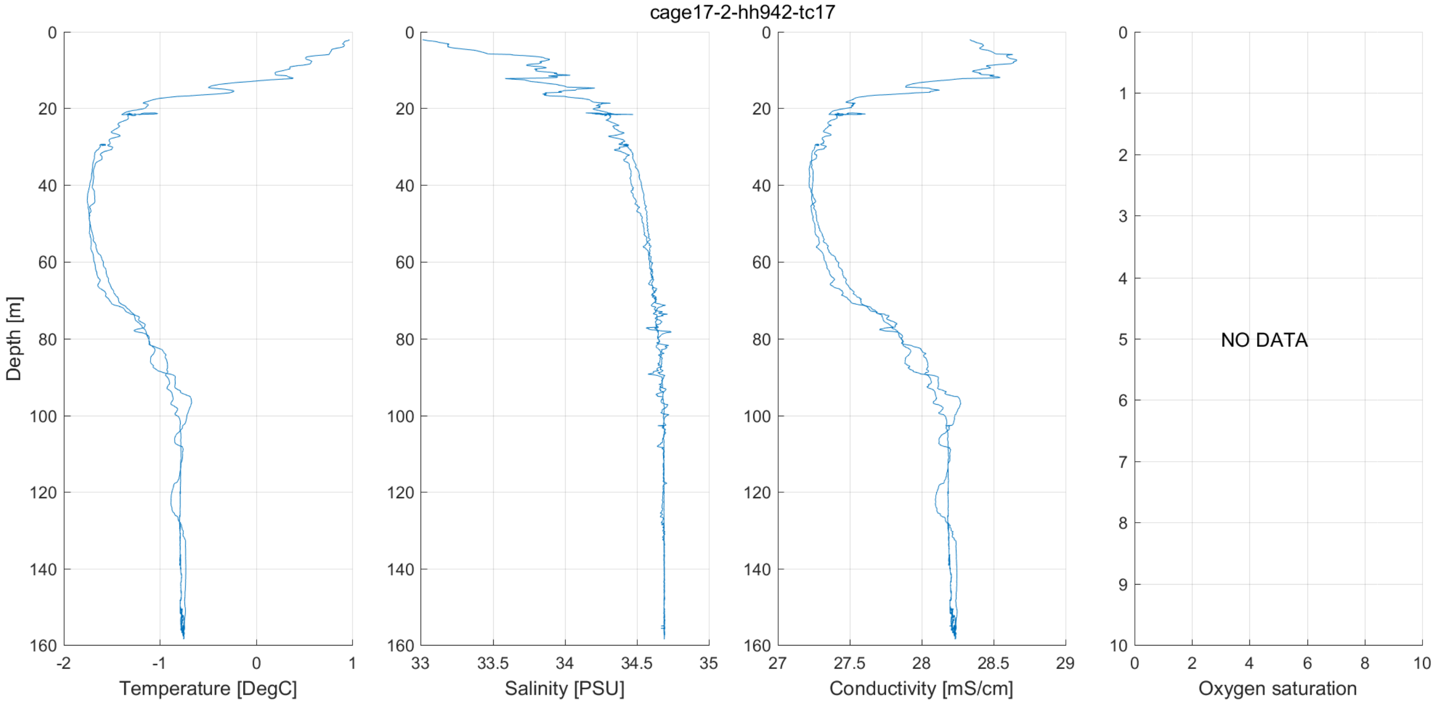


Figure 127 TCM HH942-TC17 CTD Plots

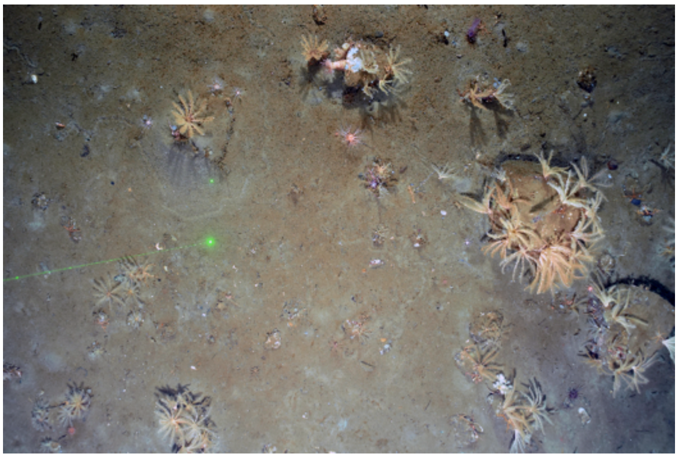


Figure 128 Image HH942-TC17_20170627_135252.
Rocky outcrops are covered with crinoids. Anemones and starfish also visible.

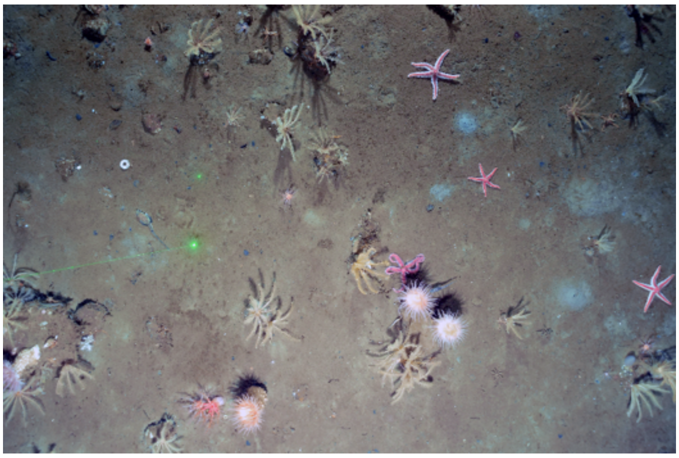


Figure 129 Image HH942-TC17_20170627_135332.
Rocky outcrops are covered with crinoids. Anemones and starfish also visible.

HH947-TC18

Survey Summary:
TCM survey HH947-TC18, was a dangle survey along with water & multicore samples over site OBC-D3. The survey and sampling were conducted in water depths of approximately 150 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
OBC-D3	18	6/28/2017	7:29:20				Bottom Time	502	6	0	In water
	HH947	6/28/2017	7:59:22	152	76 51.039	35 25.927	0:38:25				at bottom
		6/28/2017	8:36:25	154	76 51.045	35 25.894					Multicore sample
		6/28/2017	8:37:47	154	76 51.050	35 25.895	Deployed Time				Bringing up the TCM
		6/28/2017	8:52:09				1:22:49				Secure on deck

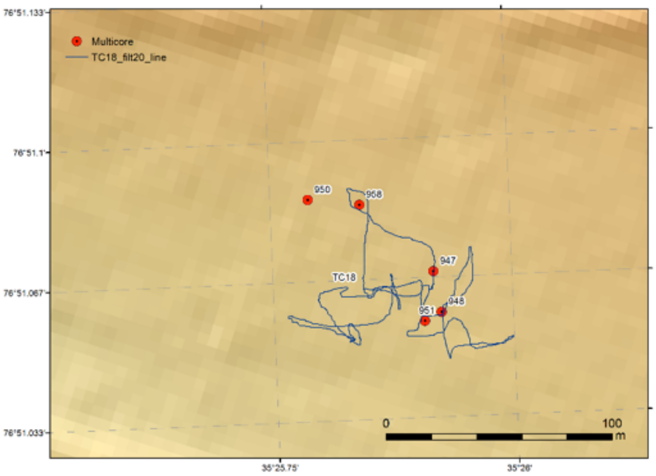


Figure 130: TCM HH947-TC18 USBL TCM Track

Figure 131: TCM HH947-TC18 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired
1	07:44:34
2	07:47:31
3	07:49:30

Bottle #	Time acquired / fired
4	08:07:19
5	08:26:18
6	08:33:42

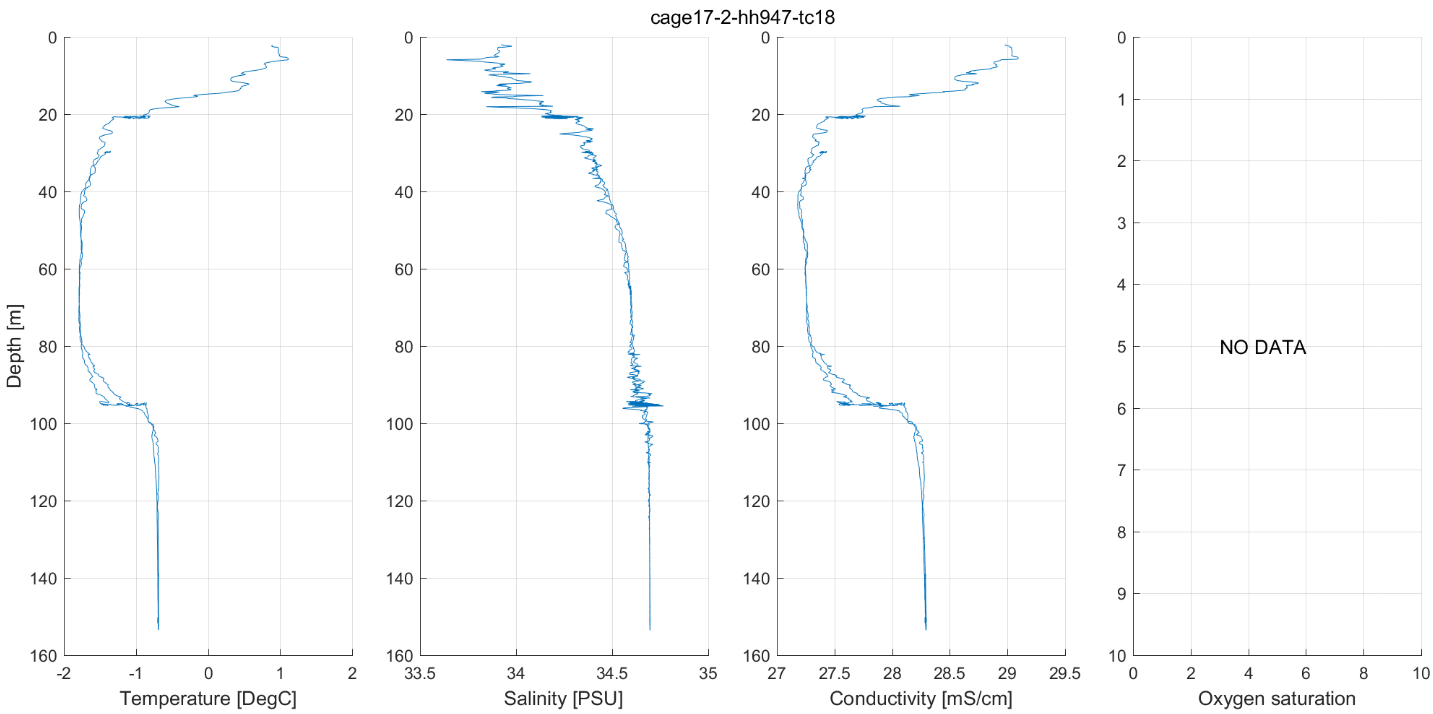


Figure 132 TCM HH947-TC18 CTD Plots

Figure 133 Image HH947-TC18_20170628_083143.
Patches of bacterial mats and crusts colonized by sessile organisms.

Figure 134 Image HH947-TC18_20170628_083613.
Muddy seafloor with brittle stars.

HH948-TC19

Survey Summary:
TCM survey HH948-TC19, was a dangle survey along with water & multicore samples over site OBC-D3. The survey and sampling were conducted in water depths of approximately 160 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
OBC-D3	19	6/28/2017	9:25:12				Bottom Time	422	0	3	In water
	HH948	6/28/2017	9:50:50	150	76 51.071	35 25.962	0:29:05				at bottom
		6/28/2017	10:19:25	162	76 51.465	35 25.935					Multicore sample
		6/28/2017	10:19:55	162	76 51.0429	35 25.933	Deployed Time				Bringing up the TCM
		6/28/2017	10:34:43				1:09:31				Secure on deck

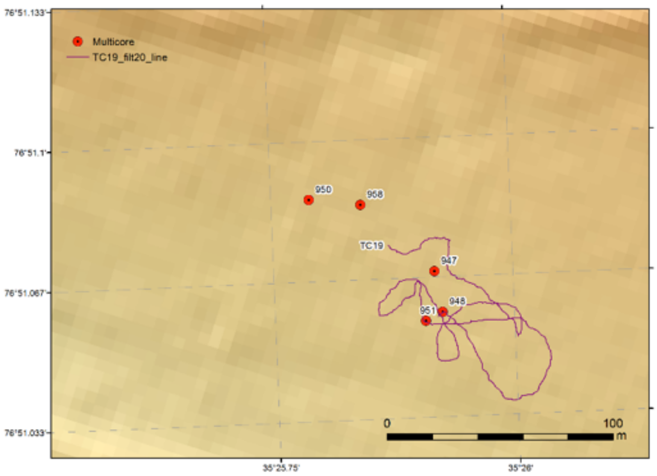


Figure 135: TCM HH948-TC19 USBL TCM Track

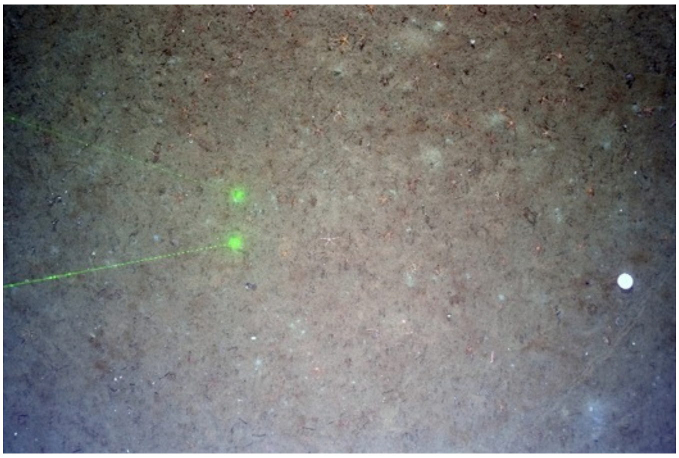


Figure 136: TCM HH948-TC19 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired
1	
2	
3	

Bottle #	Time acquired / fired
4	
5	
6	

NO CTD DATA (Slip ring issues)

Figure 137 Image HH948-TC19_20170628_100856.
Brittle starts, white soft corals and a patch of bacterial mat. Imprint of the MC948.

Figure 138 Image HH948-TC19_20170628_100406.
Crusts and small patch of bacteria. Sessile organism colonized the crust s.

HH950-TC20

Survey Summary:
TCM survey HH950-TC20, was a dangle survey along with water & multicore samples over site OBC-D3. The survey and sampling were conducted in water depths of approximately 150 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
OBC-D3	20	6/28/2017	13:02:21				Bottom Time	212	1	2	In water
	HH950	6/28/2017	13:13:30	147	76 51.077	35 25.839	0:10:01				at bottom
		6/28/2017	13:22:42	150	76 51.072	35 25.777					Multicore sample
		6/28/2017	13:23:31	150	76 51.072	35 25.777	Deployed Time				Bringing up the TCM
		6/28/2017	13:36:47				0:34:26				Secure on deck

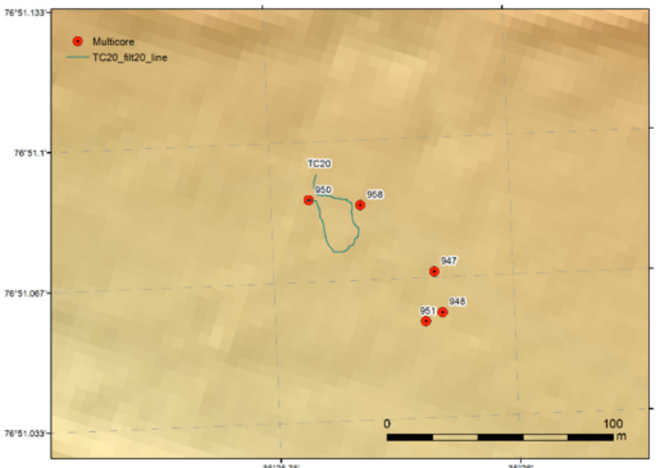


Figure 139: TCM HH950-TC20 USBL TCM Track


Figure 140: TCM HH950-TC20 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired
1	13:21:06
2	
3	

Bottle #	Time acquired / fired
4	
5	
6	

NO CTD DATA (Slip ring issues)

Figure 141 Image HH950-TC20_20170628_131617.
Brittle starts, white soft corals and a patch of bacterial mat. Pebbles.

Figure 142 Image HH950-TC20_20170628_132137.
Rocks with sessile organisms like crinoids and sponges and associated bacteria. At the seafloor brittle stars, crinoids. patch of bacterial mat. Isolated pebbles.

HH951-TC21

Survey Summary:
TCM survey HH951-TC21, was a dangle survey along with water & multicore samples over site OBC-D3. The survey and sampling were conducted in water depths of approximately 160 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
OBC-D3	21	6/28/2017	14:27:52				Bottom Time	599	2	3	In water
	HH951	6/28/2017	14:40:00	149	76 51.095	35 25.905	1:14:20				at bottom
		6/28/2017	15:53:00	162	76 51.051	35 25.919					Multicore sample
		6/28/2017	15:54:20	162	76 51.053	35 25.919	Deployed Time				Bringing up the TCM
		6/28/2017	16:08:30				1:40:38				Secure on deck

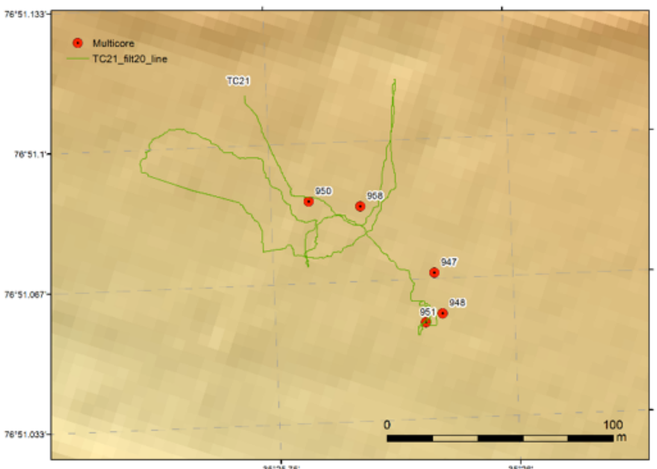


Figure 143: TCM HH951-TC21 USBL TCM Track

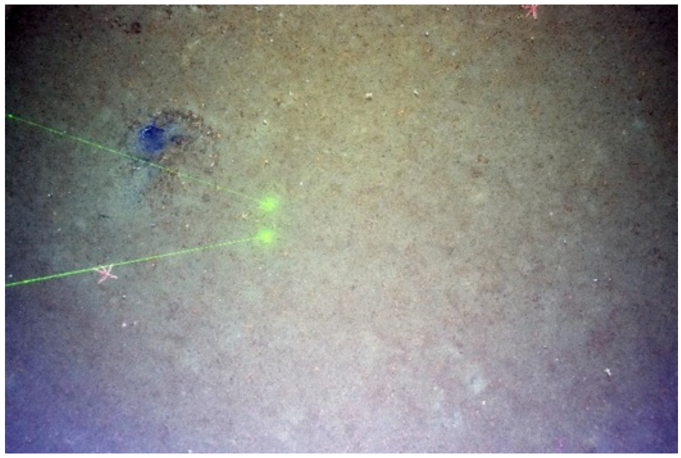


Figure 144: TCM HH951-TC21 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired	Bottle #	Time acquired / fired
1	15:37:48	4	
2	15:52:57	5	
3		6	

NO CTD DATA (Slip ring issues)

Figure 145 Image HH951-TC21_20170628_150004.
Crusts, and IRD colonized by sessile organisms. Crinoids, brittle starts, anemones.

Figure 146 Image HH951-TC21_20170628_153404.
Patches of bacterial mat. IRD or crusts colonized by sessile organisms. Crinoids, brittle starts, anemones. Brittle starts appear to be more abundant close to the bacterial mats.

HH957-TC22

Survey Summary:
TCM survey HH957-TC22, was a dangle survey along with water & multicore samples over site OBC-D4. The survey and sampling were conducted in water depths of approximately 150 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
OBC-D4	22	6/29/2017	8:17:55				Bottom Time	757	6	5	In water
	HH957	6/29/2017	8:43:49	150	76 50.199	35 26.594	1:21:50				at bottom
		6/29/2017	10:04:22	153	76 50.201	35 26.682					Multicore sample
		6/29/2017	10:05:39	153	76 50.203	35 26.681	Deployed Time				Bringing up the TCM
		6/29/2017	10:21:31				2:03:36				Secure on deck

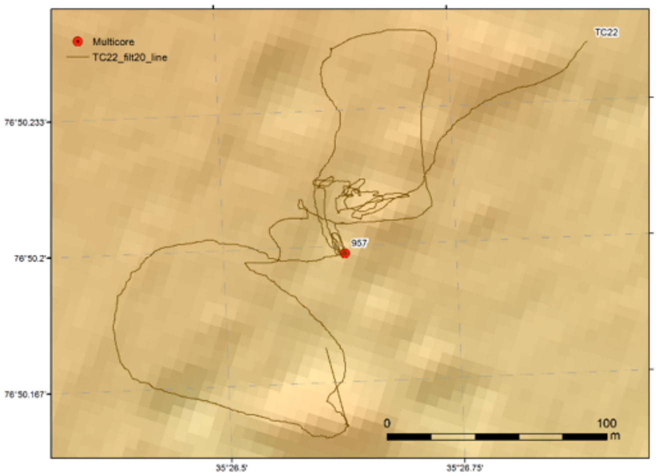


Figure 147: TCM HH957-TC22 USBL TCM Track


Figure 148: TCM HH957-TC22 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired
1	08:32:33
2	08:36:46
3	08:40:22

Bottle #	Time acquired / fired
4	08:42:07
5	08:44:37
6	10:01:30

NO CTD DATA (Slip ring issues)

Figure 149 Image HH957-TC22_20170629_100545.
Block colonised by sessile organisms, several sponges, crinoids. Abundant brittle starts sit on the rock. The seafloor is muddy with abundant brittle starts and sea spiders.

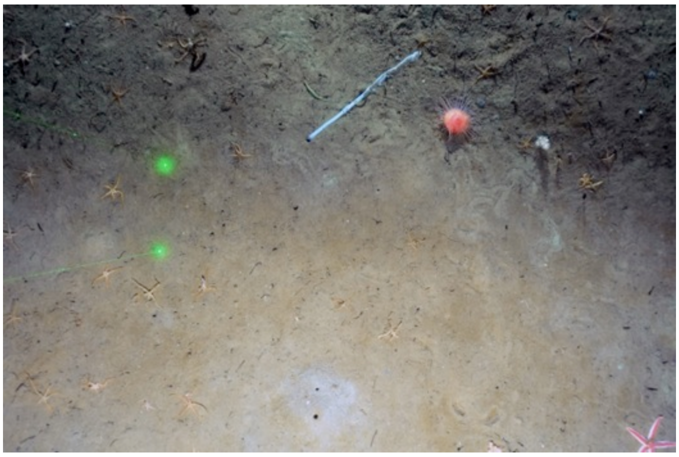


Figure 150 Image HH957-TC22_20170629_093055.
Seafloor with brittles starts, anemone and a worm tube protruding from the seafloor.

HH958-TC23

Survey Summary:
TCM survey HH958-TC23, was a dangle survey along with water & multicore samples over site OBC-D3. The survey and sampling were conducted in water depths of approximately 150 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
OBC-D3	23	6/29/2017	11:15:00				Bottom Time	434	1	0	In water
	HH958	6/29/2017	11:26:45	151	76 51.104	35 25.893	0:43:22				at bottom
		6/29/2017	12:09:30	152	76 51.070	35 25.844					Multicore sample
		6/29/2017	12:10:07	152	76 51.073	35 25.824	Deployed Time				Bringing up the TCM
		6/29/2017	12:25:34				1:10:34				Secure on deck

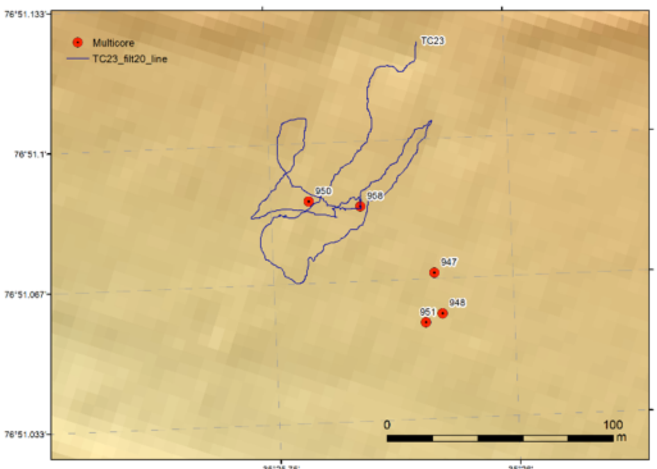


Figure 151: TCM HH958-TC23 USBL TCM Track

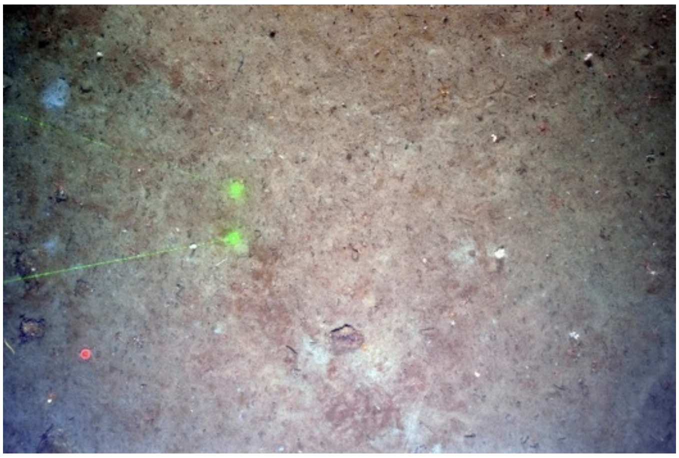


Figure 152: TCM HH958-TC23 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired
1	11:50:48
2	
3	

Bottle #	Time acquired / fired
4	
5	
6	

NO CTD DATA (Slip ring issues)

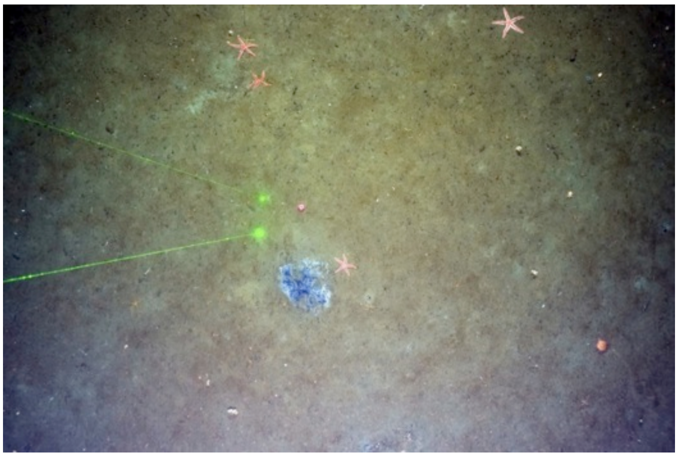


Figure 153 Image HH958-TC23_20170629_115623.
Patch bacterial mat. Brittle starts.

Figure 154 Image HH958-TC23_20170629_115033.
Rocks with sessile organisms like crinoids and sponges and associated bacteria. At the seafloor brittle stars, crinoids. patch of bacterial mat. Isolated pebbles

HH962-TC24

Survey Summary:
TCM survey HH962-TC24, was a dangle survey along with water & multicore samples over site OBC-C1. The survey and sampling were conducted in water depths of approximately 170 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
OBC-C1	24	6/29/2017	18:36:31				Bottom Time	223	0	6	In water
	HH962	6/29/2017	18:46:55	170	76 45.528	35 48.522	0:08:44				at bottom
		6/29/2017	18:54:00	170	76 45.539	35 48.373					Multicore sample
		6/29/2017	18:55:39	170	76 45.540	35 48.370	Deployed Time				Bringing up the TCM
		6/29/2017	19:12:36				0:36:05				Secure on deck

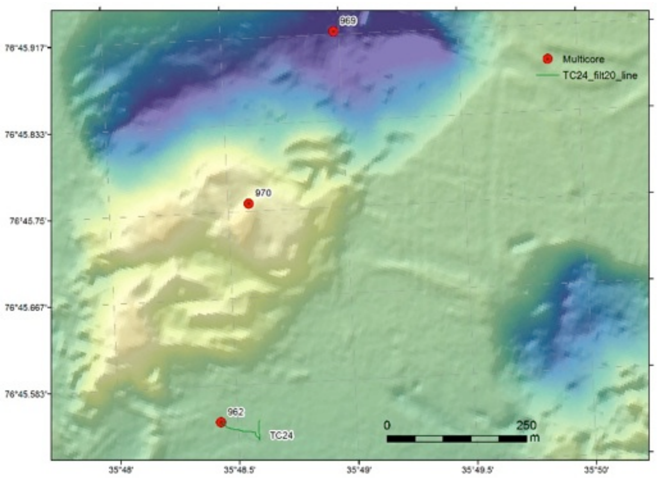


Figure 155: TCM HH962-TC24 USBL TCM Track

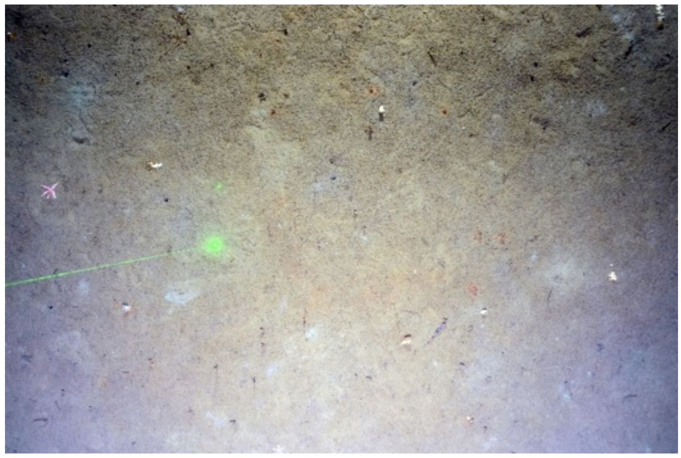


Figure 156: TCM HH962-TC24 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired	Bottle #	Time acquired / fired
1		4	
2		5	
3		6	

NO CTD DATA (Slip ring issues)

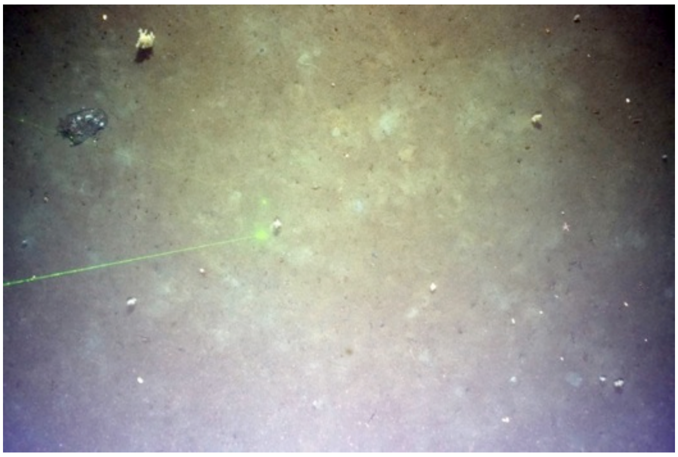


Figure 157 Image HH962-TC24_20170629_184525.
Rare peddles colonized by sessil organisms. Isolate soft corals.

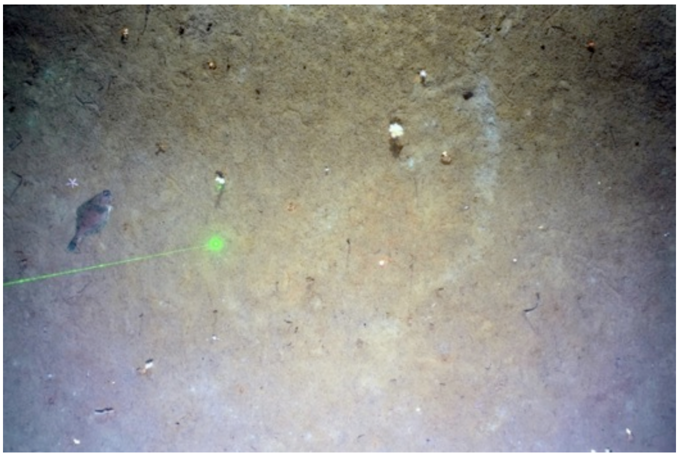


Figure 158 Image HH962-TC24_20170629_185355.
Muddy seafloor, with tubeworms, soft corals, seaspider and flat fish.

HH969-TC25

Survey Summary:
TCM survey HH969-TC25, was a dangle survey along with water & multicore samples over site OBC-C1. The survey and sampling were conducted in water depths of approximately 200 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
OBC-C1	25	6/30/2017	8:08:32				Bottom Time	357	0		In water
	HH969	6/30/2017	8:20:10	174	76 45.903	35 49.492	0:29:55				at bottom
		6/30/2017	8:49:34	202	76 45.913	35 49.922					Multicore sample
		6/30/2017	8:50:05	204	76 45.911	35 49.929	Deployed Time				Bringing up the TCM
		6/30/2017	9:06:04				0:57:32				Secure on deck

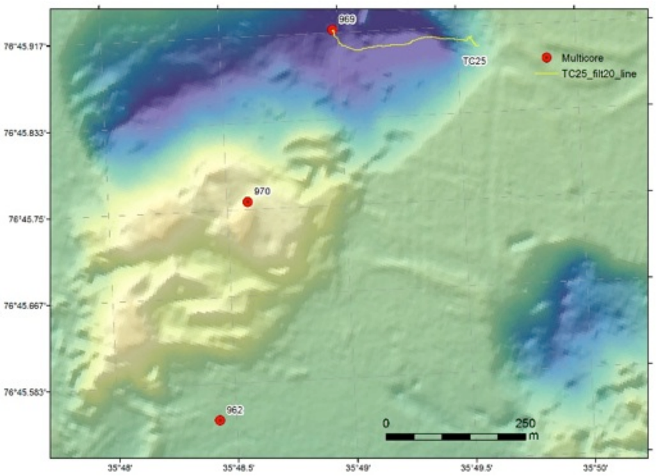


Figure 159: TCM HH969-TC25 USBL TCM Track

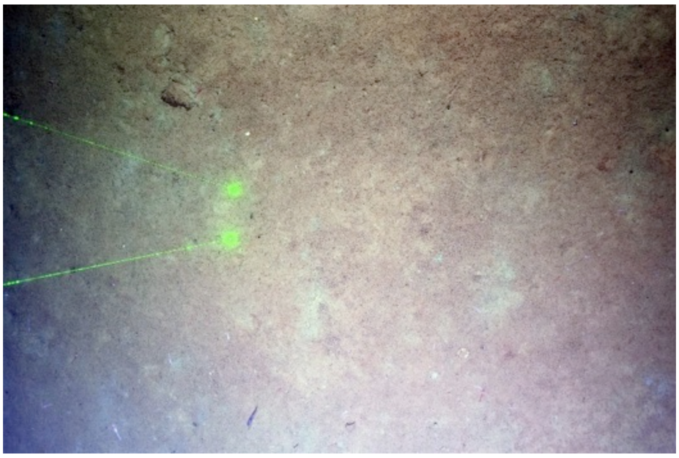


Figure 160: TCM HH969-TC25 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired	Bottle #	Time acquired / fired
1		4	
2		5	
3		6	

NO CTD DATA (Slip ring issues)

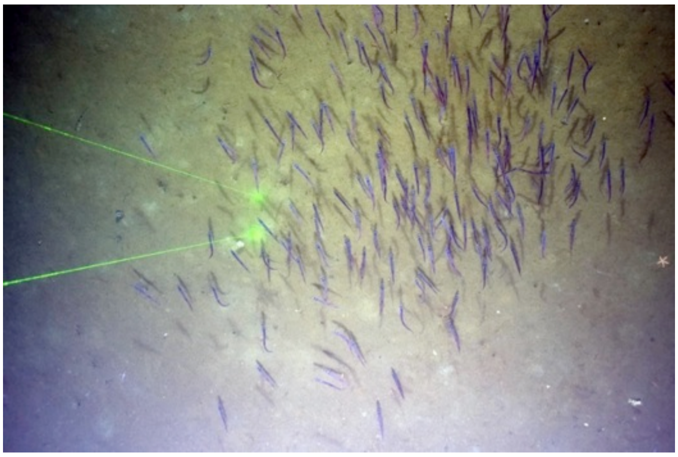


Figure 161 Image HH969-TC25_20170630_084332.
Abundant fish.

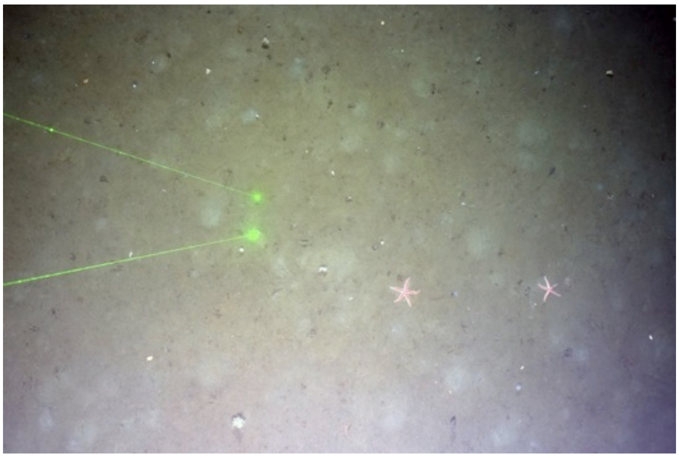


Figure 162 Image HH969-TC25_20170630_0823023.
Fauna not abundant, constituted by brittle stars and tube worms.

HH970-TC26

Survey Summary:
TCM survey HH970-TC26, was a survey along with water & multicore samples over site OBC-C1. The survey and sampling were conducted in water depths of approximately 160 meters.

Site ID	Tow / Station	Date	Time (UTC)	Depth (m)	Lat (N)	Lon (E)	Time	Images	Niskin Bottles	Cores	Comment
OBC-C1	26	6/30/2017	10:08:20				Bottom Time	449	0		In water
	HH970	6/30/2017	10:17:12	168	76 45.644	35 49.079	0:53:06				at bottom
		6/30/2017	11:02:31	163	76 45.769	35 48.526					Multicore sample
		6/30/2017	11:10:18	163	76 45.776	35 48.504	Deployed Time				Bringing up the TCM
		6/30/2017	11:23:24				1:15:04				Secure on deck

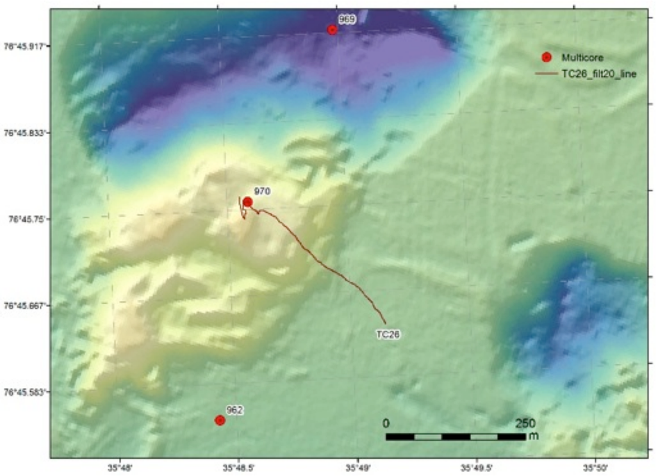


Figure 163: TCM HH970-TC26 USBL TCM Track


Figure 164: TCM HH970-TC26 Multicore Site

The camera used during this lowering was TCM SN DSC005 set at F5.6 and shutter speed at 1/60. The camera was flown between 2.5 and 4 m off the bottom.

Bottle #	Time acquired / fired	Bottle #	Time acquired / fired
1		4	
2		5	
3		6	

NO CTD DATA (Slip ring issues)

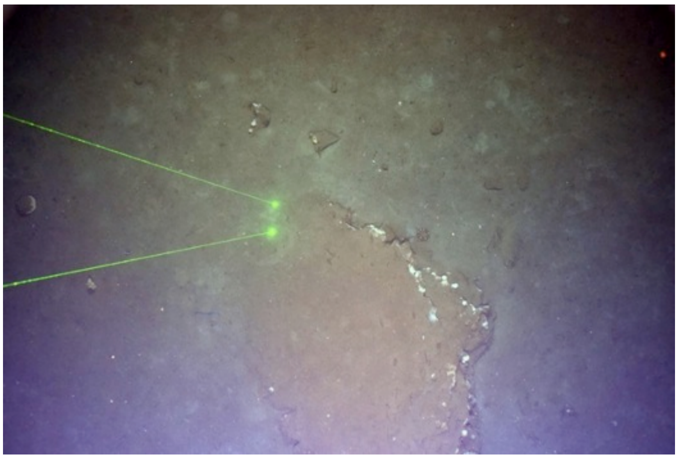


Figure 165 Image HH970-TC26_20170630_101751.
Large slabs of rock at the top of the mound south of crater C1.

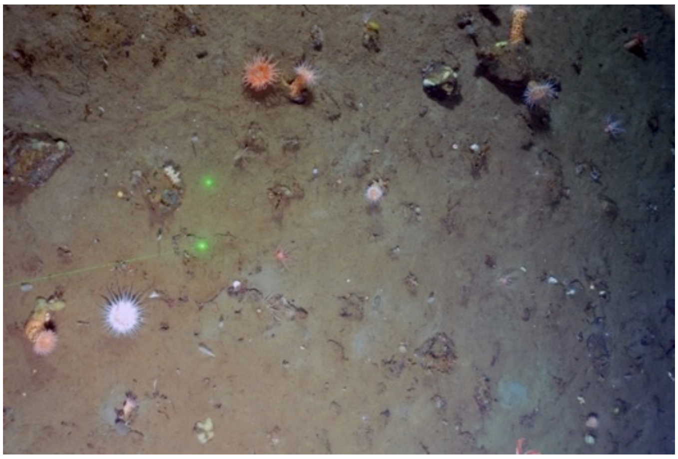


Figure 166 Image HH970-TC26_20170630_103901.
Seafloor appears to be covered by a thin veneer of soft mud. Isolated pebbles are colonized by sessile organisms.

14. Data and Sample Storage and Availability

A Cruise Summary Report was compiled and given to all cruise participants at the end of the cruise. The cruise report was submitted to CAGE Director Jurgen Mienert, and Vice Director Karin Andreassen immediately after the cruise.

Concerning data storage, the data manager of CAGE Fabio Sarti organizes and supervises data storage. In a first phase, data are only available to the project user groups. For the data availability contact Giuliana Panieri and Karin Andreassen.

15. Acknowledgments

We like to thank captain John Almestad, his Officers, and crew of RV Helmer Hanssen for their professional support of our science programme and their assistance in the TCM operations during CAGE17-2.

We like to thank Mr. H. Marshall Swartz -WHOI-PO Dept. and MISO Facility (on shore engineering support), and the Engineer Bjørn-Runar Olsen for his dedication to making things work.
We like to thanks Bjorn-Runar Olsen, Steinar Iversen and Reidar Kaasa were instrumental in helping to mobilize and stage the TCM for operations during cruise over the past 4 months of planning for the TCM deployments on CAGE17-2 AMGG.

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Bibliography

Berndt, C., T. Feseker, T. Treude, S. Krastel, V. Liebetrau, H. Niemann, V.J. Bertics, I. Dumke, K. Dünnbier, B. Ferré, C. Graves, F. Gross, K. Hissmann, V. Hühnerbach, S. Krause, K. Lieser, J. Schauer, and L. Steinle. 2014. Temporal Constraints on Hydrate-Controlled Methane Seepage off Svalbard. *Science* **343**: 284 – 287.

Boyce, R.E. 1973. Appendix I. Physical Properties – Methods. Scripps Institution of Oceanography, La Jolla, California.

Dittmar, T., Koch, B., Hertkorn, N., & Kattner, G., 2008. A simple and efficient method for the solid-phase extraction of dissolved organic matter (SPE-DOM) from seawater. Limnol. Oceanogr. Methods, 6(6), 230–235.

Niemann, H., Steinle, L., Blees, J. H., Krause, S., Bussmann, I., Treude, T., and Lehmann, M. F. 2015. Toxic effects of butyl elastomers on aerobic methane oxidation, Limnology and Oceanography: Methods, 13: 40-52.

Permthaler, A. and J. Permthaler. 2007. Fluorescence in situ hybridization for the identification of environmental microbes. *Methods in Molecular Biology.* **353:** 153 – 164.

Reeburgh, W.S. 2007. Oceanic methane biogeochemistry. *Chemistry Reviews*. **107:** 486 – 513.

Steinle, L., Graves, C. A., Treude, T., Ferre, B., Biastoch, A., Bussmann, I., Berndt, C., Krastel, S., James, R. H., Behrens, E., Boning, C. W., Greinert, J., Sapart, C. -J., Scheinert, M., Sommer, S., Lehmann, M. F., and Niemann, H. 2015. Water column methanotrophy controlled by a rapid oceanographic switch, *Natural Geosciences.* **8**: 378-382.

Legend		Stations	Samples
GC	Gravity core	12	12
PC	Piston core	0	0
MC	Multicorer	27	98
BC	Box core	0	0
GRAB	Van Veen Grab	0	0
CTD	CTD samples	17	168
SCRAPE	Scrape	3	3
PN	Plankton net	0	0
ROV	ROV	0	0
MB	Multibeam	9	65
EK60	Singlebeam	0	0
SBP	CHIRP	2	5
TOW	Tow Camera	26	26
AIR	Air sample	15	15
NK	Niskin bottles	15	47
VID	Sub-marine video	14	57

Cruise CAGE 17-2
21 June 2017 - 3 July 2017
Chief scientist: Giuliana Panieri

Total stations: 82
Total TOWCAM dives: 26

Area	Date	Cruise	Ship	Ship Station	Sampling device	N. of samples	Depth (m)	Lat	Long	UTC	Comment
Transit to Storfjord	22/ juni.	17-2	HH	896	AIR	1	-	76 34.801478	14 59.061465	07:01	
Storfjordrenna pingos	22/ juni.	17-2	HH	897	CTD	0	381	76 06.989039	16 00.21511	09:47	sound velocity profile
Storfjordrenna pingos	22/ juni.	17-2	HH	898	TOW	1	379	76 06.871272	16 00.207224	11:01	Towcam 1. Reference sediments east of GHP1
Storfjordrenna pingos	22/ juni.	17-2	HH	898	MC	6	380	76 6.962	16 1.007	11:33	0 niskin bottles
Storfjordrenna pingos	22/ juni.	17-2	HH	899	AIR	1	376	76 06.901122	16 00.236891	14:55	
Storfjordrenna pingos	22/ juni.	17-2	HH	900	TOW	1	376	76 06.905781	16 00.236627	14:58	Towcam 2. pingo transect first station on top of pingo
Storfjordrenna pingos	22/ juni.	17-2	HH	900	NK	6					
Storfjordrenna pingos	22/ juni.	17-2	HH	900	MC	4	380	76 6.907	16 0.223	15:26	
Storfjordrenna pingos	22/ juni.	17-2	HH	901	AIR	1	378	76 06.913565	16 00.103162	16:36	
Storfjordrenna pingos	22/ juni.	17-2	HH	902	TOW	1	379	7606,923303	16 00.061077	16:42	blew during deployment. Redeployed at 17:23. Second
Storfjordrenna pingos	22/ juni.	17-2	HH	902	NK	3	366				
Storfjordrenna pingos	22/ juni.	17-2	HH	902	MC	4	377	76 6.918	16 0.071	17:40	
Storfjordrenna pingos	22/ juni.	17-2	HH	903	GC	1	370	76 06.417	15 58.098	19:47	catcher sample
Storfjordrenna pingos	22/ juni.	17-2	HH	904	GC	1	375	76 06.415	15 58.102	20:17	no recovery
Storfjordrenna pingos	22/ juni.	17-2	HH	905	GC	1	376	76 06.410	15 58.062	20:50	hydrate.
Storfjordrenna pingos	22/ juni.	17-2	HH	906	CTD	12	385	76 06.570	15 55.079	21:33	(planned 9 stations)
Storfjordrenna pingos	22/ juni.	17-2	HH	907	CTD	12	384	76 06.455	15 57.890	23:19	
Storfjordrenna pingos	23/ juni.	17-2	HH	908	CTD	12	385	76 06.323	16 00.033	00:19	
Storfjordrenna pingos	23/ juni.	17-2	HH	909	CTD	12	383	76 06.416	16 02.222	01:07	
Storfjordrenna pingos	23/ juni.	17-2	HH	910	CTD	12	386	76 06.206	16 05.075	02:01	
Storfjordrenna pingos	23/ juni.	17-2	HH	911	CTD	12	367	76 07.5669	16 00.679	03:20	start of x line of transect
Storfjordrenna pingos	23/ juni.	17-2	HH	912	CTD	12	382	76 06.807	16 00.180	04:04	
Storfjordrenna pingos	23/ juni.	17-2	HH	913	CTD	12	384	76 05.838	15 59.725	04:58	
Storfjordrenna pingos	23/ juni.	17-2	HH	914	CTD	12	382,5	76 05.138	15 59.694	05:40	
Storfjordrenna pingos	23/ juni.	17-2	HH	915	AIR	1	382	76 06.816301	16 00.414077	06:55	

Storfjordrenna pingos	23/ juni.	17-2	HH	916	TOW	1	378	76 06.893553	16 00.144278	07:17	Towcam 4
Storfjordrenna pingos	23/ juni.	17-2	HH	916	NK	6					
Storfjordrenna pingos	23/ juni.	17-2	HH	916	MC	1	377	76 6.915	16 0.126	07:48	Only 1 successful core
Storfjordrenna pingos	23/ juni.	17-2	HH	917	TOW	1	379	76 06.907878	16 00.084126	08:36	transect
Storfjordrenna pingos	23/ juni.	17-2	HH	917	MC	6	377	76 6.924	16 0.074	09:03	
Storfjordrenna pingos	23/ juni.	17-2	HH	918	TOW	1	379	76 06.913	16 0.0534	10:04	Towcam 6. 4th site along transect
Storfjordrenna pingos	23/ juni.	17-2	HH	918	MC	6	389	76 6.932	16 0.040	10:21	
Storfjordrenna pingos	23/ juni.	17-2	HH	919	TOW	1	381	76 06.828778	16 0.246936	11:10	and transect along bottom to 5th
Storfjordrenna pingos	23/ juni.	17-2	HH	919	NK	4					collected multicore
Storfjordrenna pingos	23/ juni.	17-2	HH	919	MC	6	378	76 6.948	16 0.027	12:01	
Storfjordrenna pingos	23/ juni.	17-2	HH	920	TOW	1	386	76 06.643233	16 0.473977	13:34	(top of pingo ->north)
Storfjordrenna pingos	23/ juni.	17-2	HH	920	NK	1	369	76 06.708	16 00.426	13:55	
Storfjordrenna pingos	23/ juni.	17-2	HH	920	MC	3	379	76 6.693	16 0.455	13:55	
Storfjordrenna pingos	23/ juni.	17-2	HH	921	TOW	1	383	76 06.733533	16 00.378038	14:52	transect
Storfjordrenna pingos	23/ juni.	17-2	HH	921	NK	1	370	76 06.719	16 00.399	15:14	
Storfjordrenna pingos	23/ juni.	17-2	HH	921	MC	5	380	76 6.713	16 0.416	15:14	
Storfjordrenna pingos	23/ juni.	17-2	HH	922	TOW	1	390	76 06.512801	16 00.508868	16:17	GHP5
Storfjordrenna pingos	23/ juni.	17-2	HH	922	NK	1	376	76 6.745	16 0.370	17:10	
Storfjordrenna pingos	23/ juni.	17-2	HH	922	MC	5	386	76 6.740	16 0.390	17:10	GHP5
Storfjordrenna pingos	23/ juni.	17-2	HH	923	TOW	1	381	76 06.722241	16 00.393516	18:19	GHP5
Storfjordrenna pingos	23/ juni.	17-2	HH	923	NK	1	366	76 06.741	16 00.461	18:35	
Storfjordrenna pingos	23/ juni.	17-2	HH	923	MC	6	376	76 6.740	16 0.385	18:35	
Storfjordrenna pingos	23/ juni.	17-2	HH	924	TOW	1	380	76 06.835	15 51.176	20:36	Towcam 12 - reference site
Storfjordrenna pingos	23/ juni.	17-2	HH	924	MC	5	384	76 6.821	15 51.220	20:53	0 niskin bottles
Transit to Olga craters	24/ juni.	17-2	HH	925	AIR	1	53	77 46.151051	13 08.029233	06:54	On transit to LYR
Transit to Olga craters	25/ juni.	17-2	HH	926	AIR	1	242	76 20.492	20 17.596	06:56	transit LYR to Olga craters
Olga Craters	26/ juni.	17-2	HH	927	CTD	0	140	76 50.085	35 05.871	03:40	sound velocity profile
Olga Craters	26/ juni.	17-2	HH	928	MB	3	138	76 50.056164	35 05.61643	04:04	Initial survey of area
Olga Craters	26/ juni.	17-2	HH	929	AIR	1	166	76 45.721945	35 20.027703	06:49	
Olga Craters	26/ juni.	17-2	HH	930	CTD	0	177	76 45.791698	35 52.065146	07:47	sound velocity profile
Olga Craters	26/ juni.	17-2	HH	931	SBP	4	177	76 45.710789	35 51.686218	08:07	Also with EM302 multibeam
Olga Craters	26/ juni.	17-2	HH	931	MB	4	177	76 45.710789	35 51.686218	08:07	

Olga Craters	26/ juni.	17-2	HH	932	TOW	1	171	76 47.259436	35 44.909582	14:42	Towcam 13 - reference site
Olga Craters	26/ juni.	17-2	HH	932	VID	3					
Olga Craters	26/ juni.	17-2	HH	932	MC	3	163	76 47.160	35 44.639	15:04	Reference station 1 km north of D1
Olga Craters	26/ juni.	17-2	HH	933	TOW	1	169	76 46.766073	35 43.506275	15:57	Towcam 14. Transect over D1
Olga Craters	26/ juni.	17-2	HH	933	VID	7					
Olga Craters	26/ juni.	17-2	HH	933	NK	2					
Olga Craters	26/ juni.	17-2	HH	933	MC	5	221	76 46.119	35 42.921	17:57	Within D1
Olga Craters	26/ juni.	17-2	HH	934	-						Mistake on stasjonslapper
Olga Craters	26/ juni.	17-2	HH	935	GC	1	191	76 46.842004	35 30.914580	22:24	of core barrel was caked in sticky
Olga Craters	27/ juni.	17-2	HH	936	CTD	12	158	76 46.864091	35 11.348473	00:47	missed by approx 120m
Olga Craters	27/ juni.	17-2	HH	937	MB	2	158	76 48.252598	35 14.825036	01:48	Surveyed central sections
Olga Craters	27/ juni.	17-2	HH	938	AIR	1	159	76 46.843017	35 11.217931	06:58	
Olga Craters	27/ juni.	17-2	HH	939	TOW	1	159	76 46.851542	35 11.208746	07:55	Towcam 15. Observe flares found near Mound 1 (M1) on day before
Olga Craters	27/ juni.	17-2	HH	939	NK	6					flare
Olga Craters	27/ juni.	17-2	HH	939	VID	14					
Olga Craters	27/ juni.	17-2	HH	939	MC	6	156	76 46.865	35 11.194	10:26	Taken near bacterial mat
Olga Craters	27/ juni.	17-2	HH	940	TOW	1	157	76 46.907501	35 13.827051	12:07	of M1
Olga Craters	27/ juni.	17-2	HH	940	NK	1					
Olga Craters	27/ juni.	17-2	HH	940	VID	7					
Olga Craters	27/ juni.	17-2	HH	940	MC	2	157	76 46.888	35 13.941	12:38	Taken near flare. Only 10 cm
Olga Craters	27/ juni.	17-2	HH	941	AIR	1	159	76 46.861860	35 13.90634	12:37	Above flare
Olga Craters	27/ juni.	17-2	HH	942	TOW	1	132	76 47.148164	31 13.828506	13:42	flare
Olga Craters	27/ juni.	17-2	HH	942	VID	7					
Olga Craters	27/ juni.	17-2	HH	942	MC	0	159	76 46.877	35 13.885	15:00	Within c.5 m of bacterial mats. Zero recovery.
Olga Craters	27/ juni.	17-2	HH	943	SCRAPE	1	159	76 47.000451	35 14.482254	16:08	Along mound 1 to recover rock samples
Olga Craters	27/ juni.	17-2	HH	944	CTD	12	159	76 46.849610	35 11.222600	17:01	Repeat of station 936 but nearer to the flare this time
Olga Craters	27/ juni.	17-2	HH	945	MB	9	160	76 48.471173	35 36.660405	19:20	Surveyed over Mareano flares in north, and to the east
Olga Craters	28/ juni.	17-2	HH	946	AIR	1	151	76 51.140439	35 26.085416	06:59	

Olga Craters	28/ juni.	17-2	HH	947	TOW	1	153	76 51.127194	35 25.815118	07:30	Towcam 18. Dive over flare in northern area
Olga Craters	28/ juni.	17-2	HH	947	VID	5					
Olga Craters	28/ juni.	17-2	HH	947	NK	6					
Olga Craters	28/ juni.	17-2	HH	947	MC	0	154	76 51.068	35 25.915	08:36	Zero recovery - went for a quick sample near mats. Sandy bed.
Olga Craters	28/ juni.	17-2	HH	948	TOW	1	153	76 51.105418	35 25.910813	09:24	Towcam 19. Communications issue on dive start
Olga Craters	28/ juni.	17-2	HH	948	VID	0					
Olga Craters	28/ juni.	17-2	HH	948	MC	3	162	76 51.058	35 25.921	10:19	Taken in area of flare activity recorded in MAREANO
Olga Craters	28/ juni.	17-2	HH	949	CTD	12	155	76 51.004727	35 26.094504	12:09	Over flare site in D3
Olga Craters	28/ juni.	17-2	HH	950	TOW	1	154	76 51.080097	35 25.835584	13:07	Towcam 20. Over same flare site area in D3 as station 947
Olga Craters	28/ juni.	17-2	HH	950	NK	1					
Olga Craters	28/ juni.	17-2	HH	950	VID	1					
Olga Craters	28/ juni.	17-2	HH	950	MC	2	150	76 51.086	35 25.786	13:22	Near bacterial mat and carbonate. Max 20 cm sediments
Olga Craters	28/ juni.	17-2	HH	951	TOW	1	153	76 51.109399	35 25.754339	14:26	Towcam 21. Photo traverse over MAREANO flares
Olga Craters	28/ juni.	17-2	HH	951	VID	1					
Olga Craters	28/ juni.	17-2	HH	951	NK	2					
Olga Craters	28/ juni.	17-2	HH	951	MC	3	162	76 51.056	35 25.904	15:53	No more than 25-30 cm sediments
Olga Craters	28/ juni.	17-2	HH	952	GC	1	154	76 51.091651	35 25.771211	17:30	Over flares in D3. 20 cm
Olga Craters	28/ juni.	17-2	HH	953	SCRAPE	1	154	76 51.095699	35 25.764348	18:52	Scrape across flare, small piece of carbonate <5cm
Olga Craters	28/ juni.	17-2	HH	954	SCRAPE	1	154	76 51.465049	35 23.963426	19:47	Scrape across flare, bigger piece of carbonate crust
Olga Craters	28/ juni.	17-2	HH	955	MB	19	151	76 49.548092	35 27.309627	20:37	Surveyed area north and east of Mareano data
Olga Craters	29/ juni.	17-2	HH	956	AIR	1	154	76 50.514682	35 22.093980	07:06	
Olga Craters	29/ juni.	17-2	HH	957	TOW	1	152	76 50.244354	35 26.898966	08:17	Towcam 22. Dive near D4, in group of flares south of yesterday's operations. Still comms issues with towcam
Olga Craters	29/ juni.	17-2	HH	957	NK	6					
Olga Craters	29/ juni.	17-2	HH	957	VID	3					

Olga Craters	29/ juni.	17-2	HH	957	MC	5	153	76 50.198	35 26.626	10:04	Onto bacterial mat. Dark muds collected. Flare observed on multibeam but not captured on video
Olga Craters	29/ juni.	17-2	HH	958	TOW	1	151	76 51.160186	35 26.008427	11:14	Towcam 23. Back onto flares in D3 to sample on georeferenced bacterial mat locations
Olga Craters	29/ juni.	17-2	HH	958	VID	2					
Olga Craters	29/ juni.	17-2	HH	958	MC	0	152	76 51.085	35 25.840	12:09	Into bacterial mats near carbonate crust
Olga Craters	29/ juni.	17-2	HH	959	GC	1	155	76 51.069661	35 25.774906	12:52	At D3 flares
Olga Craters	29/ juni.	17-2	HH	960	GC	1	152	76 50.209208	35 26.376070	13:48	At D4 flares
Olga Craters	29/ juni.	17-2	HH	961	MB	2				15:08	Fillling in gaps over previous flares south of D3 on way to craters in south east
Olga Craters	29/ juni.	17-2	HH	962	TOW	1	176	76 45.561259	35 48.680942	18:35	Towcam 24. Targeting flare at SE side of crater area
Olga Craters	29/ juni.	17-2	HH	962	VID	1					
Olga Craters	29/ juni.	17-2	HH	962	MC	5	170	76 45.548	35 48.424	18:54	Into bacterial mats near carbonate crust
Olga Craters	29/ juni.	17-2	HH	963	MB	11	184	76 44.864681	35 50.638094	19:54	Survey filling and new coverage to southwest of Crater area
Olga Craters	30/ juni.	17-2	HH	964	CTD	12	162	76 46.317047	35 12.155687	05:00	CTD above flare site south of mound 1
Olga Craters	30/ juni.	17-2	HH	965	GC	1	162	76 46.280	35 12.300	05:55	Gravity core on flare, seemed exactly on station. No recovery.
Olga Craters	30/ juni.	17-2	HH	966	AIR	1	163	76 46.288591	35 12.475967	06:18	Sample taken on top of gravity core - stasjonslapper logged too late
Olga Craters	30/ juni.	17-2	HH	967	CTD	12	160	76 46.421338	35 11.603235	06:24	CTD over second flare site south of mound 1
Olga Craters	30/ juni.	17-2	HH	-	SBP	1		76 45.745	35 37.518		Over D1. No station log made in stasjonslapper.
Olga Craters	30/ juni.	17-2	HH	968	AIR	1	195	76 45.890439	35 41.365807	07:16	Transit to Crater 1 from M1
Olga Craters	30/ juni.	17-2	HH	969	TOW	1	174	76 45.878409	35 49.88427	08:05	Towcam 25. East to west into Crater 1. Depth sensor corrected on towcam, removing the -9 m offset on previous dives
Olga Craters	30/ juni.	17-2	HH	969	VID	2					

Olga Craters	30/ juni.	17-2	HH	969	MC	4	202	76 45.920	35 48.974	08:49	Inside eastern-most depression of C1.
Olga Craters	30/ juni.	17-2	HH	970	TOW	1	163	76 45.769	35 48.526	10:08	Towcam 26. On top of pingo adjacent to C1. Stasjonslapper not started on time.
Olga Craters	30/ juni.	17-2	HH	970	VID	4					
Olga Craters	30/ juni.	17-2	HH	970	MC	1	163	76 45.758	35 48.583	11:02	Sample on top of pingo adjacent to C1
Olga Craters	30/ juni.	17-2	HH	971	GC	1	203	76 45.860218	35 43.027849	12:47	Into southern section of D1 depression. 1.8 m recovered
Olga Craters	30/ juni.	17-2	HH	972	GC	1	203	76 45.859243	35 43.032889	13:46	Into southern section of D1 depression. 2.15 m recovered
Olga Craters	30/ juni.	17-2	HH	973	GC	1	162	76 45.763816	35 48.578809	15:05	Into top of pingo adjacent to C1. Zero recovery.
Olga Craters	30/ juni.	17-2	HH	974	GC	1	162	76 45.770422	35 48.63829	15:28	Into top of pingo adjacent to C1. Zero recovery again.
Olga Craters	30/ juni.	17-2	HH	975	MB	13	193	76 46.107407	35 41.279346	15:46	Filling in areas to the south. Preliminary survey over new area.
West Sentralbanken	1/ juli.	17-2	HH	976	AIR	1	198	75 50.209903	35 27.967423	07:05	
West Sentralbanken	1/ juli.	17-2	HH	977	MB	2	199	75 50.216658	35 28.270957	07:05	Resume multibeam station over new area
Transit to Tromsø	2/ juni.	17-2	HH	978	AIR	1	266	72 33.781289	25 51.632702	07:15	
Transit to Tromsø	2/ juni.	17-2	HH	979	MC	2	386	71 26.061854	23 06.636471	15:22	Without towcam - reference site

Seafloor Characteristics

Cruise CAGE 1/_2

21 June - 3 July 2017

Chief scientist: Giuliana Panieri

Area	Cruise	Ship	Station	Tow Cam	Date	UTC start time	Lat	Long	Depth (m)	Observations
Storfjordrenna refererence	CAGE17_2	HH	898	TC01	22/06/17	11:33:57	Lat	Long	380	trawl marks, anemones, trails
Stofrjordernna Pingo 1	CAGE17_2	HH	900	TC02	22/06/17	15:26:31	76 6.962	16 1.007	380	trawl marks, soft mud,siboglinids, sponges, corals, anemones, flares
Stofrjordernna Pingo 1	CAGE17_2	HH	902	TC03	22/06/17	17:40:47	76 6.907	16 0.223	377	trawl marks, strong flares, soft mud, anemonies, siboglinids, clusters of fish holes
Stofrjordernna Pingo 1	CAGE17_2	HH	916	TC04	23/06/17	07:48:50	76 6.918	16 0.071	377	trawl marks, muddy, rare biology, rare IRD
Stofrjordernna Pingo 1	CAGE17_2	HH	917	TC05	23/06/17		76 6.915	16 0.126	377	trawl marks, muddy, anemones, siboglinids, sea spider, and patches of bacterial mats, ice-rafted debris
Stofrjordernna Pingo 1	CAGE17_2	HH	918	TC06	23/06/17	10:21:00	76 6.924	16 0.074	389	trawl marks, muddy, fish but less organisms than previous towcam
Stofrjordernna Pingo 1	CAGE17_2	HH	919	TC07	23/06/17	12:01:40	76 6.932	16 0.040	378	trawl mark, fish, siboglinids, bacterial mats, IRD colonized by anemones, isolated gastropods, and carbonate concretions (?)
Stofrjordernna Pingo 5	CAGE17_2	HH	920	TC08	23/06/17	13:55:48	76 6.948	16 0.027	379	trawl marks, bacteria in patches, siboglinids, anemonies, sea spider, hormathia, fish, numerous IRD
Stofrjordernna Pingo 5	CAGE17_2	HH	921	TC09	23/06/17	15:14:13	76 6.693	16 0.455	380	trawl marks, muddy, fish, numerous IRD, anemonies
Stofrjordernna Pingo 5	CAGE17_2	HH	922	TC10	23/06/17	17:10:16	76 6.713	16 0.416	386	trawl marks, muddy, few IRD, siboglinids, anemonies, fish, seastar, schrimp
Stofrjordernna Pingo 5	CAGE17_2	HH	923	TC11	23/06/17	18:35:46	76 6.740	16 0.390	376	trawl marks, muddy, few IRD and centimetric carbonate crusts, fish and anemones attached to pebbles
Storfjordrenna refererence	CAGE17_2	HH	924	TC12	23/06/17	20:53:13	76 6.740	16 0.385	384	muddy, abundant bivalves (siphon), seastar
Olga basin craters reference	CAGE17_2	HH	932	TC13	26/06/17	14:42	76 6.821	15 51.220	163	

Olga basin craters D1	CAGE17_2	HH	933	TC14	26/06/17	15:57	76 47.160	35 44.639	221	tawl marks, muddy, starfish, anemones, sponge, corals
Olga basin craters Mound 1	CAGE17_2	HH	939	TC15	27/06/17	07:57	76 46.119	35 42.921	156	muddy, sea starts, patches of bacterial mats, insolated rocks densely colonized by epifauna
Olga basin craters Mound 1	CAGE17_2	HH	940	TC16	27/06/17	12:21	76 46.865	35 11.194	157	muddy, sea starts, seaspiders, patches of bacterial mats, insolated rocks densely colonized by epifauna, bubbles rising from bacterial mats
Olga basin craters Mound 1	CAGE17_2	HH	942	TC17	27/06/17	13:15:27	76 46.888	35 13.941	159	Mound top (M1):rocky, peculiar biology, abundant crinoids, and other sessile organisms. Mound base: flares
Olga basin craters D3	CAGE17_2	HH	947	TC18	28/06/17	07:44:57	76 46.877	35 13.885	154	approaching the station, several patches of bacterial mats and crusts often colonized by sessile organisms, sea stars, anemones and soft corals are accessory
Olga basin craters D3	CAGE17_2	HH	948	TC19	28/06/17	09:25	76 51.068	35 25.915	162	approaching the station several patches of bacterial mats and crusts often colonized by sessile organisms, sea stars, anemones and soft corals are accessory
Olga basin craters D3	CAGE17_2	HH	950	TC20	28/06/17	13:14:56	76 51.058	35 25.921	150	approaching the station patches of bacterial mats and crusts often colonized by sessile organisms, sea stars, anemones and soft corals are accessory
Olga basin craters D3	CAGE17_2	HH	951	TC21	28/06/17	15:26:46	76 51.086	35 25.786	162	approaching the station patches of bacterial mats and crusts often colonized by sessile organisms, sea stars, anemones and soft corals are accessory
Olga basin craters D4	CAGE17_2	HH	957	TC22	29/06/17	08:16:03	76 51.056	35 25.904	153	muddy seafloor, seastar, old trawl marks , small bacterial mats
Olga basin craters D3	CAGE17_2	HH	958	TC23	29/06/17	11:14	76 50.198	35 26.626	152	several patches of bacterial mats, crusts
Olga basin craters C1	CAGE17_2	HH	962	TC24	29/06/17	18:35	76 51.085	35 25.840	170	thin veneer of soft mud, rare seastars, isolate whire corals, no rocks (no anemones), flat fish

Olga basin craters C1	CAGE17_2	HH	969	TC25	30/06/17	08:05	76 45.548	35 48.424	202	in C1, thin veneer of soft mud, seastars, soft white corals, rare pebbles colonized by epifauna. Rock at the end the video
Olga basin craters C1	CAGE17_2	HH	970	TC26	30/06/17	08:08	76 45.920	35 48.974	163	at the top of the mound in C1. thin veneer of soft mud, seastars, soft white corals, rare pebbles colonized by epifauna


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