AKMA 3

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1 Participant list

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28	Denis Dausse	La Rochelle Uni	PAMELi Engineer	
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30	Kjetil Andersen	REV Ocean	Outreach	
31	Valentina Lanci	UiT		Media and communication

Participants Institution:

UiT The Arctic University of Norway (https://uit.no)

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IMR Institute of Marine Research, Norway (https://www.hi.no)

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NPD, Norwegian Petroleum Directorate (https://www.npd.no)

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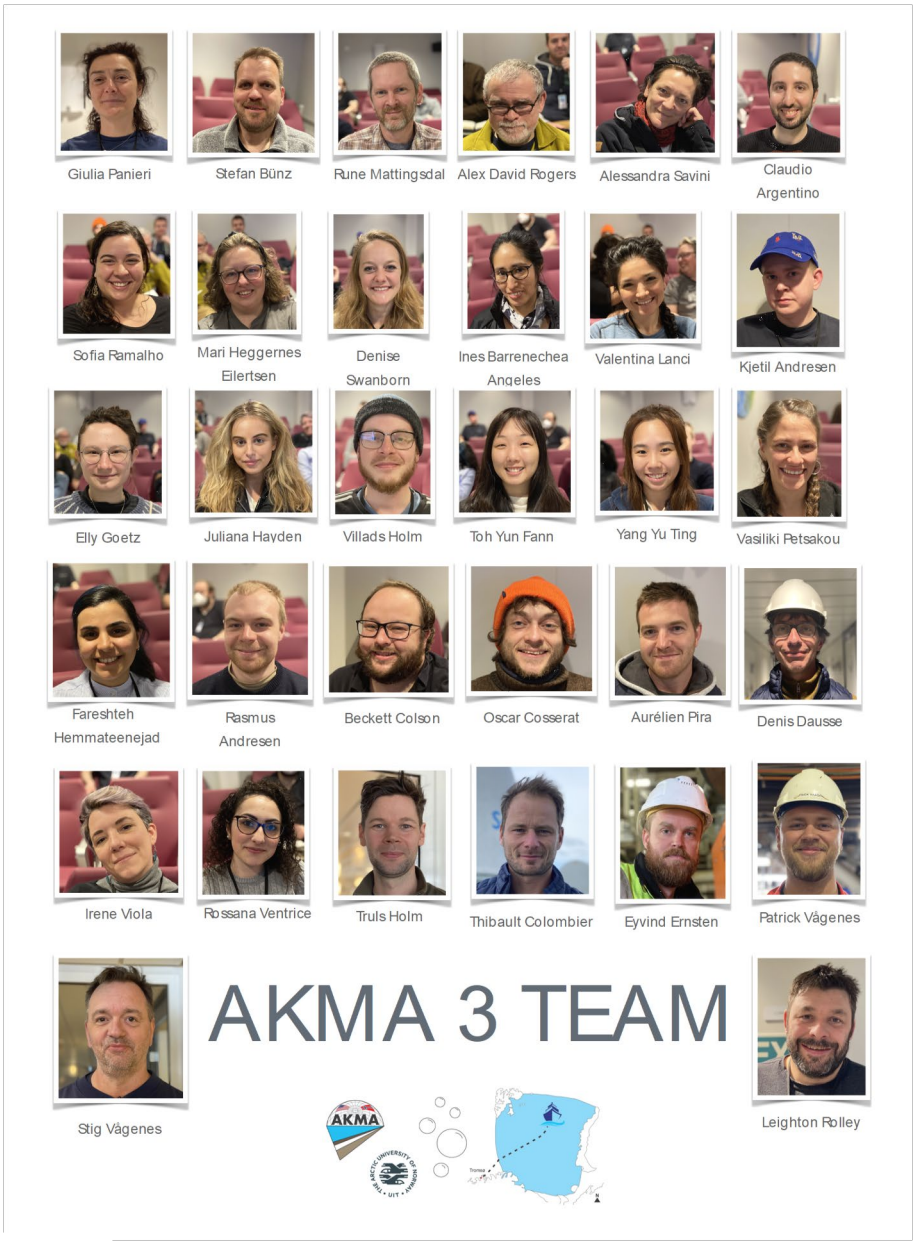
National and Kapodistrian University of Athens, Greece (https://www.uoa.gr)

Nekton, UK (https://nektonmission.org)

Ocean Census, UK (https://oceancensus.org)



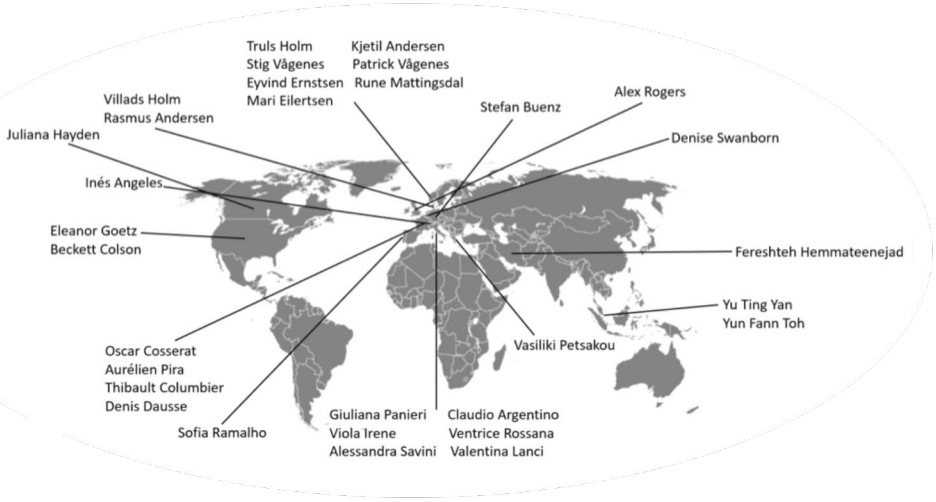


Figure 1. Cruise participants.

2 Introduction and objectives

The AKMA3 oceanographic expedition is part of the Advancing Knowledge of Methane in the Arctic, a project funded by the Norwegian Research Council (287869). The main aim of AKMA is to develop a long-term, multidisciplinary education, and research collaboration focused on Arctic methane sources, processes, ecosystems, and geological history to provide exceptional training for the next generation of experts in Arctic marine sciences and greenhouse gas phenomena.

The AKMA3 oceanographic expedition focuses on three objectives:

SCIENCE: Focus on the interplay between changing ocean conditions and the physical, biological, and chemical response of extreme environments (methane and oil seepage sites) through a multidisciplinary study of sites in the Barents Sea. Research activities: study sediment-sea-air greenhouse gas exchange; conducting water-column profiling of CH4; gas source analyses; biological and sediment sampling.

EDUCATION: This high-level science on this cruise also includes sea-going training for students to develop their knowledge in collecting, curating, and processing samples and data, providing opportunities to fully engage in marine science.

OUTREACH: To generate enthusiasm and interest in research expeditions with students and to promote a deeper understanding of science and its applications.

3 Deviation from the intended cruise schedule

During the cruise, we faced three main issues. The first one was a delay in the shipping of ROV equipment that caused a loss of several hours since during the first night, we needed to leave and return to Tromsø the next day. The second issue was related to a lack of internet connection. The extra bandwidth necessary to perform the education and outreach program has been missing or very poor for the cruise duration. However, we were able to perform several Zoom calls anyway. The last issue was regarding the navigation system and below a detailed report prepared by Leighton Rolley is presented:

Between the start of the cruise and May 5^{th,} there were 19,501 positional jumps in ROV Data (PSIMSSB) The average jump size observed during the cruise was 255m. When the fault with the MRU was initially discovered, Rolley asked the ship if it was just the Binary message or if it was present in the motion data supplied to other systems using motion messages such as PRDID (used by the ADCP). If the errors were not evident in other strings, it would indicate a port problem or hardware, such as an Overland splitter. He was told this was indeed evident in other strings. Based on the information available at the time, it would indicate a hardware issue with the Seapath. The data from the Seapath did not have a constant error, it was a series of spikes in Pitch, Roll, Heading, and Heave data that would randomly manifest. 95% of the messages were good, but the spiking data would produce erroneous positional information in the HIPAP system. The Kongsberg Em302 multibeam would not start pinging due to issues with the spiking. With such large spikes, it became apparent that conducting dive operations and survey-level observations with the ROV would be incredibly difficult, if not impossible. The ROV also uses a DVL (Doppler Velocity Log) to monitor its position. However, this system needs occasional input from the HiPAP system to correct any drift. With the HiPAP system producing erroneous positional data the DVL would reject the USBL solution from the ship. This meant that we were unable to use high-precision positioning and, thus the multibeam system.
To enable dive operations to continue, we had to circumvent the spiking data. To overcome this, Rolley wrote a Python script that analyzed a message sent out on the ship's network from the HIPAP system called GLL. This rather boring message looks like this:

$GNGLL,3150.788156,N,11711.922383,E,062735.00,A,A*76

And these are the fields:

$<TalkerID>GLL,<Lat>,<N/S>,<Long>,<E/W>,<Timestamp>,<Status>,<ModeInd>*<checksum><CR><LF>

This message contains the ROV's geographic position and acoustic depth. Using the script, I extracted the Latitude and Longitude from the message before waiting for the next HIPAP GLL message. When the next message was received, Rolley would check the distance in meters between the current and previous geographic positions. If the position varied by more than 20m he would ignore it. On later dives, he reduced this to 10m. When a large spike occurred, the script would ignore it and make a separate entry in a file logging jumps, that's how we know there were almost twenty thousand jumps! The positional information was then repackaged and sent to the QGIS software in the control room. This was the screen that we were using for dive planning and showed the live position of the ROV. This worked well, tracking was highly accurate after spike filtering, etc. However, before leaving the ship, we learned more information about the failure. The technicians onboard said that the problem had been traced to the Overland and once swapped, this solved the problem. This seems counter to the information we were told earlier in the cruise. The Overland boxes only distribute one type of message, in this case, a proprietary Kongsberg Binary message. If Overland was the source of the problem, only one message type would have been affected and could have been narrowed to the faulty device. The technicians said that they tested the system from the source, i.e., the Seapath, and the spiking error existed there, meaning it would be in all the messages. Separately, not returning to port to fix this was the right decision. Too much time would have been lost, we wouldn't have found Borealis, and the equipment to fix this problem was onboard. So, what did we gain with all this? Here's Dive 2 as shown with the MRU errors (Figure 2). This is what we initially saw in Olex/HiPAP etc.

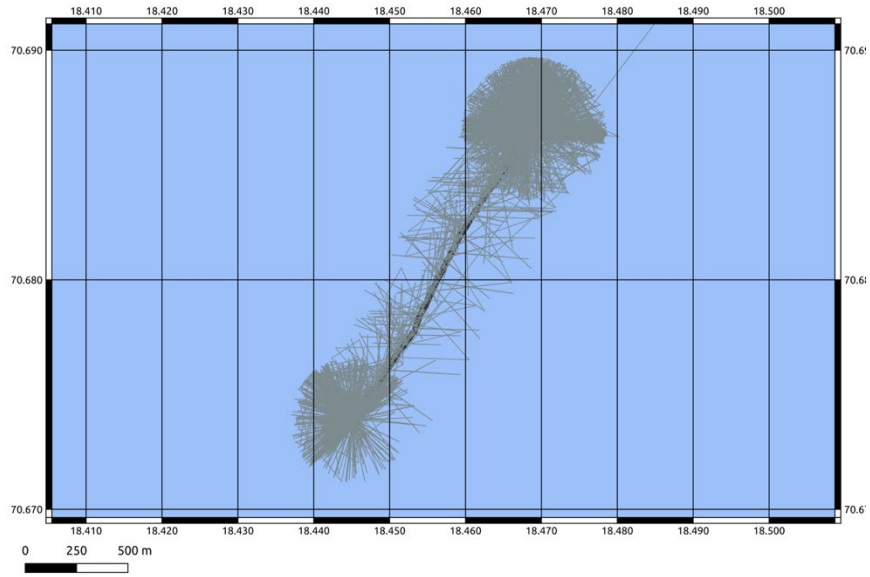


Figure 2. Dive 2 as shown with the MRU errors in Olex/HiPAP.

And after filtering (Figure 3):

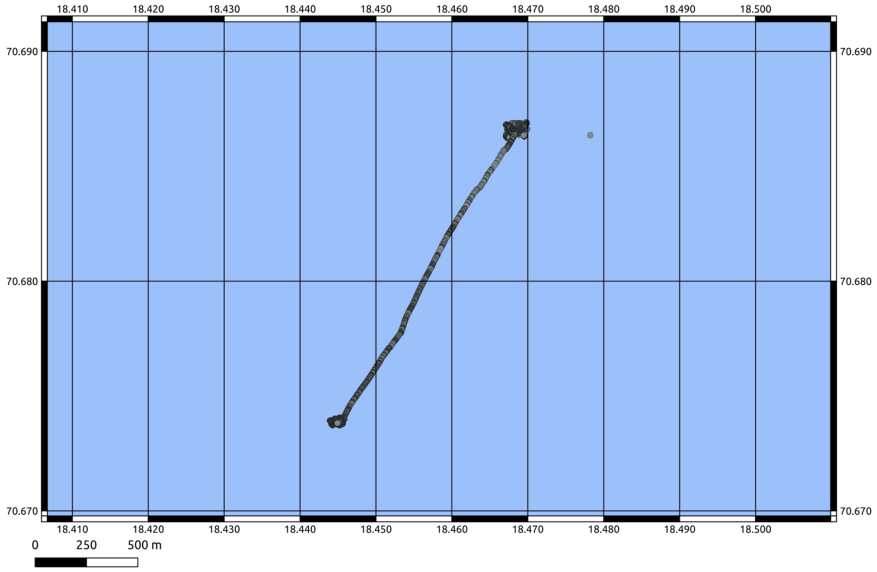


Figure 3. Dive 2 in Olex/HiPAP after correction of the MRU errors.

So, we were able to overcome the spiking for ROV Operations but the erroneous data still limited the operation of the EM302, ROV multibeam etc.

4 Geological setting of the working areas

4.1 Fugløybanken (SS1)

Fugløybanken is located offshore the Tromsø-region, and several oil slicks have previously been observed on satellite images the Mareano program has mapped many flares in the area, both indicating a site of active seepage. Geologically the area is in the Harstad Basin, a deep Cretaceous basin. The area is a shallow (~150 mbsl) fishing bank, likely consisting of rocks and gravel at the seafloor.

4.2 Håkjerringdjupet (SS2)

Håkjerringdjupet is located just north of Fugløybanken and is the site of many mapped gas flares by the Mareano program. In addition, CAGE22-6 documented a large gas flare associated with the site of a recent exploration well from 2020 (7018/5-1). The area is a trough with depths of more than 360 mbsl, with many pockmarks observed on the bathymetry. Geologically the area is located in the Troms-Finnmark Fault Complex between the Harstad Basin and the Finnmark Platform.

4.3 Vestbakken slope (SS3)

The site of interest is located in the Vestbakken Volcanic Province, southwest of Bjørnøya, directly above a buried young, pre-Quaternary volcano. Many amplitude anomalies are observed on 2D-seismic data indicating active fluid flow in the sub-surface, and UiT mapped a large gas flare from the site using MBES water column data during a cruise transit in 2022. The site is located on the continental slope at approximately 1200 mbsl.

4.4 Vestbakken shelf (SS4 and SS6)

These sites are also located in the Vestbakken Volcanic Province, on shelf areas of 360-380 m water depth. On 2D-seismic data many amplitude anomalies indicating shallow gas are observed on seaward dipping reflectors just under or at the URU (Upper Regional Unconformity) surface.

4.5 Kveithola flank (SS5)

The Kveithola flank area is located on the bank area just south of Kveithola, at water depths of around 130-150 mbsl. In this area, many gas flares are documented by the Mareano program. Geologically the area is located north of the Vestbakken Volcanic Province in the fault zone area stretching all the way up to and along the West Svalbard margin. This fault zone is a known area for active seepage (Mau et al., 2017).

4.6 Outer Bjørnøyrenna (SS7)

In the Outer Bjørnøyrenna, located in the Sørvestsnaget Basin, many seismic anomalies are observed on 3D-seismic data at URU-level and/or in the overlying Quaternary till/moraine layers. In several places, the seismic anomalies are present up to or just below the seafloor reflection, a very good indication of fluid flow in the sub-surface and active seepage at the seafloor. One of these locations (SS7) was confirmed as a seep site with MBES water column data acquired by UiT in 2022 during a cruise transit.

4.7 Snøhvit gas field (SS8)

The Snøhvit gas field consists of several gas discoveries, one of these being the Askeladd discovery, located in the Hammerfest Basin. In 2022, CAGE22-6 documented many gas flares above this field during a cruise transit, indicating active natural seepage directly above the gas field. In addition, a large gas flare was documented associated with the old discovery well from 1981 (7120/8-1).

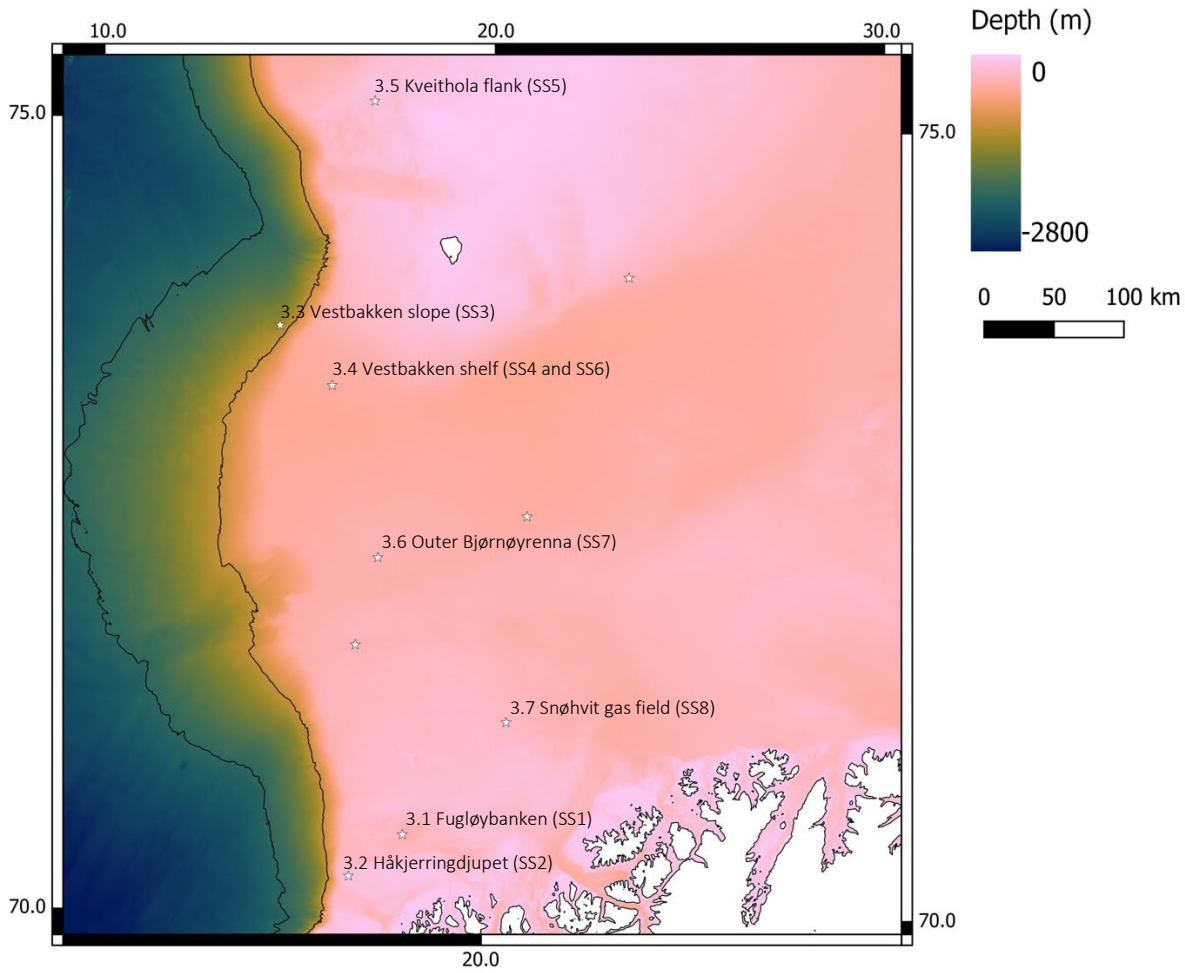


Figure 4. Study sites during the AKMA3.

5 Scientific Narrative of the Expedition

Note: Given times in the narrative are local time while the log sheets are in UTC.

Saturday 29th April DAY 1

At 9:00 the scientific team arrived onboard and at 10:00 we had the police passport and VISA control. We could have left immediately after, but the ROV team missed some equipment that will be delivered at 11:00. However, some issues at the Bergen airport prevented the equipment from arriving we decided to leave Tromsø at 16:00.

At 19:00, we had the Daily meeting with updates on the cruise and geological explanation on the next day's study site.

At 21:00 We arrived in the Harstad basin (130 m water depth) and did a sound water profile. At

21:30 we started a water column survey looking for flares that lasted until 7:00 AM on the April 30th. During the survey, several flares were observed, and two locations were selected for the next day's ROV dive. The first location is characterized by numerous and intense gas flares (on LINE11); the second location (on LINE05) is characterized by flares of gas and oil (the former identified from earlier

observations of satellite images). In both locations the flares reach ca 40 m water depth). In the area, high tide is at 10:00 and low tide at 16:00.

Sunday 30th April DAY 2

At 7:00 AM we are at the station in Fugløybanken (70.41 19N, 17.88 46E, ca 320 m water depth). We waited some time while the ROV team was preparing the push cores and the blade corer and the WHOI colleague tested the connection with SAGE.

At 9:54 ROV01 started in the first location identified last night. The first part of the dive was dedicated to surveying the area, characterised by a seafloor that shows area very gravelly, with decimetric blocks of ice rafted debris, areas with ripples and carbonate pavement. There is a very thin layer of sediment (< 10 cm) covering the carbonate crusts. The carbonate pavement hosts different species of fish in cavities along the rims. The intense flaring observed during the night water column survey was confirmed by the ROV videos. Trains on bubbles rise from the seafloor and fractures on the carbonate crusts. Some of the flares are colonized by filamentous white bacterial mats (8.21 UTC). We observed a few patches of ca 12 cm in diameter and one elongated (ca 60 cm). We measured methane using SAGE (there is a delay of 3 minutes between the beginning of the measurement and when SAGE measured methane). We measured up to 2800 ppm methane concentration at 2 cm above the seafloor with bacterial mats. At a certain point, SAGE got some sediment grains inside the spinner and we stopped the measurements. Several attempts to collect push cores failed. We collected two pieces of carbonate crusts (CarC01 and CarC02).

At 11:30 the Nekton team started macrofauna collection.

At 13:30 ROV01 ended, and we moved to the second location identified during the previous night while the team was sorting the biological material. Unfortunately, the wind picked up (till 24m/sec) and the captain did not allow any more dives. We decided to stem back to Tromsø to collect the equipment shipped from Bergen for the ROV.

At 19:00 we had the Daily meeting with updates on the cruise and geological explanation on the next day's study site. Alex Roger presented the Chagos expedition.

At 21:30 we docked in Tromsø, Pier 23.

Collected samples: 11 Bio samples, 3 Rock samples and 2 Carbonate samples.

Monday 1st May DAY 3

AT 7:00 we were at station Håkjerringdjupet (70.67 39N, 18.44 51E, ca 300 m water depth), and after a short survey to confirm the position of flares observed in the past, we were ready for ROV02. The water column survey confirmed flaring gases in three locations.

At 9:30 we started descending but we noticed that the ship's navigation system had a Problem (described in point 3).

While we were at the bottom, the ROV Engineer and the IT staff tried to solve the problem.

The ROV02 dive focused on two locations: the first in the middle was chosen where the multibeam survey evidenced a not very strong flare. After spending 2 hours we did not see any bubbles of bacterial mats. We however measured methane, between 4 and 6 ppm in the general area, that reached up to 8 ppm. These measurements confirm that the area does not seem to be very active. We kept having problems with the positioning system of the vessel. We decided to keep the ROV in the water and move southwest towards the exploration well that was reached at 15:00. We measured with SAGE methane concentration of ca 8000 ppm. The well is a regular depression surrounded by a conic edifice with exhibits whitish layers most likely consolidated bentonite or concrete from the drilling. Methane bubbles are rising from two fractures in the concrete. We video-surveyed the area but we did not see evident signs of bacteria mats. There were possibly bacterial mats inside the conic edifice. We collected 1 rock sample and 2 blade cores, 3 push cores, and 1 push core-s. We tried to collect methane with the gas sampler, but the gas sampler was leaking from the structure.

ROV03 focused on the northernmost location of the three evidenced by the water column survey and appears to be the strongest. We did not observe any methane bubbles rising from the seafloor. We collected 3 push cores (1 small), 1 blade core, and 2 rock samples. The sample was taken from an area that did not show any evidence of methane activity and can be considered background.

In the evening, we started steaming towards Outer Bjørnøyrenna. The weather started to become bad and slowed the speed of the vessel (6 kts).

At 19:00 we had the Daily meeting with updates on the cruise and geological explanation on the next day's study site.

Collected samples: 2 Blade corer, 3 Push core, and 1 Push core-metal from sediments around the exploration well; 1 Blade corer, 2 Push core and 1 Push core-small from sediments; 8 Bio samples and 3 Rock samples.

Tuesday 2nd May DAY 4

During the night the weather became very bad. The wind speed ranged between 20 and 30 kt. We reached Outer Bjørnøyrenna at 14:30 and we were supposed to arrive in the morning. Because of the condition, it was impossible to dive and do any other operations. We decided to steam north towards the next station, Vestbakken.
We cancel the daily meeting because most of the scientist team on board is seasick.

Wednesday 3rd May DAY 5

AT 2:00 this morning we arrived at the Superstation 3 Vestbakken slope (78.78 36N, 15.08 46E, ca 1120 m water depth). The weather is still rough, and we performed a water column survey to confirm the position of flares observed in the past. At 8:00 we get prepared for an ROV dive. At 9:00 we started the ROV04. The vessel has still a problem with the IMU (navigation system) and this does not prevent the ROV have positioning.

During the dive, we collected: 1 Push core, 1 Push core-s, and 1 Blade corer from bacterial mats; 1 Push core, 1 Push core-s, and 1 Blade corer from the tube worm area; 1 Push core outside the tube worm area. One Push core taken from the tube worm was lost, but it can be still used for macrofauna analyses sieving.

At 11:30 the Nekton team started macrofauna collection.

The ROV05 took place in an area where there is a mound rising from the seafloor (ca 4 m in diameter) covered with bacterial mats and tube worms. At the top of the mound, there is a carbonate crust. We made several attempts in trying to collect samples using the big push cores, but the mound seemed to be filled with carbonate. We were successful only with the small push cores and with the blade corer. In this dive, we collected 2 blade cores, 7 push cores, and one scoop.

During the evening, we, for the first time, tested UiT's seismic airgun system on RV Kronprins Håkon. The objectives were to (a) test all high-pressure connections between KPH's compressor and the seismic sources, (b) verify sufficient supply of high-pressured air, and (c) how often the seismic sources can be cycled. Two small mini-GI seismic sources (total volume 60 cu. in) were deployed using the large A-Frame. To verify the performance, we used a short analogue hydrophone cable with 1 channel and a 6 m long active section. Initially, two manifolds leaked air but were fixed after a short time. The compressor and mini-Gi sources worked well for a short test of approximately 30 min. A short seismic line was successfully acquired, and data quality will be assessed during processing.

After the seismic test, we performed a multicore from a background area that did not show any evidence of methane flares located at least 1 km away from the active area. The first attempt failed but the second one was successful. All the groups on board were able to obtain samples.

Collected samples: 1 Push core, 2 Push core-small, 2 Blade corer from bacterial mats; 1 Push core, 1 Push core-small, 1 Blade corer from tube worm area; 1 Push core-small inside the crater; 3 Push core and 2 Push core-metal from sediments; 1 Scoop from tube worm and bacterial mat area; 15 Bio samples and 1 Carbonate samples.

Thursday 4th May DAY 6

During the night we moved to Superstation 4 Vestbakken shelf west (73.82 33N, 16.41 31E, ca 373 m water depth). The water column survey performed during the night showed a vast area with intense flaring. From the survey, we selected several locations that helped to guide the following dives. ROV06 landed on an area with muddy seafloor with several bacterial mats (ca 50-100 cm diameter) closely spaced and tube worms. Dropsotnes and possibly carbonate crusts appear randomly. Bubbles were also detected on the video. We collected one sample of methane, and the gas sample is still leaking. This dive collected 6 push cores, 1 rock samples and several samples for seafloor biology.

We performed a PAMELi survey with SAGE at 10:00. The survey lasted for 4 hours and 35 minutes.

The ROV 07 was dedicated to sediment sampling (3 blades, 4 push cores and, 4 carbonate crusts). We observed extensive areas with tubeworms covered by flameout white bacteria.

ROV08 was done with SAGE. We performed SAGE measurements at several water depths, collected gas with the gas sampler and collected biological samples at the end of the dive.

At 22:00 the attempt to collect samples from a reference site but the multicore failed, most likely because of abundant pebbles on the seafloor.

During the night, we steamed to the Kveithola flank where a water column survey showed multiple flares. The flares were plotted on ArcGIS to select the proper location for the ROV dive.

Collected samples: 1 Push core, 2 Push core-small, 2 Push core-metal, and 2 Blade corer from bacterial mats; 1 Blade corer and 2 Push core-metal from tube worm area; 7 Bio samples, 1 Rock samples, and 1 Carbonate samples.

Friday 5th May DAY 7

At 8:00 we were in **Superstation 5 Kveithola flank** (74.71 47N, 17.06 44E, ca 140 m water depth). At 8.30 we started **ROV09** mostly for exploring the area looking for methane bubbles or indications of methane release as bacterial mats. The seafloor is covered by abundant pebbles and sometimes boulders that can be isolated or aggregated. Abundant epifauna (Ascidiacea, Actinaria, Zoantharia, etc.) are attached to pebbles and boulders. The bacterial mats are from 3 to 15 cm in diameter and often methane is emitted in single trains of bubbles from orifices in the bacterial mats and outside. We collected 2 samples of methane with the gas sampler. We made several attempts to collect push cores, but the seafloor was too gravelly and failed several times. As a result, we were not able to collect any sediment samples from this area. However, several samples were collected from the Nekton team.

While the ROV was at the seafloor, we did a survey with SAGE on PAMELi. The survey lasted for 3 hours. PAMELi came onboard at 16:30, and Aurora was equipped with SAGE after removing from PAMELi.

The **ROV10** was dedicated to performing measurements with SAGE along the water column. The last part of the Dive was dedicated to testing the cameras and different orientations of the lights to evaluate which is the best setting for recording high-quality images with a 4K camera at the seafloor.

During the night we steamed south towards the Vestbakken area. After a water column survey, we attempted a multicore in a reference location at 2.5 km away from the seeping flares in the Superstation 4 Vestbakken shelf west, but the wind was too strong and would have prevented the recovery. We then moved to the new **Superstation 6 Eastern Vestbakken shelf.**

At 19:00 we had the Daily meeting with updates on the cruise and geological explanation on the next day's study site.

Collected samples: 5 Bio samples and 4 Carbonate samples.

Saturday 6th May DAY 8

At 8:00 we were at **Superstation 6 Eastern Vestbakken shelf** (73.80 06N, 16.82 08E, ca 364 m water depth) where we started the **ROV11** down to ca 370 m water depth. The dive was mostly dedicated to detecting methane bubbles that were observed as flares in the water column data during the night. We therefore equipped the ROV with SAGE and we deployed the gas sampler that was left at the seafloor during all dives to fill the bottles with enough methane for measurement. With SAGE we performed several measurements with SAGE, around bacterial mats, on top of carbonates, and close to bubble streams. The higher number recorded by SAGE was 20,000 ppm on top of a patch of bacterial mats. The area is characterized by a very strong current, and it was hard to keep the ROV in position. We performed several flights surrounding a limited area at the seafloor with bacterial mats, tube worms, and carbonate crusts. Several biological samples were collected. We found a depth charge of a war remnant, densely colonized by encrusting organisms.

The next dive **ROV12** was dedicated to tacking samples for the groups on board.

Collected samples: 1 Push core-small, 1 Push core-metal from bacterial mats; 1 Push core-small, 2 Blade corer and 1 Scoop from tube worm area; 1 Push core from sediments; 7 Bio samples and 6 Rock samples.

Sunday 7th May DAY 9

During the night, we arrived at Superstition 06 Outer Bjørnøyrenna (72.43 82N, 17.67 74E, ca 390 m water depth). The target ROV13 landed in an area inside a crater of 300 x 195 meters. The crater hosts a rich community of seabed life, thriving on the steep flanks of carbonate crusts formed several thousands of years ago. This unique habitat includes sea anemones, sponges, carnivorous sponges, sea stars, corals, and crustaceans. Within the crater, there are also areas of extensive mats of bacteria which show a honeycomb arranging and tube worms. The sediments inside the crater are very coarse with the whitish rounded particles that a flowing observation revealed composed of carbonate. During this dive, there was a broken liner that prevented us from collecting long push cores. Several fish species seem to find a refuge within the crater.

The next dive rov14 started at 2:30 while descending we observed sediments at a 7m altitude. At the seafloor, in the northern depression within the crater, we observed shimmering water where the sediments were covered by extensive bacterial mats and tube worms. In this area, SAGE measured up to ca. 27000ppm. While we were exploring the crater at 4:16 we saw the Borealis mud volcano. Around 16:30 the ROV had a problem with falling pressure in the hydraulic system indicating that there was leakage. The dive had to be aborted immediately. When the ROV was safely back in the hangar, the ROV technicians discovered a hole in one of the main hoses of the hydraulic system. We were not able to dive again. During the evening the ROV team replaced the hose and confirmed that the leakage disappeared.

At 19:00 while the ROV was being repaired, we decided to acquire a short (4 nm) seismic line across the crater that hosted the mud volcano, and the seismic air gun worked well.

At 22:30 we started a survey with PAMELi equipped with SAGE. At the sea surface on top of the Borealis.

In the evening, we planned three stations for multicore and gravity coring around the periphery of the crater to obtain samples of background sediments. The first multicorer deployment started at 23:00 followed immediately after by the gravity core sampling. They were both successful. The other two multicores were taken during the night, but the crew did not allow gravity coring.

Collected samples: 2 Push core-small, 2 Blade corer from bacterial mats; 1 Push core, 2 Push core-metal from sediments close to bacterial mats; 7 Bio samples and 1 Carbonate sample.

Monday 8th May DAY 10

At 8:00 we were at Superstation 06 Outer Bjørnøyrenna. The ROV15 mounted the temperate probe and SAGE. We landed on a depression north of the crater. All around the periphery, there are carbonate pinnacles and slabs of metric dimension. The carbonates seem like reefs; underneath there are bacteria mats on sediment, and several fish. Sometimes we observed methane bubbles. The inner part of the depression is characterized by several holes of ca 50-100 cm in diameter. During the morning, we explored another small depression west of the previous one. It has similar characteristics. Towards the

end of the dive, we collected two carbonate crusts, one lying on the sediment close to where we collected bivalve shells at the seafloor with the little scoop and another rock piece from the northern depression where the carbonate looks “old”:

At the end of the dive, we collected a gas sample.

At 14:15 we started ROV16. We collected two cores in the vicinity of Borealis and a Niskin bottle at the top of it. During the dive, the sampling operations were complicated by the presence of many fish and by the remobilization of sediment. At one point, the ROV cable was entangled in carbonate. We were able to measure the temperature of fluids emitted by Borealis using the temperature probe that was recorded for at least 30 minutes; During which we moved closer and closer to the emotion point of the fluid.

Collected samples: 3 Blade corer from bacterial mats; 1 Push core-small from the crater; 6 Scoop-small from tube worm and bacterial mats. 1 Bio sample and 4 Carbonate samples.

Tuesday 9th May Day 11

In the morning, we were at Superstation 07 Snøhvit (71.40 96N, 20.43 33E, ca 267 m water depth). At 8:00 we started ROV17 exploring an area that shows intense flares. The flares seem to come from natural seeps and appear as intense methane bubbling. We observed a depression that could be the hole of the exploration well. The seafloor sediments are generally muddy-gravelly with occasionally pebbles. Overall, the seafloor looks barren of fauna, excluding patches of bacterial mats and dense tube worm mats, and isolated sponges. At 9:00 we deployed PAMELi equipped with SAGE to perform a survey in the entire area, which lasted until 14:00. In the afternoon, we did ROV18 in a location further south. Here we observed abundant carbonate crusts, methane flaring, and sparse bacterial mats. At 16:00, we ended the dive and started to steam back to Tromsø.

The ROV19 was dedicated to gas and carbonate sampling. The carbonates appear isolated

(From 20-50 cm in diameter) pieces that have been displaced most likely by trawling or anthropogenic operations (for example drilling operations or installations), but sometimes we observed carbonate crust pavement consisting of pieces that can be up to several meters in diameter. The carbonate is always colonized by anemones and epiphytic organisms. We observed abandoned fish mainly Sebastes.

Collected samples: 2 Push cores, 1 Push core-metal, and 3 Blade corer from bacterial mats; 1 Push core from tube worm; 3 Bio samples and 2 Carbonate samples.

Wednesday 10th May DAY 12

At 07:00 we arrived in Tromsø at Pier 25. This was the end of the AKMA3 cruise.

6 Scientific Equipment

6.1 Hydroacoustic systems

The hydroacoustic systems onboard RV *Kronprins Haakon* can be operated simultaneously, where dedicated software intelligently manages transducer pings to avoid interferences.

Among the hydroacoustic systems, the following were used extensively during the AKMA3 cruise:

1. Simrad Kongsberg EA 600 – 12kHz single beam echosounder
2. Kongsberg EM710 and EM 302 multibeam echosounder and SBP 300 Sub-Bottom Profiler

6.1.1 Kongsberg EA 600 –12kHz single beam ekkolodd

The EA 600 single-beam echosounder operates up to four high-power transceivers simultaneously. Available frequencies span from 12 to 710 kHz. A variety of highly efficient transducers is available to suit all your operational needs from extreme shallow water to a depth of 11.000 meters. The major application of this echosounder is to identify the depth and find high-reflective objects in the water column. During this cruise, we operated the echosounder at 12 kHz as this frequency provided the best bottom detection.

6.1.2 EM 710

The EM710 multibeam echosounder is a high to very high-resolution seabed mapping system which operates at sonar frequencies in the 70-100 kHz range. The system is mounted on the port drop keel of *Kronprins Haakon* and is particularly suited for swath bathymetry surveys up to 800 m water depth. The system sends out 400 beams at an angle of up to 70° on each side. There are options to adjust the beam spacing, either equiangular or equidistant. There is an additional high-density mode to achieve higher sounding density by reducing the acoustic footprint. During the AKMA3 cruise, the system was run on high-density equidistant mode. In addition, EM710 also allows the recording of water column backscatter data. This is particularly useful in identifying gas bubbles in the water column. The EM710 was the primary multibeam system operated during the expedition. New CTD data were acquired when necessary to update the water velocity used by the EM710 system.

6.1.3 EM 302 and SBP 300

The EM 302 multibeam echo sounder has an operating frequency of 30 kHz and is designed to perform seabed mapping with high resolution and accuracy to a maximum depth of more than 7000 m. Beam focusing is applied both during reception and transmission. EM 302 is equipped with a function to reduce the transmission power to avoid disturbing mammals if they are close by.

The system has up to 432 soundings per swath with pointing angles automatically adjusted according to achievable coverage or operator-defined limits. With dual swath (two swaths per ping) the transmit fan is duplicated and transmitted with a small difference in a long-track tilt. The applied tilt considers depth, coverage and vessel speed to give a constant sounding separation along the track. In dual swath mode, 2 swaths are generated per ping cycle, with up to 864 soundings. The beam spacing is equidistant or equiangular.

The transmit fan is split into several individual sectors with independent active steering. This allows stabilization, which compensates for the vessel movements: yaw, pitch and roll. Each transmit sector has individual beam focusing.

In conjunction with a separate low frequency transmit transducer, the EM 302 may optionally be able to deliver sub-bottom profiling capabilities with a very narrow beam width. This system is known as the SBP 300 sub-bottom profiler. During this cruise, the SBP was operated constantly with a chirp pulse of 50 ms and a frequency bandwidth of 2.5 – 6.5 kHz.

The EM 302 (including the SBP 300) is mounted in the ice window in the bottom hull of the vessel. During ice breaking, ice sliding beneath and along the ice window significantly affects the acquisition leading to high noise levels and false measurements.

During the cruise, the multibeam bathymetry data was processed and cleaned using QPS Qimera Software. Initial grid surfaces with a resolution of between 2 to 7.5 m were produced for the individual superstations. Some data merit further processing to improve map quality.

6.2 Oceanographic systems

Physical and chemical measurements are measured in the water column from a CTD/rosette. The CTD model is a Seabird 911 plus mounted on a 12 or 24 10-litres Niskin bottles carousel and was brought close to the seafloor. The CTD is coupled with different types of equipment such as oxygen sensors, transmissiometer, and fluorimeters.

6.3 Attributed Sensors

6.3.1 5.3.1 GPS/Navigation, Motion Reference Unit

integrated global navigation satellite system (GNSS), using the GPS, GLONASS, Galileo, or Beidou signals and inertial measurements to provide high-quality results for applications including hydrographic surveying, dredging, oceanographic research, seismic work, etc. This Seapath system includes a 5th generation MRU motion sensor package, providing up to 0.008° RMS roll and pitch accuracy. This accuracy is achieved by the use of accurate linear accelerometers and unique MEMS-type angular rate gyros. The processing unit of the MRU had some problems with providing accurate information on pitch and roll significantly affecting USBL positioning and EM302 multibeam acquisition.

6.3.2 USBL HiPaP

Positioning and Navigation System. ROV NUI, OFOBS, CTD and partly also coring equipment were outfitted with a HiPaP beacon for exact positioning information on the seafloor. The HiPAP 501 system operates with the transducer mounted on the hull to allow the transducer to be lowered some meters below the hull of the vessel. A transceiver unit containing a transmitter, preamplifiers, and beam-forming electronics is mounted close to the hull unit. The HiPAP 501 system has a spherical transducer with several hundred elements covering the whole sphere under the vessel. The system will dynamically control the beam so it is always pointing toward the transponder. The transponder may be moving, and roll, pitch, and yaw affect the vessel itself. Data from roll/pitch sensors are used to roll and pitch compensates for the position.

The Super Short Base Line (SSBL) principle has the obvious advantage that it only requires the installation of one hull-mounted transducer and one subsea transponder to establish a three-

dimensional position of the transponder. An SSBL system measures the horizontal and vertical angles together with the range of the transponder. An error in the angle measurement causes the position error to be a function of the range of the transponder. To obtain better position accuracy in deep water with an SSBL system it is necessary to increase the angle measurement accuracy. The frequency band of the HiPaP 501 is 21 - 31 kHz and the operating range is 1 - 5000 m. The range detection accuracy is given as 0.02 m assuming free sight between the transducer and transponder, no or very little noise in the water column, and no error from the heading/roll/pitch sensor. We recognized interference between HiPaP and multibeam EM 302 systems due to the usage of similar frequency bands. For most operations at the seafloor, the EM 302 acquisition was stopped, leading to a more stable positioning of the USBL transponder.

6.4 Sediment sampling and measurements

6.4.1 Gravity corer

The gravity corer is one of the most useful tools for the collection of marine sediment (Figure 5). The gravity corer consists of a 6m long iron barrel with iron weights attached on top of it. The whole apparatus weighs ~ 2 tons. A plastic liner with an outer diameter of 11 cm and an inner diameter of 10 cm is inserted into the steel barrel. Before the coring operation, a core catcher and core cutter are attached to the lower end of the gravity corer. The core catcher keeps the sediments from falling out of the core, whereas the core cutter helps the penetration of the core into the sediments.

The gravity corer lies on deck and during operation is lifted vertically with a winch and the gravity corer is lowered to around 20 m away from the seabed. When at the chosen core location, the gravity corer is dropped. 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 into 1-meter sections, and labelled. Cores are then sectioned and immediately sampled for pore water and gas onboard, whereas the geochemical, microbiological, and micropaleontological investigations will be conducted onshore.

6.4.1 Multicorer

The multicorer has been converted into a TowCam/Multicorer, TCM (Figure 6). The frame has been used to place a video camera. 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 multicorer lands on the seafloor, the tubes are pushed into the soft sediment by lead weights and closed on both ends. Up to 70 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 liners were carefully taken out of the sampling device, the ends were sealed, and the cores moved, into an upright position, in the wet laboratory. Once in the lab, in the racket to keep them vertical, the sampling of pore water, microbiology, micropaleontology, and macropaleontology starts. Three extruders were used from the different groups that were sampled contemporaneously. In the present cruise, we were able to use real-time imaging capability to precisely guide the sampling locations of the multicorer (MC) samples.

Left: Figure 5. Gravity corer deploying from RV Kronprins Haakon (picture taken during the CAGE22-2 cruise). Right: Figure 6. Multicorer deployment from RV Kronprins Haakon.

6.5 REV Ocean ROV "Aurora Borealis"

6.5.1 Overall description

The ROV *Aurora* is a SUPPORTER 32-type ROV from Kystdesign in Aksdal, Norway (Figure 7). The system is owned and operated by REV Ocean. *Aurora* is configured to operate as part of a two-bodied system that comprises a separate Tether Management System (TMS) called *Borealis*. Together the ROV and TMS form "*Aurora Borealis*". The TMS contains an additional 1000 m of neutrally buoyant tether. This two-bodied configuration permits rapid descent (0.8-1m/s).

Aurora has a total combined power of 115 kW, a depth rating of 6000 m and is manoeuvred by 7 Sub-Atlantic thrusters. Its dimensions are (LxBxH) 2,75 m x 1,70 m x 1,65 m and it weighs 3600 kg in air. *Aurora* is fitted with both a Schilling TITAN 4 and an Atlas manipulator for sampling and tooling operations.

For videography during AKMA3, the vehicle was fitted with 2 forward-facing Orca HD (IP) cameras and a separate SubC Rayfin 4k camera/strobe. These cameras were mounted on pan and tilt assemblies. Additional cameras for operator situational awareness, piloting and sampling operations are also fitted to the vehicle. The forward-facing lighting capacity of the vehicle includes sixteen LED lights with a total output of 120,000 lumens.

The SUPPORTER 32 can accommodate up to 24 additional hydraulic tooling functions, up to 21 additional survey sensors and 8 camera connectors. During AKMA3, besides standard the standard sensor package, connections were used by the SAGE methane sensor and 4K kamera.

The ROV control system offers a variety of auto-functions such as AutoPOS and AutoTRACK capabilities. Due to the complexity of AKMA3, *Aurora* was always flown manually by the pilot.

Figure 7. ROV Aurora is being recovered through the RV Kronprins Haakon moon pool.

Aurora is fitted with multiple, interchangeable "skids". During AKMA3 the ROV was fitted with the standard science skid. *Aurora* is equipped with a large drawer to store sample material during dives. The drawer is divided into two boxes that are mounted on the drawer for storing any type of biota as well as rocks. Aside from the manipulator arms providing the opportunity to take direct bio or rock samples, the ROV provides several sampling tools including push cores and blade corers (see below).

For Subsea tracking the ROV is fitted with two HiPAP (USBL) beacons. One beacon is configured in Responder mode and the backup beacon is configured as a transponder. The TMS (*Borealis*) is fitted with a HiPAP beacon configured as a responder.

6.5.1 ROV exploration & sampling

The ROV performed a total of 19 dives, each with different objectives, including the sampling of sediment, meiofauna, macrofauna, and gas as well as using Sagasubsea AS, the measurements of methane dissolved in seawater (at different depths and close to the seabed) using the SAGE sensor developed at WHOI, and the collection of video footage using a downward looking 4k camera to provide photomosaics and a visual representation of representative habitats and sedimentary facies for the different sites explored during the AKMA3 expedition. Precise locations for ROV dives were selected according to results obtained from seafloor mapping and water column data analysis, as described in the Equipment section of this report.

All the performed dives covered a total of more than 56 hours of ROV videos and operations at the seafloor.

6.5.2 Sampling Equipment Used by ROV Aurora

6.5.2.1 Gas sampling and flux measurements

We used a gas-sampling device from Sagasubsea AS to sample gas and conduct flux measurements (Figure 7). The gas sampler was operated by the ROV. The transparent cylinder in the centre atop the funnel allows for exact (±20 ml) volume measurements that can be translated into fluxes by measuring the time duration of the gas accumulation in the cylinder (Figure 8). Gas that accumulates in the transparent cylinder is pulled into a steel cylinder by operating a valve due to the pressure difference between the steel cylinder (atmospheric pressure) and subsea pressure. A total of 8 gas samples were taken at 7 different superstations (see station log at the end of report). Steel cylinders with sampled gas were stored in the fridge room after recovery. The gas samples will be analyzed for gas composition and isotopic signature after the cruise.
Bubbles generally appear as single bubble streams from tiny holes in the sandy and muddy sediments or through cracks in carbonate crusts. The origin of the bubble stream is often surrounded by bacterial mats. Seepage activity varied substantially between the study areas both as evidenced by the significantly different numbers of total bubble streams and the visual intensity of the bubble stream.

Figure 7. Picture of the gas sampler used during the AKMA3 cruise. The funnel at the bottom has a footprint of 0.5x0.5 m. Gas accumulates in the transparent cylinder atop the funnel. That way, the gas volume can be measured. A valve on the front can be turned and the accumulated gas will evacuate into one of the 4 steel cylinders on the back.

The in-situ gas flow was quantified at single bubble streams at 5 sites (2 at Kveithola Bank, 1 at Vestbakken shelf and 2 at Snøhvit). Results of the funnel-derived gas flow measurements at individual bubble streams are shown in Table Ⅰ and Table Ⅱ. Flow measurements lasted between 10 min to more than an hour. Temporal variations in the gas flux on timescales longer than that remain unknown. Longer measurements will be necessary to better extrapolate flux estimates to annual periods.
Other factors that contribute to uncertainties in estimating the amount of methane flow from the seabed are errors in measuring flow using the cylinder in the gas sampler, which may account for less than 3% of the uncertainty in the calculated flows, and uncertainty due to the assumption that expelled

gas consists solely of methane. This assumption may lead to an overestimation of seabed methane emissions if measured CH4 in gas compositions were much lower (<90%) than expected.
Estimating the total flux of one vent field requires several additional and representative flux measurements across a spectrum of visually different bubble streams. However, the uncertainty in the number of vents is expected to be small, as individual seep spots were identified in water column data and confirmed and counted multiple times in the video observations. Some vents have not been visited but can be counted from the water column data.

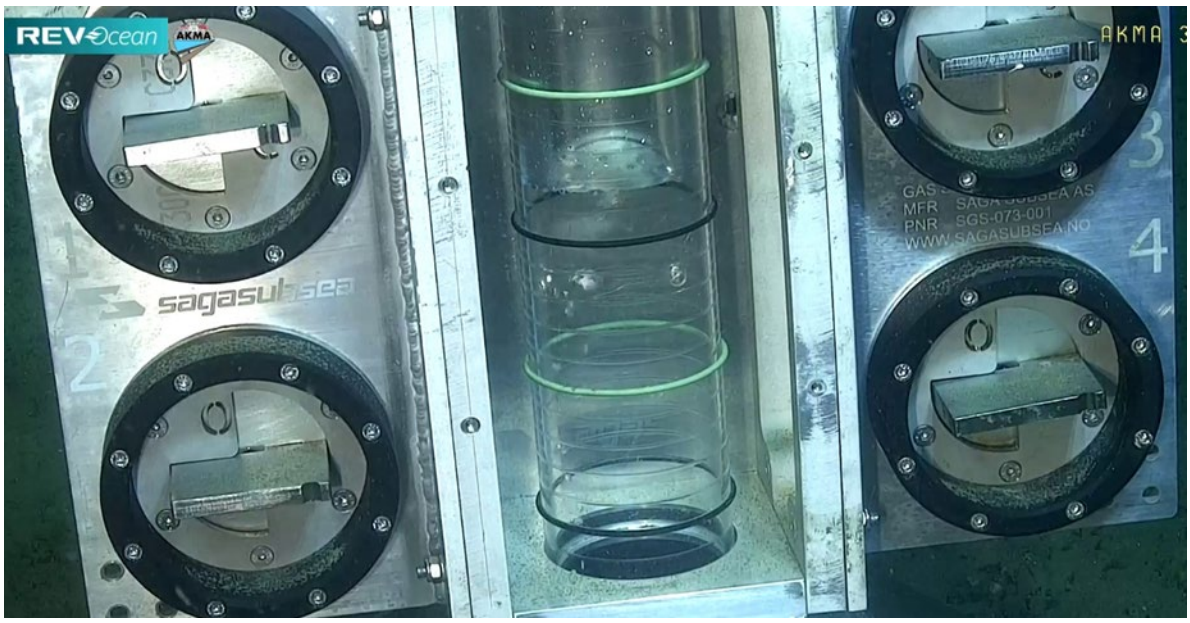


Figure 8. Example of optical-derived gas volume measurements. The green and black markings on the gas cylinder indicate volumes of 0.5, 1.0, 1.5 and 2.0 l respectively. In addition, there are markings every 100 ml in between.

Area	water depth [m]	gas volume measured [l]	duration of sampling [sec]	bottom water temperature [C]	Volume of methane gas STP [l]
Kveithola Bank	143	1.1	3882	5	16.71
Kveithola Bank	141	0.43	3160	5	6.447
Vestbakken shelf	362	1.04	1109	5	38.401
Snoehvit (Askeladd, close to well)	294	1.72	685	5	51.9
Snoehvit (natural seep site)	266	0.1	1738	5	2.74

Table Ⅰ. Overview of gas volume measurements to derive fluxes (see Table Ⅱ).

Area	The flux of methane gas at seafloor [l/min]	The flux of methane gas, STP [l/min]	mass flux of methane, STP [g/min]	mass flux of methane, STP [kg/year]	Carbon flux to the ocean [kg/year]
Kveithola Bank	0.017	0.2583	0.18	97.15	72.7
Kveithola Bank	0.0082	0.1224	0.09	46.04	34.45
Vestbakken shelf	0.056	2.078	1.49	781.5	584.8

Snoehvit (Askeladd, close to well)	0.151	4.55	3.25	1710.1	1279.6
Snoehvit (natural seep site)	0.00345	0.095	0.07	35.58	26.62

Table II: Overview of results from methane flux calculations. Please note that these results are only valid for one individual bubble stream.

6.5.2.2 Temperature probe

In AKMA3 we used the ISD400 Depth & Temperature Sensor from Impact SUbsea (Figure 9). It is impact, lightweight and highly robust, it is ideal for ROV, AUV and other underwater depth and temperature measurement applications with an optional integrated Attitude and Heading Reference System (AHRS). It provides depth accuracy of ±0.01% FS and temperature accuracy of ±0.01% °C.

Figure 9. ISD400 Depth & Temperature Sensor

6.5.2.3 Scoop

A scoop was used to collect biota.

6.5.2.4 Blade corer

Blade corers were used to sample sediment. Due to their closing mechanism, they provide the possibility to obtain pristine sediment samples with sediment surfaces preserved. Their size is 320 x 100 x 250 mm.

6.5.2.5 Pushcores

Several pushcores of different inner diameters were used to sample sediment.

6.5.2.6 Niskin Bottles

Niskin bottles operated with Aurora's articulated arm were used.

6.6 PAMELi

Coastal areas are complex environments, and their evolution is subject to interactions between various physical, chemical, biological and human factors. The PAMELi marine drone is born in 2018 from the need for repeated, co-located and simultaneous observations in different disciplines, and the need for reliable archive and easy access over time to these different observations.

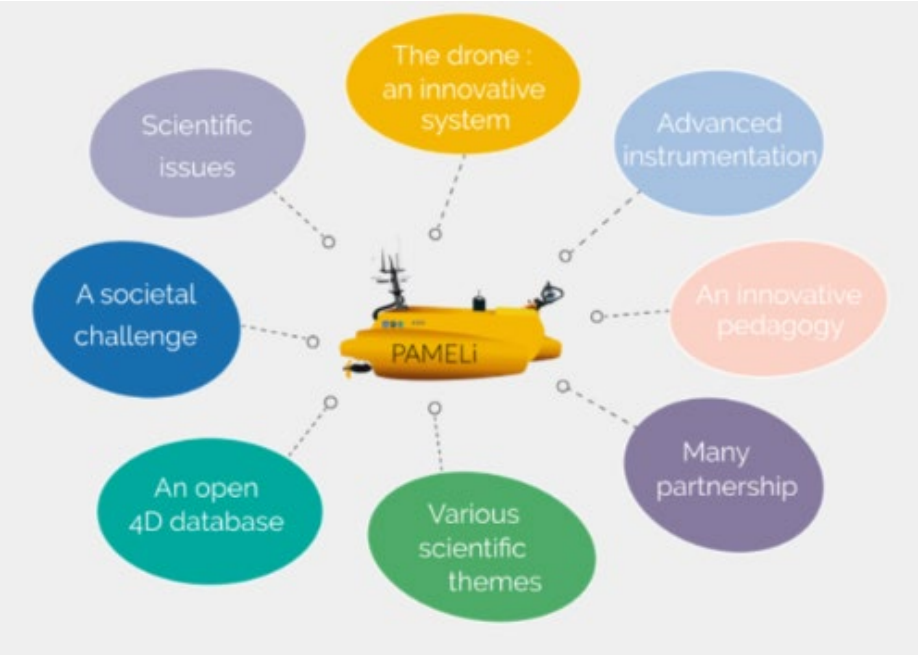


Figure 20. The PAMELi concept.

In AKMA 3, it is the first time PAMELi was deployed in cold environments. USV are particularly interesting for such methane measurements to avoid sample pollution with the boat itself. The communication setup installed on the KPH (Figure 11) is based on Wifi communication. The 3km range was used.

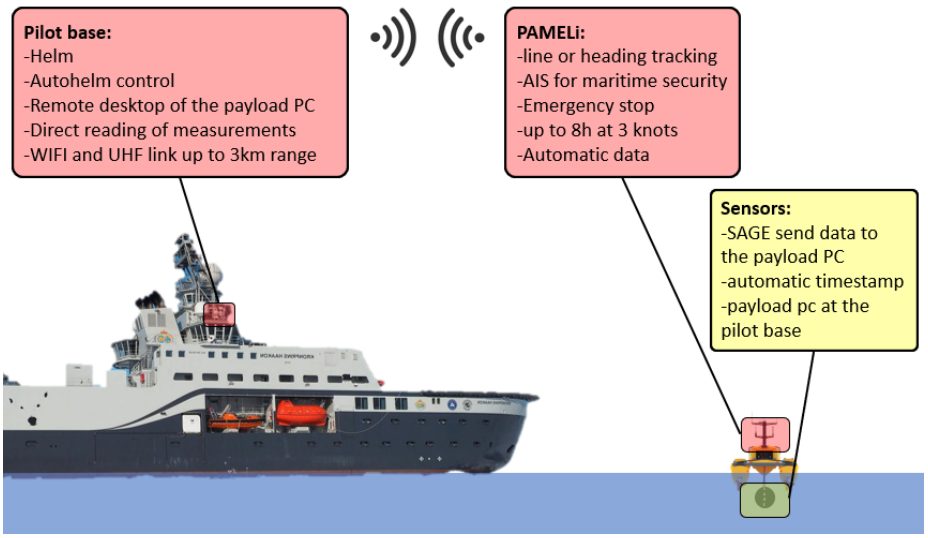


Figure 11. communication setup AKMA3

Many sensors can be installed on PAMELi: part of them is permanently onboard (water characteristics, meteorological), and some are developed for specific needs (water sampler, CTD crane, water level). It is easy to add any instrument to the system and connect it to the payload PC.
On AKMA3, PAMELi is deployed with a SAGE methane sensor. The deployment setup is described in the next section. Raw SAGE data are logged in the PAMELi database, they are georeferenced and timestamped.
The acquired data (SAGE and EXO2 sensors) are recorded and saved on board the drone in a temporary database, before validation, transfer and archiving in a multidisciplinary database on land. The goal is to build over time a comprehensive and long-lasting spatio-temporal information system promoting the development of interdisciplinary research.

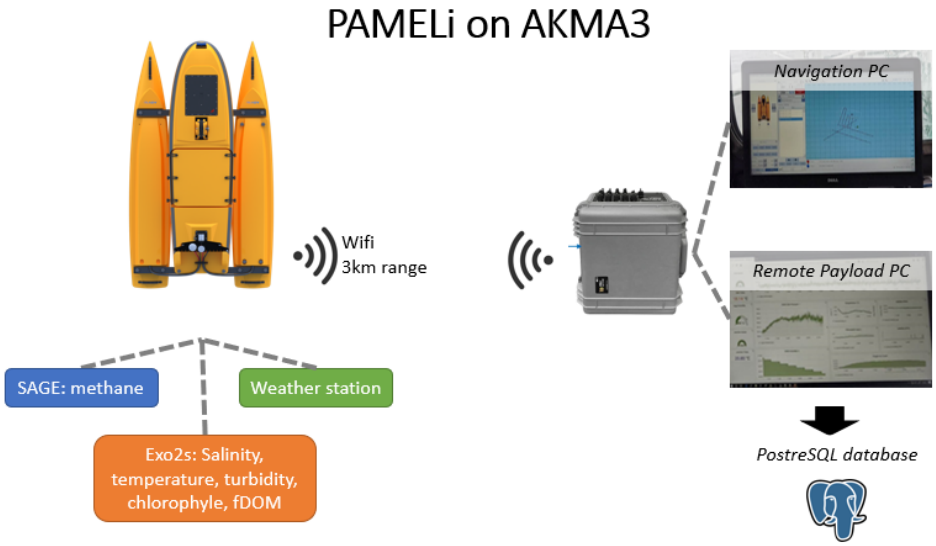


Figure12. from the sensor to the database

6.6.1 The sage sensor

Deployed on PAMELi's keel, the sage SENSOR was coupled with an SBE5 pump. To avoid pressure issues and reduce the time offset between sampling and measurement, the pump was installed near the SAGE with very short tubing (<50cm). This setup wasn't upset by surface bubbles (measured by pump pressure variation).

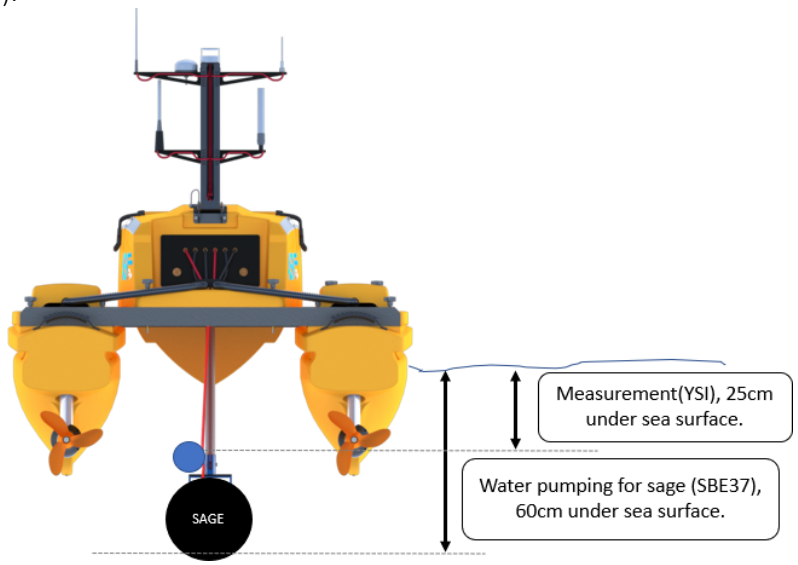


Figure 13. Instrumental offset the AKMA3 cruise.

6.7 SAGE Methane Instrument

SAGE (Sensor for Aqueous Gases in the Environment) is a dissolved methane instrument designed and built in the Chemical Sensors Laboratory at the Woods Hole Oceanographic Institution (WHOI). Anna Michel is the Principal Investigator of the Chemical Sensors Laboratory and can be reached by email at amichel@whoi.edu. SAGE uses a deep-sea membrane inlet to extract dissolved gas from seawater. Inside the instrument, the extracted gas fills a hollow core optical fibre. Laser spectroscopy is used to measure the methane inside the optical fibre, by coupling the light from a laser to the fibre. The inside of the instrument is at a vacuum (30-100 mbar absolute pressure), which continuously draws gas through the fibre, allowing SAGE to "sip" gas from behind the membrane inlet. SAGE is able to have a fast response time of roughly 5 minutes (t_{63}) because of the miniscule amount of gas needed to fill the optical fibre. SAGE continuously monitors the flow of seawater pumped past the membrane inlet.

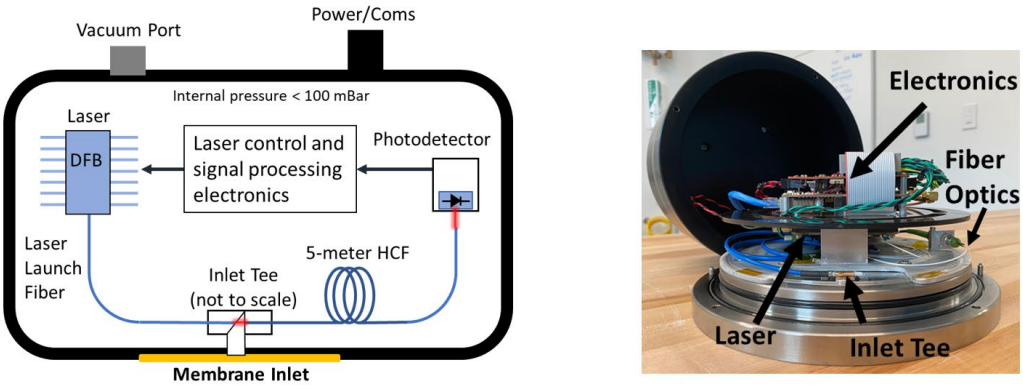


Figure 14. Left: Block diagram of the internal components of SAGE. Right: Photo of the internal components. The outer diameter of the instrument is dictated primarily by the bend radius of the optical fibre.

Upon receiving power, SAGE automatically begins measurements and saves data to an SD card inside the instrument. To monitor the measurements in real time, SAGE sends UDP messages via an Ethernet connection. The data can be observed using a computer and graphical user interface. SAGE was designed to operate from 24V DC power, but during the AKMA3 cruise SAGE was modified to operate from 48V, such that the 4K camera on the ROV could be used at the same time as SAGE.

Parameter	Value
Detection Range	0-10,000 ppm CH_4
Resolution	1 ppm CH_4
Stability	5 ppm or 2% of value
Response Time	5 min
Power	24V, 13-17W
Depth Rating	2500 m
Dimensions	9.0" OD x 5.5" L
Fluid Flow	> 3 L/min from SBE 5T or similar
Weight in Water	10.9 lb
Weight in Air	22.9 lb
Real-time Comms.	Ethernet UDP
Data Management	Onboard data storage option 2+ days
Timing	Selectable sample rate >= 1 Hz, NTP sync
Connector	Subconn DBH13M Pwr/Ethernet
Deployment Duration	1+ year at surface, 2 weeks at depth (pending biofouling)

Table Ⅲ. Specifications for the SAGE Instrument.

Variable	Units
Timestamp	DateTime
Onboard File Number	N/A
Methane Concentration	PPM
Inlet Pressure	mBar
Inlet Temperature	C
Housing Pressure	mBar
Water Temperature	C
Junction Temperature	C
Junction Humidity	%
Average PD Voltage	V
Inlet Heater State	0/1
Junction Heater State	0/1
Detector Signal	V

Table IV. Data output by SAGE via UDP messages. Example UDP string (omitting Detector Signal): 20210905T215053,501,2.0011,1002.34,24.55,248.11,24.21,26.07,26.3,0.682,0,0.

6.8 Drone surveys

The drone surveys were carried out using a DJI/Mavic 2 Enterprise DUAL quadcopter borrowed from the Remotely Piloted Aircraft Systems (RPAS) unit of UiT (droneteknologi). This aircraft is equipped with an Uncooled VOx Microbolometer infrared thermal camera acquiring data at a resolution of 160×120 (image size 640×480; video 640×360 @8.7fps) and a 1/2.3" 12M pixels CMOS visual camera (max image size 4056×3040; 4K video recordings). Visual imaging is widely used in oil slick monitoring due to its relatively low cost but it comes with some limitations mainly related to cloud cover, adverse weather conditions and sun glitter. The infrared camera can be particularly effective in detecting oil slicks on the sea surface. After being heated by the sun, oil re-emits some light in the infrared spectrum. Since oil has greater infrared emissivity than surrounding seawater, it can be detected and mapped using our drone.
This drone is 899 g (net weight) and can withstand winds up to 10 m/s and temperatures between −10℃ and +40 ℃. The drone was operated from the *DJI Go* app installed on a tablet and connected to the radio controller.

7 Methods

7.1 Multibeam echosounder Water Column Data (WCD)

Rune Mattingsdal & Stefan Buenz.

Gas seep mapping was done in the QPS FMMidwater software. Gas seeps are detected as gas flares in the water column data caused by backscatter from the gas bubble streams. The acquired data from EM302 and EM710 in *.all and *.wcd file formats were converted with FMMidwater to the generic water column format (*.gwc). *.gwc files were visualized in fan view and stacked view. Locations of individual gas flares were determined manually by observing the data in a fan view and retrieving coordinates of the gas flare initiation points where it starts at the seafloor using the geo-picking tool. Flare locations were plotted on the maps and used during ROV-flying during the ROV dives for locating streams of gas bubbles.

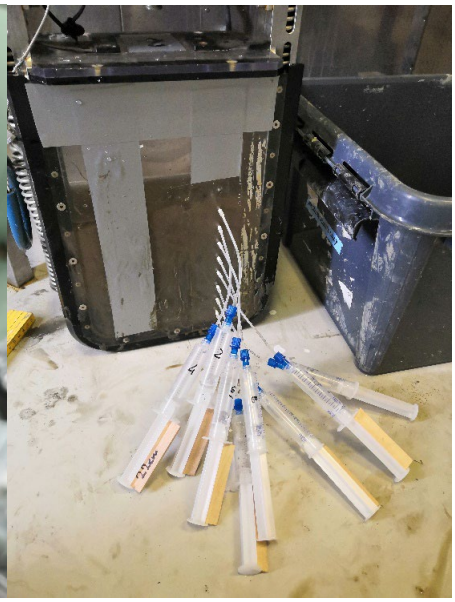
7.2 Marine Geology

Claudio Argentino& Stefan Buenz.

The complete list of all sediment samples collected during the expedition is reported in the Appendix. table XI "List of samples" with an indication of the sampling gear, namely pushcorers and bladecorers operated by ROV AURORA, by gravity, by the multicorer, as well as indication of the target analyses.

7.2.1 Pore fluids samplings

Pore water samples were extracted from blade cores at a vertical resolution of 2 cm and from pushcores, multicores and gravity cores at variable resolution depending on the expected location of the sulfate-methane transition zone. The push core and blade core liners were pre-drilled and sealed with tape prior to deployment. The pore water sampling was conducted in a chilled room (4 °C) upon recovery. We followed the methods described in Argentino et al. (2023) and summarized here: 5 cm-long pre-wetted rhizons (0.15 µm mesh) are inserted in the pre-drilled holes and the water samples are extracted by applying a suction force with 10 mL syringes (Figure 15). The pore water samples were split into different aliquots: 1) 1.5 mL subsamples were transferred into screw cap glass vials for dissolved inorganic carbon (DIC) analysis. We stored DIC samples at 4 °C without any fixative addition since it has been recently shown that it can alter the DIC geochemistry of cold seep samples (Argentino et al., 2023). 2) >0.5 mL was transferred into Eppendorf tubes and stored at -20 °C for sulfate analysis. 3) Samples for trace metals (> 1 mL) were treated with 10 µl of ultrapure 65% nitric acid (HNO_3) to lower the pH to < 2 and stored at 4 °C.
Bulk sediment samples (5 mL) were extracted at 5 cm and 10 cm depth in blade cores using a cut-off syringe. The samples were transferred into glass vials prepared with 5 mL of NaOH (1 M) to stop microbial activity (Figure 16), plugged with a rubber septum, sealed with aluminium crimp caps and shaken, then stored upside-down at 4 °C. All samples collected are listed in the Appendix. table XI.



Right: Figure 15. Pore water extraction from a blade core.
Left: Figure 16. Bulk sediment sample in a glass vial prepared with NaOH. The headspace will be analyzed for gas composition.

7.2.1 Sedimentology

The type of seafloor sediment was assessed based on high-resolution ROV imagery of the seafloor (top layer) and visual inspection during push core and bladecore slicing. X-ray fluorescence (XRF) core-scanning, a convenient non-destructive tool to rapidly assess elemental variations in grain size analyses will be done once in the lab.

7.2.2 Rock sampling

Rock samples noticed at the seafloor during the ROV Dives that were of particular interest have been collected from the seafloor using the ROV manipulator arm. Rocks were washed with freshwater to remove any salt residue and left on the deck to dry out. On some occasions, the biologist removed epiphytic organisms attached to the rocks.

7.2.3 Oil Sampling

The Oil Spill Sampling kit (Figure 17) provided by Fugro has several different containers depending on the amount of fluid. Several syringes and smaller glass bottles can be used when there is a big enough volume to extract. In the case of a thin oil slick on a water surface, a special membrane can be used which will catch in potential hydrocarbons. The membrane can be attached to the telescope rod and then be dipped into the water. The membrane will be then put into a glass bottle and afterwards into a plastic container to protect it from being shattered. A danger sign and normal labelling were attached to the sample, and it is ready to be sent in for further analysis.

Figure 17. Material of the Oil Spill Sampling Kit (photo: Maximilian Weber).

7.3 Marine Biology

Alex David Rogers, Denise Swanborn, Elly Goetz, Giuliana Panieri, Ines Barrenechea Angeles, Mari Heggernes Eilertsen & Sofia Ramalho.

7.3.1 Microbiology

Cold seeps are characterized by the presence of bacteria and archaea. During this cruise, the microbial community from microbial mats some tubeworm areas surrounding the microbial mats and some reference sites were sampled for microbiology analysis. The surface sediments were taken with a sterile spatula avoiding the rim of the core and stored at -20°C. downcore layers were taken every 2cm. During

the slicing, the spatulas were cleaned and rinsed with ethanol. All samples collected are listed in the Appendix. table XI.

7.3.2 Micropaleontology and meiofauna diversity

Sediments and the overlaying bottom water were collected from 6 of the cold seep areas investigated using either the Push cores (varying diameter, between Ø 8cm and Ø 5cm) or by means of the Blade Cores (32x25x10cm), both deployed with the ROV Aurora (see summary sample list in Appendix. table XI). The coring inside the seep sites targeted the following micro-habitats: bacterial mats, tubeworm patches and sediments in the vicinity of the seep as reference within the seep. Additionally, replicate cores were collected by means of the multi-corer (Ø 10cm) in areas outside the central active seepage locations, as a reference. This sampling aimed to investigate the infauna biodiversity, namely from the >32 µm fraction of the sediments, including both the metazoans and foraminifera. Additionally, surface sediment samples were also collected for subsequent barcoding of key Foraminifera and Nematoda species. These analyses will be conducted at UiT (Norway) and U. Aveiro (Portugal).
In each micro-habitat, three replicates' cores were collected for these analyses. The overlying water of each liner was removed and filtered over a sieve of 32 µm before slicing. For one of the selected replicate cores where environmental characterization of the sediments was conducted, the pore water was sampled before core slicing. After the pore-water extraction was completed, the liners were sliced into 6 sediment depth layers (0-1cm, 1-2cm, 2-3cm, 3-4cm, 4-5cm, 5-10cm) and fixed in a formaldehyde (4%)/seawater solution for morphological analyses. For the other two replicates aiming for morphological analyses, the liners were sliced into 3 sediment depth layers (0-3cm, 3-5cm, 5-10cm) and fixed in a formaldehyde (4%)/seawater solution for morphological analyses. For the cores where the environmental parameters were also investigated, 1⁄4 of each sediment slice was kept at -20ºC (see chapters on pore-water, sediment geochemistry and grain size analyses). Additionally, at each superstation cores were sub-sampled (according to Appendix. table XI), and sediments were preserved in 96% Ethanol solution for future molecular studies.

7.3.3 Foraminifera

7.3.3.1 Foraminifera diversity

Several methods were used to assess foraminifera biodiversity across micro-habitats such as bacterial mats, tubeworm patches, and reference sediments near the seep and outside the seep. For living foraminifera communities using the morphology approach, the samples were collected as described in the meiofauna diversity protocol. To distinguish between dead and living specimens, the collected samples will be stained with Rose Bengal. In addition, the first centimetres of three samples from two superstations (KH6 and KH7) were fixed with Cell Tracker Green (CTG) and TEM staining. Sediments were also collected for studies based on molecular analysis such as eDNA metabarcoding. A summary of collected samples can be found in Table V and Table VI.

7.3.3.2 Cell Green Tracker (CGT) staining

10 ml of sediments were collected from the surface layer (0-1 cm) into 100 ml bottles where 20 ml of seawater was added. The CGT-DMSO (Dimethyl sulfoxide) solution was prepared by adding 50µl of DMSO (Dimethyl sulfoxide) into the CGT vial. 18µl of this solution was added to the sediments and

mixed gently. The sample was incubated for 12h at room temperature and then fixed by adding 70ml of EtOH 96%

7.3.3.3 Transmission Electron Microscope (TEM) fixation

The TEM fixative solution was prepared using 10ml of glutaraldehyde, 25ml cacodylate buffer and 15ml sterile water. This solution was added to 20 ml of surface sediments (0-1cm) collected into a 100 ml bottle.

7.3.3.4 2.3 eDNA foraminifera

The surface sediments were taken with a sterile spatula avoiding the rim of the core and stored at -20°C. In some cores, downcore layers were taken every 2cm. During the slicing, the spatulas were cleaned and rinsed with ethanol.

7.3.3.5 Foraminifera propagules

Nine sediment samples were taken from the surface of multi- and push-core samples from control (non-methane seep) sites. Approximately 100g of sediment was scraped using a small metal spatula into a sterile plastic container and placed in the refrigerator for no more than 24 hours. The sediment was then washed through a 63 µm sieve using artificial seawater (~35 ‰) in an attempt to separate mature foraminifera from "propagules", their juvenile dispersal stage. Both size fractions were put in 50 ml falcon tubes in the fridge for 24 hours to allow the sediment to settle before removing extra seawater. Buffer RLT (Qiagen) was added to each tube to at least double the sediment volume. All samples are stored at -20°C.

Superstation	Location	ROV	Core	number
KH02	Håkjerringdjupet	ROV2	Pusc02	5
		ROV3	Blac01	1
KH03	Vestbakken slope	ROV4	Blac03	8
			Blac02	9
		ROV5	Blac01	10
			Pusc01	1
		MUC1	#6	10
KH04	Vestbakken shelf	ROV6	PuscC5	1
		ROV7	Blac03	6
			Blac01	9
KH06	Vestbakken shelf 2	ROV11	Pusc03	1
		ROV12	Blac01	5
			PuscC5	1
KH07	Outer Bjørnøyrenna	ROV13	Blac01	6
			Blac03	6
		ROV16	Blac02	8
			Blac01	3
			PuscC5	6
KH08	Snøhvit gas field	ROV18	Pusc03	8
			Blac01	9
			Blac02	8

Table V: Foraminifera – eDNA sample list.

Superstation	Location	ROV	Core	number
KH02	Håkjerringdjupet	ROV2	Pusc03	2
			Pusc02	1
			Blac03	1
			Blac02	2
		ROV3	Blac01	1
KH03	Vestbakken slope	ROV4	Blac03	8
			Blac02	9
		ROV5	Blac01	8
			PuscC8	1
			Pusc03	2
			Pusc01	1
		MUC1	#6	1
			#3	1
			#5	1
			#1	1
			#4	1
KH04	Vestbakken shelf	ROV6	PuscC5	1
		ROV7	Blac03	7
			Blac02	2
			Blac01	8
KH06	Vestbakken shelf 2	ROV11	Pusc03	1
		ROV12	Blac01	5
			Blac03	5
			PuscC5	1
KH07	Outer Bjørnøyrenna	ROV13	Blac01	6
			Blac03	6
			PuscC5	1
			PuscC8	1
		ROV16	Blac02	8
			Blac01	3
			PuscC5	6
KH08	Snøhvit gas field	ROV18	Pusc03	8
			Blac01	9
			Blac02	8
			Blac03	1

Table VI: Microbial eDNA sample list.

7.3.4 Biodiversity and resilience of Diatoms

From 4 of the seep areas investigated, a small portion of sediment (2ml) from reference areas was collected for biodiversity and the study of the resilience of diatoms. This sampling seeks to find Diatom species that can withstand the extreme conditions of these sites. The target is to isolate them from their environment and culture them at the University of Aveiro (Portugal) for further analysis, such as taxonomical identification, morphological description, and physiological testing of their ecological resilience to physical parameters.

7.3.5 Macrofauna

Macrofauna sampling aimed to get good coverage of the biodiversity of the various microhabitats of each seep site. To achieve this, macrofauna was extracted from samples collected with the ROV-operated Push cores (Ø 8 cm), Blade cores (32*25*10 cm), and Scoop. Fauna was also collected from the surface of carbonate rocks. At each cold seep site, we targeted areas with bacterial mats, tubeworm

fields and rocky substrates to represent the different microhabitats. Reference samples from inactive sedimented areas were collected with the Multicorer.

Figure 18. Various macrofauna were collected during the AKMA3 cruise.

All samples for macrofauna were carefully sieved through two stacked sieves with 1 mm and 0.5 mm mesh sizes. Most of the material was fixed on 96% ethanol, but some target taxa were sorted out using a Leica stereomicroscope, and frozen at -80 degrees for genomic studies. Some were also fixed on Glutaraldehyde for microscopy studies (SEM/TEM, FISH). In addition, specimens of all the common taxa at each site were frozen at -80 degrees for foodweb analyses using stable isotopes. Reference samples of sediments from the same stations were also collected and frozen. Foodweb analyses will be performed in collaboration between the University of Aveiro, Portugal, and the University of Bergen, Norway.

7.3.6 Ocean census

7.3.6.1 Introduction

Life is found everywhere in the ocean and has adapted to the most extreme marine environments including the deepest trenches (e.g., Challenger Deep in the Marianas Trench; Jamieson, 2015, Jamieson et al., 2023), anoxic hypersaline basins (Danovaro et al., 2010), and high temperature deep-sea hydrothermal vents (Van Dover, 2000). Ocean life has evolved over nearly 4 billion years (e.g., Tashiro et al., 2017) and its diversity provides numerous benefits to humankind (e.g., Worm et al., 2006; Barbier, 2017; Lotze, 2021), many of which we are only just uncovering (e.g., marine genetic resources; Blasiak et al., 2020). Yet, compared to terrestrial systems, we still only have a basic understanding of how life is distributed in the ocean (e.g., Gagné et al., 2020), how it contributes to the functioning of marine ecosystems (Gamfeldt et al., 2014; Thurber et al., 2014) as part of the Earth's life-support systems, and how it underpins human society and the well-being of its citizens. Nearly ninety per cent of an estimated 2 million species of marine life remain undescribed, and many geographic regions and ecosystems remain poorly explored (Webb et al., 2010; Mora et al., 2011; Ramirez-Llodra et al., 2011; Bouchet et al., 2023). As a result, human society cannot fully comprehend the vital importance of a healthy ocean and the indispensability of Earth's marine life in supporting human well-being.

As on land, in the ocean there has been a significant loss of biodiversity with cascading ecological changes across food webs, altering the function of marine ecosystems (McCauley et al., 2015; Cowie et al., 2022; Edgar et al., 2023) and their capacity to provide goods and services to millions of people in the world (Smale et al., 2019; Isbell et al., 2023). Assessment of the IUCN Red List of species, a metric that quantitatively estimates extinction risk in organisms (IUCN, 2017), suggests that the proportion of

marine species threatened with extinction is 11-46% and spans the range for species from terrestrial groups (20-25%; Webb and Mindel, 2015; Rogers et al., 2020). It is likely that the poor level of observation and monitoring of ocean species and, more fundamentally, less taxonomic knowledge compared to terrestrial ecosystems means that many extinctions and declines have not been recorded (e.g. Webb and Mindel, 2015, Rogers et al., 2020; Cowie et al., 2022). The ocean biodiversity crisis is driven both by the decline of species (e.g., more than three-quarters of oceanic sharks and rays are threatened with extinction; Pacoureau et al., 2021) and the degradation and collapse of ecosystems (e.g., tropical reefs have lost half of their coral cover since the 1870s; Wilkinson et al., 2016; IPCC, 2019). The current gaps in knowledge create challenges in setting baselines, monitoring how biodiversity is responding to changes in human activities and climate change (e.g., Edgar et al., 2023) and evaluating if the policies and management plans implemented are proving effective. At present, we are effectively blind to how life in the ocean is responding to our intentional and unintentional actions and to rapidly changing environmental conditions. Without transforming our knowledge of the distribution of life in the ocean we will be unable to take the necessary knowledge-based decisions to halt the decline of marine species and restore marine ecosystems. Current practices in marine taxonomy were established in the 18th and 19th Centuries and the rate of species discovery has hardly changed in 150 years (currently about 2,400 marine species a year are described). This effort is unable to address the current biodiversity crisis in the ocean and there is a need to substantially increase the rate of species discovery and accessibility to species-level data for the ocean. For these purposes, the Ocean Census (https://oceancensus.org/) programme was conceived.

Ocean Census was launched on April 27th, 2023, with the aim of accelerating the discovery of marine species and communicating the importance of the ocean to the public. The initiating partners for the programme are The Nippon Foundation of Japan, which has provided initial funding and the Nekton Foundation based in the United Kingdom which is the main implementing organisation. Support for Ocean Census is also provided by a range of partners including scientific organisations (e.g., the United Nations Environment Programme's World Conservation Monitoring Centre), vessel providers (e.g. Schmidt Ocean Institute), civil society (e.g. the Professional Association of Diving Instructors), and industry partners (e.g. Oxford Nanopore). Ocean Census is conceived as an open network of scientists anchored by Biodiversity Centres with a global distribution in developed countries and LMICs. Biodiversity Centres act as the anchor point to the Ocean Census network providing infrastructure for taxonomic studies including curation of collections of specimens and training for capacity development purposes. The first Biodiversity Centre will be located at the Oxford University Museum of Natural History.

Ocean Census aims to accelerate the rate of ocean species discovery at least tenfold by 1) employing consistent standards for the digitisation of species data to broaden access to biodiversity knowledge and enable cybertaxonomy; 2) establishing new working practices and adopting advanced technologies to accelerate taxonomy (e.g. third-generation sequencing, 3D high-resolution imagery, new sampling technologies and artificial intelligence); 3) building the capacity of stakeholders to undertake taxonomic and biodiversity-related research and development, especially targeted at low- and middle-income countries (LMICs) so that they can better assess and manage life in their waters and contribute to global biodiversity knowledge; and 4) increasing observational coverage on dedicated expeditions. One of the most expensive elements of Ocean Census is undertaking field expeditions, particularly to offshore locations and the deep sea. Such expeditions require substantial infrastructure including the use of Ocean Class and Global Class research vessels and deep-submergence infrastructure such as

remotely operated vehicles (ROVs), submersibles and autonomous platforms (Rogers et al., 2021). Partnerships on research expeditions are therefore a critical element of the Ocean Census programme. To this end, AD Rogers and D Swanborn joined the AKMA3 Cruise to collect samples of marine fauna for the Ocean Census programme. These samples will provide some of the initial samples for the programme and an opportunity to test new approaches to accelerate species discovery and description.

Methods

Samples for the Ocean Census were mainly collected using the manipulators of the Aurora ROV. It was important to observe species collection events and record the time of collection (GMT), position (latitude and longitude) and depth. Time of collection enables the identification of environmental conditions at the time of collection (from the ROV CTD) as well as a reference to the ROV video to record the environment from which the specimens are collected. Some animals were collected attached to rocks and in these cases other organisms were often found attached to the substratum such as brachiopods and smaller sponges Some samples of animals such as nemerteans and chitons (Polyplacophora) were obtained from samples of carbonate which presents a highly cryptic habitat.

All taxa were assigned a unique identification number prefixed with the expedition name, AKMA3. Following collection, all megafaunal taxa (generally larger than 1 cm) were photographed with a scale in the photo which also included the specimen label (Figure 19). This allowed the photograph to be attributed to a specific specimen. Small animals were photographed using a microscope (Leica S9i binocular microscope) fitted with a digital camera (Figure 20). Following photographs animals were preserved according to the protocols in Table Ⅶ Some specimens were also subsampled for isotope food web studies.

A single set of three cores from a single multicore were preserved whole and unsorted with single cores split at 0-3cm, 3-5cm, 5-10cm and 10-20cm (or 10 – X cm where cores were short). Slices were cut into two equal halves and preserved in 96% ethanol and 4% formalin respectively.

What is it?	What preservation?	Where does it go?
SCLERACTINIA (hard coral) – genetics subsamples	E100	1 cm^3 2ml or 5ml cryovial or 15ml (D) vials if too big
SCLERACTINIA (hard coral) - rest of specimen	Formalin > 70% ethanol	Specimen into > formalin > for ~7-14 days then transfer to 70% ethanol
STYLASTERID - genetics subsample	E100	1 cm3 2ml or 5ml cryovial > Ethanol cryobox (B) or 15ml (D) vials if too big
STYLASTERID – The rest of the specimen	E96%	In a container in 96% ethanol
OCTOCORAL - genetics subsample	E100	A few branchlets with polyps > 2ml or 5ml cryovial > Ethanol cryobox (B)
OCTOCORAL – The rest of the specimen	Formalin > 70% ethanol	First 30 specimens > Formalin > for ~1 day (NOT LONGER) > 70% ethanol All extra > 100% Ethanol
SEA CUCUMBERS - genetics subsample	E100	1 cm3 muscle tissue >2ml or 5ml cryovial > Ethanol cryobox (B)
SEA CUCUMBERS – The rest of the specimen	E100	Suitable-sized container

URCHIN - genetics subsample	E100	1 cm3 gonad tissue >2ml or 5ml cryovial > Ethanol cryobox (B)
URCHIN – The rest of the sample	E96%	Suitable sized container
SPONGE – genetics subsample	E100	3cm3 > in 15ml (D) ethanol vials> into SPONGE tube holder
	Drying	3cm3 > drying area of the wet lab with label
CRUSTACEAN	E100	If small, individual or individuals in 100% ETOH. Otherwise, excise muscle tissue from a limb.
CRUSTACEAN – The rest of the specimen	E96%	Suitable container.
Other invertebrates (MOLLUSCS, POLYCHAETES, PLATYHELMINTHES) NEMERTEA	E100 Formalin 4% E100	If small and multiple specimens, the entire specimen is in E100. If large, then excise up to 1cm3 of muscle/body tissue and preserve in E100. The animal must be anaesthetised in 7% MgCl2 and fixed straight Sub-sample in ethanol for DNA barcoding.

Table VII. Specimen preservation protocols for different taxa.

NOTE = 5 x volume 100% ethanol to tissue in vial. If the sample is too bulky for 2/5 ml tubes, use 25 ml.

Figure 19. Example of megafaunal specimen (Asteroidea) photograph showing label and scale.

Figure 20. Example of a photomicrograph (Ophiuroidea)

Preliminary Results and Observations

A total of 400 samples and subsamples were taken during the cruise by the Ocean Census team. These breakdown into the following specimens:

Taxon		Number of specimens
Porifera		39
Cnidaria	Hydroidea	4
Anthozoa	Pennatulacea	2
	Octocorallia (not Pennatulacea)	7
	Zoanthidia	6 (multiple individuals)
Polychaeta		1
Siboglinidae		1
Arthropoda	Pericarida	6 (multiple individuals)
	Pycnogonida	4 (mainly Colossendeis proboscidia)
	Crustacea	2
Mollusca	Polyplacophora	8 (multiple individuals)
	Gastropoda	6 (includes a sample of eggs and a nudibranch)
	Bivalvia	2
Bryozoa		9 (includes multiple colonies)
Brachiopoda		6 (multiple individuals)
Nemertea		6 (includes Micrura varicolor, Nipponemertes pulchra and an unknown / undescribed species)
Echinodermata	Ophiuroidea	26 (multiple individuals)
	Holothuroidea	3
	Asteroidea	21 (includes Hippastria phyrigiana, Henricia spp)
Ascidiacea		10 (includes multiple colonies)

Samples will be sent to the Oxford University Museum of Natural History (OUMNH; https://www.oumnh.ox.ac.uk/) for identification/description or subsequent dispersal to expert taxonomists. Samples will be subject to DNA barcoding or whole-genome sequencing depending on the state of DNA collected from samples. Specimens will be identified/described and submitted to the OUMNH collections for curation.

During the expedition, it was noted that many of the benthic ecosystems sampled were heavily trawl impacted. Multiple trawl scars were observed both in the ROV sonar and also in the ROV video cameras.

In the latter, these appeared as trenches with disturbed blocks of sediment and rocks. A lack of taller epifaunal organisms and mobile benthic fauna was observed and, in some cases, damaged organisms consistent with the "mowing" effect of bottom trawls (e.g., Condrocladia gigantea cut close to the seafloor). It is likely that this has resulted in impoverished seafloor fauna in many of the areas sampled. Putative blowout craters at Vestbakken Shelf (Site 6) and Outer Bjørnøyrenna (Site 7) were characterised by steep slopes and jagged broken carbonate crusts which are inimical to trawling as evidenced by lost fishing gear and lack of trawl scars. In these features, erect epifauna such as delicate plate sponges (Site 6) and octocoral colonies (Paramuricea placomus; Site 7) was observed along with a variety of mobile invertebrates including nudibranchs (Berthella sp. sampled). It was also notable that in Site 7 where very high methane levels were recorded and the presence of extensive bacterial mats non-seep associated fauna was quite restricted to abundant sea anemones of several species, large erect hydroids, cladorhizid sponges and Paramuricea placomus. This suggests that the environment was probably unsuitable in some way for many other organisms, probably because it was toxic (e.g., the presence of high levels of methane or hydrogen sulphide).

The presence of just two Ocean Census personnel on the cruise meant that the ability to process samples was quite limited within the time constraints of "hours at sea". We also note that the failure of VWR to deliver anhydrous magnesium chloride in time for the expedition meant that 7% magnesium chloride for the relaxation of invertebrates was not available. This meant that animals such as nemerteans contracted considerably during fixation. The impact of this on subsequent taxonomy is uncertain.

AD Rogers and D Swanborn would like to thank Giuliana Panieri for the opportunity to participate in the AKMA3 cruise for Ocean Census.

7.4 2D seismic test and acquisition

The expedition brought along UiT's seismic system to test and verify its operation from RV Kronprins Håkon. The technician from UiT mobilized and installed all the necessary system components during the first 4 days of the expedition. One main objective was to connect UiT's seismic airguns with the onboard compressor and verify that the supply of highly compressed air was sufficient to operate the airguns at typical shot frequencies of 3-5 sec.

UiT's seismic source system consists of two mini-GI airguns with a total volume of 60 in^3. The airguns are mounted on a frame that is towed approximately 1,8 m below sea surface. In order to verify their operation, we used a short and analogue hydrophone cable with only one channel and an active section of 6m. The airgun system was towed on the A-frame at the stern approximately 30 m behind the vessel. The hydrophone cable was towed at the port side at an offset of 10 m from the centre of the ship and approximately 40 m behind the vessel.

We were able to test the system twice. The first test was on the slope of Vestbakken volcanic province intending to cross a focused fluid flow feature that originates at the caldera of a buried volcano several hundred meters beneath the seafloor. Unfortunately, there was air leakage on one of the valves on deck at the start of the line. It took about 20 min to repair and by that point, we had just crossed the fluid flow feature. However, we let the line run to the end for about 25 min. The airguns operated successfully throughout the acquisition. Even with this simple single-channel system, data quality was excellent with penetration of up to 800 m below the seafloor.

The second line was acquired over a putative blow-out crater at the southern Bear Island Trough with an active mud volcano in its centre. Here we successfully acquired a line of 4 nm lasting almost an hour. Data quality is very good and shows the subsurface structure in high resolution (Figure 21). The conduit of the mud volcano is clearly visible in the seismic.

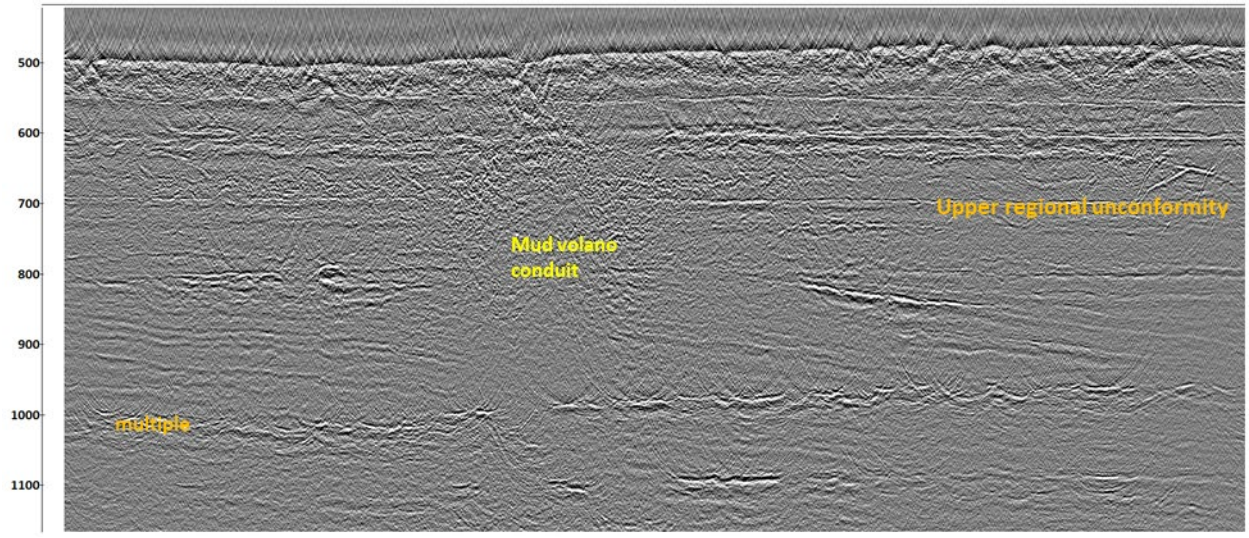


Figure 21. The seismic line across a blow-out crater at the southern Bear Island Trough. The conduit below the crater is clearly visible in the seismic data.

7.5 PAMELi

7.5.1 Typical field procedure

The deployment starts with the validation of every system of the USV. The communication with the sensor, especially SAGE, must be validated before launching.

Action	Time needed	Comment
SAGE installation	20min	Cable already installed
Database start	10min	Grafana service
Propulsion tests / e-stop	5min	
launching	15min	Side crane
survey	-	Max 6h
Support board launching	15min	
Hook PAMELi	10min	
Database stop and log download	15min	

Table VIII. field procedure

7.5.2 Notebook

Date	Site	Start (UTC)	End (UTC)	Depth	Approx. time on water	Position
01/05/2023		08h00	11h34		2h00	{"latitude": 70.68638966666667, "longitude": 18.468559833333334}
04/05/2023		08h00	12h54		4H00	{"latitude": 73.82316266666666, "longitude": 16.411388666666667}
05/05/2023		10h53	14h20	140m	3h20	{"latitude": 74.71410783333333,

						"longitude": 17.064038}
07/05/2023	Borealis	20h20	00h38	380m	4h00	{"latitude": 72.45136033333334, "longitude": 17.652859833333334}
09/05/2023		06h48	11h53	270m	3h00	{"latitude": 71.40964333333334, "longitude": 20.432873666666662}

We succeed in doing 5 PAMELi deployments during the cruise. 4 of them with the sage. In each site, the methane signal was quite different probably due to depth, methane origin...
The work done with PAMELi is described in the next sub-section.
A small "result" comment is added, with a quick coloured interpretation of the methane variation.

0ppm<Typical<3,5ppm	Spatial variation ok	Temporal coherence

7.5.3 28/04/2023

7.5.3.1 Objectives:

- Installation of PAMELi on the boat
- Setup of the sage
- Tests of the system

Figure22. PAMELi Unload

Figure 23. Keel setup

7.5.3.2 Comments:

Perfect arrival of the USV, we worked on the integration of the PAMEli.
The informatic integration needs some improvement to be able to log and see the data in real-time.
We did not have the possibility to install the pilot base: that should be organized for day 2.

7.5.3.3 Time schedule:

Time (local)	Action
10h00	Arrival of the truck
11h30	PAMELi onboard the KPH
14h30	SAGE installation on the keel of PAMELi
16h00	Tests of the informatic setup

7.5.4 29/04/2023

7.5.4.1 Objectives:

- Installation of the pilot base
- Test of the sage data logging
- Communication pilote-usv

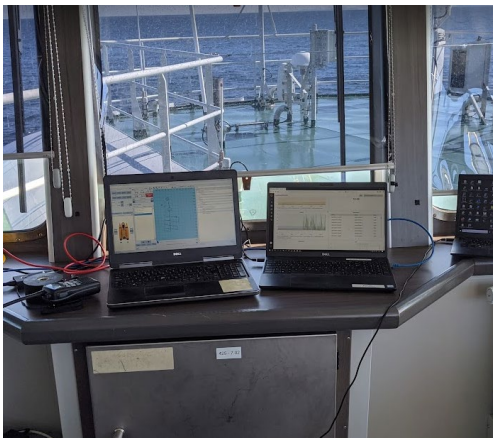


Figure 24. Based on the KPH

Figure 25. programming

7.5.4.2 Comments:

The pilot control unit is installed in the observation room, and the modem box is installed outside of the room, on deck 8. An ethernet link was set up between the inside of the room and an outside relay. The power supply is separated between the two boxes.
The source of the logging issue was identified: the udp stream must be short to be integrated into the PAMELi db. Parsing data should improve the process.

7.5.4.3 Time schedule:

Time (local)	Action
09h00	Arrival on KPH
09h30	Police visit
10h30	Safety meeting
11h30	Lunch
12h30	Work on PAMELi
13h30	Crew meeting, presentation of the project
14h00-16h00	Ethernet and electrical setup of the base
16h00	tests
17h00	Very early diner
19h00	Guiliana Conference
20h00	Improvement of the code

7.5.5 30/04/2023

7.5.5.1 Objectives:

- Validation of the UDP log.

- Tests of the water sampler
- Deployment of PAMELi for testing

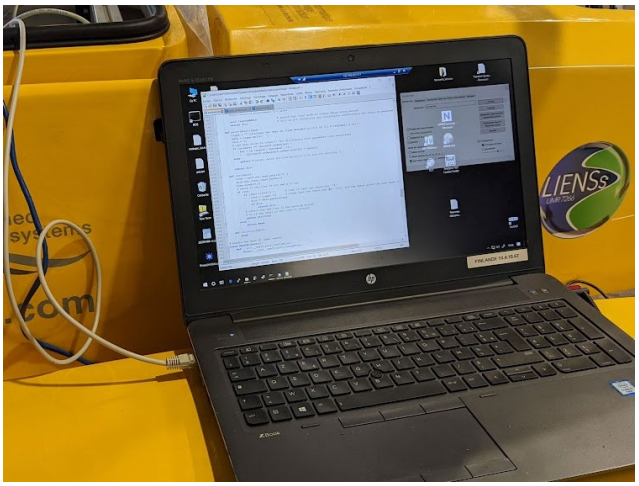


Figure 26. work on PAMELi DB

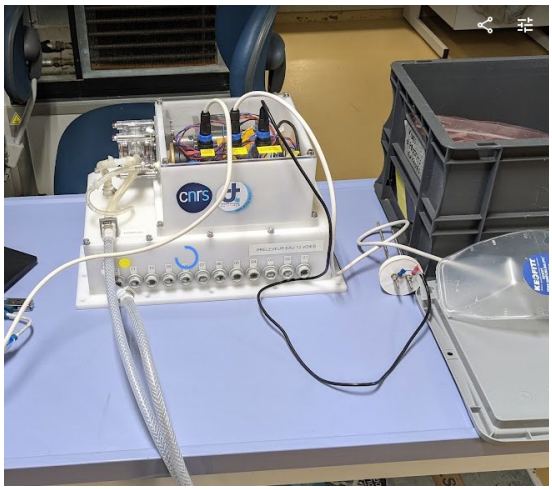


Figure 27. tests of the sampler

7.5.5.2 Comments:

A new UDP logging program was developed. It finally works well; we will now work on the data visualization to have a nice view during data acquisition.
The sampler is ready and will be installed on PAMELi in case of surface water needs (1h work). This could be an interesting solution if we find surface water with evidence of an oil leak.

7.5.5.3 Time schedule:

Time (local)	Action
08h00	Work on the PAMELi db
10h00	New recovery system for PAMELi
12h30	Tests on the sampler
17h00	Validation of PAMELi logging

7.5.6 01/05/2023 – Deployment 1

7.5.6.1 Objectives:

- Deployment of the PAMELi, stbd side. {"latitude": 70.68638966666667, "longitude": 18.468559833333334}
- Measurement of surface waters / NO SAGE DATA!
- Coordination with the captain

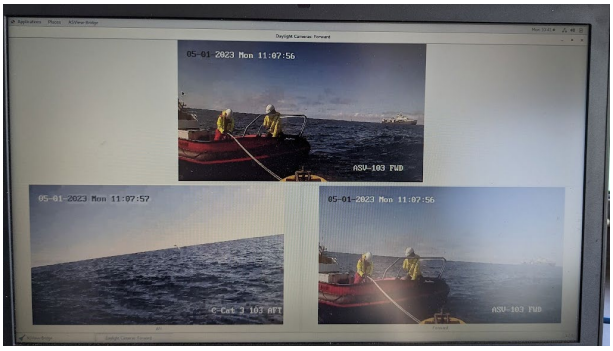


Figure 28. recovery

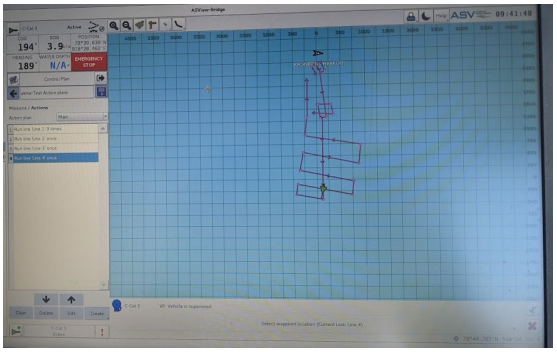


Figure 29. Navigation and range tests

7.5.6.2 Comments:

The port battery was lower, but both seemed to balance during the day. At 12h20, the starboard battery dropped from 50 to 5% and we decided to stop the acquisition. PAMELi was on the deck at 13h00. The pH sensor has drifted over 11, as the new sensor didn't arrive before the AKMA Cruise, we don't have any solution to that issue. The sensor was placed in water to re-hydrate.

7.5.6.3 Time schedule:

Time	Action
08h00	Preparation of the deployment
11h00	PAMELi in water
11h10	Seagul attack
11h30	Profil max range 3km ok
11h45	Different types of profiles
12h17	Panne batterie tribord
13h00	PAMELi rinse and battery check.
14h00	Work on SAGE data input
19h00	Test with the sage after the last ROV dive

7.5.7 02/05/2023

7.5.7.1 Objectives:

- No objectives today due to bad weather conditions
- Transit to north station

7.5.8 03/05/2023

7.5.8.1 Objectives:

- Automatic data treatment work
- Sage deployment if possible

7.5.8.2 Comments:

We worked on the automatic data treatment for mapping sea surface parameters. 1s sampling was defined and a python loop was developed by Aurelien Pira. We prepared the Grafana browser for real-time visualization and data reading.

7.5.8.3 Time schedule:

Time (local)	Action
08h00	Work on the automatic treatment
12h00	Grafana improvement
17h00	Automatic mission naming

7.5.9 04/05/2023 – Deployment 2

7.5.9.1 Objectives:

- Deployment of the PAMELi. {"latitude": 73.82316266666666, "longitude": 16.411388666666667}
- Sage measurement /Methane interpretation
- Sage deployment on the ROV

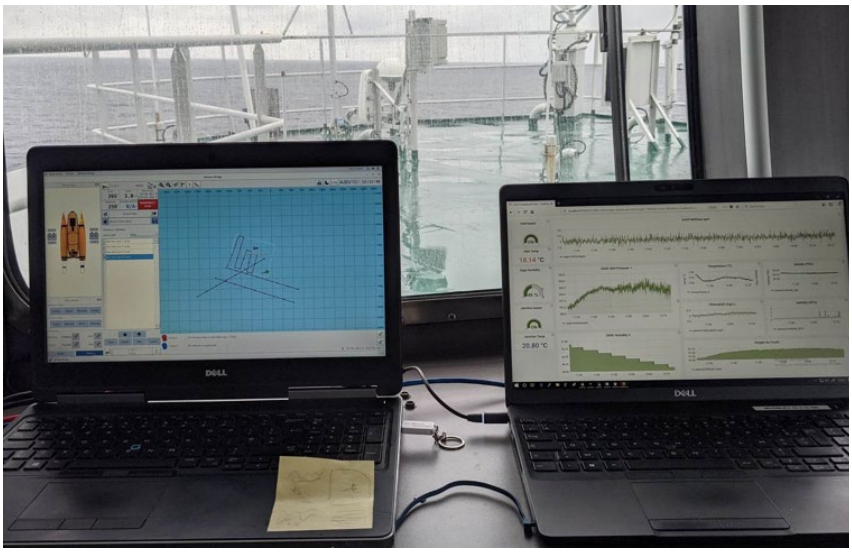


Figure 30. data acquisition.

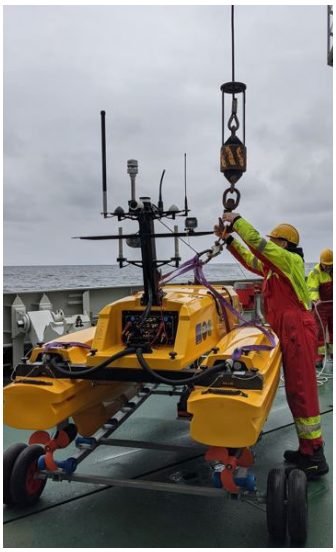


Figure 31. deployment with SAGE.

7.5.9.2 Comments:

Everything works perfectly. We are able to pilot the SBE pump and we have a direct view of the SAGE data stream. The sage data are timestamped and georeferenced in the LIENSs database. This is a huge

improvement for data visualization and logging. The PAMELi navigated well in the wavy condition, the limit was the recovery. The Ph sensor is unusable.

7.5.9.3 Time schedule:

Time (local)	Action
08h00	Deployment preparation
09h00	SAGE tests on PAMELi
10h00	Start of the survey
14h30	Travel back to the KPH
15h00	PAMELi on the deck
15h30	SAGE transfer to the ROV
16h00	Data treatment

7.5.10 05/05/2023 – Deployment 3

7.5.10.1 Objectives:

- Deployment of the PAMELi, {"latitude": 74.71410783333333, "longitude": 17.064038}
- Measurement of methane

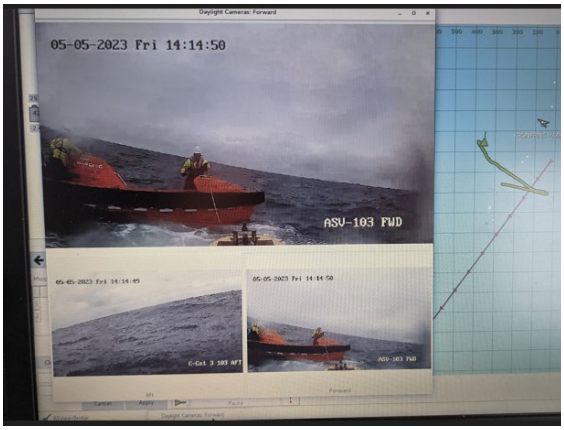


Figure 32. recovery

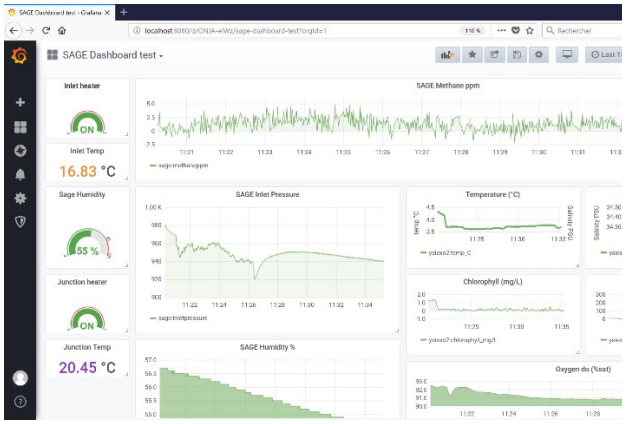


Figure 33. real-time data acquisition.

7.5.10.2 Comments:

First, the weather went bad. Then, the weather improved, and we decided to deploy PAMELi. Then the pilot computer didn't start at all. We spent 2 hours opening the computer and the repair worked! The PAMELi was launched, and we measured a nice signal of methane (compared to the last day). We can see some changes during the profiling session.

7.5.10.3 Time schedule:

Time (local)	action
08h00	Preparation of PAMELi
10h00	Cancel the deployment
11h00	Program the deployment
11h00	Computer fail
13h00	Computer repaired
13h28	PAMELi deployment

16h15	PAMELi towed
16h26	PAMELi on the deck
17h00	SAGE installation on ROV
18h00	Data treatment

7.5.11 06/05/2023

No deployment due to non-PAMELi weather conditions.

7.5.12 08/05/2023

No deployment, same site as 07/05.

7.5.13 09/05/2023 – Deployment 5

7.5.13.1 Objectives:

- Deployment of the PAMELi, {"latitude": 71.40964333333334, "longitude": 20.432873666666662}

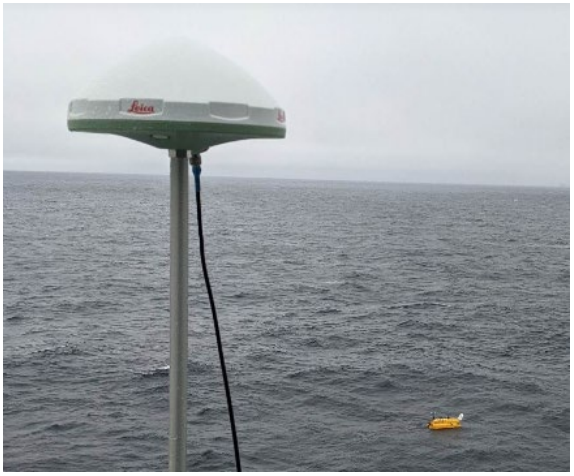


Figure 34. PAMELi and the GNSS antenna

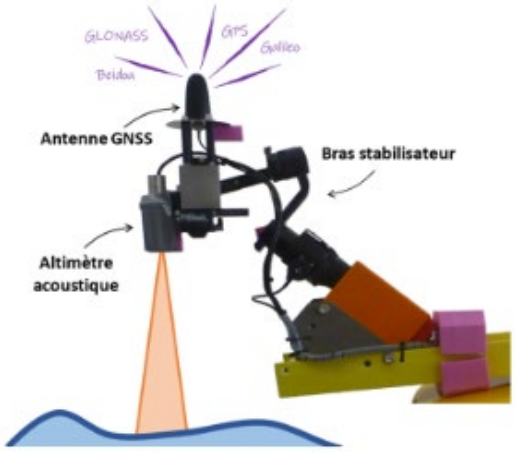


Figure 35. The cyclopée system

7.5.13.2 Comments:

With a 200m depth, we didn't have a huge variation of methane at the surface. However, we can notice that the methane concentration in different sites seems directly linked to the water depth. The best methane surface variation we observed was 05/05, where the depth was 100m. The surface process could explain such water homogenization, as waves and wind create strong horizontal and vertical movements.

This last station was the opportunity to deploy "CYCLOPEE", which is a system developed to measure sea surface height at the centimetre scale. We also installed a GNSS antenna on the KPH to test new GNSS-reflectometry methods. These new uses of GNSS signal could be a great tool to measure water height, but also humidity, sea state, surface processes, etc.

7.5.13.3 Time schedule:

Time (local)	Action
08h00	PAMELi on the deck
08h30	Deployment
09h00	Survey
14h00	End of survey

7.6 SAGE

7.6.1 SAGE ROV Deployment Methodology

SAGE was mounted on the rear basket of the ROV Aurora using hose clamps. The cabling and tubing were well-secured using zipties. The vehicle supplied 24V DC power to SAGE for all dives before and including those on 3/5/2023, and 48V DC for all dives after 3/5/2023. During ROV deployment, SAGE provided power to a Seabird 5T pump, which pumped water past the membrane inlet. The pump was supplied power 30 seconds after the instrument powered up.

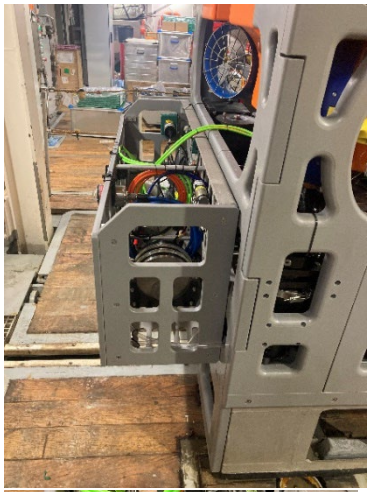


Figure 36. Upper Up: The rear basket of the Aurora ROV, where SAGE was mounted Upper Middle: Detail of SAGE in the basket. The Seabird pump is in the upper left-hand corner and drew water from the tubing and pumped it past SAGE. Bottom: The tubing path from the sampling wand location in the front basket of the ROV to the rear basket.

To enable targeted measurements, a sampling wand was used. The wand had a handle that could be held by the ROV manipulator. When not in use, the wand was stowed in the front basket of the ROV. SAGE was continuously drawing water from the wand throughout the dives. Occasionally, the ROV cameras were turned to observe the "spinner", which indicates that water was indeed flowing past the instrument. After the first few dives, on 2/5/2023, a filter was added to the sampling wand, which was effective in preventing clogging of the wand.

Figure 37. Up: The first version of the sampling wand for SAGE. Bottom: The improved sampling wand for SAGE, including a filter before the spinner.

SAGE was operated from the ROV by using a topside laptop computer to listen to the UDP data messages sent by the instrument on the Ethernet connection through the vehicle. The topside laptop logged the UDP messages and displayed the data using a MATLAB graphical user interface (GUI).

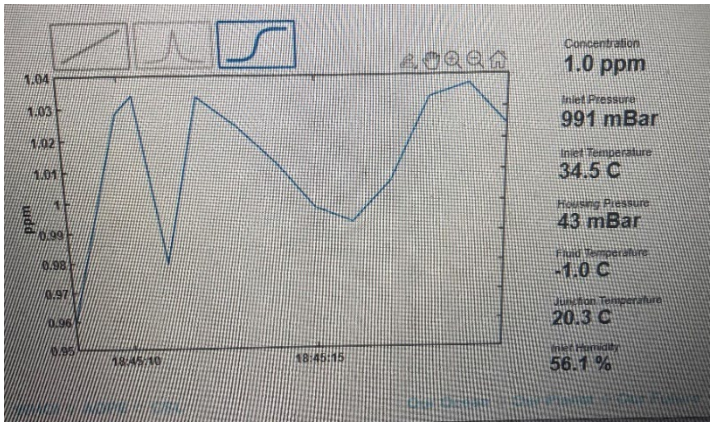


Figure 38. The MATLAB GUI for Sage, from which a continuous log of methane measurements could be observed from the ROV control room. Diagnostic information was also displayed, allowing for troubleshooting and error detection during dives.

Before every dive, the fluid lines were primed with fresh water. Unfortunately, the configuration of the ROV prevented complete priming, because the rear basket (where SAGE was mounted) is higher than the front basket (where the wand was stowed). As a result, during the initial portion of the ROV dives, bubbles went past the instrument and caused high internal pressures of approximately 1500 mbar. The data from these higher pressures should be ignored. The instrument also likely has a thermal equilibration process. In general, after approximately 15 minutes of dive time, the instrument started responding normally.

After dives the instrument, cables, and pump were rinsed with fresh water. If there was a long time between dives, the instrument was removed from the vehicle, the flow cap removed, and the membrane dried with kimwipes. This was done to prevent humidity buildup inside the instrument, which could condense inside the instrument's hollow core fibre.

7.6.2 SAGE ASV Deployment Methodology

SAGE was also deployed on the ASV PAMELi. It was mounted on the keel beneath the vehicle. The PAMELi vehicle supplied power to a Seabird 5T pump, which pumped water past SAGE's membrane inlet. The PAMELi vehicle provided 24V DC power to SAGE and monitored SAGE's UDP messages through the ethernet connection to the scientific computer inside PAMELi. The PAMELi team set up a GUI to observe the methane data over time. As with ROV dives, the instrument, cables, and pump were rinsed with fresh water, and the membrane dried with kimwipes if there was a long time between deployments. Unlike on the ROV, the tubing supplying the instrument was relatively short, so there should not be a significant time delay beyond the sensor's characteristic time response.

Figure 39. Left: The PAMELi vehicle and SAGE are mounted beneath the vehicle. Right: Close-up of the mounting position of SAGE from the front of the vehicle.

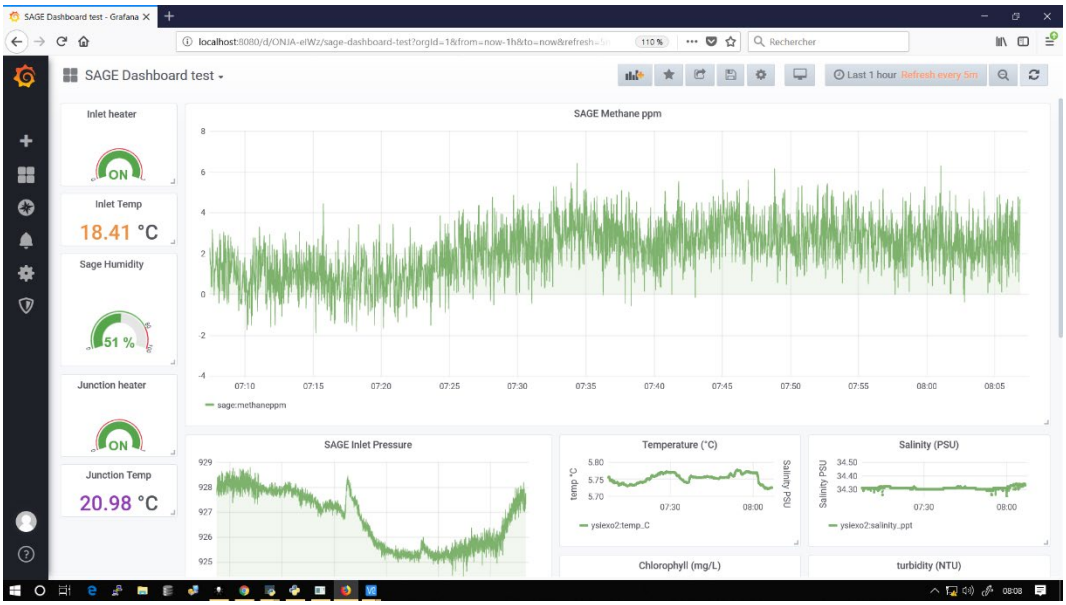


Figure 40. The data display of the live feed of methane data from SAGE on the PAMELi vehicle.

7.6.3 Onboard Performance Verification (Calibration Checks)

During the cruise, the response of SAGE to methane was verified by supplying 1000 ppm methane gas (nitrogen balance, Calgaz, +/- 2% accuracy) to the sensor and allowing it to fully equilibrate. In previous laboratory experiments, we observed that the calibration of SAGE does not change much when it operates in air versus water. A total of three calibration checks were conducted: (1) immediately after unpacking SAGE from shipping and before any deployments (2) during the cruise when SAGE was modified to operate from a 48 V supply (3) at the end of the cruise after all deployments were complete. These calibration checks serve to verify that the instrument was still working after transport to the ship after modifications were made to the instrument operation, and after all data was collected. Calibrations were performed on 29/4/2023, 3/5/2023, and 9/5/2023.

7.6.4 SAGE Deployments

Sage was deployed four times on the ASV PAMELi and 12 times on the ROV Aurora. Methane measurements were successfully collected from all eight superstations studied during AKMA3. Overall,

this cruise was very successful in collecting high-quality data from SAGE. Methane measurements ranged between nominal atmospheric levels, to beyond the measurement range of the sensor (27,000 ppm). We observed methane dynamics at cold seep habitats with high spatiotemporal resolution.

7.7 Drone surveys

Survey number	Super Station	Date	Duration	Average speed (m/s)
1	Håkjerringdjupet	01-05	45’ 03”	0.8
2	Outer Bjørnøyrenna	08-05	29’ 48”	0.6
3	Snøhvit gas field	09-05	20’ 44”	1.1

Table IX. Table reporting the main information regarding the drone surveys conducted during the AKMA3 cruise.

During this cruise, we conducted 3 drone surveys aiming at investigating some potential oil slicks found on satellite data (Table IX). The ship helideck was used as take-off and landing points and the surveys were conducted during contemporaneous ROV and PAMELi dives. The naked-eye observations from the bridge indicated the occurrence of some elongated shiny stripes resembling thin oil veneers but no color changes were visible. We flew the drone down to ~10 m from the sea surface to acquire data with the highest resolution possible. Neither the visual nor the infrared cameras provided conclusive evidence for the presence of oil on the sea surface. A sample was collected from the sea surface on one of those features at the Snøhvit gas field (drone survey 3; Figure 41), and future chemical analyses will reveal whether it contains any amount of oil.

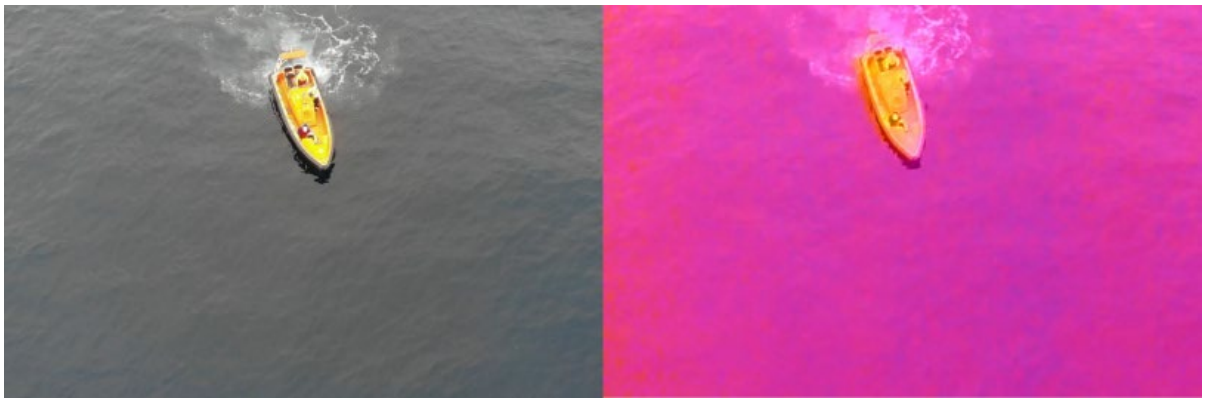


Figure 41. Visual (left side) and infrared (right side) images showing the water sampling from the sea surface on a potential oil slick. The sea surface temperatures reported by the thermal camera ranged between 19 and 21℃ with no spatial patterns (no colour variations in the infrared image), whereas the rubber boat created an evident hotspot. The rubber boat is 6 m long and provides the scale for this picture.

8 Maps of the study site samples

Examples of water column data interpretations done on bard that guided the ROV dives.

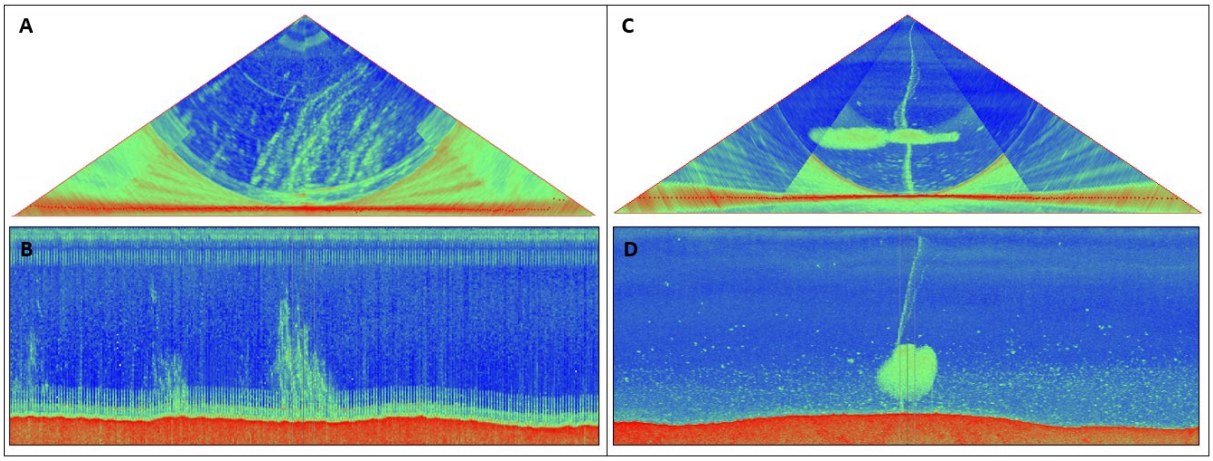


Figure 42. A, B) WCD-line 0011 from SS1 (EM302). A) Fan view of many gas flares in the water column at the site of Dive 1. B) R-Stack along ship track crossing SS1. Water depth: ~120-130 mbsl. C, D) WCD-line 0003 from SS2 (EM710). C) Fan view of gas flare in the water column at the site of Dive 2 and 3. This flare is associated with the site of exploration well 7018/5-1. Notice «biological noise» in the data partly obscuring the gas flare, most likely representing a large fish shoal. D) R-Stack along ship track crossing SS2. Water depth: ~300 mbsl.

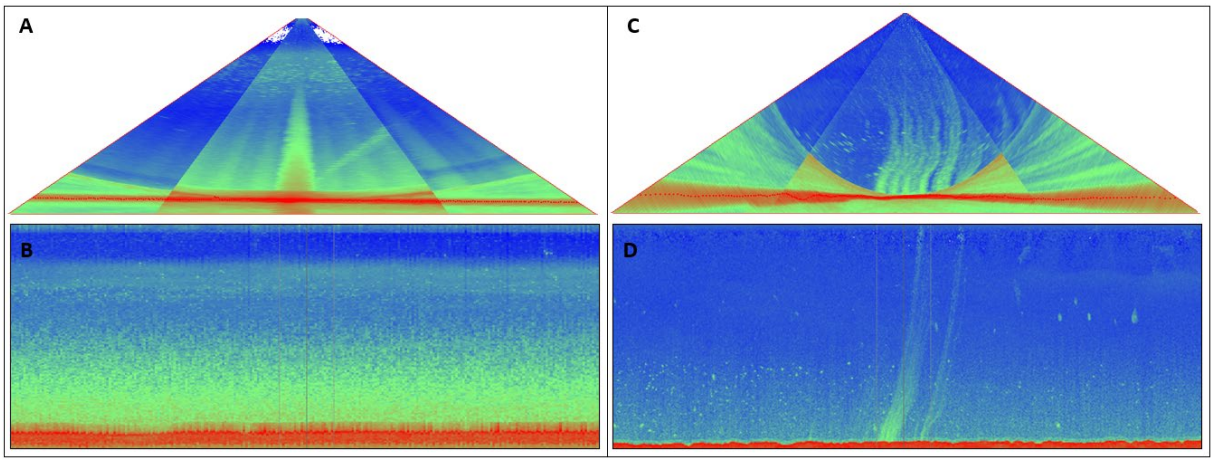


Figure 43. A, B) WCD-line 0110 from SS3 (EM710). A) Fan view of gas flare in the water column at the site of Dive 4 and 5. The flare is deviating from the centre to the right. Notice much noise in the data due to EM710 used in deep water. B) R-Stack along ship track crossing SS3. All the noise makes it impossible to notice the flare. Water depth: ~1200 mbsl. C, D) WCD-line 0159 from SS4 (EM710). C) Fan view of several gas flares in the water column at the site of Dive 6, 7 and 8. D) R-Stack along ship track crossing SS4. Water depth: ~375 mbsl.

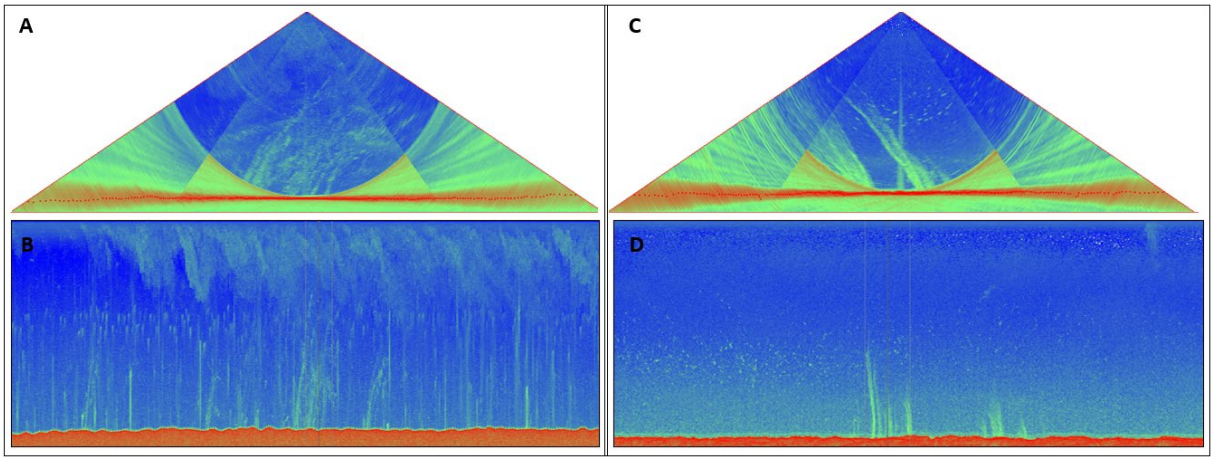


Figure 44. A, B) WCD-line 0217 from SS5 (EM710). A) Fan view of many gas flares in the water column at the site of Dive 9 and 10. B) R-Stack along ship track crossing SS5. Water depth: ~140 mbsl. C, D) WCD-line 0163 from SS6 (EM710). C) Fan view of gas flares in the water column at the site of Dive 11 and 12. D) R-Stack along ship track crossing SS6. Water depth: ~360 mbsl.

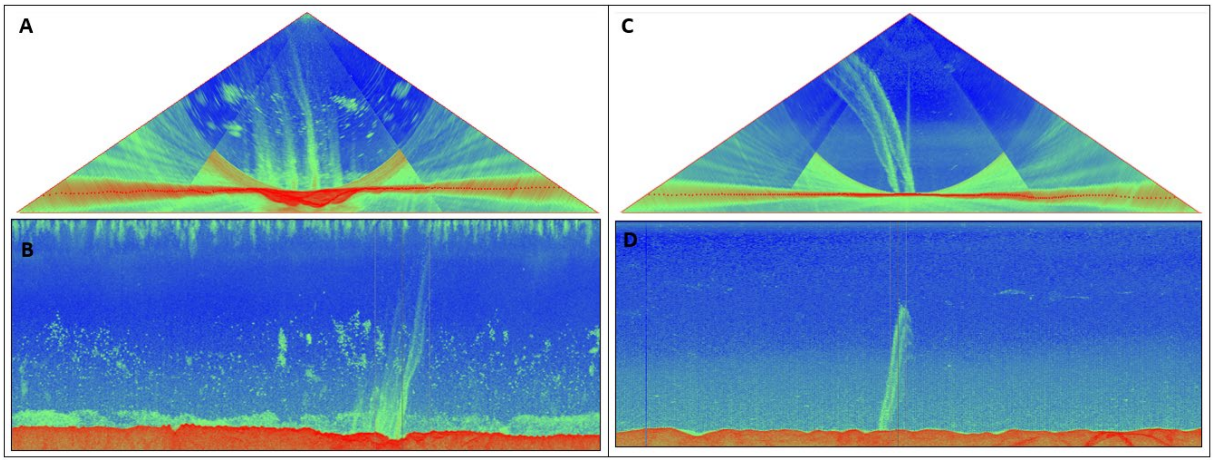


Figure 45. A, B) WCD-line 0341 from SS7 (EM710). A) Fan view of gas flares in the water column at the site of Dive 13, 14, 15 and 16. Notice depression at the seafloor at the location of the largest flare. «Biological noise» in the water column most likely mostly represents fish. B) R-Stack along ship track crossing SS7. Water depth: ~380 mbsl. C, D) WCD-line 0453 from SS8 (EM710). C) Fan view of two strong gas flares in the water column at the site of Dive 17, 18, and 19. The flares are associated with the location of exploration well 7120/8-1. D) R-Stack along ship track crossing SS8. Water depth: ~270 mbsl

8.1 SS1 (Fugløybanigen) map

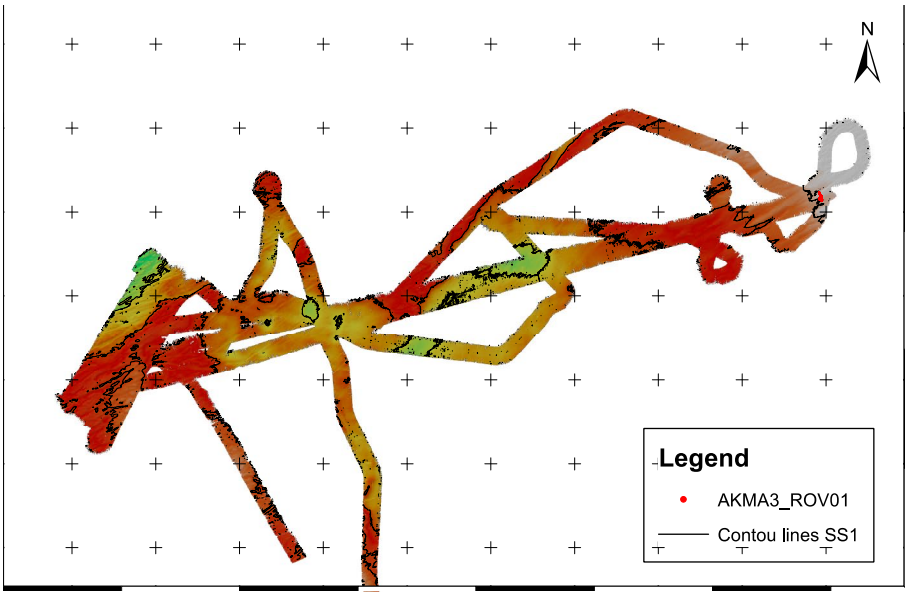


Figure 46. General map of SuperStation1 illustrating ROV01 survey area.

8.2 SS2 (Håkjerringdjupet expl well 7018/5-1) map

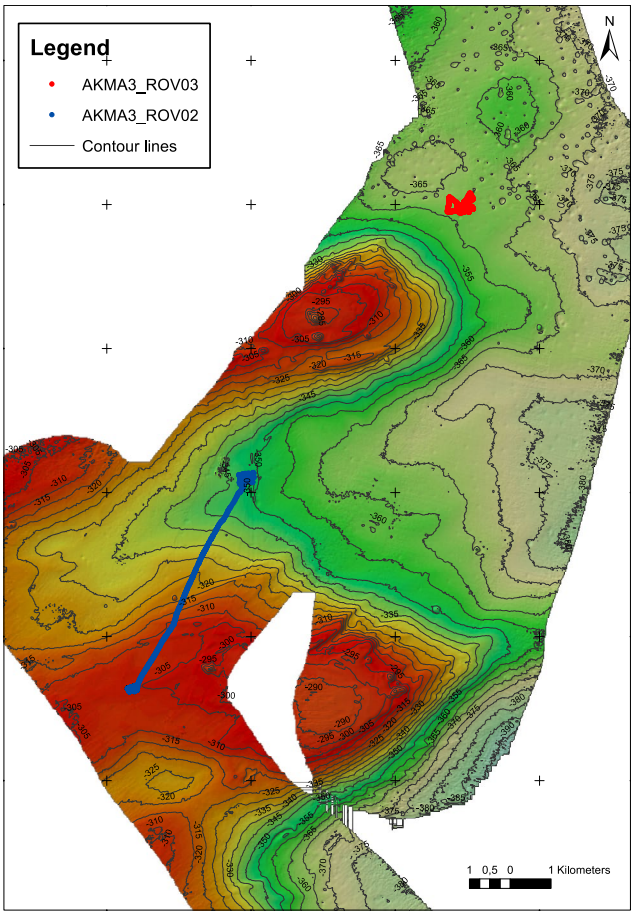


Figure 47. General map of SuperStation2 illustrating ROV02 and ROV03 survey area.

8.3 SS3 (Vestbakken slope) map

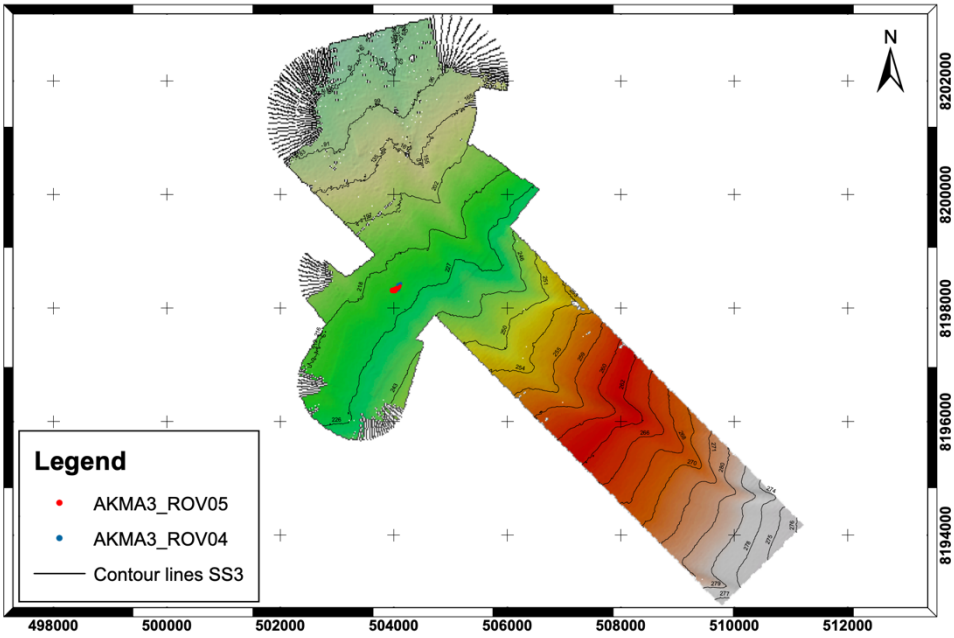


Figure 48. General map of SuperStation3 illustrating ROV04 and ROV05 survey area.

8.4 SS4 (Western Vestbakken shelf) map

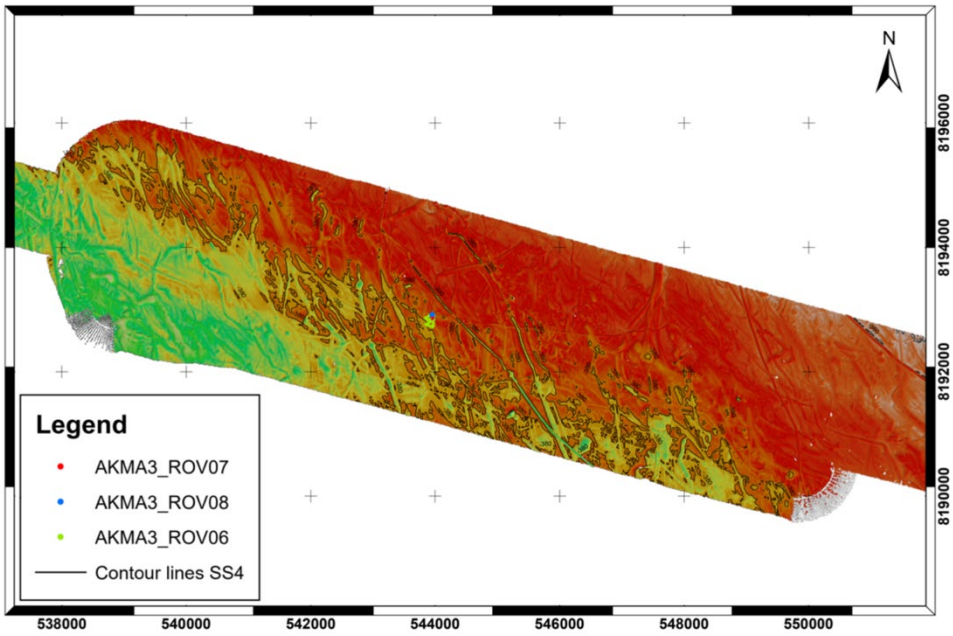


Figure 49. General map of SuperStation4 illustrating ROV06, ROV07 and ROV08 survey area.

8.5 SS5 (Kveithola flank) map

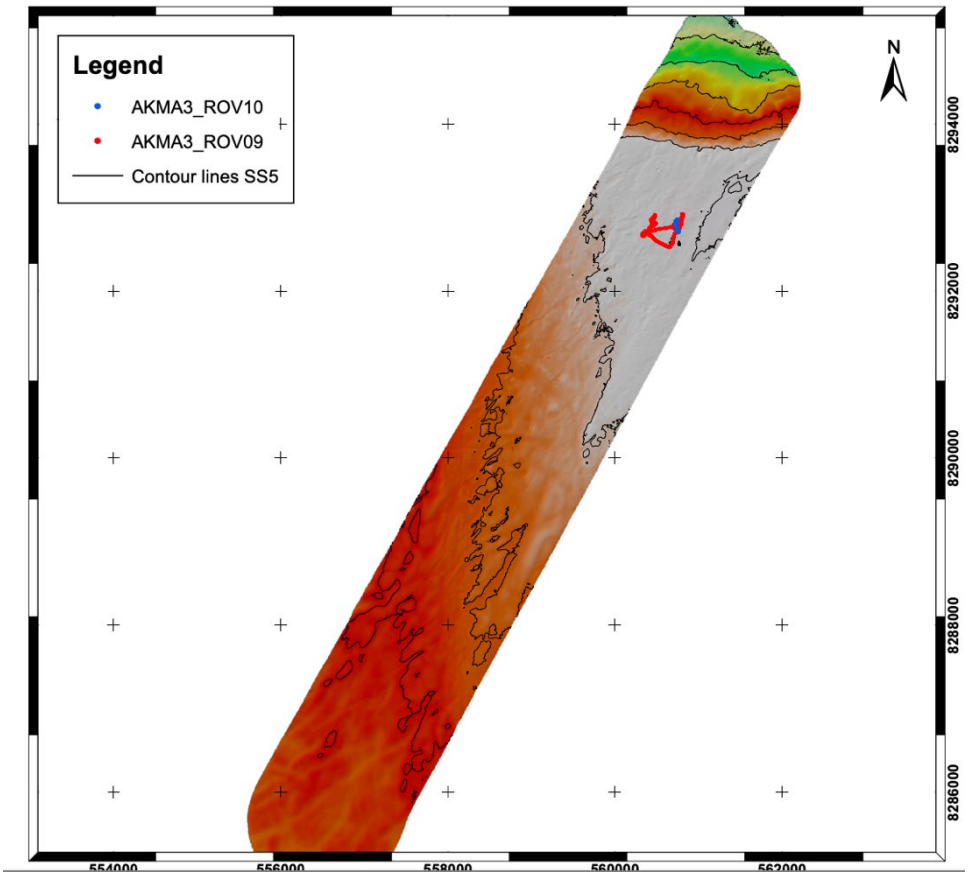


Figure 50. General map of SuperStation5 illustrating ROV09 and ROV10 survey area.

8.6 SS6 (Eastern Vestbakken shelf) map

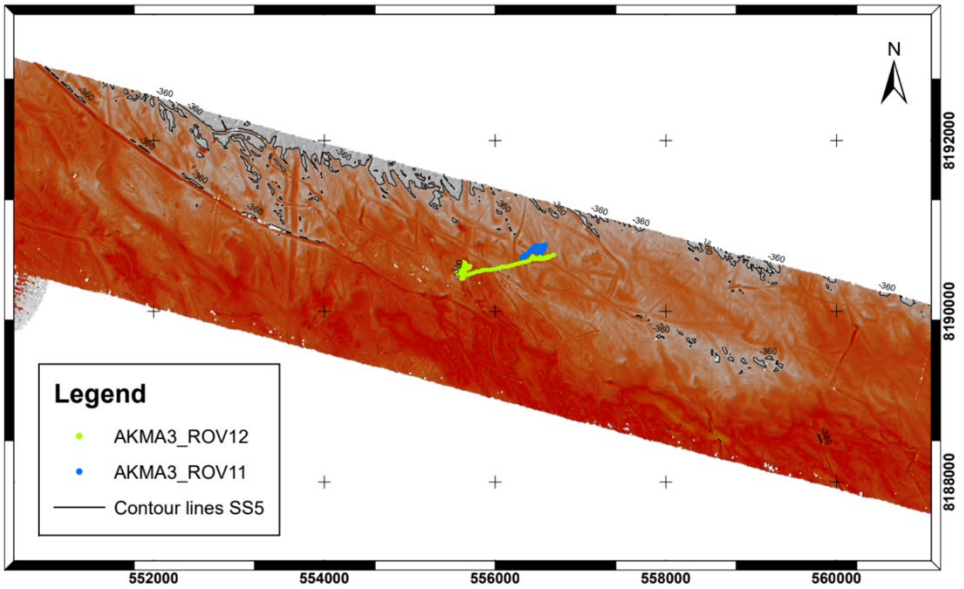


Figure 51. General map of SuperStation6 illustrating ROV11 and ROV12 survey area.

8.7 SS7 (Outer Bjørnøyrenna) map

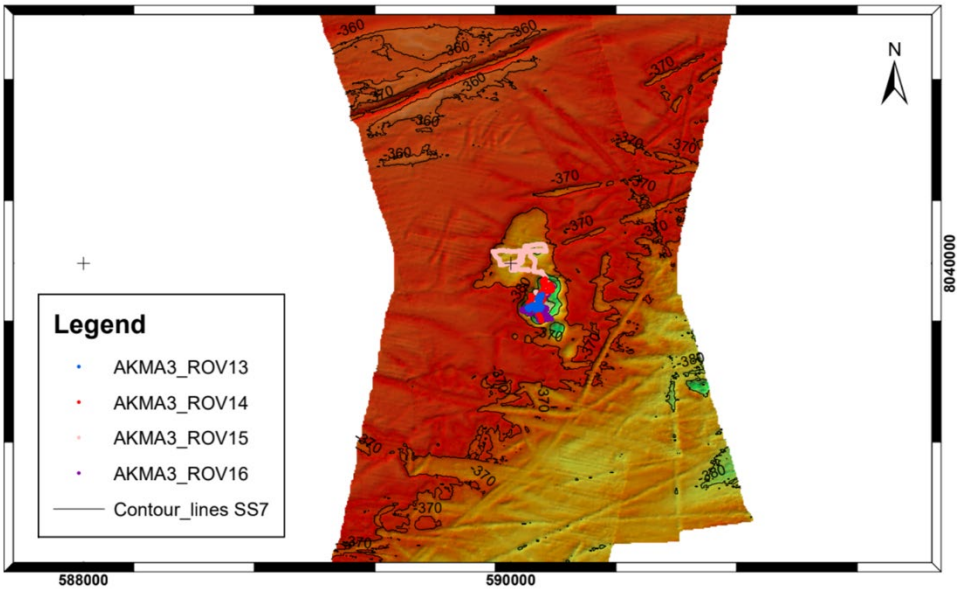


Figure 47. General map of SuperStation7 illustrating ROV13, ROV14, ROV15 and ROV16 survey area.

9 Media and Outreach

In an age where researchers are often required to demonstrate the impact of their work, engaging with the media matters. As dedicated research expeditions focused on student training in research methods, the AKMA 3 media strategy aimed at three main goals.
Connect public communities. We are convinced that public engagement enriches the research process and helps academics to become better teachers. So, we mainly used media as a bridge between the university and the outside world in order to talk to and become more visible in different public communities. Students, schools (elementary, middle and high level) and artists have been among our main targets.

Raise awareness. As scientists, we know that we can produce excellent research with profound and important findings – but if the only people who know about it are other experts in your own field, important practical applications are likely to be missed. Above all, we used media to explain and make clear the social and environmental implications of our research.
And inspire future generations. Engaging with the media can convey the wonder of research and the crucial role of science in society. It may even inspire the next generation. In this regard, we privileged online media channels - as social networks - which are popular among the younger ones and are based on visual storytelling. The use of pictures, illustrations and videos have been our tools to tell science to the youngest.

9.1 Outreach

During the AKMA3 Expedition, outreach activities have been developed in order to generate enthusiasm and interest in research expedition with students and to gain a deeper understanding of science and its applications.
Since we were conducting research on board the vessel, the only possible outreach activities were created by using online tools. ZOOM meetings and Instagram have been our privileged platforms to disseminate and share our knowledge.
Despite the technical difficulties in accessing the internet, nine of our researchers on board managed to connect with eight schools from all over the world (Tanzania, Portugal, Italy, Switzerland, Iran, Perú, Greece and Singapore). Using Zoom Meetings, they manage to give short science lessons and share

some great images from the bottom of the sea with kids beyond the screen. It was a great way to share their knowledge and experience from the vessel to the rest of the world.
Likewise, Instagram has allowed us to visually tell the AKMA3 expedition. Our communication advisor on board helped the team to update a dedicated Instagram page (@akma_project) with visual narratives and storytelling about the protagonists of this expedition.
During the AKMA3 expedition, a professional from OiOiOi, Kjetel Skardal Andersen, joined to document via pictures and videos the activities performed. The material will be used to edit some short stories post-cruise that will focus on highlights from the cruise, student work and the ROV team.

9.2 Zoom meetings

During the expedition, the scientists and early career scientists provided seminars to schools and research institutes around the world. During the Zoom meetings, we showed life-feed images from the seafloor to the participants and explained the scientific work that we were doing. This interaction with schools and communities had a really meaningful impact on all involved. The pupils that we connected with were very enthusiastic and asked many questions about science and life onboard a research vessel.

Date	Time	Name	Audience
2 May	13:00-13:30	Giuliana Panieri & Juliana Hayden	Tanzania WaterHUB-AKMA_EcoCare
3 May	10:00-10:45	Sofia Ramalho	Call the 1st grade/kindergarten students (prof. Carla Fernandes) of Jardim de Infância de Azurva, Portugal
	12:00-13:00	Claudio Argentino	University of Modena and Reggio Emilia, Dept. Chemical and Geol. Sciences_ Daniela Fontana + IESS Reggio Emilia (high school) _Barbara Callerani
	16:00-16:45	Sofia Ramalho	Call the students (prof. Sandra Pires) from the 5th/6th grade of Escola Básica e Secundária de Mora, Portugal
4 May	9:40-10:15	Ines Barrenechea	Call with High-school students in Geneva (Jonas Rufener)
5 May	11:00-12:00	Sofia Ramalho	Call with high-school students (prof. Hélder Pereira) from the 11th grade of Escola Secundaria de Loulé, Algarve, Portugal)
7 May	12:30-13:00	Fereshteh Hemmateenejad	High-school students in Iran (11th grade – Human and Environment lecture)
8 May	9:00-9:45	Ines Barrenechea	Call High-school students from Huaraz, Peru´
9 May	10:45 11:30	Vasw Petsakou	Call with a student from 109th Primary School of Athens, Odysseas Elytis
	12:00-12:30	Yan Yu Ting, Ton Yun Fann & Giuliana Panieri	Singapore - Earth Observatory of Singapore, Nanyang Technological University and The Norwegian Embassy in Singapore
	15:30-16:30	Fereshteh Hemmateenejad	Students from the Department of Geosciences, Shiraz University, Iran

10 Data management

All the data collected during this expedition and work in progress will be deposited at the UiT Dataverse. Geographical species records of fauna will be deposited in Artskart (https://artskart.artsdatabanken.no) and GBIF (https://www.gbif.org). DNA barcodes of fauna will be deposited in the BOLD Public Data Portal (www.boldsystems.org) and NCBI GenBank (https://www.ncbi.nlm.nih.gov/genbank/).

11 Acknowledgements

We would like to thank the Officers and Crew of the RV *Kronprins Haakon* for the assistance at sea. We are also grateful to all cruise participants for the passion, great professionalism and efficiency demonstrated during the expedition. We thank the Aurora ROV team for their competence. From REV Ocean we wish to thank Eva Ramirez, Lawrence Hislop and Øystein Mikelborg, At the Department of Geosciences, we thank Truls Holm for the support at sea, Simon Sagelv Bjørvik for the support with the logistics, Fabio Sarti for the data management and all the administrative staff for the constant support. The AKMA project is funded by the Norwegian Research Council, n. 287869 - Advancing Knowledge on Methane in the Arctic (AKMA): Norway-USA Collaboration. The shipping time is provided by UiT. We thank NPD for the financial support.

11.1 SAGE Acknowledgements

This deployment of SAGE would not have been successful without the tireless efforts of many others. We thank the captain and crew of the Kronprins Haakon, especially for their help during launch and recovery efforts. We thank the REVOcean ROV team and the PAMELi team, for their support in integrating SAGE with their vehicles and during deployments. Thank you very much to the chief scientists Giuliana Panieri and Stefan Bünz, as well as the scientific team onboard. A special thank you to Bjørn Olsen, Matteus Lindgren, and Truls Holm for their support and for lending calibration gas and a critical cable needed to connect SAGE to the ROV. Finally, the SAGE instrument would not exist without the development efforts from the Chemical Sensors Laboratory at WHOI. Particularly, Jason Kapit, the lead engineer on the project, William Pardis, the electrical engineer, Sarah Youngs, the laboratory tester, and Anna Michel, the principal investigator of the laboratory.

12 Appendix

Table X. ROV logs.

Dive Name	Super Station	Location	Local coordinates		main activity	date	time start	time end	total diving time	Sage on ROV	USBL start	USBL end
			Lat	Long								
ROV01	AKMA3-SS1	Fugloybanken	70.4079°	17.8811°	Exploration & sampling + SAGE	30/04/23	7:54	11:12	3h18min	yes	07:56	11:08
ROV02	AKMA3-SS2	Hakjerringdjupet exploration well 7018/5-1	70.6739°	18.4451°	Exploration & sampling + SAGE	01/05/23	6:59	14:40	7h40min	yes	07:00	07:40
ROV03	AKMA3-SS2	Hakjerringdjupet exploration well 7018/5-1	70.7028°	18.5119°	Exploration & sampling + SAGE	01/05/23	15:26	18:05	2h34min	yes	15:26	18:02
ROV04	AKMA3-SS3	Vestbakken slope	73.8771°	15.1302°	Exporation & mosaic + SAGE	03/05/23	6:38	12:20	5h42min	yes	07:25	12:14
ROV05	AKMA3-SS3	Vestbakken slope	73.8771°	15.1302°	Exporation & sampling	03/05/23	14:23	18:19	3h56min	no	14:18	17:55
ROV06	AKMA3-SS4	Western Vestbakken shelf	73.8234°	16.4131°	Exploration & sampling	04/05/23	6:40	11:05	4h35min	no	06:39	11:05
ROV07	AKMA3-SS4	Western Vestbakken shelf	73.8234°	16.4136°	Exploration & sampling	04/05/23	11:55	13:30	1h35min	no	11:57	13:31
ROV08	AKMA3-SS4	Western Vestbakken shelf	73.8236°	16.4140°	SAGE measurements & sampling	04/05/23	14:40	17:50	3h10min	yes	15:11	17:47
ROV09	AKMA3-SS5	Kveithola flank	74.7139°	17.0653°	Exploration & sampling	05/05/23	6:36	13:05	6h29min	no	06:37	12:59
ROV10	AKMA3-SS5	Kveithola flank	74.7147°	17.0644°	SAGE measurment - 4k camera test for mosaic	05/05/23	14:51	17:55	3h4min	yes	14:53	17:50
ROV11	AKMA3-SS6	Eastern vestbakken shelf	73.8016°	16.8152°	exploration/sampling/measurements + SAGE	06/05/23	6:23	11:10	4h47min	yes	06:21	11:15
ROV12	AKMA3-SS6	Eastern vestbakken shelf	73.8006°	16.8208°	exploration & samplling + SAGE	06/05/23	12:03	17:20	5h17min	yes	12:05	17:22
ROV13	AKMA3-SS7	Outer Bjornoyrenna	72.4382°	17.6774°	exploration & samplling + SAGE	07/05/23	7:07	10:30	3h23min	yes	07:07	10:34
ROV14	AKMA3-SS7	Outer Bjornoyrenna	72.4382°	17.6774°	exploration & sampling + SAGE	07/05/23	12:29	15:05	2h36min	yes	12:36	15:05
ROV15	AKMA3-SS7	Outer Bjornoyrenna	72.4382°	17.6774°	exploration & sampling + SAGE	08/05/23	7:00	10:50	3h50min	yes	06:59	10:50
ROV16	AKMA3-SS7	Outer Bjornoyrenna	72.4382°	17.6774°	exploration & sampling + SAGE	08/05/23	12:15	17:30	4h15min	yes	12:16	17:33
ROV17	AKMA-SS8	Snøhvit gasfield	71.4096°	20.4333°	exploration & sampling	09/05/23	06:55	08:55	2h	no		
ROV18	AKMA3-SS8	Snøhvit gasfield	71.4354°	20.4333°	exploration & bio-sampling	09/05/23	10:15	11:37	1h22min	no		
ROV19	AKMA3-SS8	Snøhvit gasfield	71.3815°	20.4452°	gas sampler - carbonate collection	09/05/23	12:30	14:15	1h45min	no		

Table XI. Sediment samples and sub-samples.

Superstation	Location	Sample code	ROV Dive No.	Date	Time	Latitude (positions are not accurate)	Longitude (positions are not accurate)	Water depth (m)	Micro-habitat	Photo in shared folder	Pore-Water (UiT)	Headspace (UiT)	Sediment geochemistry	Sediment biomarkers (NPD) - 20C	Microbiology (UiB)	Meiofauna/Micro paleontology (UiT/U. Aveiro)	Living Forams (UiT) + CGT + TEM	eDNA (UiT)	Macrofauna (UiB)	Macrofauna (OceanCensus)	Diatoms (Uaveiro)	Microplastics (UiT)	DNA Propagle (YaleU)
KH02	Håkjerring djupet	AKMA3-ROV02-PusC-02	2	01/05/23	00:19:00	70,6739	18,4452	304	mat(?). Partially lost at seafloor		X			x		x		x					
KH02	Håkjerring djupet	AKMA3-ROV02-BlaC-02	2	01/05/23	00:31:00	70,6739	18,4451	305	light-grey sediment		x	x	x		x	x		x	x				
KH02	Håkjerring djupet	AKMA3-ROV02-BlaC-03	2	01/05/23	12:58:00	70,6739	18,4448	301	reference		x	x	x		x	x		x	x				
KH02	Håkjerring djupet	AKMA3-ROV02-PusC-03	2	01/05/23	13:11:00	70,6739	18,444	303	reference		X	x				x	x	x	x				
KH02	Håkjerring djupet	AKMA3-ROV02-PusC-01	2	01/05/23	13:22:00	70,6737	18,4453	302	close to basket							x							
KH02	Håkjerring djupet	AKMA3-ROV02-PusC-s1	2	01/05/23	13:26:00	70,6738	18,4452	298	small puschcore REV; reference													x	
KH02	Håkjerring djupet exploration well	AKMA3-ROV03-PusC-C2	3	01/05/23	16:17:00	70,702500	18,5128	359	small puschcore REV marked "C2"							x							
KH02	Håkjerring djupet exploration well	AKMA3-ROV03-PusC-01	3	01/05/23	17:25:00	70,702800	18,5119	360					x			x		x					
KH02	Håkjerring djupet exploration well	AKMA3-ROV03-PusC-02	3	01/05/23	17:31:00	70,702800	18,5119	360					x			x		x					
KH02	Håkjerring djupet exploration well	AKMA3-ROV03-BlaC-01	3	01/05/23	17:43:00	70,702800	18,5119	360	2 anemonies, 1 rock				x			x		x					
KH03	Vestbakken slope	AKMA3-ROV04-BlaC-03A	4	03/05/23	07:59:00	-	-	1212	microbial mat		x	x	x		x	x		x	x		x		
KH03	Vestbakken slope	AKMA3-ROV04-BlaC-03B	4	03/05/23	07:59:00	-	-	1212	microbial mat							x							
KH03	Vestbakken slope	AKMA3-ROV04-PusC-C5	4	03/05/23	08:02:00	-	-	1206	small corer; microbial mat							x							
KH03	Vestbakken slope	AKMA3-ROV04-PusC-01	4	03/05/23	08:05:00	-	-	1204	microbial mat; fell off (upside-down); only for macrofauna (UiB)										x				
KH03	Vestbakken slope	AKMA3-ROV04-BlaC-02	4	03/05/23	08:14:00	-	-	1189	tubeworms		x	x	x		x	x		x	x				
KH03	Vestbakken slope	AKMA3-ROV04-PusC-02	4	03/05/23	08:22:00	-	-	1203	tubeworms				x			x	x						
KH03	Vestbakken slope	AKMA3-ROV04-PusC-C8	4	03/05/23	08:26:00	-	-	1203	small corer; tubeworms							x							
KH03	Vestbakken slope	AKMA3-ROV04-PusC-03	4	03/05/23	09:34:00	-	-	1215	reference		x		x			x	x	x					
KH03	Vestbakken slope	AKMA3-ROV05-BlaC-01	5	03/05/23	16:15:00	73,877100	15,1302	1200	Blade core on mud, tubeworms and BM	x	x		x	x	x	x		x	x				
KH03	Vestbakken slope	AKMA3-ROV05-PusC-C5	5	03/05/23	16:31:00	73,877100	15,130500	1192	reference							x							
KH03	Vestbakken slope	AKMA3-ROV05-PusC-C8	5	03/05/23	16:32:00	73,877100	15,130500	1194	reference; inside crater								x	x					
KH03	Vestbakken slope	AKMA3-ROV05-PusC-M05	5	03/05/23	16:38:00	73,877100	15,130500	1199	core in metal case, number #5	x				x									
KH03	Vestbakken slope	AKMA3-ROV05-Scoo-01	5	03/05/23	16:43:00	73,877200	15,130400	1198	tubeworms	x									x				
KH03	Vestbakken slope	AKMA3-ROV05-PusC-C/2	5	03/05/23	17:11:00	73,877200	15,129700	1202	reference	x						x	x	x					
KH03	Vestbakken slope	AKMA3-ROV05-PusC-M03	5	03/05/23	17:14:00	73,877200	15,129600	1200	core in metal case, number #3					x									
KH03	Vestbakken slope	AKMA3-ROV05-PusC-01	5	03/05/23	17:16:00	73,877200	15,129600	1198		x	x				x			x					
KH03	Vestbakken slope	AKMA3-03-MC-01	-	03/05/23	22:28:00	73,864067	15,190617	1140	first attempt failed, second attempt worked out. 6 cores; #1 ; #2 ,#3, #4 ,#5, #6 pore water and geochemistry		x		x		x	x	x	x		x	x			x
KH04	Vestbakken shelf	AKMA3-ROV06-PusC-C8	6	04/05/23	10:12:00	73,7958	16,388800	376	microbial mat							x							
KH04	Vestbakken shelf	AKMA3-ROV06-PusC-C5	6	04/05/23	10:17:00	73,7726	16,384600	376	microbial mat							x		x					
KH04	Vestbakken shelf	AKMA3-ROV06-PusC-M3	6	04/05/23	10:22:00	73,8239	16,414600	374	microbial mat							x							
KH04	Vestbakken shelf	AKMA3-ROV06-PusC-M4	6	04/05/23	10:26:00	73,8239	16,414600	374	tubeworms							x							
KH04	Vestbakken shelf	AKMA3-ROV06-PusC-M4b (label in one side)	6	04/05/23	10:35:00	73,8239	16,414500	378	tubeworms														
KH04	Vestbakken shelf	AKMA3-ROV07-BlaC-02	7	04/05/23	12:33:00	73,8234	16,413700	377	microbial mat	x	x		x			x	x		x				
KH04	Vestbakken shelf	AKMA3-ROV07-BlaC-01	7	04/05/23	12:39:00	73,8234	16,413600	376	microbial mat	x	x	X	x		x	x	x		x				
KH04	Vestbakken shelf	AKMA3-ROV07-PusC-M07	7	04/05/23	12:44:00	73,8234	16,413600	375	microbial mat	x						x							
KH04	Vestbakken shelf	AKMA3-ROV07-PusC-01	7	04/05/23	12:49:00	73,8234	16,413600	374	mat(?)	x	x												
KH04	Vestbakken shelf	AKMA3-ROV07-BlaC-03	7	04/05/23	13:10:00	73,8235	16,414000	376	tubeworms	x	x	X	x		x	x	x	x	x				
KH06	Vestbakken shelf 2	AKMA3-ROV11-PusC-03	11	06.05.2023	08:38:00	73,8006	16,809000	364	background area, penetrated ~20 cm	x								x					
KH06	Vestbakken shelf 2	AKMA3-ROV12-BlaC-03	12	06.05.2023	13:02:00	73,8006	16,820800	364	tubeworms	x	x	X	x			x	x	x	x				
KH06	Vestbakken shelf 2	AKMA3-ROV12-BlaC-01	12	06.05.2023	13:06:00	73,8006	16,820800	363	tubeworms	x	x	X	x		x	x	x	x	x				
KH06	Vestbakken shelf 2	AKMA3-ROV12-PusC-C8	12	06.05.2023	13:16:00	73,8006	16,820800	362	tubeworms	x				x		X	x	x					
KH06	Vestbakken shelf 2	AKMA3-ROV12-PusC-C5	12	06.05.2023	15:18:00	73,7993	16,787100	385		x						x	x	x					
KH06	Vestbakken shelf 2	AKMA3-ROV12-PusC-M05	12	06.05.2023	15:25:00	73,7993	16,787100	384	bubbles when pushed into sediment. Metal corer	x				x	x	x		x					
KH07	Outer Bjørnøyrenna	AKMA3-ROV13-BlaC-01	13	07.05.2023	09:20:00	72,4384	17,677100	398	mat, patchy features	x	x	X	x		x	x	x	x	x				
KH07	Outer Bjørnøyrenna	AKMA3-ROV13-PusC-C5	13	07.05.2023	09:32:00	72,4384	17,677100	397	minicore in mat+snails	x								x					
KH07	Outer Bjørnøyrenna	AKMA3-ROV13-BlaC-03	13	07.05.2023	09:42:00	72,4383	17,677300	400	mat	x	x	X	x		x	x	x	x	x				
KH07	Outer Bjørnøyrenna	AKMA3-ROV13-PusC-C8	13	07.05.2023	09:45:00	72,4383	17,677300	399	mat	x								x					
KH07	Outer Bjørnøyrenna	AKMA3-ROV13-PusC-M08	13	07.05.2023	09:50:00	72,4383	17,677300	395	mat with snails					x									
KH07	Outer Bjørnøyrenna	AKMA3-ROV13-PusC-M04	13	07.05.2023	09:54:00	72,4383	17,677300	395						x									
KH07	Outer Bjørnøyrenna	AKMA3-ROV13-PusC-01	13	07.05.2023	09:56:00	72,4383	17,677300	395		x	x				x			x					
KH07	Outer Bjørnøyrenna	AKMA3-07-MC-01	-	07.05.2023	20:49:00	72,451117	17,653217	360	trasponder ON	x	x		x			x	x	x			x	x	x
KH07	Outer Bjørnøyrenna	AKMA3-07-MC-02	-	07.05.2023	23:06:00	72,430347	17,699625	380	trasponder ON	x	x		x			x	x	x					x
KH07	Outer Bjørnøyrenna	AKMA3-07-MC-03	-	07.05.2023	23:54:00	72,420638	17,644033		trasponder ON	x			x			x	x	x			x	x	
KH07	Outer Bjørnøyrenna	AKMA3-ROV16-PusC-C5	16	08.05.2023	13:54:00	72.4377°	17.6771°	398	mat					x		x		x					
KH07	Outer Bjørnøyrenna	AKMA3-ROV16-BlaC-02	16	08.05.2023	15:12:00	72.4388°	17.6791°	388	mat		x		x		x	x	x	x					
KH07	Outer Bjørnøyrenna	AKMA3-ROV16-BlaC-03	16	08.05.2023	15:27:00	72.4388°	17.6791°	388	mat		x		x		x	x	x	x					
KH07	Outer Bjørnøyrenna	AKMA3-ROV16-BlaC-01	16	08.05.2023	17:08:00	72.4384°	17.6774°	397	Transition mat		x		x		x	x	x	x					
KH08	Snøhvit gas field	AKMA3-ROV17-PusC-02	17	09.05.2023	08:27	71.4096°	20.4341°	267	mat		x	x	x		x	x	x	x					
KH08	Snøhvit gas field	AKMA3-ROV17-PusC-M04	17	09.05.2023	08:31	71.4096°	20.4336°	268	mat							x	x	x					
KH08	Snøhvit gas field	AKMA3-ROV18-BlaC-03	18	09.05.2023	10:42	71.4096°	20.4334°	267	mat		x	x	x		x	x	x	x					
KH08	Snøhvit gas field	AKMA3-ROV18-BlaC-01	18	09.05.2023	10:45	71.4096°	20.4334°	268	mat		x	x	x		x	x	x	x					
KH08	Snøhvit gas field	AKMA3-ROV18-PusC-03	18	09.05.2023	10:57	71.4095°	20.4337°	268	reference		x		x		x	x	x	x					
KH08	Snøhvit gas field	AKMA3-ROV18-BlaC-02	18	09.05.2023	11:24	71.4095°	20.4338°	269	mat		x	x	x		x	x	x	x					

TableⅫ. Cruise logs.

Location	**Station Id**	**Date**	**Time (UTC)**	**Lat. [N] Long. [E]**	**Water Depth [m]**	**Notes**
Fugløybanken	AKMA3-01-CTD-82	29/04	20:55	70°19.734' 17°35.172'	126	
Fugløybanken	AKMA3-01-Dive-01	30/04	07:54	70°24.714' 17°53.076'	127	
Fugløybanken	AKMA3-ROV01-CH4M-01	30/04	08:24	70°24.474' 17°52.866'	128	SAGE measurements on a bubbling spot
Fugløybanken	AKMA3-ROV01-CH4M-02	30/04	08:34	70°24.474' 17°52.866'	128	SAGE measurements on a mat
Fugløybanken	AKMA3-ROV01-CH4M-03	30/04	08:49	70°24.534' 17°52.920'	128	SAGE measurements on a bubbling spot
Fugløybanken	AKMA3-ROV01-CH4M-04	30/04	08:59	70°24.534' 17°52.932'	128	SAGE measurements on the bubbling spot(same as SAGE3)
Fugløybanken	AKMA3-ROV01-PusC-fail01	30/04	09:30	70°24.576' 17°52.932'	129	ROV Push Core - on SAGE2. aborted, sediment is too hard
Fugløybanken	AKMA3-ROV01-PusC-fail02	30/04	09:34	70°24.582' 17°52.920'	124	ROV Push Core - aborted, sediment is too hard
Fugløybanken	AKMA3-ROV01-PusC-fail03	30/04	09:36	70°24.582' 17°52.932'	128	ROV Push Core - aborted, sediment is too hard

Fugløybanken	AKMA3-ROV01-PusC-fail04	30/04	09:38	70°24.582' 17°52.932'	128	ROV Push Core - aborted, sediment is too hard
Fugløybanken	AKMA3-ROV01-PusC-fail05	30/04	09:43	70°24.588' 17°52.926'	127	ROV Push Core - aborted, sediment is too hard
Fugløybanken	AKMA3-ROV01-CarC-01	30/04	09:48	70°24.600' 17°52.950'	128	ROV Carbonate Crust Collection - methane-derived carbonate slab with fish underneath
Fugløybanken	AKMA3-ROV01-CarC-02	30/04	09:49	70°24.420' 17°52.992'	127	ROV Carbonate Crust Collection - methane-derived carbonate slab with fish underneath
Fugløybanken	AKMA3-ROV01-RocC-01	30/04	09:55	70°24.636' 17°52.980'	127	ROV Rock Collection - rock collection with sponge+shrimp on top
Fugløybanken	AKMA3-ROV01-RocC-02	30/04	10:01	70°24.648' 17°52.950'	127	ROV Rock Collection - rock collection with macrofauna
Fugløybanken	AKMA3-ROV01-RocC-03	30/04	10:03	70°24.648' 17°52.956'	127	ROV Rock Collection - rock collection with sea star
Fugløybanken	AKMA3-ROV01-Biol-01	30/04	10:06	70°24.654' 17°52.992'	125	ROV Biology - red sea cucumber

Fugløybanken	AKMA3-ROV01-Biol-02	30/04	10:10	70°24.660' 17°53.004'	129	ROV Biology - Sinpuncula? And brittle star
Fugløybanken	AKMA3-ROV01-Biol-03	30/04	10:14	70°24.660' 17°53.004'	128	ROV Biology - grey tunicate
Fugløybanken	AKMA3-ROV01-Biol-04	30/04	10:17	70°24.660' 17°53.016'	128	ROV Biology - sea cucumber
Fugløybanken	AKMA3-ROV01-RocC-04	30/04	10:21	70°24.660' 17°53.028'	129	ROV Rock Collection - rock collection with white branched sponge(?)
Fugløybanken	AKMA3-ROV01-RocC-05	30/04	10:24	70°24.660' 17°53.034'	129	ROV Rock Collection - rock collection with white bryozoan
Fugløybanken	AKMA3-ROV01-Biol-05	30/04	10:28	70°24.660' 17°53.052'	129	ROV Biology - yellow anemone
Fugløybanken	AKMA3-ROV01-Biol-06	30/04	10:30	70°24.660' 17°53.052'	127	ROV Biology - gastropod
Fugløybanken	AKMA3-ROV01-Biol-07	30/04	10:36	70°24.654' 17°53.088'	129	ROV Biology - sea star (missing a leg)
Fugløybanken	AKMA3-ROV01-Biol-08	30/04	10:36	70°24.660' 17°53.094'	128	ROV Biology - small pink sea star
Fugløybanken	AKMA3-ROV01-Biol-09	30/04	10:41	70°24.660' 17°53.106'	128	ROV Biology - large pink sea star
Fugløybanken	AKMA3-ROV01-Biol-10	30/04	10:49	70°24.660' 17°53.118'	128	ROV Biology - bivalve shell

Fugløybanken	AKMA3-ROV01-Biol-11	30/04	10:56	70°24.660' 17°53.184'	129	ROV Biology - rock with sponge and anemone?
Håkjerringdjupet	AKMA3-ROV02-PusC-02	01/05	00:19	70°40.434' 18°26.712'	304	ROV Push Core - mat(?). Partially lost at the seafloor
Håkjerringdjupet	AKMA3-ROV02-BlaC-02	01/05	00:31	70°40.434' 18°26.706'	305	ROV Blade Core - light-grey sediment
Håkjerringdjupet	AKMA3-02-CTD-83	01/05	04:32	70°37.205' 18°34.667'	323	
Håkjerringdjupet	AKMA3-ROV03-Biol-05	01/05	04:51	70°42.156' 18°30.828'	357	ROV Biology - starfish
Håkjerringdjupet	AKMA3-02-Dive-02	01/05	06:47	70°41.196' 18°28.128'	342	ROV Dive - problems with ROV coordinates, got them when already mid-water
Håkjerringdjupet	AKMA3-02-DRO-01	01/05	07:23	70°37.205' 18°34.667'		takeoff from helideck; short test flight 7:23; surveys at 8:12 and 8:56am
Håkjerringdjupet	AKMA3-ROV02-CH4M-01	01/05	08:06	70°41.190' 18°28.128'	345	
Håkjerringdjupet	AKMA3-ROV02-CH4M-02	01/05	08:15	70°41.190' 18°28.128'	345	
Håkjerringdjupet	AKMA3-02-CAT_Dive-01	01/05	09:02	70°37.205' 18°34.667'	345	test dive
Håkjerringdjupet	AKMA3-02-BlaC-fail01	01/05	09:10	70°41.190' 18°28.128'	345	

Håkjerringdjupet	AKMA3-ROV02-CH4M-03	01/05	11:12	70°40.434' 18°26.706'	304	above the well
Håkjerringdjupet	AKMA3-ROV02-RocC-01	01/05	11:36	70°40.434' 18°26.706'	303	ROV Rock Collection - crust near the well, seep carbonate?
Håkjerringdjupet	AKMA3-ROV02-BlaC-03	01/05	12:58	70°40.434' 18°26.688'	301	ROV Blade Core - reference
Håkjerringdjupet	AKMA3-ROV02-PusC-03	01/05	13:11	70°40.434' 18°26.640'	303	ROV Push Core - reference
Håkjerringdjupet	AKMA3-ROV02-PusC-01	01/05	13:22	70°40.422' 18°26.718'	302	ROV Push Core - close to basket
Håkjerringdjupet	AKMA3-ROV02-PusC-M01	01/05	13:26	70°40.428' 18°26.712'	298	ROV Push Core - small puschcore REV; reference
Håkjerringdjupet	AKMA3-ROV02-GasS-01	01/05	14:25	70°40.434' 18°26.706'		ROV Gas Sampling - sampled gas through valve 3. Gas sampler was leaking periodically. Amount of gas sampled may only be 100 ml or less. Potential for mix of gas and water in sampler.
Håkjerringdjupet	AKMA3-02-Dive-03	01/05	15:26	70°42.147' 18°30.716'	361	ROV Dive - in water
Håkjerringdjupet	AKMA3-ROV03-PusC-C2	01/05	16:17	70°42.150' 18°30.768'	359	ROV Push Core - small puschcore

						REV marked "C2"
Håkjerringdjupet	AKMA3-ROV03-Biol-01	01/05	16:30	70°42.156' 18°30.804'	361	ROV Biology - coral sampling
Håkjerringdjupet	AKMA3-ROV03-Biol-02	01/05	16:34	70°42.156' 18°30.804'	361	ROV Biology - sponge
Håkjerringdjupet	AKMA3-ROV03-RocC-01	01/05	16:39	70°42.156' 18°30.804'	361	ROV Rock Collection - anemone on bioconstruction
Håkjerringdjupet	AKMA3-ROV03-Biol-03	01/05	16:41	70°42.156' 18°30.822'	357	ROV Biology - seapen
Håkjerringdjupet	AKMA3-ROV03-Biol-04	01/05	16:46	70°42.156' 18°30.828'	357	ROV Biology - anemone
Håkjerringdjupet	AKMA3-ROV03-Biol-06	01/05	16:59	70°42.150' 18°30.828'	360	ROV Biology - seapen
Håkjerringdjupet	AKMA3-ROV03-Biol-07	01/05	17:08	70°42.198' 18°30.576'	354	ROV Biology - anemone
Håkjerringdjupet	AKMA3-ROV03-PusC-01	01/05	17:25	70°42.168' 18°30.714'	360	
Håkjerringdjupet	AKMA3-ROV03-PusC-02	01/05	17:31	70°42.168' 18°30.714'	360	
Håkjerringdjupet	AKMA3-ROV03-RocC-02	01/05	17:40	70°42.168' 18°30.720'	360	
Håkjerringdjupet	AKMA3-ROV03-BlaC-01	01/05	17:43	70°42.168' 18°30.714'	360	ROV Blade Core - 2 anemonies, 1 rock

Vestbakken slope	AKMA3-03-Dive-04	03/05	06:38			ROV Dive - problems with ROV coordinates; first we did samplings; at 8:42 we started mosaiking
Vestbakken slope	AKMA3-ROV04-BlaC-03	03/05	07:59		1212	ROV Blade Core - microbial mat
Vestbakken slope	AKMA3-ROV04-PusC-C5	03/05	08:02		1206	ROV Push Core - small corer; microbial mat
Vestbakken slope	AKMA3-ROV04-PusC-01	03/05	08:05		1204	ROV Push Core - microbial mat; fell off (upside-down); only for macrofauna (UiB)
Vestbakken slope	AKMA3-ROV04-BlaC-02	03/05	08:14		1189	ROV Blade Core - tubeworms
Vestbakken slope	AKMA3-ROV04-PusC-02	03/05	08:22		1203	ROV Push Core - tubeworms
Vestbakken slope	AKMA3-ROV04-PusC-C8	03/05	08:26		1203	ROV Push Core - small corer; tubeworms
Vestbakken slope	AKMA3-ROV04-Biol-01	03/05	08:29		1210	ROV Biology - gastropod
Vestbakken slope	AKMA3-ROV04-Biol-02	03/05	08:31		1206	ROV Biology - seastar on a mat
Vestbakken slope	AKMA3-ROV04-Biol-03	03/05	08:35		1206	ROV Biology - sea spider

Vestbakken slope	AKMA3-ROV04-PusC-03	03/05	09:34		1215	
Vestbakken slope	AKMA3-ROV04-CH4M-02	03/05	09:38		1212	
Vestbakken slope	AKMA3-ROV04-Biol-05	03/05	09:48		1204	ROV Biology - rope with fauna
Vestbakken slope	AKMA3-ROV04-Biol-06	03/05	10:00		1212	ROV Biology - seastar
Vestbakken slope	AKMA3-ROV04-Biol-07	03/05	10:03		1210	ROV Biology - seastar
Vestbakken slope	AKMA3-ROV04-Biol-08	03/05	10:06		1210	ROV Biology - sea spider
Vestbakken slope	AKMA3-ROV04-Biol-09	03/05	10:07		1208	ROV Biology - seastar
Vestbakken slope	AKMA3-ROV04-Biol-10	03/05	10:16		1207	ROV Biology - seastar
Vestbakken slope	AKMA3-ROV04-Biol-11	03/05	10:20		1201	ROV Biology - seastar
Vestbakken slope	AKMA3-ROV04-Biol-12	03/05	10:26		1206	ROV Biology - filament(?)
Vestbakken slope	AKMA3-ROV04-Biol-13	03/05	10:46		1206	ROV Biology - seastar
Vestbakken slope	AKMA3-ROV04-CarC-01	03/05	10:49		1212	

Vestbakken slope	AKMA3-ROV04-Biol-15	03/05	10:58		1204	ROV Biology - piece of wood(?)
Vestbakken slope	AKMA3-ROV04-Biol-16	03/05	11:02		1205	ROV Biology - wood?
Vestbakken slope	AKMA3-ROV04-Biol-17	03/05	11:11		1213	ROV Biology - sea spider
Vestbakken slope	AKMA3-03-Dive-05	03/05	14:06	73°52.628' 15°07.897'	1200	
Vestbakken slope	AKMA3-ROV05-PusC-fail01	03/05	16:02	73°52.632' 15°07.818'	1200	ROV Push Core - failed coring
Vestbakken slope	AKMA3-ROV05-BlaC-01	03/05	16:15	73°52.626' 15°07.812'	1200	ROV Blade Core - Blade core on mud, tubeworms and BM
Vestbakken slope	AKMA3-ROV05-PusC-fail02	03/05	16:28	73°52.626' 15°07.830'	1200	
Vestbakken slope	AKMA3-ROV05-PusC-C5	03/05	16:31	73°52.626' 15°07.830'	1192	
Vestbakken slope	AKMA3-ROV05-PusC-C8	03/05	16:32	73°52.626' 15°07.830'	1194	ROV Push Core - inside crater
Vestbakken slope	AKMA3-ROV05-PusC-M05	03/05	16:38	73°52.626' 15°07.830'	1199	ROV Push Core - core in metal case
Vestbakken slope	AKMA3-ROV05-Scoo-01	03/05	16:43	73°52.632' 15°07.824'	1198	tubeworms
Vestbakken slope	AKMA3-ROV05-PusC-C/2	03/05	17:11	73°52.632' 15°07.782'	1202	ROV Push Core - large pushcorer

Vestbakken slope	AKMA3-ROV05-PusC-M03	03/05	17:14	73°52.632' 15°07.776'	1200	ROV Push Core - core in metal case
Vestbakken slope	AKMA3-ROV05-PusC-01	03/05	17:16	73°52.632' 15°07.776'	1198	
Vestbakken slope	AKMA3-ROV04-CH4M-01	03/05	20:42		1212	we keep it measuring during the mosaiking
Vestbakken slope	AKMA3-03-MC-01	03/05	22:28	73°51.844' 15°11.437'	1140	first attempt failed, second attempt worked out. 6 cores; #1 ; #2 , #3, #4 , #5, #6 pore water and geochemistry
Vestbakken shelf	AKMA3-ROV08-CH4M-01	04/05	02:42	73°55.230' 14°54.732'	378	measuring all the way down to the seafloor. Peak measured at 25 m from seafloor.
Vestbakken shelf	AKMA3-04-Dive-06	04/05	06:45	73°49.404' 16°24.810'	376	
Vestbakken shelf	AKMA3-ROV06-GasS-01	04/05	07:13	73°46.884' 16°11.058'	369	ROV Gas Sampling - big bubbling spot
Vestbakken shelf	AKMA3-ROV06-RocC-01	04/05	07:50	73°47.382' 16°32.058'	378	ROV Rock Collection - rock with fauna
Vestbakken shelf	AKMA3-ROV06-CAT_Dive-02	04/05	08:07	73°49.406' 16°24.816'		
Vestbakken shelf	AKMA3-ROV06-Biol-01	04/05	08:09	73°44.616' 16°52.283'	375	ROV Biology - hydrozoan

Vestbakken shelf	AKMA3-ROV06-Biol-02	04/05	09:28	73°49.392' 16°24.174'	376	ROV Biology - anemone
Vestbakken shelf	AKMA3-ROV06-Biol-03	04/05	09:30	73°49.392' 16°24.174'	376	ROV Biology - anemone with tube
Vestbakken shelf	AKMA3-ROV06-Biol-04	04/05	09:32	73°49.392' 16°24.174'	376	ROV Biology - sponge
Vestbakken shelf	AKMA3-ROV06-PusC-fail01	04/05	10:02	73°49.176' 16°24.174'	376	ROV Push Core - bounced back with no sediment
Vestbakken shelf	AKMA3-ROV06-PusC-C8	04/05	10:12	73°47.748' 16°23.328'	376	
Vestbakken shelf	AKMA3-ROV06-PusC-fail02	04/05	10:15	73°47.022' 16°23.076'	377	
Vestbakken shelf	AKMA3-ROV06-PusC-C5	04/05	10:17	73°46.356' 16°23.076'	376	
Vestbakken shelf	AKMA3-ROV06-PusC-M03	04/05	10:22	73°49.434' 16°24.876'	374	
Vestbakken shelf	AKMA3-ROV06-PusC-M04	04/05	10:26	73°49.434' 16°24.876'	374	ROV Push Core - tubeworms
Vestbakken shelf	AKMA3-ROV06-PusC-02	04/05	10:28	73°49.434' 16°24.870'	378	
Vestbakken shelf	AKMA3-ROV06-PusC-M04b	04/05	10:35	73°49.434' 16°24.870'	378	ROV Push Core - tubeworms; gray case n2
Vestbakken shelf	AKMA3-04-Dive-07	04/05	11:55	73°39.546' 16°23.304'	377	

Vestbakken shelf	AKMA3-ROV07-BlaC-fail03	04/05	12:24	73°49.398' 16°24.828'	372	
Vestbakken shelf	AKMA3-ROV07-BlaC-02	04/05	12:33	73°49.404' 16°24.822'	377	
Vestbakken shelf	AKMA3-ROV07-BlaC-01	04/05	12:39	73°49.404' 16°24.816'	376	
Vestbakken shelf	AKMA3-ROV07-PusC-07	04/05	12:44	73°49.404' 16°24.816'	375	
Vestbakken shelf	AKMA3-ROV07-PusC-fail04	04/05	12:48	73°49.404' 16°24.816'	374	
Vestbakken shelf	AKMA3-ROV07-PusC-01	04/05	12:49	73°49.404' 16°24.816'	374	
Vestbakken shelf	AKMA3-ROV07-PusC-fail05	04/05	12:50	73°49.404' 16°24.816'	374	
Vestbakken shelf	AKMA3-ROV07-CarC-01	04/05	13:05	73°49.404' 16°24.816'	374	ROV Carbonate Crust Collection - 4 samples, bubbling spot
Vestbakken shelf	AKMA3-ROV07-BlaC-03	04/05	13:10	73°49.410' 16°24.840'	376	
Vestbakken shelf	AKMA3-04-Dive-08	04/05	14:41	73°55.230' 14°54.732'	378	
Vestbakken shelf	AKMA3-ROV08-Biol-01	04/05	16:31	78°49.374' 16°25.086'	377	ROV Biology - sponge
Vestbakken shelf	AKMA3-ROV08-GasS-01	04/05	16:36	78°49.416' 16°24.846'	374	ROV Gas Sampling - Gas sampler at seafloor on

						a bubbling spot and CH4 measurements
Vestbakken shelf	AKMA3-ROV08-Biol-02	04/05	16:48	78°49.542' 16°23.784'	374	ROV Biology - sponge
Vestbakken shelf	AKMA3-ROV08-Biol-03	04/05	16:56	78°49.542' 16°23.760'	374	
Vestbakken shelf	AKMA3-ROV08-CH4M-02	04/05	17:22	78°49.890' 16°22.692'		measuring all the way up.
Vestbakken shelf	AKMA3-04-CTD-84	04/05	18:10	73°49.407' 16°24.810'	376	10 samples for CH4: 372, 369, 364, 350, 300, 250, 200, 150, 100, 50 m
Vestbakken shelf	AKMA3-04-MC-fail01	04/05	19:08	73°48.820' 16°23.679'	370	no trasponder. probaly bounced on the seafloor due to waves moving the ship up and down.
Kveitola bank	AKMA3-05-CTD-85	05/05	01:48	74°38.225' 16°54.699'		
Kveitola bank	AKMA3-05-Dive-09	05/05	06:36	74°42.846' 17°03.823'	140	
Kveitola bank	AKMA3-ROV09-Biol-01	05/05	07:20	74°42.834' 17°03.930'	139	
Kveitola bank	AKMA3-ROV09-PusC-fail01	05/05	09:31	74°42.846' 17°03.210'	142	ROV Push Core - it could not penetrate

Kveitola bank	AKMA3-ROV09-PusC-fail02	05/05	09:40	74°42.876' 17°03.354'	140	
Kveitola bank	AKMA3-ROV09-GasS-01	05/05	10:14	74°42.840' 17°03.846'	143	ROV Gas Sampling - gas sampled from 9:05 until 10:10; sampled into gas bottle n3
Kveitola bank	AKMA3-ROV09-CAT_Dive-01	05/05	10:25	74°42.858' 17°03.959'	143	
Kveitola bank	AKMA3-ROV09-Biol-02	05/05	10:30	74°42.858' 17°03.948'	143	ROV Biology - sponge
Kveitola bank	AKMA3-ROV09-Biol-03	05/05	10:34	74°42.858' 17°03.948'	141	ROV Biology - starfish
Kveitola bank	AKMA3-ROV09-PusC-fail03	05/05	11:05	74°42.900' 17°03.606'	144	
Kveitola bank	AKMA3-ROV09-Biol-04	05/05	11:29	74°42.858' 17°03.948'	143	ROV Biology - sponge
Kveitola bank	AKMA3-ROV09-RocC-01	05/05	11:29	74°42.858' 17°03.948'	143	
Kveitola bank	AKMA3-ROV09-Biol-05	05/05	11:33	74°42.852' 17°03.942'	142	ROV Biology - starfish
Kveitola bank	AKMA3-ROV09-CarC-01	05/05	12:20	74°42.942' 17°04.194'	141	ROV Carbonate Crust Collection - carbonate with anemone
Kveitola bank	AKMA3-ROV09-CarC-02	05/05	12:23	74°42.924' 17°04.260'	141	ROV Carbonate Crust Collection -

						carbonate pavement
Kveitola bank	AKMA3-ROV09-GasS-02	05/05	12:40	74°42.852' 17°04.086'	140	ROV Gas Sampling - gas sampled from 11:46 until 12:40; sampled into gas bottle n4
Kveitola bank	AKMA3-05-Dive-10	05/05	14:51	74°42.030' 17°16.470'	141	ROV Dive - mosaiking from 17:24 to 17:35
Kveitola bank	AKMA3-ROV10-CH4M-01	05/05	16:18	74°42.870' 17°03.870'	141	start SAGE, bubbling site
Eastern Vestbanken shelf	AKMA3-ROV12-Biol-02	06/05	04:09	73°47.946' 16°47.166'	382	ROV Biology - seastar
Eastern Vestbanken shelf	AKMA3-06-Dive-11	06/05	06:23	73°46.800' 16°57.936'	360	
Eastern Vestbanken shelf	AKMA3-ROV11-GasS-01	06/05	06:47	73°48.006' 16°49.302'	362	ROV Gas Sampling - deployed gas sampler. Until 7:11
Eastern Vestbanken shelf	AKMA3-ROV11-RocC-01	06/05	07:33	73°48.096' 16°48.912'	357	ROV Rock Collection - rock with zoanteds
Eastern Vestbanken shelf	AKMA3-ROV11-RocC-02	06/05	07:47	73°48.096' 06°19.625'	363	ROV Rock Collection - rock with snail eggs
Eastern Vestbanken shelf	AKMA3-ROV11-RocC-03	06/05	07:51	73°48.096' 06°19.625'	366	ROV Rock Collection - rock with fauna
Eastern Vestbanken shelf	AKMA3-ROV11-PusC-fail01	06/05	08:28	73°48.036' 16°48.558'	361	ROV Push Core - did not penetrate

Eastern Vestbanken shelf	AKMA3-ROV11-PusC-fail02	06/05	08:30	73°48.036' 16°48.558'	361	ROV Push Core - did not penetrate
Eastern Vestbanken shelf	AKMA3-ROV11-RocC-04	06/05	08:33	73°48.036' 16°48.558'	361	
Eastern Vestbanken shelf	AKMA3-ROV11-PusC-03	06/05	08:38	73°48.036' 16°48.540'	364	ROV Push Core - background area, penetrated ~20 cm
Eastern Vestbanken shelf	AKMA3-ROV11-Biol-01	06/05	08:51	73°48.036' 16°48.564'	362	ROV Biology - soft coral
Eastern Vestbanken shelf	AKMA3-ROV11-Biol-02	06/05	08:54	73°48.036' 16°48.564'	361	ROV Biology - sponge
Eastern Vestbanken shelf	AKMA3-ROV11-CH4M-01	06/05	09:12	73°48.024' 16°48.516'	360	SAGE bottom waters
Eastern Vestbanken shelf	AKMA3-ROV11-CH4M-02	06/05	09:36	73°48.024' 16°48.534'	367	SAGE on a mat
Eastern Vestbanken shelf	AKMA3-ROV11-CarC-01	06/05	10:25	73°48.024' 16°48.534'	363	
Eastern Vestbanken shelf	AKMA3-06-Dive-12	06/05	12:04	73°44.556' 16°55.356'	363	
Eastern Vestbanken shelf	AKMA3-ROV12-BlaC-03	06/05	13:02	73°48.036' 16°49.248'	364	ROV Blade Core - tubeworms
Eastern Vestbanken shelf	AKMA3-ROV12-BlaC-01	06/05	13:06	73°48.036' 16°49.248'	363	ROV Blade Core - tubeworms
Eastern Vestbanken shelf	AKMA3-ROV12-PusC-fail03	06/05	13:11	73°48.036' 16°49.248'	362	ROV Push Core - big push corer; two attempts

Eastern Vestbanken shelf	AKMA3-ROV12-PusC-C8	06/05	13:16	73°48.036' 16°49.248'	362	ROV Push Core - tubeworms
Eastern Vestbanken shelf	AKMA3-ROV12-PusC-fail04	06/05	15:15	73°47.958' 16°47.232'	387	ROV Push Core - mini core failed
Eastern Vestbanken shelf	AKMA3-ROV12-PusC-C4	06/05	15:18	73°47.958' 16°47.226'	385	
Eastern Vestbanken shelf	AKMA3-ROV12-PusC-fail05	06/05	15:22	73°47.958' 16°47.232'	387	ROV Push Core - failed a couple of attempts
Eastern Vestbanken shelf	AKMA3-ROV12-PusC-M05	06/05	15:25	73°47.958' 16°47.226'	384	ROV Push Core - bubbles when pushed into sediment. Metal corer
Eastern Vestbanken shelf	AKMA3-ROV12-Biol-01	06/05	16:05	73°47.946' 16°47.166'	381	ROV Biology - hydrozoan
Eastern Vestbanken shelf	AKMA3-ROV12-Biol-03	06/05	16:28	73°47.958' 16°47.166'	298	ROV Biology - seastar
Eastern Vestbanken shelf	AKMA3-ROV12-Biol-04	06/05	16:32	73°47.958' 16°47.178'	317	ROV Biology - sponge
Eastern Vestbanken shelf	AKMA3-ROV12-RocC-01	06/05	16:42	73°47.976' 16°47.202'	378	ROV Rock Collection - rock with fauna
Eastern Vestbanken shelf	AKMA3-06-MC-01	06/05	18:28	73°47.772' 16°46.381'		failed a couple of attempts, too wavy?dry test was ok
Outer Bjørnøyrenna	AKMA3-ROV14-Biol-09	07/05	02:05	72°26.256' 17°40.626'	396	

Outer Bjørnøyrenna	AKMA3-07-Dive-13	07/05	07:05	72°26.280' 17°40.632'	395	
Outer Bjørnøyrenna	AKMA3-ROV13-BlaC-fail01	07/05	09:00	72°26.298' 17°40.632'	398	ROV Blade Core - polygonal mat pattern; penetrated only ~2 cm; substrate is too hard
Outer Bjørnøyrenna	AKMA3-ROV13-BlaC-fail02	07/05	09:11	72°26.304' 17°40.620'	398	
Outer Bjørnøyrenna	AKMA3-ROV13-BlaC-01	07/05	09:20	72°26.304' 17°40.626'	398	ROV Blade Core - mat, patchy features
Outer Bjørnøyrenna	AKMA3-ROV13-PusC-fail03	07/05	09:27	72°26.304' 17°40.626'	396	ROV Push Core - large corer; mat ;substrate is too hard
Outer Bjørnøyrenna	AKMA3-ROV13-PusC-C5	07/05	09:32	72°26.304' 17°40.626'	397	ROV Push Core - minicore in mat+snails
Outer Bjørnøyrenna	AKMA3-ROV13-BlaC-03	07/05	09:42	72°26.298' 17°40.638'	400	ROV Blade Core - mat
Outer Bjørnøyrenna	AKMA3-ROV13-PusC-C8	07/05	09:45	72°26.298' 17°40.638'	399	ROV Push Core - mat
Outer Bjørnøyrenna	AKMA3-ROV13-PusC-M08	07/05	09:50	72°26.298' 17°40.638'	395	
Outer Bjørnøyrenna	AKMA3-ROV13-PusC-M04	07/05	09:54	72°26.298' 17°40.638'	395	
Outer Bjørnøyrenna	AKMA3-ROV13-PusC-01	07/05	09:56	72°26.298' 17°40.638'	395	

Outer Bjørnøyrenna	AKMA3-ROV13-PusC-fail04	07/05	10:04	72°26.298' 17°40.638'	395	
Outer Bjørnøyrenna	AKMA3-ROV13-CarC-01	07/05	10:06	72°26.298' 17°40.638'	395	ROV Carbonate Crust Collection - carbonate with anemone
Outer Bjørnøyrenna	AKMA3-07-Dive-14	07/05	12:29	72°26.278' 17°40.633'	397	
Outer Bjørnøyrenna	AKMA3-ROV14-Biol-01	07/05	13:23	72°26.082' 17°41.664'	383	ROV Biology - cold water coral
Outer Bjørnøyrenna	AKMA3-ROV14-Biol-02	07/05	13:27	72°26.082' 17°41.664'	383	ROV Biology - cold water coral
Outer Bjørnøyrenna	AKMA3-ROV14-Biol-03	07/05	13:29	72°26.082' 17°41.664'	383	ROV Biology - cold water coral
Outer Bjørnøyrenna	AKMA3-ROV14-Biol-04	07/05	13:33	72°26.082' 17°41.628'	383	ROV Biology - seastar
Outer Bjørnøyrenna	AKMA3-ROV14-Biol-05	07/05	13:45	72°26.298' 17°40.566'	387	ROV Biology - hydrozoan?
Outer Bjørnøyrenna	AKMA3-ROV14-Biol-06	07/05	13:50	72°26.292' 17°40.566'	384	
Outer Bjørnøyrenna	AKMA3-ROV14-Biol-07	07/05	13:54	72°26.286' 17°40.572'	383	ROV Biology - hydrozoan?
Outer Bjørnøyrenna	AKMA3-ROV14-Biol-08	07/05	13:59	72°26.274' 17°40.590'	386	ROV Biology - coral
Outer Bjørnøyrenna	AKMA3-07-CTD-86	07/05	15:26	72°26.291' 17°40.531'	365	above mud volcano; 11 bottles, sampled for CH4:392, 370, 350,

						325, 300, 250, 200, 150, 100, 50, 10 m
Outer Bjørnøyrenna	AKMA3-07-CAT_Dive-01	07/05	20:24	72°27.085' 17°39.143'	360	
Outer Bjørnøyrenna	AKMA3-07-MC-01	07/05	20:49	72°27.067' 17°39.193'	360	trasponder ON
Outer Bjørnøyrenna	AKMA3-07-GC-08	07/05	21:35	72°27.080' 17°39.129'	360	1.4 m; sampled pw and gas; no trasponder; Ship log station
Outer Bjørnøyrenna	AKMA3-07-MC-02	07/05	23:06	72°25.821' 17°41.978'	380	trasponder ON
Outer Bjørnøyrenna	AKMA3-07-MC-03	07/05	23:54	72°25.238' 17°38.642'		trasponder ON
Outer Bjørnøyrenna	AKMA3-07-Dive-16	08/05	00:15	72°26.256' 17°40.626'	398	
Outer Bjørnøyrenna	AKMA3-07-Dive-15	08/05	07:00	72°26.376' 17°40.548'	373	ROV Dive - in water
Outer Bjørnøyrenna	AKMA3-07-Scoo-01	08/05	08:47	72°26.388' 17°40.320'	373	shells
Outer Bjørnøyrenna	AKMA3-07-Scoo-02	08/05	08:49	72°26.388' 17°40.320'	373	shells
Outer Bjørnøyrenna	AKMA3-ROV15-CarC-01	08/05	08:51	72°26.388' 17°40.320'	373	ROV Carbonate Crust Collection - carbonate with bivaves
Outer Bjørnøyrenna	AKMA3-ROV15-CarC-02	08/05	09:17	72°26.436' 17°40.560'	373	
Outer Bjørnøyrenna	AKMA3-ROV15-GasS-01	08/05	10:05	72°26.370' 17°40.596'	370	
Outer Bjørnøyrenna	AKMA3-ROV16-Biol-01	08/05	12:44	72°26.268' 17°40.626'	403	ROV Biology - Sponge

Outer Bjørnøyrenna	AKMA3-07-DRO-01	08/05	13:09			drone survey until 14:47 for potential oil slicks.
Outer Bjørnøyrenna	AKMA3-ROV16-WatS-01	08/05	13:35	72°26.262' 17°40.626'	397	ROV Water Sampling - water sampled with 1 niskin bottle
Outer Bjørnøyrenna	AKMA3-ROV16-PusC-C5	08/05	13:54	72°26.262' 17°40.626'	398	ROV Push Core - small push core in the MV crater
Outer Bjørnøyrenna	AKMA3-ROV16-PusC-04	08/05	13:59	72°26.262' 17°40.626'	398	ROV Push Core - few sediment collected after a failure
Outer Bjørnøyrenna	AKMA3-ROV16-CarC-01	08/05	14:52	72°26.292' 17°40.638'	390	
Outer Bjørnøyrenna	AKMA3-ROV16-BlaC-02	08/05	15:12	72°26.328' 17°40.746'	388	ROV Blade Core - Blade core on white and blu BM with honeycomb pattern
Outer Bjørnøyrenna	AKMA3-ROV16-BlaC-03	08/05	15:27	72°26.328' 17°40.746'	388	ROV Blade Core - Blade core on BM bubbling
Outer Bjørnøyrenna	AKMA3-ROV16-Scoo-01	08/05	15:42	72°26.334' 17°40.734'	392	scoop on tubeworm close to BM
Outer Bjørnøyrenna	AKMA3-ROV16-Scoo-02	08/05	15:45	72°26.334' 17°40.740'	390	scoop on tubeworm close to BM
Outer Bjørnøyrenna	AKMA3-ROV16-Scoo-03	08/05	15:48	72°26.334' 17°40.740'	389	scoop on tubeworm close to BM
Outer Bjørnøyrenna	AKMA3-ROV16-Scoo-04	08/05	15:55	72°26.268' 17°40.614'	398	scoop on tubeworm in a new area without BM
Outer Bjørnøyrenna	AKMA3-ROV16-TemL-01	08/05	15:59	72°26.256' 17°40.632'	397	temperature sensor on top of Borealis MV

Outer Bjørnøyrenna	AKMA3-ROV16-CarC-02	08/05	16:50	72°26.274' 17°40.608'	392	ROV Carbonate Crust Collection - Carbonate with macrofauna
Outer Bjørnøyrenna	AKMA3-ROV16-BlaC-01	08/05	17:08	72°26.304' 17°40.644'	397	ROV Blade Core - Blade core on shining BM
Outer Bjørnøyrenna	AKMA3-07-GC-11	08/05	17:59	72°25.798' 17°42.052'		3.4 m; Ship log station
Outer Bjørnøyrenna	AKMA3-07-GC-12	08/05	19:07	72°25.206' 17°38.650'		2.36 m; Ship log station
Snøhvit gas field	AKMA3-ROV17-CAT_Dive-02	09/05	06:50	71°24.583' 20°25.998'		
Snøhvit gas field	AKMA3-08-Dive-17	09/05	06:52	71°24.583' 20°25.998'	267	
Snøhvit gas field	AKMA3-ROV17-GasS-01	09/05	08:02	71°24.576' 20°26.046'	267	ROV Gas Sampling - gas sampler deployment on bubbles
Snøhvit gas field	AKMA3-ROV17-PusC-02	09/05	08:27	71°24.576' 20°26.046'	267	ROV Push Core - on BM
Snøhvit gas field	AKMA3-ROV17-PusC-M05	09/05	08:31	71°24.576' 20°26.016'	268	ROV Push Core - on BM
Snøhvit gas field	AKMA3-08-Dive-18	09/05	10:15	71°24.582' 20°25.998'	267	
Snøhvit gas field	AKMA3-ROV18-BlaC-03	09/05	10:42	71°24.576' 20°26.004'	267	ROV Blade Core - BM, TW with ghost worms and bubbles
Snøhvit gas field	AKMA3-ROV18-BlaC-01	09/05	10:45	71°24.576' 20°26.004'	268	ROV Blade Core - ghost worms - bubbles
Snøhvit gas field	AKMA3-ROV18-PusC-03	09/05	10:57	71°24.570' 20°26.022'	268	ROV Push Core - PusC 3

						collected (tw?)
Snøhvit gas field	AKMA3-ROV18-Biol-01	09/05	11:04	71°24.570' 20°26.070'	269	white big sponge
Snøhvit gas field	AKMA3-ROV18-Biol-02	09/05	11:08	71°24.570' 20°26.124'	266	yellow sponge
Snøhvit gas field	AKMA3-ROV18-Biol-03	09/05	11:10	71°24.576' 20°26.136'	267	sponge
Snøhvit gas field	AKMA3-ROV18-PusC-01	09/05	11:19	71°24.570' 20°26.034'	268	ghost worms - bubbles
Snøhvit gas field	AKMA3-ROV18-BlaC-02	09/05	11:24	71°24.570' 20°26.028'	269	TW (ghost) bubbles
Snøhvit gas field	AKMA3-08-Dive-19	09/05	12:15	71°22.890' 20°26.742'	267	
Snøhvit gas field	AKMA3-ROV19-CarC-01	09/05	12:45	71°22.884' 20°26.712'	267	carbonate with organisms on it
Snøhvit gas field	AKMA3-ROV19-CarC-02	09/05	12:58	71°22.920' 20°26.622'	267	carbonate with organisms on it
Snøhvit gas field	AKMA3-ROV19-GasS-01	09/05	13:30	71°22.878' 20°26.712'	268	deployment of gas sampler on bubbling site
Snøhvit gas field	AKMA3-08-DRO-01	09/05	17:10			drone survey for oil slicks
Snøhvit gas field	AKMA3-08-OilS-01	09/05	17:30			oil sampling from rubber boat