Cruise report from the visual-acoustic survey for cetaceans of the Nordic Seas, May 2026

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1.0 Abstract

The Arctic Mid-Ocean Ridge system runs through the centre of the Nordic Seas, formed by the Jan Mayen Fracture Zone, Mohns Ridge and Knipovich Ridge. The region has complex bathymetry that includes seamounts, vent systems, deep water canyons and adjacent abyssal plains. Mineral resources are known to exist within the ridge system, and the region is now being evaluated for potential deep seabed mining by Norway. Between 9 May – 19 May 2026, a visual–acoustic survey for cetaceans was conducted using the *SY Witness*, focusing on areas within the proposed designated mining area east and southeast of Jan Mayen. This research follows on from two previous surveys conducted during the summers of 2024 and 2025. The survey integrated passive acoustic monitoring (PAM), a visual survey and photo-identification. A total of 10 survey days were completed, covering 2785 km of track line and including 2397 km of acoustic and 798 km of visual effort. Passive acoustic monitoring resulted in 91 detections, including 81 detections across six identifiable species: sperm whales (*Physeter macrocephalus*; 42 detections), northern bottlenose whales (*Hyperoodon ampullatus*; 34 detections), harbour porpoises (*Phocoena phocoena*; two detections), killer whales (*Orcinus orca*; one detection), white-sided dolphins (*Lagenorhynchus acutus*; one detection) and white-beaked dolphins (*Lagenorhynchus albirostris*; one detection), and 11 detections of unidentified dolphin groups. Like the previous surveys of 2024 and 2025, acoustic detections of sperm and northern bottlenose whales appeared spatially separated, with sperm whales found to the south of the study area, and northern bottlenose whales found to the east of and southeast of Jan Mayen Island.

Visual observations recorded 23 encounters, with 18 being identified to species level: northern bottlenose whales (four encounters), killer whales (one encounter), sperm whales (six encounters), fin whales (*Balaenoptera physalus*; one encounter), minke whales (*Balaenoptera acutorostrata*; two encounters), white-beaked dolphins (one encounter), white-sided dolphins (two encounters), and harbour porpoises (one encounter), and one unidentified dolphin sighting and four unidentified whale sightings. Of the 23 observations recorded, 19 occurred within the proposed mining area. Overall, the survey provided additional data on the presence of cetaceans to the east and southeast of Jan Mayen during May, appearing to show similar distributions to those seen in previous years.

2.0 Introduction

The Arctic Mid-Ocean Ridge (AMOR) runs through the centre of the Norwegian and Greenland Seas, with complex bathymetry that includes 228 known seamounts (with summits ranging from 396 m to 2638 m below sea level), vent systems and adjacent abyssal regions. The AMOR region is recognised as providing habitat for unique deep-sea species (Ramiriz-Llodra *et al.*, 2020; Eilertsen *et al.*, 2024) and as such has been identified as containing particularly valuable and vulnerable areas (in Norwegian "Særlig Verdifulle og Sårbare Områder" SVOs) under Norwegian management plans (Havforskningen Institute, 2021).

Within the wider AMOR region, mineral resources are known to exist within deposits associated with the ridge system, with both seafloor massive sulphides and manganese nodules being a focus of potential commercial-scale mining. In 2024, areas under Norwegian jurisdiction were formally opened by the Norwegian government for exploration, evaluation and potential deep seabed mining (Norwegian Government, 2024). In December 2024, Norway's prime minister called for a "postponement" of mining in the regions but highlighted that preparatory work on regulations and environmental impact would continue.

The Norwegian Sea provides feeding habitat for many pelagic cetacean species, including killer whales (*Orcinus orca*), northern bottlenose whales (*Hyperoodon ampullatus*), fin whales (*Balaenoptera physalus*), and sperm whales (*Physeter macrocephalus*), the latter two of which are listed as Vulnerable by the IUCN Red List (Cook, 2018*;* Whitehead *et al.*, 2025). The Norwegian Sea is also an important migratory corridor for baleen whales, such as humpback whales (*Megaptera novaeangliae*), as they migrate to higher latitudes during the northern hemisphere's summer months (Nøttestad *et al.*, 2015).

Research has previously been conducted by other research groups within the Nordic Seas, including visual surveys for cetaceans. For example, the North Atlantic Sighting Surveys have been routinely conducted across the Nordic Seas since 1987, yielding data on the presence and abundance of species across the region, including within the designated mining area (for example, see Leonard & Øien, 2019). Research as part of the International Ecosystem Summer Surveys in the Nordic Seas (IESSNS) is also relevant in helping to identify key areas for cetacean species (for example, Løviknes *et al.* (2021) identified feeding hotspots for both fin and humpback whales). Visual data have been collected extensively by observers onboard ships dedicated to surveying for fish, plankton and oceanographic data. Nøttestad *et al.* (2015) conducted visual surveys for cetaceans during the summer months of 2009, 2010, and 2012. The authors stated

that sightings of odontocetes, such as killer whales and pilot whales, appear to be increasingly frequent in offshore areas. Nøttestad *et al.* (2015) suggest that the distributions of species were changing, potentially as a result of climatic change and increasing sea surface temperature. Species commonly found offshore in deep waters of the Nordic Seas included killer whales, minke whales, fin whales, sperm whales and beaked whales. Northern bottlenose whales are thought to inhabit waters of deeper than 500 m depth, with highest occurrences in water depths between 750 m and 1500 m (Whitehead and Hooker, 2012). Woo *et al.* (2023) examined habitat use by northern bottlenose whales around the island of Jan Mayen and results indicated that this area could be a potential key habitat for this species in June, particularly the submarine canyon area to the southeast of the island.

Deep sea mining has the potential to cause disturbance to cetaceans, particularly deep diving species such as bottlenose whales and sperm whales. One concern is the noise likely to be generated by the mining operations, which is expected to be created throughout the water column, with machinery on the seabed, riser pumps at intermediate depths and the vessels at the surface (Williams *et al.*, 2025). Such emitted noise could mask calls, create confusion in echolocating cetaceans and, in very severe cases, could damage hearing if close enough to a loud source during deep dives (Young *et al.*, 2025, Williams *et al.*, 2025). Chemical and light pollution, and ecological impacts are also possible, which would affect cetacean food sources (Thompson *et al.*, 2023, Crane *et al.*, 2024, Dowd *et al.*, 2025).

The research documented in the current report aimed to investigate pelagic marine vertebrate presence and behaviour east and southeast of Jan Mayen during May, using passive acoustic monitoring and surface visual monitoring to assess biodiversity within the proposed mining area. Conducted within the same area surveyed in June–July 2025, the 2026 survey builds on initial research from August 2024 (Young et al., 2024; 2025). The particular focus during 2025 and 2026 was on the submarine canyons southeast of Jan Mayen, the Jan Mayen Ridge and Mohn's Ridge, to contribute to a clearer multi-annual picture of the distributions and abundances of the different species encountered.

3.0 Methods

3.1 Passive acoustic survey

3.1.1 Survey design

Two equal-spaced complementary zigzag designs were created using Distance (Miller *et al.*, 2019). The 'dssd' package (version 1.0.0) in R (version 4.2.2, R Core Team, 2022) was implemented following recommendations in Buckland *et al.* (2004), Strindberg and Buckland (2004) and Buckland *et al.* (2015) to provide a near-even coverage probability of the survey area whilst also creating an efficient track line for the survey vessel (approximate design length 2000 m) (Fig. 1 and Table 1). Conservative minimum effective strip half-width estimates for the vessel were 3,277 m for sperm whales and 699 m for non-NBHF delphinids, based on previous work (Webber *et al.*, 2022). Coverage probability was simulated using 1,000 sets of transects through the survey area, resulting in a mean coverage score of 0.09 (Sd ± 0.29). Transit lines (dotted lines in Fig 1.B) between the two zigzag designs were planned outside of the dssd package. The southern transit line was designed to follow the Jan Mayen fracture zone while providing an efficient start and end point for the vessel's transit to and from the track lines. The northern transit line was designs for efficient passage between each survey design.

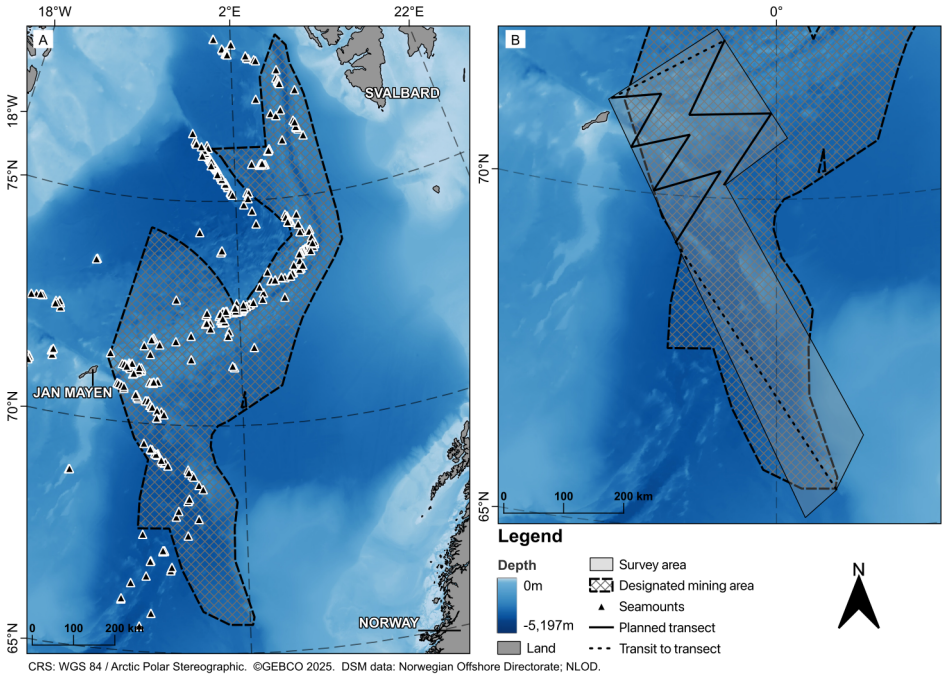


Figure 1. Study area and planned survey tracks in relation to the Norwegian Sea designated mining area. A) Designated mining area shown by shaded area and associated seamounts denoted as black triangles. B) Study area for 2026 research within the designated mining area with one of the planned transect routes shown as a black line.

3.1.2 Acoustic data collection and analysis

Acoustic data were collected onboard the *SY Witness* using a towed hydrophone array (Vanishing Point Ltd, Plymouth, United Kingdom) (Webber *et al.*, 2022). The array's streamer section comprised four hydrophone elements mounted within an oil (Isopar M) filled 5 m long, flexible, 35 mm diameter polyurethane tube. The streamer was towed using a 350 m Kevlar-strengthened tow cable. Two hydrophones, the 'medium frequency' pair (Benthos AQ4 elements and Magrec HP02 preamplifiers, nominal frequency range 50 Hz to 40 kHz) were spaced 3 m apart while the 'wide frequency' pair (Magrec HP03 hydrophone and preamplifiers units, nominal frequency range 1 kHz to 200 kHz) were spaced 0.5 m apart. Each array element was connected to one channel of a four-channel SAIL data acquisition card (St Andrews Instrumentation Ltd, Tayport, United Kingdom) where analogue filtering and gain were applied before each channel was sampled at 500 kHz. A high pass filter of 10 Hz and gain of 6 dB were applied to the 'medium frequency' channels 0 and 1, while a high pass filter of 2 kHz and gain of 12 dB applied to the 'high frequency' channels 2 and 3. Data from the SAIL acquisition card were written as four channel 16 bit lossless .wav files using PAMGuard (Gillespie *et al.*, 2026, available at www.pamguard.org), which also carried out real time acoustic processing, displayed results and logged the ship location from GPS.

Acoustic .wav files were processed in PAMGuard Viewer mode offline using a click detection threshold of 10 dB. To aid in the annotation process, three spectral template classifiers within the PAMGuard click detector module were added. The first was the default for narrow-band high-frequency species, such as harbour porpoise. The other two were used to identify periods of times that likely contained beaked whales, with one as the PAMGuard default, and the other covering a lower frequency band, more suitable to northern bottlenose whales. The whistle and moan detector within PAMGuard was also implemented between 1 and 24 kHz to aid in the annotation process, allowing the analyst to only look at periods of cetacean presence within the data (Gillespie *et al.*, 2013). A PAMGuard settings file containing the above-mentioned detectors and their associated settings can be downloaded from an online repository (https://zenodo.org/records/17571111).

Manual verification of recordings was then conducted on sections identified by the detectors as containing potential odontocete presence. Click trains and whistles were manually marked in PAMGuard Viewer Mode. Delphinid detections were defined as periods of whistles and/or echolocation clicks separated by at least 20 minutes without whistles and/or clicks either side

of the detection. Each detection was associated with a group rather than an individual dolphin, as estimating the number of individual dolphins can be unreliable given the difficulty in distinguishing between overlapping click trains (Kimura *et al.*, 2009). However, it is possible that two whales which were closely aggregated may have produced trains which could not be separated using time-bearing display, and in these cases a single click train may have contained clicks from two individuals. Click trains originating from individuals that are NBHF species were combined into one group, given the difficulty in resolving click trains to an individual. Sperm whale detections were also grouped based on the temporal proximity of one click train to another, with silences over two hours being treated as separate groups. Where silences were less than two hours, it was assessed if any click trains could be from the same individual based on the ships position and speed, as well as the time between click trains and their estimated position based on target motion analysis.

Where possible, click trains were localised using the target motion analysis module within PAMGuard using the 2D simplex method. Slant ranges to click trains were used as proxies for perpendicular distances from the track line and were subsequently used to model a detection function using the R package *Distance* (Miller *et al*., 2019) within an R Studio environment (R version 4.3.3). Both hazard-rate and half-normal key functions were used, with right truncation set to remove the top 5% of distances following Buckland *et al*. (2015), and the model with the lowest AIC value was selected to estimate an effective strip half-width (ESHW) for species groups (delphinids, sperm whales, beaked whales) from the *SY Witness*, where possible. Whistle contours were manually verified using the spectrogram annotation module and classified as either delphinid or noise.

3.2 Visual survey

A non-systematic visual survey was conducted during when conditions and observers were available (largely 0900 to 1800 local time). Observations were made to provide additional evidence of cetacean presence, and where possible data on: species identity, location, numbers of animals and behaviour. Observers were located on the vessel deck and performed a series of one-hour watches throughout the survey period, scanning using both binoculars and the naked eye throughout the watch. At the beginning and end of every watch, or if any change was noted, the following environment and effort variables were recorded: effort status (on or off effort depending on whether there was an observer on station), observer identity, vessel position, speed of vessel over ground, Beaufort sea state, swell height (low = <2 m, medium = 2–4 m, high

= >4 m) and direction, visibility (poor = <1 km, moderate = 1–5 km, good = > 5km), glare intensity (none, weak, strong, variable) and direction (none, forward, behind) and rain (none, light, moderate, heavy). Only three observers had previous cetacean visual survey experience and therefore the survey was deemed to be opportunistic.

If cetaceans were observed, the following data were recorded: date, time (local), initial observer identity, effort status, ship's heading, position, depth of seabed, sighting method (naked eye or binoculars), initial sighting cue (blow, surface activity, body), bearing to the animal, distance at first sighting (estimated), group size (minimum / maximum / best guess), presence of calves, species (lowest taxonomic group possible), and confidence of species identity (definite / probable / possible). Species identity was confirmed using Carwardine (2020). Where possible photographs were taken for species identification.

3.3 Photoidentification

Where possible, all sighted species were photographed using a Canon EOS 6D digital SLR for species identification and photoidentification. Images collected which were deemed suitable for photoidentification were then cropped and uploaded to Happywhale (https://happywhale.com/home) online repository.

3.4 Permits

Research was primarily planned to be within the area beyond national jurisdiction and the Norwegian EEZ. Consent was granted by the Norwegian authorities to Dr Kirsten Young to conduct the marine scientific research described above. Specifically, consent was provided by the Directorate of Fisheries (Reference: 25/29016) and the Norwegian Armed Forces gave permission to enter Norwegian territorial waters (Reference: 2024/047401-074/DEFNON/414).

4.0 Results

Between the 9 May – 19 May 2026 (10 days), a total of 2785 km of survey effort was conducted by the *SY Witness*. Average survey speed was 7 knots, covering a total effort of 1715 km within the proposed designated mining area. The additional 1070 km were on transit to and from Ålesund, Norway. Total track line distances for visual effort were 798 km and acoustic effort was 2397 km (Table 1). Alongside the collection of visual and acoustic data, one image of a sperm whale suitable for photoidentification was collected opportunistically during the survey.

Table 1. Effort breakdown from the visual and acoustic survey from the *SY Witness* during 9 May – 19 May 2026 (10 days).

	Track line	**Acoustic**	**Visual**
Total effort	2758 km	2397 km	798 km
Effort in proposed mining area	1715 km	1715 km	320 km

4.1 Passive acoustic survey

A total of 179 hours and 30 minutes of acoustic recordings were made, corresponding to 2397 km of track line where the vessel was on acoustic effort.

A total of 92 detections of cetaceans were made, of which 53 were recorded within the proposed designated mining area. Six species of cetacean were detected: sperm whale (42 detections), northern bottlenose whale (34 detections), harbour porpoise (two detections), killer whale (one detection), white-sided dolphin (one detection), and white-beaked dolphin (one detection) (Fig. 2). Among the 92 detections, 11 were recorded as unidentified dolphin species (non-NBHF).

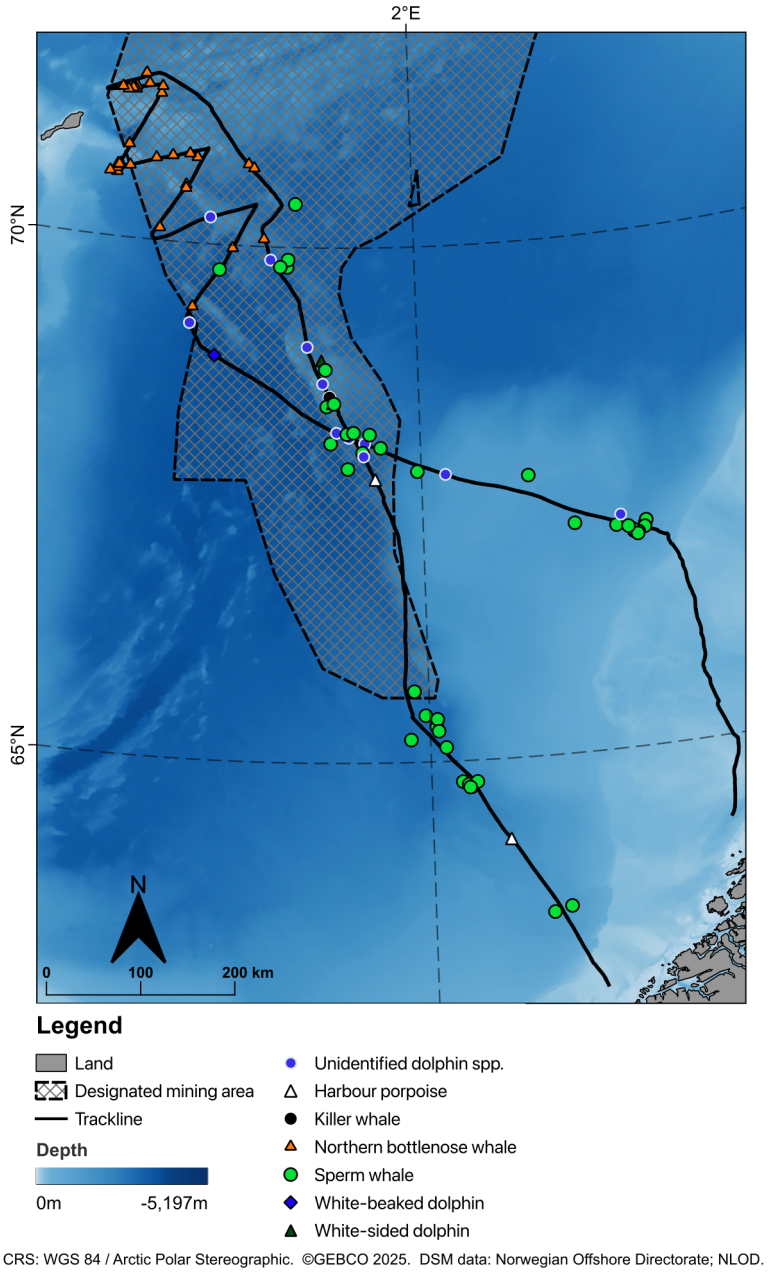


Figure 2. Map of acoustic detections of cetaceans during the visual-acoustic survey conducted by the *SY Witness* during 9 May – 19 May 2026 (10 days).

A distinct geographic separation was observed between acoustic detections of sperm whales and northern bottlenose whales. Sperm whale detections were concentrated in the southern portion of the study area, whereas northern bottlenose whale detections occurred predominantly in the north.

Table 2. Acoustic detections of cetaceans using passive acoustic monitoring from the *SY Witness* during 9 May – 19 May 2026 (10 days). Approximately 2397 km of acoustic effort was conducted within the designated mining area, and the additional 388 km were on transit to and from Ålesund. Depth ranges were derived from GEBCO bathymetric data.

Common name	**Scientific name**	**Number of detections**	**Water depth range (m)**
Sperm whale	*Physeter macrocephalus*	42	1221 - 3607 m
Northern bottlenose whale	*Hyperoodon ampullatus*	34	1086 - 3437 m
Killer whale	*Orcinus orca*	1	2238 m
White-beaked dolphin	*Lagenorhynchus albirostris*	1	3627 m
Harbour porpoise	*Phocoena phocoena*	2	1863 – 3165 m
White-sided dolphin	*Lagenorhynchus acutus*	1	2506 m
Unidentified dolphin species	*Delphinidae*	11	1432 - 3537 m
Total		92	2397 km effort
Total within mining area		53	1715 km of effort within proposed mining area

The perpendicular distances of 235 sperm whale acoustic detections across all three survey years, localised using PAMGuard's Target Motion Analysis module, were used to estimate an ESHW. A hazard-rate (hr) model without adjustment terms provided a lower AIC score (3404.5) than the half-normal model (3427.8) when modelling a detection function (Fig. 3A). This yielded an ESHW estimate for sperm whales of 5354 m (±375 m). Perpendicular distances of 199 of the northern bottlenose whale acoustic detections from all three survey years were used to produce an ESHW. A hazard-rate (hr) model without adjustment terms provided a lower AIC score (2438.2) than the half-normal model (2452.6) when modelling a detection function (Fig. 3B). This yielded an ESHW estimate for northern bottlenose whales of 2012 m (±164 m).

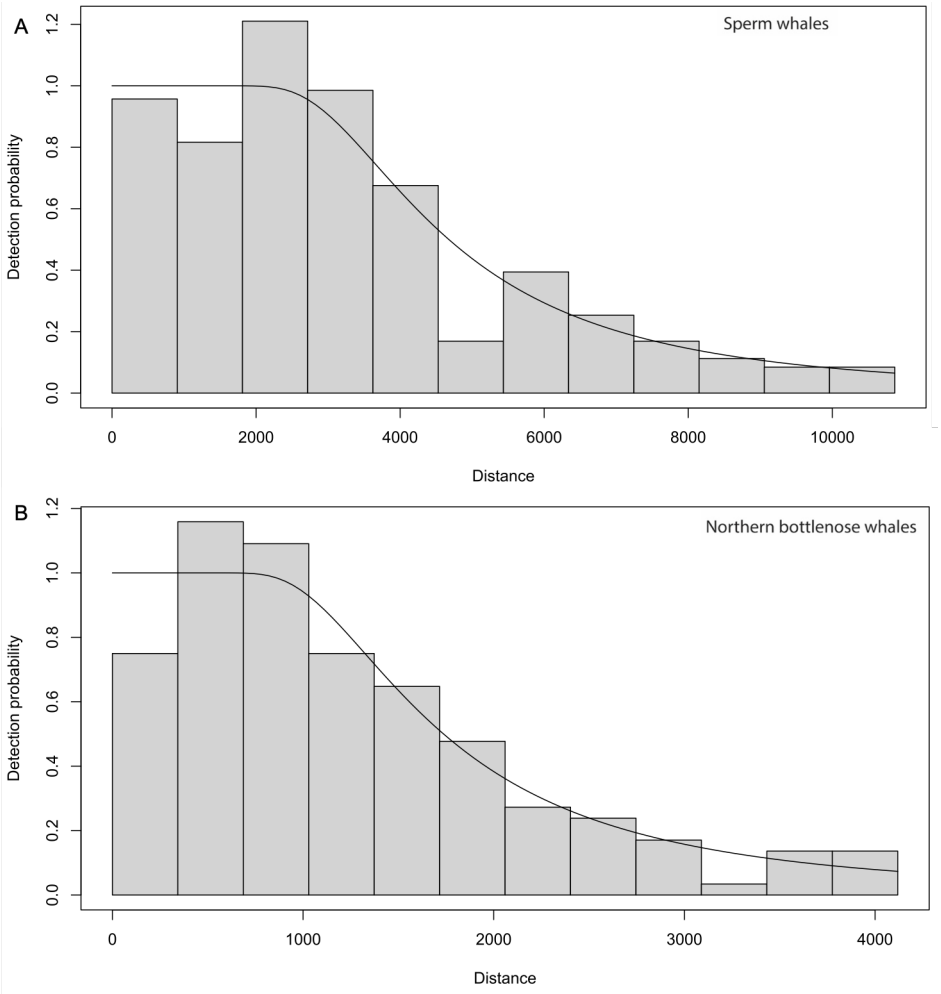


Figure 3. Detection probabilities of sperm whale and northern bottlenose whale click trains and estimated slant ranges from the track line of the *SY Witness*. A) Sperm whale hazard rate (hr) detection function is shown as the black line providing an effective strip half width of 5354 m (±375 m). B) Northern bottlenose hazard detection function is shown as the black line providing an effective strip half width of 2012 m (±164 m).

4.2 Visual survey

A total of 61 hours visual effort were completed (with two observers) during the survey, covering 798 km of track line (Fig. 4). A total of 39 hours of visual effort were within the proposed designated mining area, covering 320 km of track line. Visual effort was made in conditions that were Beaufort Sea state < 4, though other opportunistic sightings were also recorded.

A total of 23 encounters were recorded, including 18 encounters across eight identifiable species: northern bottlenose whales (four encounters), killer whales (one encounter), sperm whales (six encounters), fin whales (one encounter), minke whales (two encounters), white-

beaked dolphins (one encounter), white-sided dolphins (two encounters), and harbour porpoises (one encounter). One unidentified dolphin species encounter and four unidentified whale species encounters were also recorded.

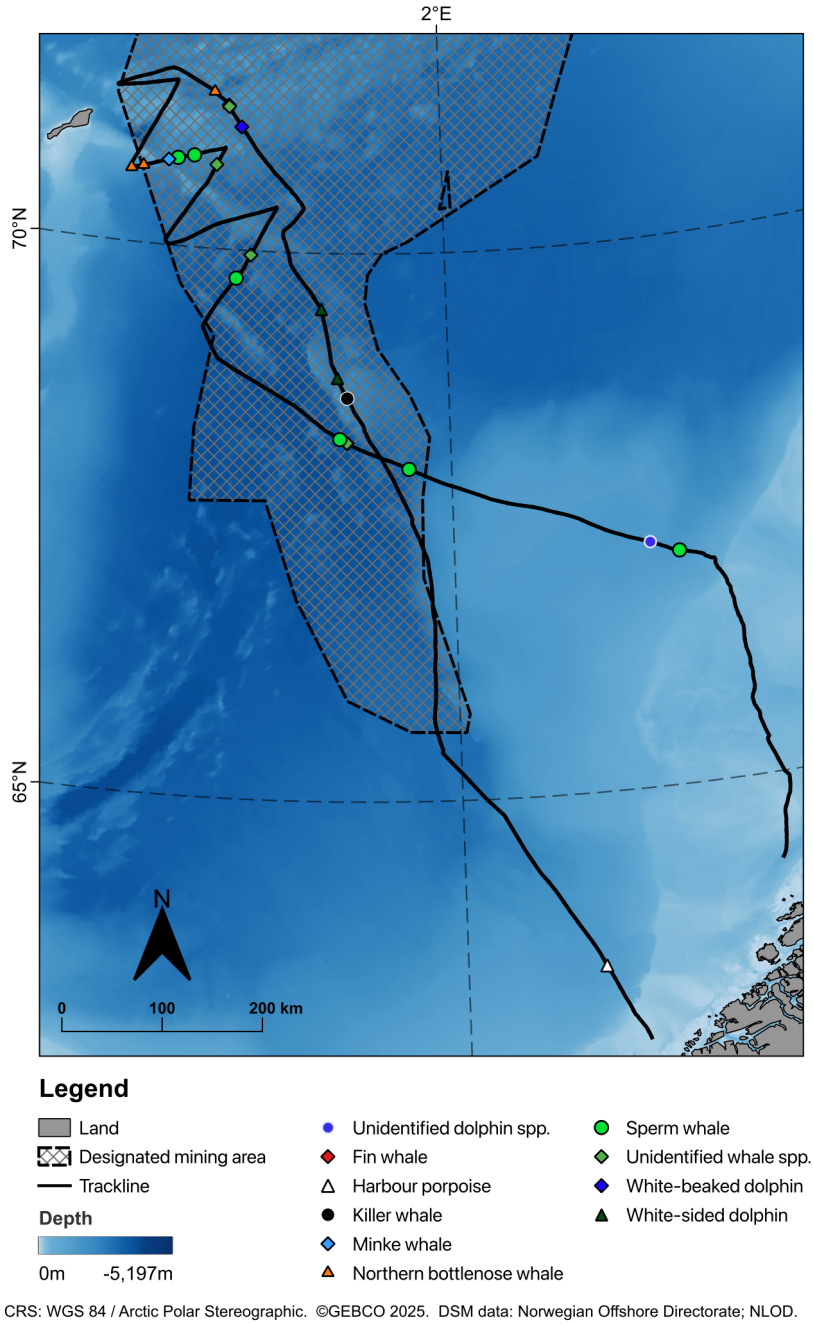


Figure 4. Map of sightings of cetaceans during the visual-acoustic survey conducted by the *SY Witness* during 9 May – 19 May 2026 (10 days).

Table 3. Visual encounters made from the deck of the *SY Witness* during 9 May – 19 May 2026 (10 days). Date and time (UTC) are provided as well as mean group sizes and range and water depth range that this species were recorded at during the survey.

Common name	Scientific name	Number of encounters	Comments
Sperm whale	*Physeter macrocephalus*	**6** 1 whale (11 May 2026, 11:30) 1 whale (12 May 2026, 10:21) 1 whale (12 May 2026, 15:44) 1 whale (13 May 2026, 10:11) 1 whale (14 May 2026, 12:14) 1 whale (15 May 2026, 13:27)	All encounters were with lone whales. Water depth range: 1330 – 3554 m The individual on the 11 May 2026 was photo-identified. The individual on the 12 May 2026 fluked but was not photo-identified. All other individuals shallow dived at 200 – 1500 m distance from the vessel.
Northern bottlenose whale	*Hyperoodon ampullatus*	**4** 4 whales (14 May 2026, 16:08) 2 whales (14 May 2026, 17:08) 2 whales (15 May 2026, 14:44) 2 whales (15 May 2026, 16:24)	Mean group size: 2.5 (range 2 – 4) Water depth range: 1602 – 2814 m
Killer whale	*Orcinus orca*	**1** 5 whales (16 May 2026, 19:17)	Group size: 5 whales Water depth: 1914 m Photographs of this group were taken but not used for photoidentification. Available on request.
White-beaked dolphins	*Lagenorhynchus albirostris*	**1** 3 dolphins (15 May 2026, 18:29)	Group size = 3 Water depth: 2326 m

Common name	Scientific name	Number of encounters	Comments
Minke whale	*Balaenoptera acutorostrata*	**2** 1 whale (12 May 2026, 13:13) 1 whale (14 May 2026, 14:11)	Mean group size: 1 Water depth range: 2328 – 3454 m
Fin whale	*Balaenoptera physalus*	**1** 1 whale (15 May 2026, 16:20)	Single whale Water depth: 2002 m
Harbour porpoise	*Phocoena phocoena*	**1** 2 individuals (18 May 2026, 17:00)	Group size: 2 Water depth: 1186 m
White-sided dolphin	*Lagenorhynchus acutus*	**2** 3 dolphins (16 May 2026, 11:53) 3 dolphins (16 May 2026, 17:36)	Mean group size: 3 Water depth range: 2544 – 2987 m
Unidentified dolphin species		**1** 1 dolphin (11 May 2026, 14:19)	
Unidentified whale species		**4** 1 whale (12 May 2026, 13:14) 1 whale (13 May 2026, 12:19) 1 whale (14 May 2026, 06:30) 1 whale (15 May 2026, 16:32)	Four separate individual whales sighted Water depth range: 2145 – 3456 m
Total within mining area		**19**	
Total		**23**	

4.3 Photo-identification

One sperm whale was photo-identified (Fig. 5). One image was of sufficient quality for identification purpose and was uploaded to the online repository Happywhale (www.happywhale.com).



Figure 5. Photo-identified sperm whale during the visual-acoustic survey conducted by the *SY Witness* during 9 May – 19 May 2026 (10 days). The sperm whale was photo-identified on 11 May 2026 at position latitude 67.1125 and longitude -7.2684.

5.0 Conclusions

The 2026 visual–acoustic survey conducted aboard the *SY Witness* successfully achieved its objectives of assessing cetacean presence east and southeast of Jan Mayen within the proposed deep-sea mining area in the Norwegian Sea. Over a 10-day period between 9 May – 19 May 2026, a total of 2785 km of survey effort was completed, comprising 2397 km of acoustic monitoring and 798 km of visual observation.

Passive acoustic monitoring produced 179 hours and 30 minutes of data and 92 cetacean detections, of which approximately 58% occurred within the proposed designated deep-sea mining area. Six species were acoustically detected: sperm whale, northern bottlenose whale, killer whale, harbour porpoise, and white-beaked dolphin. Additionally, one unidentified dolphin was also detected.

Visual effort recorded 23 encounters, including 18 encounters across eight identifiable species. The most frequently observed species were sperm whales and northern bottlenose whales,

confirming their consistent presence within deep-water habitats of the Jan Mayen Ridge and adjacent sub-marine canyons to the southeast of Jan Mayen Island. Baleen whales, including fin whales (*Balaenoptera physalus*), minke whales (*Balaenoptera acutorostrata*), humpback whales (*Megaptera novaeangliae*), four unidentified whales and an additional unidentified dolphin, were also observed, indicating a diverse assemblage of cetaceans using the region.

6.0 Acknowledgements

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