Visual-acoustic survey for cetaceans of the Norwegian Sea, August 2024

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Suggested citation: Young, KF, Lomas, AC, Rossi, M, Østvold, O, Saalman, F, Santillo, D. (2024). Visual-acoustic survey for cetaceans of the Norwegian Sea, August 2024. Greenpeace Research Laboratories Analytical Report-2024-04. 20 pp.

Abstract

The central region of the Norwegian Sea running north to the Greenland Sea has recently been designated as an area for potential deep seabed mining. In late 2024, the first round of licensing was postponed, though this was seen by many as a pause whilst regulations and assessments of the potential environmental impact of mining are developed. The area is known to provide habitat to a high diversity of cetaceans who forage there year-round and migrate through the area at certain periods of the year. Many of these data were generated using visual surveys and few acoustic surveys of the area have been conducted. In August 2024, the *SY Witness* conducted a visual-acoustic survey for cetaceans during a transit between Ålesund, Norway, to Longyearbyen, Svalbard, using a towed hydrophone array. We identified six species of cetacean during the survey: sperm whale (*Physeter macrocephalus*) (eight sightings, 22 acoustic detections); white-beaked dolphin (*Lagenodelphis albirostis*) (6 sightings, 15 acoustic detections) minke whale (*Balaenoptera acutorostrata*) (eight sightings); northern bottlenose whale (*Hyperoodon ampullatus*) (four acoustic detections); killer whale (*Orcinus orca*) (one sighting also detected acoustically); fin whale (one sighting). In addition, two large whales were sighted that could not be identified to species level. Sperm whales were tracked acoustically where possible and three images were collected for the purposes of photo-identification. At least three of the species detected are known to be sensitive to noise, raising additional concerns regarding future plans for deep sea mining in the area.

Introduction

Approximately 281,000 km^2 of the Norwegian Sea running north to the Greenland Sea has recently been allocated as an area designated for deep sea mining (Figure 1) (European Parliamentary Research Service, 2024). Some regions within this broader area are the first proposed licensing areas and are likely to be the first to undergo commercial deep-sea mining if it is allowed to go ahead. In early 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 bathymetry is highly complex within the designated mining area, with mid-Atlantic ridge systems and 228 seamounts, with summits ranging from 396 m to 2638 m deep. There are deep-sea habitats associated with the extensive active and inactive vent systems, and as such the area has been identified as particularly valuable and vulnerable areas (in Norwegian " Særlig Verdifulle og Sårbare Områder" SVOs) under Norwegian management plans (Havforskningen Institute, 2021). As such, the region is recognised as providing habitat for unique deep-sea species, such as dense stalked crinoids and sponges (Ramiriz-Llodra *et al.*, 2020). The Norwegian Sea provides feeding habitat for many cetacean species, including species like 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; Taylor *et al*., 2019). 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).

Significant research has been conducted across the Norwegian Sea, including visual surveys for cetaceans. For example, visual surveys have been conducted across the Norwegian Sea routinely since 1987 as part of the North Atlantic Sighting Surveys, yielding data on the presence and abundance of species across the designated mining area (for example, see Leonard & Øien, 2019). Also relevant are the International Ecosystem Summer Surveys in the Nordic Seas (IESSNS) 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 also been collected by observers onboard ships dedicated to surveying for fish, plankton and a variety of oceanographic data. Nøttestad *et al.* (2015) conducted visual surveys for cetaceans during the summer months of 2012-2019. The authors state 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 are changing, potentially as a result of climatic change and increasing sea surface temperature. Species found commonly in the deeper regions of the Norwegian Sea included killer whales, minke whales, fin whales, sperm whales and beaked whales, which were significantly associated with deeper waters. 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 and perhaps even mortality to cetaceans, particularly deep diving cetaceans such as bottlenose whales and sperm whales. One concern is the noise created by the mining operations, directly from the machinery on the seabed and the vessels at the surface, which could mask calls, create confusion in echolocating cetaceans and in very severe cases could damage hearing if close enough to a loud source. Biochemical and ecological impacts are also likely, including through impacts on cetacean food sources, for example (Thompson *et al*., 2023, Crane *et al*., 2024).

The primary aim of this survey was to investigate further the presence of cetaceans within the designated mining area by combining visual observations with passive acoustic monitoring during a period in the summer of 2024, as well as attempting to track and collect photo-identification images of sperm whales in this offshore area. Data on the presence of cetaceans were collected during a single ten-day period between 30th July 2024 and 10th August 2024. We present the results of downstream analyses of recordings as a contribution to the overall knowledge-base on the distribution of cetaceans within the regions targeted for mining and hope that these data can be integrated into larger, long-term studies of cetacean distributions across the designated mining area.

Methods

Survey design

The survey area was chosen to best cover as many of the proposed licensing areas (as shown in Fig, 1) within the period available. A visual-acoustic survey was conducted across the survey area. Standard principles for line-transect survey design were used to help ensure coverage of the wider area, including blocks to the south and northeast of the designated mining area. An equal-spaced complementary zigzag design was created using the *'dssd'* package (version 1.0.0, Marshall and Rexstad, 2022) in R (version 4.2.2, R Core Team, 2022) 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 (total design length 2041.38 km) (Table 1 and Figure 1). Surveys were conducted from the *SY Witness*, a 22 m sailing yacht, hereafter known as *Witness*.

Previous acoustic studies using the *MY Arctic Sunrise* (a 50 m ship) have estimated the combined hazard rate detection functions for sperm whales and non-narrow band high frequency (NBHF) delphinids (Webber *et al*., 2022). Effective strip half-width (ESHW) estimates for the *MY Arctic Sunrise* were estimated at 3,277m for sperm whales and 699m for non-NBHF delphinids. Given that the *Witness* is a sailing yacht and known to be much quieter than the *MY Arctic Sunrise* based on previous surveys, we can assume that the ESHW will be greater in this vessel (Thompson *et al*. 2024). Coverage probability was simulated using 1,000 sets of putative transects through the survey area, resulting in a mean coverage score of 0.65 (SD ± 0.06). Given the homogenous open ocean nature of the survey area (mean depth = 4259m) with no clear stratification, survey lines were oriented for an efficient start and end point for the vessel's transit from and to port.

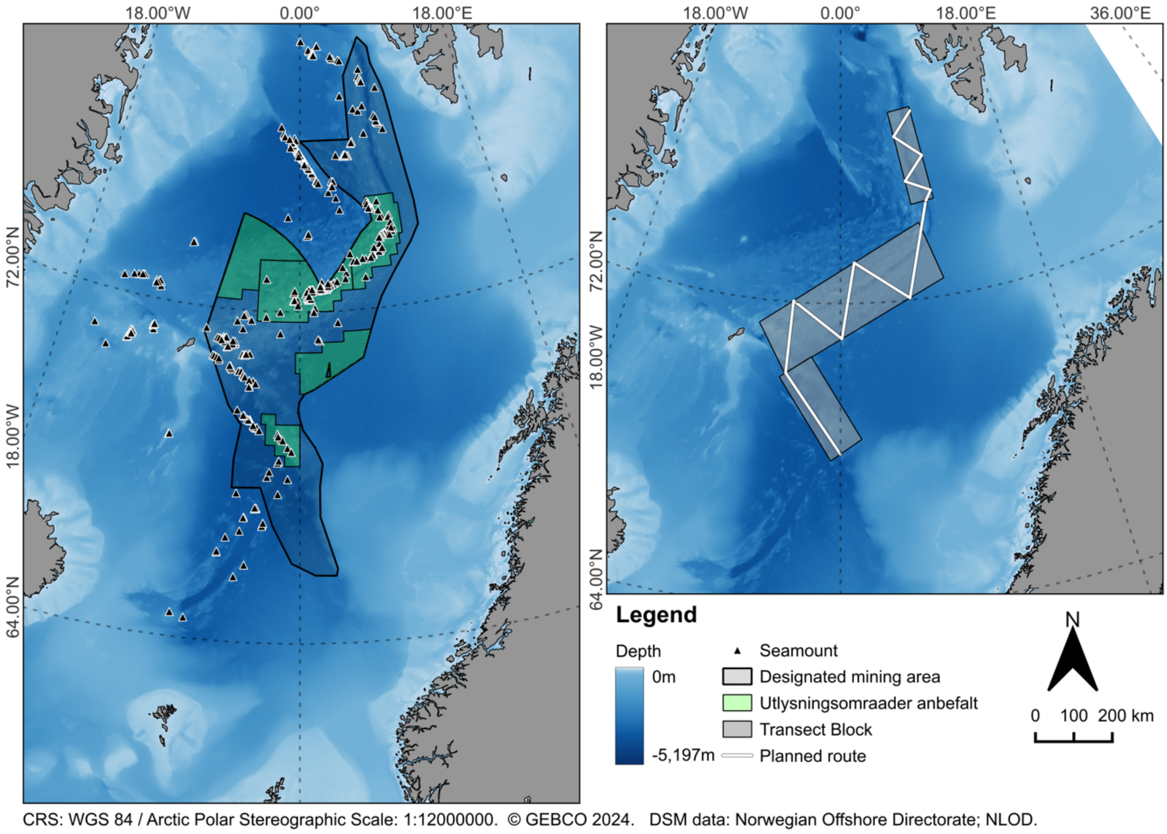


Figure 1. Planned transect routes and design areas within the designated mining area for *SY Witness* survey from Ålesund, Norway, to Longyearbyen, Svalbard, August 2024. The larger designated mining area is shown on the left, with light green denoting the proposed licensing areas. On the right, the survey transect blocks are shown in grey and the planned survey route represented by the white line.

Acoustic data collection and processing

Acoustic data were collected on-board the *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 5m long, flexible, 35mm diameter polyurethane tube. This was towed using a 350m Kevlar-strengthened tow cable. Two hydrophones, the 'medium frequency' pair (Benthos AQ4 elements and Magrec HP02 preamplifiers, nominal frequency range 50Hz to 40kHz) were spaced 3m apart while the 'wide frequency' pair (Magrec HP03 hydrophone and preamplifiers units, nominal frequency range 1kHz to 200kHz) were spaced 50cm 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 500kHz. A high pass filter of 10Hz and gain of 6dB were applied to the 'medium frequency' channels 0 and 1, while a high pass filter of 2kHz and gain of 12dB 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.* ,2009, 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 12dB. The whistle and moan detector within PAMGuard was also implemented between 1 and 24kHz (Gillespie *et al.,* 2013). 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, with the true location of acoustic detections estimated using the two-dimensional simplex method within the PAMGuard target motion analysis module. Delphinid detections were defined as periods of whistles and/or echolocation clicks separated by at least 20 minutes of silence before and after, with each detection 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). Individual sperm whale and beaked whale click trains were treated as separate detections as individual whales can be tracked using the time-bearing click display in PAMGuard. However, it is possible that two whales which are so closely aggregated may produce a train which cannot be separated using time-bearing display, and in these cases a single click train may contain clicks from two individuals. 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. For delphinids, if any overlap between clicks and whistles occurred, they were included in the same detection.

Visual survey

A non-systematic visual survey was conducted during 0800 to 1800 local time to provide additional evidence of cetacean presence in the survey area, and where possible data on: species identity, location, numbers of animals and behaviour. Due to long periods of fog, we also extended visual effort beyond 1800 on occasion to take advantage of suitable conditions. Observers were located on the port and starboard sides of the vessel deck and performed 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, depth (according to the sounder on the bridge), swell height and direction, visibility, glare and rain. Only two of the five observers had previous cetacean visual survey experience and therefore the survey was deemed to be opportunistic.

Visual surveys were only conducted in conditions where Beaufort Sea state was <4, and visibility was moderate or good.

If cetaceans were observed, the following data were recorded: date, time (local), initial observer identity, effort status, ship's heading, position, depth, sighting method (naked eye or binoculars), initial sighting cue (blow, surface activity, body), bearing to the animal, closest distance (estimated), group size (minimum / maximum / best guess), presence of calves, species (highest 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. Where sperm whales were heard and visual conditions allowed, diving whales were tracked acoustically to collect photo-identification images whilst they were at the surface.

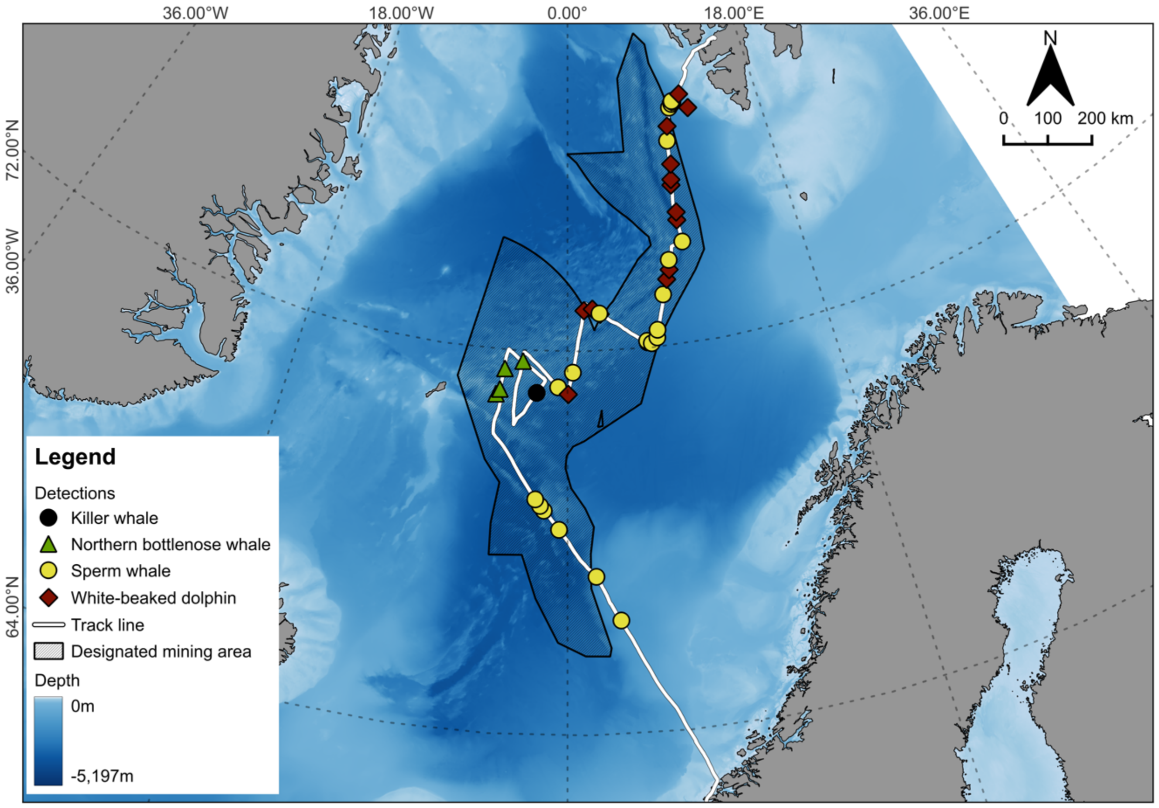
Results

Witness set sail from Ålesund on the evening of the 30th of July 2024, arriving in Longyearbyen on the 10th of August 2024. A total of 2778 km of survey track line was covered over 10 days, with 211 hours of acoustic recordings. The survey was paused on the 5th of August 2024 to move recording equipment during calm conditions. The time lost during this process is not included in the survey time. Of the 2778 km, 398 km were on visual effort over 32 hours, while 2707 km were acoustically recorded. Average speed over ground was 6.2 knots during the transect.

Acoustic detections

There were 42 acoustic encounters during the survey, which were attributed to four species (Figure 2, Table 1). Of the 42 acoustic encounters, 35 were within the designated mining area (Figure 2). Sperm whales (22 acoustic encounters, 18 within the designated mining area) were heard making characteristic 'creaks' indicating that they were foraging within the designated mining area. White-beaked dolphins (*Lagenodelphis albirostis*) (15 acoustic encounters, 12 within the mining area) were detected throughout the survey. Nine of the acoustic encounters were from delphinids without a concurrent visual sighting. These were attributed to white-beaked dolphins due to the spectral banding characteristics present in their echolocation clicks (Rasmussen *et al.*, 2006, Yang *et al.*, 2021). Only Risso's dolphins (*Grampus griseus*) and white-beaked dolphins are known to show this type of banding in their click characteristics and Risso's are not known to be present this far north in the Norwegian Sea (Genov *et al.*, 2023).

Four of the 42 acoustic encounters were from beaked whales, and these were further identified as northern bottlenose whales due to the similarities of click characteristics described for the species (Hooker & Whitehead, 2002; Clarke *et al.*, 2019). Mean peak click frequencies for each of the events ranged from 23 to 27 kHz, with 3dB centre frequencies also between 23 and 27 kHz (Fig. 3, Table 1). From an analysis of click trains, all detections are estimated to be from single individuals except for one potential group of two whales (Table 1). All northern bottlenose whale acoustic detections occurred to the east of Jan Mayen Island and within the larger designated mining area. A single group of two male killer whales was detected within the designated mining area based on both a close sighting and acoustics.



CRS: WGS 84 / Arctic Polar Stereographic. Scale: 1:9500000. Bathemetric data: © GEBCO 2024; DSM data: Norwegian Offshore Directorate; NLOD.

Figure 2. Acoustic survey conducted by the *SY Witness* during the survey from Ålesund, Norway, to Longyearbyen, Svalbard, during the period 30th July 2024 to 10th August 2024. Track line is shown in white. The hatched area denotes the wider designated mining area. Bathymetric data derived from GEBCO (https://www.gebco.net/data_and_products/gridded_bathymetry_data/).

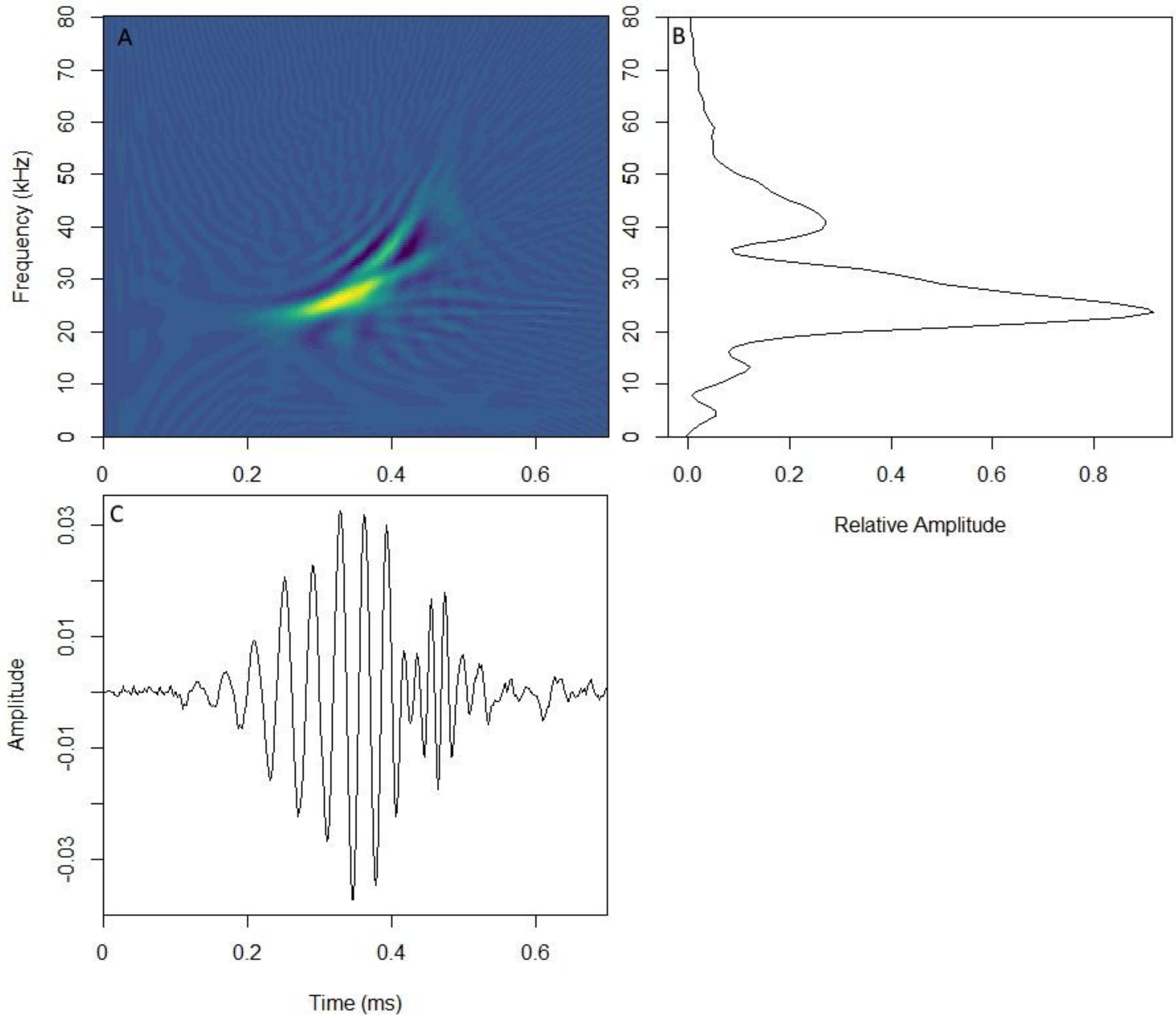


Figure 3. An example of an echolocation click from one of the beaked whale detections on the 4th August 2024 determined to be from a northern bottlenose whale (*Hyperoodon ampullatus*). A) The characteristic upsweep of beaked whale echolocation clicks in the Wigner-Ville distribution. B) The peak frequency of echolocation clicks at 26.3 kHz (mean 25.6 kHz) is characteristic of northern bottlenose whales (Hooker & Whitehead, 2002; Clarke et al., 2019). C) A click waveform, with a click length of approximately 350 µs.

Table 1. Acoustic detections and species encountered during the visual acoustic survey conducted by the SY *Witness* during the survey from Ålesund, Norway, to Longyearbyen, Svalbard, during the period 30th July 2024 to 10th August 2024. Where there was no concurrent visual sighting, group-size of beaked whales and sperm whales were estimated from click trains.

Species	**Encounter** (date, time UTC)	**Comments**
Sperm whale (*Physeter macrocephalus*)	1 whale (2nd Aug 2024, 16:22) 1 whale (2nd Aug 2024, 23:31) 3 whales (3rd Aug 2024, 08:15) 3 whales (3rd Aug 2024, 11:46) 1 whale (3rd Aug 2024, 12.49) 1 whale (3rd Aug 2024,14:01) 1 whale (6th Aug 2024, 17.44) 2 whales (7th Aug 2024, 01.55) 1 whale (7th Aug 2024, 19.15) 2 whales (8th Aug 2024, 07.53) 2 whales (8th Aug 2024, 09.50) 1 whale (8th Aug 2024, 13.44) 3 whales (8th Aug 2024, 15.55) 3 whales (8th Aug 2024, 18.31) 1 whale (9th Aug 2024, 00.45) 1 whale (9th Aug 2024, 07.01) 1 whale (9th Aug 2024, 12.18) 1 whale (10th Aug 2024, 05.57) 3 whales (10th Aug 2024, 12.01) 2 whales (10th Aug 2024, 13.28) 1 whale (10th Aug 2024, 14.16)	22 acoustic encounters were recorded, 8 of which were visually sighted. 18 of the 22 encounters were within the designated mining area. Encounters with multiple individuals indicates multiple individuals were vocalising within the range of the hydrophone and it is unknown whether these whales are within groups.

	1 whale (10th Aug 2024, 15.10)	
Northern bottlenose whale (*Hyperoodon ampullatus)*	1 whale (4th Aug 2024, 12.07). Mean peak frequency 23.1 kHz (± 2.0), mean 3dB centre frequency 23.0 kHz (±2.0). 1 whale (4th Aug 2024, 13.10). Mean peak frequency 26.9 kHz (± 0.4), mean 3dB centre frequency 27.4 kHz (±0.3). 2 whales (4th Aug 2024, 17.56). Mean peak frequency 25.6 kHz (± 0.5), mean 3dB centre frequency 25.7 kHz (±0.5). 1 whale (6th Aug 2024, 05.36). Mean peak frequency 25.6 kHz (± 0.4), mean 3dB centre frequency 25.5 kHz (±0.5).	4 acoustic encounters were recorded, with no visual sightings of this species. All 4 encounters were within the designated mining area, north-east of Jan Mayen.
White-beaked dolphin (*Lagenodelphis albirostis*)	1 individual (6th Aug 2024, 21.53) 1 individual (7th Aug 2024, 13.20) 20 individuals (7th Aug 2024, 16.13) 1 individual (7th Aug 2024, 18.02) 8 individuals (9th Aug 2024, 03.29) 10 individuals (9th Aug 2024, 05.24) 1 individual (9th Aug 2024, 16.19) 1 individual (9th Aug 2024, 17.49) 1 individual (9th Aug 2024, 22.25) 1 individual (9th Aug 2024, 23.25) 1 individual (10th Aug 2024, 02.01) 10 individuals (10th Aug 2024, 08.28) 8 individuals (10th Aug 2024, 14.50)	15 acoustic encounters were recorded; however, group size could not be determined without visual confirmation. Nine of the 15 acoustic encounters had no concurrent visual confirmation. Twelve of the 15 encounters were within the designated mining area.

	1 individual (10^{th} Aug 2024, 16.29) 1 individual 10^{th} Aug 2024, 17.58)	
Killer whale (*Orcinus orca*)	2 whales (5^{th} Aug 2024, 13.19)	2 males were recorded acoustically and visually. Males were observed travelling together within the designated mining area.

Sightings

Visibility was generally poor due to fog during the time at sea, resulting in only 32 hours of visual effort over the entire survey. Within that time, 32 sightings were recorded, which included five species of cetaceans and one unidentified whale species (Fig. 4, Table 2). Nineteen of the encounters were within the designated mining area. It is important to note that, where possible, sperm whales were tracked acoustically to collect photo-identification images, therefore, some encounters may have been resighted individuals.

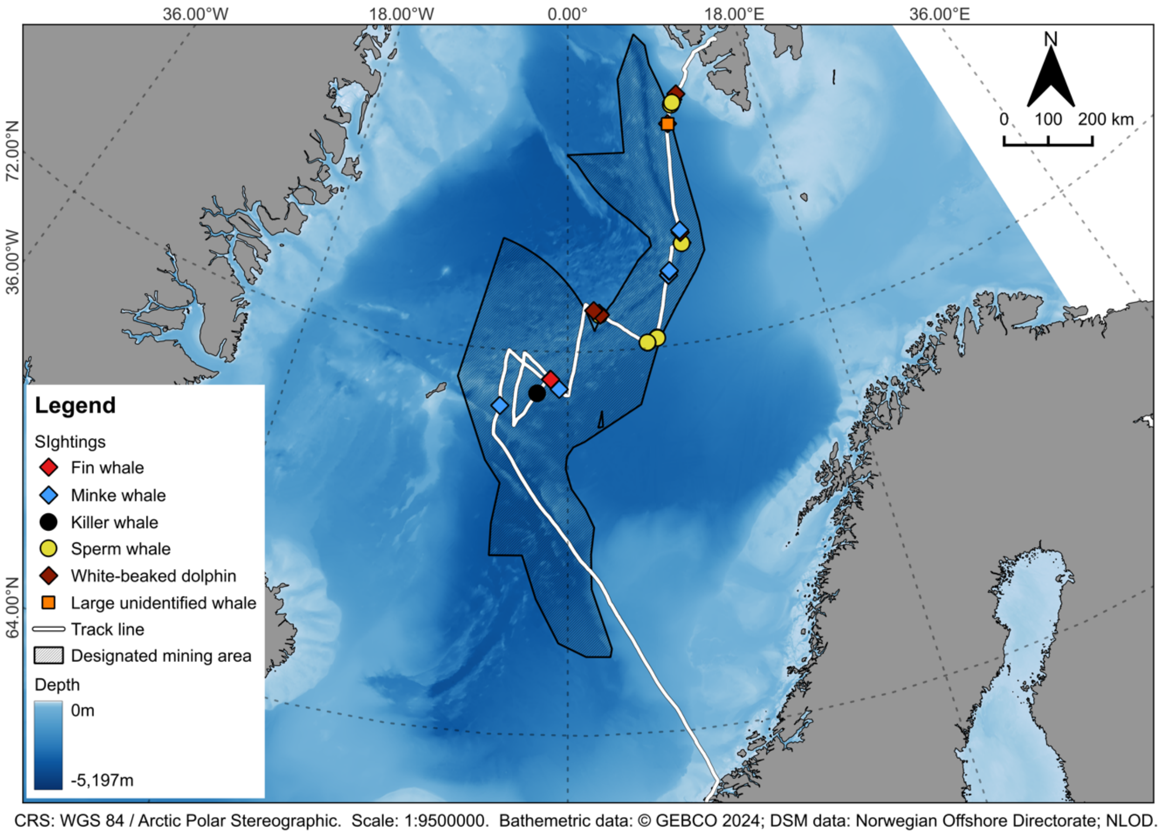


Figure 4. Visual survey conducted by the *SY Witness* during survey from Ålesund, Norway, to Longyearbyen, Svalbard, during the period 30th July 2024 to 10th August 2024. Track line is shown in white. The hatched area denotes the wider designated mining area. Bathymetric data derived from GEBCO (https://www.gebco.net/data_and_products/gridded_bathymetry_data/).

Table 2. Sightings and species encountered during the visual acoustic survey conducted by the *SY Witness* during survey from Ålesund, Norway, to Longyearbyen, Svalbard, during the period 30th July 2024 to 10th August 2024.

Species	Encounter (date, time and depth)	Comments
Sperm whale (*Physeter macrocephalus*)	1 whale (7th Aug 2024, 18.43 at 2500m) 1 whale (8th Aug 2024, 08.23 at 2800m) 1 whale (8th Aug 2024, 09.50 at 2800m) 1 whale (8th Aug 2024, 15.50 at 2900m) 1 whale (8th Aug 2024, 16.35 at 2800m) 1 whale (9th Aug 2024, 11.50 at 3200m) 1 whale (10th Aug 2024, 13.11 at 2000m) 1 whale (10th Aug 2024, 14.58 at 1900m)	Eight visual encounters. One encounter was within the proposed licensing area, four were within the designated mining area and three were outside area designations. Photo-identification images were collected of three whales.
Minke whale (*Balaenoptera acutorostrata)*	1 whale (2nd Aug 2024, 16.25 at 200m) 1 whale (4th Aug 2024, 09.33 at 2000m) 1 whale (6th Aug 2024, 15.05) 1 whale (6th Aug 2024, 18.30 at 3000m) 1 whale (7th Aug 2024, 19.54 at 2500m) 1 whale (9th Aug 2024, 04.26 at 3000m) 1 whale (9th Aug 2024, 05.17 at 2400m) 1 whale (9th Aug 2024, 14.37 at 3000m)	Eight encounters of which three were within the proposed licensing areas, three were in the designated mining area and two were outside area designation. All individuals were travelling alone.
White-beaked dolphin (*Lagenodelphis albirostis*)	20 individuals (7th Aug 2024, 16.28 at 2400m) 1 individual (7th Aug 2024, 17.59 at 2600m) 8 individuals (9th Aug 2024, 04.22 at 2400m) 10 individuals (9th Aug 2024, 05.07 at 2400m) 1 individual (9th Aug 2024, 07.15 at 2400m) 5 individuals (9th Aug 2024, 12.13 at 2400m)	Four of the 12 encounters were in the proposed licensing area, one was within the designated mining area and seven were outside area designation. Four groups were observed bow-riding. Maximum group size was 20 individuals while the smallest group was five individuals, with some groups seen to have juveniles.

	5 individuals (9th Aug 2024, 14.11 at 3000m) 1 individual (10th Aug 2024, 1900m) 10 individuals (10th Aug 2024, 09.07 at 1900m) 10 individuals (10th Aug 2024, 11.02 at 1600m) 1 individual (10th Aug 2024, 13.55 at 1400m) 8 individuals (10th Aug 2024, 15.00 at 1900m)	
Killer whale (*Orcinus orca*)	2 whales (5th Aug 2024, 13.12 at 2200m)	Two males seen travelling, potentially a third individual sighted but not confirmed. Poor visibility (fog) made ID difficult. Encounter was in the designated mining area.
Fin whale (*Balaenoptera physalus*)	1 whale (6th Aug 2024, 15.13 at 2000m)	One individual sighted on the horizon within the designated mining area. Large and upright blow seen.
Unidentified large whale	2 whales (10th Aug 2024, 09.04 at 2400m)	Two unidentified whale species seen travelling in the designated mining area. Large upright blow.

Sperm whale photo-identification

A total of three sperm whales were photo-identified (Fig. 5). Images were uploaded to the online repository Happywhale (www.happywhale.com). One whale, coded as Pma02 also had a large area of white discolouration, or scarring, in front of the dorsal fin that was highly visible and could be another feature with which to identify this whale (Fig. 5B and 5C).

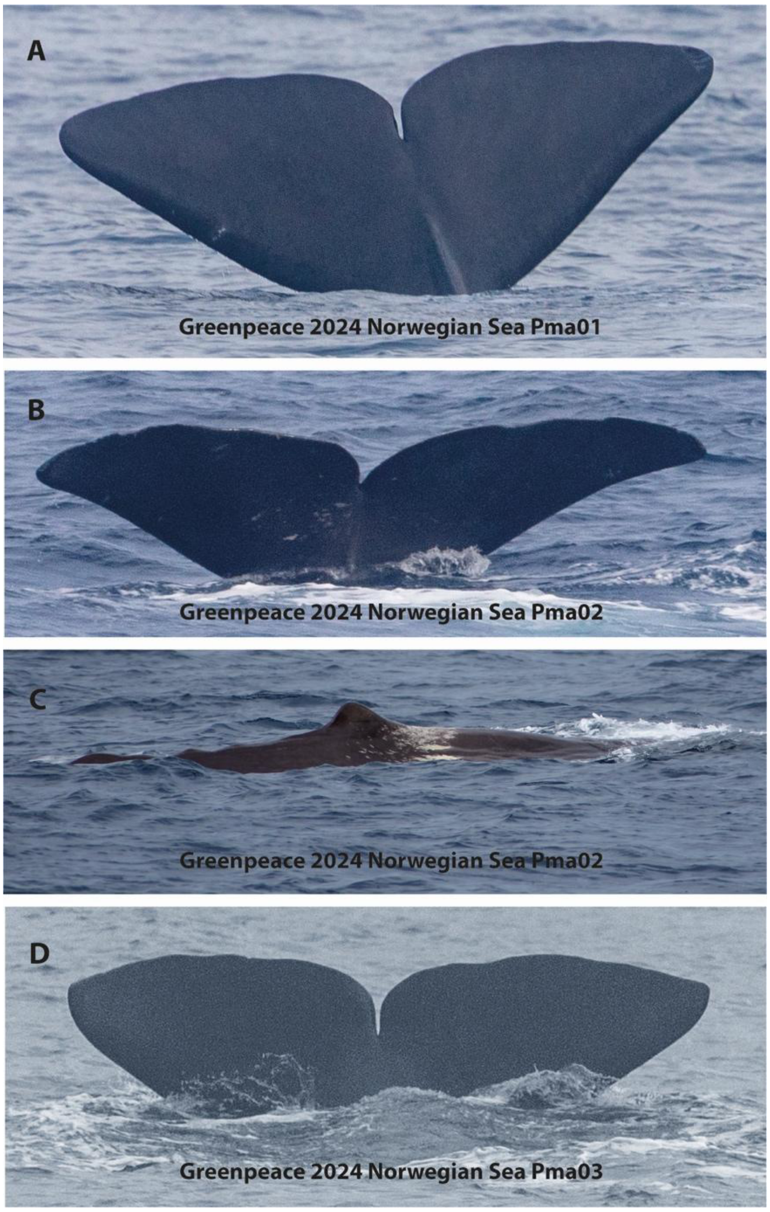


Figure 5. Sperm whale photo-identification images collected during the survey conducted by the *SY Witness* from Ålesund, Norway, to Longyearbyen, Svalbard, during the period 30th July 2024 to 10th August 2024.

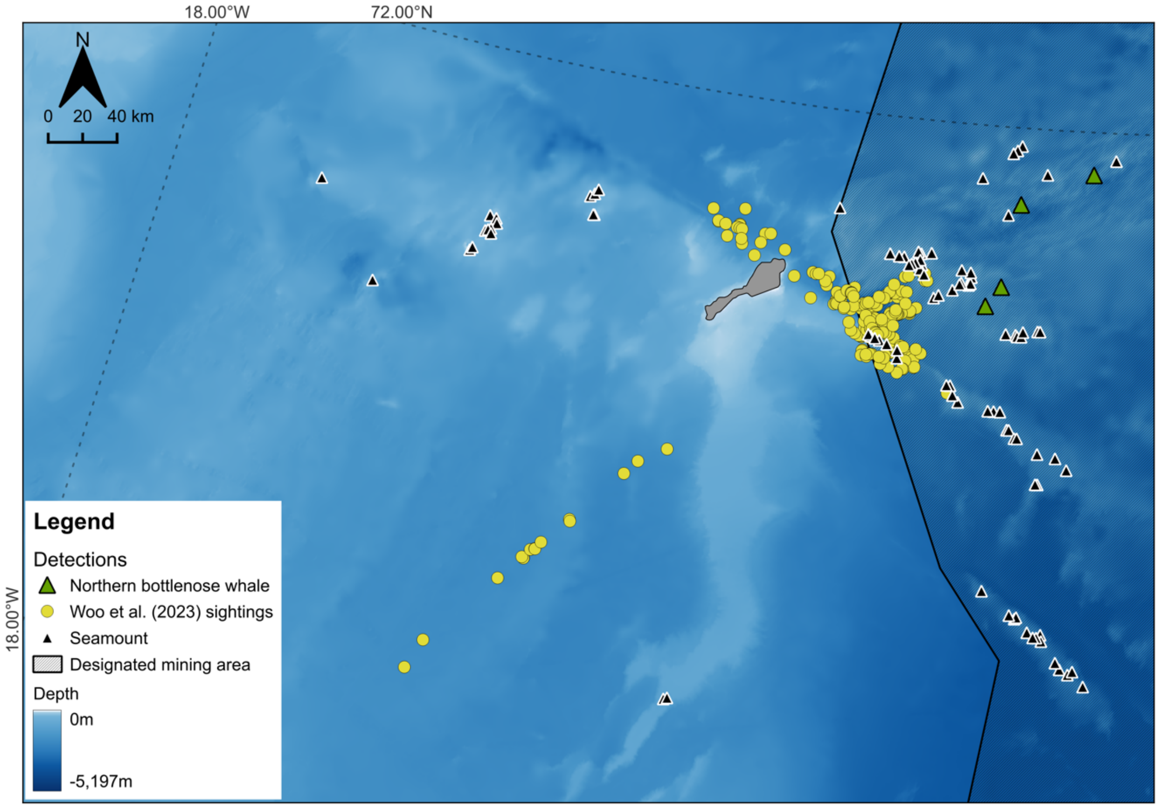
Table 3. Location and dates of sperm whales that were photo-identified during the survey conducted by the *SY Witness* from Ålesund, Norway, to Longyearbyen, Svalbard, during the period 30th July 2024 to 10th August 2024.

Sperm whale code	Encounter date	Latitude	Longitude	Comments
GP2024NorwSeaPma01	7th August 2024	72.773	2.243	
GP2024NorwSea Pma02	8th August 2024	72.122	5.489	Prominent scarring in front of the dorsal region.
GP2024NorwSea Pma03	10th August 2024	77.067	9.856	

Discussion

The visual-acoustic survey confirmed the presence of multiple cetacean species, including sperm whales, northern bottlenose whales, fin and minke whales, white-beaked dolphins, and killer whales. Sperm whales were foraging in the area as determined by notable ‘creaks’ that indicate prey capture (Miller *et al.*, 2004). Three photo-identification images were collected and these are now publicly available for use by other researchers within the online repository HappyWhale.

Our results suggest that deep seabed mining activities in this region will have the potential to impact cetacean populations, particularly through acoustic disturbance. The high incidence of acoustic detections of sperm whales, and the detection of northern bottlenose whales’ northeast of Jan Mayen, underscores the vulnerability of these deep-diving species to increased underwater noise and habitat degradation. The detections of northern bottlenose whales east of Jan Mayen is consistent with the finding by Woo *et al.* (2023), which found the submarine canyons to the east and south-east of the island to be an important area for this species (Fig. 6). Our survey did not cover these canyons, and more data are needed to assess any association with bathymetric features, but the four detections of northern bottlenose whales appear to be near ridges and seamounts. Taken together, it is clear that this species is found at least within the western region of the designated mining area and likely across the Norwegian Sea (based on other published surveys). According to Miller et al. (2015) northern bottlenose whales are highly sensitive to acoustic disturbance from human activities, particularly naval sonar and, therefore, could be at risk from industrialised activities such as planned deep seabed mining.



CRS: WGS 84 / Arctic Polar Stereographic. Scale: 1:2375000. Bathemetric data: © GEBCO 2024; DSM data: Norwegian Offshore Directorate; NLOD.

Figure 6. Northern bottlenose whale (*Hyperoodon ampullatus*) sightings and acoustic detections. The yellow dots indicate sightings recorded by Woo *et al.* (2023) and the green triangles show acoustic detections during the survey conducted by the *SY Witness* from Ålesund, Norway, to Longyearbyen, Svalbard, during the period 30th July 2024 to 10th August 2024. Black triangles indicate the location of seamounts as described by Yesson *et al.* (2011).

White-beaked dolphins are known to respond to the noise of vessel traffic (Reverberi et al., 2024). Periods of low vessel traffic due to the COVID-19 epidemic provided an opportunity for researchers in Iceland to examine dolphin vocalisation rates at different levels of traffic in Skjálfandi Bay, Iceland. The white-beaked dolphins were found to whistle more during periods of low traffic and when the Bay was quiet.

Our findings suggest that these dolphins are distributed across the designated mining area and therefore are a species that could be impacted by an increase in noise as a result of mining. Further studies are recommended to assess the potential long-term impact of mining operations on cetacean behaviour, distribution, and acoustic communication.

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