Acquisition of marine seismic data in Jammerbugt in 2023

CCS2022-2024 WPl: Seismic data acquisition across the Jammerbugt structure on research vessel Jákup Sverri

Thomas Funck, Axel Ehrhardt, Nicki Riber Andreasen, Thomas Behrens, Nicklas Christensen, Ümit Demir, Timo Ebert, Tony Buhl Nielsen, Egon Nørmark, Henning Pedersen, Bettina Schramm, Leon Smith, Peter Steinborn & Per Lynnerup Trinhammer

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
DANISH MINISTRY OF CLIMATE, ENERGY AND UTILITIES

G E U S

Acquisition of marine seismic data in Jammerbugt in 2023

CCS2022-2024 WPl: Seismic data acquisition across the Jammerbugt structure on research vessel Jákup Sverri

Thomas Funck[1], Axel Ehrhardt[2], Nicki Riber Andreasen[3], Thomas Behrens[2], Nicklas Christensen[1], Ümit Demir[2], Timo Ebert[2], Tony Buhl Nielsen[4], Egon Nørmark[5], Henning Pedersen[4], Bettina Schramm[2], Leon Smith[6], Peter Steinborn[2] & Per Lynnerup Trinhammer[5]

[1] Geological Survey of Denmark and Greenland
[2] Federal Institute for Geosciences and Natural Resources (BGR)
[3] Andreasen Hydrospatial Consulting
[4] FOGA Consult ApS
[5] Department of Geoscience, Aarhus University
[6] Havstovan, Faroe Marine Research Institute

GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
DANISH MINISTRY OF CLIMATE, ENERGY AND UTILITIES

G E U S

Contents

1. Summary

An offshore seismic survey (GEUS2023-JAMMERBUGT) was conducted in April 2023 to map the Jammerbugt structure in the eastern North Sea offshore northwestern Jutland. The overall objective of the survey was provide new data to map the structure for maturation towards potential deep underground storage of CO_2. GEUS had the overall project management for the survey and collaborated with BGR (Bundesanstalt für Geowissenschaften und Rohstoffe, Federal Institute for Geosciences and Natural Resources) under a formal collaboration agreement between the two institutions. In addition, Aarhus University contributed seismic equipment and personnel to the project. Two fishery liaison officers from FOGA ApS assisted in the coordination with fishing activities in the survey area.

The seismic acquisition was carried out from the Faroese research vessel Jákup Sverri that towed a solid-state streamer (Sentinel SSRD from Sercel) with an active length of 2100 m (336 channels) with a hydrophone group interval of 6.25 m. The streamer was towed at a depth between 3 and 5 m. The seismic source was a GI-gun cluster consisting of two guns. Initially, data were acquired with a small cluster (two GI-guns with a generator chamber of 45 cubic inches volume and an injector chamber of 105 cubic inches each) triggered every 6 s. After some initial onboard date processing, it was decided to switch to a larger array (two GI-guns with a generator chamber of 250 cubic inches and an injector chamber of 105 cubic inches) triggered every 10 to 12 s, to ensure that the target depth is reached. The first ten lines were acquired with the small array, of which five were shot a second time with the large array.

In total, 1450 km of seismic reflection data were acquired in the ten days the ship was in the survey area. There was very little downtime and it was related to compressor maintenance and the switch of the air gun array. There was no downtime related to weather. The study area is characterized by shallow water and a hard seafloor, which is challenging for any seismic acquisition. Nevertheless, the chosen configuration for the seismic experiment was adequate for this type of conditions. Onboard processing and an initial evaluation of the data indicate that there was seismic penetration down to the base of Zechstein (at depths of 3 to 4 s two-way travel time) and that the reservoir rocks (Gassum and Haldager formations) are resolved. One of the main tasks for the post-cruise processing will be the removal of multiple energy.

The survey not only provides a dense grid of seismic lines across the Jammerbugt structure, but also made a tie to the well J-1X to the northwest of the structure that was crossed by three lines. In addition, two lines crossed the Hanstholm structure to the west of the Jammerbugt structure. While the larger Hanstholm structure was not the prime target, it was deemed useful to connect the two structures for future reference. Towards land, the survey was restricted by the 10-m depth contour given the draught of the ship and the setup of the seismic equipment. This leaves a coastal zone, about 10 km wide, that could not be surveyed.

The ship was equipped with the shallow to medium water multibeam echosounder (Kongsberg EM 712) and a sub-bottom profiler (Kongsberg TOPAS PS18). Both systems were in operation in the survey area and can be used to improve the interpretation of the seismic

data. The TOPAS data give a high-resolution image of the upper 30 ms two-way travel time below the seafloor and may provide linkages to possible faults at deeper levels. The swath-bathymetric data provide information about the morphology of the seafloor and can also aid the processing of the seismic data in the shallow water. For calibration, a multibeam patch test was carried out and two sound velocity profiles (SVP) were measured. An additional 14 SVPs are available from another vessel (Poul Løwenørn) that carried out a bathymetric survey in close vicinity.

To mitigate the risk of potential harm to marine mammals related to the acoustic signals emitted from the seismic survey, the guidelines provided by the Danish energy Agency were followed. Two certified marine mammal observers were onboard, and a passive acoustic monitoring (PAM) system (Sercel QuietSea) was integrated into the streamer configuration. Prior to the start of seismic acquisition, a 30-minute pre-watch was carried out followed by a 60-minute ramp-up procedure of the air gun array. During the survey, two harbour porpoises were sighted but beyond the critical distance of 500 m.

2. Introduction

In April 2023, a seismic reflection acquisition (Figure 1) was carried out across the Jammerbugt structure as part of the Carbon Capture and Storage (CCS) project for which GEUS is the project leader. The Jammerbugt structure off northwest Jutland between Hanstholm and Hirtshals is one of several possible sites for CCS and an updated seismic database is required to assess its suitability for CCS. The existing data are rather sparse and mostly not of good quality. Both the shallow water and the hard seafloor make the area challenging for any seismic data acquisition.

For the acquisition in Jammerbugt, GEUS worked together with BGR (Bundesanstalt für Geowissenschaften und Rohstoffe, Federal Institute for Geosciences and Natural Resources) in Hanover, Germany. BGR owns a state-of-the-art solid-state streamer system that was successfully used for a CCS project in the German sector of the North Sea (see acquisition report in Ehrhardt *et al*. 2021). A formal cooperation agreement was signed between BGR and GEUS. At BGR, the internal name of the project is Seis-Jam, while GEUS refers to the project as JammerbugtSeis23 and to the seismic survey as GEUS2023-JAMMERBUGT. For line names, the prefix GEUS23_JB_ is used followed by the line number.

The main constraints to define the time window for the survey was the availability of the seismic acquisition system from BGR, in addition to finding a suitable ship small enough to operate in the shallow waters of Jammerbugt but big enough to provide sufficient deck space for the seismic equipment. The ship also had to be able to provide enough power to run the compressors for the air guns (98 kW for each of the two compressors). Based on that, it was decided to charter the Faroese research vessel Jákup Sverri (Figure 2) for a three-week period in April 2023. The ship is owned by Havstovan Faroe Marine Research Institute and was built in 2020, has a length of 54 m and a draught of 6.4 m. There were 14 berths for the science party, which was sufficient for the required number of technicians and scientists to carry out the survey. Another advantage of the vessel is its built-in multibeam echosounder (Kongsberg EM 712) and sub-bottom profiler (Kongsberg TOPAS PS18). While not necessarily required for the seismic acquisition, both systems provide valuable information that can help with the processing and interpretation of the seismic data.

Collaboration was a key in the seismic survey. BGR contributed the streamer cable (Figures 3 and 4) together with a PAM (passive acoustic monitoring) system, a small GI-gun array and the necessary hardware for acquisition/registration. GEUS chartered the vessel and provided additional equipment from the seismic equipment pool jointly run by GEUS and Aarhus University (AU). This included a compressor for the air guns, a larger GI-gun array (Figure 5), a backup PAM system, a navigation system, and a trigger box for the air guns. All three partners (AU, BGR, and GEUS) provided technical and scientific staff for the survey. COWI was responsible for getting all the necessary permits to conduct the seismic acquisition and the multibeam survey. This included the drafting of the required environmental assessment documents including a comprehensive modelling of the acoustic sound sources on the vessel. COWI assisted also with logistical issues and established the contact with FOGA ApS, from where two fishery liaison officers (FLO) were hired. With large fishing ports in the area (Hanstholm, Thorup Strand, and Hirtshals), it was important to coordinate the seismic survey

with ongoing fishing activities. A detailed account on the fishing activities and the work of the FLO is given in Appendix C.

Weather (wind) can be a problem year-round in Jammerbugt and was therefore a big uncertainty for the project, as the ship was rented for a fixed term with no possibility for an extension in case of delays in the acquisition. In the end, the weather was very favourable, and acquisition did not have to be paused. In contrast, the weather pattern was rather unusual with a long period of mainly easterly winds. With the land providing shelter, the sea was rather calm in the near-shore study area.

The design of the seismic lines (Figure 1) consists of a grid composed of NW-SE and SW-NE oriented lines across the Jammerbugt structure to obtain the best possible image in relation to the strike direction of known and assumed faults in the area. The acquisition stopped at the 10-m bathymetric contour to ensure safe navigation for the vessel towing 2400 m of seismic gear. With a turning circle of about 1.5 km in radius, the lines had to be stopped in time to allow the ship to turn before reaching 10 m water depth. A set of lines parallel to the coast was added. Seismic acquisition had to stop 10 km before reaching the Natura 2000 marine protection areas in Jammerbugt. This is why the survey could only be tied to one well (J-1X) with three crossings very close to this buffer zone. To the west of the Jammerbugt structure, another much larger structure is located (Hanstholm structure) that almost completely lies within the Natura 2000 area and the 10-km buffer zone around it. The only possibility to connect the seismic survey with the Hanstholm structure was in a small corridor just to the north of Hanstholm, which was surveyed with two lines (GEUS23_JB_20 and 21). All other lines were chosen to obtain ties to existing seismic lines.

The survey area crosses two main shipping lanes and navigational warnings were published prior to the seismic acquisition. Even though there was substantial traffic on those routes, all vessels were very cooperative when they were contacted, and they altered their course according to the needs of the seismic operation.

After a presentation of the staff involved in the survey, this report provides an account on the details of the seismic data acquisition followed by the hydroacoustic measurements that were carried out with the multibeam echosounder and the sub-bottom profiler. Finally, the mitigation actions to prevent distress and injury to marine mammals are described. One common species in the area is the harbour porpoise and regulations were in place to prevent harm to them or any other marine mammals by the acoustic sounds that were emitted during the survey. There are three appendices presenting a diary of the work that was carried out, logsheets for the individual seismic lines that were acquired, and the report prepared by the FLO on the coordination with the fishing activities in the area.

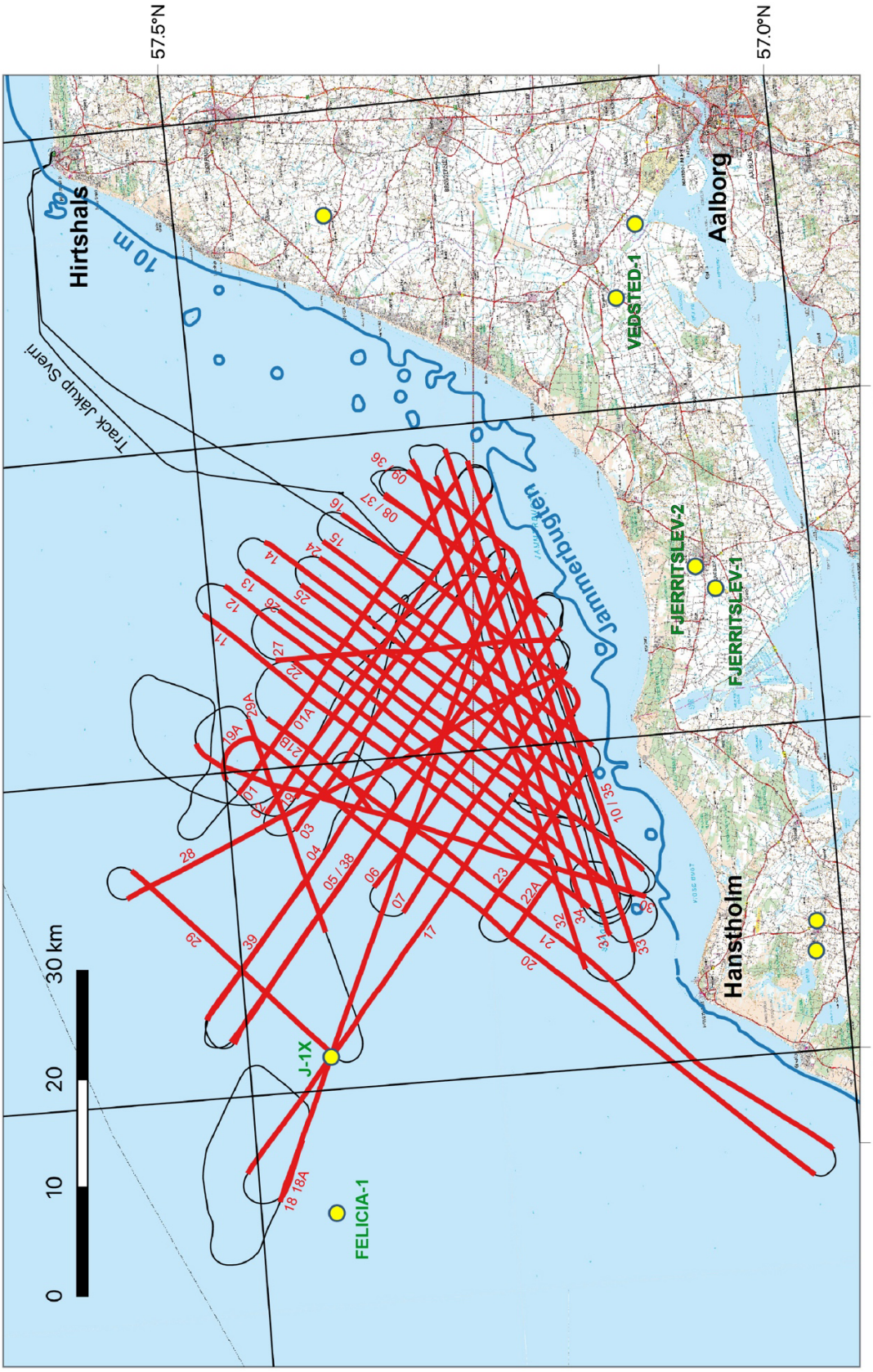


Figure 1. *Topographic map showing the location of the acquired seismic reflection lines (red lines); numbers indicate the line numbers without the prefix GEUS23_JB_. The track of the research vessel Jákup Sverri is marked by red and black lines. Yellow circles show the location of wells. The blue line shows the 10-m bathymetric contour.*

Figure 2. *Faroese research vessel Jákup Sverri upon arrival for mobilization in Hirtshals on April 8, 2023. Photo credit: Thomas Funck (GEUS).*

Figure 3. *Deployment of the streamer tail buoy from the aft deck of Jákup Sverri. In the foreground one of the two winches for the solid-state streamer (Sercel Sentinel SSRD; yellow cable). Photo credit: Thomas Funck (GEUS).*

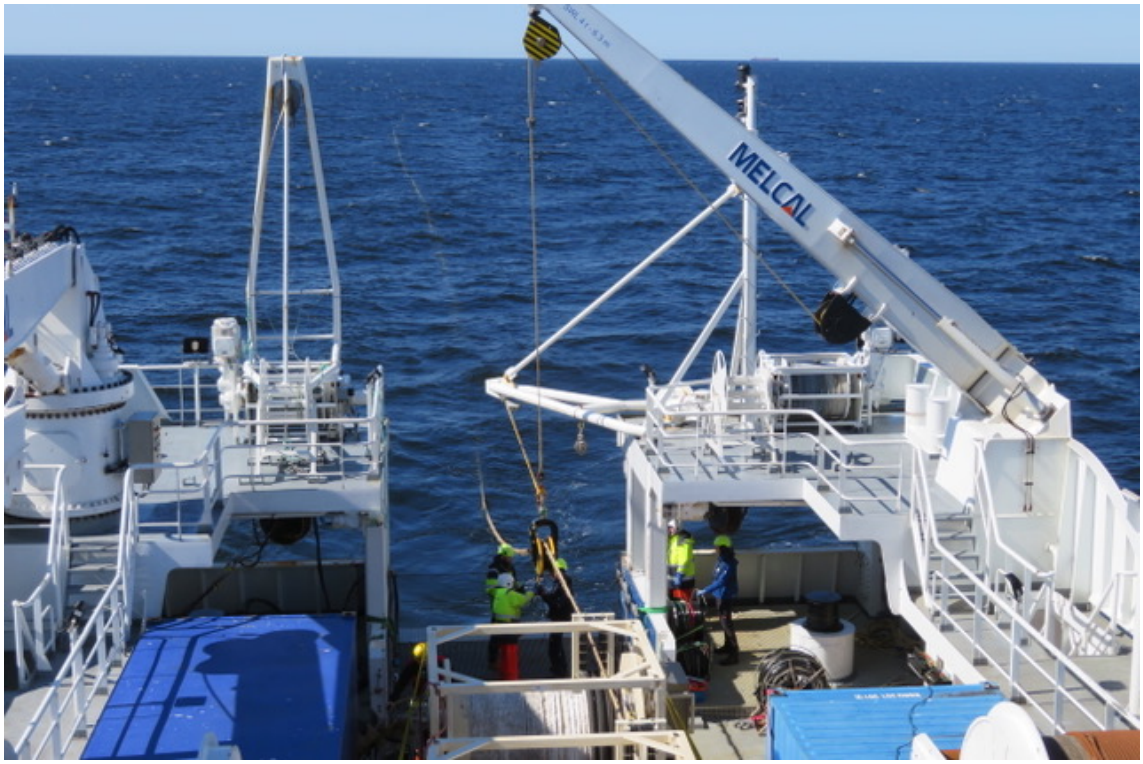


Figure 4. *Recovery of the 2100-m-long streamer cable (Sercel Sentinel SSRD). Photo credit: Thomas Funck (GEUS).*

Figure 5. *Recovery of the large GI-gun array. Photo credit: Thomas Funck (GEUS).*

3. Participants

During the seismic survey GEUS2023-JAMMERBUGT, a total of 24 persons were on board the Faroese research vessel Jákup Sverri. The ship's crew (Table 1) consisted of ten persons, while the science party (Table 2 and Figure 6) comprised 14 people. Leon Smith from the Faroe Marine Research Institute Havstovan was contracted to provide support with the onboard technical systems.

The German Federal Institute for Geosciences and Natural Resources (BGR) in Hanover, Germany, had six staff members onboard to support the seismic acquisition and processing. BGR group leader Axel Ehrhardt functioned as second scientist and together with chief scientist Thomas Funck from GEUS, he participated in the watch system for marine mammal observations. The BGR seismic processing team consisted of Axel Ehrhardt and Bettina Schramm, their technical team comprised Timo Ebert, Thomas Behrens, Peter Steinborn and Ümit Demir.

Aarhus University (AU) was presented by Per Lynnerup Trinhammer, the chief engineer for the seismic equipment from GEUS/AU, and Egon Nørmark supporting the seismic processing team.

The hydroacoustic team running the multibeam echosounder EM 712 and TOPAS PS18 subbottom profiler consisted of Nicklas Christensen from GEUS and Nicki Riber Andreasen from Andreasen Hydrospatial Consulting. The two fishery liaison officers (FLO) Tony Buhl Nielsen and Henning Pedersen were contracted through FOGA ApS.

Name	Function
Martin í Grund	Master
Manbjørn í Grund	Chief officer
Jónsvein Joensen	Chief engineer
Terji Holm Jacobsen	First engineer
Dánjal Jørgin Djurhuus	Cook
Dan Askham	Cook
Rósing Lydersen	Boatswain
Andreas Johansen	Able seaman
Kenneth Strøm Bech	Able seaman
Eyðfinnur í Búðini	Able seaman

Table 1. Crew members on research vessel Jákup Sverri.

Name	Affiliation	Function
Thomas Funck	GEUS	Chief scientist, MMO
Axel Ehrhardt	BGR	Seismic processing, MMO
Peter Steinborn	BGR	Technician
Timo Ebert	BGR	Technician
Thomas Behrens	BGR	Technician
Ümit Demir	BGR	Technician
Bettina Schramm	BGR	Seismic processing
Egon Nørmark	AU	Seismic processing
Per Lynnerup Trinhammer	AU	Technician
Nicklas Christensen	GEUS	MB, SBP
Nicki Riber Andreasen	Andreasen Hydrospatial Cons.	MB, SBP
Leon Smith	Havstovan	Ship technician
Tony Buhl Nielsen	FOGA Consult ApS	FLO
Henning Pedersen	FOGA Consult ApS	FLO

Table 2. Members of the science party. Abbreviations are AU, Aarhus University; BGR, Bundesanstalt für Geowissenschaften und Rohstoffe (Federal Institute for Geosciences and Natural Resources); Cons., Consulting; FLO, fishery liaison officer; GEUS, Geological Survey of Denmark and Greenland; MB, multibeam echosounder; MMO, marine mammal observer; SBP, sub-bottom profiler.

Figure 6. Group picture of the science party. From left to right, in the back: Axel Ehrhardt, Nicki Riber Andreasen, Ümit Demir, Tony Buhl Nielsen, Henning Pedersen, Timo Ebert, Bettina Schramm, Peter Steinborn, Egon Nørmark, and Nicklas Christensen; in the front: Thomas Funck, Thomas Behrens, Leon Smith, and Per Lynnerup Trinhammer.

4. Seismic Measurements

The seismic survey in Jammerbugt aimed to provide a high-quality image of the subsurface structure from the seafloor down to the target reflectors at depths of up to 3 km. The main challenges in this context were the very shallow water depths of as little as 10 m in the study area, and the chalk sediments with high seismic velocities right beneath the seafloor.

4.1 Seismic Sources and Receivers

For the seismic acquisition, a 2100-m-long streamer cable of type Sercel Sentinel SSRD with 336 channels and a channel interval of 6.25 m was used (Figures 3, 4, and 7). Two different seismic sources were utilized during the survey:

- **Setup A**: two GI-guns triggered simultaneously in “true GI mode” with a generator chamber of 45 cubic inches (0.7 L) volume and an injector chamber of 105 cubic inches (1.7 L) each, operated at a working pressure of 2000 psi (138 bar),

- **Setup B**: two GI-guns with a generator chamber of 250 cubic inches (4.1 L) and an injector chamber of 105 cubic inches (1.7 L) operated in “harmonic mode” at a pressure of 1958 psi (135 bar).

In both setups, the source depth was 3 m. The compressed air was provided by two electrically powered Hamworthy compressors of type 4TH190W70 MkII from the joint GEUS/Aarhus University seismic equipment pool. The compressors have a capacity of 185 cfm each when operated at 138 bar. This corresponds to a total capacity of 10,000 L/min.

During acquisition in source setup A, the depth of the streamer cable was 3 m. This resulted in a notch frequency of 250 Hz. For source option B, the depth of the streamer cable was either 4 or 5 m. This resulted in a notch frequency of 187 and 150 Hz, respectively. The trigger interval was 6 s for setup A, yielding a nominal fold of 76 assuming a constant vessel speed of 4.5 knots. In setup B, the trigger interval was initially 12 s but was later decreased to 10 s, resulting in nominal folds of 38 and 45, respectively.

4.1.1 Streamer Cable

The Sercel Sentinel SSRD streamer cable with 336 channels and a channel distance of 6.25 m supports the recording of high frequencies (Figure 7). To image the seafloor and to avoid too much normal moveout stretch within the CDP (Common Depth Point) gathers, a special stretch section was used between the active seismic cable sections and the lead-in cable. This only 17.5-m-long section enabled a near trace offset of only 22 m (see Figure 7).

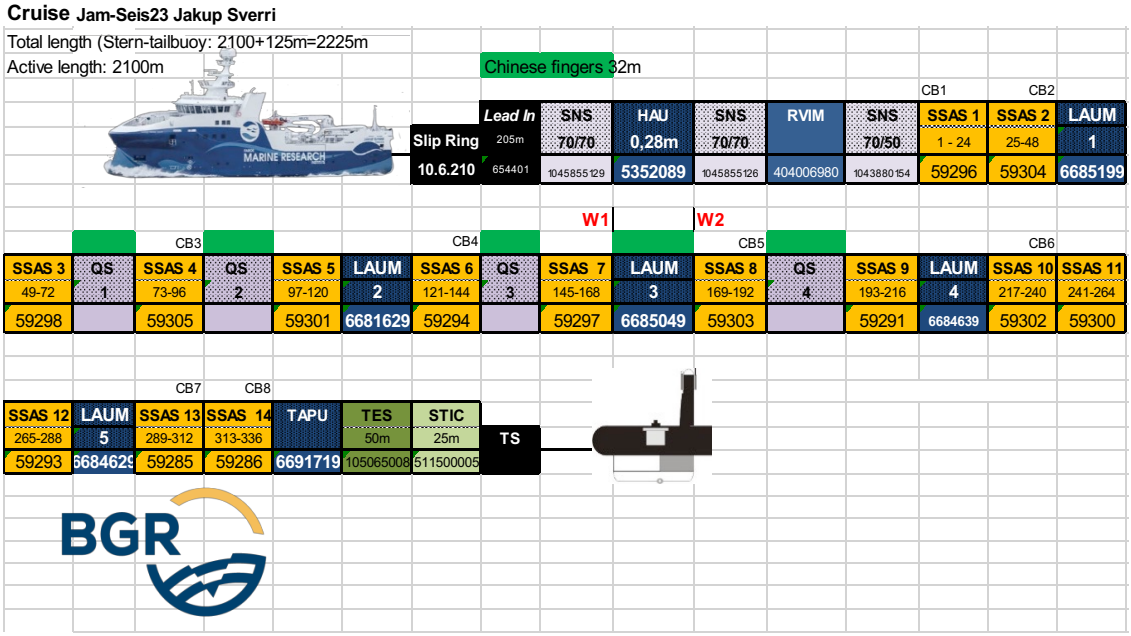


Figure 7. Configuration of streamer cable. The streamer cable is of type Sercel Sentinel SSRD with a group distance of 6.25 m. Each section has a length of 150 m and consists of 24 channels. Abbreviations are CB, control bird; HAU, head acquisition unit; LAUM, line acquisition module; QS, Quiet Sea module (for passive acoustic monitoring/PAM); RVIM, reduced stretch section; SNS, short Nautilus connector/adapter; SSAS, solid-state acquisition section; STIC, streamer tail interface cable; TAPU, tail acquisition power unit; TES; tail end swivel; TS, tail stretch; W, winch.

4.1.2 Seismic Sources

For the reflection seismic data acquisition, two different setups of GI-guns were used. Setup A consisted of two GI-guns 210 in “true GI mode” with 45 cubic inches generator volume and 105 cubic inches injector volume. This configuration generates a high-resolution signal with frequencies up to 250 Hz. Setup B consisted of two GI-guns 355 in “harmonic mode” with 250 cubic inches generator volume and 105 cubic inches injector volume. This resulted in a stronger signal with deeper frequencies when compared to setup A.

The air guns were mounted to a hanger system designed by BGR, which arranges the guns in a row (Figure 8). The trigger impulses for the air guns were created by the Bigshot system from RTS. A time delay of 50 ms between trigger and release of the air guns was applied.

During the seismic survey, a hydrophone module of the QuietSea system (Sercel) was towed behind the vessel. It is designed for high-frequency marine mammal detection and location. This AUX-module was connected via a 10-m-long towing rope to the gun hanger resulting in a towing depth of 7 m (Figure 8). A small buoy was connected to the AUX-module to provide buoyancy.

The nominal towing depth of the air guns was 3 m for the GI-gun clusters in setup A, and 4 or 5 m in setup B. The distance to the vessel was 42 m throughout the survey. The cluster had a total towing length of 2.5 m. The nominal working pressure of the guns was 2000 psi (138 bar). A summary of the acquisition parameters is given in Table 3.

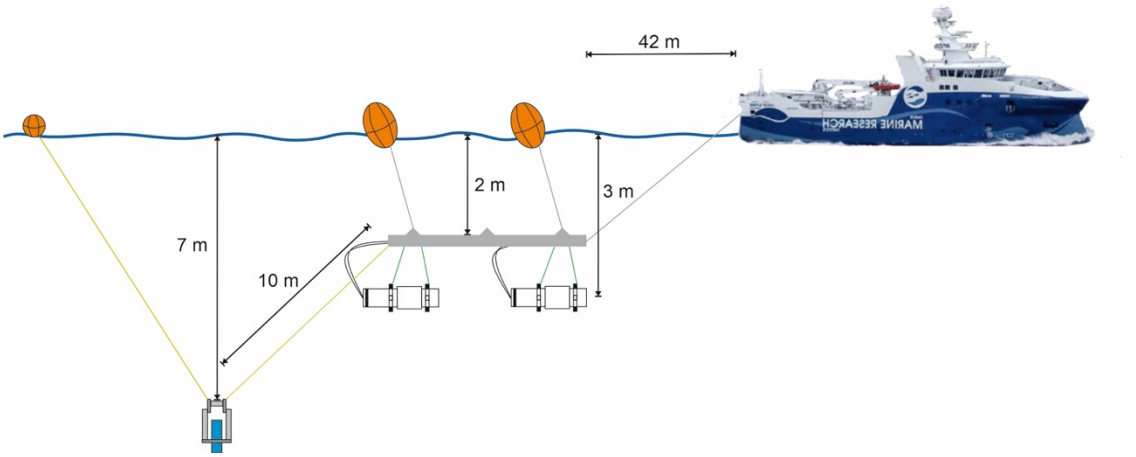


Figure 8. Source setup with two GI-guns (setup A 45/105 cubic inches and setup B 250/105 cubic inches for generator/injector, respectively). Behind the sources, a high-frequency AUX-module for the QuietSea passive acoustic monitoring (PAM) system was towed.

Parameter	Setup A	Setup B
GI-gun: volume of generator	45 cubic inches (0.7 L)	250 cubic inches (4.1 L)
GI-gun: volume of injector	105 cubic inches (1.7 L)	105 cubic inches (1.7 L)
Gun operation mode	True GI-mode	Harmonic mode
Number of GI-guns in cluster	2	2
Depth of seismic source	3 m	3 m
Depth of streamer cable	3 m	4 m / 5 m
Pressure of GI-guns	2000 psi (138 bar)	1958 psi (135 bar)
Sample interval	1 ms	1 ms
Record length	5 s	6 s
Shot delay	50 ms	50 ms
Number of channels	336	336
Distance between channels	6.25 m	6.25 m
Shot interval	6 s	10 s / 12 s
Shot spacing	~14 m	~23 m / ~27 m

Table 3. Summary of acquisition parameters.

4.2 Seismic Data Acquisition System

For the seismic data acquisition, BGR provided the SEAL 428 seismic recording system from Sercel and the digital solid state cable Sentinel SSRD from Sercel with an active length of 2100 m (336 channels) and a hydrophone group interval of 6.25 m. For the depth control of the streamer, the DigiCOURSE System3 was used together with nine birds (depth steering units) attached to the streamer. All systems were controlled and monitored from the dry lab of the research vessel Jákup Sverri (Figure 9). The trigger system NaviPac from EIVA was provided by Aarhus University. Figure 10 illustrates the setup of the different modules that were used during the seismic acquisition.

Figure 9. Dry lab on research vessel Jákup Sverri from where the streamer cable and air guns were controlled, including the recording of the incoming seismic data, and the monitoring of the PAM system. Ümit Demir (left) and Timo Ebert (right) on watch.

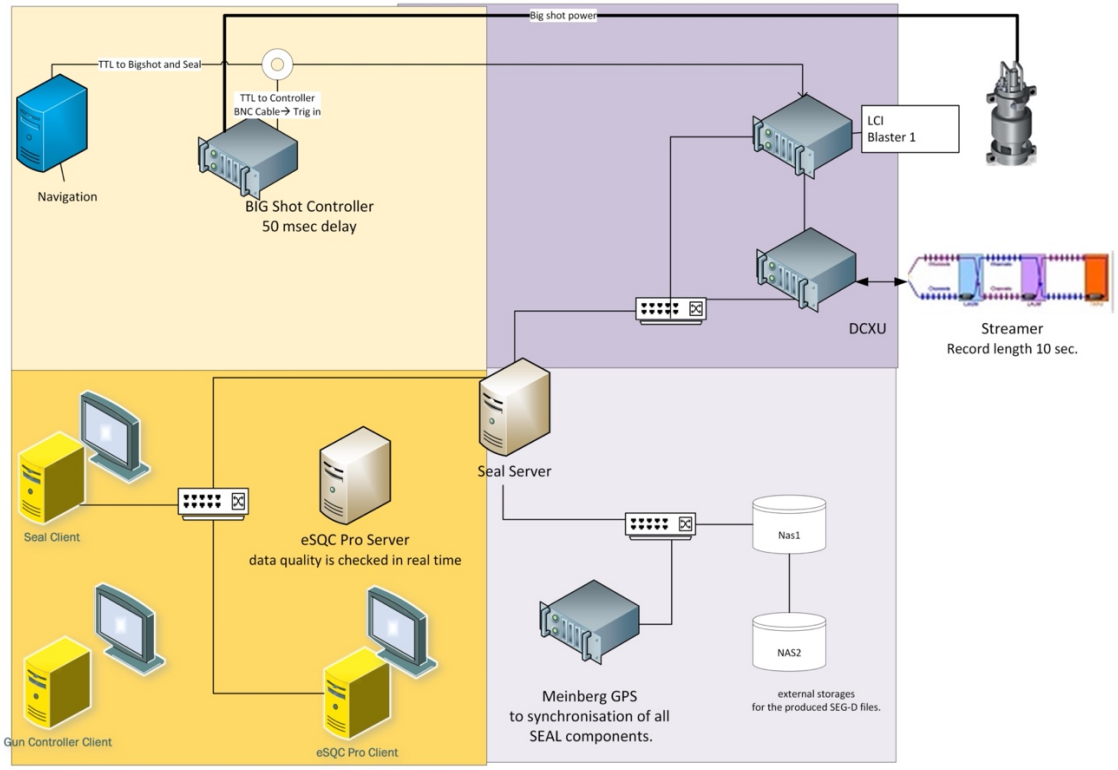


Figure 10. Illustration of the BGR seismic acquisition system with modules from Sercel (recording), BigShot (gun controller), and the DigiCOURSE System3 (bird control). For navigation, Aarhus University provided the NaviPac system from EIVA.

The recording time was 5 s for setup A and 6 s for setup B. In both cases a sampling rate of 1 ms was used, resulting in a Nyquist frequency of 500 Hz. All data were saved in SEG-D format onto redundant NAS (network access server) systems.

4.3 Navigation and Timing

For navigation and timing, equipment provided by Aarhus University was used. Figure 11 illustrates the placement of the GPS receiver on board the research vessel Jákup Sverri in relation to the GI-gun cluster and the seismic streamer cable towed on the starboard and port side, respectively. The GPS system NV08-RTK from NVS Technologies AG was used for positioning together with the navigation and data logging software NaviPac from EIVA A/S.

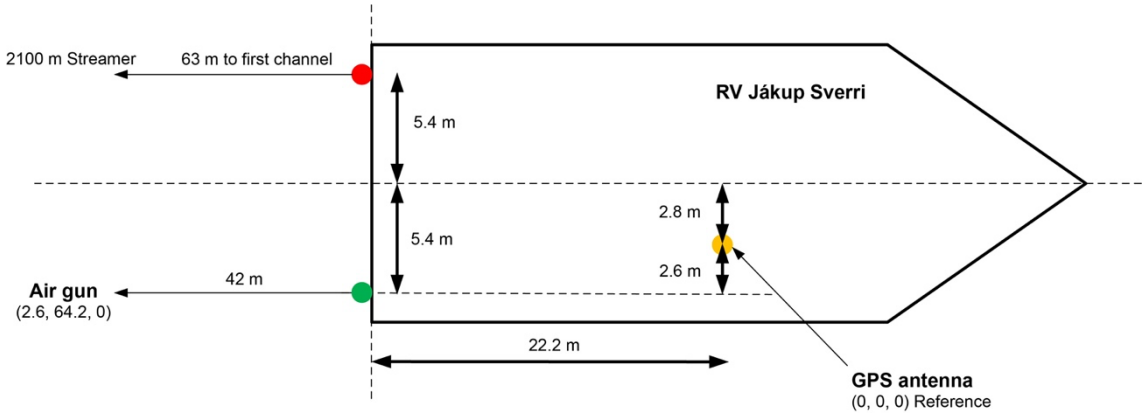


Figure 11. Illustration of the location of the navigation system used for the seismic data acquisition on the research vessel (RV) Jákup Sverri.

The GPS has a built-in WAAS (Wide Area Augmentation System) receiver for differential corrections. The NaviPac software received antenna coordinates from the GPS and the setup of the ellipsoid is given in Table 4.

Parameter	Value
Ellipsoid	World Geodetic System: WGS 84
Inverse flattening	298.2572235630
Semi major	6378137.0000 m
Projection	Universal Transverse Mercator: UTM (north)
Projection type	05
Orig. scale	0.9996
First parallel	000° 00' 0.0000"
Second parallel	000° 00' 0.0000"
Longitude	009° 00' 0.0000" East
Latitude	000° 00' 0.0000"
Easting	500000 m
Northing	0 m
UTM zone	32
EPSG	00

Table 4. Setup of the ellipsoid in the NaviPac software.

In NaviPac, all items such as the GPS, gyro and POI (Point of Interest / gun behind the vessel) were defined the following way:

```
1: GPS1 NMEA XYZ: 0.000 0.000 0.000
2: NMEA1 Gyro, XYZ: 0.000 0.000 0.000
3: ZDA time + PPS XYZ: 0.000 0.000 0.000
----------- User Defined Offsets ------------
4: Ref, XYZ: -2.800 -22.200 0.000
5: Gun array, XYZ: 2.600 -64.200 0.000
----------- Data Acquisition     ------------
6: Echo Sounder, XYZ: 0.000 0.000 0.000, Name: DBS, channel=1
```

The ships gyro data were available on the ship's network and used in NaviPac. Furthermore, the ship's echosounder data were distributed across the network and stored in the log-files of NaviPac.

The PPS pulse (pulse per second) was used as reference signal for the gun controller and the streamer system. On lines GEUS23_JB_01 to 05, the event interval was set to 6 s – the PPS is used as a timer and a divider lets every 6th signal pass, by which an event is obtained at an interval of 6 s. At that rate, the compressor was able to build up a pressure of around 130 bar for the two GI-guns (45/105 cubic inches) in use. When the array-size was increased (two 105/250 cubic inches GI-guns), the shot interval was increased to 10 or 12 s. Figure 12 illustrates the setup of the navigation and timing.

During the seismic survey, a GPS synchronizer recorded the absolute time of each shot with an accuracy of better than 1 μs. The device used for that was the model GPS Sync by Verif-i SG Ltd. It recorded the GPS time for each trigger signal that was created for the recording and gun controller systems.

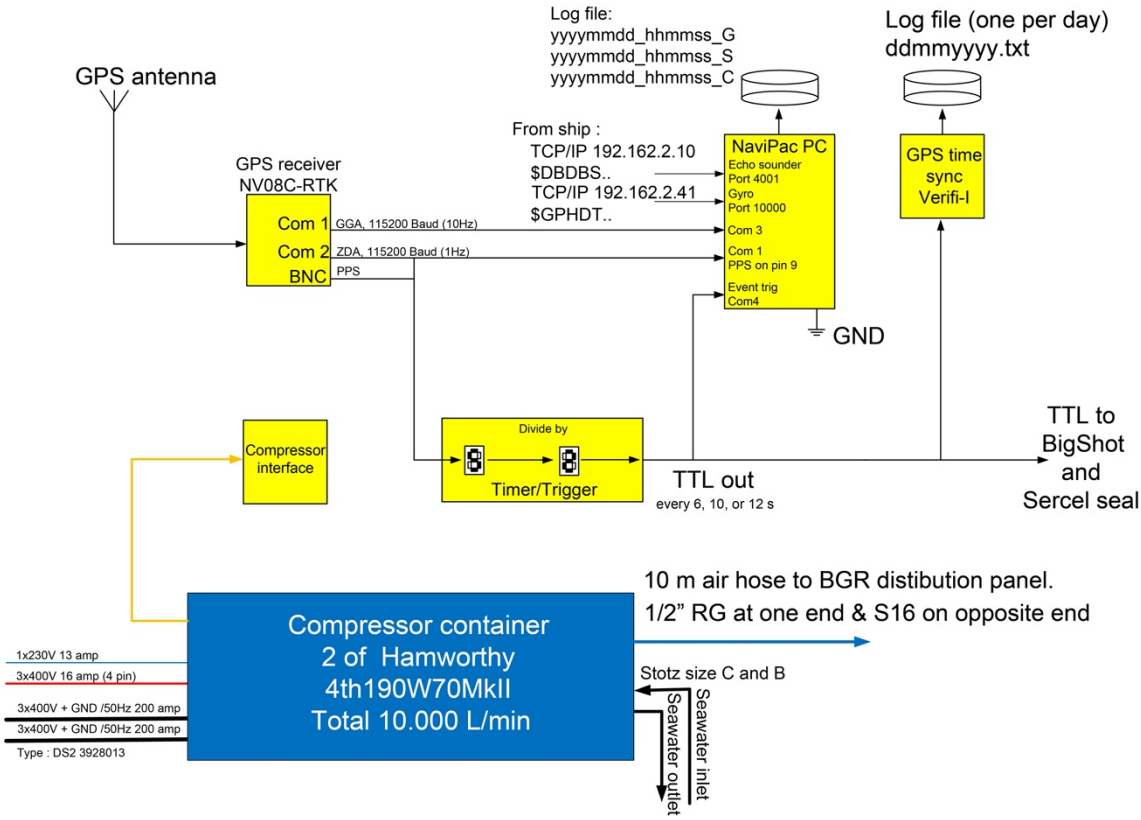


Figure 12. Drawing illustrating the setup of the navigation, timing, and compressor. Abbreviations are BGR, Federal Institute for Geosciences and Natural Resources; BNC, Bayonet Neill–Concelman connector; GGA, Global Positioning System Fix Data; GND, ground; GPS, Global Positioning System; PC, personal computer; PPS, pulse per second; TCP/IP; Transmission Control Protocol/Internet Protocol; TTL, time-to-live; ZDA, date and time.

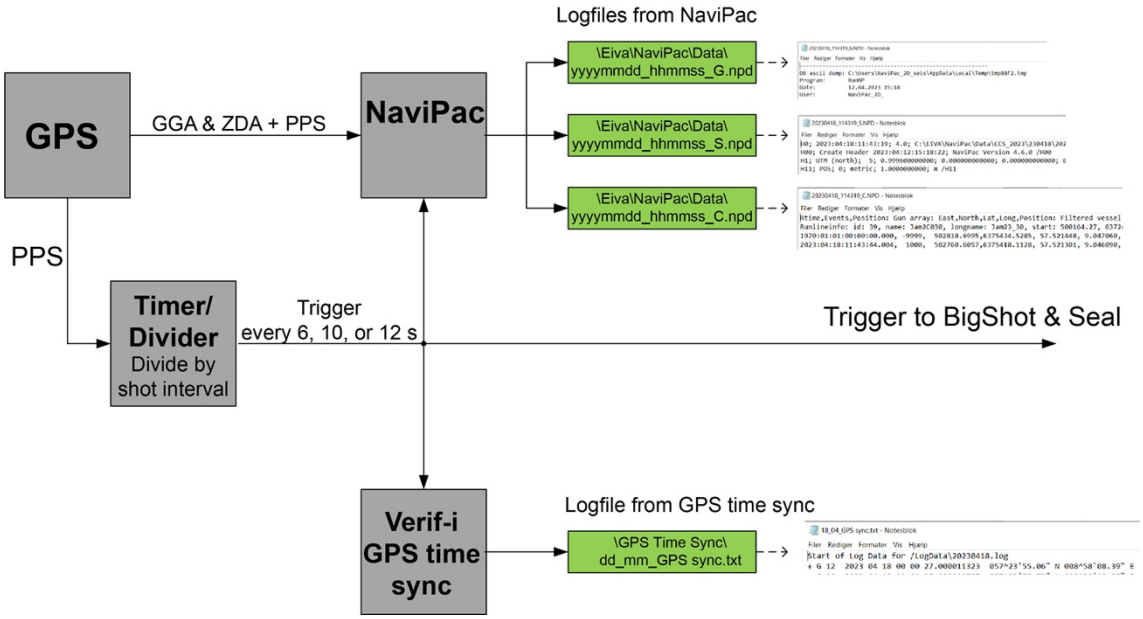


Figure 13. Setup of the navigation and timing systems, and the files that are created by the NaviPac software and the GPS synchronizer from Verif-i. Abbreviations are GGA, Global Positioning System Fix Data; GPS, Global Positioning System; PPS, pulse per second; ZDA, date and time.

The files created by the NaviPac software and the GPS synchronizer from Verif-i are illustrated in Figure 13. NaviPac creates three types of files, namely general, survey, and custom log-files.

General log files, named yyyy.mm.dd_hhmmss_**G**.npd
This file type contains among others information on the used ellipsoid, the UTM zone, and the defined offset points. In addition, the raw data from each instrument are stored in this file.

Survey log files, named yyyy.mm.dd_hhmmss_**S**.npd
This is a proprietary file format from EIVA/NaviPac. This file contains data for each offset point and can be easily handled by the software packaged NaviEdit from EIVA.

Custom log files, named yyyy.mm.dd_hhmmss_**C**.npd
This is a file format that is defined by the user and saved as a CSV file (comma separated value). For this survey, the log file had the following structure:

Rtime,Events,Position: Gun array: East,North,Lat,Long,Position: Filtered vessel position: East,North,Lat,Long,Data: Echo Sounder {DBS},

Runlineinfo: id: 4, name: Jam2C006, longname: Jam23_06, start: 510587.02, 6341153.83 end: 488389.74, 6360203.23

The first line provides information on:

- RTime: Time for the event,
- Events: event number,
- Position of the gun array: in UTM and geographical coordinates,
- Filtered vessel position: the GPS position, with a Kalman filter applied to reduce the GPS data errors,
- Echo sounder: echo sounder data from the ship providing “Depth Below Ship” (DBS).

The second line stores the runline information in addition to the planned start and end coordinate of the lines in UTM.

The **GPS synchronizer** from Verif-I creates files with the name dd_mm_GPS.txt. Every day at midnight, a new file is created. Each event creates a new line in the file in the format

```
+G12 2023 04 18 00 00 27.000011323 Position in geographical format
```

with G=number of satellites, year, month, day, hour, minute, second, and the geographical coordinates. The time zone used in all systems is UTC.

4.4 Acquired Profiles

Table 5 summarizes the start and end times of each of the acquired seismic lines in addition to the respective coordinates and shot point numbers. Lines GEUS23_JB_35 through 39 are re-shootings of lines GEUS_JB_04 through 05 and 08 through 09, using the larger GI-gun array. The recording parameters for individual lines are listed in Table 6. See also Appendix B for notes taken by the seismic watchkeepers. Figure 14 shows the location of the lines, while the length of individual seismic profiles is listed in Table 7.

	Start of line					End of line				
Line name **GEUS23_JB_***	Day. Month. **2023**	Time in UTC	Shot point number	Latitude in °N	Longitude in °E	Day. Month. **2023**	Time in UTC	Shot point number	Latitude in °N	Longitude in °E
01	11.04.	19:18:37	1000	57.489171	8.968482	11.04.	19:39:58	1183	57.470149	9.008559
01A	11.04.	19:41:08	1000	57.469171	9.010746	11.04.	23:53:15	3251	57.257693	9.412921
02	12.04.	00:06:23	1002	57.260767	9.386281	12.04.	04:15:17	3491	57.467628	8.934293
03	12.04.	04:51:18	1000	57.444662	8.904964	12.04.	08:35:06	3238	57.265026	9.293619
04	12.04.	09:11:24	1000	57.244398	9.260496	12.04.	15:09:24	4580	57.531819	8.625834
05	12.04.	15:49:29	1000	57.510137	8.586000	12.04.	21:36:11	4467	57.230697	9.218382
06	12.04.	22:14:51	1000	57.212540	9.173273	13.04.	01:55:21	3205	57.383669	8.807400
07	13.04.	02:37:55	1000	57.361344	8.764819	13.04.	05:45:07	2872	57.212092	9.106173
08	13.04.	06:25:51	1000	57.223818	9.197719	13.04.	08:31:45	2259	57.345301	9.401932
09	13.04.	09:08:30	1000	57.323812	9.432644	13.04.	10:27:12	1787	57.248208	9.302592
10	13.04.	10:29:30	1000	57.245958	9.298687	13.04.	14:29:12	3397	57.174098	8.769467
11	13.04.	17:09:59	1000	57.206584	8.742648	13.04.	22:16:53	2535	57.505008	9.244709
12	13.04.	22:59:02	1000	57.484866	9.284439	14.04	04:23:38	2623	57.183676	8.766570
13	14.04.	04:58:20	1000	57.162238	8.798554	14.04.	10:14:44	2582	57.466073	9.305795
14	14.04.	10:54:05	1000	57.448378	9.346430	14.04	15:03:41	2248	57.212478	8.952395
15	14.04.	15:42:19	1000	57.195356	8.994518	14.04.	19:16:55	2073	57.400826	9.340044
16	14.04.	19:48:42	1000	57.381947	9.377097	14.04.	22:49:06	1902	57.209032	9.085572
17	14.04.	22:51:14	1000	57.207119	9.082029	15.04.	05:28:26	2988	57.508061	8.384359
18	15.04.	06:08:08	1000	57.480957	8.345301	15.04.	06:44:56	1184	57.461779	8.424569
18A	15.04.	12:00:23	1000	57.484032	8.334242	15.04.	19:20:35	3201	57.253404	9.287223
19	15.04.	19:52:59	1000	57.273948	9.314008	15.04.	23:22:59	2050	57.443261	8.951875
19A	16.04	00:26:20	1000	57.500097	8.992065	16.04	01:11:12	1261	57.465544	9.035547
20	16.04.	01:12:16	1000	57.464480	9.033971	16.04.	08:49:06	3741	57.040965	8.314503
21	16.04.	09:24:04	1000	57.023755	8.350629	16.04.	16:27:34	3541	57.405288	8.979150
21B	16.04.	18:09:28	1000	57.382617	8.924508	16.04.	19:38:08	1532	57.459403	9.075086
22	16.04.	20:42:11	1050	57.424289	9.143727	17.04.	00:15:51	2332	57.236055	8.828645
22A	17.04.	00:34:43	1000	57.237919	8.792815	17.04.	01:22:03	1284	57.274578	8.714398
23	17.04.	01:59:48	1000	57.296561	8.747711	17.04.	04:00:58	1727	57.205716	8.946950
24	17.04.	04:04:17	1000	57.203484	8.952582	17.04.	07:47:47	2341	57.403897	9.313767
25	17.04.	08:22:36	1000	57.421740	9.275313	17.04.	12:05:56	2340	57.208944	8.916771
26	17.04.	12:44:34	1000	57.227887	8.880844	17.04.	16:41:44	2423	57.441499	9.239038
27	17.04.	17:36:02	1000	57.448020	9.165548	17.04.	20:40:42	2108	57.219001	9.158283
28	17.04.	21:08:19	1000	57.211716	9.113544	18.04.	02:43:29	3011	57.588030	8.820944
29	18.04.	03:29:47	1000	57.583251	8.859721	18.04.	06:33:27	2102	57.428209	8.549272
29A	18.04	08:17:34	1000	57.428482	8.745512	18.04.	10:46:14	1892	57.476253	9.075559
30	18.04.	11:43:44	1000	57.521107	9.045081	18.04.	16:58:54	2891	57.162602	8.756267
31	18.04.	17:55:39	1000	57.193439	8.704025	18.04.	23:19:09	2941	57.292940	9.459968
32	18.04.	23:49:35	1000	57.321406	9.450283	19.04.	05:45:35	3136	57.216245	8.656964
33	19.04.	06:35:48	1000	57.174107	8.675395	19.04.	12:24:38	3093	57.275283	9.438558
34	19.04.	12:59:09	1000	57.302682	9.421217	19.04.	18:01:39	2815	57.213846	8.751197
35	19.04.	18:57:42	1000	57.173821	8.771011	19.04.	22:36:12	2311	57.240530	9.263371
36	19.04.	22:37:16	1000	57.240722	9.265917	20.04.	00:17:46	1603	57.324626	9.433747
37	20.04.	00:57:46	1000	57.346099	9.398625	20.04.	02:54:16	1699	57.242994	9.229812
38	20.04.	02:57:34	1000	57.240201	9.224275	20.04.	08:35:04	3025	57.512696	8.588813
39	20.04.	09:10:45	1000	57.531331	8.624647	20.04.	11:13:55	1739	57.432364	8.843033

Table 5. Coordinates, times, and shot point numbers at the start and end of the seismic lines.

Line name GEUS23 _JB_*	Record length (s)	Shot inter-val (s)	Source depth (m)	Streamer depth (m)	Source (with generator/injec-tor volume in cubic in.)	Comments
01	5	6	3	3	2 GI (45/105)	
01A	5	6	3	3	2 GI (45/105)	
02	5	6	3	3	2 GI (45/105)	
03	5	6	3	3	2 GI (45/105)	
04	5	6	3	3	2 GI (45/105)	
05	5	6	3	3	2 GI (45/105)	
06	5	6	3	3	2 GI (45/105)	
07	5	6	3	3	2 GI (45/105)	
08	5	6	3	3	2 GI (45/105)	
09	5	6	3	3	2 GI (45/105)	
10	5	6	3	3	2 GI (45/105)	
11	5	12	3	4	2 GI (250/105)	
12	6	12	3	4	2 GI (250/105)	
13	6	12	3	4	2 GI (250/105)	
14	6	12	3	4	2 GI (250/105)	
15	6	12	3	4	2 GI (250/105)	
16	6	12	3	4	2 GI (250/105)	
17	6	12	3	4	2 GI (250/105)	Streamer at 6 m (SP 2262-2560)
18	6	12	3	4	2 GI (250/105)	
18A	6	12	3	5	2 GI (250/105)	
19	6	12	3	5	2 GI (250/105)	
19A	6	10/12	3	5	2 GI (250/105)	Testing shot interval
20	6	10	3	5	2 GI (250/105)	Streamer at 7 m (SP 3128-3252)
21	6	10	3	5	2 GI (250/105)	
21B	6	10	3	5	2 GI (250/105)	
22	6	10	3	5	2 GI (250/105)	
22A	6	10	3	5	2 GI (250/105)	
23	6	10	3	5	2 GI (250/105)	
24	6	10	3	5	2 GI (250/105)	
25	6	10	3	5	2 GI (250/105)	
26	6	10	3	5	2 GI (250/105)	
27	6	10	3	5	2 GI (250/105)	
28	6	10	3	5	2 GI (250/105)	
29	6	10	3	5	2 GI (250/105)	
29A	6	10	3	5	2 GI (250/105)	Lower pressure (SP 1020-1077)
30	6	10	3	5	2 GI (250/105)	
31	6	10	3	5	2 GI (250/105)	Issues with one gun (SP 1050-1300)
32	6	10	3	5	2 GI (250/105)	Lower Pressure (SP 1022-1107)
33	6	10	3	5	2 GI (250/105)	
34	6	10	3	5	2 GI (250/105)	
35	6	10	3	5	2 GI (250/105)	Re-shoot of line GEUS23_JB_10
36	6	10	3	5	2 GI (250/105)	Re-shoot of line GEUS23_JB_09
37	6	10	3	5	2 GI (250/105)	Re-shoot of line GEUS23_JB_08
38	6	10	3	5	2 GI (250/105)	Re-shoot of line GEUS23_JB_05
39	6	10	3	5	2 GI (250/105)	Re-shoot of line GEUS23_JB_04

Table 6. Recording parameters of the seismic lines. Abbreviations are GI, GI-guns; SP shot point.

Line	Number of shot points	Length (km)
GEUS23_JB_01	184	3
GEUS23_JB_01A	2252	33
GEUS23_JB_02	2490	35
GEUS23_JB_03	2239	31
GEUS23_JB_04	3581	50
GEUS23_JB_05	3468	49
GEUS23_JB_06	2206	29
GEUS23_JB_07	1873	26
GEUS23_JB_08	1260	18
GEUS23_JB_09	788	12
GEUS23_JB_10	2398	31
GEUS23_JB_11	1536	45
GEUS23_JB_12	1624	46
GEUS23_JB_13	1583	45
GEUS23_JB_14	1249	35
GEUS23_JB_15	1074	31
GEUS23_JB_16	903	26
GEUS23_JB_17	1989	52
GEUS23_JB_18	185	5
GEUS23_JB_18A	2202	62
GEUS23_JB_19	1051	29
GEUS23_JB_19A	262	5
GEUS23_JB_20	2742	65
GEUS23_JB_21	2542	59
GEUS23_JB_21B	533	12
GEUS23_JB_22	1283	28
GEUS23_JB_22A	285	6
GEUS23_JB_23	728	16
GEUS23_JB_24	1342	31
GEUS23_JB_25	1341	32
GEUS23_JB_26	1424	32
GEUS23_JB_27	1109	26
GEUS23_JB_28	2012	45
GEUS23_JB_29	1103	25
GEUS23_JB_29A	893	20
GEUS23_JB_30	1892	43
GEUS23_JB_31	1942	47
GEUS23_JB_32	2137	49
GEUS23_JB_33	2094	47
GEUS23_JB_34	1816	42
GEUS23_JB_35	1312	31
GEUS23_JB_36	604	14
GEUS23_JB_37	700	15
GEUS23_JB_38	2026	49
GEUS23_JB_39	740	17
Total:	68997	1449

Table 7. Length of seismic profiles and number of shot points.

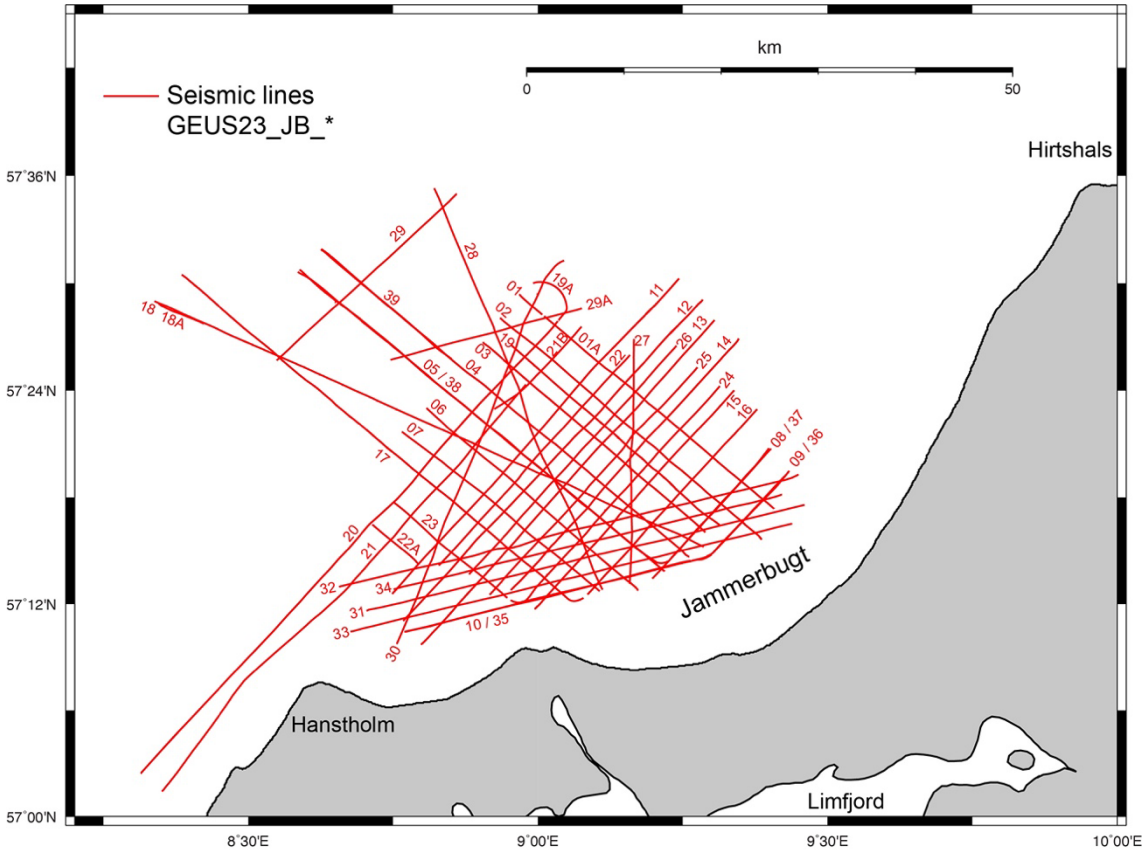


Figure 14. Location map of the seismic lines. All lines have the prefix GEUS23_JB_.

4.5 Onboard Processing

For quality control, onboard processing of the seismic data was carried out on selected lines. The main purpose of the processing was to identify the penetration of the seismic signals to ensure that the target depth is reached. The preferred seismic source was the small GI-gun cluster (two GI guns with 45/105 cubic inches generator/injector volume) that BGR used successfully in the German sector of the North Sea for the mapping of a potential structure for CO_2-storage (Ehrhardt *et al*. 2021). There, the small cluster reached the target depth and provided a high-resolution image of the subsurface structure. The alternative source with the larger volume (two GI guns with 250/105 cubic inches generator/injector volume) is more powerful but has a lower frequency content and thereby a lower resolution than the smaller array. This is why the survey started with the smaller source to find out how it performs in this area of the North Sea with a known hard seafloor. After onboard processing of the data from the first lines, a decision was made on the array size for the remainder of the survey. The initial analysis showed reduced seismic energy/reflectivity at greater depth, and it was therefore decided to switch to the large array for line GEUS23_JB_11 and onward.

For the onboard processing, two processing systems were available. Egon Nørmark from Aarhus University used an internet connection to a server on land that had the processing

software ProMAX installed. From BGR, Axel Ehrhardt and Bettina Schramm brought a Linux workstation to the vessel that was running the processing system Reveal by Shearwater.

4.5.1 Noise in the Field Data

Three types of noise are abundant in the field data, caused by the very shallow environment and three-dimensional effects (Figures 15 and 16).

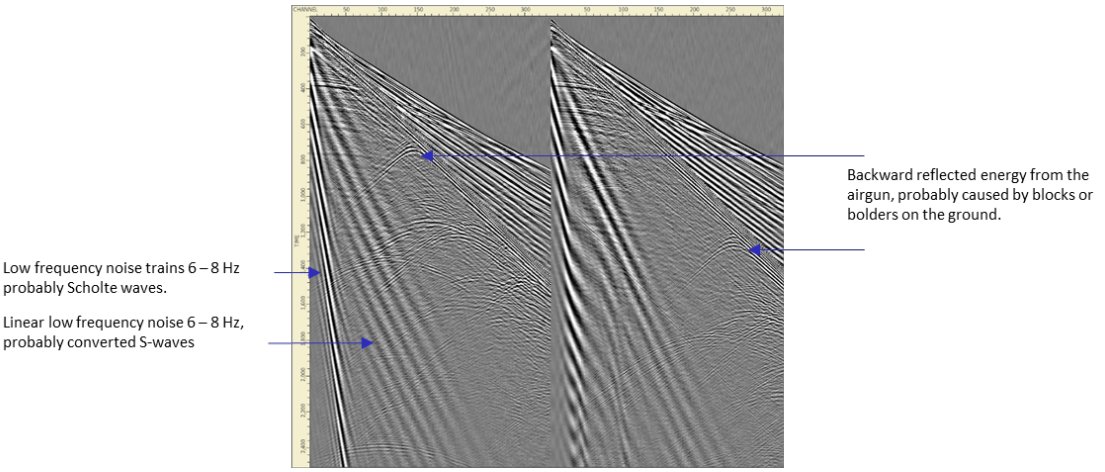


Figure 15. (1) Low-frequency noise, probably Scholte-waves and potential *P-S-P* converted waves. (2) Backward reflected energy from blocks or boulders on the ground as a special example of out of plane reflections. The vertical time axis is from 0 to 2.5 s.

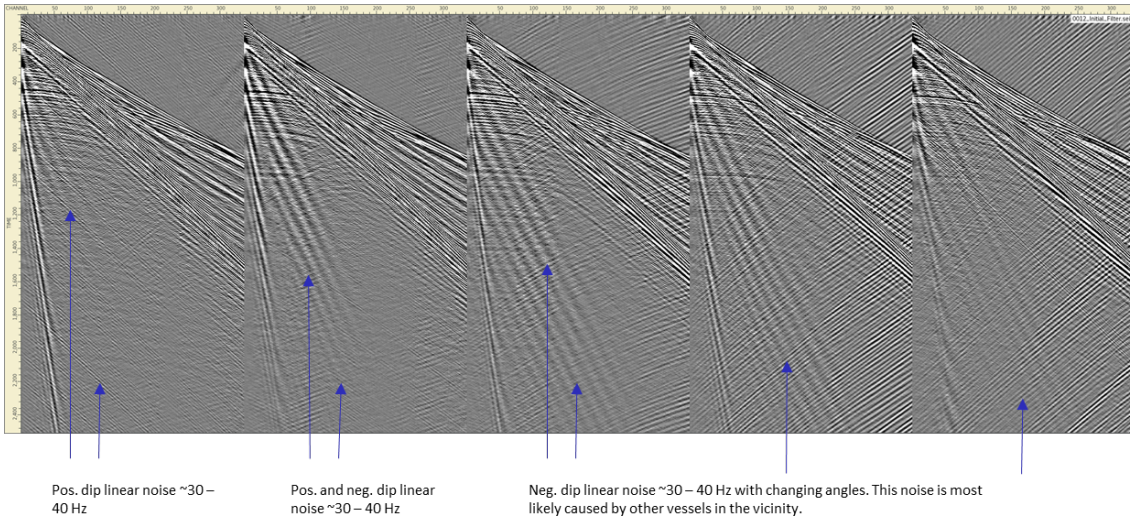


Figure 16. Linear noise with varying dips crossing the entire shot gather. This noise is probably a result of vessels passing in the vicinity of the streamer cable. The vertical time axis is from 0 to 2.5 s.

Several processes are conceivable to address the noise. As the low-frequent noise is below the main bandwidth of the source signal, a simple low-cut filter at 10 Hz could eliminate this noise. More difficult is the linear noise, as it is within the frequency bandwidth of the source

signal. Here we distinguish between negative dip and positive dip linear noise. As for the negative dip noise, we can assume that we do not have primary reflections with negative dip within shot gathers (this is not true for large synclinal structures where parts of the reflected bow tie have also negative dips). Filtering and subsequent subtraction of the filtered data shows reasonable results (Figure 17).

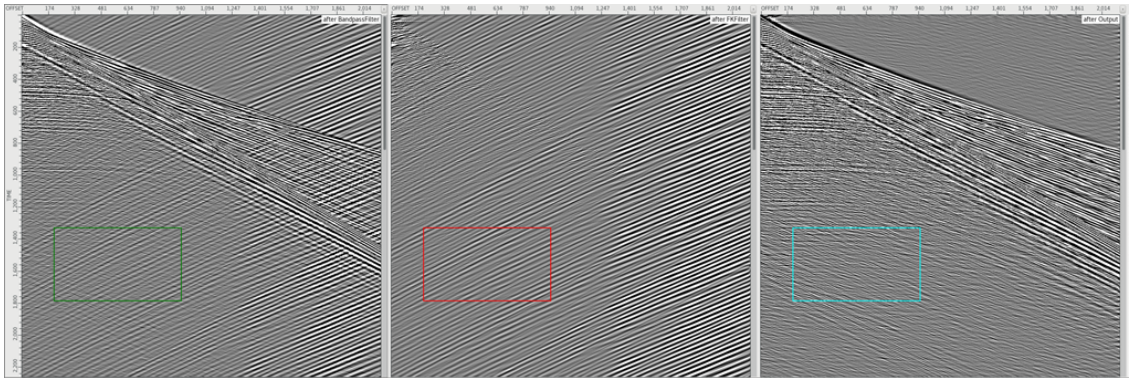


Figure 17. Results of negative dip filtering and subtraction in the shot domain. The vertical time axis is from 0 to 2.26 s.

As for the positive dip linear noise, it is much more complicated to distinguish between noise and primary reflections. Here we take advantage of the coherent appearance of the noise. We model the coherent noise and apply a subsequent adaptive subtraction with reasonable results (Figure 18).

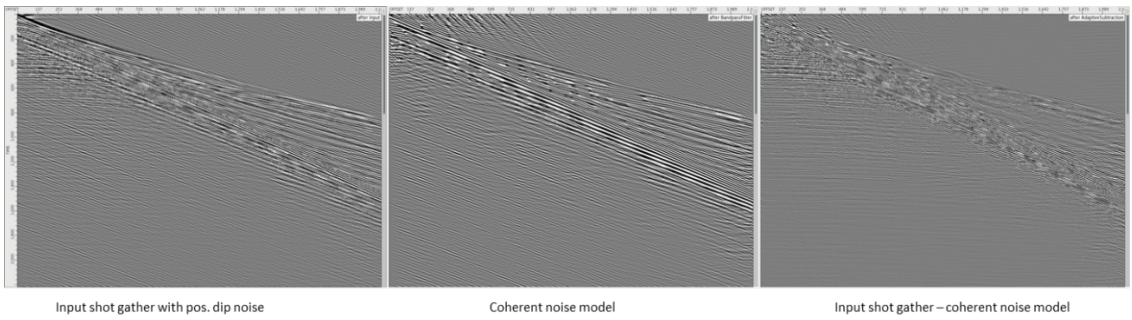


Figure 18. Shot gather, modelled noise, and the noise subtracted from the shot gather. This results in a reasonable suppression of the linear positive dip noise. The vertical time axis is from 0 to 2.22 s.

Out of plane reflections from rocks or boulders (see Figure 15) are more complicated as they do not show any difference in appearance in comparison to the primary reflections. However, in case they have negative dip, they will be tackled by the negative dip filter.

4.5.2 Multiple Energy

The acquired seismic lines show various multiple events. Whereas multiple events caused by the seafloor can be reduced by tools like SRME (Surface-Related Multiple Elimination) or SWME (Shallow Water Multiple Elimination), multiple events caused by the prominent base of the chalk are difficult to address. Figure 19 shows two stacks of line GEUS23_JB_30. The left frame presents a simple stack, while the right frame displays the same stack with both SRME and SWME tools applied. The seafloor induced multiples are well reduced (blue), however, multiples induced by the base of the chalk are still prominent. Standard tools like SRME, predictive deconvolution (tau-P and t-x domains) or velocity discrimination methods like radon filtering are not able to separate the multiple energy. Other techniques like wave equation modelling are probably successful in suppressing the base-chalk multiples.

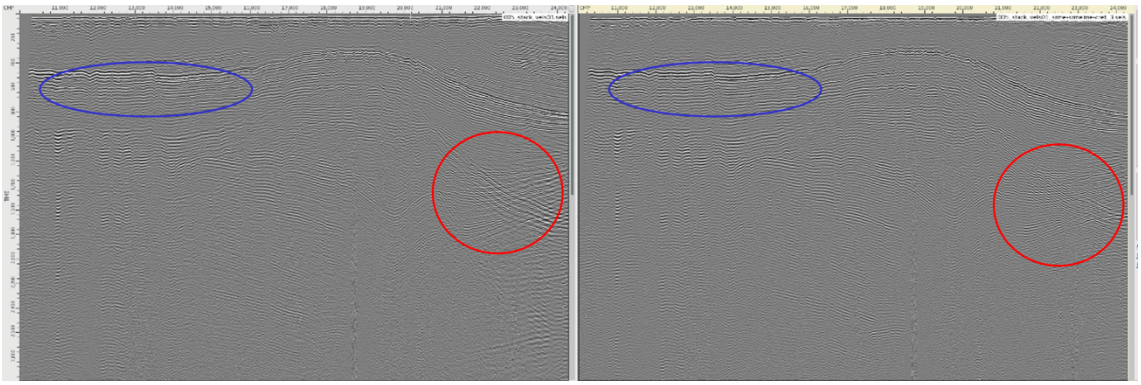


Figure 19. Line GEUS23_JB_30: (left) stack, (right) stack with SRME and SWME tools applied. Seafloor related multiples are well reduced (marked in blue), while multiple events caused by the prominent base of the chalk (red) are still present within the stack. The vertical time axis is from 0 to 3 s.

4.5.3 Data Examples

Figures 20 and 21 show examples of the onboard processing for lines GESU23_JB_13 and 20, respectively. An initial interpretation (by Michael Bryld Wessel Fyhn, GEUS) of the seismic records indicate that there is penetration down to base Zechstein and that potential reservoir rocks (Haldager Sand and Gassum formations) are well imaged.

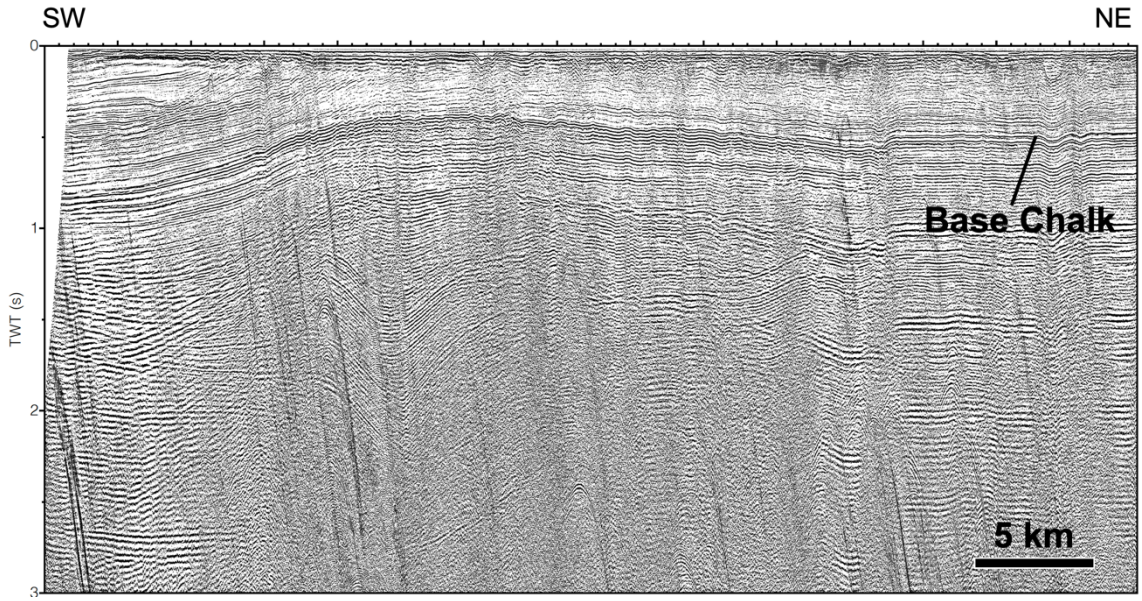


Figure 20. Example of a seismic record section after initial onboard processing: a stack of line GEUS23_JB_13 produced with Shearwater's Reveal software with a preliminary interpretation of the base chalk. Vertical scale is two-way travel time (TWT) in seconds.

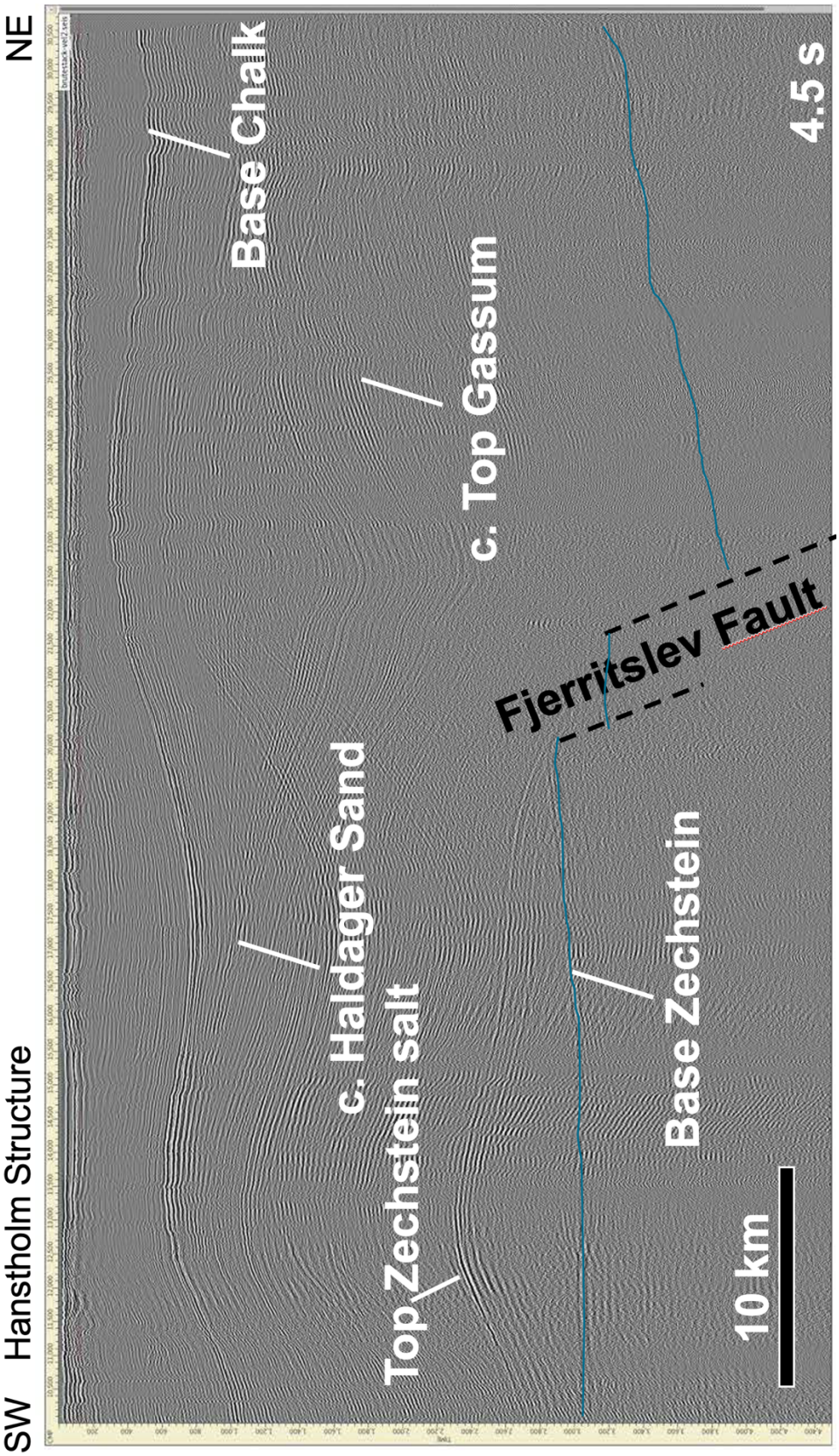


Figure 21. Example of a seismic record section after initial onboard processing: a brute stack of line GEUS23_JB_20 produced with Shearwater's Reveal software with a preliminary interpretation by Michael Bryld Wessel Fyhn (GEUS). Vertical scale is two-way travel time spanning from 0 to 4.5 s.

5. Hydroacoustic Measurements

5.1 Location of Sensors

The multibeam, sub-bottom profiler, positional and motion data were all acquired with vessel-owned sensors. The sensors were installed during the building of the vessel in 2020. During the installation, all sensor offsets were measured by the Norwegian company Anko Maritime. These offsets are summarized in Table 8 with the important ones marked by an asterisk (*). See also Figure 22 for a schematic illustration of the location of sensors.

Sensor	+X (for-ward)	+Y (star-board)	+Z (down)	Description
MGC*	0.000	0.000	0.000	Accelerometer cross point
EM 712 TX*	11.545	1.502	13.965	Centre face
EM 712 RX*	10.817	1.602	13.965	Centre face
Seapath aft*	-7.896	1.834	-14.044	Centre antenna
Seapath forward*	-3.900	1.852	-13.964	Centre antenna
TOPAS*	1.707	1.612	14.559	Centre face
ADCP	2.781	1.589	14.558	Centre face
SU 90	9.820	1.758	15.132	Calculated fully extracted position
CS 90	10.152	1.183	14.849	Calculated fully extracted position
Plimsoll port	-7.750	-5.201	7.938	Centre sign
Plimsoll starboard	-7.749	8.418	7.992	Centre sign
COG*	-9.530	1.594	7.583	LCG=24.336, TCG=-0.001, VCG=6.396

Table 8. The location of sensors on the vessel Jákup Sverri as determined by the company Ankor Maritime. The important offsets for this survey are marked by an asterisk (*). All values are given in meters. See also Figure 22 for a schematic illustration of the sensor positions. Abbreviations are ADCP, Acoustic Doppler Current Profiler; COG, center of gravity; LCG, longitudinal center of gravity; MGC, motion sensor and gyro compass; TCG, transverse center of gravity; VCG, vertical center of gravity.

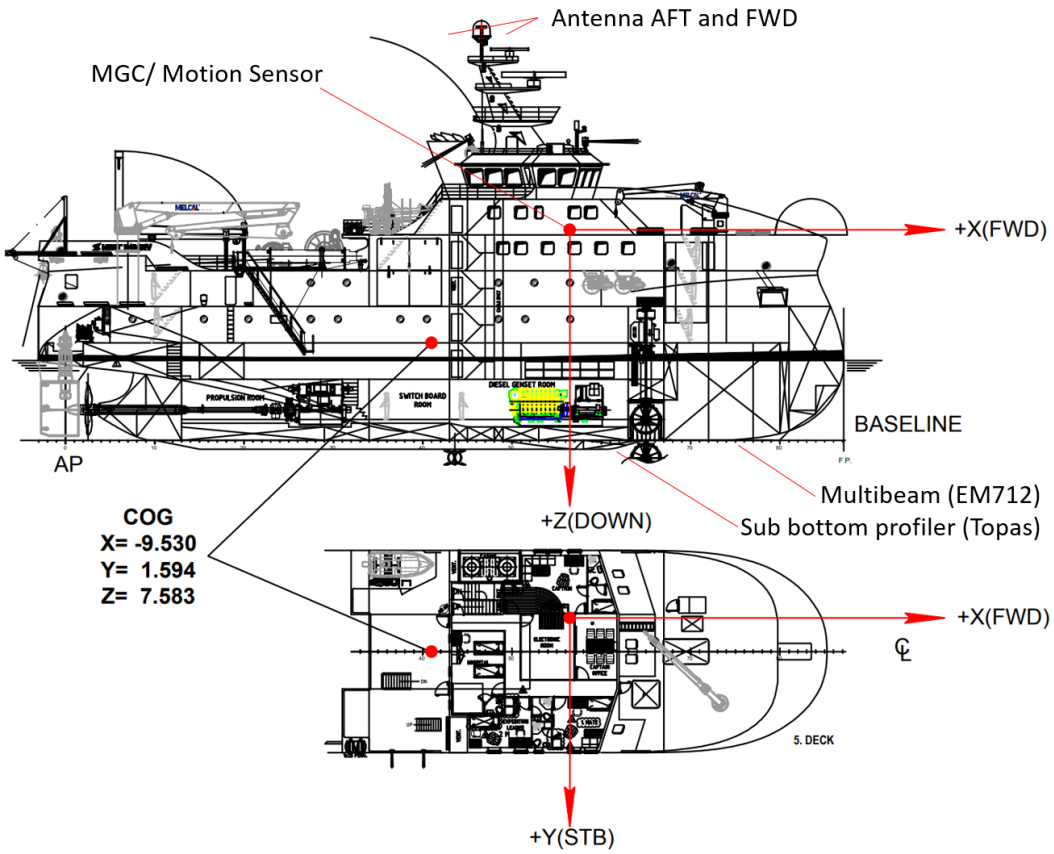


Figure 22. Drawing of the research vessel Jákup Sverri showing the approximate positions of the relevant sensors. Abbreviations are COG, center of gravity; FWD, forward; MGC, motion sensor and gyro compass; STB, starboard.

5.2 Motion Sensor

The position and motion data were acquired by a Seapath 380-R from Kongsberg as shown in Figure 23. Seapath 380-R integrates RTK (real-time kinematic positioning) GNSS (global navigation satellite system) data with the inertial sensor data from the motion reference unit. The most important technical specifications for position and motion accuracy of the motion sensor are summarized in Table 9.

Parameter	Accuracy
Roll and pitch	0.008° to 0.08°
Heave	Less than 5 cm
Position with RTK (X and Y)	1 cm + 1 ppm (RMS)
Position with RTK (Z)	2 cm + 1 ppm (RMS)

Table 9. The accuracy for position and motion with a Seapath 380-R system from Kongsberg. Abbreviations are ppm, parts per million; RMS, root mean square; RTK, real-time kinematic positioning. 1 ppm means the error has a 1 mm increase for every 1 km of movement of the vessel.

Figure 23. The Seapath 380-R from Kongsberg.

At the end of the survey, all the relevant Seapath log files were exported and stored. The log files will be necessary for later post-processing of the kinematic (PPK) GNSS data, which is important in relation to the bathymetric measurements.

5.3 Sound Velocity Profiles

The sound velocity profiles (SVP) were acquired with an AML Minos X (Figure 24). Given that the vessel could not stop during the seismic survey, only two SVPs could be acquired, one prior to the start of the seismic acquisition and one after it was completed. However, it was possible to obtain SVPs from the survey vessel Poul Løwenørn operating in the vicinity and covering the period from April 16 to 19, 2023. The survey vessel was conducting a multibeam bathymetric survey for the Danish Geodata Agency (Geodatastyrelsen, GST) as part of the annual hydrographic chart campaign. The survey took place approximately 15 km west from our survey area. Table 10 lists the SVP measurements made from both Poul Løwenørn and Jákup Sverri. The locations of the SVP measurements are shown in Figure 25.

Figure 24. AML Minos X was used for sound velocity profiles.

SVP name	Date [DD-MM-YYYY]	Time (UTC) [HH:MM]	Easting (m)	Northing (m)
2023-04-10_20-52-03	10-04-2023	19:30	520791.41	6358559.86
Poul Løwenørn 16 APR 01	16-04-2023	11:33	466040.66	6336538.69
Poul Løwenørn 16 APR 02	16-04-2023	11:57	460925.06	6333388.97
Poul Løwenørn 16 APR 03	16-04-2023	12:21	455801.51	6330234.45
Poul Løwenørn 17 APR 01	17-04-2023	15:20	454839.22	6330857.15
Poul Løwenørn 17 APR 02	17-04-2023	15:40	458861.85	6333442.41
Poul Løwenørn 17 APR 03	17-04-2023	15:57	462647.90	6335844.42
Poul Løwenørn 18 APR 01	18-04-2023	19:36	457984.12	6335800.24
Poul Løwenørn 18 APR 02	18-04-2023	20:01	461755.65	6338112.50
Poul Løwenørn 19 APR 01	19-04-2023	04:49	449846.62	6326161.01
Poul Løwenørn 19 APR 02	19-04-2023	05:15	446102.35	6321242.78
Poul Løwenørn 19 APR 03	19-04-2023	05:39	442441.69	6316415.72
Poul Løwenørn 19 APR 04	19-04-2023	06:16	446024.95	6313884.96
Poul Løwenørn 19 APR 05	19-04-2023	06:39	449450.03	6318495.35
Poul Løwenørn 19 APR 06	19-04-2023	07:03	453209.85	6323327.31
2023-04-20_17-45-17	20-04-2023	16:45	509899.60	6355468.81

Table 10. Time and location of the acquired sound velocity profiles (SVP) from Jákup Sverri and Poul Løwenørn. Coordinates (northing and easting) are for UTM zone 32.

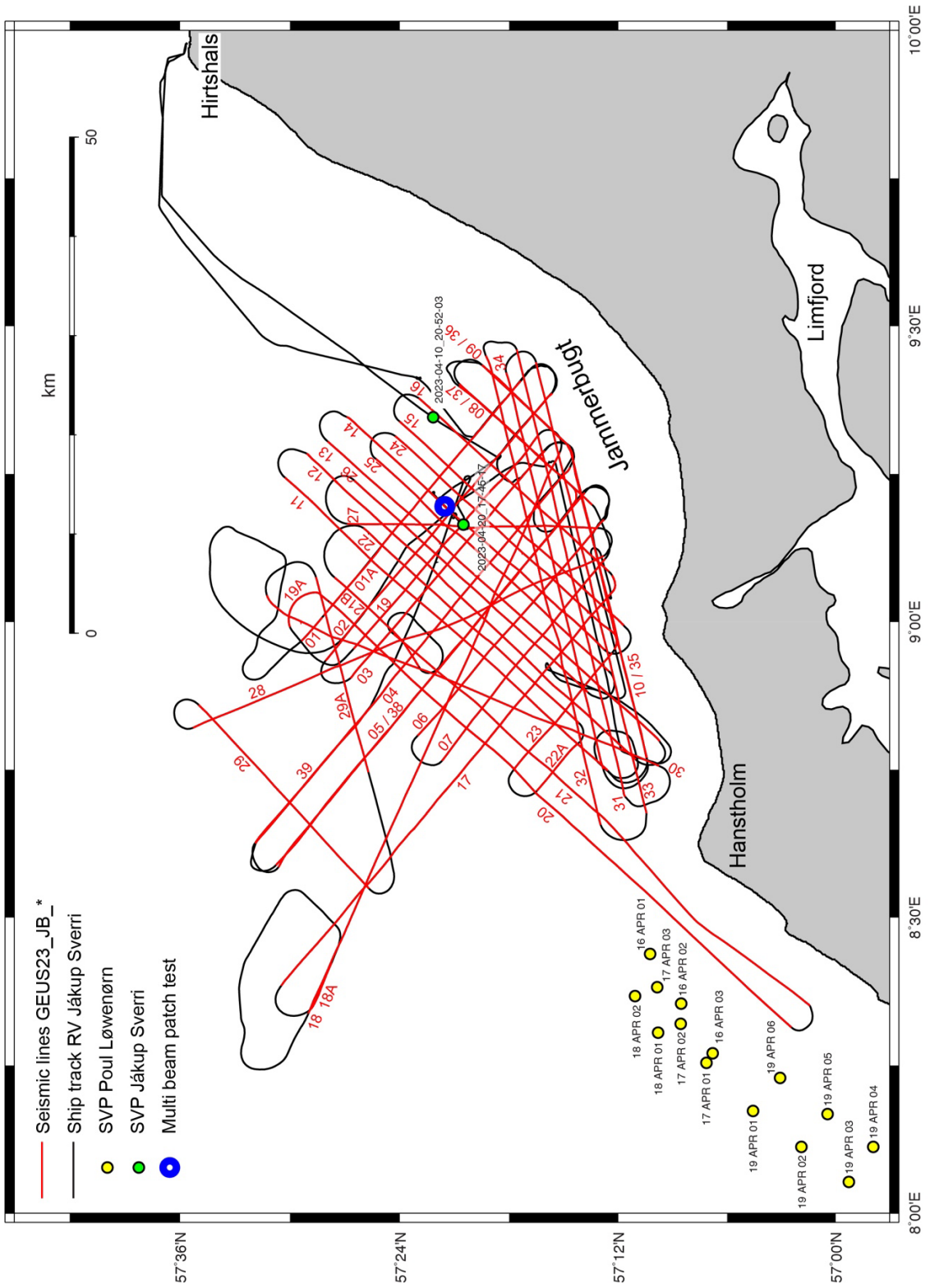


Figure 25. Map showing the locations of the SVP measurements and the multi beam patch test. In addition, the seismic profiles and the track of research vessel Jákup Sverri are marked by red and black lines, respectively.

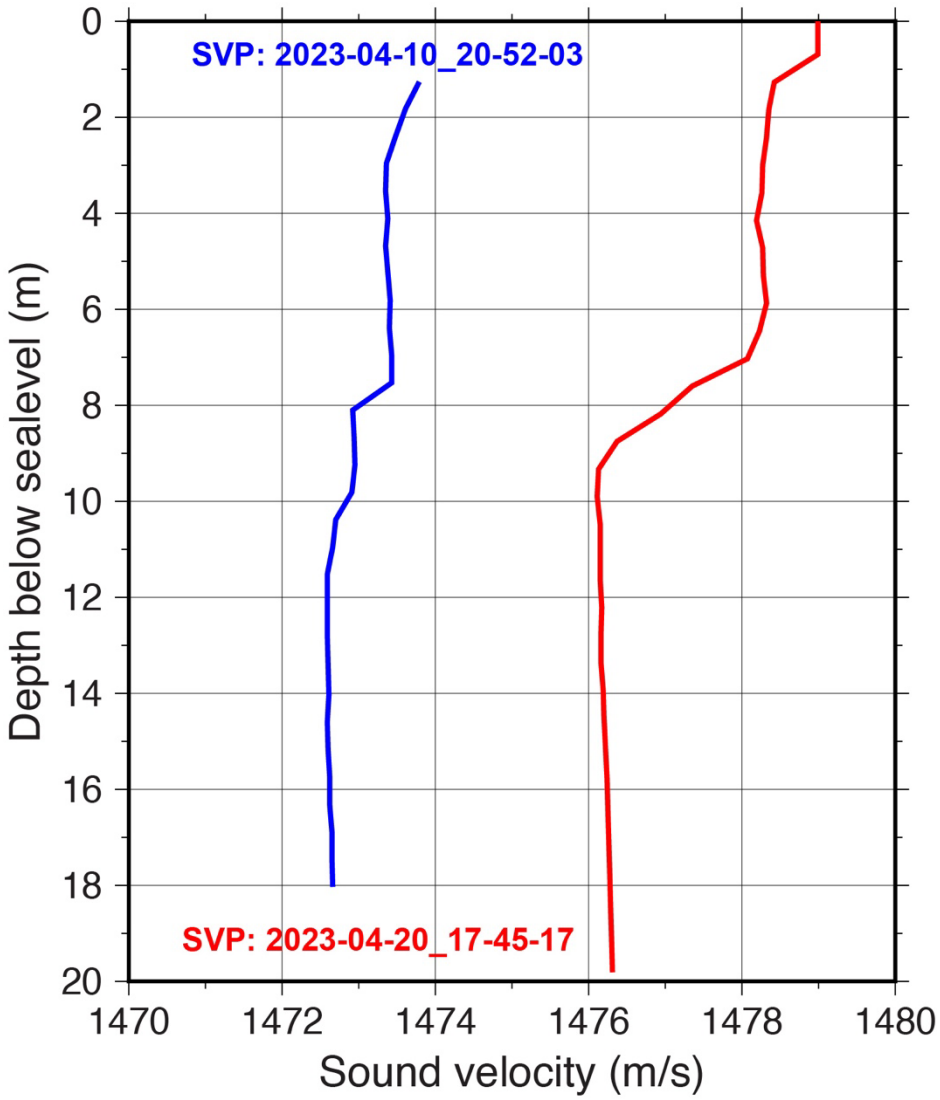


Figure 26. Sound velocity profile (SVP) from April 10, 2023 (blue), and April 20, 2023 (red). Both profiles were measured from Jákup Sverri and are approximately in the same area.

Figure 26 shows the SVPs acquired from Jákup Sverri. The SVP from April 10, 2023 (in blue), has a minimum velocity of 1472.6 m/s and a maximum of 1473.8 m/s. The measurement from April 20, 2023 (in red), displays a minimum velocity of 1476.3 m/s and a maximum of 1478.0 m/s. The two profiles illustrate the difference in sound velocity over time and are caused by an increase in water temperature. On April 10, the average sound velocity was 1473 m/s while it was 1477.5 m/s ten days later.

5.4 Multibeam Echosounder

The bathymetric and backscatter data were acquired using the Kongsberg multibeam echosounder EM 712. The EM 712 has a minimum acquisition depth of less than 3 m below the transducer, while the maximum depth is 3600 m. The swath angle for this survey was set to 120 degrees with an equidistant beam spacing. The main settings applied during the survey are shown in Figure 27. No automatic filters, gain or data cleaning settings were applied.

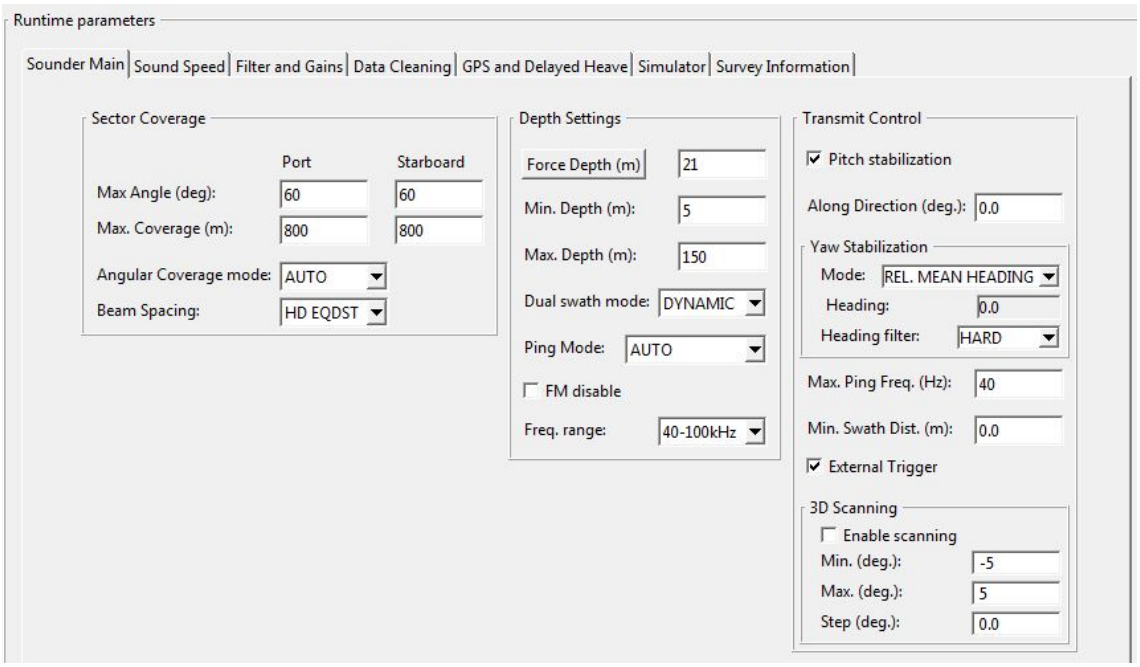


Figure 27. Screen dump of the seafloor information system (SIS) from Kongsberg showing the main settings of the EM 712 multibeam echosounder.

The acquisition software used during the survey was the seafloor information system (SIS) from Kongsberg. The online quality control (QC) and acquisition window of the software is shown in Figure 28. The ping rate/frequency did not exceed 12 Hz since the beams were triggered by the sub-bottom profiler and the sonar of the vessel to prevent sonar signals to interfere with the bathymetric data.

During the survey, the bathymetric data were quality controlled and manually spike cleaned using the EIVA software NaviEdit and NaviModel. Figure 29 illustrates the processing steps that were carried out during the survey.

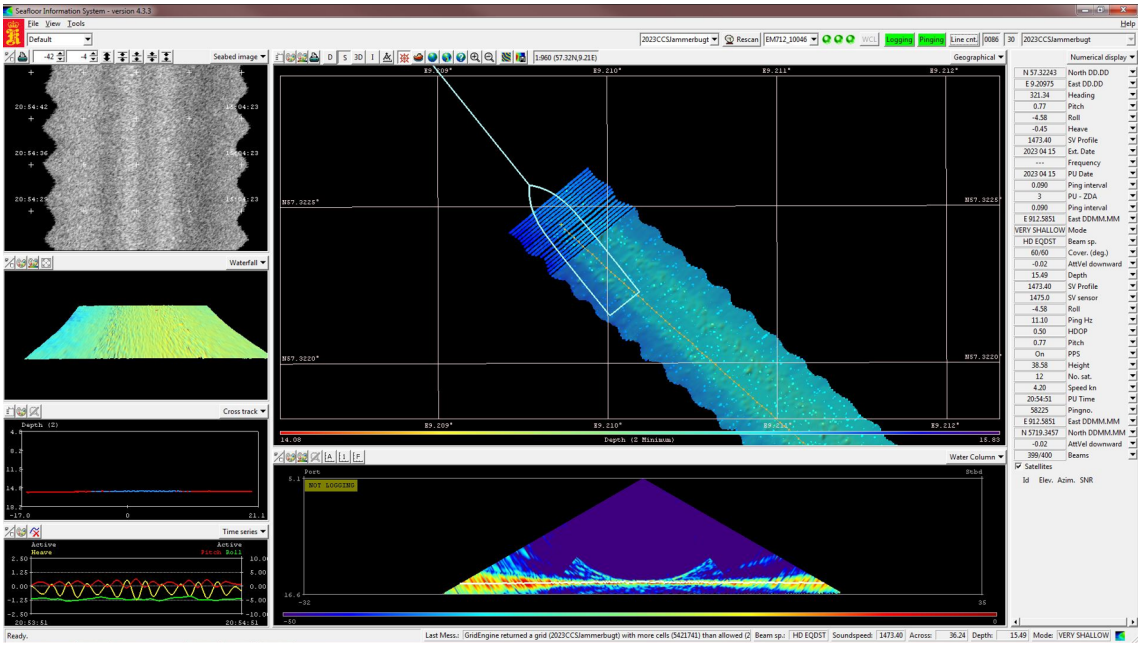


Figure 28. The online acquisition window of the seafloor information system (SIS). At the left side, the backscatter, waterfall, cross track, and pitch/roll/heave are displayed (from top to bottom). The two large windows in the center show the online DTM (Digital Terrain Model; top) and water column data (bottom). Parameters and other numerical values are displayed in the right.

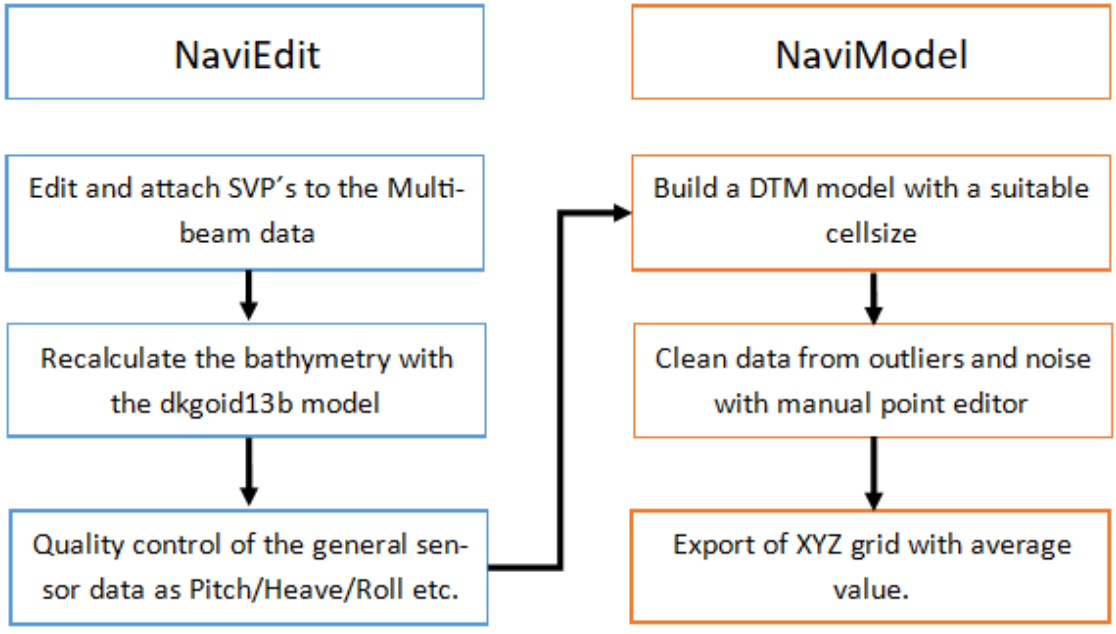


Figure 29. Flowchart of the on-board processing of the bathymetric data by means of the software packages NaviEdit and NaviModel. Abbreviations are DTM, Digital Terrain Model; SVP, sound velocity profile.

Post processing the kinematic will improve the accuracy of the data. The bathymetric data were acquired using the relevant RTK base stations from RTKConnect that are located in

Hanstholm and Løkken. A significant part of the survey area was more than 40 km away from the nearest base station (see coverage map of RTKConnect in Figure 30). Due to the long distance, the real time kinematic is not reliable and a PPK routine is recommended together with a suitable automatic cleaning tool.

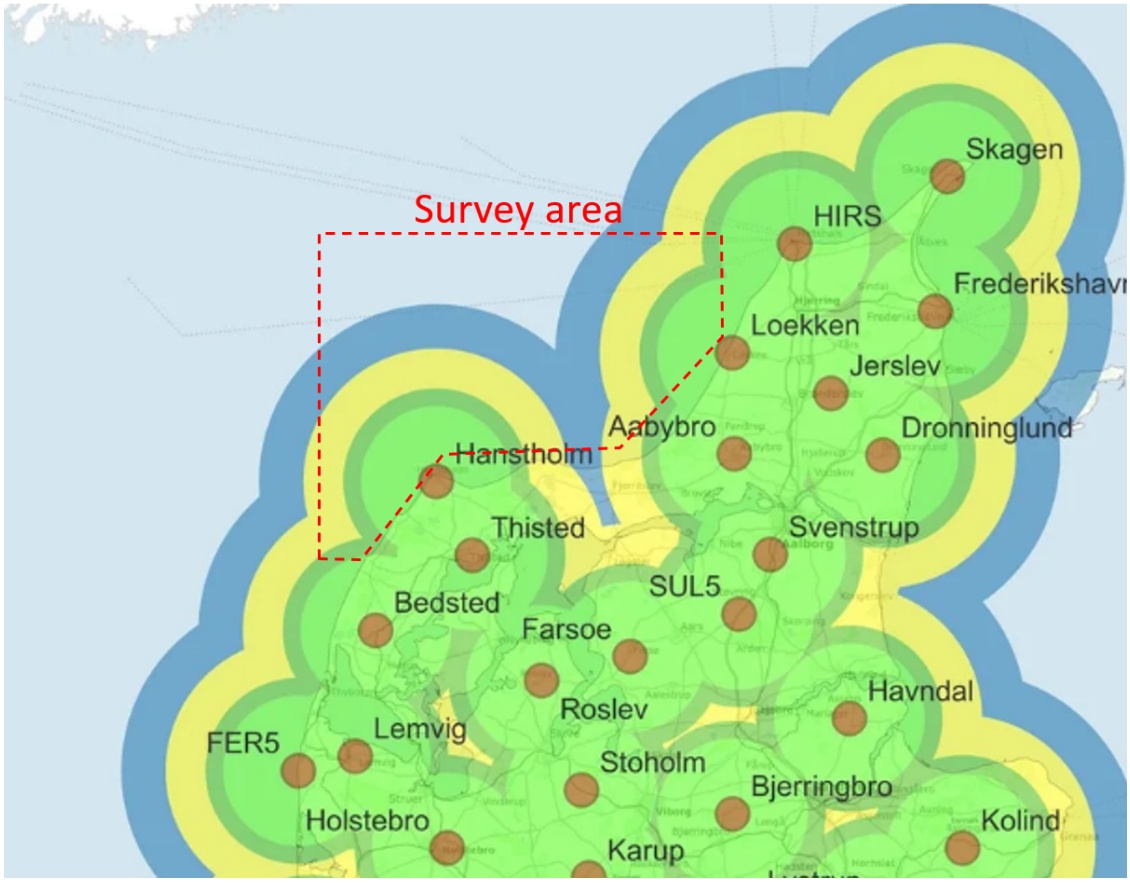


Figure 30. Coverage map of RTKConnect with the survey area indicated by a dashed red line. The available base stations are marked by red circles. Colored areas show the distance to the nearest base station: green is less than 20 km away, yellow less than 30 km away, and blue less than 40 km away.

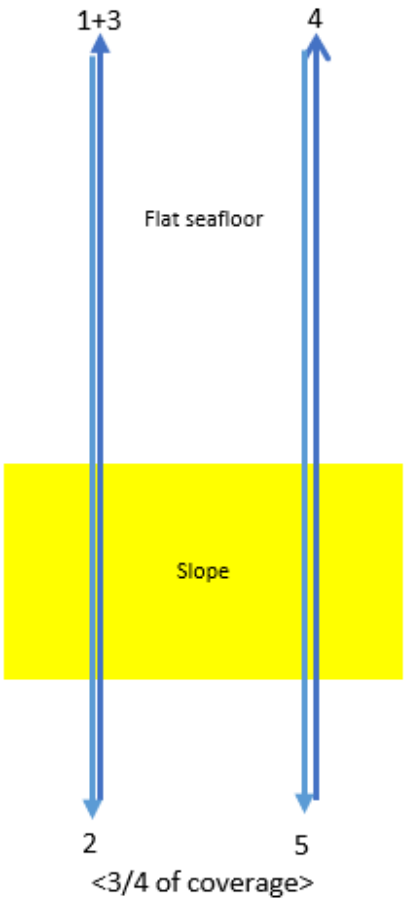
5.5 Multibeam Patch Test

On the last day of the survey on April 20, 2023, a calibration of the multibeam system was performed using a patch test. Such a test has two objectives:

- To determine the mount angles of the multibeam transducer (roll, pitch, and heading) in relation to the local coordinate system and the motion sensor.

- To confirm the relationship between the time tagging on the multibeam and position data.

For the multibeam data acquired with the Kongsberg EM 712, a standard patch test for a single head multibeam was implemented. Calibration of the time validation as well as the pitch, roll, and heading requires a navigation pattern consisting of two parallel lines that are perpendicular to a sharp linear morphological feature followed by a flat surface as shown in Figure 31.



Calibration type	Lines
Time	1+3
Pitch	1+2 or 5+4
Roll	1+2 or 5+4
Heading	1+4 or 2+5

Figure 31. Sailing pattern for performing a patch test with a single head multibeam echosounder.

For the different elements of the patch test, the following navigational requirements are necessary:

- For the time validation: a line is surveyed at survey speed and repeated with the same heading at twice the speed.
- For the calibration of the pitch: a line is surveyed twice with opposite headings at survey speed over the steep slope.
- For the calibration of the roll: a line is surveyed twice with opposite headings at identical survey speed over a flat seafloor.
- For the calibration of the heading: two parallel lines are separated by 3/4 of the full coverage of the swath and surveyed with the same heading.

The patch test was conducted over a 2-meter-high slope with an inclination of five degrees. Figure 32 shows the digital terrain model (DTM) of the site before and after the patch test. The location of the slope (Easting: 511747.11 m; Northing: 6357328.99 m; UTM zone 32) was on line GEUS23_JB_14 between lines GEUS23_JB_01A and GEUS23_JB_02 and is indicated in Figure 25.

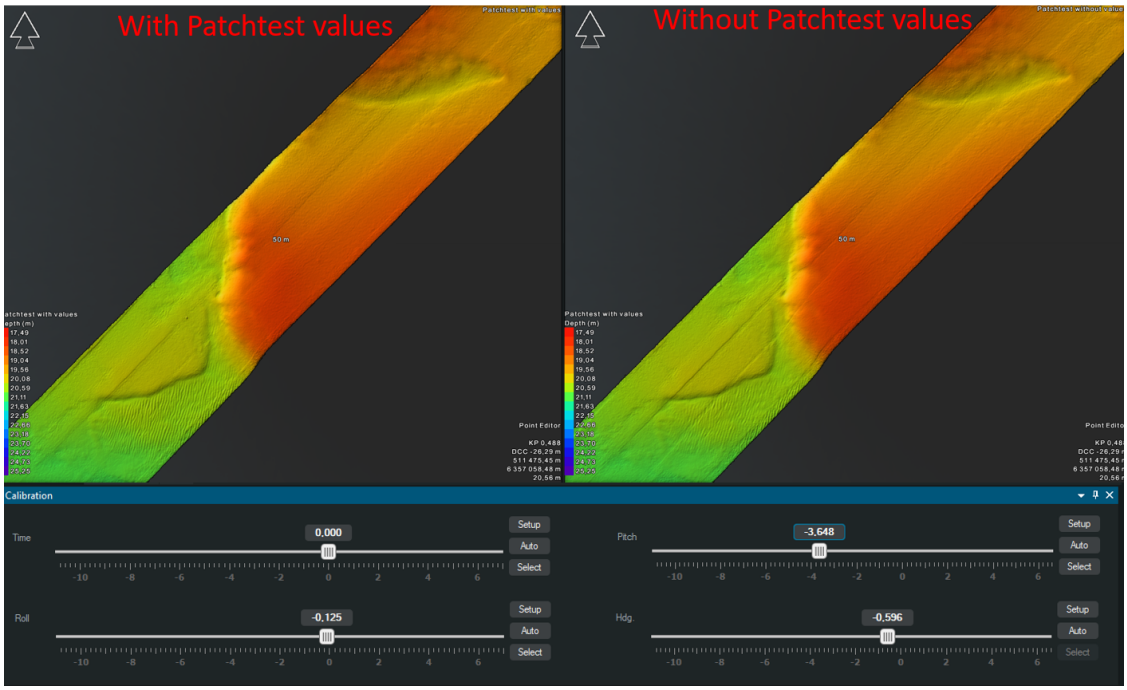


Figure 32. The digital terrain model (DTM) with (top left) and without (top right) applying the results from the patch test. At the top left corner is the DTM model with the patch test values. The corresponding values from the patch test are shown at the bottom. The coordinates of the slope are Easting 511747.11 m and Northing 6357328.99 m (UTM zone 32).

5.6 Sub-Bottom Profiler

The sub-bottom profiler data were acquired using the ship's Kongsberg TOPAS PS18 system. TOPAS PS18 is designed for sub-bottom profiling with high spatial resolution in water depth from less than 20 m to full ocean depth. The system creates a low frequency signal in the water column by non-linear interaction between two high-frequency signals centered symmetrically around 18 kHz. In addition, a sum frequency signal is generated. However, only the low frequency signal is used for the sub-bottom profiling.

The system can operate with various signal waveforms such as CW (continuous wave), Chirp, or Ricker pulses. For this survey, all data were acquired using a Ricker pulse with a frequency of 3 kHz. The Ricker wavelet is a single pulse suitable for very high-resolution work due to its time domain behavior. The CW and Chirp pulses were tested at the start of the survey but did not have the same high resolution or penetration as the Ricker pulse has in this area.

The sub-bottom profiler data are delivered as files with the extension raw, sgy, and seg. Both the seg and sgy files refer to data in SEG-Y format. The raw files are in the default raw data format produced by the TOPAS software. At the end of the survey, all raw data were converted to sgy-files while the seg files denote the data that were produced by real-time processing during the survey. The processing includes a bandpass filter and a time-variable gain. The bandpass filter had a high/low stop of 1/2 kHz and a high/low pass of 5/6 kHz. The time-variable gain followed the seafloor using manual tracking. The online quality control of the sub-bottom profiler data was performed by monitoring the real-time processed data (Figure 33). Based on the online quality control, the sub-bottom profiler could not penetrate the till or pre-Quaternary formations in the area. In soft sediments, the penetration was up to 30 ms two-way travel time.

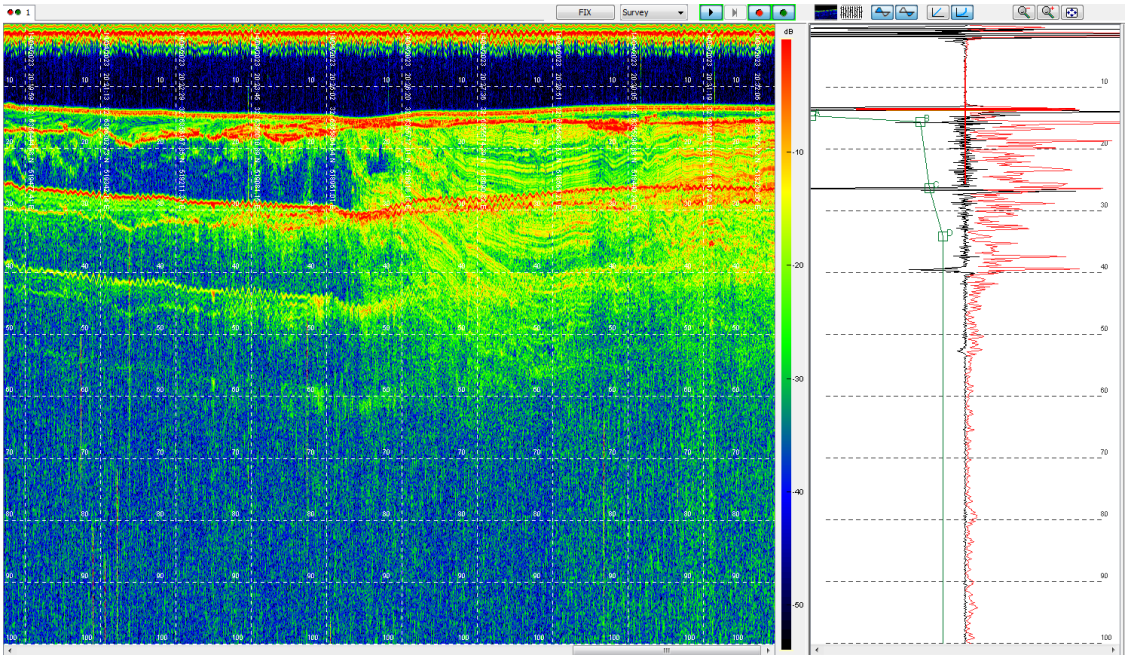


Figure 33. The echo-diagram (left) and the signal with the time variable gain (right) used for online quality control of the sub-bottom profiler data.

6. Marine Mammal Observation

To protect the marine environment and in particular marine mammals, the procedures as outlined in the permission for the seismic survey by the Danish Energy Agency were followed. This required compliance with the "*Standard conditions for pre-investigations at sea"* (*Standardvilkår for forundersøgelser til havs*, version August 2018) but with an extension of the soft-start period to 60 minutes based on a recommendation by the Danish Environmental Protection Agency.

Two certified marine mammal observers (MMO) were on board (Axel Ehrhardt and Thomas Funck) the vessel Jákup Sverri, being on opposite watches to ensure around-the-clock availability of an MMO. During critical phases such as pre-watch, soft start, and line turns, additional staff from the crew and the science party assisted with the lookout for marine mammals. The observation was carried out with two Steiner Commander 7x50 binoculars with compass and reticules. The reticules were calibrated at the start of the survey.

For passive acoustic monitoring (PAM), BGR provided a QuietSea system from Sercel. The QuietSea system uses the streamer cable hydrophones for baleen whale detection. Four additional high-frequency modules were included in the streamer cable for the detection of toothed whales. In addition, a special module designed for the detection of harbor porpoises was attached to the air gun hanger (Figure 8). The PAM software (Figure 34) was installed on a computer in the dry lab and was monitored by the seismic watchkeepers there.

As spare, GEUS/Aarhus University brought their PAM system from Vanishing Point Marine Ltd. in the United Kingdom with a 350-m-long cable and PAMGUARD open source software. This system requires more interaction with the operator than the QuietSea system does and has the disadvantage that another cable would need to be towed in the water, which increases the risk of entanglement during turns. With the functional QuietSea system, there was no need to deploy the spare system.

During seismic operation (including pre-watch and soft-start), the seismic watch informed the MMO whenever the QuietSea system reported a detection, in order to obtain a visual confirmation. However, only in once case there was a visual observation. Table 11 summarizes the observations made by the MMO. There were additional detections by the PAM system that were singular (non-repetitive) events classified as false alarms or vocalizations at very large distance.

Prior to the start of seismic acquisition and after breaks for repairs, a 30-minute pre-watch was conducted by the MMO to ensure that there were no marine mammals in the vicinity of the vessel. The MMO were supported by additional available staff, while the seismic watchkeeper monitored the PAM system. Following the pre-watch, the MMO gave permission to begin with the soft-start procedure of the air gun array according to the scheme in Table 12.

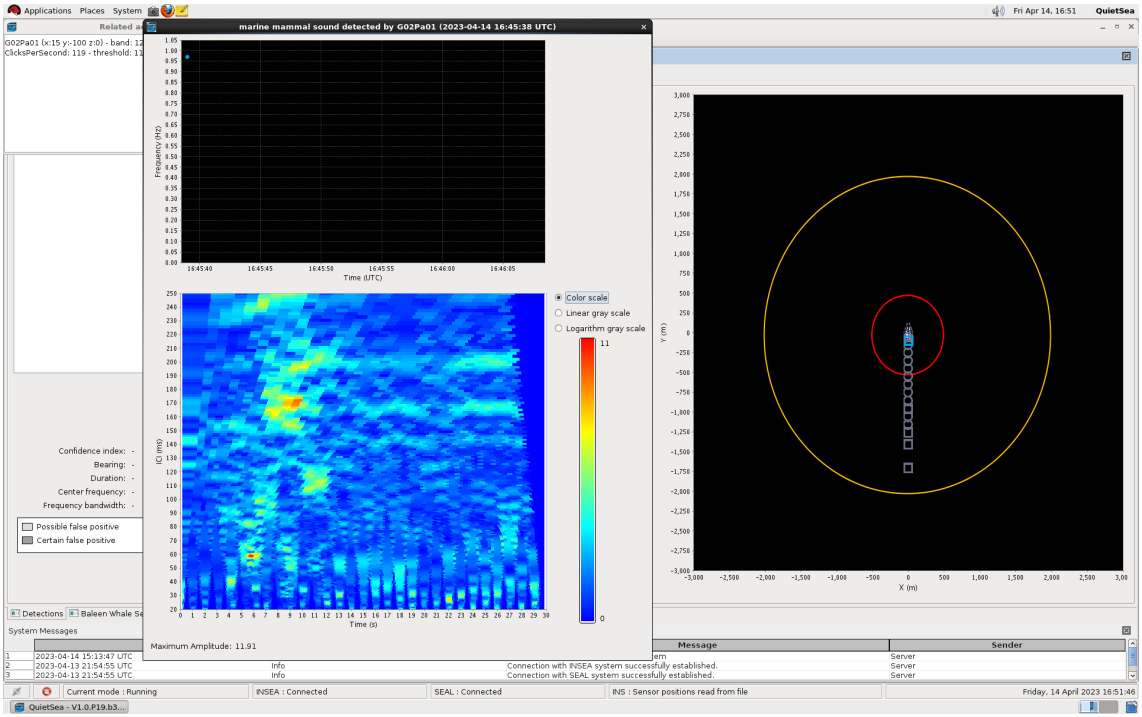


Figure 34. Display of the QuietSea system after an automatic detection of a harbor porpoise. This detection was later confirmed visually by the marine mammal observers (see entry for April 14, 2023 at 17.08 UTC in Table 11).

Date	Time (UTC)	Latitude	Longitude	Observation
14/04/2023	08:48	57° 24’ N	9° 12’ E	Possible detection of harbor porpoise on PAM. Could not be confirmed by MMO and happened at a time when JS was passed by another vessel (Embla R) in just 300 m distance.
14/04/2023	16:35	57° 15’ N	9° 05’ E	Possible PAM detection of harbor porpoise. MMO was supported by four additional persons, but no whale could be detected visually.
14/04/2023	17:08	57° 16’ N	9° 08’ E	Detection of harbor porpoise on PAM. Two individuals were confirmed visually at 600 m distance ahead of ship, moving from starboard to port side, mainly diving.
18/04/2023	06:56	57° 24’ N	8° 35’ E	PAM detection of toothed whale in 2 km distance during pre-watch. No visual confirmation.

Table 11. Summary of marine mammal observations. Abbreviations are JS, Jákup Sverri; MMO, marine mammal observer; PAM, passive acoustic monitoring.

Time interval	Number of GI-guns in use	Shot interval
0 – 10 minutes	1	60 s
10 – 20 minutes	1	40 s
20 – 30 minutes	1	30 s
30 – 40 minutes	2	40 s
40 – 50 minutes	2	30 s
50 – 60 minutes	2	15 s
>60 minutes (end of soft-start)	2	Regular shot rate (6 to 12 s)

Table 12. Soft-start procedure for the GI-gun array after completion of a 30-minute pre-watch.

7. References

Ehrhardt, A., Barckhausen, U., Behrens, T., Demir, Ü., Ebert, T., Engels, M., Hahn, B., Kuhlmann, G., Schnabel, M., Steinborn, P. & Stück, H. 2021: High resolution reflection seismic imaging of the Cenozoic barrier structures of the West-Schleswig Block and the fluid migration system of the blowout structure 'Figge Maar'. MARIA S. MERIAN-Berichte, Cruise No. MSM 97 (GPF 20-3_085), 48 pages, Gutachterpanel Forschungsschiffe, Bonn, Germany, doi:10.48433/cr_msm97.

Appendix A – Diary

All times are given in Central European Summer Time (CEST, corresponding to UTC+2 hours) in 24-hour format.

Saturday April 8, 2023

Easterly winds 6 m/s, 9°C

The science party arrived in the harbor of Hirtshals at 08:30, half an hour before the vessel arrived at the pier (Sildekajen). After the ship docked, the loading of the containers and equipment started by means of a mobile crane. This was followed by installing the equipment with very good progress before stopping at 20:30 for the night.

At 13:00, a kickoff meeting was held in the conference room of the ship. It was attended by the captain, the chief mate, the ship's technician, the two COWI consultants assigned to the project, the two Fishery Liaison Officer (FLO) and several persons from the science party who were not needed for the ongoing mobilization. The chief scientist guided through the scientific objectives, the seismic gear, line locations, as well as the permission and its conditions. The FLO reported about their visits to the fishing communities around the study area in Jammerbugt. One particular concern is the start of the fishing season for sand eel. The FLO have established a good connection to the fishers in Thorup Strand and will provide them with regular updates on the progress of the data acquisition and plans for the near future.

Two major problems had to be dealt with during the day. The ship's agent communicated that the entire science party must go to the police station in Aalborg to get their passports stamped prior to departure of the vessel. A taxi ride with a 12-person vehicle was organized for the following day.

The second problem was that the ship had no equipment to tie down the containers on the aft deck. Aarhus University technician Per Trinhammer could locate a supplier for the missing parts in Esbjerg that had an emergency service over the Easter weekend, but pick-up had to be organized. In addition, some wood is required to secure the containers. For this, a hardware store could be identified along the way to the police station in Aalborg that is open on Easter Sunday and has the required quantities.

Sunday April 9, 2023

Southeasterly winds 3 m/s, 12°C, light rain showers in the morning

At 08:00, a taxi from *Hirtshals Turistfart* drove 12 persons of the scientific party to the police station in Aalborg to get people checked out of the Schengen area. On the way, the taxi

stopped at a *Jem & Fix* hardware store in Hjørring to buy 6 m of wooden beams needed to secure the two streamer winches on the deck. At 10:45, the taxi was back at the ship and the mobilization of the equipment continued. Things moved forward but a little slower than expected. During the day, it became clear that the ship cannot leave Hirtshals before the next day.

Egon Nørmark stayed in Esbjerg Saturday night, to rent a car in the morning and pick up the missing gear to tie down the containers on the deck. He arrived at the vessel in the late afternoon.

Meetings during the day included a safety and familiarization tour for the science party at 13:00, as well as a toolbox meeting at 19:00 attended by the scientists and crew involved in the operation of the seismic gear on deck. In addition, a routine was established with the FLO how to provide daily updates to the local fishermen on progress and plans.

During the compressor test in the evening, one of the two compressors failed. After carrying out an extensive trouble shooting procedure, a damaged thermistor was identified as the immediate reason why the compressor failed to start. However, it was unclear, what caused the damage to the thermistor. External help is required to investigate this issue.

Monday April 10, 2023

Southeasterly winds 9 m/s, 11°C

In the morning of this Easter Monday, a marine electrician in Hirtshals with emergency service was contacted and identified a power adapter as reason for the compressor failure. The electrician could organize a spare adapter in town and the thermistor was exchanged as well. By 11:00, both compressors were fully functional again.

As Per Trinhammer was heavily involved with the compressor repairs, the mobilization of some of the remaining equipment was delayed but the entire team worked very hard, and the groups helped each other. The main task for the afternoon was to work on the gun controller, the NaviPac system, and solving some problems with the birds, while the main task was to secure boxes and all other equipment on deck.

A safety drill was carried out at 17:00 and the ship left Hirtshals at 17:37. During a science meeting at 19:00, an introduction to the science program was given, the plans for the next day were presented, and procedures for marine mammal observation and the ramp-up of the air gun array were outlined. In addition, general safety rules were explained.

The ship proceeded to the southeastern study area, where a sound-velocity-profile (SVP) measurement was made to obtain velocities for the multibeam echosounder. Since the first deployment of the air gun array is planned for daytime, the night was assigned to a bathymetry survey along the planned seismic lines close to the shore. This is to secure that the ship can safely operate there as the various bathymetric data sets available for the area show inconsistencies and are characterized by a low data density.

Tuesday April 11, 2023

Southerly winds 8 m/s, 8°C

At 6:00 it was planned to stop with the bathymetric survey and to start with the deployment of the seismic gear (tail buoy, streamer, and air guns). However, the tail buoy had a problem with the power supply, which meant that its flashing light was not working. It was decided to contact the manufacturer Sercel to find a solution for it and in the meantime the bathymetric survey continued. At 10:00, the problem was fixed, and the deployment of the seismic gear could start at 10:30. There were several interruptions of the deployment process as there was no stable communication with the birds. At 18:00, the pre-watch for marine mammals started while the air guns were deployed. When the soft-start of the air gun array started at 18:40, it was noticed that the guns did not trigger as they should. The failure was luckily not with the air guns themselves and a recovery was not necessary. After the problem was fixed, the ramp-up process started again. The first seismic line started at 21:15 (line GEUS23_JB_01). During the entire day, radio communication was made with vessels in the area, including a few fishing vessels to avoid interference with the seismic acquisition. The contacts with the fishers were made by the FLOs and all vessels were very cooperative.

Wednesday April 12, 2023

Southeasterly winds 11 m/s, 7°C

During the day, lines GEUS23_JB_01 through 05 were completed without any incidents. Lines 04 and 05 crossed the main shipping route but all vessels gave wide berth after they were contacted by the bridge officers. Radio contact to the ships was made at a distance of 12 nm, to give them as much pre-warning as possible. After the first seismic line was completed, seismic processing started for QC purposes.

Thursday April 13, 2023

Southeasterly winds 7 m/s, 6°C

Seismic acquisition continued along lines GEUS23_JB_06 through 10. In the morning, an initial seismic record section with a very basic processing flow was produced. That section showed some good reflectivity in the upper part but at the target depth of around 2 s two-way travel time, the signal strength was rather weak, and reflectors were laterally broken up. For this reason, it was decided to change the seismic source from the two 150 cubic inches GI-guns (G=45, I=105) to the two larger 355 cubic inches GI-guns (G=105, I=250). This swap was carried out at the western end of line GEUS23_JB_10 and was accompanied by a pre-watch for marine mammals, followed by a soft-start procedure of the guns. At 19:10, line GEUS23_JB_11 could be started with a shot interval of 12 s.

During the swap of the air guns, in proximity to Hanstholm, the FLO made additional contacts with fishers. The FLO succeeded in getting some fishers to remove their nets that would have been otherwise in the way the following day.

Friday April 14, 2023

Easterly winds (SE to E) 4 m/s, 7°C

Seismic acquisition continued along lines GEUS23_JB_12 through 16. There was fishing activity at the westernmost end of the lines towards Hanstholm but the FLOs were able to organize a safe passage. The PAM system detected harbor porpoises in three instances but only one detection could be confirmed by MMO, when two individuals crossed ahead of the ship in 600 m distance.

Saturday April 15, 2023

Northeasterly winds 13 m/s, 8°C

Seismic acquisition continued. During the passage of the main shipping lane on line GEUS23_JB_17, the streamer was lowered from 4 to 6 m. After the start of line GEUS23_JB_18, one compressor stopped working and the pressure to the air guns went down to 120 bar, which was accompanied by a deterioration of the online record section. At 09:00 it was decided to stop acquisition, perform maintenance on the compressor, and then go back to the start of the line with pre-watch for marine mammals and soft-start of the array. Maintenance was carried out on both compressors. When the first compressor was done at 10:00, MMO pre-watch began to be able to start with the soft-start of the air guns immediately after completion of the maintenance of the second compressor. This was the case at 13:03 and line GEUS23_JB_18A was then be acquired from 14:06 onward. During the pre-watch, several detections were made by the PAM system, all concerning baleen whales as close as 180 m. Despite an intensive visual search with up to five people, no sightings were made.

At 14:30, it was noticed that there is still some leakage in one of the compressors although a pressure of 130 bar could be maintained, which is what it was before. After some discussion, it was decided to run the next two lines and then do the maintenance during a longer turn between lines GEUS23_JB_19 and 20.

Sunday April 16, 2023

Winds from Northeast 5 m/s, 7°C, sunny in afternoon

During the turn from line GEUS23_JB_19 to 20, the leaky compressor was maintained while acquiring one extra line (GEUS23_JB_19A). The repair was a full success as the pressure was 150 bar at 12 s shot interval with the large array. During the acquisition of line GEUS23_JB_20, it was then decided to decrease the shot interval to 10 seconds, at which a pressure of 140 bar could be maintained.

The two main lines of the day (GEUS23_JB_20 and 21) passed by Hanstholm and continued further to the southwest. There was intense fishing activity out of Hanstholm and westward. The FLOs did again coordinate very well with the fishing vessels and the seismic acquisition could be carried out without any problems. Line GEUS23_JB_21 was slightly modified with two minor bends to get more clearance from the wave energy test area just outside Hanstholm.

When Jákup Sverri passed Hanstholm in the early afternoon, some CO_2 bottles for the ship's cooling system were delivered by Zodiac. There was no interference with the seismic data acquisition.

Also in the afternoon, the FLOs received a report about a fisher who set four nets in the way of the planned lines GEUS23_JB_23 and 26. The fisher promised to remove them the next morning. However, this was too late for line 23, which is why that line was moved to the west to have enough clearance.

During the regular safety inspection tour on deck, it was noticed that the buoy attached to one of the five sensors of the Quiet Sea PAM system was lost. At 18:28, shooting along line GEUS23_JB_20 was stopped, and recovery of the air guns and the cable to the PAM buoy started. While the ship started to turn to do a loop and restart the line, pre-watch for marine mammals and soft-start was carried out. The line was then resumed as GEUS23_JB_20B at 20:02. Unfortunately, the hydrophone was lost but it will be reported in next day's newsletter to the fishers and hopefully will be found. The PAM system remains in operation with the other four sensors.

Monday April 17, 2023

Winds from Northeast 6 m/s, 7°C

After completion of line GEUS23_JB_22, a short transit profile was shot (GEUS23_JB_22A) to get to the start of line GEUS23_JB_23. Acquisition continued all day in sunny weather without any problems and lines GEUS23_JB_24 through 27 could be completed. After evaluation of the initial processing results and considering the remaining time, it was decided to re-shoot some of the first lines that were acquired with the small air gun array. This will be done after completion of line GEUS23_JB_34 and will likely comprise lines 10, 9, 8, 6, and the southwestern part of line 5 if time allows.

Tuesday April 18, 2023

Winds from Northeast 7 m/s, 9°C

After completion of lines GEUS23_JB_28 and 29 at 08:33, the ship entered the 10 km buffer zone around the Natura 2000 area. Here, all acoustic systems (air gun array, multibeam, and subbottom profile) were turned off and the pre-watch started during which the PAM system

noticed a weak signal from a toothed whale more than five hundred meters away. No mammals could be detected by the MMO and the two additional observers that were on lookout. After the buffer zone was left at 09:17, the ramp-up of the systems started along the transit to line GEUS23_JB_30. After completion of the soft-start, data were acquired along the remainder of the transit to line 30 and were recorded as line GEUS23_JB_29A. After line GEUS23_JB_30 was completed, the acquisition of a series of lines parallel to the coast east of Hanstholm started. Some of them were shortened at the western end to allow for a fast turn between lines and thereby maximize the available time for the re-shooting of lines that were acquired with the small GI-gun array. At the start of line GEUS23_JB_31 it was noticed that the gun signature of one of the GI-guns on the control monitor was not displayed properly. Some tests were carried out to check if the gun was still shooting, which was the case and acquisition continued. Additional measurements then showed that the hydrophone that was mounted to the gun was broken.

Wednesday April 19, 2023

Winds from Northeast 8 m/s – in afternoon northerly winds 10 m/s, 9°C

At the start of line GEUS23_JB_33, compressor 2 reported an error in the control system and stopped working. The pressure of the air guns sank to 100 bar, but the technicians acted quickly and had the compressor running again before the crossing with line GEUS23_JB_30. However, it remained unclear what the underlying reason for the problem was. Since the compressor stays onboard for another seismic acquisition, a technician will check the compressor after return to Hirtshals.

The ship's crew had a fire drill at 13:00 with an exercise in the engine room. The science program was not affected by the drill and acquisition continued without any interruption.

After completion of the last planned line (GEUS23_JB_34), the reshooting of some of the earlier lines began using the large air gun array. In the evening, GEUS23_JB_35 was acquired along the earlier line GEUS23_JB_10.

Thursday April 20, 2023

Winds from Northeast 10 m/s, 8°C

Lines GEUS23_JB_09 and 08 were re-shot as lines GEUS_JB_36 and 37, respectively. During line 36, the ship lost the GPS position for the multibeam and subbottom profiler. The ship's technician was informed and after a reset, navigation was available again after an interruption of about 10 minutes.

Line GEUS23_JB_38 is the re-run of line 05. In the northeastern half of the line, a group of four fishing vessels (Silje-Sofie S123, Amalie-Benjamin A59, Lone, and Lis Hansa R86) approached the seismic line from the west. The FLO called the vessels on the radio and could negotiate a free path. At 11.10 the ship turned onto line GEUS23_JB_39 that is a re-run of

the northeastern part of line GEUS23_JB_04. The line was stopped at 13.14, half a streamer length after passing the crosspoint with line GEUS23_JB_29A. Two set of 20 shots each were fired afterwards just using the generators and the injectors, respectively.

After the compressor was stopped, the ship turned towards the site for the patch test for the multibeam system and the speed was reduced to 3 knots. This was a suitable course for the retrieval of the air guns, the streamer, and the tail buoy. The recovery of the gear finished at 17.27.

At 18.30, a Sound Velocity Profile (SVP) was done from the port side of the aft deck. This was the start of a patch test for the multibeam system. The test was completed at 20.30. From there, the vessel proceeded to a site three nautical miles away, where multibeam data earlier indicated a possible wreck at the seafloor. However, this could not be confirmed by a detailed survey and the mapping ended at 21.15 when the ship started the transit to port in Hirtshals.

Friday April 21, 2023

Winds from East 2 m/s, 14°C

The ship arrived in Hirtshals at 1.00. The mobile crane for unloading the containers arrived at 9.00 and the rest of the day went with packing gear and demobilizing. At 18.00, the ship's crew and science party went for a joint dinner at restaurant Fiskehus.

Appendix B – Log Sheets of Seismic Lines

Appendix B contains copies of the handwritten log sheets prepared by the watchkeepers during the acquisition. Please note that the survey name is noted as SEIS-JAM, which is the internal name that collaboration partner BGR is using for the project.

The forms are partly written in English and partly in German. Comments in German are translated to English in the respective figure captions. German words in the template are:

Messgebiet: Nordsee	– Study area: North Sea
Schiff: Jakup Sverri	– Vessel: Jákup Sverri
Profil	– Profile
Kurs	– Heading
Datum	– Date (format is DD.MM.YYYY)
Streamersollstiefe	– Nominal depth of streamer
Schussabstand	– Shot distance/interval
Hilfskanäle	– Auxiliary channels
Nav	– Refers to the name of the navigation file
Zeit	– Time (UTC)
Schuss Nr.	– Shot number
File Nr.	– File number

English abbreviations are EOL, end of line; SOL, start of line.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_01
Kurs:
Datum:

Aufnahmelänge:	5000 ms	Streamersollstiefe:	3 m
Schussabstand:	6 ~~s~~	Hilfskanäle	
Sample Rate:	1 ms		

Zeit	Schuss Nr.	File Nr.	
19:18:37	1000	1000	SOL ~~Shotpoint~~ Schussabstand 7 S
19:39:58	1184	1184	EOL

Figure B1. Log sheet for seismic line GEUS23_JB_01. Translation: Shot spacing 7 s.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_01A
Kurs:
Datum: 11.04.2023

Aufnahmelänge:	5000 ms	Streamersollstiefe:	3 m
Schussabstand:	6 s	Hilfskanäle	
Sample Rate:	1 ms		

Zeit	Schuss Nr.	File Nr.	
19:41:08	1000	1000	SOL Schussabstand wieder 6 Sekunde
23:16:25	3251	3251	EOL

Figure B2. Log sheet for seismic line GEUS23_JB_01A. Translation: Shot spacing again 6 s.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_02
Kurs:
Datum: 12.04.2023

Aufnahmelänge:	5000 ms	Streamersollstiefe:	3 m
Schussabstand:	6 s ~~m~~	Hilfskanäle	
Sample Rate:	1 ms		

Zeit	Schuss Nr.	File Nr.	
00:06:11	1000	1000	SOL
~~04:15:17~~ 04:15:17	3491	3491	EOL

Figure B3. Log sheet for seismic line GEUS23_JB_02.

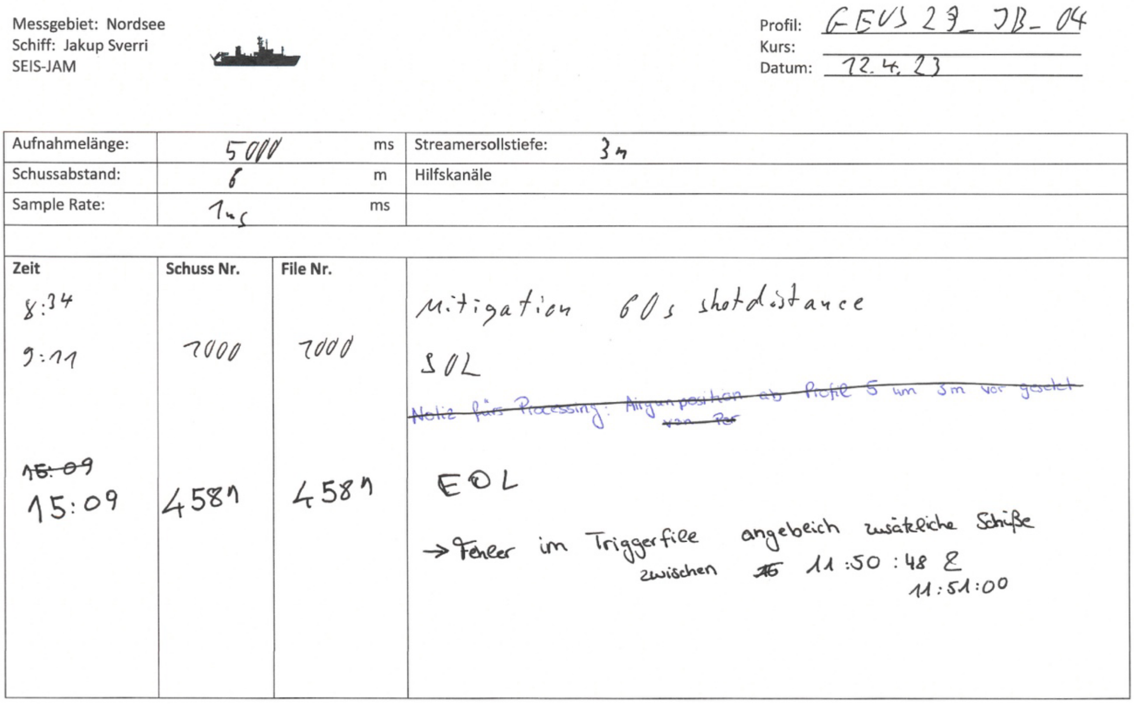
Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_03
Kurs:
Datum: 12.04.2023

Aufnahmelänge:	5000 ms	Streamersollstiefe:	3 m
Schussabstand:	~~m~~	Hilfskanäle	
Sample Rate:	1 ms		

Zeit	Schuss Nr.	File Nr.	
04:51:18	1000	1000	SOL
8:32:54	3216	3216	EOL
			Notiz fürs Processing: bis zu diesem Profile (01,01A,02 & 03) ist die Position der Gun in Pers File 4 m weiter vorne

Figure B4. Log sheet for seismic line GEUS23_JB_03. Translation of last comment: Note for the processing: up to this profile (01,01A,02 & 03) is the position of the gun in Per's file 4 m farther to the front. Notes: "Per's file" refers to the Navipac navigation files. There are additional SEGD files and navigation entries. EOL is shot point 3238 at 08:35:06 UTC.



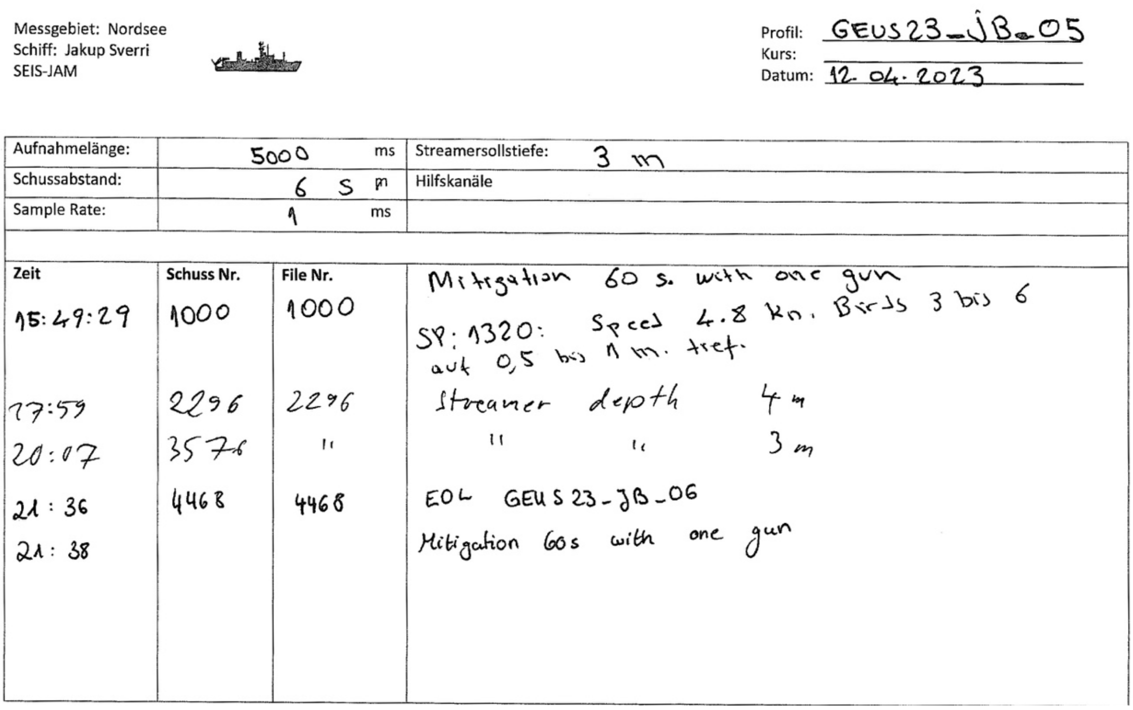
Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS 23_JB_04
Kurs:
Datum: 12.4.23

Aufnahmelänge:	5000 ms	Streamersollstiefe:	3 m
Schussabstand:	6 m	Hilfskanäle	
Sample Rate:	1 ms ms		

Zeit	Schuss Nr.	File Nr.	
8:34			Mitigation 60 s shotdistance
9:11	1000	1000	SOL
			~~Notiz fürs Processing: Airgunposition ab Profil 5 um 3 m vor gesetzt~~
~~15:09~~ 15:09	4581	4581	EOL
			→ Fehler im Triggerfile angebeich zusätzliche Schüße zwischen ~~15~~ 11:50:48 & 11:51:00

Figure B5. Log sheet for seismic line GEUS23_JB_04. Translation of last comment: Error in trigger file, supposedly additional shots between 11:50:48 and 11:51:00. Note: last shot point /SEGD file number is 4580.



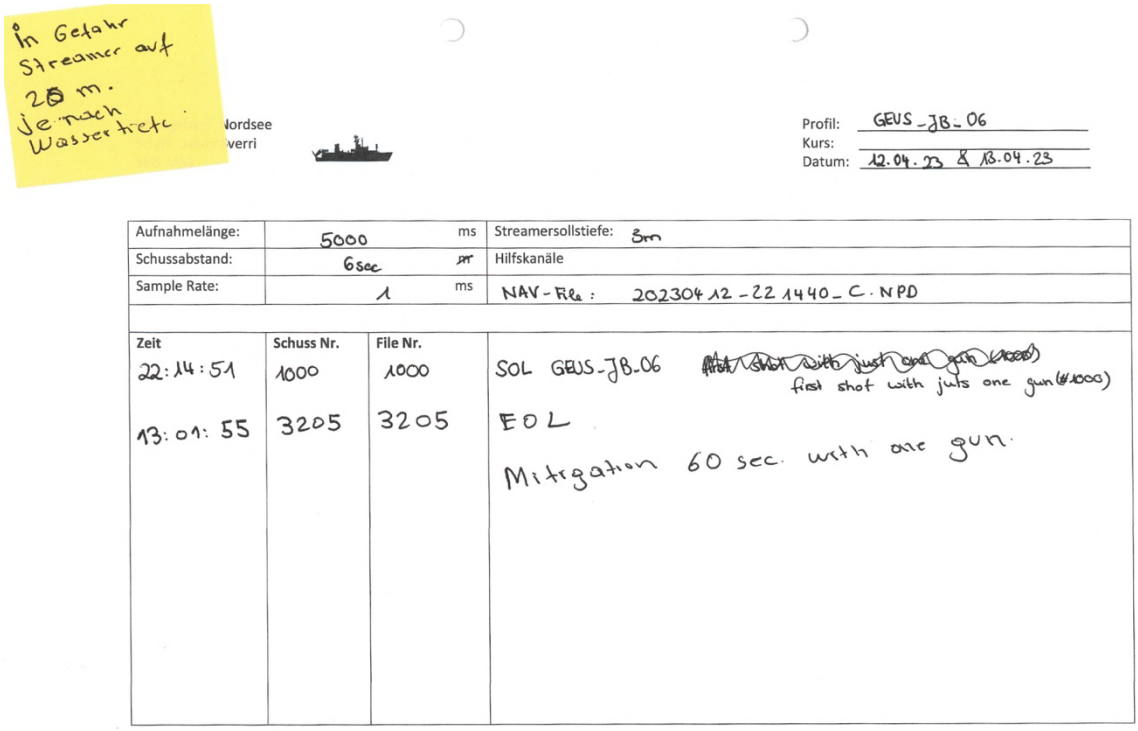
Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_05
Kurs:
Datum: 12.04.2023

Aufnahmelänge:	5000 ms	Streamersollstiefe:	3 m
Schussabstand:	6 s ~~m~~	Hilfskanäle	
Sample Rate:	1 ms		

Zeit	Schuss Nr.	File Nr.	
			Mitigation 60 s. with one gun
15:49:29	1000	1000	SP: 1320: Speed 4.8 kn. Birds 3 bis 6 auf 0,5 bis 1 m. tief.
17:59	2296	2296	Streamer depth 4 m
20:07	3576	"	" " 3 m
21:36	4468	4468	EOL GEUS 23-JB_06
21:38			Mitigation 60 s with one gun

Figure B6. Log sheet for seismic line GEUS23_JB_05. Translation: Birds 3 to 6 at a depth between 0.5 and 1.0 m.



In Gefahr Streamer auf 20 m. je nach Wassertiefe

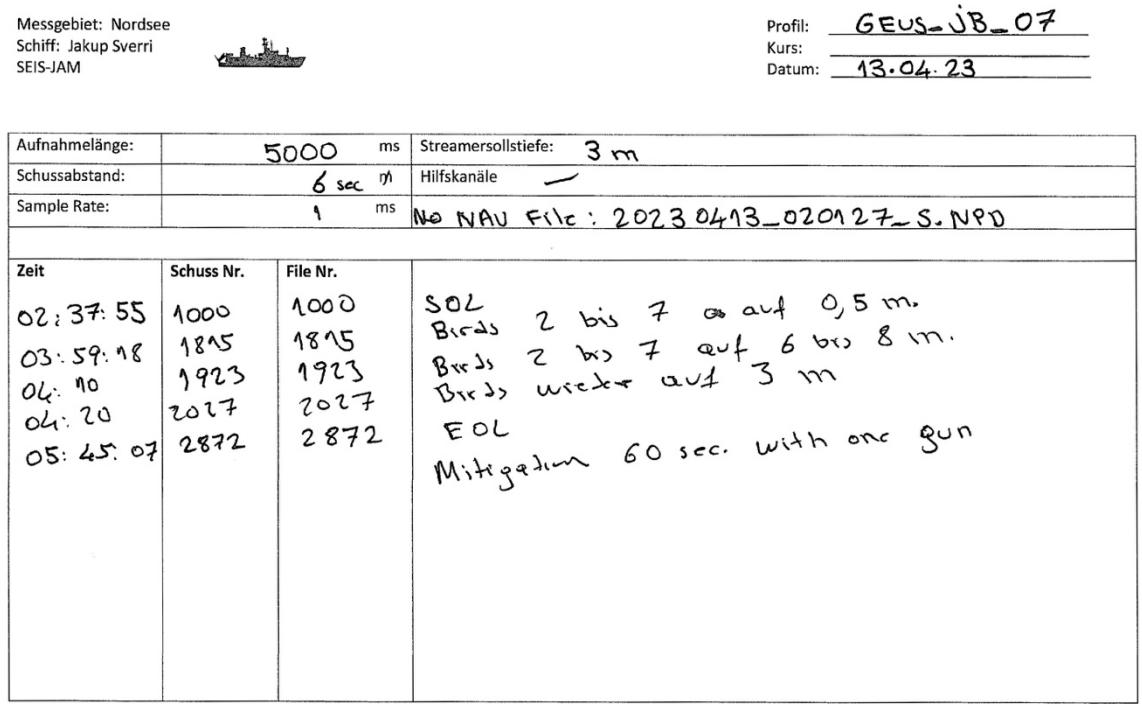
Nordsee
Sverri

Profil: GEUS_JB_06
Kurs:
Datum: 12.04.23 & 13.04.23

Aufnahmelänge:	5000 ms	Streamersollstiefe:	8m
Schussabstand:	6sec m	Hilfskanäle	
Sample Rate:	1 ms	NAV-File:	20230412-221440_C.NPD

Zeit	Schuss Nr.	File Nr.	
22:14:51	1000	1000	SOL GEUS_JB_06 first shot with just one gun (#1000)
13:01:55	3205	3205	EOL
			Mitigation 60 sec. with one gun.

Figure B7. Log sheet for seismic line GEUS23_JB_06. Translation of yellow post-it note: In danger, streamer lowered to 20 m, dependent on water depth.



Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS_JB_07
Kurs:
Datum: 13.04.23

Aufnahmelänge:	5000 ms	Streamersollstiefe:	3 m
Schussabstand:	6 sec m	Hilfskanäle	—
Sample Rate:	1 ms	NAV File:	20230413_020127_S.NPD

Zeit	Schuss Nr.	File Nr.	
02:37:55	1000	1000	SOL
03:59:18	1815	1815	Birds 2 bis 7 auf 0,5 m.
04:10	1923	1923	Birds 2 bis 7 auf 6 bis 8 m.
04:20	2027	2027	Birds wieder auf 3 m
05:45:07	2872	2872	EOL
			Mitigation 60 sec. with one gun

Figure B8. Log sheet for seismic line GEUS23_JB_07. Translation:
Birds 2 to 7 at 0.5 m.
Birds 2 to 7 at 6 to 8 m.
Birds again at 3 m.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS_JB_08
Kurs:
Datum: 13. 04. 2023

Aufnahmelänge:	5000 ms	Streamersollstiefe:	3 m
Schussabstand:	6 sec ~~m~~	Hilfskanäle	
Sample Rate:	1 ms	Nav File: ~~20~~ 20230413_~~0555~~055959_C.NPD	

Zeit	Schuss Nr.	File Nr.	
6:25:57	1000	1000	SOL evtl ~~sind die event nummern in Navigationsfile falsch~~ OK
8:31:45	22~~00~~59	2259	EOL

Figure B9. Log sheet for seismic line GEUS23_JB_08.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS-JB-09
Kurs:
Datum: 13.4.2023

Aufnahmelänge:	5000	ms	Streamersollstiefe: 3m
Schussabstand:	6s	m	Hilfskanäle
Sample Rate:	1ms	ms	Nav-File: 20230413_~~0557~~20_C.NPD
			— 11 — 085755_C.NPD

Zeit	Schuss Nr.	File Nr.	
09:08:30	1000	1000	SOL
10:27:22	1787		EOL

Figure B10. Log sheet for seismic line GEUS23_JB_09.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS_JB_10
Kurs:
Datum: 12.4. 2023

Aufnahmelänge:	5000 ms	Streamersollstiefe:	3 m
Schussabstand:	6 s	Hilfskanäle	
Sample Rate:	1 ms	Nav-File: 20230413_102907_C.NPD	

Zeit	Schuss Nr.	File Nr.	
10:29:38	1000	1000	
10:46	1180	1180	SOL
14:29:18	3397	~~2~~3397	EOL

Figure B11. Log sheet for seismic line GEUS23_JB_10.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS_JB_11
Kurs:
Datum: 13.04.2023

Aufnahmelänge:	~~5000~~ 6000 ms	Streamersollstiefe:	~~3 m~~ 4 m
Schussabstand:	12,5 ~~6,5~~ m	Hilfskanäle	
Sample Rate:	1 ms		

Zeit	Schuss Nr.	File Nr.	
17:13:36	1000	1000	15:37 UTC Begin ramp up; GI Gun 355 (Volume vergrößert). SOL. Die ersten Schüsse mit 6 s Schuss-abstand. Bird 5 ist die ganzen Linien tiefer und steuert hoch (Streamer zu schwer?)
22:16:53	2535	2535	EOL

Figure B12. Log sheet for seismic line GEUS23_JB_11. Translation:
GI Gun 355 (increased volume).
The first shots at 6 s interval.
Bird 5 is deeper for the entire profile and is steering upward (streamer too deep?).

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23-JB_12
Kurs:
Datum: 13.04.23

Aufnahmelänge:	6000 ms	Streamersollstiefe:	4m
Schussabstand:	12 sec	Hilfskanäle	
Sample Rate:	1 ms	Nav file:	20230413-225842-S.NPD

Zeit	Schuss Nr.	File Nr.	
22:16:53	1000	1000	SOL
04:23:38	2623	2623	EOL
			Mitigation 60 sec with one gun.

Figure B13. Log sheet for seismic line GEUS23_JB_12. Note: Time for SOL should be 22:59:02.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_13
Kurs: NE
Datum: 14.04.2023

Aufnahmelänge:	6000 ms	Streamersollstiefe:	~~1m~~ 4m
Schussabstand:	12sec m	Hilfskanäle	
Sample Rate:	1 ms	Nav file:	20230414_045702_S.NPD

Zeit	Schuss Nr.	File Nr.	
04:58:20	1000	1000	SOL
10:14:44	2583	2583	EOL
			Mitigation 60 sec with just one gun.

Figure B14. Log sheet for seismic line GEUS23_JB_13. Note: Shot point and file number at EOL should be 2582.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS 23 - JB - 14
Kurs:
Datum: 14.04.23

Aufnahmelänge:	6000 ms	Streamersollstiefe:	4m
Schussabstand:	12 sec ~~m~~	Hilfskanäle	
Sample Rate:	1 ms	20230414-10 4927_C.NPC	

Zeit	Schuss Nr.	File Nr.	
10:54:05 15:03:41	1000 2248	1000 2248	SOL EOL Mitigation with one gun

Figure B15. Log sheet for seismic line GEUS23_JB_14.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23-JB-15
Kurs:
Datum: 14.03.2023

Aufnahmelänge:	6000 ms	Streamersollstiefe:	4m
Schussabstand:	12 sec m	Hilfskanäle	✓
Sample Rate:	1 ms		

Zeit	Schuss Nr.	File Nr.	
15:42:19 19:16:55	1000 2073	1000 2073	SOL EOL Mitigation with one Gun Last event Navi Rec: 2075

Figure B16. Log sheet for seismic line GEUS23_JB_15.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS_JB_16
Kurs:
Datum: 14.3.2023

Aufnahmelänge:	6000 ms	Streamersollstiefe:	4 m
Schussabstand:	12 s m	Hilfskanäle	
Sample Rate:	1 ms	Nav-File: 20230414_194321-C.NPD	

Zeit	Schuss Nr.	File Nr.	
19:48:42	1000	1000	SOL
22:49:06	1902	1902	EOL

Figure B17. Log sheet for seismic line GEUS23_JB_16.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS 23_JB_17
Kurs: NW
Datum: 14.04.23

Aufnahmelänge:	6000 ms	Streamersollstiefe:	4m
Schussabstand:	12sec ~~m~~	Hilfskanäle	
Sample Rate:	1 ms	20230414_225100-C.NPD	

Zeit	Schuss Nr.	File Nr.	
22:51:26	1000	1000	SOL
23:16	1123	1123	auf Profilkopie JB-17 6 m. (Verkehrstraße)
03:03:50	2262	2262	Streamer out
04:03:26	2560	2560	Streamer wieder out 4 m.
05:28:50	~~2998~~ 2988	~~20~~ 2998	EOL

Figure B18. Log sheet for seismic line GEUS23_JB_17. Note that the last shot point number has a typo and is not 2998 but 2988.Time at SOL should be 22:51:14. Translation:
At start of profile JB-17.
Streamer at 6 m (shipping lane).
Streamer again at 4 m.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_18
Kurs:
Datum: ~~17.04.2023~~
15.4.23

Aufnahmelänge:	6000 ms	Streamersollstiefe: 4m	
Schussabstand:	12 sec ~~m~~	Hilfskanäle —	
Sample Rate:	1 ms	Nav. file: 20230415_053311_@S.NPD	
Zeit	**Schuss Nr.**	**File Nr.**	
6:08:08	2000	2000	Mitigation 60 sec with one gun SOL die ersten Schüsse war der Streamer an der Oberfläche, ~~in der~~ am Ende der Kurve Streamer auf 6m Solltiefe
6:30	2223		Streamer hat Tiefe von 3 – 8m erreicht
	ca 2280		Kompressor defekt nur ~120 bar (bemerkt)
6:44	2280		EOL Reparatur Kompressor

Figure B19. Log sheet for seismic line GEUS23_JB_18. Translation:
The streamer was at the surface during the first shots, at the end of the turn the streamer was at the nominal depth of 6 m.
Streamer has reached a depth of 3 to 8 m.
Compressor is broken, only a pressure of 120 bar (noticed).
Repair of compressor.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23-JB-18A
Kurs:
Datum: 15.04.23

Aufnahmelänge:	6000 ms	Streamersollstiefe: 5m	
Schussabstand:	12 sec ~~m~~	Hilfskanäle	
Sample Rate:	1 ms	NAV: 20230415-115430_C.NPD	
Zeit	**Schuss Nr.**	**File Nr.**	
11:00 12:00:23	1000	1000	Mitigation start (Mitigation ovdan Seal (Post3_2delete) start of normal shooting
12:06:11	1029	1029	SOL (airgun pressure just ≈130 bar) (pressure compressor)
17:15:54	2577	2577	Speed reduced, 3,7 Knoten (Fisher boat)
17:40:11	2699	2699	Geschwindigkeit wieder normal.
19:20:35	3201	3201	EOL NavEvent & Seal nummer identisch
			Mitigation

Figure B20. Log sheet for seismic line GEUS23_JB_18A. Translation:
Speed back to normal.
EOL NavEvent and Seal number are identical.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS_JB_19
Kurs:
Datum: 15.04.2023

Aufnahmelänge:	6000 ms	Streamersollstiefe:	5m
Schussabstand:	12 s ~~m~~	Hilfskanäle	
Sample Rate:	1 ms	Nav File: 20230415_195155_C.NPD	

Zeit	Schuss Nr.	File Nr.	
19:52:59	1000	1000	SOL
23:22:59	2050	2050	EOL
			Mitigation: every 60 sec with one gun

Figure B21. Log sheet for seismic line GEUS23_JB_19.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_19A
Kurs:
Datum: 16.04.23

Aufnahmelänge:	6000 ms	Streamersollstiefe:	5m
Schussabstand:	12 sec ~~m~~	Hilfskanäle	
Sample Rate:	1 ms		

Zeit	Schuss Nr.	File Nr.	
00:26:20	1000	1000	Pressure back on 150 bar SOL [redacted] Test new shotpoint ~~int~~ interval 10 sec Pressure at about 140 bars
	1041	1041	↳ next lines with 10 sec shotpoint interval
01:11:12	1261	1261	EOL

Figure B22. Log sheet for seismic line GEUS23_JB_19A.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23-JB-20
Kurs:
Datum: 16.04.23

Aufnahmelänge:	6000 ms	Streamersollstiefe:	5m
Schussabstand:	10sec ~~25m~~	Hilfskanäle	
Sample Rate:	1 ms	Nav-File:	20230416_011156_C.NPD

Zeit	Schuss Nr.	File Nr.	
01:12:16	1000	1000	SOL
7:06:56	3127	3128	Streamer 7m (Fischer kreuzt)
7:27:26	3252	3252	" 5m
8:49:06	3741	3741	EOL
8:49			Mitigation

Figure B23. Log sheet for seismic line GEUS23_JB_20. Translation: Streamer 7 m (fishing boat crossing).

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS_JB_21
Kurs: SW
Datum: 16.4.23

Aufnahmelänge:	6000 ms	Streamersollstiefe:	5m
Schussabstand:	10s m	Hilfskanäle	
Sample Rate:	1 ms	Nav-File:	20230416_085507_C.NPD

Zeit	Schuss Nr.	File Nr.	
9:24:04	1000	1000	SOL
11:04:40	1603	1603	changing course
~~16:24~~	~~3524~~	~~3524~~	
16:27:34	3541	3541	EOL (Linienabbruch wegen QuietSea Modul Verlust)

Figure B24. Log sheet for seismic line GEUS23_JB_21. Translation: EOL (truncation of profile due to loss of QuietSea module).

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_21B_Pr
Kurs:
Datum: 16.4.23

Aufnahmelänge:		ms	Streamersollstiefe:
Schussabstand:		m	Hilfskanäle
Sample Rate:		ms	
Zeit	**Schuss Nr.**	**File Nr.**	Internal TQ continius wegen QuietSea in der Kurve.
16:29:53	1000	1000	Rump Up
17:02	1325	1325	
18:06	1957	1957	End of Ramp Up

Figure B25. Log sheet for seismic line GEUS23_JB_21B-Pr. Translation: Internal triggering (?) continues due to QuietSea during the turn.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_21B
Kurs:
Datum: 16.4.23

Aufnahmelänge:	6000	ms	Streamersollstiefe: 5 m
Schussabstand:	10	m	Hilfskanäle
Sample Rate:	1	ms	Navfile: 20230416_170153_S.NPD
Zeit	**Schuss Nr.**	**File Nr.**	
18:09:28	1000	1000	SOL
19:38:08	1532	1532	EOL Nav. Event 1532
19:39			Mitigation

Figure B26. Log sheet for seismic line GEUS23_JB_21B.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23-JB-22
Kurs:
Datum: 16.4.23

Aufnahmelänge:	6000 ms	Streamersollstiefe: 5m	
Schussabstand:	10s m	Hilfskanäle	
Sample Rate:	1 ms	Navfile: 20230416_202702_C.NPD	
Zeit	**Schuss Nr.**	**File Nr.**	
20:33:57	1000	1000	
20:42:11	1050	1050	SOL
00:15:51	2332	2332	EOL
			Events fit together
			Mitigation 60 sec with 1 gun

Figure B27. Log sheet for seismic line GEUS23_JB_22.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23-JB-22A
Kurs:
Datum: 17.04.23

Aufnahmelänge:	6000 ms	Streamersollstiefe: 5m	
Schussabstand:	10sec ~~m~~	~~Hilfskanäle~~ Kommentar: zusätzliches Transitprofil	
Sample Rate:	1 ms	Nav: 20230417_003047-C.NPD	
Zeit	**Schuss Nr.**	**File Nr.**	
00:34:53	1000	1000	SOL
01:21:53	1288	1284	EOL
			Shots in NAV & Seal are the same
			Mitigation 60 sec /one gun

Figure B28. Log sheet for seismic line GEUS23_JB_22A. Note: File number is 1284 at EOL.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23-JB-23
Kurs:
Datum: 17.04.23

Aufnahmelänge:	6000 ms	Streamersollstiefe:	5m
Schussabstand:	10 sec ~~m~~	Hilfskanäle	
Sample Rate:	1 ms		

Zeit	Schuss Nr.	File Nr.	
01:59:48	1000	1000	SOL
04:00:58	1727	1727	EOL
			Last event from Nav ~~1727~~ 1727

Figure B29. Log sheet for seismic line GEUS23_JB_23.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_24
Kurs: NE
Datum: 17.03.2023

Aufnahmelänge:	6000 ms	Streamersollstiefe:	5m
Schussabstand:	10 sec ~~m~~	Hilfskanäle	
Sample Rate:	1 ms	Naulele: 20230417_040355_C.NPD	

Zeit	Schuss Nr.	File Nr.	
04:04:17	1000	1000	SOL
04:20:07	1096	1096	Aut Profillinie (on Profil Course)
7:47:47	2341	2341	EOL Nav_System Event 2342
7:49			Mitigation

Figure B30. Log sheet for seismic line GEUS23_JB_24.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: ~~GEUS23-7~~ GEUS23_JB_25
Kurs:
Datum: 17.08.2023

Aufnahmelänge:	6000 ms	Streamersollstiefe:	5 m
Schussabstand:	10 s m	Hilfskanäle	
Sample Rate:	1 ms	Nav-File	20230417_082028_C.NPD

Zeit	Schuss Nr.	File Nr.	
8:22:36	1000	1000	SOL
12:05:56	2340	2340	EOL (check Nav-file)
			Mitigation 60sec / 1 gun

Figure B31. Log sheet for seismic line GEUS23_JB_25.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23-JB-26
Kurs: From SW to NE
Datum: 17.04.23

Aufnahmelänge:	6000 ms	Streamersollstiefe:	5m
Schussabstand:	10 sec ~~m~~	Hilfskanäle	
Sample Rate:	1 ms	NAV:	20230417_124119.C.NPD

Zeit	Schuss Nr.	File Nr.	
12:44:34	1000	1000	SOL (eventuell Schuß 1000 - 1005 löschen, da nicht ~~aussenbor~~ geschossen)
16:49:44	2423	2423	EOL (shot 2424 is not saved)
			Start of Mitigation with one gun.

Figure B32. Log sheet for seismic line GEUS23_JB_26. Translation: SOL (possibly delete shots 1000 to 1005 because they were not fired).

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_27
Kurs: From N to S
Datum: 17.04.2023

Aufnahmelänge:	6000 ms	Streamersollstiefe:	5m
Schussabstand:	10sec/m	Hilfskanäle	—
Sample Rate:	1 ms	Nav: 20230417_164518_S.NPD	

Zeit	Schuss Nr.	File Nr.	
17:36:02	1000	1000	SOL
20:40:42	2108	2108	EOL (same as Nav)
20:41			Mitigation

Figure B33. Log sheet for seismic line GEUS23_JB_27.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_28
Kurs: From SSE to NWE
Datum: 17.04.2023

Aufnahmelänge:	6000 ms	Streamersollstiefe:	5m
Schussabstand:	10s ~~m~~	Hilfskanäle	
Sample Rate:	1 ms	Nav: 202304_210343_C.NPD	

Zeit	Schuss Nr.	File Nr.	
21:08:19	2100	2100	SOL
02:43:35	3091	3091	EOL (Same as Nav)
			Mitigation with one gun (Every 60 sec)

Figure B34. Log sheet for seismic line GEUS23_JB_28.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS_JB_29
Kurs: from NE to SE
Datum: 18.04.2023

Aufnahmelänge:	6000 ms	Streamersollstiefe:	5 m
Schussabstand:	10 s m	Hilfskanäle	\
Sample Rate:	1 ms	Nav: 20230418_024611_S.NPD	

Zeit	Schuss Nr.	File Nr.	
03:29:47	1000	1000	SOL
06:33:27	2102	2102	EOL Nav_event 2103
			No Mitigation
			PRewatch / Ramp Up

Figure B35. Log sheet for seismic line GEUS23_JB_29.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_29A_pr
Kurs:
Datum: 18.04.2023

Aufnahmelänge:	ms	Streamersollstiefe:	
Schussabstand:	sec	Hilfskanäle	
Sample Rate:	ms	Nav:	

Zeit	Schuss Nr.	File Nr.	
6:35:35	1000	1000	Prewatch
7:18:42	1411	1411	start Ramp Up

Figure B36. Log sheet for seismic line GEUS23_JB_29A-Pr.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_29A
Kurs:
Datum: 18.04.2023

Aufnahmelänge:	6000 ms	Streamersollstiefe:	5m
Schussabstand:	10 sec	Hilfskanäle	
Sample Rate:	1 ms	Nav:	20230418_081415_C.NPD

Zeit	Schuss Nr.	File Nr.	
8:17:34	1000	1000	SOL
8:21:04	1020	1020	nur 100 Bar Fallend
8:25:04	1045	1045	115 Bar ansteigend
8:30:24	1077	1077	138 Bar
10:46:14	1892	1892	EOL
			Mitigation 60 sec / one gun

Figure B37. Log sheet for seismic line GEUS23_JB_29A. Translation:
Only 100 bar decreasing.
115 bar increasing.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_30
Kurs: From NNE to SSW
Datum: 18.04.23

Aufnahmelänge:	6000 ms	Streamersollstiefe:	5m
Schussabstand:	10 sec	Hilfskanäle	
Sample Rate:	1 ms	Nav:	20230418_114319_N.NPD

Zeit	Schuss Nr.	File Nr.	
11:43:33	1000	1000	start shooting due to 60 min, SOL, but check during processing if we are curved or its already ok
16:58:54	2891	2891	EOL (~~Shot~~ NOU event 2892 is not recorded)
			Mitigation 60 sec / one gun.

Figure B38. Log sheet for seismic line GEUS23_JB_30.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_31
Kurs: From West to East
Datum: 18.04.2023

Aufnahmelänge:	6000 ms	Streamersollstiefe:	5 m
Schussabstand:	10 sec	Hilfskanäle	—
Sample Rate:	1 ms	Nav:	20230418_170706_C.NPD

Zeit	Schuss Nr.	File Nr.	
17:55:39	1000	1000	SOL
18:03:59	1050	1050	Gun-Problem Gun 1 Ab SP 1098 (18:11:59) Probleme mit einem der Kanonen (BB) Problems with BB-Gun
18:45:39	1300	1300	Gun 1 delay festgelegt. (Vermutung Hydrophon wird nicht ausgelesen oder ist defekt)
23:19:09	2941	2941 = fit with nav-file	EOL Mitigation 60 sec / 1 gun

Figure B39. Log sheet for seismic line GEUS23_JB_31. Translation:
Gun problem with gun 1.
Starting at shotpoint 1098 (18:11:59) problems with one of the guns (port side).
Gun 1 delay is fixed (assumption that the hydrophone is not read or faulty).

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23-JB-32
Kurs:
Datum: 18.04.23 - 19.04.23

Aufnahmelänge:	6000 ms	Streamersollstiefe:	5m
Schussabstand:	10 sec	Hilfskanäle	/
Sample Rate:	1 ms	Nav:	20230418_234739_B.NPD

Zeit	Schuss Nr.	File Nr.	
23:49:35	1000 1072	1000 1072	SOL Streamer cable straight behind vessel
05:45:35	3136	3136 ↓ fit with nav.	EOL Mitigation with one gun. (60 sec)

Figure B40. Log sheet for seismic line GEUS23_JB_32.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_33
Kurs:
Datum: 19.05.2023

Aufnahmelänge:	6000 ms	Streamersollstiefe:	5m
Schussabstand:	10 sec	Hilfskanäle	
Sample Rate:	1 ms	Nav:	20230419_055039_C.NPD

Zeit	Schuss Nr.	File Nr.	
6:35:48	1000	1000	SOL
6:39:28	1022	1022	200 BAR Druck ⇒ 77bar
6:50:58	1089	1089	117 " ansteigend
6:53:38	1107	1107	170 bar
12:24:38	3093	3093	EOL
			Mitigation 60 sec / 1 gun

Figure B41. Log sheet for seismic line GEUS23_JB_33.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_34
Kurs:
Datum: 19.04.23

Aufnahmelänge:	6000 ms	Streamersollstiefe:	5m
Schussabstand:	10 sec	Hilfskanäle	
Sample Rate:	1 ms	Nav:	20230419

Zeit	Schuss Nr.	File Nr.	
12:59:09	1000	1000	SOL
18:09:39	2815	2815	EOL
			Mitigation with one gun (60 sec).
			GEUS23_JB_35_pr

Figure B42. Log sheet for seismic line GEUS23_JB_34.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_35
Kurs:
Datum: 19.04.2023

Aufnahmelänge:	6000 ms	Streamersollstiefe:	5m
Schussabstand:	10 sec	Hilfskanäle	
Sample Rate:	1 ms	Nav:	20230419_180419_C.NAV

Zeit	Schuss Nr.	File Nr.	
18:57:42	1000	1000	SOL
22:36:12	2311	2311	EOL
			Comment: same profil as GEUS 23_JB_10

Figure B43. Log sheet for seismic line GEUS23_JB_35.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_36
Kurs:
Datum: 19.04.23

Aufnahmelänge:	6000 ms	Streamersollstiefe:	5m
Schussabstand:	10 sec	Hilfskanäle	
Sample Rate:	1 ms	Nav:	

Zeit	Schuss Nr.	File Nr.	
22:37:16	1000	1000	SOL
00:17:41	1603	1603	EOL
			Mitigation 60 sec/1 gun
			Comment: = GEUS 23_JB_09

Figure B44. Log sheet for seismic line GEUS23_JB_36.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23-JB-37
Kurs:
Datum: 20.04.23

Aufnahmelänge:	6000 ms	Streamersollstiefe:	5m
Schussabstand:	10 sec	Hilfskanäle	—
Sample Rate:	1 ms	Nav:	20230420-005314_C.NPD

Zeit	Schuss Nr.	File Nr.	
00:57:56	1000	1000	SOL
~~20~~ 20:02:54	1699	1699	EOL
			= GEUS23_JB_08

Figure B45. Log sheet for seismic line GEUS23_JB_37. Note: SOL time should read 00:57:46, and EOL time 02:54:16.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS23_JB_38
Kurs:
Datum: 20.04.2023

Aufnahmelänge:	6000 ms	Streamersollstiefe:	5m
Schussabstand:	10 sec	Hilfskanäle	—
Sample Rate:	1 ms	Nav:	20230420_025708_C.NPD

Zeit	Schuss Nr.	File Nr.	
02:57:34	1000	1000	SOL
03:11:14	1082	1082	Ship on Profilcourse
6:19:24	2210	2210	Fahrt reduziert auf 4kn
			Laut TF um 7:00 Geschwindigkeit normal
8:35:04	3025	3025	EOL Nav-Event 3025
8:36			Mitigation
			= GEUS23_JB_05

Figure B46. Log sheet for seismic line GEUS23_JB_38. Translation:
Speed reduced to 4 knots.
According to TF (Thomas Funck) speed back to normal at 7:00.

Messgebiet: Nordsee
Schiff: Jakup Sverri
SEIS-JAM

Profil: GEUS 23-JB-39
Kurs:
Datum: 20.04.23

Aufnahmelänge:	6000 ms	Streamersollstiefe: 5 m	
Schussabstand:	10 sec	Hilfskanäle	
Sample Rate:	1 ms	Nav: 20230420_090043_C.NPD	
Zeit	**Schuss Nr.**	**File Nr.**	
09:10:45	1000	1000	SOL
11:13:55	1739	1739	EOL
			~~just~~ shooting with generator (20 shots) (pressure 170)
			& after injector (20 shots)
			= GEUS23_JB_04

Figure B47. Log sheet for seismic line GEUS23_JB_39.

Appendix C – Fishing Activity Report

GEUS contracted two Fishery Liaison Officers (FLO) from FOGA Consult ApS for participation in the seismic data acquisition and for informing fishers in the Jammerbugt area prior to the seismic survey. The motivation for bringing FLO was to avoid possible conflicts with fishery and to advise bridge personnel to ensure safe navigation in areas with fishing activity. The two FLO Henning Pedersen and Tony Buhl Nielsen prepared a report on the fishing activities that is attached here as Appendix C. Permission for this is given by the two FLO and FOGA Consult ApS.

FISHING ACTIVITY REPORT

CO2 SURVEY JAMMERBUGTEN

Period: April 8 – 22, 2023
Fisheries Liaison Officer: Henning Pedersen &Tony Buhl Nielsen
Client: COWI/GEUS
Vessel: Jákub Sverri

TABLE OF CONTENTS

OVERVIEW

PROJECT

COWI and GEUS performs seismic survey in Jammerbugten with the vessel Jakup Sverri. The study is a preliminary study on whether the subsoil is usable for storing CO2. The vessel is towing a 2400-meter-long cable in 3 to 6 meters debts with a speed of 4-5 knots. The FLO's have been onboard the vessel.

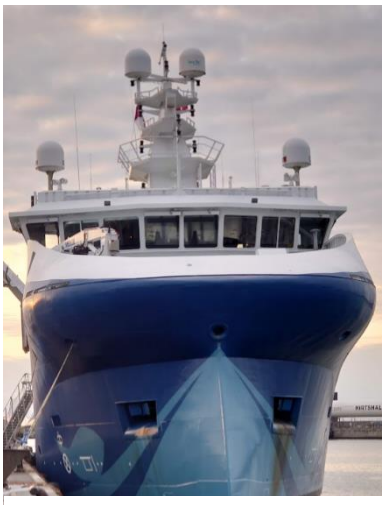


Figure 1 Jakob Sverri

FISHERIES LIAISON OFFICER (FLO)

The primary objectives if the Fisheries Liaison Consultant is to ensure that:

- the fishing fleet are appraised of COMPANYS's work schedule,
- effective and efficient communications are maintained between the survey vessel and the fishing fleet at all times during the operations,
- offshore negotiations between the survey vessel and fishing vessels with respect to rights of way are concluded to COMPANY's benefits,
- all incoming weather forecasts are reviewed and collated,
- all relevant aspects of the interaction between survey vessel and fishing vessels are described in a written report.

FISHING

First of all, the weather has been in favor of the survey. Cool easterly winds have delayed the fishing for sandeel in the area. There have been few attempts to find and catch sandeel on the sandeel banks. The net boats have fished very close to the coast and only occasionally tried to fish in the survey area. But there have only been many crabs to catch in the survey area. Few trawlers and Danish seiners have been fishing in the western part of the survey area. So, the delay of southwest wind and heat has delayed all fishing in the area.

It is our opinion that the harbor information tour before start-up has been a success. The daily update with the status and plan for the next few days has been valuable. Almost all fishermen we have had contact with had seen and read the info.

COUNT OF OBSERVATIONS AND CONTACTS

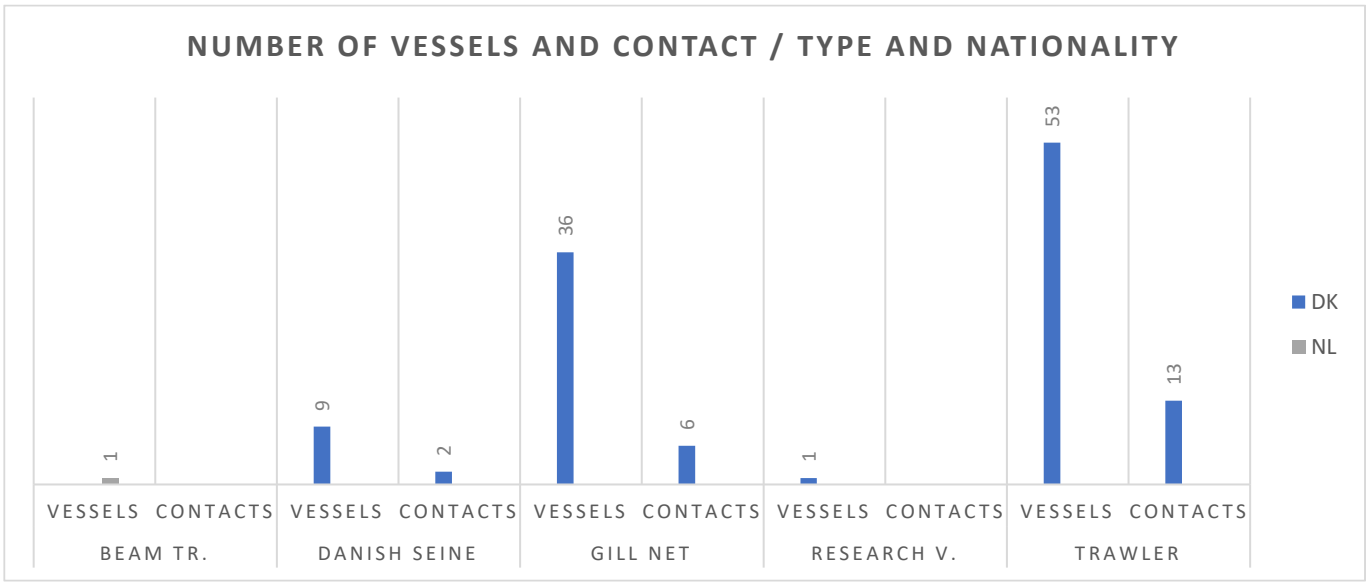
Some fishing vessels have been observed and contacted on several occasions. 58 individual fishing vessels, which were in the vicinity of Jakup Sverri.

Nationality	Name Harbor no. Call Sign MMSI	Number of observations	Number of Contact
DK	Havfisken,, OWRB, 219021235	1	
	Emilie, FN267, OXSE, 219023911	2	1
	Andrea, R194, OUIW, 220137000	1	
	Janni, HM96, OWFW, 219023588	3	
	Flipper, HM 335, OXAV, 219709000	2	1
	Astrid, S264, OZPO, 219030452	1	
	South Ocean, HG165, OWUY, 219021428	1	1
	Mikamale, HM8, OU2181, 219005778	2	
	Trutte, AS357, 5QTP, 219871000	1	
	Malia Alberte, L40, OWNV, 219001588	3	
	Nordstrand, S43, OZCG, 219012521	2	
	Tor-On, , OUJF, 219030383	1	1
	Inger Kristine, HM17, OU 3620, 219005909	4	
	Tenna, FN111, XPA4274, 219025478	2	
	Em Olsen, HM94, OZYA, 219001204	2	
	Alberte Marie, HM60, 5PDP, 219005893	1	1
	Nemo, HM19, OX2403, 219005953	2	1
	Nanna-Pia, HM210, OU6887, 219005931	1	
	Christine, HM22, OYFA, 219024924	2	
	Ida Emilie, HM42, XP4450, 219001587	3	
	Limfjorden, T72, XP4066, 219007925	4	1
	Ida Sara, E710, OYHO, 219011867	2	1
	Rosa Sofie, HM222, XP4080, 219006092	3	1
	Ida, HM65, XP4060, 219005763	2	
	Jammerbugten, HM62, XP3220, 219005777	1	
	Strander, ND17, XP3953, 219005964	2	
	Silje-Sofie, S123, XP3776, 219007034	3	1
	Orion, R3, OU4805, 220353000	1	
	Hanne, H10, OU7604, 219004128	2	1
	Amalie Benjamin, A59, OYKB, 219005867	2	
	Tanja, ND80, XP3053, 219005964	2	
	Katrine Kim, R254, XP3619, 219004161	2	
	Tasmania, R60, OZNK, 220339000	2	
	Lis Hansa, R86, OU6679, 219002506	3	3
	Inge Sofie, HM70, XP3590, 219010818	2	
	Astoria, HM120, OWBW, 22004400	1	
	Christina Paulsen, HM862, OWST, 219439000	1	
	Stella Nova, S464, OYQN, 219026318	1	
	August, HM95, OYOD, 219028021	1	
	Nordkysten, RI428, OXJD, 220225000	1	
	Mathilde, HM426, XP3839, 219009738	2	2
	Samantha, RI 159, OUVG, 219002838	1	
	Merle, HM373, OU8738, 219003066	1	

Nationality	Name Harbor no. Call Sign MMSI	Number of observations	Number of Contact
	Sally, HM45, XPE7446, 219021124	1	
	Kansas, HM52, XPBO, 219001569	1	1
	Lismille, T913, FTJ2246,	1	1
	Tobias Skoedt, HM24, OU7929, 219005513	3	2
	Isafold, HG 333, OZUV, 219030593	1	
	Mille, T18, OU8281, 219030200	2	
	Goliat, HM 92, OXPU, 219028381	2	
	Birgit, SG36, OU6417, 219009464	2	
	Elin, HG281, OYOL, 219027752	1	
	Karen Margrethe, L423, OYMD, 219799000	1	
	Madsalune, RI566, OZZH, 219959000	1	
	Montana, H273, OZOC, 220205000	1	
	Mette Juhl, HM84, OUQE, 219002464	1	1
	Vera Marie, S15, XP2671, 219011136	1	
	Randi, O159, OZNS, 220368000	1	
DK Total		**99**	**21**
NL	Jan De Wit, UK157, PBHN, 244880000	1	
NL Total		**1**	
Total		**100**	**21**

Number of vessels .			
Type/Nationality	DK	NL	Total
Research V.	1		1
Trawler	53		53
Gill net	36		36
Danish Seine	9		9
Beam tr.		1	1
Total	**99**	**1**	**100**

Number ofContact .			
Type/Nationality	DK	NL	Total
Research V.			
Trawler	13		13
Gill net	6		6
Danish Seine	2		2
Beam tr.			
Total	**21**		**21**



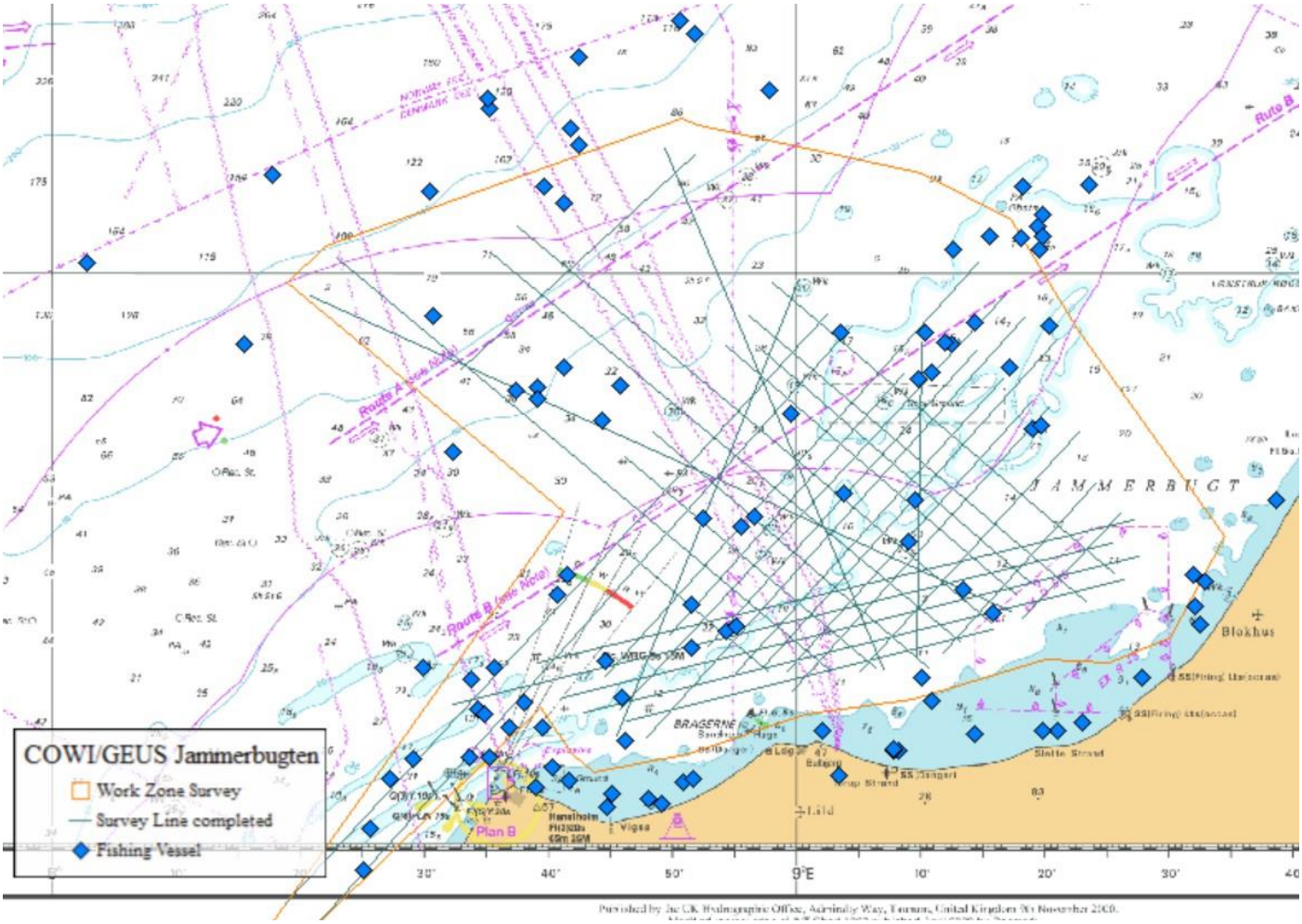


Figure 2 Fishing vessels April 10 - April 20

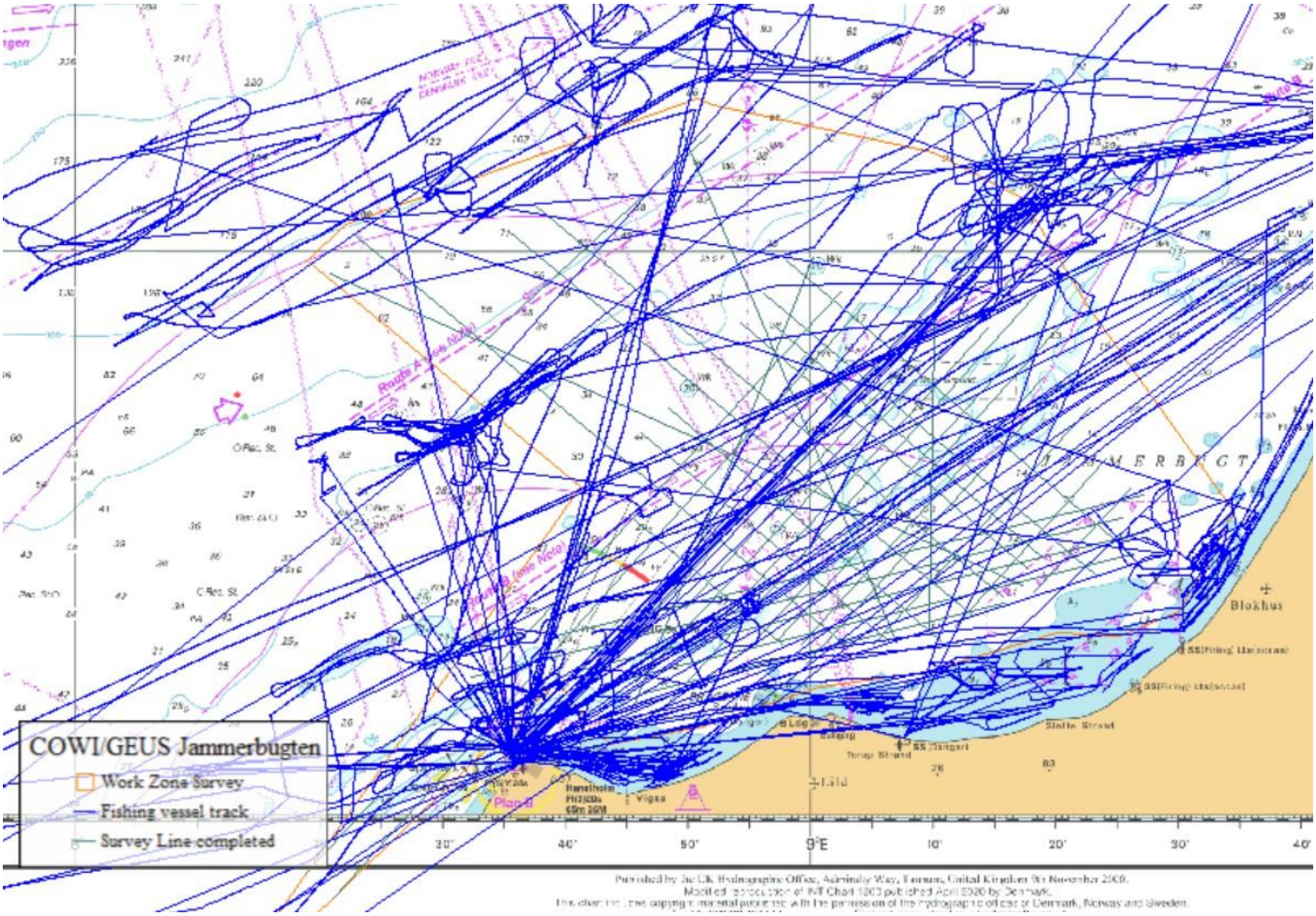


Figure 3 Track fishing vessels April 10 - April 20

PRE-INFORMATIVE ACTIONS

The project has been published in Notices to Mariners, Denmark and in Foga's weekly newsletter.

NOTICES TO MARINERS

Skagerrak

*

NM-1083-22 (T)

Denmark. Skagerrak. Jammerbugt. Seismic Surveys.

Details

In the period 8 April - 22 April 2023, seismic surveys will be carried out in an area bounded by a line through postion 1) -20)

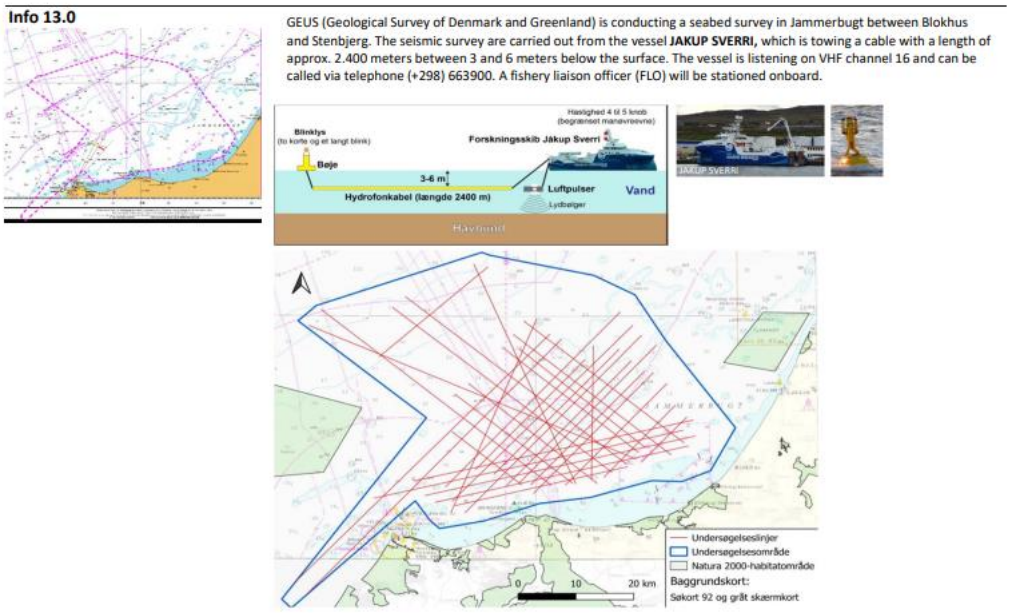
1)	57° 00.749'N - 008° 16.591'E
2)	57° 19.535'N - 008° 41.183'E
3)	57° 29.424'N - 008° 18.869'E
4)	57° 31.010'N - 008° 21.987'E
5)	57° 36.577'N - 008° 50.646'E
6)	57° 36.276'N - 008° 52.054'E
7)	57° 34.210'N - 009° 10.050'E
8)	57° 32.186'N - 009° 17.216'E
9)	57° 27.465'N - 009° 22.503'E
10)	57° 18.449'N - 009° 34.418'E
11)	57° 14.052'N - 009° 30.076'E
12)	57° 12.942'N - 009° 25.151'E
13)	57° 13.051'N - 009° 19.969'E
14)	57° 11.331'N - 009° 09.324'E
15)	57° 10.723'N - 009° 00.654'E
16)	57° 08.921'N - 008° 51.156'E
17)	57° 08.130'N - 008° 43.532'E
18)	57° 08.964'N - 008° 41.873'E
19)	57° 10.972'N - 008° 39.339'E
20)	56° 59.841'N - 008° 18.248'E

The work is carried out from the vessel »JAKUP SVERRI« (XPZO) which can be contacted on VHF Channel 16.
Towage up to 2 nm can be expected. Mariners are requested to pass with caution.

Charts 92 (INT 1300), 93 (INT 1044).

(COWI 9 December 2022. Published 16 December 2022)

FOGA'S WEEKLY NEWSLETTER



LOGBOOKS

The “Activity log” contents chronological events and includes the “Fishing Vessels” log with detailed information of contact and observations. Range and bearing are from Jakup Sverri.

PHOTOS

Photos credit © Tony Buhl Nielsen & Henning Pedersen

THANKS

It has been a very good cooperation with the bridge team and survey team. Meals have been a very nice experience and tasted good. Very good cook.

BEAUFORT WIND SCALE, SPEED AND SEA DISTURBANCE SCALE (WMO)

Wind Speed in:				**Sea Disturbance**		**Average height of Wave, crest to trough in meter**
Beaufort	**Knots**	**m/s**	**Descriptive terms**	**Scale in Beaufort**	**Disturbance**	
0	< 1	0 - 0.2	calm	0	calm	0 - 0
1	1 - 3	0.3 - 1.5	light air	1	very smooth	0.1 - 0.1
2	4 - 6	1.6 - 3.3	light breeze	} 2	smooth	0.2 - 0.3
3	7 - 10	3.4 - 5.4	gentle breeze		smooth	0.6 - 1.0
4	11 - 16	5.5 - 7.9	moderate breeze	3	slight	1.0 - 1.5
5	17 - 21	8.0 - 10.7	fresh breeze	4	moderate	2.0 - 2.5
6	22 - 27	10.8 - 13.8	strong breeze	5	rather rough	3.0 - 4.0
7	28 - 33	13.9 - 17.1	near gale	6	rough	4.0 - 5.5
8	34 - 40	17.2 - 20.7	gale	} 7	high	5.5 7.5
9	41 - 47	20.8 - 24.4	strong gale		high	7.0 - 10.0
10	48 - 55	24.5 - 28.4	storm	8	very high	9.0 - 12.5
11	56 - 63	28.5 - 32.6	violent storm	} 9	precipitous	11.5 - 16.0
12	64 - >	32.7 - >	Hurricane		precipitous	14 - >

ABBREVIATIONS

Abbreviation	**Equals**
2DHR	Two-dimensional high resolution
BE	Belgium
Beam tr.	Beam trawler
CPTU	Piezocone penetration test
Da. Seine	Danish Seine
DE	Germany
DK	Denmark
E	East
ENE	East-Northeast
ESE	East-Southeast
F2F	Face-to-Face
FLO	Fisheries Liaison Officer
FR	France
FRV	Fishing Research Vessel
GB	United Kingdom
GRAD	Gradiometer
hPa	Hectopascal
MAG	Magnetometer

Abbreviation	Equals
MBES	Multibeam echosounder
MRU	Motion recording unit
MV	Motor Vessel
N	North
NE	Northeast
NL	The Netherlands
NNE	North-Northeast
NNW	North-Northwest
NO	Norway
NW	Northwest
PAM	Passive acoustic monitoring
S	South
SBES	Single beam echosounder
SBP	Sup bottom profiler
SE	Southeast
SE	Sweden
SSE	South-Southeast
SSS	Side scan sonar
SSW	South-Southwest
SVP	Sound velocity profiler
SW	Southwest
TBT	Toolbox meeting
UHRS	Ultra-high resolution seismic
UN	Unknown
UTC	Coordinated Universal Time
W	West
WNW	West-Northwest
WOW	Waiting on weather
WSW	West-Southwest

ACTIVITY LOG

Time UTC +2

APRIL 8, 2023

07:00 Flo Henning and Tony leaves their home in private cars.

07:30 FLO Henning and Tony meets at the “Brejning Kryds” and continues to Hirtshals in Tony’s private car.

11:00 FLO Henning and Tony arrives on board Jakup Sverri, Hirtshals Østhavn.

13:00 Kick Off meeting.

15:00 Phone contact with Kim Bjerre, Thorup Strand Fiskeriforening to make agreement of daily contact with update fishing buoys and progress of survey. Next contact tomorrow afternoon.

Figure 4 Jakup Sverri

FISHING ACTIVITY

None

FISHING VESSELS

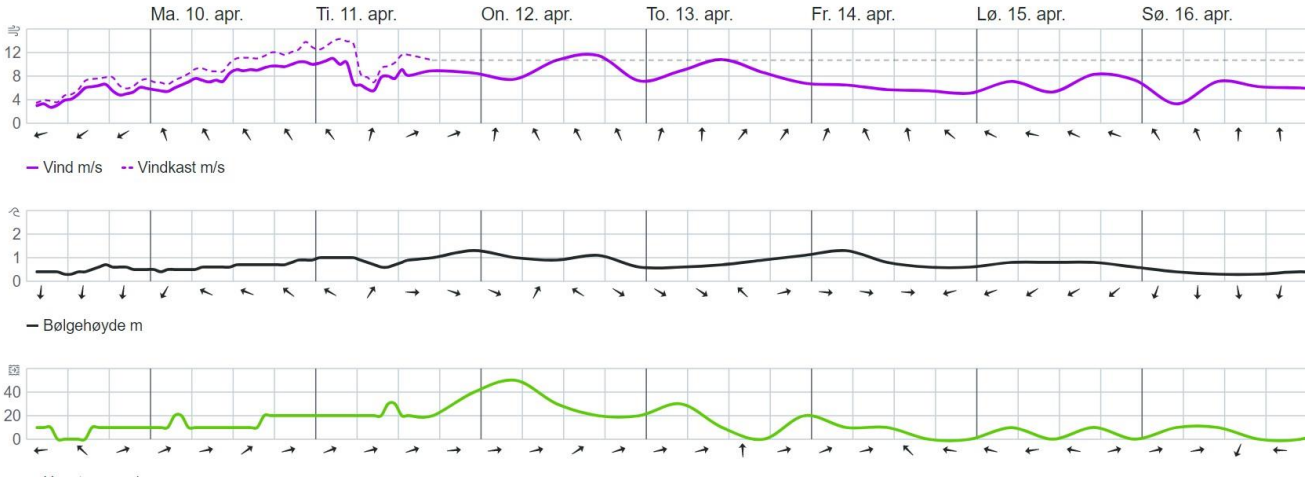
None

APRIL 9, 2023

00:00 Jakup Sverri in Hirtshals, Østhavn

Weather forecast

A high, 1034 hPa, over the Scandinavian Peninsula is almost stationary. A front zone over the North Sea can give light rain and mist and perhaps locally fog.



08:00 All on signers in taxa to emigration in Aalborg and back to the ship.

13:00 Familiarization tour.

13:40 MOB boat drill

18:00 Contact via mail and phone to update Kim Bjerre, Thorupstrand Fiskeriforening

19:00 Meating onboard Danish Seine Fru Fjord HM 196, Lars Fjord to install plotter files on his Sodena plotter and give info.

19:45 Meating to give info to Sandeel trawler Milton, HG236, Jan Woller.

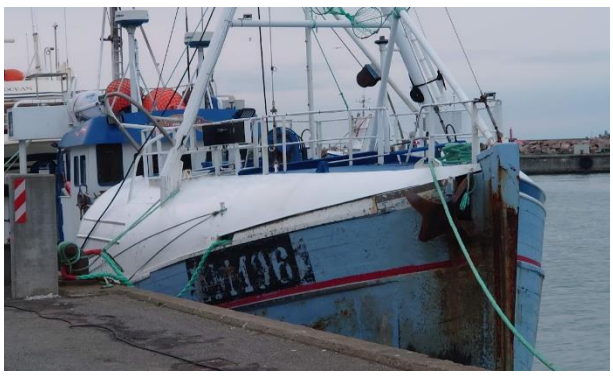


Figure 5 Fishing vessel Fru Fjord

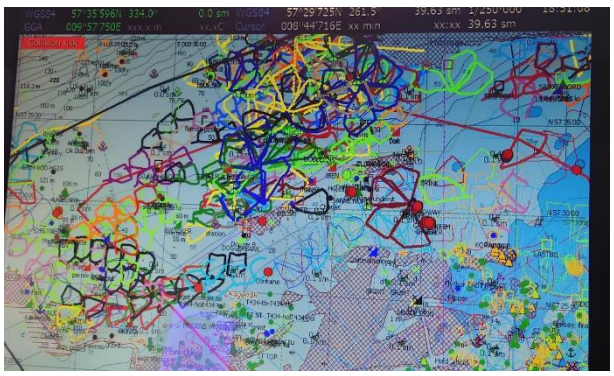


Figure 6 Pasttrack Danish Seine Fru Fjord

Figure 7 Sandeel trawler Milton


Figure 8 Getting ready for survey

Figure 9 MOB boat drill


Figure 10 Sunset

FISHING ACTIVITY

None

FISHING VESSELS

None

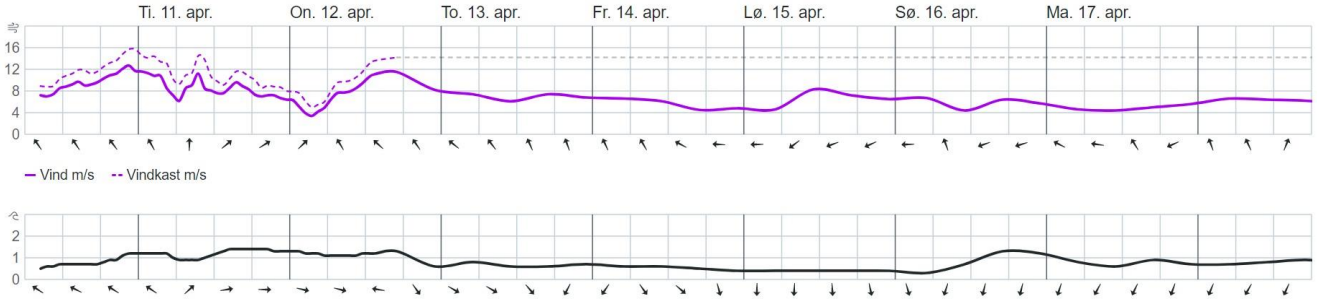
APRIL 10, 2023

00:00 Jakup Sverri in Hirtshals Østhavn.

Weather forecast

There is gale warning for the Belts and the Sound, Kattegat, Skagerrak, Fisher and German Bight.

High, 1033 hPa, over the Scandinavian Peninsula, is moving towards southeast. Low, about 1000 hPa, west of Scotland, is moving towards east to the northern part of the North Sea, then north along the west coast of Norway. An associated okklusion in western part of the North Sea, with widespread rain and mist, and locally perhaps fog, is moving towards east and is expected Tuesday morning over the central part of Denmark.



13:05 Phone contact to Fishing vessels Inger Kristine HM17, skipper Rasmus H. Olsen to receive info of his nets and give info. Fishing in less than 10-meter water dept.

16:50 Musterdrill.

17:15 Mail to Kim Bjerre, Thorupstrand Fiskeriforening with update of progress Jakup Sverri.

17:40 Jakup Sverri departures Hirtshals.


Figure 11 Muster drill

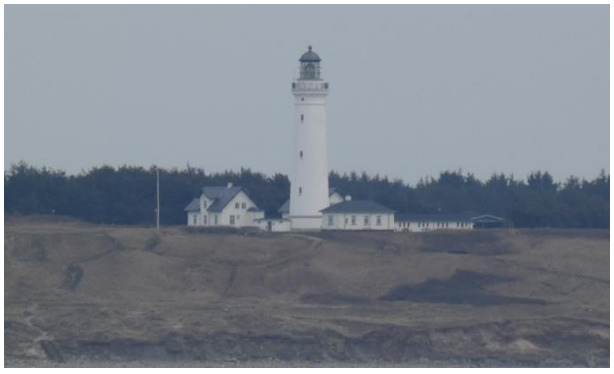


Figure 12 Light tower Hirtshals

FISHING ACTIVITY

The Sandeel fishing has started. Most concentration of sandeel trawlers in the southwest and northeast side of survey area. Net boats fishing along the coast. Looks like they are in less water debt than 10 meters so far.

Inger Kristine, HM17 positions of net:

1. 57° 16.35' N - 09° 33.55' E to 57° 14.45' N - 09° 30.32' E
2. 57° 15.45' N - 09° 33.08' E to 57° 13.61' E - 09° 30.47' E
3. 57° 15.33' N - 09° 33.62' E to 57° 13.50' E - 09° 30.97' E

FISHING VESSELS

None

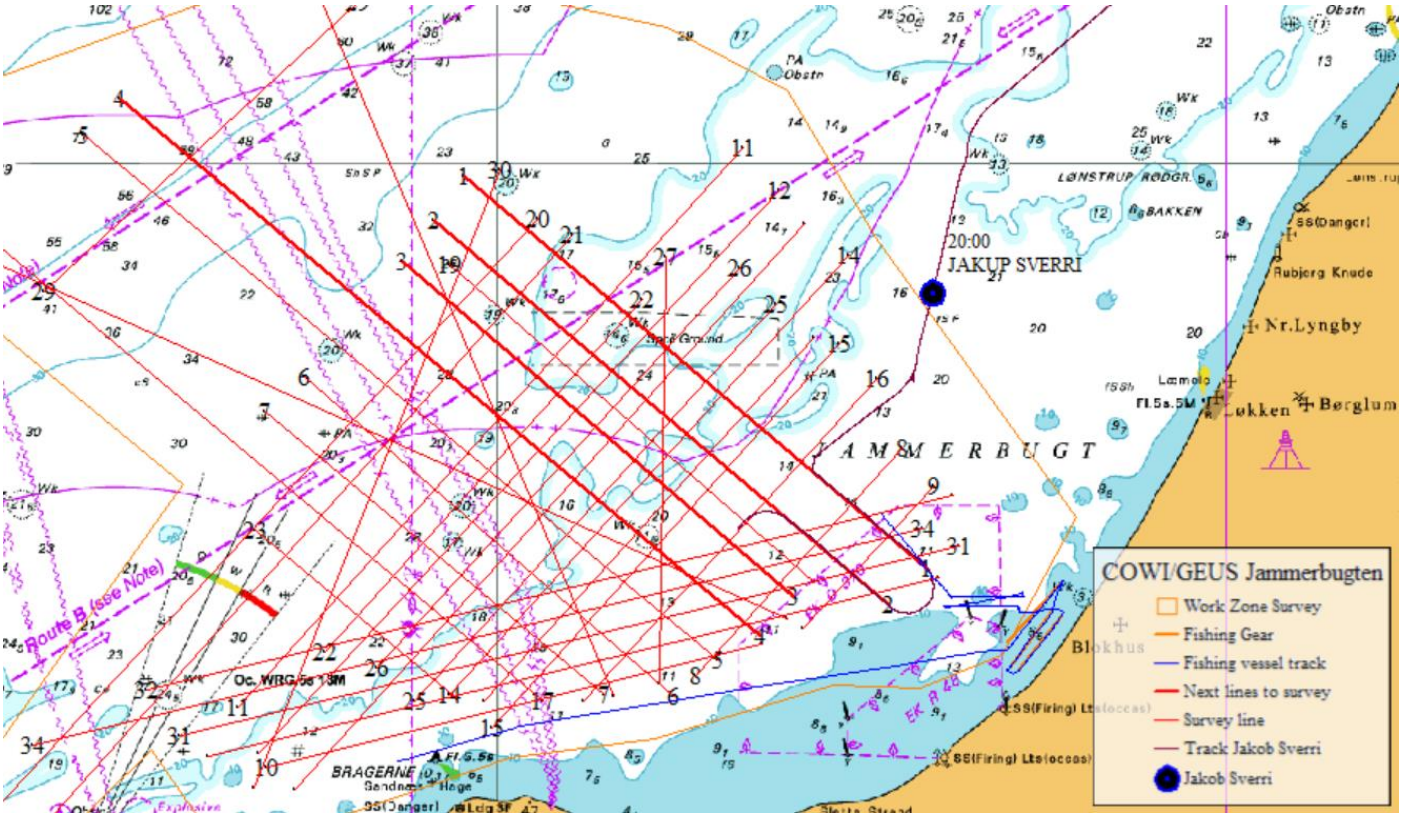


Figure 13 Vessels April 11

APRIL 11, 2023

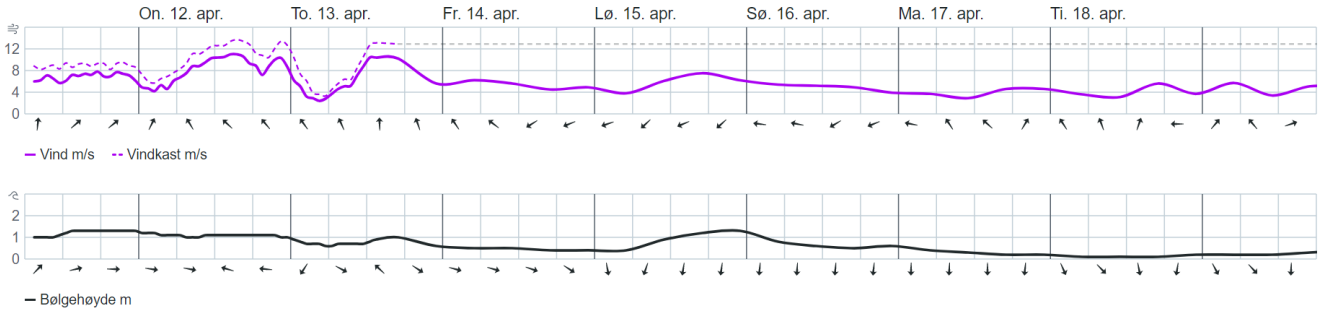
00:00 Jakup Sverri performs depth measurement.

Position and weather

- Position 57.301455° N - 9.238425° E

There is gale warning for Skagerrak, Fisher, and German Bight.

A low, 995 hPa, between Scotland and southern Norway, is moving slowly towards northeast, the associated occlusion with widespread rain and mist over the central part Denmark, is moving towards east and is expected this evening just east of Bornholm. West of the occlusion rain showers, with local risk of hail.



10:40 Start deployment of tail buoy and streamer.


Figure 14 Deployment tail buoy


Figure 15 Deployment streamer

15:54 Mail with update Jakup Sverri progress to Kim Bjerre, Thorupstrand Fiskeriforening, Emillie FN267.

FISHING ACTIVITY

Few Sandeel trawlers fishing northeast and southwest of survey area. Few net boats along the coast at sea today. VHF contact to trawlers to give info.

FISHING VESSELS

Date	Time	Name Harbor no. Call Sign MMSI	Nationality	Type	Latitude	Longitude	Course deg.	Speed	Bearing	Range	Fishing Y/N	Contact	Remarks
11-04-23	12:55	Havfisken,, OWRB, 219021235	DK	Research V.	57 30.9 N	09 19.5 E	54	1.8	34	10	Y		
11-04-23	12:57	Emilie, FN267, OXSE, 219023911	DK	Trawler	57 32.4 N	09 19.8 E	233	2	31	11.3	Y		
11-04-23	12:58	Andrea, R194, OUIW, 220137000	DK	Trawler	57 31.9 N	09 19.4 E	90	3.6	10.8	32	Y		
11-04-23	15:00	Emilie, FN267, OXSE, 219023911	DK	Trawler	57 25.6 N	09 10.8 E	202	7.4	7.1	104	N	VHF	Transit to Hanstholm
11-04-23	15:29	Janni, HM96, OWFW, 219023588	DK	Trawler	57 25.0 N	08 45.7 E	190	6.8	234	7.4	N		
11-04-23	19:50	Flipper, HM 335, OXAV, 219709000	DK	Trawler	57 37.8 N	08 37.7 E	192	8.2	352	6.2	N	VHF	Transit to Hanstholm
11-04-23	22:00	Astrid, S264, OZPO, 219030452	DK	Trawler	57 26.8 N	09 12.4 E	245	11.9	59	3.1	N		Transit
11-04-23	22:05	South Ocean, HG165, OWUY, 219021428	DK	Trawler	57 25.8 N	09 17.1 E	248	6.6	59	3.1	N	VHF	Safety info given. Transit

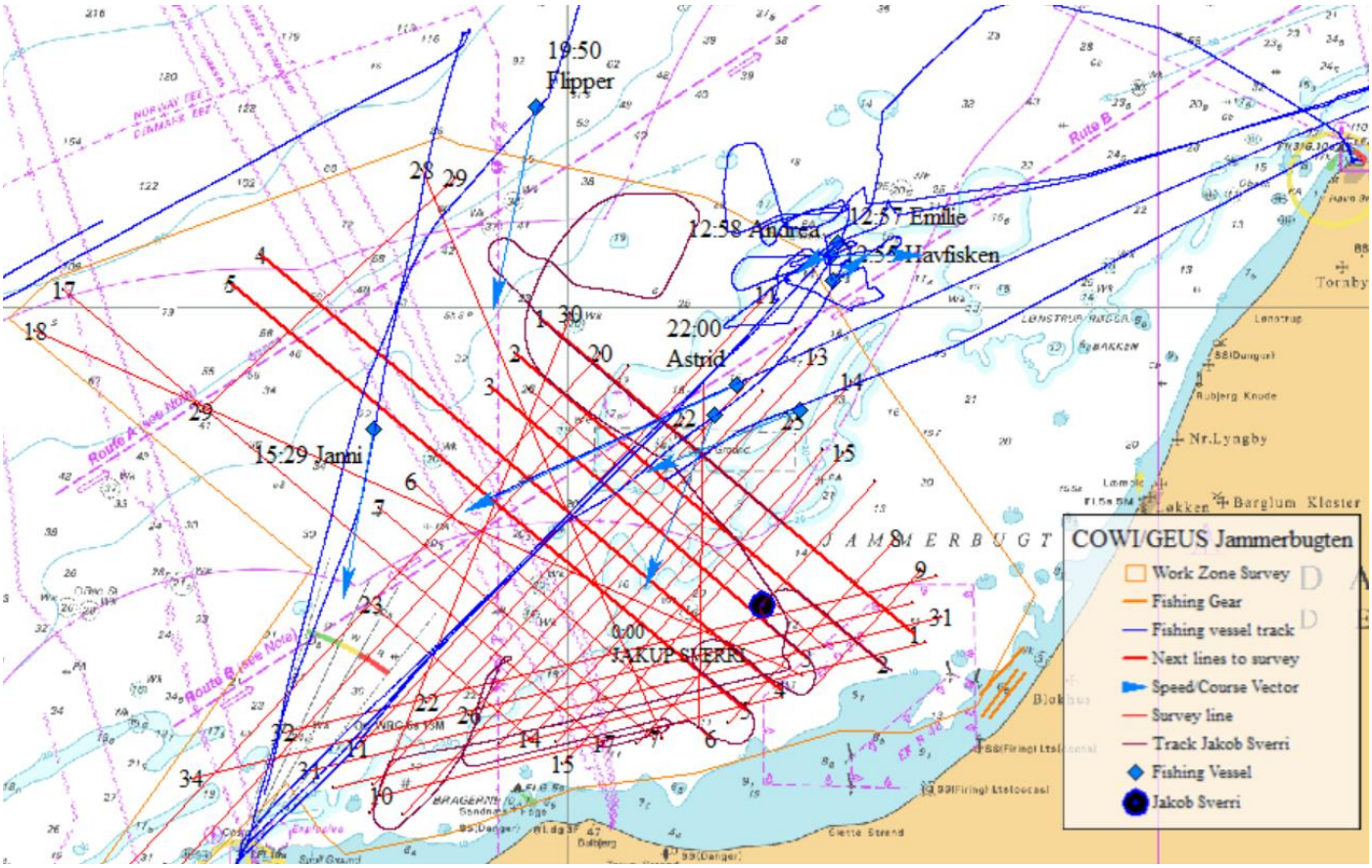


Figure 16 Vessels April 11

APRIL 12, 2023

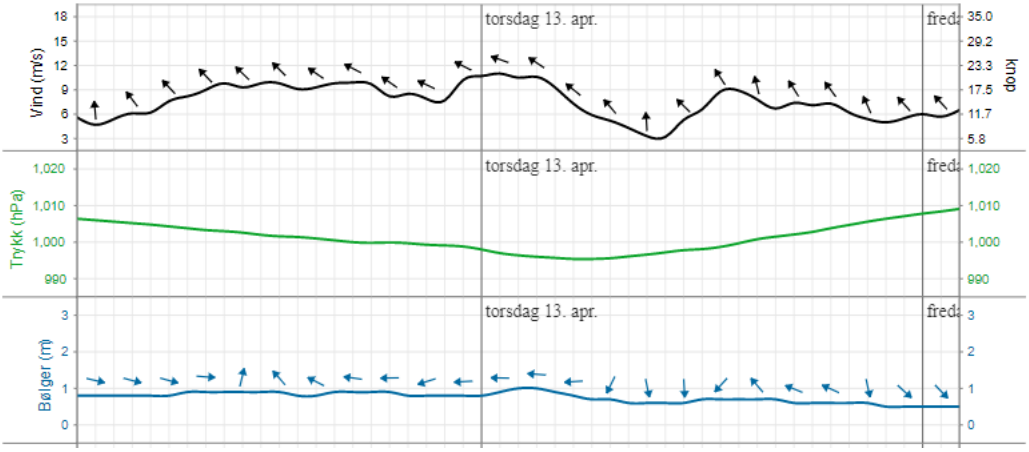
00:00 Jakup Sverri in production

Position and weather

- Position 57° 21.1' N - 09° 16.2' E

There is gale warning for Fisher and German Bight.

A low, 990 hPa, west of Norway, is moving slowly towards north, the associated occlusion with rain and mist over Sweden and the eastern part of Denmark, is moving towards east and is expected this evening just east of Bornholm. West of the occlusion rain showers, with local risk of hail, gradually more dry and clear weather towards west. Late at night and in the morning possibility of local fog especially towards east. Tomorrow, Wednesday, around 06 am a new low, 975 hPa, over Scotland, the associated occlusion is moving towards the North Sea from southwest with widespread rain, followed by dry and clear weather.



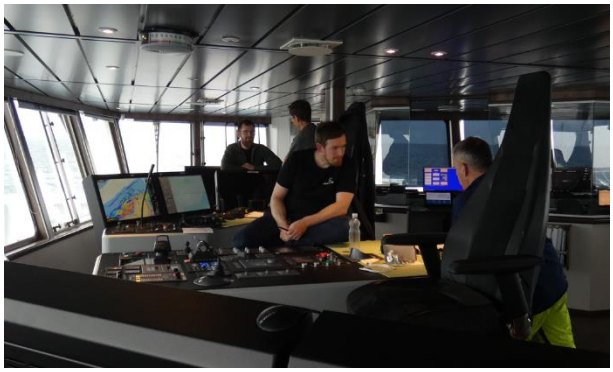


Figure 17 Captain gives orders


Figure 18 FLO Office

FISHING ACTIVITY

Fishing activity close to the coast in less than 10-meter debt of gill netters. One Danish seiner and a few trawlers fishing just outside survey area. Few fishing vessels in transit passing through the survey area. One VHF contact.

FISHING VESSELS

Date	Time	Name Harbor no. Call Sign MMSI	Nationality	Type	Latitude	Longitude	Course deg.	Speed	Bearing	Range	Fishing Y/N	Contact	Remarks
12-04-23	01:44	Mikamale, HM8, OU2181, 219005778	DK	Gill net	57 12.3 N	09 27.7 E	58	6.4	156	3.4	Y		
12-04-23	01:47	Trutte, AS357, 5QTP, 219871000	DK	Trawler	57 23.1 N	09 19.0 E	219	3.3	338	8.5	N		
12-04-23	16:45	Malia Alberte, L40, OWNV, 219001588	DK	Danish Seine	57 36.1 N	08 41.7 E	171	0.9	13	5.1	Y		
12-04-23	16:47	Nordstrand, S43, OZCG, 219012521	DK	Trawler	57 37.0 N	08 35.2 E	247	3.4	339	6.4	Y		
12-04-23	19:50	Tor-On, , OUJF, 219030383	DK	Trawler	57 25.3 N	09 09.8 E	262	12.4	85	10.5	N	VHF	

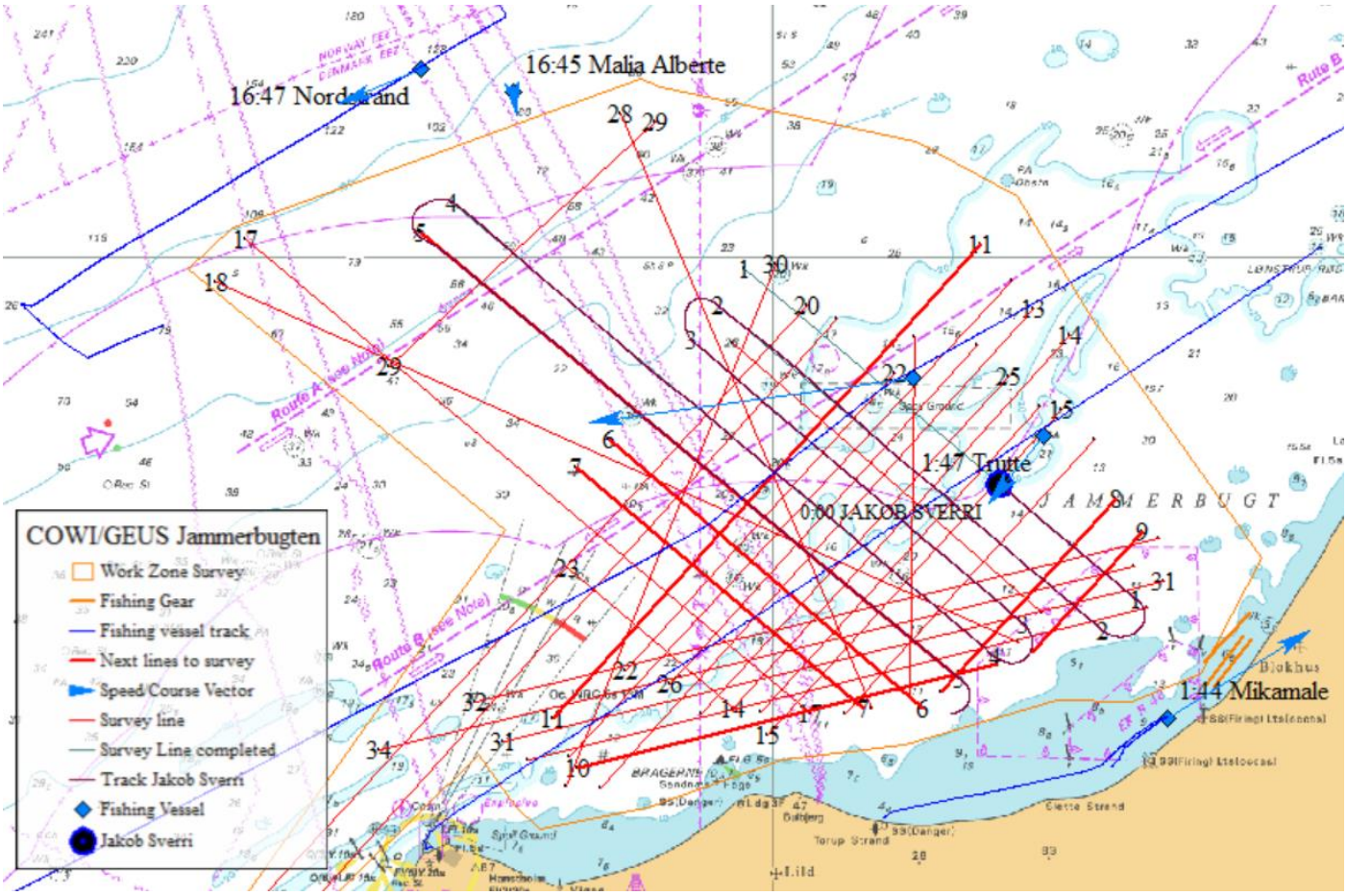


Figure 19 Vessels April 12

APRIL 13, 2023

00:00 Jakup Sverri in production.

Position and weather

- Position 57.208573° N - 9.208583° E

There is gale warning for Kattegat, Skagerrak, Fisher and German Bight.

A storm force low, 975 hPa, over Ireland and Scotland is moving slowly towards east and southeast, while it weakens. An associated occlusion with rain over Jutland is moving towards northeast and is out of the area Thursday morning. West of the front south- and southwesterly flow of unstable air with scattered showers, that Thursday can be with hail and thunder.

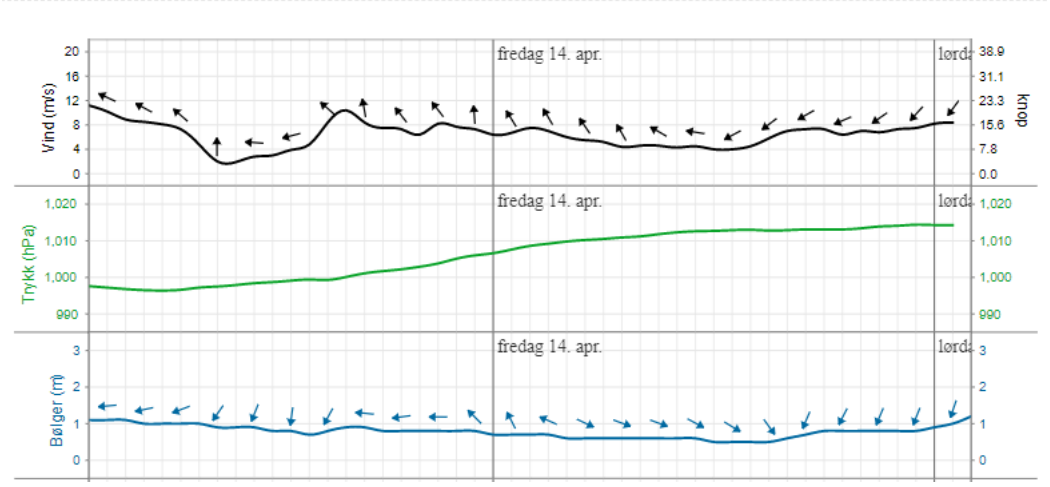



Figure 20 Fishing vessel Nemo


Figure 21 Fishing buoy belongs to fishing vessel Nemo

Figure 22 Fishing vessel Ida Sara

Figure 23 Passing Thorupstrand

Figure 24 Passing Lild Strand

Figure 25 Bulbjerg

FISHING ACTIVITY

Only one Sandeel trawler observed fishing today outside Hanstholm. One small trawler fishing for konsum inside the survey area and one trawler in transit observed. Along the coast some net fishing in progress. VHF contact to two gill netters to give info and receive info of nets in the survey area. There was five lines of net in the survey area, one of them was picked up early evening. Many lines of net between the coast and the survey area.

Position of nets:

1. 57 10.20, 8 45.20 - 57 10.20, 8 41.80, HM19 Nemo (picked up)
2. 57 09.20, 8 43.50 - 57 09.20, 8 44.55, HM65 Ida
3. 57 09.00, 8 44.20 - 57 09.00, 8 45.20, HM65 Ida
4. 57 13.05, 8 42.10 - 57 13.25, 8 43.10, HM65 Ida
5. 57 12.75, 8 44.20 - 57 13.20, 8 44.50, HM65 Ida

FISHING VESSELS

Date	Time	Name Harbor no. Call Sign MMSI	Nationality	Type	Latitude	Longitude	Course deg.	Speed	Bearing	Range	Fishing Y/N	Contact	Remarks
13-04-23	09:15	Inger Kristine, HM17, OU 3620, 219005909	DK	Gill net	57 14.6 N	09 32.5 E	98	1.2	98	9.1	Y		
13-04-23	09:25	Tenna, FN111, XPA4274, 219025478	DK	Gill net	57 16.8 N	09 31.9 E	32	5.9	87	8.2	Y		
13-04-23	10:10	Em Olsen, HM94, OZYA, 219001204	DK	Gill net	57 10.0 N	09 20.9 E	75	1.1	182	9.1	Y		
13-04-23	14:05	Alberte Marie, HM60, 5PDP, 219005893	DK	Gill net	57 07.2 N	08 45.1 E	0	3.3			Y	VHF	Safety info given
13-04-23	14:12	Nemo, HM19, OX2403, 219005953	DK	Gill net	57 07.7 N	08 50.8 E	78	4.6	235	8.9	Y	VHF	Safety info given
13-04-23	15:04	Nanna-Pia, HM210, OU6887, 219005931	DK	Gill net	57 08.4 N	08 40.2 E	274	5.9	249	10.2	Y		
13-04-23	15:07	Christine, HM22, OYFA, 219024924	DK	Gill net	57 06.6 N	08 44.6 E	304	5.2	233	8.7	Y		
13-04-23	15:10	Ida Emilie, HM42, XP4450, 219001587	DK	Trawler	57 10.9 N	08 34.2 E	46	2.4	265	12.2	Y		
13-04-23	15:52	Limfjorden, T72, XP4066, 219007925	DK	Trawler	57 10.1 N	08 39.5 E	147	2.6	259	6.4	Y		
13-04-23	19:18	Ida Sara, E710, OYHO, 219011867	DK	Trawler	57 15.5 N	08 51.5 E	241	11.1	51	4	N		

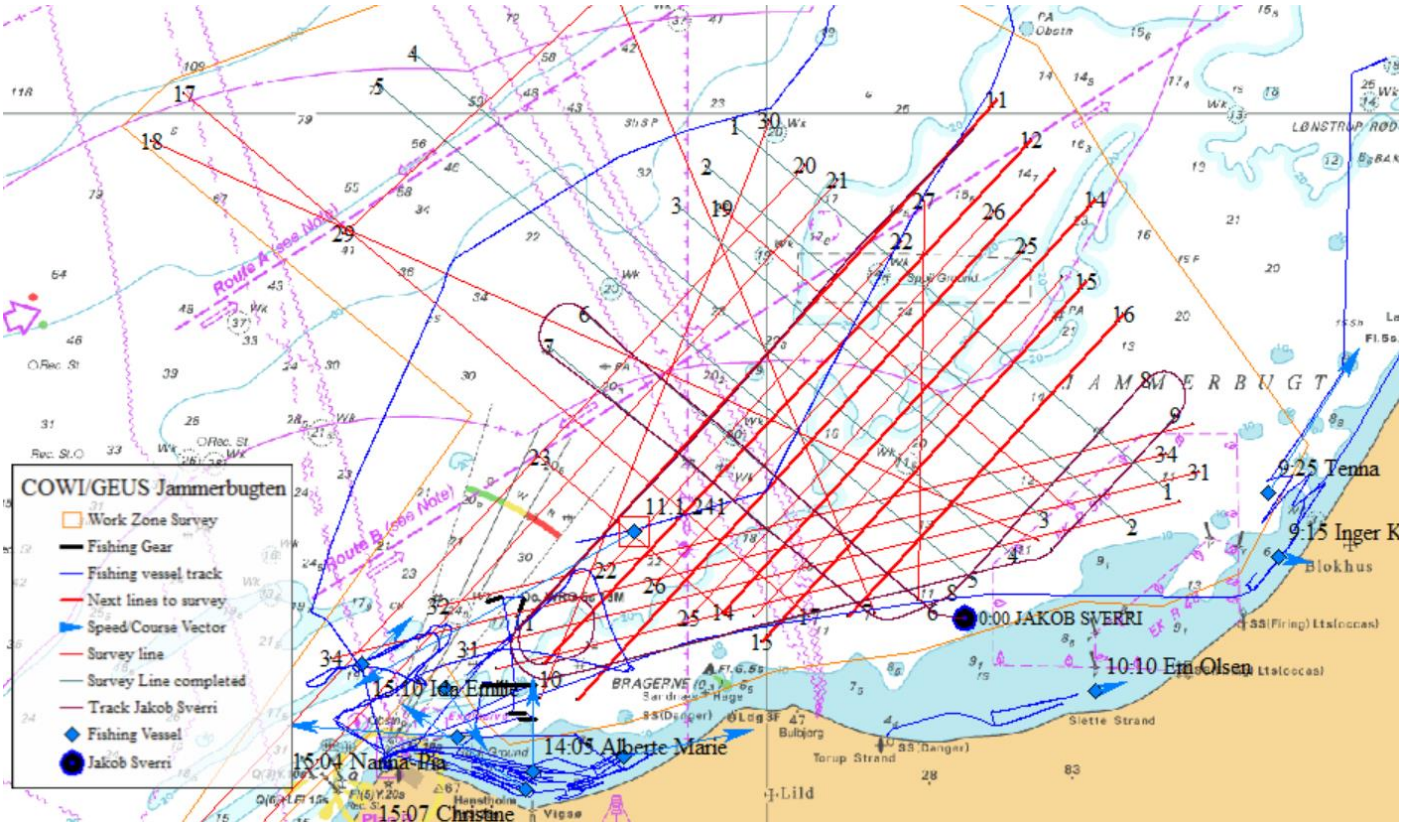
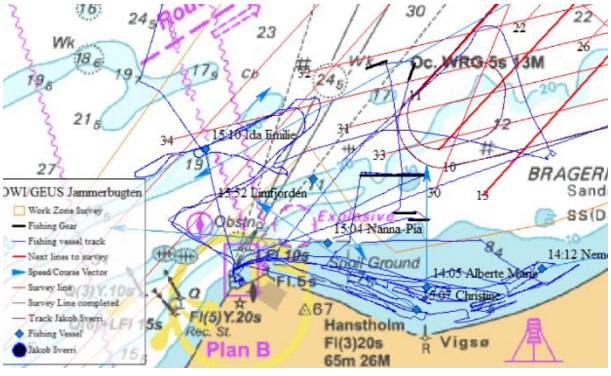


Figure 26 Vessels April 13



APRIL 14, 2023

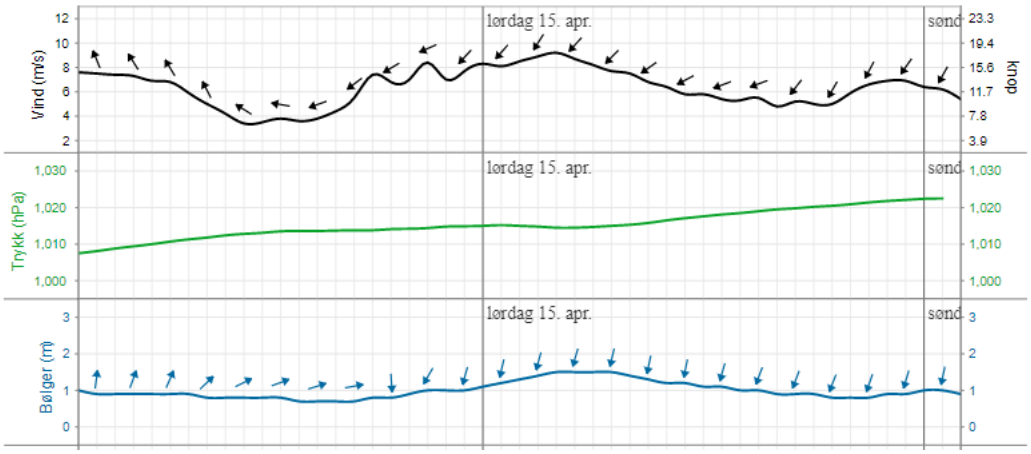
00:00 Jakup Sverri in production

Position and weather

- Position 57.489030° - 9.218280°

There is gale warning for Fisher.

Southern flow of unstable air gives showers during daytime, locally with hail and thunder, especially over the North Sea, Skagerrak and the inner danish waters. A warmfront with rain and mist is moving towards Bornholm during the night from east and continues slowly towards west and is expected late in period from Göteborg to Rostock.



16:35 Mail with update and plan until Sunday morning sent to growing mailing list.

20:10 A buoy was detected at pos.57° 18.70' N - 09° 11.20' E. No problem for the survey. It is possible that the buoy belongs to Jammerbugten HM 62.


Figure 27 Fishing vessel Silje Sofie


Figure 28 Fishing vessel Hanne

FISHING ACTIVITY

Fishing along the coast of gill netters. Two Danish seiners been fishing in the survey area, well clear of Jakup Sverri. Some Sandeel trawlers been searching for Sandeel, but they think the water temperature is still too low for the Sandeel to come closer to the coast yet. So, they went back to port again.

FISHING VESSELS

Date	Time	Name Harbor no. Call Sign MMSI	Nationality	Type	Latitude	Longitude	Course deg.	Speed	Bearing	Range	Fishing Y/N	Contact	Remarks
14-04-23	04:45	Rosa Sofie, HM222, XP4080, 219006092	DK	Danish Seine	57 13.6 N	08 51.5 E	180	0.4	180	1.1	Y	VHF	
14-04-23	08:15	Limfjorden, T72, XP4066, 219007925	DK	Gill net	57 16.8 N	08 41.5 E	232	1.7	287	7.9	Y		
14-04-23	08:30	Ida, HM65, XP4060, 219005763	DK	Gill net	57 13.0 N	08 44.5 E	33	1.5	238	7.2	Y		
14-04-23	10:10	Jammerbugten, HM62, XP3220, 219005777	DK	Gill net	57 18.2 N	09 09.0 E	237	4.2	119	3.4	Y		
14-04-23	11:00	Strander, ND17, XP3953, 219005964	DK	Trawler	57 26.9 N	09 11.9 E	57	8	359	2.7	Y		Searching for Sand-eel
14-04-23	11:15	Silje-Sofie, S123, XP3776, 219007034	DK	Trawler	57 27.7 N	09 14.3 E	200	6.6	18	3.2	Y		Searching for Sand-eel
14-04-23	11:55	Orion, R3, OU4805, 220353000	DK	Trawler	57 31.5 N	09 19.8 E	185	2.7	20	4.7	Y		Searching for Sand-eel
14-04-23	11:57	Hanne, H10, OU7604, 219004128	DK	Trawler	57 31.4 N	09 18.0 E	188	3	8	4.4	Y		Searching for Sand-eel
14-04-23	11:58	Amalie Benjamin, A59, OYKB, 219005867	DK	Trawler	57 30.9 N	09 12.5 E	189	2.8	328	4.4	Y		Searching for Sand-eel
14-04-23	12:00	Tanja, ND80, XP3053, 219005964	DK	Trawler	57 31.5 N	09 15.5 E	28	4	348	4.3	Y		Searching for Sand-eel
14-04-23	12:02	Katrine Kim, R254, XP3619, 219004161	DK	Trawler	57 33.6 N	09 18.2 E	253	2.7	4	6.2	Y		Searching for Sand-eel
14-04-23	12:03	Tasmania, R60, OZNK, 220339000	DK	Trawler	57 33.7 N	09 23.5 E	120	4.8	28	7	Y		Searching for Sand-eel
14-04-23	13:30	Lis Hansa, R86, OU6679, 219002506	DK	Trawler	57 27.6 N	09 20.3 E	91	8.9	32	3.6	Y	VHF	Searching for Sand-eel
14-04-23	15:20	Inge Sofie, HM70, XP3590, 219010818	DK	Gill net	57 09.1 N	09 08.1 E	90	3.6	175	9.3	Y		

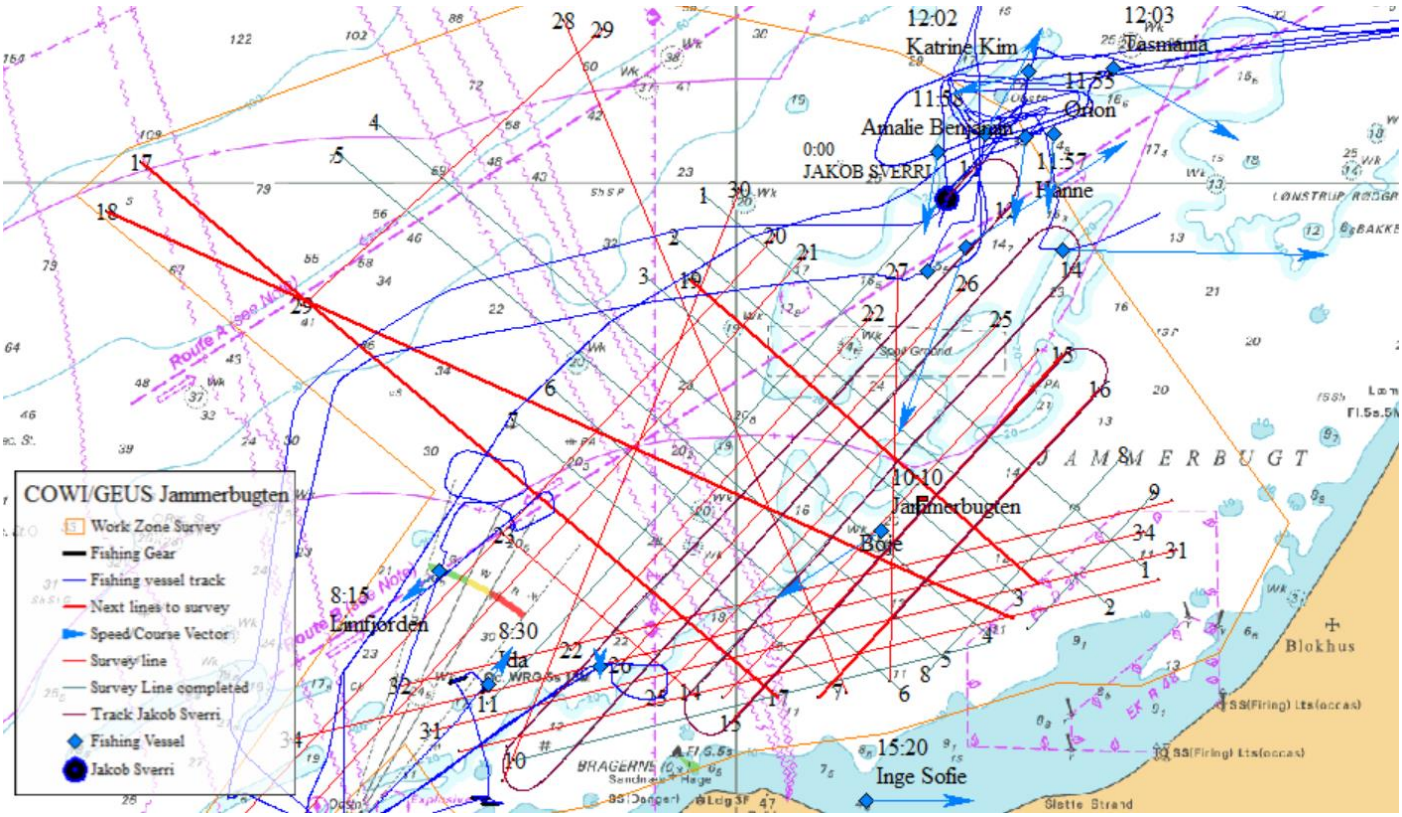


Figure 29 Vessels April 14

APRIL 15, 2023

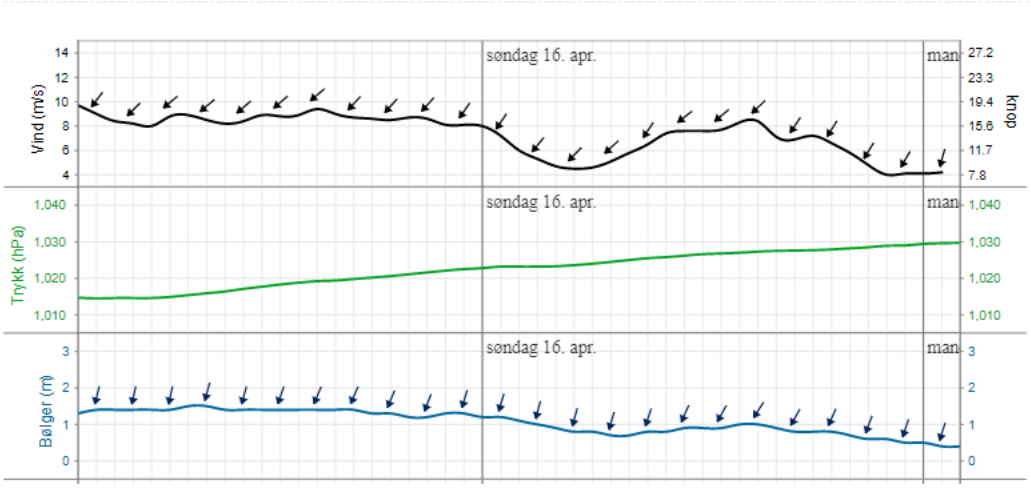
00:00 Jakup Sverri in production

Position and weather

- Position 57.253867° - 9.162043°

There is gale warning for Southern Baltic, Skagerrak, and Fisher.

A warm front with rain from Norway to Poland is moving slowly towards west. In connection with the front locally there is risk og mist and local patches of fog. East of the front it will slowly clear up. The front is expected over the eastern part of the North Sea by Saturday evening.



16:34 Mail with updated plan until Sunday evening sent to mailing list.

20:00 Phone call to duty officer at Hanstholm Harbor about the lines 20 and 21, passing the harbor entrance. We were welcome and they were ready to help to give info to vessel outbound of the harbor. New contact on the phone tomorrow morning. Only planned traffic is a merchant vessel to be expected tomorrow between 10 and 15 o'clock.

Figure 30 Fishing vessel Lis Hansa


Figure 31 Evening sky

FISHING ACTIVITY

Few trawlers fishing along the Danish – Norwegian border. Well clear of Jakup Sverri. Windy and weekend today so not much fishing activity along the coast. A couple of trawlers in transit passing by. Contact to give info.

FISHING VESSELS

Date	Time	Name Harbor no. Call Sign MMSI	Nationality	Type	Latitude	Longitude	Course deg.	Speed	Bearing	Range	Fishing Y/N	Contact	Remarks
15-04-23	07:45	Nordstrand, S43, OZCG, 219012521	DK	Trawler	57 26.8 N	08 15.5 E	215	4.5	245	3	Y		
15-04-23	07:55	Astoria, HM120, OWBW, 22004400	DK	Trawler	57 34.1 N	08 17.7 E	338	4	239	3.3	Y		
15-04-23	08:05	Flipper, HM 335, OXAV, 219709000	DK	Trawler	57 30.3 N	08 02.8 E	270	9.3	76	2.4	Y		
15-04-23	10:20	Christina Paulsen, HM862, OWST, 219439000	DK	Trawler	57 37.4 N	08 35.1 E	16	6.9	243	2.7	Y		
15-04-23	19:15	Lis Hansa, R86, OU6679, 219002506	DK	Trawler	57 20.0 N	09 09.5 E	237	9.4	80	4.4	N	TLF/VHF	Safety info given
15-04-23	22:10	Tasmania, R60, OZNK, 220339000	DK	Trawler	57 20.3 N	09 03.8 E	253	8	292	7.1	N		

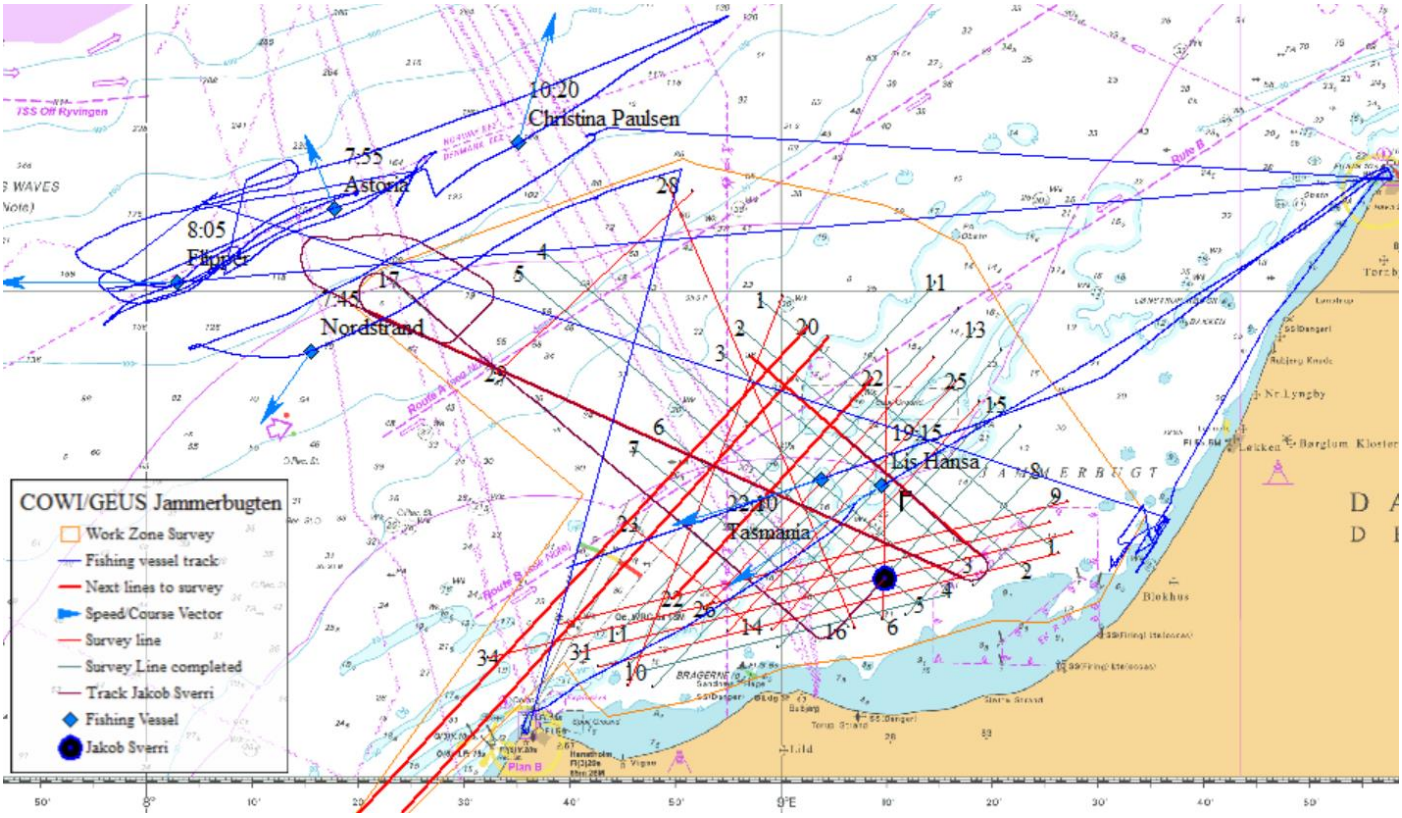


Figure 32 Vessels April 15

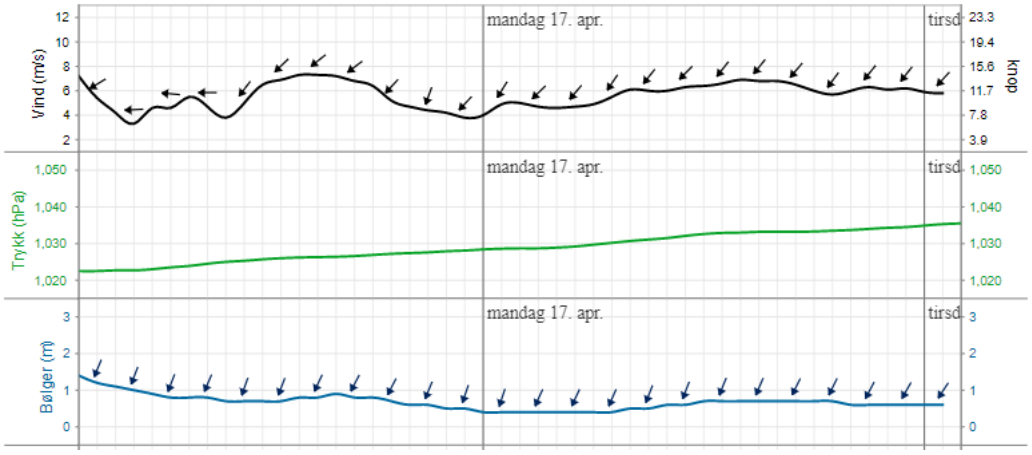
APRIL 16, 2023

00:00 Jakup Sverri in production

Position and weather

- Position 57.373803° - 9.100222°

A ridge of high pressure is almost stationary from Norway to England and is building up. A weak frontal zone may bring mist and light rain over the western waters, and another weak frontal zone may bring some light rain over the easternmost waters. Over the other waters possibility of a few light rain showers.



16:27 Mail with progress and plan for the next couple of day to mailing list.


Figure 33 Fishing vessel Mathilde

Figure 34 Fishing vessel Lismille

Figure 35 Fishing vessel Kansas

Figure 36 Fishing vessel Katrine Kim

FISHING ACTIVITY

In the early morning ten ships were fishing in the Vigsø bay, with and without AIS system. Quite a lot of activity outside Hanstholm Harbor both fishing and searching for fish. The contact to Hanstholm Harbor was a great help. Gill netter Ida has no more nets in survey area. The gill netter Tobias Skoedt gives info of 4 lines of net in survey area. Position of the eastmost and westmost line.

1. 57° 14.15'N - 08° 55.46' E to 57° 14.64' N - 08° 55.01' E
2. 57° 14.39' N - 08° 54.10' E to 57° 13.91' N - 08° 54.42' E

The lines conflict with survey lines 23 – 26 – 34. Tobias Skoedt departures Hanstholm harbor 5 o'clock tomorrow and starts to pick up the westmost line first.

FISHING VESSELS

Date	Time	Name Harbor no. Call Sign MMSI	Nationality	Type	Latitude	Longitude	Course deg.	Speed	Bearing	Range	Fishing Y/N	Contact	Remarks
16-04-23	00:43	Stella Nova, S464, OYQN, 219026318	DK	Trawler	57 27.3 N	09 10.3 E	240	10.6	62	5.5	N		
16-04-23	03:12	August, HM95, OYOD, 219028021	DK	Trawler	57 23.5 N	08 44.2 E	16	6.9	246	10.5	N		
16-04-23	06:00	Strander, ND17, XP3953, 219005964	DK	Trawler	57 12.2 N	08 33.7 E	230	8.7	267	6.1	N		
16-04-23	06:10	Nordkysten, RI428, OXJD, 220225000	DK	Trawler	57 07.9 N	08 27.2 E	259	7.2	224	14.5	N		
16-04-23	06:15	Tanja, ND80, XP3053, 219005964	DK	Trawler	57 08.8 N	08 35.2 E	350	7.7	211	10.4	N		
16-04-23	06:30	Limfjorden, T72, XP4066, 219007925	DK	Trawler	57 08.8 N	08 33.6 E	14	3.3	215	10.7	N		
16-04-23	09:00	Mathilde, HM426, XP3839, 219009738	DK	Trawler	57 08.7 N	08 29.0 E	229	2.4	223	10.9	Y	VHF	
16-04-23	09:20	Samantha, RI 159, OUVG, 219002838	DK	Trawler	57 12.7 N	08 35.6 E	83	5.1	225	5	N		
16-04-23	09:40	Ida Sara, E710, OYHO, 219011867	DK	Trawler	57 05.7 N	08 25.6 E	52	7.7	170	0.7	N	VHF	
16-04-23	10:10	Merle, HM373, OU8738, 219003066	DK	Trawler	57 03.9 N	08 25.0 E	204	2.7	177	2.1	Y		
16-04-23	12:20	Mathilde, HM426, XP3839, 219009738	DK	Trawler	57 10.7 N	08 34.8 E	275	2.7	40	6.5	Y	VHF	
16-04-23	12:36	Limfjorden, T72, XP4066, 219007925	DK	Trawler	57 10.1 N	08 36.8 E	81	2.5	51	6.7	Y	VHF	
16-04-23	13:28	Sally, HM45, XPE7446, 219021124	DK	Gill net	57 07.5 N	08 38.9 E	274	2.7	109	4	Y		
16-04-23	13:36	Ida, HM65, XP4060, 219005763	DK	Gill net	57 07.8 N	08 41.6 E	102	5.3	275	6.8	Y		No net in survey area any more
16-04-23	13:55	Kansas, HM52, XPBO, 219001569	DK	Gill net	57 12.7 N	08 29.8 E	151	6.8	316	3.6	N	VHF	Safety info given
16-04-23	14:00	Lismille, T913, FTJ2246,	DK	Gill net	57 11.2 N	08 38.0 E	230	4.6	61	1.9	Y	VHF	No AIS, Pick up nets
16-04-23	14:41	Tobias Skoedt, HM24, OU7929, 219005513	DK	Gill net	57 11.4 N	08 45.8 E	245	7.7	101	3.8	N	VHF	Info of his nets
16-04-23	16:56	Katrine Kim, R254, XP3619, 219004161	DK	Trawler	57 19.2 N	08 52.4 E	207	6.6	99	0.8	N		
16-04-23	20:30	Amalie Benjamin, A59, OYKB, 219005867	DK	Trawler	57 27.3 N	09 03.5 E	194	7.3	38	4.2	N	VHF	Transit

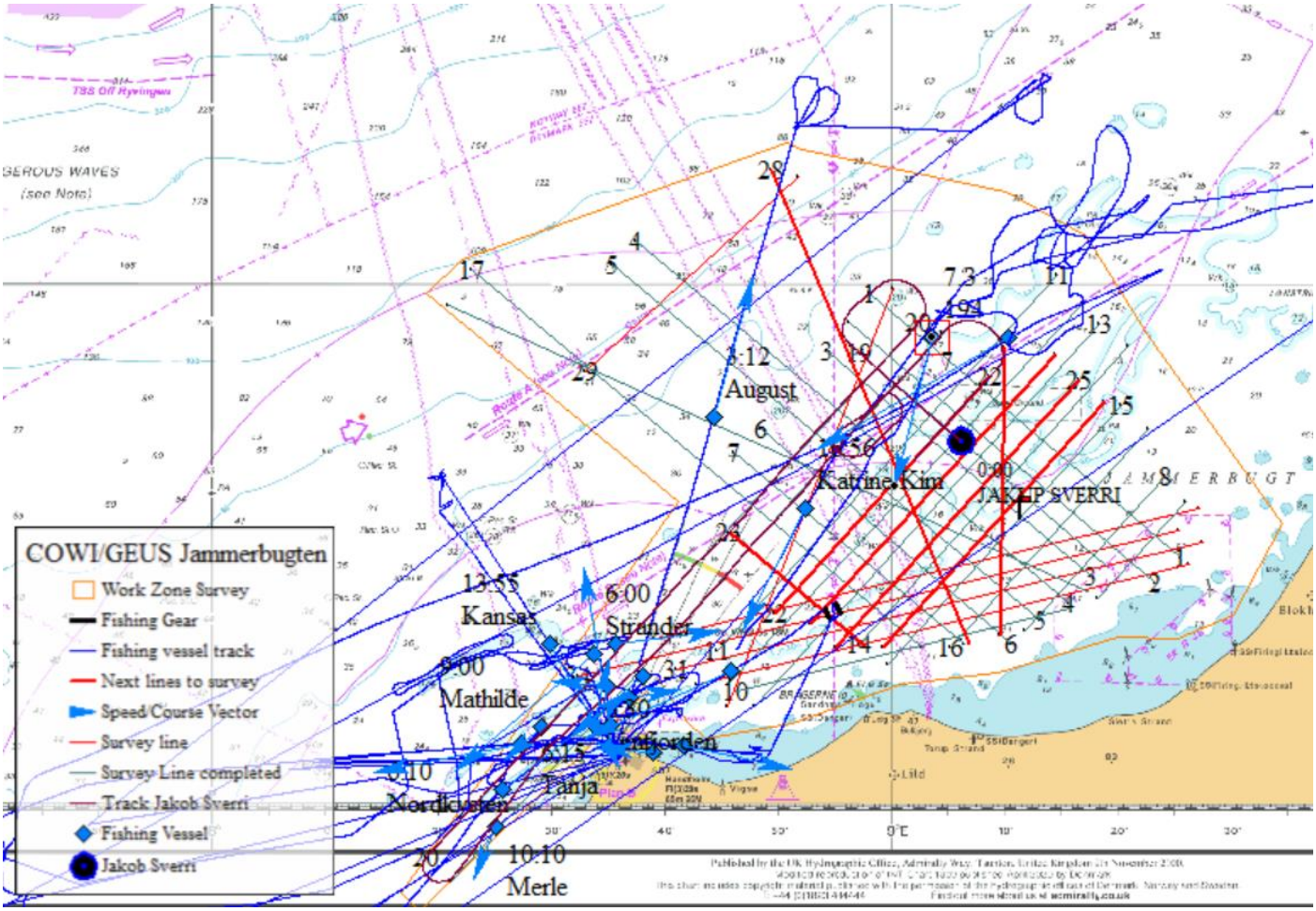


Figure 37 Vessels April 16

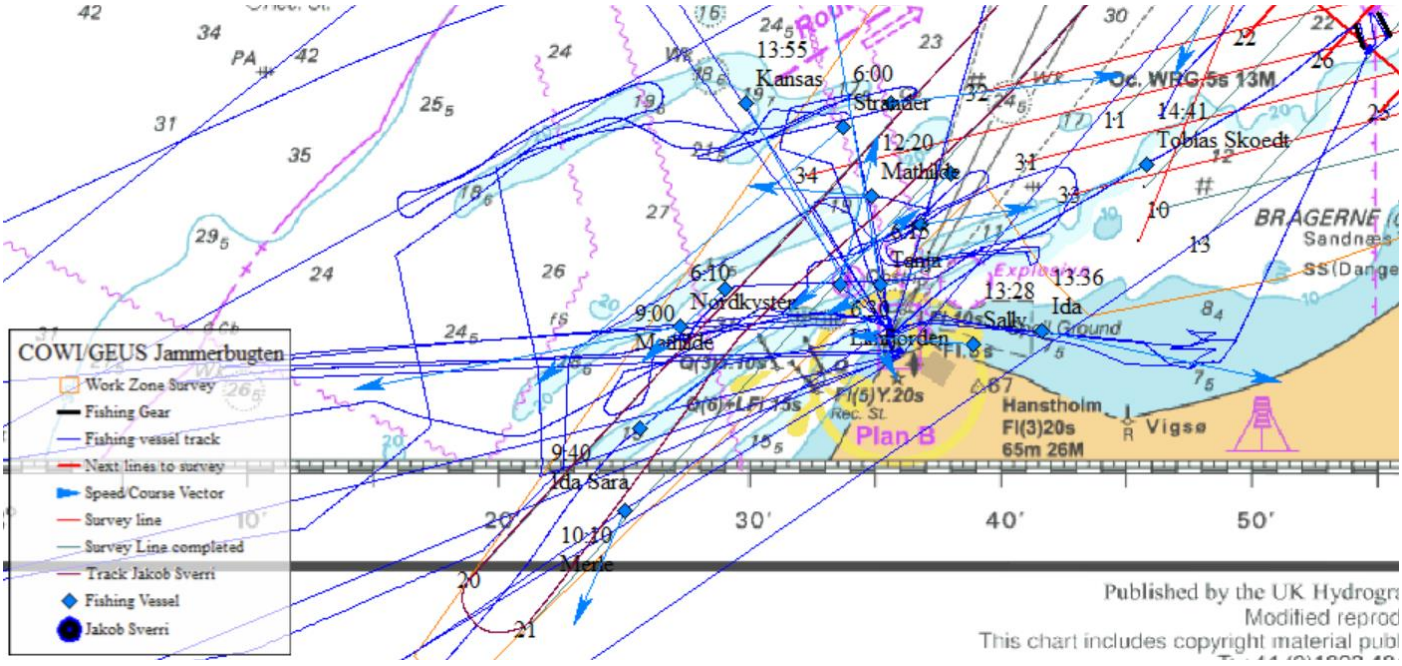


Figure 38 Traffic in and out of Hanstholm today

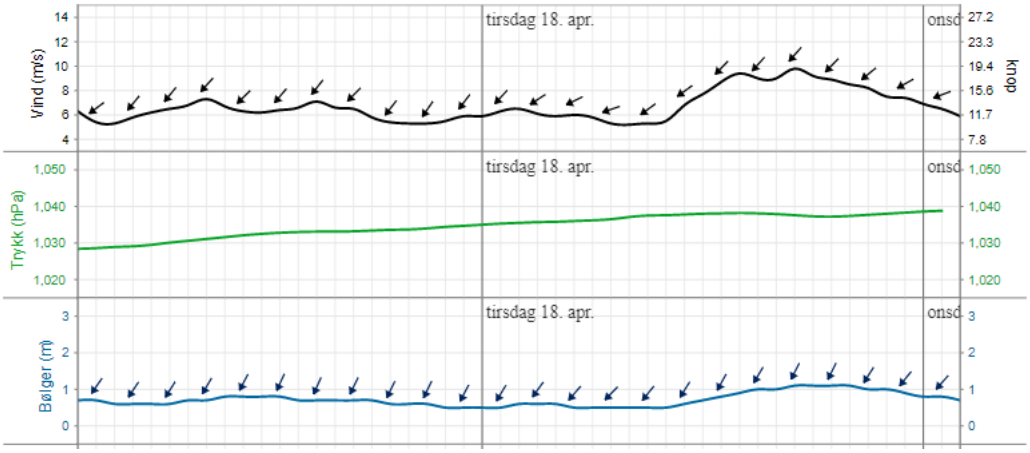
APRIL 17, 2023

00:00 Jakup Sverri in production

Position and weather

- Position 57.358072° - 9.031477°

A stationary high, 1025 hPa, over southern Norway intensifying. A weak front zone over centrale part of the North Sea with local mist and rain dissolves.



17:06 Update of progress and plan for the next day. Also attached search for lost hydrophone. Sent to mailing list by mail.


Figure 39 Fishing vessel Tobias Skoedt


Figure 40 Fishing vessel Tobias Skoedt approaching the last buoy.

FISHING ACTIVITY

The fishing vessel Tobias Skoedt picked up his nets today and went back to Hanstholm to clean up his nets. Much fishing activity along the coast of net boats. Few fishing vessels in transit observed. Fishing for Sandeel at the moment is further west and southwest of Hanstholm outside the survey area.

FISHING VESSELS

Date	Time	Name Harbor no. Call Sign MMSI	Nationality	Type	Latitude	Longitude	Course deg.	Speed	Bearing	Range	Fishing Y/N	Contact	Remarks
17-04-23	02:56	Isafold, HG 333, OZUV, 219030593	DK	Trawler	57 15.9 N	08 40.7 E	237	11.6	281	2.6	N		
17-04-23	03:40	Silje-Sofie, S123, XP3776, 219007034	DK	Trawler	57 18.9 N	08 55.5 E	241	6.8	80	7	N	VHF	
17-04-23	06:30	Ida Emilie, HM42, XP4450, 219001587	DK	Gill net	57 10.0 N	09 02.0 E	60	0.3	170	3.6	Y		
17-04-23	06:35	Tobias Skoedt, HM24, OU7929, 219005513	DK	Gill net	57 14.3 N	08 54.3 E	260	0.2	279	3.7	Y		
17-04-23	06:40	Mille, T18, OU8281, 219030200	DK	Gill net	57 11.3 N	09 10.8 E	266	2.8	117	5.6	Y		
17-04-23	06:45	Inger Kristine, HM17, OU 3620, 219005909	DK	Gill net	57 15.1 N	09 15.7 E	257	7.2	85	7.2	N		
17-04-23	12:30	Tobias Skoedt, HM24, OU7929, 219005513	DK	Gill net	57 14.5 N	08 55.1 E	122	1.2	235	5.8	Y	VHF	Pick up nets and transit to harbor
17-04-23	13:58	Goliat, HM 92, OXPU, 219028381	DK	Gill net	57 09.1 N	09 07.8 E	315	0.7	122	7.8	Y		
17-04-23	14:00	Inge Sofie, HM70, XP3590, 219010818	DK	Gill net	57 09.2 N	09 07.8 E	315	1.5	120	7.6	Y		
17-04-23	14:01	Nemo, HM19, OX2403, 219005953	DK	Gill net	57 07.9 N	08 51.6 E	123	0.5	204	5.5	Y		
17-04-23	14:02	Birgit, SG36, OU6417, 219009464	DK	Gill net	57 06.8 N	08 49.0 E	275	1.8	211	7	Y		

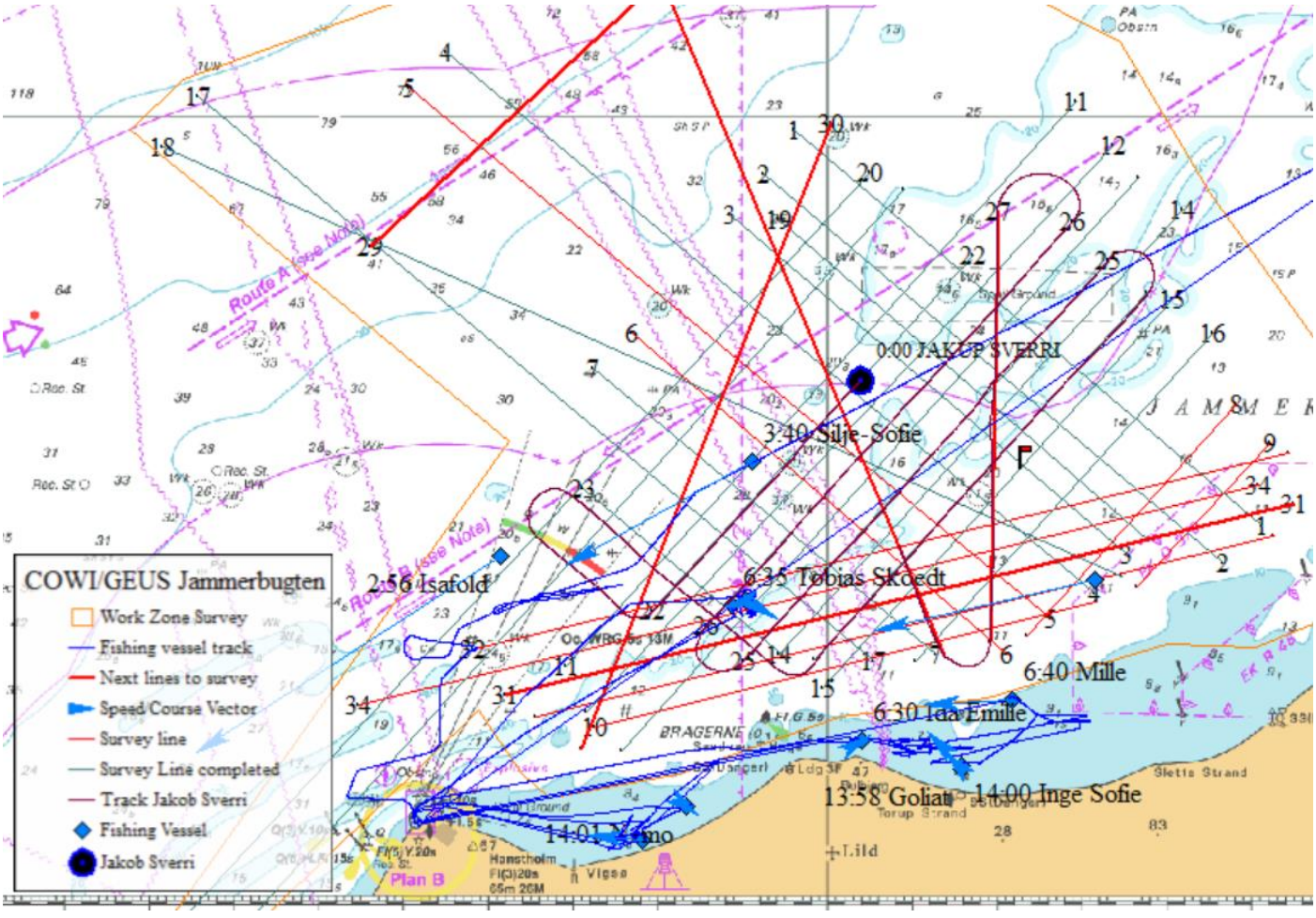


Figure 41 Vessels April 17

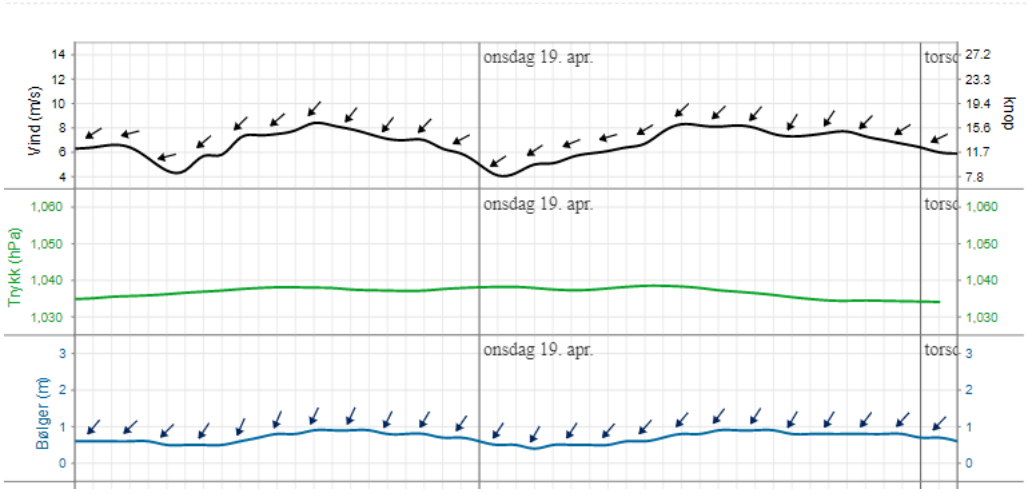
APRIL 18, 2023

00:00 Jakup Sverri in production

Position and weather

- Position 57.269863° N - 9.069408° E

A high, 1036 hPa, over southern Norway, is almost stationary and intensifying further. Northeastern flow of dry air over Denmark.



16:54 Mail to mailing list with today's update of progress and plan for tomorrow.


Figure 42 Fishing vessel Montana


Figure 43 Air gun fires

FISHING ACTIVITY

In the morning Jakup Sverri is working in the NW-ern part of the survey area. The fishing vessels in the area doesn`t interfere our work. At break of dawn the fishing vessels start working near the coast in Vigsø Bugt and Jammerbugten. When Jakup Sverri start surveying the eastern lines about sundown we are all alone.

FISHING VESSELS

Date	Time	Name Harbor no. Call Sign MMSI	Nationality	Type	Latitude	Longitude	Course deg.	Speed	Bearing	Range	Fishing Y/N	Contact	Remarks
18-04-23	01:15	Elin, HG281, OYOL, 219027752	DK	Trawler	57 23.8 N	08 59.5 E	246	8	352	2.7	N		
18-04-23	04:25	Malia Alberte, L40, OWNV, 219001588	DK	Danish Seine	57 35.4 N	08 42.4 E	22	0.6	288	4.4	Y		
18-04-23	05:00	Karen Margrethe, L423, OYMD, 219799000	DK	Danish Seine	57 40.8 N	08 50.5 E	238	0	5	5.8	Y		
18-04-23	06:35	Janni, HM96, OWFW, 219023588	DK	Trawler	57 33.6 N	08 39.6 E	53	3.4	308	3.5	Y		
18-04-23	06:40	Rosa Sofie, HM222, XP4080, 219006092	DK	Danish Seine	57 33.4 N	08 30.4 E	178	7.6	288	7.7	Y		
18-04-23	08:00	Jan De Wit, UK157, PBHN, 244880000	NL	Beam tr.	57 22.1 N	08 32.2 E	78	5.9	200	6.1	Y		
18-04-23	10:30	Madsalune, RI566, OZZH, 219959000	DK	Trawler	57 28.0 N	08 30.6 E	282	9	68	3	Y		
18-04-23	17:56	Montana, H273, OZOC, 220205000	DK	Trawler	57 19.3 N	08 56.5 E	228	8	39	6.8	N		

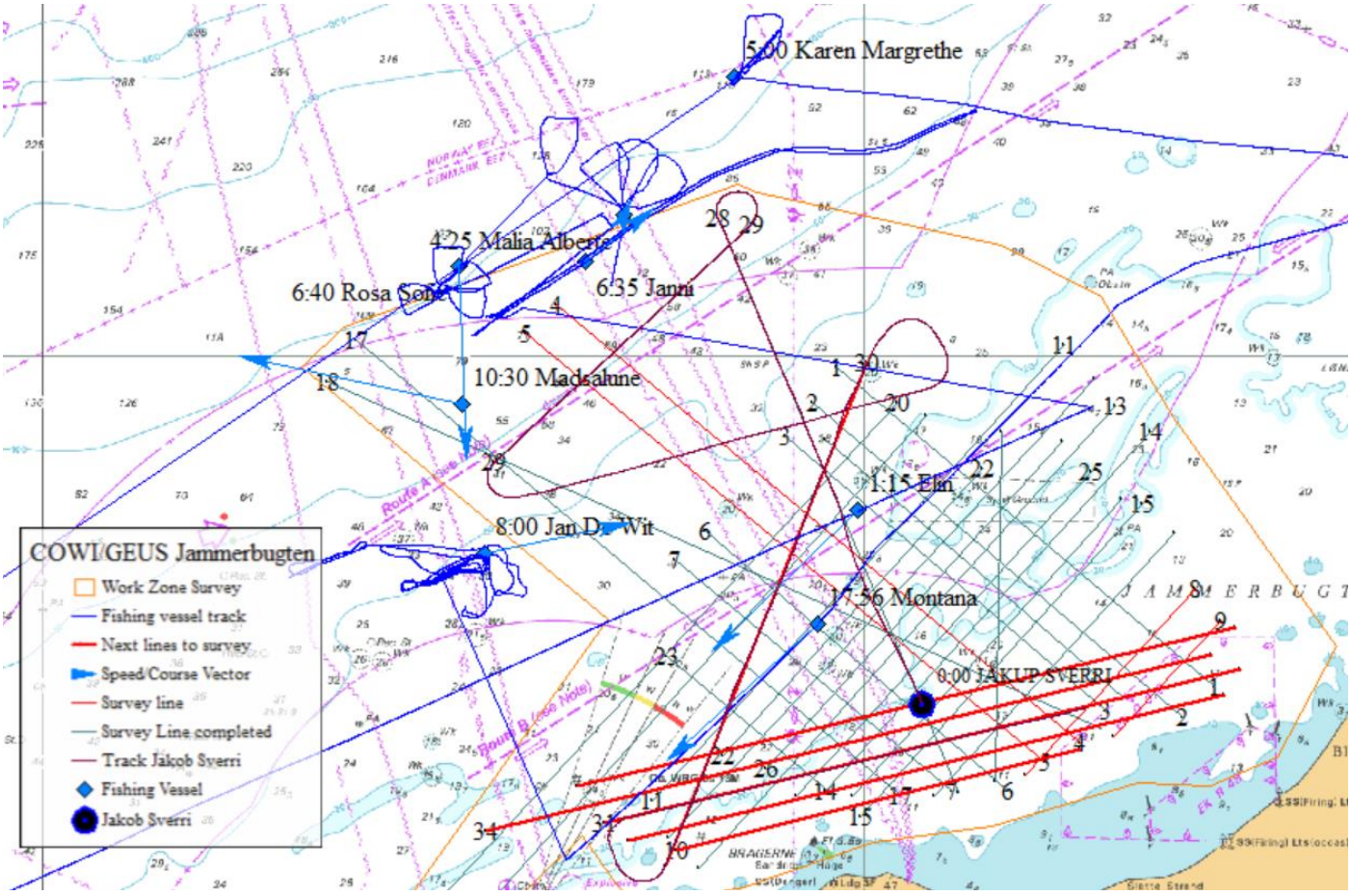


Figure 44 Vessels April 18 (Note track of Danish Seiner)

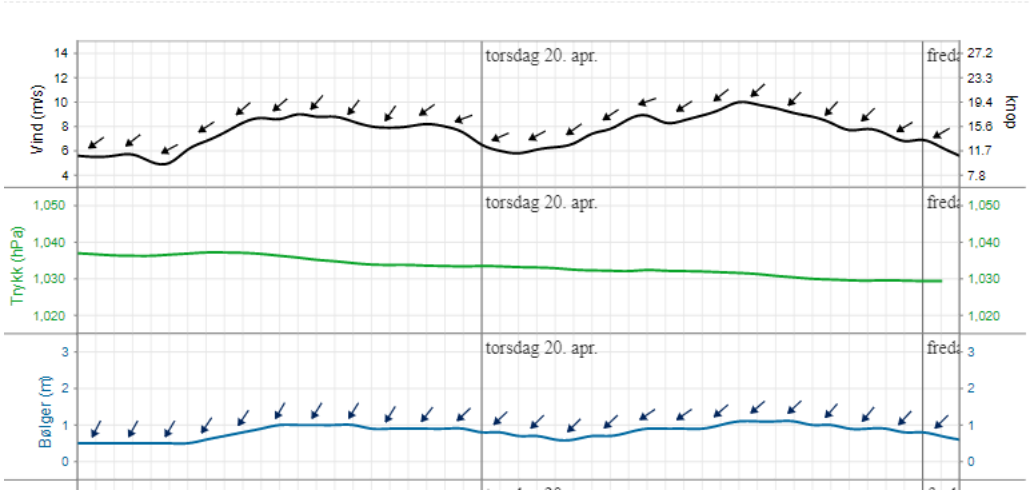
APRIL 19, 2023

00:00 Jakup Sverri in production

Position and weather

- Position 57.267215° N - 9.269447° E

A high, more than 1040 hPa, over central Scandinavia is moving a little towards west, and dry and gradually a little colder air is moving down over Denmark and the waters from northeast.



16:55 Mail to mailing list of progress and plan.

Figure 45 Collage of some of the gill netters today

FISHING ACTIVITY

VHF contact to a Danish Seiner in transit to give safety info. Much fishing activity along the coast of gill netters. They are fishing in less than 10-meter dept well clear of Jakub Sverri. Mobile contact with Danish Seiner Inger Kristine to give info. Very cooperative.

FISHING VESSELS

Date	Time	Name Harbor no. Call Sign MMSI	Nationality	Type	Latitude	Longitude	Course deg.	Speed	Bearing	Range	Fishing Y/N	Contact	Remarks
19-04-23	03:55	Mette Juhl, HM84, OUQE, 219002464	DK	Danish Seine	57 12.3 N	09 10.0 E	20	7.1	194	5	N	VHF	Safety info given
19-04-23	05:40	Mille, T18, OU8281, 219030200	DK	Gill net	57.10.1 N	08 52.1 E	73	6.6	196	5.2	N		
19-04-23	05:45	Christine, HM22, OYFA, 219024924	DK	Gill net	57 09.5 N	08 46.1 E	81	7.2	220	7.2	N		
19-04-23	08:30	Birgit, SG36, OU6417, 219009464	DK	Gill net	57 07.0 N	08 48.0 E	51	0.4	130	5.2	Y		
19-04-23	10:20	Ida Emilie, HM42, XP4450, 219001587	DK	Gill net	57 08.0 N	09 03.4 E	8	1	119	4.8	Y		
19-04-23	12:22	Em Olsen, HM94, OZYA, 219001204	DK	Gill net	57 09.8 N	09 14.3 E	20	7.1	194	5	Y		
19-04-23	12:24	Goliat, HM 92, OXPU, 219028381	DK	Gill net	57 10.0 N	09 19.8 E	270	4.8	132	6.2	Y		
19-04-23	14:16	Tenna, FN111, XPA4274, 219025478	DK	Gill net	57 20.0 N	09 38.6 E	30	5.5	63	8	Y		
19-04-23	14:17	Inger Kristine, HM17, OU 3620, 219005909	DK	Gill net	57 16.5 N	09 32.8 E	34	2.4	89	4	Y	Mobile	Info given
19-04-23	14:18	Vera Marie, S15, XP2671, 219011136	DK	Gill net	57 15.4 N	09 32.0 E	249	3.3	107	3.7	Y		

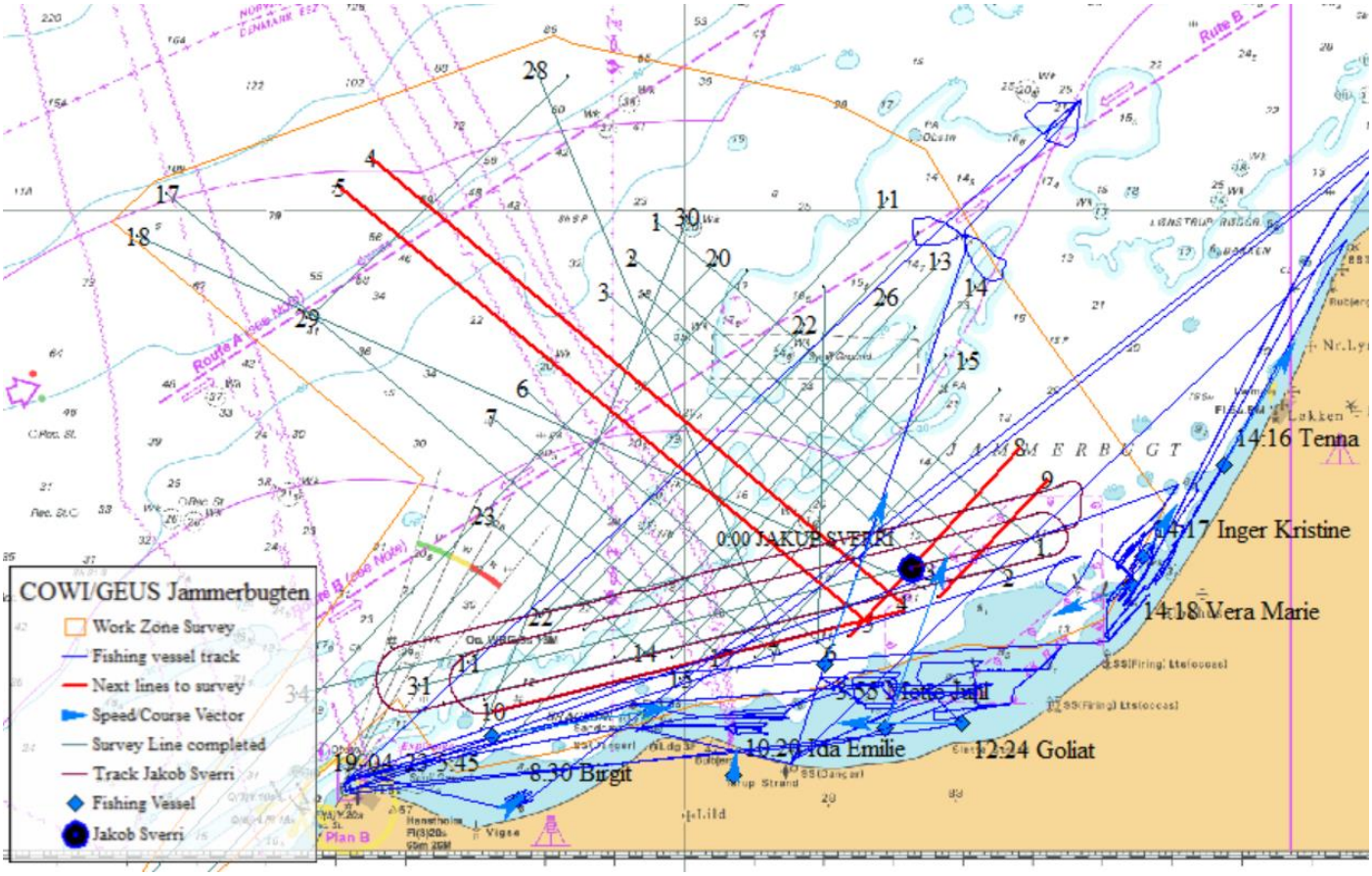


Figure 46 Vessels April 19

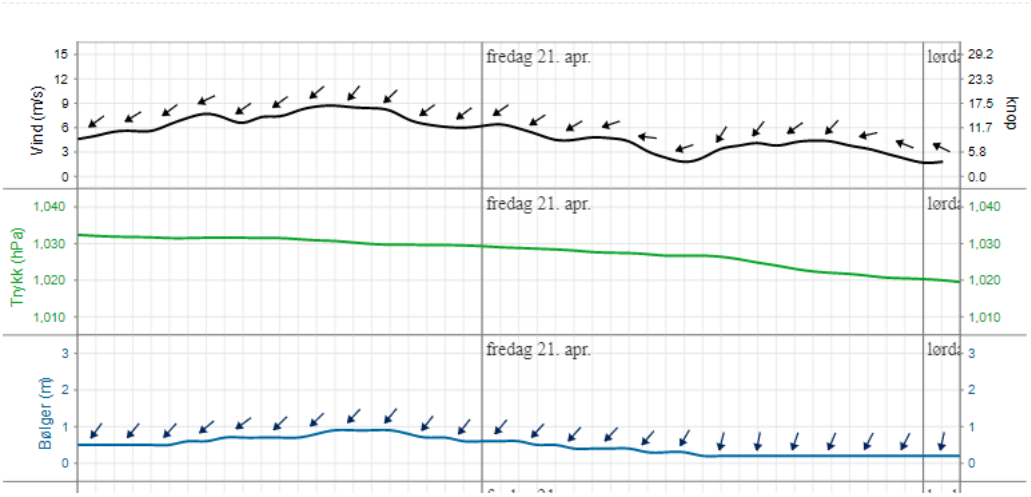
APRIL 20, 2023

00:00 Jakup Sverri in production

Position and weather

- Position 57.229258° N - 9.179053° E

A stationary high, 1040 hPa, over Shetland islands. Northeasterly flow of dry air over the Danish waters, however with light rain over the Baltic Sea.



13:14 End of last line. Start recovering of gear.

17:36 All gear onboard.


Figure 47 Fishing vessel Rosa Sofie

Figure 48 Streamer recovery

21:15 Jakup Sverri heading for Hirtshals.

FISHING ACTIVITY

In the morning the coastal fishermen start working but we are heading NW in line five so no problem for the survey. In the western part of the survey area, we meet different kind of vessels, both twin rig trawler, Danish seine and sandeel trawlers. The four sandeel trawlers were very cooperative after contact on VHF.

FISHING VESSELS

Date	Time	Name Harbor no. Call Sign MMSI	Nationality	Type	Latitude	Longitude	Course deg.	Speed	Bearing	Range	Fishing Y/N	Contact	Remarks
20-04-2023	00:30	Mikamale, HM8, OU2181, 219005778	Dk	Gill net	57 10.3 N	09 22.9 E	209	4.9	130	5.8	Y		
20-04-2023	01:21	Randi, O159, OZNS, 220368000	DK	Trawler	57 23.3 N	09 19.6 E	237	7.9	355	6.9	N		
20-04-2023	07:55	Lis Hansa, R86, OU6679, 219002506	DK	Trawler	57 25.8 N	08 41.2 E	39	2.8	292	5.8	Y	VHF	
20-04-2023	08:00	Hanne, H10, OU7604, 219004128	DK	Trawler	57 24.9 N	08 39.1 E	52	2.7	279	6.5	Y	VHF	
20-04-2023	08:15	Silje-Sofie, S123, XP3776, 219007034	DK	Trawler	57 24.8 N	08 37.3 E	47	2.6	292	5.8	Y		
20-04-2023	08:20	Amalie Benjamin, A59, OYKB, 219005867	DK	Trawler	57 24.4 N	08 39.1 E	56	2.5	259	6.5	Y		
20-04-2023	10:00	Rosa Sofie, HM222, XP4080, 219006092	DK	Danish Seine	57 32.9 N	08 41.2 E	26	3.8	24	0.4	Y		
20-04-2023	10:10	Malia Alberte, L40, OWNV, 219001588	DK	Danish Seine	57 39.2 N	08 42.4 E	28	8.5	350	0.7	Y		
20-04-2023	10:30	Janni, HM96, OWFW, 219023588	DK	Trawler	57 40.2 N	08 51.8 E	47	13	87	3.4	Y		
20-04-2023	16:50	Inger Kristine, HM17, OU 3620, 219005909	DK	Danish Seine	57 16.1 N	09 13.3 E	249	7.7	162	5.5	N		

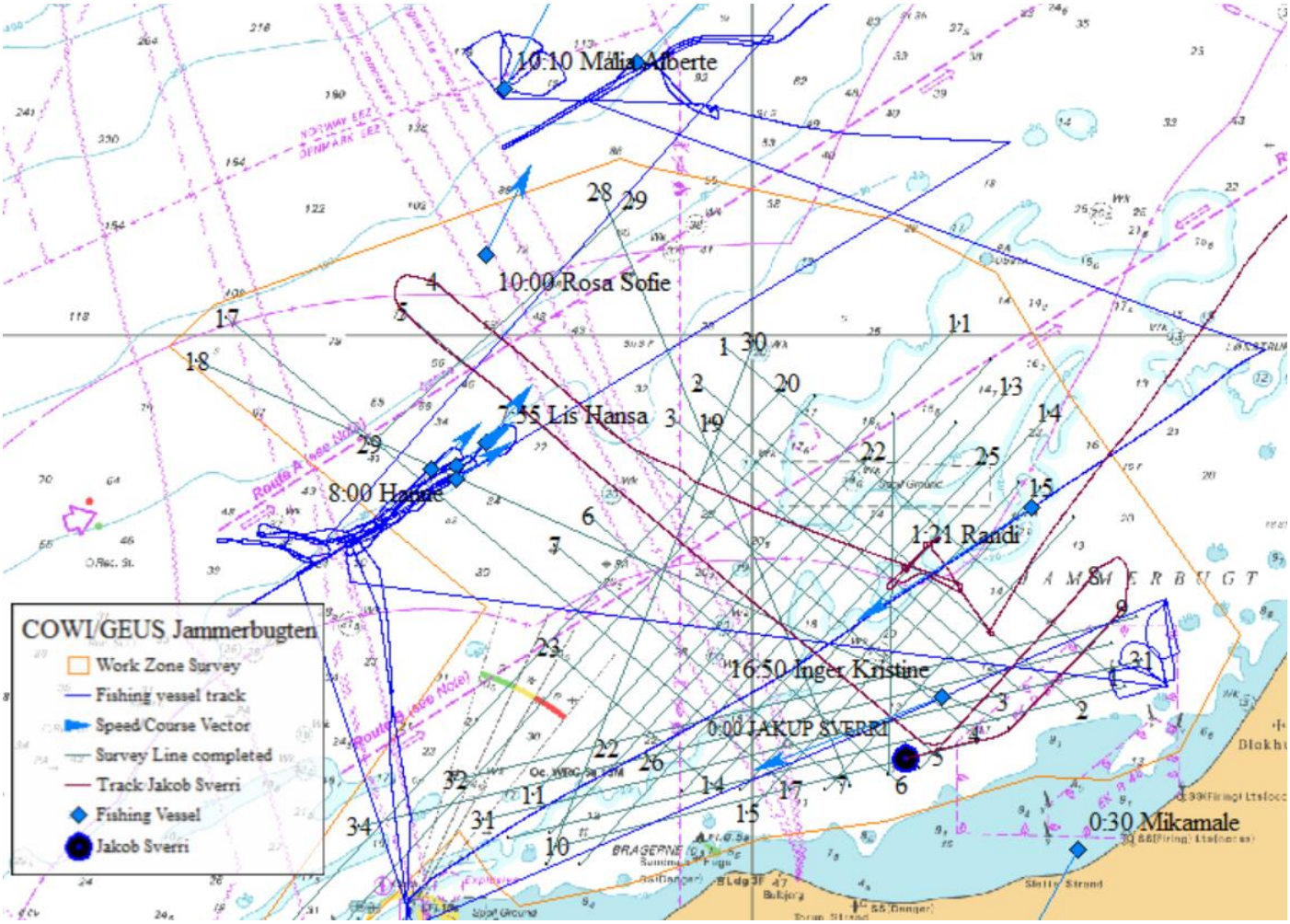


Figure 49 Vessels April 20

APRIL 21, 2023

00:00 Jakup Sverri in transit to Hirtshals.

00:45 Jakub Sverri alongside in Hirtshals.

09:35 Mail update to mailing list that Jakup Sverri alongside in Hirtshals.

FISHING VESSELS

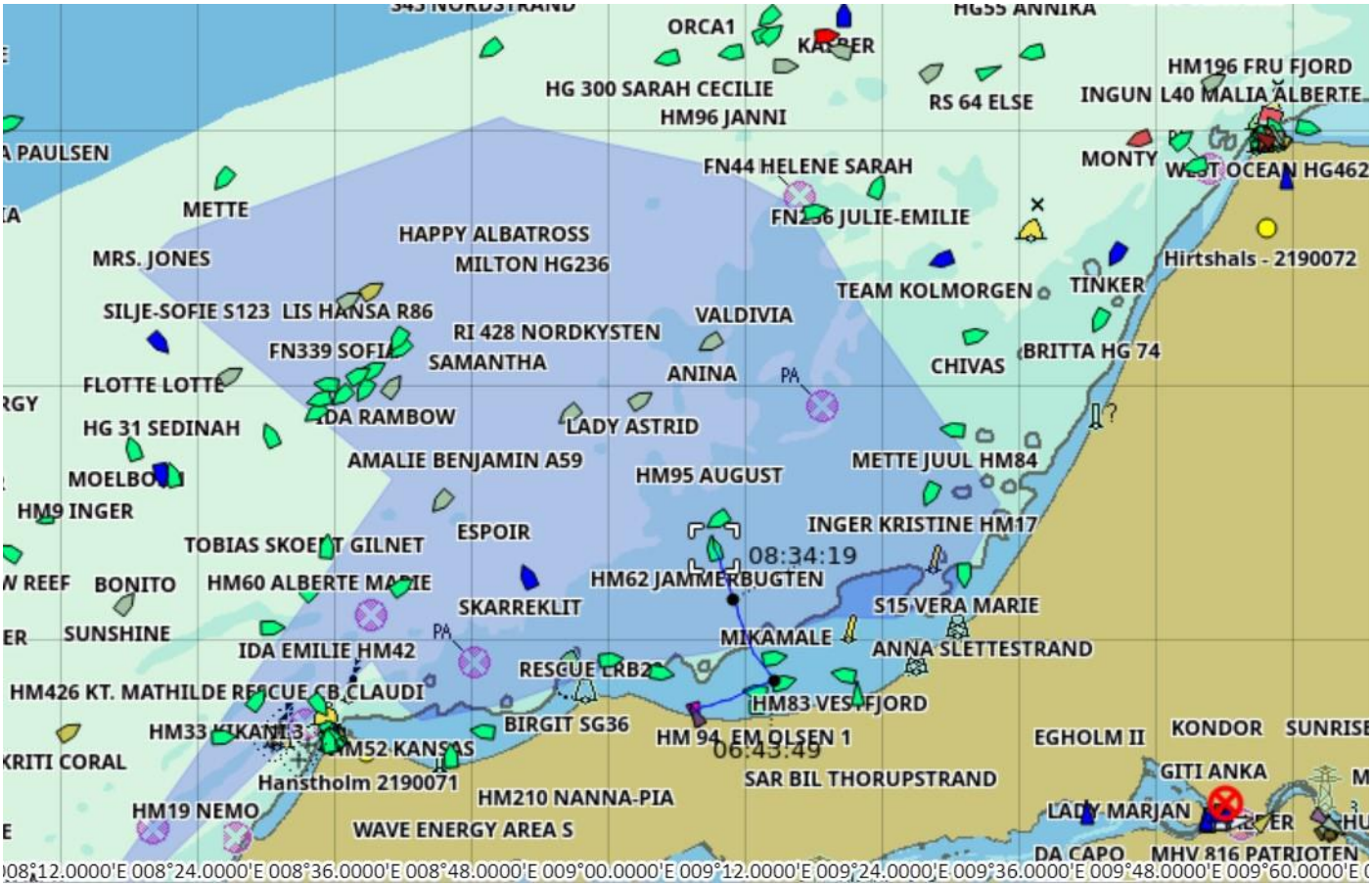


Figure 50 Web-Ais the fishing vessel are returning to area. (Green = Fishing vessel)

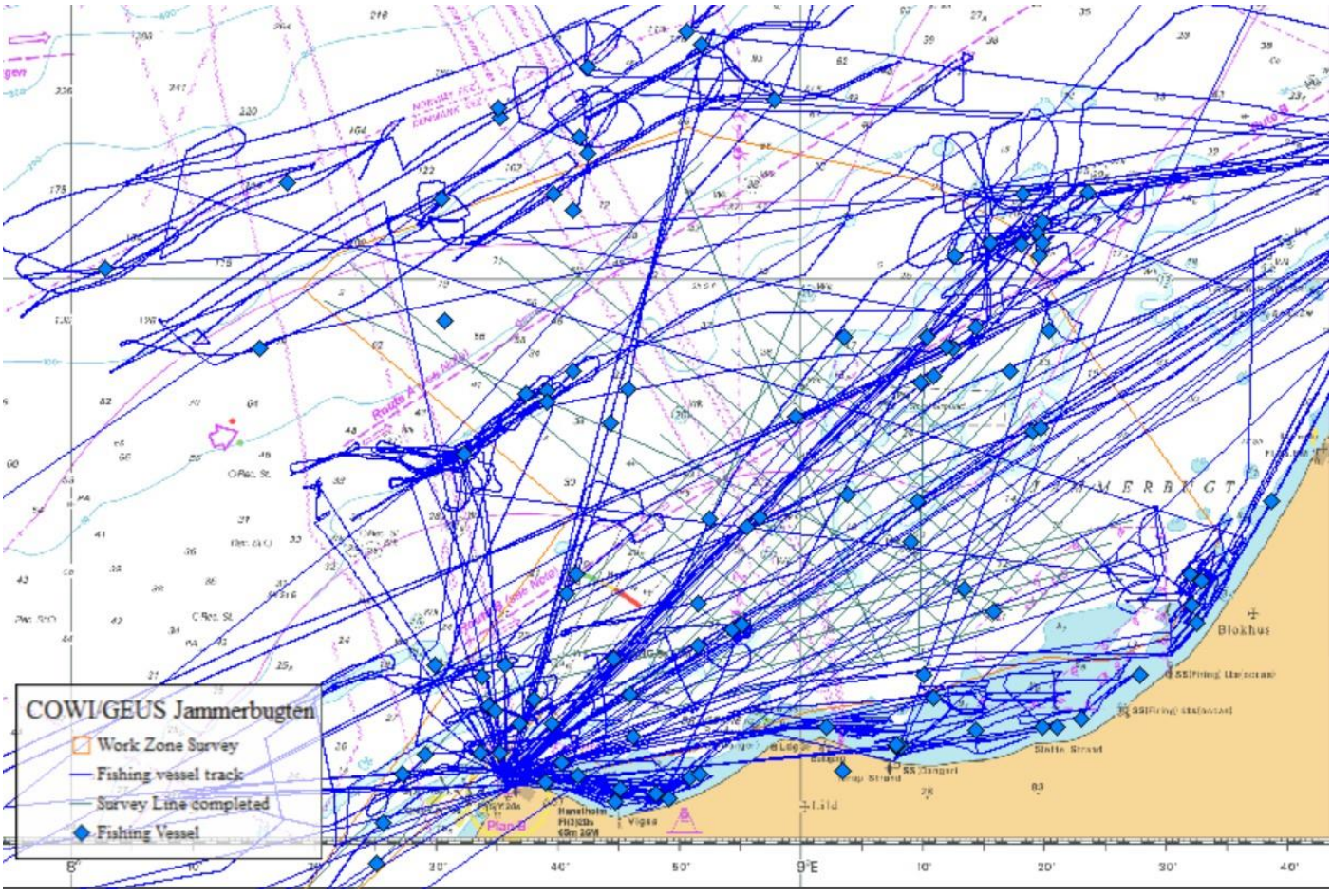


Figure 51 Fishing vessels and tracks April 10 - April 20