Hirtshals, 20 August 2022

Cruise report

R/V DANA Cruise 03/2022

International Ecosystem survey in the Nordic Seas (IESNS) in 2022

Calibration of Echo-sounders

22 – 24/4 2022

Acoustic Monitoring of Herring and Blue whiting in the Norwegian Sea

25/4 – 20/5 2022

Cruise participants

Calibration 22 – 24 April

Susan Mærsk Lusseau	Denmark (Cruise leader)
Torben Filt Jensen	Denmark
Eik Ehlert Britch	Denmark
Christian Skou Petersen	Denmark
Luiza Reis de Souza	Brazil

Acoustic monitoring part 1. 25 April – 5 May

Susan Mærsk Lusseau	Denmark (Cruise leader)
Torben Filt Jensen	Denmark
Beanne Snaar	Netherlands
Gert Holst	Denmark
Peter Vingaard Larsen	Denmark
Axel Hjelm	Sweden
Eik Ehlert Britch	Denmark
Jan Werner Thomsen	Denmark
Luiza Reis de Souza	Brazil

Acoustic monitoring part 2. 6 May – 20 May

Matthias Kloppmann	Germany (Cruise leader)
Serdar Sakinan	Netherlands
Sven Gastauer	Germany
Jan Werner Thomsen	Denmark
Christian Skou Petersen	Denmark
Jakob Looström	Sweden
Karl Bentley	Ireland

Cruise timeline

22 April 2022	12.00 UTC*	Departure Hirtshals, Denmark, towards Grønsfjorden, Norway
23 April 2022	05:15	Arrive Grønsfjorden, start calibration
24 April 2022	16:00	Calibration finished, depart towards Risavika, Norway
25 April 2022	05:00	Arrival Risavika for crew change
	08:00	Departure Risavika towards survey area
26 April 2022	10:36	Start monitoring Part 1
04 May 2022	20:39	Stop monitoring Part 1, depart towards Bodø, Norway
05 May 2022	12:00	Arrive Bodø, Norway for crew change
07 May 2022	19:00	Depart Bodø towards survey area
08 May 2022,	08:01	Start monitoring part 2
16 May 2022,	17:50	Monitoring finished part 2, departure for Hirtshals
20 May 2022,	14:00 UTC*	Arrival Hirtshals, end of survey

*All times in UTC. Local time = UTC + 2.

Cruise summary table

Survey days	29	
Mileage	Transit for calibration	102 nm
	Transit to Risavika	90 nm
	Transit to start transects part 1	216 nm
	Transit to Bodø	149 nm
	Transit to start transects part 2	106 nm
	Transit to Hirtshals at end survey	894 nm
	Acoustic transects (including intertransects)	2670 nm
	Total	4073 nm
Number of trawl hauls	20	
Number of CTD stations	36 (+ 5 during calibration)	
Number of WP2 stations	35	
Number biological samples – herring	257	
Number genetic samples - herring	227	
Number biological samples – blue whiting	848	
Number biological samples - mackerel	168	

The cruise track and the sampling positions are shown in figure 1.

Introduction

The Norwegian spring spawning herring is a highly migratory and straddling stock carrying out extensive migrations in the NE Atlantic. After spawning, the main spawning areas being along the Norwegian west coast from 62°N to 65°N in February – March, the herring migrates NW-wards towards the Norwegian Sea feeding grounds. In general, the main feeding has taken place along the polar front from the island of Jan Mayen and NE-wards towards Bear Island. During the latter half of the 1990's there has been a gradual shift of migration pattern with the herring migrations shifting north and eastwards. In 2002 - 2004 this development seems to have stopped and the herring had a more southerly distribution at the end of the feeding season than in 2001. After feeding, the herring concentrated in August in the northern parts of the Norwegian Sea prior to the southern migration towards the Vestfjord wintering area (68°N, 15°E). Since the winter 2002-2003 most of the stock seems to winter in the Norwegian Sea off Lofoten. In January the herring start their southerly spawning migrations.

Besides herring, abundant stocks of blue whiting and mackerel exploit the Norwegian Sea as an important feeding area. The blue whiting stock is currently supporting one of the largest fisheries of the Northeast Atlantic. The main spawning areas are located along the shelf edge and banks west of the British Isles. The eggs and larvae drift both northwards and southwards, depending on spawning location and oceanographic conditions. The northward drift spreads juvenile blue whiting to all warmer parts of the Norwegian Sea and adjacent areas from Iceland to the Barents Sea. Adult blue whiting carry out active feeding and spawning migrations in the same area. Blue whiting consequently has an important role in the pelagic ecosystems of the area, both by consuming zooplankton and small fish, and by providing a resource for larger fish and marine mammals.

Background and objective of the survey

This survey is carried out in order to investigate distribution and migrations of the Norwegian Spring Spawning herring, blue whiting and other pelagic fish, and to produce a biomass index for herring and a recruitment index for blue whiting for the Working Group on Widely Distributed stocks (WGWIDE). Furthermore hydrographic conditions and plankton abundance in the Norwegian Sea and adjacent waters are monitored in order to investigate how distribution and migration of herring and other pelagic fishes are influenced by environmental conditions.

This survey was coordinated with Norway as an international survey with participation of Norway, Iceland, Faroe Islands and the EU, where the Danish R/V Dana conducted the EU survey part. With the exceptions of 2002 and 2003 the survey has been carried out since 1997 with participation of EU countries together with Norway, Russia, Iceland and the Faeroese Islands.

Calibration

The echo sounders were calibrated immediately before the survey Grønsfjorden, Norway during the 23th and 24th April 2022. The calibration was performed according to the standard operation procedures as described in the WGIPS manual for three frequencies (18, 38 and 120 kHz). The calibrations of the towed body split-beam transducer at 38 kHz and the three hull-mounted split-beam

transducers at 18, 38, and 120 kHz were conducted against a 38.1mm tungsten carbide sphere. The resulting calibration parameters are shown in Annex 1 and were used during the subsequent survey.

Materials and methods

Acoustic data

Acoustic data was collected with the EK60 using a 38 kHz splitbeam transducer, mounted in a towed body (paravane). During the acoustic survey along transects, echo integration was conducted continuously and the data was scrutinized using the LSSS software. During trawling, the EK60 using the hull mounted 38 kHz transducer was used to visualize the echo traces but the data were not logged. The echo sounder data during trawling were only informative for the scrutinizing process.

A biomass estimate will not be carried out based on data of this cruise alone, but the data will be included in the survey's database from all IESNS participating vessels from which a biomass index will be calculated. The final estimate methodology is presented at the remote post cruise meeting 14-16 June 2022 and in the WGIPS report of January 2023.

Similar to previous years, inter-transects were skipped, i.e. the towed body was hoisted up at the end of each transect and the distance to the next transect was travelled without echo integration. On reaching the next transect, the towed body deployed again and a new integrating section was started.

Hydrographical and zooplankton data

At fixed positions, determined by ICES WGIPS, CTD casts were carried out to a maximum depth of 1000 m or 5 m above the seabed with a Seabird CTD and rosette water sampler. The following parameters were measured: pressure (depth), temperature, conductivity (salinity) and oxygen. Each day, one water sample was taken at 1000 m and one in a shallower layer for calibration of the CTD's conductivity sensor.
Plankton samples were taken at predetermined positions by means of vertical tows from 200 m or 5 m above the seabed to the surface with a WP2 equipped with 180 µm mesh. The biomass samples were oven-dried in size-class fraction of > 2000 µm, > 1000 µm, and > 180 µm, respectively, on board at 70 °C for 24 hours, and subsequently frozen for later dry weight determination at DTU Aqua.

Due to delay caused by poor weather it was decided to drop 7 of the planned CTD and WP2 stations on transects 5 and 6 on part 1 of the cruise. One CTD station (wpt26 on transect 3) failed due to an electrical fault in a connecting cable. All together 36 CTD and 35 successful WP2 stations were carried out (Table 1, Figure 1)

Additionally, sea surface temperature, salinity and fluorescence were continuously monitored from the ship's bow intake and were stored along with information on meteorological conditions (e.g. wind direction, wind speed etc.) utilizing R/V Dana's hydrographic and meteorological data collection system.

Biological data

During the survey, fishing was carried out regularly on acoustic registrations to verify the species composition and to give information about the size composition to be used in the biomass estimation. A pelagic "Fotø" trawl was used either at the surface or in midwater down to a maximum of 380 m depth (Table 2, Figure 1).

Catches were sorted and weighed by species. Length measurements were taken for all species. For herring, blue whiting and mackerel samples of 50 fish were also randomly taken in order to determine individual length to weight relationships as well as sex and maturity. For age determination in herring and blue whiting, otoliths were taken from those 50 individuals, each, and will be read at DTU Aqua. In total 257 individual herring, 848 blue whiting and 168 mackerel were sampled.

Additionally tissue sampling for genetic analysis from 227 herring in 6 stations were collected on request from WGIPS for use in stock discrimination of herring in the IESNS survey. This was the first year genetics were sampled systematically across the survey area.

All trawl data were entered into the DTU database "Fiskeline" and validated. The data were also stored in the PGNAPES formats and will be uploaded to the PGNAPES database at the Faeroes Institute of Marine Research at the end of the survey. This year the data from the survey will also, as last year, be available on the ICES acoustic trawl surveys database (https://www.ices.dk/data/data-portals/Pages/acoustic.aspx).

Logbook *(as reported to coordinator during the survey)*

27-4-2022 Dana is presently at **62 16.82N, 01 36.94W** and nearly at the end of the first transect. We have had lovely weather and been following a continuous layer of blue whiting almost since the start of this transect. We had three trawl stations since we started the transect:
Station 10. 26-4-2022 19:16UTC. Position 62 22.26N, 02 33.91E. Blue Whiting 28.5kg (mean length 18cm), 3kg mixed Risso's barracudina (*Arctozenus rissoi*), pearlsides (*Maurolicus muelleri*) and lanternfishes (*Notoscopelus kroyeri and Benthosema glaciale*).
Station 11. 26-4-2022 23:02UTC. Position 62 20.94N, 01 57.06E. Mackerel 10.3kg (mean length 31cm), Herring 4.3kg (mean length 29.5cm), Blue whiting 2.3kg (mean length 20cm)
Station 14. 27-4-2022 06:48UTC. Position 62 20.65N, 00 37.17E. Blue whiting 371kg (mean length 18cm), 2kg mixed Risso's barracudina and lantern fishes.

28-04-2022 Dana is presently at **62 55.42N, 01 51.38E** sailing East on the second transect. We have had two trawls since last night:
Station 17. 28-4-2022 00:37UTC. Position 62 45.00N, 02 01.43W
We hauled in the surface just before the start of the transect as we had seen some suspected herring along the intertransect. This yielded 6kg mackerel, some small (18cm) and the rest large (34-39cm). 6kg blue whiting (21cm mean) and 44 kg herring (31cm mean).
Station 20. 28-4-2022 10:51UTC. Position 62 53.56N, 00 14.53E. We had been seeing small hard herring marks on and off along the transect in 20-40m depth and when we stopped for the CTD at WP11 we came upon some large herring mark in 50-100m. We fished from surface to 70m depth. Herring 1000kg (31cm mean) and 500kg mackerel (mean 34cm). Would have been nice to have the larger marks on the recorded transect, but at least we know they are here!

29-04-2022 Dana is presently at **64 2.67N, 4 44.55E** and have just started the third transect going west this afternoon. We did not see anything exciting since the last trawl station yesterday and have spent much of today going between transects in fine weather. We have completed all planned CTD stations on the two completed transects.

30-04-2022 Dana is presently at **64 26.24N, 0 18.44W**. We finished the third transect and are just about to start the fourth this evening. We have seen quite a bit of blue whiting all along the middle of this transect. Not much herring action today. Two hauls with a total of 4 individual herring:
Station 29. 29-04-2022 23:11UTC. Position 64 02.06N, 02 58.90E. Surface haul at night.
Blue whiting 25kg (two distinct sizes ml 18cm and ml 23cm), Mackerel 23kg (2 distinct sizes: ml 33 and 18cm), Herring 3 individuals (ml 32cm).
Station 32. 30-04-2022 08:52UTC. Position 64 01.63N, 00 42.03E. Daytime at 275m.
Blue whiting 732kg (same as before, two distinct sizes at 18 and 23cm), herring 1 individual (ml 29.5cm).

01-05-2022 Dana is presently at **64 36.14N, 5 02.35E**.
We have nearly completed the fourth transect now and have had two hauls since last night. The first haul we had a lovely dense layer of herring in 30m depth running for several miles. We fished and caught 2T of the largest herring I have ever seen! I measured one at 38.5cm!
Second haul we had been following a strong layer in 300m for several miles with occasionally very strong schools of something in it. My initial thoughts were that these were really dense aggregations of blue whiting within a less dense layer of the same, but trawling through several of these we had no indications on the trawl sounder of catching anything. In the end we had an OK haul of blue whiting (but nothing compared to what we thought we would have) and large amounts of small mysid shrimp in the meshes and on the trawl deck.
Station 37. 30-04-2022UTC. Position 64 34.73N, 00 32.06E. Surface haul at night. Herring 2335kg (ml 32cm), Blue whiting 10kg (ml 20cm).
Station 40. 01-05-2022 09:42UTC. Position 64 36.51N, 03 13.83E. Daytime at 300m. Blue whiting 216kg (ml 20cm), 2 individual herring (31.5cm).

02-05-2022 Dana is presently at **65 07.36N, 07 34.99E** and waiting out the weather. We finished transect 4 last night and have spent today slowly making our way north to the next transect in pretty severe waves (up to 6m significant height still). We are still not able to continue the survey and are waiting at the start of next transect for conditions to improve.

03-05-2022 Dana is presently at **65 08.87N, 1 31.04E** and heading west. After the close to 24h involuntary weather break Dana started the fifth transect this morning at 0500. The large delay meant we are running out of time and we decided to prioritize getting as much of the transects completed at the expense of CTD stations and fishing before we have to head into Bodø. We have also with Are's help negotiated for Iceland to take on 60nm of the east end of our last transect before our stop in Bodø for the crew change on the 5-6th May. About an hour ago however the updated weather forecast has forced us to reconsider even further and I have been asked to cut this transect short too, so we will turn north at waypoint 41 and not cover the last 30nmi of this transect. This decision was made to try to get ahead of the large low pressure system coming this way over the next few days. The worst of it is now forecasted to hit us in the middle of the transect in towards Bodø and potentially both jeopardizing our ability to complete most of the transect but also risk not being able to reach Bodø in time for the crew change. By cutting this transect short we hope that we can manage both.

Along the transect we are currently on we have seen some thick deep layers at 300m most of the day. We are also just now passing over what looks like fairly large herring schools raising above the blue whiting layer with the dark in about 40- 50m depth now.

04-05-2022 Dana is presently at **66 13.70N, 7 34.37E** and nearly at the end of the last transect before the crew change break. It seems our gamble last night paid off and we will manage to complete this transect apart from the 60nmi in the west that Iceland will hopefully have time for covering. The weather has been increasingly challenging, but we will finish the transect before it gets really tough. The quality of the data we have collected is obviously not perfect, but does not look too bad. We have had a continuous layer in 200-300m most of this transect with occasional stronger more defined marks a little above it. Unfortunately we were not able to carry out fishing operations due to weather and time constraints. As soon as this transect is completed we will go directly to Bodø and hopefully get in ahead of the worst of the weather.

05-05-2022 Dana finished the last transect at 20:39 UTC last night in pretty heavy weather. We did manage to continue recording until the very end. Data recorded was affected but still useable. Dana is now in Bodø and was scheduled to leave tomorrow afternoon. The weather forecast for Saturday and Sunday are not good so some delays in departure for the second part is expected. I will leave the survey here in Bodø and hand the reins to Matthias Kloppmann for the second part. He will keep you updated from now on.

06-05-2022 No progress to be reported for today as Dana will stay in Bodø until Sunday morning 04:00 UTC to shelter from a passing storm, which is about to hit our survey area tonight until tomorrow late evening. This delay of about 39 hours will almost certainly use up most of our time reserved for fishing with the current cruise plan. We will, however, carry on with executing the survey as planned starting with transect 10 of stratum 2, including all CTD/WP2 stations and trawl on reasonable targets.

07-05-2022 not much progress to talk about today other than that we will be sailing this evening at 19:00 UTC and hope to be in place for the first CTD/WP2 station tomorrow morning around 05:00 UTC.

08-05-2022 We started on transect 10 of stratum 2 this morning on waypoint 82 with our first CTD/WP2 station of the second cruise leg. Not very long after our start along that transect we started registering fish concentrations close to the seafloor at about 350 m depth with another layer at about 300 m appearing as soon as the bottom depth dropped to 400 m. We decided to fish on this layer starting on 67 17.9N, 009 00.1E, headline depth varying between 260 and 345 m. The catch yielded 5.8 kg blue whiting, mean length 17.6 cm, 4.1 kg herring, mean length 29.3 cm, about 500 g Krill and a few mesopelagics: *Maurolicus muelleri*, *Notoscopelus kroyeri* and *Benthosema glaciale*.
We continued on the transect towards WP 80 where in the afternoon we registered some very distinct echoes at about 350 m. Again, we decided to fish on these registrations. The trawl started at 67 19.7N, 007 59.9E. Unfortunately, the trawl geometry was apparently unclear with an apparent too low vertical net opening. The haul, however yielded 5.7 kg blue whiting, mean length 17.8 cm, and 1.7 kg herring, mean length 30.4 cm as well as some mesopelagics and krill.

09-05-2022 We continued along transect 10 of stratum 2 and did our last CTD station on this transect a short while ago. We are now at 67 23.6N, 002 13.8E heading towards the end of the transect. The schools we fished on last afternoon continued for a couple of miles and rising slowly to depth < 300 m. At about 20:30, however, we observed quite a large school stretching between 50 and 100 m depth. Considering it would be herring, we fished on it starting at 67 20.8N 007 25.2E. The haul yielded to our surprise a clean catch of 104 kg blue whiting, mean length 17.6 cm.
We did another haul later that day on a number of smaller but very distinctive schools, but at greater depths between 230 and 270 m at 67 23.5N, 002 58.0E. Though we encountered some of those schools on our trawling track, we didn't manage to catch any of them, unfortunately.
We will complete transect 10 of stratum 2 tonight and steam northeastwards towards transect 2 of stratum 4, which we will (hopefully) reach tomorrow, early morning.

10-05-2022 In the morning around 05:00 UTC, we started this transect at WP 8 with the usual CTD and WP2 casts. During our approach and during the CTD station itself we started registering strong signals at depths between 100 and 150 m. After we put the towed body in to start recording on the transect, these registrations of distinctive schools continued, with intensive echoes varying between 100 and 200 m depth. After a few miles of continuation of these registrations, we decided to take the towed body back in and try to get a sample from these schools. The haul started at 68 12.1N, 003 05.3E, aiming at headline depths between 150 and 200 m. The catch was about 705 kg and consisted almost entirely of juvenile blue whiting, mean length 18.1 cm. We also got 0.5 kg herring (3 individuals: 27.0, 29.0 and 33.5 cm). During the late afternoon, distinct small schools at about 300 m were observed once more.

11-05-2022 At 13:15 UTC, we completed our part of transect 3 in stratum 4 at WP 15 and are now on our transit to transect 4, WP 20.
We didn't see much worth fishing for, apart from the now usual distinct small registrations around 400 m depth. During the night at 68 23.2N, 008 18.5E we did a haul close to the surface - headline depth varied between 15 and 20 m. We caught 3 small herring, 0.1 kg, 2 x 16.5 cm and 1x 18.5 cm total length.
For the rest of the transect there were no further opportunities for fishing. At 20:58 UTC, we started on waypoint 20.

12-05-2022. Scattered small schools of presumably blue whiting continued to appear at depths between 200 and 300 m almost along the entire transect until just recently, when these registrations stopped as we headed into the colder waters of (sub)-arctic origin.
We did one trawl haul yesterday at the beginning of the transect at 22:57 UTC at 68 54.3N, 007 42.5E. We set our headline to depths varying between 150 and 200m, targeting two very distinct schools at this depth range, which we hoped could be herring. Though we didn't hit any of those schools, unfortunately, the catch still yielded almost 5 kg of herring, mean length 26.8 cm, and 16 kg blue whiting, mean length 19.2 cm.
We are about to complete our small part on transect 2 of stratum 4 in about an hour at waypoint 24, after which we head northwards towards transect 3. We started our penultimate transect yesterday evening, 19:16 UTC.

13-05-2022 During the night, winds and waves picked up considerably. So we had to slow down our speed along the transect. In the early morning hours, we saw a few small but very distinct marks on the echosounder and decided to do a trawl haul on them. The haul started 04:46 UTC at 69 22.4N,

005 19.0E with the headline between 250 and 300 m. Though we didn't exactly hit any of those schools, we caught 14.8 kg of blue whiting and one herring. Blue whiting mean size was 21.0 mm, the length distribution ranged between 15 and 31 showing two modes: one at 18 cm and another at 21 cm. The herring was 21.5 cm long.
After the fishing station, we continued towards the CTD/WP2 station at waypoint 27. Before reaching that waypoint, we realized that though recording was activated, the computer didn't store the data. Consequently, after completion of the CTD/WP2 station, we had to go back to the point, where we started the recording after the last fishing station and repeat that part of the transect.
We are now at 69 26.8N 007 53.3E heading towards our next CTD station. Up until now, registrations were rather scarce with just single small, very isolated schools appearing now and then at depths between 100 and 300 m.

14-05-2022 We are now at waypoint 34 of stratum 4 and are about to haul in the net from trawl at a continuous layer, which we observed for a couple of miles on our way here, between >350 and 300 m depth. Apart from this haul, we didn't see anything on the echogram worth fishing for.
About the results of this haul, I will inform you tomorrow. After this haul is in, we will continue toward, waypoint 35, do the CTD/WP2 station there and then head towards our last transect.

15-05-2022 We started this morning on our last transect (no 6 of stratum 4) on waypoint 59. Not long after our first CTD/WP2 station and while passing the slope, we encountered a distinct layer at 370 - 390 m depth, which we targeted with our trawl at 70 30.9N, 017 11.3E. Unfortunately, the trawl opening was not as desired. However, we caught almost 50 kg of small blue whiting, mean size 17.5 cm.
The layer continued for a couple of miles and is visible now still, though not as pronounced. Our current position is 70 31.1N, 15 20.0E. We are now approaching the next CTD/WP2 station at waypoint 56, which we will reach in about an hour.
The catch of last night gave 322 kg blue whiting, mean length 18.6 cm, a few saithe, haddock and one cod.

16-05-2022 About 1.5 hours ago, we completed the CTD/WP2 station at waypoint 52 and are now steaming towards waypoint 51 while recording echo registrations. There, we will have to terminate our program and start our trip home to Hirtshals.
This morning, we observed a layer of scattered but distinct schools at depths between 300 and 350 m and decided to trawl on these. We started the haul at 70 33.7N, 010 49.9E over breakfast this morning (05:30 UTC). The headline depth was kept at about 300 - 315 m. We caught 133.2 kg blue whiting, mean length 18.5 cm. Length distribution was bimodal, with modes at 17 and 21 cm length classes. There was also 1 herring, 19 cm.

Results

Conditions during the survey
The calibration on 23-24 April was carried out in fine weather. The transit from Risavika to the start of the first transect however took 6 hours longer than anticipated due to strong headwinds along the route. Otherwise the weather conditions were pleasant during the first part of the survey until 1 May, when a series of low pressure systems developed over mainly the eastern part of the Norwegian Sea. The combination of wave height (5-6m) raised by high sustained winds of 20-25m/s winds and wave direction (from the North and therefore perpendicular to the transect direction) caused a considerable

delay to the survey. From 01/05/2022 23:00UTC to 03/05/2022 05:00 the vessel was not able to safely sail in the transect direction due East with the towed body over the side. This delay necessitated to drop all CTD stations on the two last transects of part 1 and also an agreement with Iceland to cover 60nm of transect on the western end of transect 6. In the evening on 3rd May the forecast for the last two days of part 1 of the survey had deteriorated to the point where it was decided to cut short the second to last transect also (by 30nm) to ensure timely passage back to Bodø. The forecast at that point was for heavy seas with waves of 5-6m in from the South-East. The worry was that the pilot would not be able to board for the passage to Bodø. The decision paid off and Dana managed to finish transect 6 before heading to Bodø ahead of the worst of the weather.
Another low-pressure system, which passed the survey area on late Friday and Saturday, 6 and 7 May 2022, didn't allow for leaving Bodø as planned on 6 May at 15:00 LT. The start of the second survey part had to be postponed until the next day 21:00 LT. Though weather remained favorable for conducting the survey properly, the extended stay in Bodø couldn't be compensated and the last transect needed to be shortened.

Catch composition
The catch composition of all trawl hauls is presented in Table 3. Herring was the most abundant species, followed by blue whiting and mackerel. But this was only true when based on total catch. With respect to presence in the catches, blue whiting was encountered the most. Mackerel was present in four hauls: three in the surface layer and one in 70 m depth. All mackerel were caught in the southern part of the survey area. Mackerel mean length per haul ranged from 20.3 to 33.9 cm (Tab. 3). As usual, lanternfish and spotted barracudina were caught together with blue whiting in the deeper midwater tows. Mean length per tow for herring and blue whiting ranged from 17.2 to 32.2 cm and from 17.5 to 21.1 cm, respectively (Table 3). Blue whiting mean length < 20 cm was observed on more than 2/3 of all catches where the species occurred. In all other catches with blue whiting, however, their mean length was only just > 20 cm.

Distribution and density of target species

Herring
Distribution and densities of herring along the survey transects are presented in Figure 3.

Herring distribution was sparse compared to the pattern observed in 2021 and clear herring schools were rare in the second part of the survey. The majority of herring was observed in the upper 100 m of the water column in the southern part of the survey. The distribution was more concentrated in a few areas in the western area of the southern strata covered by Dana with a single higher density area in the south of the northern strata. Large schools observed in the blue whiting layer (200 - 400 m) that could have been mistakenly identified as herring, as well as many large schools in the upper 200 m of the water column observed in the second part of the survey, were validated to be blue whiting schools after fishing. Substantial herring catches were only present in the first part of the survey. Surface trawls in the second part of the survey contained very few herring.

Blue whiting
Distribution and densities of blue whiting are presented in Figure 4. Blue whiting was observed in large continuous aggregations in 200 – 400m depth, even extending into the upper 100 m, particularly

near the continental slope throughout the survey area. Compared to the 2021 survey blue whiting was significantly more abundant and even more widely distributed. In line with previous years, blue whiting was almost entirely absent from the furthest Northwestern area with the exception of 2021, while in 2022 blue whiting was observed even on the northern most part of the survey and throughout the entire survey area. A substantial number of schools that without catch validation would have been mistaken for herring schools turned out to be almost clean blue whiting schools.

Hydrographic conditions

Surface temperatures were between < 6 °C in the North and > 8.5°C in the Southwest. Overall, the pattern of surface temperature distribution was comparable to those of last year in the same area: warmer waters in the South, colder waters in the North and West (Figure 5). Temperature and salinity distributions clearly illustrate the distribution of the major water masses in the survey area: the warmer and more saline Atlantic waters, which spread particularly in the shallower layers northeast- and north-westwards in the Norwegian Sea. The cold and less saline Arctic waters was confined to depths > 200, occurring shallower in the southwest from where its progressive spread into the Norwegian Sea Basin was observed at increasing depths of down to 600 m. Closer to the Norwegian coast a layer of cooler and less saline water of coastal origin was observed in the surface down to approximately 200 m in the North.
As in the previous years, the water column was clearly vertically structured with warmer water masses of Atlantic origin in the upper layers and cold Arctic waters at depth (Figs. 5 and 6). The magnitude of these layers varied with latitude. In the southern part of the survey area, the layer of warmer Atlantic water was detected down to about 500 m only close to the coast. In the oceanic area, this layer was only 300 – 400 m of magnitude decreasing to < 200 m at the westernmost stations. On the northernmost transect the warm Atlantic water layer reached deeper to >500 m close to the shelf edge but was slightly cooler than in the south (Fig. 4).

Concluding remarks on the survey time and program

Adverse weather situations with strong winds and rough sea states resulted in loss of valuable ship time. During the first part, all CTD/WP2 and fishing activities had to be abandoned for its two last transects. Though echo integration could be continued on these transect, the data quality particularly in the top 20 m was conspicuously affected by strong bubble penetration. The start of the second survey part was delayed by 30 hours due to another passing storm. As a consequence, the program of this part could not be completed.

Again, it has to be stressed that either shortening of the EU survey program for IESNS or increasing RV Dana's available ship time – ideally by 2 days for each cruise leg –is advisable to allow for operations to be paused during severe weather. As in many previous years, and provided with the days at sea allocated to RV Dana for this survey, the intended survey program was only just achievable under optimal weather and sea conditions, i.e. low winds and calm sea.

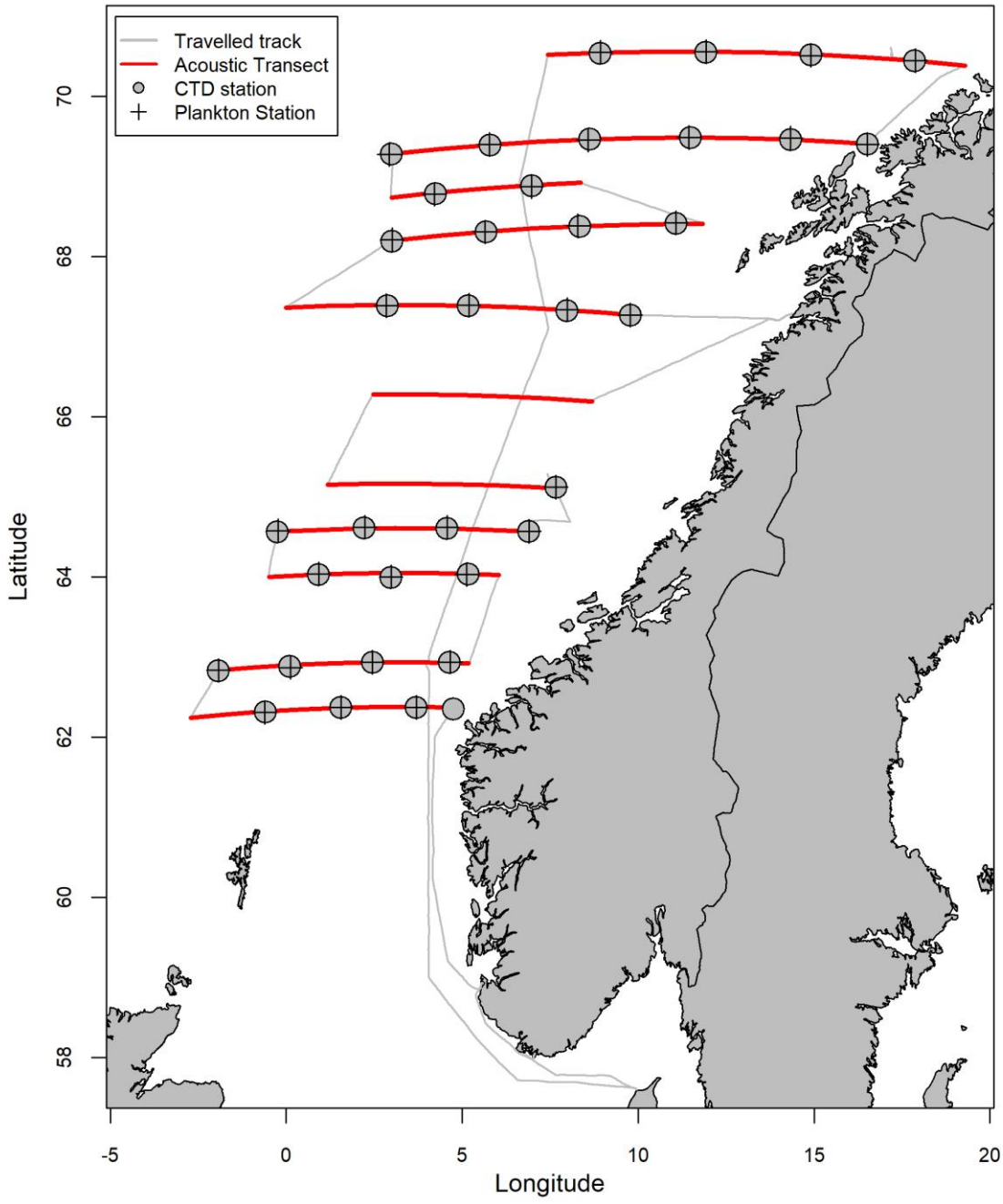

Figure 1. Cruise track and sampling locations by R/V Dana during IESNS 2022. Acoustic integration was carried out along red track only.

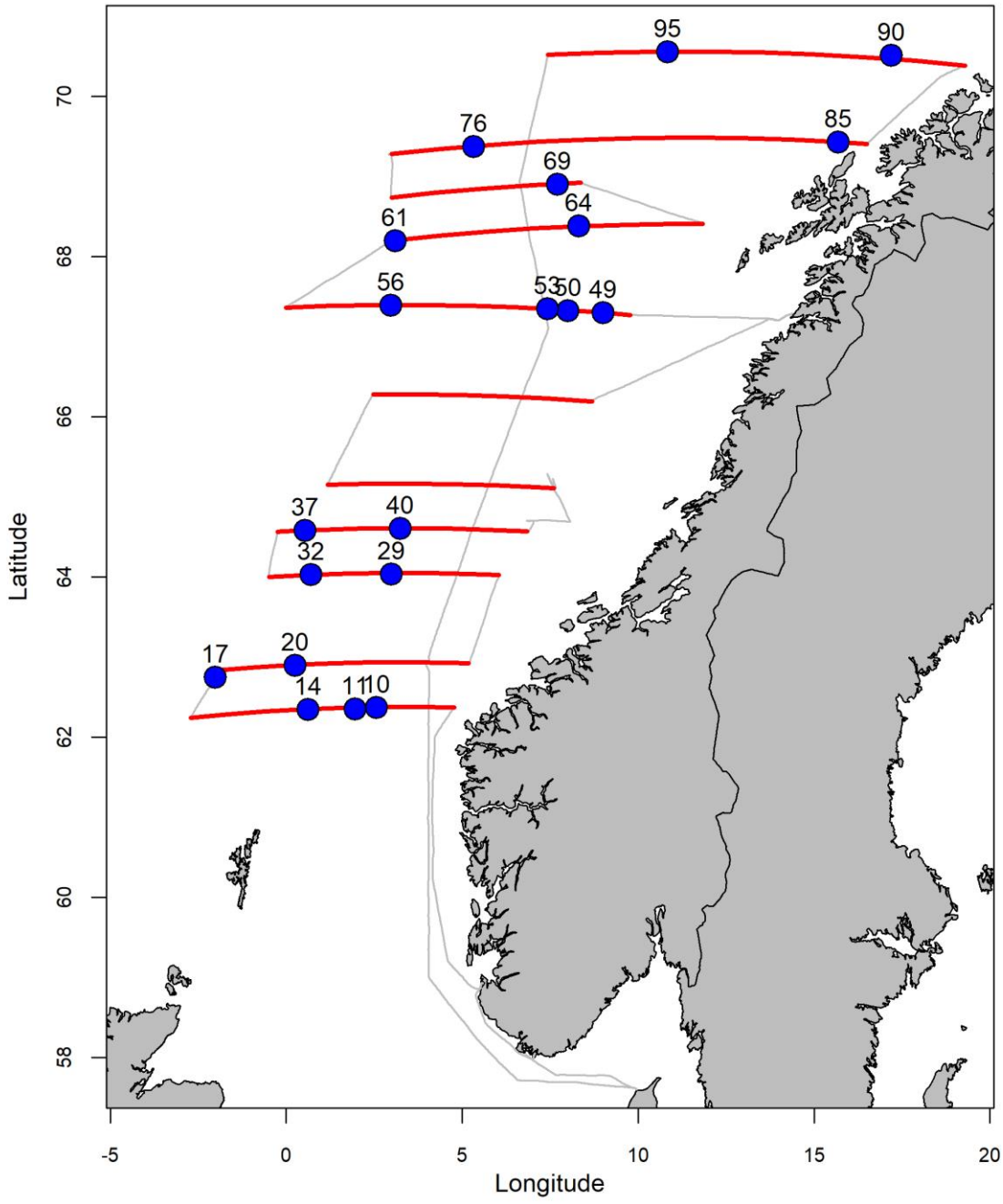

Figure 2. Cruise track and trawling locations by R/V Dana during IESNS 2022. Acoustic integration was carried out along red track only.

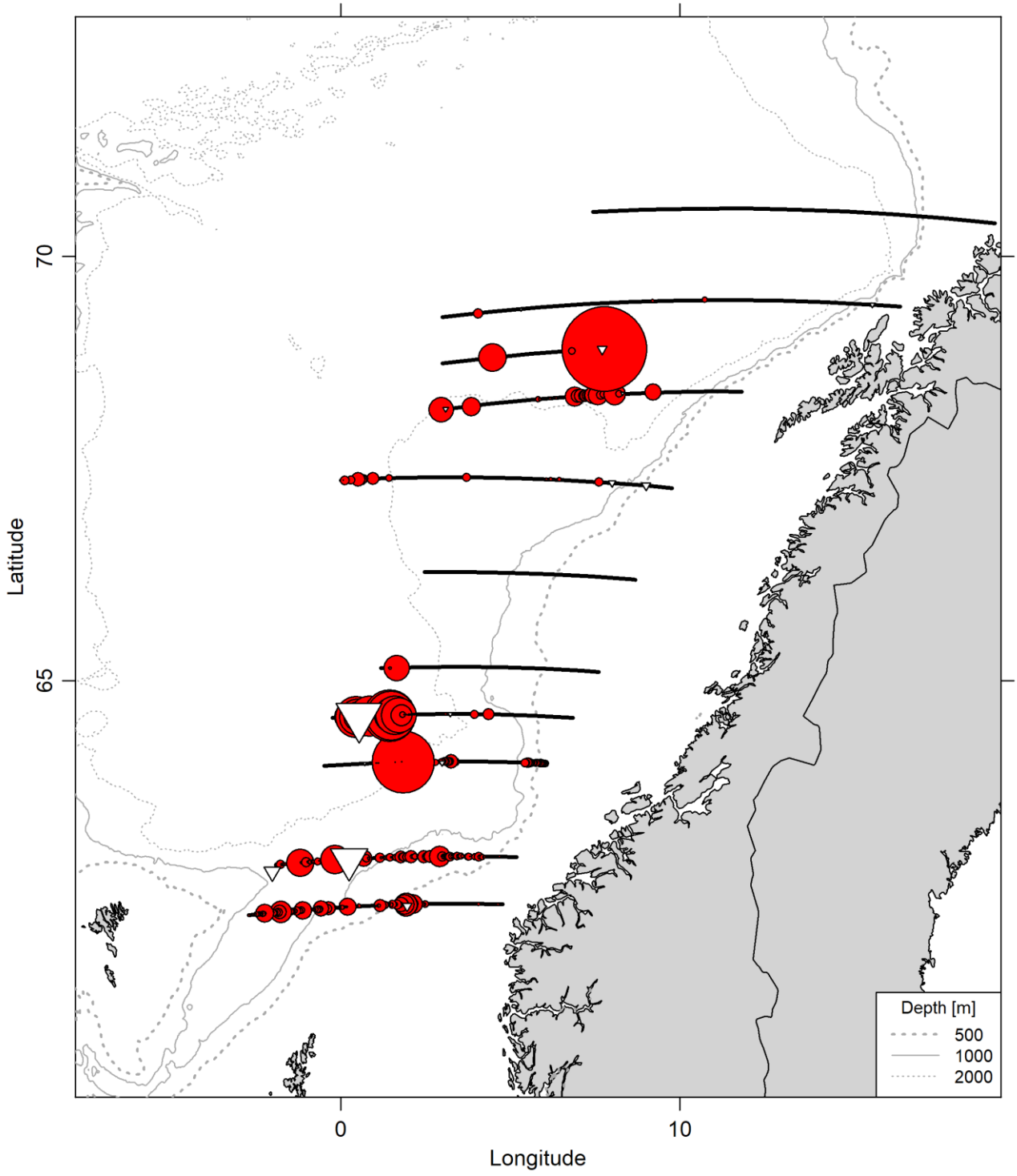

Figure 3. Distribution of NASC (Nautical area scattering coefficient, m2 /nmi2) for herring. Max NASC 14 272 m2/nmi2. White triangles are scaled to square root transformed catches of herring in kg/tow. Max catch 2 335kg.

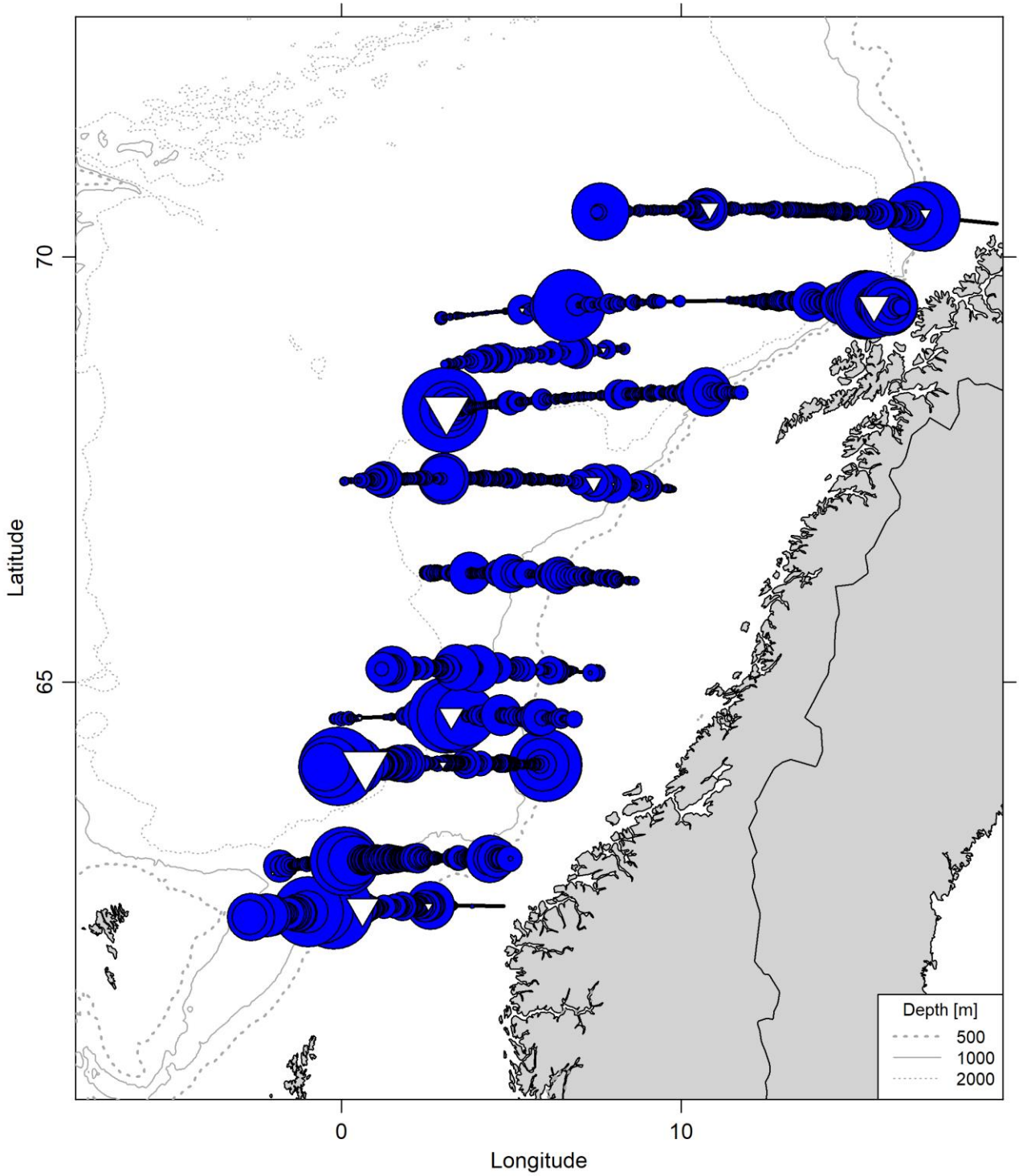

Figure 4. Distribution of NASC (Nautical area scattering coefficient, m2/nmi2) for blue whiting (blue circles). Max NASC 8 146 m2/nmi2. White triangles are scaled to catches of blue whiting in kg/tow. Max catch 732 kg.

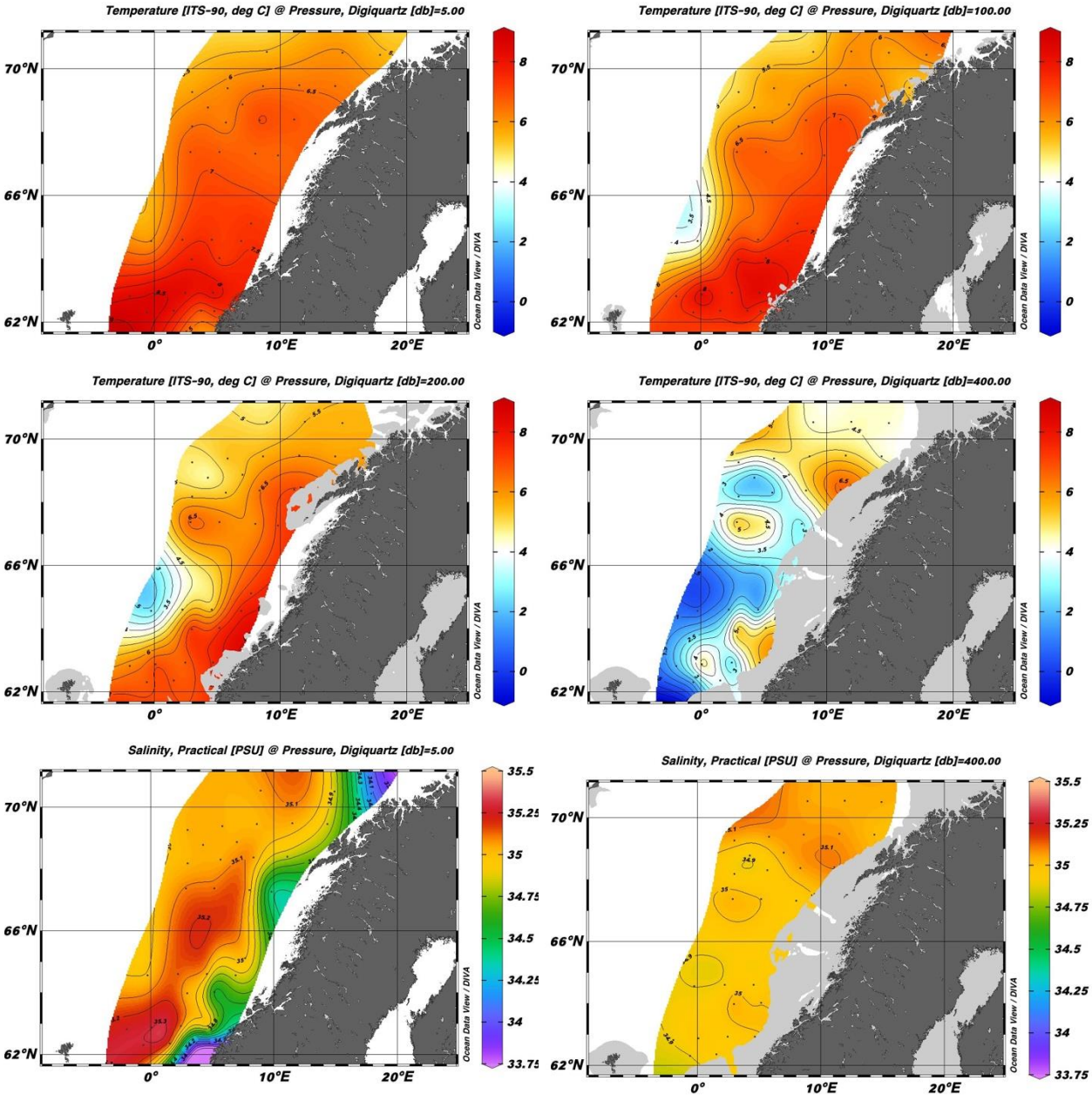

Figure 5: Horizontal temperature distribution at the surface, 100, 200 and 400 m depth, and of salinity at the surface and 400 m depth R/V Dana IESNS 2022.

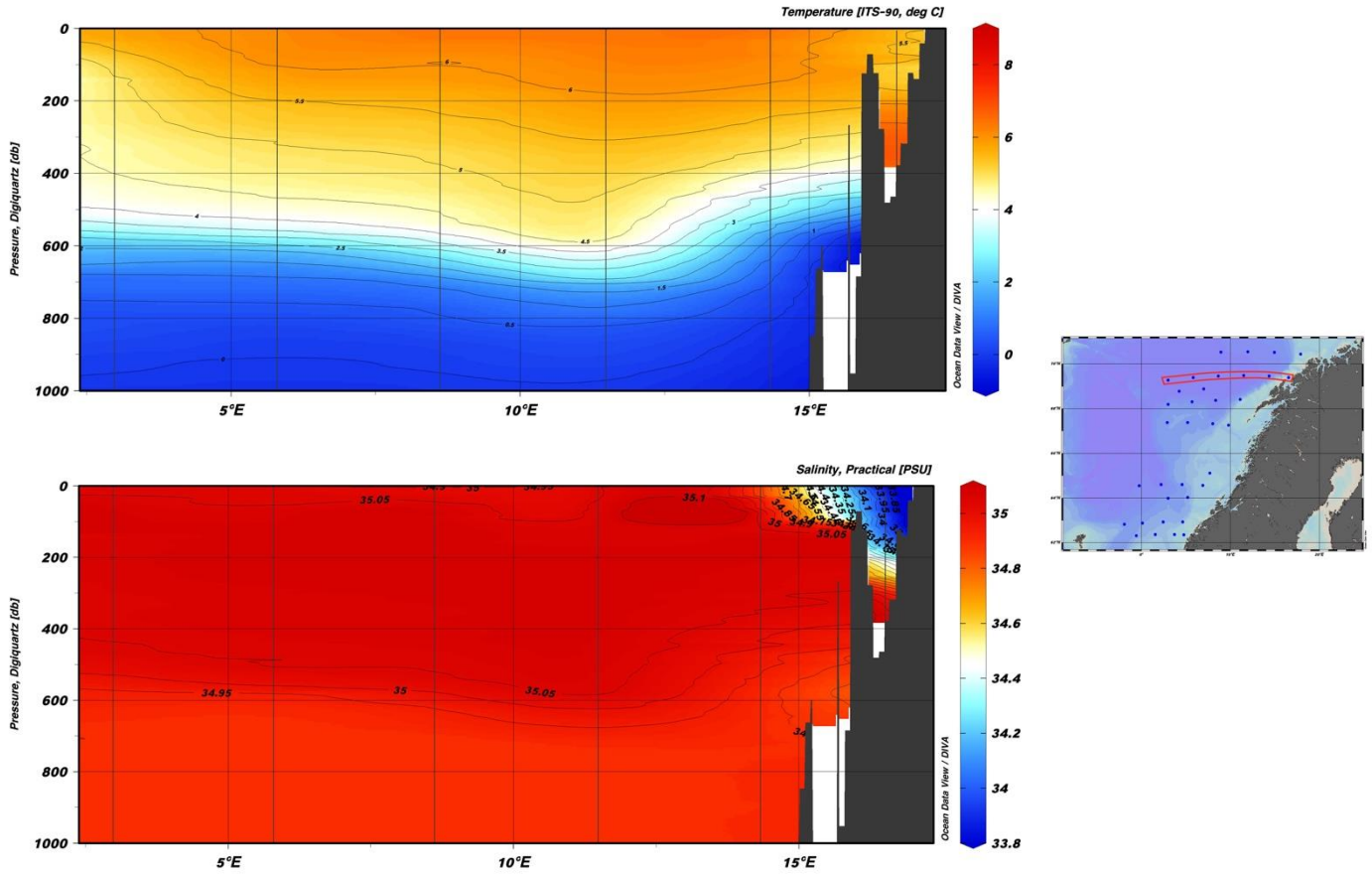

Figure 6: Temperature and salinity distributions along a northern transect perpendicular to the coast (see map for latitudinal positions of the stations included), R/V Dana IESNS 2022.

Table 1: Seabird CTD profiles (SEA) and valid WP2 stations taken by R/V Dana during IESNS 2022.

RV Dana cruise	Station number	Station Type	Year	Month	Day	Start Hour (UTC)	Minute	Latitude	Longitude	Bottom depth (m)	Wind direction (°)	Wind speed (m/s)
202203	7	SEA	2022	4	26	9	45	62.3537	4.7436	142.7	27.6	11.95
202203	8	SEA	2022	4	26	13	44	62.3714	3.6890	195.4	21.5	9.74
202203	9	WP2	2022	4	26	14	17	62.3689	3.6962	194.9	17.9	9.55
202203	12	SEA	2022	4	27	1	46	62.3671	1.5494	232.0	325.8	4.34
202203	13	WP2	2022	4	27	2	38	62.3687	1.5524	525.5	12.7	3.77
202203	15	SEA	2022	4	27	12	53	62.3159	-0.5915	1074.8	282.4	10.15
202203	16	WP2	2022	4	27	14	20	62.3054	-0.6092	1063.4	270.8	11.55
202203	18	SEA	2022	4	28	1	55	62.8292	-1.9360	1805.1	334.2	2.90
202203	19	WP2	2022	4	28	3	13	62.8319	-1.9254	1804.5	358.5	5.27
202203	21	SEA	2022	4	28	12	3	62.8871	0.0867	1287.7	332.9	3.68
202203	22	WP2	2022	4	28	13	31	62.8682	0.1179	1257.8	322.9	4.48
202203	23	SEA	2022	4	28	20	39	62.9323	2.4412	847.6	301.2	2.09
202203	24	WP2	2022	4	28	21	43	62.9354	2.4410	850.6	316.8	2.87
202203	25	SEA	2022	4	29	3	56	62.9324	4.6309	467.3	317.7	5.59
202203	26	WP2	2022	4	29	4	39	62.9362	4.6593	449.4	307.6	5.73
202203	27	SEA	2022	4	29	15	16	64.0342	5.1660	1007.4	215.4	1.70
202203	28	WP2	2022	4	29	16	43	64.0303	5.1218	1042.8	176.2	2.49
202203	30	SEA	2022	4	30	0	13	63.9934	2.9731	1778.7	294.2	8.17
202203	31	WP2	2022	4	30	1	38	64.0021	2.9762	1755.2	291.8	7.91
202203	33	SEA	2022	4	30	10	29	64.0332	0.9112	2321.4	256.6	3.78
202203	34	WP2	2022	4	30	10	54	64.0353	0.9228	2319.0	252.5	4.17
202203	35	SEA	2022	4	30	18	19	64.5633	-0.2544	2673.8	249.5	6.88
202203	36	WP2	2022	4	30	19	34	64.5730	-0.2335	2679.8	252.1	5.31
202203	38	SEA	2022	5	1	4	7	64.6098	2.2081	2725.5	225.0	10.09
202203	39	WP2	2022	5	1	5	20	64.6213	2.2366	2754.7	223.4	9.40
202203	41	SEA	2022	5	1	15	19	64.6059	4.5601	1275.9	249.0	13.85
202203	42	WP2	2022	5	1	16	33	64.6179	4.5732	1215.1	247.9	14.74
202203	43	SEA	2022	5	1	23	14	64.5663	6.8912	528.5	270.8	14.73
202203	44	WP2	2022	5	1	23	43	64.5692	6.9023	256.9	281.4	19.31
202203	45	SEA	2022	5	3	3	36	65.1201	7.6564	249.9	335.1	14.63
202203	46	WP2	2022	5	3	4	8	65.1184	7.6619	248.3	359.6	12.36
202203	47	SEA	2022	5	8	6	5	67.2701	9.7771	298.6	288.7	9.75
202203	48	WP2	2022	5	8	6	43	67.2698	9.7804	301.5	282.3	10.80
202203	51	SEA	2022	5	8	17	8	67.3281	7.9787	1332.8	237.6	6.18
202203	52	WP2	2022	5	8	18	30	67.3379	7.9869	1332.8	227.2	6.71
202203	54	SEA	2022	5	9	3	6	67.3849	5.1717	1416.3	160.9	9.25
202203	55	WP2	2022	5	9	4	29	67.3935	5.1886	1417.1	155.7	8.51
202203	57	SEA	2022	5	9	12	52	67.3866	2.8733	1340.2	212.0	8.85
202203	58	WP2	2022	5	9	14	10	67.3851	2.8427	1347.7	210.4	9.04
202203	59	SEA	2022	5	10	5	8	68.1949	2.9899	1493.2	90.7	4.18
202203	60	WP2	2022	5	10	6	26	68.2115	3.0139	1815.8	87.0	4.42
202203	62	SEA	2022	5	10	16	0	68.3130	5.6691	572.2	160.6	8.43
202203	63	WP2	2022	5	10	17	13	68.3075	5.6446	560.1	165.8	7.52
202203	65	SEA	2022	5	11	1	48	68.3790	8.3381	1183.2	165.5	6.94
202203	66	WP2	2022	5	11	3	13	68.3849	8.2879	1192.5	180.0	6.64
202203	67	SEA	2022	5	11	10	6	68.4134	11.0724	632.1	188.2	5.14
202203	68	WP2	2022	5	11	11	3	68.4229	11.0801	661.7	194.5	4.82
202203	70	SEA	2022	5	12	2	35	68.8846	6.9758	3092.1	67.3	8.39
202203	71	WP2	2022	5	12	3	51	68.8718	6.9716	3085.5	55.6	8.13
202203	72	SEA	2022	5	12	11	8	68.7894	4.2331	3219.3	97.3	8.51
202203	73	WP2	2022	5	12	12	23	68.7783	4.2102	3202.9	88.8	8.02
202203	74	SEA	2022	5	12	19	16	69.2805	2.9866	3200.2	77.5	13.13
202203	75	WP2	2022	5	12	20	39	69.2744	2.9238	3200.2	71.4	15.01
202203	77	SEA	2022	5	13	8	15	69.3963	5.7938	3216.0	135.2	4.07
202203	78	WP2	2022	5	13	9	36	69.4009	5.7749	3215.5	155.4	6.18
202203	79	SEA	2022	5	13	18	15	69.4656	8.6151	3048.0	156.1	7.81
202203	80	WP2	2022	5	13	19	36	69.4559	8.5747	3053.2	138.5	7.03
202203	81	SEA	2022	5	14	2	19	69.4866	11.4853	3304.0	154.6	8.17
202203	82	WP2	2022	5	14	3	41	69.4885	11.4392	2932.2	159.7	8.47
202203	83	SEA	2022	5	14	10	31	69.4644	14.3266	2458.2	146.1	3.54
202203	84	WP2	2022	5	14	11	54	69.4804	14.3364	2484.9	155.5	4.37
202203	86	SEA	2022	5	14	19	30	69.4056	16.5146	372.6	150.2	6.52
202203	87	WP2	2022	5	14	20	5	69.3996	16.5097	376.8	150.4	7.19
202203	88	SEA	2022	5	15	6	47	70.4459	17.8584	122.1	19.9	6.96
202203	89	WP2	2022	5	15	7	13	70.4460	17.8774	121.5	16.7	8.11
202203	91	SEA	2022	5	15	17	15	70.5196	14.9006	2381.9	356.0	12.89
202203	92	WP2	2022	5	15	18	32	70.5120	14.9017	2386.6	328.5	14.51
202203	93	SEA	2022	5	16	1	16	70.5552	11.9136	2386.3	328.8	10.97
202203	94	WP2	2022	5	16	2	37	70.5606	11.9369	2684.6	311.4	10.52
202203	96	SEA	2022	5	16	12	9	70.5419	8.9189	2813.9	302.2	5.73
202203	97	WP2	2022	5	16	14	25	70.5543	8.9359	2813.9	315.7	5.77

Table 2. Valid Pelagic trawl stations taken by R/V Dana during IESNS 2022.

RV Dana cruise	Station number	Trawl type	Year	Month	Day	Start Hour (UTC)	Minute	Start Latitude	Start Longitude	Tow Direction (°)	STW (kn)	SOG(kn)	Tow duration (min)	Wire length	Headline depth (m)	Door spread (m)	Vertical opening (m)	Wind direction (°)	Wind speed (m/s)	Sea State
202203	10	FOTØ	2022	4	26	19	16	62.22.261 N	002.33.911 E	88.1	4.0	3.65	33	1200	280	97	25	22.5	8.8	3
202203	11	FOTØ	2022	4	26	23	2	62.20.939 N	001.57.063 E	125.6	3.9	4.47	41	320	8	62	20	1.2	6.9	3
202203	14	FOTØ	2022	4	27	6	48	62.20.646 N	000.37.174 E	88.0	3.8	4.24	54	1700	300	94	23	309.6	5.4	3
202203	17	FOTØ	2022	4	28	0	37	62.45.003 N	002.01.432 W	36.4	4.1	3.86	30	324	0	76		345.3	1.7	3
202203	20	FOTØ	2022	4	28	10	51	62.53.855 N	000.14.528 E	263.8	5.4	4.93	47	800	70	90	26	318.9	3.9	3
202203	29	FOTØ	2022	4	29	23	11	64.02.060 N	002.58.899 E	120.6	4.5	3.93	32	400	0	86	26	287.8	13.0	3
202203	32	FOTØ	2022	4	30	8	52	64.01.625 N	000.42.026 E	82.5	5.0	4.52	60	1235	260	85	24	280.2	4.7	3
202203	37	FOTØ	2022	4	30	22	19	64.34.728 N	000.32.061 E	267.1	4.3	4.23	30	470	5	87	25	232.4	7.3	3
202203	40	FOTØ	2022	5	1	9	42	64.36.510 N	003.13.833 E	274.9	5.1	4.14	61	1880	320	96	23	246.7	11.9	3
202203	49	FOTØ	2022	5	8	10	2	67.17.901 N	009.00.147 E	100.8	3.9	3.66	30	1600	320	93	24	253.1	5.5	3
202203	50	FOTØ	2022	5	8	15	25	67.19.697 N	007.59.858 E	91.2	4.6	4.44	31	1450	320	108	21	240.0	11.4	3
202203	53	FOTØ	2022	5	8	20	51	67.20.823 N	007.25.180 E	93.1	4.6	4.56	20	550	50	93	24	213.0	6.7	3
202203	56	FOTØ	2022	5	9	11	6	67.23.549 N	002.57.994 E	83.2	6.0	4.83	30	1330	230	110	22	214.1	11.8	3
202203	61	FOTØ	2022	5	10	8	4	68.12.052 N	003.05.317 E	253.1	5.4	4.02	30	1400	200	92	25	114.9	5.7	3
202203	64	FOTØ	2022	5	11	0	18	68.23.168 N	008.18.535 E	263.3	4.0	4.22	30	400	20	75	25	173.9	6.6	3
202203	69	FOTØ	2022	5	11	22	57	68.54.319 N	007.42.546 E	86.2	5.9	4.70	40	1250	175	94	23	101.6	6.5	3
202203	76	FOTØ	2022	5	13	4	46	69.22.448 N	005.18.964 E	267.6	4.3	4.17	34	1500	250	100	15	88.1	11.9	5
202203	85	FOTØ	2022	5	14	16	1	69.25.867 N	015.40.654 E	273.6	6.7	4.14	19	1600	300	96	24	139.8	4.4	2
202203	90	FOTØ	2022	5	15	9	55	70.30.915 N	017.11.345 E	0.8	3.8	5.29	60	2000	380	99	15	14.9	11.7	2
202203	95	FOTØ	2022	5	16	6	6	70.33.692 N	010.49.940 E	86.9	3.5	3.79	30	1625	320	91	25	311.3	9.3	5

Table 3. Composition of pelagic trawl catches (kg/tow) taken by R/V Dana IESNS 2022

			Station																			
			10	11	14	17	20	29	32	37	40	49	50	53	56	61	64	69	76	85	90	95	
Scientific name	**English name**	**Danish name**																					**Total catch**
Clupea harengus	Herring	Sild		4.328		43.690	1025.644	0.714	0.171	2334.588	0.422	3.872	1.734			0.534	0.114	4.981	0.073	0.484		0.048	3421.397
Micromesistius poutassou	Blue whiting	Blåhvilling	28.481	2.348	371.378	5.505		25.169	731.674	10.160	214.744	5.100	5.740	102.246		705.925		16.199	14.800	322.550	49.802	133.240	2745.060
Scomber scombrus	Mackerel	Makrel		10.292		5.863	327.684	22.620															366.459
Pollachius virens	Saithe	Sej																		21.280	1.820		23.100
Scyphozoa	Scyphozoans	*Storgopler						2.645	0.148		0.208		0.854			2.544		3.150	0.789	0.628	2.128	1.594	14.688
Cyclopterus lumpus	Lumpfish	Stenbider								2.268					0.982			2.210	2.020				7.480
Salmo salar	Salmon	Laks					5.700																5.700
Melanogrammus aeglefinus	Haddock	Kuller																		5.330			5.330
Notoscopelus kroyeri	Lancet fish	Krøyers prikfisk	2.640		1.528	0.027					0.024	0.178	0.024										4.421
Euphausiidae	Krill	Lyskrebs	0.036	0.011				1.364				0.656	0.020					0.478	0.017	0.039	0.052	0.001	2.674
Myctophum punctatum	Spotted lanternfish	Slankhalet prikfisk						1.916															1.916
Arctozenus risso	Ribbon barracudina	Risso's lakstobis	0.038		0.096						0.980		0.434		0.060			0.068				0.116	1.792
Gadus morhua	Cod	Torsk																		1.620			1.620
Illex coindetii	Southern shortfin squid	Rød blæksprutte						0.882						0.020					0.085	0.051			1.038
Maurolicus muelleri	Pearlside	Laksesild	0.102									0.062	0.010		0.030			0.022	0.008	0.012	0.028	0.001	0.275
Benthosema glaciale	Glacier lantern fish	Isprikfisk	0.002									0.003						0.017	0.024	0.004	0.002	0.001	0.053
Argyropelecus hemigymnus	Silver Hatchetfish	Plettet sølvøkse	0.001																				0.001
		Total catch	31.300	16.979	373.002	55.085	1359.028	55.310	731.998	2347.016	216.378	9.871	8.816	102.266	1.072	709.003	0.114	27.125	17.816	352.000	53.832	135.001	6603.012
		headline depth	280	8	300	0	70	0	260	5	320	320	320	50	230	200	20	175	250	300	380	320	
		mean length (cm) herrng	--	29.7	--	31.1	31.2	32.2	29.5	32.2	31.5	29.3	30.4	--	--	29.8	17.2	26.8	21.5	22.4	--	19.0	
		mean length (cm) blue whiting	18.2	19.9	18.5	20.6	--	20.1	19.5	20.5	20.3	17.6	17.8	17.7	18.1	--	--	19.2	21.1	18.8	17.5	18.5	
		mean length (cm) mackerel	--	31.4	--	27.8	33.9	20.3	--	--	--	--	--	--	--	--	--	--	--	--	--	--	

Annex 1: Calibration report for the towed body mounted transducer used for abundance estimation, April 2022.

Transceiver Menu	
Frequency	38 kHz
Sound speed	1480 $m.s^{-1}$
Max. Power	2000 W
Equivalent two-way beam angle	-20.5 dB
Default Transducer Sv gain	25.31 dB
3 dB Beamwidth	6.9°
TS of sphere	-42.27 dB
Range to sphere in calibration	12.2 m
Measured NASC value for calibration	2550 m^2/nmi^2
Calibration factor for NASCs	1.00
Absorption coeff	6.355 dB/km
Log Menu	
Distance	1,0 n.mi. using GPS-speed
Operation Menu	
Ping interval	0.9 – 1.6 s
Analysis settings	
Bottom margin (backstep)	1.0 m
Integration start (absolute) depth	7 - 9 m
Range of thresholds used	-85 dB