



Hirtshals, 3 December 2021

Cruise report

R/V DANA Cruise 03/2021

International Ecosystem survey in the Nordic Seas (IESNS) in 2021

Calibration of Echo-sounders

27 – 30/4 2021

Acoustic Monitoring of Herring and Blue whiting in the Norwegian Sea

1/5 – 27/5 2021



European Union

Cruise participants

Calibration 27 – 30/4

Susan Mærsk Lusseau	DTU Aqua, Monitoring Hirtshals	Cruise leader
Torben Filt Jensen	DTU Aqua, Monitoring Hirtshals	Acoustics
Ronny Sørensen	DTU Aqua, Monitoring Hirtshals	Technician
Christian Petersen	DTU Aqua, Monitoring Hirtshals	Technician

Acoustic monitoring 1 – 27/5

Susan Mærsk Lusseau	DTU Aqua, Monitoring Hirtshals	Cruise leader
Torben Filt Jensen	DTU Aqua, Monitoring Hirtshals	Acoustics
Christian Skou Petersen	DTU Aqua, Monitoring Hirtshals	Technician, CTD
Laura Diernæs	DTU Aqua, Monitoring Lyngby	Acoustics
Matthias Kloppmann	Thünen-Institute of Sea Fisheries, Germany	
Søren Larsen Grønby	DTU Aqua, Monitoring Hirtshals	Fish lab, WP2
Jan Werner Thomsen	DTU Aqua, Monitoring Hirtshals	Fish lab, WP2
Farivar Azour	DTU Aqua, Monitoring Lyngby	Fish lab, WP2

The acoustic monitoring is usually done by an international team with participants from Denmark, Germany, the Netherlands and UK England, and a complete crew exchange is done in Bodø, Norway, after the first half of the acoustic monitoring. Travel restrictions and other precautionary measures related to the Corona crisis, however, prevented to do so this year again. To ensure that a reasonable data collection could be done and to minimize the risk of Covid-19 infections onboard, the entire monitoring survey was run by a Danish team and one German scientist. The crew exchange in Bodø was dropped.

Cruise itinerary

27 April 2021,	12:00 UTC*	Departure Hirtshals for calibration of acoustic equipment at Bornö, Gulmarsfjorden, Sweden
	17:30	at pilot station off Gulmarsfjord
28 April 2021,	04:00	Start of calibration
29 April 2021,	16:00	Calibration finished, waiting for pilot
	18:00	Departure Bornø
30 April 2021,	06:00	Arrival Hirtshals, crew change. One crewmember could not join due to illness and a replacement was identified. Departure to survey area was delayed by ~24h to maintain appropriate Covid precautionary quarantine period and PCR testing of the replacement crew member.
	13:00	Departure Hirtshals to carry out equipment tests while waiting for replacement crew member.
1 May 2021,	19:30	Return to Hirtshals for remaining crewmember and departure for acoustic monitoring.
3 May 2021,	07:00	Start monitoring
23 May 2021,	12:30	Monitoring finished
27 May 2021,	06:30 UTC*	Arrival Hirtshals, end of survey

*: local time = UTC + 2

Cruise summary

Survey days	30
Mileage	Steaming for calibration 150 NM Steaming to start of transects, between transects and to home port 1866 NM Acoustic transects 2056 NM Total 4073 NM
Number of trawl hauls	20
Number of CTD stations	35 (+ 5 during calibration)
Number of WP2 stations	35
Number of biological samples – herring	476
Number of biological samples – blue whiting	675

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 at Bornö Island in the Gullmar Fjord, Sweden during the 28th and 29th April 2021. 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 16-18 June 2021 and in the WGIPS report of January 2022.

Similar to last year, 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 800 m or 5 m above the seabed with a Seabird CTD and rosette water sampler. The survey protocol calls for stations to be carried out to a depth of 1000m, but this was not possible due to a cable incident on a survey prior to this one that left the CTD cable too short. The following parameters were measured: pressure (depth), temperature, conductivity (salinity) and oxygen. Each day, one water sample was taken at 800 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 $> 2000 \mu\text{m}$, $> 1000 \mu\text{m}$, and $> 180 \mu\text{m}$, respectively, on board at 70 °C for 24 hours, and subsequently frozen for later dry weight determination at DTU Aqua.

Due to weather restrictions two of the planned CTD and 3 of the planned WP2 stations were not completed, and all together 35 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 “Turbo” trawl was used either at the surface or in midwater down to a maximum of 360 m depth during most of the survey. Due to the heavy weather during the last part of the survey the last stations were a conducted with the smaller pelagic “Fotø” trawl which is easier to handle in those conditions (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 476 individual herring and 675 blue whiting were sampled.

Outwith the standard survey program for this cruise, herring scales were collected from 88 individual herring in 10 stations for a workshop aiming to compare age readings from scales and otoliths from the same individuals.

Additionally tissue samples for genetic analysis from 25 mackerel from one station and 30 and 50 herring in 2 stations were collected on request from DTU Aqua in Silkeborg.

All trawl data were entered into the Fiskeline database 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 for the first time be made 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)

03-05-2021 Dana has made progress towards the west along the first transect and our position is now 62°03.75’N, 00°11.58’E. We have completed the WP2 and CTD at WPT5 and have just landed a catch at our current position of 800 kg blue whiting, some greater argentines (*Argentina silus*) and Kroyers lanternfish (*Notoscopelus kroyeri*).

04-05-2021 Dana started on transect 2 in the morning. Over the last section of transect 1 and all along transect 2, good registrations of what looked like Blue Whiting were detected at around 180-220m. Also, small herring marks were detected in the surface layers. Two hauls were done during over the course of the day:

- A haul early morning after midnight (UTC) in the surface at 61°59.66’N 01°56.33’W. The catch consisted of 672 kg mackerel (mean length 29cm), 16 kg herring (mean length 27.5cm), one large monk fish and 1 pink salmon (550g).
- Another haul at 10:43UTC in 200m depth (62°33.37’N 01°50.25’W), revealing 35kg herring (mean length 30.5cm), 22kg mackerel (mean length 36cm) and 113kg blue whiting (mean length 20cm).

A CTD and WP2 station at WPT 10 in stratum 2 (62°37.00’N 01°00.19’W) was completed. Progress was slow due to strong wind and building seas

05-05-2021 Transect 2 of stratum 2 was completed in the morning as well as the CTD/WP2 station at WPT22. More blue whiting registrations and some herring were also seen on transect 3 of stratum 2. The weather didn't allow for any fishing until the afternoon when a haul on some nice-looking layers in 200m depth at 63°14.05'N 00°29.97'W was done. We caught 5.6kg herring (mean length 30.5cm) and 82kg blue whiting (mean length 20cm). Continued sailing east with the swell rolling the vessel quite a lot. Due to this, a surface haul in the evening was not possible.

06-05-2021 Dana has completed all transects in the UK sector and spent most of the day travelling north to transect 5 of stratum 2 with a little stop for the 4nm of transect 4 plus CTD/WP2 at the end of that transect. Very little was seen on the start of transect 5 apart from a diffuse layer at 300m during the afternoon. We trawled on this at 64°27.45'N 01°50.142'E and caught 128kg blue whiting, 18kg herring, 3kg Risso's barracudina (*Arctozenus rissoi*) and a few pearlsheds (*Maurolicus muelleri*) and Kroyer's lanternfish. Heading further eastwards the day was completed at WPT 36 with the scheduled CTD and WP2 station and a surface haul around midnight.

07-05-2021 The midnight surface haul at 64 27.87N 02 39.18E aimed at a stretch of herring marks between the surface and 100m. The resulting catch was 3900kg herring, 600kg mackerel, 140kg blue whiting, 5 pink salmon and one porbeagle which was unfortunately in a poor shape after being towed in the trawl. During most of the day we have seen very little until we reached the shallower water at the end of the transect where we fished on marks in around 300m depth and caught 166kg blue whiting, 22kg Risso's barracudina and a handful of various small lanternfishes (64°25.97'N 05°34.66'E). The transect was completed later that evening and Dana started steaming northwards towards the next transect.

08-05-2021 Dana started on transect 7 of stratum 2 in the morning and two hauls were completed during the day. The first at ~250m depth was done on the shelf on some very strong registrations, which resembled herring marks (65°35.60'N 06°32.18'E). Turned out to be small blue whiting posing as deep going herring. The catch consisted of 510kg blue whiting (mean size 18cm), 7kg greater argentines and a few mesopelagics. The second haul was on a series of small herring marks in the surface 0-30m (65°39.45'N 04°55.55'E) which gave 372kg herring (mean size 34cm), 1 Atlantic salmon and 3 pink salmon.

09-05-2021 At midnight, Dana had a haul in the surface (65°37.94'N 02°14.23'E), resulting in 622kg blue whiting (mean length 19cm), 585kg herring (mean length 31cm), 162kg Mackerel and 28 pink salmon. Transect 9 of stratum 2 was started in the evening at 66°46.09'N 00°00.00'E.

10-05-2021 Dana encountered some promising herring marks during the night and a surface tow in that area was started at midnight (66°47.52'N 01°55.96'E). We caught 1562kg herring (mean length 29cm) and 3 pink salmon. During most of the day, distinct blue whiting layers in 250 to 350m depth were observed. Around lunchtime, a tow on this layer was started at 66°48.41'N 04°20.01'E. The catch consisted of 537kg blue whiting (mean length 19cm), 3 herring (mean length 28.5cm) and a small assortment of mesopelagic species. So far, catches of juvenile blue whiting indicate a good year for recruitment.

11-05-2021 Dana started the day with a tow in the surface at midnight (66°45.49'N 06°29.48'E) and caught 342kg herring (mean length 26.5 cm, range 21 to 33.5cm, 69kg blue whiting and again 7 pink salmon. We have just started the last transect 10 of this stratum and are sailing west at 67°17.48'N 09°01.30'E. In the late evening at 21:00UTC Dana fished on some conspicuous herring aggregations in 0-100m depth (67°17.36'N 09°08.52'E). Catch was 229kg herring (mean length 28.5cm) and 797kg blue whiting (mean length 18.5cm).

12-05-2021 The blue whiting, which were caught with last day's late evening catch, seemed to have appeared while we were trawling and continued to show on the echo registrations for a while afterward along the track, too. Between 08:40 and 16:40UTC we had to stop monitoring and keep

our position dodging the weather. Though weather improved and we could continue monitoring westward, trawling was still not possible due to the large swell.

13-05-2021 Today has been a quiet day on Dana. We had finished the last transect in this stratum and headed towards the start of transect 2 in stratum 4. We saw a little bit of blue whiting last night but were still not able to fish due to the weather while during the day we had sufficiently good weather, nothing was seen worth fishing for.

14-05-2021 Dana struggled with the weather during the day and had to survey at very reduced speed along transect 2 of stratum 4. Trawling was not possible and the CTD/WP2 at WPT11 had to be dropped for safety reasons.

15-05-2021 Dana continued to struggle with the strong winds. We have completed transect 2 in stratum 4 without any trawling though some nice strong layers, supposedly blue whiting, were detected on the way onto the shelf. We started steaming towards the start of our next transect.

16-05-2021 Dana has started going west on transect 4 in stratum 4. The weather has let up a bit and we are hoping to make it across to the end of the transect before it closes in again. A very consistent and strong blue whiting layer was detected at around 350m for quite a long stretch as we came off the shelf in the afternoon. A trawl was done on it at 69°50.12'N 16°30.62'E. Catch was 810kg small blue whiting, four large cod and a saithe. On the way to this transect, the trawl was changed over from the Turbo to the smaller FOTØ net in anticipation of continued poor weather where this net would be easier to handle. It is hoped that we will be able to fish in worse weather than with the bigger TURBO trawl.

17-05-2021 Dana has made steady progress today in slightly better weather, things are a lot easier going towards the west with the wind in our back. We have not seen much along the current transect, we fished at 69°53.37'N 09°37.67'E on a diffuse layer with some stronger marking small schools in it and caught an assorted small bag of 3kg small blue whiting, 300g krill and 300g small mesopelagic species, mainly *Benthosema glaciale*.

18-05-2021 Dana completed transect 4 in stratum 4 and is continuing west along transect 5 in stratum 3. Although having managed to outrun the worst of the weather, we are still experiencing very strong north easterly winds and have not been fishing and also will not be able to take some of the CTD/WP2 stations along this transect. Incredibly, the towed body continues to collect good data in these conditions as long as we are heading west.

19-05-2021. Dana continued west and finished this transect this afternoon with some skipped CTD stations due to the weather. We have seen very little on the echo sounder on the entire transect. We are now heading north towards transect 6. Weather is OK over on this side but we are waiting until tomorrow to begin the next transect while we wait for the weather to ease for the crossing over the next 12 hours.

20-05-2021. After completing transect 5 in stratum 3 yesterday afternoon, Dana took a break while waiting for the weather to improve further east. Transect 6 was started after lunch. We have seen very little out here so far until about 30min ago when we started to see a weak layer develop in around 200-300m. We are watching this now and hoping it turns into something we can fish on.

21-05-2021. Despite the weather being much calmer today, Dana has been travelling at reduced speed due to the unfavorable direction of the waves relative to our course resulting in noisy acoustic recordings. We registered a distinct weak layer at around 300-400m all day and fished on it at 70°23.28'N 00°32.90'E. The catch consisted of 16 large blue whiting of a mean size of 30.5cm, much larger than those caught earlier. In the evening, Dana trawled at 70°22.01'N 02°15.36'E and caught 1.2kg krill, 1.4kg glacier lanternfish, 5 barracudina and 9 large blue whiting (mean length 29cm). This confirmed nicely the composition of the weak layer with the more distinct weak schools in amongst it we have been looking at on this transect.

22-05-2021 Early morning, transect 6 of stratum 3 was completed and transect 5 of stratum 4 was started. The weather was pleasant most of the day with occasional sunny intervals. This last transect was completed around midnight with a last haul at the surface, which revealed just 1 pink salmon.

23-05-2021 After completion of transect 5 of stratum 4, Dana steamed southwards towards transect 2 of the same stratum to conduct a CTD/WP2 station at WPT11, which had to be cancelled a few days ago because of bad weather conditions. This station was complete after lunch and Dana started her way home.

Results

Conditions during the survey

Weather conditions were mostly pleasant during the first part of the survey until 12 May, when a low pressure system developed over the northeastern part of the Norwegian Sea. Until the end of the monitoring program on the 23rd of May, wind forces of up to 8 Bft, occasionally 9 Bft, and either wind waves or swell from the northeast hampered the work. The speed of the vessel had to be lowered during most of the time in order to not impede the quality of echo registration, 2 CTD and 3 WPT stations had to be dropped and 1 CTD/WPT2 station was postponed to the end of the survey. Fishing, particularly in the surface, was also impossible during longer stretches of the transect. See also the detailed narrative of the survey (Logbook chapter) above.

Catch composition

The catch composition of all trawl hauls is presented in Table 3. Mackerel was the third most abundant species in the catches after herring and blue whiting. Mackerel was present in five surface layer and in one deeper layer (180 m) tow. The majority though was caught in two surface tows in the southern part of the survey area. Mackerel mean length per haul ranged from 29.3 to 37.0 cm (Tab. 3). As usual, lanternfish and spotted barracudina were caught together with blue whiting in the deeper midwater tows. Some of the surface tows gave almost clean herring catches whereas in others also a few lumpfish occurred. A striking feature during the survey was the regular occurrence of juvenile pink salmon (*Oncorhynchus gorbuscha*) in the surface tows with a maximum number of 28 in one haul. This invasive species from the Pacific has increased in abundance during recent years and potentially poses a threat to native populations of Atlantic salmon (*Salmo salar*), of which only 1 specimen was caught. Mean length per tow for herring and blue whiting ranged from 26.7 to 31.1 cm and from 17.8 to 30.2 cm, respectively (Tab. 3). Most of the blue whiting were juveniles and only in 3 hauls was the mean length of the species > 23 cm. The majority of the hauls contained blue whiting, which were around 20 cm and less in mean length.

Distribution and density of target species

Herring

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

Most acoustic registrations of herring were observed as high intensity scattering marks in the upper 50 m of the water column throughout the survey area with some deeper observations in the furthest south. The herring aggregations seemed associated with the continental slope at depths between 500 – 2000m. Herring were completely absent in the furthest Northwestern corner of the survey area.

Trawl catches of herring were largest in surface tows and in the center of the study area largely reflecting the acoustic distributions.

Herring distribution was similar to the pattern observed in 2020 although this year herring was absent on the shelfbreak immediately to the west and north of the Lofoten islands.

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, particularly near the continental slope throughout the survey area. Compared to the 2020 survey blue whiting was significantly more abundant and widely distributed. In line with previous years, blue whiting was almost entirely absent from the furthest Northwestern area.

Hydrographic conditions

Surface temperatures were between < 3.5 °C in the Northwest close to Jan Mayen and > 8.0 °C in the Southeast. Overall, the pattern of surface temperature distribution was comparable to those of last year in the same area: warmer waters in the South and East, colder waters in the North and West (Figure 6). 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 northwestwards in the Norwegian Sea. The cold and less saline Arctic waters was detected almost over the entire water column at only one station at northwestern tip of the survey area close to Jan Mayen. At all other stations, it 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 comparatively thin layer of cooler and less saline water of coastal origin was observed in the surface down to approximately 50 m.

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). The core of the Atlantic water with temperatures > 7 °C and salinities above 35.1‰ was submerged to depths between 60 – 180 m beneath a layer of cooler and fresher coastal water (Fig. 6).

Concluding remarks on the survey time and program

The “Fotø” trawl proved to be much more maneuverable and thus better for accurately targeting specific aggregations and layers of interest compared to the “Turbo” trawl usually deployed on this survey. It is also safer to handle on deck in inclement weather which is common during the survey and it is worth considering to permanently switching to this net for the survey.

This year a large persistent low pressure system was sitting over the survey area causing sustained strong westerly winds. As there was no additional time to wait it out it, acoustic transects were

completed without fishing, hydrographic and plankton sampling to minimize danger to personnel on deck. Overall 2 CTD and 3 WP2 stations were cancelled and fishing trawls to ground truth acoustic registrations were not carried out on some sections of transect in the far north for this reason. This did not significantly affect the quality of the acoustic scrutiny this year though due to the general scarcity of acoustic registrations in the area affected.

Overall however, it appears advisable to either shorten the survey program for the EU participation in IESNS or increase RV Dana's available ship time for the survey to allow for operations to be paused during severe weather.

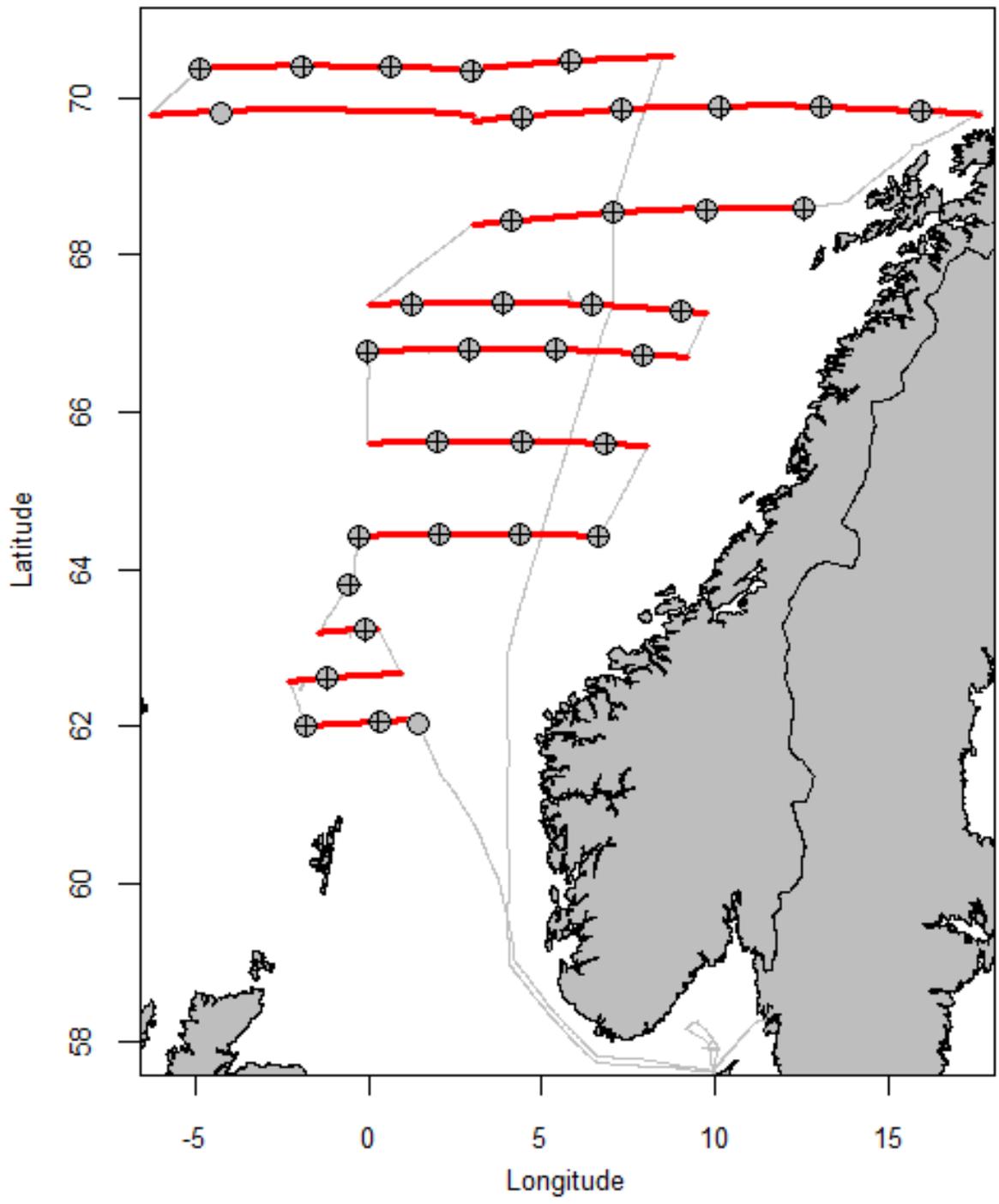


Figure 1. Cruise track and sampling locations for CTD (grey circles) and WP2 (black crosses) by R/V Dana during IESNS 2021. Acoustic integration was carried out along red track only.

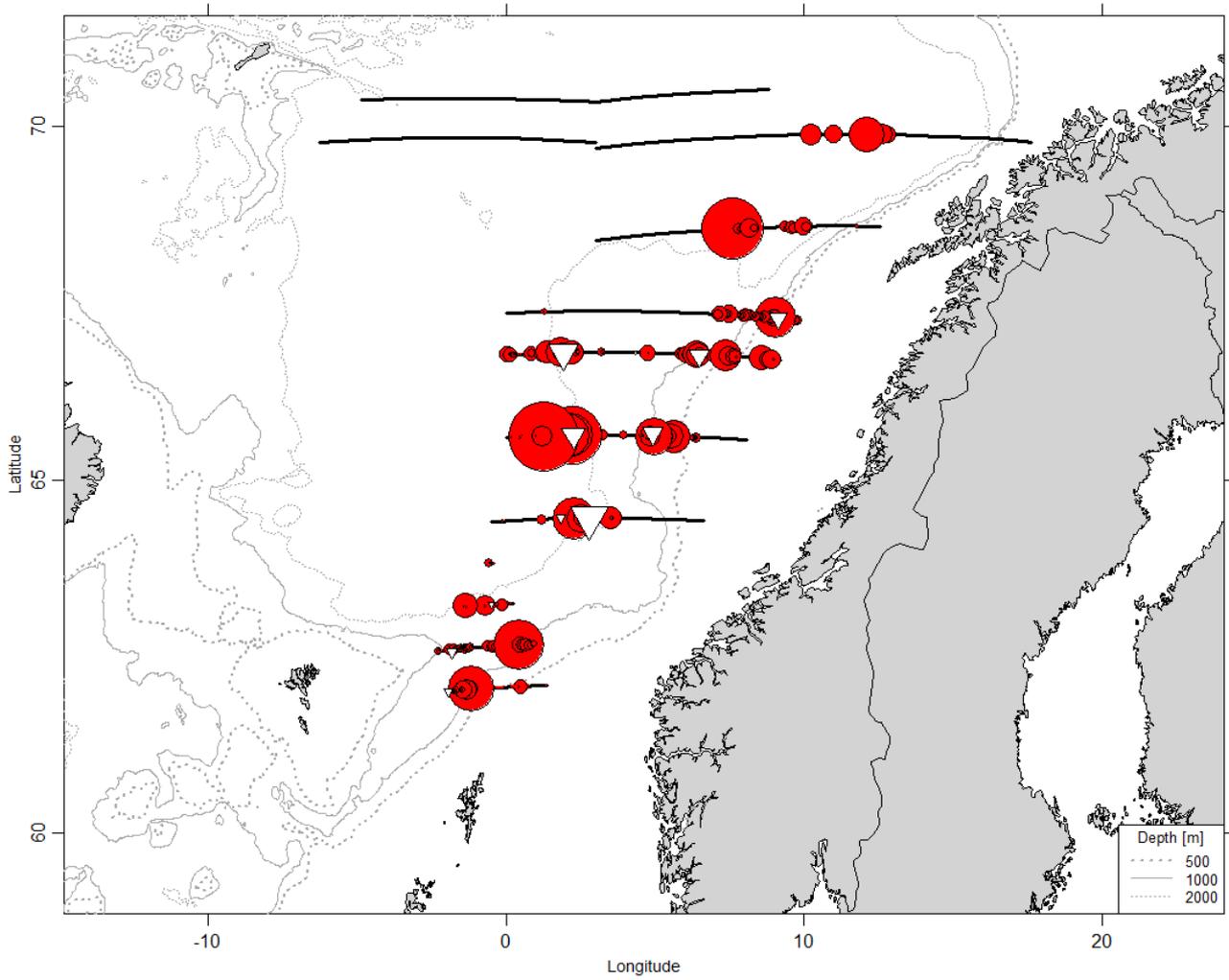


Figure 3. Distribution of NASC (Nautical area scattering coefficient, m² /nmi²) for herring. **Max NASC 7804 m² /nmi².** White triangles are scaled to square root transformed catches of herring in kg/tow. Max catch 3919kg.

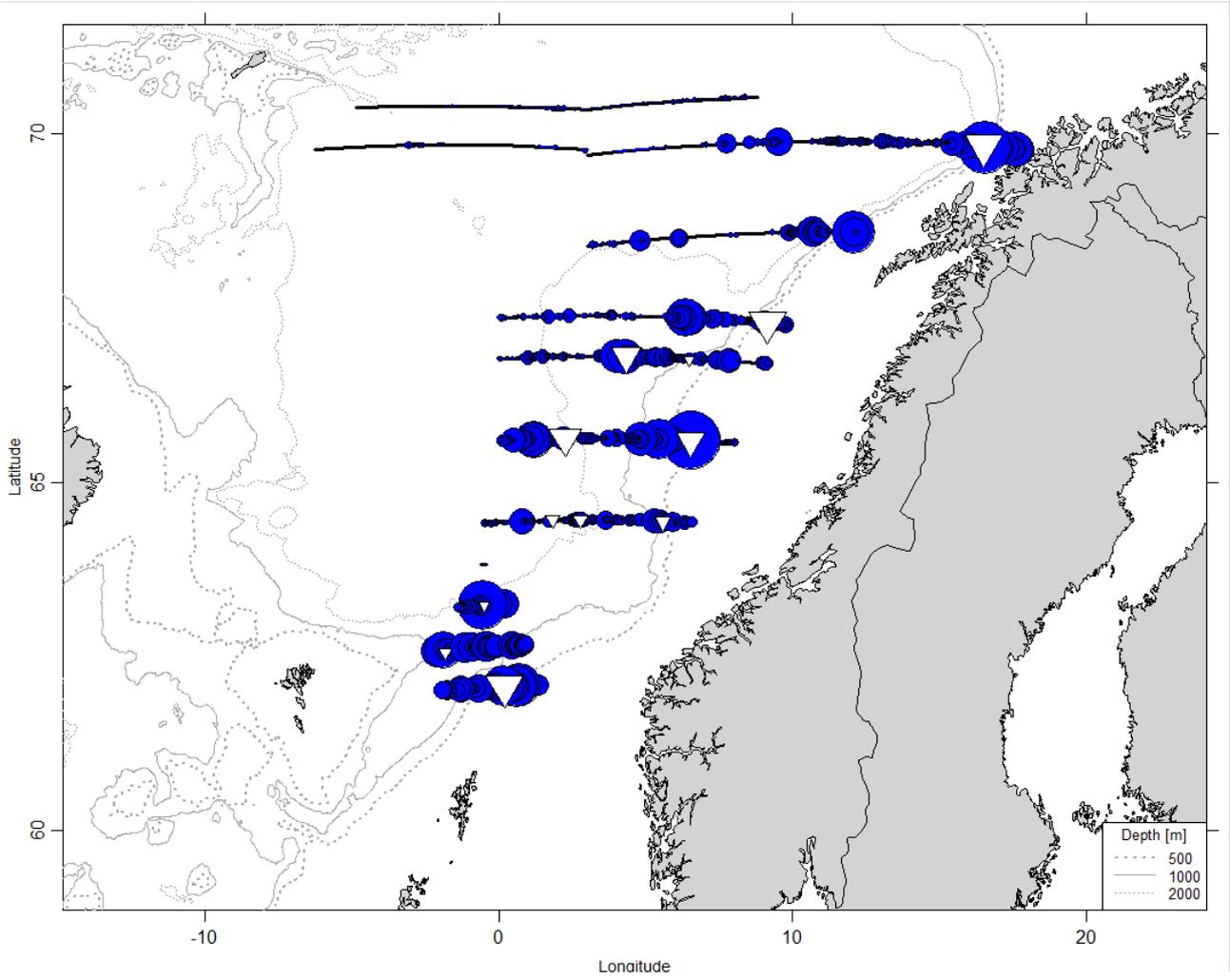


Figure 4. Distribution of NASC (Nautical area scattering coefficient, m^2 / nmi^2) for blue whiting (blue circles). Max NASC 5552 m^2 / nmi^2 . White triangles are scaled to catches of blue whiting in kg/tow. Max catch 830kg.

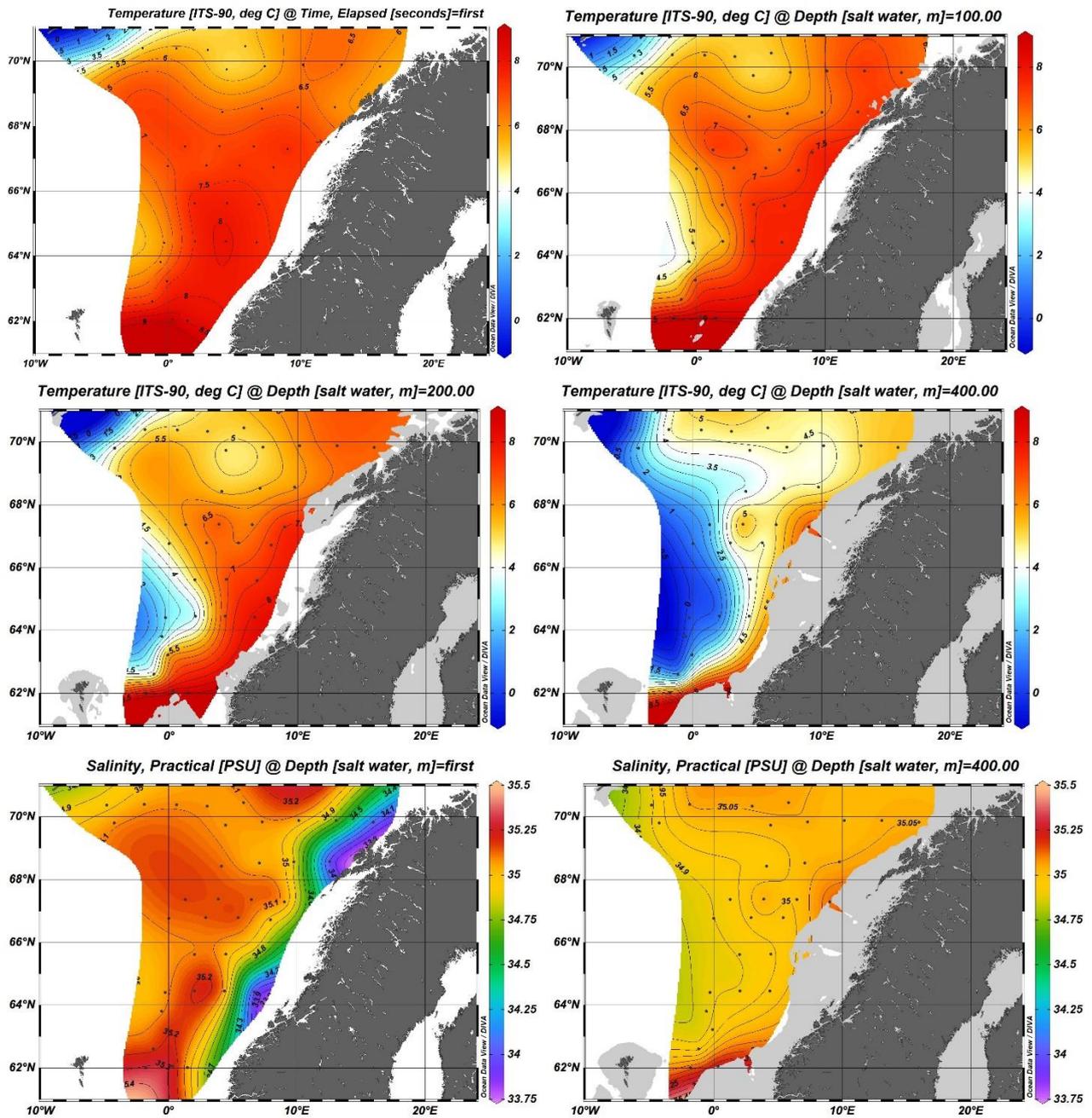


Figure 5: Horizontal temperature distribution at the surface, 100, 200 and 400 m depth, and of salinity at the surface and 400 m depth R/V Dana IESNS 2021.

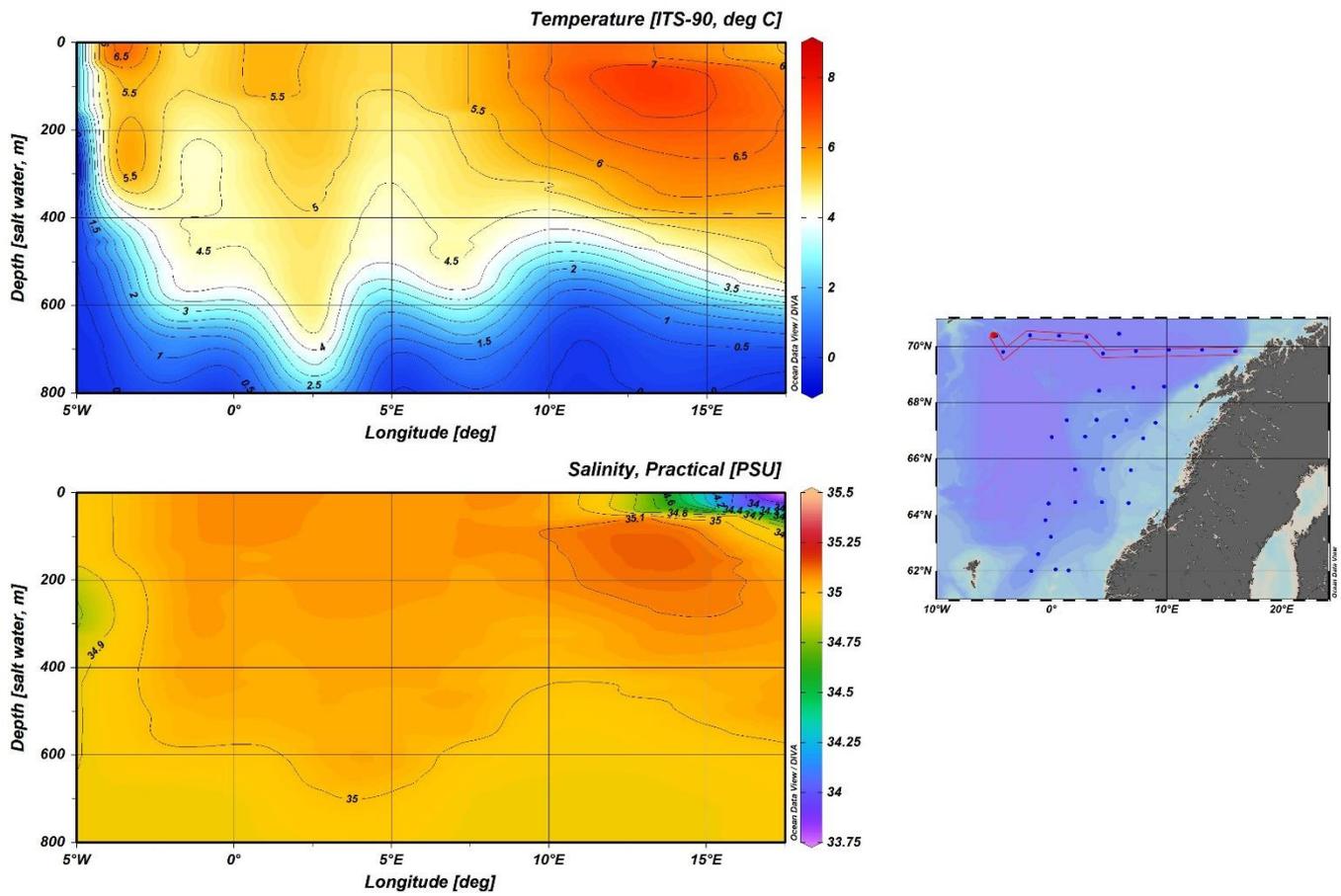


Figure 6: Temperature and salinity distributions along a northern transect perpendicular to the coast (see map for latitudinal positions of the stations included), R/V Dana IESNS 2021.

Table 1: Seabird CTD profiles (SEA) and valid WP2 stations taken by R/V Dana during IESNS 2021.

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)
202103	12	SEA	2021	5	3	6	52	62.0200	1.4547	371.5	44.8	1.75
202103	13	SEA	2021	5	3	11	31	62.0635	0.3081	427.1	67.3	7.8
202103	14	WP2	2021	5	3	12	10	62.0588	0.3013	423.5	86.6	6.52
202103	17	SEA	2021	5	4	2	17	62.0039	-1.8049	1526.3	55.8	10.14
202103	18	WP2	2021	5	4	3	22	62.0009	-1.8118	1527.6	32.8	14.9
202103	20	SEA	2021	5	4	17	20	62.6088	-1.1992	1584.4	12.8	16.57
202103	21	WP2	2021	5	4	18	18	62.6011	-1.1991	1583	5.1	12.7
202103	22	SEA	2021	5	5	8	45	63.2256	-0.0955	1692.3	2.1	11.58
202103	23	WP2	2021	5	5	9	49	63.2060	-0.1009	1668	25	12.08
202103	25	SEA	2021	5	6	0	6	63.8117	-0.5673	2332.3	42.9	10.62
202103	26	WP2	2021	5	6	1	13	63.7999	-0.5522	2321.9	48.3	11.17
202103	27	SEA	2021	5	6	6	32	64.4086	-0.2978	2608.8	21.3	8.13
202103	28	WP2	2021	5	6	7	36	64.4015	-0.2978	2604.7	42.2	7.46
202103	30	SEA	2021	5	6	18	30	64.4522	2.0230	2514.2	11.4	8.02
202103	31	WP2	2021	5	6	19	29	64.4513	2.0354	2515.2	13	6.68
202103	33	SEA	2021	5	7	4	39	64.4535	4.3439	1531.9	1.5	6.75
202103	34	WP2	2021	5	7	5	43	64.4397	4.3687	1519.6	358.6	4.51
202103	36	SEA	2021	5	7	15	50	64.4215	6.6517	355.1	341.9	4.86
202103	37	WP2	2021	5	7	16	21	64.4182	6.6564	353.1	316.7	5.23
202103	38	SEA	2021	5	8	2	36	65.5948	6.8356	391.8	270.7	5.08
202103	39	WP2	2021	5	8	3	13	65.5916	6.8515	385.3	255.5	4.41
202103	42	SEA	2021	5	8	16	8	65.6272	4.4387	1110.8	248.8	1.77
202103	43	WP2	2021	5	8	17	9	65.6231	4.4643	1098.7	292.3	1.58
202103	45	SEA	2021	5	9	2	20	65.6234	2.0106	2831.1	121	3.77
202103	46	WP2	2021	5	9	3	20	65.6211	1.9882	2825.1	110.5	3.41
202103	47	SEA	2021	5	9	15	46	66.7719	-0.0109	3358.2	46.2	8.08
202103	48	WP2	2021	5	9	16	47	66.7567	-0.0116	3332.9	40.7	11.56
202103	50	SEA	2021	5	10	4	57	66.7954	2.8909	1396.2	25.5	9.75
202103	51	WP2	2021	5	10	6	4	66.7802	2.8881	1407.6	57.9	10.16
202103	53	SEA	2021	5	10	17	26	66.7937	5.3950	1169.6	55.4	11.5
202103	54	WP2	2021	5	10	18	26	66.7839	5.4048	1164.2	31.5	13.75
202103	56	SEA	2021	5	11	6	17	66.7282	7.9343	329	31.8	12.58
202103	57	WP2	2021	5	11	6	48	66.7223	7.9374	318	37.1	16.27
202103	58	SEA	2021	5	11	17	31	67.2905	9.0105	404.9	66	16.12
202103	59	WP2	2021	5	11	18	9	67.2839	9.0128	405.9	81.7	12.6
202103	61	SEA	2021	5	12	5	29	67.3766	6.4504	1417	322.8	6.18
202103	62	WP2	2021	5	12	6	37	67.3750	6.4466	1416.8	338.4	6.75
202103	63	SEA	2021	5	12	22	13	67.3842	3.8701	1187.3	32.2	12.47
202103	64	WP2	2021	5	12	23	14	67.3691	3.8647	1192.2	30.6	11.15
202103	65	SEA	2021	5	13	6	25	67.3731	1.2701	2317	24.9	11.37
202103	66	WP2	2021	5	13	7	27	67.3758	1.2715	2321.3	32.7	13.42
202103	68	SEA	2021	5	14	1	25	68.4360	4.1016	2281.4	6	11.97
202103	69	WP2	2021	5	14	2	26	68.4305	4.1172	2243.7	21.3	13.85
202103	70	SEA	2021	5	15	1	19	68.5748	9.7485	2788	25.8	16.33
202103	71	WP2	2021	5	15	2	24	68.5568	9.7516	2746.8	33.5	13.08
202103	72	SEA	2021	5	15	13	20	68.5841	12.5614	109.6	32.4	13.99
202103	73	WP2	2021	5	15	13	39	68.5800	12.5664	110	33.7	11.23
202103	75	SEA	2021	5	16	15	56	69.8343	15.9485	2269.6	51.4	13.44
202103	76	WP2	2021	5	16	16	59	69.8265	15.9732	2134.7	53.4	12.43
202103	77	SEA	2021	5	17	0	12	69.8880	13.0609	2711.9	50	15.8
202103	78	WP2	2021	5	17	1	14	69.8845	13.0527	2714.1	50.5	14.6
202103	79	SEA	2021	5	17	8	59	69.8886	10.1505	2848	38.8	11.87
202103	80	WP2	2021	5	17	10	2	69.8645	10.1564		52	13.06
202103	82	SEA	2021	5	17	21	2	69.8442	7.2870	3066.6	39.1	11.85
202103	83	WP2	2021	5	17	22	4	69.8374	7.3278	3062.8	49.3	12.03
202103	84	SEA	2021	5	18	5	45	69.7489	4.4115	3173.9	19.5	15.72
202103	85	WP2	2021	5	18	6	45	69.7240	4.4423	3173.5	23.8	15.23
202103	86	SEA	2021	5	19	7	59	69.8118	-4.2550	3233	349.5	14.44
202103	87	SEA	2021	5	20	6	36	70.3779	-4.8706	2859.1	23.8	11.01
202103	88	WP2	2021	5	20	7	44	70.3568	-4.8476	2883.8	13	9.59
202103	89	SEA	2021	5	20	20	37	70.3998	-1.9037	2995.8	23.7	13.04
202103	90	WP2	2021	5	20	21	40	70.3885	-1.8955	2972.1	25.4	12.38
202103	92	SEA	2021	5	21	10	47	70.3914	0.6234	3134.3	34.9	13.25
202103	93	WP2	2021	5	21	11	47	70.3809	0.6128	3129.2	36.5	13.8
202103	95	SEA	2021	5	22	0	35	70.3450	2.9928	3171.9	63.4	10.15
202103	96	WP2	2021	5	22	1	36	70.3390	3.0015	3170.8	51	11.92
202103	97	SEA	2021	5	22	11	9	70.4608	5.8188	3113.7	48.7	9.53
202103	98	WP2	2021	5	22	12	8	70.4456	5.8046	3116.8	45.5	9.46
202103	100	SEA	2021	5	23	10	38	68.5392	7.0549	2850.8	62.2	14.93
202103	101	WP2	2021	5	23	11	38	68.5363	7.0671	2839.3	62.6	11.57

Table 2. Valid Pelagic trawl stations taken by R/V Dana during IESNS 2021.

RV Dana cruise	Station number	Trawl type	Year	Month	Day	Start Hour (UTC)		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
202103	15	stf	2021	5	3	13	52	62.03.754 N	000.11.453 E	86.8	4.7	4.01	60	1800	280	121	23	53.7	7.2	1
202103	16	stf	2021	5	4	0	0	61.59.659 N	001.56.494 W	176.8	4.1	3.31	60		0	95	29	48.1	11.0	6
202103	19	stf	2021	5	4	10	43	62.33.368 N	001.50.249 W	221.4	4.6	4.09	60	1350	190	115	24	38.8	11.9	6
202103	24	stf	2021	5	5	14	7	63.14.045 N	000.29.893 W	173.9	4.4	4.64	60	1200	180 / 290**	120	25	27.0	12.7	6
202103	29	stf	2021	5	6	15	21	64.27.453 N	001.50.142 E	259.0	4.6	4.53	60	1550	282	120	26	11.3	7.6	2
202103	32	stf	2021	5	6	22	52	64.27.535 N	002.47.014 E	269.3	4.1	4.41	46	300	0	87	31	37.7	4.3	2
202103	35	stf	2021	5	7	10	40	64.25.968 N	005.34.655 E	273.8	4.5	4.17	60	1600	295	123	25	321.7	3.8	1
202103	40	stf	2021	5	8	5	16	65.35.603 N	006.32.176 E	95.2	4.4	4.56	60	1500	238	120	26	263.2	4.0	1
202103	41	stf	2021	5	8	13	13	65.39.452 N	004.55.552 E	186.2	4.2	4.11	60	225	10	80	33	240.8	2.6	1
202103	44	stf	2021	5	8	23	47	65.38.042 N	002.15.467 E	83.2	4.2	4.17	60	300	0	85	32	22.6	6.0	1
202103	49	stf	2021	5	9	23	10	66.47.521 N	001.55.964 E	273.8	4.4	4.39	60	310	0	90	27	29.7	11.3	4
202103	52	stf	2021	5	10	11	50	66.48.405 N	004.20.008 E	268.0	4.8	4.30	60	1850	350	124	24	26.3	11.6	5
202103	55	stf	2021	5	10	22	53	66.45.495 N	006.29.480 E	238.8	4.2	3.90	60	320	0	82	28	47.3	13.7	5
202103	60	stf	2021	5	11	21	4	67.17.355 N	009.08.523 E	274.3	4.3	3.90	60	500	28	102	26	94.6	11.1	5
202103	67	stf	2021	5	13	23	21	68.25.057 N	004.05.528 E	219.5	4.5	3.59	60	300	0	84	32	24.1	11.1	5
202103	74	FOTØ	2021	5	16	11	51	69.50.124 N	016.30.618 E	170.2	5.5	4.88	60	1800	343	103	22	54.0	11.3	4
202103	81	FOTØ	2021	5	17	14	32	69.53.371 N	009.37.672 E	267.3	3.9	3.97	66	1400	262	90	26	42.5	14.7	4
202103	91	FOTØ	2021	5	21	8	1	70.23.278 N	000.32.898 E	249.6	4.3	4.13	60	1650	270	96	24	29.8	13.8	3
202103	94	FOTØ	2021	5	21	19	25	70.22.012N	002.15.361 E	272.3	4.0	3.84	60	2050	360	99	24	33.1	14.8	3
202103	99	FOTØ	2021	5	22	22	31	70.32.009 N	008.43.215 E	252.9	4.2	4.23	60	415	0	75	27	47.8	10.2	3

* calculated mean values from Scanmarplot files
** 30min each depth

Table 3. Composition of pelagic trawl catches (kg/tow) taken by R/V Dana IESNS 2021.

Scientific name	English name	Danish name	Station																	Total Catch					
			15	16	19	24	29	32	35	40	41	44	49	52	55	60	67	74	81		91	94	99		
<i>Clupea harengus</i>	Herring	Sild		15.560	34.693	4.878	17.249	3919.392			373.012	585.829	1561.645	0.498	337.441	228.333									7078.529
<i>Micromesistius poutassou</i>	Blue whiting	Blåhvilling	801.204		112.654	82.403	123.898	137.445	165.585	511.329		622.838		536.635	73.266	797.564		830.040	2.980	3.018	1.562				4802.421
<i>Scomber scombrus</i>	Mackerel	Makrel		672.400	21.654	0.226		599.557				162.520				0.850									1457.207
<i>Lamna nasus</i>	Porbeagle	Sildehaj						115.000																	115.000
<i>Oncorhynchus gorbuscha</i>	Humpback salmon	Pukkellaks		0.548							1.798	16.145	2.896		4.304		2.544							1.046	31.845
Scyphozoa	Jellyfish	Stor gopler	2.390			1.180	4.240		2.020					4.500				3.020	2.930	5.020	4.300				29.600
<i>Argentina silus</i>	Greater silversmelt	Guldlaks	20.900							7.110															28.010
<i>Arctozenus risso</i>	Spotted barracudina	Risso's laksetobis					2.540			22.327	1.560				0.342		0.010		0.029	0.018	0.031	0.152			27.009
<i>Cyclopterus lumpus</i>	Lumpsucker	Stenbider									4.010		2.454			9.250	0.522								16.236
<i>Gadus morhua</i>	Cod	Torsk																9.820							9.820
<i>Notoscopelus kroyeri</i>	Kroyer's lanternfish	Kroyer's Prikfisk	9.200				0.080		0.058						0.022										9.360
<i>Lophius piscatorius</i>	Monkfish	Havtaske		5.500																					5.500
<i>Todarodes sagittatus</i>	European flying squid	Flyveblæksprutte	2.300					1.050																	3.350
<i>Pallachius virens</i>	Saithe	Sej																2.090							2.090
<i>Bentosema glaciale</i>	Glacier lanternfish	Isprifikfisk							0.001						0.001				0.302	0.016	1.363				1.683
<i>Centrolophus niger</i>	Blackfish	Almindelig sortfisk										1.624													1.624
Euphausiidae gen. Sp.	Krill	Krill																	0.321		1.203				1.524
<i>Salmo salar</i>	Atlantic salmon	Laks									1.172														1.172
<i>Maurolicus muelleri</i>	Pearlside	Laksesild				0.102	0.002		0.008	0.004					0.002				0.003	0.005					0.126
<i>Gonatus fabricii</i>	Boreoatlantic gonate squid																				0.025			0.094	0.119
<i>Argyropelecus olfersi</i>	Hatchetfish	Sølvøkse																	0.000						0.000
	Total catch		835.993	694.008	169.001	88.789	148.009	4775.008	190.000	520.003	379.992	1388.955	1566.995	542.000	415.011	1036.006	3.066	845.002	6.556	8.110	8.580	1.140			13622.224
	Headline Depth (m)		280	0	190	235	282	0	295	238	10	0	0	350	0	28	0	343	262	270	360	0			
	Mean length (cm) herring		-	27.3	30.4	30.9	30.7	31.1	-	-	29.0	31.0	29.0	28.5	26.7	28.4	-	-	-	-	-	-	-	-	-
	Mean length (cm) blue whiting		20.9	20.3	23.0	-	27.2	19.5	19.2	18.0	-	18.9	-	19.0	18.5	18.4	-	17.8	18.7	30.2	29.2				
	Mean length (cm) mackerel		-	29.3	35.9	30.0	-	35.0	-	-	-	35.6	-	-	-	37.0	-	-	-	-	-	-	-	-	-

Annex 1: Calibration report for the towed body mounted transducer used for abundance estimation, April 2021.

Transceiver Menu	
Frequency	38 kHz
Sound speed	1474 m.s ⁻¹
Max. Power	2000 W
Equivalent two-way beam angle	-20.5 dB
Default Transducer Sv gain	25.45 dB
3 dB Beamwidth	6.9°
TS of sphere	-42.29 dB
Range to sphere in calibration	13.00 m
Measured NASCvalue for calibration	2009 m ² /nmi ²
Calibration factor for NASCs	1.00
Absorption coeff	9.778 dB/km
Log Menu	
Distance	1,0 n.mi. using GPS-speed
Operation Menu	
Ping interval	1 s
Analysis settings	
Bottom margin (backstep)	1.0 m
Integration start (absolute) depth	7 - 9 m
Range of thresholds used	-85 dB