Hirtshals, 17 June 2020

Cruise report

R/V DANA Cruise 04/2020

International Ecosystem survey in the Nordic Seas (IESNS) in 2020

Calibration of Echo-sounders

27 – 30/4 2020

Acoustic Monitoring of Herring and Blue whiting in the Norwegian Sea

1/5 – 25/5 2020

Cruise participants

Calibration 27 – 30/4

Kai Wieland	DTU Aqua, Monitoring Hirtshals	Cruise leader
Torben Filt Jensen	DTU Aqua, Monitoring Hirtshals	Acoustics
Karl-Johan Stæhr	DTU Aqua, Monitoring Hirtshals	Acoustics
Eik Ehlert Britsch	DTU Aqua, Monitoring Hirtshals	Technician
Christian Petersen	DTU Aqua, Monitoring Hirtshals	Technician

Acoustic monitoring 1 – 25/5

Kai Wieland	DTU Aqua, Monitoring Hirtshals	Cruise leader
Torben Filt Jensen	DTU Aqua, Monitoring Hirtshals	Acoustics
Kjetil Gjeitsund Thorvaldsen	DTU Aqua, Oceans and Arctic Lyngby	Acoustics
Eik Ehlert Britsch	DTU Aqua, Monitoring Hirtshals	Technician, CTD
Nikolaj Kolding Petersen	DTU Aqua, Monitoring Lyngby	Fish lab, WP2
Brian Werner Thomsen	DTU Aqua, Monitoring Hirtshals	Fish lab, WP2
Dirk Tijssen	DTU Aqua, Monitoring Hirtshals	Fish lab, WP2
Dennis Ulrik Andersen	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. To ensure that a reasonable data collection could be done and to minimize the risk of getting Corvid-19 infection onboard, the entire monitoring survey was run by a Danish team and the crew exchange in Bodø was dropped.

Cruise itinerary

27 April 2020,	17.00 UTC*	Departure Hirtshals for calibration of acoustic equipment at Bornö, Gulmarsfjorden, Sweden
28 April 2020,	04:00	at pilot station off Gulmarsfjord
	06:00	Start of calibration
29 April 2020,	17:00	Calibration finished, waiting for pilot
	20:00	Departure Bornø
30 April 2020,	05:15	Arrival Hirtshals, Quarantined in harbor (one team member showed Corvid-19 like symptoms) until negative test results was received
1 May 2020,	14:45	Departure Hirtshals for acoustic monitoring
3 May 2020,	08.30	Start monitoring
9 May 2020,		Monitoring interrupted to drop off one crew member at Bodø pilot station
22 May 2020,	00:20	Monitoring finished
25 May 2020,	07:15 UTC*	Arrival Hirtshals, end of survey

*: local time = UTC + 2

Cruise summary

Survey days	29	
Mileage	Steaming for calibration	150 NM
	Steaming to start of transects, between transects and to home port	1951 NM
	Acoustic transects	1820 NM
	Total	3931 NM
Number of trawl hauls	23	
Number of CTD stations	29 (+ 8 during calibration)	
Number of WP2 stations	32	
Number of biological samples – herring	477	
Number of biological samples – blue whiting	371	

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 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 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 has consequently 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 Atlanto-Scandian 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 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 is 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 30yh April 2020. 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 calibration of the towed body split-beam transducer at 38 kHz was conducted against a 38.1 mm tungsten sphere. Calibration of the three hull-mounted split-beam transducers at 18, 38,

and 120 kHz were carried out against 63mm copper sphere, 38.1 mm tungsten sphere, 38.1 mm tungsten and spheres, respectively. 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 2020 and in the WGIPS report of January 2021.

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 was put in the water again and a new integrating section was started.

Hydrographical and zooplankton data

At fixed positions, a priory 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, water samples were taken at 1000 m and in one shallower layer for calibration of the CTD's conductivity sensor.
Plankton samples were taken at the predefined 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 time restrictions a few of the CTD stations were dropped, and all together 29 CTD and 32 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 scrutinized 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 450 m depth during most of the survey. As this trawl got damaged the last stations were a conducted with the smaller "Fotø" trawl (Table 2, Figure 1). Trawl specifications and performance are given in Annex 2.

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 age, sex and maturity. For age determination in herring, blue whiting and mackerel otoliths were taken and will be read at Aqua DTU. In total 477 individual herring and 371 blue whiting were sampled.

All trawl data were entered into the Fiskeline database and validated. The data were also stored in the WGNAPES formats and will be uploaded to the WGNAPES database at the Faeroes Institute of Marine Research at the end of the survey.

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

03-05-2020 Started out southernmost transect in the east (WP16) at 06:02 UTC with a CTD to set the environment parameters in EK60. Had some dense acoustic recordings in the beginning and fished in 130-200 m at 62°58.65'N 4°53.20'E and got about 300 kg pearlside, some krill and 1 single blue whiting. Thereafter very scarce recordings.
04-05-2020 Fished at night in the surface at 62°57.50'N 1°07.79'E and got 275 kg herring (mean length 30.3 cm), 37 kg blue whiting (mean length 21.7 cm) and 514 kg mackerel. Otherwise not much to see on the echograms. Fished in the late afternoon in 85 – 115 m at 62°53.78'N 1°31.62'W depth but almost missed the spots seen on the echogram which resulted in a catch of 5.44 kg herring (mean length 30.7 cm) and 2.89 kg mackerel. Finished the transect on WP9 at 17:45 UTC and steamed to the next.
05-05-2020 Started transect on WP24 at 02:00 UTC and 'surfed' with the sea towards the east. Westerly wind with up to 20 m/s peaked at noon. Herring marks at the beginning of the transect in 50 m and a series of scattered spots along a distance of about 5 nm between 300 and 400 m in the afternoon. Completed two CTD/WP2 stations (WPs 26 and 28).
06-05-2020 Fished at night in the surface at 64°09.05'N 5°16.79'E and got a catch of 80 kg krill and a few spotted barracudina. Finished the transect with CTD/WP2 on WP30 at 5:50 UCT. Steamed towards NE to next transect. Westerly swell made the transit a bit unpleasant and delayed the start of our 3rd transect which occurred first at 18:13 UTC.
07-05-2020 Fished in the evening between 275 and 325 m at 65°19.92'N 2°11.36'E. The catch was 13.6 kg herring (mean length 29.3 cm) and 14.4 kg blue whiting (mean length 23.2 cm) and some mixed mesopelagics (laternfishes and spotted barracudina).
08-05-2020 Did a surface tow in the night at 65°19.10'N 0°58'15E with a catch of 64.2 kg herring (mean length 29.5 cm) and 0.6 kg blue whiting (mean length 30.0 cm). Finished the transect at 04:35 UCT with all CTD/WP2 stations completed. Started our fourth transect at 11:20 UCT. Recognized scattered schools in the midwater and fished in the afternoon at 66°28.83'N 0°19.85'E at 225 – 275

m depth but got only 1 herring (28.5 cm) and 2 blue whiting (mean length 28.5 cm) in addition to 3.96 kg haddock (2 individuals) and 4.12 kg saithe (2 individuals). Thereafter continued transect towards east.

09-05-2020 Did a surface tow in the night at 66°30.16'N 2°37'99E with a catch of 219.7 kg herring (mean length 30.6 cm). Recorded thin layer of strong herring marks at 35 m depth in the early morning. Thereafter not much until the late afternoon when some registrations between 200 and 300 m appeared. Fished at 66°27.65'N 6°30.30E in 200 – 275 m depth and got about 182.3 kg blue whiting (mean length 30.6) together with some mesopelagics.

10-05-2020 A surface tow at night at 66°27.39'N 7°41.15'E yielded a catch of 1384.2 kg herring (mean length 27.3 cm) together with a few small mackerel. Some herring marks in the surface layer just east from the fishing position which diminished towards the end of the transect. Finished transect at 05:43 UTC. Steamed towards northeast heading for the next transect. Changed course on half the way to drop a crew member at pilot station off Bodø.

11-05-2020 Started recording with the towed body on WP1 at 04:58 UTC. After 2 nm some marks begin to occur in the surface which became stronger after about 15 nm. We did a surface tow at 67°51.89'N 10°02.28'E and got 2 tons of herring (mean length 25.8 cm). Thereafter we saw thin layers of probably herring in 70 m depth, which thinned out a bit when approaching our 1st CTD/WP2 station on this transect. Thereafter again, herring recordings in surface layer west from the CTD/WP2 station for about 10 nm. Fished in late afternoon at 67°50.25'N 8°33.86'E in 375 – 400 m depth getting about 102.1 kg blue whiting (mean length 20.0 cm) together with some mesopelagics, 1 redfish (*S. marinus*), 1 haddock and 1 saithe.

12-05-2020 No fishing due to weather. Almost nothing to see on the echo sounder and some problem with noise at the surface. Stopped recording at 67°42.87'N 4°26.48'E 07:50 UTC due to weather (unfavorable wind and wave direction relative to the E-W orientation of the transect, 18-20 m/s northerly wind). We are planning to do the missing part of our 5th transect (appr. 10 nm east from WP6 to WP7) on our way back home. Steamed now slowly towards northwest heading for WP24 on our next transect and started recording there with the towed body at 23:29 UTC.

13-05-2020 Almost no fish marks on the echosounder until weak marks were recorded in 350 m depth in late morning and in the afternoon. Fished at 68°53.22'N 6°49.42'E and got 5.7 kg blue whiting (mean length 27.8 cm) together with mesopelagics and 2 redfish (*S. mentella*).

14-05-2020 Saw marks in the surface layer during early night and fished in 60 – 80 m depth at 68°55.22'N 8°23.44'E and got 0.9 kg herring (mean length 26.4 cm) and 40 kg blue whiting (mean length (19.7 cm) together with a lot of krill and measopelagics. Recorded some dense signatures close to surface during the morning, and a tow at 68°56.77'N 10°24.41'E in 20 – 30 m depth yielded 1 ton herring (mean length 26.4 cm), a few mackerel and 1 lumpsucker (40 cm). Observed herring marks all the way. Recorded a high density layer undulating between 200 and 300 m depth in the evening. Fished in 200 – 250 m depth at 68°55.62'N 12°59.24'E and got 1.6 ton blue whiting (mean length 19.0 cm), no laternfish but 1 dealfish and a few saithe and cod. Finished transect at 21:21 UTC and steamed northeastward to our next transect.

15-05-2020 Start of transect delayed due to bad weather (westerly wind > 25 m/s). Steamed to the northern entrance of Andfjorden seeking shelter.

16-05-2020 Started our 7th transect at bit further offshore than WP36 (which is within the 4 nm limit) at 00:02 UTC. Recorded strong marks in the upper 50 m and some weaker signals at 300 - 400 m depth when having passed the slope at a bottom depth > 1000 m. Decided to fish in the surface layer at 69°57.06'N 16°23.30'E and got 2.6 ton herring (mean length 23.9 cm) and 1 single lumpsucker of 6 cm length. Almost nothing to see except for zooplankton patches in the surface layer when continuing towards the west. Agreed in correspondence to the coordinator to take over the northernmost Icelandic transect and give our two northernmost transect to Norway in change.

Dropped every second CTD (but keep all WP2 stations) in order to ensure sufficient time to cover the Icelandic and our remaining transects.

17-05-2020 Periods with registrations in a continuous layer at 20 – 50 m depth and sporadic weak recordings in 250 – 300 m depth. Fished at 69°54.14'N 4°51.98'E in the surface layer at got juvenile squid, 2 lumpsucker, 1 capelin and 1 wolffish (*A. denticulatus*; 44 cm). Transect finished on WP47 at 19:38 UTC. Started our 8th transect at WP38 at 23:05 UTC.

18-05-2020 Almost nothing to see on the echo sounder until late morning. Thereafter scattered weak echo registrations in 225 – 350 m. Fished on these aggregations at 70°07.52'N 0°58.33'W in 240 – 290 m depth but hit only a bit of them and got 13 blue whiting (2.5 kg, mean length 30.8 cm), juvenile squid, 1 lumpsucker, 1 wolffish (*A. denticulatus*; 43 cm) and a few spotted barracudinas (*A. risso*). The scattered weak echoes continued sporadically in 300 – 450 m depth westward but disappeared when approaching WP42. No fish echoes detected thereafter. Last 30 nm of transect skipped in order to have more time available for the remaining transects. Hence, transect 8 was terminated at WP49 after CTD/WP2 at 20:10 UTC. Steamed towards northeast to next transect which started at 23:50 UTC logging acoustics with the towed body.

19-05-2020. Recorded weak marks scattered in 300 – 400 m depth in the morning for a few nautical miles. Thereafter only single marks around 400 m depth which became a bit stronger in the late afternoon. A total catch of 26 kg at 70°39.18'N 1°48.18'E from 400 – 435 m depth contained 10 blue whiting (1.7 kg; mean length 30.0 cm), 1 herring (32 cm), 1 redfish (*S. mentella*), mixed mesopelagics, a few juvenile squid and 10 kg jellyfish. Finish the transect 9 with CTD/WP2 at 20:51 UTC and steamed southward to WP37, the northernmost Icelandic transect.

20-05-2020. Started the 10th transect, which has originally been allocated to Iceland, in the east with towed body at 03:12 UTC and went. Almost anything to see on the echo sounders in the beginning. Later some loosely scattered schools around 150 m and 300 m depth which disappeared after a short distance and returned later, again for just a few nautical miles. The echogram became almost completely empty when approaching WP32. Terminated the transect there with CTD/WP2. Fished a few miles back on the transect at 69°32.74'N 3°23.44'W in the surface receiving 70 kg krill, 5 kg juvenile squid and 11 lumpsucker. Steamed towards southeast to do the missing western part of our transect 5.

21-05-2020. Started the remaining western part of transect 5 with echo recording with the towed body at 16:38 UTC. Some scattered signals mainly between 200 – 250 m depth. Fished on these aggregations at 67°42.71'N 4°08.13'E and got 29 herring (5.2 kg, mean length 29.2 cm), 1 blue whiting (22 cm) and the usual mixed mesopelagics.

22-05-2020 Did a surface tow in the night at 67°42.14'N 3°47.30'E catching 14 herring (2.6 kg, mean length 29.2 cm), 2 lumpsucker and juvenile squid. Started travel back to Hirtshals at 02:00 UTC.

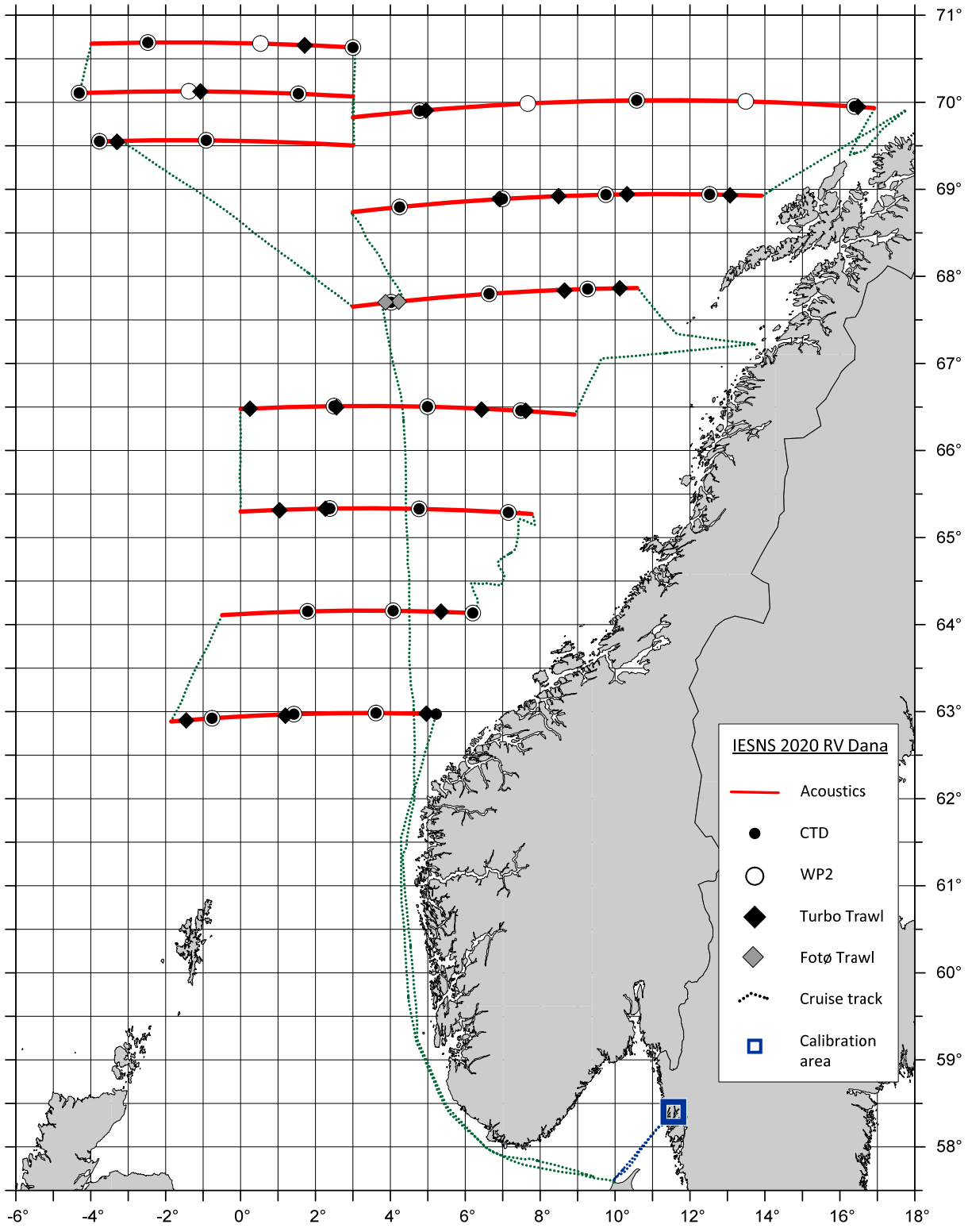


Figure 1. Cruise track and sampling locations by R/V Dana during IESNS 2020.

Table 1: Seabird CTD profiles (SEA) and valid WP2 stations taken by R/V Dana during IESNS 2020.

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)
202004	9	SEA	2020	5	3	6	2	62.9692	5.2238	126.7	339.3	6.9
202004	11	SEA	2020	5	3	13	56	62.9847	3.6202	911.0	329.0	12.5
202004	13	WP2	2020	5	3	15	19	62.9766	3.6371	904.4	333.7	11.2
202004	15	SEA	2020	5	4	1	56	62.9710	1.4264	1038.8	318.0	10.4
202004	16	WP2	2020	5	4	3	9	62.9637	1.4513	1036.0	317.1	10.4
202004	17	SEA	2020	5	4	9	41	62.9241	-0.7802	1577.5	301.9	9.3
202004	18	WP2	2020	5	4	11	2	62.9120	-0.7848	1575.1	303.7	7.5
202004	20	SEA	2020	5	5	7	52	64.1568	1.8031	2118.3	235.9	16.2
202004	21	WP2	2020	5	5	9	52	64.1790	1.8247	2121.7	240.1	19.2
202004	22	SEA	2020	5	5	17	6	64.1581	4.1157	1571.4	275.3	12.0
202004	23	WP2	2020	5	5	18	22	64.1638	4.1132	1579.9	278.3	14.3
202004	25	SEA	2020	5	6	4	58	64.1261	6.2003	397.2	281.9	12.2
202004	26	WP2	2020	5	6	5	38	64.1325	6.2049	396.9	280.0	12.6
202004	27	SEA	2020	5	6	20	20	65.3035	7.1884	332.9	312.4	9.5
202004	28	WP2	2020	5	6	20	54	65.3032	7.2045	330.2	296.9	9.5
202004	29	SEA	2020	5	7	6	5	65.3334	4.7714	829.5	350.0	1.8
202004	30	WP2	2020	5	7	7	10	65.3336	4.7711	831.1	23.9	1.8
202004	31	SEA	2020	5	7	13	48	65.3328	2.3790	2892.9	151.6	2.2
202004	32	WP2	2020	5	7	15	8	65.3377	2.3631	2891.4	101.4	3.1
202004	38	SEA	2020	5	9	1	23	66.5093	2.4948	1649.2	325.9	9.7
202004	40	WP2	2020	5	9	3	4	66.4995	2.5564	1646.4	327.6	10.6
202004	41	SEA	2020	5	9	9	31	66.5037	5.0196	1091.3	323.7	10.1
202004	42	WP2	2020	5	9	11	10	66.5015	5.0630	1083.3	327.8	8.9
202004	45	SEA	2020	5	10	0	57	66.4582	7.4850	393.4	327.9	4.3
202004	46	WP2	2020	5	10	1	33	66.4602	7.4965	390.9	317.0	6.1
202004	48	SEA	2020	5	11	10	47	67.8592	9.2589	1651.1	356.6	11.5
202004	49	WP2	2020	5	11	12	4	67.8708	9.2727	1641.0	344.3	9.5
202004	51	SEA	2020	5	12	0	1	67.8033	6.6347	1262.8	342.1	12.3
202004	52	WP2	2020	5	12	1	16	67.7954	6.6650	1266.5	345.0	13.8
202004	53	SEA	2020	5	13	2	41	68.7859	4.2515	3238.1	308.7	12.6
202004	54	WP2	2020	5	13	4	4	68.7969	4.2981	3238.6	302.2	16.0
202004	56	SEA	2020	5	13	14	36	68.8890	7.0340	3094.4	299.9	5.5
202004	57	WP2	2020	5	13	16	2	68.8960	7.0632	3092.5	248.8	8.2
202004	60	SEA	2020	5	14	2	46	68.9394	9.7637	3023.4	195.3	5.9
202004	61	WP2	2020	5	14	4	0	68.9443	9.7559	3024.0	179.9	5.7
202004	63	SEA	2020	5	14	13	32	68.9397	12.5591	1507.9	198.7	5.2
202004	64	WP2	2020	5	14	14	49	68.9536	12.6074	1516.0	189.3	5.6
202004	67	SEA	2020	5	16	4	1	69.9500	16.3887	1804.7	116.8	14.5
202004	68	WP2	2020	5	16	5	18	69.9449	16.4047	1799.8	125.4	12.9
202004	69	WP2	2020	5	16	12	8	70.0091	13.4721	2699.0	102.7	11.9
202004	70	SEA	2020	5	16	19	28	70.0263	10.5631	2901.2	69.0	13.3
202004	71	WP2	2020	5	16	20	47	70.0549	10.5900	2899.8	65.3	13.3
202004	72	WP2	2020	5	17	4	4	69.9812	7.6692	3092.7	19.2	12.2
202004	74	SEA	2020	5	17	13	34	69.9028	4.7731	3229.7	8.4	7.4
202004	75	WP2	2020	5	17	14	51	69.8911	4.7412	3229.0	0.1	6.8
202004	76	SEA	2020	5	18	0	25	70.0988	1.5374	3237.4	340.0	10.1
202004	77	WP2	2020	5	18	1	40	70.0988	1.5070	3237.3	323.6	10.1
202004	79	WP2	2020	5	18	11	18	70.1270	-1.3099	3170.2	22.3	8.0
202004	80	SEA	2020	5	18	18	35	70.1031	-4.3283	3076.1	249.5	3.4
202004	81	WP2	2020	5	18	19	51	70.0829	-4.3256	3076.1	264.5	5.3
202004	82	SEA	2020	5	19	2	54	70.6874	-2.4716	3162.9	226.1	6.6
202004	83	WP2	2020	5	19	4	8	70.6900	-2.4540	3171.1	250.0	5.0
202004	84	WP2	2020	5	19	10	32	70.6781	0.5663	3207.5	222.9	3.9
202004	86	SEA	2020	5	19	19	20	70.6285	3.0234	3226.9	219.1	2.4
202004	87	WP2	2020	5	19	20	35	70.6230	3.0424	3227.2	205.4	1.8
202004	88	SEA	2020	5	20	11	19	69.5629	-0.9457	2834.4	257.8	8.4
202004	89	WP2	2020	5	20	12	35	69.5733	-0.9561	2837.5	243.4	6.8
202004	90	SEA	2020	5	20	19	5	69.5507	-3.7888	3472.6	132.5	4.3
202004	91	WP2	2020	5	20	20	21	69.5403	-3.7972	3472.9	119.3	3.6
202004	94	SEA	2020	5	21	22	24	67.7144	4.0765	1297.1	145.4	10.8
202004	95	WP2	2020	5	21	23	43	67.7115	4.0538	1295.8	151.7	11.0

Table 2. Valid Pelagic trawl stations taken by R/V Dana during IESNS 2020.

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) at desired depth	Headline depth (m)*	Door spread (m)*	Vertical opening (m)*	Wind direction (°)	Wind speed (m/s)
202004	10	Turbo	2020	5	3	8	8	62.9775	4.8866	84.4	3.5	3.9	60	152.8	109.2	-	33.6	2.4
202004	14	Turbo	2020	5	3	23	23	62.9584	1.1298	94.6	3.9	4.0	60	6.1	88.0	25.2	307.9	11.0
202004	19	Turbo	2020	5	4	14	14	62.8963	-1.5271	79.5	3.5	4.5	60	86.9	104.9	29.2	242.8	9.1
202004	24	Turbo	2020	5	6	0	0	64.1509	5.2798	76.0	3.6	3.7	60	2.0	82.0	31.2	273.9	10.2
202004	33	Turbo	2020	5	7	17	17	65.3319	2.1893	89.2	3.8	3.8	60	280.1	113.4	34.5	45.3	4.9
202004	34	Turbo	2020	5	8	0	0	65.3183	0.9692	85.9	3.5	3.7	60	5.0	89.1	35.6	22.4	8.3
202004	36	Turbo	2020	5	8	15	15	66.4805	0.3308	266.6	4.0	3.9	60	245.0	91.2	28.8	40.9	9.1
202004	37	Turbo	2020	5	8	23	23	66.5027	2.6331	263.2	3.9	3.6	60	2.1	90.5	27.1	350.2	10.9
202004	43	Turbo	2020	5	9	17	17	66.4608	6.5049	270.5	3.6	3.8	60	223.5	113.7	22.3	315.8	6.9
202004	44	Turbo	2020	5	9	23	23	66.4566	7.6856	274.1	3.9	3.6	60	7.4	87.2	33.6	298.1	6.1
202004	47	Turbo	2020	5	11	6	6	67.8649	10.0380	92.9	3.9	4.1	60	4.0	88.7	34.2	342.4	5.3
202004	50	Turbo	2020	5	11	16	16	67.8376	8.5643	97.8	4.0	3.9	63	375.0	117.0	26.8	354.2	15.0
202004	55	Turbo	2020	5	13	12	12	68.8871	6.8236	105.1	3.7	4.0	60	326.6	113.8	28.8	304.9	8.1
202004	59	Turbo	2020	5	13	22	22	68.9222	8.4168	79.6	3.6	3.8	60	73.6	102.8	28.4	237.1	8.2
202004	62	Turbo	2020	5	14	7	7	68.9462	10.4068	276.2	3.7	4.1	60	18.8	87.8	-	268.0	5.2
202004	65	Turbo	2020	5	14	17	17	68.9270	13.1516	255.6	3.8	3.4	62	225.2	113.4	26.7	285.2	5.6
202004	66	Turbo	2020	5	16	1	1	69.9510	16.3883	108.8	3.6	3.9	60	8.5	73.8	38.8	109.6	14.3
202004	73	Turbo	2020	5	17	11	11	69.9023	4.8663	86.9	3.3	3.0	61	25.0	94.6	30.4	346.3	7.7
202004	78	Turbo	2020	5	18	8	8	70.1254	-1.1728	91.5	3.7	4.0	60	264.1	114.0	27.7	337.8	9.1
202004	85	Turbo	2020	5	19	14	14	70.6530	1.8030	271.6	3.8	3.7	60	413.9	113.2	25.8	182.8	2.3
202004	92	Turbo	2020	5	20	21	21	69.5457	-3.3907	85.9	3.8	4.1	60	21.0	92.2	25.5	130.8	8.5
202004	93	Fotø	2020	5	21	20	20	67.7118	4.3104	272.1	3.6	3.9	60	225.6	98.9	26.3	148.1	9.9
202004	96	Fotø	2020	5	22	0	0	67.7046	3.9551	265.5	3.6	3.8	60	1.4	65.2	36.2	147.6	11.5

*: calculated mean values from Scanmar plot files and stored in fish database 'Fiskeline' (but not corrected in SIS)

Results

Conditions during the survey

Weather conditions were mostly pleasant with only short periods at which the wind exceed 15 m/s. However, a strong westerly swell made the transit between the southernmost transects unpleasant. The wave and swell direction became thereafter northerly and the direction perpendicular to the direction of the transects caused such a strong rolling of the vessel that the work on one of the transect has to be abandoned. Wind speed between 25 and 29 m/s (Fig. 2) delayed the work in the northwestern part of the survey area whereas excellent weather condition were met in the northeastern part of the survey area. Head waves and strong wind (about 20 m/s) during the way back to Hirtshals caused a slowdown of travel speed and a delay of the intended arrival time.

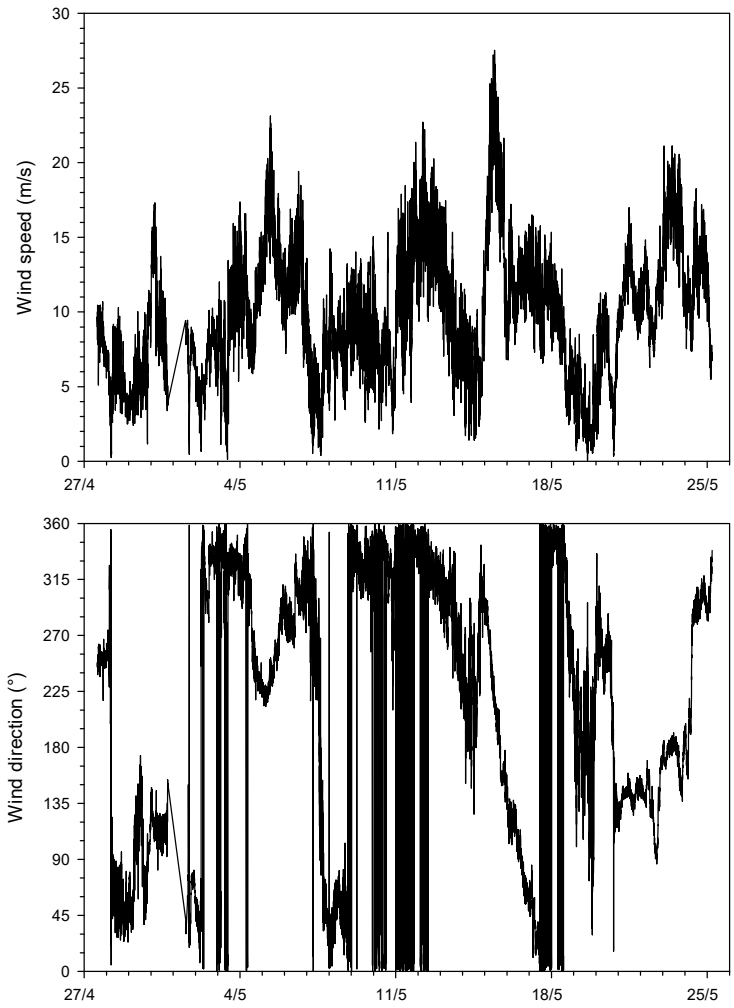


Figure 2. Wind speed and direction along cruise track, R/V Dana IESNS 2020.

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 tows but the by far major part was caught in one single surface tow in the southern part of the survey area (mackerel mean length: 32.2 cm, Tab. 3). As usual, laternfish and spotted barracudina were caught together with blue whiting in the deep midwater tows. Juvenile squid was regularly found in both, the surface layer and the deep tows. Some of the surface tows gave almost clean herring catches whereas in others also a few lumpfish occurred. Mean length per tow for herring and blue whiting ranged from 23.9 to 32.0 cm and from 19.0 to 30.8 cm, respectively (Tab. 3).

Table 3. Composition of pelagic trawl catches (kg/tow) taken by R/V Dana IESNS 2020.

		Station																							
Latin name	Danish name	10	14	19	24	33	34	36	37	43	44	47	50	55	59	62	65	66	73	78	85	92	93	96	Total
Clupea harengus	Herring		274.793	5.440		13.620	64.230	0.154	219.656		1384.160	2001.764			0.883	1057.860		2620.984			0.264		5.186	2.618	7651.612
Micromesistius poutassou	Blå hvilling	0.044	36.883			14.360	0.580	0.347		182.301			102.066	5.738	39.960		1631.443			2.518	1.712		0.064		2018.017
Anarhichas denticulatus	Blå havkat																		0.932	1.159					2.091
Arctozenus risso	Risso's laksetobis				0.131	3.580	0.029	0.028		2.062			2.500	0.790	0.958		0.410			0.313	1.068		0.452		12.321
Benthosema glaciale	Isprikfisk		0.570	0.010	1.250	7.300	0.035	0.008		0.330			1.180	3.089	7.133		0.002			0.003	2.618		0.494		24.022
Cyclopterus lumpus	Lumpfish										0.023	0.023				2.342		0.010	1.778	0.544		8.600	2.118	1.868	17.306
Gadus morhua	Cod																10.240								10.240
Mallotus villosus	Capelin																		0.019						0.019
Maurolicus muelleri	Laksesild	299.828	0.356		0.106	0.005	0.003	0.002		0.606							0.002						0.018		300.926
Melanogrammus aeglefinus	Haddock							3.960					1.220										1.276		6.456
Merlangius merlangus	Hvilling																0.934								0.934
Notoscopelus kroyeri	Kroyer's prikfisk					1.400				0.360			1.062	0.021	0.014		0.012								2.869
Pollachius virens	Saithe							4.120					2.840				16.580								23.540
Scomber scombrus	Mackerel		514.063	2.890							0.809	0.172				1.806									519.740
Sebastes marinus	Lille rødfisk												1.850												1.850
Sebastes viviparus	Stor rødfisk													1.515	0.620						0.786				2.921
Trachipterus arcticus	Vågmær																14.400								14.400
Euphausiidae sp.	Krill	0.098	10.351	0.250	78.299	2.960		0.204		2.071			0.549	2.506	6.828					0.045	1.770	71.003	0.548		177.482
Pasipaeidae	Glasrejer				0.212	0.240															0.008				0.460
Pasiphaea tarda																					0.242				0.242
Gonatus fabricii									0.181																0.181
Todarodes sagittatus								0.027							0.194				0.579	0.421	1.111	4.397	0.034	0.210	6.974
Todaropsis eblanae														0.051											0.051
Scyphozoa sp.	Stor gopler																			1.904	16.400				18.304
	Vandmand																						0.968		0.968
Invertebrata	Invertebrater	0.030				3.510		1.300		0.275			4.735	17.770	2.410		5.980								36.010
																			0.002				0.001		0.003
	Total	300.000	837.016	8.590	79.998	46.975	64.877	10.150	219.837	188.005	1384.992	2001.959	118.002	31.480	59.000	1062.008	1680.003	2620.994	3.310	6.907	25.980	84.000	11.159	4.696	10849.939
Headline depth (m):		152.8	6.1	86.9	2.0	280.1	5.0	245.0	2.1	223.5	7.4	4.0	375.0	326.6	73.6	18.8	225.2	8.5	25.0	264.1	413.9	21.0	225.6	1.4	
mean length (cm) herring:			30.3	30.7		29.3	29.5	28.5	30.6		27.3	25.8			26.4	26.4		23.9			32.0		29.2	29.2	
blue whiting:		20.0	21.7			23.2	30.0	28.5		19.9			20.0	27.8	19.7		19.0			30.8	30.0		22.0		
mackerel:			32.2	31.5							31.6	20.7				19.6									

Distribution and density of herring and blue whiting

Distribution and densities of herring and blue whiting along the survey track are presented in Figure 3. For both, species, highest trawl catches were found in the northeastern part of the survey area, in particular near the continental slope. Considerable densities were occasionally also observed in the south and both species were scare in the northwestern part of the survey area.

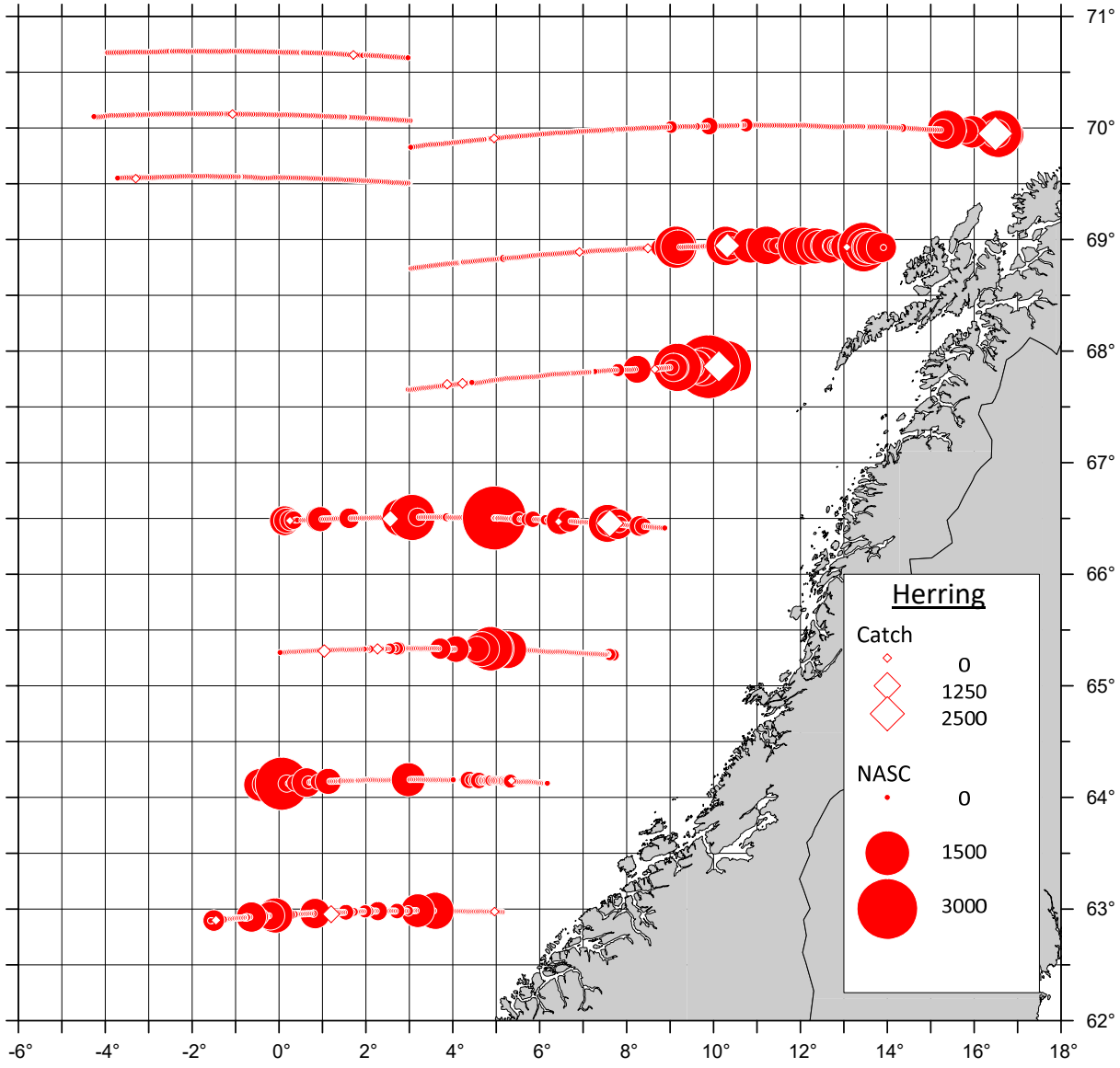


Fig. 3a. Distribution of catch (kg/tow) and NASC (Nautical area scattering coefficient, m^2/nmi^2) for herring.

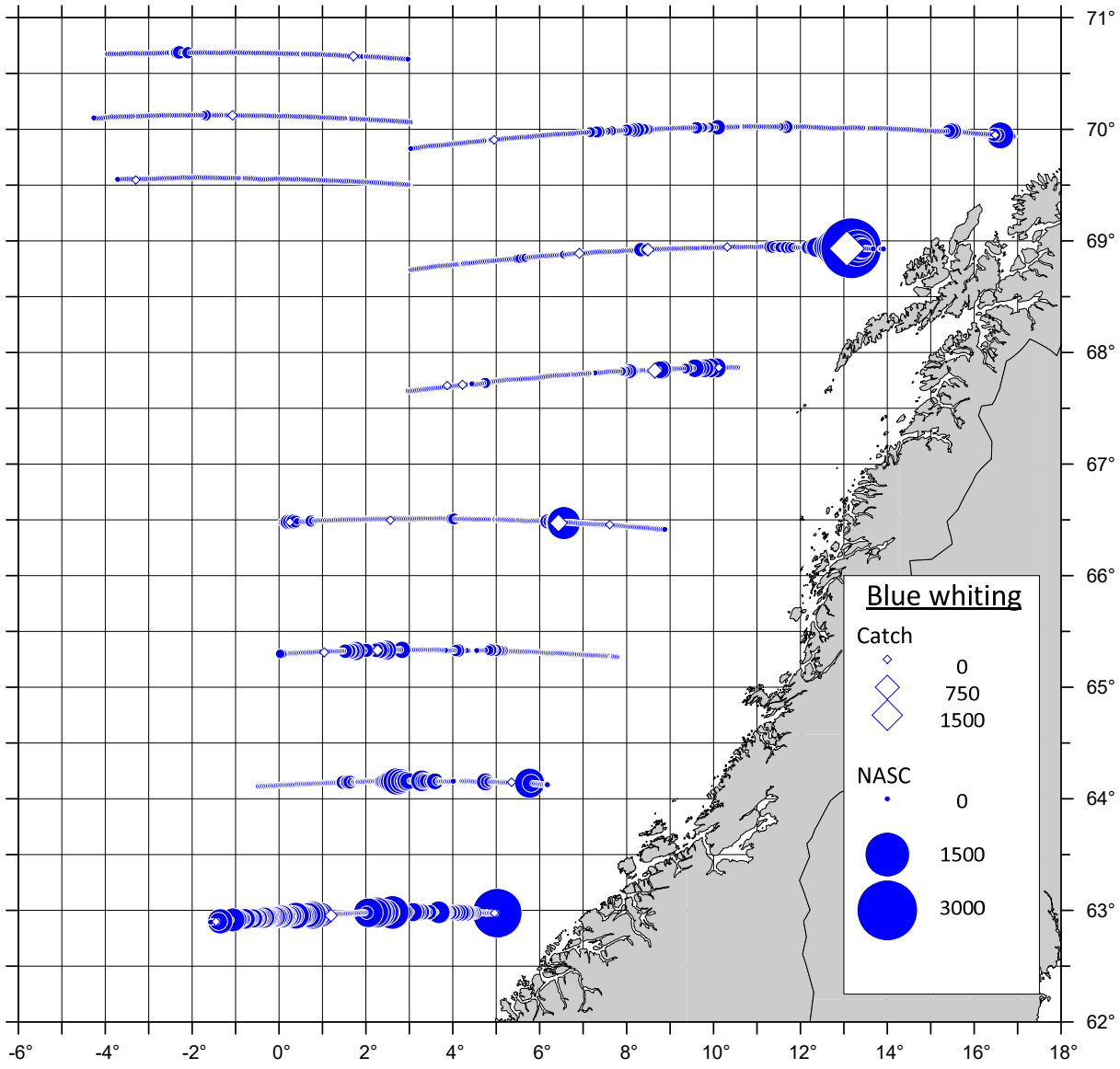


Fig. 3b. Distribution of catch (kg/tow) and NASC (Nautical area scattering coefficient, m^2/nmi^2) for blue whiting.

Hydrographic conditions

Surface (10 m) temperatures were between < 4.5 °C in the Northwest and > 7.5°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 4).
As in the previous years, the water column was clearly vertically structured into warmer water masses of Atlantic origin in the upper layers and cold Arctic waters at depth (Figs. 4 and 5). The magnitude of these layers varied with latitude. In the southern part of the survey area, the layer of warmer Atlantic water could be detected down to about 300 m only close to the coast. In the North, the cold water layer was elevated to depths of 600 m and above. In the oceanic area, this layer was only 400 – 450 m of magnitude decreasing to < 400 m at the westernmost stations. On the northernmost transect the warm Atlantic water layer reached deeper to > 600 m close to the shelf edge but was cooler than in the south (Fig. 5).

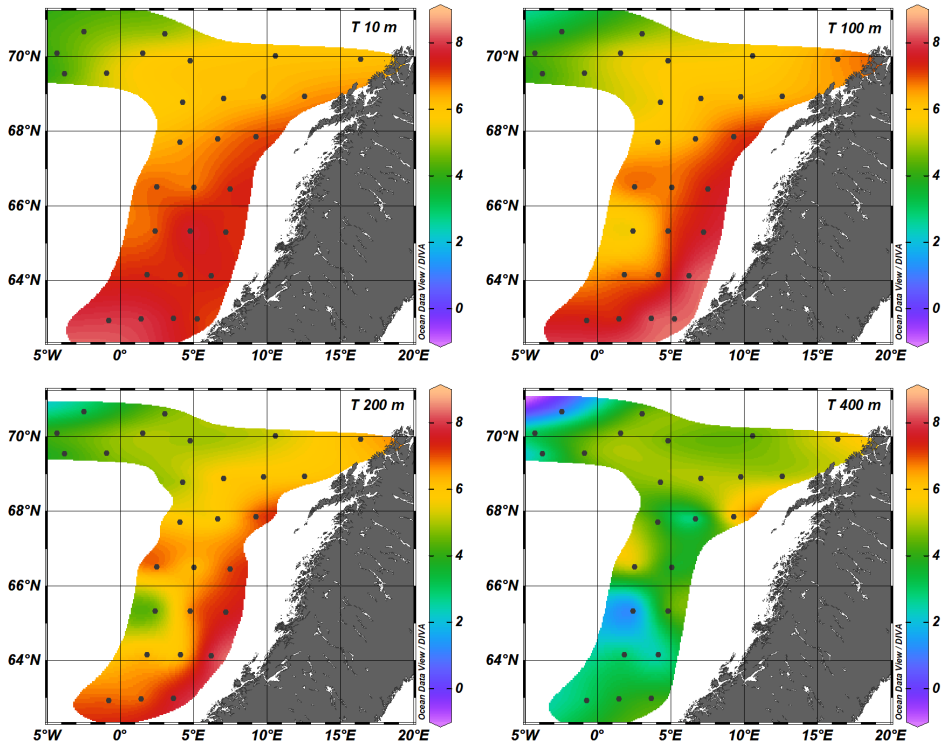


Figure 4: Horizontal temperature distribution in 10, 100, 200 and 400 m depth, R/V Dana IESNS 2020.

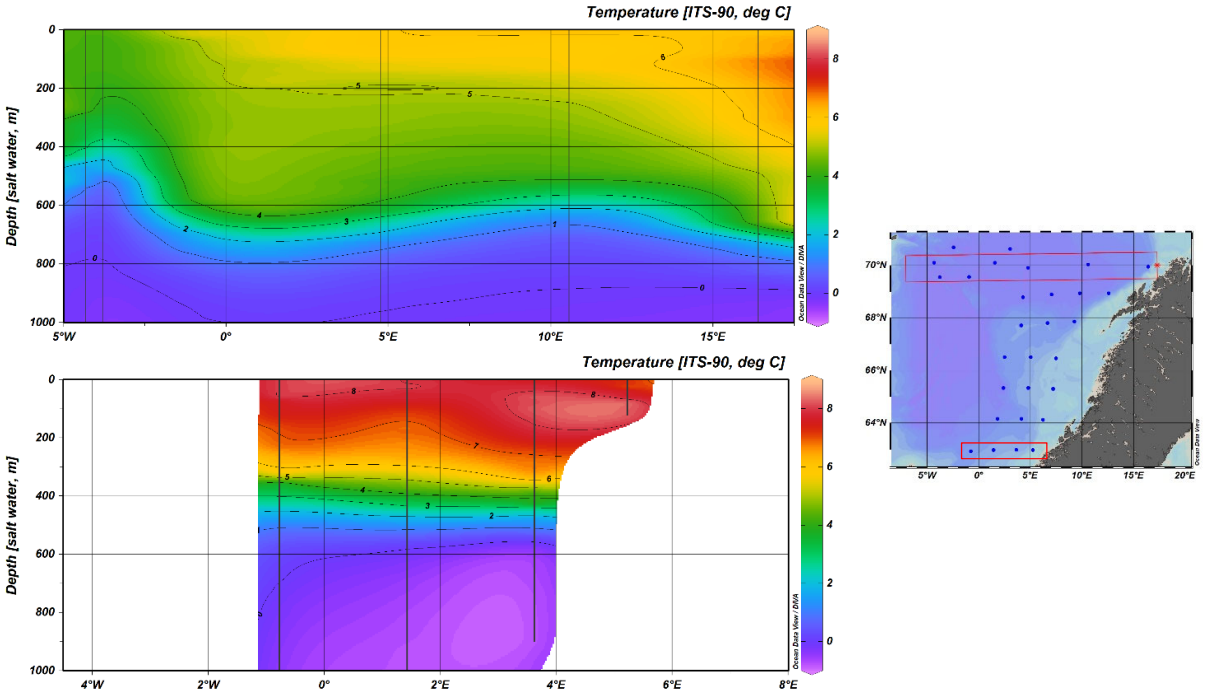


Figure 3: Temperature distributions along a northern and a southern transect perpendicular to the coast (see map for latitudinal positions of the stations included), R/V Dana IESNS 2020.

Concluding remarks on the survey time and program

Despite the, in general, favourable weather conditions not all survey tasks could be completed, e.g. 3 CTD stations were cancelled to have enough time for completing the acoustic transects and to perform fishing tows necessary for ground-truthing of the echo recordings. At one transect the work with the towed body had to be stopped because the rolling of the vessel caused that the crane bearing the towed body came dangerously close to dipping into the water surface. Such a risk might have been reduced if a stabilizing tank system would had been installed.

Overall, 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.

Acknowledgements

We wish to thank Benoit Berges (Wageningen Marine Research, IJmuiden, The Netherlands) for scrutinizing the acoustic data.

Lab team (DTU Aqua):

Stina Hansen: Age readings herring

Helle Rasmussen: Age readings blue whiting

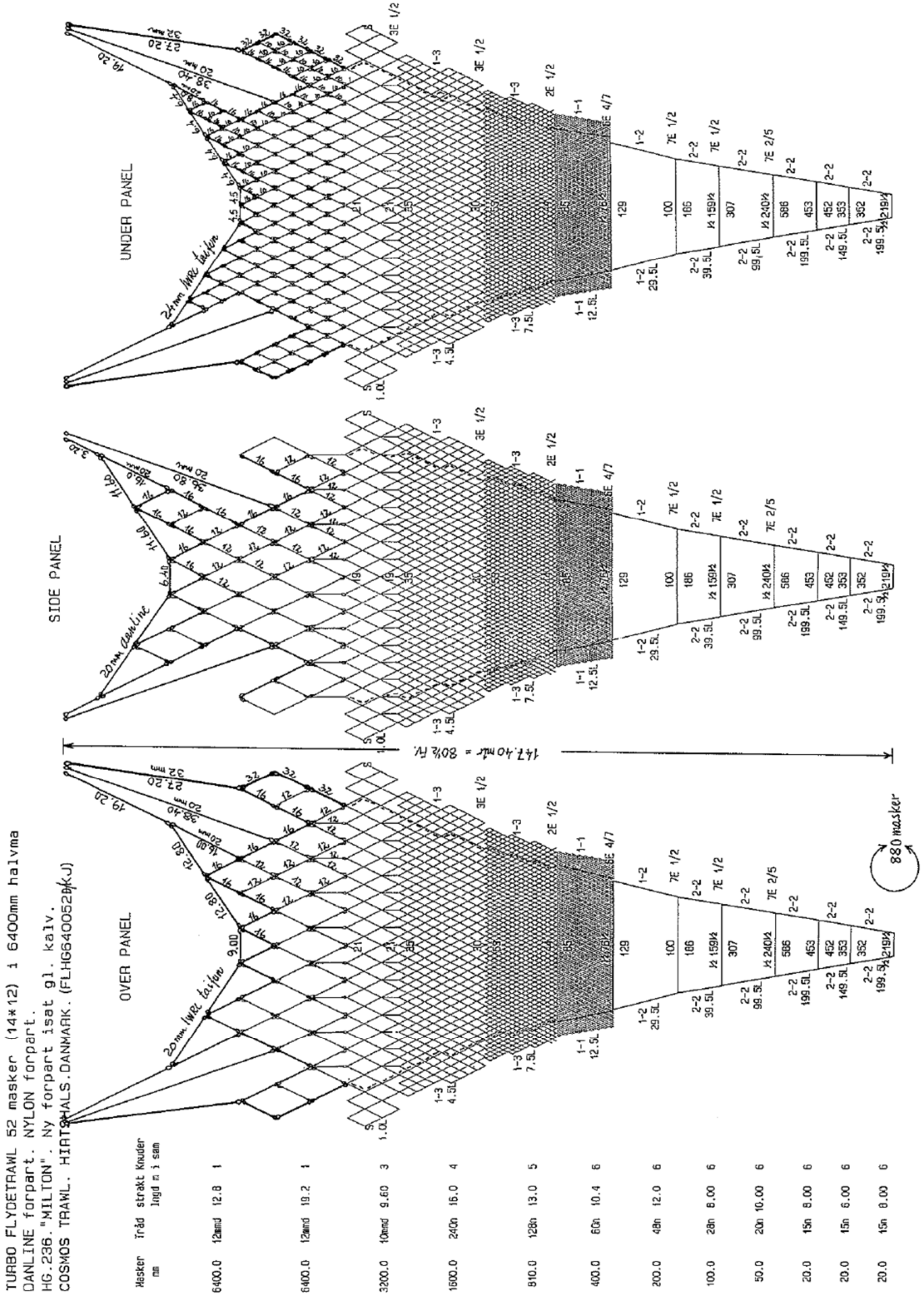
Annegrete Dreyer-Hansen: Analysis WP2 samples

Annex 1: Calibration report for the towed body mounted transducer used for abundance estimation, April 2020.

Transceiver Menu	
Frequency	38 kHz
Sound speed	1482.6 $m.s^{-1}$
Max. Power	2000 W
Equivalent two-way beam angle	-20.5 dB
Default Transducer Sv gain	25.17 dB
3 dB Beamwidth	6.8°
TS of sphere	-42.34 dB
Range to sphere in calibration	10.00 m
Measured NASCvalue for calibration	2600 m^2/nmi^2
Calibration factor for NASCs	1.00
Absorption coeff	7.627 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

Annex 2: IESNS Trawl specification, rigging and performance

Turbo Trawl:



with:

- 80 m sweeps and 13 m backstrop
- Thyborøn 15V7 Pelagic trawl doors: 1120 kg, 4.3 ∗ 1.4 m, 6.02 m^2, Scanmar SS4 door sensors (with depth, pitch and roll)

- Scanmar pressure sensor: on headrope set to 600 m depth range
- Sanmar trawl sensor (or TrawlEye): upward looking on footrope
- Scanmar symmetry sensor: on footrope

Surface tows:

- 2 ∗ 6 float set on headrope
- Fender buoys on sweeps just prior upper wing tips
- Round buoys on sweeps just before fender buoys
- 600 kg chains prior to lower wing tips (300 kg is too less)

Midwater shallow (< 150 m):

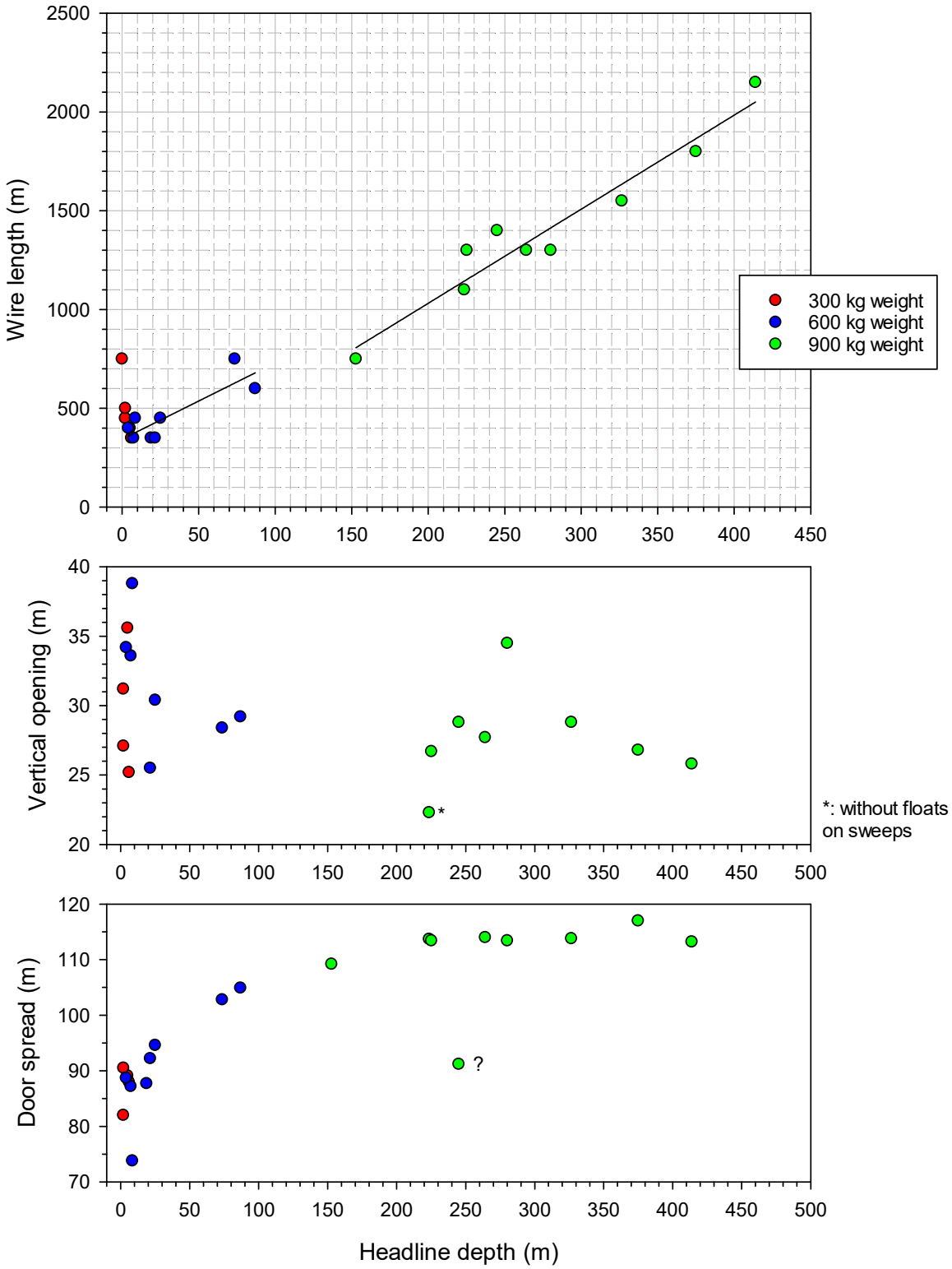
- 2 ∗ 6 float set on headrope
- Fender buoys just prior upper wing tips
- 600 kg chains prior to lower wing tips

Midwater deep (> 150 m):

- 2 ∗ 6 float set on headrope
- 2 ∗ 6 float set on sweeps prior upper wing tips
- 900 kg chains prior to lower wing tips

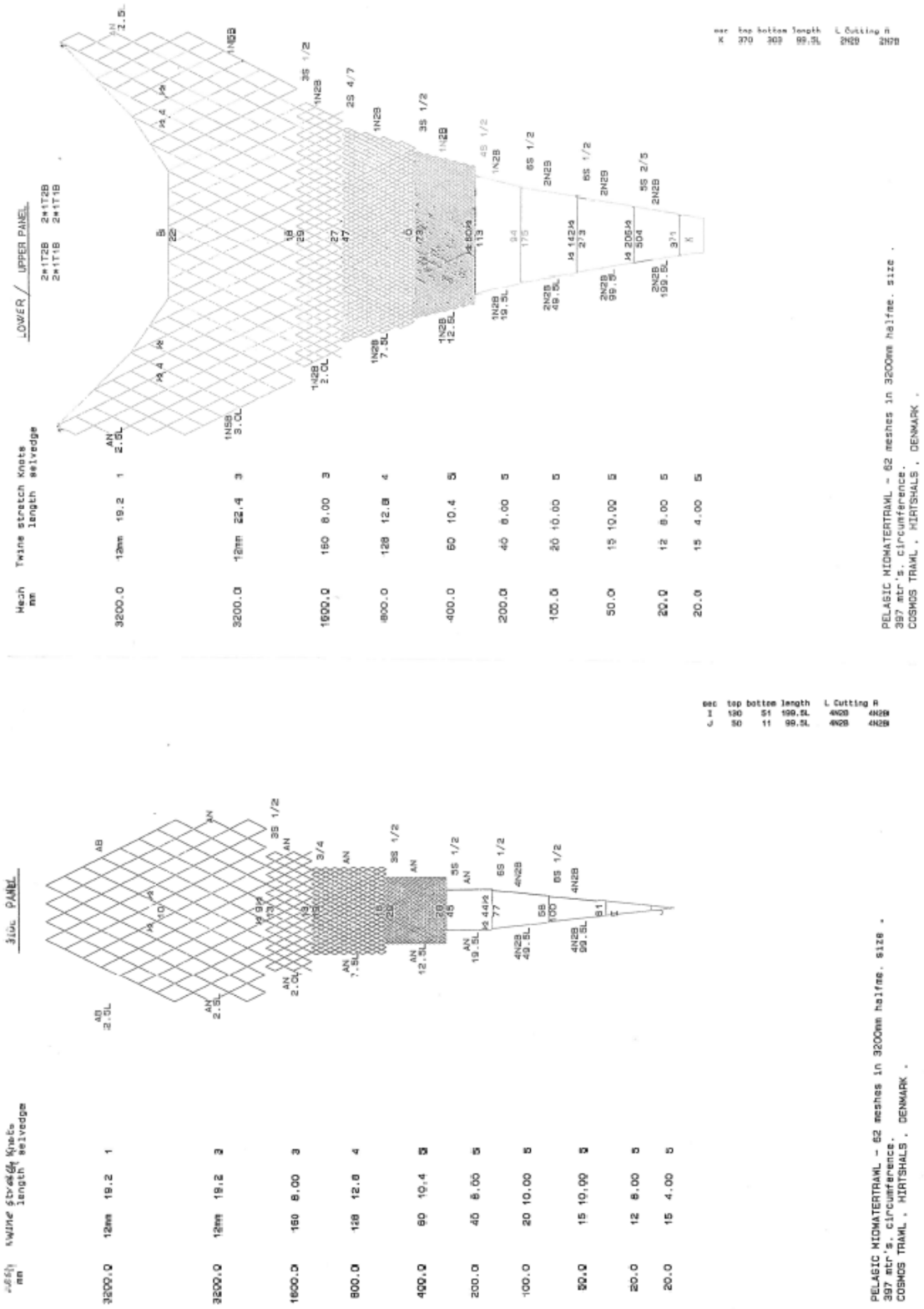
Notes
Surface tows: start with 300 m wire, let trawl stabilize and add subsequently more wire to prevent that doors come shallower than 10 m depth
Set trawl on the upper net drum for easier handling and repairs
Use automatic trawlsounder winch linked to headrope when setting the trawl

Turbo trawl IESNS 2020



Note: Headline depth, door spread and vertical opening are average values from Scanmar plot files (may differ from the manual entries in SIS (Ship Information System)

Fotø Trawl:


LOWER / UPPER PANEL
PELAGIC MIDWATERTRAWL - 62 meshes in 3200mm halfme. size .
397 mtr's. circumference.
COSMOS TRAWL , HIRTSHALS , DENMARK .

with:

- 110 m sweeps and 13 m backstrop
- Thyborøn 107" Type 2 Trawl doors: 770 kg, 5.12 m^2, Scanmar SS4 door sensors (with depth, pitch and roll)

Setup of the other Scanmar sensors same as for Turbo Trawl

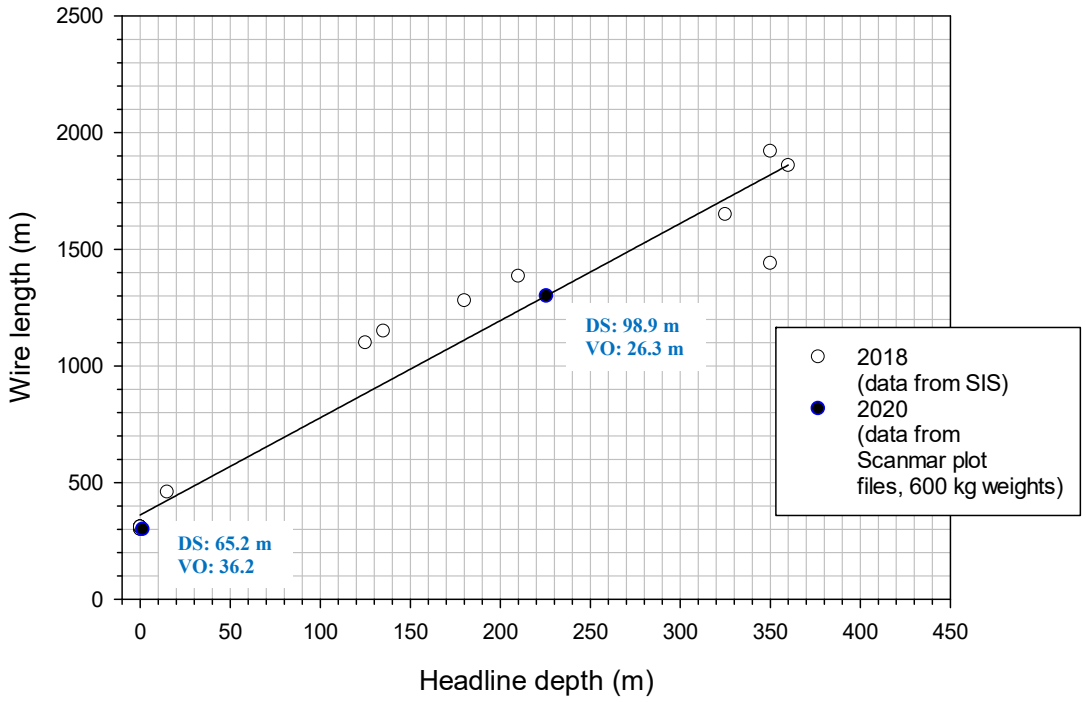
Surface tows:

- 1 Fender buoy central on headline
- Round buoys on sweeps just prior upper wing tips
- 600 kg chains prior to lower wing tips

Midwater tows:

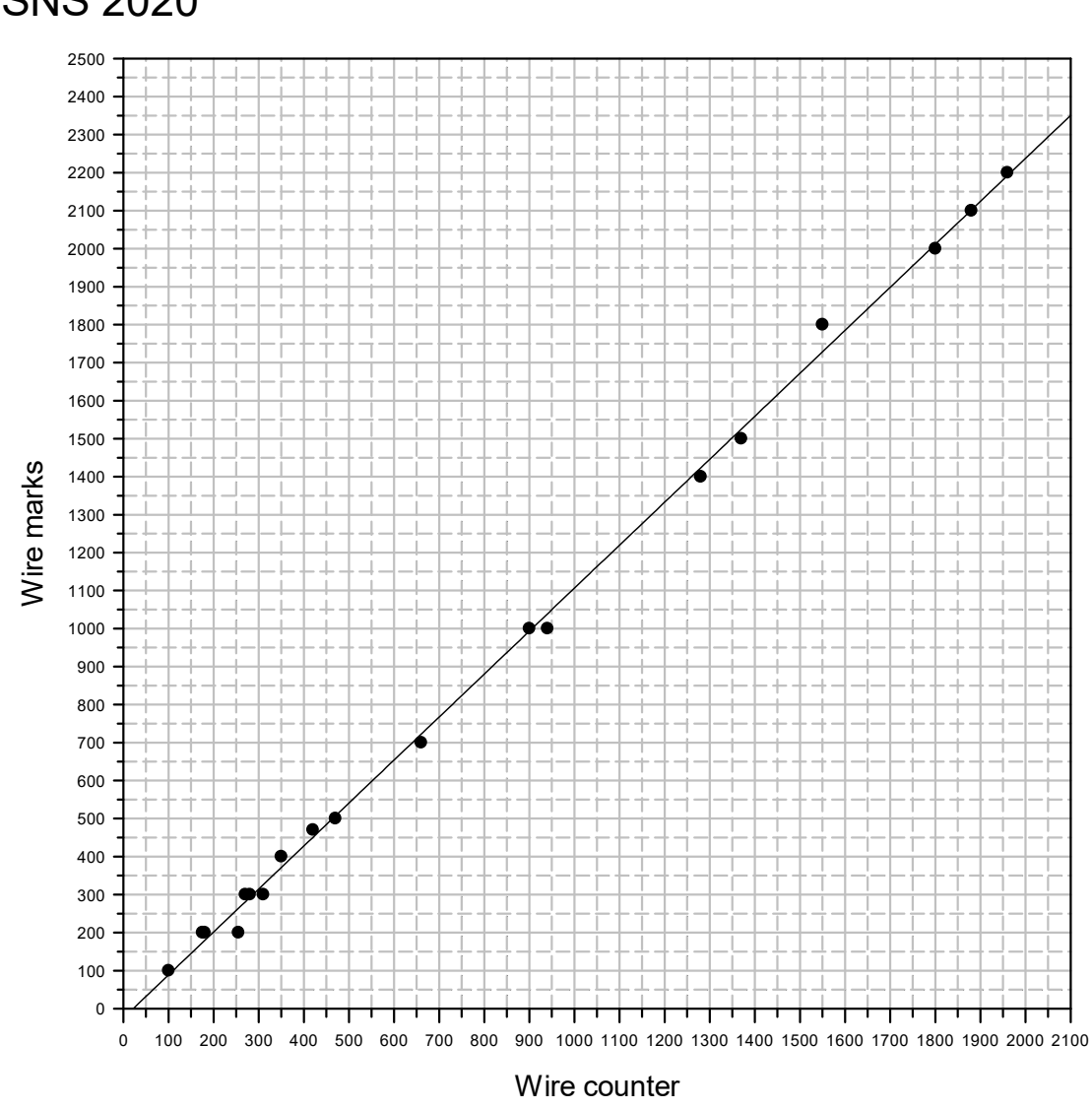
- 1 ∗6 float set on on sweeps just prior upper wing tips Fender buoys just prior upper wing tips
- 600 kg chains prior to lower wing tips

Fotø trawl IESNS

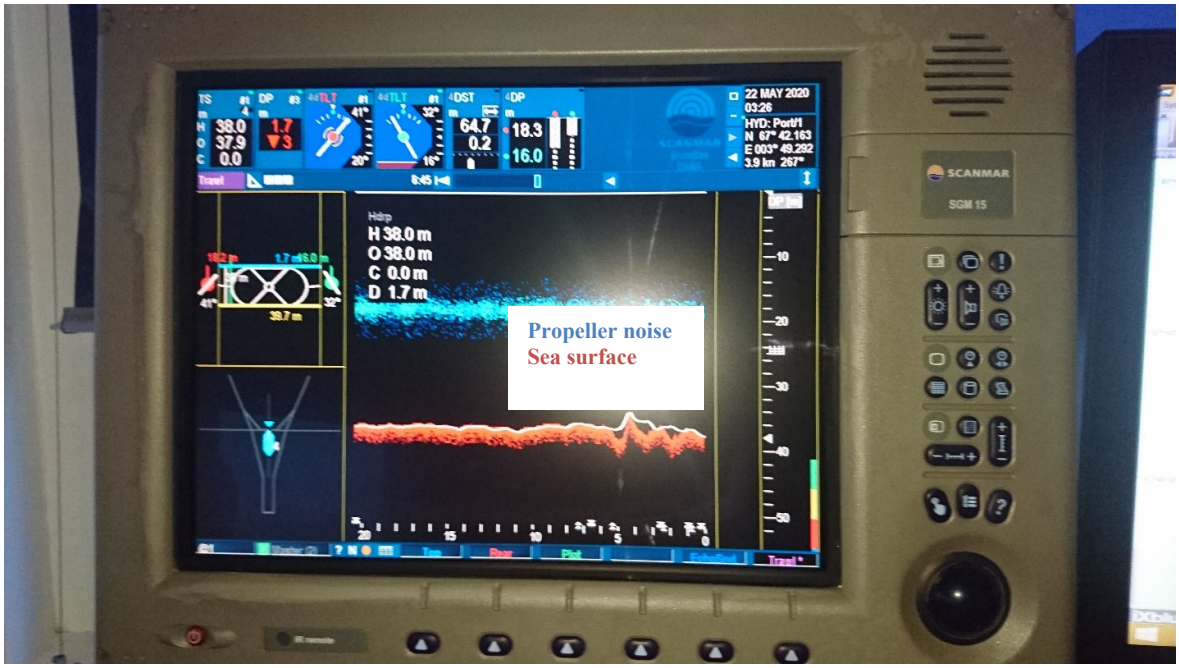


DS: Door spread, VO: Vertical opening

Wire counter check versus wire marks:
Gear performance is based on ‘true’ wire length as given by the wire marks



Scanmar display with upward looking trawl sensor



Surface tows:
H: Distance footrope to sea surface
O: Vertical opening (Headline to footrope)
C: Headline depth (Distance headline from sea surface)
D: Pressure at headline (not so accurate (600 m range setting), signal may be disturbed by noise)

H: Distance footrope to headline
O: Vertical opening (headline to footrope)
C: same as H
D: Headline depth (Pressure at headline)