The International Ecosystem survey in the Nordic Seas in May 2019

IESNS

R/V DANA Cruise No. 7/2019

Calibration of Echo-sounders

2/5 – 4/5 2019

International Acoustic Monitoring of Herring and Blue whiting

5/5 – 31/5 2019

Cruise participants

Calibration 2/5 – 4/5

Karl-Johan Staehr	Denmark (Cruise leader)
Torben Filt Jensen	Denmark
Eik Ehlert Britsch	Denmark
Christian Petersen	Denmark
Rune Garmund	Denmark

Acoustic monitoring 5/5 - 15/5

Karl-Johan Staehr	Denmark (Cruise leader)
Acoustic Torben Filt Jensen	Denmark
Acoustic Benoit Berges	Netherlands
Fishlab Lisa Sörman	Sweden
Fishlab Samantha Barnet	United Kingdom
Fishlab Helle Rasmussen	Denmark
Fishlab Peter Vingaard	Denmark
Tech. Christian Petersen	Denmark

Acoustic monitoring 16/5-31/5

Matthias Kloppmann	Germany (Cruise leader)
Acoustic Serdar Sakinan	Netherlands
Acoustic Sven Kupschus	United Kingdom
Fishlab Per Andersson	Sweden
Fishlab Sean O‘Connor	Ireland
Fishlab Jane Gudmansen	Denmark
Fishlab Gert Holst	Denmark
Tech. Eik Ehlert Britsch	Denmark

Cruise summary

Effective survey days	30
Mileage	Calibration 143 NM Steaming to start of transects 401 NM Monitoring 3365 NM Steaming for end port 1222 NM
Number of trawl hauls	20
Number of CTD stations	38
Number of WP2 stations	38
Number of biological samples – herring	473
Number of biological samples – blue whiting	352
Number of biological samples – mackerel	323
Remarks	

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. The acoustic survey tracks of Dana are shown in figure 1.
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 2nd May and 4th May 2019. 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 60 mm copper sphere. Calibration of the three hull-mounted split-beam transducers at 18, 38, and 120 kHz were carried out against 63mm, 60 mm, and 23 mm copper 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 post cruise meeting in Reykjavik 18-20 June 2019 and in the WGIPS report of January 2020.

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, plankton samples were taken 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.
At the same positions, 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. All together Dana carried out 38 CTD and 38 successful WP2 stations (Table 1, Figure 1)
Each day, water samples were taken at 1000 m and in one shallower layer for calibration of the CTD's conductivity sensor. 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 trawl "*Turbo*", was used either at the surface or in midwater down to a maximum of 450 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 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 473 individual herring, 352 blue whiting and 323 mackerel 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.

Itinerary of the survey

2 May 2019, 04.00 UTC	Leave Hirtshals for calibration of acoustic equipment at Bornö
4 May 2019, 14.40 UTC	Dock Hirtshals, end of calibration.
5 May 2019, 12.00 UTC	Leave Hirtshals for start of IESNS
7 May 2019, 04.37 UTC	Start monitoring at 62°19 N, 004°50 E
14 May 2019, 17.48 UTC	Stop monitoring at 66°18 N, 011°10 E, end of 1st of the survey
15 May 2019, 12.10 UTC	Dock Bodø for staff exchange
16 May 2019,14.30 UTC	Leave Bodø for start of the second part
17 May 2019, 01.30 UTC	Start monitoring at 68°38 N, 013°37 E
26 May 2019, 04.32 UTC	Stop monitoring at 73°33'N, 018°53'E, end of 2nd part of the survey
31 May 2019, 08.00 UTC	Dock Hirtshals, end of survey

Log during the first half of the survey as reported during the survey to the other participating vessels:

07-05-2019 16.38 UTC. We started this night at 04.37 UTC at the eastern end of transect 1 in stratum 1 with a CTD to set our environment parameters in EK60. During the late morning we had a weak continues layer at 150-200 meters with some scatter read spots at 62 N 18.4, 002 E 37.4 we fished in the layer and got 26.9 kg HER, 8.7 kg MAC and 7.9 kg pearlside. Else it has been scares with registrations. We expect to do a surface haul during the dark period to night. Our current position is 62 N 17.4, 002E 04.4.

08-05-2019 16.12 UTC. We made a trawl haul last night at 23 UTC at 62N 14.6, 000E 39.8 in 90 m depth. The catch was 704 kg WHD (mean length 20.0 cm), HER 1 kg (mean length 28.6), 7 kg MAC (mean length 32.7) together with some KRZ and LPR. This morning we had a second trawl haul at 62N 10.7 in 220 m depth with 308 kg WHB (mean length 23.4 cm), 35 kg MAC (mean length 30.7 cm) and 26 kg HER (mean length 29.1 cm). We will finalize transect 1 in strata 1 this

evening and go for Way point 10 in the western end of transect 2 in strata 1. We have planned a haul for the dark period to night in the surface. Our position is now 62N 04.7, 002W 35.9

09-05-2019 17.01 UTC. We made a trawl haul last night at 24 UTC at 62N 55.1, 001W 47.8 in the surface. The catch was 2189 kg HER (mean length 30,2 cm)and 188 kg MAC (mean length 31.7). This afternoon we had a second trawl haul at 63N 04.0, 001E 01.1 on small marks around 65 m and up to 20 m depth with 257 kg MAC (mean length 29.0 cm), 38 kg HER (mean length 29.4 cm). We have planned a haul for the dark period to night in the surface.Our position is now 63N 05.3, 001E 38.8

10-05-2019 18.25 UTC. We made a trawl haul last night at 24 UTC at 63N 07.4, 003E 14.7 in the surface. The catch was 2438 kg MAC (mean length 27.1 cm), 862 kg HER (mean length 29.5) and 24 kg WHB (mean length 18.9 cm). This afternoon we arrived at WP 18 Strata 1 and is now steaming north-east for WP38 were we expect to be tomorrow morning. Our current position is now 64N 05.9, 008E 14.1.

11-05-2019 16.25 UTC. This morning we started at WP 38 in Strata 1 going west. For the first part in the shallow we did not see much. We have in the afternoon ben fishing on a diffuse layer from 135 to 150 m at 65N 34.2, 007E 23.3. We had a 0 catch. Our current position is now 65N 33.9, 007E 33.7.

12-05-2019 16.40 UTC. During last night we had a trawl haul in the surface at 65N 34.8, 005E 10.9 with 27 kg MAC (mean length 26.4 cm) and some LUM, KRZ, NRK and BSX. Throughout the day we have had very little of registrations. We are now near to the western end of the transect but will continue further west to take the Faeroes CTD/WP2 station at WP 46 before going north for the next transect. Our current position is now 65N 30.8, 000E 46.1

13-05-2019 17.21 UTC. We continue west on our 3 transect to take the Faeroes CTD/WP2 station at WP 46 before going north for the next transect stating at WP 48 in strata 1. We made a surface haul at 65N 54.9, 000W 06.8 during the night with 5 HER (mean length 34.1 cm). During the night and this morning we have been struggling with old swells, a bit unpleasant. This afternoon we have had a haul at a dispersed layer around 300 m at 66N 23.3, 002E 40.7. The only real layer. After some problems during shooting the trawl we had a catch of 6 kg WHB (mean length 23.0 cm) Our current position is now 66N 22.2, 003E 01.3

14-05-2019 17.45 UTC We had a trawl haul last night in the surface at 66N 24.2, 004E 53.0 The catch was 14 Salmon and 3 herring. Going east in the shallow part of the transect we have seen nearly nothing. We have just finalized the transect at 66N 17.3, 011E 16.2. We are now heading for Bodö for change of crew. We will leave again Thursday the 16 May with Matthias Kloppmann as cruise leader. The departure from Bodö is planned for 13 UTC. Our current position is now 66N 17.9, 011E 10.6

Integration on first half on the survey was ended 14thMay at 17.40 UTC at 66°17N, 11°16E. Bodø was entered at 15th May at 12.10 UTC for change of crew.

Conditions during first half of the survey:

On the way to the starting point we had strong northerly wind and were delated by 4-5 hours at the start. The weather conditions during the first half have then been excellent except for a short period only in short periods the wind has increased above 10-15 m/s.

All CTD and WP2 stations were successfully completed as planned including one extra station conducted for the Faeroes. 11 trawl hauls has been taken during the first half of the survey.

Log during the second half of the survey as reported during the survey to the other participating vessels:

16-05-2019 The scientific as well as major part of the ship's crew was exchanged on the 16th May., Dana sailed NW to the beginning of transect 9 of stratum 1 at 16:30 (13:00 UTC) from Bodø into calm seas.

17-05-2019 The first transect of the second leg was reached at 01:30 UTC (all times hereafter given in UTC). Recording of echo registrations from the towed body started at 01:35. The first CTD and WP2 was conducted at way point 82 at 04:22 followed by trawl haul at a band of weak to medium registrations at 220 - 270 m. Trawl station started at 68°39.9' N, 012°07.0' E. The haul gave 77 kg juvenile blue whiting, mean length 17.6 cm and 32 kg saithe, mean length 60.8 cm plus some small amounts of mesopelagics (*B. glaciale* and *M. muelleri*) as well as some krill.

Another trawl was done on some scattered but strong marks at 20 - 30 m depth in the late afternoon. at 68°46' N, 009°45' E. The catch revealed 1900 kg of herring of a mean size of 24 cm.

18-05-2019 Dana approached its last CTD/WP2 station of its first transect (#9 of stratum 1). There was nothing seen worth trawling for since the last haul the evening before. The transect was completed with reaching way point 91 at around 22:00 and Dana steamed northwestwards towards transect 2 of stratum 5.

19-05-2017 Transect 3 of stratum 5 was reachted at 09:30 UTC started with the CTD/WP2 station. After that, echo registration was resumed on the way eastwards. There wasn't much to be seen on the echo sounders if anything at along the first couple of hours. Later in the afternoon, there were some very small schools losely scattered along the transect. Their strongest response was on the 18 and 120 kHz hull mounted trandsducers, weaker and sometimes not seen on the 38 kHz of the one on the towed body. Because of the very limited time that was available for trawling, it wasn't dared to do a haul on them in order not to waste time with a zero catch. Those schools were most probably herring.

20-05-2019 Transect 3 of stratum 5 was completed at 09:57 UTC and Dana headed a few miles southwestwards to start with transect 2 of stratum 2 with a CTD/WP2 station at 11:28. RV Dana had been slowed down considerably due to strong northeasterly to easterly winds and waves to 7 - 8 knots since the early morning.

Along the transect, some very scattered small schools of herring at depths between 200 and 350 m were observed. Because of the limited available time for fishing and the low probability of catching any of them, it was decided not to fish on them. However, later in the evening, a trawl haul was done on some very strong echoes of small schools of presumably herring. None of the schools was

hit by the trawl, but 15.8 kg of blue whiting with a mean size of 28.2 cm, 3.5 kg of beaked red fish (*S. mentella*, mean size 38.8 cm), some mesopelagics and some krill were caught.

21-05-2019 Wind and waves went slowly down during the day and the normal survey speed of 10 knots could be regained. In the evening another haul was done at 70°57'N, 013°20'E targeting a layer close to the surface at 10 - 20 m. The catch was 8 kg herring with a mean length of 24.4 cm, and 15 kg of lumpsuckers.

22-05-2019 In the morning at 70°52'N, 015°38'E a haul was done, again targeting a layer with some stronger echo registrations close to the surface, again at 10 - 20 m depth. The catch was 107 kg herring, mean length 22.9 cm and 34 kg lumpsuckers, and 1 pink or humpback19:00 and Dana headed northwards to transect 4 of stratum 2.

23-05-2019 Transect 4 of stratum 2 was started in the early morning around 03:00 UTC. A trawl haul was done later that morning at 72°14'N, 017°26'E at a layer between 10 and 20 m depth with some strong echoes. However, the haul only gave 8.6 kg herring, mean length 22.7 cm, 21.6 kg lumpsuckers, 1 pink salmon (41 cm) and couple of 3-spined sticklebacks.

At 15:20 another haul was done at 72°15'N, 016°10'E at 350 m headline depth, targeting a layer of scattered echoes between 350 and 380 m. The haul gave 5.6 kg blue whiting, mean length 23.0 cm, as well as 26 kg haddock, 6.8 kg cod (3 specimens), 2 saithe (3.4 kg), 1 beaked redfish (0.8 kg), and a few Risso's barracudinas (2.0 kg).

24-05-2019 Transect 4 of stratum 2 completed at 15:00 with the CTD/WP2 station. Also, a haul was done at 72°08'N 007°53'E trawling at 325 - 350 m targeting some loosely scattered echoes from that depth. It gave a few mesopelagics, 1 redfish and some krill.

25-05-2018 Transect 6 of stratum 2 – the final one of the survey – was started at 03:35 UTC. The weather had again become worse and slowed RV Dana down to survey speeds between 7 and 8 knots. Forecasts for the following night and the coming day were that weather may improve over night slightly but should become worse later again. A last trawl station was done at 22:26 at 73°34'N, 017°47'E at some densely scattered echoes at 250 - 340 m depth, which were believed to originate from blue whiting. The result, however, was 317 kg haddock and only 0.136 kg of blue whiting.

26-05-2019 we're on our way back to Hirtshals.

Weather started worsening in the early morning hours and strong winds and waves slowed the vessel down again. By the time the final CTD/WP2 station was reached, the situations had turned so bad that the entire station had to be skipped and also echo registration until the end of the transect had to be curtailed. Because the forecast also predicted further worsening, it was decided to finish

the survey.

Conditions during second half of the survey:

Weather conditions were mostly pleasant during the second part of the survey. However, two events with strong wind and head waves slowed Dana down considerably and reduced the already tight survey time, which from the beginning of the second part didn't allow for any temporal reduction in survey effort, let alone for doing the necessary trawling stations. We had to abandon 1 complete transect (transect 4 of stratum 5) and to curtail our last transect 6 in stratum 2
18 out of 20 planned CTD and WP2 stations have been taken and only 9 trawl hauls had been made.

Results

Catch composition

Table 2 gives information on trawling depth, speed, wire length and weather conditions during all fishery hauls while the catch composition of all trawl hauls is presented in Table 3. Distribution of trawl hauls is shown in Figure 1. During the first half of the survey, mackerel appeared to be abundant again in the shallower catches. However, despite 1 large catch of 2417 kg, the incidence of positive mackerel catches was lower than last year (6 incidences opposed to 8 in last year). Particularly in the northern part of this years survey area, mackerel were not observed in the catches. It has to be noted, however, that the number of hauls in the surface was also lower as last year.

Distribution and density of herring and blue whiting

Distribution and densities of Herring and Blue Whiting along the survey track are presented in Figure 1(b). Compared to 2018, herring abundance was similar with more herring in the South than in the North, apart from the one transect west of the Lofoten islands where high abundances of presumably juvenile herring were recorded. Otherwise, herring were almost absent in the Northeast of the survey area. Abundance of blue whiting was again lower than the previous year and highest densities seemed to occur further south. Towards the North, blue whiting occurrence became scarce.

Through the scrutinizing process, most Herring marks were found as high intensity scattering marks in the first 50 m of the water column. In the North, the marks of the presumably juvenile herring were recorded in these top layers as well, while most other recordings from adult herring were from larger depths of about 150 – 200 m.

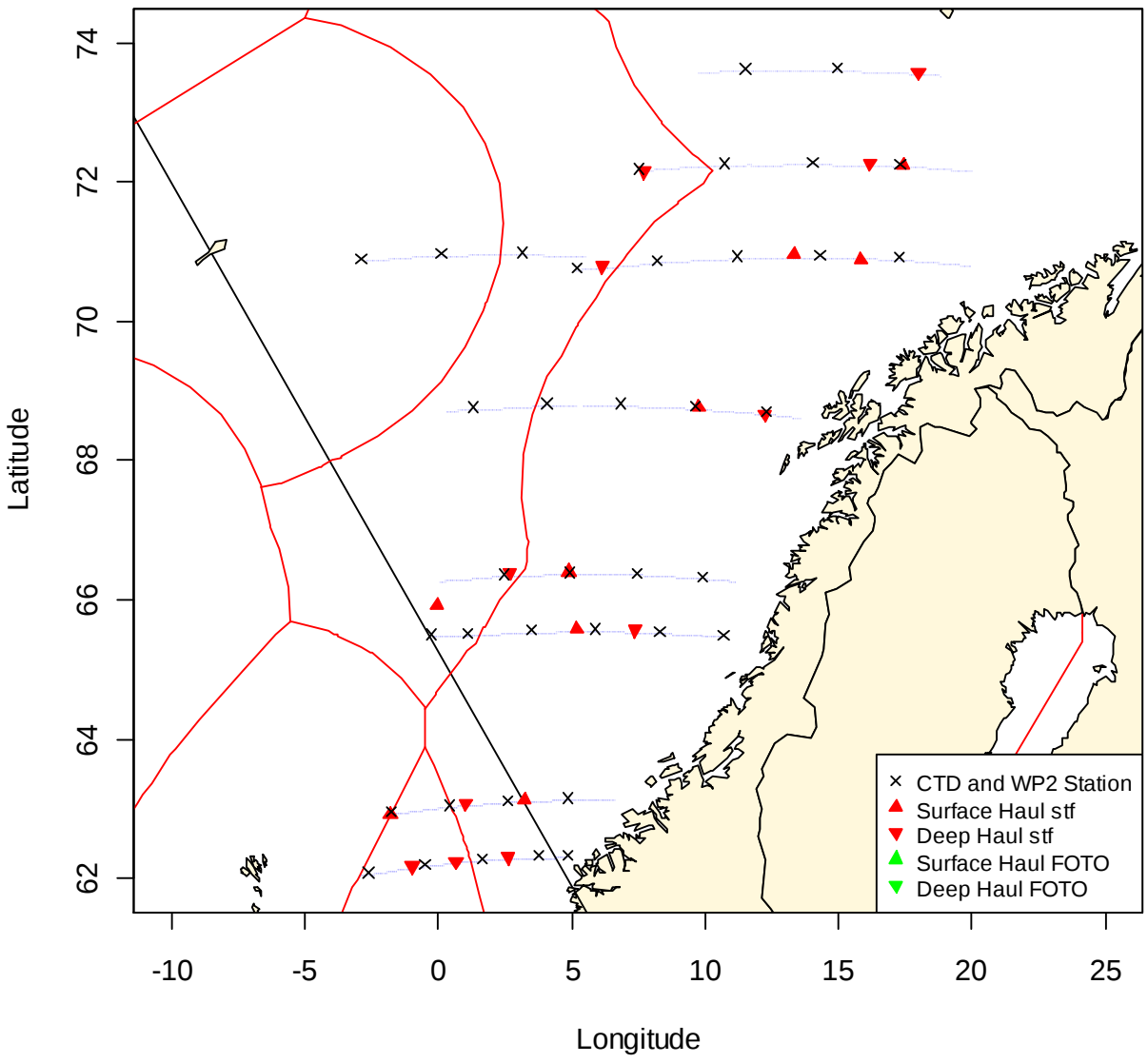

Figure 1a.Sailed transects and hydrographical stations and trawl hauls.

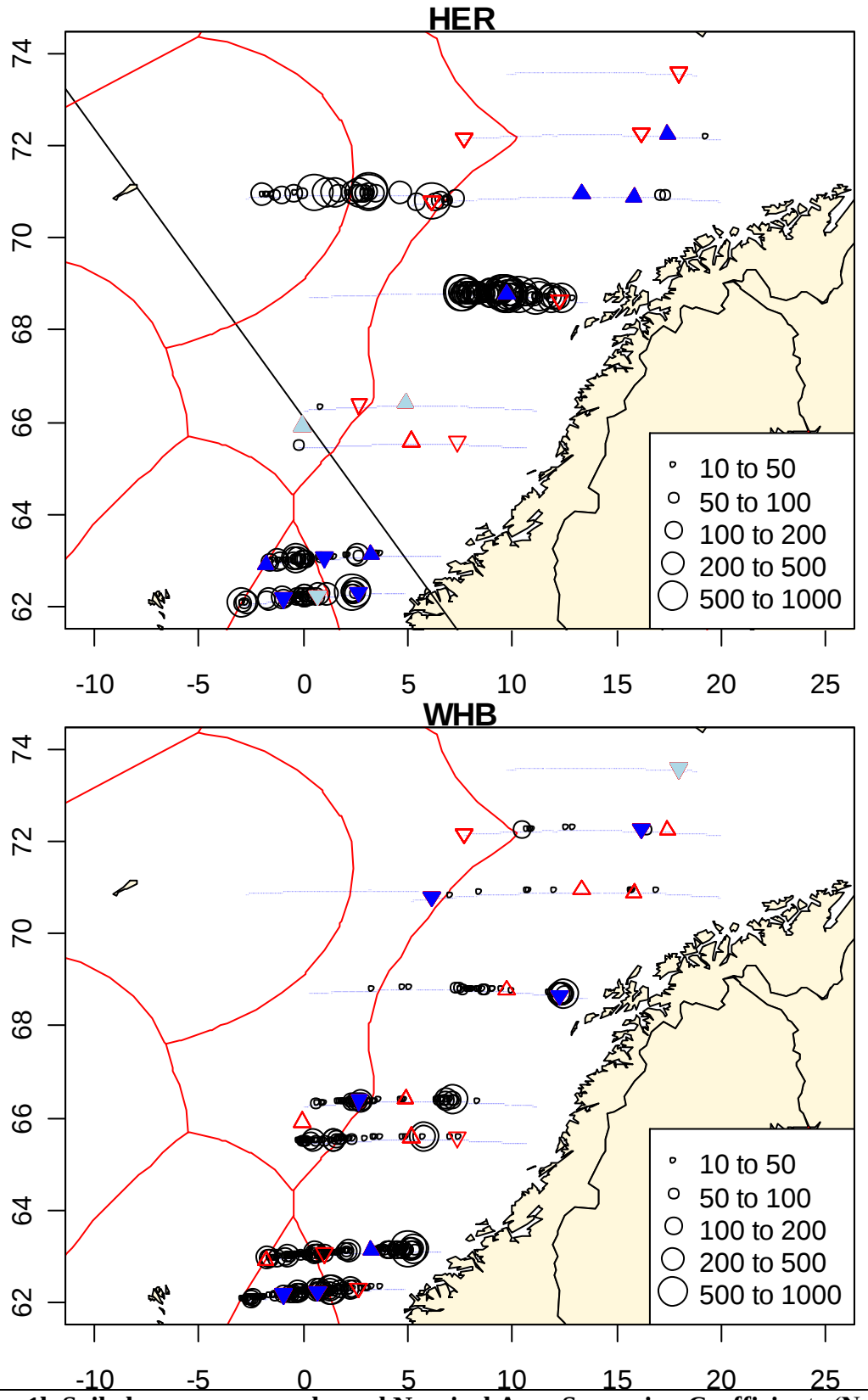

Figure 1b.Sailed transects, trawl - and Nautical Area Scattering Coefficients (NASC's) assigned to herring and blue whiting. Triangles indicate trawl catches. Light blue > 5kg, Dark blue < 5kg; red, non-filled = no catch.

Hydrographic conditions

Sea surface temperatures were between < 5.5 °C in the North and > 8°C in a very small area in the South of the survey area. 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 North and West (Figure 2). Waters in the immediate surface layer were about 0.5 – 1.0 °C cooler than last year, while deeper layers were slightly warmer. (Figures 2, 3 & 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 (Figures 3 & 4). 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 500 m only close to the coast. Above the Vøring Plataeau as well as at the entrance to the Barents Sea in the North the cold water layer was elevated to depths of 350 m and above. In the oceanic area, this layer was only 400 – 450 m of magnitude decreasing to < 200 m at the westernmost stations. On the northernmost transect this warm Atlantic water layer reached deeper to > 600 m close to the shelf edge but was cooler than in the south.

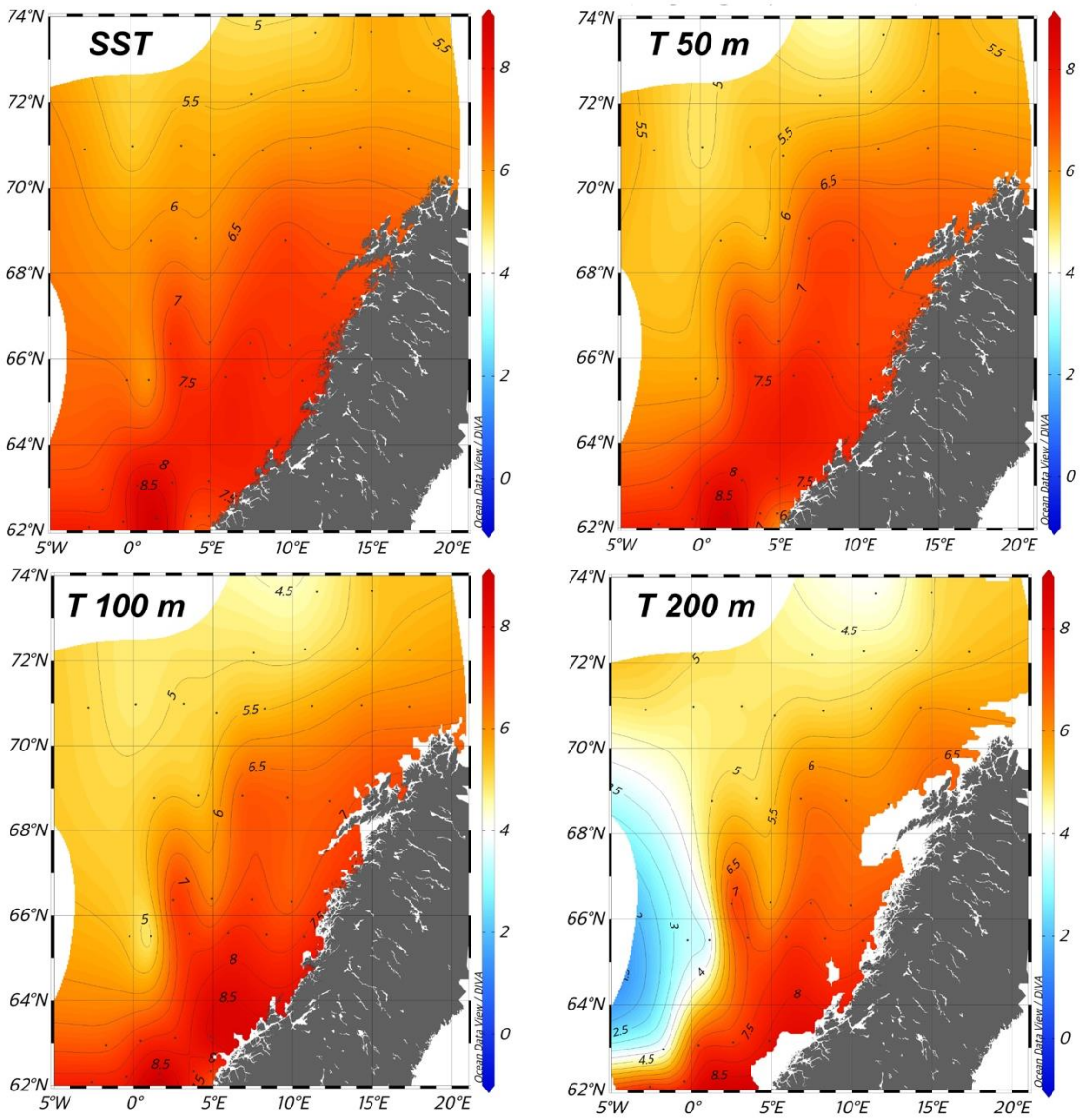

Figure 2: Horizontal temperature distribution interpolated from CTD data at selected depths: surface (top left), 50 m (top right), 100 m (bottom left), and 200 m (bottom right)

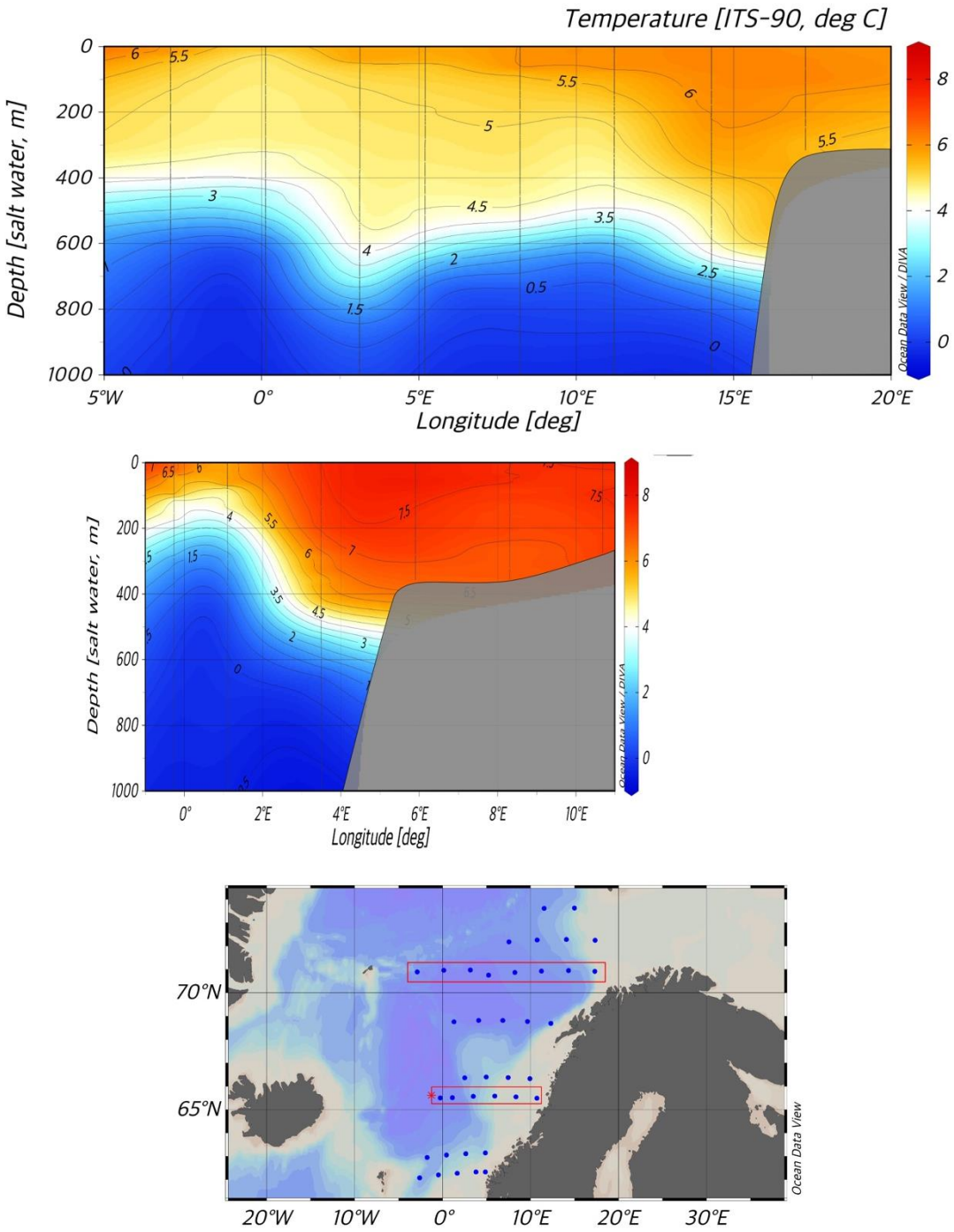

Figure 3: Vertical temperature distributions from South (bottom) to North (top) along 2 transects perpendicular to the coast. The latitudinal position of the transect can be seen in the map at the bottom.

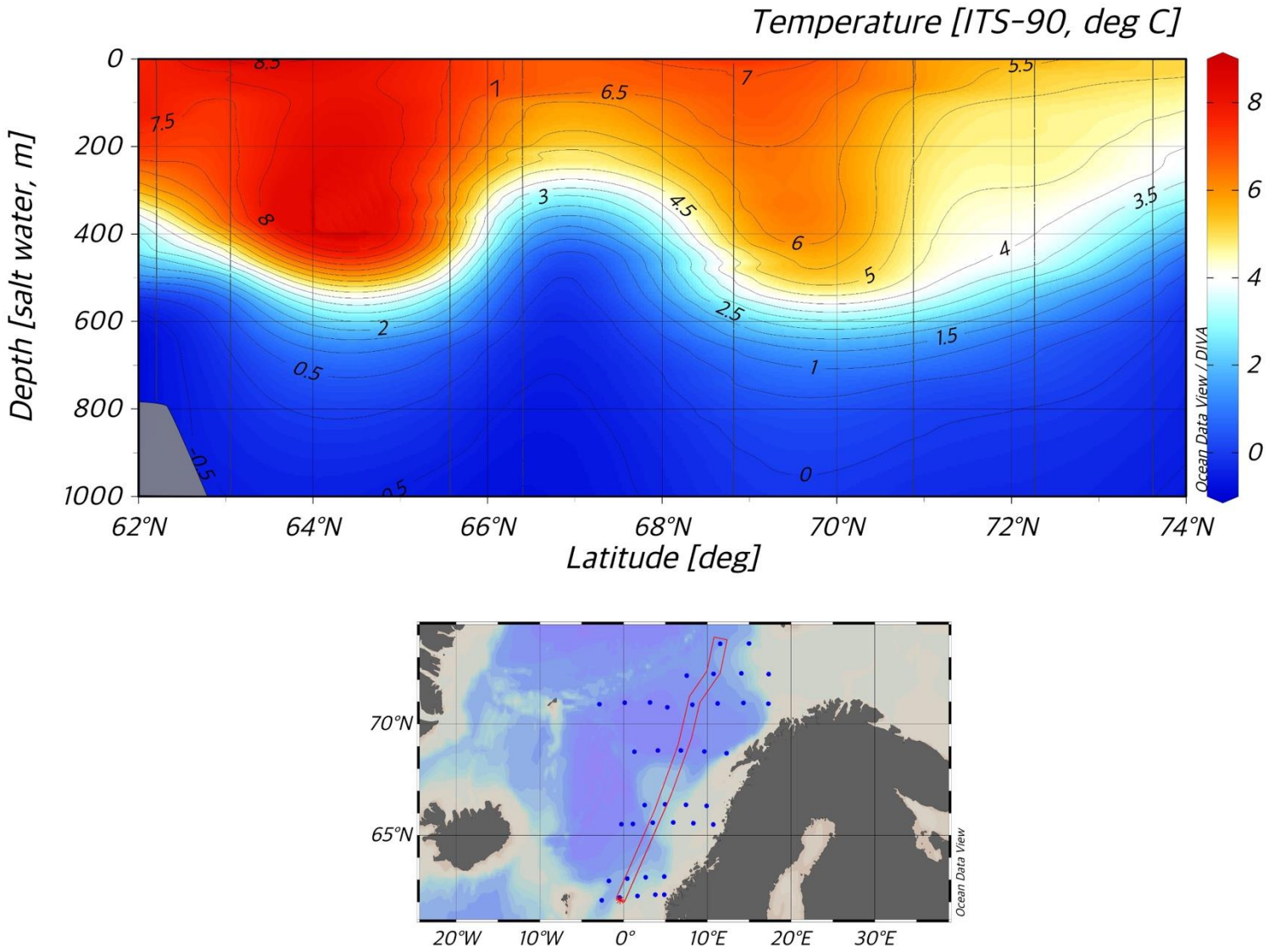

Figure 4: Vertical temperature distributions from South to North along an arbitrarily chosen transect parallel to the Norwegian coast. The selected stations can be seen in the map at the bottom.

Issues regarding the towed body deployment IESNS 2019

The survey data on board the R/V Dana is collected by a Simrad EK60 echo sounder using a 38 kHz transducer mounted on a towed body. At the beginning of the survey transect, while the vessel was underway at normal survey speed (10 kn), it was observed that the towed body was breaking through the sea surface. This resulted in unwanted impacts on the data quality. In order to prevent this, the position of the towed body was changed aft-wards by lengthening the towing wire. While this adjustment helped maintaining the depth of the towed body in the desired position, some additional effects were observed in the acoustic recordings such as fuzziness in the sea bottom detection and distorted shape of single targets. These patterns in the data suggested that the towed body was slightly tilted forward. To understand the impact of this, an experiment was conducted at a trawling location. On R/V Dana, in addition to the towed body, there is also a hull mounted Simrad EK60 echo sounder with 18 kHz, 38 kHz and 120 kHz. The experiments simply consisted of collecting data in the same area first with the towed body and then tracing the same path by the hull mounted 38 kHz echo sounder for comparison. Because these two echo sunders are calibrated at the beginning of the survey the results should be comparable. The experiment was conducted in calm weather conditions ensuring that the bubble-sweep-down was minimum and the targets in the water column were rather homogeneous and relatively evenly scattered between 300 and 500 meters depth (Figure 1).

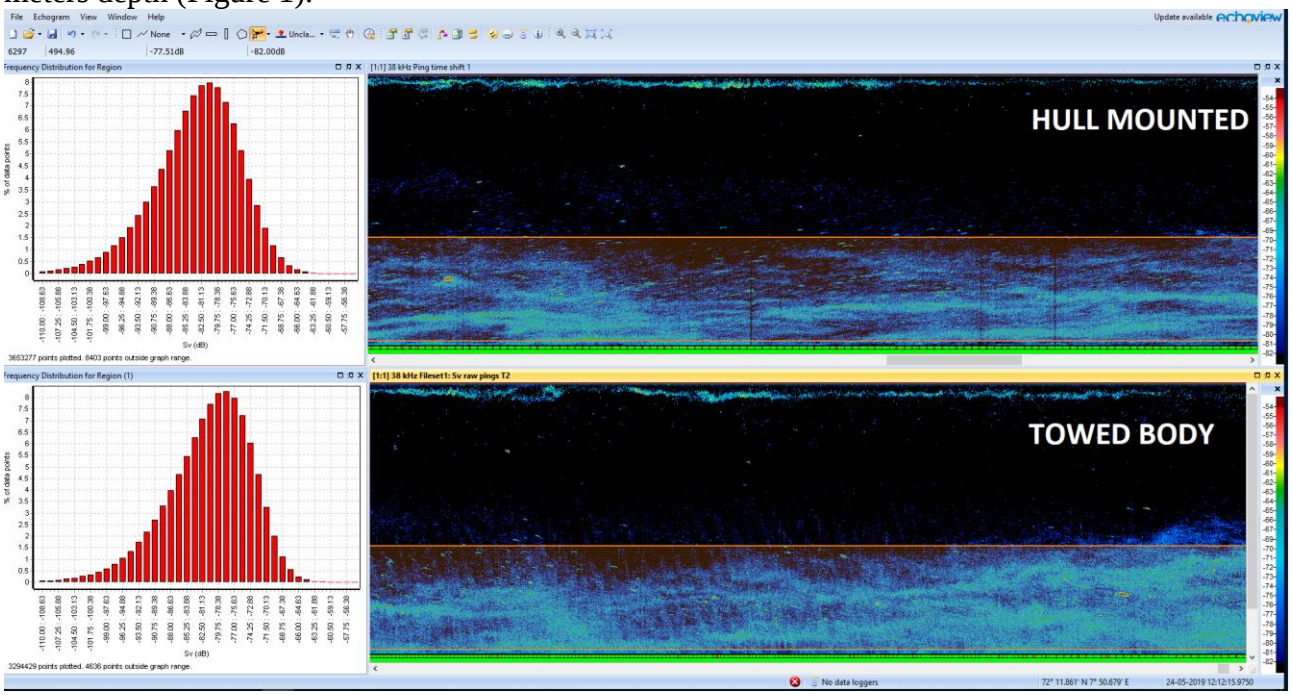

Figure 1 Data collected with 38 kHz echo sounders; first with the towed body and then with the hull mounted echo sounder. The left panel shows the distribution of the Sv samples. The upper panel is showing the Sv echogram of the hull mounted system corresponding to a similar region of that was ensonified with the towed body. The orange rectangle shows the echo integration region.

The time difference between two measurements was approximately 5:30 hours. The area (72° N) remains within the Arctic Circle with 24 h daylight conditions. Therefore time dependent effects were considered as being at minimum.

Results and Discussion

Distribution of the Sv samples seem similar, however not identical. The mean Sv of the towed body seems to be 1.5 dB (40%) greater than that of the hull mounted echo sounder. Although this seems to be an important difference, the reason is unlikely due to the effects of the tilting. There appears

be a slight interference noise in the towed body in the shape of regular diagonal stripes. This may be due to the lengthening of the towing cable. In addition, because the integration depth is rather deep (from 300m to 500m) and the observed targets are weak, the differences in the sensitivities of the two echo sounders may also cause this difference. This is an effect hard to account for with the standard sphere calibration (the observation depth and the strength of the echoes measured during the calibration are not comparable to the observation in this experiment). Furthermore, it is known that the hull mounted echo-sounders of R/V Dana are quite susceptible to bubble sweep-down. Although it was assumed to be negligible in this experiment owing to calm weather conditions, there may still be some sweep-down effects causing signal attenuation in the hull-mounted system.

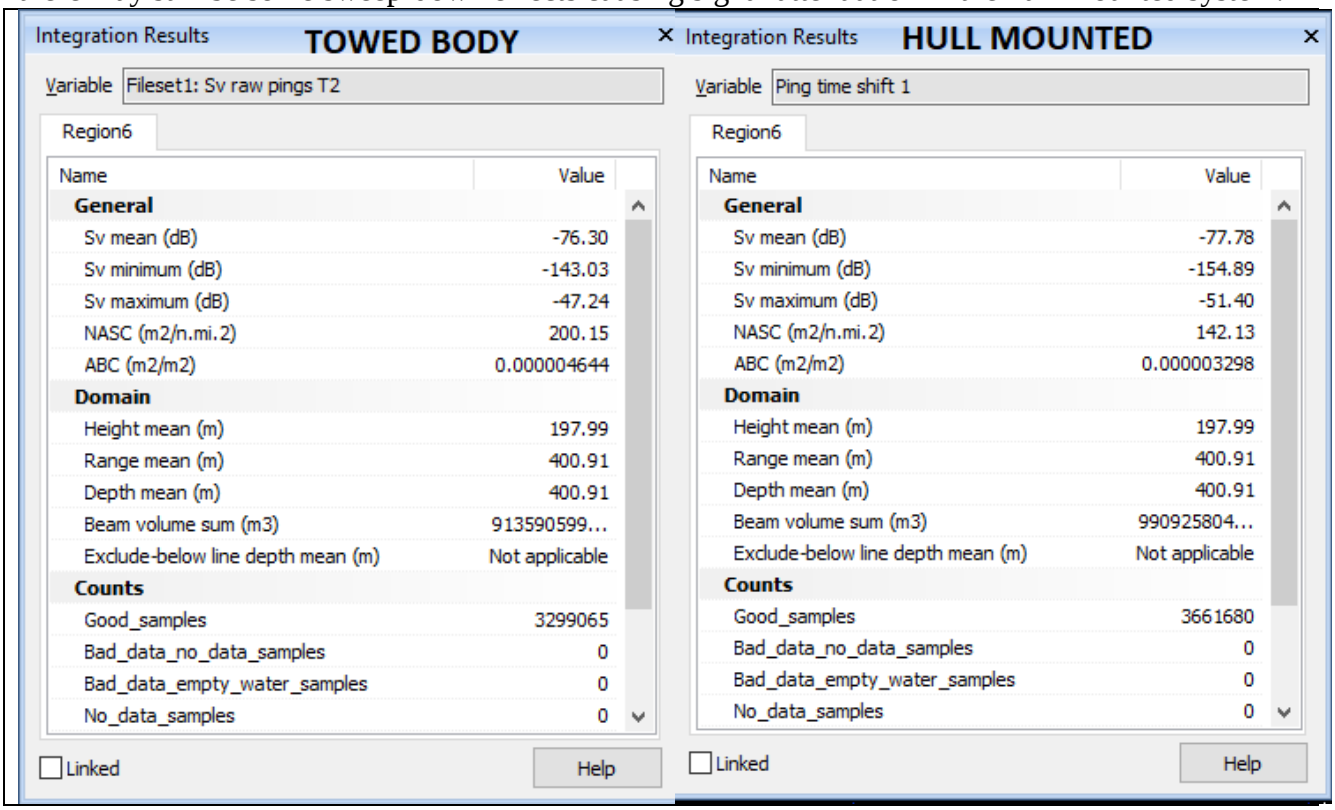

Figure 2 Echo integration results of similar echo-regions. The left panel shows the results for the towed body and the right panel shows the results for the hull mounted echo sounder recordings.

Conclusions

The results of the measurements carried out during a short-simple experiment showed that recordings of the towed body are not identical to the hull-mounted echo sounder at the same 38 kHz frequency. Normally and because these two echo sunders are calibrated at the same time with same material, the results should be comparable. However, considering the several number of potential other factors that may lead to such difference, including the bubble-sweep-down effects, uncertainties in the transducers' sensitivities at greater ranges, the time difference between the observations and changed cable length, the observed difference does **not** seem to be **a major concern** for the reliability of the survey data.

Recommendations

Although or concerns about the negative impacts of the lengthening of the towed body's towing cable on the survey results were not corroborated by the experiment, we believe that these concerns should be ruled out from the beginning. Also and w.r.t. the often necessary direct comparison between the 38 kHz recordings from the towed body with those of the 18 and 120 kHz transducers

from the ship's hull, we think that it is desirable to position the towed body further to the front and closer to the latter transducers. We therefore recommend that the deployment of the towed body should be tested each time before the start of the survey, preferably during the trips between the home port and the calibration site. During these tests, the different configurations between cable lengths and wing settings of the towed body could be thoroughly investigated. These experiments appear to be of particular importance each time a new towed body, a new towing cable or both are introduced to the survey.

Concluding remarks on the survey time and program

Particularly during the second part of the survey, we struggled a lot with completing the survey tasks in the overall available time. From the beginning of the second part, it was already apparent that the time to do fishing tows necessary for ground-truthing of the echo recordings was limited if the total distance and all CTD/WP2 would be covered. Two events with bad weather in the middle and at the end of the second part slowed us down considerably, so that two transects needed to be cut shorter and two CTD/WP2 needed to be cancelled. Despite these omissions, we were only able to conduct 9 fishing station, which we consider much too few to fully support the interpretation of the hydro-acoustic recordings. We, therefore, advise to either shorten the survey program for the EU participation in IESNS or increase RV Dana's available ship time for the survey.

Table 1: CTD and WP2 stations taken by R/V Dana during 1 to 31 May 2019

Station	Station Type	Year	status	Month	Day	Hour	Min	Latitude decimal	Longitude decimal	Bottom depth (m)	Wind direction	Wind speed
4	SEA	2019	Successful	5	7	4	37	62.3333	4.8499	180.1	51.1	5.07
5	SEA	2019	Successful	5	7	8	17	62.3310	3.7670	191.6	347.5	10.87
6	WP2	2019	Successful	5	7	8	44	62.3331	3.7748	192.6	338.8	7.5
8	SEA	2019	Successful	5	7	18	0	62.2812	1.6359	431.3	227.9	2.06
9	WP2	2019	Successful	5	7	18	46	62.2765	1.6459	426.3	103.3	1.37
11	SEA	2019	Successful	5	8	3	51	62.2051	-0.4862	793	327.4	2.34
12	WP2	2019	Successful	5	8	4	58	62.2089	-0.4543	792.9	304.8	4.34
14	SEA	2019	Successful	5	8	14	49	62.0815	-2.6167	399.3	348.5	9.65
15	WP2	2019	Successful	5	8	16	3	62.0782	-2.5984	1682.7	0	8.56
17	SEA	2019	Successful	5	9	1	44	62.9535	-1.7600	1851	49.2	4.11
18	WP2	2019	Successful	5	9	3	2	62.9507	-1.7400	1840.1	45.8	5.42
19	SEA	2019	Successful	5	9	9	36	63.0546	0.4176	1399.1	60.4	7.45
20	WP2	2019	Successful	5	9	10	53	63.0505	0.4190	1393.7	65.4	7.95
22	SEA	2019	Successful	5	9	19	42	63.1176	2.6109	969.4	6.8	9.2
23	WP2	2019	Successful	5	9	20	56	63.1076	2.6306	960.4	4.6	8.69
25	SEA	2019	Successful	5	10	6	3	63.1506	4.8400	775.6	326.8	5.47
26	WP2	2019	Successful	5	10	7	7	63.1552	4.8609	778	331.9	6.53
27	SEA	2019	Successful	5	11	3	27	65.4963	10.6878	288	258.4	4.45
28	WP2	2019	Successful	5	11	3	58	65.5010	10.6832	277.4	247.2	3.8
29	SEA	2019	Successful	5	11	10	39	65.5493	8.3073	365.9	317.6	10.44
30	WP2	2019	Successful	5	11	11	15	65.5487	8.3189	356.3	309.2	10.68
32	SEA	2019	Successful	5	11	20	34	65.5820	5.9003	346	280	9.02
33	WP2	2019	Successful	5	11	21	10	65.5845	5.8995	356.7	271.5	9.09
35	SEA	2019	Successful	5	12	6	1	65.5673	3.4818	1352.6	237	5.83
36	WP2	2019	Successful	5	12	7	16	65.5679	3.5093	1341.1	271.5	7.33
37	SEA	2019	Successful	5	12	13	52	65.5133	1.0959	2987.8	257	12.76
38	WP2	2019	Successful	5	12	15	6	65.5224	1.1160	2990.8	279.8	11.17
39	SEA	2019	Successful	5	12	19	26	65.5077	-0.2647	3058.9	267.1	12.38
40	WP2	2019	Successful	5	12	20	41	65.5150	-0.2615	3070.4	249.7	12.22
42	SEA	2019	Successful	5	13	9	37	66.3643	2.4826	1546.1	278.8	14.62
43	WP2	2019	Successful	5	13	11	1	66.3817	2.5024	1570.4	266	13.32
45	SEA	2019	Successful	5	13	21	40	66.3941	4.9222	1113.7	235.9	6.39
46	WP2	2019	Successful	5	13	23	2	66.4098	4.9278	1114.5	237.4	6.95
48	SEA	2019	Successful	5	14	7	3	66.3798	7.4393	368	91.1	2.68
49	WP2	2019	Successful	5	14	7	39	66.3836	7.4518	366	102.7	3.91
50	SEA	2019	Successful	5	14	14	1	66.3330	9.9170	221.9	98.2	2.46
51	WP2	2019	Successful	5	14	14	29	66.3340	9.9195	219.8	73.8	2.76
52	SEA	2019	Successful	5	17	4	33	68.6952	12.2772	805.3	238.8	3.77
53	WP2	2019	Successful	5	17	5	45	68.7061	12.3072	881.5	242.7	6.13
56	SEA	2019	Successful	5	17	18	2	68.7739	9.6285	3004.8	311.7	0.62
57	WP2	2019	Successful	5	17	19	18	68.7722	9.6399	3005.3	322.2	2.4
58	SEA	2019	Successful	5	18	1	33	68.8186	6.8177	3093.5	20.8	3.44
59	WP2	2019	Successful	5	18	2	52	68.8144	6.8464	3089.1	356.1	2.16
60	SEA	2019	Successful	5	18	9	7	68.8212	4.0684	3236.3	24.5	4.35
61	WP2	2019	Successful	5	18	10	22	68.8241	4.0822	3236.5	27.9	5.28
62	SEA	2019	Successful	5	18	16	54	68.7697	1.2920	2991.6	61.8	7.82
63	WP2	2019	Successful	5	18	18	10	68.7655	1.2745	2984.6	64.4	8.95
64	SEA	2019	Successful	5	19	9	42	70.8966	-2.8835	2793.2	50	10.26
65	WP2	2019	Successful	5	19	11	5	70.8944	-2.8927	317.3	53.5	10.73
66	SEA	2019	Successful	5	19	17	30	70.9751	0.1287	2334.9	70.1	14.64
67	WP2	2019	Successful	5	19	18	57	70.9544	0.1497	2340.9	62.3	13.9
68	SEA	2019	Successful	5	20	2	6	70.9879	3.1340	3161.8	73	11.95
69	WP2	2019	Successful	5	20	3	30	70.9691	3.0957	3164.8	63.7	14.22
70	SEA	2019	Successful	5	20	11	28	70.7649	5.2071	3145.2	74.2	13.3
71	WP2	2019	Successful	5	20	12	54	70.7455	5.1719	3147.6	69.6	15.25
73	SEA	2019	Successful	5	21	2	24	70.8753	8.2123	2864.3	76	12.53
74	WP2	2019	Successful	5	21	3	45	70.8784	8.2212	2863.2	58.2	14.92
75	SEA	2019	Successful	5	21	12	17	70.9381	11.2110	2592.6	41.3	12.22
76	WP2	2019	Successful	5	21	13	34	70.9181	11.1967	2601.8	66.4	12.59
78	SEA	2019	Successful	5	22	0	21	70.9551	14.2973	2164.4	44.1	12.37
79	WP2	2019	Successful	5	22	1	44	70.9512	14.3002	2167.2	53.7	13.1
81	SEA	2019	Successful	5	22	12	41	70.9210	17.2798	316.9	59.2	11.94
82	WP2	2019	Successful	5	22	13	17	70.9179	17.2956	309.5	61.1	9.72
84	SEA	2019	Successful	5	23	10	13	72.2514	17.3075	384.9	283	0.64
85	WP2	2019	Successful	5	23	11	1	72.2484	17.2794	382	332.9	1.21
87	SEA	2019	Successful	5	23	21	18	72.2868	14.0405	1197.6	348.3	8.14
88	WP2	2019	Successful	5	23	22	31	72.2900	14.0600	1187.7	347.2	7.77
89	SEA	2019	Successful	5	24	4	52	72.2675	10.7438	2142.1	351.7	7.76
90	WP2	2019	Successful	5	24	6	6	72.2605	10.7140	2149	334.1	5.31
91	SEA	2019	Successful	5	24	12	52	72.1865	7.5407	2666.8	346.2	6.86
92	WP2	2019	Successful	5	24	14	6	72.1678	7.5398	2670.3	15	5.11
94	SEA	2019	Successful	5	25	6	39	73.6192	11.5138	2049.8	343.8	6.39
95	WP2	2019	Successful	5	25	7	55	73.6202	11.5400	2039.1	314.4	7.03
96	SEA	2019	Successful	5	25	15	22	73.6348	14.9784	860.9	33.4	12.8
97	WP2	2019	Successful	5	25	16	26	73.6372	14.9772	865.1	29.7	11.74

Table 2: Fishing stations taken by R/V Dana during 1 to 31 May 2018

Country	Vessel	Cruise	Station	Gear	Month	Day	Hour	Min	Lat_decimal	Lon_decimal	windDir	Wind Speed (m/s)	Towing Speed (knots)	Towing Time (min)	Catch weight (kg)	gear Depth (m)
DK	OXBH	201907	7	stf	5	7	12	59	62.3062	2.6249	5.8	4.89	4.0	60	43.44	150
DK	OXBH	201907	10	stf	5	7	22	30	62.2437	0.6635	88.7	5.31	4.0	60	815.00	78
DK	OXBH	201907	13	stf	5	8	7	50	62.1780	-0.9697	279.6	2.23	5.3	60	375.01	220
DK	OXBH	201907	16	stf	5	8	23	59	62.9198	-1.7973	21.7	10.28	4.0	60	2379.97	0
DK	OXBH	201907	21	stf	5	9	13	23	63.0723	1.0181	26.7	6.97	4.0	60	294.98	65
DK	OXBH	201907	24	stf	5	9	23	45	63.1249	3.2444	351	10.42	3.9	60	3300.02	0
DK	OXBH	201907	31	stf	5	11	14	48	65.5697	7.3641	292.4	8.21	4.0	60	0.00	130
DK	OXBH	201907	34	stf	5	11	23	36	65.5804	5.1822	285.4	8.33	3.9	60	27.03	0
DK	OXBH	201907	41	stf	5	12	23	38	65.9143	-0.0478	253.7	13.84	3.8	60	4.41	0
DK	OXBH	201907	44	stf	5	13	12	51	66.3878	2.6783	272.1	11.31	3.4	60	6.22	340
DK	OXBH	201907	47	stf	5	13	23	37	66.4030	4.8841	209.6	4.61	3.5	60	13.84	0
DK	OXBH	201907	54	stf	5	17	7	15	68.6642	12.2403	222.9	5.29	2.7	60	116.72	200
DK	OXBH	201907	55	stf	5	17	15	44	68.7740	9.7590	296	3.06	3.9	60	1927.35	20
DK	OXBH	201907	72	stf	5	20	17	54	70.7912	6.1429	64.3	12.75	3.9	60	29.19	280
DK	OXBH	201907	77	stf	5	21	20	49	70.9524	13.3397	59.8	14.11	3.2	60	23.84	0
DK	OXBH	201907	80	stf	5	22	7	2	70.8806	15.8207	41.9	12.57	4.0	60	143.87	0
DK	OXBH	201907	83	stf	5	23	7	42	72.2393	17.4348	31	3.48	4.1	60	30.91	0
DK	OXBH	201907	86	stf	5	23	15	11	72.2604	16.1640	17.7	7.09	3.3	60	120.00	380
DK	OXBH	201907	93	stf	5	24	15	9	72.1495	7.7062	330.1	6.86	3.6	62	23.32	350
DK	OXBH	201907	98	stf	5	25	23	24	73.5735	17.9976	41.4	15.12	3.6	60	321.01	270

Table 3: Catch composition in trawl stations taken by R/V Dana during 1 to 31 May 2019

Station	Latitude	Longitude	average depth (m)	Total catch (kg)	*Anarhichas denticulatus*	*Anarhichas lupus*	*Arctozenus risso*	*Argyropelecus hemigymnus*	*Benthosema glaciale*	*Cephalopoda*	*Clupea harengus*	*Cyclopterus lumpus*	*Euphausiidae sp.*	*Eutrigla gurnardus*	*Gadus morhua*	*Gasterosteus aculeatus*	*Illex coindetii*	*Loligo vulgaris*	*Maurolicus muelleri*	*Melanogrammus aeglefinus*	*Merlangius merlangus*	*Micromesistius poutassou*	*Notoscopelus elongatus*	*Oncorhynchus gorbuscha*	*Pollachius virens*	*Salmo salar*	*Scomber scombrus*	*Scyphozoa sp.*	*Sebastes mentella*	*Todaropsis eblanae*	*Trachurus trachurus*
7	62.18.373 N	002.37.493 E	150	43.4	0.0	0.0	0.0	0.0	0.0	0.0	26.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.7	0.0	0.0	0.0	0.0
10	62.14.623 N	000.39.810 E	78	815.0	0.0	0.0	0.1	0.0	36.7	0.0	0.8	0.0	60.6	3.4	0.0	0.0	0.1	0.0	0.0	0.0	0.0	704.0	0.9	0.0	0.0	0.0	7.0	1.1	0.0	0.0	0.2
13	62.10.680 N	000.58.181 W	220	375.0	0.0	0.0	0.0	0.0	0.0	0.0	25.9	0.0	5.5	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	308.4	0.0	0.0	0.0	0.0	34.6	0.3	0.0	0.0	0.0
16	62.55.189 N	001.47.840 W	0	2380.0	0.0	0.0	0.0	0.0	0.0	0.0	2188.5	3.1	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	187.5	0.0	0.0	0.0	0.0
21	63.04.340 N	001.01.086 E	65	295.0	0.0	0.0	0.0	0.0	0.0	0.0	38.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	256.6	0.0	0.0	0.0	0.0
24	63.07.492 N	003.14.661 E	0	3300.0	0.0	0.0	0.0	0.0	0.0	0.0	855.3	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.1	0.0	0.0	0.0	0.6	2417.7	0.0	0.0	0.0	0.0
31	65.34.184 N	007.21.844 E	130	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
34	65.34.822 N	005.10.931 E	0	27.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	2.4	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	24.2	0.2	0.0	0.0	0.0
41	65.54.859 N	000.02.868 W	0	4.4	0.0	0.0	0.0	0.0	0.0	0.0	1.5	1.9	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0
44	66.23.268 N	002.40.696 E	340	6.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.9	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
47	66.24.182 N	004.53.046 E	0	13.8	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.7	2.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.6	0.0	0.0	0.0	0.0	0.0
54	68.39.850 N	012.14.420 E	200	116.7	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.2	1.6	0.0	77.7	0.0	0.0	32.7	0.0	0.0	3.0	0.0	0.0	0.0
55	68.46.438 N	009.45.541 E	20	1927.4	0.0	0.0	0.0	0.0	0.0	0.0	1927.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
72	70.47.472 N	006.08.573 E	0	29.2	1.5	0.0	0.5	0.0	0.7	0.3	0.0	0.8	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.8	0.0	0.0	0.0	0.0	0.0	4.7	3.6	0.0	0.0
77	70.57.143 N	013.20.382 E	0	23.8	0.0	0.0	0.0	0.0	0.0	1.0	7.8	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
80	70.52.833 N	015.49.242 E	0	143.9	0.0	0.0	0.0	0.0	0.0	0.1	108.0	34.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
83	72.14.359 N	017.26.090 E	0	30.9	0.0	0.0	0.0	0.0	0.0	0.0	8.6	21.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
86	72.15.622 N	016.09.842 E	380	120.0	0.0	0.0	2.0	0.0	0.3	1.6	0.0	0.0	66.2	0.0	6.8	0.0	0.0	0.0	0.4	26.1	0.0	5.6	0.0	0.0	3.4	0.0	0.0	6.7	0.8	0.0	0.0
93	72.08.969 N	007.42.369 E	350	23.3	1.4	0.0	0.3	0.0	0.0	1.6	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2	0.0	0.0	0.0	0.0	16.1	0.6	0.0	0.0
98	73.34.407 N	017.59.857 E	280	321.0	0.0	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	317.8	0.3	0.1	0.0	0.0	1.8	0.0	0.0	0.5	0.0	0.0	0.0

Annex 1 - Calibration report.

Annex 1 - Calibration report for the towed body mounted transducer used for abundance estimation.

Transceiver Menu	
Frequency	38 kHz
Sound speed	1466.4 $m.s^{-1}$
Max. Power	2000 W
Equivalent two-way beam angle	-20.5 dB
Default Transducer Sv gain	25.55 dB
3 dB Beamwidth	6.8°
TS of sphere	-33.6 dB
Range to sphere in calibration	11.24 m
Measured NASCvalue for calibration	22100 m^2/nmi^2
Calibration factor for NASCs	1.00
Absorption coeff	8.197 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