WORKSHOP ON SCRUTINIZING OF ACOUSTIC DATA FROM THE IESSNS SURVEY (WKSCRUT2)

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i Executive summary

This report describes the results of the Workshop on acoustic scrutinising procedures for the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) recommended by the Working Group of International Pelagic Surveys (WGIPS). The IESSNS targets mackerel, herring and blue whiting during their summer feeding migration in the Nordic Seas. However, mackerel is estimated by standardized swept-area trawl method as it currently cannot be estimated by acoustic methods, while herring and blue whiting are estimated using standard acoustic methods. In internationally coordinated acoustic surveys the scrutinisation procedures may differ slightly among participating nations. It is therefore very important that all scientists responsible for the scrutinisation are following the same general procedures, and that the procedures are revisited on a regular basis to ensure a standardised categorization and allocation into species or species groups during pelagic ecosystem surveys.

The group defined three areas with typical and common acoustic backscatter features within the total survey area covered by IESSNS: the Irminger Sea including East Greenland and West Iceland , the Norwegian Sea and adjacent areas including Iceland Sea and the area around the Faroes, and shelf areas. Further, two general procedures were presented; the first was how to separate herring from plankton (the "200 kHz" method), and the second how to deal with the acoustic backscatter in the upper layers in years when strong year-classes of blue whiting occur in the survey area (that resemble small herring schools).Analyses of several examples showed that all participants used the same general procedure during the scrutinising process. However, some minor adjustments were made by individual participants to ensure that an identical procedure was followed by the whole group, as shown by the examples in this report.

An important lesson learnt from this workshop was to urge cruise leaders to take frequent trawl samples of the acoustic recordings during the survey, to be able to ground-truth (= identification by trawling) the echograms ('always trawl when in doubt'). This is especially necessary to identify all observed acoustic layers/scatters in the area at the beginning of the survey, to ensure consistent and good quality scrutinising during the survey.

The 'threshold method' (i.e. adjusting the lower threshold) is described in the report and advice is given on how to use the method to identify schools and fish targets among masking plankton layers. A standardised threshold method reduces the need for human 'expert' judgement during the scrutinising process.The group recommends that all participants store the data at maximum -72 dB and preferably at -82 dB, but are aware of possible problems for some vessels with noise at that low level.

ii Expert group information

Expert group name	Workshop on scrutinizing of acoustic data from the IESSNS survey (WKSCRUT2)
Expert group cycle	Annual
Year cycle started	2019
Reporting year in cycle	1/1
Chair(s)	Jan Arge Jacobsen, Faroe Islands
	Åge Høines, Norway
Meeting venue(s) and dates	17-18 September 2019, Bergen (13 participants)

1 Introduction

This report describes the results of the workshop on acoustic scrutinising procedures for the International Ecosystem Summer Survey in the Nordic Seas (IESSNS) held at the Institute of Marine Research, Bergen on September 17th and 18th, 2019. The IESSNS targets mackerel, herring and blue whiting during their summer feeding migration in the Nordic Seas. Mackerel density is estimated by a standardized swept-area trawl method as it currently cannot be estimated by acoustic methods, while herring and blue whiting are estimated using standard acoustic methods. Thus the scrutinising of herring and blue whiting were the main focus of this report. However, time was also spent on how to distinguish these two main species from less important species such as pearlside, mesopelagic fish, phytoplankton, and other species in the deep scattering layer.

In internationally coordinated acoustic surveys scrutinisation procedures may differ slightly among participating nations. It is therefore very important that all scientists responsible for the scrutinisation are following the same general procedure. Uncertainty regarding the scrutinising procedure, i.e. categorization and allocation into species or species groups, emphasized the need for a workshop which involved scientists responsible for the scrutinisation on the pelagic ecosystem surveys, i.e. scientists participating in the IESSNS: Iceland, Norway, Faroes, Greenland and Denmark.

Focus was on the IESSNS, but also IESNS was considered, as the scrutinising situations are similar.

To gain the most from the exercise, participants were requested to scrutinise and post-process acoustic data collected during their parts of the surveys. To facilitate this, 2-3 exemplary IESSNS acoustic RAW-datasets (of at least one full day) considered representative of the survey area from each nation were discussed in plenary during the workshop. Typical situations and challenges/problems in the scrutinising procedures were identified and discussed among the participants, and the results with examples are described in the report.

2 The procedures used to scrutinise acoustic data in IESSNS

LSSS (MAREC) and EchoView (Echoview Software) were used by the participants for scrutinising the acoustic raw data collected using EK60 or EK80 echosounders. Scrutinised sA data have primarily been exported at minimum threshold of -70, -72 or -82 dB.

Scrutinisation general procedure starts with excluding the surface, upper 5 to 10 m, bottom backscatter, remove acoustic data where the vessel is travelling between transects, and excluding bad data/pings, as well as hydrographic and trawl stations.

Next step is to identify backscatter from the two target species. Herring is identified with strong thresholding (up to between -55 and -45 dB) of the echogram visually judged by the scrutunizing personnel ('tresholding' method), aided by previous knowledge of herring spatiotemporal distribution and vertical location in the water column, combined with trawl-information. To assign echo-values (sA) to herring, the regions are adjusted at lower threshold-values to include marks belonging to herring-echo. Blue whiting is identified based on echogram-'experience' combined with ground truthing information from trawl hauls (i.e. identification of the acoustic targets by trawling), refer to examples in report.

The 'thresholding' method mentioned above is described for two examples (sec. 3.1, Figure 2 and sec. 3.2, Figure 5); the descriptions differ slightly, but reflect the same procedure.

3 Description and evaluation of scrutinising procedures for the IESSNS

Iceland, Norway, Faroes, Greenland and Denmark presented their scrutinising procedures with examples of different echograms illustrating both typical situations and examples of challenging and problematic echograms. The presentations from the participants in the IESSNS showed that all were using the scrutinising protocol stated in the survey manual (SISP 9, ICES 2015) regardless of whether LSSS or EchoView were used as tool in the scrutinising process. Only minor differences were found in echograms scrutinising procedures between workshop participants.

All workshop participants reported problematic situations for scrutinising echograms in their survey area. Problematic situations included mixtures of different species that occurred at various depths in the water column and in most parts of the survey area, although the problems encountered depended on time of day and geographical location. Therefore, it was decided to discuss general and problematic acoustic backscatter data for different species and species mixtures encountered during the survey, illustrate them with screenshots and give recommendations to the scrutinising process.

The group decided to define areas with typical and common acoustic backscatter features within the total survey area covered by IESSNS. Three "typical" areas were identified: The Irminger Sea including East Greenland and West Iceland (sec. 3.1), the Norwegian Sea and adjacent areas including Iceland Sea and the area around the Faroes (sec. 3.2), and shelf areas (sec. 3.3). See the areas with the IESSNS 2019 coverage superimposed on the map in Figure 1. The areas are also listed in Table 1 along with the main species encountered and typical and problematic scrutinisation situations observed in the areas during the surveys.

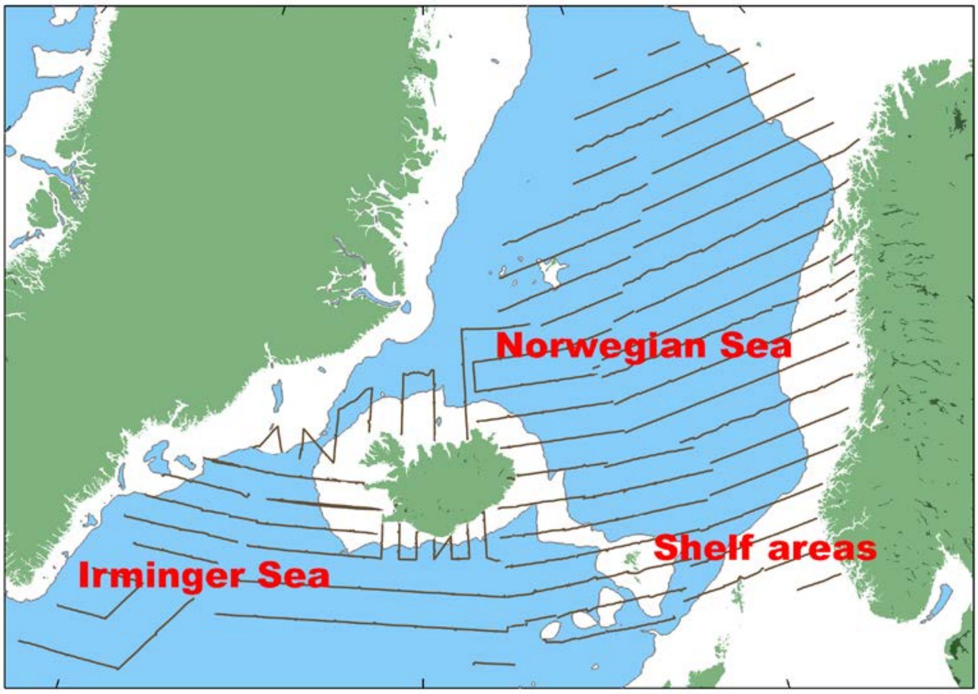

Figure 1. Map illustrating the IESSNS "typical" areas identified at the workshop: The shelf areas (i.e. less than 500 m depth), the Irminger Sea/Greenland/West Iceland, and the Norwegian Sea and adjacent areas. The total IESSNS coverage (cruise tracks) in 2019 is superimposed on the map. The areas deeper than 500 m depth are shaded in blue. See Table 1 for details of the areas.

Table 1. IESSNS "typical" areas with references to examples.

Area	Target species	Examples/challenges
Irminger Sea/Greenland/West Iceland (sec.3.1)	Blue whiting	Typical situations: “clean” blue whiting layer at 200-300 m depth on the shelf edge (Figure 2a) weak BW layer at 300-400m with single fish scatters on the shelf edge (Figure 2b-c). typical low density blue whiting scatter at 300 – 450 m depth in the Irminger Basin (Figure 3a-b) blue whiting near the shelf slope on Dohrn Bank (Figure 4). Challenges/problems: to identify low densities of blue whiting from a scatter of plankton and mesopelagic fish (Figure 12 a-c).
Norwegian Sea and adjacent areas (sec. 3.2) incl. Iceland Sea & the sea around Faroes	Herring Blue whiting	Typical situations: herring in the surface layer (0-50m), one layer of scatters and the other of individual schools. Herring and blue whiting on the east coast of Iceland (Figure 8). north coast of Iceland - herring mixed with plankton (Figure 9). Challenges/problems: Juvenile blue whiting may resemble herring acoustically. This is particularly an issue when large year classes of blue whiting are recruiting to the stock: central Norwegian Sea with mixture of herring and blue whiting with good recruitment of blue whiting (Figure 6). Central Norwegian Sea with mixture of herring and blue whiting with poor recruitment of blue whiting (Figure 7). south of 60°N with 0-group blue whiting (Figure 15).
Shelf areas (sec. 3.3) i.e. areas < 500 m depth (see Fig 1.)	Blue whiting	Typical situations: Blue whiting is typically distributed along the shelf edge in the whole survey area. example from the south coast of Iceland (Figure 12a-b) example of herring on the shelf west of Iceland mixed with plankton in the surface layer (0-50m) (Figure 13a-b). Challenges/problems: to determine how much of the acoustic recordings to include in shallow areas towards the shelf in order not to include demersal species (Figure 12c).

3.1 Irminger Sea/Greenland/West Iceland

The Irminger Sea basin presents the fringe westward distribution of adult blue whiting in the Northeast Atlantic (although it may occasionally be found further west). Typical situations during the IESSNS:

1) Blue whiting is scattered in very low densities above deep water (several kilometres) off the shelf. Here they are found in the upper part of the deep scattering layer (~300-400m depth) with weak schooling patterns.
2) Blue whiting layers nearer the shelf edge, especially in the area near Dohrn Bank. These registrations usually show stronger signals than in the oceanic areas.

Generally the off-shelf signals are weak and contain no clear characteristic schooling patterns. The whole area generally lacks observations for ground-truthing (identification by trawling) to confirm acoustic observations.

Blue whiting densities are usually low in the area. In some years blue whiting layers are observed (Figure 2a-c) at 200 – 400 m depth, but not in all years, for example during IESSNS 2019. It is possible to observe a layer of blue whiting that is neither mixed with plankton nor other fish (herring, mesopelagic, red fish), see Figure 2a. Usually, blue whiting is mixed with plankton and some thresholding is needed (Figure 2b-c). Given the great depth and low densities of blue whiting thresholding is usually within the range of -68/-70 dB to -71 dB.

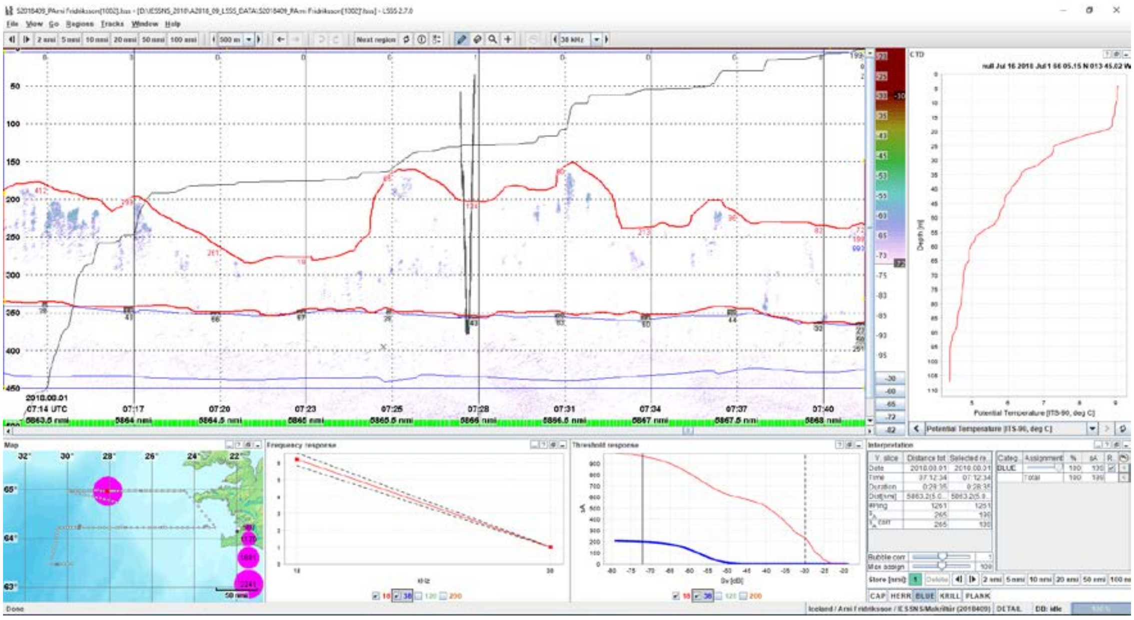

Figure 2a. Blue whiting scatter, of two different densities, in the Irminger Sea from IESSNS 2018. At 200 to 300 m depth (between the red lines) all backscatter ≥-72 dB is allocated to blue whiting. The echogram is displayed at 38 kHz, is 5 nmi long, shows depth from surface to 500 m depth, and lower threshold is at -72dB. Nearest temperature profiler (0-110m) also displayed along with frequency and threshold responses, geographical location of echogram (red dot on map), and the interpretation window in the lower right corner showing scrutinising results.

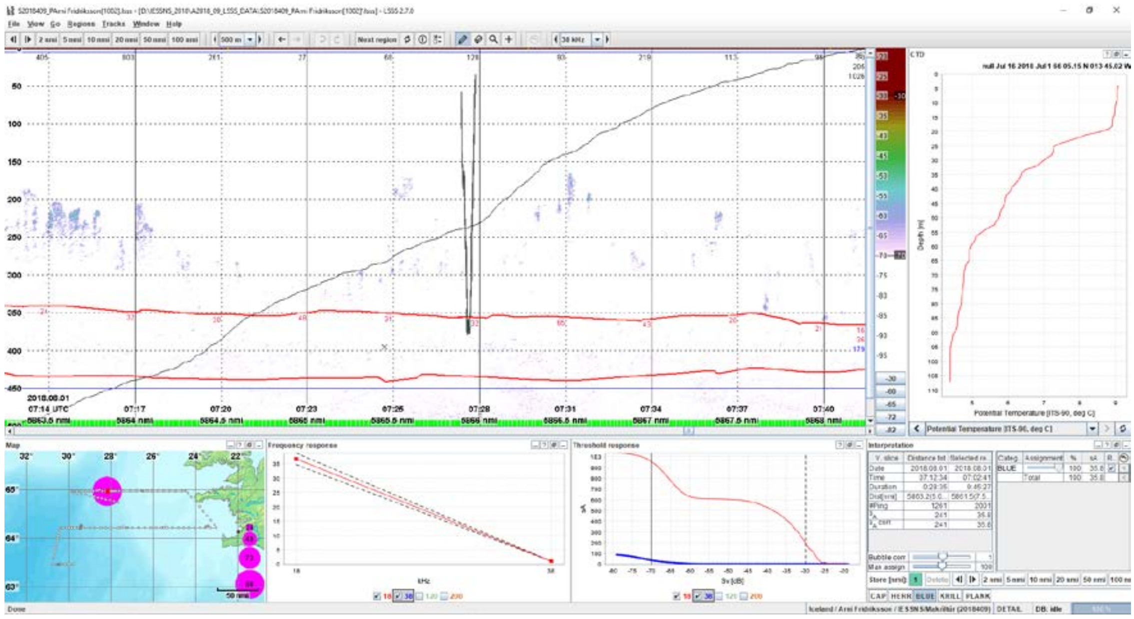

Figure 2b. Blue whiting scatter, of two different densities, in the Irminger Sea from IESSNS 2018. At 300 to 450 m depth (between the red lines) all backscatter ≥-70 dB is allocated to blue whiting. The echogram is displayed with a lower threshold of -70dB. Here the weak signals from scattered blue whiting can be seen.

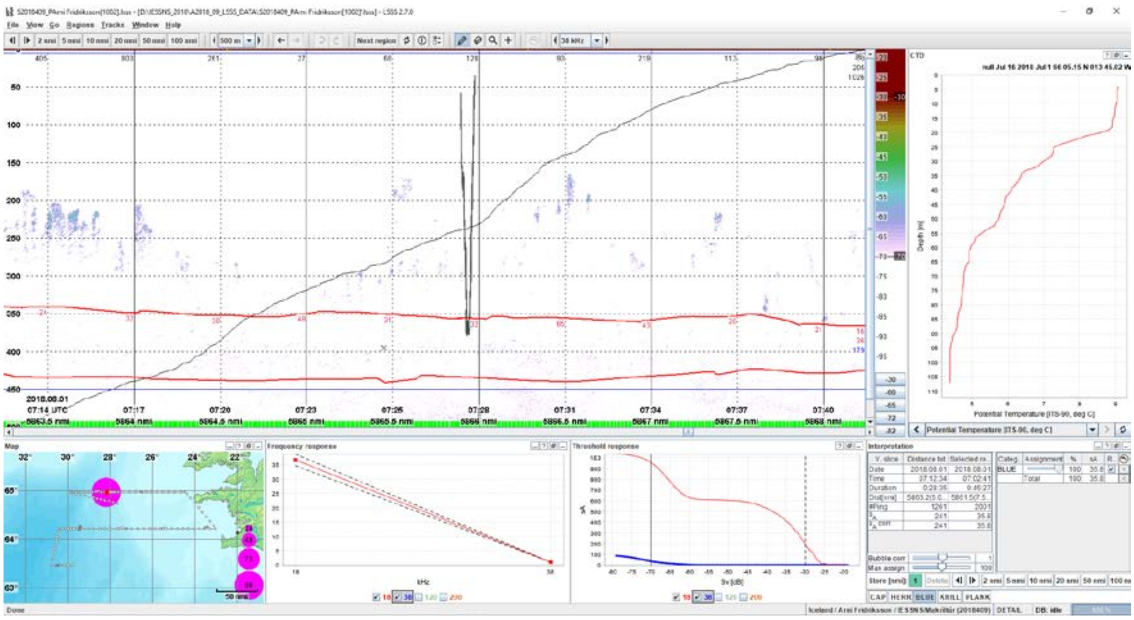

Figure 2c. Blue whiting scatter, of two different densities, in the Irminger Sea from IESSNS 2018. At 300 to 450 m depth (between the red lines) all backscatter ≥-70 dB is allocated to blue whiting. The echogram is displayed with a lower threshold of -72dB. In the interpretation window the s_A value was manually set to the 100% s_A value from lower threshold of -70dB in Figure 2b.

The presented method described for the echogram in Figure 2a-c is the general method for using thresholding in LSSS when assigning backscatter to species despite the results are exported fixed at a lower threshold of -70, -72 or -82 dB.

Examples showing acoustic recordings of low density blue whiting aggregations at ~300-400m depth in the centre of the Irminger Sea (several km of depth) are shown in Figure 3a-b. Screenshots of the acoustics can be seen below (Figure 3a and b).

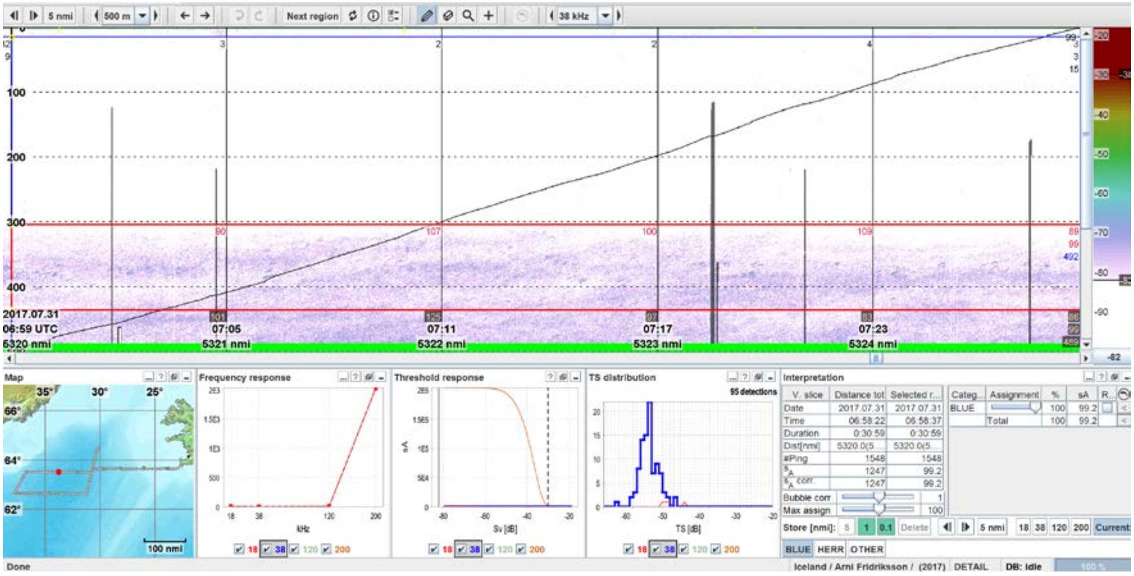

Figure 3a. Acoustic recordings of scattered blue whiting at ~300-400m of depth in the Irminger Sea 2017. Threshold response of -82dB. The echograms do not show the actual scrutinising results, but were solely made for illustration purposes.

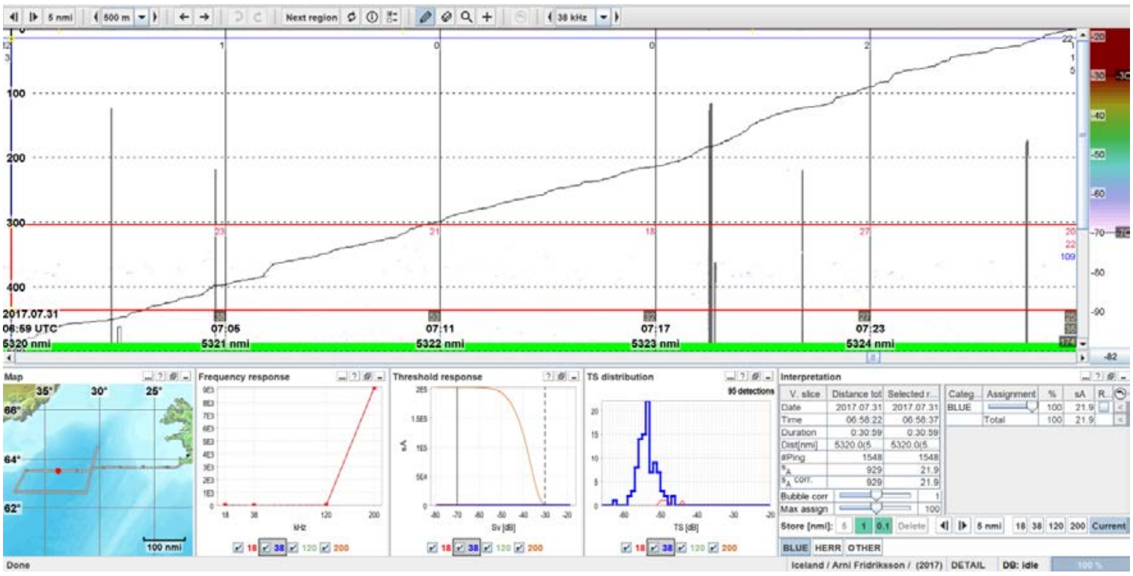

Figure 3b. Acoustic recordings of scattered blue whiting at ~300-400m of depth in the Irminger Sea 2017. The same echogram as in 3a but with a threshold response of -70dB. Here weak recordings of blue whiting can be seen between the red lines after tresholding. The echograms do not show the actual scrutinising results, but were solely made for illustration purposes.

A third common situation of blue whiting signals in the area was presented in Figure 4a-b. Here, acoustic signals of blue whiting near the shelf slope on Dorhn Bank (Figure 4) were discussed. Multiple trawl hauls on Arni Fridriksson in 2016 confirmed the presence of blue whiting along the shelf.

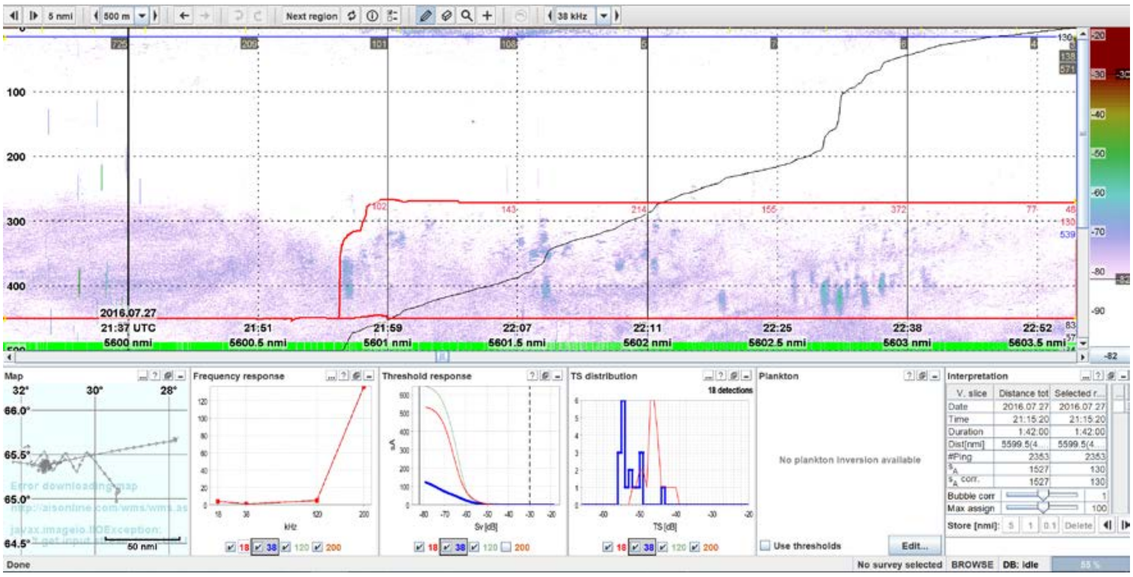

Figure 4a. Blue whiting layer at 300-450 m depth mixed with other scatteres near the shelf slope on Dohrn Bank on IESSNS 2016. Lower threshold is -82 dB.

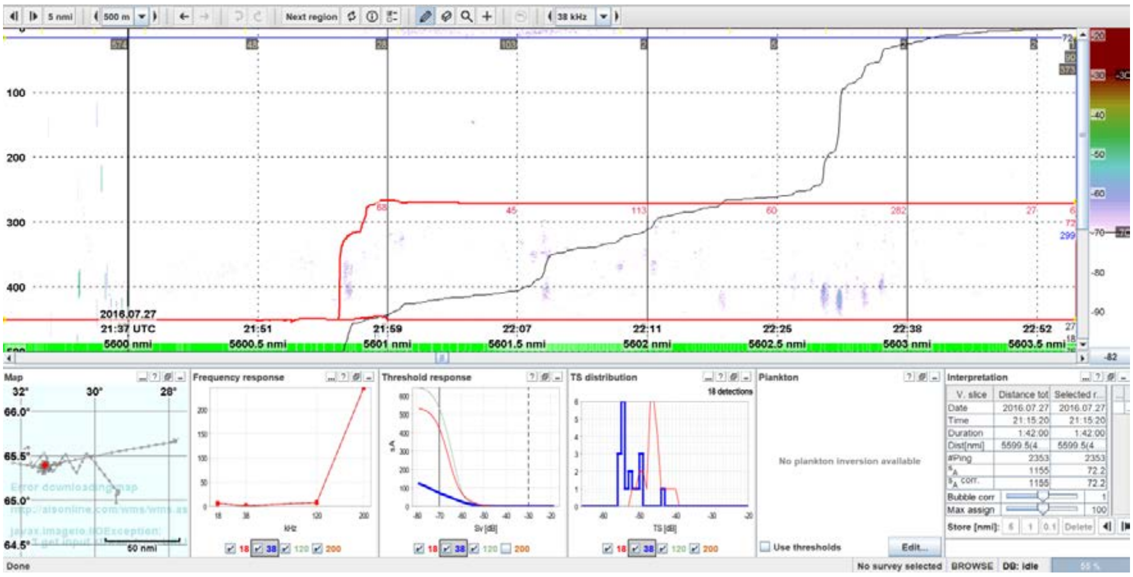

Figure 4a. Blue whiting layer at 300-450 m depth mixed with other scatteres near the shelf slope on Dohrn Bank on IESSNS 2016. Lower threshold is -70 dB. Now the blue whiting recordings can be seen in the layer between the red lines at 300-450 m depth.

3.2 Norwegian Sea and adjacent oceanic areas

In Figure 5 an example is illustrated from the IESNS cruise in May 2019 on the Norwegian vessel G.O. Sars, but the interpretation method is similar to the one used at the IESSNS survey in July-August. Figure 5a shows a standard five nautical mile echogram that contains the two acoustic target species herring and blue whiting. In principle, three acoustic categories are used: herring, blue whiting and others. Others can be plankton, demersal fish, mesopelagic fish etc., but this category must be regarded as useless for scientific purposes since it may contain sonar noise etc. Standard lower threshold for storing of data is -82 dB in Norwegian surveys.

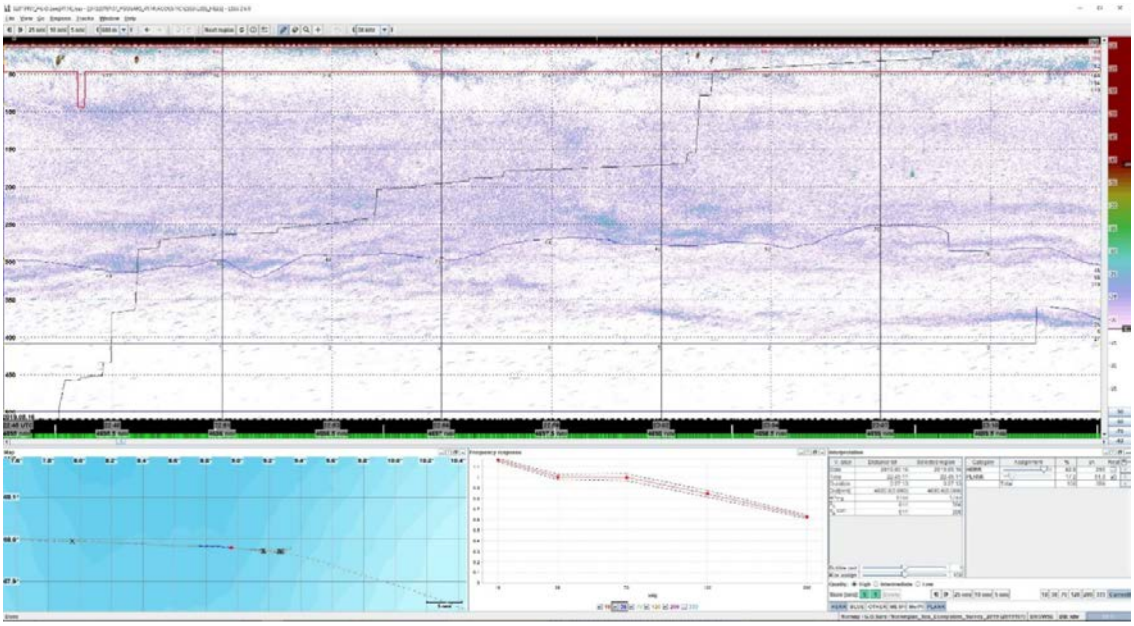

Figure 5a. Echogram in LSSS where the top layer (upper 50 m) is activated, and the dB threshold is set to -82. The strong marks in the top layer are herring schools.

The ecogram in Figure 5a is from the Norwegian Sea 90 nmi west of Lofoten. A few nautical miles before, a surface haul was carried out and the catch there was 3 tonnes of herring, which strongly suggests that the strong marks in the upper part of the echogram are herring schools. In the map on the lower left in Figure 5a the five nautical miles from the echogram is shown as a blue line (with a red dot on the west end showing where the cursor is in the echogram), and the start/stop of the trawl haul is indicated by open rectangles. The echogram is split in four horizontal layers that are interpreted separately; one from ca. 15 to 50 m, a so-called "mesopelagic" layer from ca. 50 to 300 m, a so-called "blue whiting layer" from ca. 300 to 400 m and a deep layer from 400 to 500 m (500 m is the lower integration limit). The normal procedure is to start from the top layer and work downwards. In Figure 5a the top layer is activated (the layer limits then become red in LSSS) and the s_A value in this layer can be distributed in different categories in the interpretation window (lower right in the figure). In this case the total s_A value of 356 is split between herring (295) and plankton (61). The next figure (Figure 5b) shows the logic behind the value assigned to herring: the dB threshold is set to -58 and it is assumed that the "remaining echo" in the layer is herring (this value is shown in the red circle on the lower right in the interpretation window). The s_A values per half nautical mile in the upper right corners (in Figure 5b) can in this case be used to determine the appropriate "herring threshold"; the half mile with log distance 4697.5-4698 seems to not contain any herring and the s_A value of this half mile is 1 (i.e. close to zero) when the threshold is set to -58 dB.

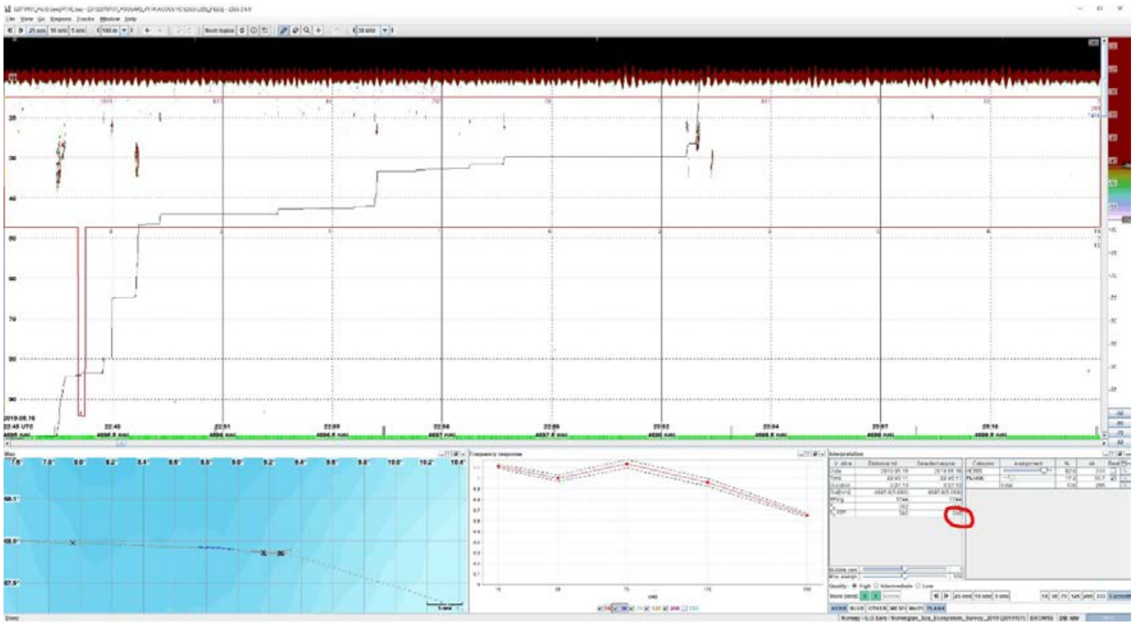

Figure 5b. Echogram in LSSS where the top layer (upper 50 m) is activated and zoomed in and the threshold is set to -58 dB. The total s_A at this threshold is 295 (in red circle).

Generally, a higher threshold should be used to separate out fish from plankton in the upper layers. In deeper layers (around 100 m and deeper) it is common to use a threshold of around -70 dB to separate out fish. Figure 5c shows the interpretation of the next layer (50-300 m) were all echo is assigned to the category Me/Pl (in practice “others”).

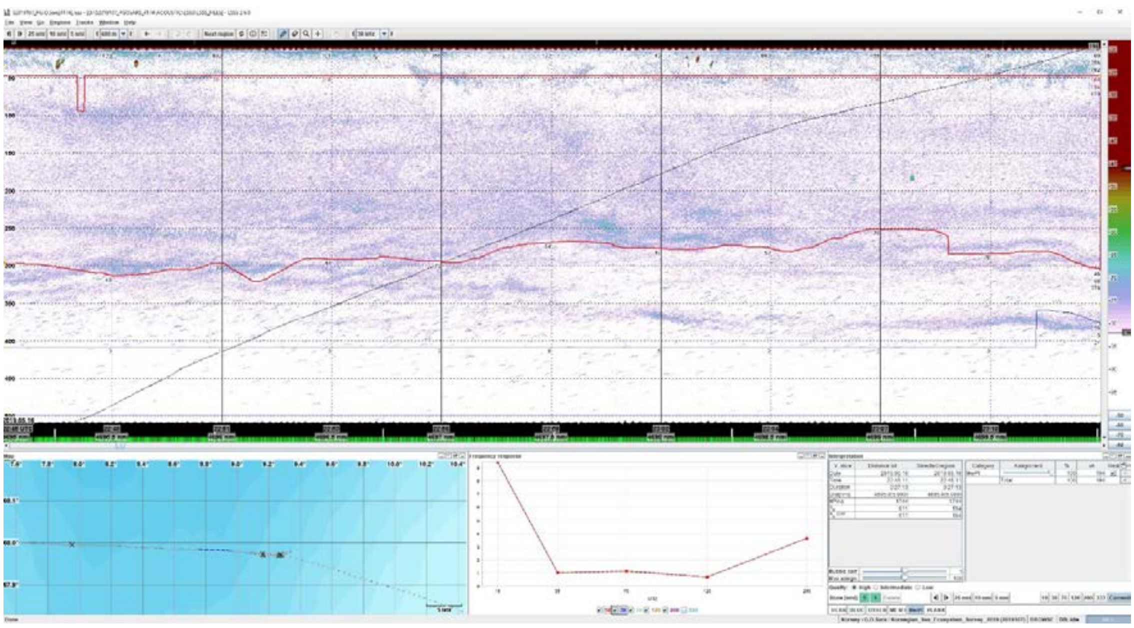

Figure 5c. Echogram in LSSS where the second layer (50-300 m) from the top is activated and the dB threshold is set to -82. The acoustic recordings in this layer was assigned to "other", i.e. not herring nor blue whiting.

In the third layer from the top (activated in Figure 5d), that can be termed the “blue whiting layer” a lot of single traces can be seen and these are assumed to be blue whiting individuals. In the interpretation window (lower right in Figure 5d) we see that the value 18 is assigned to blue whiting, and the rest is assigned to Me/Pl ("other"). The blue whiting value was found by thresholding to -70 dB and give what then remained to blue whiting (Figure 5e). The same method is used in the deepest layer (Figure 5f and 5g) but here the blue whiting threshold is set to -72 dB (Figure 5g).

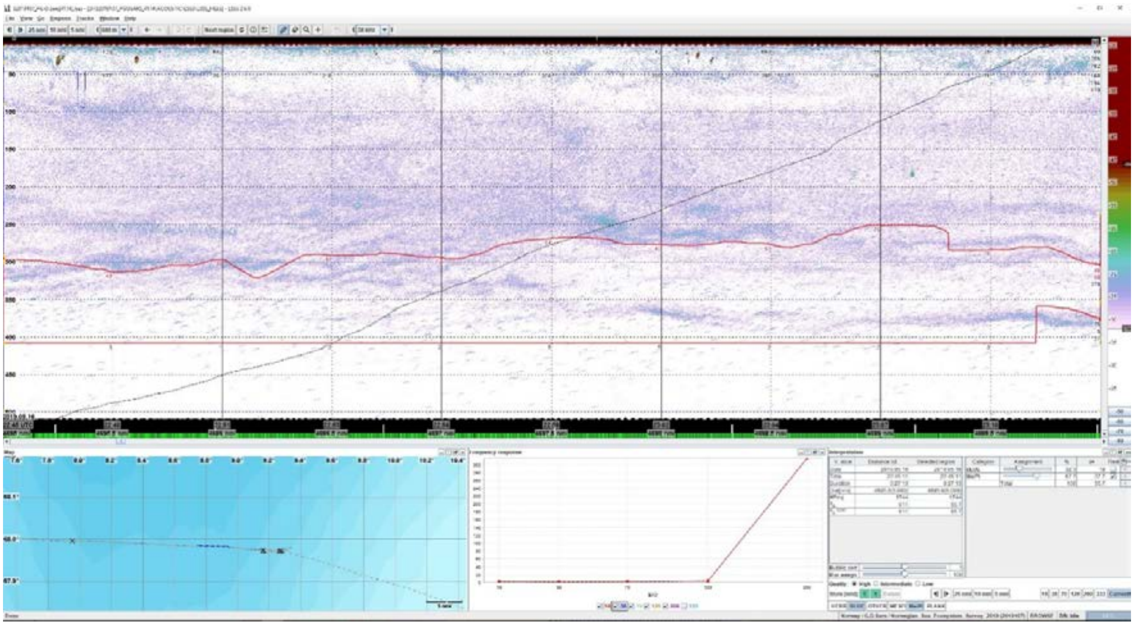

Figure 5d. Echogram in LSSS where the third layer (300-400 m) from the top is activated and the DB threshold is set to -82. This layer contains a mixture of "other" and blue whiting.

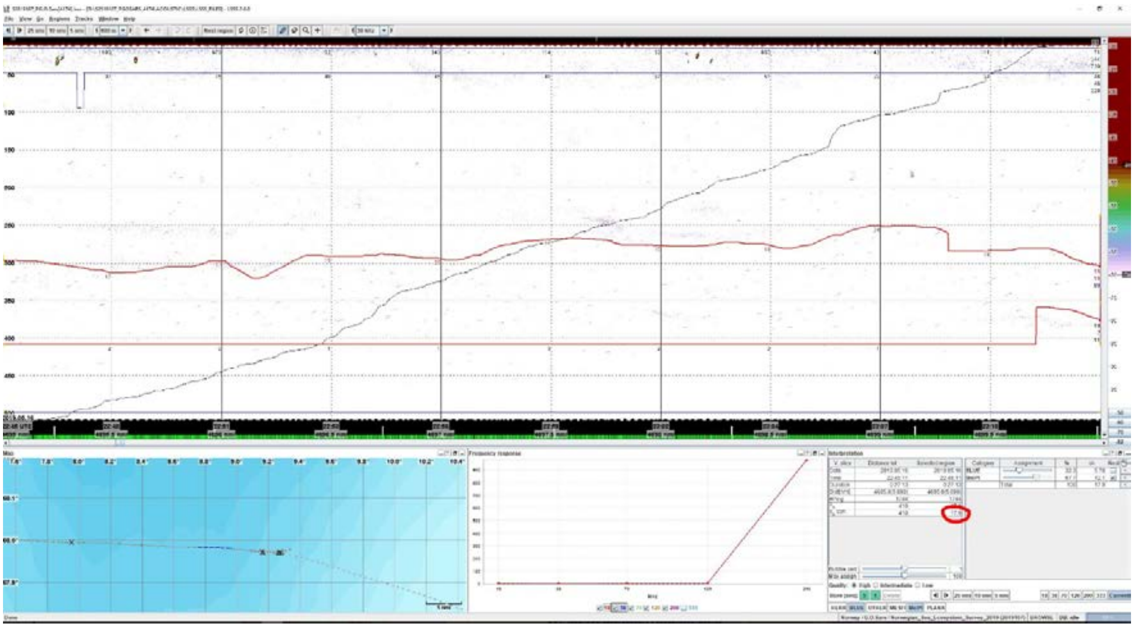

Figure 5e. Echogram in LSSS where the third layer (300-400 m) from the top is activated and the dB threshold is set to -70. Now the blue whiting scatterers can be seen while most of the "other" has been tresholded.

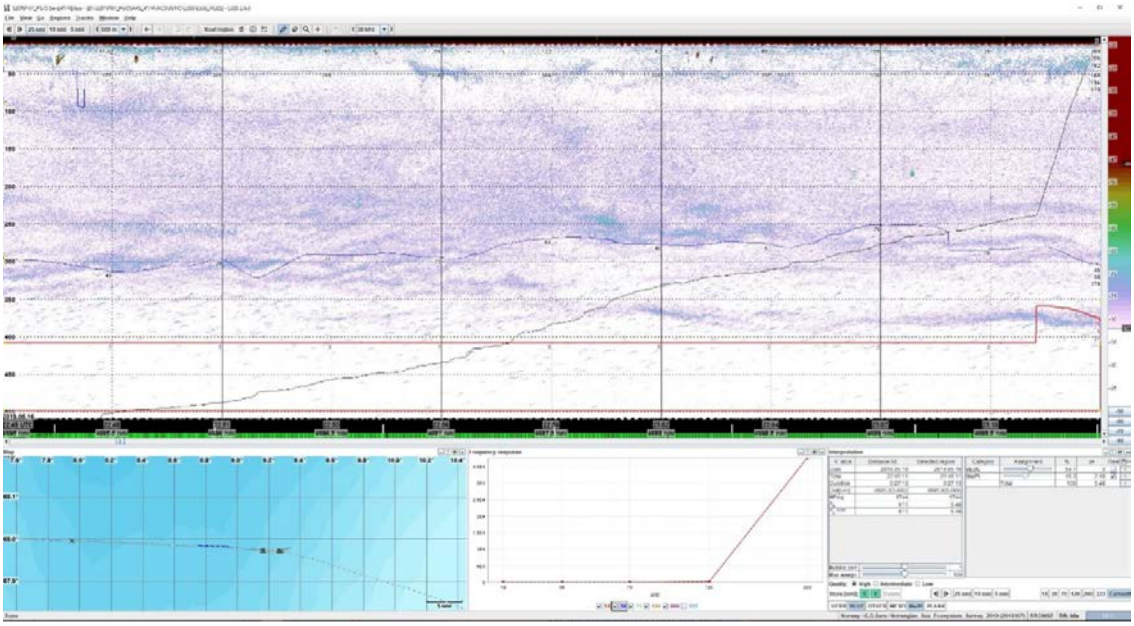

Figure 5f. Echogram in LSSS where the deepest layer (400-500 m) is activated and the dB threshold is set to -82. This layer contains a mixture of blue whiting and "other".

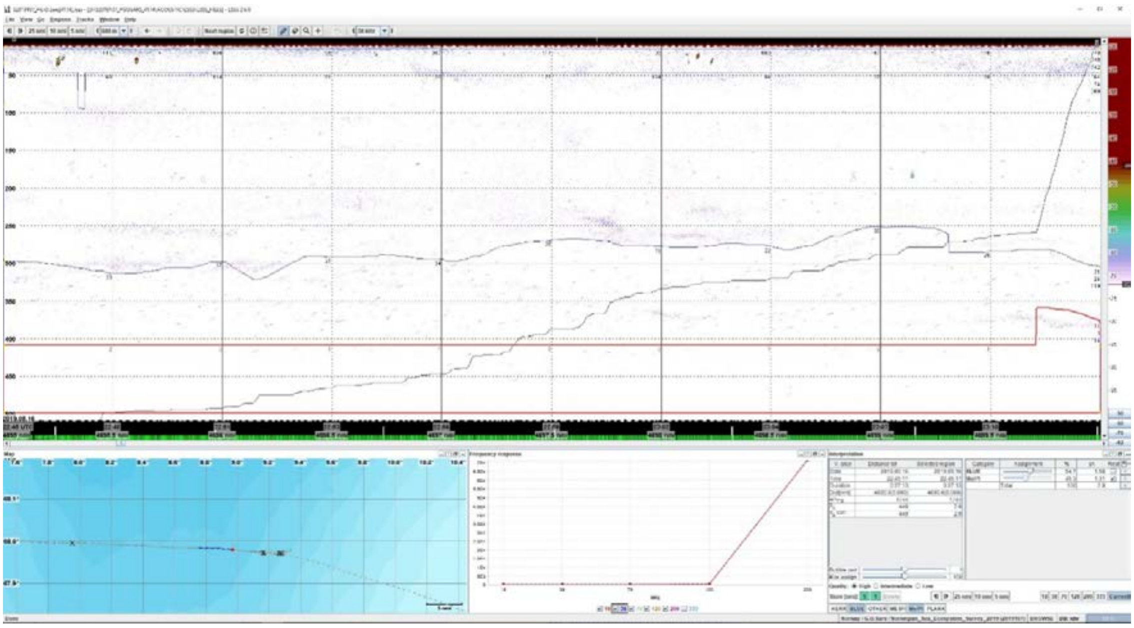

Figure 5g. Echogram in LSSS where the deepest layer (400-500 m) is activated and the dB threshold is set to -72 dB. Total remaining s_A is 3, which is assigned to blue whiting, and the rest to "other".

In the central Norwegian Sea there can be extensive mixture between herring and blue whiting. Figure 6 shows a typical echogram from IESSNS 2015 when there was a lot of juvenile blue whiting in the area (i.e. a "good recruitment" period in Table 1). Figure 7 shows an echogram from IESSNS 2019, when there was much less juvenile blue whiting ("poor recruitment" period in Table 1). In years with large incoming year classes it can be hard to distinguish between herring schools and blue whiting because schools of juvenile blue whiting resemble herring schools acoustically. Often, these blue whiting schools are in the top of a more characteristic blue whiting backscattering layer (Figure 6), further complicating the scrutinisation. In general, the same procedure should be applied as described for Figure 5. One possible help in identifying species can be looking at the integration line, which generally makes more distinct jumps by herring schools; the strongest blue whiting schools, however, may also cause the integration line to make jumps similar to those of herring schools. Another guideline is to observe the general pattern of the top edge of the blue whiting backscatter – if the mark is integrated part of this backscatter, it is an indication it might be blue whiting.

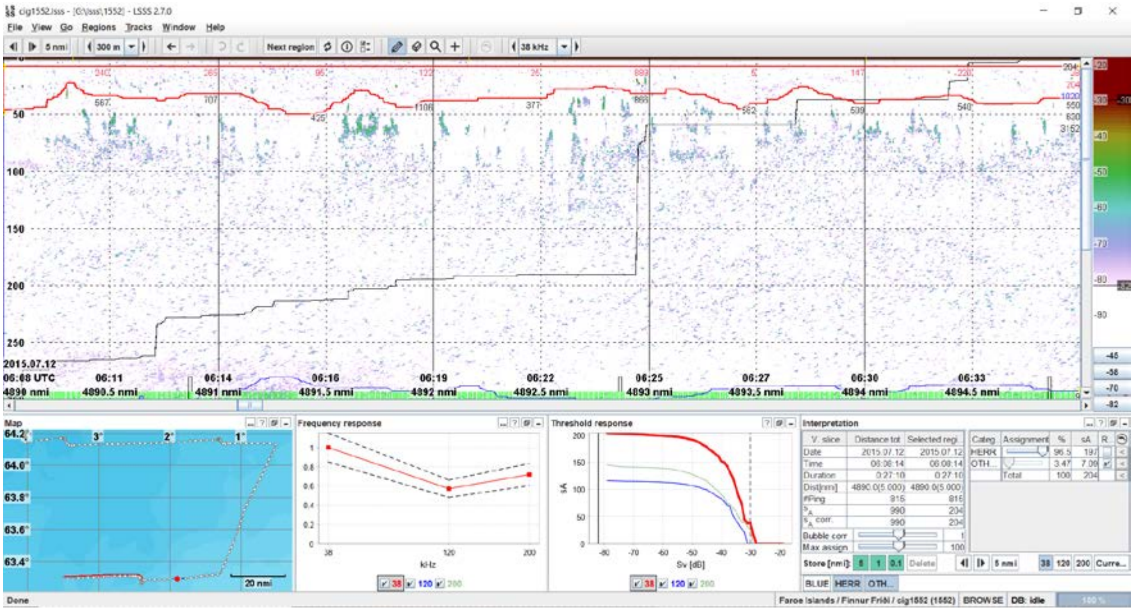

Figure 6a. Example in the central Norwegian Sea in IESSNS 2015 with herring and a lot of juvenile blue whiting 0-250 m. Surface layer (upper 50 m) activated where herring s_A values are shown as red numbers in the upper right corners of the active layer. Threshold was set to -72 dB.

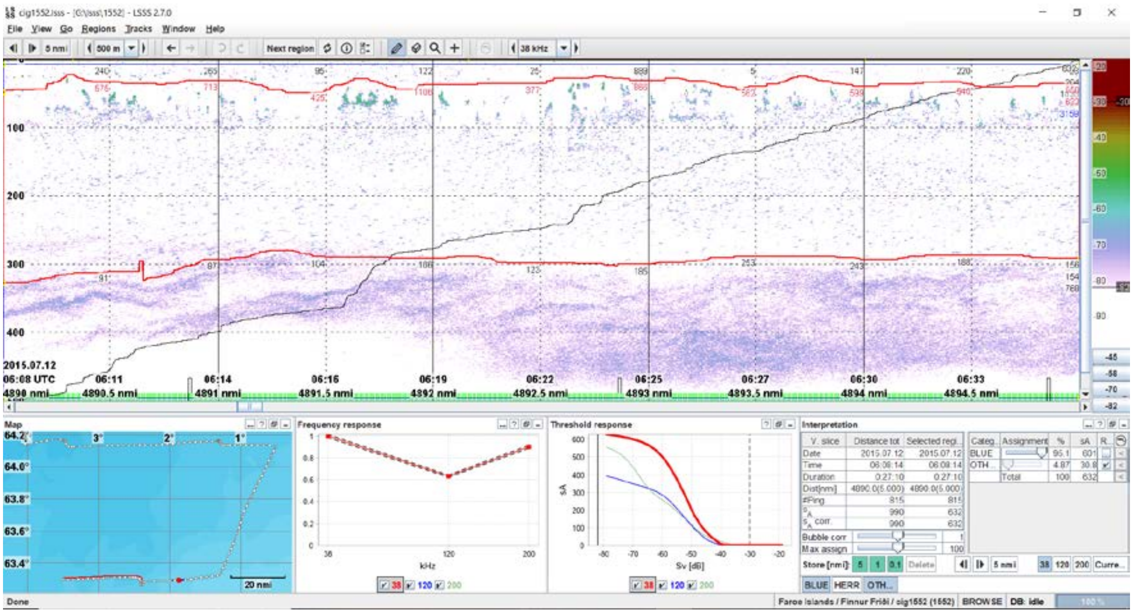

Figure 6b. Example in the central Norwegian Sea in IESSNS 2015 with herring and a lot of juvenile blue whiting (same echogram as in Figure 6b except different layer selected). Intermediate layer (50-300 m) activated with blue whiting s_A values shown as red numbers in the upper right corners of the active layer. Threshold was set to -72 dB.

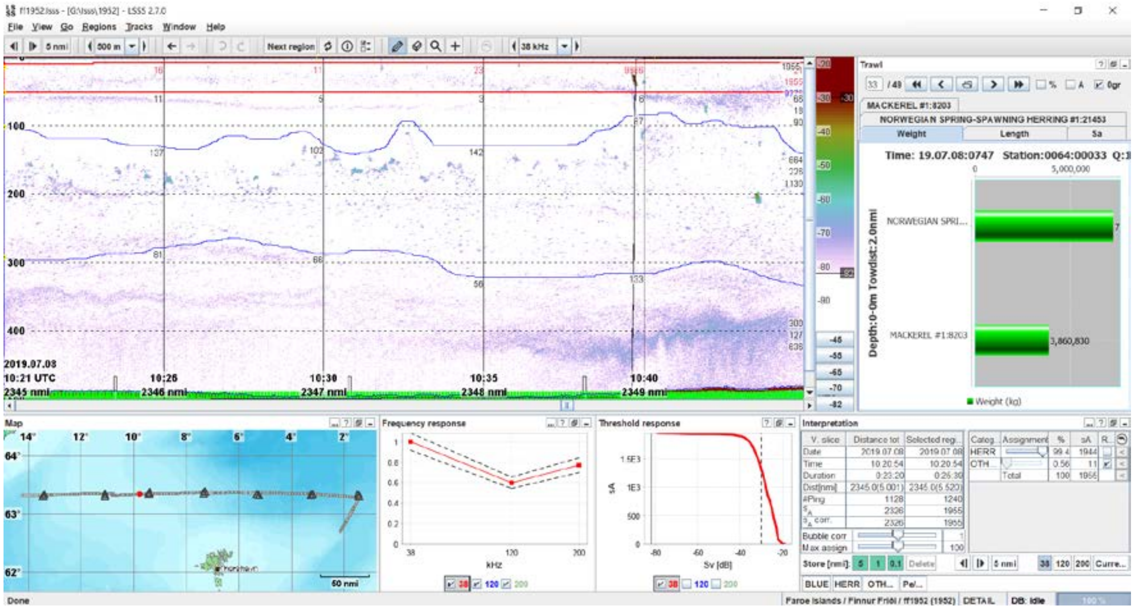

Figure 7. Example in the central Norwegian Sea in IESSNS 2019 with less blue whiting backscatter than in Figure 6. Surface layer (upper 50 m) activated where herring s_A values are shown as red numbers in the upper right corners of the active layer. Threshold was set to -72 dB.

The echograms east of Iceland (Figures 8a-c) follow the same general pattern as in the central Norwegian Sea with herring in the top layer and a blue whiting scattering layer below the herring layer.

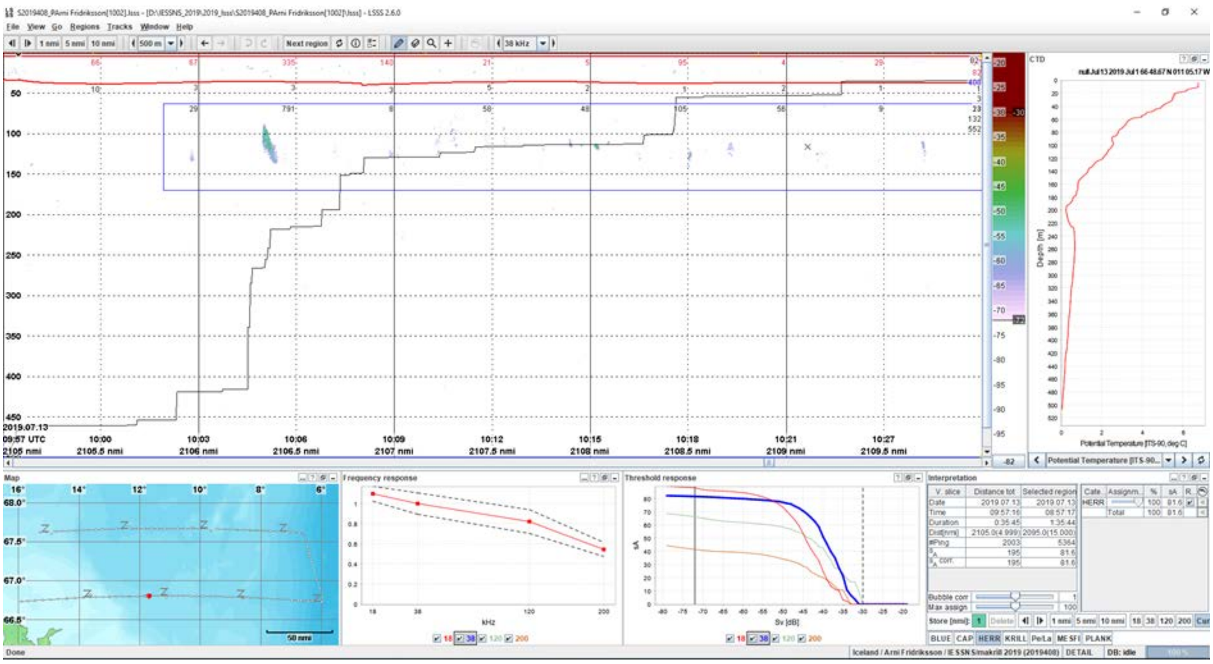

Figure 8a. Typical herring backscatter at 0 -50 m depth (layer between the red lines) offshore east of Iceland from IESSNS 2019. The echogram is displayed at 38 kHz, is 5 nmi long, shows depth from surface to 500 m depth, the lower threshold is at -72dB, and the geographical location is displayed as red dot on echogram map. Nearest temperature profiler (0-500m) also displayed along with frequency and threshold responses. The scrutinising results of herring using a threshold at -72dB are shown as red numbers in the active layer.

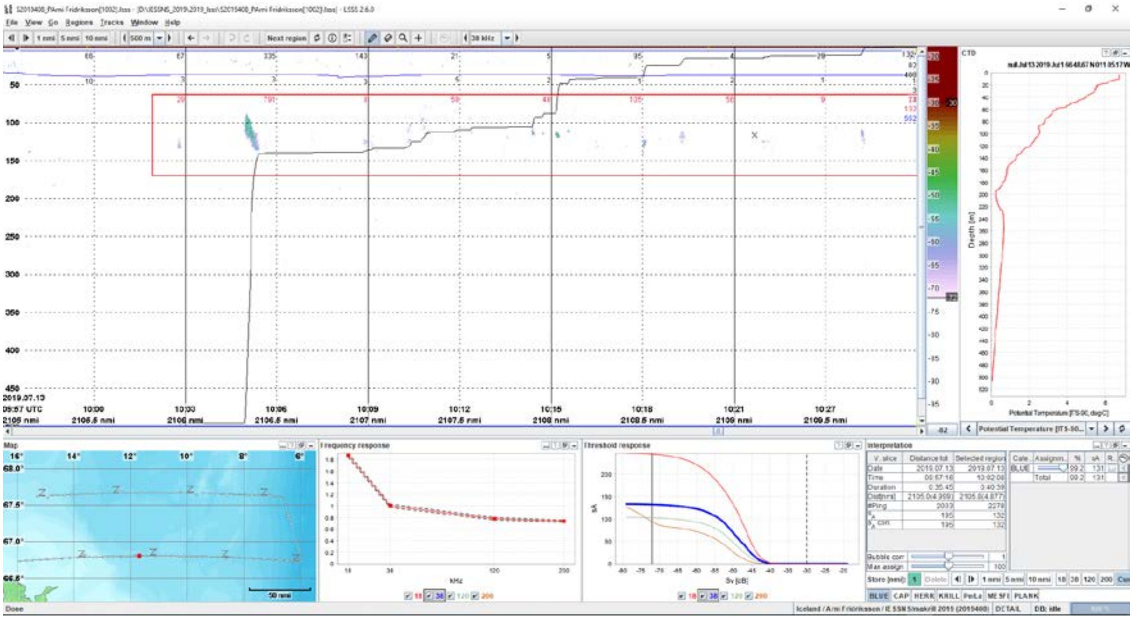

Figure 8c. Typical blue whiting backscatter at 50 -150 m depth (rectangle outlined by red lines) offshore east of Iceland from IESSNS 2019. The echogram is displayed at 38 kHz, is 5 nmi long, shows depth from surface to 500 m depth, the lower threshold is at -72dB, and the geographical location is displayed as red dot on echogram map. Nearest temperature profiler (0-500m) also displayed along with frequency and threshold responses. The scrutinising results of blue whiting using a threshold at -70dB are shown as red numbers in the active layer. This is the same echogram as in Figure 8a except different layer selected.

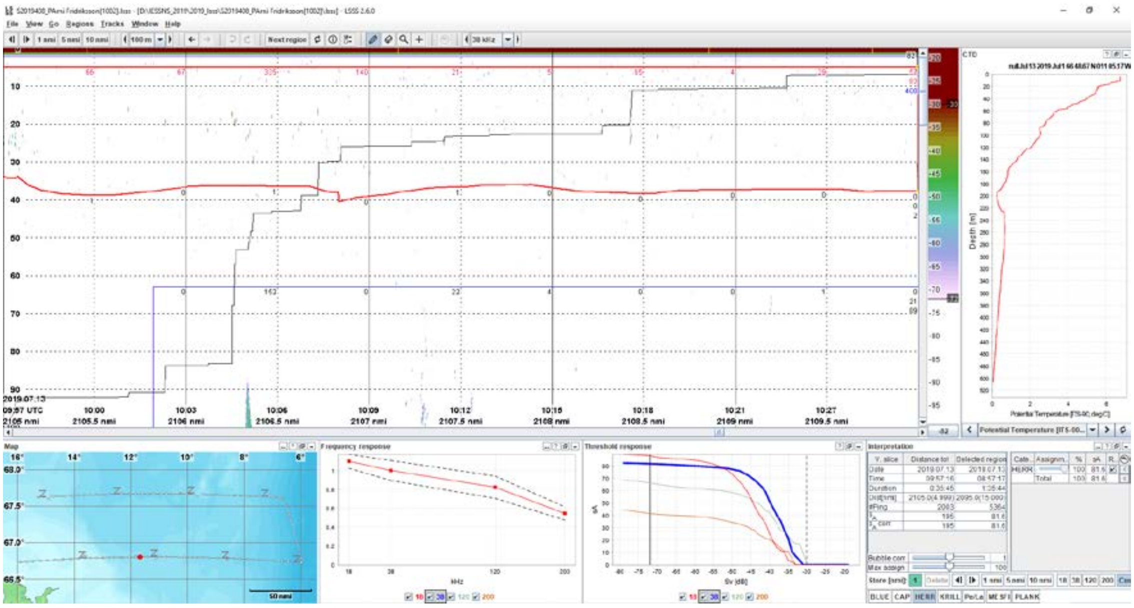

Figure 8b. Typical herring backscatter at 0 -50 m depth (between red lines) offshore east of Iceland from IESSNS 2019. Same echogram as in Figure 8a except it shows only 0 - 100 m vertical depth range. Now the small scattered herring schools can be seen.

A typical herring like backscatter in the surface layer during the IESSNS in the area north of Iceland (Figure 9a-c). Herring was caught at predetermined surface trawl stations and visible in the surface layer with some plankton present. Herring is indicated by jumps in integration line, threshold responses (herring will remain when lower threshold set between -55 or -65dB in the surface 50-100m) and frequency responses (expect herring to be ~1.5x stronger backscatter on 18kHz compared to 38kHz). High number of herring schools makes it laborious to identify individual schools, hence recommended to define a surface layer approximately 50m deep. Suggested scrutinising method for that layer is to set lower threshold usually within the range of -

55 to -65dB and assign that backscatter to herring. When selecting the "best" lower threshold lower and increase the dB until plankton like backscatter disappears but herring like signal remains intact.

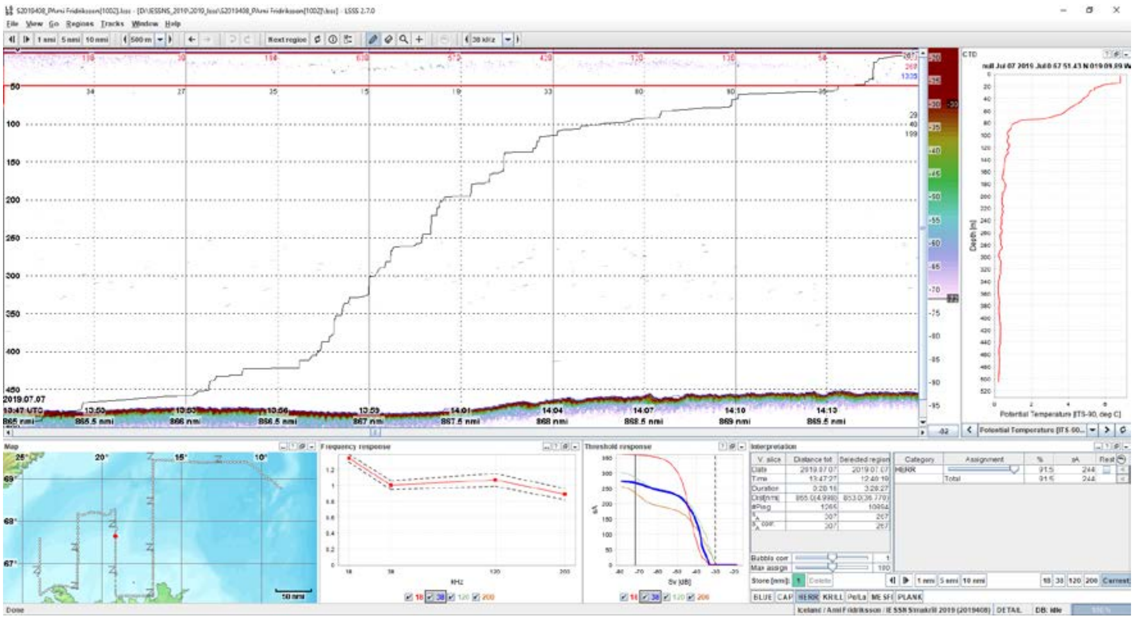

Figure 9a. Typical herring scatter in the Iceland Sea from IESSNS 2019. Herring like backscatter at 0 - 50 m which is identified as layer and all backscatter ≥-60 dB is allocated to herring (red numbers in the top layer). The echogram is displayed at 38 kHz, is 5 nmi long, shows depth from surface to 500 m depth, and lower threshold is at -72dB. Nearest temperature profiler (0-500m) also displayed along with frequency and threshold responses, geographical location of echogram (red dot on map), and the interpretation window in the lower right corner showing scrutinising results.

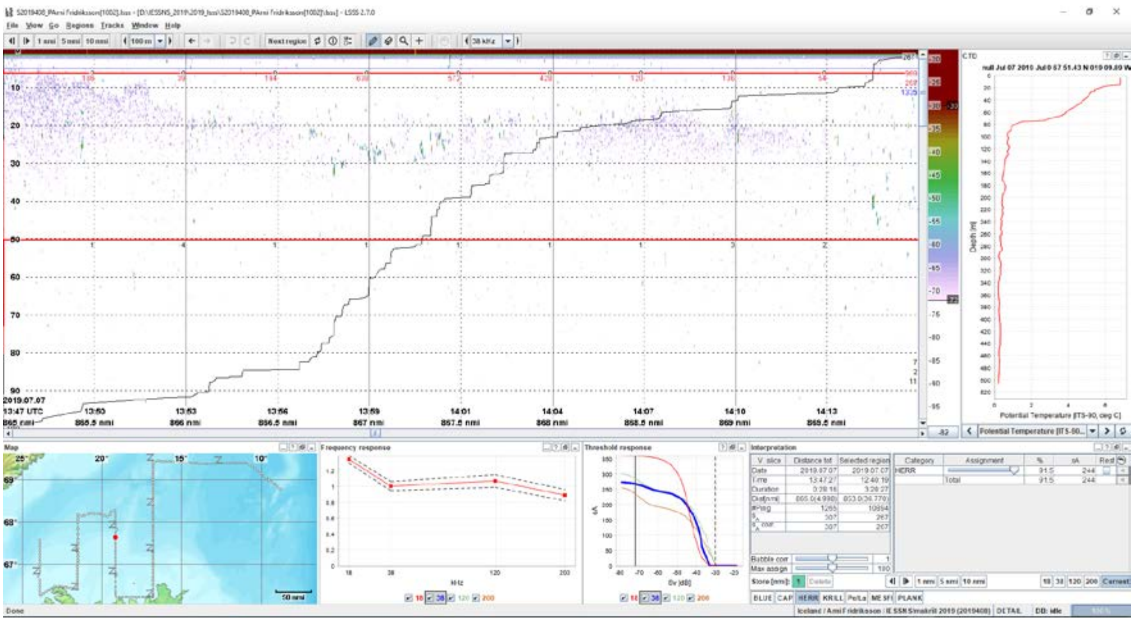

Figure 9b. Same echogram as in Figure 9a except vertical depth range is limited to 0 - 100 m.

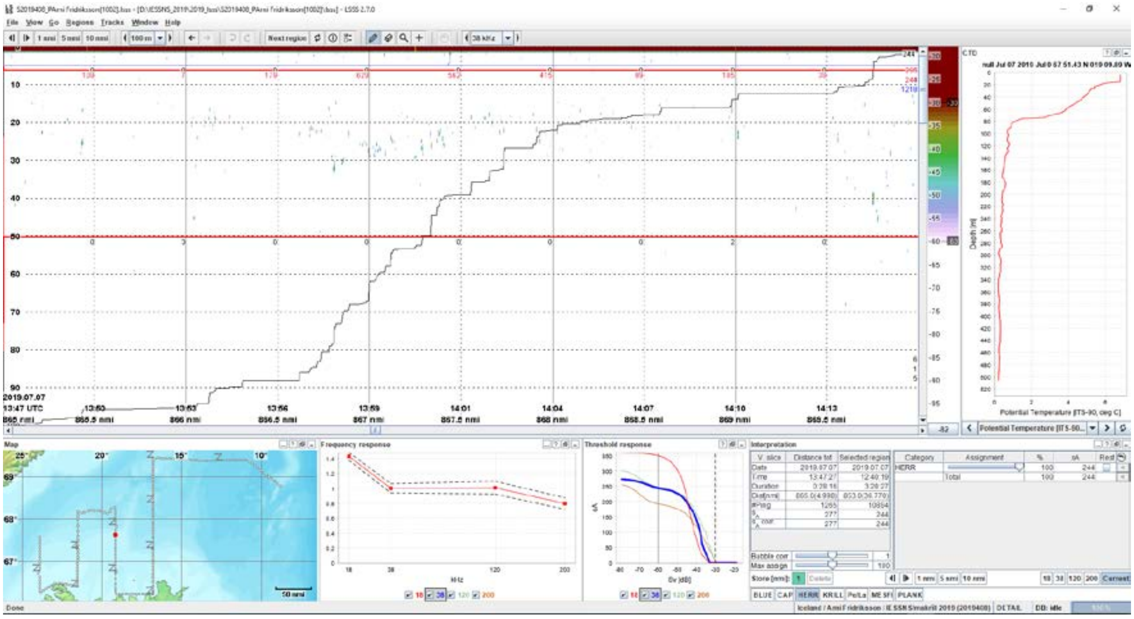

Figure 9c. Same echogram as in Figure 9b except the lower threshold is set to -60 dB which was the threshold used to identify herring is this example. Note there is no fixed lower threshold for herring in this area. Approximate lower thresholds range is from -55 to -65 dB.

When frequency of herring schools is low the school module can be used to identify individual herring schools (Figure 10a-b). To identify the herring schools the threshold response and jumps in the integration line can be used. For herring there is a clear jump in the integration line and the frequency response (red rectangle in Figure 10a). See typical "not-herring-like" backscatter (red rectangle in Figure 10b) with no clear jump in the integration line and the threshold responses do not show a sharp increase between Sv -30db to -40db which is flat.

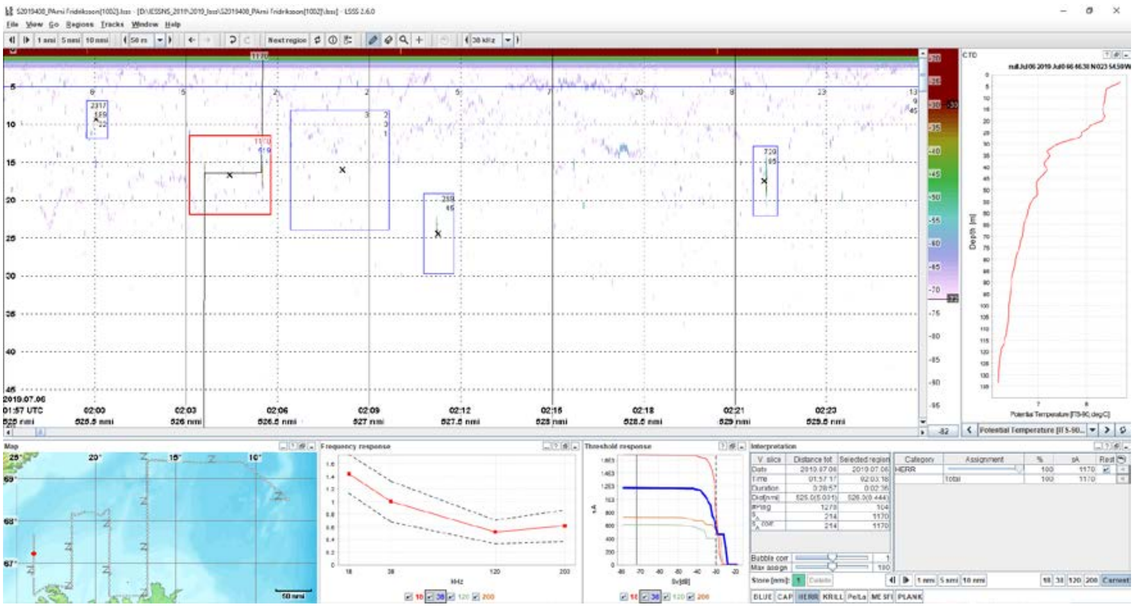

Figure 10a. Four herring schools (one red and three small blue rectangles) and "not-herring-like" backscatter (largest blue rectangle) in the Iceland Sea from IESSNS 2019. The echogram is displayed at 38 kHz, is 5 nmi long, shows depth from surface to 500 m depth, and lower threshold is at -72dB. Nearest temperature profiler (0-500m) also displayed along with

frequency and threshold responses, scrutinisation for the red rectangle, geographical location of echogram (red dot on map), and the interpretation window showing scrutinising results.

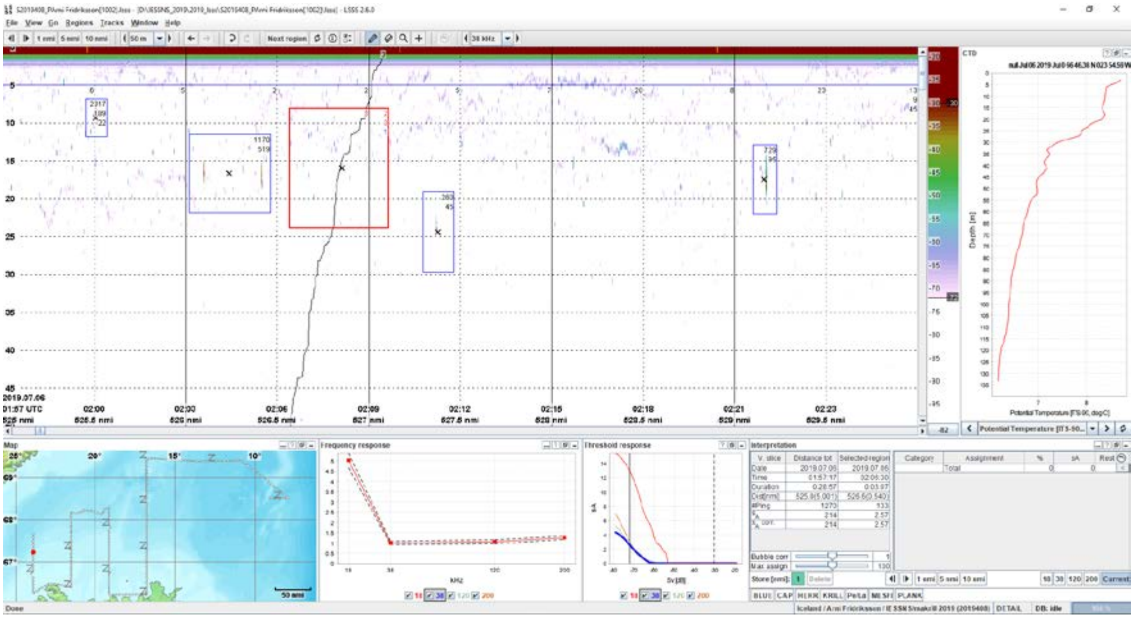

Figure 10b. Same echogram as displayed in Figure 10a except the school module is used to select backscatter that is not herring (red rectangle). The blue boxes are all considered herring backscatter. The rest was allocated to "other", i.e. not herring/blue whiting.

In the Iceland basin a strong backscattering layer is occasionally recorded at around 40-70 m depth. An example from IESSNS in 2019 in the basin south of Iceland (Figure 11) shows an echogram with a scattering layer at 50 m depth and a deeper scattering layer below 300 m depth. Two tows were performed targeting the upper layer. No fish were caught but small squids (5-10 cm) were caught at most stations in the Iceland Basin including the two trawls targeting this layer. It is likely that small squid is part of this scattering layer mixed with plankton.

Further east towards the Faroe Islands and south of the Faroe Islands, this upper layer (from 50-150 m) often contains pearlside mixed with plankton (see e.g. Figure 16).

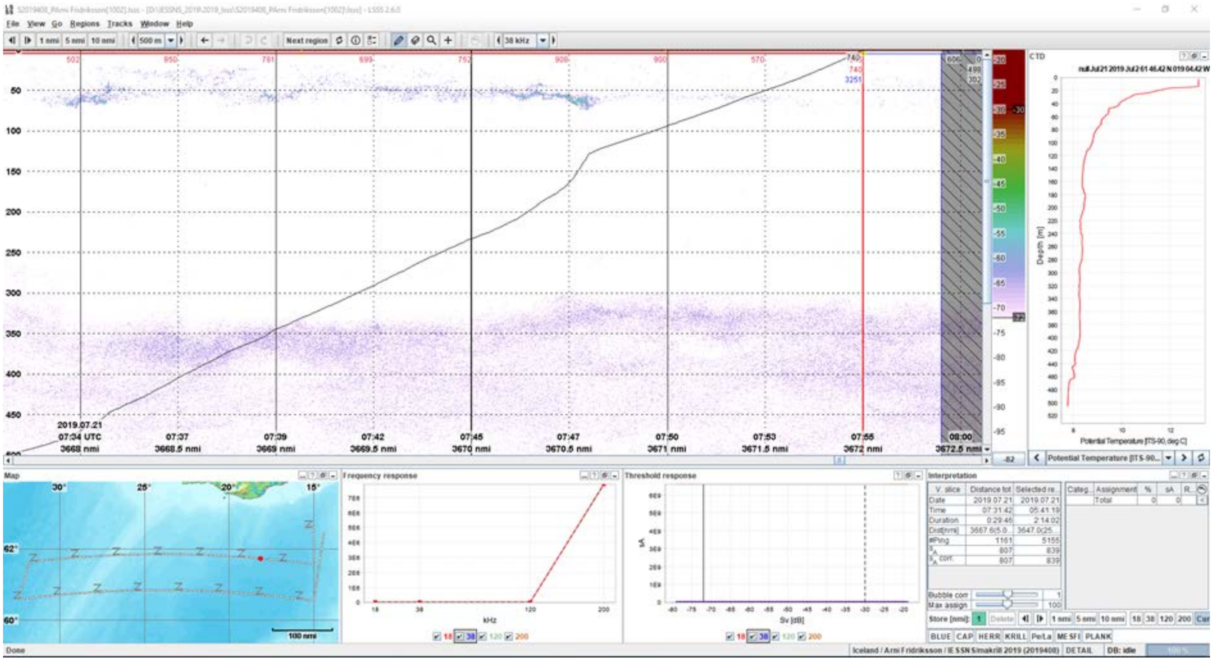

Figure 11. Strong plankton backscatter and potential backscatter from squid at approximate 40-70 m in the basin south of Iceland from IESSNS 2019. The echogram is displayed at 38 kHz, is 5 nmi long, shows depth from surface to 500 m depth, the lower threshold is -72dB, and the geographical location is displayed as red dot on echogram map. Nearest temperature profiler (0-500m) also displayed. Two tows were preformed targeting the upper layer and only small squids (5-10 cm) were caught.

3.3 Shelf areas

Blue whiting is usually distributed along the continental shelve edge (usually deeper than 250 m) in the whole Northeast Atlantic, from Portugal in the south, northwards along the coasts north to Northern Norway and westwards around Faroes, south of Iceland, Reykjanes Ridge and into the shelves west towards Greenland. The blue whiting distribution often extends further off the shelf at around 350 m depth into the ocean.

The blue whiting scattering layer can also be located close to or at the bottom in slope areas with bottom depth ranging from 250-350 m. In some situations it can be difficult to distinguish blue whiting back scatter from other species associated with shelve edges. Typical situations encountered on shelf edges and in shelf areas are presented in the following examples.

Along the south coast of Iceland and over the Reykjanes ridge, blue whiting is usually distributed over the shelf edge and sometimes over the ridge. In this location, blue whiting is typically distributed in scattered layers or in distinct schools located at 200 m to 400 m depth. Within these layers/schools single targets can be visible (Figure 12a-b).

At the shelf edge, the blue whiting layer sometimes forms a relative narrow continuous layer located close to the bottom (Figure 12c) or a relatively wide layer of single fish targets (Figure 12d) extending from the shelf into open waters and far off the bottom. In the present cases (Figure 12c and 12d) all backscatter were allocated to BW at -72dB threshold.

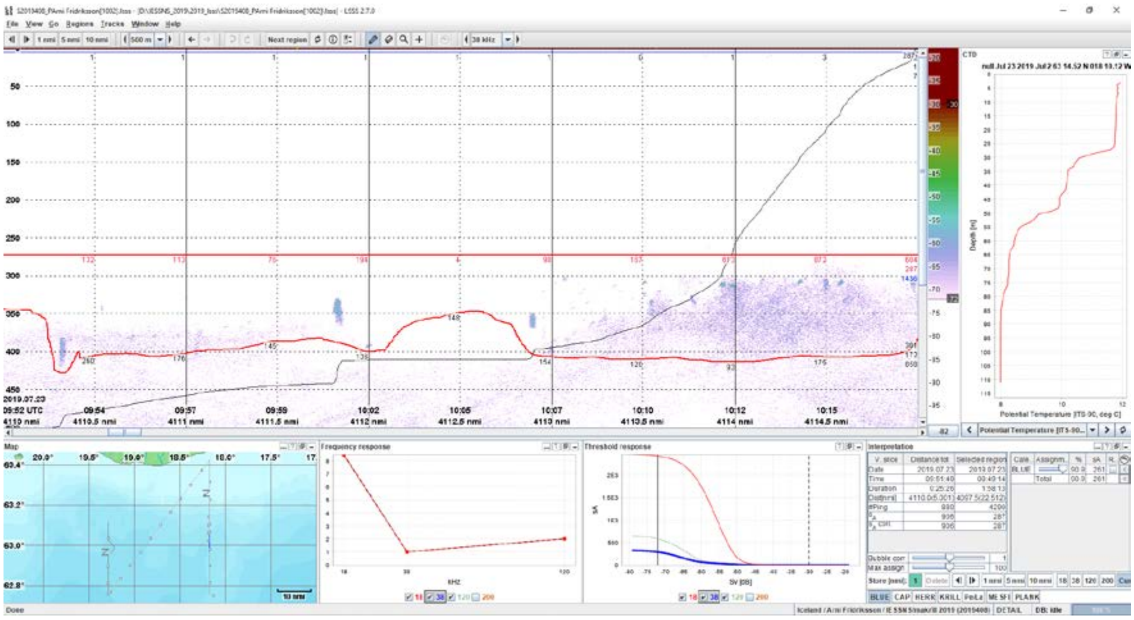

Figure 12a. Blue whiting schools backscatter at approximately 270 – 400 m depth (layer between red lines) few miles south of the shelf edge south of Iceland from IESSNS 2019. The echogram is displayed at 38 kHz, is 5 nmi long, shows depth from surface to 500 m depth, the lower threshold is at -72dB, and the geographical location is displayed as red dot on echogram map in Figure 12b. Nearest temperature profiler (0-110m) also displayed along with frequency and threshold responses. The final s_A values of blue whiting in the active layer were obtain with a higher threshold of -70 dB, as shown in the next figure (Figure 12b).

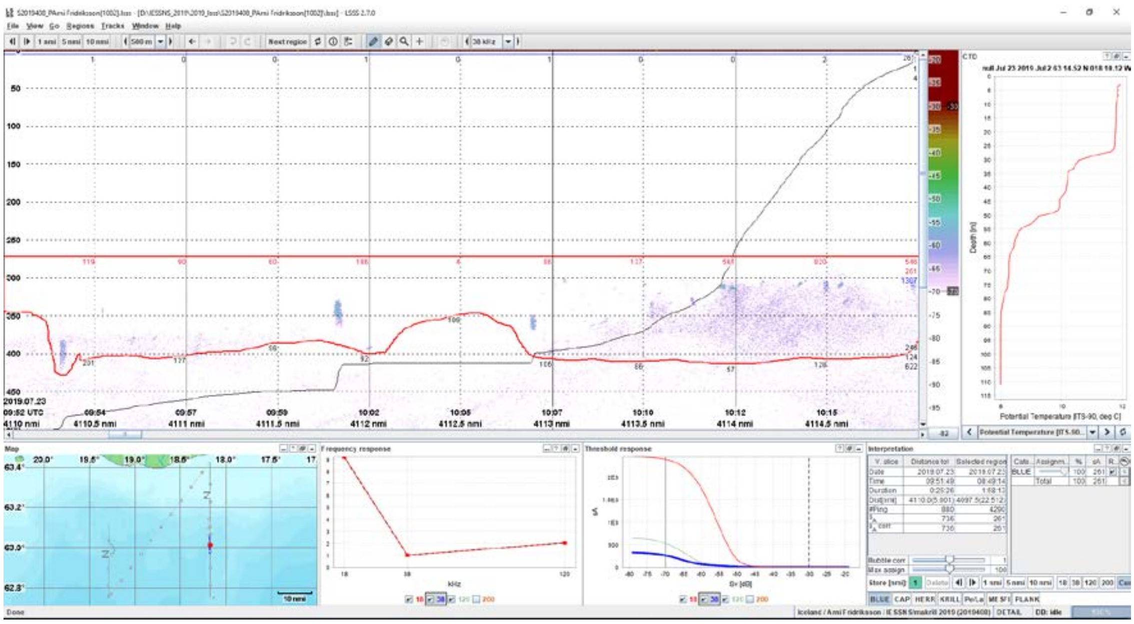

Figure 12b. Blue whiting schools backscatter at approximately 270 – 400 m depth (layer between red lines) on the shelf edge south of Iceland from IESSNS 2019. Same echogram as in Figure 12a except lower threshold set at -70dB to reduce plankton scatter. The scrutinising results using s_A values (shown as red numbers in the active layer) were assigned to blue whiting using a threshold set at -70 bB.

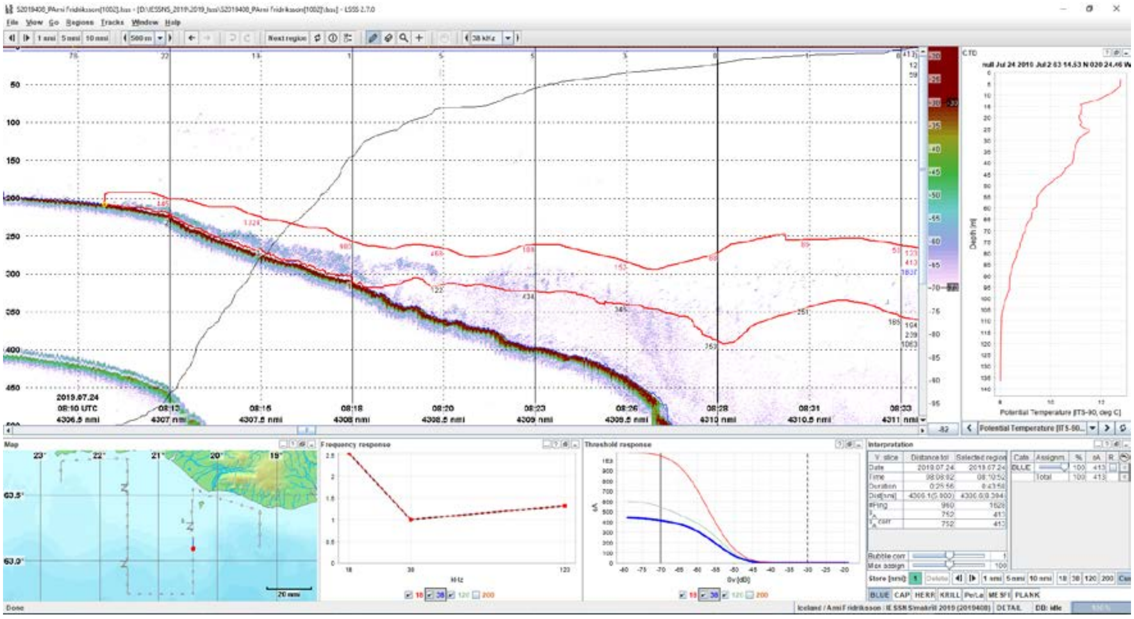

Figure 12c. Blue whiting backscatter layer on the shelf and individual targets further offshore at approximately 250 - 400 m depth (layer between red lines) on the shelf edge south of Iceland from IESSNS 2019. The echogram is displayed at 38 kHz, is 5 nmi long, shows depth from surface to 500 m depth, the lower threshold is at -72dB, and the geographical location is displayed as red dot on echogram map. Nearest temperature profiler (0-135m) also displayed along with frequency and threshold responses, and scrutinising results shown as red numbers in the active layer using a lower threshold of -72 dB.

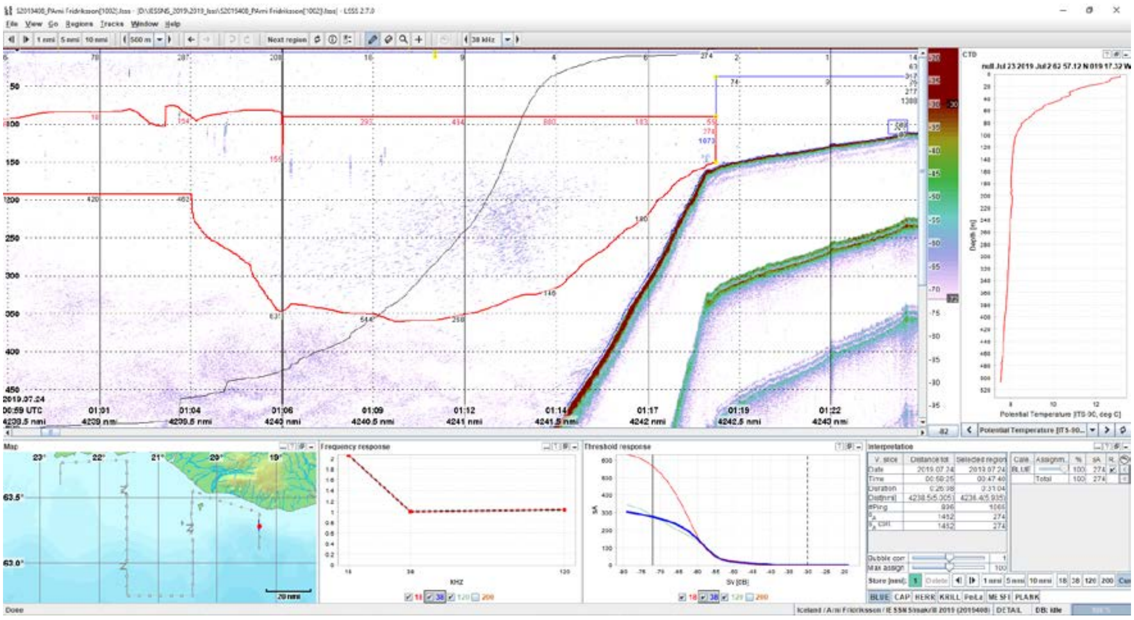

Figure 12d. Blue whiting scattering layer and small schools at approximately 100 - 350 m depth (layer between red lines) on the shelf edge south of Iceland from IESSNS 2019. The echogram is displayed at 38 kHz, is 5 nmi long, shows depth from surface to 500 m depth, the lower threshold is at -72dB, and the geographical location is displayed as red dot on echogram map. Nearest temperature profiler (0-500m) also displayed along with frequency and threshold responses, and scrutinising results shown as red numbers in the active layer using a lower threshold of -72 dB.

4 Separating herring from plankton (200 kHz method)

Sometimes during spring and summer a dense layer of phytoplankton in the upper 50 m (occasionally deeper) is observed acoustically in the Norwegian Sea and adjacent areas. The echo from this layer can be strong on 38 kHz (even with hard thresholding like -55 dB and above) and this makes it problematic to use the standard 'threshold method', method i) below, on 38 kHz to separate herring backscatter and phytoplankton backscatter.

Two methods are possible to separate herring from phytoplankton:

i) use 38kHz, set lower threshold to ~-55 to -60dB or until the plankton backscatter disappears and use the school module to individually identify each herring backscatter see 10a-b. This method does not always work as the plankton backscatter can be as strong as scatter from herring or frequency of herring schools is too high for manual single school scrutinising;

ii) use 200kHz, set lower threshold to -50 or 55dB which should eliminate the plankton but not the herring, then take the average s_A at 200kHz and multiply with a factor ranging between 2-4 and manually put that as the s_A value at 38kHz (Figure 13a-b). Selecting a multiplication factor is the tricky part. The factor has to be estimated from case to case, e.g. in the example below the estimated factor was 4, see example below.

An example with herring mixed with plankton in the surface layer (0 - 50m) is shown in Figure 13a-b. This is from the IESSNS 2018 located on the Icelandic shelf. Herring present in catches from surface trawl stations, jumps in the echogram integration line, and previous experience suggest that there is a herring signal within the plankton layer in the upper 50 m in this case.

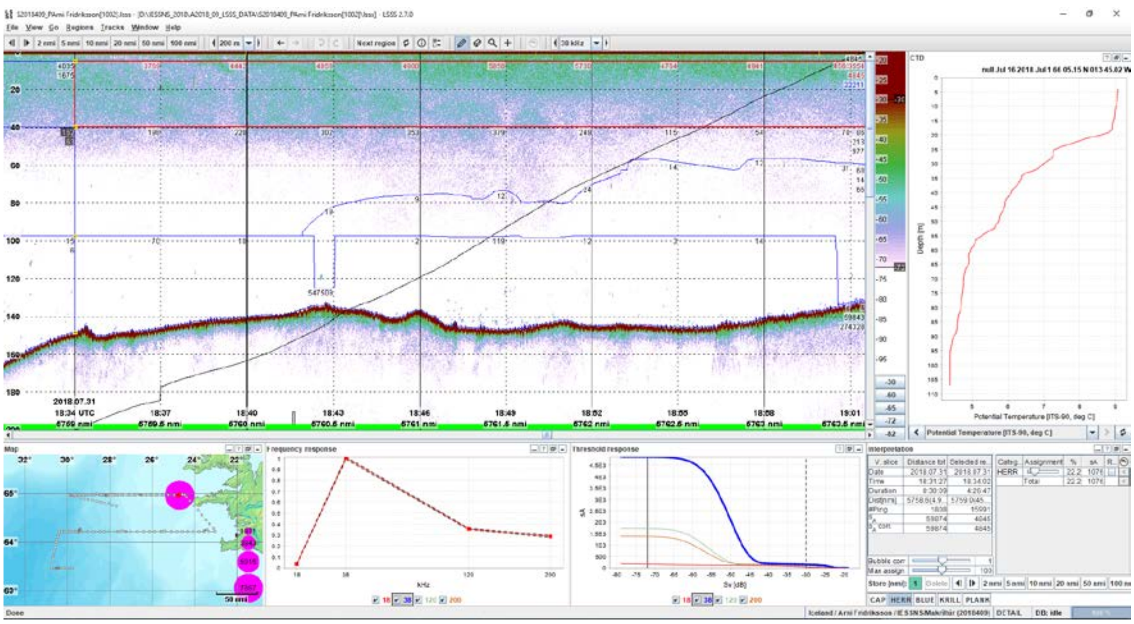

Figure 13a. Strong plankton backscatter in the surface 50 m masking some herring scatter (jump in integration line for the red rectangle. Echogram located on the shelf west of Iceland from IESSNS 2018. The echogram is displayed at 38 kHz, is 5 nmi long, shows depth from surface to 200 m depth, the lower threshold is at -72dB, the bottom is visible at approximately 140 m depth, and the geographical location is displayed as pink dot on echogram map. Nearest temperature profiler (0-105m) also displayed along with frequency and threshold responses. The scrutinising results using the 200 kHz method (Figure 13b) was used (see description of method in the text for explanation).

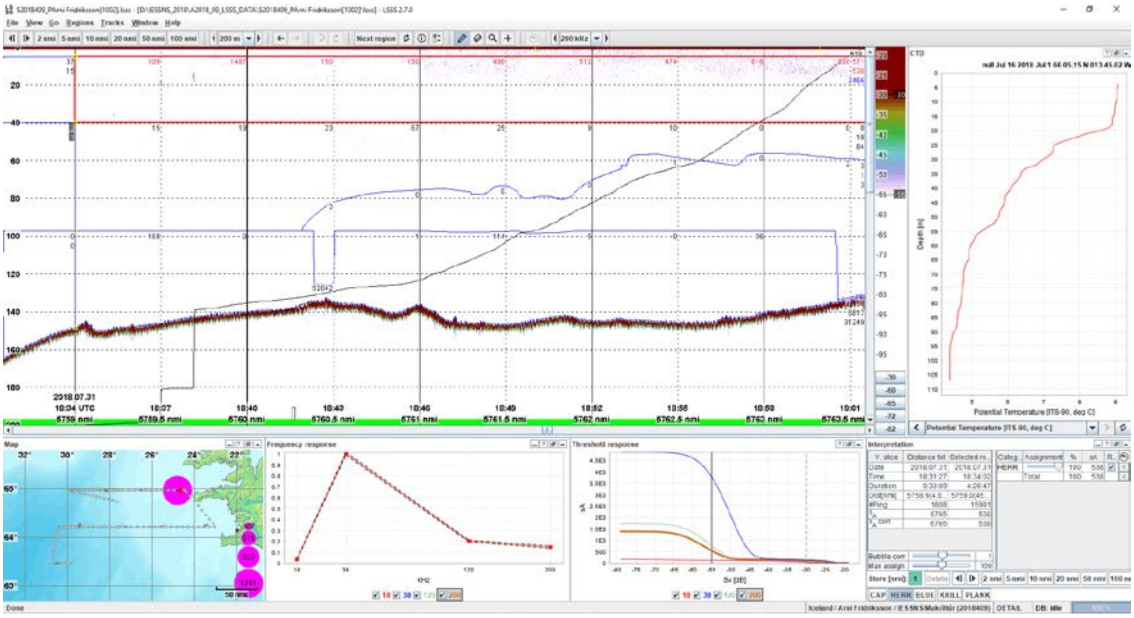

Figure 13b. Same echogram as in Figure 13a except the frequency is 200 kHz and the lower threshold is set to -55 dB. To estimate herring s_A values for the red rectangle, the s_A values at 200 kHz using lower threshold of -55dB was used as basis to be compared with the value from the 38 kHz (see text for further explanation).

The herring schools can normally be identified when applying a high threshold of approximately -55 dB (i). One used method is to make school boxes around each school, but this can however be quite laborious with many small schools. In many cases the echo from the phytoplankton disappears and the fish remains on 200 kHz when applying a high threshold of approximately -55 dB (ii). By multiplying the remaining s_A value on 200 kHz by a factor (higher than 1), the s_A value on 38 kHz can be estimated. This factor must be estimated from case to case by boxing a school, threshold to around -55 and calculating the ratio between s_A on 200 kHz and 38 kHz. Doing this on several schools from the data in the example below an appropriate factor for this case seemed to be around 4.

Another example is shown in Figure 14a-c, showing the upper 100 m of a standard 5 nautical mile echogram recorded during IESSNS 2019, about 50 nmi north of Tromsø. Some herring schools in the dense plankton layer can be seen as red marks on 38 kHz at a dB threshold of -82 (Figure 14a). When the dB threshold is changed to -53 the schools are easier to detect visually but parts of the plankton layer remains (Figure 14b). Using the same dB threshold on 200 kHz the plankton layer seems to disappear and the herring schools remain (Figure 14c). A suggested s_A value to allocate to herring (on 38 kHz) in this case is 268 (67 x 4).

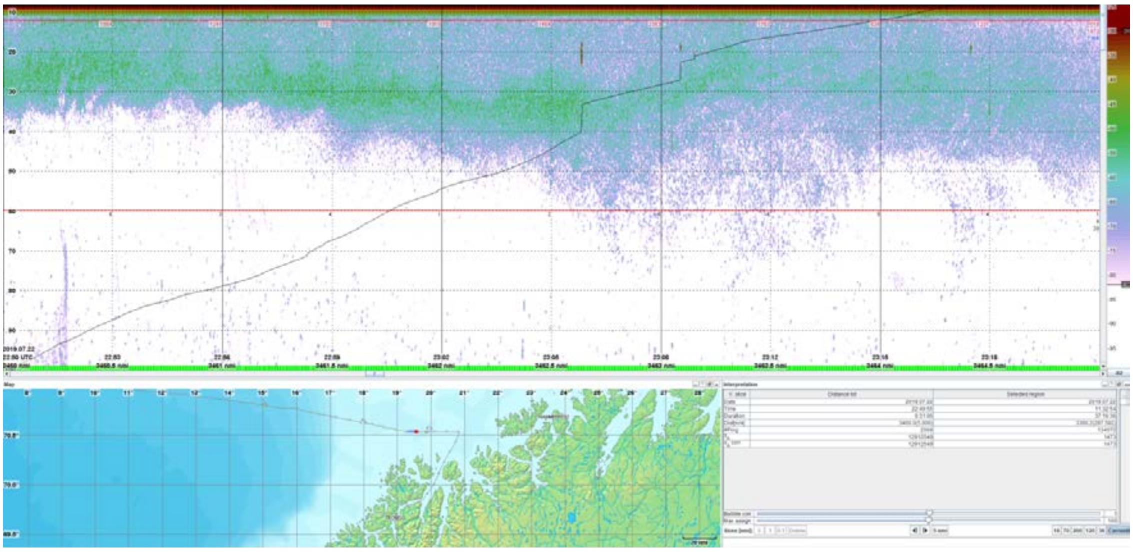

Figure 14a. Echogram in LSSS on 38 kHz where the top layer is activated and the dB threshold is set to -82.

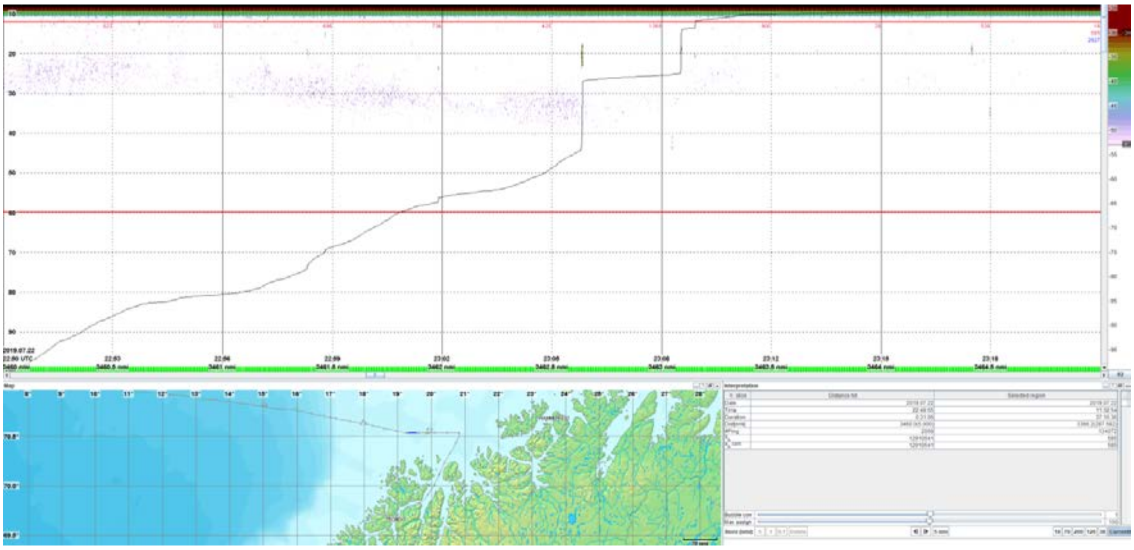

Figure 14b. Echogram in LSSS on 38 kHz where the top layer is activated and the dB threshold is set to -53.

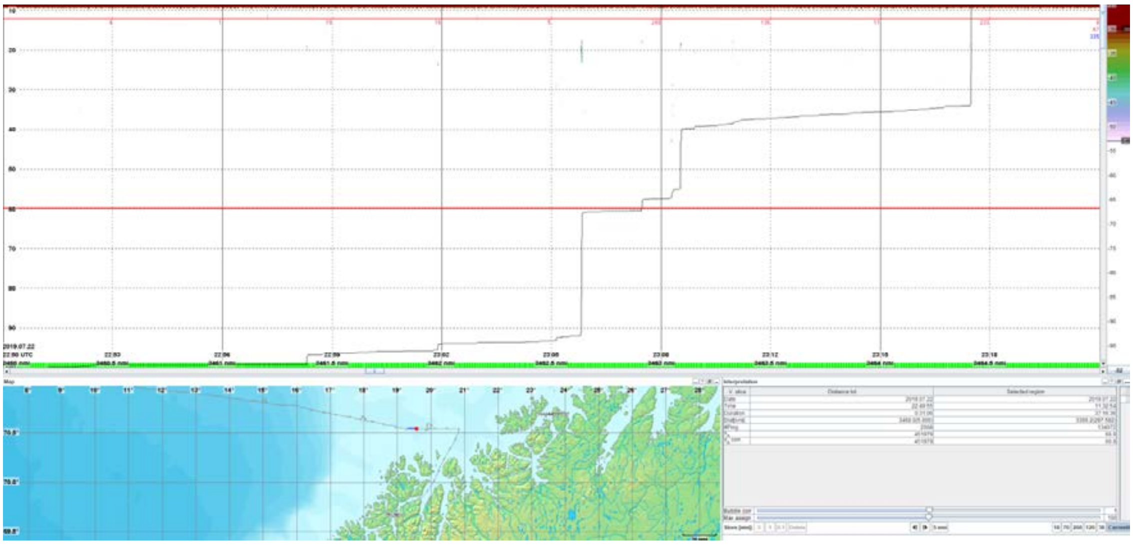

Figure 14c. Echogram in LSSS on 200 kHz where the top layer is activated and the dB threshold is set to -53. The remaining S_A value is 66.9.

5 Problems when strong year-classes of blue whiting occur in the survey area

Sometimes dense aggregations of 0-group blue whiting are encountered in the area south of 62°N, i.e. south of the Faroes and around the Shetland Islands. These dense aggregations resemble herring backscattering. Therefore trawl stations are important to groundtruth the echograms. Two such examples are illustrated in Figures 15 and 16. In Figure 15, the 0-group blue whiting scattering was in the surface layer (top 100 m). In Figure 16, the echogram presumably describes a mixture of blue whiting and pearlsides; no trawl information was available immediately around the echograms in Figure 16 – but both 30 nmi earlier and later on the same transect 0-group blue whiting and pearlsides were caught.

Figures 6 and 15 illustrate examples where dense schools of 0-group or juvenile blue whiting resemble the characteristics of herring schools. The dense aggregations of 0-group blue whiting have hitherto only been encountered in the southernmost part of the survey area (i.e. south of 62°N). Juvenile blue whiting is generally distributed over wide areas in the Nordic Seas (e.g. Figure 6) and when recruitment is good the scientists need to be alert regarding the resembling features of juvenile blue whiting and herring schools, even in open waters in the central Norwegian Sea.

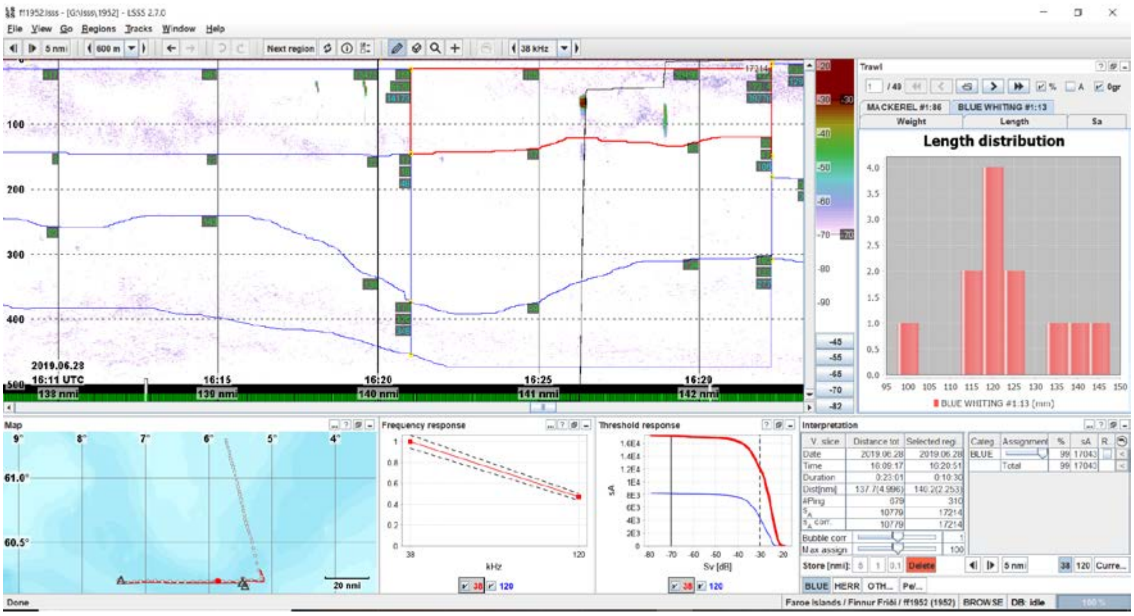

Figure 15. Echogram south of the Faroes from IESSNS 2019. The dense aggregations are 0-group blue whiting backscattering. Length distribution of blue whiting from the trawl station (triangles) are shown in a histogram to the right. The jump in the integration line resembles echograms of herring schools.

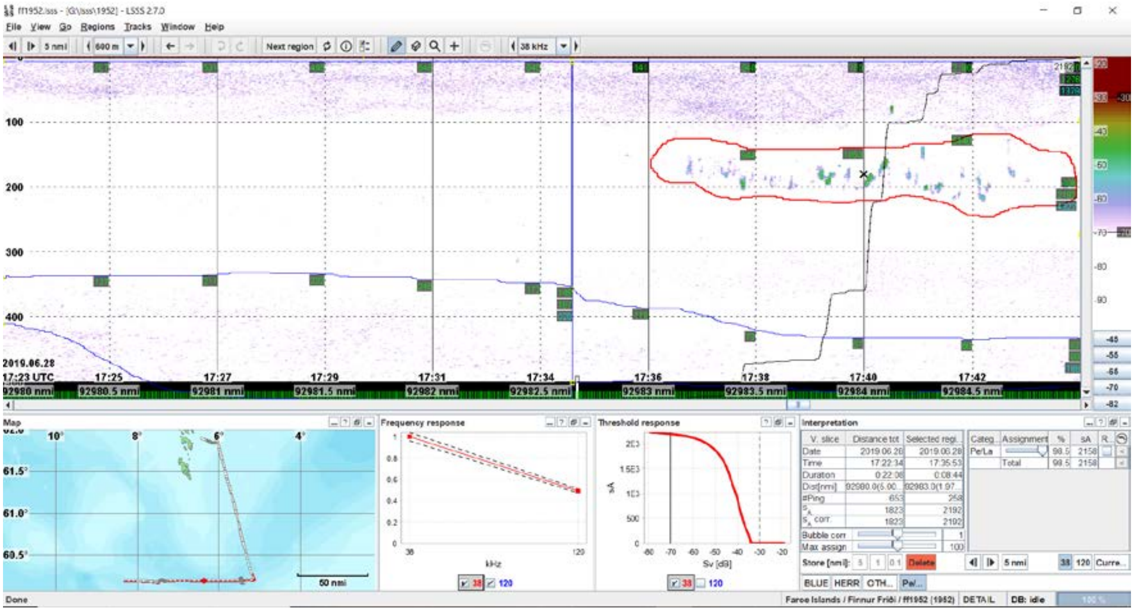

Figure 16. . Echogram south of the Faroes from IESSNS 2019. NB! The backscattering is most likely a mixture of pearlsides and 0-group blue whiting.

6 Conclusions from discussions at the workshop

It was noted that participants were storing the acoustic data at four different thresholds levels (-70, -72, -82 and -85 dB), although not important with respect to the target species. This difference is related to traditions at the different institutes and applies to all their acoustic surveys. The group recommends that all participants store the data at maximum -72 dB and preferably at -82 dB, but is aware of possible problems for some vessels with noise at that low level.

It is recommended that participants bring the acoustic data from the surveys to the post-cruise meetings and spend some hours in the beginning going through potential problems regarding the scrutinising.

7 Recommendations on scrutinising approach for IESSNS

Recommendations for survey leaders of IESSNS surveys

Threshold: The group recommends that all participants store the data at maximum -72 dB and preferably at -82 dB.

Ground truthing: always trawl when in doubt (= trawl as much as possible). It is important to trawl (identify) all observed acoustic layers/scatters in the area at the beginning of the survey, to ensure consistent and good quality scrutinising during the survey.

Quality checks should be done during the survey on the analysis of the acoustic data, e.g. plot acoustic recording by species, check for extreme and missing values.

Recommendations to WGIPS (WGFAST)

Investigate whether there is any difference in the probability of acoustic detection of shallow schools with a survey speed of e.g. 10 vs. 12 knots – does a higher survey speed result in less detection probability?

The group recommends that WGIPS update the description of scrutinising procedures for the IESSNS in the Series of ICES Survey Protocols (SISP) manual, to reflect the methods described in the present report.

8 References

ICES. 2015. Manual for International Pelagic Surveys (IPS). Series of ICES Survey Protocols SISP 9 – IPS. 92 pp.http://www.ices.dk/sites/pub/Publication%20Reports/ICES%20Survey%20Protocols%20(SISP)/SISP%209%20Manual%20for%20International%20Pelagic%20Surveys%20(IPS).pdf

Annex 1: List of participants

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Annex 2: Resolutions

WKSCRUT2 – Workshop on scrutinizing of acoustic data from the IESSNS survey

2018/2/EOSG12 The **Workshop on scrutinizing of acoustic data from the IESSNS survey** (WKSCRUT2), chaired by Jan Arge Jacobsen, Faroes, and Age Høines, Norway, will meet in Bergen, Norway, September 17 to 18 2019 to:

a) Evaluate and report on the procedures used to scrutinise acoustic data by the different nations contributing to the International ecosystem survey in the Nordic Seas (IESSNS)
b) Describe and adopt common scrutinizing procedures for the International ecosystem survey in the Nordic Seas (IESSNS)
c) Update the description of scrutinizing procedures for the International ecosystem survey in the Nordic Seas (IESSNS) in the Series of ICES Survey Protocols (SISP) manual.

WKSCRUT2 will report by 31st October 2019 for the attention of ACOM, SCICOM.

Supporting information

Priority	A workshop on scrutinising of acoustic data from the IESSNS survey is highly recommended by the WGIPS. Scrutinisation procedures may differ slightly between coordinated surveys, however, it is very important that all scientists responsible for the scrutinisation are following the same general procedure. The workshop should preferably take place prior to the survey in 2019. Uncertainty regarding the scrutinising procedure, i.e. categorization and allocation into species or species groups, emphasizes the need for a workshop which involves scientists responsible for the scrutinizing in the survey (e.g. from Iceland, Norway, Faroes, Greenland and EU).
Scientific justification	Scrutinisation procedures, including using biological samples and allocation of species to echotraces need to be scientifically reviewed periodically for all acoustic surveys and a set of technical procedures agreed for eash survey. This is particularly important in the internationally coordinated surveys. The Manual for International Pelagic Surveys (SISP 9) needs updating with the results of this workshop.
Resource requirements	The research programmes which provide the main input to this Workshop are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this Workshop is negligible.
Participants	It is expected that this Workshop will be attended by 4-5 members of WGIPS; in particular, participants of the IESSNS survey.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to advisory committees	WGWIDE
Linkages to other committees or groups	There is a close working relationship to WGWIDE, and linkages with WGIPS and PGDATA.
Linkages to other organizations	There are no obvious direct linkages to outside organisations.