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Report of the Workshop on scrutinisation procedures for pelagic ecosystem surveys (WKSCRUT)

7–11 September 2015

Hamburg, Germany

ICES CIEM
International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

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Executive Summary

The Workshop on scrutinisation procedures for pelagic ecosystem surveys (WKSCRUT), chaired by Matthias Schaber, Germany, met at the Thünen-Institute of Sea Fisheries, Hamburg, from 7–11 September 2015. The overall aims of the workshop were a) to compare, evaluate and harmonize echogram scrutinisation and post-processing procedures currently applied by different participants of pelagic surveys coordinated by the ICES Working Group of International Pelagic Surveys (WGIPS); b) to document recommended methods to be followed by survey participants to produce acoustic density values by species and sampling units from raw acoustic energy data, and implement data requirements needed for a move to a new database for the storage of disaggregated survey data; c) update the WGIPS survey manual with the recommended methods.

Under the auspices of WGIPS, several internationally coordinated pelagic ecosystem surveys are conducted annually, namely the North Sea, West of Scotland and Malin Shelf summer herring acoustic survey (HERAS), the International blue whiting spawning stock survey (IBWSS), the International Ecosystem survey in the Nordic Sea (IESNS) and the Coordinated Nordic Seas Ecosystem Survey (IESSNS).

Based on the aims specified above, the working group in 2014 recommended that a corresponding workshop on scrutinisation procedures be held in 2015.

During the workshop, example datasets based on acoustic raw data collected during HERAS (GER, NL, IRL, SCO), IBWSS (NL) and IESNS (NOR) surveys were scrutinised and post-processed by the participants. The example datasets were provided after a data call scheduled prior to the meeting and were classified into "typical" and "challenging" situations encountered during the corresponding surveys. Additional trawl catch data had been made available to specifically allocate species aggregations and echotraces.

The scrutinisation exercises revealed that even across surveys and with post-processors unfamiliar with individual surveys, there was a very high degree of consensus on how to identify and categorize echotraces from acoustic raw data. This was also observed across software platforms utilized for post-processing.

Causes for variance and deviation in results in most cases could be identified and discussed and were further specified and addressed in resulting recommendations.

A planned comparison of then harmonized scrutinisation procedures applied to a larger dataset more typical for actual survey datasets could not be conducted due to time constraints but is intended to be repeated at a later stage.

1 Introduction

1.1 Terms of Reference 2015

The Workshop on scrutinisation procedures for pelagic ecosystem surveys (WKSCRUT), chaired by Matthias Schaber, Germany, will be established for a single meeting and will meet in Hamburg, Germany, 7–11 September 2015 to:

a) Compare, evaluate and harmonize echogram scrutinisation and post-processing procedures currently applied by different participants of pelagic surveys coordinated by WGIPS;

b) Document recommended methods to be followed by survey participants to produce acoustic density values by species and sampling units from raw acoustic energy data, and implement data requirements needed for a move to a new database for the storage of disaggregated survey data.

c) Update the WGIPS survey manual with the recommended methods.

WKSCRUT will report by 1 December 2015 (via SSGIEOM) for the attention SCICOM, ACOM, WGISDAA, WGFAST, WGIPS and HAWG.

1.2 Participants

Name	Country
Matthias Schaber (Chair)	Germany
Åge Høines	Norway
Are Salthaug	Norway
Aril Slotte	Norway
Ben Scoulding	Netherlands
Bram Couperus	Netherlands
Cormac Nolan	Ireland
Karl-Johan Stæhr	Denmark
Michael O'Malley	Scotland
Pablo Carrera	Spain
Phillip Copland	Scotland
Sascha Fässler	Netherlands
Sven Gastauer	Australia

A full address list for the participants is provided in Annex 1.

2 HERAS International survey program

2.1 Background

International acoustic surveys in the North Sea, West of Scotland and Malin Shelf are collectively known as the HERAS survey program. Surveys are carried out annually in June/July to determine the distribution and abundance of herring and sprat in the North Sea region (HERAS) and to the west of Ireland and Scotland (Malin Shelf Herring Acoustic Survey- MSHAS; Figure 2.1.1). Acoustic estimates are used as a tuning index by ICES to estimate the size of the populations of herring and sprat and the results are submitted annually to HAWG. Synoptic surveys are carried out by vessels from Denmark, Germany, Netherlands, Ireland, Norway and Scotland. Coordination and planning of the surveys are reported through WGIPS in January each year.

Further details on the survey including the time-series are available in the latest WGIPS report (WGIPS).

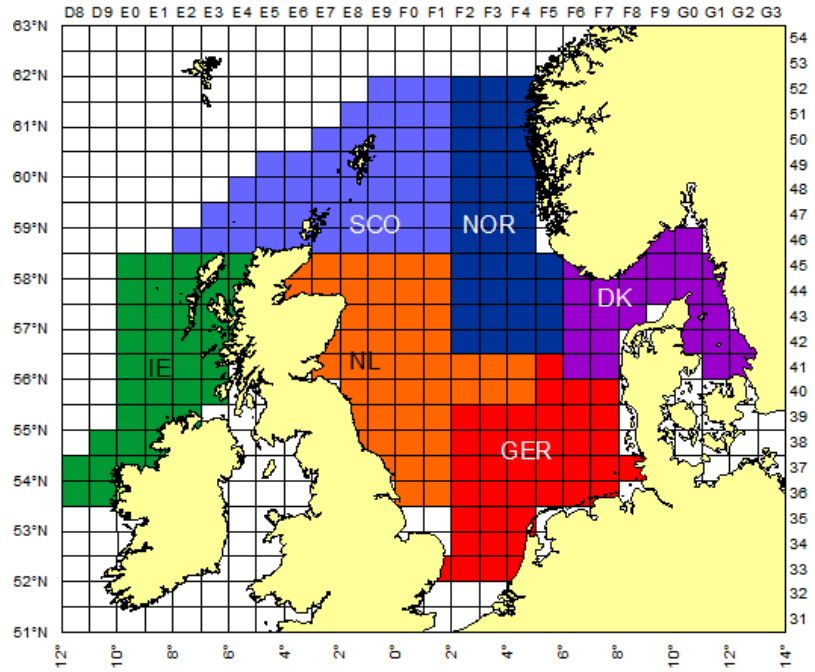


Figure 2.1.1. HERAS area coverage by ICES rectangle in 2014 (IE = Ireland; SCO = Scotland; NOR = Norway; DK = Denmark; NL = Netherlands; GER = Germany).

2.1.1 Survey objectives

The survey aims to provide an annual estimate of the distribution, abundance and population structure to inform the assessment of the following herring and sprat stocks: Western Baltic Spring-spawning herring (in ICES Divisions IV and IIIa), North Sea Autumn Spawning herring (in IV, IIIa and VIId), West of Scotland herring (in VIaN), Malin Shelf herring (west of Scotland/Ireland in VIaN-S and VIIb,c), North Sea sprat (in IV) and Sprat in IIIa (Skagerrak/Kattegat).

The derived estimates and age structure of herring and sprat are used as tuning indices in the respective assessments and are submitted annually to the HAWG.

2.1.2 Survey time-series

The ICES Coordinated acoustic surveys started in 1979 around Orkney and Shetland with the first major coverage in 1984. An index derived from that survey has been used in the assessment of North Sea autumn spawning herring since 1994 with the time-series data extending back to 1989. The survey was extended to IIIa to include the overlapping western Baltic spring-spawning stock in 1989, and the index has been used together with a number of other tuning indices in the assessment of North Sea herring since 1991. The early survey had occasionally covered VIaN during the 1980s and was extended westwards in 1991 to cover the whole of VIaN. Since 1991, this survey provides the only tuning index for West of Scotland (VIaN) herring and from 2008 for the whole of the Malin Shelf area (VIaN-S and VIIb,c). Since 2000, the survey has also provided age disaggregated abundance indices for sprat in the North Sea and since 2006 for sprat in IIIa.

2.2 Methods currently applied for scrutinising acoustic data

2.2.1 Ireland (Malin Shelf Herring Acoustic Survey)

The Malin Shelf Herring Acoustic Survey (MSHAS) conducted annually (June-July) on the RV 'Celtic Explorer' uses Simrad EK60 multifrequency (18, 38, 120 and 200 kHz) echosounders with transducers mounted on a drop keel. The drop keel is at 3.3m extension during the survey, therefore the transducers are at 8.8 m depth from the surface. Data are collected between 02:00 to 22:00 GMT. Acoustic calibration is carried out at the beginning of each survey. Estimates of herring abundance and biomass are derived exclusively from 38 kHz data. A pelagic trawl (Figure 2.2.1.14) is used to sample fish marks and hauls are monitored using a transducer mounted on the headline of the net. Detailed notes are taken during trawl operations to assist scientists during scrutinisation.

Echosounder settings – Simrad split-beam EK60

Echosounder settings for the Irish Marine Institute portion of the MSHAS on the RV 'Celtic Explorer' are shown in Table 2.2.1.1. Survey environmental data, i.e. sound velocity, is entered into Echoview and EK 60 manually, from CTD readings taken during calibration. Raw EK60 files are saved at 10MB intervals. The echogram is also live-viewed and in Echoview and raw Echoview files recorded at 50MB intervals.

Table 2.2.1.1. Simrad EK60 settings on RV 'Celtic Explorer' for MSHAS 2014.

FREQUENCY (KHZ)	18	38	120	200
Power (w)	2000	2000	500	300
Pulse Duration (ms)	1.024	1.024	1.024	1.024
Sample Interval (μs)	256	256	256	256
Interval (Hz)	1.0	1.0	1.0	1.0
Absorption dB/km	2.3	8.9	40.1	58.2
Sound velocity (m/s)	1504	1504	1504	1504
Athw. Beam Angle	10.46°	6.95°	7.26°	7.01°
Along. Beam Angle	10.43°	6.90°	7.22°	6.71°
Two-way beam angle (dB)	-17.0	-20.6	-20.8	-20.7

Echogram Preparation

- Software – Echoview (version 5.3).
- Files imported into Echoview template (e.g. from previous year).
- The most recent calibration file (.ecs file) is imported (calibration of all four frequencies is carried out before each MSHAS).
- Information on transducer location is imported; important for accurate depth readings and multifrequency analysis. Settings for MSHAS 2014 are shown in Table 2.2.1.2.

Table 2.2.1.2: Echoview transducer location settings for RV 'Celtic Explorer'.

FREQUENCY (KHZ)	18	38	120	200
x-alongship offset (m)	0	0.68	0.39	0.39
y-athwartship offset (m)	0	0	-0.29	0.28
z-vertical offset (m)	8.8	8.8	8.8	8.8

The echograms are first processed to determine analysis and bad data regions. Information about on-transect and off-transect times are taken from acoustic and trawl log sheets from the survey. Procedures are as follows:

- Generate appropriate surface exclusion line (generally ca. 12 m, weather dependent
- Generate appropriate seabed offset line (1 m)
- Thoroughly examine bottom offset line to correct for any irregularities (e.g. drop outs, etc.) as well as ensuring that line is neither excluding schools or including seabed in fish schools
- Apply cell grid: 1 nautical mile by 50 m depth bins
- Define bad data regions (not included in analysis) and classify (e.g. type = bad data; class = pre/post survey track)
    - Data prior to start of transect
    - Data collected during trawls/CTD casts
    - Off transect for any other reason (e.g. end of day)
    - Inter-transect data

Echogram Scrutinising Procedure

Once the echograms have been partition by transect, the cell grid has been applied, and off-transect events have been excluded, the process of assigning schools and allocating species to those schools can begin. The echograms are generally analysed and echo integrals calculated at a threshold of -70 dB; where necessary heavy backscatter from plankton was filtered out by thresholding at –65 dB. Echo integration is performed on school (regions) that are defined by enclosing selected parts of the echogram and allocated to species categories described below. All schools are drawn manually in Echoview (vers. 5.3) using the various box, freehand, and layer tools to delineate appropriate regions (no schools detection algorithm is used). The allocation of species to schools requires experience and many factors are incorporated; including information from trawl catch data, depth, location, environmental factors, known species behaviour, and relative frequency responses.

Allocation relies mainly on capture data from the closest trawl as this is the best indication of the species making up schools. There is an assumption that what is observed during trawling is representative of what is observed on survey track. This is obviously not always the case; however, the best evidence based judgement is made by the scrutinising scientists. Factors considered when classifying school regions might include:

- Was trawl catch data directly from schools surveyed?
- Was trawl catch data in the area on similar schools?
- Was the catch large enough to be representative of the traces surveyed?
- Depth of schools in water column
- School shape/dimension
- Location and environment (temperature)
- NASC value for school
- Individual harder S_v values of data points within school (a distinct "kernel" of harder S_v values in middle of school)
- Experience from previous surveys/years
- Other information from survey boats in the area (e.g. Scottish vessels conducting other half of MSHAS)
- Time of day/light levels
- Frequency response curves:
  - Relative frequency response ($NASC/NASC_{ref}$)
  - Relative mean dB (mean dB – mean dB_{ref})
  - Threshold response ($NASC/S_v$ Threshold)

Species Classification

Examples of echograms prior to fishing and the associated species classifications are presented in Figures 2.2.1.1 to 2.2.1.13.

The NASC (Nautical Area Scattering Coefficient) values from each herring echotrace are allocated to one of four categories:

1) "Definitely herring" echotraces are identified on the basis of captures of herring from the fishing trawls that had sampled the echotraces directly, and on large echotraces which have the characteristics of "definite" herring traces (i.e. very high intensity (red), narrow inverted tear-shaped marks either directly on the bottom or in midwater).

2) "Probably herring" were attributed to smaller echotraces that had not been fished but which had the characteristic of "definite" herring traces.

3) "Herring in a mixture" were attributed to NASC values arising from all fish traces in which herring were thought to be contained, owing to the presence of a proportion of herring within the nearest trawl haul or within a haul, which had been carried out on similar echotraces in similar water depths.

4) "Possibly herring" were attributed to small echotraces outside areas where fishing was carried out, but which had the characteristics of definite herring traces.

Boarfish schools are classified into "Definitely", "Probably", "Possibly", and "in a mixture" using very similar criteria. Boarfish data from the Irish portion of the MSHAS are

sent to the coordinator of the dedicated Boarfish Acoustic survey (BFAS), which covers the shelf area to the south of the MSHAS.

Other species such as sprat, blue whiting, mackerel, horse mackerel, juvenile gadoids, and sandeel are also classified.

General considerations

For each school, it is very likely that a combination of all information will be considered before final classification. The rules are subjective, with the experience of the scientists very important at this stage. However, there are some general considerations that are useful as a starting point:

- Herring schools are often tall and pillar-like with strong backscatter on all 4 frequencies (Figures 2.2.1.4 and 2.2.1.6) However, herring can present in various shaped aggregations (Figure 2.2.1.8).
- There should be many individual strong S_v values of data points on all 4 frequencies within the school to classify as herring.
- Surface/midwater herring schools also have strong S_v values for data points within the school, but due to the narrower beam and less overlap between frequencies higher in the water column, may appear smaller in size.
- Gadoids are often in mixed aggregations along the bottom, with herring also in proximity.
- Sprat schools can appear like herring, but often in shallower water, closer to shore and may be in very thin pillars compared to herring.
- The MSHAS is conducted out to the shelf edge (250m) but herring are not often found close to the edge. Dense schools near or at shelf edge are usually another pelagic species, e.g. boarfish.
- Mackerel show up stronger on 200 kHz, and schools are often very large and in layers (e.g. Korneliussen, 2010).
- Midwater marks in the Minches region are hard to sample but occasionally trawl hauls produce meshed juvenile gadoids or lesser sandeel.

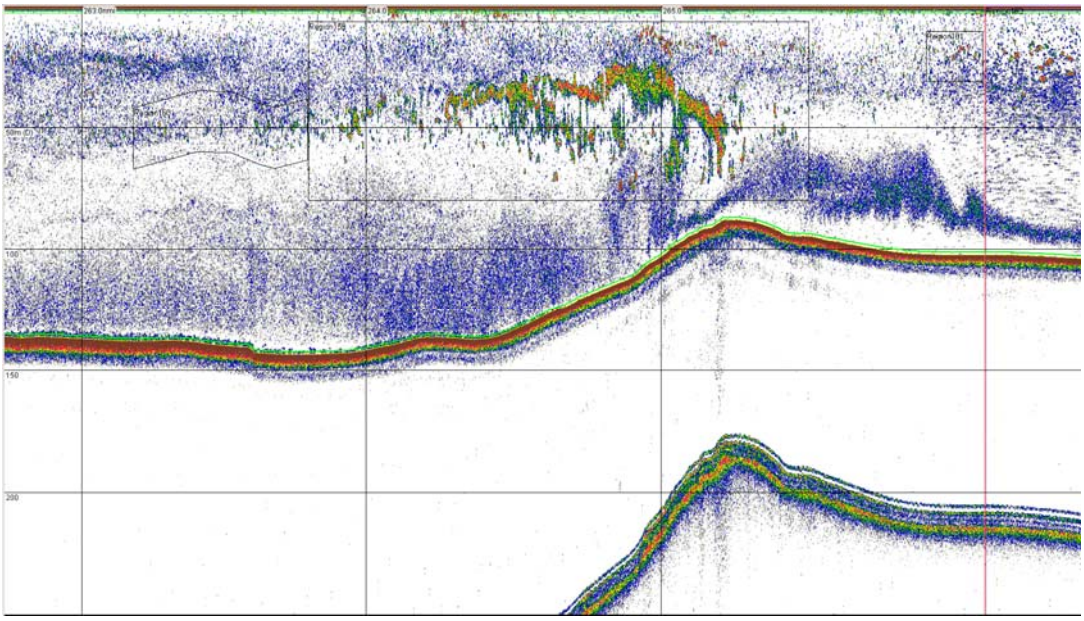


Figure 2.2.1.1. A scattered, midwater mark in the Minch. Vertical lines represent 1 nmi, horizontal lines represent 50 m depth. Catch: Juvenile gadoids meshed in the codend of the net. Scrutiny category: "Other".

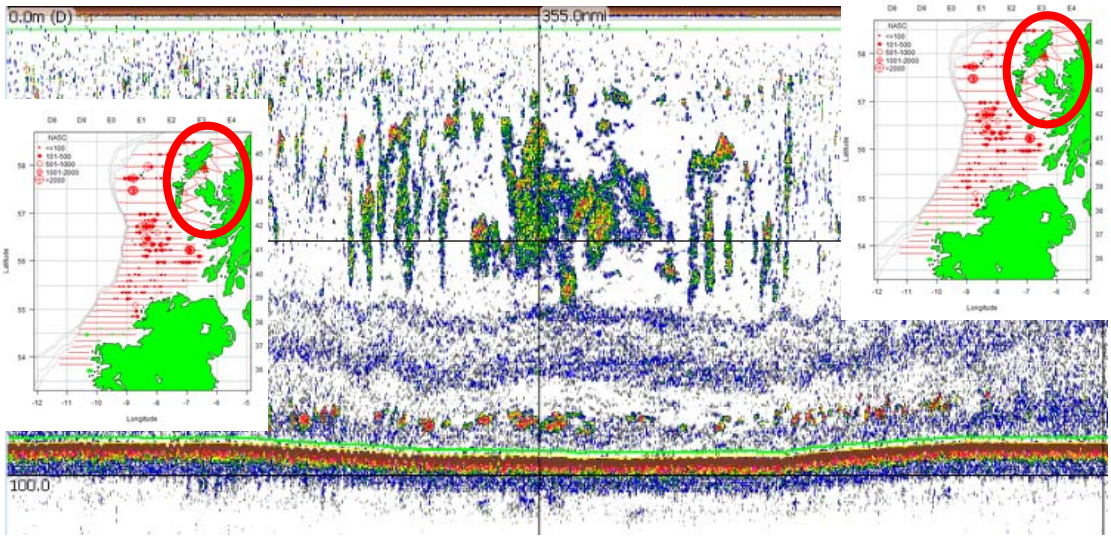


Figure 2.2.1.2. A number of midwater and bottom marks in the north Minch. Catch: The lower marks were targeted and yielded 58 kg; a mixture of demersal species and 4% herring. Similar midwater marks targeted in other hauls and previous years have yielded meshed juvenile gadoids. Scrutiny category top: "Other", bottom: "Herring in a mix".

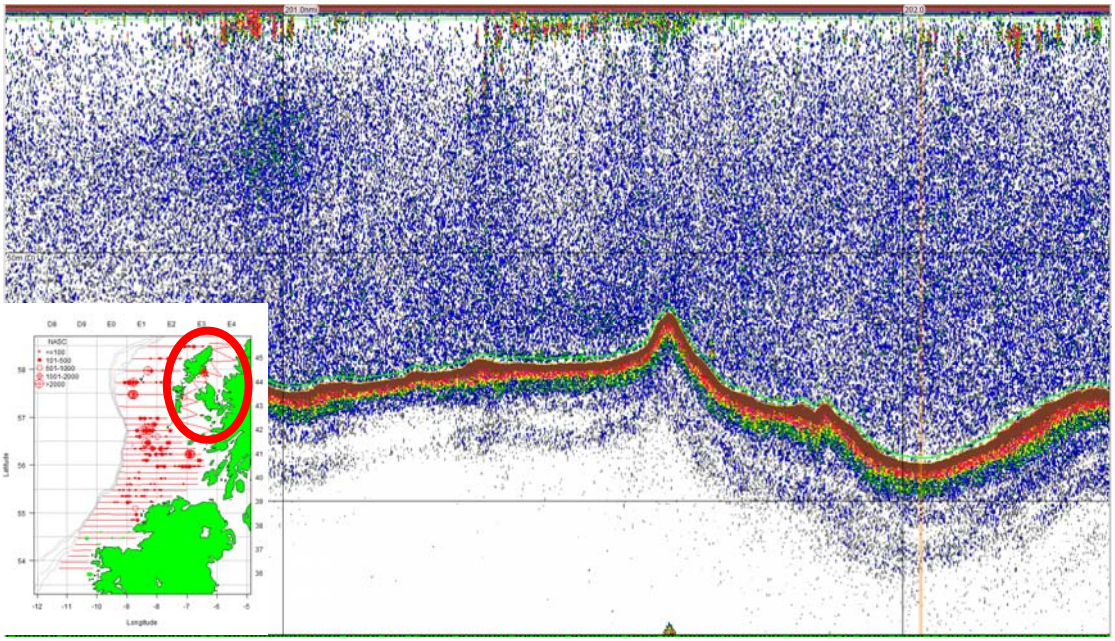


Figure 2.2.1.3. Catch: Meshed lesser sandeel from surface marks in the north Minch. Scrutiny category: "Other".

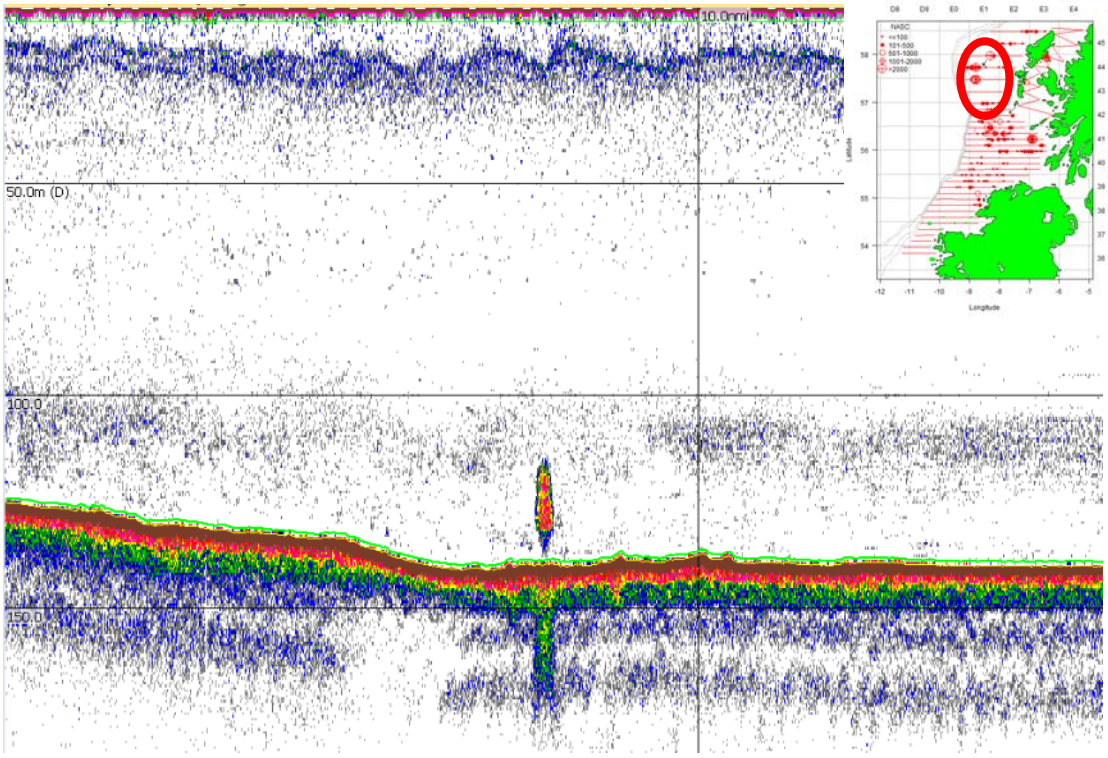


Figure 2.2.1.4. A typical pillar of herring northeast of St Kilda in 2014. Catch: 4000 kg 100% Herring. Scrutiny category: "Definitely Herring".

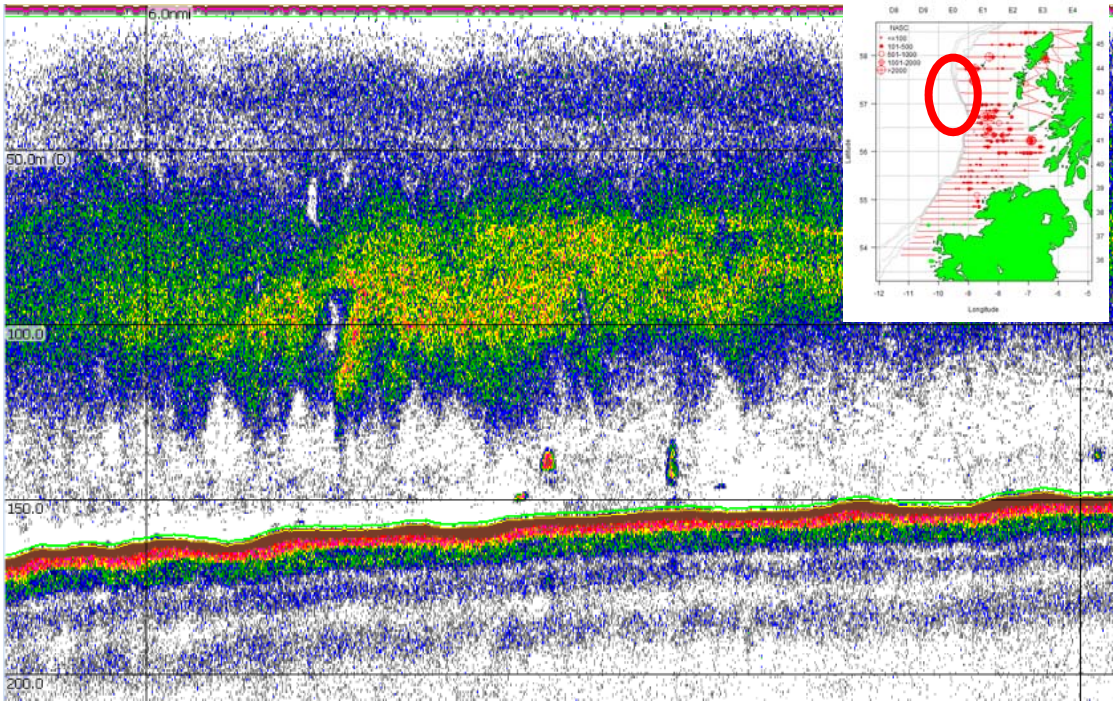


Figure 2.2.1.5. Two small schools of boarfish on the shelf edge in stat rectangle 44E0. Catch: 88 kg (98% BOF). Scrutiny category: "Definitely Boarfish".

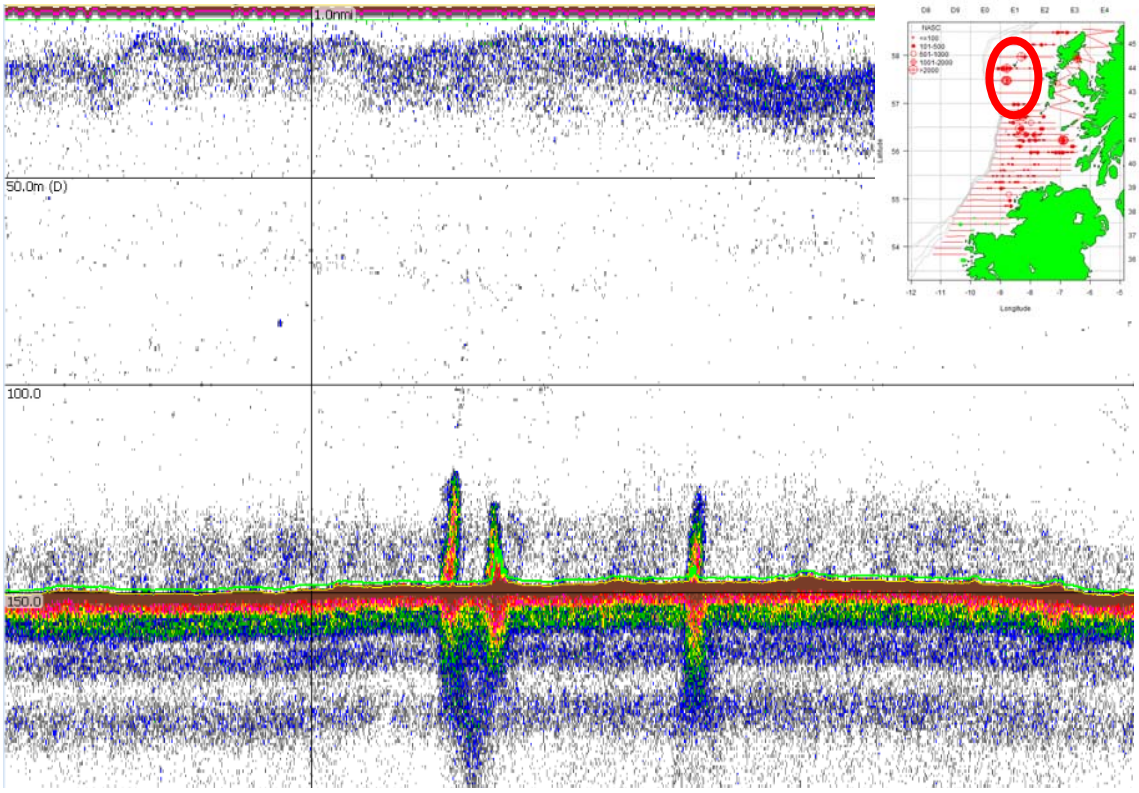


Figure 2.2.1.6. Three typical herring marks in 150m of water west of St Kilda. Catch: 7000 kg, 98.5% Herring. Scrutiny category: "Definitely Herring".

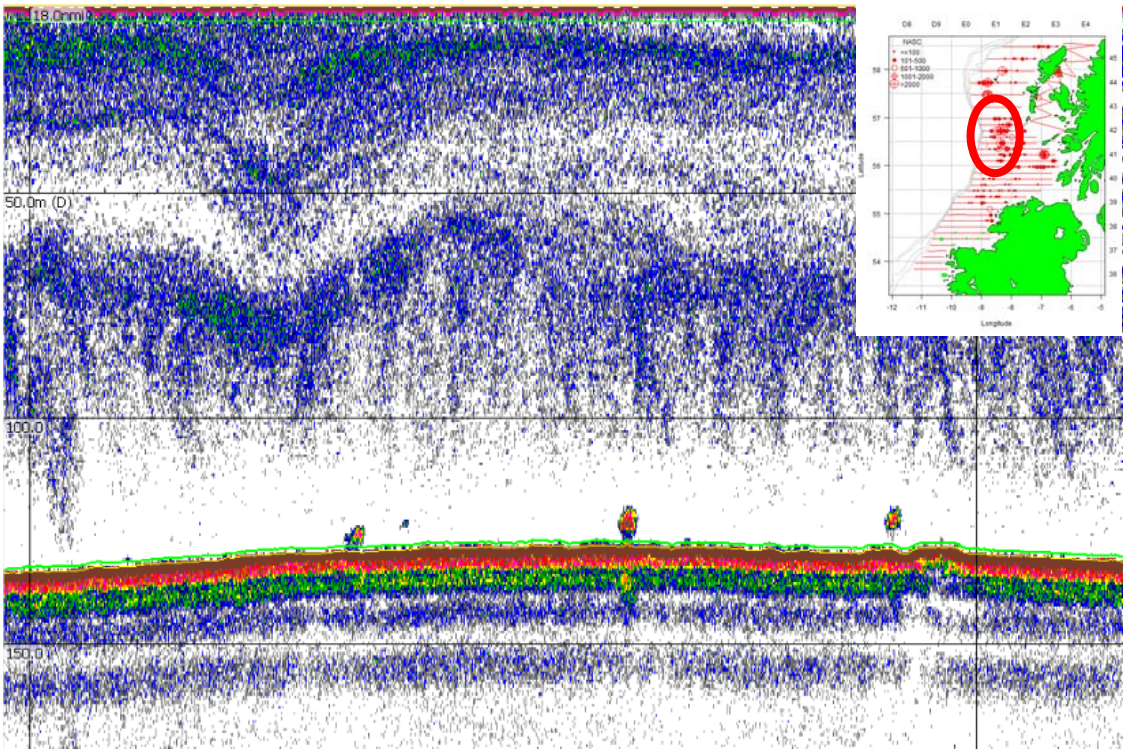


Figure 2.2.1.7. Three marks of herring in stat rectangle 42E1. Catch: One mark captured 750 kg of herring. Scrutiny category: "Definitely Herring".

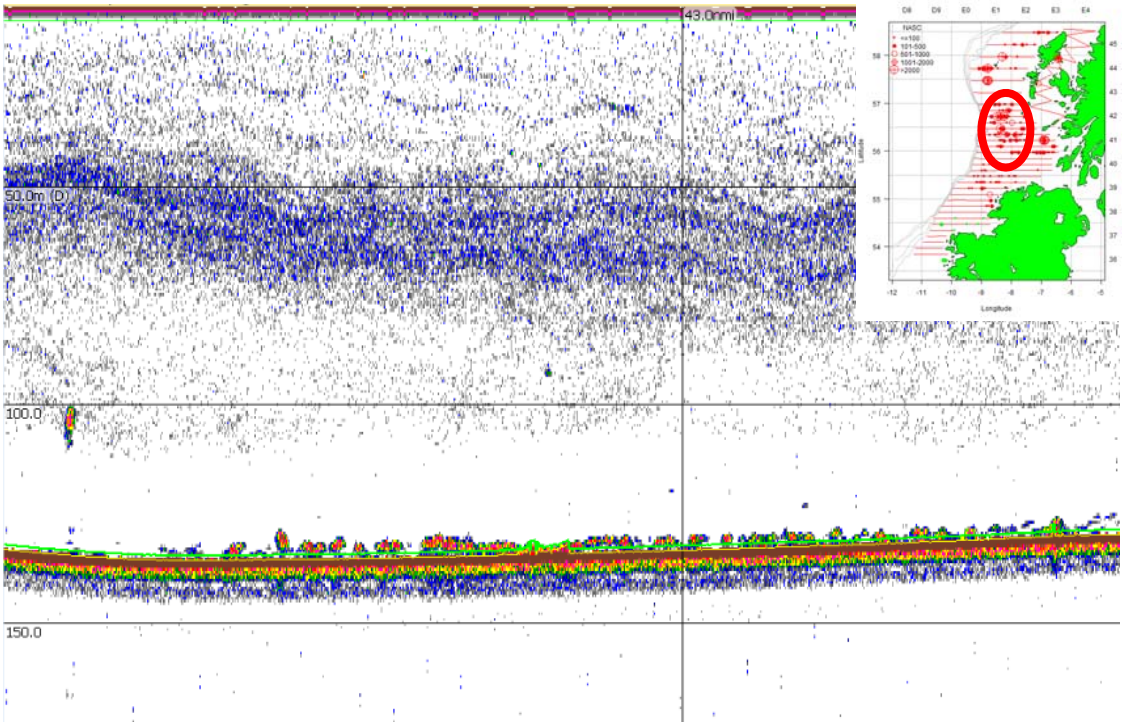


Figure 2.2.1.8. This scattered bottom layer, observed early in the morning west of Mingulay. Catch: 750 kg, 100% Herring. Scrutiny category: "Definitely Herring".

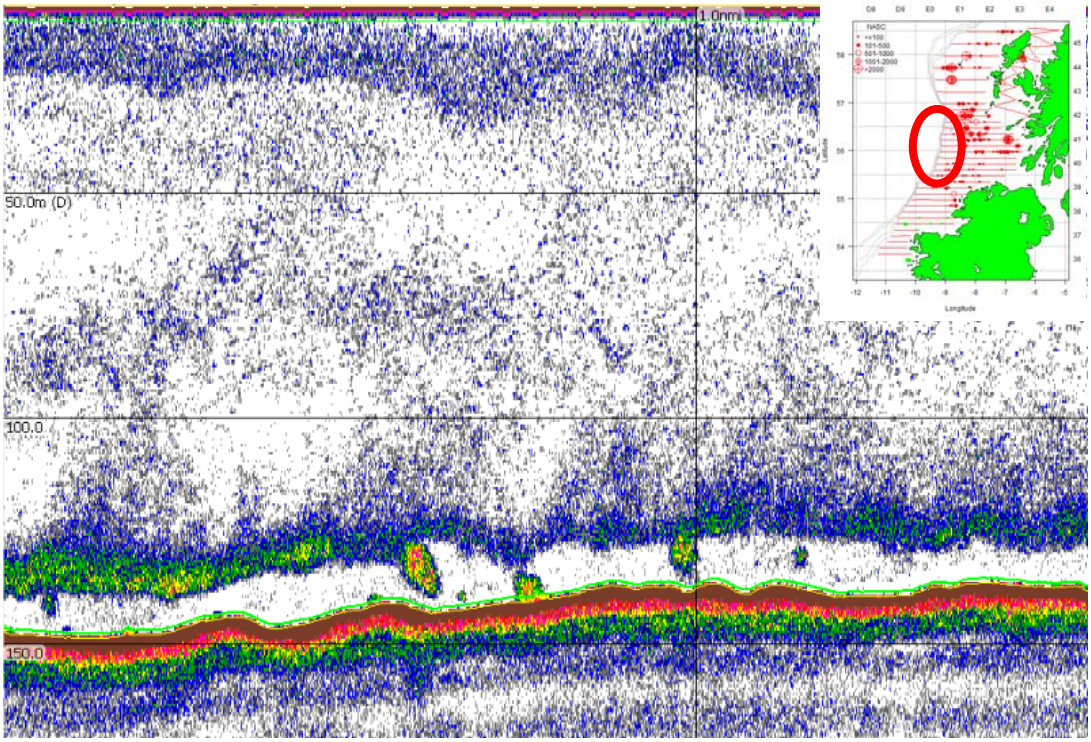


Figure 2.2.1.9. A number of marks on the shelf edge near 56.5° N. One mark, seen entering the net mouth on the headline transducer. Catch: 500 kg of boarfish. Scrutiny category: "Definitely Boarfish".

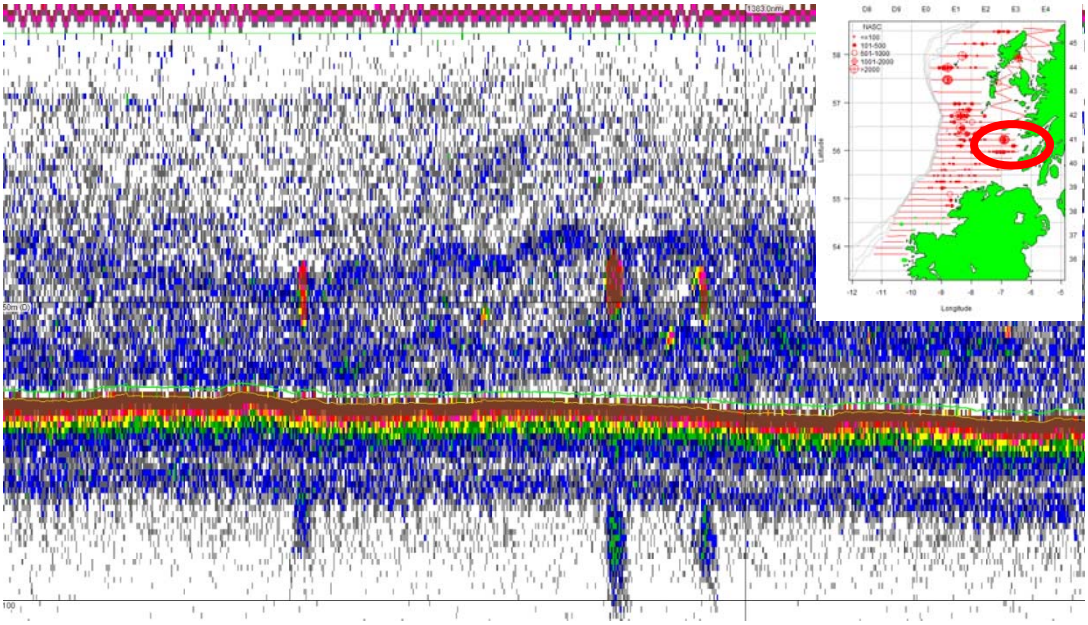


Figure 2.2.1.10. A number of marks in the eastern extreme of the survey grid. Catch: Sprat. Scrutiny category: "Definitely Sprat".

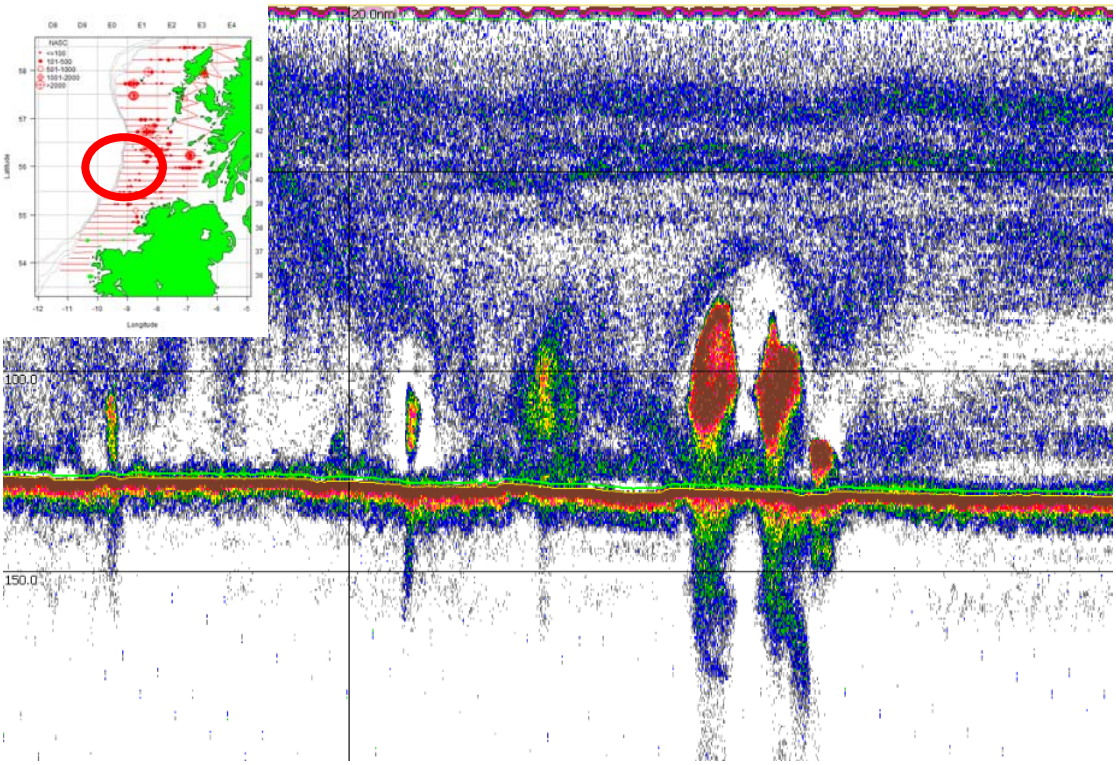


Figure 2.2.1.11. Despite seeing roughly half of one of these huge marks passing under the headline transducer the net contained just 55 kg of juvenile blue whiting in 2014. The rest were small enough to escape through the mesh. A number of other huge marks of juvenile blue whiting were seen west of Donegal. These large schools were highly mobile and required a number of passes with the net just to obtain a 50 kg sample. 2014 was the only year when marks like these were seen. Scrutiny category: "Blue Whiting".

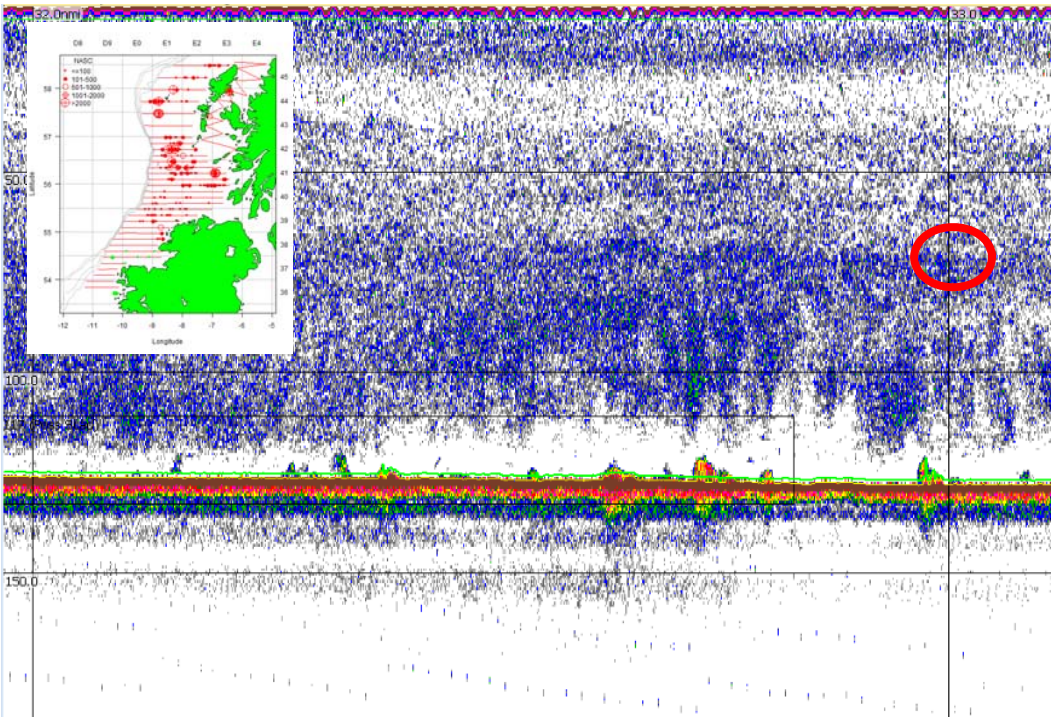


Figure 2.2.1.12. A scattering of bottom marks near the shelf edge. Catch: 31 kg, 11% herring, 75% mackerel, 13% horse mackerel and other assorted species. Scrutiny category: "Herring in a mix".

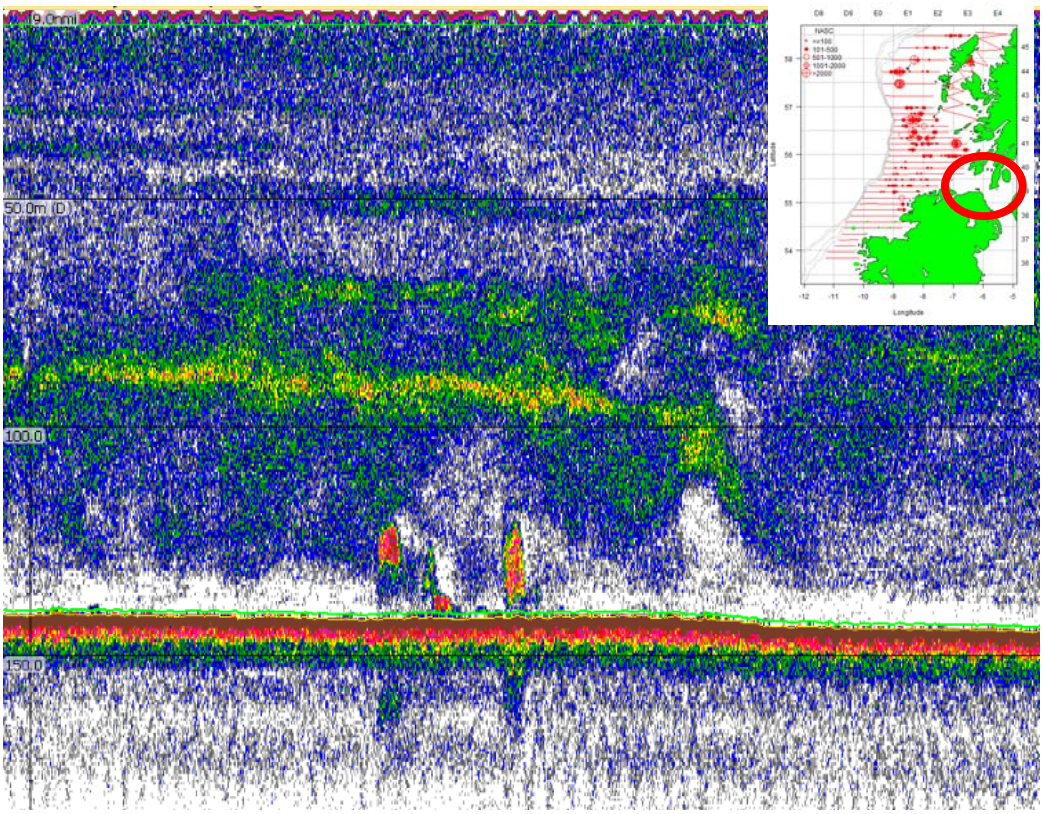


Figure 2.2.1.13. Marks close to the shelf edge, Northwest of Donegal. Catch: Target was not captured. Scrutiny category: "Probably Herring".

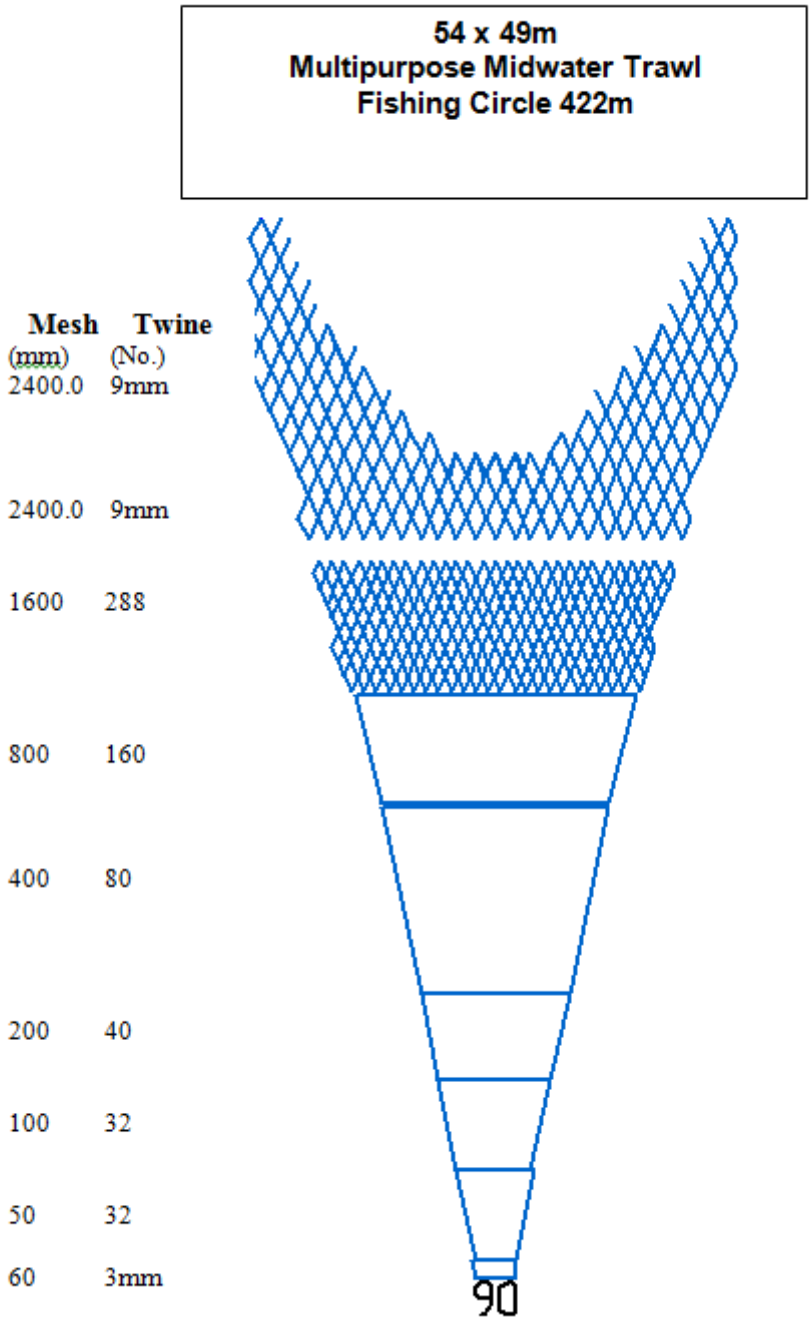


Figure 2.2.1.14. 'Celtic Explorer' multi-purpose midwater trawl employed during the Northwest herring acoustic survey, June\July 2014

2.2.2 Netherlands

Survey

From 1996 – 2014 a Simrad 38 kHz split-beam transducer was towed in a towed body off the Scottish design ("shark"). From 2001 onwards a 200 kHz transducers was mounted next to it. Since 2015 RV 'Tridens' is equipped with a drop keel, holding 18, 38, 70, 120, 200, and 333 kHz transducers, which are operated with a EK60 for a transition period. In future, a broadband EK80 echosounder will be used. In addition, data are collected with a multi beam MS70. Currently this system is used as an additional help for verifying and judging echograms.

In the tunnel of the trawl, a GoPro high-resolution camera is mounted with two torch light sources heading in different angles. Footage is collected during every haul to time and identify schools entering the net. This is used for species identification of echo's which were previously spotted on the echograms of the EK60/80 and the netsonde.

Currently – in the 2015 situation – these additional data sources, together with trawl notes have been used in an ad hoc way. In the near future, a system will be developed to log this information during fishing and have it readily available during the scrutiny process.

Scrutinisation procedure

LSSS is used for scrutinisation. Files of all available frequencies are used. Korona modules for filtering spikes and school selection are prepared before the actual assignment of species to echo's. For judgement of difficult schools the in-build categorization tool is used as a help. The basis of the scrutiny in the HERAS survey is that no "filtering" by means of shifting the threshold is used. In the IBWSS, in some cases plankton and mesopelagic fish are removed by increasing the threshold in the range of -66 to -70 dB to better identify blue whiting. Schools and layers are selected with the LSSS tools available. The Korona is used frequently to select schools. Some automatically selected schools are manually removed according to the judgement of the scrutiniser. The data are stored at -70 dB for both HERAS and IBWSS. The 38 kHz data are used for further abundance estimation.

The scrutiny is done during the survey, starting two days after the start and keeping up approximately with a delay of one day. Normally the work is conducted by one person during his or her shift. However, the acoustic operators discuss echo's which are less typical in order make sure that the methods and decisions are in line with each other.

2.2.3 Norway

Survey

The Norwegian part of the HERAS survey is covered by RV 'Johan Hjort'. This vessel is equipped with a scientific Simrad EK60 echosounder operating four transducers at 18, 38, 120 and 200 kHz, mounted on a drop keel. All transducers are calibrated – either some time before the survey, or right before the survey. The resulting calibration parameters are applied during data recording. Hydroacoustic data are recorded continuously 24–7 during the survey.

We are usually aiming at two trawl hauls (can be both pelagic and bottom trawl) per ICES statistical rectangle, targeting fish aggregations and schools that can be herring

or sprat (as evaluated from the echosounder). In addition, blind hauls in the surface is conducted every night to get herring samples from the herring in the surface layer.

Scrutinisation procedure

Scrutinization is done twice a day at survey, with the LSSS software. The standard EDSU is 1 nmi. In bad weather, with many air bubbles in the surface layer, the drop keel is used (can be lowered max 5 m). This means that, dependent on weather conditions and accordingly surface turbulence, integration of acoustic values starts at 8-15 m below surface. At the seabed, a 0.5 m bottom margin is applied. Transport between port and survey area, transport between transects, survey tracks departing from transects (to cover IBTS hauls etc.), and trawl hauls against transect direction are removed from the acoustic integration. The amount of plankton varies within the survey area, as well as between survey years. A variable threshold is therefore used to remove plankton before scrutinizing. In the LSSS scrutinizing process, identification of herring marks is done based on trawl hauls, frequency response, down-thresholding to -62 to -55 dB, as well as earlier experience from trawl hauls (both from earlier and the current survey, e.g. for separating herring from Norway pout). Larger herring schools are boxed.

Abundance and biomass estimate

Acoustic density values (s_A) of herring are exported by 1nm EDSU. Only herring sample data with age are used for estimation, and only samples with at least 20 herring are used. Abundance and biomass for the survey area is calculated by an Excel-sheet, where the mean NASC, sea area, no of n.miles covered, age distribution, maturity-at-age, mean length-at-age, mean weight-at-age, and %WBSS by age per rectangle are input values. Samples used for each rectangle are decided by the biological strata defined - based on the samples' age and length distribution, as well as %WBSS. The abundance and biomass estimates have up to now been delivered by rectangle to FishFrame.

2.2.4 Denmark (Skagerrak–Kattegat Acoustic Survey)

Survey

The vessel employed for conducting the Danish part of the annual HERAS survey, RV 'Dana' is equipped with a scientific Simrad EK60 echosounder operating two hull-mounted split-beam transducers at 18 kHz and 120 kHz respectively. Furthermore, a split-beam 38 kHz transducer is operated from a towed body in approx. 3 m depth. Prior to the survey, all transducers are calibrated and resulting calibration parameters are applied during data recording. Hydroacoustic data are sampled at a pulse length of 1.024 ms and a ping interval of 1 pings s^{-1} according to settings described in ICES, (2015).

Hydroacoustic data are recorded continuously all 24 hour and are stored as EK60 raw files. Fisheries are conducted 4 times a day in two time windows (10–15 UTC and 20–02 UTC) due to Danish working regulations for the crew.

The depth and the hydrographic situation vary over the Danish survey area. Depth varies from shallow down to 687 m. 32 % of the survey area have depth larger than 150 m. Salinity varies from 35 0/00 in the western Skagerrak down to 29–30 0/00 in Kattegat.

The herring in the survey area belong to two different stocks, North Sea Autumn Spawners (NSAS) and Western Baltic Spring Spawners (WBSS). NSAS consist mostly of immature fish 0 to 6 WR and WBSS consist mostly of mature 2–12 WR. Both stocks

are during the survey period in a feeding situation and be in dispersed in layers mixing with other species either near to the bottom in shallow areas or connected to spring layers at larger depth. Schooling behavior is only seen to a smaller extend.

Scrutinisation procedure

As herring occurs in scattered layers mixing with other species in the survey area acoustic values are not scrutinized to species Sa within the Danish survey area but scrutinized to "mixed Sa" and the abundance of fish are calculated based on the mean TS in allocated trawl stations.

The scrutinization process is therefore focused on removing energy from the acoustic signals not belonging to fish. The Danish scrutinisation process is conducted with a DTU-Aqua developed software, Ev2Akubio, using facilities in Echoview.

Step 1:

EK60 raw data are merged into 1 day long Echoview files. A bottom line is created and checked for missing bottom or bottom generated on top of what is believed to be fish concentrations. . Furthermore, areas, which should be excluded as noise from wind, introduced bobbles in the surface or other disturbances are marked as bad areas.

Step 2:

By the support of Echoview the EK60 raw data are integrated into 3 dB intervals in 1 meter depth layers.

This process will for each Log (ESDU) sort echoes in each ping in 1 meter depth layers and 3 dB windows storing the number of echoes in each depth/dB cell.

Example of data structure:

Threshold / Dybde	-70 dB	-67 dB	-64 dB	-61 dB	-58 dB	.....	-25 dB +	op til Max Sv value in highest interval
3						....		Exclude above line
4						.....		
5						...		
6						...		
7						...		
.....								
499						....		
500						...		Exclude below line

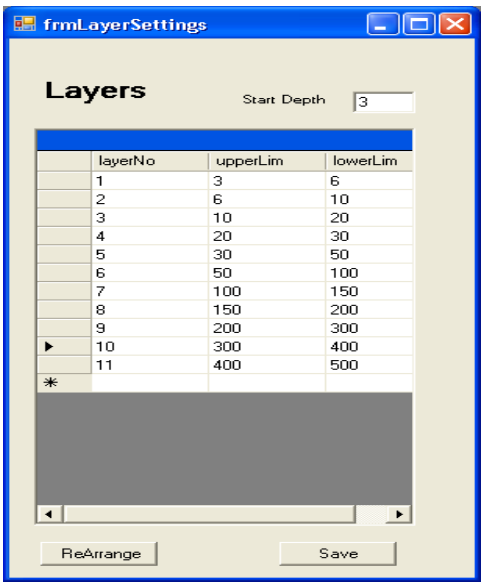
This process for exporting from the daily Echoview files is facilitated in Ev2Akubio.

Step 3:

The export Echoview data are now imported in the Ev2Akubio program where it is stored in a SQL database.

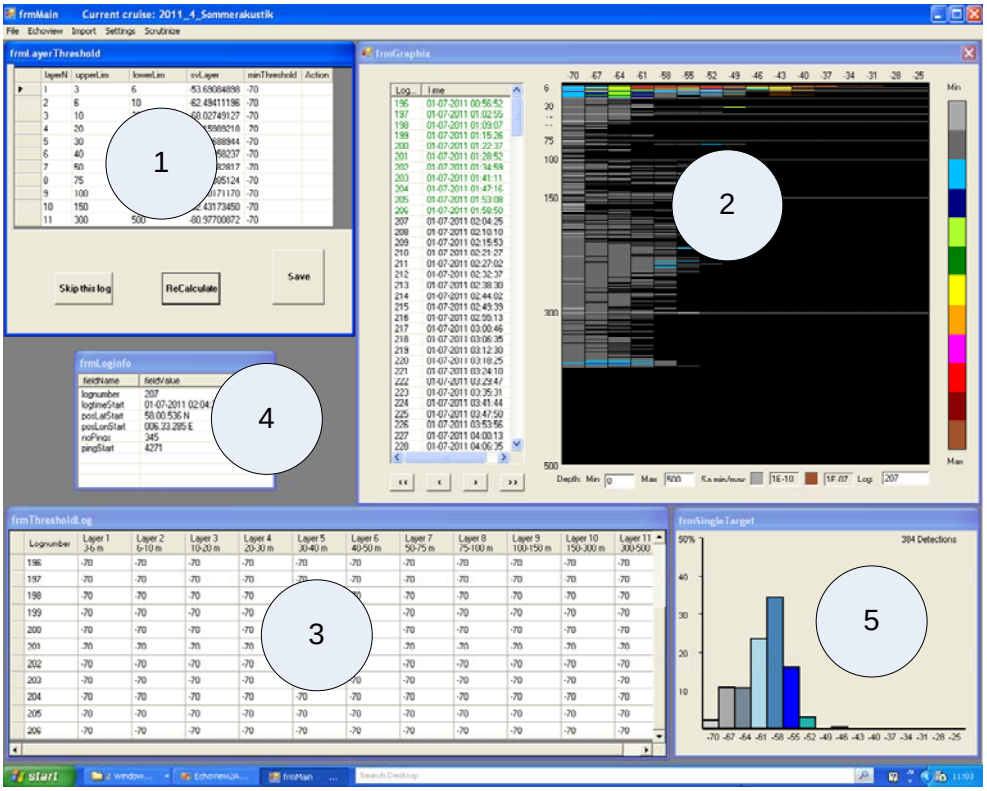
Step 4:

Data will be available in Ev2Akubio in 1 meter depth layers but to speed up the process it will be advisable to merge data into user defined depth layers.



Step 5:

After choosing the survey and the log interval/day to be scrutinized the program will now open the following screen picture:



1) A table over the defined depth layers and corresponding Sv values.

2) A table of the logs in the file and a contour plot of the distribution of echoes in the log.

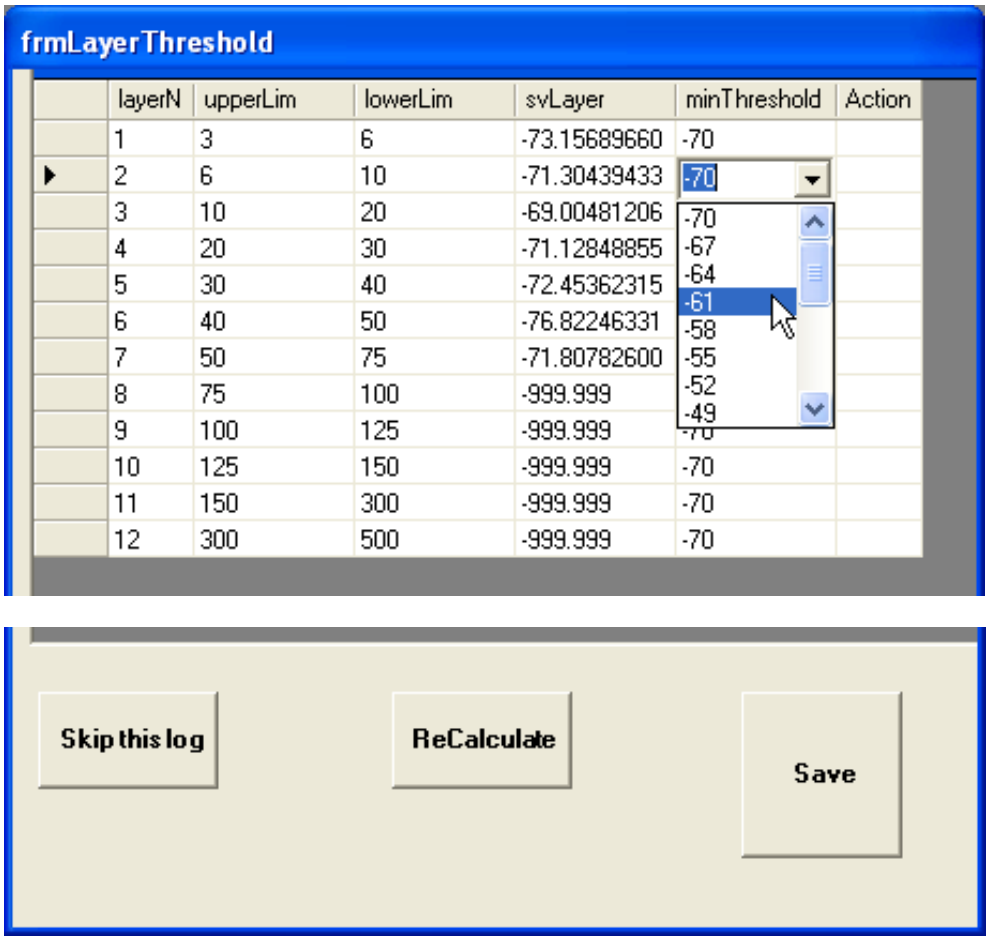
3) Table showing used thresholds in the process.

4) Information on time, location and number of pings in the given log.

5) Histogram on the TS distribution in the log.

Step 6:

The threshold in a layer can now be changed in the LayerThreshold window of the screen.



After pressing ReCalculate the new Sv values per layer will showed in 1) and the new TS distribution in 5).

In 2) the new thresholds will be shown.

By pressing Save the new values per layer will be saved in the database.

Step 7:

Result can now be exported in two formats. Either in the input format for the Danish calculation software AKUBIO that calculates the number of fish per length and species or in the new reporting format for HERS surveys defined at the WKEVAL meeting.

2.2.5 Germany

Survey

The vessel employed for conducting the German part of the annual HERAS survey, RV 'Solea' is equipped with a scientific Simrad EK60 echosounder operating two hull-

mounted split-beam transducers at 38 kHz (ES 38-B) and 120 kHz (ES 120–7C) respectively. Prior to the survey, both transducers are calibrated and resulting calibration parameters are applied during data recording. If due to weather constraints etc. calibration cannot be conducted prior to the survey, transducers are calibrated during or directly after the survey, with resulting calibration parameters stored in an ECS-calibration file and loaded into the scrutinization software (see below). Hydroacoustic data are sampled at a pulse length of 1.024 ms and a ping interval of 0.4 pings s^{-1} according to settings described in ICES (2015).

Hydroacoustic data are recorded continuously during daily survey operations (i.e. generally from 04:00–18:00 GMT). Data are stored and further evaluated on a daily basis, i.e. one file is created for evaluation for each survey day.

For the allocation of target categories in the scrutinization process (and for the latter computation of a species-specific abundance and biomass estimate), usually two trawl hauls per ICES statistical rectangles are conducted, generally targeting fish aggregations/schools considered representative. In rectangles with only low registrations and/or no trawl haul information available, hauls from neighboring rectangles are combined and allocated to "blank" rectangles.

Scrutinisation procedure

Scrutinisation is either conducted on board during the survey or (depending on survey manning) after accomplishing survey operations in the lab. In either case, the software used for processing is Echoview (latest version at the time of scrutinisation). A template is used that applies correct transducer locations (x-, y-, z-offset of transducers) and (since 2015) incorporates motion readings from a Simrad MRU-Z motion reference unit that then are utilized to smooth the seabed in case of rough weather conditions and resulting increased heave, pitch and roll of the vessel.

Due to insufficient overlap of both transducer beams in shallow areas as present in the survey area, only the 38 kHz data are utilized for scrutinisation and classification procedures while the 120 kHz data are utilized for a rather subjective comparison of echo registrations. The standard EDSU is 1 nmi. Dependent on weather conditions and accordingly surface turbulence, integration of acoustic values starts at ca. 8 m below surface, while at the seabed a 0.5 m bottom margin is applied. All acoustic recordings conducted at a vessel speed of significantly less than 10 knots (i.e. trawling operations, CTD stations etc.) are marked as bad data regions and removed from integration, together with corresponding unfinished intervals. Echoes originating from scattering layers (thermoclines) etc. are marked as bad data (no data) regions and are removed from integration. As the survey covers areas with comparatively clear acoustic registration of fish schools as well as areas with lots of plankton and other scattering organisms in the water column, a variable threshold between -50 and -60 dB is used for scrutinisation. After removal of the abovementioned regions and echoes, a school detection algorithm (implemented in Echoview) is run in a "school by school" approach on manually selected regions with comparatively nonrestrictive detection settings (Table 2.2.5.1).

Resulting schools are –based on experience during the survey or based on trawl haul information after the survey- allocated categories "Clup" and "Other". Based on school shape etc., manual allocation of the category "Clup" to the schools is conducted. This is considered feasible, as there are no other fish species other than clupeids forming the typical inverted tear-shaped, columnar schools that represent the majority of fish ag-

gregations observed, detected as schools and allocated category "Clup". Only the category "Clup" regions are further exported (by region by cell) for an abundance estimate. Export is conducted at a threshold of -50 (-70) dB.

Table 2.2.5.1. School detection virtual echogram parameters in Echoview applied during German HERAS surveys.

School detection parameter	Setting
Minimum total school length (m)	1.00
Minimum total school height (m)	1.00
Minimum candidate length (m)	1.00
Minimum candidate height (m)	1.00
Maximum vertical linking distance (m)	2.00
Maximum horizontal linking distance (m)	5.00
Distance mode	GPS distance

Abundance and biomass estimate

As clupeid species co-occurring in the survey area (herring, sprat, pilchard and anchovy) form similarly to identically shaped schools and often co-occur in mixed schools, no species-specific allocation of NASC values is possible. Accordingly, the mean NASC per ICES statistical rectangle is calculated from all EDSUs sampled within the corresponding rectangle. Based on a common TS for all clupeids (TS = 20 log10 (L) -71.2) and on further parameters calculated from length–frequency distributions (L^2, σ) as well as catch ratios of the corresponding species in trawl hauls conducted in or allocated to the corresponding rectangle, NASC values per rectangle are dis-aggregated and abundance estimates are derived for any of the clupeid species occurring in the rectangle. Based on further biological sampling conducted during trawl haul samples (i.e. individual age (otolith sampling), length-at-age as well as weight-at-age), biomass estimates are calculated from resulting abundance estimates and observed length–frequency-distributions of clupeid species. A detailed description of abundance and biomass estimation procedures is given in ICES (2015).

2.2.6 Scotland

Survey

The herring acoustic survey (HERAS) on MRV 'Scotia' uses a Simrad EK60 multifrequency (18, 38, 120 and 200 kHz) split-beam echosounder with transducers mounted on a drop keel. The drop keel is at 2 m extension during the survey, therefore the transducers are at 7.5 m depth from the surface. Data are collected between 0200 to 2200 GMT. Calibrations are carried out twice – usually at the beginning and middle/end of survey. A PT160 pelagic trawl is used to identify fish marks and hauls are monitored with a Simrad FS70 scanning netsounder mounted on the headline. Detailed notes are taken during trawl operations which assist scientists during scrutinisation (example haul sheet shown in Figure 2.2.6.10).

Echosounder settings for the Marine Scotland HERAS on MRV 'Scotia' in 2014 are shown in Table 2.2.6.1. Beam widths are calculated by the LOBE program during calibration. Two-way beam angles are from the Simrad delivery data sheet supplied with each transducer. Survey environmental data i.e. sound velocity is entered into Echoview and EK60 manually, from readings taken in "open water" at a midwater depth location (100 m approx.). Raw files are saved at 10MB intervals.

Table 2.2.6.1. Simrad EK60 HERAS settings on MRV 'Scotia' in 2014.

FREQUENCY (KHZ)	18	38	120	200
Power (w)	2000	2000	250	120
Pulse length (ms)	1.024	1.024	1.024	1.024
Sample Interval (μs)	256	256	256	256
Interval (Hz)	1.0	1.0	1.0	1.0
Absorption dB/m	0.003	0.01	0.039	0.055
Sound velocity (m/s)	1494	1494	1494	1494
Minor-axis beam width	10.880°	6.940°	8.110°	6.470°
Major-axis beam width	11.130°	7.140°	7.960°	6.570°
Two-way beam angle (dB)	-17.3	-20.9	-20.6	-20.6

Echogram post-processing

- Software: Echoview.
- Files imported into Marine Scotland's multi frequency template.
- The most recent calibration file (.ecs file) is imported (calibration of all four frequencies is carried out before and midway through each HERAS).
- Transducer location information is imported; important for accurate depth readings and multifrequency analysis. Settings for MRV 'Scotia' on HERAS 2014 are shown in Table 2.2.6.2.

Table 2.2.6.2. Echoview transducer location settings for RV 'Scotia' on HERAS 2014.

FREQUENCY (KHZ)	18	38	120	200
x-alongship offset (m)	0	-0.6	-0.31	-0.32
y-athwartship offset (m)	0	-0.08	-0.29	0.28
z-vertical offset (m)	7.6	7.6	7.6	7.6

The echograms are first processed to determine analysis and bad data regions. Information about on-transect and off-transect times are taken from acoustic and trawl log sheets from the survey. Procedures are as follows:

- Generate 12 m depth surface line and 0.5 m seabed offset line
- Examine bottom offset line to correct for any irregularities (e.g. drop outs, etc.) as well as ensuring that analysis area is neither excluding schools or including seabed
    - Define bad data regions (not included in analysis) and classify (e.g. type = bad data; class = pre/post survey track). Examples of bad data regions include:
    - Data prior to start of transect
    - Data collected during trawls/CTD casts
    - Off transect for any other reason (e.g. end of day)
    - Inter-transect data

Echoview data flow template for HERAS

Marine Scotland scientists use an algorithm developed in Echoview for the detection of schools of fish with swimbladders, based on the multifrequency approach (e.g. SIMFAMI, 2005; Fässler *et al.*, 2007; Korneliussen *et al.*, 2008). The frequency response of weak scattering organisms (e.g. zooplankton) is more variable than the frequency response of fish with swimbladders; therefore, when the S_v of the four frequency channels are summed and a threshold is applied by the algorithm, the contrast between the two categories is enhanced. The fish response stays constant while the response of weak scatterers is more contrasted among the frequencies.

The school detection module in Echoview is used to filter out unwanted backscatter (e.g. zooplankton) and automatically define schools. The initial detection of schools with the Marine Scotland algorithm is conservative and captures all herring schools, plus other fish schools and backscatter layers that require further validation and scrutiny. The final allocation of species to schools requires experience and many factors to be considered; including information from trawl catch data, depth, location, environment, known species behaviour and relative frequency responses. Application of horizontal and vertical smoothing incorporates data that would otherwise be lost by the threshold settings. The result is an accurate definition of the outline of schools within the defined settings (Table 2.2.6.4). A mask is applied to the 38 kHz frequency channel to highlight the detected schools at this frequency for processing. The Marine Scotland Echoview algorithm data flow diagram for HERAS is shown in Figure 2.2.6.1.

The specific processing steps are:

- A virtual channel is created which is the sum of the four frequency channels (18 + 38 + 120 + 200 kHz)
- A threshold of -240 dB is applied to the virtual channel that separates the fish detections from other sources of backscatter and layers, etc.

- A bitmap mask is applied between 0.5 m seabed offset and 12 m from surface
- Horizontal and vertical smoothing (averaging) is applied to the data;
  - A median filter (3 x 3) is applied (this replaces each data point with the median of the data points in the surrounding cell)
  - A dilation filter (5 x 5) is applied (this replaces each data point with the maximum of the data points in the surrounding cell)
- A "fish mask" is applied with the condition: summed virtual channel > threshold
- A bitmap mask is applied between the dilated data and the 0.5 m seabed offset and 12 m surface line
- The "fish mask" is applied to the frequency channel that is to be processed for fish assessment (normally 38 kHz)
- "Fish School Candidates" virtual channel shows all data points meeting minimum threshold (-240 dB) these are schools ready for scrutinising validation

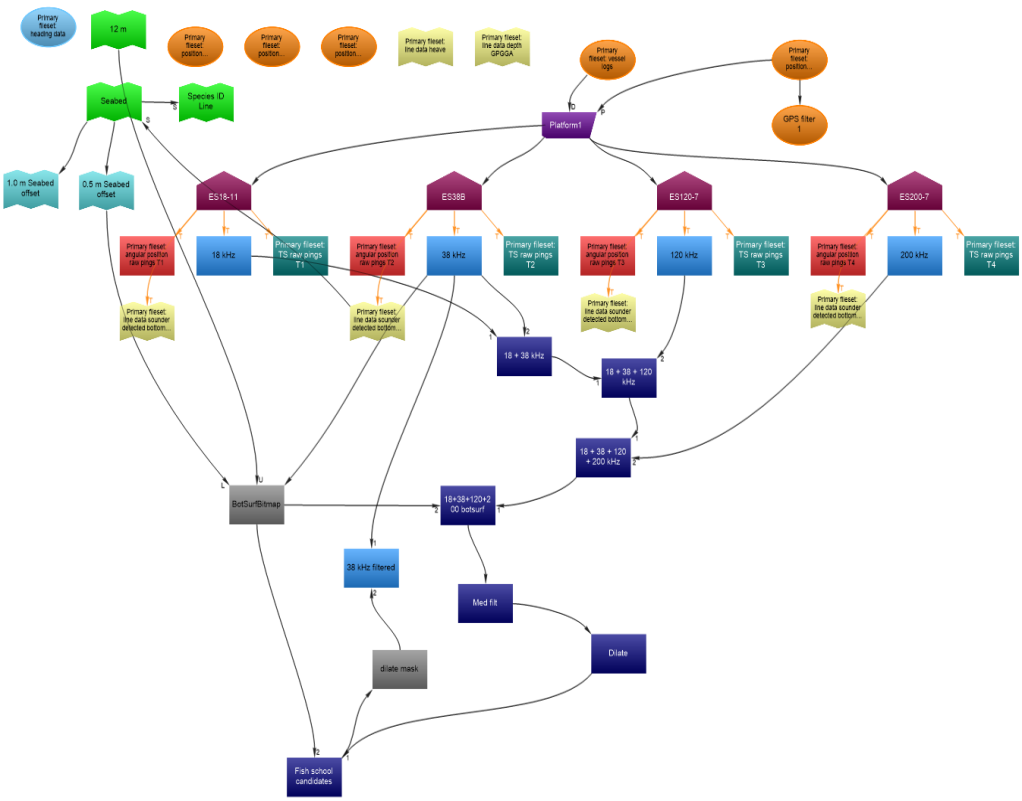


Figure 2.2.6.1. Marine Scotland HERAS Echoview data flow algorithm.

Scrutinisation procedures

Within Echoview variable property settings, echograms are set up for analysis. Variable Properties settings are shown in Table 2.2.6.3.

Table 2.2.6.3. Variable property settings in Echoview.

PROPERTY	SETTING
Data	min threshold = -100dB
Echogram display	min = -70dB; range = 36; colour scheme EK500; upper display limit = 0m; lower display limit = 250 m
Grid	time = 15min; depth = 500 m
Analysis	exclude above 12m and below 0.5m seabed offset; exclude bad data regions
Calibration	Set to latest good calibration (ECS file) for each frequency
Lines	show all

The schools detection module in Echoview is used to define schools for analysis. This is generated from the "Fish School Candidates" virtual channel. Detection settings are shown in Table 2.2.6.4.

Table 2.2.6.4. School detection virtual echogram parameters in Echoview.

SCHOOL DETECTION PARAMETER	SETTING
Minimum total school length (m)	10.00
Minimum total school height (m)	2.00
Minimum candidate length (m)	5.00
Minimum candidate height (m)	1.50
Maximum vertical linking distance (m)	2.00
Maximum horizontal linking distance (m)	15.00
Distance mode	GPS distance

Allocation of schools to species classification

The 38 kHz echogram with defined schools is used for the final allocation of species to each school. This is carried out manually with at least two acoustic scientists present. The process is somewhat subjective but evidence based, and both scrutinising scientists agree on allocations of species to schools. Each of the detected school regions for each day of the survey is processed manually and given a region classification (e.g. definitely herring, probably herring, etc.). When species cannot be allocated to a particular school, then the region is assumed to be unclassified. Only region classifications of definitely, probably and surface herring are used in the biomass estimate.

- School region classifications:-
  - Definitely herring
  - Probably herring
  - Possibly herring
  - Surface herring
  - Norway pout
  - Unclassified

Classification relies mainly on capture data from the closest trawl as this is the best indication of the species making up schools. There is an assumption that what is observed during trawling is representative of what is observed on the survey track. This

is obviously not always the case; however, the best evidence based judgement is made by the scrutinising scientists. Factors considered when classifying school regions might include:

- Was trawl catch data directly from the schools surveyed?
- Was trawl catch data in the area on similar schools?
- Was the catch large enough to be representative of the schools surveyed?
- Depth of schools in water column
- School shape/dimension
- Location and environment (temperature)
- NASC value for school
- Individual harder S_v values of data points within school (a distinct "kernel" of harder S_v values in middle of school)
- Experience from previous surveys/years
- Other information from survey boats in the area (e.g. Scottish HERAS charter boat, other HERAS vessels)
- Time of day/light levels
- Frequency response curves:
  - Relative frequency response ($NASC/NASC_{ref}$)
  - Relative mean dB (mean dB – mean dB_{ref})
  - Threshold response (NASC/S_v Threshold)

General considerations

For each school, a combination of all information will be considered before final classification. The rules are subjective, with the experience of the scientists very important at this stage. However, there are some general considerations that are useful as a starting point:

- Herring schools are often tall and pillar-like with strong backscatter on all 4 frequencies (Figures 2.2.6.2a and 2.2.6.2d). However, herring can present in various shaped aggregations.
- There is usually many individual strong S_v values of data points on all 4 frequencies within herring schools.
- Surface/midwater herring schools also have strong S_v values for data points within the school, but due to the narrower beam and less overlap between frequencies higher in the water column, may appear smaller in size. In addition, surface herring schools in water < 40 m may not be entirely suitable for multifrequency analysis due to reduced beam overlap higher in the water column.
- The relative frequency response ($NASC/NASC_{ref}$) is generally close to 1 on all 4 frequencies for herring (Figure 2.2.6.2b and 2.2.6.9b).
- Relative mean dB (mean dB – mean dB_{ref}) is generally close to 0 on all 4 frequencies for herring (Figure 2.2.6.2c and 2.2.6.9c).
- Norway Pout are often along the bottom (snake-like) in connected aggregations in water less than 100 m (Figures 2.2.6.3a, 2.2.6.4 and 2.2.6.5). The individual schools tend not to be as tall as herring and sometimes weaker with a less distinct shape (Figure 2.2.6.5). In some years (e.g. 2014) NPO and HER

are in close proximity with regular mixed catches (Figures 2.2.6.3a and 2.2.6.7).

- The relative mean dB (mean dB – mean dB_{ref}) is generally lower on the higher frequencies for NPO than for herring (Figure 2.2.6.8).
- The backscatter in NPO schools can still be quite strong on all 4 frequencies, although overall NASC for an individual school usually weaker than herring for example (threshold response - Figure 2.2.6.3d).
- The proportion of NPO and other small gadoids cannot usually be reliably quantified using trawl catches as they not retained in proportion to their abundance due to their small size. This is an issue with the catch efficiency of the trawl gear.
- Gadoids are often in mixed aggregations along the bottom (Figure 2.2.6.6).
- Sprat schools can appear like herring, but often in shallower water, closer to shore and may be in very thin pillars compared to herring.
- The HERAS is conducted out to the shelf edge on the west of Scotland and herring not often found close to the edge. Strong pillar-like schools near or at shelf edge could be another pelagic species, e.g. boarfish.
- Mackerel show up stronger on 200 kHz (e.g. Korneliussen, 2010).
- Juvenile blue whiting are sometimes found in large aggregations close to bottom on the HERAS on the west coast, as well as in continuous layers.

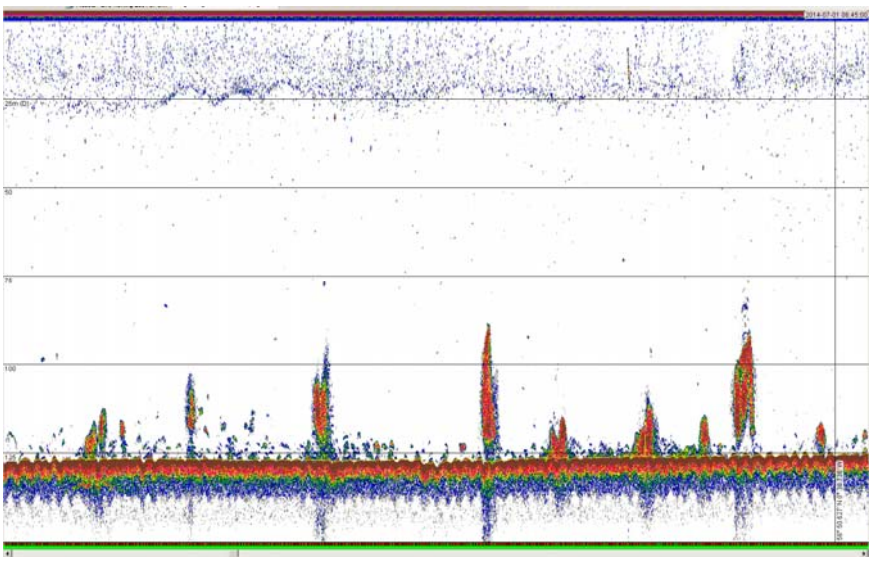


Figure 2.2.6.2a. Haul S14/184 (125 m depth, 1290 kg HER; 3.9 kg MAC).

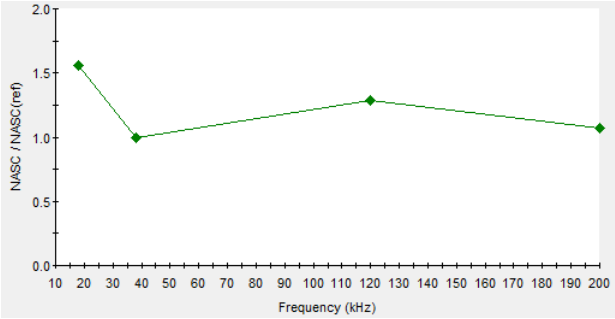


Figure 2.2.6.2b. Haul S14/184: Rel. frequency response (NASC/NASCref) of an individual herring school. Ref = 38kHz.

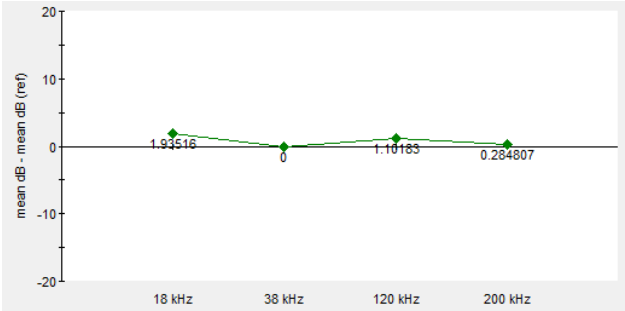


Figure 2.2.6.2c. Haul S14/184: Rel. mean dB (mean dB – mean dBref) of an individual herring school. Ref = 38kHz.

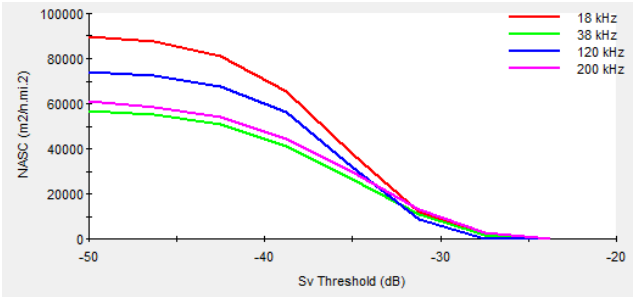


Figure 2.2.6.2d. Haul S14/184: Threshold response (NASC/Sv Threshold) of an individual herring school.

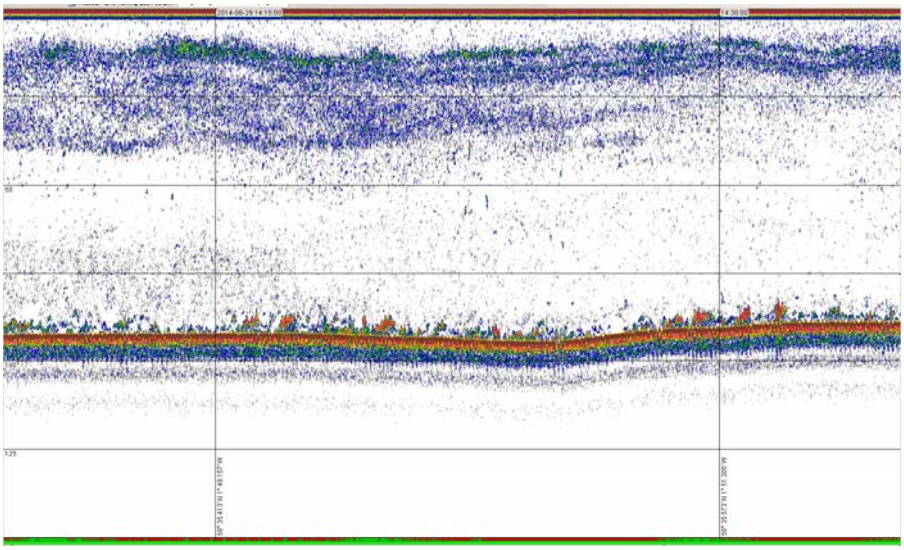


Figure 2.2.6.3a. Haul S14/179B (85 m depth, 22.49 kg NPO, 4.10 kg HER, plus 2.73 kg mixed fish).

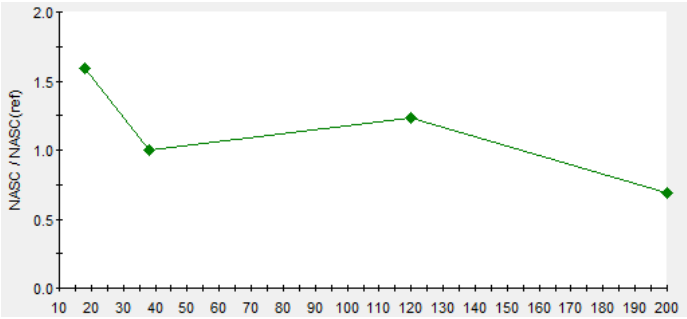


Figure 2.2.6.3b. Haul S14/179B: Rel. frequency response (NASC/NASCref) of an individual school. Ref = 38 kHz.

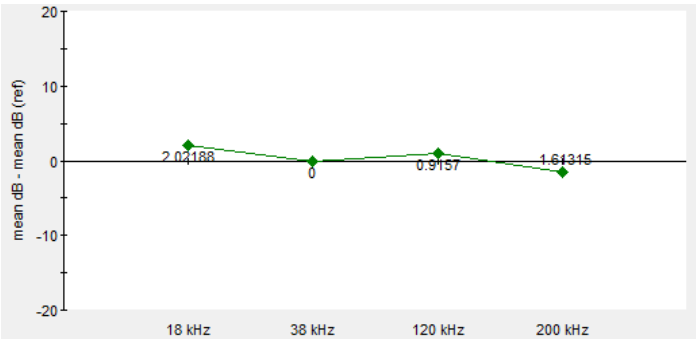


Figure 2.2.6.3c. Haul S14/179B: Rel. mean dB (mean dB – mean dBref). Ref = 38 kHz.

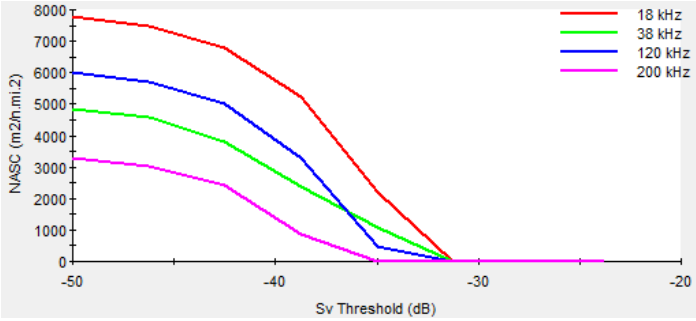


Figure 2.2.6.3d. Haul S14/179B: Threshold response (NASC/Sv Threshold).

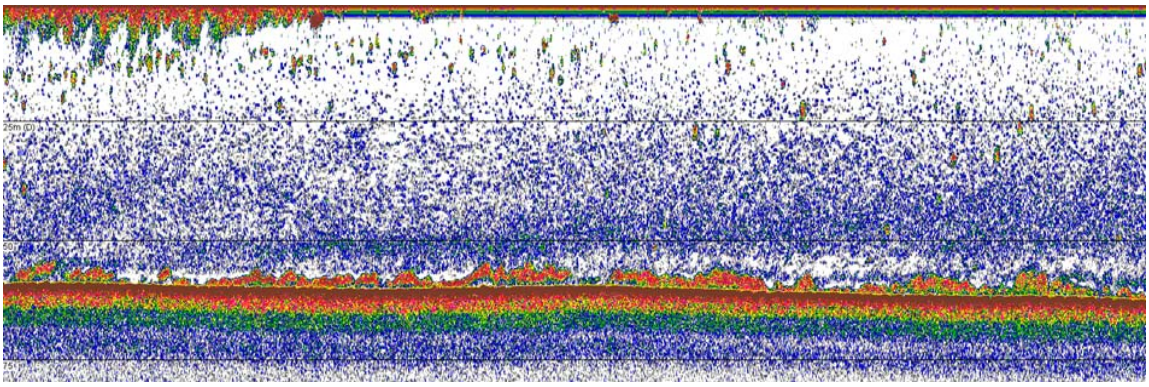


Figure 2.2.6.4. Haul S14/186. Haul summary comments: "Very little seen going in the net from the headline transducer". Catch: 0- group fish (NPO 0.002kg; HAD 0.004 kg; WHI 0.005 kg) and MAC 0.31 kg. (Note that NPO may not be retained in the codend of the trawl - they can be meshed in the panels).

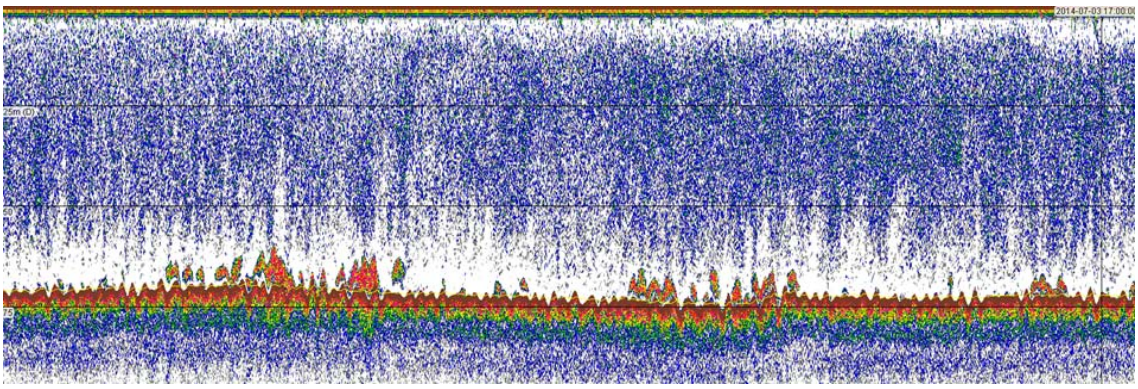


Figure 2.2.6.5. Haul S14/193. Haul summary comments: "Very little seen going in the net from the headline transducer". Catch: - NPO 0.004kg. In addition, evidence of NPO meshed in the wings.

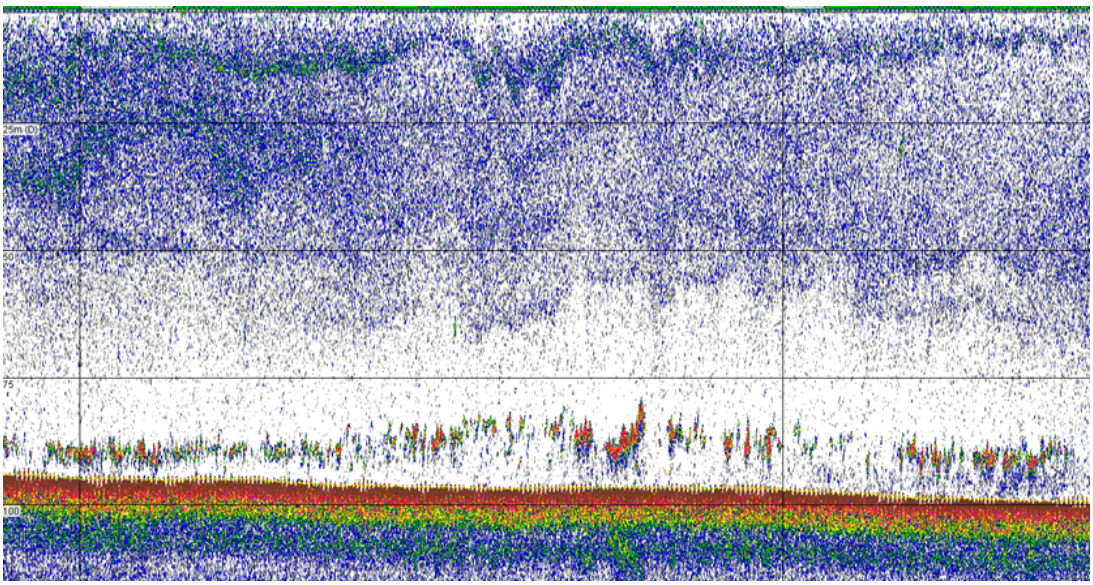


Figure 2.2.6.6. Haul S14/219. Catch: - NPO 1.774 kg; BWH 0.007 kg; WHI 0.003 kg and GGU 0.554 kg.

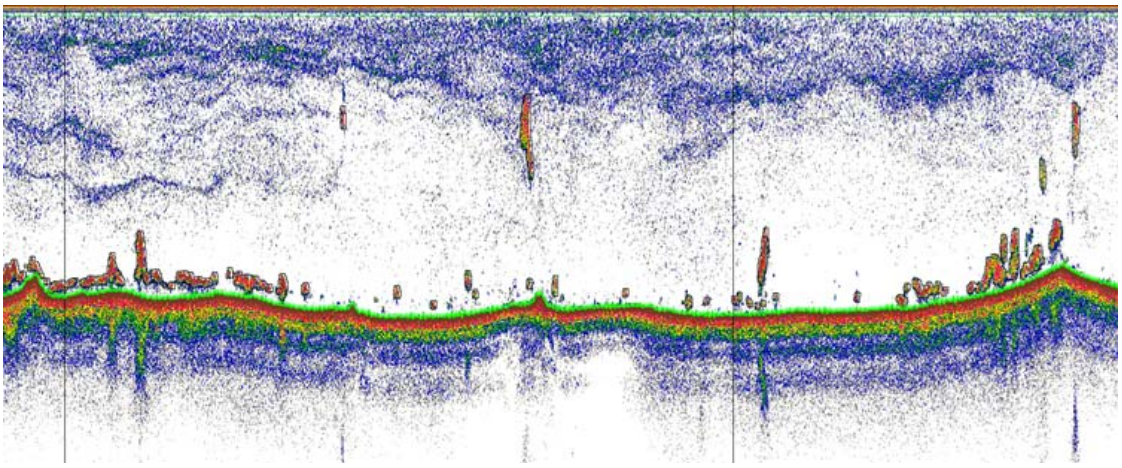


Figure 2.2.6.7. Haul S14/211. Catch: - HER 116.9 kg and NPO 0.3 kg.

There were problems distinguishing between herring and Norway pout in some areas in 2014. Marine Scotland scientists analysed 485 considered definite herring schools and 95 considered definite Norway pout schools from the HERAS in 2014 and found evidence of a difference in the mean dB frequency response curves (Figure 2.2.6.8). There appears to be a slightly negative mean dB response on the higher frequencies (120 and 200 kHz) compared to the 38 kHz. This is supported by work conducted by Fässler *et al.* (2007). Further work is required to build on evidence of such a relationship, but the results are encouraging.

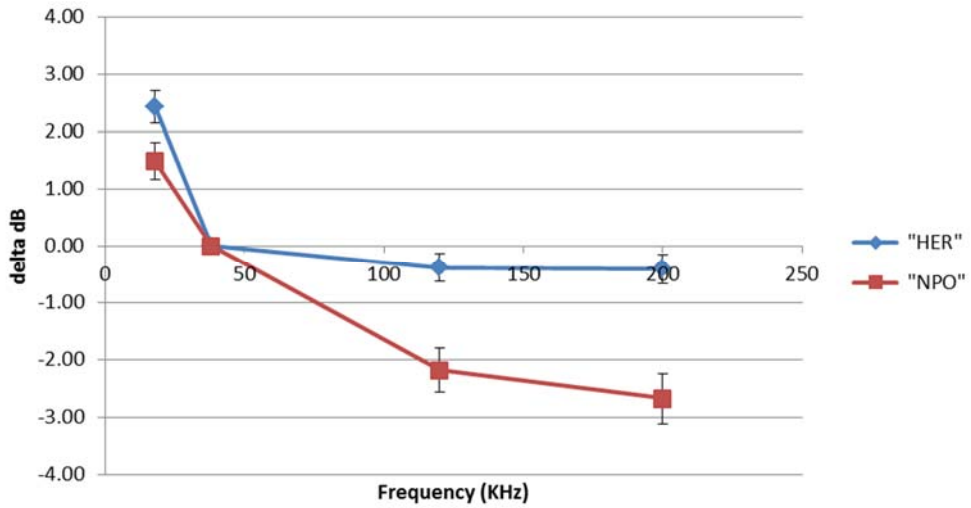


Figure 2.2.6.8. Average relative mean dB (mean dB – mean dBref; Ref = 38 kHz) for 485 herring schools and 95 Norway Pout schools identified during HERAS 2014.

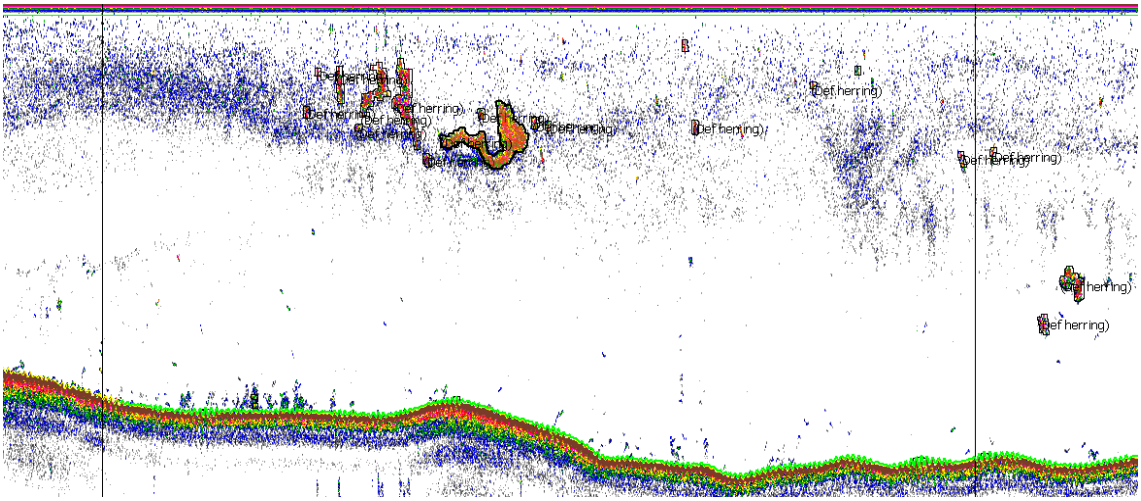


Figure 2.2.6.9a. Haul S15/212. Surface herring schools identified by trawl on HERAS 2015. Catch: HER 200kg; MAC 0.24kg; HMO 0.5kg; GGU 3.1kg.

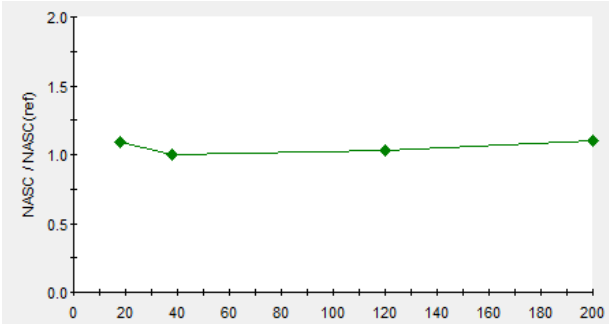


Figure 2.2.6.9b. Haul S15/212: Rel. frequency response (NASC/NASCref) of an individual surface school. Ref = 38 kHz.

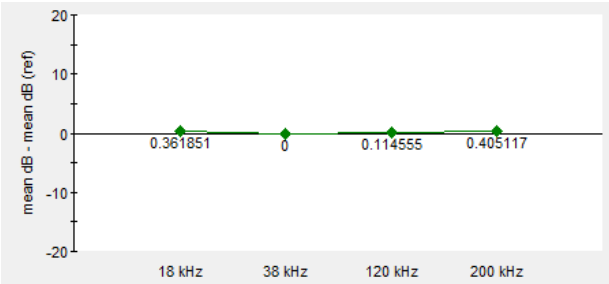


Figure 2.2.6.9c. Haul S15/212. Rel. mean dB (mean dB – mean dBref) of an individual surface school Ref = 38 kHz.

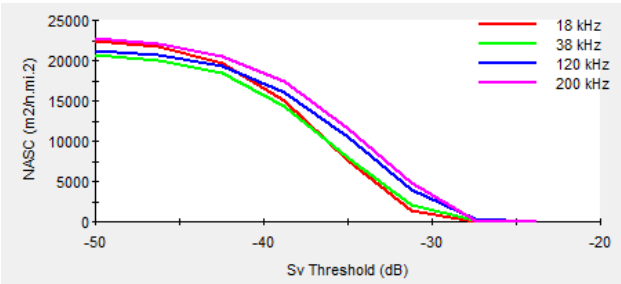
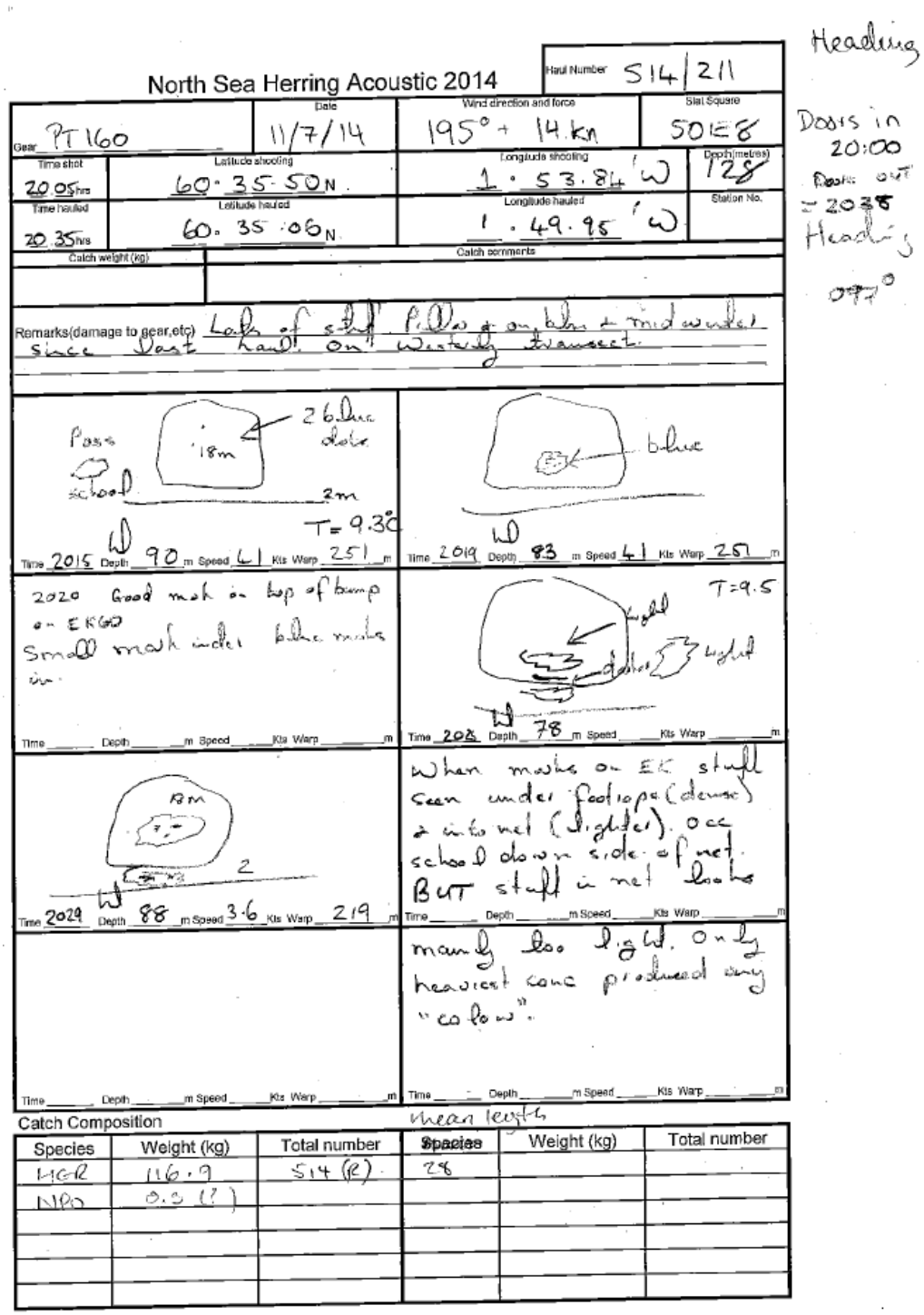


Figure 2.2.6.9d. Haul S15/212. Threshold response (NASC/Sv Threshold) of an individual surface school.



North Sea Herring Acoustic 2014

Haul Number 514/211

Gear PT 160 | Date 11/7/14 | Wind direction and force 195° + 14 kn | Stat Square 50E8

Time shot 2005 hrs | Latitude shooting 60° 35·50 N | Longitude shooting 1° 53.84' W | Depth (metres) 128

Time hauled 2035 hrs | Latitude hauled 60° 35·06 N | Longitude hauled 1° 49.95' W | Station No.

Catch weight (kg) | Catch comments

Remarks (damage to gear, etc) Lots of stuff P. Blue + on blue + mid water since last haul. On Westerly transect.

Pass school 18m 2m 26 blue dots T = 9.3° W Time 2015 Depth 90 m Speed 4.1 Kts Warp 251 m

W Time 2019 Depth 83 m Speed 4.1 Kts Warp 251 m blue

2020 Good mark on top of bump on EK60 Small mark under blue marks in. Time Depth m Speed Kts Warp m

T = 9.5 light dark light W Time 2025 Depth 78 m Speed Kts Warp m

8m 2 W Time 2029 Depth 88 m Speed 3.6 Kts Warp 219 m

When marks on EK stuff seen under footrope (denser) & into net (lighter). Occ school down side of net. BUT stuff in net looks mainly too light. Only heaviest conc produced any "co flow".

Time Depth m Speed Kts Warp m

Time Depth m Speed Kts Warp m

Catch Composition

Species	Weight (kg)	Total number	Mean length ~~Species~~	Weight (kg)	Total number
HER	116.9	514 (R)	28		
NPD	0.5 (?)				

Heading Doors in 20:00 Doors out 2038 Heading 077°

Figure 2.2.6.10. Example haul summary sheet from MRV 'Scotia' in 2014 (the corresponding echogram screenshot is shown in Figure 2.2.6.7).

3 IBWSS International survey program

3.1 Background

The International Blue Whiting Spawning Stock Survey (IBWSS) was established in 2004 and is carried out annually in March/April to determine the distribution and abundance of the Northeast Atlantic blue whiting stock during the spawning season west of Britain and Ireland. Participating vessels are from Russia, Norway, Ireland, Faroes and the Netherlands.

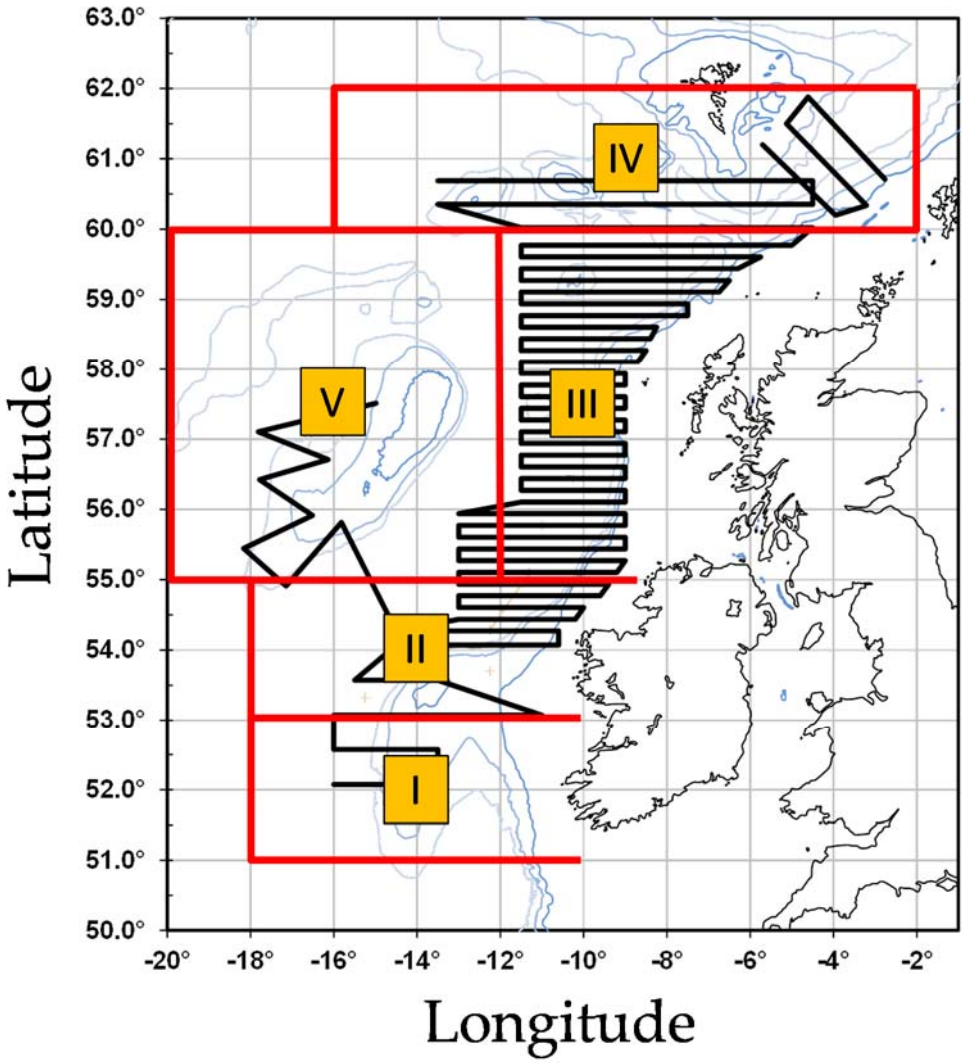


Figure 3.1.1. Geographical extent of the IBWSS survey area (red lines) with planned vessel cruise tracks (black lines) of the 2013 survey indicated as an example. Numbers indicate survey subareas used for reporting purposes (I: southern Porcupine Bank; II: northern Porcupine Bank; III: Hebrides; IV: Faroes/Shetland; V: Rockall).

3.1.1 Survey objectives

The survey aims to determine the distribution and abundance at age and length of the Northeast Atlantic blue whiting stock during the spawning season to the west of Britain and Ireland (Figure 3.1.1). This estimate is used as a tuning index by ICES to determine the size of the population and the results are submitted annually to WGWIDE.

Survey data are submitted to the WGNAPES online database. Coordination and planning of blue whiting surveys is undertaken during an annual post-cruise meeting and reported to WGIPS.

3.1.2 Survey time-series

Before 2004, the spawning areas of blue whiting west of the British Isles have most actively been surveyed by Norway and Russia. Some coordination of these survey activities took place over a number of years, until the Russian spawning stock survey was discontinued in 1996. Russia resumed the blue whiting spawning stock survey in 2001. In 2003, ACFM concluded that: "Several surveys on blue whiting are currently going on. ICES recommends that a coordinated survey be organized covering the main spawning grounds of blue whiting".

3.2 Methods currently applied for scrutinising acoustic data

3.2.1 Ireland

The Irish component of the International blue whiting spawning stocking survey (IBWSS) is conducted annually on board the RV 'Celtic Explorer' in March-April as part of the larger five vessel international survey. The RV 'Celtic Explorer' uses an Simrad EK60 scientific echosounder with four transducers (18, 38, 120 and 200 kHz) mounted on a drop keel. The drop keel is at 3.3 m extension during the survey, therefore the transducers are at 8.8 m depth from the surface. Data are collected over 24 hours per survey day. Acoustic calibration is carried out at the beginning of each survey. Estimates of blue whiting abundance and biomass are derived exclusively from 38 kHz data. A pelagic trawl (Figure 3.2.1.12) is used to sample fish marks and hauls are monitored using a transducer mounted on the headline of the net. Detailed notes are taken during trawl operations to assist scientists during scrutinisation.

Echosounder settings – Simrad split-beam EK60

Echosounder settings for the Irish Marine Institute portion of the IBWSS on the RV 'Celtic Explorer' are shown in Table 3.2.1.1. Survey environmental data, *i.e.* sound velocity, is entered into Echoview and EK 60 manually, from CTD readings taken during calibration. Raw EK60 files are saved at 10MB intervals. The echogram is also live-viewed and in Echoview and raw Echoview files recorded at 50MB intervals.

Echogram Preparation

- Software – Echoview (version 6.0).
- Files imported into Echoview template (e.g. from previous year).
- The most recent calibration file (.ecs file) is imported (calibration of all four frequencies is carried out before each IBWSS).
- Information on transducer location is imported; important for accurate depth readings and multifrequency analysis. Settings for IBWSS 2015 are shown in Table 3.2.1.2.

Table 3.2.1.1. Simrad EK60 settings on the RV 'Celtic Explorer' for IBWSS 2015.

FREQUENCY (KHZ)	18	38	120	200
Power (w)	2000	2000	500	300
Pulse Duration (ms)	1.024	1.024	1.024	1.024
Sample Interval (μs)	256	256	256	256
Interval (Hz)	1.0	1.0	1.0	1.0
Absorption dB/km	2.3	8.9	40.1	58.2
Sound velocity (m/s)	1490.2	1490.2	1490.2	1490.2
Athw. Beam Angle	10.72°	6.95°	7.26°	6.64°
Along. Beam Angle	10.61°	6.90°	7.22°	6.93°
Two-way beam angle (dB)	-17.0	-20.6	-20.8	-20.7

Table 3.2.1.2. Echoview transducer location settings for the RV 'Celtic Explorer'.

FREQUENCY (KHZ)	18	38	120	200
x-alongship offset (m)	0	0.68	0.39	0.39
y-athwartship offset (m)	0	0	-0.29	0.28
z-vertical offset (m)	8.8	8.8	8.8	8.8

The echograms are first processed to determine analysis and bad data regions. Information about on-transect and off-transect times are taken from acoustic and trawl log sheets from the survey. Procedures are as follows:

- Generate appropriate surface exclusion line (generally ca. 12 m, weather dependent
- Generate appropriate seabed offset line (1 m)
- Thoroughly examine bottom offset line to correct for any irregularities (e.g. drop outs, etc.) as well as ensuring that line is neither excluding schools or including seabed in fish schools
- Apply cell grid: 1 nautical mile by 50 m depth bins
- Define bad data regions (not included in analysis) and classify (e.g. type = bad data; class = pre/post survey track)
    - Data prior to start of transect
    - Data collected during trawls/CTD casts
    - Off transect for any other reason (e.g. end of day)
    - Inter-transect data

Echogram Scrutinising Procedure

Once the echograms have been partition by transect, the cell grid has been applied, and off-transect events have been excluded, the process of assigning schools and allocating species to those schools can begin. The echograms are generally analysed and echo integrals calculated at a threshold of -70 dB; where necessary heavy backscatter from plankton was filtered out by thresholding at –65 dB when isolating schools, but data export is carried out at -70 dB. Echo integration is performed on school (regions) that

are defined by enclosing selected parts of the echogram and allocated to species categories described below. All schools are drawn manually in Echoview (vers. 6.0) using the various box, freehand, and layer tools to delineate appropriate regions (no schools detection algorithm is used). The allocation of species to schools requires experience and many factors are incorporated; including information from trawl catch data, depth, location, environmental factors, known species behaviour, and relative frequency responses.

Allocation relies mainly on capture data from the closest trawl as this is the best indication of the species making up schools. There is an assumption that what is observed during trawling is representative of what is observed on survey track and is verified using video ground-truthing within the trawl. The best evidence based judgement is made by the scrutinising scientists. Factors considered when classifying school regions might include:

- Was trawl catch data directly from schools surveyed?
- Was trawl catch data in the area on similar schools?
- Was the catch large enough to be representative of the traces surveyed?
- Depth of schools in water column
- School shape/dimension
- Location and environment (temperature)
- NASC value for school
- Individual harder S_v values of data points within school (a distinct "kernel" of harder S_v values in middle of school)
- Experience from previous surveys/years
- Analysis of video footage
- Other information from survey boats in the area
- Time of day/light levels
- Frequency response curves:
  - Relative frequency response ($NASC/NASC_{ref}$)
  - Relative mean dB (mean dB – mean dB_{ref})
  - Threshold response ($NASC/S_v$ Threshold)

Species Classification

Examples of echograms prior to fishing and the associated species classifications are presented in Figures 3.2.1.1 to 3.2.1.11.

The NASC (Nautical Area Scattering Coefficient) values from each echotrace are allocated to one of 4 categories:

a) Blue whiting

b) Mesopelagic fish

c) Plankton

d) Pelagic fish (Including herring and mackerel)

General considerations

For each school, it is very likely that a combination of all information will be considered before final classification. The rules are subjective, with the experience of the scientists

very important at this stage. However, there are some general considerations that are useful as a starting point:

- Blue whiting during the spawning period (IBWSS survey) are found as homogenous schools, the appearance of other species within trawl catches should be carefully considered and is described further below.
- Mesopelagics contained within the trawl catches are often taken as bycatch during the passage of the trawl through the mesopelagic layer to the blue whiting target depth and should not be considered as a component of a mixed blue whiting layer.
- Small high density echotraces of mackerel are sometimes observed on the shelf /shelf slope area and are distinct from blue whiting aggregations. When trawling close to the seabed on the shelf slope these echotraces may appear as mixed catches within the trawl and this should be considered during the analysis.
- Small numbers of mackerel occurring in catches from what are considered 'pure' blue whiting echotraces may be due to the fact that individuals were actively feeding on the mesopelagic layer and were taken as bycatch during the passage of the trawl through this surface layer.
- Care should be taken to ensure representative sampling of the high-density blue whiting echotraces. Lighter density patches occurring above high-density regions especially close to the shelf edge have been known in some instances to contain a larger proportion of juveniles.
- Trawling into depths of less than 300 m will increase the chances of capturing more juveniles than maybe present in high density off shelf/shelf regions and so care should be taken to curtail trawling before these shallow depths area reached.

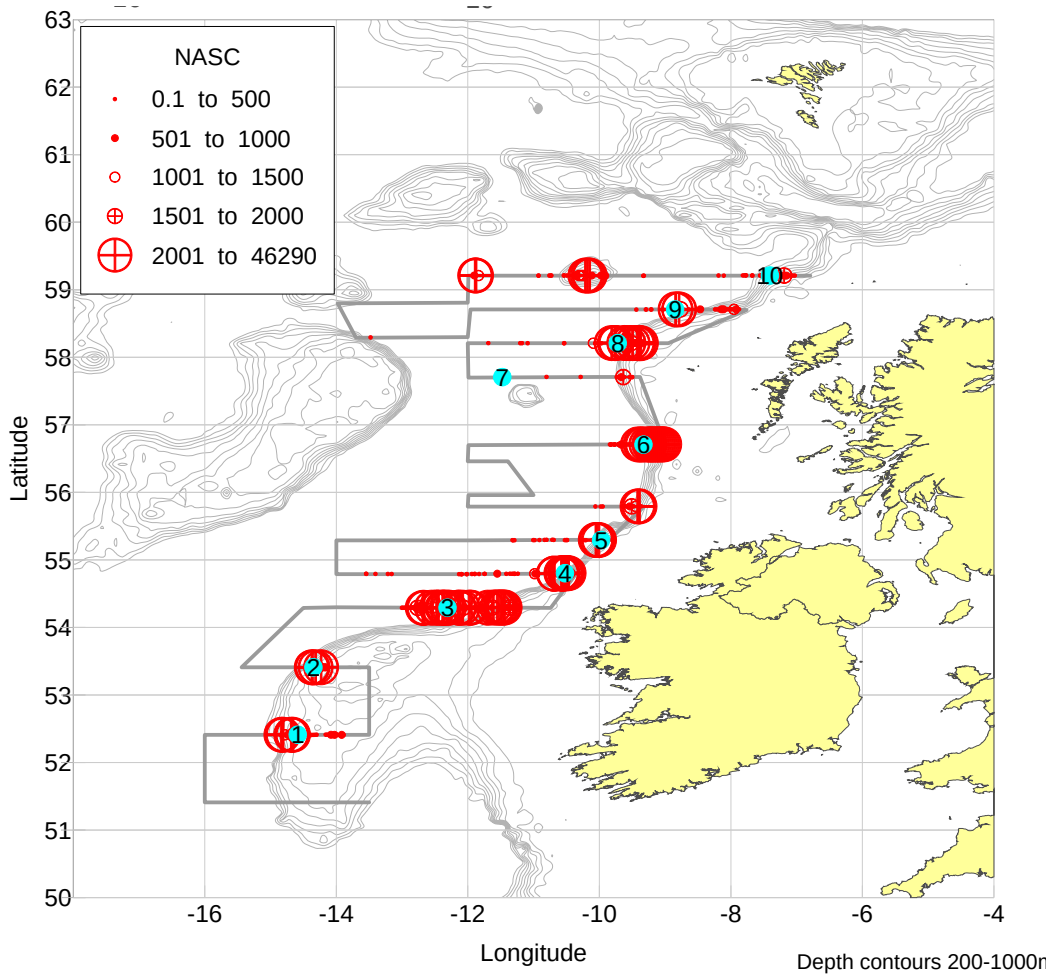


Figure 3.2.1.1. Map of blue whiting distribution (NASC) and trawl number (circled) for 2015. Echograms corresponding to haul number are listed below as verified examples.

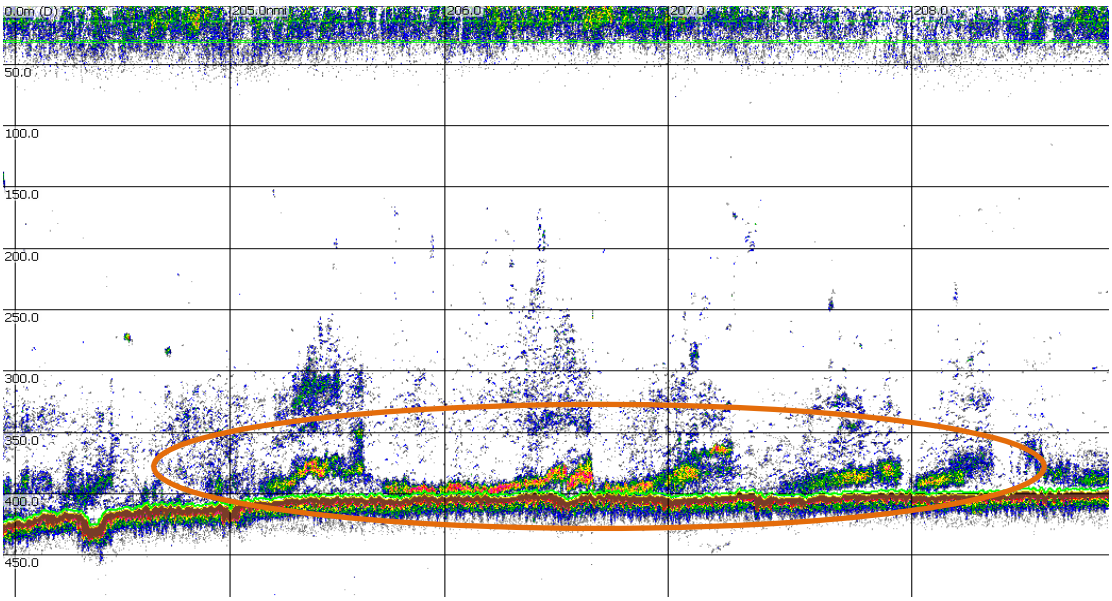


Figure 3.2.1.2. Haul 01, western Porcupine Bank. Catch 99.8% blue whiting (circled orange), weight 3,500 Kg. Daylight haul.

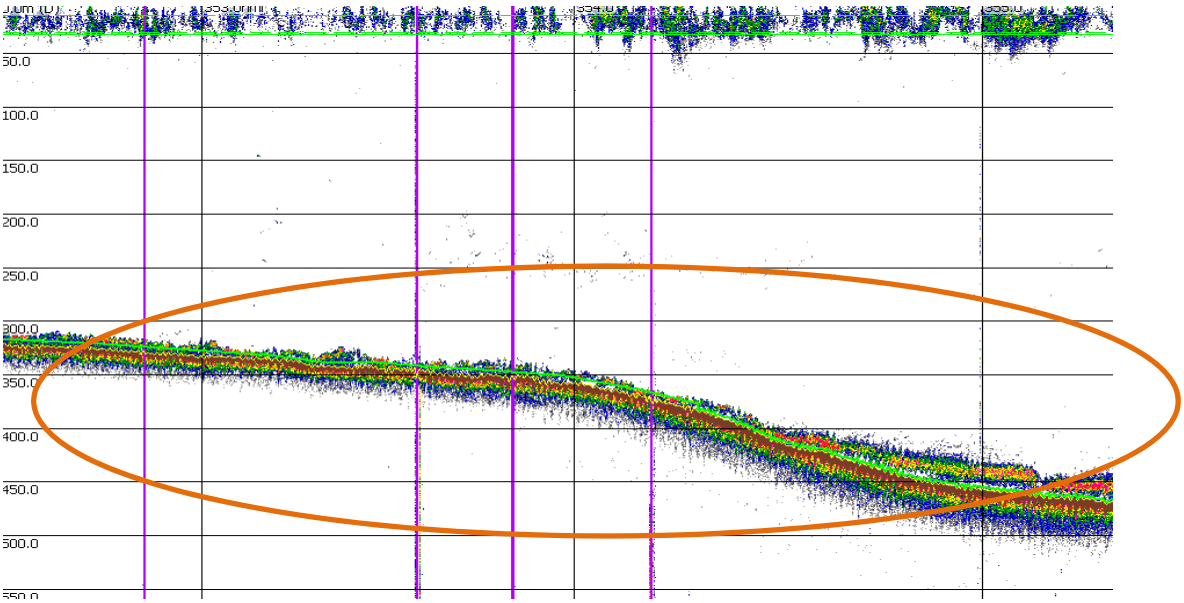


Figure 3.2.1.3. Haul 02, Shelf slope western Porcupine Bank. Catch 99.8% blue whiting (circled orange), weight 2,500 Kg. Daylight haul.

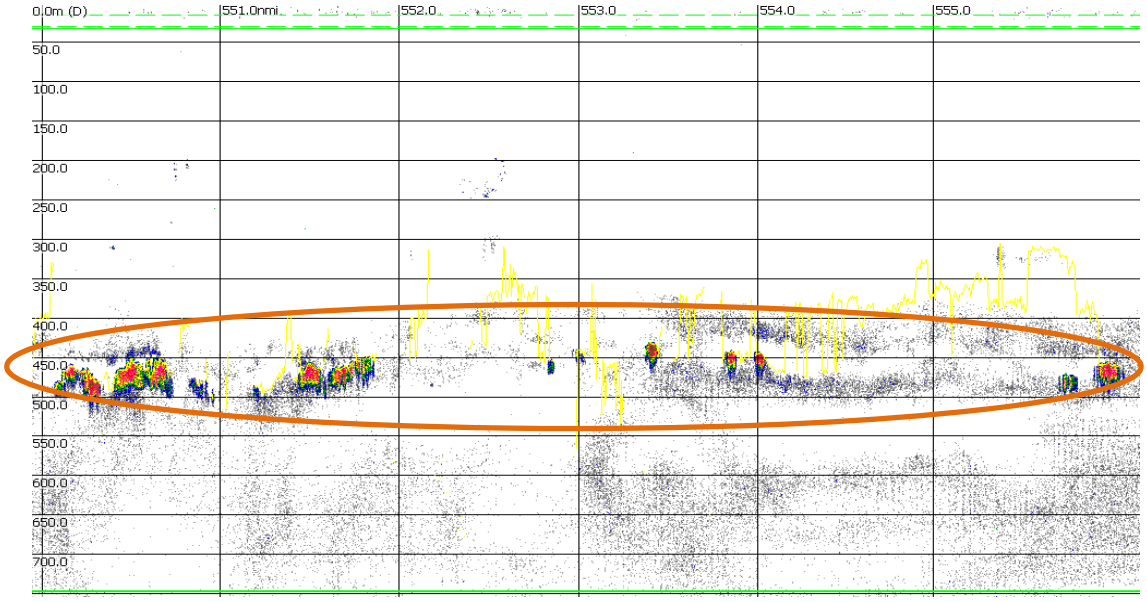


Figure 3.2.1.4. Haul 03, Open water north Porcupine Bank. Typical off-shelf aggregations. Catch 90.6% blue whiting (circled orange), weight 200 Kg. Daylight haul.

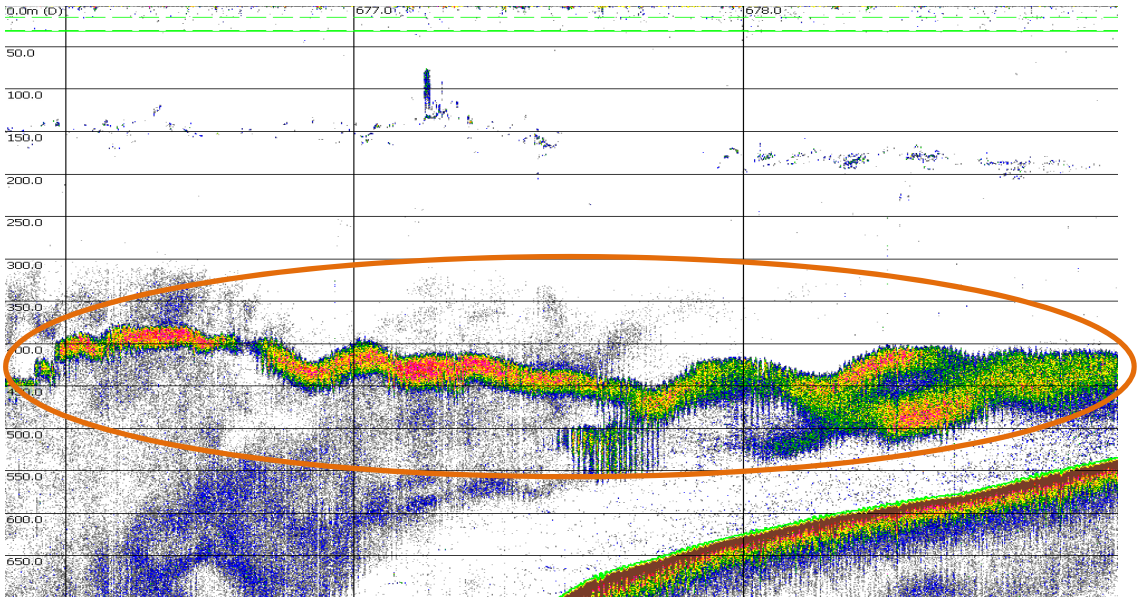


Figure 3.2.1.5. Haul 04, West of Ireland. Typical shelf slope aggregations. Catch 84.8% blue whiting (circled orange), 14.2% mackerel, weight 4,000 Kg. Mackerel not visible here but were taken in close proximity to seabed. Note mesopelagic layer at 130–200 m. Daylight haul.

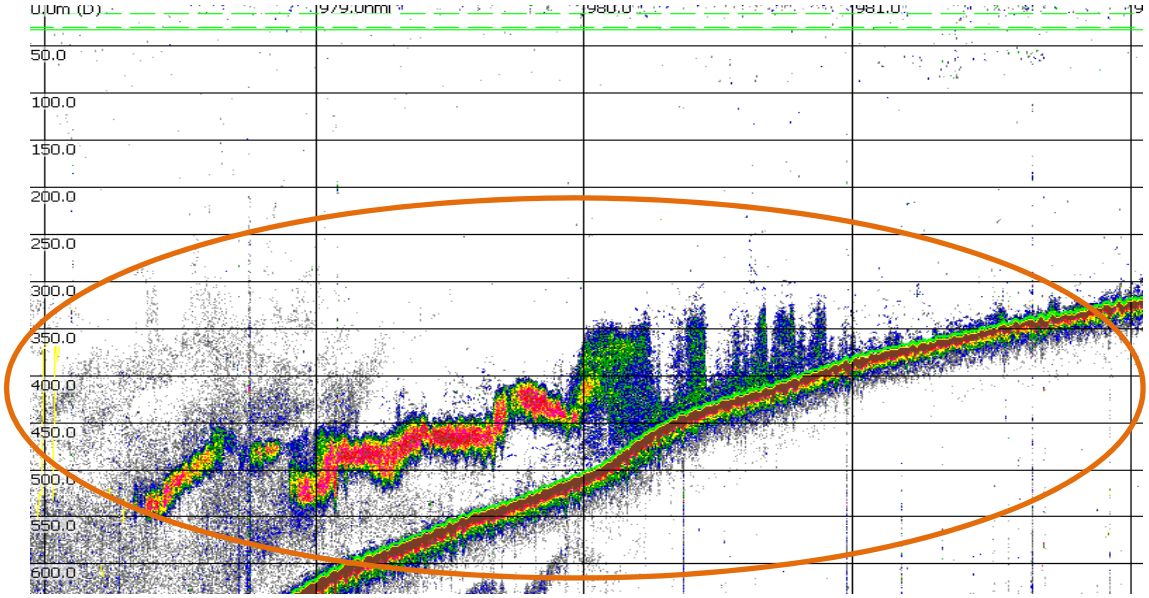


Figure 3.2.1.6. Haul 05, West of Ireland. Typical shelf slope aggregations. Catch 100% blue whiting (circled orange), weight 3,500 Kg. Daylight haul.

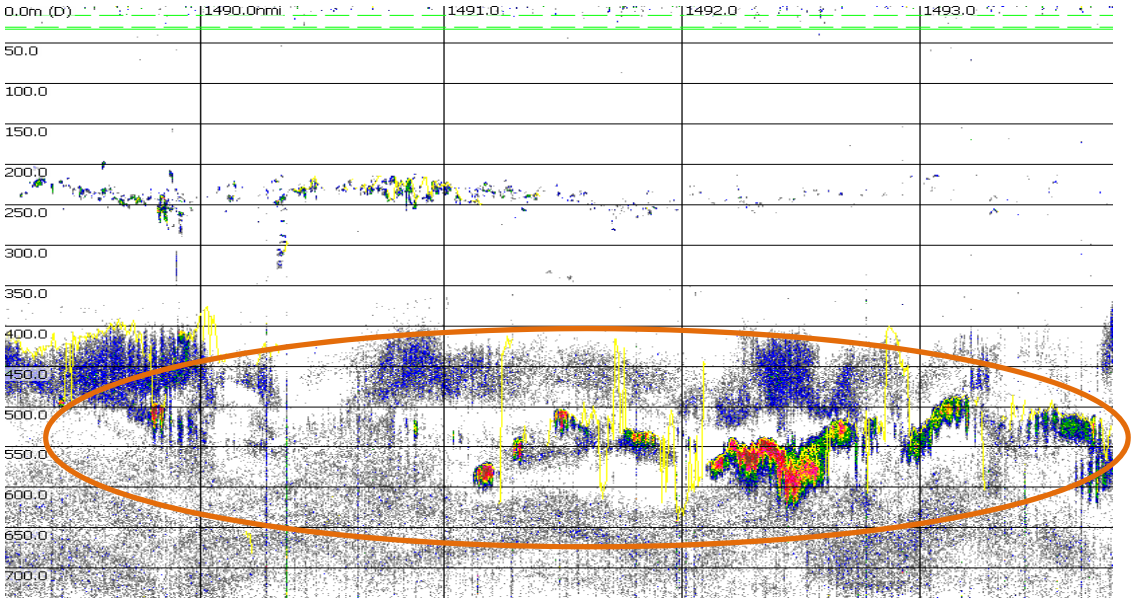


Figure 3.2.1.7. Haul 06, West of Ireland. Typical open water aggregations. Catch 99.7% blue whiting (circled orange), weight 3,500 Kg. Note mesopelagic layer at c.200–250 m. Daylight haul.

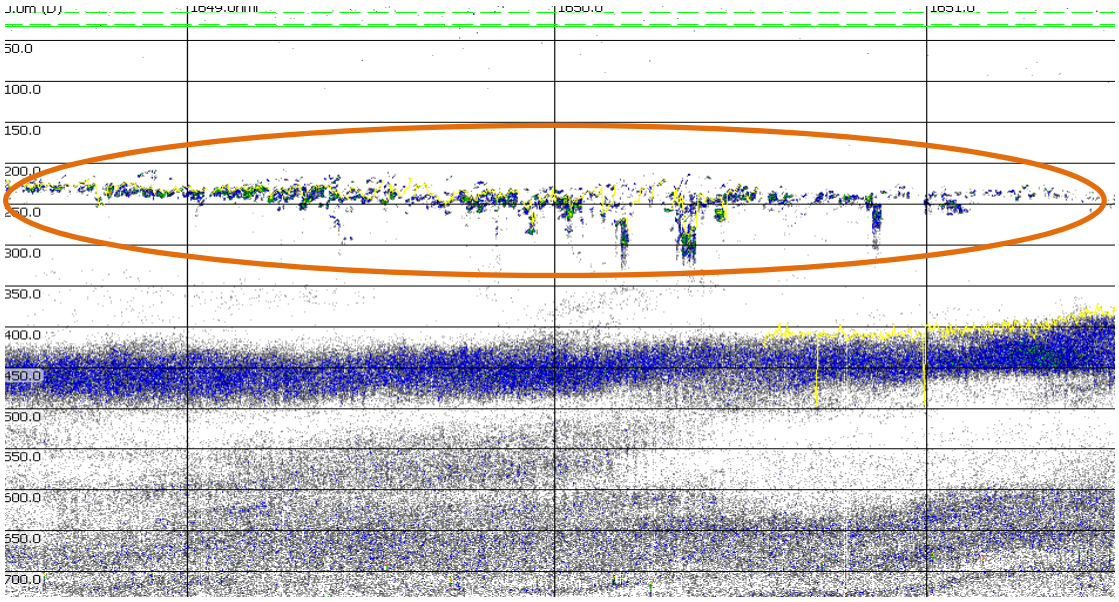


Figure 3.2.1.8. Haul 07, Open water west of the Anton Dohrn Seamount. Dedicated mesopelagic haul. Catch 100% mesopelagics (circled orange), weight 2 Kg. Note target layer at c.200–250 m. Daylight haul.

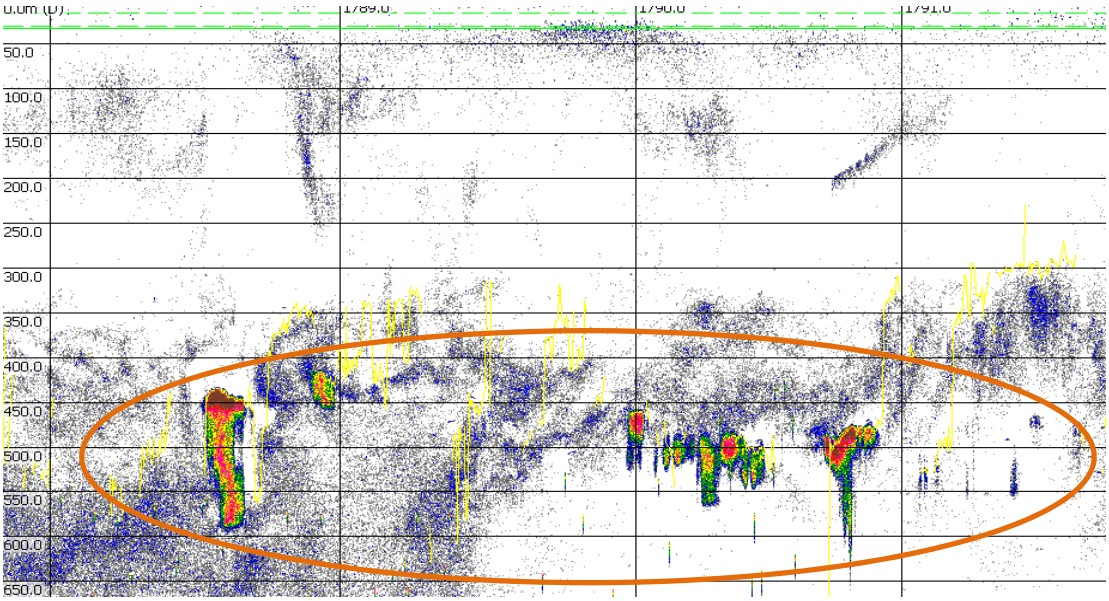


Figure 3.2.1.9. Haul 08, Hebrides shelf area. Typical open water aggregations. Catch 99.7% blue whiting (circled orange), weight 4,000 Kg. Dawn haul.

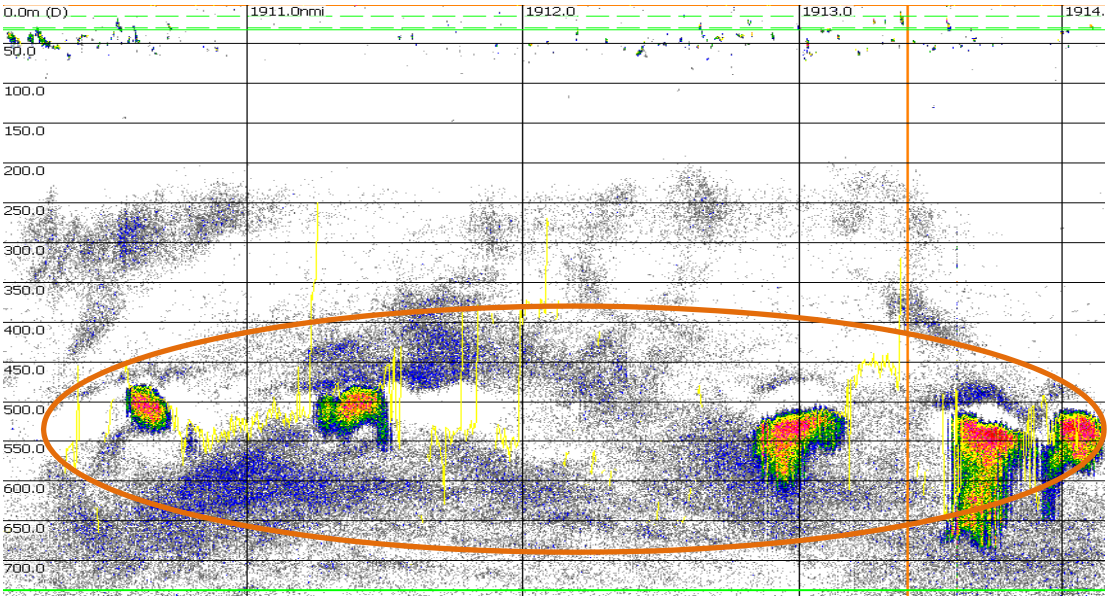


Figure 3.2.1.10. Haul 09, Hebrides shelf area. Typical open water aggregations. Catch 97.5% blue whiting (circled orange), weight 1,500 Kg. Note mesopelagic layer near surface. Daylight haul.

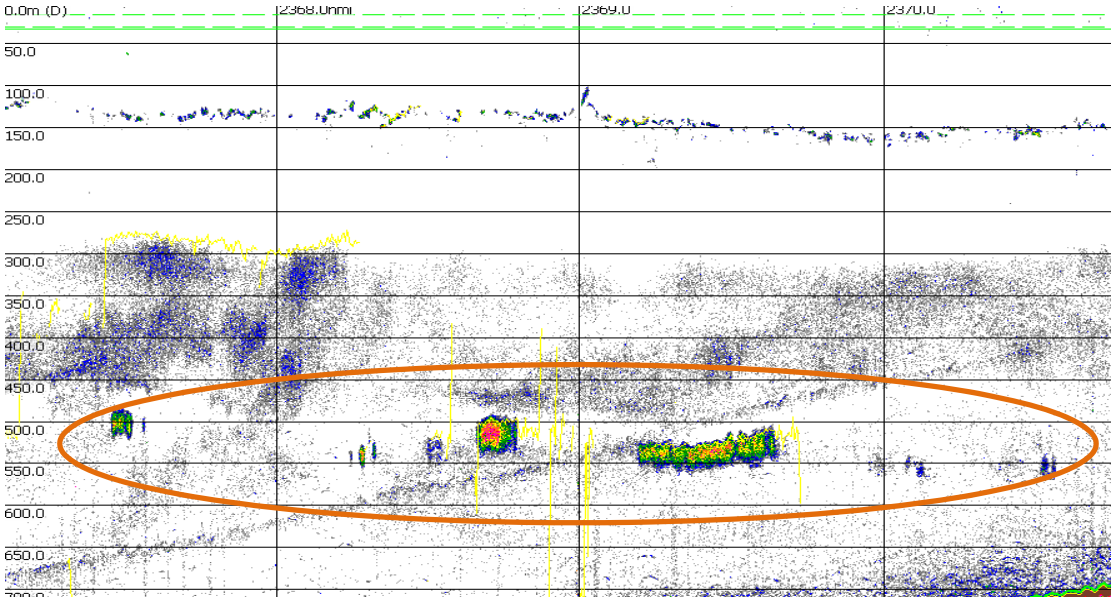


Figure 3.2.1.11. Haul 10, West of Ireland. Typical open water aggregations. Catch 96.2% blue whiting (circled orange), weight 500 Kg. Note mesopelagic layer at c.100–180 m. Daylight haul.

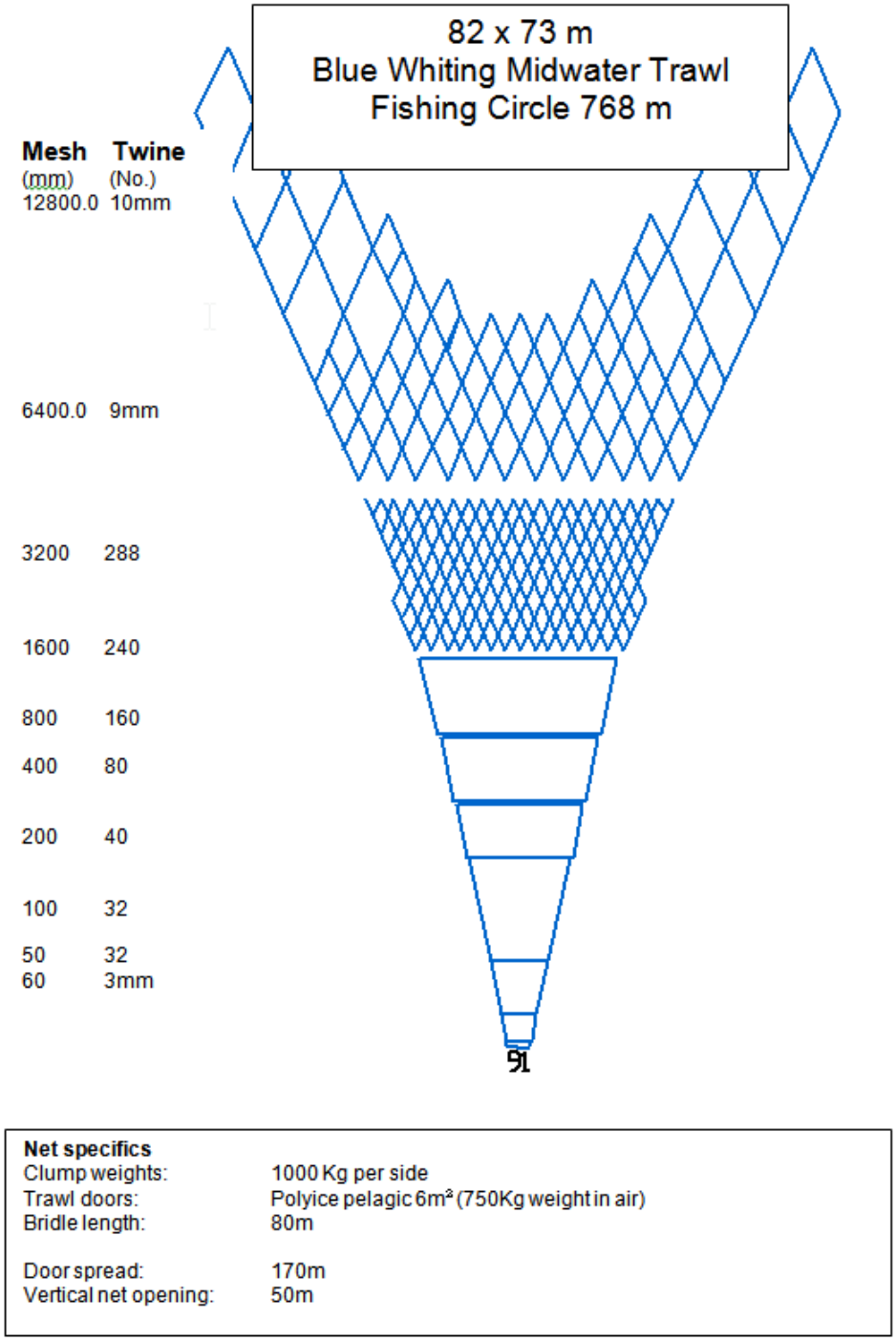


Figure 3.2.1.12. RV 'Celtic Explorer' blue whiting midwater trawl employed during the blue whiting acoustic survey, March 2015.

3.2.2 Netherlands

Survey

The Dutch component of the ICES coordinated International blue whiting spawning stocking survey (IBWSS) is conducted annually on board the RV 'Tridens' in March/April. From 1996 to 2014, a Simrad EK60 38 kHz split-beam transducer mounted in a towed body ("shark") was used during the surveys. In 2001, a Simrad EK60 200 kHz echosounder was added to the towed body.

In 2015 the RV 'Tridens' underwent an extensive refit. Transducers are now mounted close together on a newly fitted drop-keel, which protrudes 3.23 m below the vessel giving a total transducer depth of around 9 m below the water surface. The drop-keel is equipped with Simrad EK60 scientific echosounders operating at 18, 38, 70, 120, 200, and 333 kHz. In future broadband Simrad EK80 echosounders will replace the existing EK60 units. All acoustic systems are synchronized using the Kongsberg K-sync unit. All acoustic equipment is calibrated prior to the start of each survey, typically in a sheltered location on the West coast of Ireland. A second opportunistic mid-survey calibration (weather and time-dependent) is sometimes performed west of Scotland. If time allows inter-vessel calibrations are organized opportunistically. The last inter-vessel calibration was done with the RV 'Celtic Explorer' in 2012.

Acoustic data are logged 24 hours per survey day down to a depth of 750 m using a threshold of -82 dB. The EK60 receives position data and vessel speed from the ship's GPS. The data are logged in 1 nautical mile intervals. A variable ping rate is used near the shelf edge to avoid false bottom echoes. A typical vessel speed of 10 knots is used to avoid interference with the acoustic data.

Acoustic recordings are identified using a 5600 mesh pelagic trawl with 20 mm meshes in the codend. Fishing is carried out when large or dense recordings are observed on the echogram and to obtain biological samples of blue whiting. If time allows, one deep haul (approx. 1000 m) has been carried out to collect mesopelagic species. A netsonde system is mounted to the headline of the net to monitor the position of schools in the water column and direct the trawl during fishing events.

Scrutinisation procedure

Typically, scrutinisation is carried out using the latest version of LSSS. Additionally, the Live Viewing module of Echoview is used to screencast the echograms on different computers in near real time. In 2015, raw data were logged and post-processed with Echoview (v 6.0) software. This was due to the spikes caused by the bad weather and the ease at which a spike removal algorithm could be developed in Echoview. Scrutiny is carried during the survey, usually starting two or three days after the start and thereafter on a daily basis. Scrutiny is generally conducted by two expert scientists who are able to discuss complex or uncertain cases until agreement is reached. The following describes the procedure carried out using LSSS.

After setting up a new survey (i.e. database directory, location of calibration files, vessel information etc.) the acoustic data are read in to LSSS. The data are then preprocessed using the KORONA module, which filters the raw data by removing spikes and noise. Bad data regions (i.e. trawling events, hydrographic stations, inter-transects, and streaming to and from the survey area) are then removed from the analysis. Integration of acoustic values starts at 10 m below the transducer and ends 0.5 m above the bottom. Estimates of blue whiting abundance and biomass are obtained exclusively from 38

kHz data. However, if available other frequencies are used to help with target classification. Schools and layers are manually selected across the whole survey by the scrutinisers. Acoustic density values (Nautical Area Scattering Coefficient [NASC]) by log interval corresponding to blue whiting, based on school characteristics, trawl catch composition and expert judgement, are assigned to the category "blue whiting". Other acoustic categories include: "mesopelagic", "plankton", "mackerel" and "unidentified". These are assigned based on the judgement and experience of the expert scrutinisers, as well as using dB differencing and variable thresholds. Integrated data are then exported to the LSSS database using an EDSU of 1 nmi at a threshold of -82 dB. These data are then formatted according to the requirements of the assessment.

3.2.3 Norway

The Norwegian component of the International blue whiting spawning stock survey (IBWSS) is conducted annually on board a research vessel or a larger hired commercial vessel in March-April as part of the larger five vessel international survey. The vessel uses a Simrad EK60 scientific echosounder with multiple transducers (normally 4 to 6 different frequencies) mounted on a drop keel. The drop keel is at 3–4m extension during the survey, therefore the transducers are at approx. 9 m depth from the surface. Data are collected over 24 hours per survey day. Acoustic calibration is carried out at the beginning of each survey. Estimates of blue whiting abundance and biomass are derived exclusively from 38 kHz data. A pelagic trawl is used to sample fish marks and hauls are monitored using a transducer mounted on the headline of the net. Detailed notes are taken during trawl operations to assist scientists during scrutinisation.

Scrutinisation is carried out using the latest version of LSSS following the procedures above.

4 IESNS International survey program

4.1 Background

The International Ecosystem surveys of the Nordic Seas (IESNS) aims for exploring the pelagic ecosystem, with a special focus on herring, blue whiting, zooplankton and hydrography. The survey is carried out annually in April-June with participating vessels from EU, Iceland, Faroe Islands, Norway and Russia. The annual report from the IESNS survey is published as an appendix to the report of the ICES Working Group on Widely Distributed Stocks (WGWIDE).

The survey area is split into three Subareas: Area I, Barents Sea area, Area II, Northern and central Norwegian Sea Area, and Area III, the Southwestern Area (Figure 4.1.1),

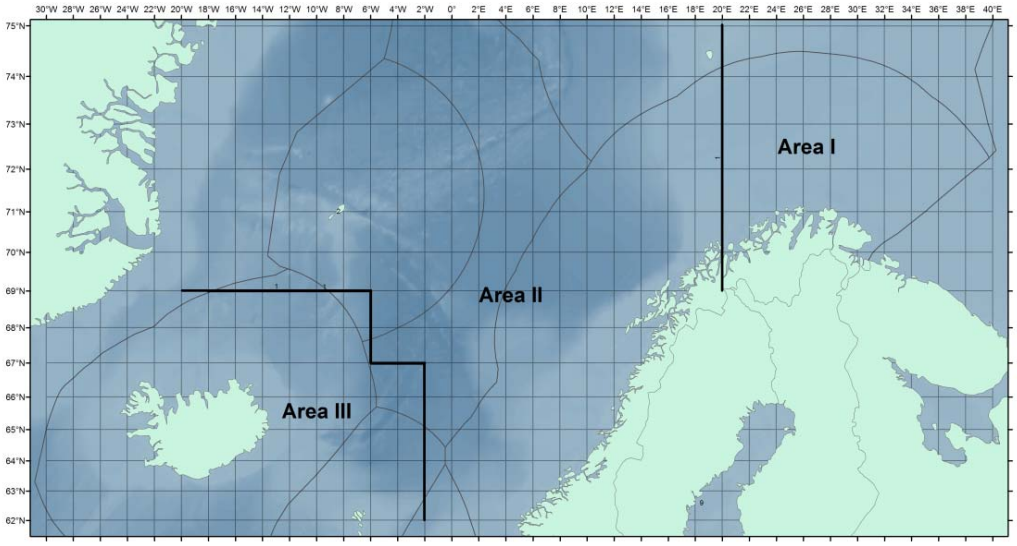


Figure 4.1.1. Areas defined for acoustic estimation of Norwegian spring-spawning herring in the Nordic Seas.

The survey was first established in 1995 by the Faroese, Iceland, Norway and Russia. Since 1997, the EU has participated (except 2002 and 2003) and from 2004 onwards it was more developed into an ecosystem survey.

4.1.1 Survey objectives

The main objective of the IESNS cruise is obtaining age-disaggregated biomass estimates of Norwegian Spring-spawning (NSS) herring, which are used as tuning series in the analytical assessment. Acoustical data are sampled for NSS herring and blue whiting, as well as biological samples (such as length, weight, age) from all species caught in opportunistic trawl samples. In addition hydrographical and zooplankton data are collected.

4.1.2 Survey time-series

Age-disaggregated abundance estimates of herring and blue whiting are available from 1996 onwards. Data from the survey are stored in the NAPES database currently managed by the Faroes.

4.2 Methods currently applied for scrutinising acoustic data

The acoustic methods used by the participating countries are fairly similar. A rough description of the methods is given in Annex 4 which are notes taken on a cruise-specific scrutinizing meeting held in Reykjavik in March 2015. These notes must, however, be regarded as tentative as they will be changed continuously as new information and methods turn up.

5 Scrutinisation exercises conducted during the workshop

5.1 Data call

The group identified a need for a workshop to review current scrutinisation methods applied in surveys coordinated by WGIPS during the corresponding meeting in January 2014 (WGIPS Report 2014)

The data call

Survey coordinators and national post-processors of acoustic data were asked to provide acoustic raw data of echorecordings that were considered

a) Representative for the area, time of year as well as species composition of the corresponding surveys, i.e. typical echograms encountered regularly during the surveys.
b) Exceptional and challenging to scrutinise, i.e. observations that would require a broader plenary discussion on both interpretation of echotraces as well as post-processing procedures applied.

Additionally, participants were asked to provide trawl information data (catch composition) related to the corresponding acoustic raw data to aid in species allocation of echotraces.

The deadline for submissions of data was **Friday the 14th August 2015.**

Pre-workshop tasks

Methods review

It was requested that each participant provide a detailed description of echo recording as well as scrutinisation methods employed at a national level in advance of the WKSCRUT workshop. This included all steps involved from echosounder settings for recording of raw data to scrutinisation methods and approaches followed by the corresponding post-processors.

A SharePoint had been set up specifically for the WK: WKSCRUT SharePoint.

Data

Acoustic raw data, together with trawl haul information, were provided by participants from the Netherlands, Germany, Scotland as well as Ireland by the deadline specified above. During the meeting, further raw data was made available from Spain (PELACUS survey), Norway (IESNS survey) as well as Denmark (HERAS Skagerrak-Kattegat acoustic survey). Due to time constraints and preparation procedures required for scrutinisation exercises, only exemplary data from IESNS could be scrutinised and discussed during the meeting.

Altogether, 97 sets of acoustic raw data from three surveys were made available from five countries, categorized into “typical” and “challenging” situations (Table 5.1.1).

Table 5.1.1. Datasets made available by participants.

Survey	Country	"typical"	"challenging"
HERAS	GER	4	6
	IRL	1	4
	NL	21	10
	SCO	12	17
IBWSS	NL	10	11
IESNS	NOR		1
TOTAL		**48**	**49**

5.2 Scrutinisation exercise

Germany, Scotland, Ireland and the Netherlands provided data in the agreed format before the workshop. These were made available on a server. During the workshop Norway, Scotland and Denmark added further files. Some time was spent to synchronize the format of the files which were available. In addition, differences in output of LSSS and Echoview had to be solved. LSSS has a limited number of output reports. Therefore, Echoview files had to be adjusted it to the outputs, which were created by LSSS.

For the German, Dutch and Scottish data a semi-random selection was made out of the available files. The set of files to be scrutinized were given a case number. After a rough scrutiny by the group, for separate file the acoustic categories (species) for assignment were agreed.

The available datasets were scrutinized by the participants with the post-processing system (EV or LSSS) that are used during their National surveys. The scrutiny teams consisted of experts who participate on several ICES coordinated surveys and therefore each had a particular knowledge of an area, survey, species or group of species. No single individual or team of individuals had experience with all types of survey data and species. The teams and the post-processing systems they were using are listed in Table 5.2.1. Participants were required to allocate species-specific NASC-values to echotraces detected in predetermined categories. Additional trawl haul information was provided for each dataset. Results (species- or category NASC values)-were entered in an Excel score-sheet for the collection of the data. Table 5.2.2 provides the headers and the first lines as an example.

Table 5.2.1. Post-processing applications used be the participants.

TEAM	ECHOVIEW	LSSS
Germany	X	
Netherlands 1	X	
Netherlands 2		X
Netherlands 3		X
Norway		X
Scotland	X	
Ireland	X	
Spain	X	
Denmark	(X)	

Table 5.2.2. Exemplary combined score sheet for the collection of scrutinized data. ID – Dataset ID, Log Int – Interval, HER – Herring, SPR – Sprat, WHB – Blue Whiting, MAC – Mackerel, BOC – Boarfish, OTH – Others.

ID	Survey	Log Int	HER	SPR	WHB	MAC	BOC	OTH	(…)	HER/SPR	Name
1	NL_HERAS	562	0	0	0	0	0	0	(…)	0	MS
1	NL_HERAS	563	173	0	0	0	0	0	(…)	0	MS
1	NL_HERAS	564	206	0	0	0	0	0	(…)	0	MS
1	NL_HERAS	565	0	0	0	0	0	0	(…)	0	MS
1	NL_HERAS	566	1292	0	0	0	0	0	(…)	0	MS
1	NL_HERAS	567	82	0	0	0	0	0	(…)	0	MS
1	NL_HERAS	568	2	0	0	0	0	0	(…)	0	MS
1	NL_HERAS	569	375	0	0	0	0	0	(…)	0	MS
1	NL_HERAS	570	0	0	0	0	0	0	(…)	0	MS
1	NL_HERAS	571	2	0	0	0	0	0	(…)	0	MS

Not all file sets have been scrutinized by all the teams, whereas some teams scrutinized additional files. The actual overview of scrutinized files by country or team is given in Annex 2. Denmark and Spain did not participate in the scrutinisation exercise.

5.3 Results

Generally, there was good agreement between individual scrutinisers or teams of scrutinisers. As would be expected for simple single-species echograms, results were very comparable to each other. However, for more complex, mixed-species situations results were much more variable. Typically experienced scrutinisers of the same survey agreed very well with each other, whereas differences originated from inexperience of post-processing across surveys (IBWSS, HERAS). For example, several of the participants had never seen a blue whiting echogram prior to the workshop. This naturally resulted in partially incorrect allocations of NASC-values to blue whiting. This was particularly apparent from the occasional misidentification and erroneous inclusion of mesopelagic scattering layers or plankton as dispersed schools of blue whiting. Furthermore, when analysing scattering layers close to the continental shelf scrutinisers sometimes had difficulties identifying where the blue whiting marks ended when crossing the shelf. This resulted in some discrepancies in the scrutiny of the echotraces in this area. In such circumstances, analysing acoustic data over wide temporal and geographical scales was helpful to clearly identify different scattering layers in these oceanic offshore situations. Thresholding techniques were used by some of the more experienced blue whiting scrutinisers. However, the use of thresholding techniques to identify scattering layers were sometimes different between scientists.

Lack of adequate trawl information was highlighted as a particular issue. This resulted in misallocation of species from trawl information and therefore differences in the allocation of proportions of the catch to NASC-values. Some scrutinisers were not confident with allocating NASC to species knowing the limitations and selectivity of certain sampling gear. For example, there was an issue with herring and Norway pout catches in some areas in 2014. Many smaller Norway pout were assumed to have slipped through the mesh and therefore were unrepresented in the trawl. This led to difficulties

in allocating NASC-values to herring and Norway pout in some areas. During this exercise, although trawl data were available for each of the 25 datasets, scrutinisers often felt that they did not have access to all the data that is usually available during the surveys. These included for example; trawl sheets, which have notes on trawl location and depth, plus incidences of fish moving through the net according to netsonde systems. Also, optical systems attached to the inside of the net close to the codend are now used by several participating nations during acoustic surveys. Both of these provide additional ground-truthing information, which are used during scrutiny on board research vessels during the surveys. Furthermore, those involved in the specific surveys were aware of certain details unknown to the rest of the group, which would have proven very useful in the correct allocation of NASC values. There was agreement among the group that having species- and survey- specific experienced scientists on each survey was the most important part of correct echogram scrutiny.

Quite often in-experienced scrutinisers would simple miss aggregations of fish during the scrutinisation procedure. For example, some groups missed herring schools close to the surface. These often form small dense marks, which can contribute a large amount to the total NASC-value for a particular EDSU. Some groups would ignore or misinterpret schools which were hard on the seabed. These particular echotraces were sometimes considered misleading as some scrutinisers marked these as fish schools whereas others considered them as features of the seabed such as boulders, shipwrecks and pipelines. A precautionary approach sometimes led to the exclusion of some of these dense marks, which would contribute a considerable proportion to the NASC. During a survey, marks such as these would be mapped several times to confirm whether they are in fact stationary seabed features or very dense mobile fish schools. Use of multibeam systems was also suggested to help distinguishing such marks from stationary objects due to the additional availability of 3D shape information. The surface and bottom line margins were also sometimes different between the groups. For example, a bottom margin of 0.5 m led to exclusion of parts of schools if not manually redrawn, whereas a surface line of 10 m would ignore clear marks, which would otherwise be included in the analysis. In discussing those cases, it was evident that both echotraces close to the seabed and close to the surface have to be treated with caution due to for example, acoustic dead zone or transducer nearfield effects.

Further difficulties were encountered when different species formed similar school shapes and demonstrated similar schooling behaviour (i.e. distance from seabed and schooling density). This was a common problem for clupeid species in particular, as well as Norway pout and herring in the Scottish and Dutch areas of the HERAS survey in some years. Splitting of NASC is difficult if species have similar or identical scattering and schooling properties which are not discernible from echograms (or if the fish occur in mixed schools). This problem was not helped by the low (vertical) resolution of acoustic raw data (pulse length: 1.024 ms) in shallow areas. In mixed-species aggregations e.g. consisting of herring and sprat, post-processors in the exercise either provided a "mixed" category NASC or split the corresponding NASC values according to catch composition (in case of similar known scattering characteristics merely based on bulk catch ratios of both species).

Some of the acoustic data available for scrutiny were collected at only two frequencies whereas most were available at four or five frequencies. This lack of multifrequency data were highlighted as a concern when discriminating between some species as dB differencing is a common tool used in the scrutinisation procedure to help with species identification. Use of multifrequency/wideband information helps to distinguish echotraces and to allow for more precise species categorization. Some scrutinisers used

algorithms which required four frequencies and therefore ran into difficulties when required to adapt these to datasets with less frequencies. This lack of flexibility meant scrutiny was sometimes slow and ineffective at identifying some species and schools. In addition, the school detection settings and thresholding techniques applied were mostly developed internally and generally species and area specific. Therefore, transferring scrutinising methods across surveys in the time available was not straightforward.

Despite the differences in scrutinisation results highlighted above, there was a good agreement (even across surveys and across scrutinisation teams unfamiliar with corresponding surveys) in overall NASC results and a high degree of similarity in the score sheets for most datasets between the teams. Differences originated, as described above, for example, from misidentification, lack of survey experience, different treatment of mixed-species aggregations and incorrect inclusion/exclusion of seabed structures or fish aggregations. Detailed accounts of noteworthy scrutinisation results (Case IDs, overview see Annex 2) are given in Annex 3, together with the scoresheets and issues identified leading to possible differences in NASC values across post-processing teams.

6 Recommendations

6.1 Recommendations for post-processors of hydroacoustic data

6.1.1 Integration Resolution

Standardization of the integration interval is necessary to facilitate improved inter-country and survey comparisons. It was decided that 1 nmi (vessel long distance) should be employed as elementary distance sampling unit throughout surveys (for HERAS surveys, please also refer to corresponding recommendations from WKEVAL (ICES, 2015b). Vessel log distance should always be recorded and is the most suitable integration interval, allowing best inter-comparability. Prior to exporting data, the performance of the employed software package in integrating incomplete intervals has to be checked and be corrected accordingly. Incomplete intervals, should be weighed with actual distance sampled in the interval (Case study ID 68, 69).

6.1.2 Sounder settings and additional data sources

The ping interval has to be adjusted manually according to the given circumstances. If a too short ping interval is selected, ghost bottoms are likely to occur and ping interval has to be increased. The deeper the water column, the longer the ping interval will have to be. It is suggested that ping interval should be changed at the end of an EDSU. During the LOBE calibration the ping interval can (in disagreement with the official Simrad manual; Kongsberg, 2012) be set to maximum, to speed up the process (Demer *et al.*, 2015).

In general terms, pulse length should not be modified during a survey. In exceptional cases, when passing from very deep into very shallow water, it might be necessary to decrease the pulse length to allow for effective target detection. If this is the case it is crucial that all pulse length settings are calibrated separately and applied to the data accordingly.

A word of caution should be raised when using commercial sounders such as the ES70 which allow power settings to be higher than the recommended maximum settings. Potential impacts of wrong power settings are discussed in Korneliussen *et al.*, 2008.

Motion Reference Units (MRU's) should be standard equipment on every vessel. Correcting data for pitch and roll via motion correction algorithms that are based on MRU data can be very important as uncorrected data may contain biases in NASC estimates. Furthermore, motion (heave) corrected echograms facilitate the detection of schools close to the seabed (Saavedra *et al.*, 2012).

6.1.3 General post-processing/scrutinisation

Expert staff should be available on every cruise to improve scrutinisation decisions and monitor trawl operations. It is advised that scrutinising should be completed during the survey, to allow for best possible use of expert judgement in the allocation of catch information to echotraces. The catchability of the different species in the target area should be considered. Differences in catchability can potentially introduce a highly significant bias (for example, boarfish vs. horse mackerel). Scrutinising echograms where post-processors have not been present at collection is very challenging. In such cases, additional information other than just catch composition is required to aid the process (see below).

It should be stressed that experience on surveys in the specific area is essential. Experience from species surveys from other areas may have limited value where there are practical differences, i.e. temporal and water depth.

There should be minimal time-lag between collection and analysis of acoustic data. Scrutinising becomes increasingly difficult the further from the actual survey it is conducted and is increasingly challenging even for post-processors that have been on board during the survey.

Screenshots from aggregations and marks targeted during trawl hauls (see below) could be used as a reference collection aiding the process of species allocation. Although aggregation patterns may differ across regions or from year-to-year, corresponding screenshots from previous surveys still often aid the scrutinisation process. If catches from some trawl hauls have been low, screenshots of similarly looking targets can be a valuable aid. During post-cruise meetings certain example echograms and challenging echograms should be discussed more in depth. Time should be allocated to this task specifically in advance. It is good practice to retain catch annotated echogram screenshots from hauls on board for subsequent surveys.

6.1.4 Scrutinisation of mixed marks

During the HERAS survey in 2014 there was a proliferation of Norway Pout (*Trisopterus esmarkii*, NOP) in the Scottish survey area. Quantities of NOP were present in a number of trawl hauls (3 – 6 cm lengths). As the catching efficiency of the pelagic trawl is likely to be very low for smaller fish, it is not feasible to use the catch composition to assign proportions to the mixed aggregations. The catch could only be used to indicate that NOP had been encountered during the trawl at some point. Observation of the netsonde system during trawls showed periods of light blue traces entering the net which are assumed to be NPO and harder, denser marks which are assumed to be herring.

The issue was discussed at WKSCRUT using trawl and echogram examples. The conclusion among the group was that there may not currently be a reliable method of separating these species using acoustic properties alone, even with data from four individual frequencies. However, ongoing work by Marine Scotland looking at a number of specific NOP hauls suggests that the frequency response at the higher frequencies (120 and 200 kHz) for small NOP is slightly lower than the herring response (relative to the 38 kHz).

The very different catching efficiency for herring and NOP still remains a concern in using trawl catches for species composition in this situation, as most NOP will continue to escape through the large meshes on the side panels.

The use of optical systems was suggested as a method to attempt to correlate when NOP entered the net with traces seen on the echosounder and netsonde systems. The conclusion among WKSCRUT members was that it is likely that auxiliary optical/acoustic data together with visual inspections of individual schools on the echogram with regard to shape, density, linking distances and association with seabed remains the only method of separating these species at this time in this survey area, a separation that has to be based on expert judgment (see also below: Ground-truthing). However, this still gives no indication of relative abundance if the schools are mixed.

6.1.5 Ground-truthing

Ground-truthing of acoustic data remains challenging. The group agreed that isolated trawl catch data are insufficient for confident species allocation to echo data, as often important information on actual trawl position and real time catch monitoring are missing. Trawls should always be monitored with a net sonar and/or another sonar system, to identify the captured schools or parts of a school immediately.

Optical ground-truthing

It is recommended that alongside more detailed information on actual trawl paths (linking catch sensors with echograms) etc., additional information is collected and provided to verify and allocate trawl catches to echotraces observed (e.g. optical ground-truthing with portable high definition cameras mounted to the trawl gear; Case study ID 35, 42, 61). In "un-trawlable" areas there has been some success in using camera landers to identify fish traces. In pelagic trawls the use of cameras is now more common. The dimensions of pelagic gears, and the depths that they are used at, means that artificial lighting will probably be required. Consideration should be given to the impact on fish behaviour and catchability if lights are positioned too close to the net opening. Most camera systems are placed further down the net to lessen the effect of any such problems.

Trawl gear

To improve ground-truthing methods and inter-vessel compatibility, ideally nets used in a given survey should be standardized, if possible. Nets should be chosen in a way that mesh-sizes and overall net size ensures that the catch is representative. Small-sized fish can have a low catchability in some nets, but can contribute significantly to regional NASC values. Additional use of e.g. optical systems is recommended and would contribute to a better allocation of species to echotraces (e.g. Norway Pout, Case study ID 78). For most surveys, it is desirable to have nets that are not limited to the midwater column fishing, but are able to fish on the surface and / or very close to the bottom as well. Essentially, the trawl gear should be designed to reliably and representatively capture echotraces encountered in a survey area. Given the progression towards integrated survey setups, this should definitely not be limited to a certain 'target species'. The group agreed that, where applicable, it is important to have standardized nets operating within the different surveys. If different nets are used by different participants it should be assessed through intercalibrations, how effectively they are working in direct comparison (i.e. if representative catches can be achieved with either net by using both nets on the same vessel).

Together with general catch composition data, length frequency distributions are required. Additional data on maturity, stomach contents and overall condition etc. may help to establish why the fish are in particular parts of the survey area, the water column and in which type of aggregations, i.e. migrating, feeding, spawning, diurnal activity patterns etc.

Trawl haul information

The location and path of the trawl should always be available. Depth of the headline, towing speed and footrope clearance are crucial to establishing what fish aggregations were available to be caught. The use of illustrations of the trawl progress as "snapshots" during the scrutinisation should be considered. This should include time of events, headline depth, footrope clearance, spread and opening, a representation of when and where marks entered the net and their density; additionally, whether

echotraces were underneath the trawl or past the net. Further notes on towing speed, weather conditions, changes of warp length, seabed depth or sediment changes can also be included. The use of a video recording of the net sounder screen should also be considered (a standard function on Simrad FS70 netsonde system).

It is essential to consider whether trawl catch information can be allocated to echotraces. This includes situations where the targeted mark was missed but catch from similar marks (or other marks!) were obtained; or situations where the mark was missed completely and only a small amount of fish (or no catch at all) was obtained.

Catch size could be used as an indicator of how representative the catch was of the targeted marks. However, a minimum catch/sample size cannot be suggested, as large catches are required to validate scattered marks while smaller catches might be acceptable when targeting denser marks of similar appearance. Using very small catches to allocate species to marks might introduce uncertainty. However, when marks are moving quickly in the surface in bright sunlight, getting any catch might be acceptable. Catches with similar length distributions can be aggregated using a Kolmogorov–Smirnov comparison algorithm. Marine Scotland uses this test and has found that results have tended to show that similar distributions from catches are in geographically close proximity. This gives a robust idea of length distributions for smaller catches.

6.1.6 Thresholding

Standard threshold settings to export NASC values have to be applied. During the scrutinisation process, these values can of course be adjusted to facilitate an easier species or species group discrimination. In order to produce standardized data outputs, it is crucial to set the right export threshold for any given survey: HERAS -70 dB; IBWSS -82dB; IESNS -82 dB.

6.1.7 Frequency response patterns and school detection algorithms

In recent years different Study and Working groups (WGTC, SIMFAMI project) have been focusing on an improved understanding of species-specific frequency responses. An understanding of the species, seasonal and area specific acoustic responses is of high importance to improve accuracy of acoustic fisheries surveys. Recently, emerging technologies such as multifrequency, broadband/widebandwidth acoustics are a promising tool for higher detail frequency response mapping and improved target classification (Case study ID 10, 27, 42, 61). While frequency response methods work fairly well in single species school situations, they remain challenging in multi species, mixed schools. Here a combination of trawl information as well as other ground-truthing information with frequency response remains best practice.

Where water depth precludes the use of the highest frequencies, the scrutiniser's experience is more valuable as he would be expected to have a number of years of collecting and analysing the data from these surveys

School detection algorithms are commonly used in many acoustic surveys. Generally, survey specific algorithms are being developed and being adopted over time. Independent of how well these automatic detections work, they should always been regarded as detection aids and results have to be checked for misdetections manually. In some situations schools might be missed and have to be added manually. Additionally, due to the varying nature of schools encountered during different surveys and also within surveys in different regions, there are no universal settings applicable across surveys.

6.1.8 Sampling close to the bottom

Scrutinising close to the bottom remains challenging but is important in certain areas and times, where fish occur very close to the bottom (e.g. herring, cod, hake). It is crucial that prior to any data extraction, the detected bottom line is checked manually, to assure no bottom data are included in the final export. In general, it is good practice to add a 0.5 m back-step to the corrected sounder detected bottom line, to ensure the exclusion of any seabed echo. If fish schools occur very close to the bottom at similar amplitude to the seabed, their backscatter might merge. In such cases, a separation can be difficult and relies on expert judgement. If possible, the area should be covered again; the use of multibeam sounders could be helpful in some occasions (Case study ID 1, 2, 47, 62). For a single fish to be detected as a target, its minimum distance from the ground must be

$> \frac{c\tau}{2} + fh$ with $c = soundspeed\ and\ \tau = pulse\ duration..$

When analysing data close to the bottom, considerations with respect to the acoustic dead zone (ADZ) have to be made as well. The ADZ is the area close to the seabed, where (at the edge of the wavefront) due to the shape of the acoustic beam, no fish can be detected. ADZ is defined as

$$ADZ = \frac{4\pi}{3} d^3 \left\{ \frac{1}{2}[1 - \cos\theta_3] \left(\frac{\cos\frac{\theta_3}{2}}{\cos\theta_3} \right)^2 - 1 \right\} \text{ with } d = depth\ [m], \theta_3 = half\ beam\ angle\ to - 3\ dB$$

or the equivalent lost height (h_{eq}) can be approximated through:

$heq = 2404\ \left(\frac{d * tan^4 \Theta_3}{\Theta_3} \right)$ (Ona and Mitson, 1996).

For some surveys, the effect might be irrelevant, but in other cases, where fish can occur in high densities, close to the bottom, it is recommended that an error estimate be computed. Ignoring the ADZ might result in a significant underestimation of the stock. In any case where fish are found very close to the bottom, the ADZ effect should be compensated for during post-processing. Procedures on sampling close to the bottom have to be defined more clearly in the survey working groups and be discussed during post-cruise meetings (including the effects of the ADZ).

6.1.9 Sampling close to the surface

When scrutinising close to the water surface, it is good practice to generally exclude at least the top 5 – 15 m prior to any further analysis. The main reason for this exclusion is the resolution of acoustic data in the nearfield. In the nearfield of the transducer, no reliable quantitative acoustic energy data information can be extracted as the acoustic energy is not stable (wave fronts are fluctuating). For standard Simrad EK60 transducers currently employed during surveys, the following nearfield range (R) can be estimated, according to

$R = d^2 * f/c$ (Simmonds and MacLennan, 2005)

where d = *greatest width of the transducer face*, f = *acoustic frequency* and c = *sound speed in water*. Assuming a sound speed of 1500 m/s and dimensions of the most commonly used Simrad transducers, the following nearfields apply:

Frequency	Transducer	Beam angle	Nearfield
18 kHz	18–11	11°	4.69 m
38 kHz	ES38-B	7°	5.84 m
70 kHz	ES70–7C	7°	3.66 m
120 kHz	ES120–7C	7°	2.60 m
200 kHz	ES200–7C	7°	1.92 m

The transition from near- to far-field conditions occurs gradually around R (Simmonds and MacLennan, 2005). For this reason, acoustic measurements that depend on the assumption of far-field conditions should be done at ranges of at least 2 x R. A precautionary approach should therefore be taken and at least two times the nearfield of the transducer with the largest nearfield should be used as the upper echo integration depth. In shallow coastal areas with water depths of 20 m or less, an integration starting depth of transducer draft + 2 x R in many cases could lead to the whole water column being outside the recommended range for integration. Accordingly, if fish occur in these areas or close to the surface but below the nearfield (below 1 x R), data can be integrated, but the actual effects of integrating data from less than the recommended range of 2 x R have to be evaluated. Data collected close to the surface can be noisy, depending on weather conditions. If conditions do not allow for data integration close to the surface, the surface exclusion zone has to be adapted to exclude bubbles and wave generated noise. The surface area should always be monitored for the presence of bubbles, to be able to identify issues of signal blocking.

6.2 Recommendations for future scrutinisation exercises/workshops

Based on the limited time available and on the high diversity of data from different surveys and areas it became evident during the scrutinisation exercise that, despite a high degree of agreement across scrutinisation results, an ad-hoc scrutinisation of unfamiliar datasets in a "blind" exercise highlights differences at a possibly too late stage of the workshop. Accordingly, it can be recommended that in future scrutinisation workshops participants from different surveys prior to common scrutinisation exercises post-process representative examples of their survey data on a big screen. This would help to communicate their handling of the data (i.e. line correction, school detection procedures, species allocation) based on the information available and commonly used (haul summary, adjacent hauls, archive school shapes, optical data, netsonde images, expert knowledge etc.) to the audience, together with a final numeric output of results. Accordingly, all scrutinisation teams could afterwards apply their own routines post-processing the corresponding dataset and compare it with the official results from the national team responsible for scrutinising the survey data.

As differences were evident in the application of school detection algorithm settings or in the manual/automatic detection of schools, as well as in e.g. the use of multifrequency data, corresponding approaches should be addressed more in-depth in forthcoming exercises to possibly test and correct for the overall effect such situations have on the numerical output of post-processing results and to facilitate evaluation of possible common procedure recommendations.

After the exercises mentioned above, certain time should be allocated for participants to scrutinise not specifically picked "typical" or "challenging" datasets but exemplary full sets of actual survey data (e.g. one day of survey data) which would include not only the situations highlighted above but also "empty" sections etc. This would allow

a comparison of numeric outputs as generated within the survey and actually used for biomass estimates etc.

6.3 Recommendations to other Groups

RECOMMENDATION	FOR FOLLOW UP BY:
1. WKSCRUT identified that there are no standard procedures in place for how to deal with bad weather conditions and how to treat the data. There is a need for an improved understanding of effects such as signal loss due to bad weather situations. WKSCRUT recommends that standardized methods to quantify the signal to noise ratio during normal survey operations should be defined and established.	WGFAST
2. Expert judgments on the degree of data quality are diverging. The actual decision to interrupt acoustic survey operations due to bad weather so far is based on expert judgment and subjective. WKSCRUT recommends that standardized approaches for the interruption of acoustic survey operations in bad weather should be defined and established.	WGFAST

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Annex 1: List of participants

List of participants to WKSCRUT meeting 7–11 September 2015

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Annex 2: Overview of scrutinised datasets

Table: Datasets utilized for a cross-check of scrutinisation procedures and methods applied by different post-processors across surveys (green cells). D = Germany, NL1–3 = Netherlands 1–3, SCO = Scotland, NO = Norway, IR = Ireland.

case_ ID	folder	D	NL2	SCO	NL1	NO	NL3	IR	E
1	NL WKSCRUT data\HERAS typical herring\Haul 1 (2010 haul 7)	x	x	x	x	x	x	x	x
2	NL WKSCRUT data\HERAS typical herring\Haul 2 (2010 haul 9)		x	x	x	x	x	x	
3	NL WKSCRUT data\HERAS typical herring\Haul 3 (2011 haul 1)								x
4	NL WKSCRUT data\HERAS typical herring\Haul 4 (2012 haul 5)								x
5	NL WKSCRUT data\HERAS typical herring\Haul 5 (2013 haul 2)								x
6	NL WKSCRUT data\HERAS typical herring\Haul 6 (2013 haul 3)								x
7	NL WKSCRUT data\HERAS typical herring\Haul 7 (2013 haul 6)	x	x	x	x	x	x	x	x
8	NL WKSCRUT data\HERAS typical herring\Haul 8 (2013 haul 12)								
9	NL WKSCRUT data\HERAS typical herring\Haul 9 (2013 haul 16)								
10	NL WKSCRUT data\HERAS typical herring\Haul 10 (2014 haul 1)								
11	NL WKSCRUT data\HERAS typical herring\Haul 11 (2014 haul 18)								
12	NL WKSCRUT data\IBWSS typical blue whiting\IBWSS TRIDENS 2007 haul 2	x	x	x	x	x	x	x	x
13	NL WKSCRUT data\IBWSS typical blue whiting\IBWSS TRIDENS 2007 haul 6								
14	NL WKSCRUT data\IBWSS challenging mix\IBWSS TRIDENS 2007 haul 2								
15	NL WKSCRUT data\IBWSS typical blue whiting\IBWSS TRIDENS 2009 haul 7				x				
16	NL WKSCRUT data\IBWSS challenging mix\IBWSS TRIDENS 2009 haul 1								
17	NL WKSCRUT data\IBWSS challenging mix\IBWSS TRIDENS 2010 haul 3	x	x		x	x	x	x	
18	NL WKSCRUT data\IBWSS typical blue whiting\IBWSS TRIDENS 2010 haul 5								
19	NL WKSCRUT data\IBWSS challenging mix\IBWSS TRIDENS 2010 haul 6								
20	NL WKSCRUT data\IBWSS typical blue whiting\IBWSS TRIDENS 2010 haul 9	x	x		x	x	x	x	
21	NL WKSCRUT data\IBWSS challenging mix\IBWSS TRIDENS 2011 haul 2								
22	NL WKSCRUT data\IBWSS challenging mix\IBWSS TRIDENS 2011 haul 7								
23	NL WKSCRUT data\IBWSS typical blue whiting\IBWSS TRIDENS 2011 haul 9								
24	NL WKSCRUT data\IBWSS typical blue whiting\IBWSS TRIDENS 2011 haul 14	x	x		x	x	x	x	
25	NL WKSCRUT data\IBWSS typical blue whiting\IBWSS TRIDENS 2011 haul 15								
26	NL WKSCRUT data\IBWSS typical blue whiting\IBWSS TRIDENS 2012 haul 2								
27	NL WKSCRUT data\IBWSS challenging mix\IBWSS TRIDENS 2012 haul 9	x	x		x	x	x	x	x
28	NL WKSCRUT data\IBWSS typical blue whiting\IBWSS TRIDENS 2014 haul 8								x
29	NL WKSCRUT data\IBWSS challenging mix\IBWSS TRIDENS 2015 haul 10	x	x	x	x	x	x	x	
30	NL WKSCRUT data\IBWSS challenging mix\IBWSS TRIDENS 2008 haul 3								
31	NL WKSCRUT data\IBWSS challenging mix\IBWSS TRIDENS 2007 haul 5								
32	NL WKSCRUT data\\IBWSS challenging mix\IBWSS TRIDENS 2006 haul 5								
33	NL WKSCRUT data\HERAS challenging mix\Tridens haul 5 2009								

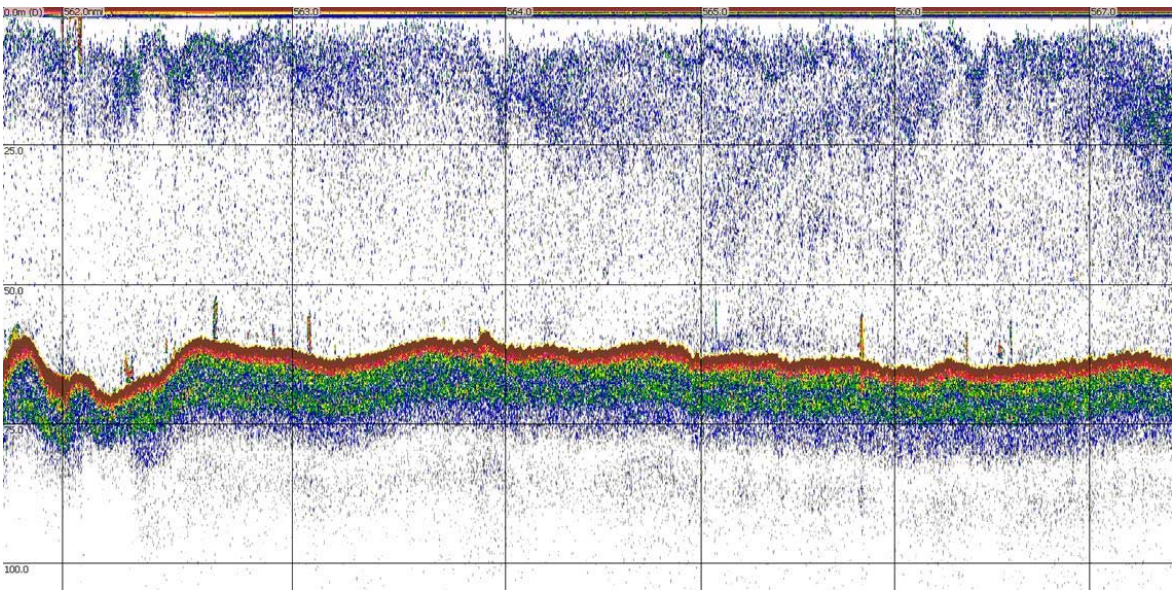
case_ID	folder	D	NL2	SCO	NL1	NO	NL3	IR	E
34	NL WKSCRUT data\HERAS challenging mix\Tridens haul 16 2009								
35	NL WKSCRUT data\HERAS challenging mix\Tridens haul 3 2010		x		x	x	x	x	
36	NL WKSCRUT data\HERAS challenging mix\Tridens haul 4 2010								
37	NL WKSCRUT data\HERAS challenging mix\Tridens haul 8 2010								
38	NL WKSCRUT data\HERAS challenging mix\Tridens haul 10 2010								
39	NL WKSCRUT data\HERAS challenging mix\Tridens haul 6 2011								
40	NL WKSCRUT data\HERAS challenging mix\Tridens haul 22 2013								
41	NL WKSCRUT data\HERAS challenging mix\Tridens haul 4 2014	x	x			x	x	x	
42	NL WKSCRUT data\HERAS challenging mix\Tridens haul 9 2015		x	x		x	x	x	
43	NL WKSCRUT data\HERAS typical sprat\Tridens haul 13 2005								
44	NL WKSCRUT data\HERAS typical sprat\Tridens haul 21 2005								
45	NL WKSCRUT data\HERAS typical sprat\Tridens haul 6 2010		x			x	x		
46	NL WKSCRUT data\HERAS typical sprat\Tridens haul 11 2010		x				x		
47	NL WKSCRUT data\HERAS typical sprat\Tridens haul 15 2010		x				x		
48	NL WKSCRUT data\HERAS typical sprat\Tridens haul 4 2012								
49	NL WKSCRUT data\HERAS typical sprat\Tridens haul 10 2012								
50	NL WKSCRUT data\HERAS typical sprat\Tridens haul 13 2012								
51	NL WKSCRUT data\HERAS typical sprat\Tridens haul 14 2012								
52	NL WKSCRUT data\HERAS typical sprat\Tridens haul 19 2015								
53	GER WKSCRUT data\HERAS typical\2005_07_08_SB544_Clupeids\ekdata		x						
54	GER WKSCRUT data\HERAS typical\2014_07_06_SB690_Clupeids\ekdata		x						
55	GER WKSCRUT data\HERAS typical\2015_06_29_SB706_Clupeids\ekdata	x	x	x	x		x		
56	GER WKSCRUT data\HERAS typical\2015_07_13_SB706_Sprat	x	x		x		x		
57	GER WKSCRUT data\HERAS challenging\2008_07_15_SB591_BadWeatherClupeidsOthers\ekdata								
58	GER WKSCRUT data\HERAS challenging\2015_06_29_SB706_Mackerel								
59	GER WKSCRUT data\HERAS challenging\2015_07_01_SB706_ClupeidsPlankton\ekdata								
60	GER WKSCRUT data\HERAS challenging\2015_07_03_SB706_MissedTheMark								
61	GER WKSCRUT data\HERAS challenging\2015_07_08_SB706_Sprat&Sandeel\ekdata	x	x	x	x		x		
62	GER WKSCRUT data\HERAS challenging\2015_07_15_SB706_Anchovies\ekdata	x	x		x		x		
63	IRL WKSCRUT data\MSHAS Blue whiting\ekdata		x	x					
64	IRL WKSCRUT data\MSHAS Boarfish\ekdata		x						
65	IRL WKSCRUT data\MSHAS Herring bottom scatter\ekdata		x	x					
66	IRL WKSCRUT data\MSHAS Herring in a mix\ekdata		x	x					
67	IRL WKSCRUT data\MSHAS Typical Herring\ekdata (files not available)								
68	SCO WKSCRUT data\2014_06_29\ekdata Haul 180	x	x	x	x		x		
69	SCO WKSCRUT data\2014_07_01\ekdata Haul 184	x	x	x	x				x
70	SCO WKSCRUT data\2014_07_04\ekdata1 Haul 194				x				
71	SCO WKSCRUT data\2014_07_04\ekdata2 Haul 194				x				
72	SCO WKSCRUT data\2014_07_08\ekdata1 Haul 203				x				

case_ ID	folder	D	NL2	SCO	NL1	NO	NL3	IR	E
73	SCO WKSCRUT data\2014_07_08\ekdata2 Haul 203				x				
74	SCO WKSCRUT data\2014_07_10\ekdata Haul 207								
75	SCO WKSCRUT data\2014_07_11\ekdata1 Haul 209								
76	SCO WKSCRUT data\2014_07_11\ekdata2 Haul 210								
77	SCO WKSCRUT data\2014_07_11\ekdata3 Haul 210								
78	SCO WKSCRUT data\2014_07_11\ekdata4 Haul 211	x	x	x			x		
79	SCO WKSCRUT data\2014_07_13\ekdata Haul 213	x	x	x			x		
80	SCO WKSCRUT data\2014_07_14\ekdata1 Haul 214								
81	SCO WKSCRUT data\2014_07_14\ekdata2 Haul 214								
82	SCO WKSCRUT data\2014_07_14\ekdata3 Haul 215								
83	SCO WKSCRUT data\2014_07_14\ekdata4 Haul 216								
84	SCO WKSCRUT data\2014_07_15\ekdata1 Haul 217								
85	SCO WKSCRUT data\2014_07_15\ekdata2 Haul 218								
86	SCO WKSCRUT data\2014_07_15\ekdata3 Haul 218								
87	SCO WKSCRUT data\2014_07_16\ekdata1 Haul 219								
88	SCO WKSCRUT data\2014_07_16\ekdata2 Haul 219								
89	SCO WKSCRUT data\HERAS challenging mix\Scotia 2015 Haul 219\ekdata		x	x			x		
90	SCO WKSCRUT data\HERAS challenging mix\Scotia 2015 Haul 222\ekdata	x	x	x					
91	SCO WKSCRUT data\HERAS typical herring\Scotia 2015 Haul 191\ekdata	x	x	x					
92	SCO WKSCRUT data\HERAS typical herring\Scotia 2015 Haul 195\ekdata		x	x					
93	SCO WKSCRUT data\HERAS typical herring\Scotia 2015 Haul 196\ekdata								
94	SCO WKSCRUT data\HERAS typical herring\Scotia 2015 Haul 202\ekdata		x	x					
95	SCO WKSCRUT data\HERAS typical herring\Scotia 2015 Haul 212\ekdata		x	x					
96	SCO WKSCRUT data\HERAS typical herring\Scotia 2015 Haul 221\ekdata			x					
97	LSSS_IESNS_norwegian_data\raw		x	x					x
	Danish dataset		x						

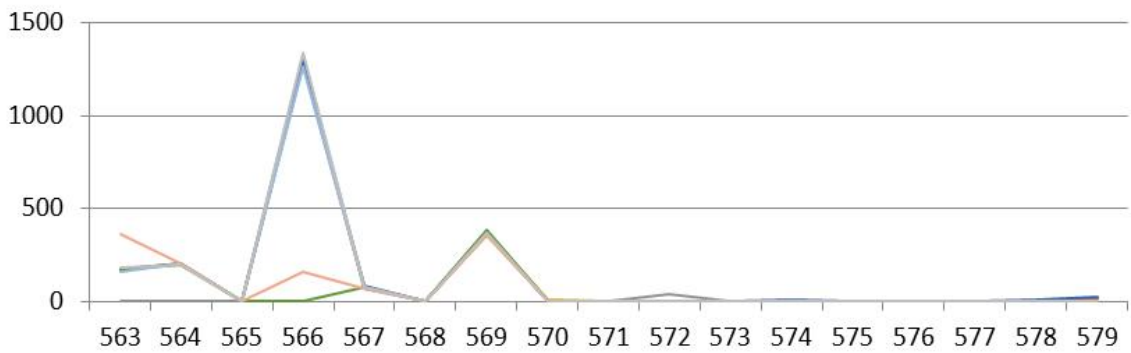
Annex 3: Results (Example datasets)

Participants were required to process corresponding datasets according to their regular scrutinisation procedures and allocate species-specific NASC-values to echotraces detected in predetermined categories. Additional trawl haul information was provided for each dataset (catch composition: total catch per species in kg). For each case ID (see Annex 2 for detailed information), a representative screenshot of the echo marks to be processed and allocated is given. Additionally, the score sheets for all participating teams for the corresponding dataset are provided on an interval basis (integrated NASC values per EDSU). Line diagrams provide visual information on differences in scrutinisation results on interval/EDSU basis. In mixed-species aggregations/echograms, NASC values were allocated to species based on catch composition etc. HER – herring, NOP – Norway pout, GAD – other Gadoids, MAC – mackerel, SPR – sprat, WHB – blue whiting, BOC – boarfish, HOM – horse mackerel, ARG – argentines/silver smelt, ANE – European anchovy, SAN – sandeel).

ID 1 – NL HERAS, typical, HER



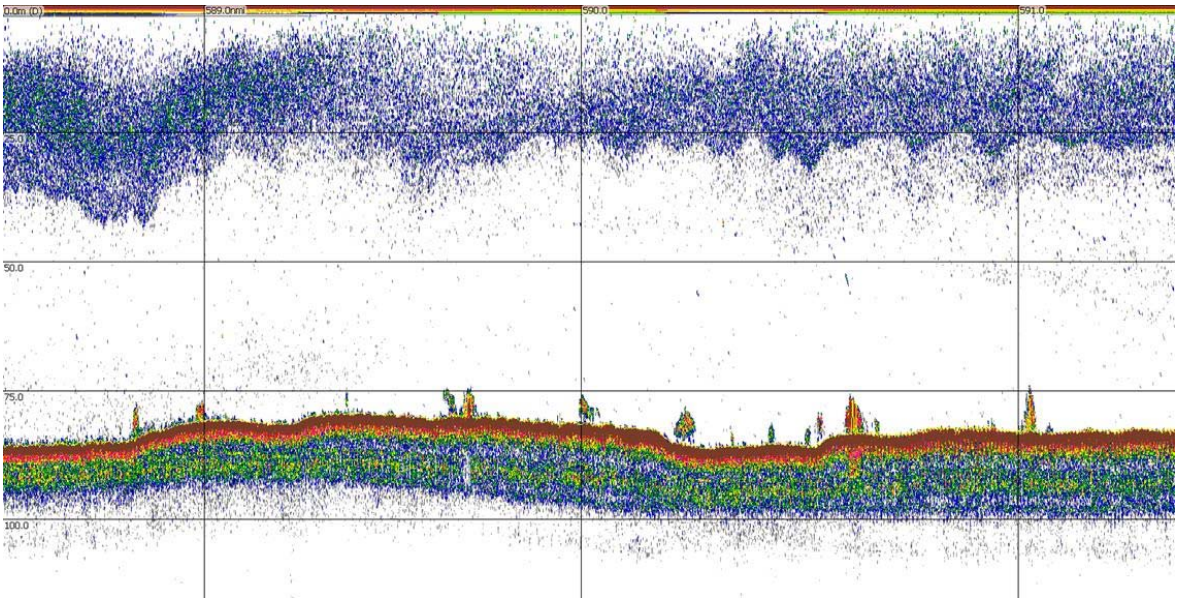
Intervals:	563	564	565	566	567	568	569	570	571	572	573	574	575	576	577	578	579
NL_1	164	206	0	1282	77	0	364	0	0	0	0	0	0	0	0	0	15
NL_2	0	0	0	1320	69	0	379	0	0	41	0	0	0	0	0	0	0
IRL	175	207	0	1288	78	0	376	9	0	0	0	0	0	0	0	0	0
GER	173	206	0	1292	82	2	375	0	2	0	5	9	0	0	0	9	25
NOR	172	199	0	0	79	0	381	0	0	0	0	0	0	0	0	0	0
SPA	161	203	0	1263	76	0	362	0	0	0	0	0	0	0	0	0	0
SCO	365	202	0	157	72	0	358	0	0	0	0	0	0	0	0	0	0
NL_3	179	198	0	1338	79	0	372	0	0	0	0	0	0	0	0	0	0



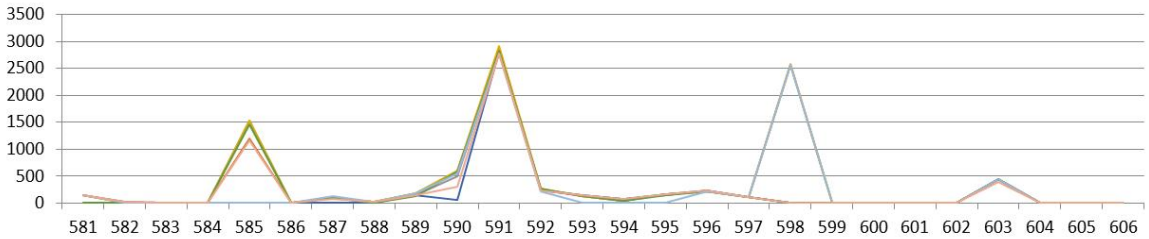
Identified issues:

- Unclear separation of schools from seabed led to inclusion of school to seabed (i.e. interval 566).
- Identification of (small) schools close to the seabed.

ID 2 – NL HERAS, typical, HER



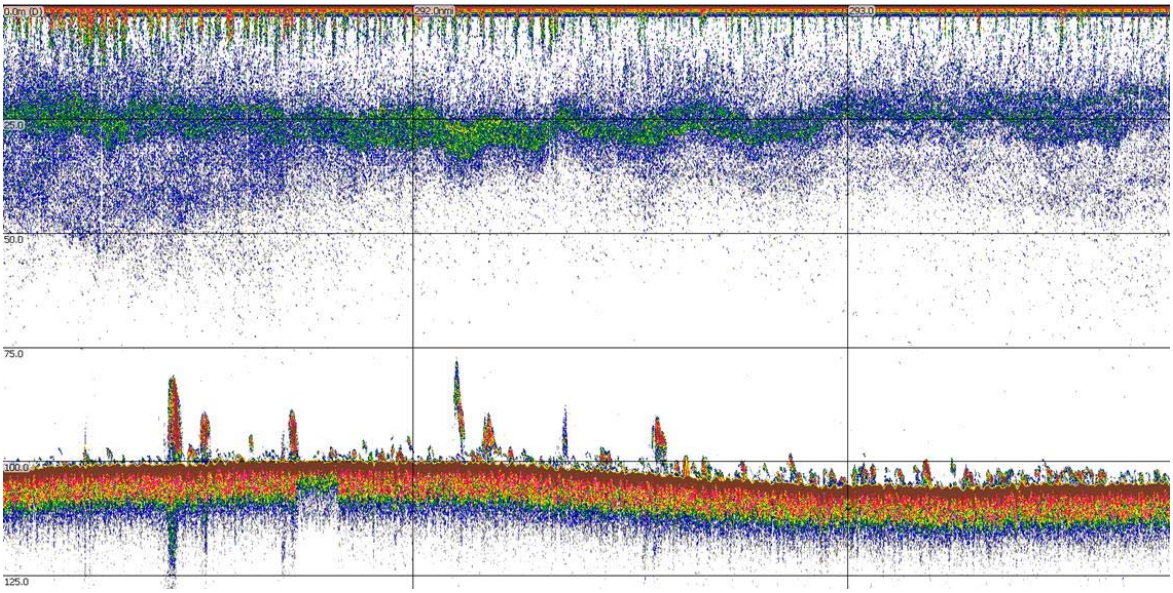
Intervals:	581	582	583	584	585	586	587	588	589	590	591	592	593	594	595	596	597	598	599	600	601	602	603	604	605	606
NL_1	142	0	0	0	1194	0	84	18	186	585	2881	254	121	39	154	209	112	2570	0	0	0	0	443	0	0	0
NL_2	0	0	0	0	1537	0	83	18	146	498	2830	240	140	76	152	225	114	0	0	0	0	0	443	0	0	0
IRL	142	0	0	0	1536	0	85	18	186	599	2906	264	134	41	158	219	112	2576	0	0	0	0	445	0	0	0
NOR	139	12	0	0	0	0	0	9	147	49	2811	231	139	72	163	225	114	0	0	0	0	0	443	0	0	0
SPA	0	0	0	0	1465	0	84	0	133	577	2819	261	120	42	151	209	112	0	0	0	0	0	443	0	0	0
SCO	138	0	0	0	0	0	125	17	184	554	2779	220	0	0	0	206	112	2569	0	0	0	0	442	0	0	0
NL_3	141	12	0	0	1167	0	76	18	150	294	2774	233	147	81	161	224	115	0	0	0	0	0	388	0	4	0



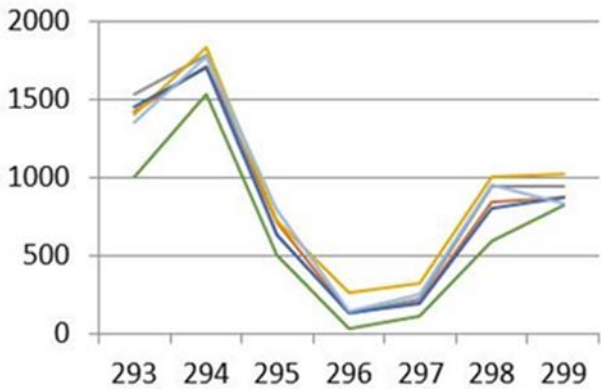
Identified issues:

- Separation of schools and seabed.

ID 7 – NL HERAS, typical, HER



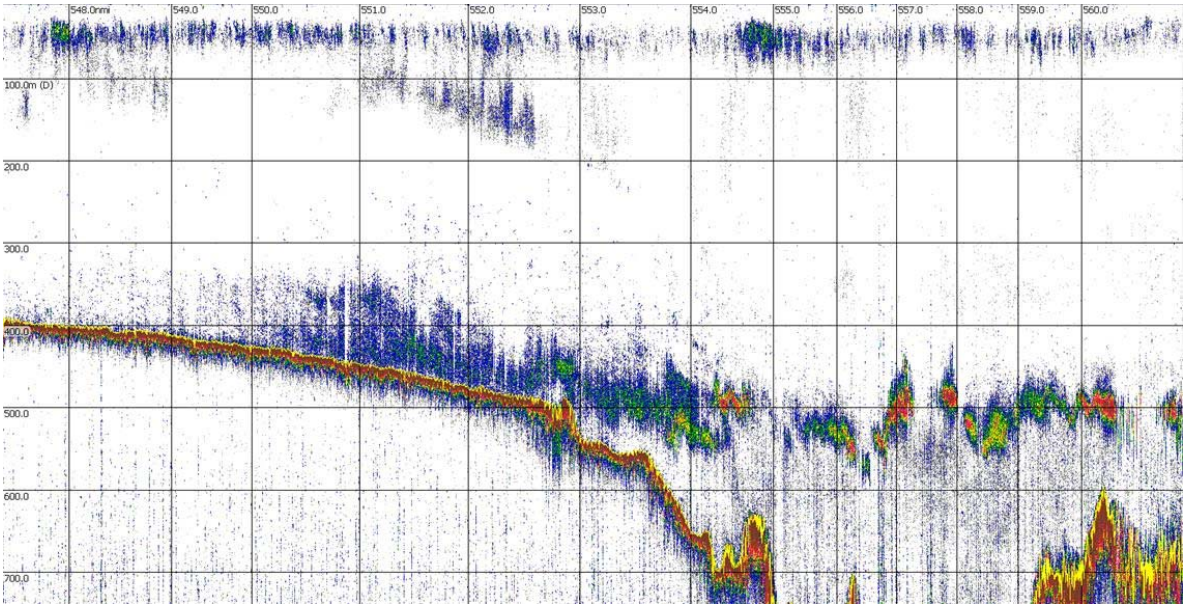
Intervals:	293	294	295	296	297	298	299
NL_1	1422	1717	709	137	204	839	871
IRL	1537	1785	629	136	218	943	944
NOR	1407	1836	728	266	323	1007	1022
SPA	1458	1704	636	132	193	799	876
SCO	1000	1531	502	30	113	593	828
NL_3	1357	1772	794	139	252	957	835



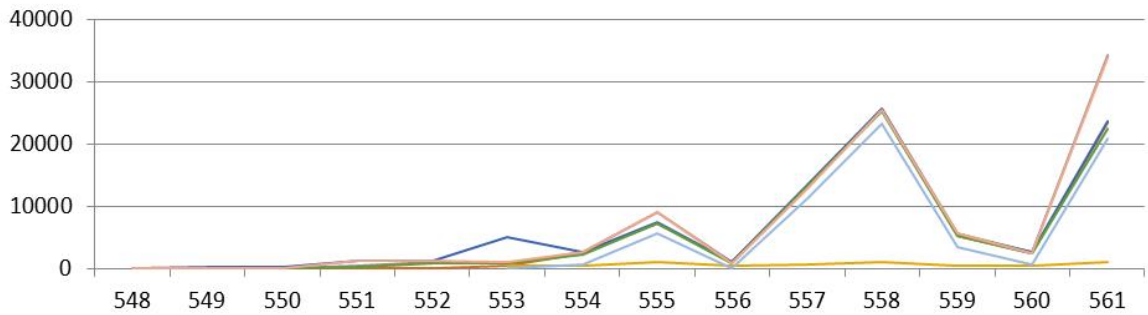
Identified issues:

- Detection (inclusion) of small schools along the seabed. Bottom margin of 0.5 m led to exclusion of parts of schools if not manually redrawn.

ID 12 – NL IBWSS, typical, WHB



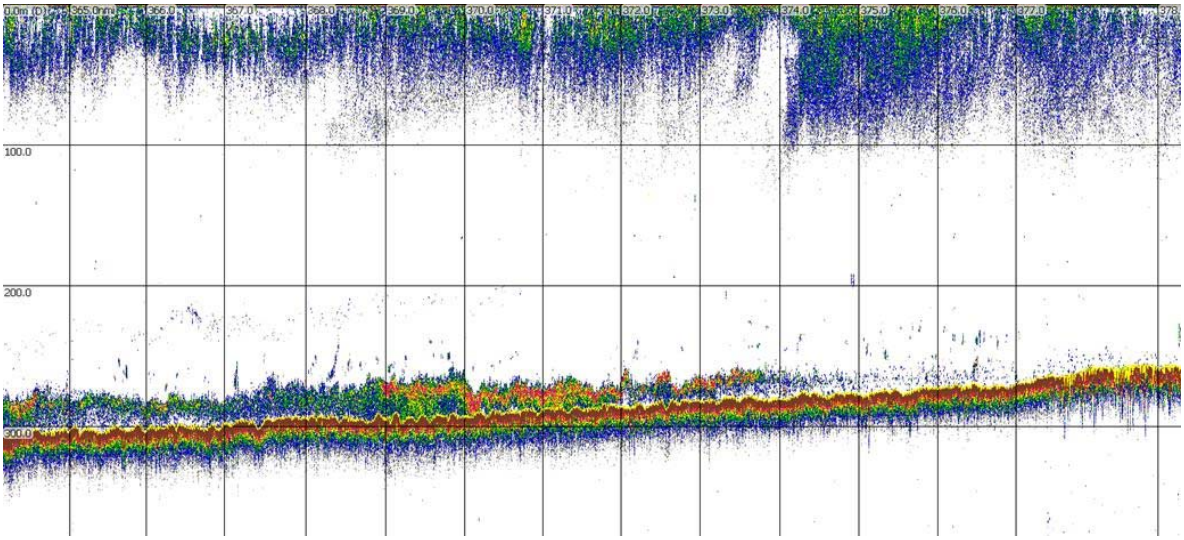
Intervals:	548	549	550	551	552	553	554	555	556	557	558	559	560	561
NL_1	0	0	0	0	0	474	2356	7277	1132	13333	25510	5278	2458	23569
NL_2	0	0	34	411	1074	924	2547	9119	1011	13103	25646	5716	2598	34322
IRL						445	493	1027	519	541	976	516	484	990
GER	45	164	284	1322	1301	4982	2582	7419	994	13426	25587	5416	2574	23641
SPA	0	0	39	248	912	805	2311	7163	781	13210	25330	5207	2387	22544
SCO						13	550	5664	135	11292	23265	3389	647	20912
NL_3	0	0	0	1293	1259	1127	2545	8976	903	12916	25460	5590	2501	33847



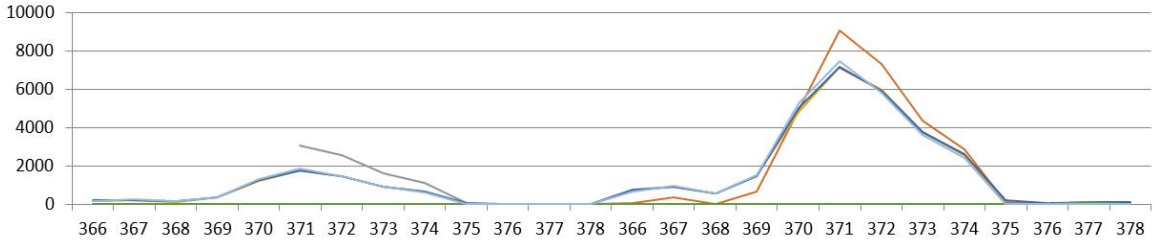
Identified issues:

- Differences originated from inexperience of post-processors across surveys (HERAS, IWBSS).

ID 17 – NL IBWSS, challenging, WHB and HOM



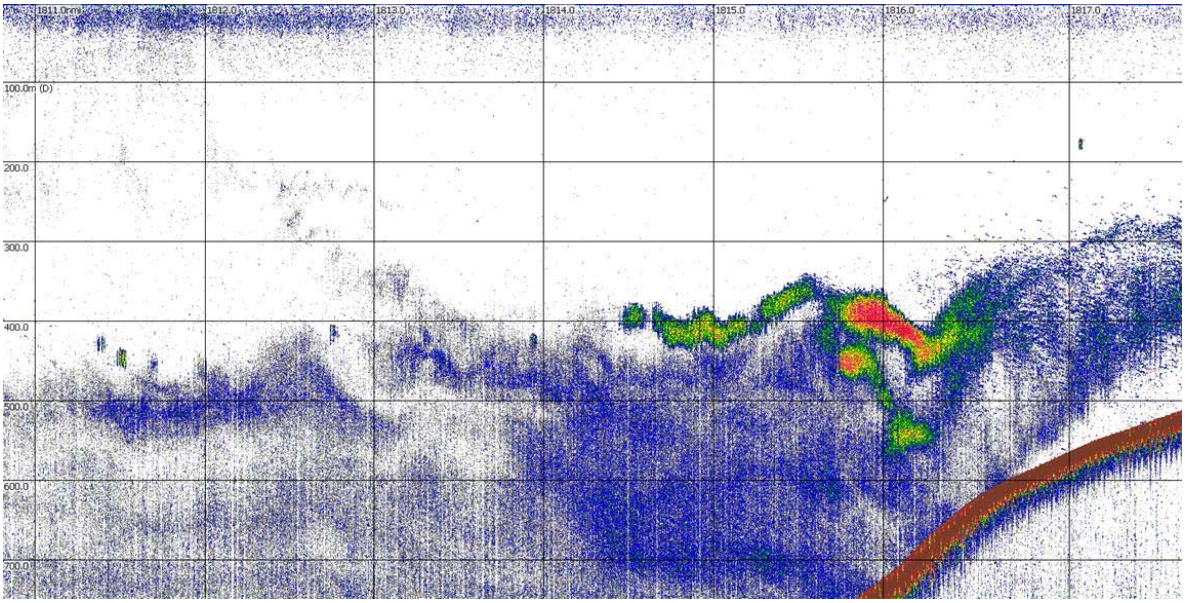
	WHB													HOM												
Intervals:	**366**	**367**	**368**	**369**	**370**	**371**	**372**	**373**	**374**	**375**	**376**	**377**	**378**	**366**	**367**	**368**	369	370	371	372	373	374	375	376	377	378
NL_1	0	0	0	0	0	0	0	0	0	0	0	0	0	79	347	0	661	4903	9072	7306	4387	2877	93	0	52	0
NL_2						3046	2548	1612	1106	83									7108	5946	3762	2580	195			
IRL	173	230	134	370	1189	1773	1475	929	638	0	0	0	0	697	926	540	1493	4794	7148	5948	3746	2572	0	0	0	0
GER	186	231	136	369	1240	1775	1475	930	644	47	18	22	29	750	929	549	1485	4994	7151	5940	3746	2595	189	71	90	118
NOR	0	0	0	0	0	0	0	0	0	0	0	0	0	5	11	10	18	30	4	1	4	4	6	22	100	5
NL_3	170	242	141	375	1323	1874	1460	910	603	0	0	0	0	679	968	564	1499	5291	7495	5838	3640	2414	0	0	0	0



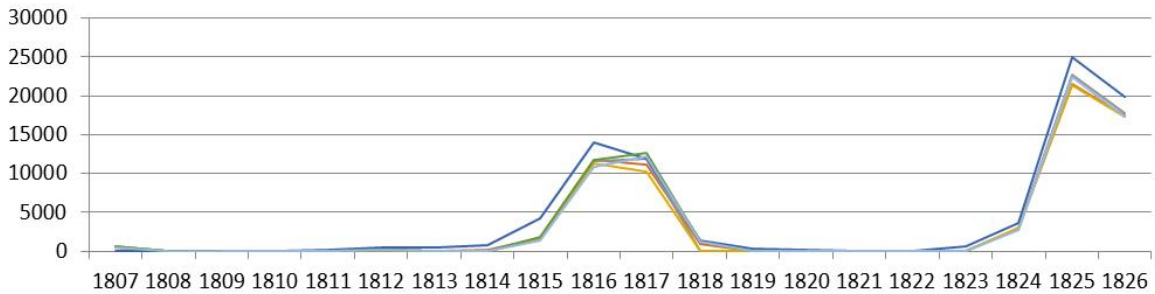
Identified issues:

- Need for representative catches and knowledge of catch performance. Trawl catch data available for scrutinisation example regarded insufficient for precise allocation of species.

ID 20 – NL IBWSS, typical, WHB



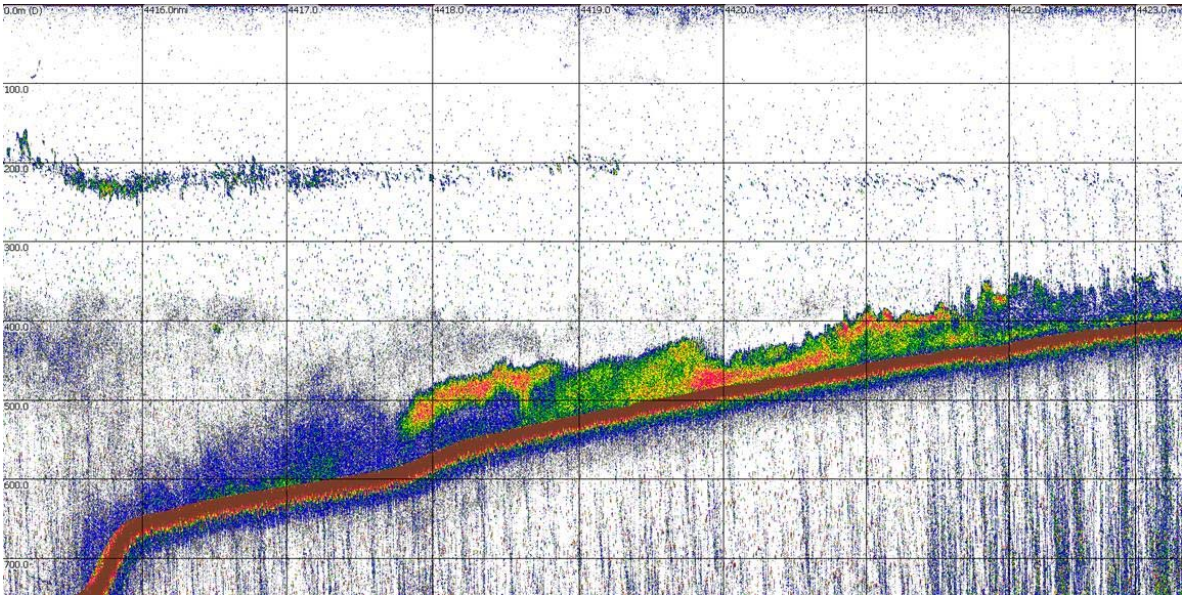
Intervals:	1807	1808	1809	1810	1811	1812	1813	1814	1815	1816	1817	1818	1819	1820	1821	1822	1823	1824	1825	1826
NL_1	552	0	0	0	17	117	10	178	1657	11717	11214	915	0	0	0	0	23	2855	21514	17390
NL_2	555	0	0	0	0	106	0	0	1557	11565	11966	0	0	0	0	0	0	2902	22791	17772
IRL	558	0	0	0	0	120	12	20	1596	11309	10191	7	0	0	0	0	0	3054	21323	17283
GER	0	0	0	0	136	534	509	741	4309	14066	11936	1319	337	170	0	34	585	3648	24919	19896
NOR	559	0	0	0	25	146	21	50	1817	11772	12695	1299	0	0						
NL_3	553	0	0	0	16	124	11	17	1364	10916	12226	1195	0	0	0	0	0	2709	22457	17366



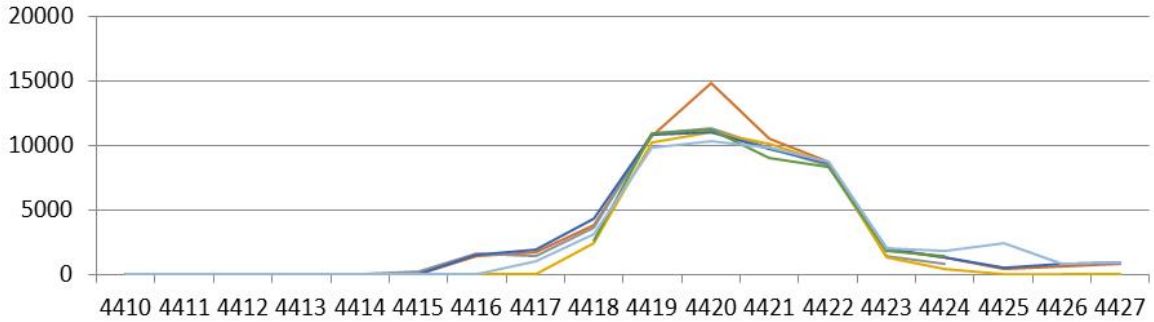
Identified issues:

- Differences originated from missed smaller marks of schools in the echogram as well as from inclusion/exclusion of weakly scattering parts to WHB schools due to inexperience in post-processing across surveys.

ID 24 – NL IBWSS, typical, WHB



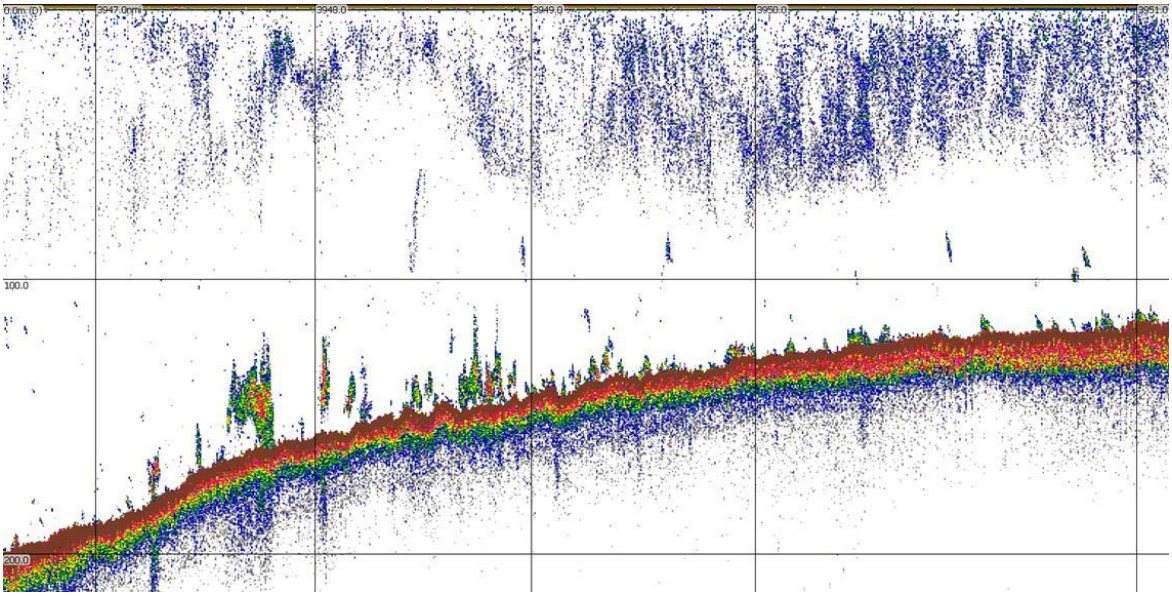
Intervals:	4410	4411	4412	4413	4414	4415	4416	4417	4418	4419	4420	4421	4422	4423	4424	4425	4426	4427
NL_1	0	0	0	0	0	0	1407	1761	3792	10711	14879	10505	8766	1944	1335	397	592	857
NL_2	0	0	21	0	0	185	1636	1465	3663	10952	11363	9805	8424	1451	817			
IRL	0	0	0	0	0	0	0	0	2433	10264	11068	10144	8589	1362	467	0	0	0
GER	0	0	0	0	0	0	1490	1892	4346	10821	10994	9687	8588	1997	1340	544	779	923
NOR									2590	10909	11248	9012	8305	1840	1379			
NL_3	0	0	0	0	0	0	11	1024	3079	9803	10356	9805	8707	2071	1803	2440	863	904



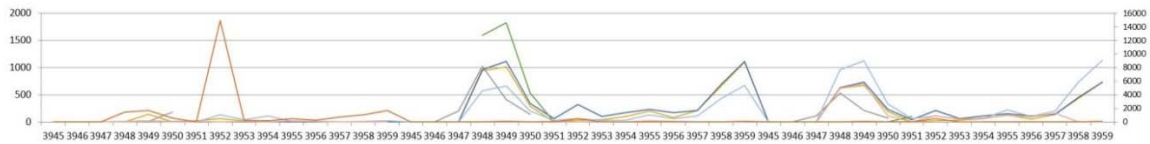
Identified issues:

- Separation of blue whiting and seabed close to the shelf edge.
- Identification of (weakly scattering) start of blue whiting aggregations.

ID 27 – NL IBWSS, challenging, MAC, BOC, HOM



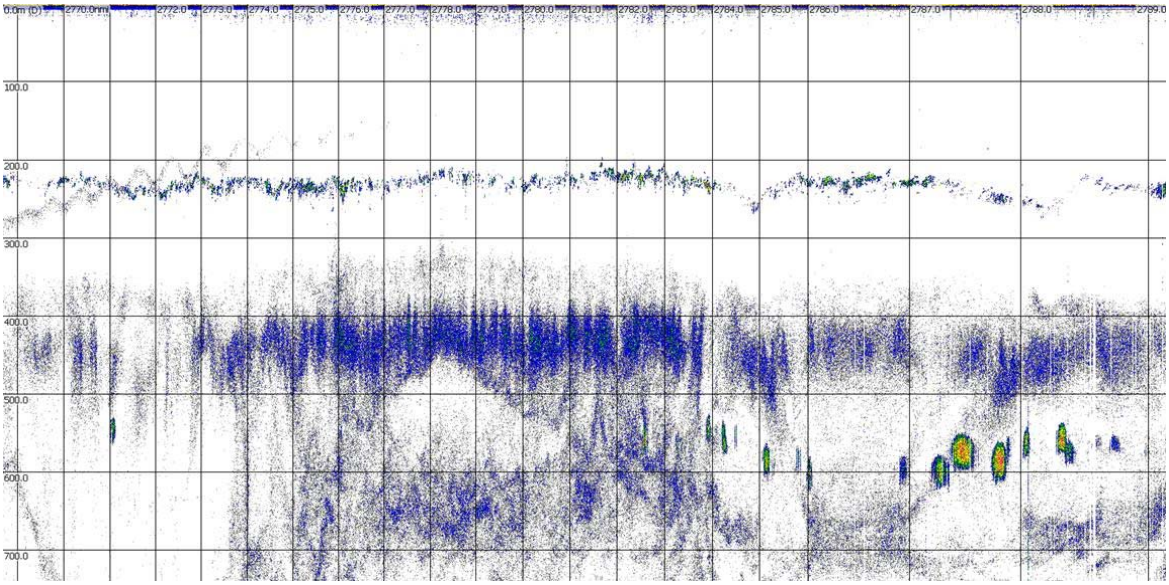
	MAC															BOC													HOM												
Intervals:	3945	3946	3947	3948	3949	3950	3951	3952	3953	3954	3955	3956	3957	3958	3959	3945	3946	3947	3948	3949	3950	3951	3952	3953	3954	3955	3956	3957	3958	3959	3945	3946	3947	3948	3949	3950	3951	3952	3953	3954	3955	3956	3957	3958	3959
NL_1	0	0	0	1488	1726	541	22	14916	280	162	504	242	735	1086	1729	0	0	0	47	55	17	0	476	9	5	16	7	23	34	55	0	0	0	47	55	17	0	476	9	5	16	7	23	34	55
NL_2		0	0	0	9	179											0	207	1027	408	146												0	107	529	210	75								
IRL	0	0	0	0	144	5	21	64	23	0	0	0	0	0	0	0	0	0	947	1015	297	0	34	42	99	202	79	215	660	1107	0	0	0	626	671	196	0	23	28	65	134	52	142	436	732
GER	0	0	0	1	7	7	4	0	0	2	0	5	1	6	0	0	0	1	959	1111	345	66	318	99	176	232	172	209	692	1111	0	0	1	634	735	228	44	210	65	116	154	114	138	457	734
NOR				0	0	7	0												1595	1829	535	0												0	0	0	97							
SPA	0	0	0	15	18	10	3	131	39	115	14	8	5	12	18	0	0	0	572	662	199	34	65	33	34	131	61	117	436	669	0	0	0	967	1121	337	58	110	56	57	221	103	198	738	1132
NL_3		0	0	0	7	6	10	0	16	5	24	16	2	0	0		0	0	0	7	6	10	0	16	5	24	16	2	0	0		0	0	622	705	115	0	110	56	69	122	96	158	0	0



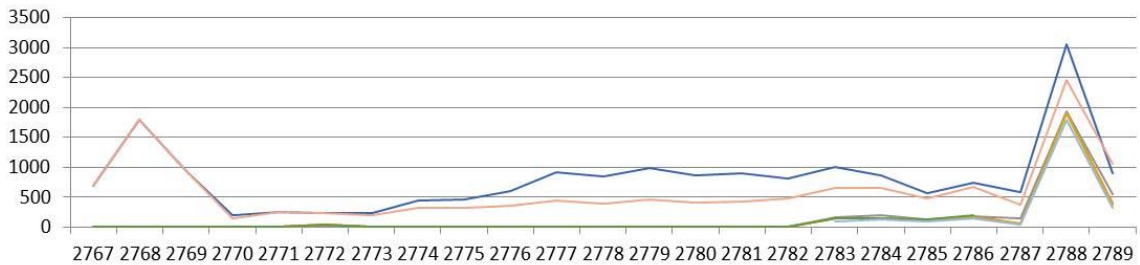
Identified issues:

- Need for representative catches and knowledge of catch performance as well as species-specific behaviour towards trawl gear.
- Use of multifrequency/wideband information helps to distinguish echotraces and to allow for more precise species categorization.
- Missing intervals: No scrutinising of trawl haul sections in exercise (like in actual post-processing of survey data).

ID 29 – NL IBWSS, challenging, WHB



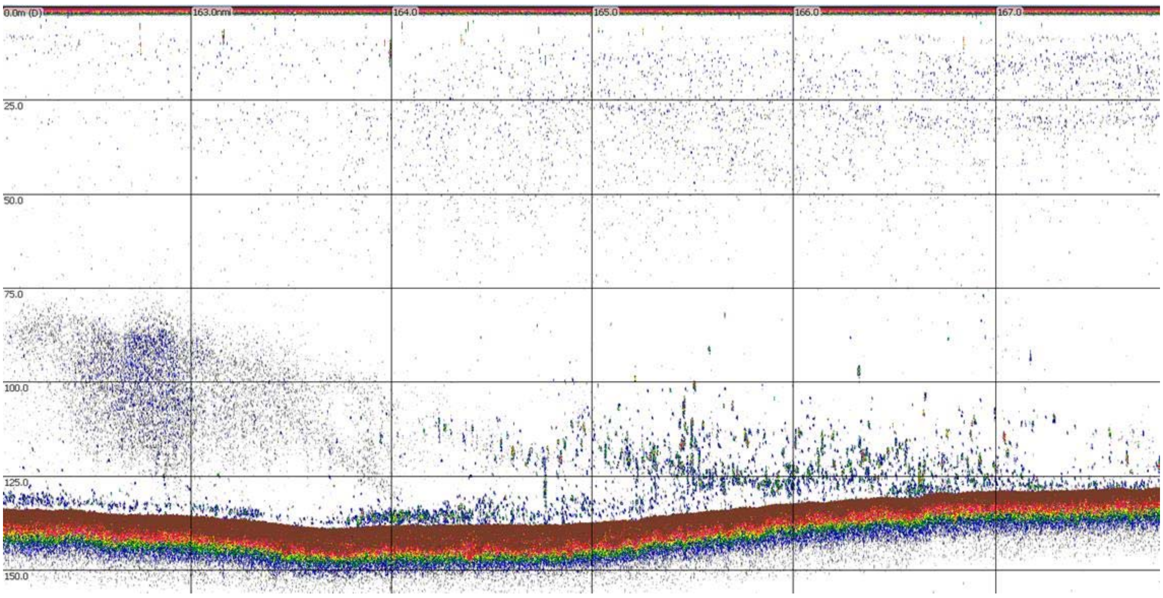
Intervals:	2767	2768	2769	2770	2771	2772	2773	2774	2775	2776	2777	2778	2779	2780	2781	2782	2783	2784	2785	2786	2787	2788	2789
NL_1	0	0	0	0	0	36	0	0	0	0	0	0	0	0	0	0	145	141	117	183	55	1917	382
NL_2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	169	198	134	187	145	1929	552
IRL	0	0	0	0	1	41	0	0	0	0	0	0	0	0	0	0	135	142	122	169	51	1899	375
GER	695	1783	934	197	251	228	230	450	456	592	922	853	990	855	890	809	994	865	562	734	579	3050	900
NOR	0	0	0	0	0	45	0	0	0	0	0	0	0	0	0	0	138	151	127	188			
SCO																	96	122	99	140	43	1786	321
NL_3	693	1792	932	135	244	223	194	324	318	351	447	389	460	404	416	469	644	647	482	678	374	2464	1047



Identified issues:

- Need for data over wide temporal and geographical scales to clearly identify different scattering layers in oceanic offshore situations.
- Use of thresholding techniques to identify scattering layers: Erroneous inclusion of mesopelagic scattering layer to assumed WHB aggregation.

ID 35 – NL HERAS, challenging, HER and NOP

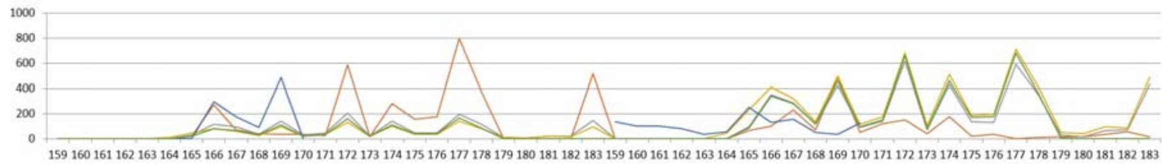


HER

Intervals:	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183
NL_1	0	0	0	0	0	0	23	273	71	42	38	34	24	589	14	280	158	176	797	375	0	0	1	1	518
NL_2	0	0	0	0	0	0	33	118	95	38	143	30	47	205	23	143	46	44	197	116	10	5	22	23	145
IRL	0	0	0	0	0	9	45	80	63	26	97	23	34	133	20	100	37	38	139	80	10	8	19	17	95
NOR	0	0	0	0	0	0	0	295	176	91	485	0													
NL_3	0	0	0	0	0	0	21	83	68	30	112	23	37	160	20	112	41	43	166	87	2	0	0	0	0

NOP

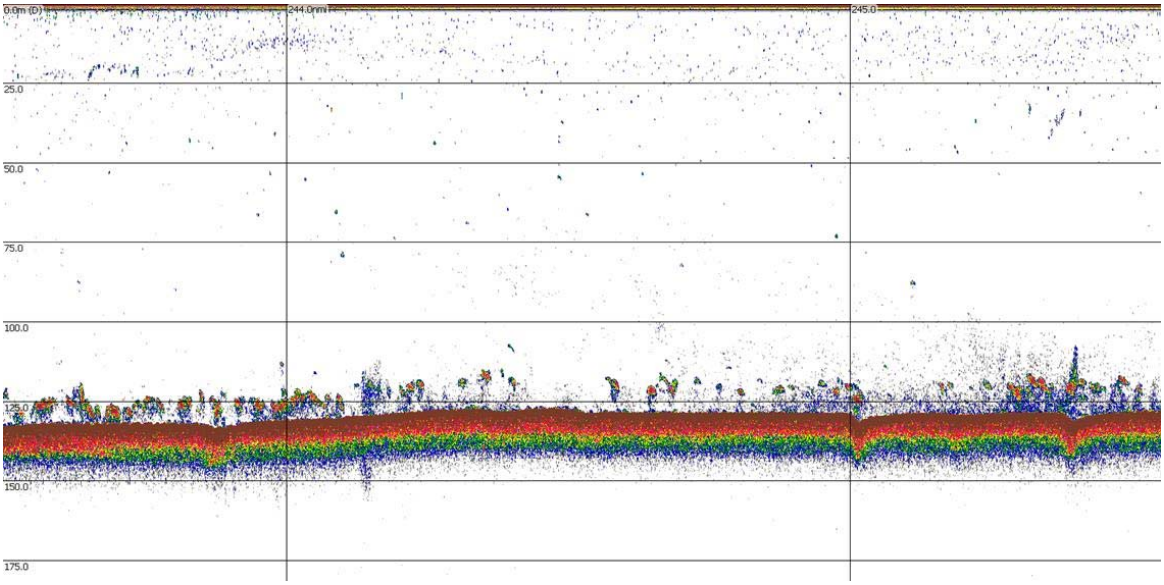
Intervals:	159	160	161	162	163	164	165	166	167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183
NL_1	0	0	0	0	0	0	68	99	229	70	490	49	120	151	42	178	21	34	0	9	15	14	37	54	15
NL_2	0	0	0	0	0	0	98	354	284	115	429	90	141	615	70	430	138	131	592	349	29	15	66	70	434
IRL	0	0	0	0	0	46	233	411	323	134	499	116	175	680	105	512	188	194	713	408	51	42	95	88	488
NOR	136	101	100	79	35	55	251	131	155	50	34	124													
NL_3	0	0	0	0	0	1	86	343	282	123	460	96	152	660	83	463	171	176	684	358	7	0	0	0	0



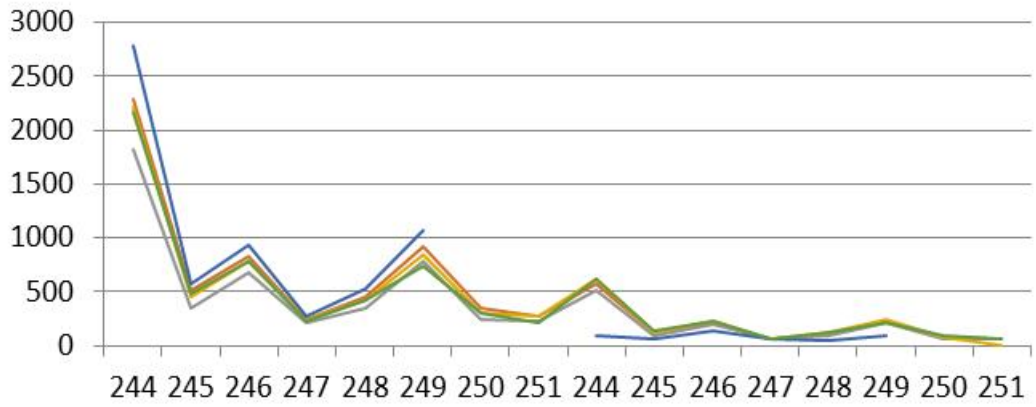
Identified issues:

- Need for representative catches and knowledge of catch performance.

ID 41 – NL HERAS, challenging, HER and NOP



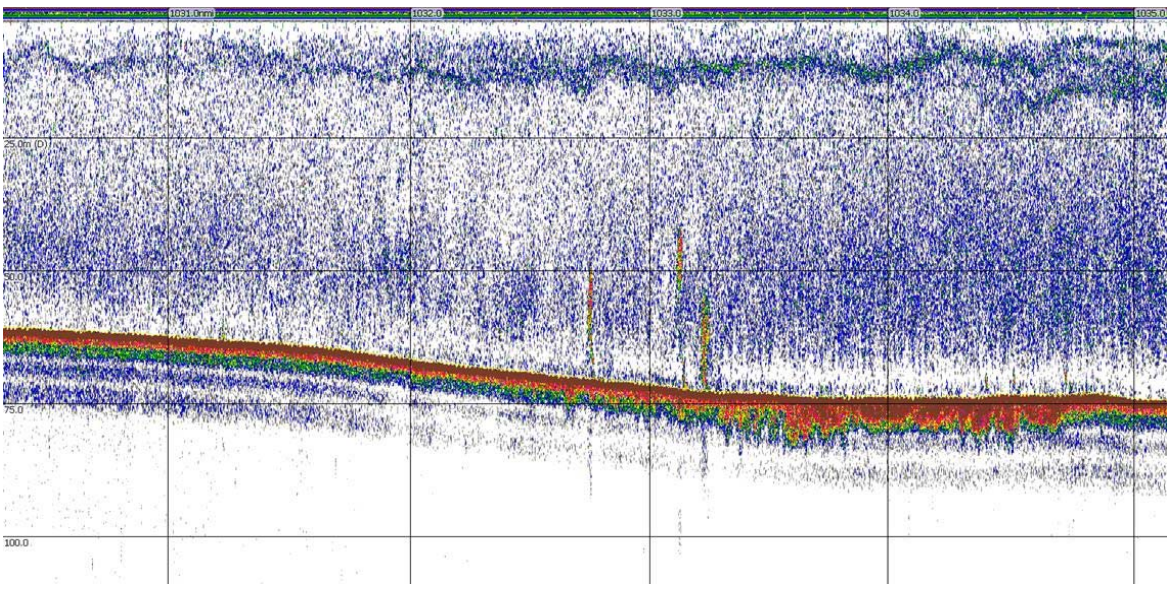
	HER								NOP							
Intervals:	**244**	**245**	**246**	**247**	**248**	**249**	**250**	**251**	**244**	**245**	**246**	**247**	**248**	**249**	**250**	**251**
NL_1	2291	508	829	248	450	922	341	266	573	127	207	62	113	230	85	66
NL_2	1821	353	683	210	350	779	245	226	514	100	193	59	99	220	69	64
IRL	2218	460	789	240	425	842	297	267	623	127	223	65	119	236	83	0
GER	2785	577	929	268	527	1070			87	67	132	57	45	92		
NOR	2171	479	784	223	418	741	309	212	612	135	221	63	118	209	87	60
NL_3	1992	406	665	202	363	720	243	166	854	174	285	87	155	309	104	71



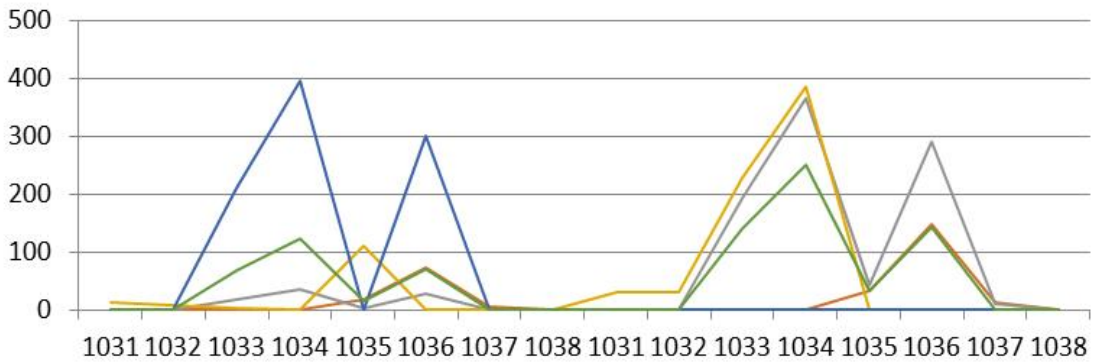
Identified issues:

- Need for representative (big) catches and knowledge of catch performance.

ID 42 – NL HERAS, challenging, HER and NOP



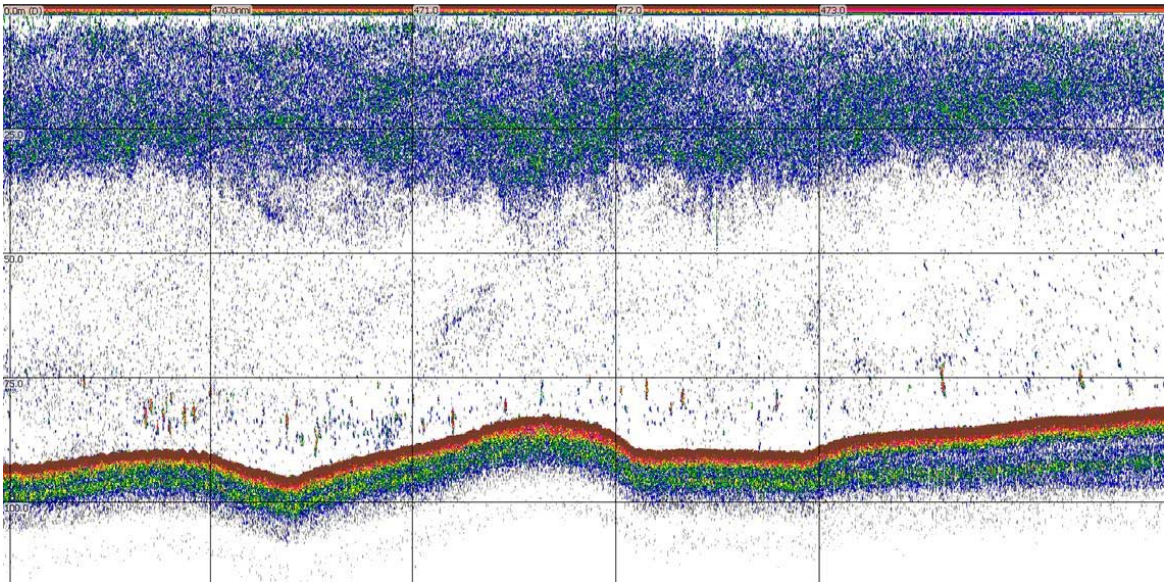
	HER								NOP							
Intervals:	**1031**	**1032**	**1033**	**1034**	**1035**	**1036**	**1037**	**1038**	**1031**	**1032**	**1033**	**1034**	**1035**	**1036**	**1037**	**1038**
NL_2	0	0	0	0	17	74	6	0	0	0	0	0	33	149	12	0
IRL	0	0	19	36	4	29	1	0	0	0	194	366	42	290	10	0
NOR	13	9	3	0	110	0	0	0	30	30	228	386	0	0	0	0
SCO	0	0	210	396	0	300	0	0	0	0	0	0	0	0	0	0
NL_3	0	0	69	124	16	70	0	0	0	0	140	250	32	142	0	0
NL_1	0	0	210	377	0	0	0	0	0	0	0	0	0	300	0	0



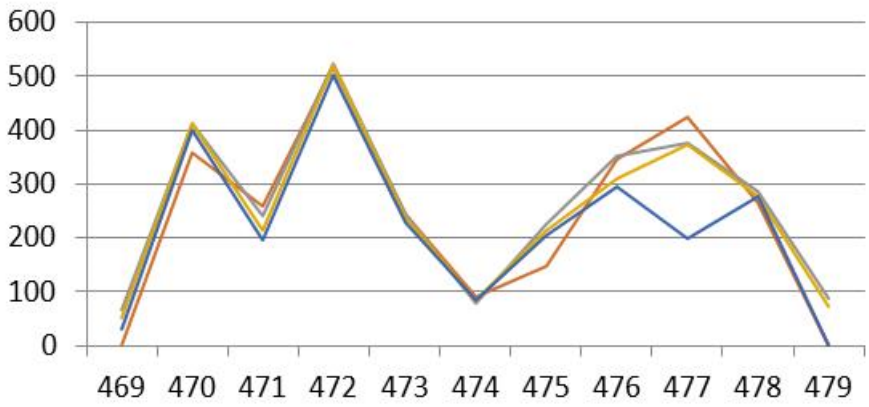
Identified issues:

- Need for representative catches and knowledge of catch performance: Clear marks on echogram vs. mixed catches – species allocation difficult.
- Use of multifrequency/wideband information helps to distinguish echotraces.

ID 45 – NL HERAS, typical, SPR



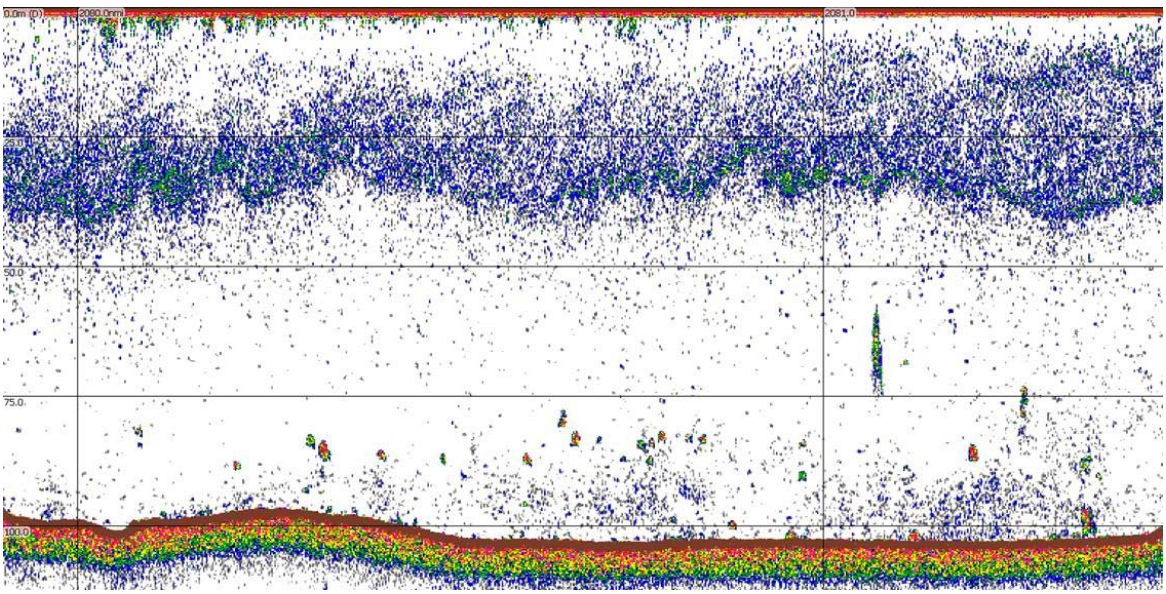
Intervals:	469	470	471	472	473	474	475	476	477	478	479
NL_2	0	357	258	518	244	90	147	345	425	266	0
NOR	67	412	242	523	245	78	225	352	376	285	88
NL_3	51	412	215	519	238	85	214	311	372	277	74
NL_1	31	400	195	503	228	85	206	294	198	276	0



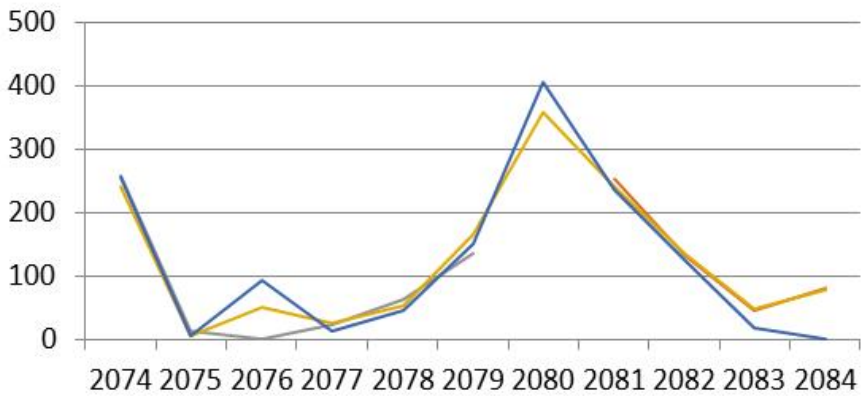
Identified issues:

- If applicable, appropriate school detection properties should be used.
- Separation of (small) schools from seabed.

ID 46 – NL HERAS, typical, SPR



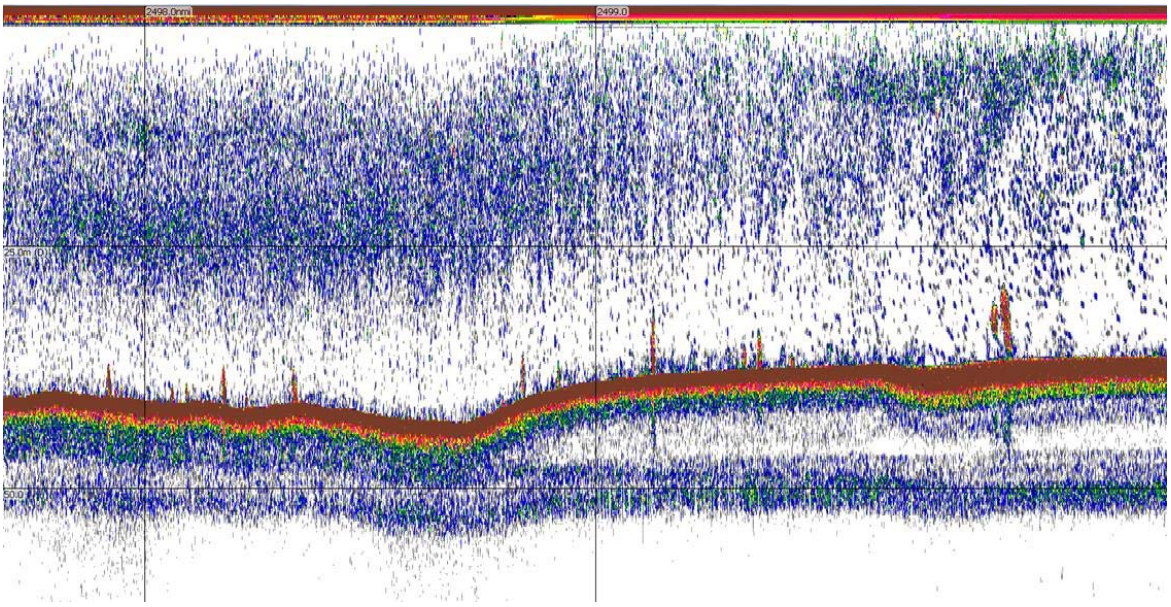
Intervals:	2074	2075	2076	2077	2078	2079	2080	2081	2082	2083	2084
NL_2								254	133	45	81
NOR	258	13	0	24	62	136					
NL_3	242	6	51	25	54	165	358	240	136	47	77
NL_1	255	6	93	14	46	151	406	236	125	19	0



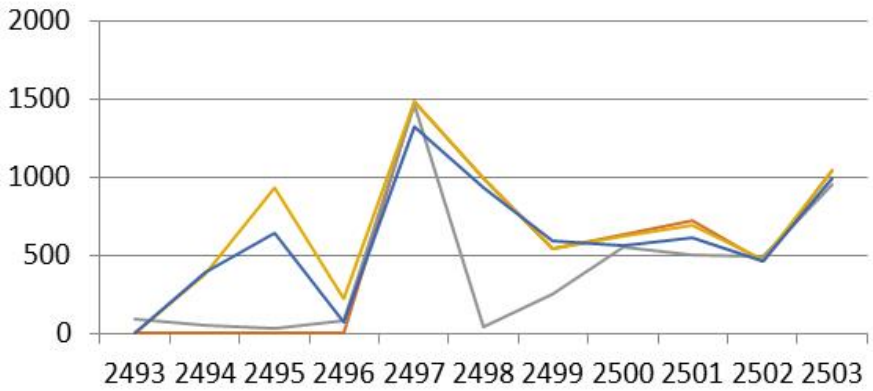
Identified issues:

- Use of appropriate school detection properties.
- Separation of (small) schools from seabed.
- Missing intervals: No scrutinising of trawl haul sections in exercise (like in actual post-processing of survey data).

ID 47 – NL HERAS, typical, SPR



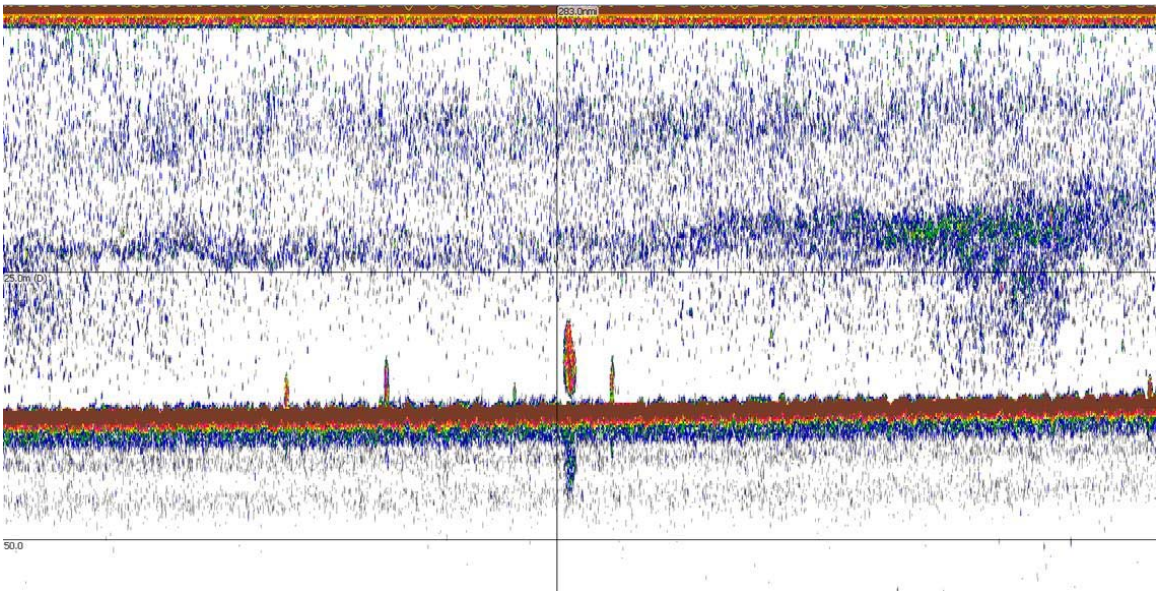
Intervals:	2493	2494	2495	2496	2497	2498	2499	2500	2501	2502	2503
NL_2	0	0	0	0	1480	991	539	631	727	460	1041
NOR	94	51	29	86	1466	39	252	552	503	497	949
NL_3	0	384	929	219	1488	991	542	621	694	470	1048
NL_1	0	396	639	72	1328	934	592	566	616	460	996



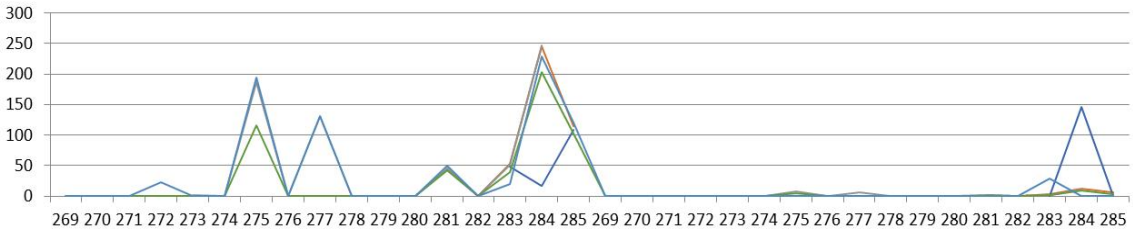
Identified issues:

- Use of appropriate school detection properties.
- Separation of schools from seabed.
- Identification of (small) schools close to the seabed.

ID 55 – GER HERAS, typical, SPR and HER



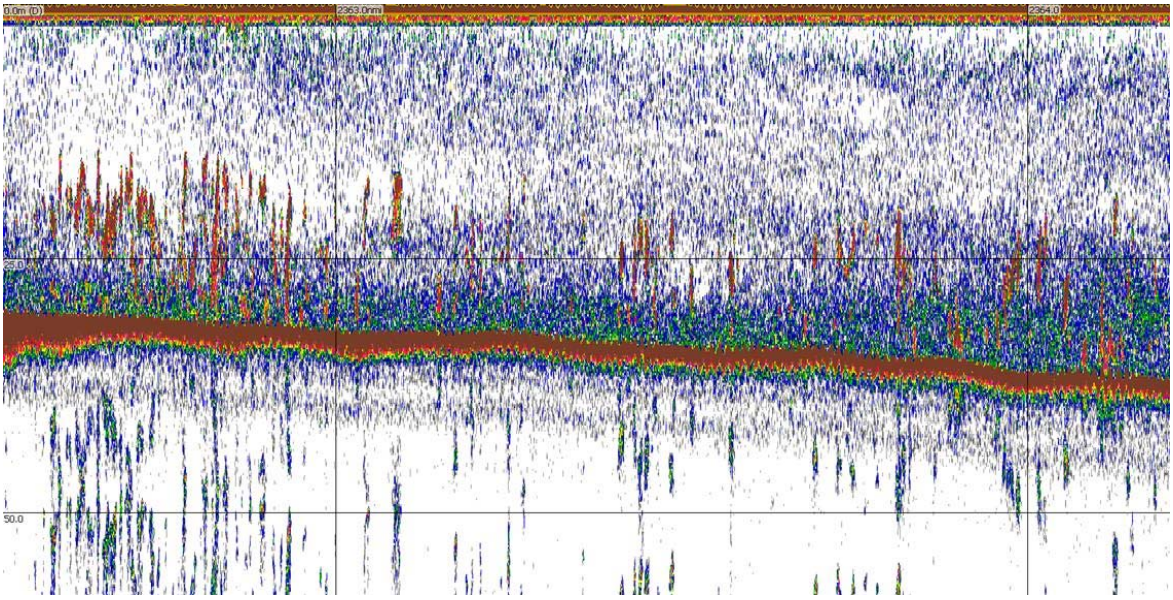
	SPR																	HER																
Intervals:	**269**	**270**	**271**	**272**	**273**	**274**	**275**	**276**	**277**	**278**	**279**	**280**	**281**	**282**	**283**	**284**	**285**	**269**	**270**	**271**	**272**	**273**	**274**	**275**	**276**	**277**	**278**	**279**	**280**	**281**	**282**	**283**	**284**	**285**
NL_2													46	0	53	245	115													2	0	3	13	6
GER					2	0	187	0	131	0	0	0	46	0	51	247						0	0	8	0	6	0	0	0	1	0	2	11	
SCO				9			164		127				41		49	17	108				0			0		0				0		0	146	0
NL_3	0	0	0	0	0	0	116	0	0	0	0	0	43	0	39	203	102	0	0	0	0	0	0	5	0	0	0	0	0	2	0	2	9	4
NL_1	0	0	0	23	0	0	194	0.6	131	0	0	0	49	0	20	229	121	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29	0	0



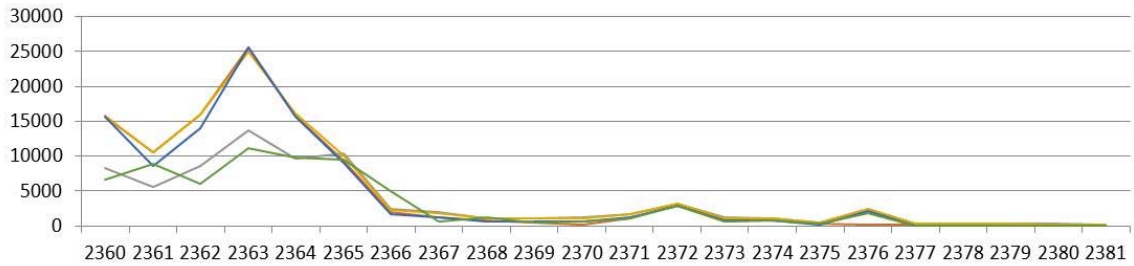
Identified issues:

- Use of appropriate school detection properties.
- Separation of schools from seabed.
- Identification of (small) schools close to the seabed.
- Need for representative catches and knowledge of catch performance.
- Subjective, experience based allocation of schools to species based on school shape.

ID 56 - GER HERAS, typical, SPR



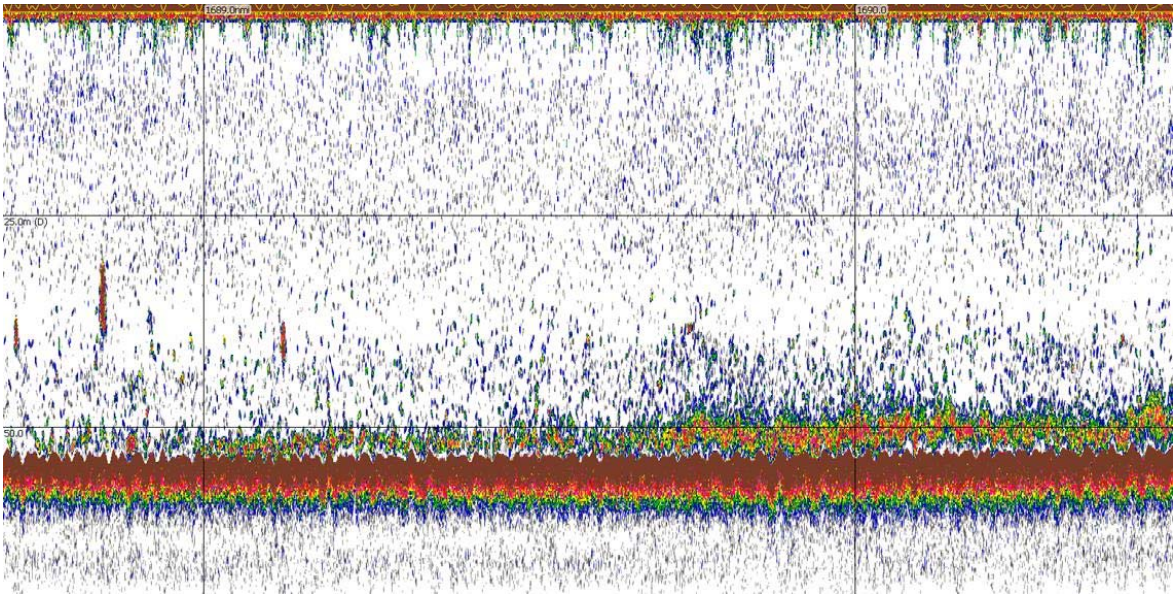
Intervals:	2360	2361	2362	2363	2364	2365	2366	2367	2368	2369	2370	2371	2372	2373	2374	2375	2376	2377	2378	2379	2380	2381
NL_2	15646	10497	15998	25506	15840	9282	1911	1259	721	551	251	1126	2975	874	907	347	226	183	93	32	0	0
GER	8332	5559	8624	13737	9663	10451	2395	1945	1103	1121	1217	1616	3192	1181	1097	476	2368	336	310	280	255	232
NOR	15837	10610	15994	24958	16067	10090	2354	1839	1065	1048	1054	1622	3159	1056	1053	459	2481	325	280	266	241	218
NL_3	15679	8548	13998	25505	15690	9038	1669	1278	691	618	574	1250	2893	754	716	205	2085	0	0	0	0	0
NL_1	6596	8925	6094	11194	9800	9471	5028	698	1295	530	638	1040	2942	568	718	389	1885	23	19	9	7	77



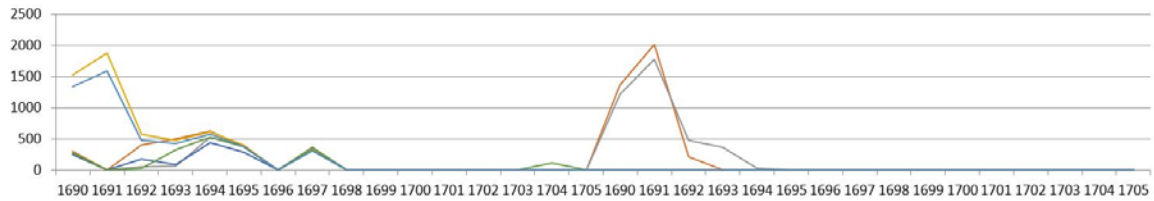
Identified issues:

- Use of appropriate school detection properties.
- Separation of (small) schools from seabed.
- Detection (inclusion) of small schools/layers along the seabed.
- Splitting of NASC according to catch composition if species are due to their identical scattering and schooling properties not discernible from echograms (or occur in mixed schools).

ID 61 – GER HERAS, challenging, SPR and SAN(?)



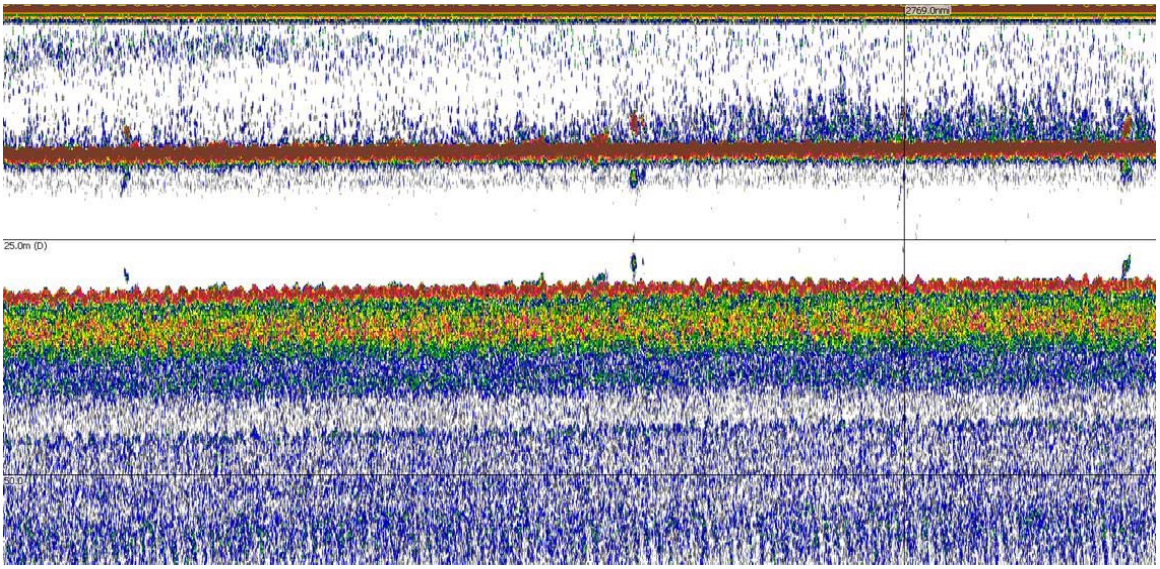
	SPR																SAN															
Intervals:	**1690**	**1691**	**1692**	**1693**	**1694**	**1695**	**1696**	**1697**	**1698**	**1699**	**1700**	**1701**	**1702**	**1703**	**1704**	**1705**	**1690**	**1691**	**1692**	**1693**	**1694**	**1695**	**1696**	**1697**	**1698**	**1699**	**1700**	**1701**	**1702**	**1703**	**1704**	**1705**
NL_2	305	0	407	508	633	384	6	350	0	0	0	0	0	0	0	0	1362	2013	213	0	0	0	0	0	0	0	0	0	0	0	0	0
GER	255	2	48	65	525	378	0	361	0	0	0	0	0	0	0	0	1217	1776	484	362	33	0	0	0	0	0	0	0	0	0	0	0
NOR	1536	1878	582	477	615	397	0	325	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
SCO	255	0	177	96	445	290	0	320	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NL_3	1341	1596	476	426	573	377	5	314	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
NL_1	273	0	27	324	528	374	0	360	0	0	0	0	0	0	116	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0



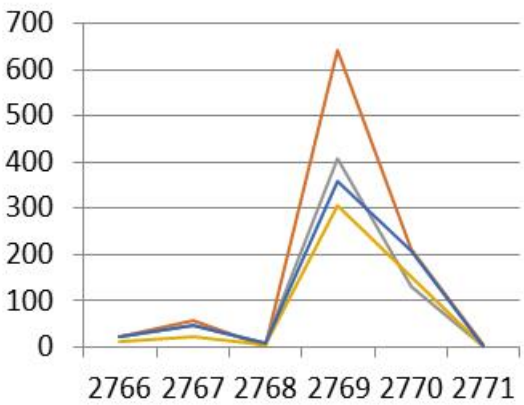
Identified issues:

- Need for representative catches and knowledge of catch performance.
- Use of multifrequency/wideband information helps to distinguish echotraces and to categorize scatterers.
- Expert knowledge/judgment on either species and/or survey region.

ID 62 – GER HERAS, challenging, ANE



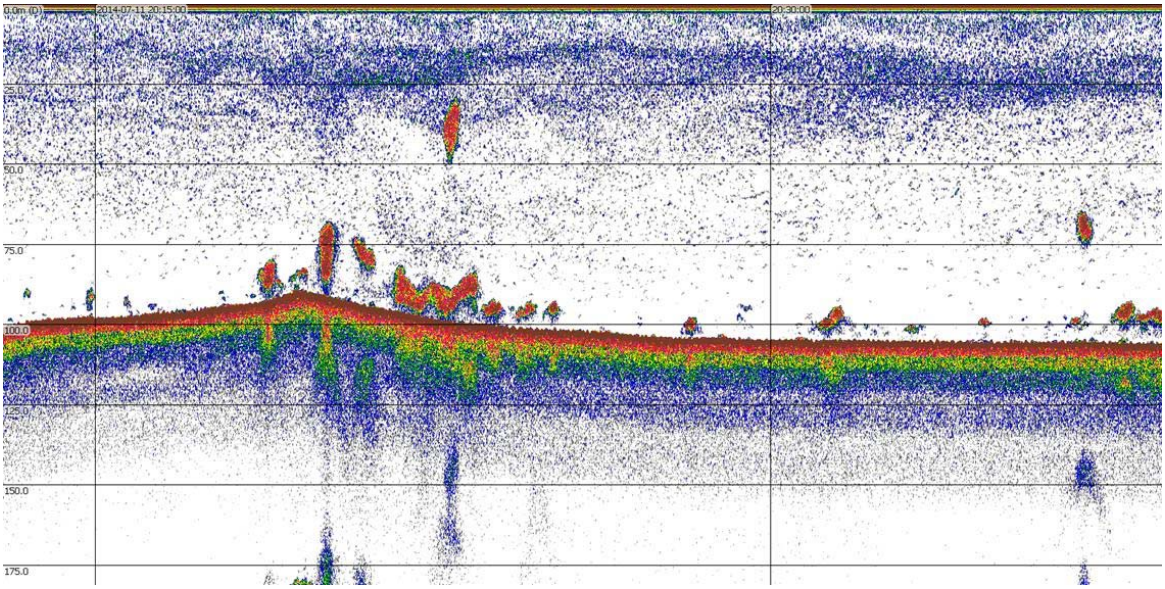
Intervals:	2766	2767	2768	2769	2770	2771
NL_2	22	58	0	643	211	3
GER	20	47	6	409	131	0
NOR	11	20	5	306	151	1
NL_3	22	45	8	358	209	0
NL_1	22	51	11	366	131	0



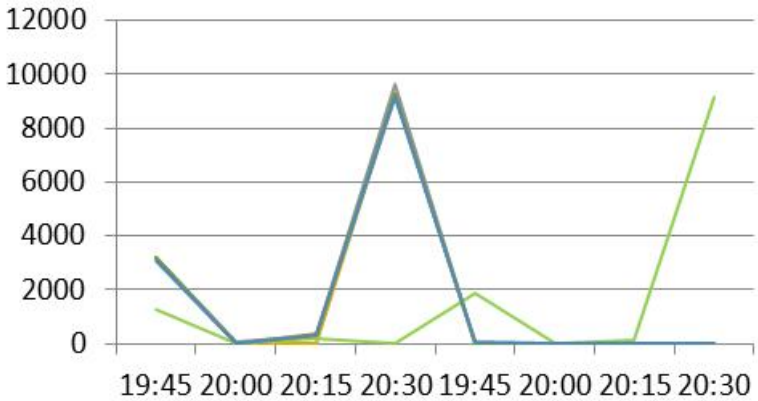
Identified issues:

- Separation of schools from seabed.
- Identification of (small) schools close to the seabed.
- Low (vertical) resolution of acoustic raw data (pulse length: 1.024 ms) in shallow areas.

ID 78 – SCO HERAS, challenging, HER and NOP



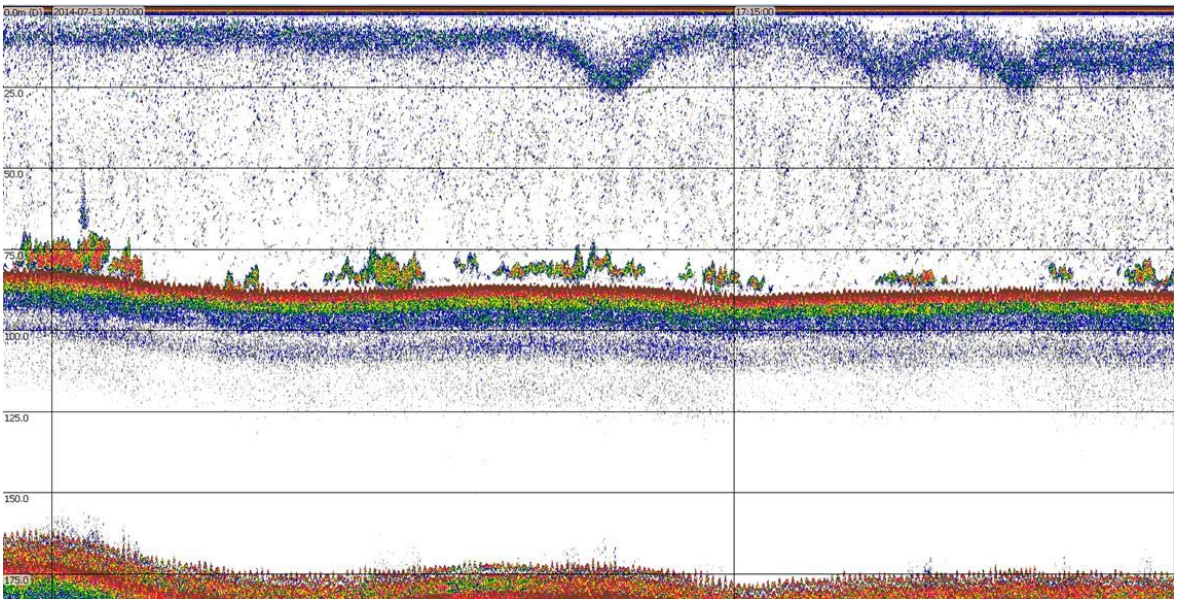
	HER				NOP			
Intervals:	**19:45**	**20:00**	**20:15**	**20:30**	**19:45**	**20:00**	**20:15**	**20:30**
NL_2	3209	0	351	9265	0	0	0	0
GER	3168	55	336	9615	0	0	0	0
NOR	3201	0	0	9238	0	0	0	0
SCO	1287	0	195	0	1854	16	134	9121
NL_3	3202	0	338	9257	0	0	0	0
NL_1	3049	16	334	9130	94	0	0	0



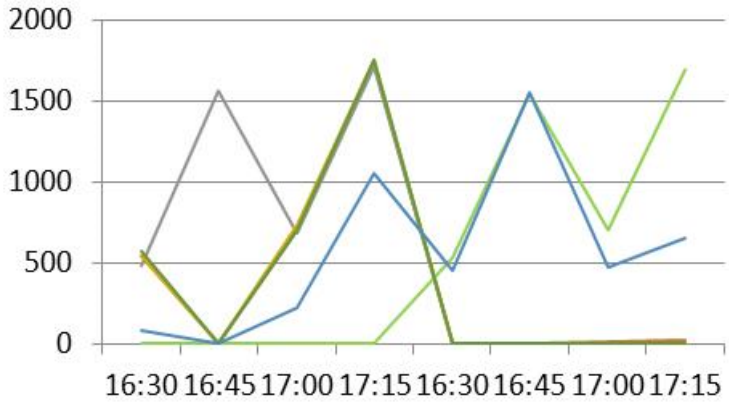
Identified issues:

- Need for representative catches and knowledge of catch performance.
- Splitting of NASC and allocation to schools based on catch composition vs. assumed schooling characteristics and catchability of different species.

ID 79 – SCO HERAS, challenging, HER and NOP



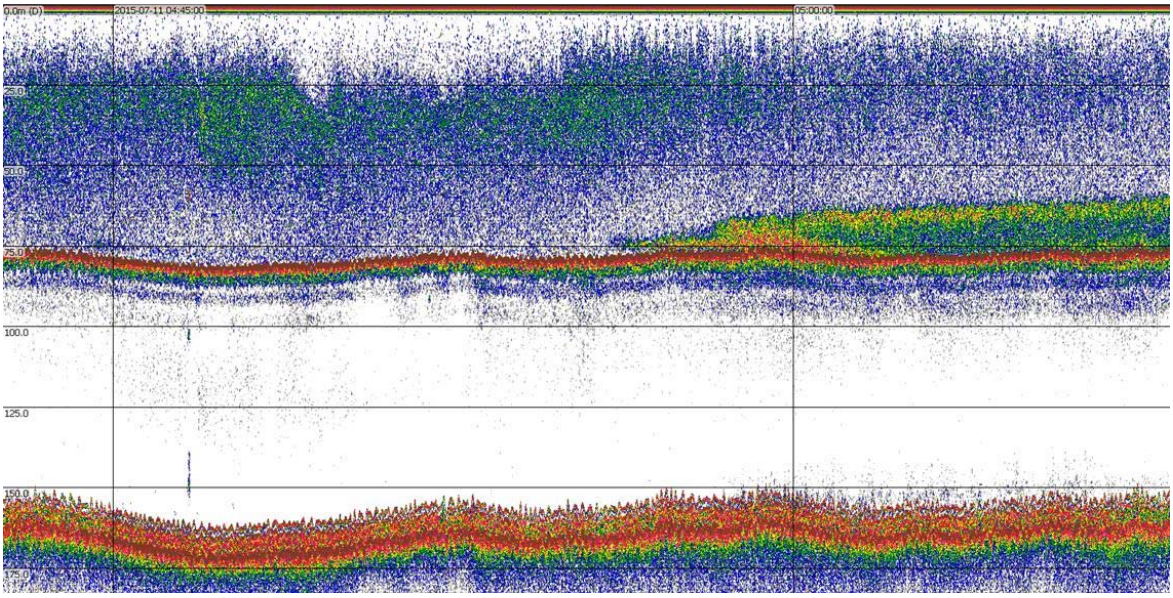
	HER				NOP			
Intervals:	**16:30**	**16:45**	**17:00**	**17:15**	**16:30**	**16:45**	**17:00**	**17:15**
NL_2	540	0	703	1739	5	0	7	18
GER	486	1569	687	1712	0	0	0	0
NOR	541	0	732	1755	0	0	0	0
SCO	0	0	0	0	529	1547	699	1694
NL_3	569	0	704	1753	0	0	0	0
NL_1	85	0	227	1051	450	1552	474	651



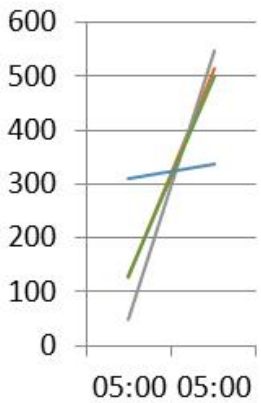
Identified issues:

- Need for representative catches and knowledge of catch performance: Unclear/difficult allocation of NASC values especially to NOP (see also case ID 78).

ID 89 – SCO HERAS, challenging, HER and NOP



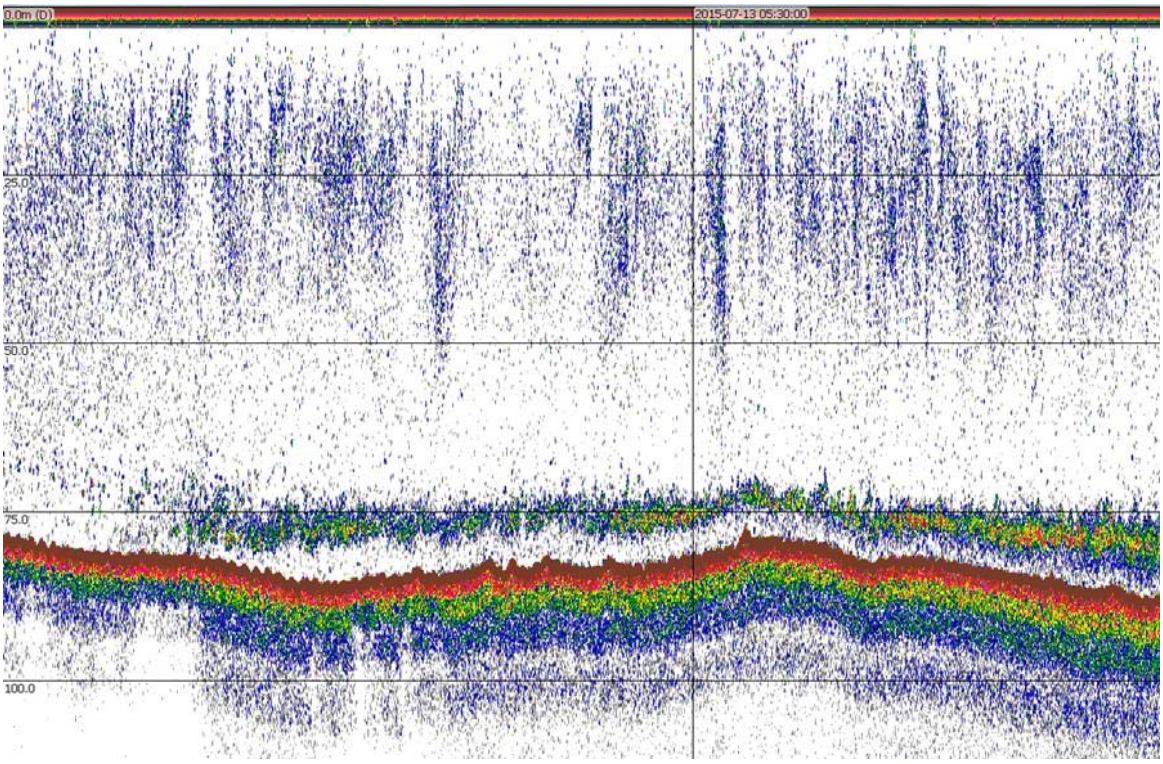
	HER	NOP
Intervals:	**05:00**	**05:00**
NL_2	128	514
GER	50	549
NL_3	129	499
NL_1	310	339



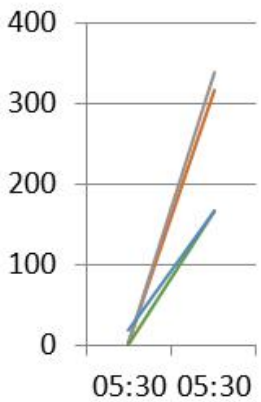
Identified issues:

- Need for representative catches and knowledge of catch performance. Difficult allocation of NOP to observed aggregations.
- Detection (inclusion) of layers along the seabed.

ID 90 – SCO HERAS, challenging, HER and NOP



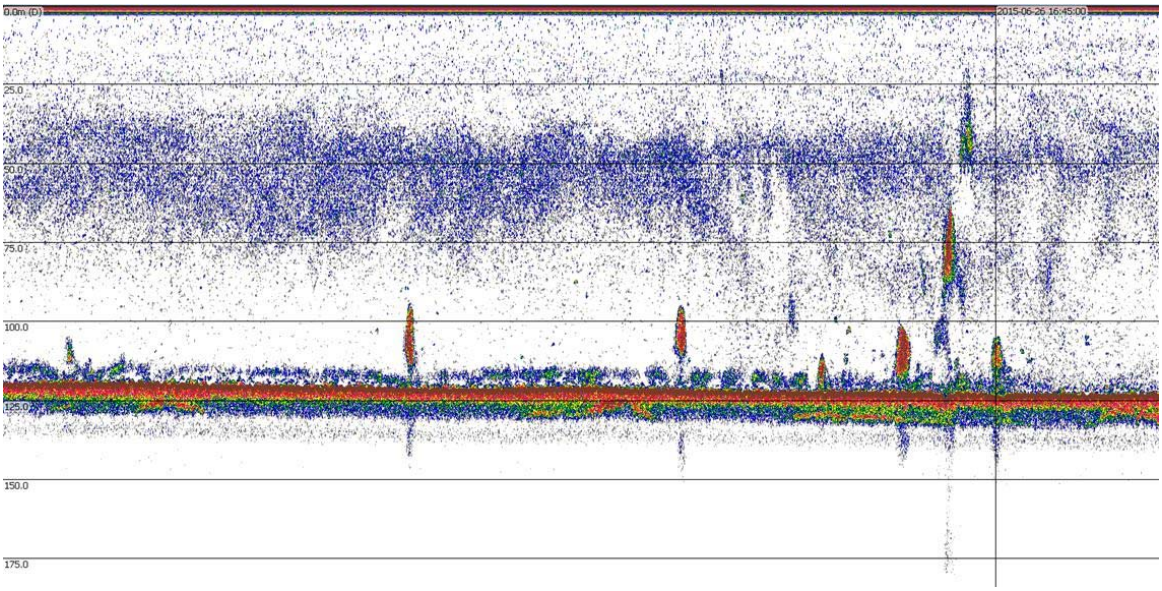
	HER	NOP
Intervals:	**05:30**	**05:30**
NL_2	3	317
GER	2	339
NOR	3	0
SCO	0	167
NL_1	19	167



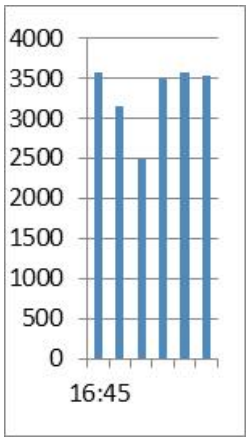
Identified issues:

- Use of multifrequency/wideband information helps to distinguish echotraces.
- Need for representative catches and knowledge of catch performance.

ID 91 – SCO HERAS, typical, HER



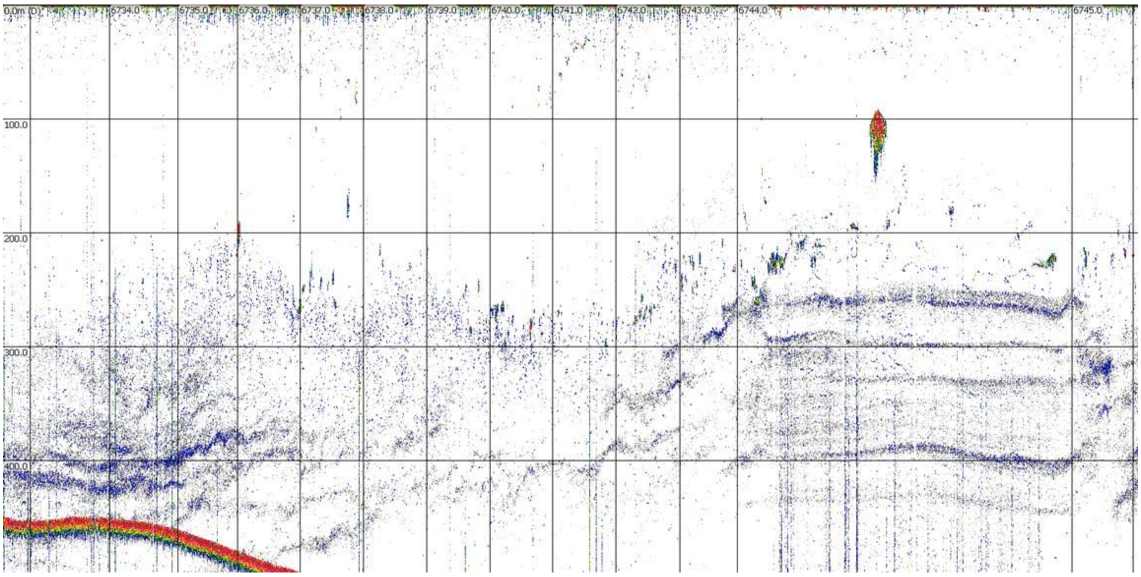
	HER
Intervals:	**16:45**
NL_2	3571
GER	3156
NOR	2487
SCO	3492
NL_3	3563
NL_1	3525



Identified issues:

- Detection (inclusion) of layers along the seabed.

ID 97 – NOR IESNS, challenging, WHB and HER



HER

Intervals:	6732	6733	6734	6735	6736	6737	6738	6739	6740	6741	6742	6743	6744	6745	6746	6747	6748	6749	6750	6751	6752
NL_2	0	0	0	0	1	2227	174	0	0	41	214	0	0	320	29	204	0	0	0	0	62
NOR	15	125	0	0	180	1967	432	165	170	301	306	284	222	522	166	129	11	7	6	54	43
SPA	1	16	0	0	0	213	33	5	9	25	11	20	12	146	21	22	1	5	5	13	16
SCO	0	0	0	0	0	2107	315	0	0	0	0	0	0	1325	0	0	0	0	0	0	0

Intervals:	6753	6754	6755	6756	6757	6758	6759	6760	6761	6762	6763	6764	6765	6766	6767	6768	6769	6770	6771	6772	6773	6774	6775	6776	6777	6778
NL_2	0	0	0	0	0	0	0	5	0	76	25	0	0	0	0	0	0	0	0	0	123	114	670	6848	0	0
NOR	6	7	45	344	44	5	4	151	9	55	26	10	9	9	6	70	6	377	144	285	248	106	519	6919	997	20
SPA	6	13	13	47	11	4	2	17	22	14	16	7	6	5	3	6	2	37	15	32	26	2	2	3	4	41
SCO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	65	0	360	6605	1052	0

WHB

Intervals:	6732	6733	6734	6735	6736	6737	6738	6739	6740	6741	6742	6743	6744	6745	6746	6747	6748	6749	6750	6751	6752
NL_2	391	404	374	431	430	351	493	319	307	439	239	486	417	540	605	416	360	521	254	346	398
NOR	55	30	59	60	53	315	59	38	38	68	34	65	51	70	85	99	59	130	94	161	222
SPA	11	145	0	0	0	1897	292	44	81	220	95	180	107	1303	184	197	12	47	47	120	138
SCO	0	160	0	0	0	0	0	0	66	206	33	134	53	83	125	0	0	0	0	46	39

Intervals:	6753	6754	6755	6756	6757	6758	6759	6760	6761	6762	6763	6764	6765	6766	6767	6768	6769	6770	6771	6772	6773	6774	6775	6776	6777	6778
NL_2	300	473	506	759	428	257	368	396	418	303	339	208	180	171	136	185	214	661	475	617	372	320	272	283	242	527
NOR	148	213	168	196	149	88	87	66	266	199	201	113	106	77	58	44	66	86	71	107	41	49	36	51	74	270
SPA	57	114	112	418	97	32	16	151	200	124	142	59	50	46	30	57	21	330	135	283	234	21	18	6627	1090	365
SCO	0	7	34	339	48	0	0	138	54	5	18	0	0	0	0	0	0	308	110	215	134	0	0	0	0	309

Identified issues:

- Need for representative catches and knowledge of catch performance. Mis-allocation of WHB and HER echoes.
- Use of appropriate thresholding techniques.

Annex 4: Notes from the IESNS scrutinising workshop

Notes from acoustic scrutinizing workshop in relation to the International Ecosystem Survey in Nordic Seas (IESNS).

3 – 5 March 2015
Marine Research Institute, Reykjavik

List of participants:
Karl-Johan Stæhr[2], Denmark
Bram Couperus[4], Netherlands
Leon Smith[3], Faroe Island
Eydna i Homrum[3], Faroe Island
Guðmundur J. Óskarsson[5], Iceland
Birkir Bárðarson[5], Iceland
Sigurður Þ. Jónsson, Iceland
Are Salthaug[1], Norway
Åge Høines[1], Norway

1 Institute of Marine Research, Bergen, Norway
2 DTU-Aqua, Hirtshals, Denmark
3 Faroese Marine Research Institute, Tórshavn, Faroe Islands
4 IMARES, IJmuiden, The Netherlands
5 Marine Research Institute, Reykjavik, Iceland

Introduction

During the Post Cruise Meeting for the International Ecosystem Survey in Nordic Seas (IESNS) in April – June 2014 conducted in Copenhagen 24 – 26 June 2014, it was recognized that major differences in registrations allocated to herring occured on parallel transects for two participating vessels. The post cruise report stated:

There are concerns with the acoustic estimates from Dana during this year's survey, which adds uncertainty to the present acoustic estimates of the herring. The concerns are because of almost zero registrations of herring on their fourth and fifth east-west transects, and also weak registrations on the third, compare to neighbour transects from G.O. Sars with much higher registrations (Figures 1). The fact that herring was caught by Dana along these transects in areas without herring registrations adds to the concerns that something is wrong with the data from Dana and needs a further attention. Two possible reasons for this discrepancy are of consideration: (1) Time-lag where Dana was around 10 days later compare to other vessels; (2) Problems related to the scrutinizing procedure in Dana. Catches of herring where herring was not recorded acoustically, only blue whiting, supports the second option and calls for re-scrutinizing of the acoustic data where the procedure described in the WGIPS manual is strictly followed. Until the re-scrutinizing has been done there is not much to add to this discussion.

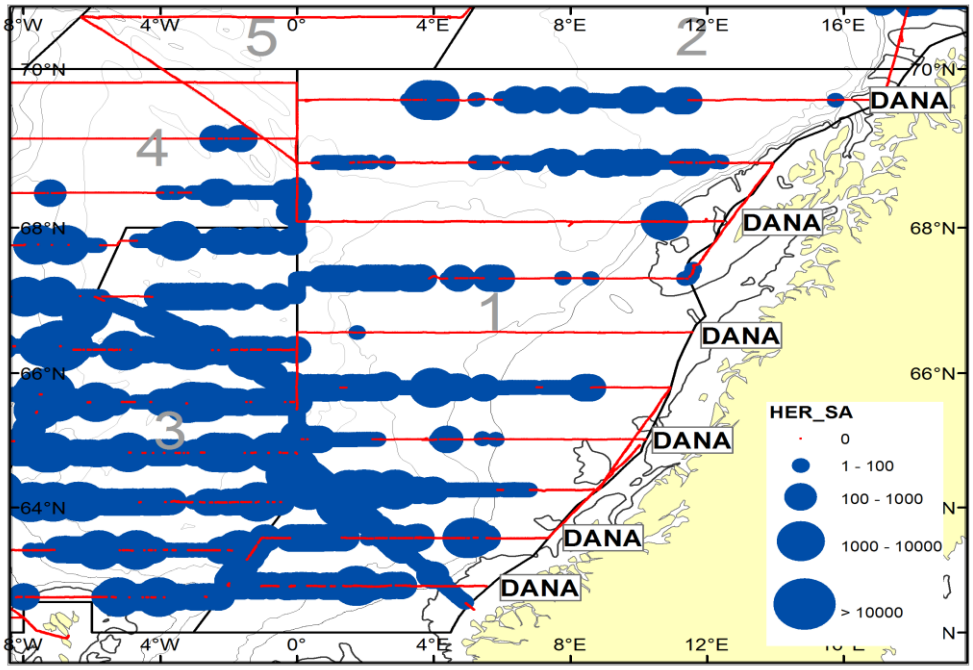


Figure 1. Distribution of HER_Sa for R/V Dana and R/V G.O. Sars during the 2014 IESNS survey

Therefore it was decided to conduct a scrutinizing workshop for all participating parties in the IESNS survey before the 2015 survey. The workshop was conducted 3 - 5 March 2015 in Reykjavik, Iceland with the aim to:

- Review scrutinizing procedure used by the different participants in IESNS
- Clarify of the observed differences between RV DANA and RV G.O. Sars in the 2014 survey
- Agree on future scrutinizing approaches and update scrutinizing protocol for IESNS.

Review of scrutinizing procedures

Iceland, Norway, Faeroes and EU presented their scrutinizing procedures with examples of different echograms illustrating both general situations and more importantly examples of problem echograms. The presentations from the participants in the IESNS showed that all were using the scrutinizing protocol stated in the survey manual even if LSSS or EchoView were used as tool in the scrutinizing process. Only minor differences were found in the processes without larger influence on the results. Problematic situations with different mixtures of different species and distributions in the water column were observed by all participants, although the problems encountered depend on time and place. Therefore it was decided in this document to discuss general situations for different species and species mixtures in the survey, illustrate them with screenshots and give recommendations to the scrutinizing process. Furthermore it was decided to revise and update the scrutinize description in the manual from 2008 with respect to the newest versions of the software used for scrutinization, and to account for the discussions during this meeting. The product will be an IESNS specific description of agreed scrutinization process and can be added to the IESNS scrutinization chapter in the next revision of the WGIPS acoustic survey manual.

Clarification of the observed differences between RV DANA and RV G.O. Sars in 2014 survey

The transects in question from RV Dana were investigated by the workshop participants and situations were identified where different interpretations between herring and other species are of a subjective nature. This means that differences in the scrutinizing procedure, although of minor importance for the total estimate, could in part explain the observed differences between the results of parallel transects of RV Dana and RV G.O. Sars. The time lag of 10 days between the vessels is probably also having an impact, which emphasizes the importance of a proper international coordination securing that parallel transects are covered within a short time window.

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 scrutinizing.

Agreement on future scrutinizing approach and update of scrutinizing protocol for IESNS

Echogram scrutiny is partly a subjective process that should be carried out in the presence of someone experienced **not only with the process but also with the survey area and the target species**. Species aggregation appearance may vary greatly between species in addition to temporal and geographical variation.

As a result the allocation of NASC to species always needs support from trawl-information. However, it should be noted that catch composition is influenced by the fish behaviour in response to the gear and/or the gear selectivity. It is therefore necessary to judge whether the catch-composition is a true reflection of the real species composition of the school or layer registered and whether the allocated percentage species composition needs to be further investigated.

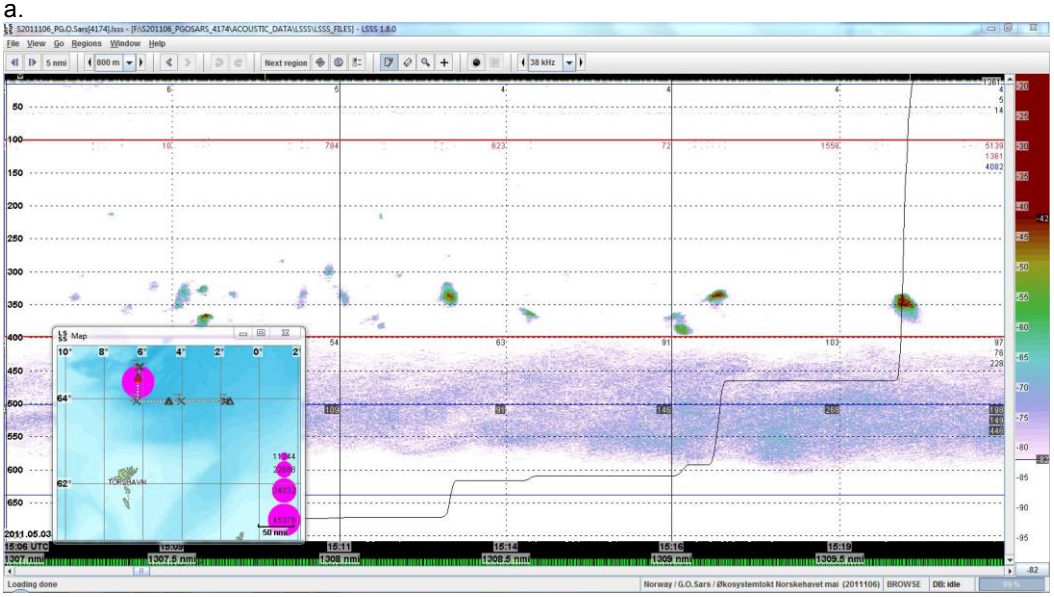
The scrutinizing is based on a combination of visual clues in the echograms, information from single echoes, disappearance of echoes when adjusting the lower integration threshold upwards, trawl catches, and possibly comparing echoes from different frequencies. This is an expert process prone to errors and subject to some degree of subjectivity. Often it is useful to look at observations over tens of miles at time and between neighboring transects, as some continuity that facilitates scrutinizing can usually be expected.

Target species specifications

Herring (*Clupea harengus*)

Remarks: Can occur at great depth in dense schools (~300-400m), inter-mediate depths in small and large schools, and near surface (often small dense schools can be recognized from sharp increases of the integration line). Figure 2 shows typical examples of these situations.

a.



b.

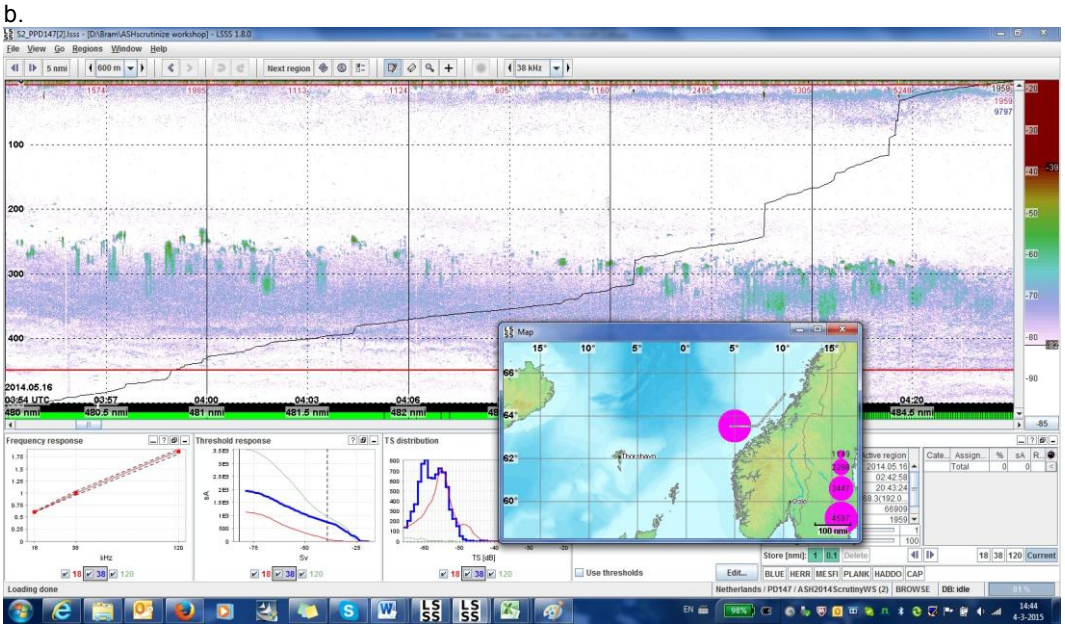


Figure 2. Typical herring schools in Norwegian Sea at (a) around 350 m depth and (b) small dense registrations (red dots) near the surface (blue whiting at 250m).

Blue whiting (*Micromesestius poutassou*)
Remarks: Blue whiting can be found as layers of variable density or as scattered registrations (Figures 4 and 5). In years of high abundance of blue whiting in the survey area it can be difficult to distinguish between herring and blue whiting.

Meso-pelagics
Remarks: Meso-pelagic fish species is a name often used for all unidentified backscatter layers in deeper waters (300m – 750m) not likely to be plankton. Generally not a problem to distinguish between meso-pelagics and herring. However, below 400m it can be problematic to distinguish between dispersed blue whiting and meso-pelagics (these NASC values are generally low).

Mackerel (*Scomber scombrus*)
Remarks: Mackerel will hardly be detected by the 38kHz transducer but will show up as weak registrations on the 200kHz.

Pearlside (*Maurolicus müelleri*)
Remarks: Usually found in thin zig-zag shaped layers in the Norwegian Sea and adjacent waters (Figure 3).

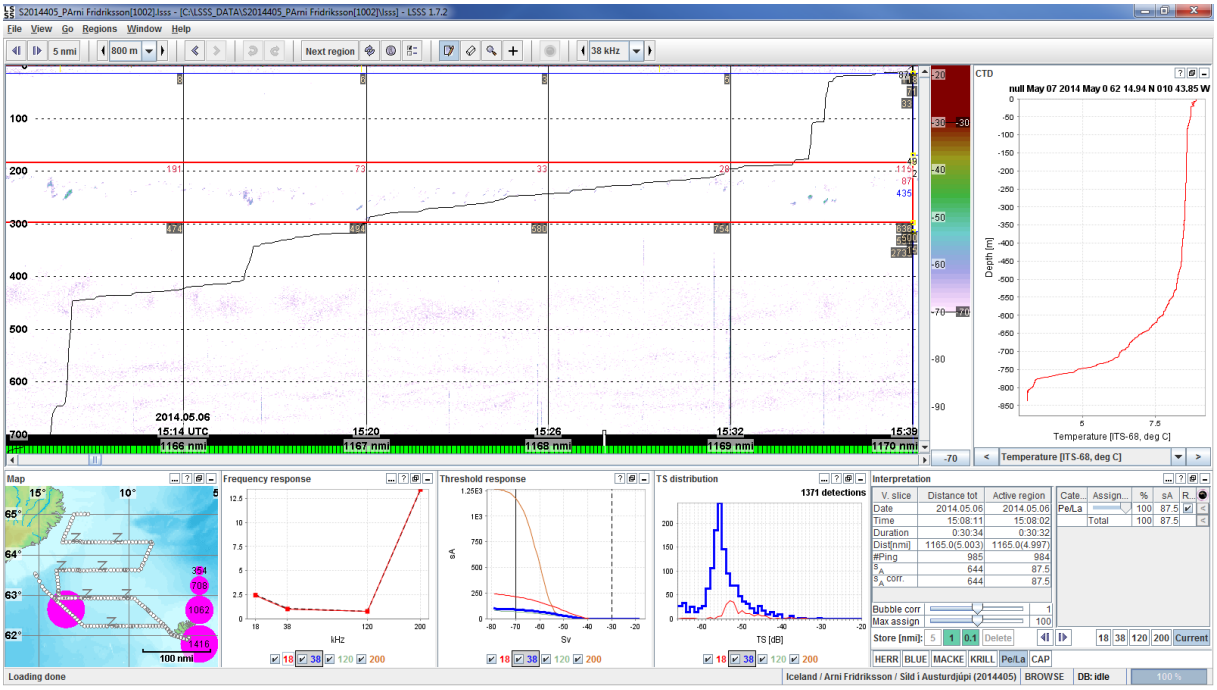


Figure 3. Example of pearlside registrations at 200-300m depth.

Thresholding to remove unwanted echoes and keep target species

By changing the db-threshold non-target-species (plankton in particular) can be filtered out. The threshold used may differ, depending on a variety of conditions, including the water depth (more care should be taken at greater depth) and the species and its size range and density. The main principle has been to use as little threshold as possible at any time, but experience shows that for herring down to approximately 50 meters about -60db is suitable. However, at extremely high levels of plankton as experienced in coastal waters a threshold of up to -54 db maybe required in order to remove unwanted plankton.

When starting a new 5 nautical mile interval, a layer boundary is created, which defines the lower depth of the vertical herring distribution. This depth is found by looking for herring schools as discrete jumps in the integrator line and including the lowest school. Then the threshold is set at a level where all the plankton is removed. This is done by varying the threshold and looking for changes in the coloring of the upper level. Herring schools will often appear as very tiny red dots, size only a few pixels, hardly visible.

The NASC value at the higher threshold is allocated to herring, the threshold is lowered again to -82 db and the rest is given to plankton.

Use of single target TS distribution data

A TS distribution can be produced for each echogram. In some situations there may be two species with substantially different TS values present in an area, and this could be used to aid in the species allocation. Again, this information must be used with caution since single targets are unlikely to be detected from fish in schools. As schools are often the main subject for herring acoustic surveys, TS data may be unrepresentative for the population. However, where the survey encounters diffuse mixtures, there may be value in such data.

TS distribution is often useful in separating blue whiting from mesopelagics in the upper layers. If blue whiting is present, one usually expects to see a prominent peak somewhere around –35 dB.

Recommended solutions to some scrutinizing problems in Norwegian Sea in May

<u>Problem A:</u> identify herring in mixed layers (Figure 4)
On 38 kHz, set the minimum threshold to around -60 to -50 dB (stronger threshold with increasing depth) and look for “jumps” in the integration line. The strongest echoes are ‘possible herring’. (1) Either use school boxes and assign the NASC values inside to herring or (2) make a layer and assume that the NASC values remaining are from herring (after thresholding).

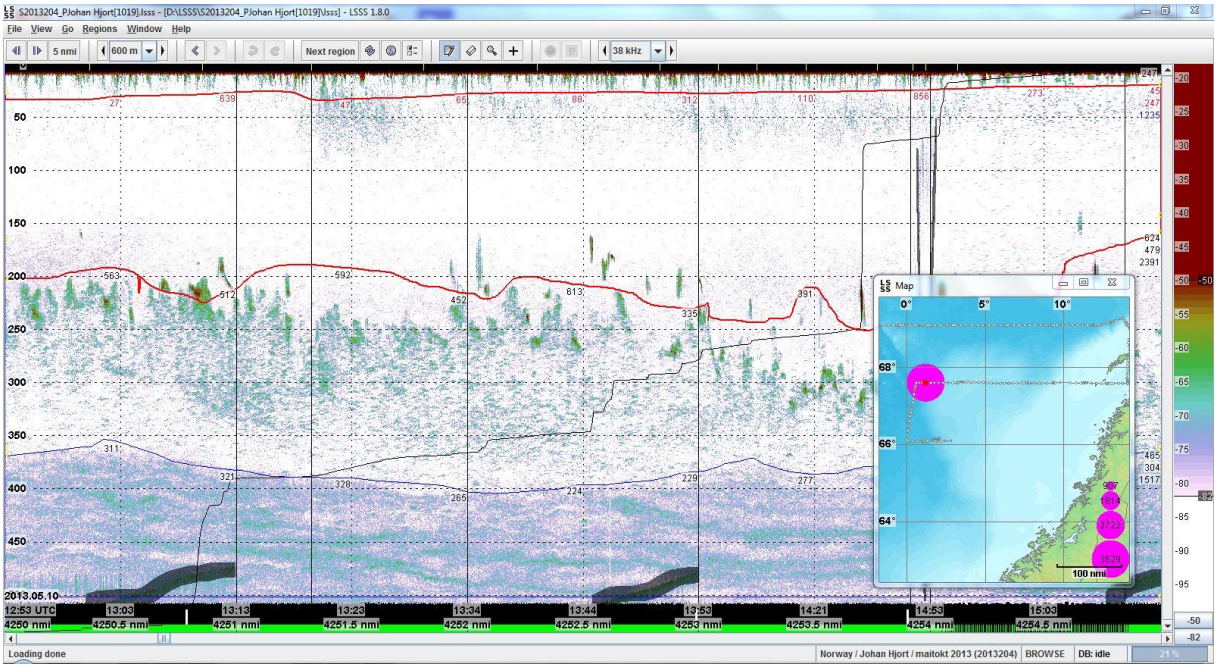


Figure 4. An example of a mixture of blue whiting (layer at ~200-400m) and herring (30-200m).

Problem B: evaluate whether a layer contains fish of around 30 cm (i.e. herring and/or blue whiting) in LSSS:

1. Set lower dB threshold on 38 kHz to -70 dB
2. Configure pelagic echogram (right click) and click on “TS distribution”
3. Set MinTS = -55 and MaxTS = -25 (this affects the algorithm, not only the scale)
4. Make a school box and study the TS distribution window
5. Observations between -40 and -30 dB are likely herring/blue whiting

Problem C: separate herring from air-filled phytoplankton near the surface (this method must not be applied deeper than 100 m) (Figure 55):

1. View the echogram on 200 kHz
2. Set lower dB threshold to -50 dB
3. The remaining echoes are ‘probable herring’
4. To get the NASC values to be assign to herring on 38 kHz the values on 200kHz should be multiplied with around 2.

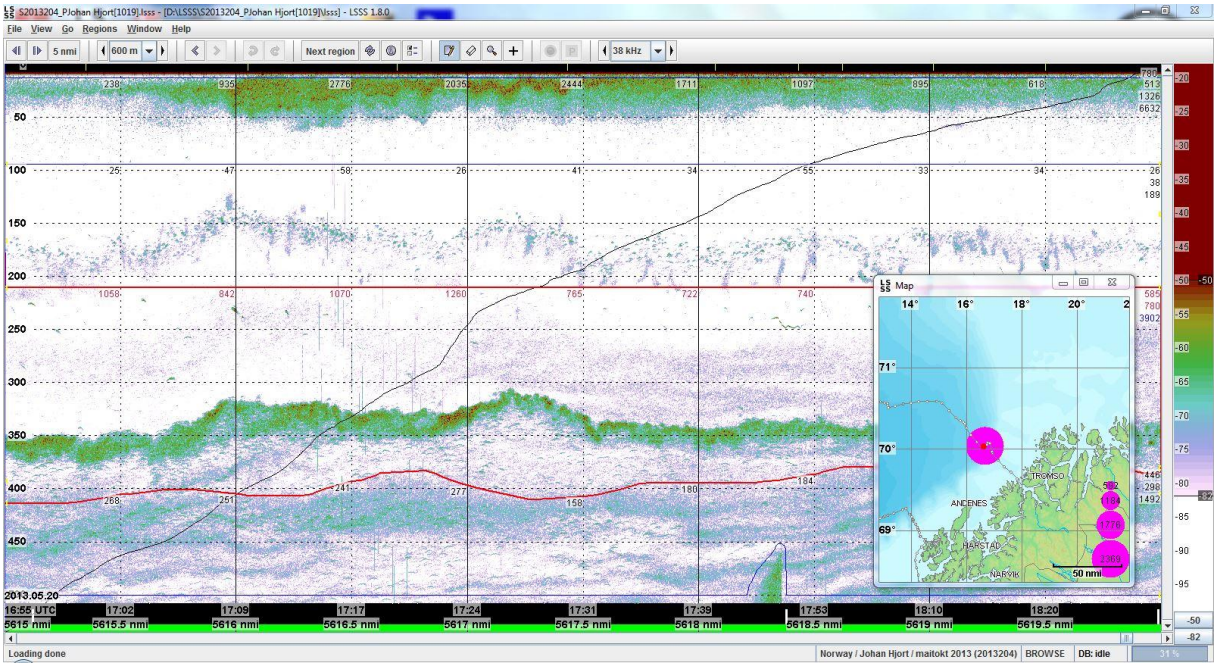


Figure 5. An example of air-fillled phytoplankton near the surface, in which herring can be found. Blue whiting is seen ~350m, and pearlside at 100-200m.

<u>Problem D:</u> separate herring schools from blue whiting schools:

- Make a school box around the school that covers around 0.5 nm horizontally: NASC values far above 1000 indicate herring.
- “Ball” formed school may also indicate herring (blue whiting schools have a more “loose” shape)