Preliminary Cruise report

The international acoustic survey in the Norwegian Sea in May 2006

R/V DANA Cruise No. 3/2006

Calibration of Echo-sounders

25/4 – 28/5 2006

International Acoustic Monitoring of Herring and Blue whiting

28/4 – 25/5 2006

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Calibration 25-28/4

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Nils Håkansson (acoustic)	Sweden
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Acoustic monitoring 11/5-25/5

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Background of the survey

The Norwegian spring spawning or Atlanto-Scandian herring stock is highly migratory and straddling, carrying out extensive migrations in the NE Atlantic. After a major stock collapse in the late 1960's the stock has been rebuilt and varied from approximately 5 to 10 million tonnes of biomass during the 1990's.
After spawning in February – March, mainly in the Norwegian Fjord between 62°N to 64°N, the Norwegian spring spawning herring migrate north-east towards the feeding grounds in the Norwegian Sea. In general, the main feeding takes place along the polar front from the island of Jan Mayen and north-east in the dirtection of Bear Island. During the latter half of the 1990's this migration gradually shifted north and eastwards. In the period 2002 - 2004 this development seemed to have stopped as herring had a more southerly distribution at the end of the feeding season than in 2001. After feeding, the herring have concentrated in August in the northern parts of the Norwegian Sea prior to the southern migration towards the Vestfjord wintering area (68°N, 15°E). Since the winter of 2002-2003, part of the stock seems to winter in the Norwegian Sea off Lofoten. In January the herring start their southerly spawning migrations again.

Besides herring, abundant stocks of blue whiting and mackerel exploit the Norwegian Sea as an important feeding area. Blue whiting is currently is supporting the largest fishery of the Northeast Atlantic. The main spawning areas are located along banks and the shelf edge west of the British Isles. The eggs and larvae can drift both north- or southwards, depending on location and oceanographic conditions. The northward drift spreads juvenile blue whiting to all warmer parts of the Norwegian Sea and adjacent areas from Iceland to the Barents Sea. Adult blue whiting carry out active feeding and spawning migrations in the same area. Blue whiting has consequently an important role in the pelagic ecosystems of the area, both by consuming zooplankton and small fish, and by providing a resource for larger fish and marine mammals.

Objective of the survey

The main objective of this survey is to map the distribution and migrations of herring and other pelagic fish and to assess their biomass (abundance?). Other objectives are to monitor hydrographic and plankton conditions of the Norwegian Sea and adjacent waters and describe how feeding and migration of herring and other pelagic fishes are influenced by these conditions.

Calibration

The echo sounders (name frequencies here) were calibrated prior to the survey at the Bornö Island in the Gullmar Fjord, Sweden on 26 April 2006.
The calibration was performed according to the procedures followed in 2003 when the echo sounder equipment has been upgraded to EK60 with three frequencies (18, 38 and 120 kHz).

This calibration was the first in 2006, the latest calibration has been conducted in June 2005.
The calibration of the towed body split-beam transducer at 38 kHz was conducted against a 60 mm copper sphere. Calibration of the three hull-mounted split-beam transducers at 18, 38, and 120 kHz were carried out against 63mm, 60 mm, and 23 mm copper spheres respectively.
The results of the calibration for all frequencies were similar to the previous calibrations in 2005. The calibration parameters used during the survey and for abundance estimates for 38 kHz are shown in table 1.

EK 60 calibration parameters April 2006		
	EK 38 kHz Hull	**EK 38 kHz Paravane (wordt pas later genoemd)**
Transducer name	ES38B	ES 38BP
Max Power	2000.0	2000.0
2 way beam angle	-20.50	-20.50
Gain (pulse dur. 1024)	25.15	25.07
Sa correction	-0.50	-0.56
Angle sensitivity - alongship	21.90	21.90
Angle sensitivity - athwartship	21.90	21.90
3dB beam width - alongship	6.95	6.75
3dB beam width – athwartship	6.86	6.89
Angle offset – alongship	-0.03	-0.09
Angle offset – athwartship	0.09	-0.08

Materials and methods

Acoustic data

The survey is coordinated by ICES and includes EU countries, Norway Iceland, Russia and Faeroe Islands. EU contribution consisted this year of the Netherlands, Denmark, Ireland, Sweden, Scotland and Germany. The Danish research vessel "Dana" conducted the EU survey part. The acoustic survey tracks of Dana are shown in figure 1.
Acoustic data was collected with EK60 using a 38 kHz splitbeam transducer, mounted in a towed body (paravane). During trawling, acoustic data was collected by the EK60 using the hull mounted 38 kHz transducer: the recordings during trawling were only used for scrutiny of the echograms. Echo integration was conducted for 24 hours per day and the data was scrutinized regularly during the survey by use of the Simrad BI500 software.

Hydrographical and zooplankton data

At approximately every 60 nautical miles plankton sampling, using a WP2 net was carried out as a vertical haul from 200m depth to the surface. The plankton sample was split into two parts; one part was stored in formaldehyde, whereas the other was sorted into three groups of zooplankton based on size for biomass estimation. The biomass samples were dried in an onboard heater and brought back to the laboratory in Denmark for weighing.

Together with plankton sampling a hydrographical profile, using the Seabird CTD unit was carried out over a 0-1000 m depth range. All together Dana carried out 41 combined CTD and WP2 stations (Figure 1).

Once a day two water samples were taken to calibrate of the CTD unit; one surface and one bottom sample . Also water surface conditions (temperature and salinity) and weather conditions (e.g. wind direction, wind speed etc.) were continuously monitored during the survey using R/V Dana's hydrographic and meteorological analysis system.

Biological data

The acoustic recordings were verified by fishing with a 2000 mesh pelagic Fotö midwater trawl. Fishing was carried out when there was doubt about the species composition of recordings observed on the echo sounder and to obtain biological samples of herring and blue whiting. In general, after it was decided to make a tow with a pelagic trawl, the vessel turned and fished back on its track line. The trawl was used either at the surface or in midwater down to 450 m depth. In total 44 trawl hauls were carried out during the survey, well spread over the surveyed area, but more frequently in areas with high fish densities (Figure 1).

Fish samples were divided into species by weight. Length measurements were taken for all species in ½ cm length groups for herring and 1 cm length groups for all others. For herring and blue whiting a sub sample of 50 fish were taken randomly of the total species sample. The following parameters were measured: length, weight, sex and maturity. Scales and otoliths were brought to the laboratory in Norway for age reading. In addition to these 50 fish, length measurements were taken from another 200 randomly sampled fish in order to achieve an estimate of the size distribution of the two target species. In some stations with only some tens of herring, only a length frequency samples was taken. In total 15 samples of herring and 20 samples of blue whiting were taken.
A comparison of the length distributions for the 50 fish and the 200 fish sample length distributions were made. It was seen that the length distribution for the 50 fish sample for herring were *not representative for the length distribution of the total catch based on the 200 fish sample. (see Discussion).*
Trawl data were entered into the Babelfisk database and all data were validated. The data was also put into the PGNAPES formats and sent to IMR, Bergen at the end of the survey.

Biomass estimation

Data collected during this cruise was included in an overall dataset containing data from other participating vessels as well. The final estimate methodology is presented in the upcoming PGNAPES report.

Itinerary of the survey

R/V Dana left Hirtshals, Denmark on Tuesday 25 April at 14:00. On the 25th of April we arrived at the calibration site “Bornö” near Lysekil in Sweden. Calibration took place during the 26th of April. The morning after, the ship set course back to Hirtshals. After changing of some crew members and scientists, Dana left Hirtshals on the 28th April at 15:00 to start the survey. Echo integration started at 19:11 on the 29th of April. The cruise track was followed northward and at 10th of May 08:26 the track was left for changing crew and scientists in Bodö, Norway. Bodö was left again at 15:00 hours the following day. Echo integration was resumed at 18:56 on the 11th of May and completed on the 21th of May at 15:04. Dana headed south towards Hirtshals and arrived at 25 May at 06:00 hours and thereby finishing the survey.

Adjustments of the programme during the survey

Because of the good weather situation on the first part of the cruise between Hirtshals and Bodö, there was time to cover more than the planned cruise track. The track was extended further to the West on the last E-W transect to cover some of the cruise track of R/V Magnus Heinason. Back on the track there was still time to go north to the next E-W transect of Dana, to cover some of the integration and take some stations in order to save time on the second part of the cruise, so that more time was available if bad weather should come up.
In the second part of the survey, the weather was still so good, that full speed could be reached most of the time. The end of the planned cruise track was reached on the 20th of May on 08:20. The remaining ship time was then used to focus on a selected area in order to provide additional information on layer and school behavior and species composition in the western areas, where we have encountered problems with scrutinizing the echograms and catching the schools. The focus area was reached at 13:50. 25 hours of integration and trawling in a 10 times 10 nm area has been executed (see Annex 2).

Results

Distribution and density of herring and blue whiting

Herring schools were found scattered over most of the surveyed area. The main concentrations were found along the line between 62°N-5ºW and 72°N-10ºW and, to a lesser extent, in the southwest, between 62° and 64°N. This year, only a relatively small concentration of small sized herring was found west of the Lofoten/Vesterålen (figure 2 and 4).

Like last year, blue whiting was found spread over the whole survey area. At the shelf edge a lot of young blue whiting was found. The NASC's (Nautical Area Scattering Coefficients: "S_A values") along the shelf edge were higher than off the shelf (figure 4 and 6).

Size and age distribution

These data are not prepared yet. The first impressions are that young and adult herring were found mixed in the northern part of the area.

Hydrographic conditions and zooplankton biomass

The hydrographical conditions were similar to last year's conditions. The frontal area between cold arctic water and warmer Atlantic water was apparent at all depths from the surface and down to 200 m (Figure 6). The zooplankton data is not prepared yet.

Discussion

Air bubbles and phytoplankton

Similar as in 2004 and 2005, we experienced problems with air bubbles under the transducer. The Difres towed body ("paravane") performs very well, but with higher windspeeds (above approximately 12 m/s) airbubbles under the transducer may conceal herring in the surface layer. Hence an unknown fraction of herring has not been recorded, either because the schools were above the transducer or because air bubbles hid the schools. In figure 2 the relative herring distribution is shown versus the wind speed (synoptic). The figure suggests a relation between wind speed and the detection of herring schools. In particular in the 68º55N transect, surface school may have been missed due to air bubbles in the surface layer.

We suspect that air bubbles in the upper 50 m may also be caused by high (phyto)plankton concentration. In some WP2 samples high concentrations of diatoms were found, particularly on the northern transects with a lot of herring schools. These diatoms produce a slimy layer, in which oxygen bubbles may get caught and may, therefore, become strong acoustic reflectors.

Scrutiny and trawling

Unlike last year, no big problems in the scrutiny were encountered. Uncertainties occurred only in situation with small NASC values. In some case herring was found mixed with blue whiting in the northern part of the area, while it was not clear which part of the echo had to be assigned to either species. See "*24 hours echo-integration along a 10 nautical miles transect*" below.

During the survey we were able to collect a lot of herring and blue whiting samples. However, like in the 2004 and the 2005 survey, we seriously wonder if these samples are representative of the composition of the recorded schools. Fishing was only possible on layers or many small schools. We were never able to hit targeted schools when they were comparatively large and separated from other schools. For most of the trawl catches there seemed to be no relationship between the size of the echoes and the catch; whether we fished on a layer of blue whiting echoes or on no echo at all at the same depth, the catch was a few baskets. The same accounts for herring in the upper layer, but that may also have been caused by herring swimming above the transducer. The circumference of the trawl opening in the Fotø trawl, is about the same of that of the Åkra trawl, which as a routine used by the Norwegian vessels in pelagic surveys (Fotø trawl 397m vs. Åkra trawl 384m). GO Sars is able to veer the trawl lines much quicker, which is an advantage for fishing in midwater. However, that may not be enough for representative samples of school recorded by the echosounder. For example, during an inter ship-calibration in March of GO Sars with the Dutch research vessel Tridens, the total catch (blue whiting), was smaller than the catch of Tridens. More important, the lengths of the fishes were smaller. Tridens used a commercial trawl of 1040m circumference. According to observers on commercial trawlers, with trawls of this size, it is possible to hunt dense school of herring and blue whiting in midwater. ***We strongly recommend for future surveys to obtain a bigger trawl.***

PGNAPES exchange format

We were like 2004 and 2005 missing a formal description of the exchange-format. An example file together with the database format description from 2005 helped a lot, but still it would be good to have a description targeting the exchange format directly.
There was still some uncertainty about what species codes to use. We received a short list of species codes from G.O.Sars (with "POK" for Saithe, is this correct? It sounds more like Pollack…), but the 10 species codes are not enough to cover all caught species (25 species). We would recommend that all caught species are reported, since this is an "ecosystem" survey. Instead of different three-letter codes (internationally, there are at least four different three-letter systems in use: Danish, Dutch, PGNAPES, FAO); we would recommend that TSN (Taxonomical Serial Number) codes are used. TSN is the numbering system provided by ITIS (Integrated Taxonomic Information System, www.itis.usda.gov). A TSN number links to a species name and its hierarchical classification. TSN also handles taxonomical niceties like synonymy and subspecies.

Furthermore it has codes for higher levels like genera, families etc. ITIS is updating and maintaining the system (in contradiction to the NODC-system, that is now outdated).

It would be an advantage to have a data quality assurance application that followed with the exchange format specification. It could then be used for checking the exchange-file before submitting data. The application should be an executable that works at sea with no internet connection, since it is always faster and easier to correct errors in data during the cruise than after.

Biological sampling and station information

The participants change from year to year to a greater extent than in other (national) surveys. Hence a good manual is required. In particular it would be useful to have an ASH survey maturity manual for blue whiting, because not all participants from EU countries have experience with this species. We recommend also to include *international* maturity key tables in the survey manual. A table with maturity keys from different countries for herring can be found in the *Manual for herring acoustic surveys in ICES divisions III, IV AND VIa* (appendix to the PGHERS report 2005). The acoustic section of the manual can be derived from the PGHERS manual. However, the acoustic section of the PGHERS manual needs a thoroughly update due to the switch from the EK500 to the EK60 and the switch from the BI500 post-processing software to Sonardata Echoview. We therefore recommend to work on the PGNAPES manual, after the PGHERS manual has been updated.

Future switch from BI500 to Echoview

The scrutiny procedure currently in use by the Norwegian and the European vessel, is heavily based on changing the threshold in order to distinct blue whiting and mesopelagic fish from zooplankton. It is not possible to copy this procedure easy in Echoview, because every separate species-composition needs to be saved as a class. During the cruise Eric Armstrong has investigated the possibilities to translate the BI500 procedure to EV. We intend to come up with a proposal during PGNAPES in August 2006.

Plankton splitter

In order to check the accuracy of the plankton splitter, displacement volumes of the resulting partitionings were determined at 4 selected stations (stns # 101, 110, 114 and 131). The total plankton volume at those selected stations varied between 11 and 44 mL. The splitter was never able to divide the sample into equal halves. Depending on whether the larger or the smaller partitioning was selected the deviation was between 13.3 and 42.9 % (mean = 28.4 %, SD = 15.6 %) or 15.4 and 75.0 % (mean = 44.9 %, SD 31.6 %), respectively. It is recommended that in future cruises the displacement volume of all partitionings should be determined. (See also Annex 1 for details).

24 hours echo-integration along a 10 nautical miles transect

During the survey in the northern part of the survey area we experienced problems in assigning different concentrations to herring or blue whiting. We observed that schools were built up in the mixed layer from 100 to 200 m and seemed to move out of this layer for periods of the day, while other intermediate forms of schools seemed to stay in the layer. To get a better understanding of the system, an intensive monitoring of a test area was set up. During this test the same survey gridlines were covered several times over a period of 24 hours and midwater trawling was conducted for species identification. The experimented is described in more detailed in Appendix 2.

The conclusion of the test is that both herring and blue whiting are in the mixed layer between 100-200 m depth at parts of the 24 hour cycle. When herring appear in the mixed layer there are periods when the concentrations are dispersed in the layer and cannot be recognised as herring schools. At other periods, herring can be found in both intermediate and concentrated schools. No clear daily cycle can be recognized.
For blue whiting there are periods when the concentrations are dispersed in the mixed layer between 100 and 200 meters. But no clear daily pattern between the dispersed and schooling situation was observed as described by Bethke (2000) when schools were seen during day-time and dispersed during night time.

References

Bethke, E. 2000. Einfluss des Tag-Nacht-Verhaltens von Fische auf das Ergebnis hydroakustischer Messungen. Inf. Fischwirtsch. Fischereiforsch. 47(3): 139-143.

Annex 1: Plankton splitter

Annex 2: 24 hours echo-integration along a 10 nautical miles transect

Hans Mose Jensen and Matthias Kloppmann

Figures

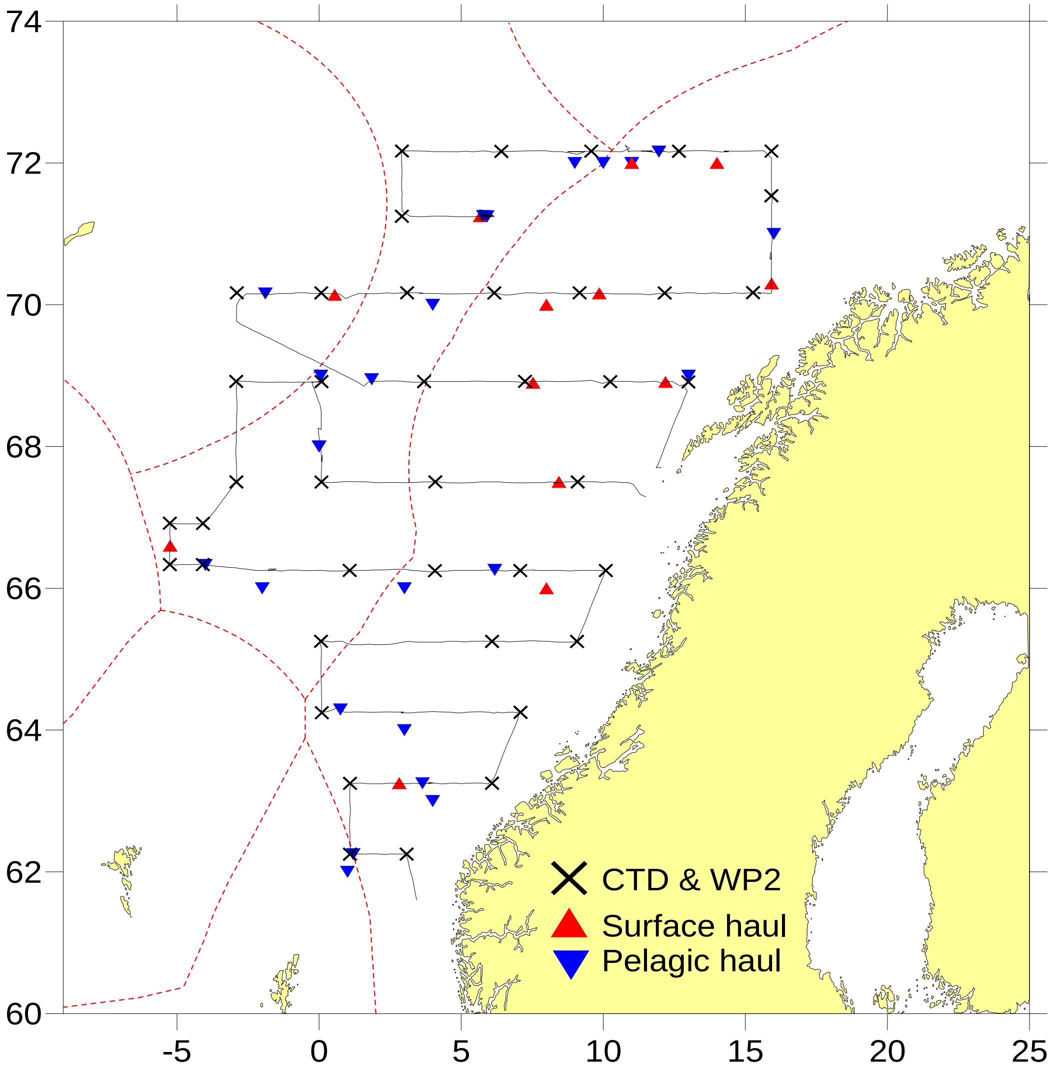


Figure 1. CTD stations (down to 1000 m), WP2 stations and trawl stations taken by R/V Dana from 29 April to 21 May 2006.

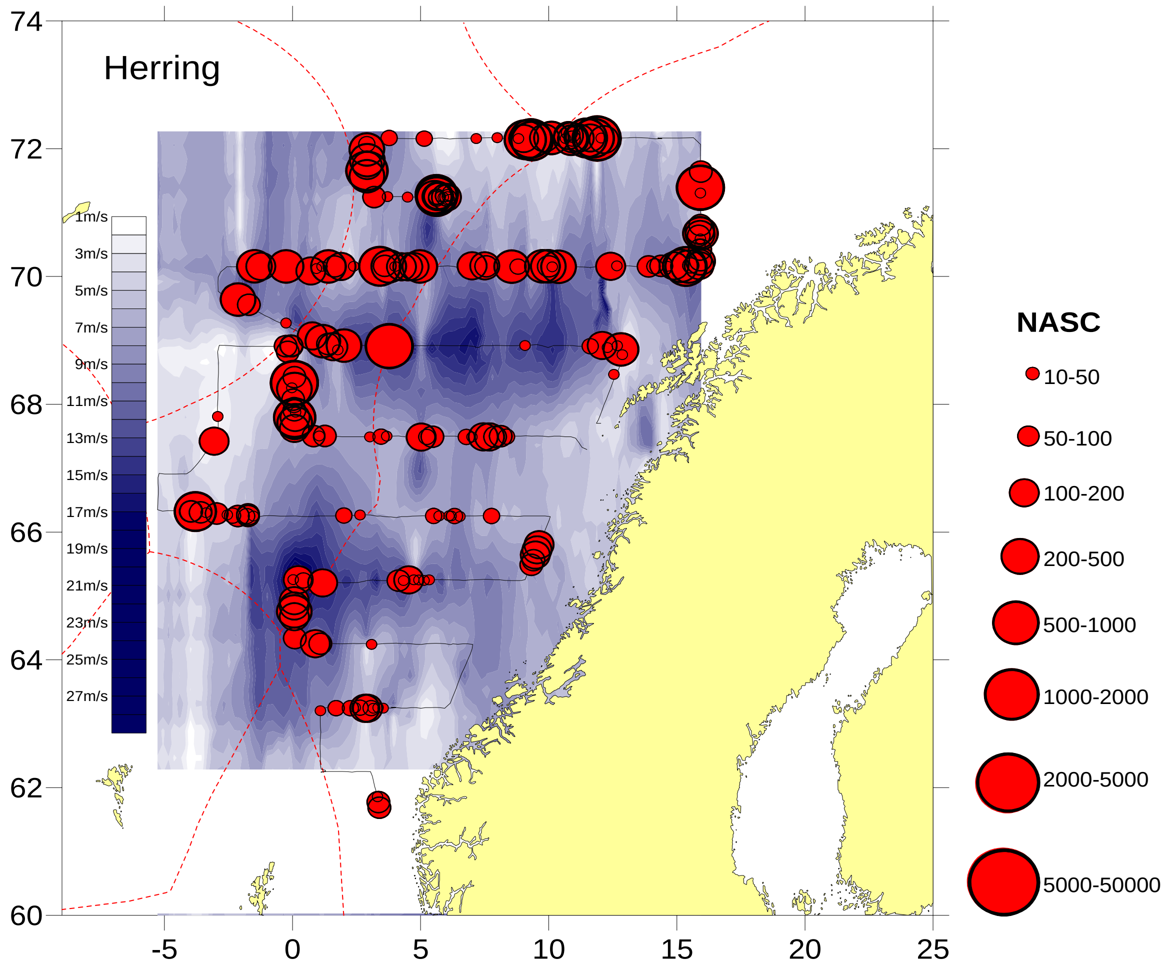


Figure 2. Distribution and area echo abundance (mean NASC per 5 nm) of herring recorded by R/V Dana during 29 April to 21 May 2006 in relation to wind speed (average over three hours).

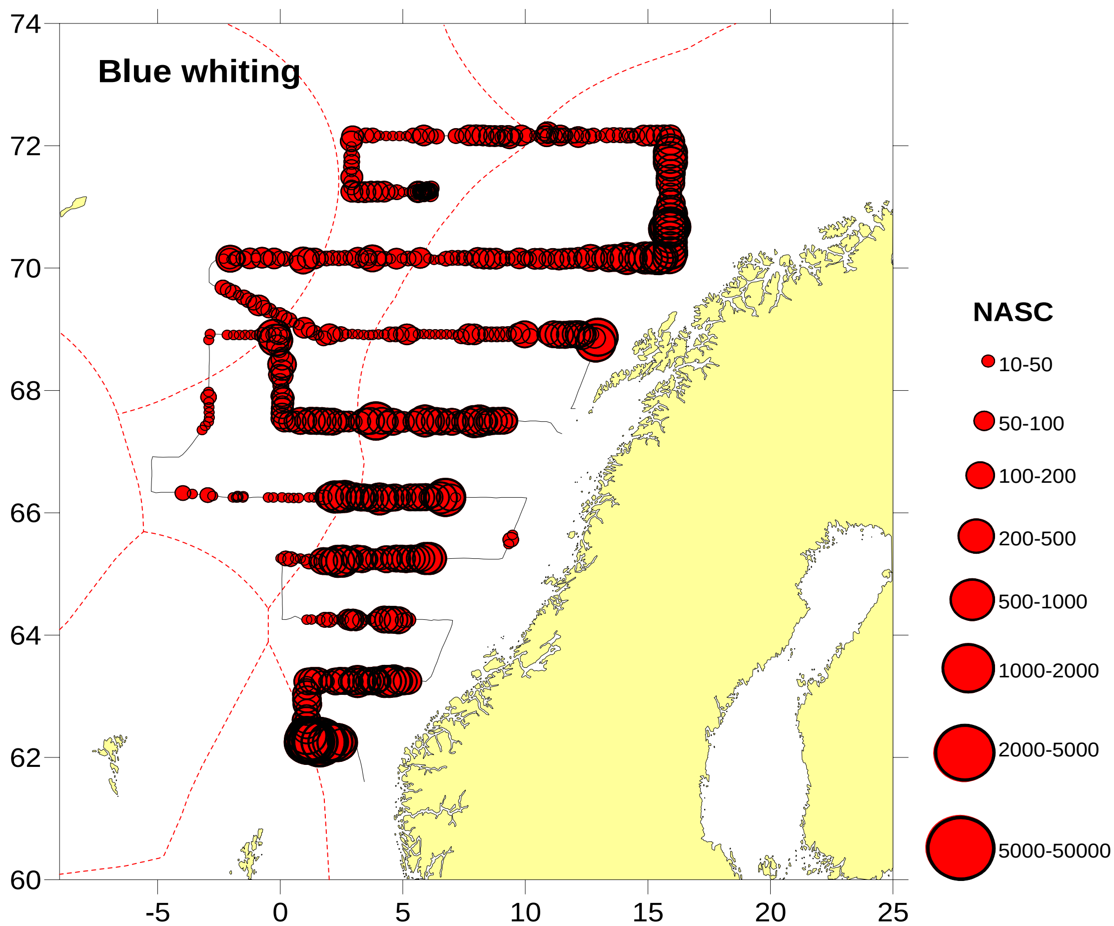


Figure 3. Distribution and area echo abundance (mean NASC per 5 nm) blue whiting recorded by R/V Dana during 29 April to 21 May 2006.

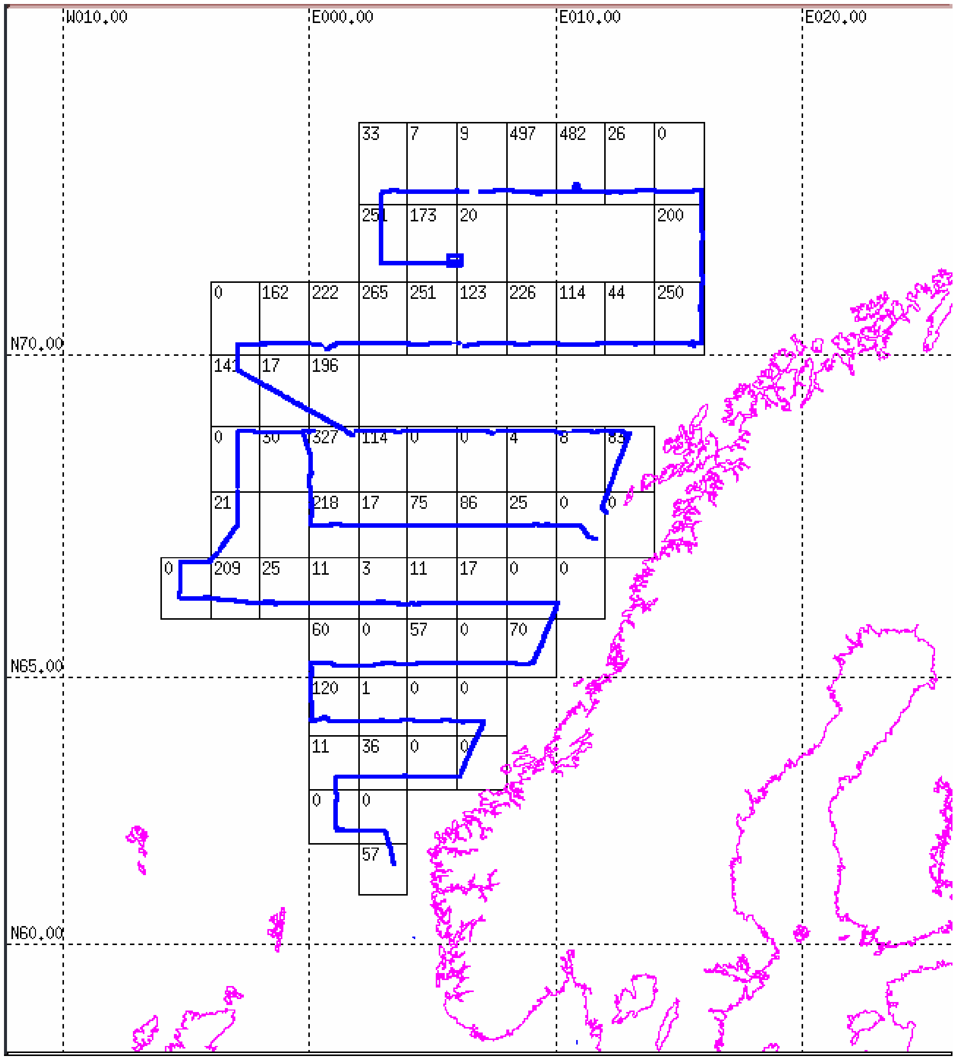


Figure 4. Mean area echo abundance (NASC's) of herring by grid cells recorded by R/V Dana during 29 April to 21 May 2006. Map made with BI500 software.

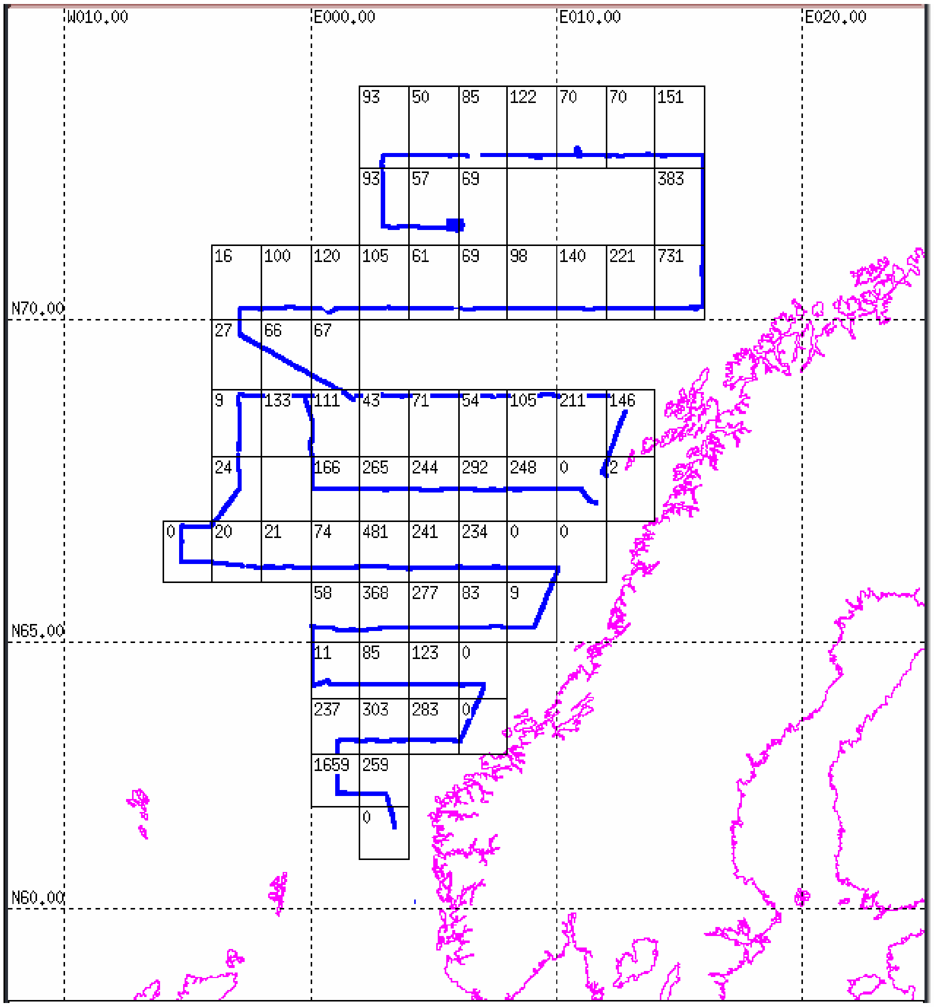


Figure 5. Mean area echo abundance (NASC's) of blue whiting by grid cells recorded by R/V Dana during 29 April to 21 May 2006. Map made with BI500 software. Grid cells containing missing intervals (interrupted blue transectline) do not provide the correct values. The missing intervals sections were scrutinized with BI60 software from the raw ER60 files.

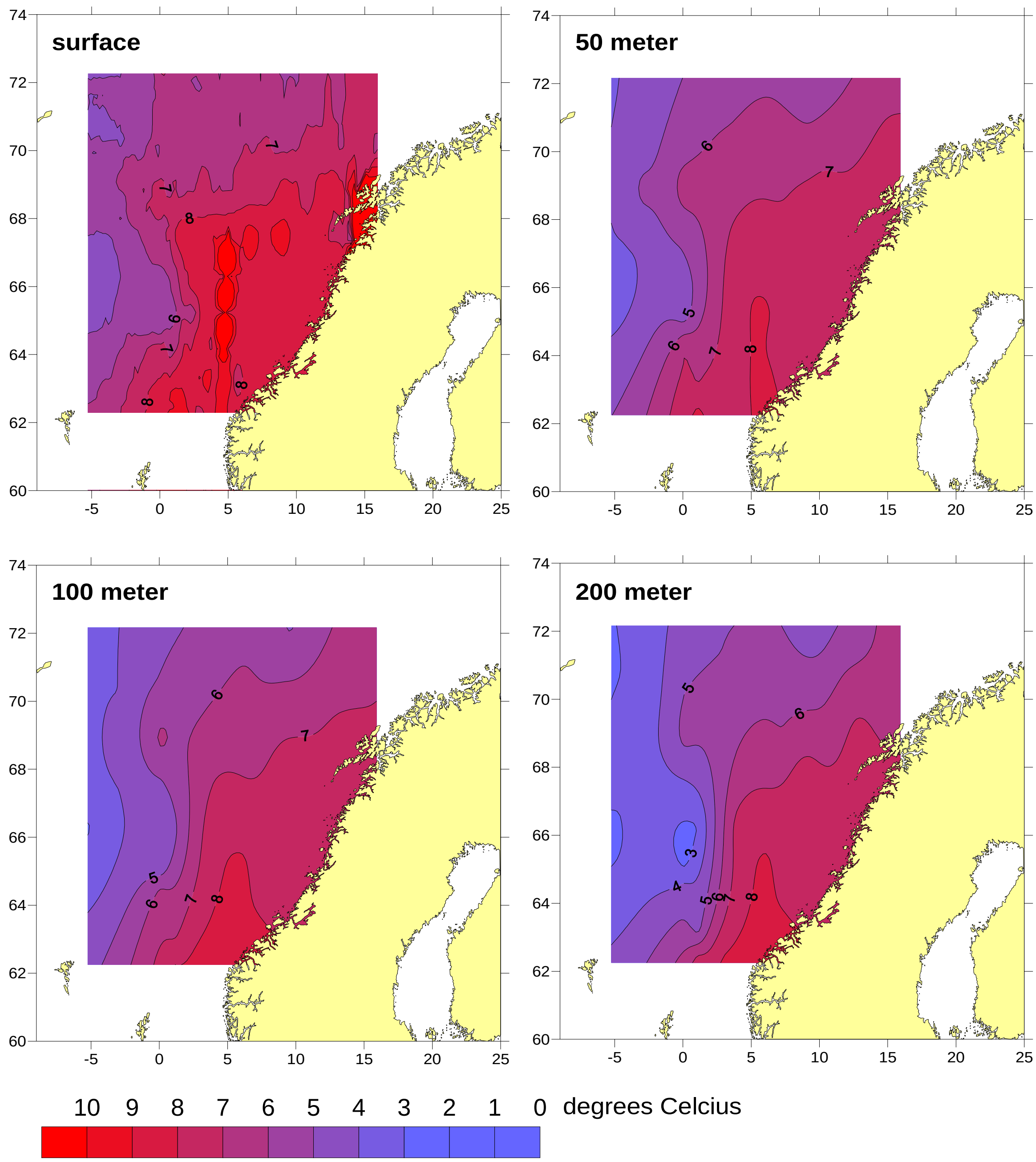


Figure 6. Contour plots of the temperature at surface (metrological station), 50, 100 and 200 m depth as measured by CTD stations taken by R/V Dana during 29 April to 21 May 2006.

Annex 1: The plankton splitter

According to the PGNAPES manual for the hydroacoustic survey all WP2 plankton samples have to be split into 2 parts of which one is preserved in formalin and the other is size fractioned and dried for biomass determination. In order to test the quality of the plankton splitter used on board RV Dana the volumes of the resulting partitions were measured at 4 selected stations (stns # 101, 110, 114 and 131).

The plankton splitter is a large cylindrical container that is closed over half of its opening. Inside is a septum with a height of the cylinder radius. It is attached to the wall of the cylinder as well as to the inner edge of the half circular lid so that the plankton splitter is enabled to hold half of the sample while the other half is emptied into a plankton sieve. Equal partitioning should be achieved by thoroughly mixing the sample inside the splitter.

Determination of plankton volume of the 2 partionings was done by determining the displacement volume of the respective halves. The plankton is washed into a graded cylinder and filled up to a certain volume with water. The whole contents are then washed through a sieve into another graded cylinder and the amount of the drained of water is measured. The difference between those two volumes is the displacement volume of the plankton.

Results

The total plankton volume at those selected stations varied between 11 and 44 mL (Table 1). The splitter was never able to divide the sample into equal halves (Fig. 1). Depending on whether the larger or the smaller partitioning was selected the deviation from each other was between 13.3 and 42.9 % (mean = 28.4 %, SD = 15.6 %) or 15.4 and 75.0 % (mean = 44.9 %, SD 31.6 %), respectively.

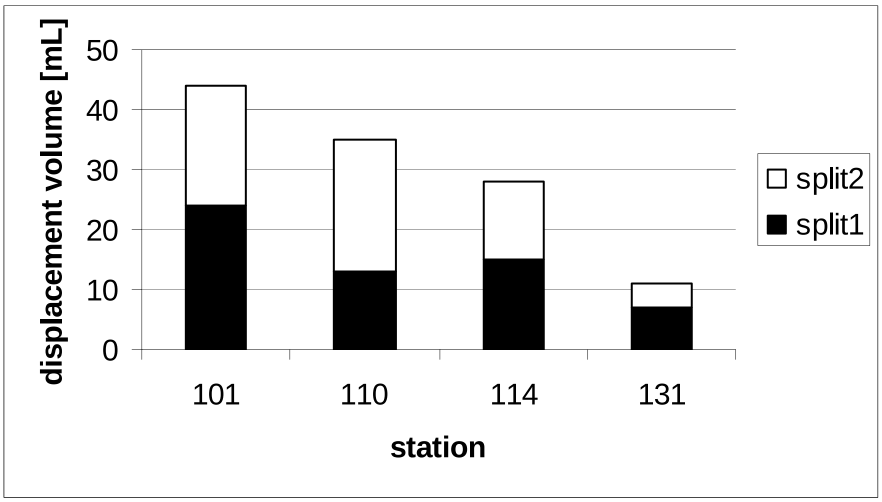
Table 1: The displacement volumes of the plankton partitionings at the selected stations

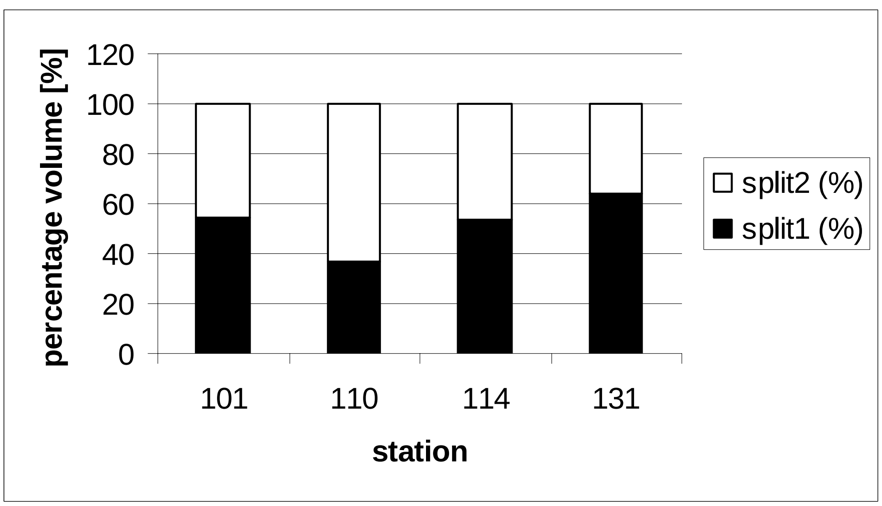
station#	Split 1 [mL]	Split 2 [mL]	total [mL]
101	24 (54.5 %)	20 (45.5 %)	44
110	13 (37.1 %)	22 (62.9 %)	35
114	15 (53.6 %)	13 (46.4 %)	28
131	7 (63.6 %)	4 (36.4 %)	11

Two main reasons might be responsible for these results. Once the ship’s movements and, secondly, the construction of the splitter itself could prevent a good splitting result. During sampling the weather was calm and the ship’s movement minimal so that we rule out a major influence of that source of error. However, the ship’s movement during rough weather should have a negative effect on the accuracy of plankton splitting. With respect to the splitter’s design, we noted that mixing and subsequent splitting within the splitter is obstructed. After filling the splitter the content has to be transferred into the closed quarter where it is mixing by tipping the splitter from one side to the other. After that the contents have to flow back partly around the septum such that the partitioning is achieved. We believe that simply the law of gravity rules out a good splitting result.

For future cruises another type of splitter might be recommended. A Folsom splitter might be a good alternative. Its quality has been tested. However, it is mandatory for this splitter to be stood on a horizontal plane. A prerequisite that can hardly be achieved on a constantly moving ship. We, therefore, recommend that the displacement volumes of the splitting results are determined are recorded for each plankton sample taken.

Fig. 1: Plankton sample partitioning utilizing the plankton splitter onboard RV Dana at 4 selected stations. Top: in mL displacement volume. Bottom: in percentage of total plankton volume (100 %)

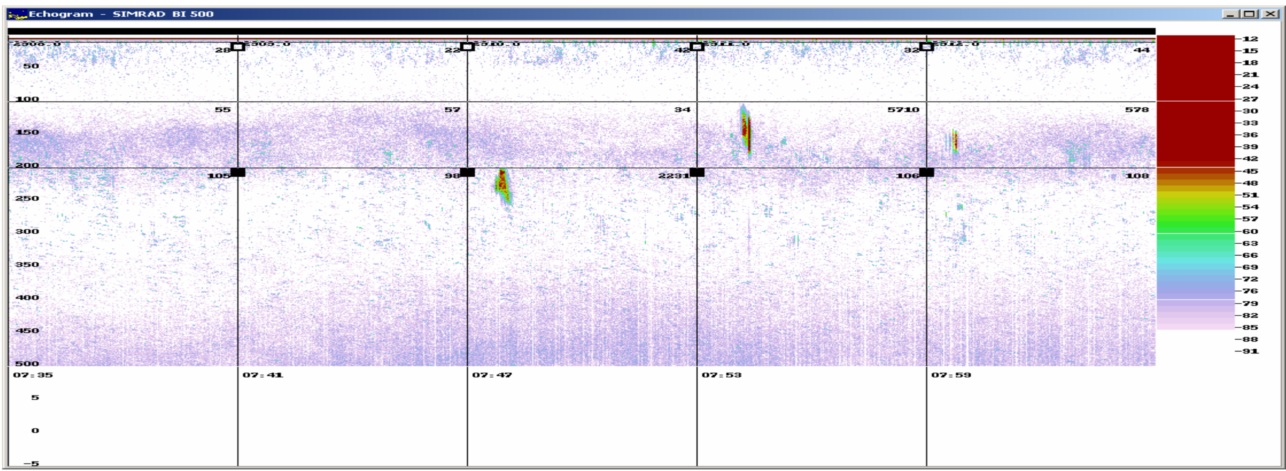


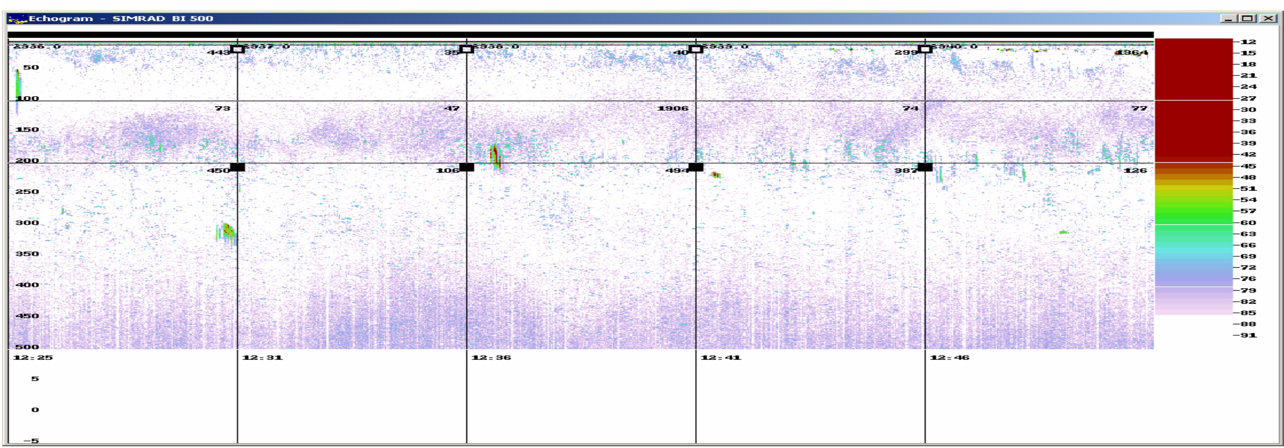


Annex 2: 24 hours echo-integration along a 10 nautical miles transect

Background

During the scrutinising process in the northern part of the survey area, occasionally questions came up if school structures should be assigned to herring or blue whiting or if herring and blue whiting could be found in higher number dispersed in mixed layers. It was seen that schools appeared both above, below and in the middle of a mixed layer from 100 to 200 m depth. Different forms of schools were seen from very dense schools both above and below the mixed layer and in the mixed layer at 100 to 200 m, see pictures below.





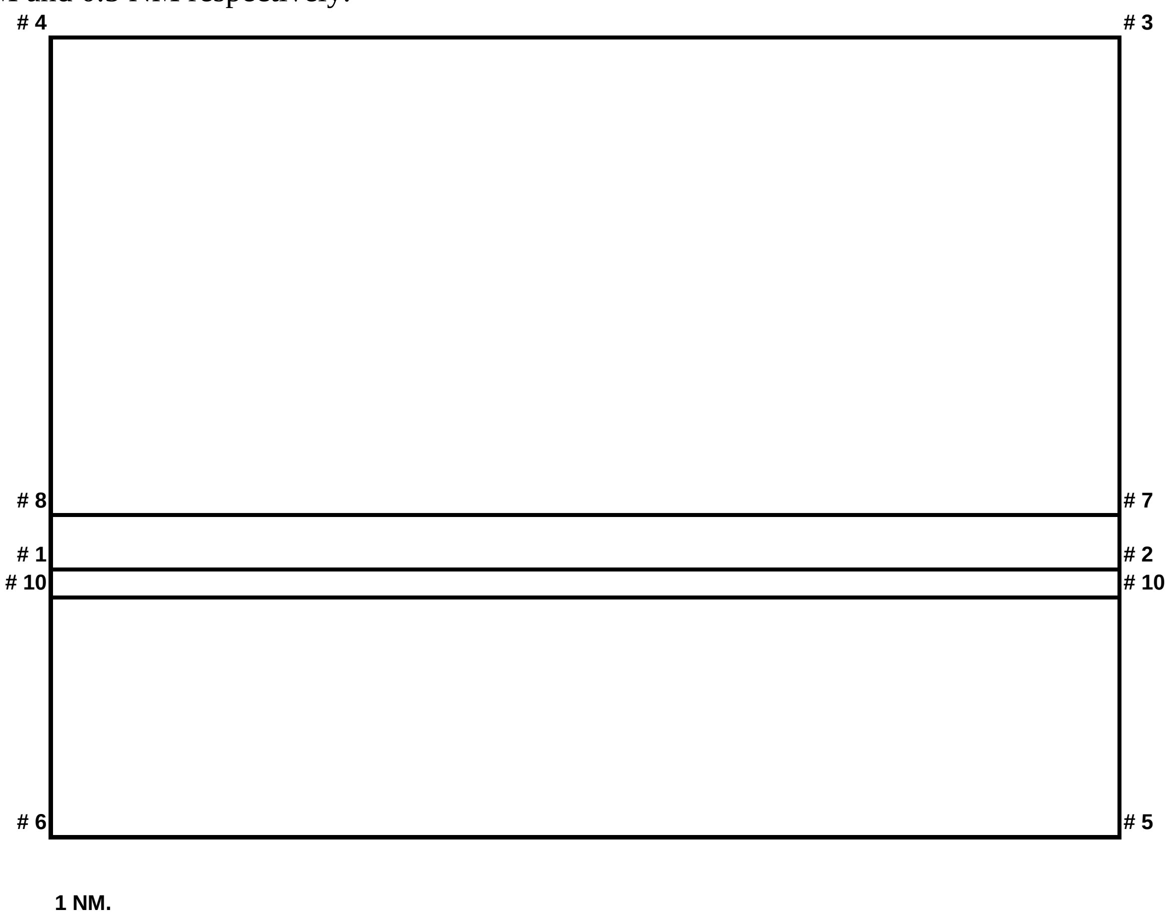
As it turned out nearly impossible to catch targeted schools by trawling, it was very difficult to assign echoes from separate schools to blue whiting or herring based on the catches. The question is, whether the dense schools (still visible at a threshold of -42 dB, “red”) should be assigned to herring and the less dense concentrations (still visible at a threshold lover than -50 dB, “green”) be assigned to blue whiting? To which species should the intermediate forms of schools and more lose concentrations be assigned?

As a general rule in the scrutinising process during this survey, dense (“red”) schools are assigned to herring and the intermediate schools and more lose concentrations are assigned to blue whiting.

During the two northern transects in this survey it was observed that schools built up in the mixed layer from 100 to 200 m and seemed to move out of this layer for periods of the day, while other intermediate forms of schools seemed to stay in the layer. This lead to the hypothesis that:
Herring are feeding in the mixed layer between 100 and 200 m in a dispersed formation.
Non-feeding herring formed schools in this layer, in all stages from intermediate schools to dense schools and may move out of this layer either up or down.
To improve the scrutinising process for the survey, a better understanding of the daily patterns of behaviour and schooling formation was needed for herring. Furthermore, were the distribution patterns seen in the vertical orientation along the survey grid, stable in the horizontal orientation over time.

Methods
To investigate the daily movement of schools and to investigate the stability of the systems horizontally a test grid was established as shown in the figure below. The grid was situated with

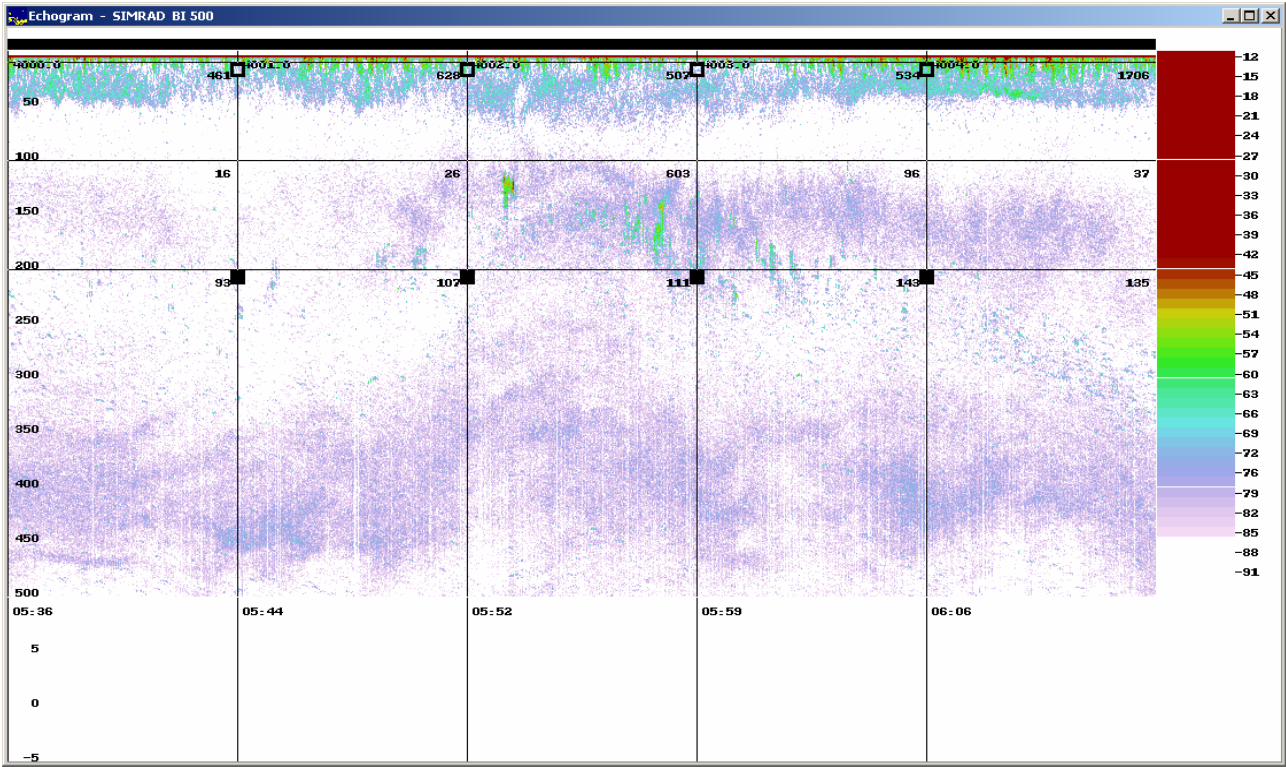
1 at 71º 15.1 N, 5º 37.5E. Five parallel gridlines (# 1-# 2, # 4-#3, #6-#5, #8-#7, and #10-#9) were going from west to east at a course of 90º, all with a length of 10 NM. The distance between #1 and #4, # 1and #6, #1 and #8, and # 1 and # 10 were 5 NM, 2.5 NM, 1 NM and 0.5 NM respectively.



In the period from 20th May at 13:50 UTC to 21st May at 15:04 UTC the gridline #1-#2 was covered from west to east 8 times, gridline #4-#3 was covered from east to west 1 time, gridline #4-#3 was covered from east to west 1 time, gridline #6-#5 was covered from east to west 1 time, gridline #8-#7 was covered from east to west 3 times and gridline #10-#9 was covered from east to west 2 times. The time for each coverage is given in the table below. The test grid was integrated acoustically with the 38 kHz transducer in the towed body at the normal cruise speed of 10 knots..

Start		End	
Wave point	Time, UTC	Wave point	Time, UTC
#1	13:50	#2	14:41
#3	15:08	#4	16:04
#1	16:35	#5	17:38
#5	17:50	#6	18:51
#1	19:08	#2	20:12
#7	20:14	#8	21:16
#1	21:21	#2	22:31
#7	22:27	#8	23:24
Fishery in the surface from #1 and east			
Fishery in 100 to 200 m from east to #1			
#1	03:10	#2	04:19
#9	04:22	#10	05:34
#1	05:39	#2	07:01
#7	07:01	#8	08:21
#1	08:28	#2	09:59
#9	10:03	#10	11:05
#1	11:23	#2	12:48
Fishery in 100 to 200 m from east to #1			

During the trial period, we fished three times with the Foto trawl on the grid line #1-#2 in one time in the surface by night and two times at 100-200 m, one by night and one by day.



Start of gridline #1-#2 at 05:36 to 06:36 UTC, taken from BI 500.

Results and discussion:
During surveying the test grid a general picture was observed, with three different layers in the depth range from 0 to 500 m (see picture above).
A layer of plankton was found in the surface down to aproximately 50 meters. From aproximately 100 to 200 m a mixed layer was found, with dense and intermediate schools. The density of this layer varied along the grid lines, but structures in concentration whitin the layer could be recognised in later passages of the same gridline. Throughout the entire exercise a deeper plankton layer below 250 m was observed.

Most attention in the test was put on the layer from 100-200 m and the associated schools. This layer seem based on the trawl catches to consist of Krill, Calanus, Blue whiting, Herring and Mesopelagics in proportions varying over time and position.

Horizontally, special attention was given to a specific part of gridline #1 to #2 as this part which hadbeen covered 10 times over the 24 hour test period, containeddense (“red”) schools in and above the mixed layer and intermediate (“green”) schools in and below the layer. Echograms from the BI500 for each of the 10 coverage’s including the same specific structure are shown below in picture A to J.

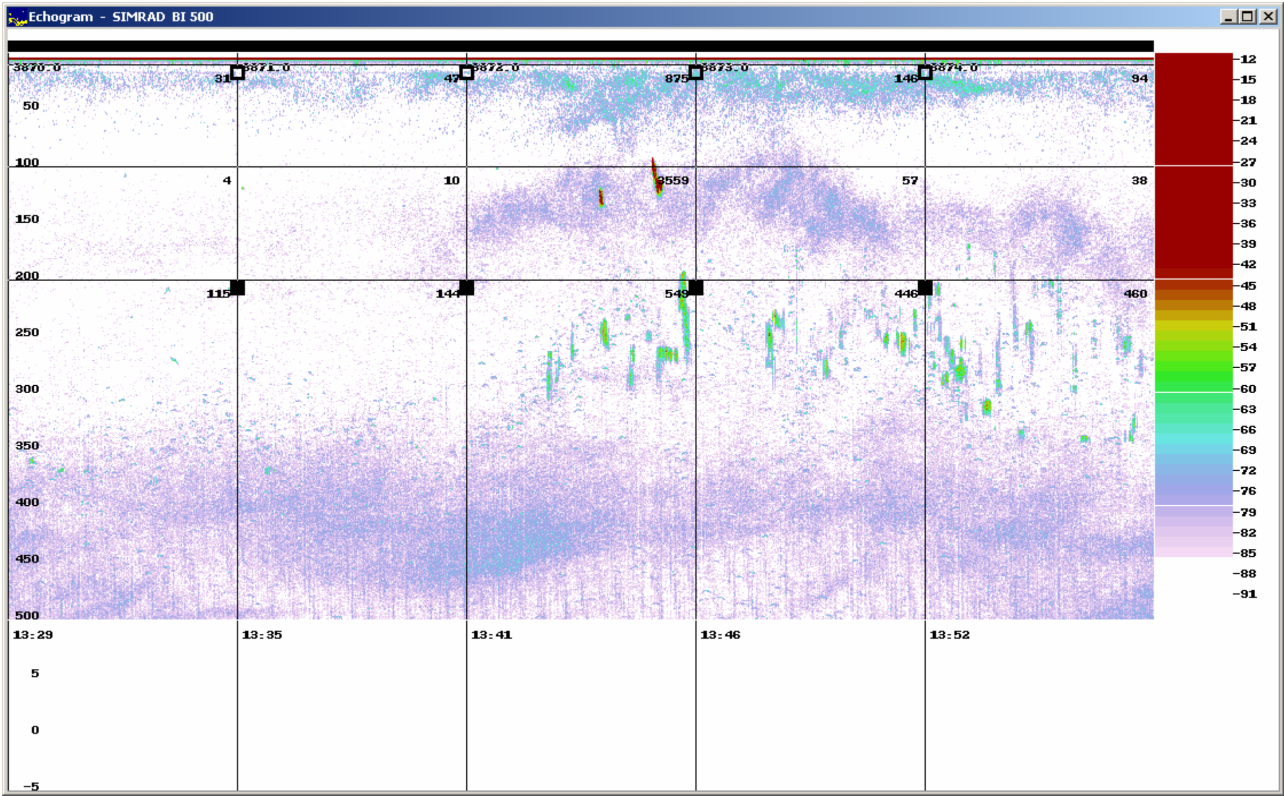
Over time, dense (“red”) schools seems to build up in the mixed layer and migrate up towards the surface. Also intermediate (“green”) schools seem to build up in the layer and migrate down below the mixed layer.
No daily pattern in the creation of either dense or intermediate schools was observed.

To identify the species compositions in the different situations described above, three midwater trawl hauls were conducted in the structure shown in the picture A to J below. One haul was conducted in the surface layer as dense schools were appearing above the mixed layer at around 24:00 UTC, picture E below. This catch contained pure herring with empty stomachs.
Immediately after this haul another haul was conducted (aproximately 01:40 UTC) in the same area in the mixed layer from 100-200 m, picture F below. This catch contained blue whiting and herring in the proportion 7 to 1. For the blue whiting the stomachs were moderate filled with krill where as the stomachs of the herring were totally filled with Calanus.
The third trawl haul was conducted in the mixed layer at 100-200 m around 12:30 UTC in the structure shown at picture J. This catch contained blue whiting and no herring. The stomachs of the blue whiting were empty to moderate filled with krill.

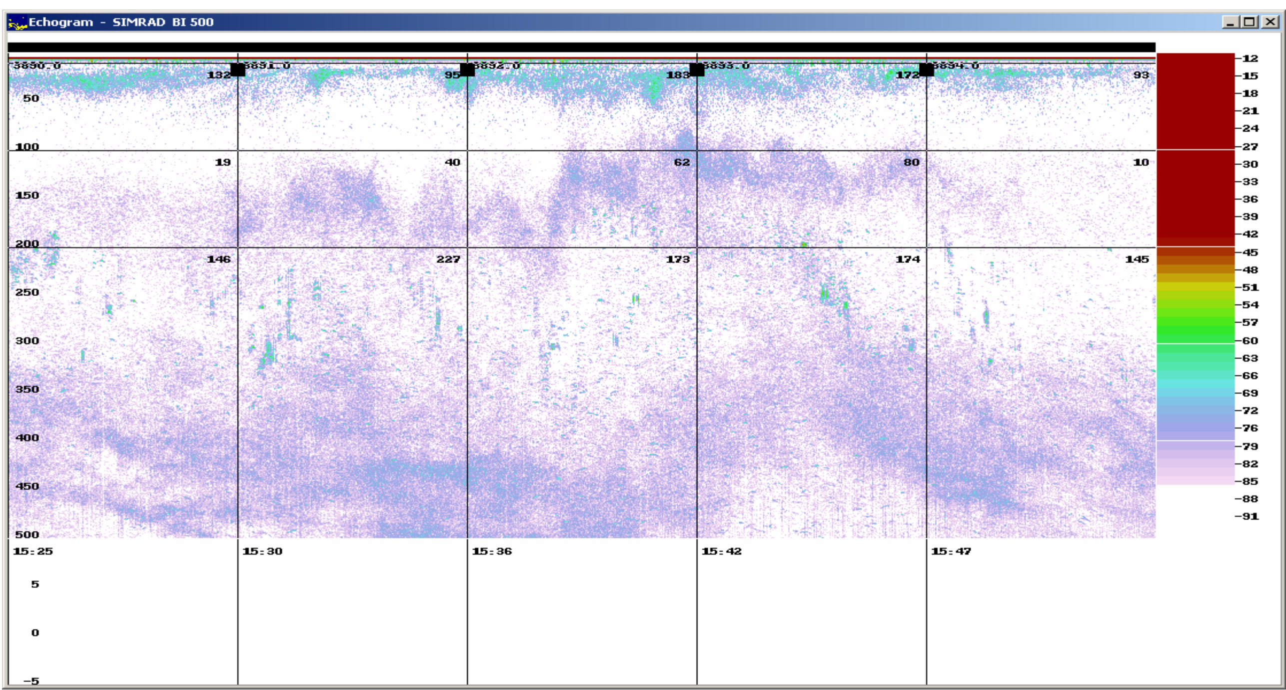
We conclude that both herring and blue whiting were in the mixed layer between 100-200 m depth at parts of the 24 hour cycle. When herring appears in the mixed layer there seem to be periods when the concentrations are dispersed in the layer and cannot be recognised as herring schools. At other periods herring may be found in both intermediate and concentrated schools. No clearly daily cycle can be recognized. This situation is different from the situation described by Bethke (2000), where analyses made during the survey in 2000 showed that herring schools were located mainly in the upper 50 m and no daily cycle between dispersed formations and schools were found.
For blue whiting there are periods when the concentrations are dispersed in the mixed layer between 100 and 200 meters. But no clear daily pattern between the dispersed - and schooling situation were seen as described by Bethke 2000, when schools were seen during day-time and dispersed during night time.
This difference in result between the experiment during the survey in 2000 and this experiment may be due to the geographical difference in the test area. During this survey the test area was chosen at 71º 15 N “on the spot” within a range of 10 miles, with no clear difference between day and night. Bethke’s experiment on the other hand covered a much wider area, comparable with the southern part of the 2006 survey, with more or less distinctive day and nights.
We recommend that more investigations should be made on the question of vertical distribution patterns of both herring and blue whiting during the survey period to secure a more accurate scrutinising process of the recorded concentrations

References

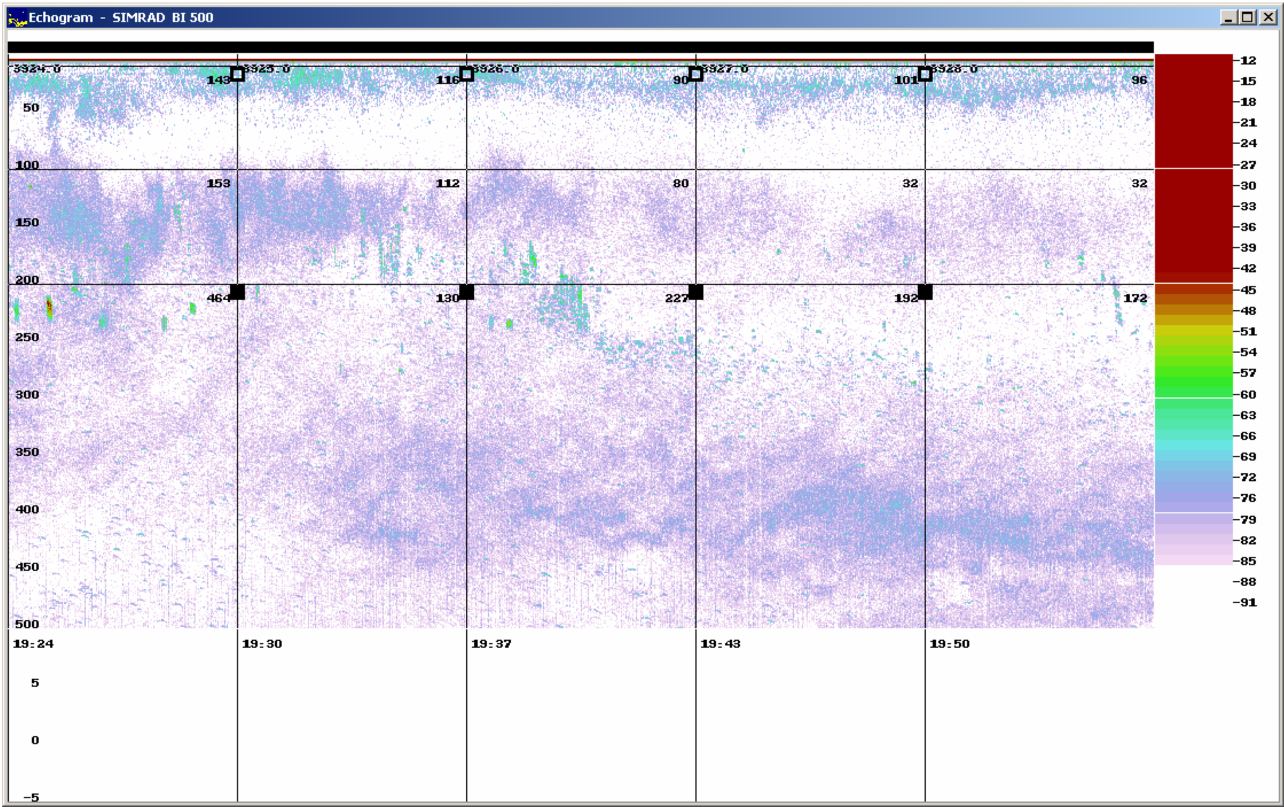
Bethke, E.: Einfluss des Tag-Nacht- Verhaltens von Fischen auf das Ergebnis hydroakustischer Messungen. Inf. Fischwirtsch. Fischereiforsch. 47(3), 2000



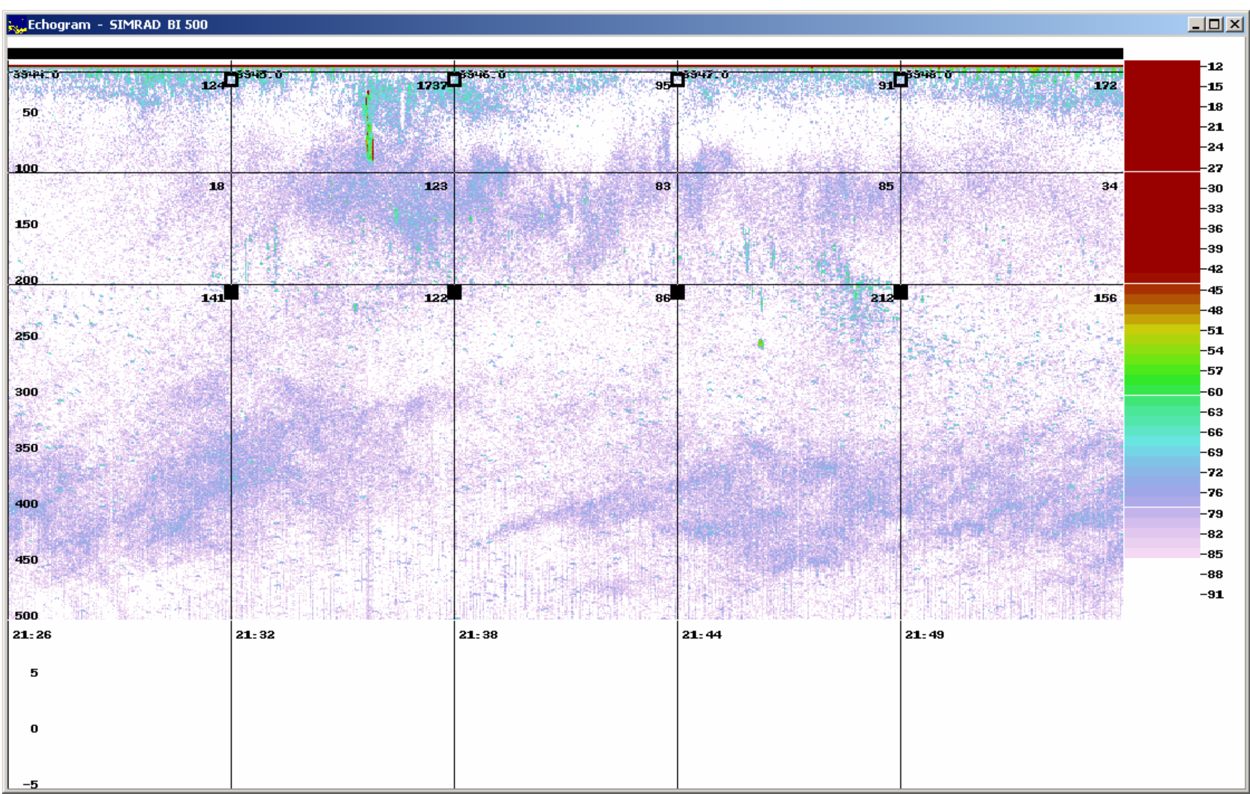
A. *Start of gridline #1-#2 at 13:29 to 13:52 UTC, taken from BI 500.*



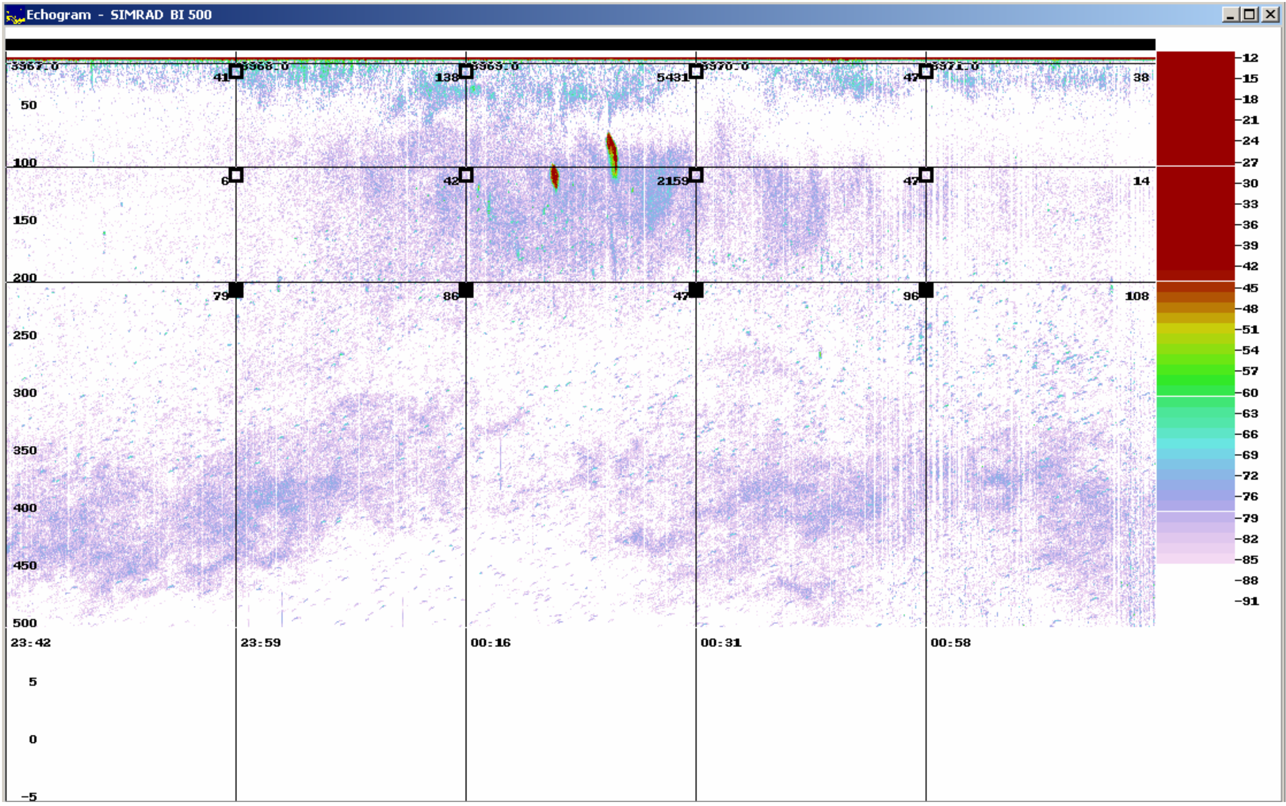
B. *Start of gridline #1-#2 at 15:35 to 15:47 UTC, taken from BI 500.*



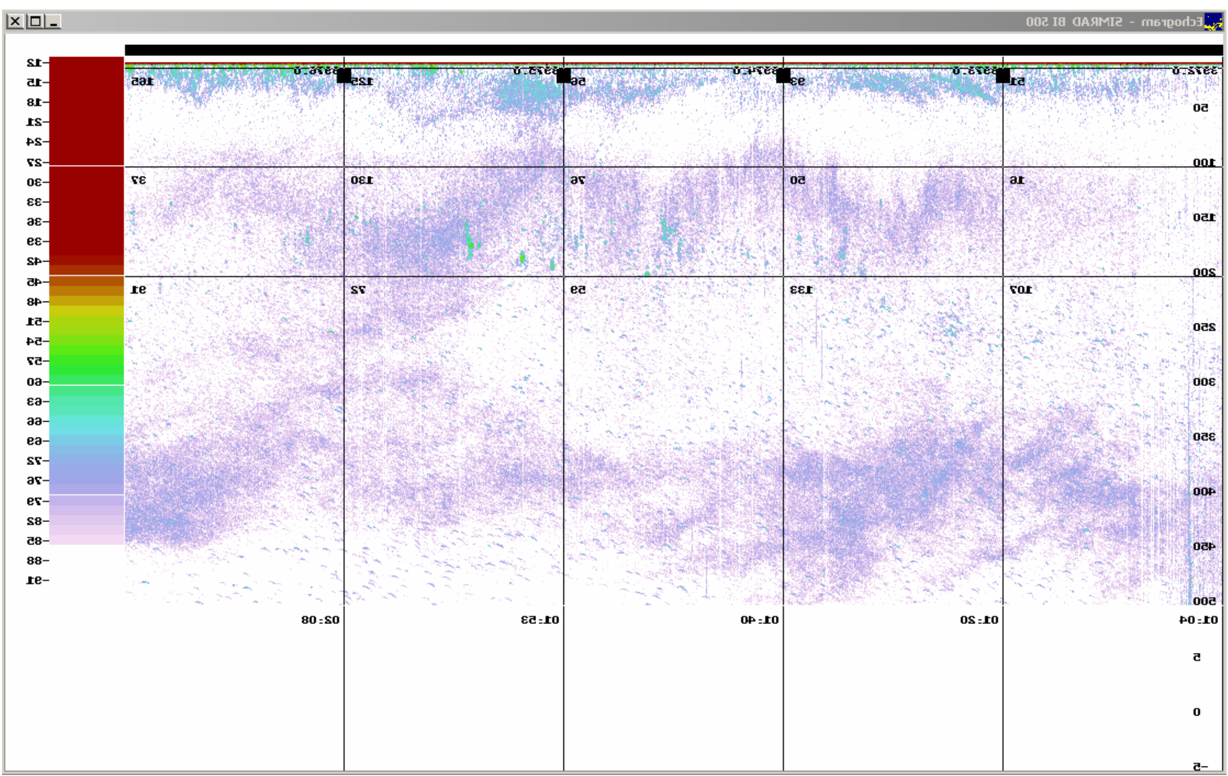
C. *Start of gridline #1-#2 at 19:24 to 19:50 UTC, taken from BI 500.*



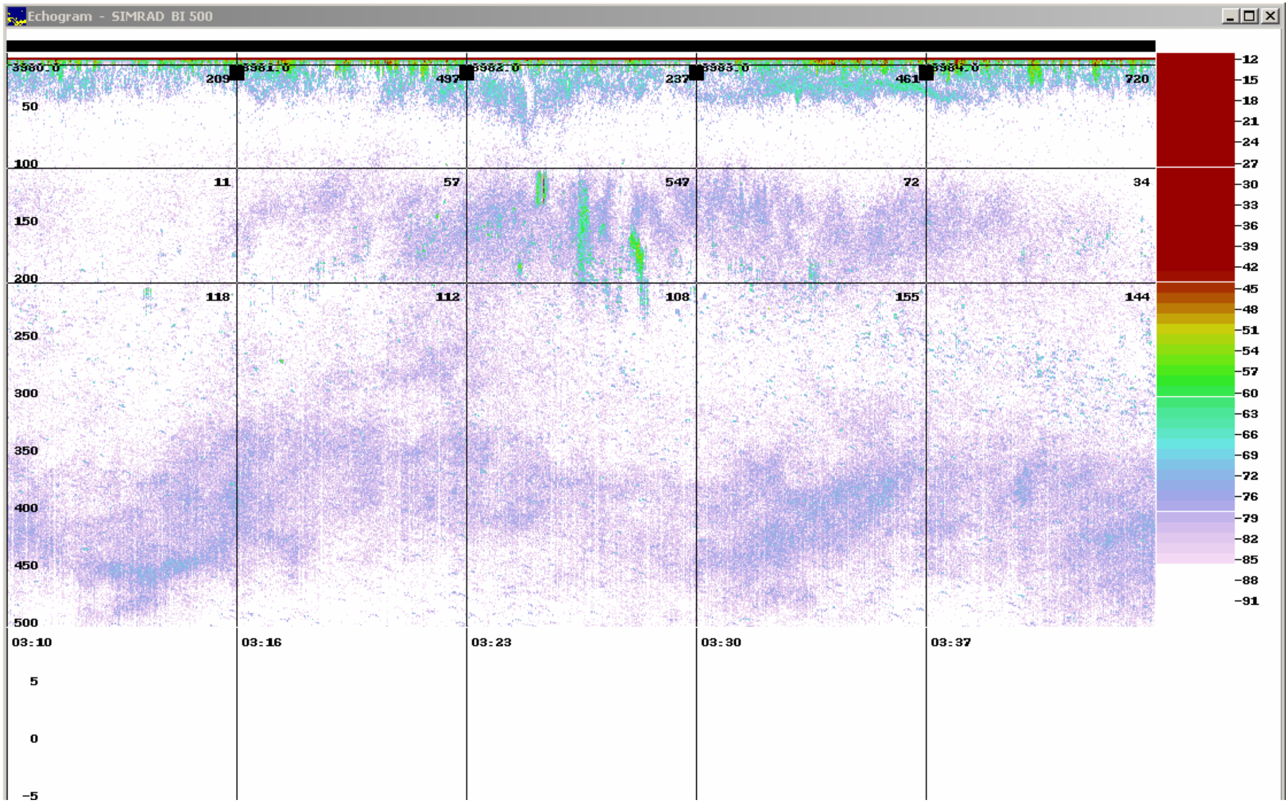
D. *Start of gridline #1-#2 at 21:26 to 21:49 UTC, taken from BI 500.*



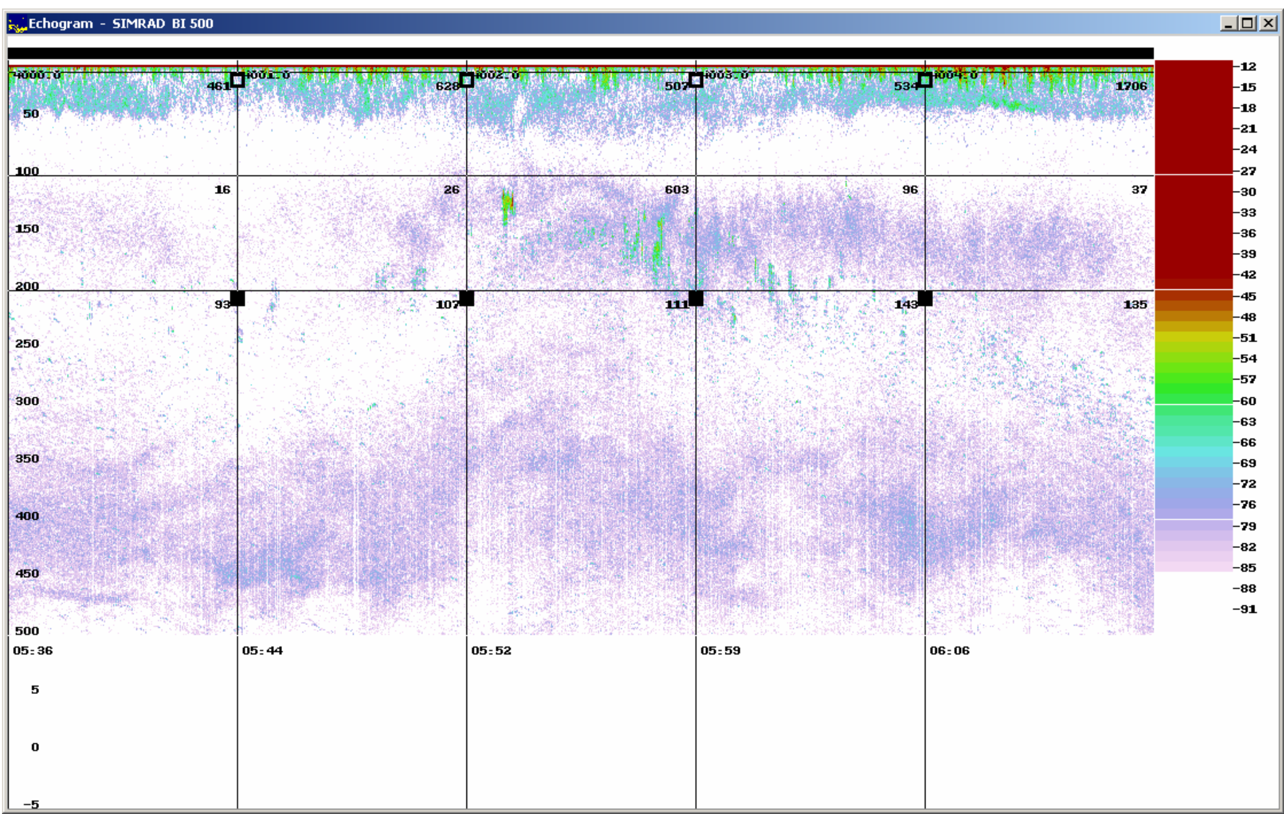
E. *Start of gridline #1-#2 at 23:42 to 00:58 UTC, taken from BI 500.*



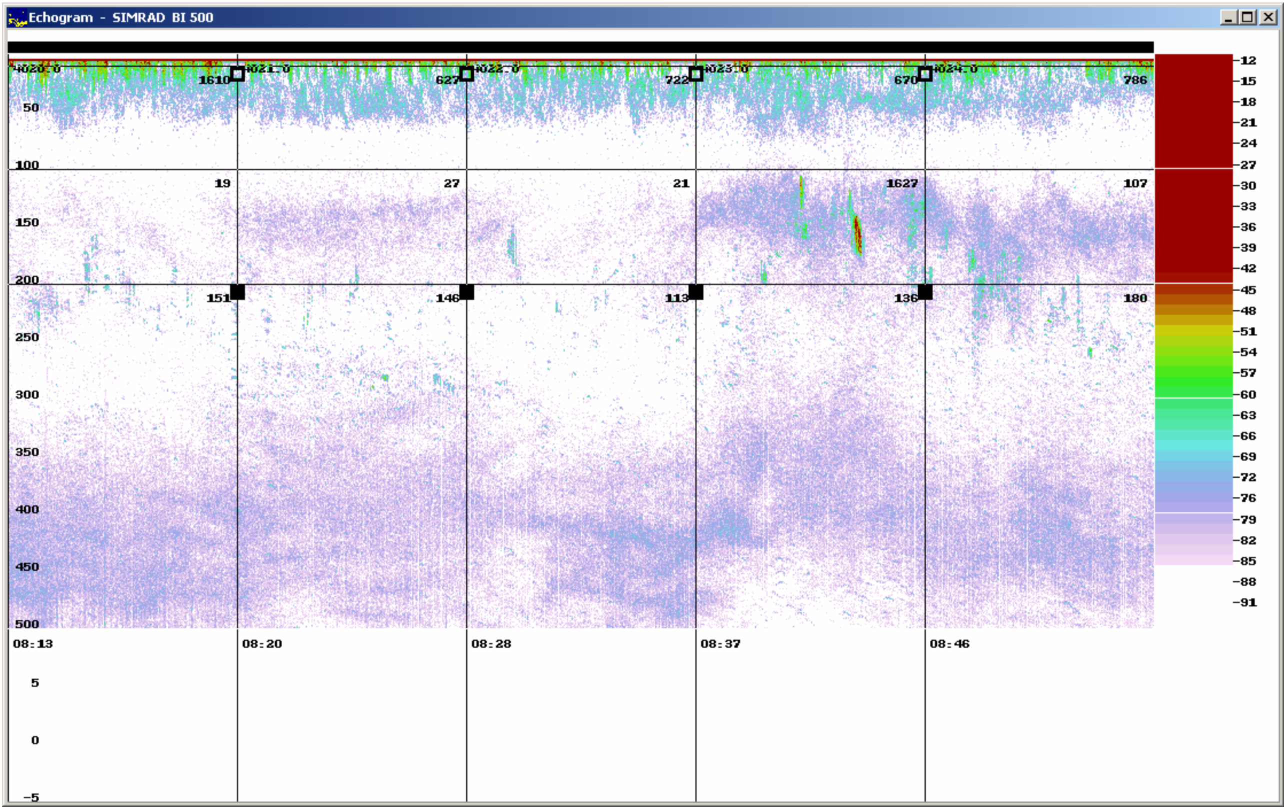
F. *Start of gridline #1-#2 at 01:04 to 02:08 UTC, taken from BI 500.(mired to give the direction from #1 to #2)*



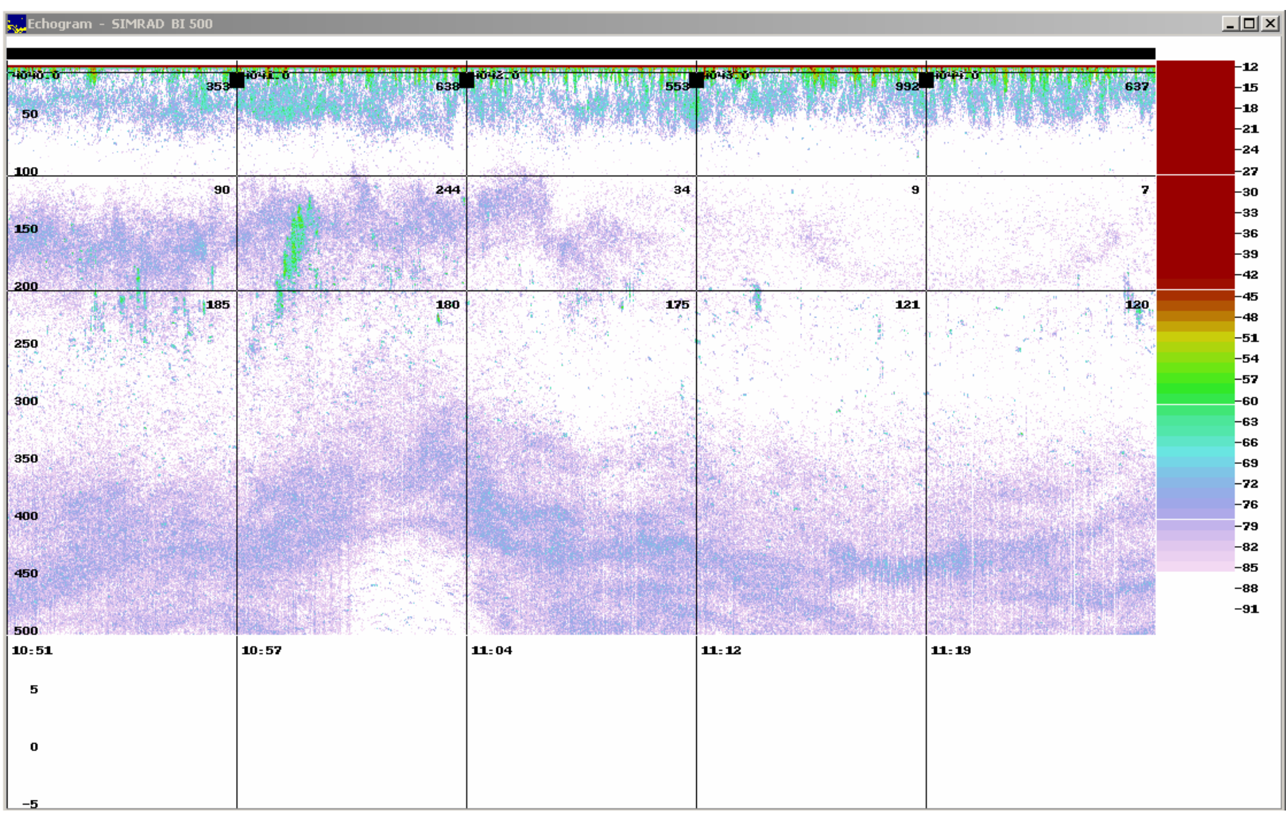
G. *Start of gridline #1-#2 at 03:10 to 03:37 UTC, taken from BI 500.*



H. *Start of gridline #1-#2 at 05:36 to 06:06 UTC, taken from BI 500.*



I. Start of gridline #1-#2 at 08:13 to 08:46 UTC, taken from BI 500.



J. Start of gridline #1-#2 at 10:51 to 11:19 UTC, taken from BI 500.