Cruise report

The international acoustic survey in the Norwegian Sea in May 2005

R/V DANA Cruise No. 3/2005

Calibration of Echo-sounders

International Acoustic Monitoring of Herring and Blue whiting

26/4 – 25/5 2005

Cruise participants

Calibration 26-29/4

Bo Lundgren	Denmark
Mogens Sørensen	Denmark
Thyge Dyrnesli	Denmark
Bo Tegen Nielsen	Denmark
Torben Filt Jensen	Denmark
Aril Slotte	Norway (28/4-29/4)

Acoustic monitoring 29/4-12/5

Aril Slotte (Cruise leader) (acoustic)	Norway
Bram Couperus (acoustic)	Netherlands
Eric Armstrong (acoustic)	Scotland
Anders Svensson (plankton/fishlab)	Sweden
Stina Bilstrup (plankton/fishlab)	Denmark
John Boyd (plankton/fishlab)	Ireland
Niels Jørgen Pihl (plankton/fishlab)	Denmark
Thyge Dyrnesli (acoustic/technician)	Denmark

Acoustic monitoring 12/5-26/5

Bram Couperus (Cruise leader) (acoustic)	Netherlands
Niklas Larson (acoustic)	Sweden
Teunis Janssen (acoustic)	Denmark
Susanne Hansen (plankton/fishlab)	Denmark
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Matthias Kloppmann (plankton/fishlab)	Germany
Thyge Dyrnesli (acoustic/technician)	Denmark

Background of the survey

The Norwegian spring spawning herring is a highly migratory and straddling stock 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, the main spawning areas being in the Norwegian Fjord from 62°N to 64°N in February – March, the herring migrates NE-wards towards the Norwegian Sea feeding grounds. In general, the main feeding has taken place along the polar front from the island of Jan Mayen and NE-wards towards Bear Island. During the latter half of the 1990's there has been a gradual shift of migration pattern with the herring migrations shifting north and eastwards. In 2002 -

2004 this development seems to have stopped and the herring had more southerly distribution at the end of the feeding season than in 2001. After feeding, the herring 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 2002-2003 part of the stock seems to winter in the Norwegian Sea off Lofoten. In January the herring start their southerly spawning migrations.

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

Objective of the survey

The main objective of this survey was to map the distribution and migrations of herring and other pelagic fish and to assess their biomass. Furthermore to monitor the 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 this.

Materials and methods

Acoustic data

This survey was coordinated with Norway as an international survey with participation of Norway, Iceland, Faroe Islands and EU, where the Danish R/V Dana conducted the EU survey part. The acoustic survey tracks of Dana are shown in figures.
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. 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. In two cases where data was accidentally not logged by the BI500, the raw ER60 data files have been scrutinized with BI60 software.

In advance of the acoustic monitoring of the Norwegian Spring Spawning herring and the blue whiting in the Norwegian Sea, calibration of the acoustic equipment (echo-sounders) had to be carried out. The calibration of the equipment took place near Aalesund.

Norway, on 28 April. In addition to the two 38 kHz transducers, also the hull mounted 18 and 120 kHz transducers were calibrated.

Hydrographical and zooplankton data

At approximately each 60 nm 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 Denmark for weighing.

In connection with the plankton sampling a hydrographical profile using the Seabird CTD unit was carried out from 0-1000 m depth. All together Dana carried out 50 combined CTD and WP2 stations (Figure 1).

Once a day two water samples were taken from the surface respectively from the bottom for calibration of the CTD unit. Also surface temperature and salinity was continuously monitored along with information on weather conditions (e.g. wind direction, wind speed etc.) during the survey utilizing R/V Dana's hydrographic and meteorological analysis system.

Biological data

During the survey fishing was carried out regularly on acoustic registrations to verify the species scrutinized and to give information about the size composition to be used in the biomass estimation. A Fotö midwater trawl was used either at the surface or in midwater down to 400 m depth. A total of 44 trawl stations were carried out during the survey, well spread over the surveyed area, but more frequently in areas with high fish densities (Figure 2).

All trawl hauls were sorted into species. Catches were sorted and weighed by species. Length measurements were taken for all species. For herring and blue whiting representative samples of 50 fish were taken. The following parameters were measured: length, weight, sex and maturity. Scales and otoliths were brought to Norway for age reading. In addition to the 50 fish, length measurements were carried out on up to a further 150 fish in order to achieve an estimate of the size distribution of the two target species. In total 18 samples of herring and 19 samples of blue whiting were taken.

Trawl data were entered into the Babelfisk database and all data was validated. The data was also put into the PGNAPES formats and sent by email to the coordinating vessel (GO Sars) at the end of the survey.

Otoliths and scales for comparison of age readings

In the majority of herring samples taken during the second half of the trip, otoliths have been taken for comparison to age readings from scales (samples from station numbers: 106, 111, 129, 130, 134 and 139; and additionally from herring not sampled for scales at stations 116, 119 and 120). The age readings from the otoliths will be sent to IMR in Bergen on separate copies of the biological sampling forms. The otoliths will be archived by the Marine Laboratory in Aberdeen.

Biomass estimation

A biomass estimate was not carried out based on Dana's data alone, but included as part of the data from all four vessels involved in the survey. The final estimate methodology is presented in the coming PGNAPES report.

Itinerary of the survey

R/V Dana left Hirtshals, Denmark on Tuesday 26 April at 15:00. On 28 April at 10:30, we arrived at the calibration site "Mauseidvågen" near Aalesund. Calibration took place on 28 and 29 April after which the ship set course to Aalesund at 8:20. We arrived in Aalesund on the same day at 9:10.
Dana left Aalesund on 29 April at 18:00, after changing of some crew members, to start the survey. Echo integration started at 20:20 hours on 29 April. At 11 May 16:00 hours Dana arrived in Bodø for changeover of crew, and left again at 18:00 hours the following day. At 14:00 hours 21 May we finished surveying and headed for Hirtshals where we arrived and thereby finished the survey at 25 May at 12:00 hours.

Adjustments of the programme during the survey

Small adjustments ("shortcuts") were made during the first half of the survey due to shortage of time.
In the second part of the survey, from the evening of 13 May untill the morning of 18 May the survey was obstructed by bad weather conditions (wind 7-9 Bft). The speed had to be lowered to 8 or 7 (6) knots for the major part of this period. During two periods it was not possible to collect acoustic data at all: 14 May 1:20 – 17:10 and 15 May 1:50 – 20:30). After consultation with G.O. Sars it was decided to shift the next two transects slightly to the north and to skip the last transect (73º25N). However, additional time had to be gained, by reducing the number of trawl stations and by cutting the western end of the 72º30N transect at 2º W.

Results

Distribution and density of herring and blue whiting

Herring schools were found scattered over most of the surveyed area. Their main concentrations were found on the 69°50N and the 71°10N transects and, to a lesser extent, in the southwest, between 62° and 64°N. No herring was found in the relatively cold waters in the northwestern survey area, on the 69°50N, the 71°10N and the 72°30N transect, west of 1°W. The transect parallel to the Lofoten/Vesterålen revealed concentrations of smaller herring, though not as much as in the 2004 survey (figure 3 and 5).
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 7). The zooplankton data is not prepared yet.

Discussion

Air bubbles and phytoplankton

During two days it was not possible to collect acoustic data due to air bubbles in the upper fifty meters. Apart from the fact that these bubbles may have covered herring schools, they also produced some transmission loss (lost pings due to obstruction by air bubbles).
An unknown fraction of herring has not been recorded, either because the schools were above the transducer or because air bubbles hid the schools. However, we assume that this occurred to a lesser extent compared to the 2004 survey. In figure 3 the relative herring distribution is shown versus the wind speed (synoptic). Unlike last year, the figure does not suggest a relation between wind speed and the detection of herring schools.

We suspect that air bubbles in the upper 50 m may also be caused by high phytoplankton 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. At the western end of the 69°50N transect, when the wind had decreased, but the waves and swell were still strong, it was very difficult or even impossible to distinct wind induced air bubbles from these assumed phytoplankton echo's.

Scrutiny

Unlike last year, no big problems in the scrutiny were encountered. Uncertainties occurred only in situation with small NASC values. In the southern part of the survey herring was found at night mixed with blue whiting and mackerel when the blue whiting would rise to the upper layers. We carried out some trial hauls to distinct the species from each other with Sonardata Echoview post-processing software (see Appendix 1). The results are not conclusive, but we think it likely that better results can be obtained after improvement of the algorithms and with more reliable trawl information (see below).

Trawling

During the survey we were able to collect a lot of herring and blue whiting samples. However, like in the 2004 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. 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 the same depth, the catch was a few baskets. The same accounts for herring, 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. We recommend future intership-calibrations between vessels, including trawl catch performance during this survey.
The new installed Scanmar Catch Control component performed very well. The added improvement being that one was able to see whether fish was entering the net or if it was escaping under or above the trawl.

BI60 software

Two transect sections had not been logged by the BI500 and were therefore scrutinized with BI60 software. This turned out to be very time consuming, partly because of lack of experience with this application. Working with the BI60 was cumbersome, because of its slowness. Some aspects of the program are irritating. It is not possible to put it in the pelagic mode. In deep water one may look all the time at a false bottom line. We also wonder why it isn't possible to get rid of the bottom channel. There were a lot of other small items of which it took some time to find out how to deal with. e.g. one can only draw a layer if the whole file fits in the window. This is strange because the scroll tap at the lower end of the window suggests that this could be done. Other things like when drawing a school box in zoom-mode seemed to be real bugs.

PGNAPES exchange format

We were missing a formal description of the exchange-format. An example file together with the database format description helped a lot, but still it would be good to have a description targeting the exchange format directly.
We were uncertain about what species codes to use, since there are several systems around and some of the species names were given in Faroese. We would recommend that TSN (Taxonomical serial number) codes are used instead of the current species codes. 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. ITIS is updating and maintaining the system (in contradiction to the NODC-system, that are now outdated).
A data quality assurance application that could be used for checking the exchange-file before submitting data would be an advantage. The application should be executable that works at sea with no Internet connection, since it is always faster and easier to correct errors in data during the cruise.

Biological sampling and station information

The participants change from year to year to a greater extent than in other (national) surveys. Therefore 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 present method of importing station information (time, duration, wind etc.) into the Babelfisk database should be protected against faulty entrances. We had to adjust station information in 5 cases.

Figures

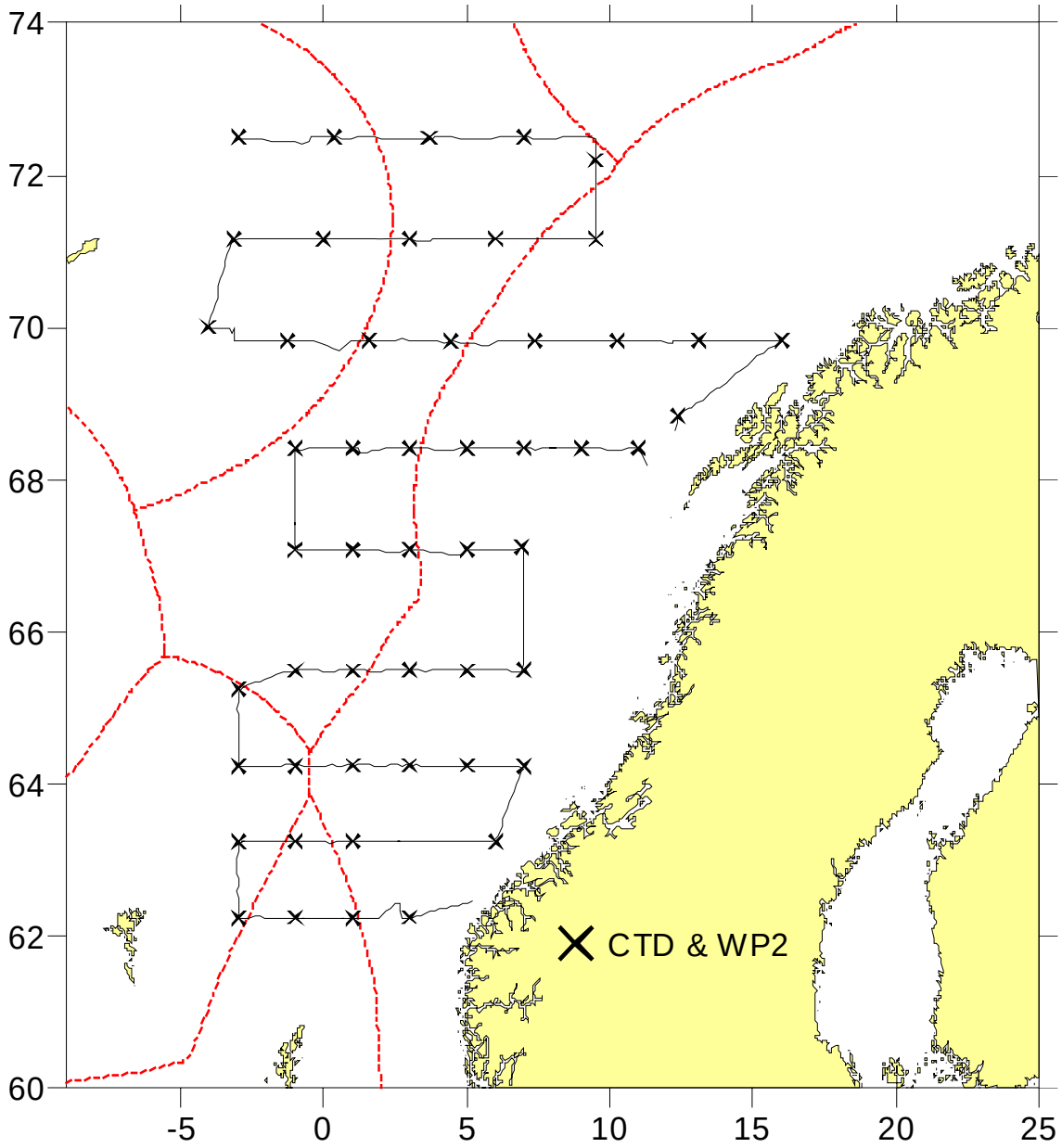

Figure 1. CTD stations (down to 1000 m) and WP2 stations taken by R/V Dana during 29 April to 21 May 2005.

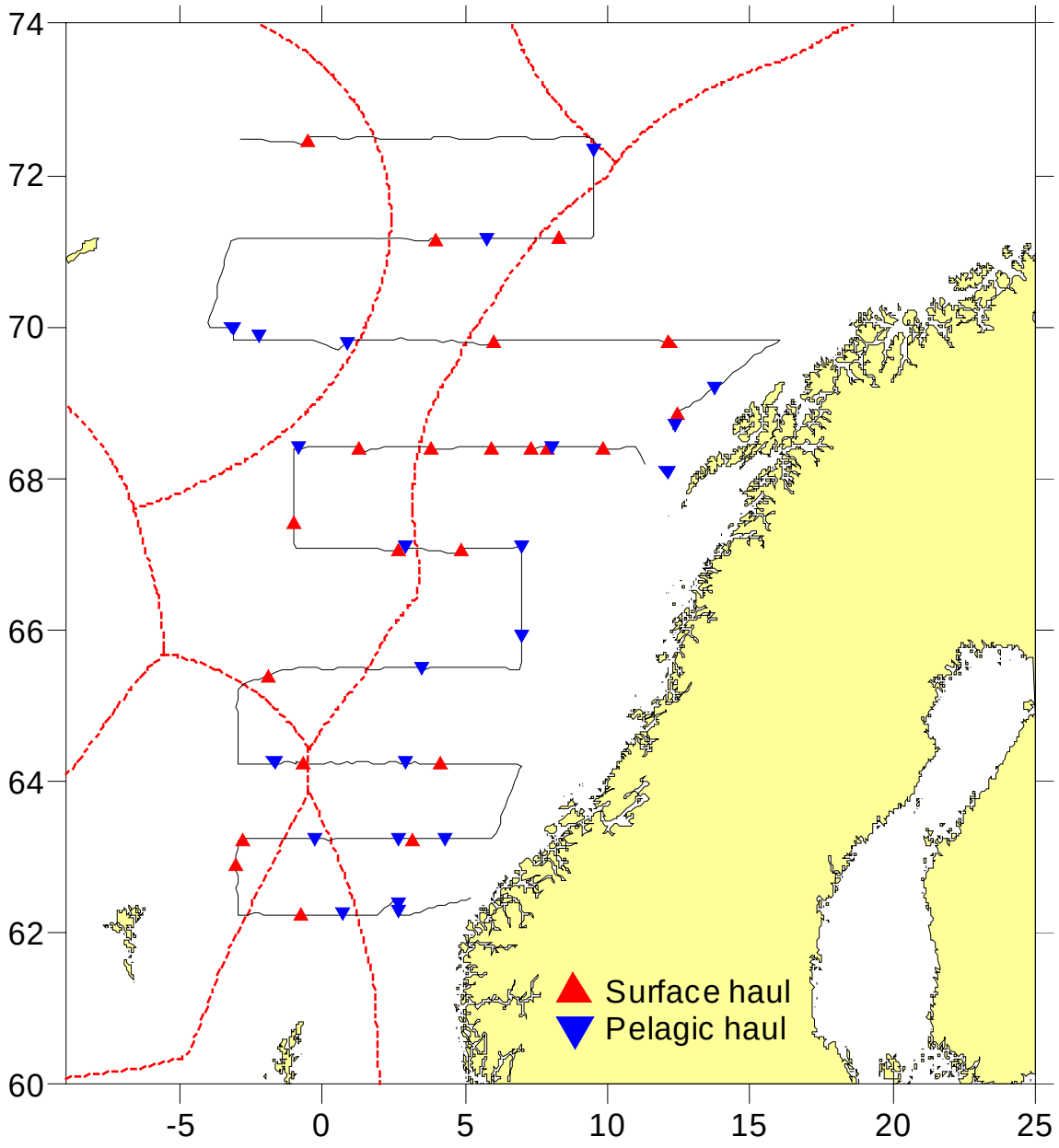

Figure 2. Trawl stations (surface and pelagic hauls) taken by R/V Dana during 29 April to 21 May 2005.

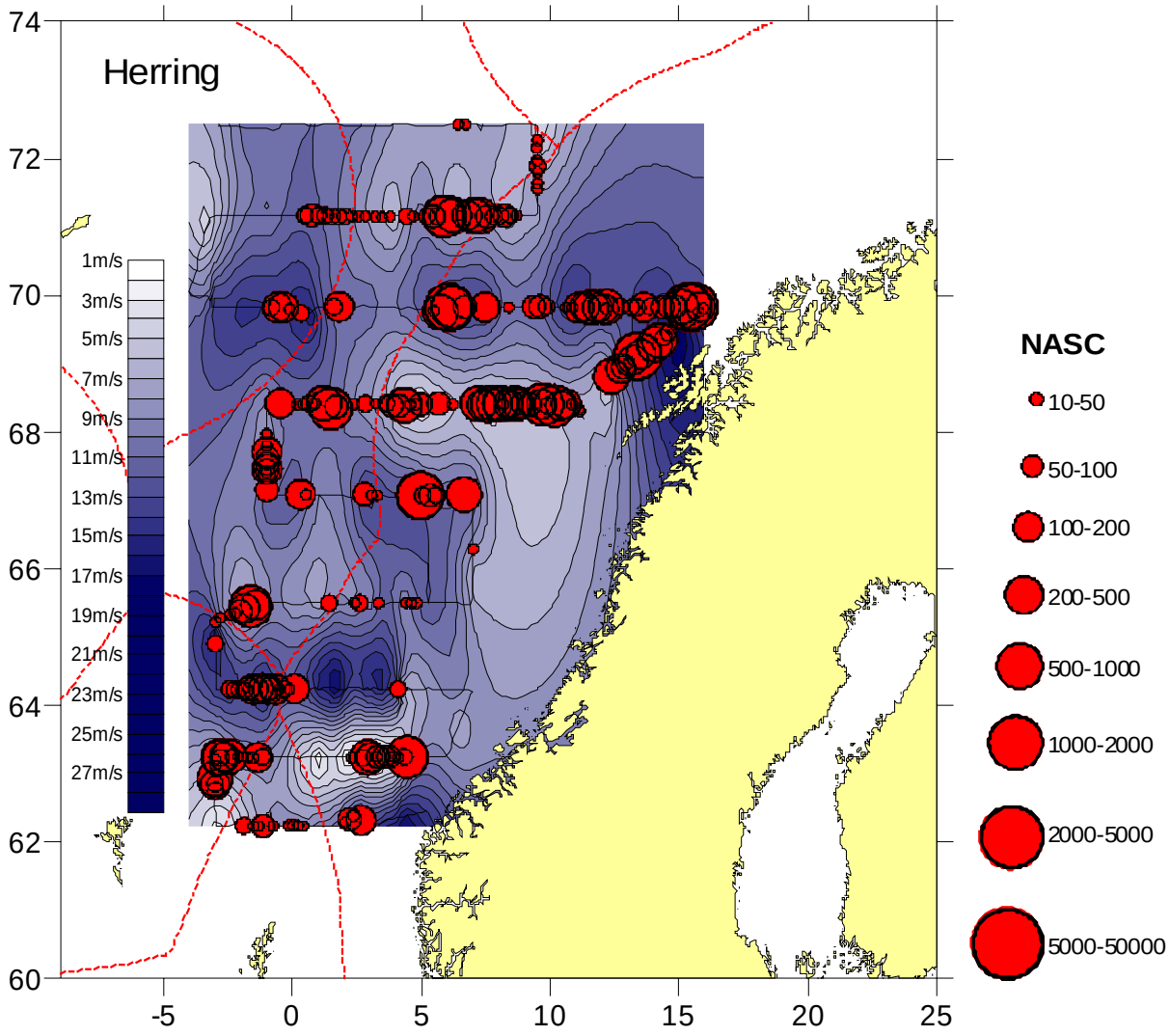

Figure 3. Distribution and area echo abundance (mean NASC per 5 nm) of herring recorded by R/V Dana during 29 April to 21 May 2005 in relation to wind speed (average over three hours).

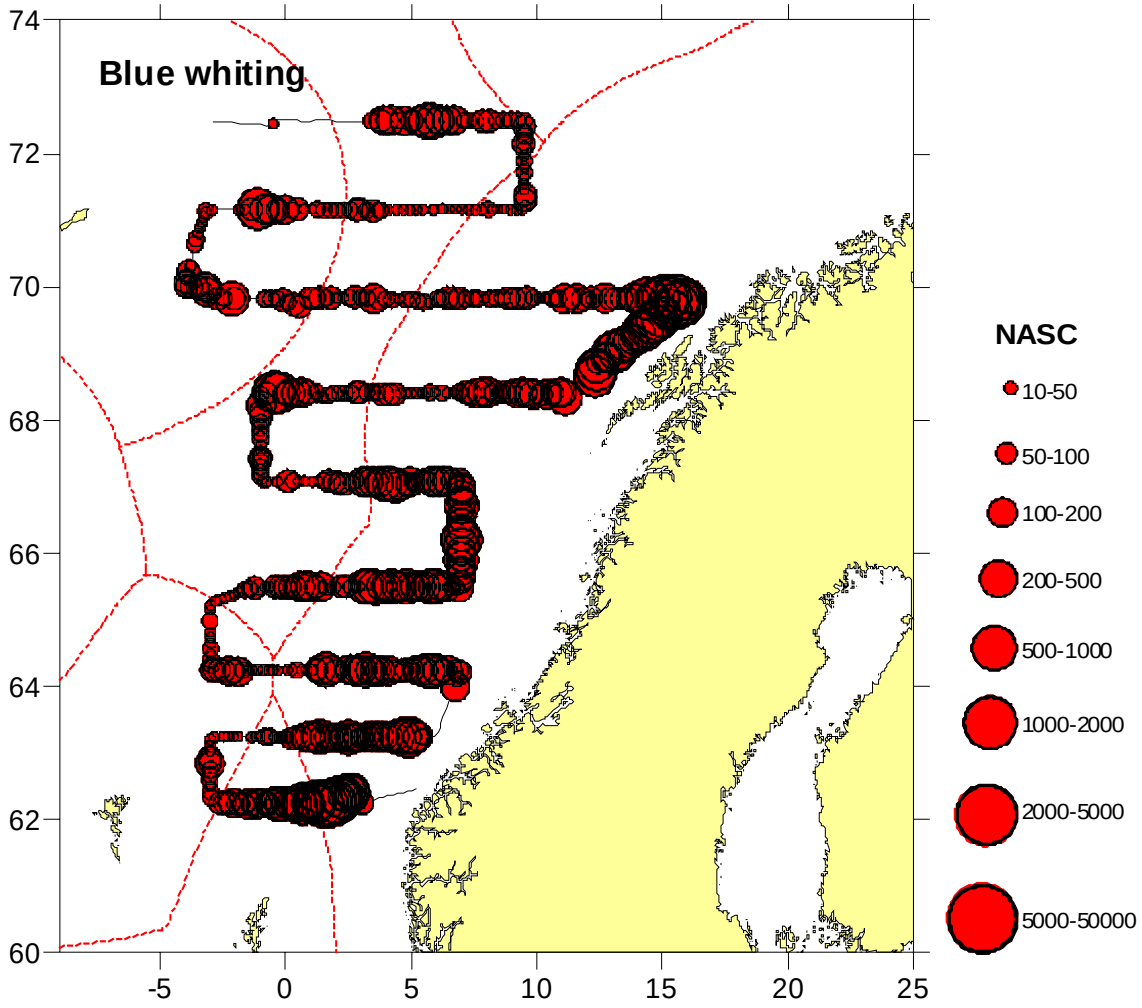

Figure 4. Distribution and area echo abundance (mean NASC per 5 nm) blue whiting recorded by R/V Dana during 29 April to 21 May 2005.

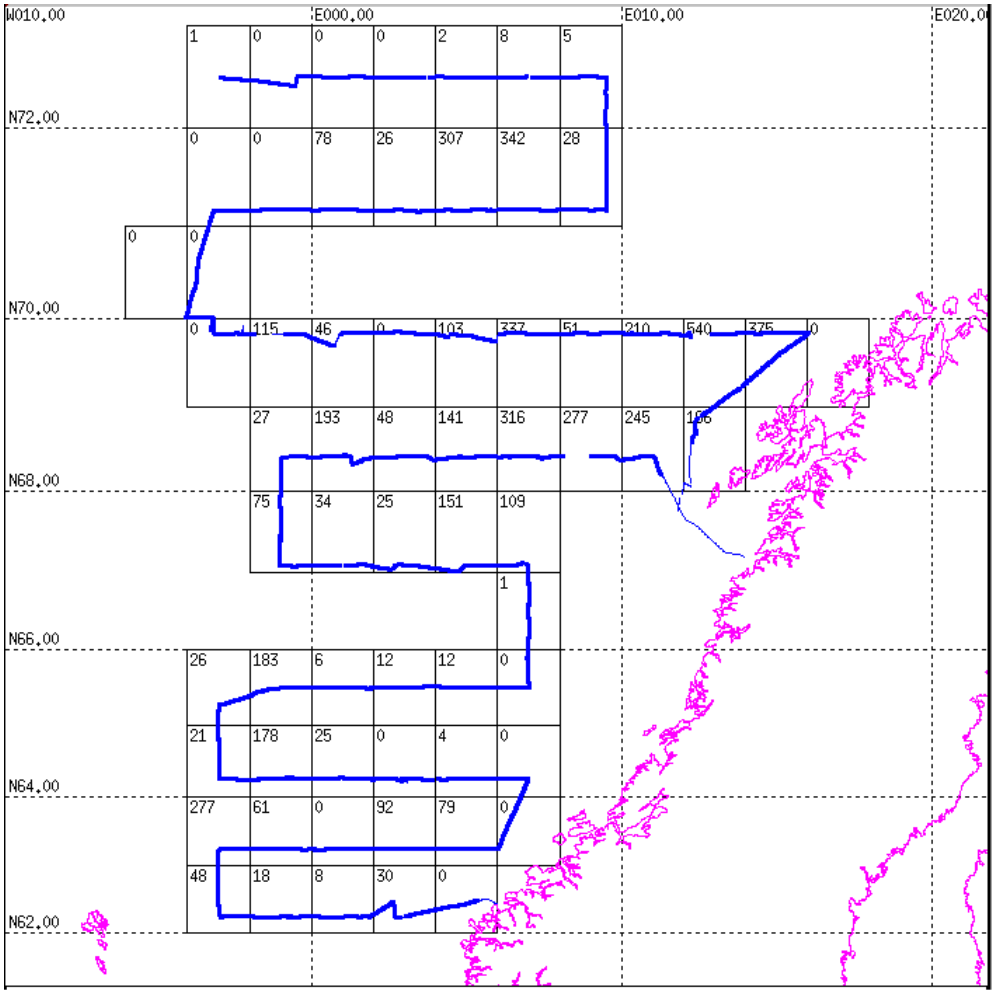

Figure 5. Mean area echo abundance (NASC's) of herring by grid cells recorded by R/V Dana during 29 April to 21 May 2005. Map made with BI500 software. Grid cells containing missing intervals (interrupted blue transectline) do not provide the correct values. The missing intervals sections were scrutinized with BI60 software from the raw ER60 files.

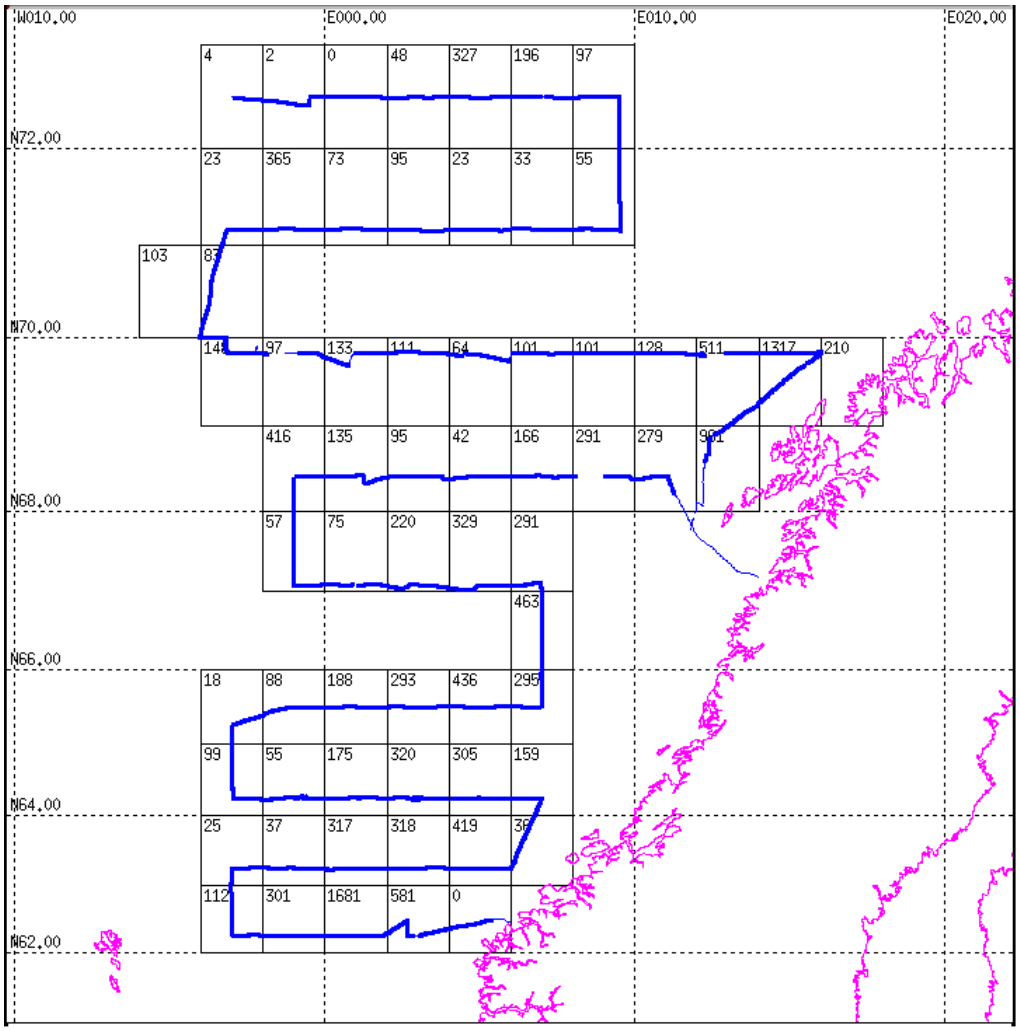

Figure 6. Mean area echo abundance (NASC's) of blue whiting by grid cells recorded by R/V Dana during 29 April to 21 May 2005. Map made with BI500 software. Grid cells containing missing intervals (interrupted blue transectline) do not provide the correct values. The missing intervals sections were scrutinized with BI60 software from the raw ER60 files.

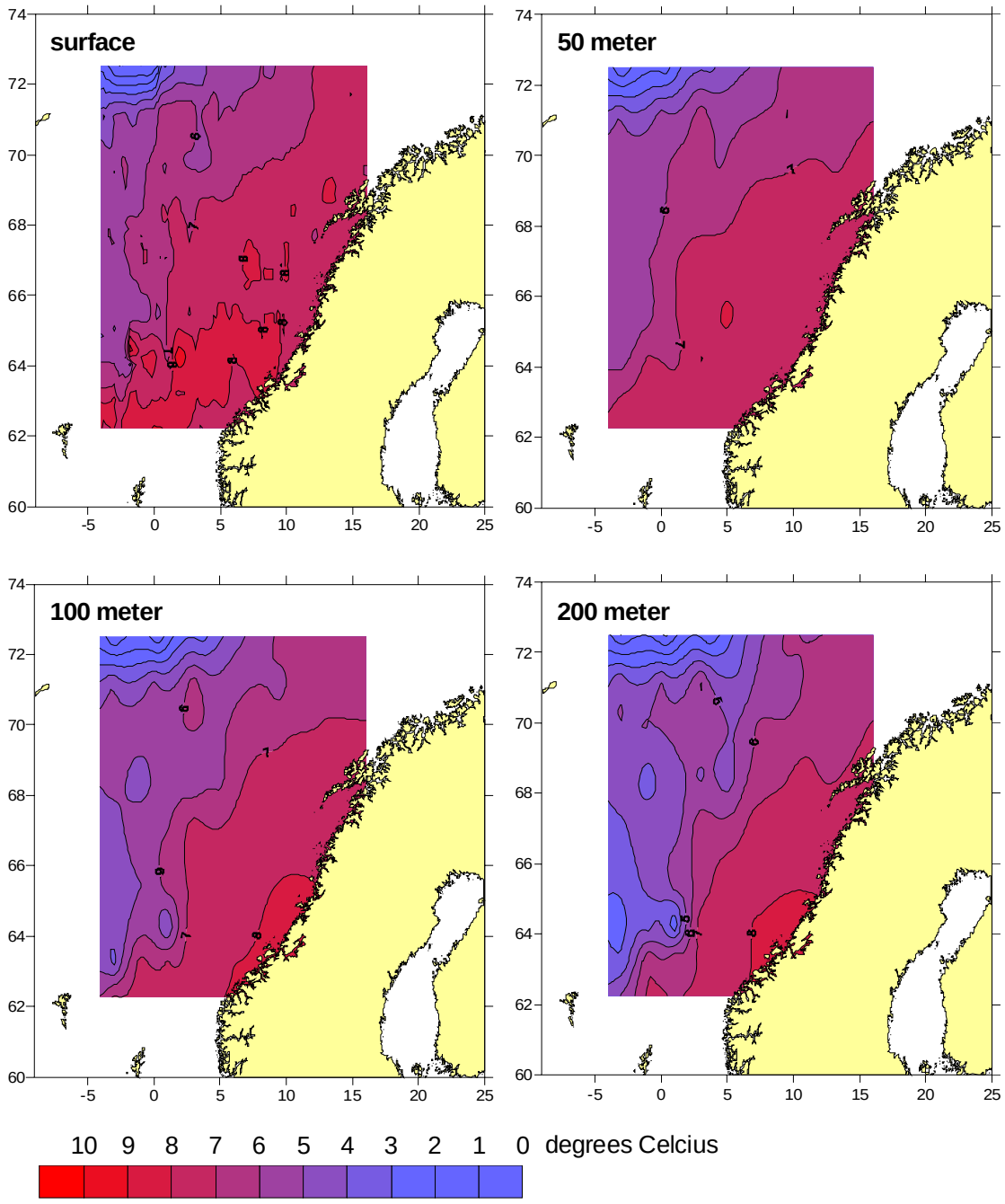

Figure 7. Contour plots of the temperature at surface (metrological station), 50, 100 and 200 m depth as measured by CTD stations taken by R/V Dana during 29 April to 21 May 2005.

Appendix 1.

Trial with multi frequency techniques

During the cruise, investigations were made into fish species identification using multi frequency techniques developed as part of the SIMFAMI project. Using Sonardata's Echoview software, data at 38 & 120 kHz were manipulated using the "variables and geometry" module to produce virtual echograms using the following algorithm (Fig 1). As has been used in most previous algorithms the data from the two frequencies were summed; a threshold was applied to this sum to eliminate low intensity reflectors such as plankton from the data. The remaining summed data was then processed with a 3 x 3 median filter to eliminate single isolated points. This causes an erosion of the data around aggregations of points from fish school echoes, which is recovered by applying a 3 x 3 dilation filter. This is then passed through a Data Range Bitmap to provide a mask to only include potential fish echoes. This mask can then be used to extract regions using the School Detection module. The mean of these regions, when displayed as a virtual echogram (Fig.2), highlight differences in the frequency response of the schools detected, which may provide a guide to species separation/identification.
By grouping the data into 3dB bins and plotting in a graph (Fig 3.) the data appears to show a multi modal distribution which may have potential in identifying schools with similar acoustic relationships. This is emphasized by taking the log of the distribution.

The algorithms were applied on echogram log 955.6 – 968.6, shortly before station number 24 (surface haul at night). The approximate catch was 160 kg blue whiting, 57 kg mackerel and 18 kg herring.

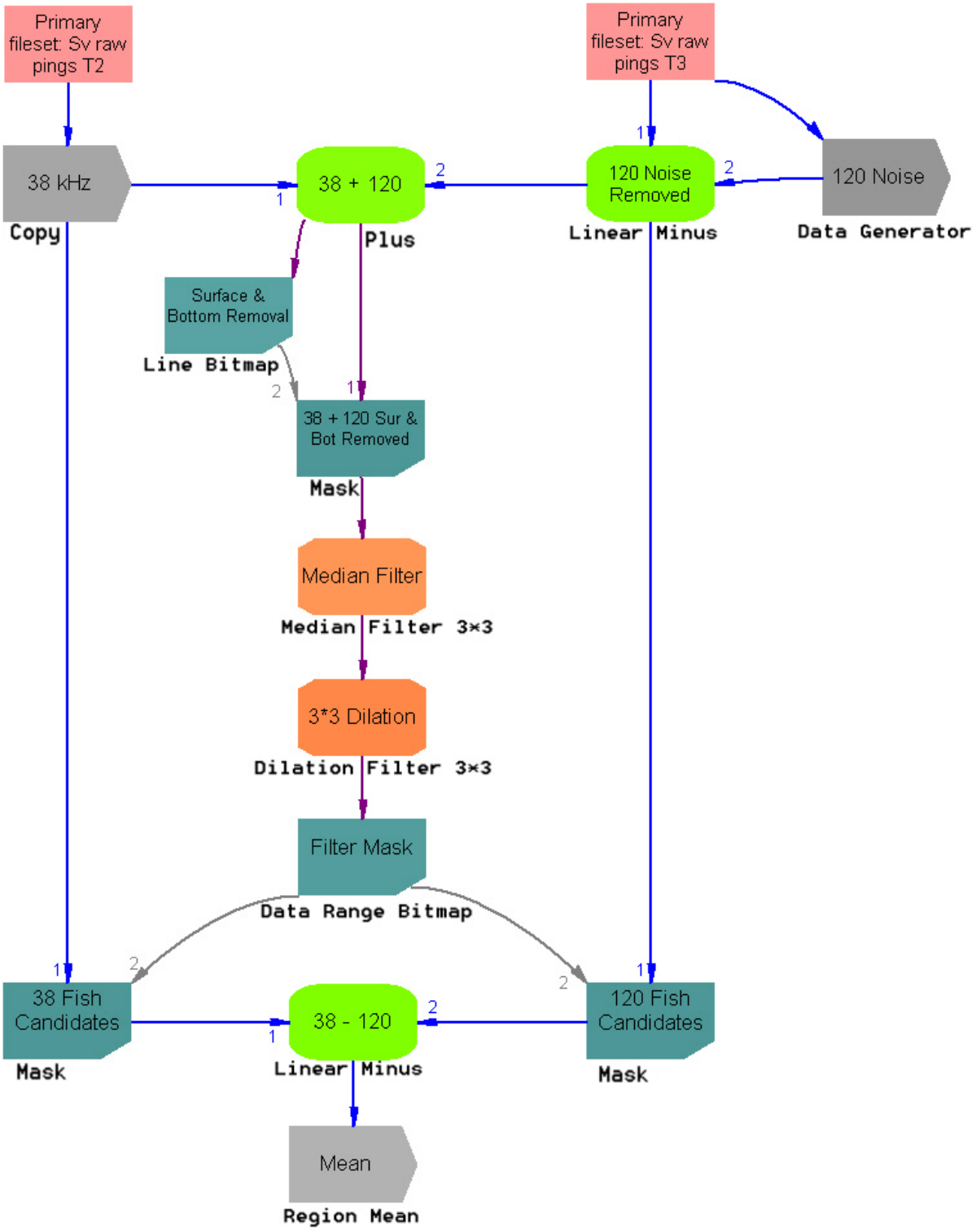

Fig 1. A flow chart showing the variables used to extract information from 38 & 120 kHz, in an attempt to develop a technique to separate/identify fish species.

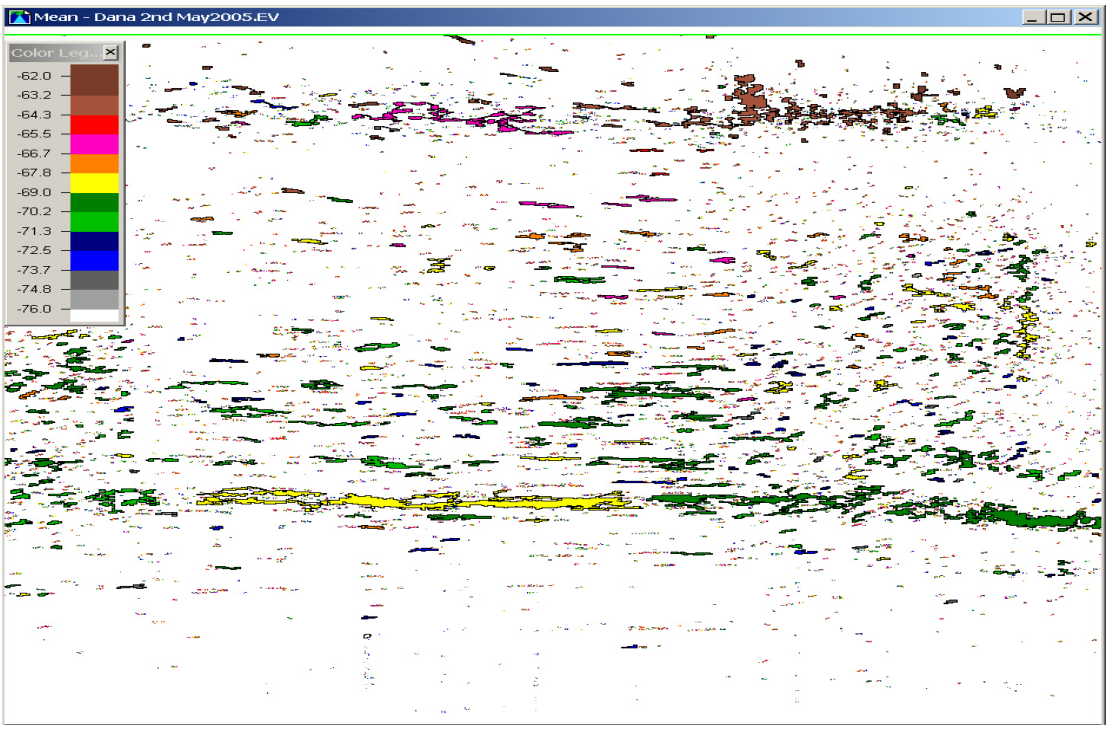

Fig 2. A section of the virtual echogram of the region means of the difference between 38 & 120 kHz data for detected schools, after processing using the technique outlined in Fig 1.

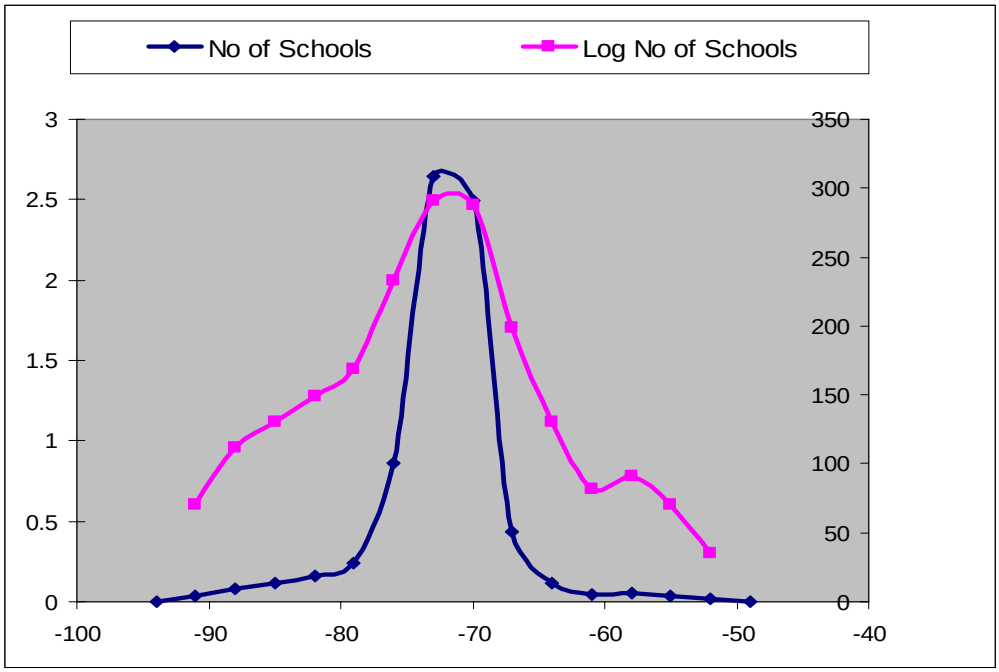

Fig 3. A graph of the distribution of schools identified in the echogram shown in Fig 2. grouped in bins of 3dB