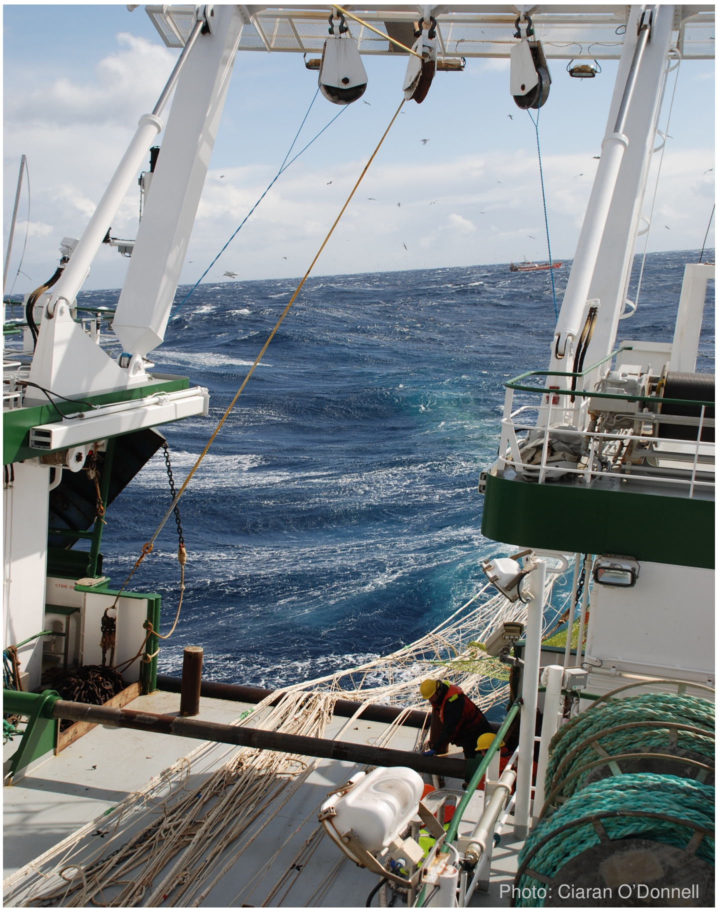
FSS Survey Series: 2008/01

Blue Whiting Acoustic Survey Cruise Report

Spring 2008



Ciaran O'Donnell[1], Eugene Mullins[1], Graham Johnston[1], Kieran Lyons[2]
Eckhard Bethke[3], Gert Holst[4] and David Wall[5]

[1]The Marine Institute, Fisheries Science Services,

[2]The Marine Institute, Ocean Science Services

[3]Institute for Sea Fisheries, Hamburg

[4] DTU Aqua, Denmark

[5] Irish Whale and Dolphin Group.

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1 Introduction

Acoustic surveys on the blue whiting (*Micromesistius poutassou*) stock in the north east Atlantic have been carried out by the Institute of Marine Research (IMR), Norway since the early 1970s. In the early 1980s a coordinated acoustic survey approach was adopted, with both Russia and Norway participating to estimate the size of this migratory stock within its key spawning grounds. Since 2004, the coordinated survey program has expanded and to include vessels from the EU (Ireland and the Netherlands) and the Faroes.

Due to the highly migratory nature of the stock a large geographical area has to be surveyed. Spawning takes place from January through to April, with a peak time between mid-March and mid April. Consequently acoustic surveys are routinely carried out during the peak spawning period within known geographic confines. To facilitate a more coordinated spatio-temporal approach to the survey participating countries meet annually to discuss survey methods and define target areas at the ICES led Planning Group of Northern Pelagic Ecosystem Surveys (PGNAPES).

Data from the annual spawning stock abundance survey (March/April, western waters), juvenile surveys (May, Norwegian Sea and January-March, Barents Sea trawl survey) and commercial landings data are presented annually at the ICES Working Group of Widely Distributed Stocks (WGWDS). Ultimately, combined data inputs into the management and catch advice for this international cross boundary stock.

The 2008 survey was part of an International collaborative survey using the vessels RV *Celtic Explorer* (Ireland), RV *Fridtjof Nansen* (Russia), RV *Tridens* (Netherlands) and the RV *Magnus Heinason* (Faroes) and the FV Gardar (Norwegian commercial charter). The total combined area coverage in 2008 extended from the Faroe Islands in the north (62°N) to south of Ireland (51.30°N), with east -west extension from 5°-19° W. Combined area coverage included shelf break areas (>250m) and large bathymetric features including the slope areas of the Porcupine, Rockall and Hatton Banks.

The Irish component of the survey was made up of transects covering 2,480nmi (nautical miles) covering the slope areas (>250m) of the north Porcupine area, the eastern fringes of the Rockall Bank, the Rockall Trough and the eastern slopes of the Hebrides shelf. This survey represents the 5th survey in the Irish time series.

2 Materials and Methods

2.1 Scientific Personnel

Name	Institute	Capacity
Ciaran O'Donnell (Cruise Leader)	FSS	Acoustics
Eugene Mullins	FSS	Acoustics
Graham Johnston	FSS	Acoustics
Andre Pires	FSS	Biologist
Visiting Scientists		
Eckhard Bethke	vTI SF	Acoustics
Gert Holst	DTU Aqua	Biologist
Dave Wall	IWDG	MMO
Jevon Brennan-Keane	NUIG	PhD

2.2 Survey Plan

2.2.1 Survey objectives

The primary survey objectives are listed below:

- Collect acoustic data on spawning and post spawning aggregations of blue whiting (*Micromesistius poutassou*) along the northern migration pathway from key spawning areas in target sub areas 1 and 2b and 2a (PGNAPES defined)
- Determine an age stratified estimate of relative abundance and biomass of blue whiting within the survey area
- Collect biological samples from directed trawling on insonified fish echotraces to determine age structure and maturity state of survey stock
- Collect physical oceanography data as horizontal and vertical profiles from a deployed sensor array
- Conduct a abundance and distribution survey of marine mammals and seabirds

2.2.2 Area of operation

The spring 2008 survey covered the primary core spawning area of blue whiting to the west of the Ireland and the Western Isles (Figure 1). The survey track commenced off the west coast of Ireland at the shelf break and progressed northwards to the Hebrides using east-west transects up to 170nmi long. Westward extension reached the eastern flanks of the Rockall Bank. The survey was carried out in continuity from south to north with no scheduled or unforeseen disruptions.

2.2.3 Survey design

A parallel transect design was adopted with transects running perpendicular to the lines of bathymetry where possible. Offshore, transects extended to the 15°W. Transect spacing was set at 30nmi and maintained throughout the survey.

In total, the survey accounted for 2,950nmi, with 2,480nmi of data available for acoustic integration. Survey design and methodology adheres to the methods laid out in the PGNAPES acoustic survey manual.

2.3 Equipment and system details and specifications

2.3.1 Acoustic array

Equipment settings for the acoustic equipment were determined before the start of the survey program and were based on established settings employed by FSS on previous surveys (O'Donnell *et al.,* 2004). The settings used on the *Celtic Explorer* acoustic array are shown in Table 1.

The acoustic data were collected using the Simrad ER60 scientific echosounder. A Simrad ES-38B (38 KHz) split-beam transducer is mounted within the vessels drop keel and lowered to the working depth of 3.3m below the vessels hull or 8.8m below the sea surface. Three other operating frequencies were used during the survey (18, 120 and 200kHz) for trace recognition purposes, with the 38KHz data used solely to generate the abundance estimate.

Whilst on survey track the vessel is normally propelled using DC twin electric motor propulsion system with power supplied from 1 main diesel engine, so in effect providing "silent cruising" as compared to normal operations (Anon, 2002). Cruising speed is maintained at a maximum of 10 Kts (knots) where possible. During fishing operations normal 2 engine operations were employed to provide sufficient power to tow the net.

2.3.2 Calibration of acoustic equipment

A calibration of the ER60 array was not carried during this survey. A calibration was attempted on the 16th April at the end of the survey but was not possible due to a strong tidal race in the selected area (Saint John's Point, Co. Donegal). The ER60 was last calibrated in October 2007 (O'Donnell *et al,* 2007). The results from the last calibration (38kHz) are presented in Table 1.

2.3.3 Inter-vessel calibration

During an acoustic intercalibration, firstly an area of blue whiting abundance was located. Vessels steaming to a pre-determined site are often able to highlight at area of interest with relative ease. The characteristics of a focus area include high-density isolated schools and in clear and open water away from the commercial fleet, if possible. The lead vessel is chosen and runs a course over the afore mentioned schools, commonly in the order of 10 to 20nmi, with the trail vessel following at a distance of 0.5nmi and a bearing of 0.5° off the lead vessels port/starboard quarter, to avoid bubble attenuation from the propeller of the lead vessel. The lead vessel then communicates the start point at which the first nautical mile data logging point begins. Once the lead vessel is through the main area of interest logging is stopped and communicated to the trail vessel. Roles can then be reversed, if desired, with the lead vessels switch places running over the same area again. Total NASC values per 100m depth layer and NASC values allocated to blue whiting, after echogram scrutinisation, were summed per 1nmi interval and transmitted between vessels for analysis.

Once complete, comparative trawls commonly are undertaken with the aim of sampling the same schools. Data on length, weight, sex, maturity and age are then compared between samples.

2.3.4 Acoustic data acquisition

Acoustic data were observed and recorded onto the hard-drive of the processing unit using the equipment settings from previous surveys (Table 1). The "RAW files" were logged via a continuous Ethernet connection as "EK5" files to the vessels server and the ER60 hard drive as a backup in the event of data loss. In addition, as a further back up a hard copy was stored on an external HDD and copied to DVD. Sonar Data's Echoview® Echolog (Version 4.2) live viewer was used to display the echogram during data collection to allow the scientists to scroll through echograms noting the locations and depths of fish shoals. A member of the scientific crew monitored the equipment continually. Time and location (GPS position) data was recorded for each transect within each target area. This log was used to monitor the time spent off track during fishing operations and hydrographic stations plus any other important observations.

2.3.5 Echogram scrutinisation

Acoustic data was backed up onto the vessels server every 24 hrs and scrutinised using Echoview. Partitioning of data into the above categories was largely subjective and was viewed by a scientist experienced in viewing echograms.

The "EK5" files were imported into Echoview for post-processing. The echograms were divided into transects. Echo integration was performed on regions defined by enclosing selecting marks or scatter that belonged to one of the target species categories. The echograms were analysed at a threshold of -70 dB and where necessary plankton were filtered out by thresholding at –65 dB.

Echograms were scrutinised into one of the following categories:

a). Blue whiting
b). Mesopelagic fish
c). Plankton
d). Plankton and mesopelagic fish
e).Pelagic fish

Selection criteria are based upon behavioural, including diurnal migrations and habitat preference of each category, as well as target strength (TS) information.

2.3.6 Biological sampling

A single pelagic midwater trawl with the dimensions of 70m in length (LOA) and a fishing circle of 768m was employed during the survey (Figure 13). Mesh size in the wings was 12.5m through to 20mm in the cod-end. The net was fished with a vertical mouth opening of approximately 50m, which was observed using a cable linked "BEL Reeson" netsonde (50 kHz). The net was also fitted with a Scanmar depth sensor. Spread between the trawl doors was monitored using Scanmar distance sensors, all sensors being configured and viewed through a Scanmar Scanbas system.

All components of the catch from the trawl hauls were sorted and weighed; fish and other taxa were identified to species level. Fish samples were divided into species composition by weight. Species other than the blue whiting were weighed as a component of the catch. Age, length, weight, sex, stomach fullness and maturity data were recorded for individual blue whiting within a random 50 fish sample from each trawl haul with a further 100 random length and weight measurements were also taken. All blue whiting were aged onboard. The appropriate raising factors were calculated and applied to provide length frequency compositions for the bulk of each haul.

Decisions to fish on particular echo-traces were largely subjective and an attempt was made to target marks in all areas of concentration not just high density shoals. No bottom trawl gear was used during this survey.

2.3.7 Oceanographic data collection

Oceanographic stations were carried out during the survey at predetermined locations along the track. Data on temperature, depth and salinity were collected using a Seabird 911 sampler from 1m subsurface to 1000m where depth allowed or to within 10m of the bottom on shelf slopes.

2.3.8 Marine mammal and seabird observations

During the survey an observer kept a daylight watch on marine mammal and seabird sightings from the crow's nest (18m above sea level).

During cetacean observations, watch effort was focused on an area dead ahead of the vessel and 45^{o} to either side using a transect approach. Sightings in an area up to 90^{o} either side of the vessel were recorded. The area was constantly scanned during these hours by eye and with binoculars. Ship's position, course and speed were recorded, environmental conditions were recorded every 15 minutes and included, sea state, visibility, cloud cover, swell height, precipitation, wind speed and wind direction. For each sighting the following data were

recorded: time, location, species, distance, bearing and number of animals (adults, juveniles and calves) and behaviour. Relative abundance (RA) of cetaceans was calculated in terms of number of animals sighted per hour surveyed (aph). RA calculations for porpoise, dolphin species and minke whales were made using data collected in ≤ Beaufort sea state 3. RA calculations for large whale species were made using data collected in ≤ Beaufort Sea state 5.

2.4 Analysis methods

2.4.1 Echogram partitioning and abundance estimates

The recordings of area back scattering strength (NASC) per nautical mile were averaged over one nautical miles, and the allocation of area backscattering strengths to species was made by comparison of the appearance of the echo recordings to trawl catches.

The allocation of NASC (Nautical Area Scattering Coefficient) values to blue whiting and other acoustic targets was based on the composition of the trawl catches and the appearance of the echotraces. To estimate the abundance, the allocated NASC values were averaged for ICES statistical rectangles (1° latitude by 2° longitude). For each statistical area, the unit area density of fish ($\square_A$) in number per square nautical mile ($N*nm^{-2}$) was calculated using standard equations (Foote et al. 1987, Toresen *et al.* 1998).

For blue whiting a TS= 21.8 log(L) – 72.8 dB was applied.

To estimate the total abundance of fish, the unit area abundance for each statistical rectangle was multiplied by the number of square nautical miles in each statistical square and then summed for all statistical rectangles within defined sub areas and for the total area. Biomass estimation was calculated by multiplying abundance in numbers by the average weight of the fish in each statistical rectangle and then sum of all squares within defined sub areas and the total area.

The scrutinized acoustic data from the participating vessels were reported to the Marine Institute, Bergen, to produce combined assessments of the blue whiting in accordance with PGNAPES agreements.

Acoustic, biological and oceanographic data are submitted to PGNAPES for inclusion into a dedicated survey database.

3 Results

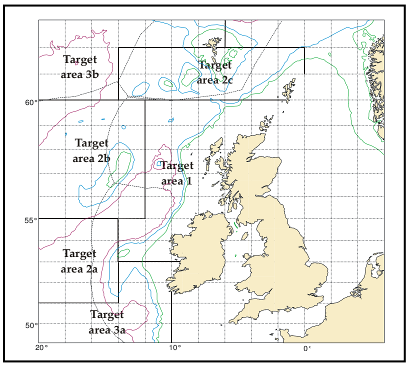
3.1 Blue whiting abundance and distribution

A total of 15 directed trawls were carried out over the course of the survey (Figure 1, Table 2). Of this, all contained blue whiting as the dominant species both by weight and numbers. The second most frequently encountered species, by weight, was blackfish (*Centrophagus niger*) and was represented in over 86% of trawl samples (Table 2). Dealfish (*Trachipterus arcticus*) were almost absent from this years trawl catches with only two individuals were recorded However, these mainly represented individuals caught in the forward larger meshes of the net and therefore were not included in the sample. Adult mackerel (*Scomber scombrus*) *were observed* in 4 of trawls, three of which occurred along the eastern fringes of the Rockall Bank. Mesopelagic species including Myctophidae were also heavily represented in trawl catches occurring throughout the survey area and in 85% of trawl samples. Overall, some 21 species were identified from trawl samples (Table 6).

3.1.2 Blue whiting biomass and abundance

A full breakdown of the survey stock structure is presented by distribution, age, length, biomass, abundance and area in Tables 3, 4 & 5 and Figures 2 & 4.

Target area	TSN (millions)	SSN (Millions)	TSB ('000t)	SSB ('000t)
2a	6.6	6.58	0.7	0.7
1	31634.7	31222.8	3478.01	3456.34
2b	2538	2534.7	266.3	266.5
Total	34179.7	33992.1	3744.73	3730.8
			3.74mt	**3.73mt**



3.1.3 Blue whiting distribution

Blue whiting were distributed throughout the survey area, with the bulk distributed close to or along shelf break areas and along offshore banks and features (Figure 2). Shelf break areas, to the west of Scotland in the Hebrides and north Porcupine Bank areas, contributed over 99% to the total biomass. Target area 1 contributed over 92% to the recorded TSB. In particular, in the northern area of north of 57°N blue whiting distribution extended further into the Rockall Trough from the shelf break than in the central Trough area. The eastern Rosemary Bank area produced the highest recorded values during the survey (rectangle mean NASC value of 2066) see Tables 3 & 4. This is consistent with expected results at this time in the northern core spawning area. This area was also the focus of the bulk of commercial fishing activity within the EU zone at this time. At the start of the survey the area to the north of the Porcupine Bank contained another band of high density schools accounting for the second highest density area observed. The results from Target area 2a should be discounted due to poor coverage in this area.

In the zone between 55°30N and 57°N blue whiting aggregations were confined to the eastern shelf edge. Little or no schools were observed in the Rockall Trough or on the eastern flanks of Rockall Bank. Overall, blue whiting distribution was low in open ocean area of the Rockall Trough. Some medium-high density schools were recorded in open water in the southern area and also in the northern area often observed as a continuation of schools extending out from the shelf break. Such schools were mainly observed to the north of the Porcupine Bank and also around bathymetric features such as the Rosemary Bank.

3.1.4 Blue whiting stock structure

Blue whiting samples taken within the surveyed area revealed the stock to be dominated by 5-year old fish (2003 year class) and is consistent with commercial samples taken from the Irish fleet. This year class represented over 25% of blue whiting stock in numbers and 31% by weight within the survey area. Four and 6 year old fish (2004 and 2002 year classes) were

also well represented accounting for 34% and 17% of numbers respectively. Fish of age group 2 and 3 were encountered during the survey and represented 0.6% and 3.4% of numbers, and 0.3% and 4.1% of biomass respectively. This is consistent with the poor strength of the 2005 and 2006 year classes. Older age groups, 7 and 8-year olds, were less abundant and composed the remainder of the stock.

Maturity analyses of combined survey data from International survey revealed a significant proportion of 2 year old fish (2005 year class) were immature. It was deemed prudent to apply the international maturity data to the findings of this survey as the main area of survey effort by the Celtic Explorer also contained the highest biomass for combined data. This new information was retrospectively applied across the results of this survey relating to 36% of 2 year of fish being regarded as immature.

In 2008, as in 2007, Target area 1 was found to contain the greatest abundance of immature fish. In 2008, this represented 0.6% by weight and 1.2% in numbers, as compared to 2007 with 0.06% and 0.17% respectively. Immature individuals were observed close to the shelf edge in the eastern survey area.

During the survey 750 fish were aged and 2,250 fish measured. Overall, trawl samples were observed to contain individuals of 1 to 8 years of age. Immature fish, 1 year olds (2007 year class) represented just less than 1% in numbers. Overall, mature individuals of lengths 26-29cm dominated the catches with 27cm fish dominating at 21.4% in numbers (Table 5).

3.2 Oceanography

3.2.1 Physical oceanography

The mixed layer depth (MLD) of the water column varies between 400 and 800 metres (based on a temperature difference of 0.5 degrees with surface value). The MLD is deeper in the northern part of the survey area. As expected there is a general cooling and freshening of the water in the top few hundred metres as one goes from south to north (Figures 6 & 7) with the warmest, most saline water being found in the southwest of the studied are (i.e. western flank of Rockall Trough). At deeper levels, the situation is more interesting with an intrusion of warm, saline water being very evident on the western flank of the Rockall Trough (Figures 8 & 9) and a “core” of colder, fresher water in the centre of the Trough. This may be the expression of a warm core (anti-cyclonic) eddy. The coldest (and freshest) water is found to the west of the Anton Dohrn seamount at depths > 1000 m.

The TS diagram (Figure 10) shows that the predominant water mass represented by the data is Eastern North Atlantic Water (ENAW) which is as expected because this is the dominant water mass in the upper 600m of this region. There is no indication of Mediterranean Water (too far north) and the cold deep water to the east of the Anton Dohrn seamount is probably a signature of overflow water from the Nordic Seas.

3.2 Inter-vessel calibration

Two inter-calibration exercises were carried out between R/V Celtic Explorer and R/V Fridtjof Nansen (acoustic only) and the R/V Celtic Explorer and R/V Magnus Henson. The results are presented in Appendices 1 & 2 respectively and summarised below.

The acoustic inter-calibration between the C. Explorer and the F. Nansen was carried out in an area with no blue whiting and so the exercise was carried out on a low density mesopelagic layer over a single 15 nautical mile transect, with the F. Nansen acting as lead vessel. The results show little agreement between vessels even though acoustic log intervals were appeared well synchronised. Overall, the F. Nansen appeared to record significantly higher acoustic values than the C. Explorer. The possibility of vessel induced avoidance by the lead vessel (F. Nansen) should not be ruled out as the target layer was relatively close to the surface (150m) and therefore more likely to be disturbed by passing vessels. No comparative tow was carried out due to the absence of suitable targets. The lack of acoustic density in the area was not ideal. However, the exercise still was still valuable as a means of inter-vessel correlation. A synchronised CTD cast was carried out with 0.4nmi spatial distance between vessels to a maximum depth of 1000m. Analysis of results indicate that profiles

show the difference between recorded temperatures was close to zero and for salinity within the whole profile did not exceed 0.005 psu.

The acoustic inter-calibration between the C. Explorer and the M. Heinason represented the second exercise between the vessels, the first was in 2007. The selected area contained high density registrations of blue whiting. The exercise was performed over a single 15 nautical mile transect, with the M. Heinason acting as lead vessel. Data analysis we focused on acoustic densities allocated to blue whiting. Acoustic recordings show variable and little or no agreement. Recordings by the Celtic Explorer appear more consistent and less variable than those recorded by the M. Heinason for most of the recorded transect. Recordings from the M. Heinason show much greater mile by mile variability with sharp contrasts in recorded values between successive miles. This may be accounted for to a degree by spatial heterogeneity of schools as vessels were 0.5nmi apart (Figure 2).

Data from the comparative trawl exercise showed vessels had a similar overall catchability. Celtic Explorer (mean length: 27.7 cm, range 24-36cm) and Magnus Heinason (mean length: 28cm, range 23.5-36cm). For the same trawling period the C. Explorer recorded a higher catch (250Kg compared to 150Kg). In 2007, the Celtic Explorer showed a tendency to capture larger individuals during the same exercise. However, this may be related to the schools available to the trawls.

3.3 Marine mammal and seabirds

Marine mammal activity

A total of 73.8 hours of survey time were logged with 10.7% (7.9 hrs) of this at Beaufort sea state three or less and 37.9% (28hrs) at Beaufort sea state four or less. 33 sightings of at least seven cetacean species, totalling 339 individuals were recorded (Figure 10).

Identified cetacean species were common dolphin (*Delphinus delphis*), bottlenose dolphin (*Tursiops truncatus*), pilot whale (*Globicephala melas*), Atlantic white-sided dolphin (*Lagenorhynchus acutus*), Sowerby's beaked whale (*Mesoplodon bidens*) and sperm whale (*Physeter macrocephalus*). A sighting of the blow of a large baleen whale was thought to be of a fin whale and two sightings of small unidentified whales were possibly of beaked whale species.

Pilot whales were the most commonly encountered and abundant species recorded during the survey. On 3 occasions pilot whales were encountered in mixed groups with another dolphin species. On two occasions they were seen in association with groups of Atlantic white-sided dolphins and on one occasion in association with a group of bottlenose dolphins. Sperm whales were encountered on three occasions over deep waters in the Rockall Trough (Table 7) while only a single large baleen whale was encountered on the shelf slopes to the west of Uist, in the Outer Hebrides. During a transect across the Rockall Trough, just to the north of the Anton Dohrn Seamount two small whales were observed in the distance. Their size and behaviour suggested that they might have been beaked whale species. Later on the same transect a group of three Sowerby's beaked whales was sighted to the south of the vessel.

Bird Activity

Daily species lists were made of all seabird species seen around the survey vessel. 12 seabird species were recorded during the survey (Figure 12): Pomerine skua (*Stercorarius pomarinus*), great skua (*Stercorarius skua*), glaucous Gull (*Larus hyperboreus*), great black-backed gull (*Larus marinus*), lesser black backed gull (*Larus fuscus*), kittiwake (*Rissa tridactyla*), Manx shearwater (*Puffinus puffinus*), fulmar (*Fulmarus glacialis*), gannet (*Morus bassanus*), puffin (*Fratercula arctica*), guillemot (*Uria aalge*) and razorbill (*Alca torda*). A number of passerines and waders were also noted on or around the vessel during the survey.

Discussion and Conclusions

4.1 Discussion

Overall, the survey was a great success. Survey aims were achieved and exceeded. Good weather dominated overall and no time was lost due to poor weather or mechanical failure. The cruise track was run in continuity with all pre-planned target areas covered without the need to leave the cruise track due to the effects of weather induced data degradation. Only 3 of the planned 31 CTD casts had to be dropped due to poor weather.

The original cruise track was cut in the southern region to account for the late start of the vessel as compared to previous surveys (6 day time lag) and also on advice from the IMR vessel already covering the southern survey area. The planned cruise track was completed in under the allotted time frame and thus reduced the impact of the late survey start to nil.

In area of low blue whiting density it was noted that schools appeared to be actively moving, this was observed during fishing operations where trawls directed on specific schools were sometimes absent when the vessel returned to take a sample. This was most apparent along the eastern fringes of the Rockall Bank and also in the north mid Rockall Trough. At the Rosemary Bank, the first visit to the area to intercalibrate with the F. Nansen found no blue whiting schools. However, on our return, with the M. Heinason, 3 days later we found schools of significant biomass and up to 15 commercial vessels in the locale.

Overall, the biomass observed in Target area 1 (Hebrides and north Porcupine) was over 11% by weight and over 22% by numbers lower than 2007. The decrease in abundance may be some way accounted for by the growth of the dominant years classes (5 and 4-year olds) from the previous year. In 2008 as compared to 2007 the survey started later (6 days) and further north. As a result direct comparisons of abundance and biomass in the southern areas should be treated with caution. The northern area of Target area 1 (Hebrides) was covered during the same time period and with the same degree of geographical coverage. However, a notable decrease in both biomass and abundance was observed across the survey area as a whole.

During the survey, school depth of blue whiting appeared to be shallower than observed in 2007, with an observed range of 350-550m. In 2007, schools were observed as deep as 750m with mean school depth of 500m.

Deal fish (*Trachypterus* arcticus) were notably absent from trawl catches in this years survey with only 3 individuals encountered from 15 trawl stations. Whereas blackfish (*Centrophagus niger*) were present in 80% of trawls. It will be interesting to compare all vessel data to see if the above correlation was observed throughout the combined survey area.

The inter-vessel calibrations (acoustic, CTD and trawl gear) carried out with the RV *Fridtjof Nansen* and the RV *Magnus Heinason* represent the fourth vessel the Explorer has inter-calibrated with during the survey time series, the others being the IMR vessels *Johan Hjort* (2004) and the *G.O. Sars* (2005)*,* and the *Magnus Heinason* (2007).

4.2 Conclusions

The biomass of blue whiting recorded during the survey, although distributed widely, is lower than would have been expected especially from the core area of the Hebrides. Overall, the density of individual schools was lower than in previous years and was dominated by areas of medium to low-density schools interspersed with smaller areas of high-density schools close to the shelf edge.

Signals of young year classes (<3 yrs) are still poor from the results of this survey. Overall the stock appears to be supported by older larger individuals with little signs of new recruitment to the stock.

A greater proportion of immature individuals were detected in 2008 and this was most notable in 2 year old individuals indicating a possible slower in growth rate of this year class.

Coordination and temporal progression of the participating vessels was greatly improved this year. The unforeseen time lag imposed on the Explorer was made up due to favourable weather conditions on route resulting in the survey finishing within the agreed time slot. Intercalibration exercises were undertaken by all participants. This was especially important due to the noise problems identified by the Norwegian charter vessel. Inter vessel communication was good. However, the main problem which still exists within the group is the adherence to pre-agreed area coverage and survey effort. More attention needs to be paid in maintaining agreements made at PGNAPES meeting.

Acknowledgements

We would like to express our thanks and gratitude to Ciaran Flanagan (Captain) and crew of the Celtic Explorer for their good will and professionalism during the survey.

Our special thanks also go to our visiting scientists Dr. Eckhard Bethke (Germany), Gert Holst (Denmark) and Jevon Brenan-Keane (Ireland). Their help and hard work was greatly appreciated and we look forward to future collaborations.

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Table 1. Survey settings and calibration report for the Simrad ER 60 echosounder from the last calibration of the 38kHz in October 07. Blue whiting survey, March-April 2008.

Reference Target:			
TS	-33.50 dB	Min. Distance	10.00 m
TS Deviation	9.5 dB	Max. Distance	17.00 m
Transducer: ES38B Serial No. 30227			
Frequency	38000 Hz	Beamtype	Split
Gain	25.55 dB	Two Way Beam Angle	-20.6 dB
Athw. Angle Sens.	21.90	Along. Angle Sens.	21.90
Athw. Beam Angle	6.67 deg	Along. Beam Angle	6.39 deg
Athw. Offset Angle	0.03 deg	Along. Offset Angl	0.04 deg
SaCorrection	-0.65 dB	Depth	5.00 m
Transceiver: GPT 38 kHz 1 ES38B			
Pulse Duration	1.024 ms	Sample Interval	0.191 m
Power	2000 W	Receiver Bandwidth	2.43 kHz
Sounder Type:			
EK60 Version 2.1.1			
TS Detection:			
Min. Value	-50.0 dB	Min. Spacing	100 %
Max. Beam Comp.	6.0 dB	Min. Echolength	80 %
Max. Phase Dev.	8.0	Max. Echolength	180 %
Environment:			
Absorption Coeff.	9.9 dB/km	Sound Velocity	1488.5 m/s
Beam Model results:			
Transducer Gain =	25.82 dB	SaCorrection =	-0.70 dB
Athw. Beam Angle =	7.18 deg	Along. Beam Angle =	7.10 deg
Athw. Offset Angle =	-0.03 deg	Along. Offset Angle=	-0.06 deg

Data deviation from beam model:

RMS = 0.10 dB
Max = 0.22 dB No. = 36 Athw. = 3.3 deg Along = 2.5 deg
Min = -0.36 dB No. = 1 Athw. = 4.5 deg Along = -0.7 deg

Data deviation from polynomial model:

RMS = 0.06 dB
Max = 0.18 dB No. = 136 Athw. = -2.1 deg Along = 3.4 deg
Min = -0.18 dB No. = 159 Athw. = -2.1 deg Along = -1.4 deg

Table 2. Catch composition, time and location of trawl hauls. Blue whiting survey, March-April 2008.

No.	Date	Lat. N	Lon. W	Time	Bottom (m)	Target (m)	Bulk Catch (Kg)	Blue whiting %	Mackerel %	Mesopleagic spp %	Deal fish %	Others* %
1	03.04.08	55 20.18	12 49.46	09:45	>2000	442	175	97.6	-	0.1	-	2.3
2	03.04.08	55 19.79	11 02.73	20:12	2258	550	550	100.0	-	-	-	-
3	05.04.08	55 49.63	14 40.91	02:12	800	500	115	93.9	0.9	5.1	-	0.2
4	06.04.08	56 19.56	09 16.40	12:35	800	400	500	98.0	-	-	-	2.0
5	07.04.08	57 06.04	13 06.94	21:14	650	200	122	88.0	0.4	3.1	-	8.5
6	08.04.08	57 19.58	09 33.85	21:34	750	350	140	97.0	1.4	-	-	1.6
7	09.04.08	57 49.73	09 50.98	03:11	900	420	200	97.8	-	0.4	-	1.8
8	09.04.08	58 18.71	13 28.71	22:34	>2000	450	150	97.8	0.2	1.8	-	0.2
9	11.04.08	58 19.53	09 43.85	05:10	1500	450	250	95.7	-	2.6	-	1.7
10	11.04.08	58 47.37	08 35.07	13:50	>1000	500	250	97.5	-	2.1	-	0.4
11	12.04.08	58 49.13	11 55.87	02:21	>2000	450	800	99.1	-	0.9	-	-
12	12.04.08	59 19.75	10 23.74	23:54	800	250	750	99.6	-	0.1	-	0.3
13	13.04.08	59 19.49	08 09.88	12:27	>1000	550	1000	98.0	-	1.3	-	0.7
14	13.04.08	59 19.56	07 13.23	17:50	900	500	500	99.0	-	0.8	-	0.2
15^	13.04.08	59 28.13	09 10.74	02:11	1600	470	250	95.7	-	2.2	-	2.1

Note: “Others” was used to represent fish and non-fish species occurring in the catch.
^: Denotes haul carried out during intercalibration exercise with the RV *Magnus Heinason*.

Table 3. Breakdown of abundance estimate by sub area, including trawl haul allocation. Blue whiting survey, March-April 2008.

Note: Target area 1: Hebrides & north Porcupine Bank; Target area 2a: western Porcupine Bank; Target area 2b: Rockall

Rectangle	NASC $m^2/n.m^2$	Area $n.mile^2$	Trawl haul(s) #	length cm	Density coeff. $1.488 * 10^6\ L^{-2.18}$	Abundance $N * 10^6$	weight gram	Biomass 1000 tonnes
5414	388.8	16	3	27.8	1060.737	6.60	106.2	0.701
Target Area 2a					**Sub area total**	**6.60**		**0.70**
5410	699.0	1430	2	28.6	997.054	996.66	116.4	116.011
5412	1181.7	1532.5	1	27.8	1060.737	1920.87	105.7	203.036
5510	1841.3	2550	2	28.6	997.054	4681.53	116.4	544.930
5508	731.3	552	2	28.6	997.054	402.48	116.4	46.849
5608	1299.4	1380	4	27.0	1125.975	2019.06	93.4	188.620
5610	140.2	1104	4	27.0	1125.975	174.32	93.4	16.285
5710	518.3	3420	6&7	27.2	1106.098	1960.65	100.0	196.144
5708	1562.4	1320	6&7	27.2	1106.098	2281.16	100.0	228.207
5808	1986.5	2358	9&10	28.3	1017.908	4767.95	113.8	542.592
5810	223.8	838	11	28.3	1016.081	190.59	105.0	20.021
5910	711.3	1275	12	28.4	1010.628	916.49	121.9	111.702
5908	2066.5	3600	13&15	28.0	1041.834	7750.69	109.3	847.151
5906	1660.1	2100	14	28.2	1024.737	3572.37	116.5	416.252
Target Area 1					**Sub area total**	**31634.8**		**3477.8**
5514	415.2	450	3	27.8	1060.737	198.17	106.2	21.0473
5512	1979.3	720	1	27.8	1060.737	1511.64	105.7	159.7800
5612	262.2	20	5	27.6	1077.583	5.65	105.6	0.5967
5614	279.8	422	3	27.8	1060.737	125.24	106.2	13.3017
5712	304.8	1025.5	5	27.6	1077.583	336.79	105.6	35.5629
5812	281.2	1127	8&11	27.2	1109.795	351.67	99.4	34.9556
5912	744.8	12	11	28.3	1016.081	9.08	105.0	0.9539
Target Area 2b					**Sub area total**	**2538.2**		**266.2**
					Grand total	**34179.7**		**3744.7**

Table 4. Breakdown of abundance and biomass by survey sub area as used during analysis. Blue whiting survey, March-April 2008.

Target area	Area nm^s	Abundance (Mils) Immature	Mature	Total	Biomass ('000s t) Immature	Mature	Total	Mean Length (cm)	Mean weight (g)	Density t/nmi2
2a	388.78	0.0175	6.58	6.6	0.01	0.7	0.7	27.7	106.21	43.81
1	14671.23	411.88	31222.845	31634.72	21.67	3456.34	3478.01	28	109.93	148.24
2b	4267.15	3.6	2534.66	2538.2	0.1	266.47	266.6	27.66	104.87	70.49
Total	19327.16	415.47	33764.085	34179.555	13.93	3730.8	3744.73			

Table 5. Aged stratified estimate of surveyed stock abundance and biomass. Blue whiting survey, March-April 2008.

Length	Age (years)										TSN	TSB	Mn Wt
(cm)	1	2	3	4	5	6	7	8	9	10	(Mils)	('000t)	(g)
16.5	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0	0	0	0	0	0
18	1.2	0	0	0	0	0	0	0	0	0	1.17	0.04	33.19
18.5	42.4	0	0	0	0	0	0	0	0	0	42.42	1.48	35
19	101.1	0	0	0	0	0	0	0	0	0	101.11	3.72	36.75
19.5	42.9	0	0	0	0	0	0	0	0	0	42.90	1.82	42.33
20	58.0	19.3	0	0	0	0	0	0	0	0	77.29	4.25	55
20.5	31.4	15.7	0	0	0	0	0	0	0	0	47.16	2.18	46.25
21	28.5	28.5	0	0	0	0	0	0	0	0	57.04	2.92	51.25
21.5	14.6	14.6	0	0	0	0	0	0	0	0	29.24	1.54	52.5
22	0	28.3	0	0	0	0	0	0	0	0	28.28	1.60	56.5
22.5	0	8.4	8.4	0	0	0	0	0	0	0	16.78	0.97	58
23	0	43.9	0	0	0	0	0	0	0	0	43.87	2.92	66.67
23.5	0	2.2	0	0	0	0	0	0	0	0	2.16	0.14	65
24	0	0	36.6	36.6	0	0	0	0	0	0	73.18	5.10	69.67
24.5	0	44.4	44.4	222.1	0	0	0	0	0	0	310.94	23.23	74.72
25	0	0	100.0	600.1	0	0	0	0	0	0	700.08	56.47	80.67
25.5	0	0	217.3	978.0	0	0	0	0	0	0	1195.36	99.26	83.04
26	0	0	295.8	1922.8	443.7	0	0	0	0	0	2662.28	231.56	86.98
26.5	0	0	196.4	2003.8	943.0	39.3	0	0	0	0	3182.49	287.43	90.32
27	0	0	226.8	1724.0	1633.3	136.1	0	0	0	0	3720.25	356.17	95.74
27.5	0	0	108.8	1413.9	2610.4	163.1	0	0	0	0	4296.21	436.19	101.53
28	0	0	91.3	1324.5	2055.3	411.1	0	0	0	0	3882.30	409.38	105.45
28.5	0	0	44.4	710.3	1908.9	310.7	0	0	0	0	2974.30	336.62	113.18
29	0	0	44.7	223.4	1474.1	1072.1	0	0	0	0	2814.22	333.24	118.41
29.5	0	0	0	419.1	1071.0	745.0	46.6	0	0	0	2281.60	282.71	123.91
30	0	0	0	176.7	486.0	795.3	176.7	0	0	0	1634.86	208.64	127.62
30.5	0	0	0	68.8	378.1	515.6	68.8	0	0	0	1031.27	140.79	136.53
31	0	0	0	55.1	165.4	606.6	55.1	0	0	0	882.29	127.25	144.23
31.5	0	0	0	27.3	81.9	327.7	81.9	0	0	0	518.81	76.77	147.97
32	0	0	0	0	66.7	200.1	66.7	0	0	0	333.50	54.60	163.73
32.5	0	0	0	0	0	232.6	46.5	0	0	0	279.16	47.79	171.19
33	0	0	0	0	0	218.1	54.5	0	0	0	272.64	48.86	179.21
33.5	0	0	0	0	0	53.0	53.0	0	0	0	106.09	20.28	191.17
34	0	0	0	0	0	0	220.7	0	0	0	220.66	45.72	207.18
34.5	0	0	0	0	0	0	30.0	0	0	0	30.03	6.32	210.5
35	0	0	0	0	0	9.5	19.1	0	0	0	28.64	6.81	237.75
35.5	0	0	0	0	0	0	54.1	0	0	0	54.11	13.53	250.11
36	0	0	0	0	0	0	30.0	0	0	0	29.97	8.53	284.5
36.5	0	0	0	0	0	0	20.5	20.5	0	0	41.06	11.99	292.09
37	0	0	0	0	0	0	0	0	0	0	0	0	0
37.5	0	0	0	0	0	0	0	0	0	0	0	0	0
38	0	0	0	0	0	0	23.3	23.3	0	0	46.65	15.37	329.5
38.5	0	0	0	0	0	0	11.9	11.9	0	0	23.86	8.04	336.89
39	0	0	0	0	0	0	20.3	20.3	0	0	40.54	14.19	349.99
39.5	0	0	0	0	0	0	0	22.9	0	0	22.88	8.26	361
40	0	0	0	0	0	0	0	0	0	0	0	0	0
TSN (Mils)	320.15	205.30	1415.03	11906.48	13317.81	5836.10	1079.84	98.94	0	0	**34179.6**	**3744.7**	
% Mature	0	64*	100	100	100	100	100	100	100	100			
TSB ('000t)	13.93	12.49	128.65	1147.96	1445.73	762.87	200.02	33.06	0	0	**3744.7**		
SSB ('000t)	0	8.12	128.65	1147.96	1445.73	762.87	200.02	33.06	0.00	0	**3726.4**		
Mn Wt	44.03	56.4	89.81	106.25	119.66	137.12	215.78	333.89	0	0			
Mn L	19.56	21.9	26.48	27.08	28.18	30.01	33.18	38.17	0	0			

* Indicates percentage maturity at 2 years as taken from combined International survey data

Table 6. Species occurrence from trawl stations. Blue whiting survey, March-April 2008.

Category	Common Name	Scientific Name	Occurrence
Pelagic	Blue Whiting	*Micromesistius poutassou*	**15**
	Mackerel	*Scomber scombrus*	**4**
	Horse mackerel	*Trachurus trachurus*	**0**
Mesopelagics	Hatchet Fish (large)	*Argyropelecus olfersi*	**1**
	Hatchet Fish (small)	*Argyropelecus hemigymnus*	**4**
	Silver Pomfret	*Pterycombus brama*	**1**
	Dealfish	*Trachipterus arcticus*	**0**
	None	*Diretmus argentus*	**0**
	Lantern fish	*Myctophidae*	**10**
	None	*Lampadena speculigera*	**0**
	Pearlside	*Maurolicus muelleri*	**7**
	Greater Argentine	*Argentina silus*	**0**
	Greenland Argentine	*Nansenia groenlandica*	**3**
	Sloanes Viper fish	*Chauliodus sloani*	**0**
	Schnakenbeck's searside	*Sagamichthys schnakenbecki*	**0**
	Alfonsino	*Beryx decadactylus*	**0**
	None	*Notolepis rissoi*	**2**
	Greater Pipefish	*Syngnathus acus*	**1**
	Shrimps	*Pandalidae*	**5**
	Scaly dragonfish	*Stomias boa*	**0**
	Blackfish	*Centrophagus niger*	**12**
	None	*Astronethus gemmifer*	**0**
	None	*Opisthoproctus soleatus*	**0**
	None	*Gonastoma elongatum*	**2**
	Bean's sawtoothed eel	*Serrivomer beani*	**0**
	Forgotten argentine	*Nansenia oblita*	**3**
	Balbo sabretooth	*Evermanella balbo*	**0**
	Bluntsnout smooth-head	*Xenodermichthys copei*	**1**
	None	*Scopelosaurus lepidus*	**1**
	None	*Echiostoma barbatum*	**0**
	Searsids	*Maulisia*	**0**
		Searsia koefoedi	**2**
		Howella sherborni	**1**
Demersal	Grey Gurnard	*Eutrigla gurnardus*	**5**
	Silvery Pout	*Gadiculus argentus*	**1**
Squid	Lesser flying squid	*Todaropsis elbanae*	**2**
	Northern flying squid	*Todarodes sagittatus*	**0**
	Short finned squid	*Omnastrephidae*	**0**
	Unknown		
		Total Number of Trawls	**15**
		Total number of Species:	**21**

Table 7. Sightings, counts and group size ranges for cetaceans sighted. Blue whiting survey, March-April 2008.

Species	No. Sightings	No. Individuals	Range of Group Size
Bottlenose dolphin	1	7	
Common dolphin	2	151	1-150
Pilot whale	16	132	2-24
White-sided dolphin	3	18	5-8
Sowerby's beaked whale	1	3	
Sperm whale	3	5	1-2
Large Baleen Whale	1	1	
Unidentified whale	1	2	
Unidentified small whale	2	2	
Unidentified Dolphin	3	18	2-10

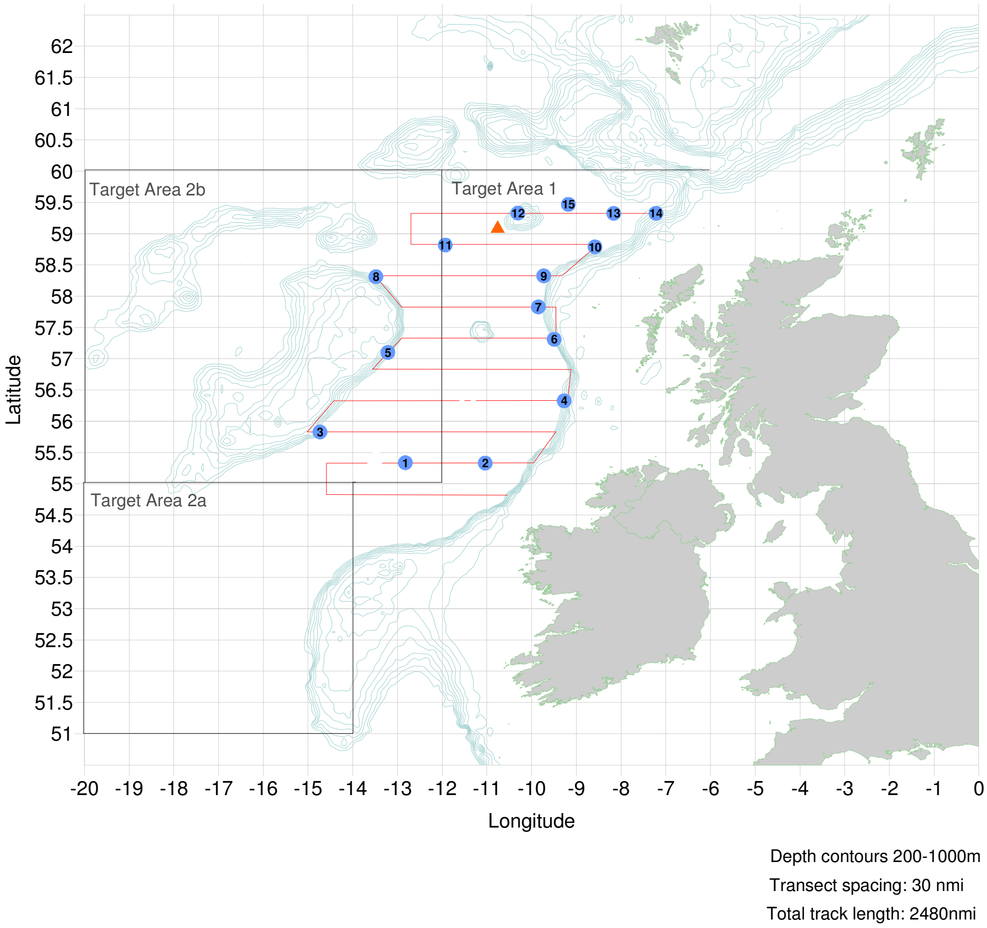


Figure 1. RV Celtic Explorer cruise track showing position of trawl stations and Target areas of operation numbered in order of important based on the result of previous surveys. Blue whiting survey, March-April 2008. Note: Haul 15 inter-calibration exercise with the RV "*Magnus Heinason*" Orange triangle represents intercalibration exercise with the RV *Fridtjof Nansen.*

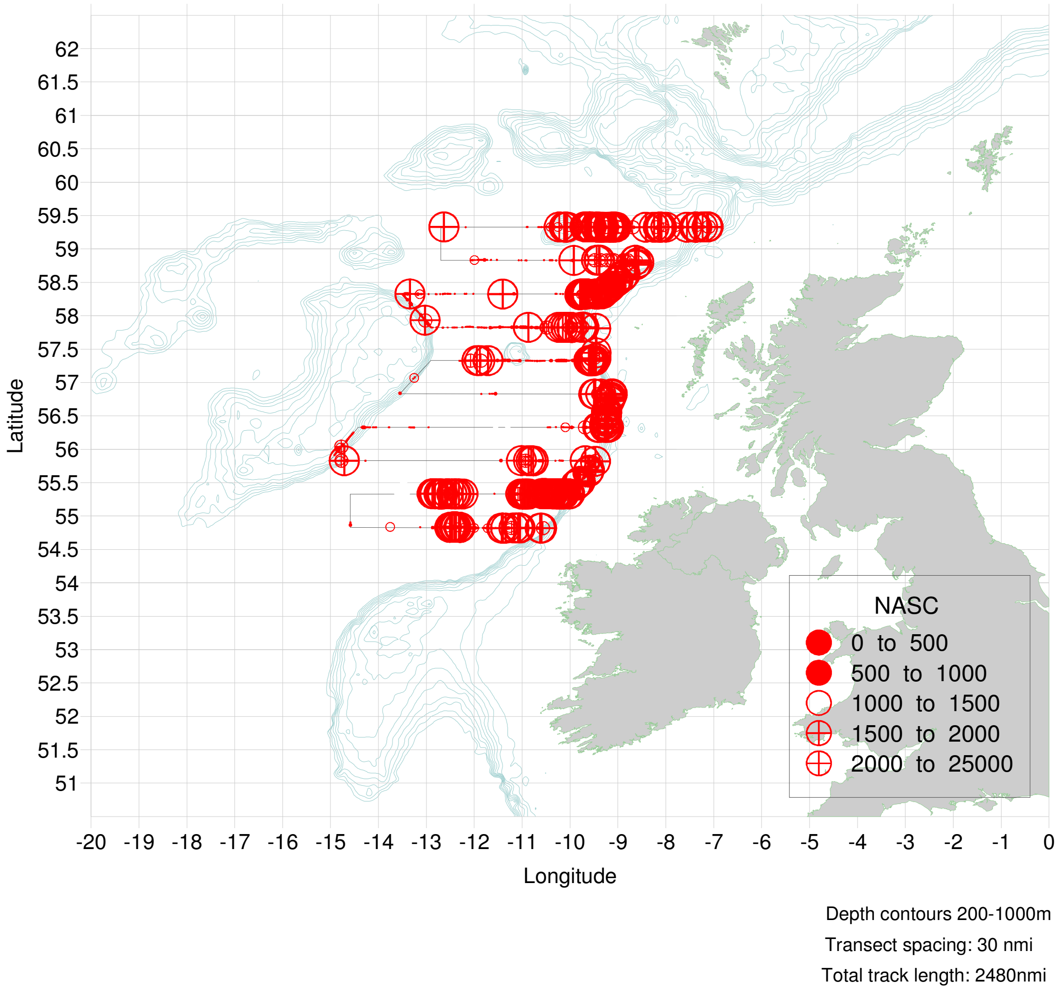
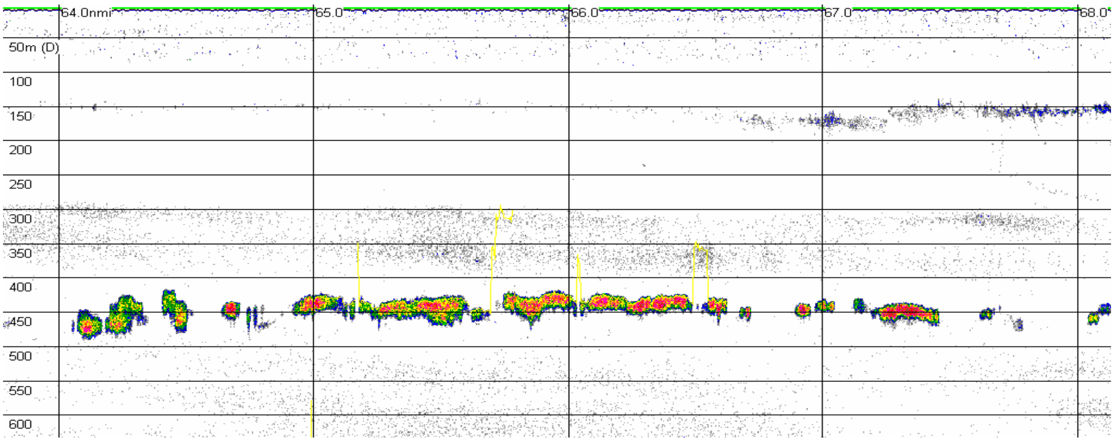
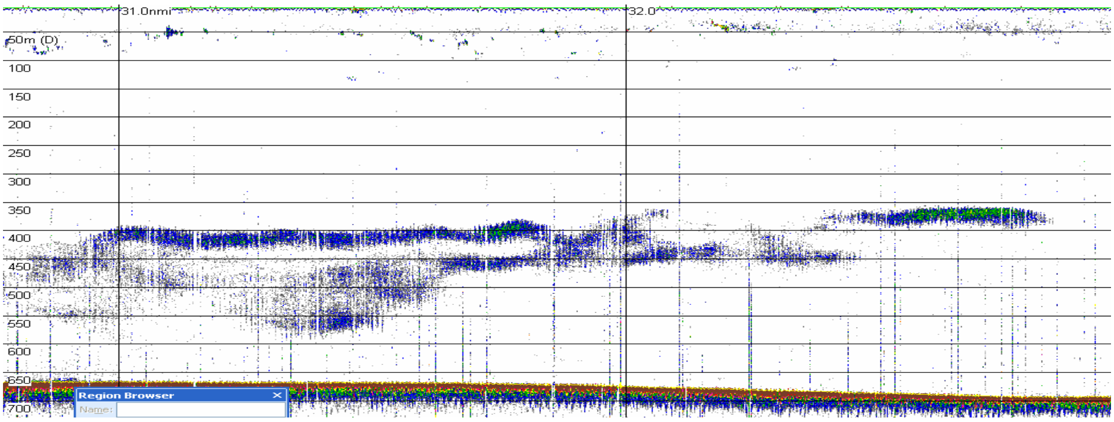


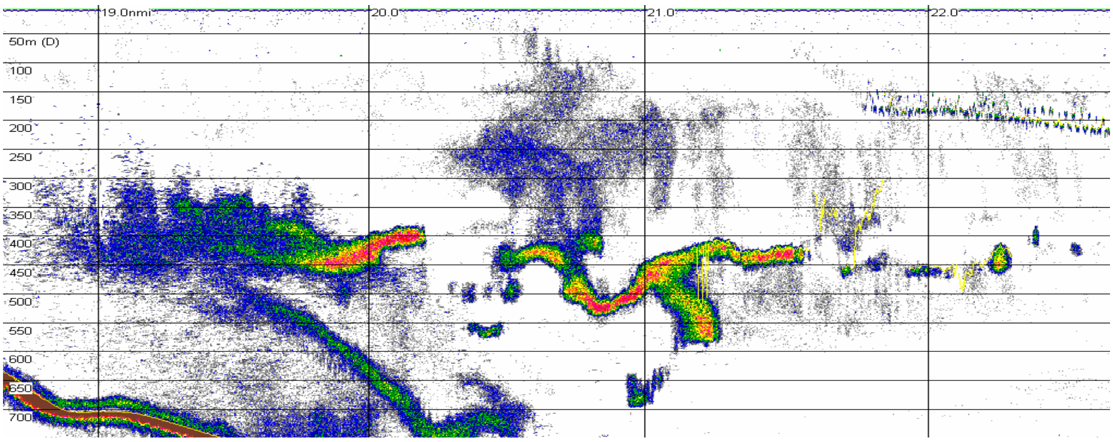
Figure 2. NASC distribution plot of blue whiting occurrence, circle size relative to NASC value. Blue whiting survey, March-April 2008.



a). *High-density schools of blue whiting recorded prior to* ***Haul 01*** *on* ***Transect 1*** *(55°20N & 12°49W). Vertical bands on echogram represent 1nmi (nautical mile) intervals. Depth scale (m) shown on left of image.*



b). *Low-density schools of blue whiting typical of those encountered along the eastern slopes of the Rockall Bank. Recorded prior to* ***Haul 5*** *(57°03N & 13°16W) on* ***Transect 10****. Vertical bands on echogram represent 1nmi (nautical mile) intervals. Depth scale (m) shown on left of image. Vertical blue striations on the bottom of the echogram represent weather-induced interference.*



c). *High-density schools of blue whiting typical of those encountered along the eastern slopes of the Hebrides shelf. Recorded prior to* ***Haul 7*** *(57°49N & 09°48W) on* ***Transect 12****. Vertical bands on echogram represent 1nmi (nautical mile) intervals. Depth scale (m) shown on left of image. False bottom echo visible in top right of echogram (150-250m).*

Figures 3a-c. Blue whiting echotraces recorded on the ER60 echosounder with images captured from Echoview during the blue whiting survey, March-April 2007.

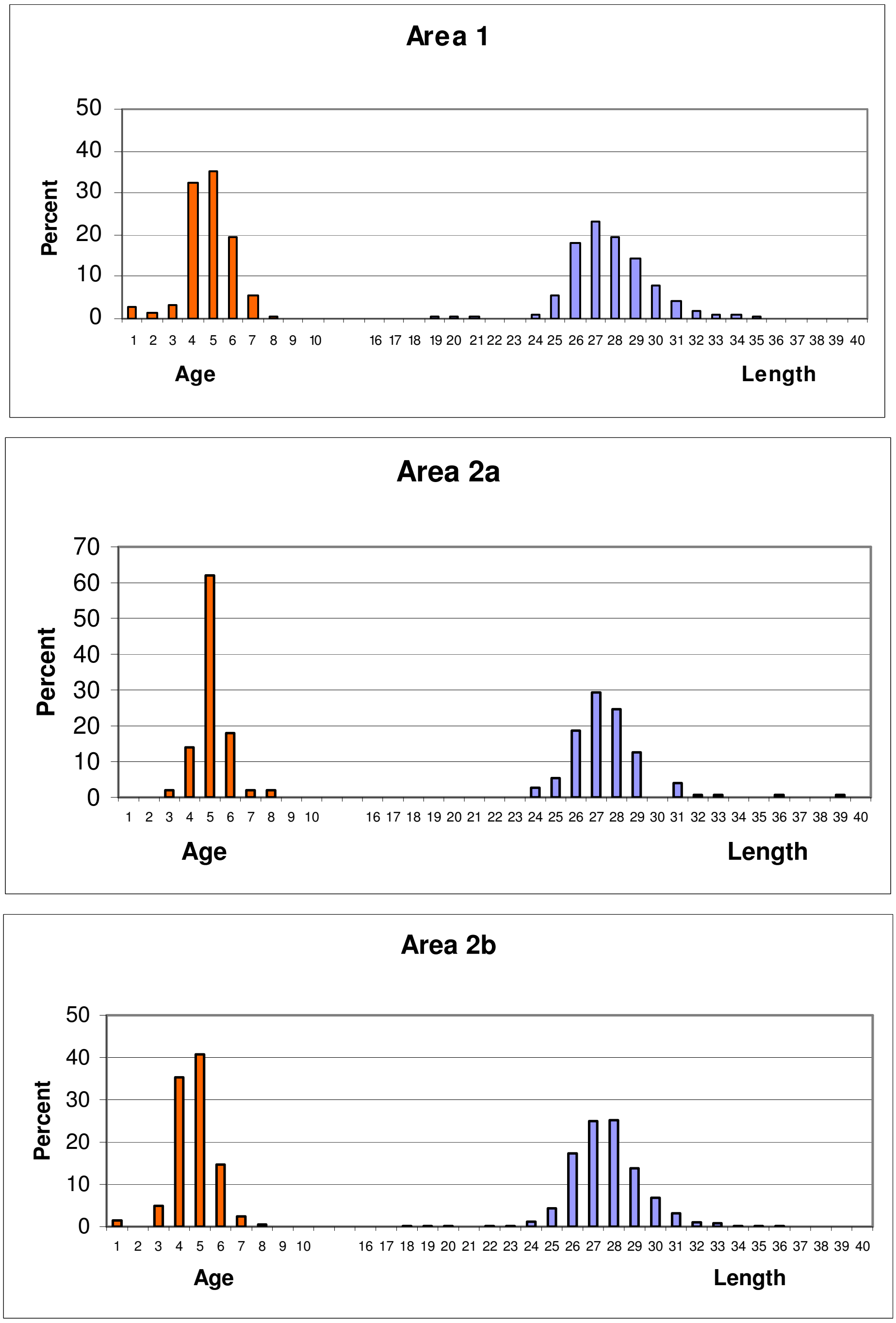


Figure 4. Age (left) and length (right) composition of blue whiting by main sub area. Blue whiting survey, March-April 2008. Note: Target Area 2a sample of composed of one biological sample form a single trawl haul (n=200).

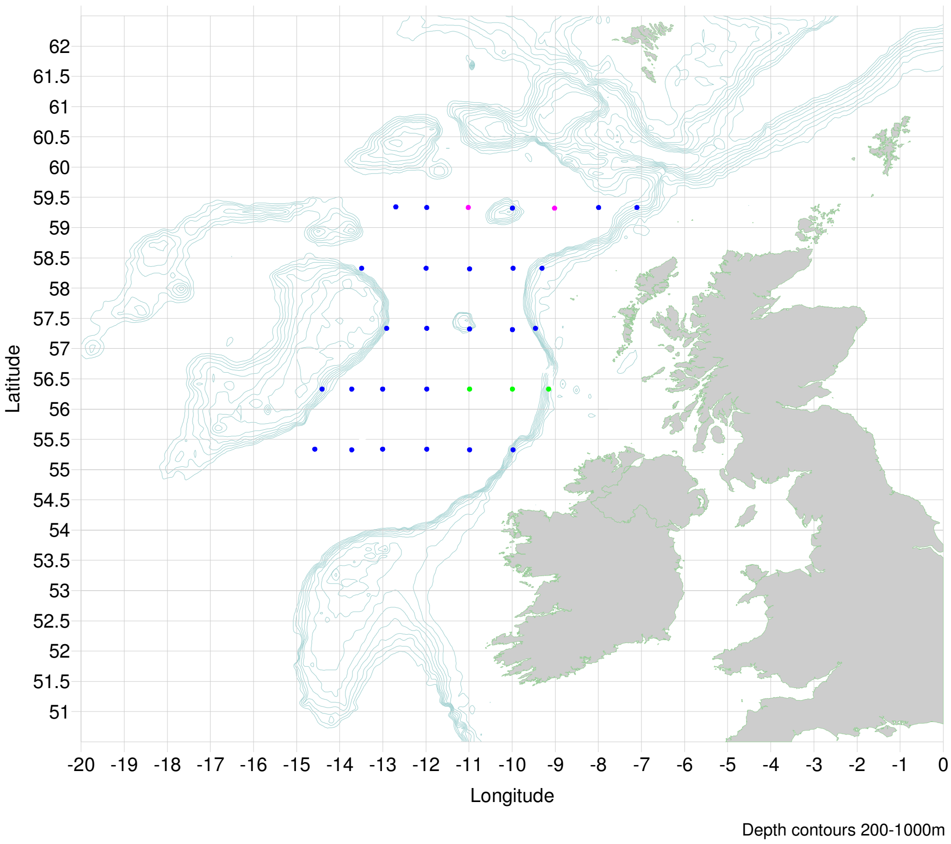


Figure 5. Oceanography stations taken as CTD casts. Blue points represent stations taken to a maximum depth of 1000m, purple points indicate full depth stations, green points stations dropped due to poor weather. Blue whiting survey, March-April 2008.

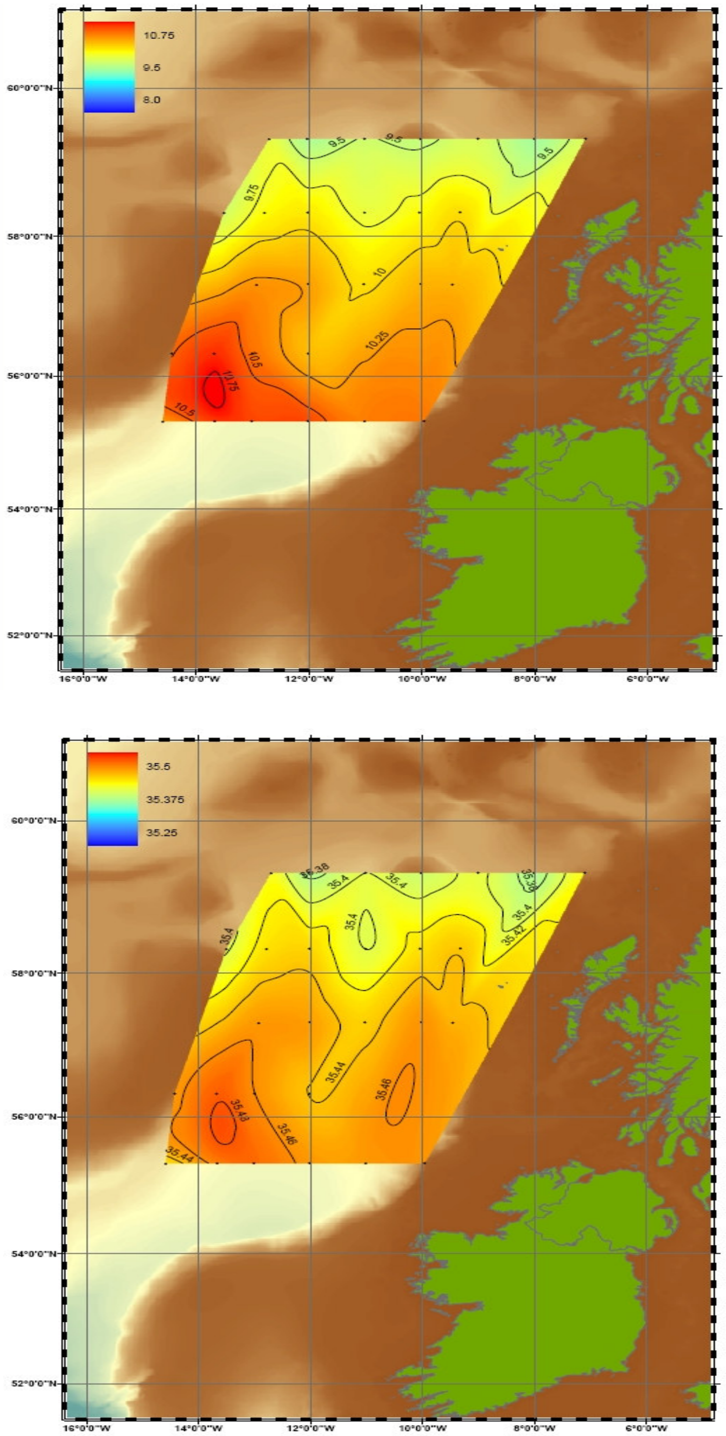


Figure 6. Horizontal temperature (top panel) and salinity (bottom panel) at 10m subsurface as derived from vertical CTD cast data. Blue whiting survey, March-April 2008.

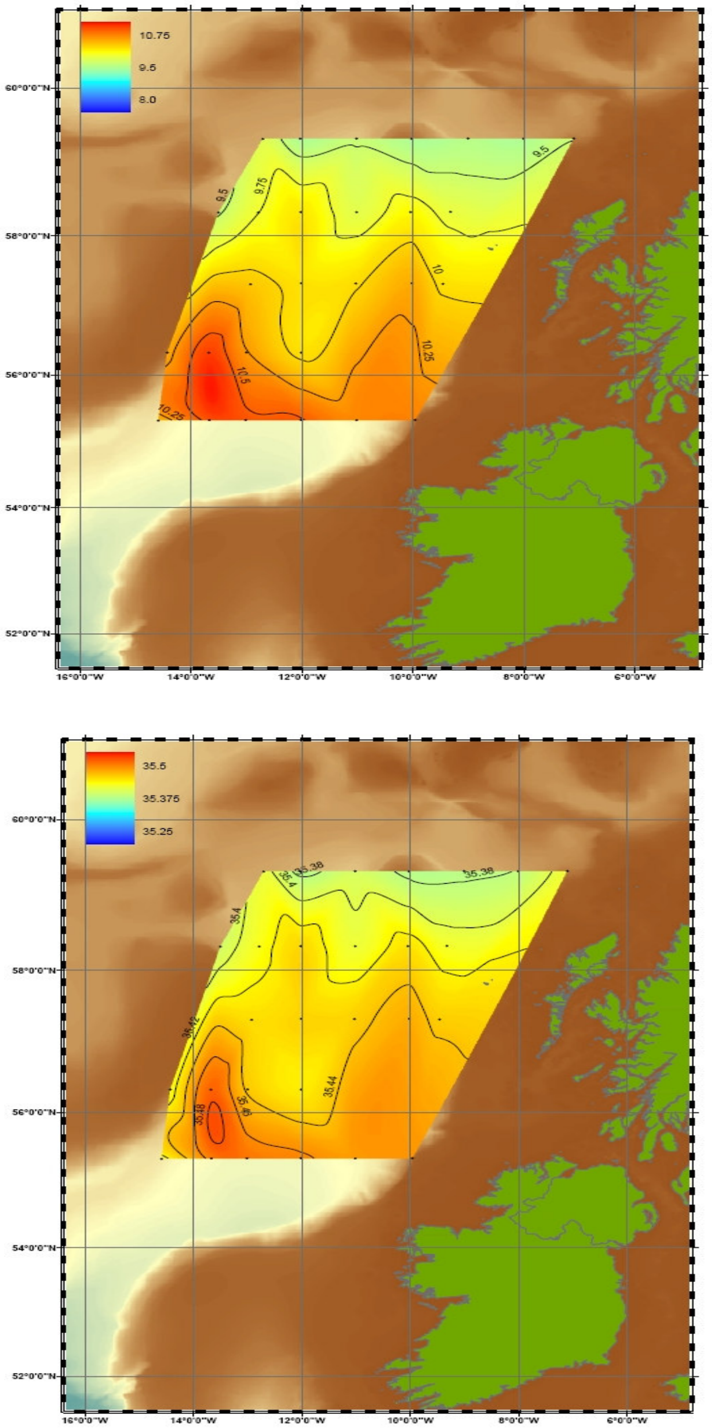


Figure 7. Horizontal temperature (top panel) and salinity (bottom panel) at 200m subsurface as derived from vertical CTD cast data. Blue whiting survey, March-April 2008.

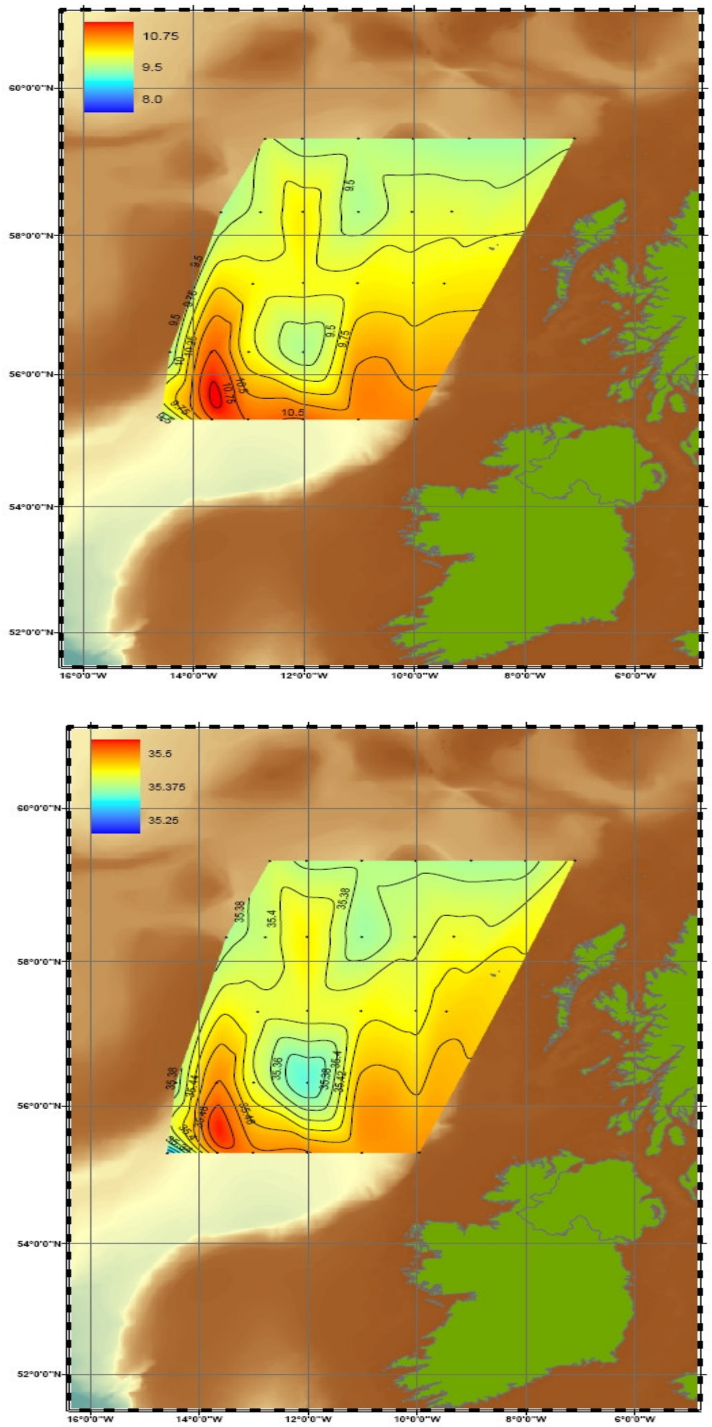
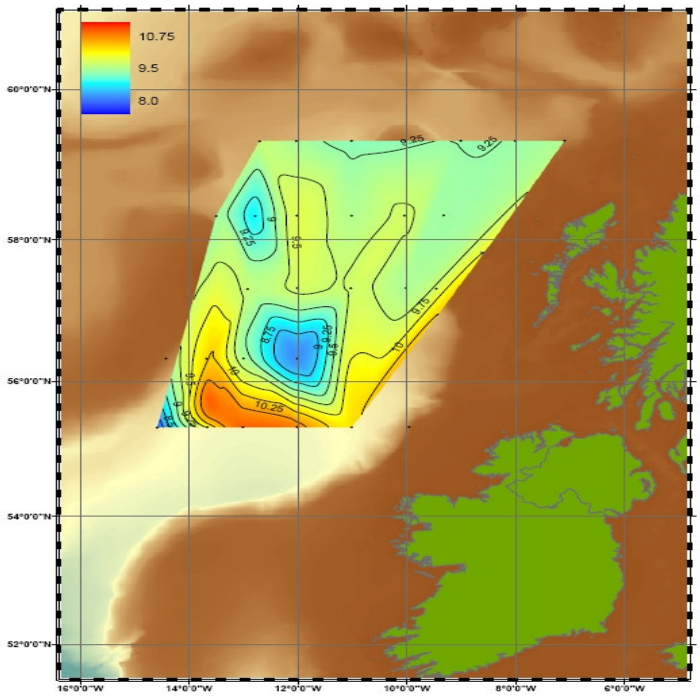


Figure 8. Horizontal distribution of temperature (top) and salinity (bottom) at 400 m. 100 m depth contour shaded grey. Blue whiting survey, March-April 2008.



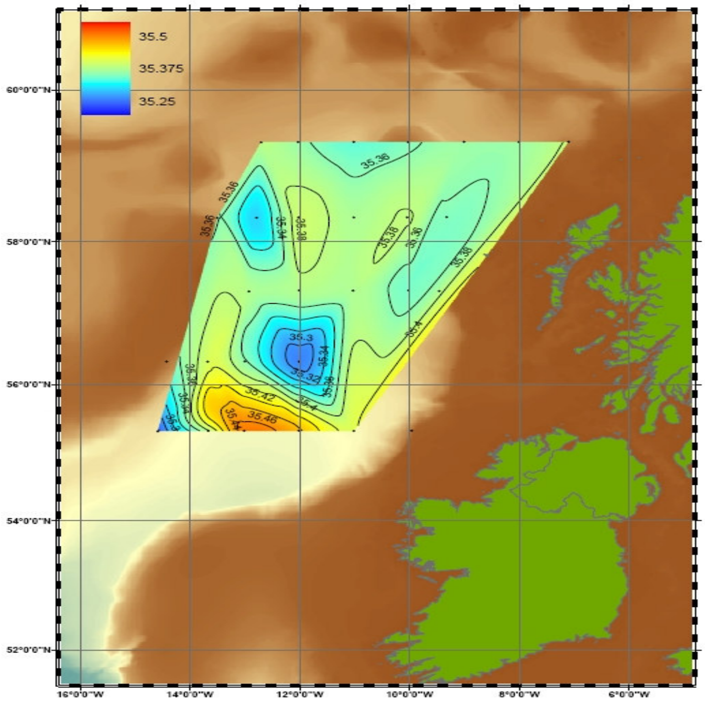


Figure 9. Horizontal distribution of temperature (top) and salinity (bottom) at 600 m depth. 100 m depth contour shaded. Blue whiting survey, March-April 2008.

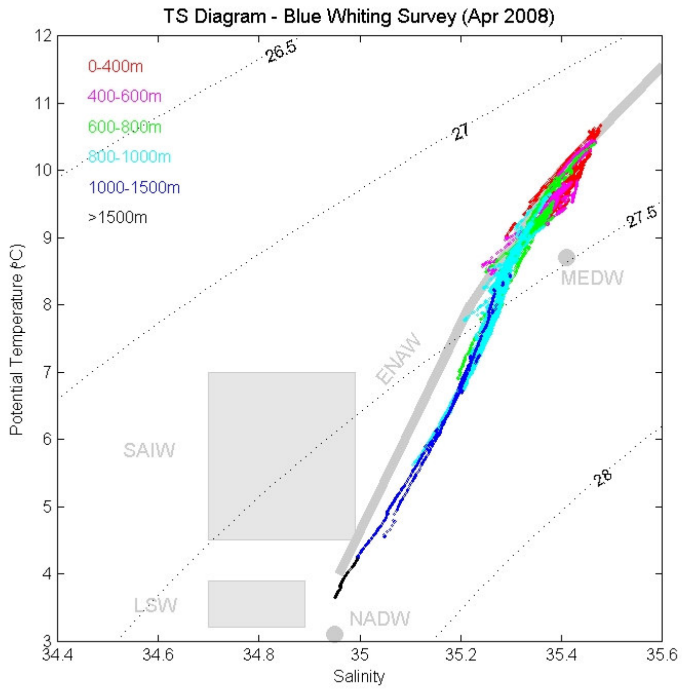


Figure 10. TS diagram created from vertical CTD cast data. Blue whiting survey, March-April 2008. Note: SAIW: Sub artic intermediate water; LSW: Labrador seawater; NADW: North Atlantic deepwater; MEDW: Mediterranean water; ENAW: Eastern north Atlantic water.

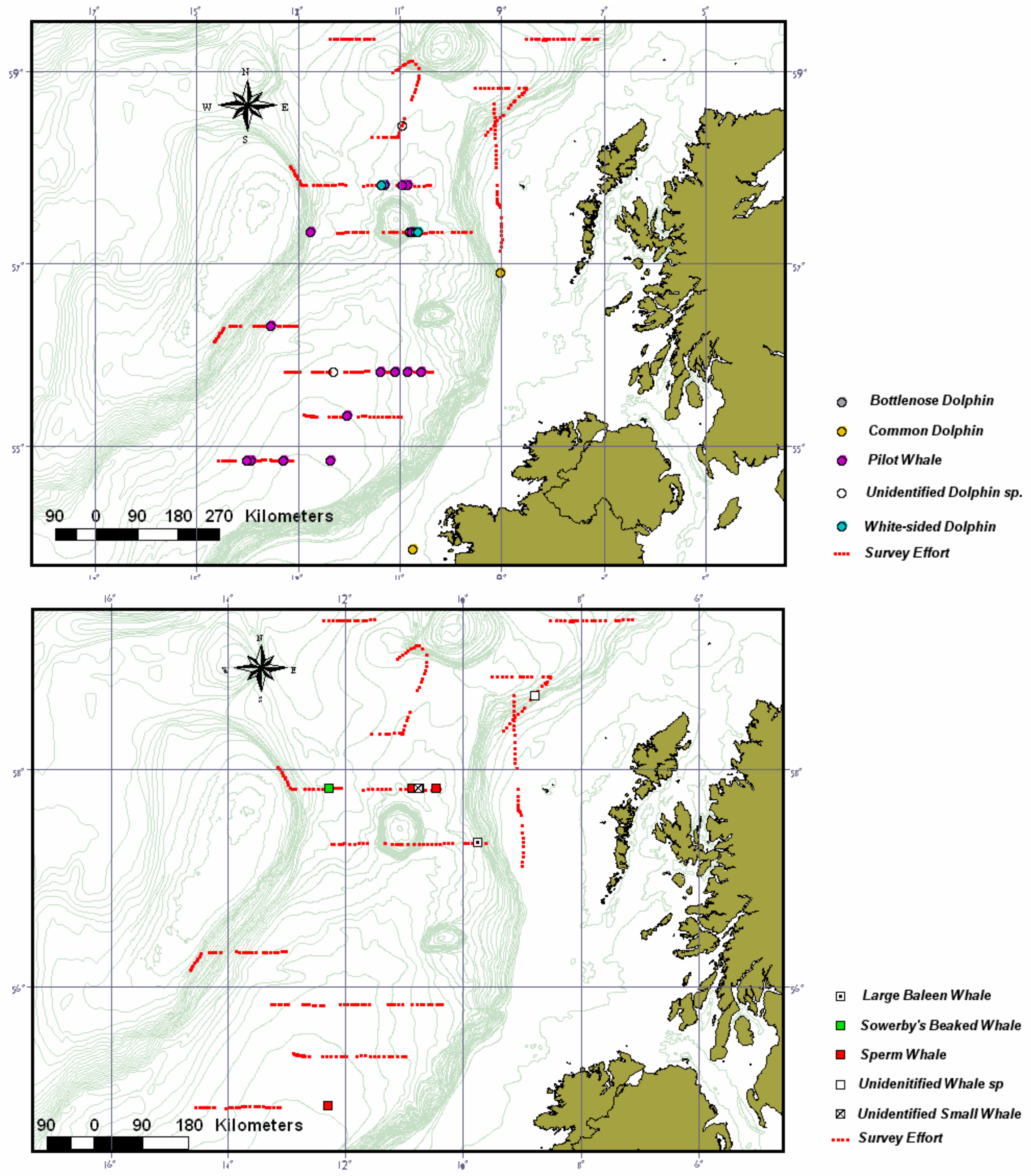


Figure 11. Distribution of Dolphins (top) and whales (bottom) sighted during the survey. Blue whiting survey, March-April 2008.

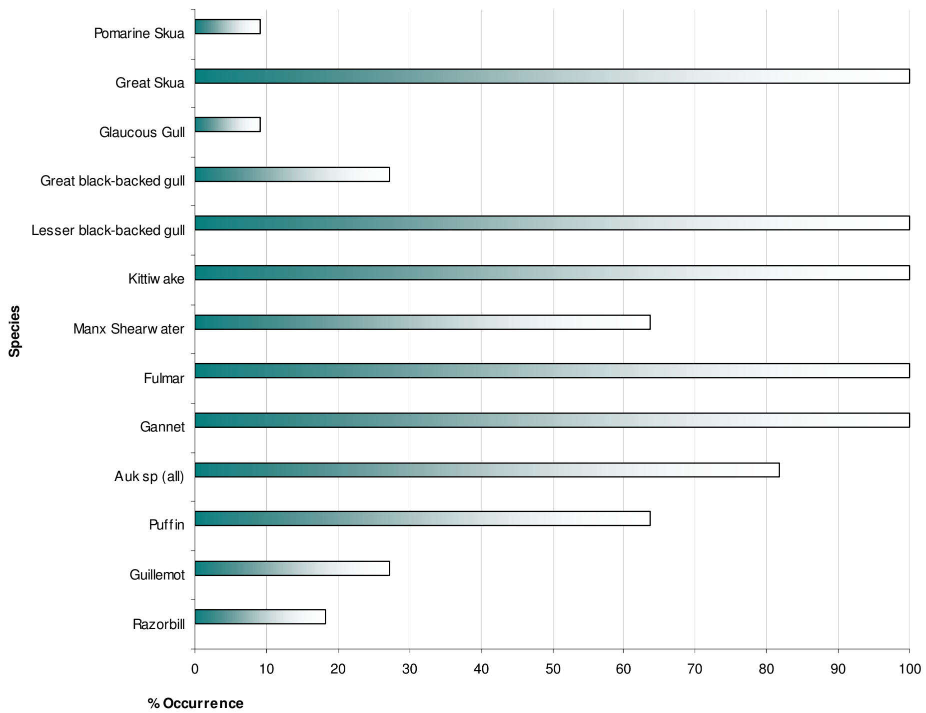
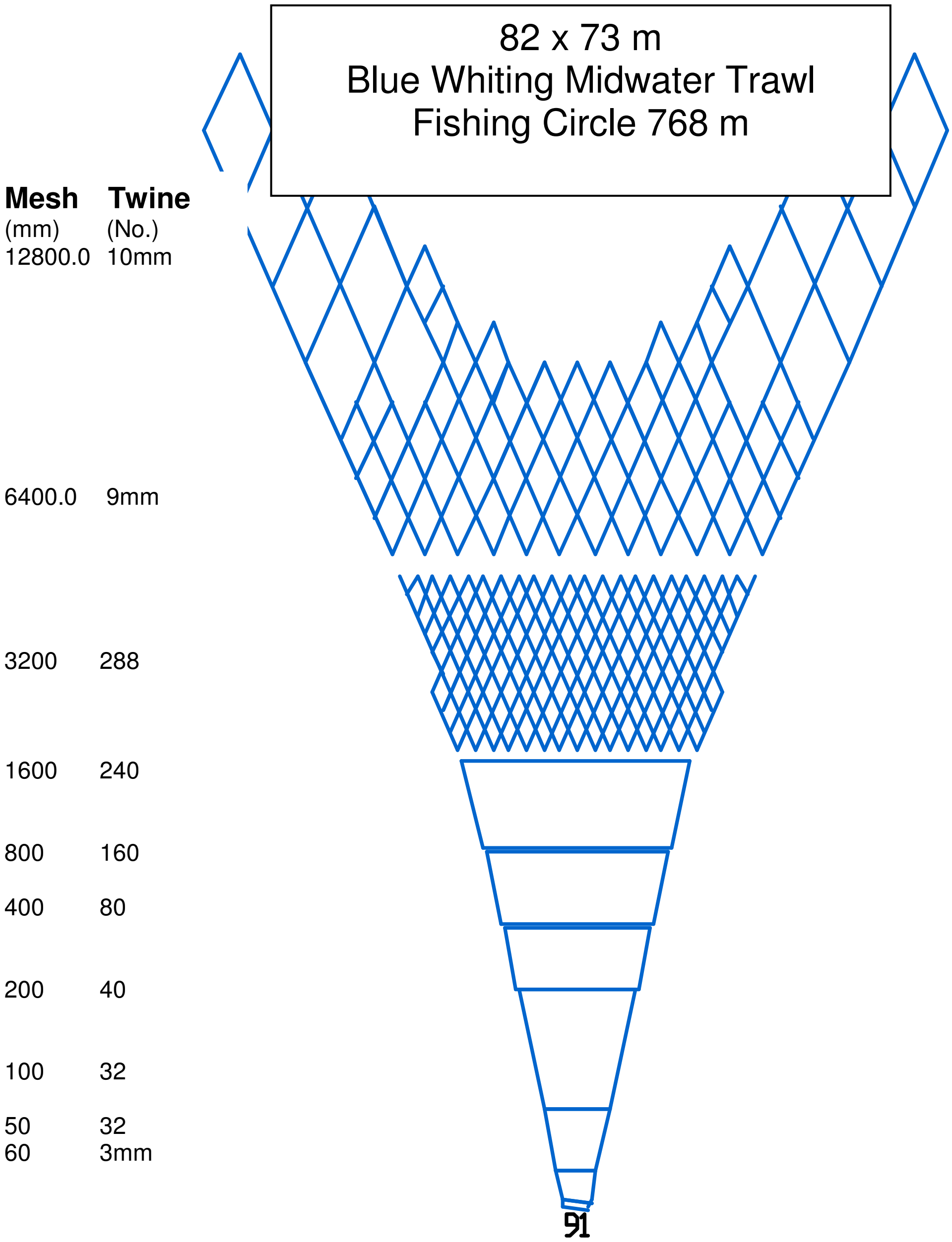


Figure 12. Percentage occurrence of bird species recorded during the survey. Blue whiting survey, March-April 2008



Net specifics

Clump weights:	1000 Kg per side
Trawl doors:	Polyice pelagic 6m² (750Kg weight in air)
Bridle length:	80m
Door spread:	170m
Vertical net opening:	50m

Figure 13. Pelagic midwater trawl employed during the Blue whiting Acoustic Survey, March-April 2008.

Appendix 1

Intercalibration exercise between the RV Celtic Explorer and the RV F. Nansen. Ciaran O'Donnell

Acoustic inter-calibration between R/V Celtic Explorer and R/V Fridtjof Nansen was conducted on April 10 to the southwest of the Rosemary Bank. The weather conditions were moderate with winds recorded at 5-20kts from the E and moderate swell of 2.5m from the N. The main acoustic feature in the area was the mesopelagic layer present at approximately 150m. After time spent by both vessels actively searching for blue whiting schools in the area it was decided to use this, the highest acoustic density schools, as the focus of the exercise.

The exercise was carried out over a single 15nmi transect with the F. Nansen acting as lead vessel cruising at 7kts and beginning at 15:35 at position 59°07'N & 010°45W. The Explorer followed at 0.4nmi and 0.5 degrees to port of the F. Nansen. Transect orientation was aligned to run with the prevailing wind direction to reduce the effects of data drop outs on the hull mounted transducer onboard the F. Nansen. The requested ER60 settings from the F. Nansen were adopted by the Explorer (ping rate 1.2; bottom detection minimum 750, max 790m).

In the data analysis the entire channel data (surface to 750m) for each 1nmi ESDU was analysed as no obvious schools were visible. Figure 1 show acoustic densities recorded by the two vessels and for each ESDU. Acoustic recordings show no agreement with the exception of the second and third nautical mile intervals. From 4 to 15nmi the recorded data is very different. At 6,7nmi and 9, 10 and 11nmi data appears to follow a similar rise and fall in trend but with markedly different values. However, it appears from Figure 1 that the F. Nansen is recording much higher densities than observed by the Explorer. This may be some way accounted for by the spatial heterogeneity of the mesopelagic layer. The possibility of vessel induced disturbance by the lead vessel (F. Nansen) should not be ruled out as the target layer was relatively close to the surface (150m) and therefore more likely to be disturbed by passing vessels.

The plot of each vessel (Figure 2) during the exercise vessels show close geographical correlation but not in recorded density. At log intervals of 12-14nmi vessels appear to be most aligned but the recorded densities are still substantially different. It is difficult to draw any conclusions form these data due to the large unexplained variation in recorded densities suffice to say that intercalibration exercises on low density acoustic registrations of mesopelagic layer are not ideal.

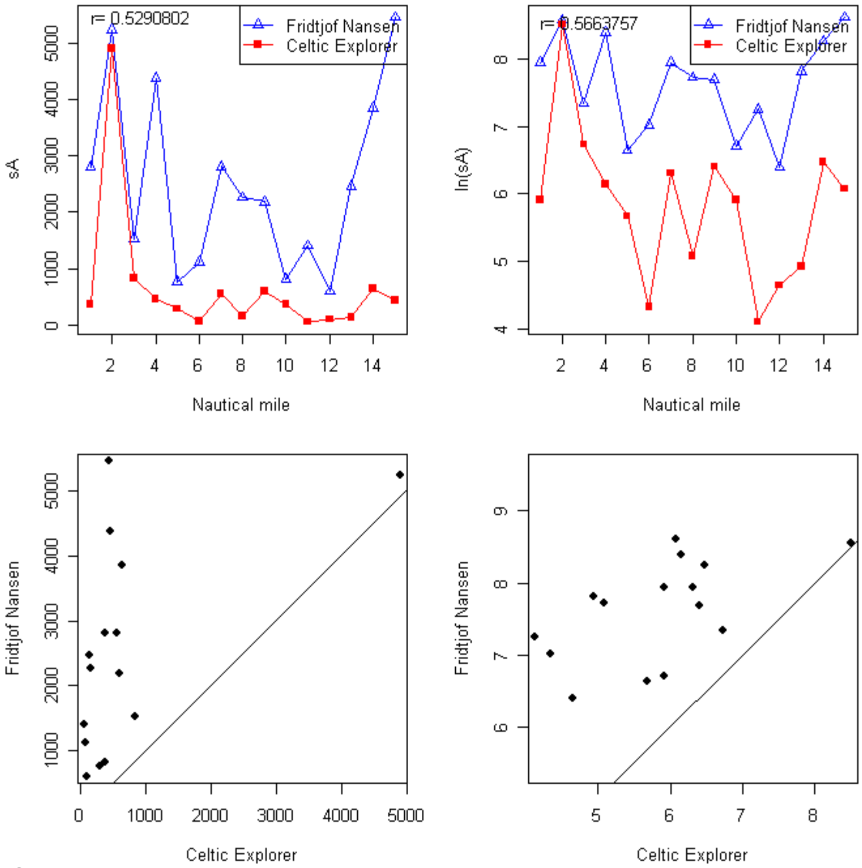


Figure 1. Comparison of blue whiting acoustic densities recorded by Fridtjof Nansen (open triangles) and Celtic Explorer (squares). The lower panels show the data as scatterplots. The diagonals are drawn as continuous lines.

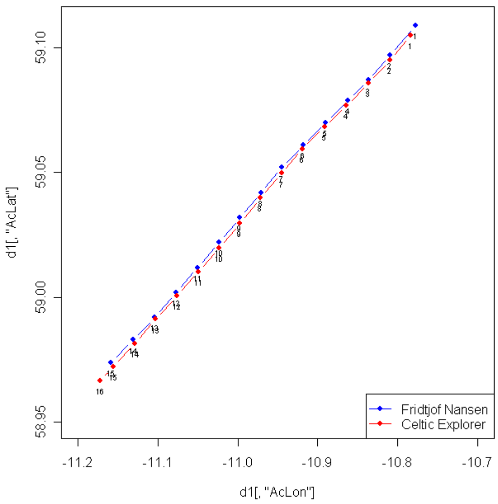


Figure 2. Intercalibration track followed by the Fridtjof Nansen (blue squares) and Celtic Explorer (red squares).

Appendix 2

Intercalibration exercise between the RV Celtic Explorer and the RV M. Heinason
Ciaran O'Donnell

Acoustic inter-calibration between R/V Celtic Explorer and R/V Magnus Heinason was conducted on April 13 at 23:40 to the northeast of the Rosemary Bank at position 59 28.07N & 008 50.84W and took a westward direction over a 15nmi single transect with the M. Heinason acting as the lead vessel cruising at 8.5 Kts for 15nmi to position 59 28.04N & 009 20.11W. Weather conditions were moderate with winds of 25Kts from the N and a northerly swell of 3-3.5m.

The main acoustic features in the area were (1) up to 200 metres thick layer of blue whiting in depths between 400 and 600m, (2) a layer of presumed macro-zooplankton from depth 300 metres downward (3) plankton and mesopelagic fish, in the uppermost 200 metres.

Data analysis we focused on acoustic densities (s_A, m^2/nm^2) allocated to blue whiting. On both vessels the routine procedures were followed for scrutinizing the data. Figure 1 shows acoustic densities recorded by the two vessels allocated to blue whiting. The recordings show variable agreement. Recordings by the Celtic Explorer appear more consistent and less variable per mile interval than those recorded by the M. Heinason for most of the recorded transect. Two distinct areas of interest are visible. Firstly, at 5-9nmi medium density schools are recorded progressing to an area of lower density. The second, from 10-14nmi shows a similar pattern of acoustic density. The recording of the M. Heinason show much greater mile by mile variability with sharp contrasts in recorded values between successive miles. This may be accounted for to a degree by spatial heterogeneity of schools as vessels were 0.5nmi apart (Figure 2).

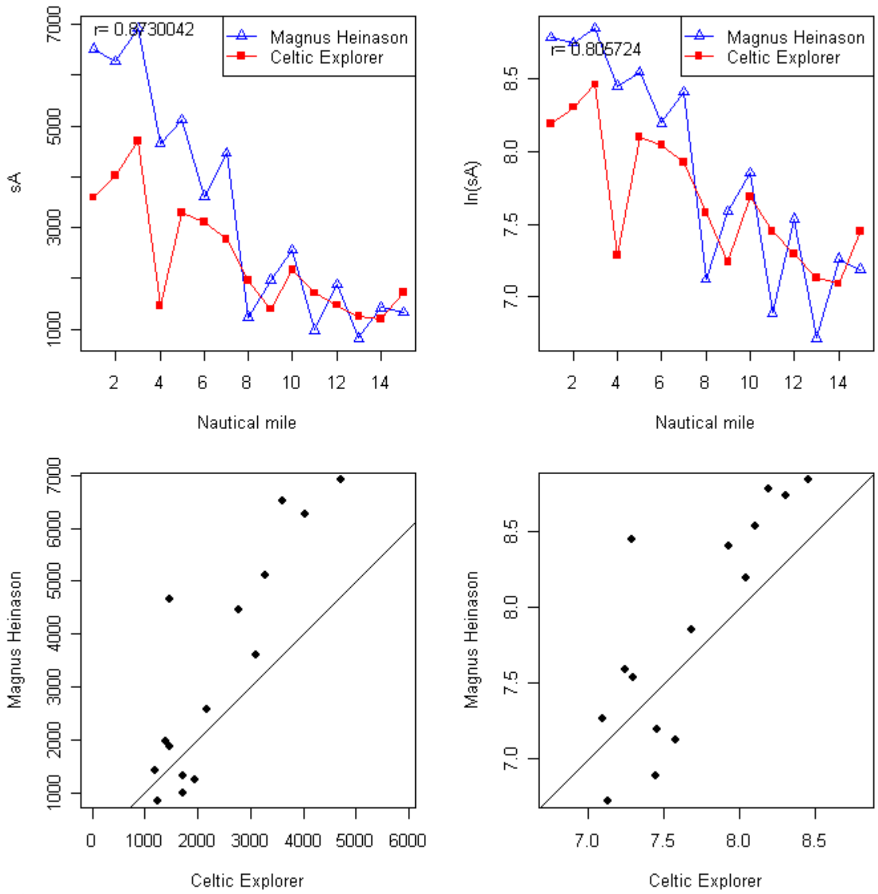


Figure 1. Comparison of blue whiting acoustic densities recorded by Magnus Heinason (open triangles) and Celtic Explorer (squares). The lower panels give same data as scatterplots. The diagonals are drawn as continuous lines.

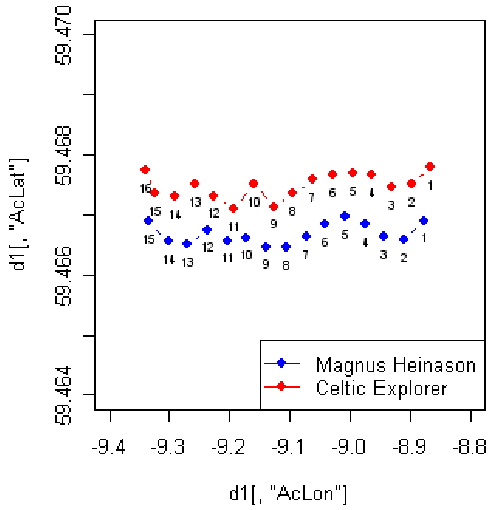


Figure 2. Intercalibration track followed by the Magnus Heinason (blue diamonds) and Celtic Explorer (red diamonds).

At the end of the acoustic inter-calibration a comparative trawl exercise was undertaken. Both vessels turned and towed in parallel over the area that acoustic integration was carried out at a distance of about 0.3nmi apart. Celtic Explorer actively towed for 20 minutes at depths of 410–460 metres and caught 250 kg of blue whiting. Magnus Henson towed in the same depth for the same time and caught 150 kg of blue whiting.

Blue whiting in the catch of Celtic Explorer were larger in mean length (mean length: 27.7 cm, range 24-36cm) compared to the blue whiting in the catch of Magnus Heinason (mean length: 28cm, range 23.5-36cm) as shown in Figure 3. The results indicate that both the Celtic Explorer and the Magnus Heinason equally captured similar blue whiting size classes with no bias towards smaller or larger individuals. In 2007, the Celtic Explorer showed a tendency to capture larger individuals during the same exercise. However, this may be some way attributed to the spatial heterogeneity of schools encountered.

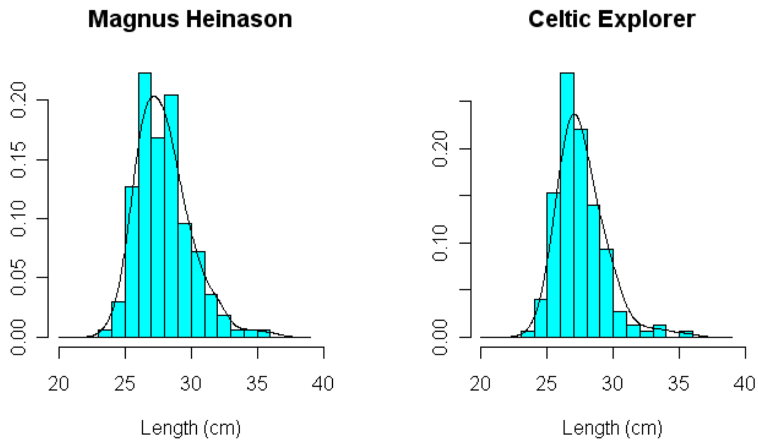


Figure 3. Length distributions from the trawls hauls by Magnus Heinason and Celtic Explorer. Smoothing is obtained by normal kernel density estimates.