FSS Survey Series: 2014/01

Blue Whiting Acoustic Survey Cruise Report

March 22- April 11, 2014

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1 Introduction

Acoustic surveys targeting blue whiting (*Micromesistius poutassou*) spawning and post spawning aggregations 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 the main spawning grounds to the west of Ireland and Britain. Since 2004, an International coordinated survey program has expanded 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 along the shelf edge from the southern Porcupine Bank area northwards to the Faroe/Shetland Ridge including offshore areas as the Rosemary, Hatton and Rockall Banks. Peak spawning occurs between mid-March and mid April and acoustic surveys are timed to occur during this phase. To facilitate a more coordinated spatio-temporal approach to the survey participating countries meet annually to discuss survey methods and define effort allocation at the ICES led Working Group International Pelagic Surveys (WGIPS).

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 (WGWIDE). Ultimately, combined data inputs into the management and catch advice for this international cross boundary stock.

The 2014 survey was part of an international collaborative survey using the vessels RV *Celtic Explorer* (Ireland), FV *Fridtjof Nansen* (Russia), RV *Tridens* (Netherlands) and the RV *Magnus Heinason* (Faroes). The total combined area coverage extended from the Faroe Islands in the north (62° N) to south of Ireland (52° N), with east -west extension from 4°-19° W.

International survey participants meet shortly after the survey to present data and produce a combined relative abundance stock estimate and report. The combined survey report is presented annually at the WGIPS meeting held in January. The information presented here relates specifically to the Irish survey.

2 Materials and Methods

2.1 Scientific Personnel

Organsiation	*Name*	*Capacity*
FEAS	Ciaran O'Donnell	Acoustics (SIC)
FEAS	Grahan Johnston	Acoustics
FEAS	Eugene Mullins	Acoustics
FEAS	Robert Bunn	Acoustics
FEAS	Dermot Fee	Biologist
DTU Aqua	Jan Pedersen	Biologist
NPWS	Machiel Oudejans	MMO
Birdwatch Irl	Niall Keogh	SBO
Birdwatch Irl	Jackie Hunt	SBO
GMIT	William Hunt	PhD
Liv Uni	Nealy Carr	PhD
Liv Uni	Calum Preece	PhD

2.2 Survey Plan

2.2.1 Survey objectives

The primary survey objectives are listed below:

- Collect acoustic data on blue whiting spawning aggregations within the pre-determined areas based on terms agreed at the WGIPS meeting 2014
- Collect biological samples from directed trawling on fish echotraces to determine age structure and maturity state of survey stock
- Determine an age stratified estimate of relative abundance of blue whiting within the survey area using acoustic survey techniques
- Collect physical oceanography data as horizontal and vertical profiles from a deployed sensor array
- Submit survey data (acoustic, biological and hydrographic) to the internationally coordinated database
- Conduct a sighting survey of marine mammals and seabirds

2.2.2 Survey design and area coverage

The survey covered the core spawning area of blue whiting to the west of Ireland and Scotland (Figure 1). Coverage extended from the shelf slopes (250 m) westward into the Rockall Trough and was carried out in continuity from south to north.

Transect design and effort allocation was pre-agreed for each vessel at the WGIPS meeting in 2014. A parallel transect design was used to allow transect interlacing in co-surveyed target areas (east-west orientation). Offshore, transects extended to 15° W. Transect spacing was set at 30 nmi for individual vessels and maintained throughout the survey.

In total, the Irish survey covered 58,392 nmi² using 2,134 nmi of transects. Survey design and methodology adheres to the methods laid out in the WGIPS acoustic survey manual.

2.3 Equipment and system details and specifications

2.3.1 Acoustic array

Equipment settings for the EK60 are based on established settings employed on previous surveys (O'Donnell *et al.,* 2004) and are shown in Table 1.

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 3.3 m below the vessels hull or 8.8 m below the sea surface. Three other frequencies were used during the survey (18, 120 and 200 kHz) for trace recognition purposes, with the 38 kHz data used solely to generate the abundance estimate.

While on 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 (ICES, 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

The EK60 was calibrated in Dunmanus Bay on March 23 at the start of the survey and again in Donegal Bay on April 8 at the end. The results of the first calibration (38 kHz transducer) are shown in Table 1.

2.3.3 Inter-vessel calibration

Inter-vessel acoustic calibrations are carried out when participant vessels are working within the same general area and time and weather conditions allow for an exercise to be carried out. The procedure follows the methods described by Simmonds & MacLennan 2007.

No inter-calibration exercise was carried out in 2014.

2.3.4 Acoustic data acquisition

EK60 "RAW files" were logged via a continuous Ethernet connection to the vessels server and the EK60 hard drive as a backup. Sonar Data's Echoview® Echolog (Version 4.8) 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.

EK60 "Raw" 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. Echograms were analysed at a threshold of -70 dB and, where necessary, plankton were filtered out by thresholding to –65 dB.

Echograms were scrutinised into one of the following categories:

a). Blue whiting (further classified as; Definitely, Probably, Possibly and Mixed)
b). Mesopelagic fish
c). Plankton
d). Pelagic fish (Including herring and mackerel)

2.3.6 Biological sampling

A single pelagic midwater trawl with the dimensions of 70 m in total length and a fishing circle of 768 m was employed during the survey (Figure 12). Mesh size in the wings was 12.5 m through to 20 mm in the cod-end. The net was fished with a vertical mouth opening of approximately 50 m and 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 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 (Figure 5). Data on temperature, depth and salinity were collected using a Seabird 911 sampler from 1 m subsurface to 1000 m where depth allowed or to within 10 m of the bottom on shelf slopes.

2.4 Analysis methods

2.4.1 Echogram partitioning and abundance estimates

The recordings of area back scattering strength per nautical mile (NASC) were averaged over one nautical mile elementary distance sampling units. NASC values were allocated 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 1° latitude by 2° longitude strata (4 ICES rectangles). For each strata, the unit area density of fish (S_A) in number per square nautical mile ($N*nmi^{-2}$) was calculated using standard equations (Foote et al. 1987, Toresen *et al*. 1998).

For blue whiting a target strength (TS) of= 20 $\log_{10}$ – 65.2 dB was applied based on Pedersen *et al,* 2011.

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.

2.5 Marine mammal and seabirds

2.5.1 Marine mammals

A dedicated marine mammal visual survey was conducted during daylight hours during the survey. The ships crow's nest, located 17m above sea-level, formed the primary survey platform, with the monkey island (14m) and the bridge (11m) were used as secondary platforms during rough weather conditions. The observer surveyed 180 degrees in front of the line of the vessel track (90 degrees starboard to 90 degrees port), with the emphasis on the

middle 120 degrees in front of the survey vessel. Visual effort included scanning with the use of 7x30 binoculars (7x30 ruggedized Steiner Navigator with built-in compass) and with the naked eye. Binoculars were used to conduct systematic scans and to aid with species identification, the estimation of group size and group composition for distant sightings.

Visual survey effort and sightings data were recorded using Logger 2000 software (IFAW) running on a ruggedized laptop (Panasonic Toughbook CF18 with GPS receiver (Globalsat BU353)). Logger 2000 was set to automatically store GPS metadata including the vessel position, vessel speed and vessel course. Environmental conditions were recorded every 15 minutes in a customised effort form in Logger, and included: Beaufort sea state, wind speed (Bft), wind direction, swell height, cloud cover, visibility (km) and glare (%).

For each sighting, the species, group size, group composition and behavioural characteristics were recorded, along with distance and angle from the ship, used to determine the geographical location and direction of movement. The distance of the sightings was estimated using a distance stick or estimated visually by the observer.

2.5.2 Seabirds

Surveys of seabirds at sea were conducted from R.V. *Celtic Explorer* between 25th March and 7th April 2014. A standardised line transect method with sub-bands to allow correction for species detection bias and 'snapshots' to account for flying birds was used (following the recommendations of Tasker et al. 1984; Komdeur et al. 1992; Camphuysen et al. 2004).

Two observers (a primary observer and a scribe, who also acted as a secondary observer) worked in rotating one hour shifts, surveying between 08:00 and 18:00 hours. Environmental conditions, including wind force and direction, sea state, swell height, visibility and cloud cover, and the ship's speed and heading were noted at regular intervals during surveys. No surveys were conducted in conditions greater than sea state 6, when high swell made working on deck unsafe, or when visibility was reduced to less than 300m.

Seabird surveys were conducted from the platform of the bridge deck. The platform for observation was changed to either the port or starboard side on the basis of suitable viewing conditions at the time (e.g. presence of glare). The platform height was 10.5m above the waterline, providing an uninterrupted view of the survey area. The survey area was defined as a 300m wide band operated on one side (in a 90˚ arc from the bow) and ahead of the ship. This survey band was sub- divided (A = 0-50m from the ship, B = 50-100m, C = 100-200m, D = 200-300m, E = >300m) to subsequently allow correction of species differences in detection probability with distance from the observer. A fixed-interval range finder (Heinemann 1981) was used to periodically check distance estimates. The area was scanned by eye, with binoculars used only to confirm species identification. All birds seen within the survey area were counted, and those recorded on the water noted as 'in transect'. All flying birds within the survey area were also noted, but only those recorded during a 'snapshot' were regarded as 'in transect'. This method avoids overestimating bird numbers in flight (Tasker et al. 1984). The frequency of the snapshot scan was ship-speed dependent, such that they were timed to occur at the moment the ship passed from one survey area (300m long x 300m wide) to the next. Any bird recorded within the survey area that was regarded as being in association with the survey vessel was noted as such (to be excluded from abundance and density calculations). Survey time intervals were set at 1 minute.

Additional bird species observed outside the survey area or during periods of casual observations were also recorded and added to the species list for the duration of the survey. In this report we present our daily total count data for each species across all days along with the daily survey effort.

3 Results

3.1 Blue whiting abundance and distribution

A total of 11 directed blue whiting trawls were carried out during the survey (Figure 1, Table 2).

In total 702 echotraces were positively identified as blue whiting over the 22 strata surveyed (Table 9). Blue whiting aggregations were most frequently encountered between 350-550m with a range extending from 250 to 650m.

The second most frequently encountered group of species were the Myctophidae present in 7 of 11 survey hauls (Table 9). High density mesopelagic echotraces were observed in a number of areas during daylight hours. The presence of mesopelagic species in trawl catches is generally regarded as by-catch due to the passage of the trawl through the mesopelagic layer (70-200 m) to the target blue whiting layer (250-650 m).

3.1.2 Blue whiting biomass and abundance

The table below shows the estimated abundance and biomass of each category of blue whiting acroos the entire survey area. A full breakdown of the survey estimate is presented by distribution, age, length, biomass, abundance and area in Figures 2 & 4 and Tables 3-9.

Blue whiting	Millions	Biomass (t)	% contribution
Total estimate			
Definitely	13,666	1,574,804	100.0
Mixture	0	0	0.0
Probably	0	0	0.0
Total estimate	13,666	1,574,804	100
SSB Estimate			
Definitely	12716	1,509,815	100.0
Probably	0	0	0.0
Mixture	0	0	0.0
SSB estimate	12716	1,509,815	100

3.1.3 Blue whiting distribution

For the purposes of the international survey, spawning areas are broken into target areas ranked according to historic core abundance (Figure 1).

Four target areas were surveyed with varying degrees of coverage as part of the agreed component of international effort allocation. Two target areas; south Porcupine and Rockall were only partly covered by this survey and combined accounted for less than 14% (7,800nmi^2) of the total area. As a result they are not considered representative outside of the international survey effort. Blue whiting distribution within the south Porcupine area was dominated by a small number of high density echotraces (Table 9, Figure 3a). The Hebrides and north Porcupine areas were comprehensively covered using 66% (38,500nmi^2) and 21% (12,000nmi^2) of survey effort respectively and are thus considered representative.

Overall high density echotraces dominated near shelf regions (c.15nmi) from south to north at depths of between 250-650m (Figure 3b). This year the centre of gravity of the stock was located further to the south than observed in 2013. Western extension of high density echotraces into the Rockall Trough was similar to last year lattitudinally but with increased westward spread. This spread of echotraces was centred on the northern edge of the Porcupine Bank (54ºN) to 56ºN and extended to up to 100nmi (60nmi in 2013) from the shelf

edge (Figure 2 & 3d). This area contained the highest single blue whiting echotrace recorded during the survey (Figure 3b). North of 56ºN the distribution of high density echotraces were observed in close proximity out to 15nmi from the shelf edge.

The distribution of biomass within target areas is broken down as follows (detailed in Tables 5 & 6):

South Porcupine Bank represented 3.5% (2033nmi²) of survey effort and contained 2.0% of TSB (c.30,000t) and 25.7 million individuals.

North Porcupine Bank represented 20.6% (12,031nmi²) of survey effort and contained 25.6% TSB (c.403,000t) and 3,515.5 million individuals.

The Rockall area represented 9.8% (5,700nmi²) of survey effort and contained 8.1% of TSB (c.128,200t) and 941.7million individuals.

The Hebrides area represented 66.1% (38,600nmi²) of survey effort and contained 66.1% of TSB (c.1,041,000t) and 9,183.4 million individuals.

3.1.4 Blue whiting stock structure

During the survey 550 fish were aged with length, weight, sex, maturity and stomach fullness data recorded. A further 1,100 fish were measured and weighed. Age analyses of otiliths showed individuals from 1 to 14-years old from trawl samples (Figure 4).

The age structure of survey stock was dominated by 3 strong year classes; the 4 (2010 yr class), 5 (2009 yr class) and 3-year old fish (2011 yr class) respectively. Together these year classes represented 65.4% of the TSB and 73% of the TSN.

In terms of biomass the breakdown is as follows: 4-year old fish 29.3% (462,200t), 5-year old fish 20.7% (326,100t) and 3-year old fish 15.4% (242,400t). In terms of abundance: 4-year old fish 33% (4,509 million individuals), 5-year old fish 20.7% (2,822 million individuals) and 3-year old fish 19.3% (2,642 million individuals).

Maturity analysis (international data) indicates 14% of 1-year old, 56% of 2-year old and 90% of 3-year old fish were mature. Of the mature fish sampled, most were spent and a smaller proportion was actively spawning. Over 97% of the surveyed stock was found to be mature with less than 3% immature. Immature fish were found in all strata surveyed (n=22) with the highest concentrations in the Faroe/Shetland area as observed previously

3.2 Oceanography

Overall 29 CTD casts were carried out during the survey. Open water stations were conducted to a maximum of 1,000m. Horizontal profiles of temperature and salinity from 10m subsurface to 600m are shown in Figures 8-11.

Surface water conditions (10m) indicate relatively stable conditions south of 60ºN in terms of temperature and salinity.

At 200m the influence of warmer Atlantic water is evident to the north of the Porcupine Bank and southeast of Rockall (Figure 9). For profiles at depths at 400m and 600m both temperature and salinity profiles appear relatively uniform for the main body of the survey area to the south of 59ºN (Figures 10 & 11). Uniform temperatures and salinity regions are the preferred spawning habitat for blue whiting and are often observed when the sub polar gyre is weak allowing the influence of Atlantic water to dominate on the spawning grounds (Monstad 2004). During weak gyre cycles the distribution of spawning aggregations of blue whiting occurs further west into the Rockall Trough and on the Rockall Bank than during strong cycles where spawning is limited predominantly to shelf edge (Hatun *et al* 2009.

3.3 Marine mammal and seabirds

3.3.1 Marine mammals

3.3.1.1 Effort

In total 120 hours of visual survey were conducted, of which 50.47 hours (42%) were conducted in Beaufort sea state three or less (Figures 6 & 7). Of this 106.1 hours (88%) of visual effort were conducted from the primary platform, followed by the bridge (11.5 hours) and Monkey Island (2.1 hours). Despite relatively calm sea conditions, visual effort was often constrained due to limited visibility resulting from sea fog.

3.3.2.1 Sightings

In total 31 sightings of five marine mammal species were recorded, totalling 138 individuals (Table 12 and Figure 6). Long-finned pilot whales (*Globicephala melas*) were the most observed species with 16 confirmed sightings of 97 individuals, which include seven calves and six juveniles / sub-adults. The long-finned pilot whale sightings were recorded in areas with steep bathymetry along the continental shelf edge and near the Rosemary seamount (Figure 6). The sperm whale (*Physeter macrocephalus*) was the second most observed species with six sightings of seven individuals. Sperm whales sightings were confined to deep waters (>1000m depth) in the northern section of the Rockall trough, west of the Hebrides, Scotland (Figure 6). Small groups of common dolphins (*Delphinus delphis*) were observed bow-riding the survey vessel on two occasions, and a single sighting of a group of six individuals including two calves, was recorded inside Dunmanus Bay. One group of bottlenose dolphins (*Tursiops truncatus*) was observed in close proximity to a number of long-finned pilot whale groups, located within the shelf edge waters Northwest of Co. Donegal. A single breaching event of an unidentified beaked whale was observed by Niall Keogh while conducting a seabird survey from the bridge deck. The animal, observed in the deep waters of the Rockall trough, was not resighted despite its close distance to the vessel. Two groups of unidentified dolphins and a single unidentified small whale, possibly a minke whale (*Balaenoptera acutorostrata*), were sighted in deep water of the Rockall trough. Finally, a single grey seal was observed in the coastal waters west of Dunmanus Bay.

3.3.2 Seabirds

3.3.2.1 Effort

A total of 4,003 minutes (66 hours and 43 minutes) of dedicated seabird surveying was conducted between 25th March and 7th April 2014 with an average of 286 minutes (4 hours and 46 minutes) surveyed per day (range of 180 minutes to 360 hours). A total of 240 minutes was conducted from inside the Bridge on 25th March with the remaining 3,763 minutes being conducted from the Bridge Deck between 26th March and 7th April (Table 13).

3.3.2.2 Sightings

An uncorrected, cumulative total of 7749 individual seabirds of 15 species were recorded (Table 14). A total of 1442 seabirds were noted as 'off survey', outside of dedicated survey time or associating with the vessel and as such will be excluded from future analysis of abundance and density. Thus, the corrected total of seabird recorded during dedicated survey time was 6307. A synopsis of daily totals for all seabird species recorded is presented in Table 14.

More detail and information can be found in the species accounts, in which taxonomy and nomenclature follows Irish Rare Birds Committee (2012).

4 Discussion and Conclusions

4.1 Discussion

Overall, the survey objectives were carried out as planned with the exception of one transect that was dropped from the original plan (southern most transect 51º30N) due to poor weather at the start of the survey. In total poor weather accounted for 36 hrs of lost survey time and the track plan was adjusted to ensure continuity of coverage with participant vessels. Good weather conditions dominated the remainder of the survey. At the mid point 3 planned CTD stations were dropped to allow the Explorer to catch up with Russian and Dutch vessels and maintain pace.

Communication between vessels was very good and this allowed for close spatio-temporal alignment and adaptive changes to the survey design to be implement quickly and efficiently.

The abundance estimate is considered robust as the stock was well contained within the survey area (international coverage) and good trawl sampling was undertaken in core as well as peripheral abundance areas.

The distribution of the bulk of the stock in the mid latitudes indicated that the timing of the survey was good and post spawning migration was not fully underway.

4.2 Conclusions

As this survey is part of a cooperative survey covering the larger spawning range of the stock it is difficult to take the results from the Irish survey as an indicator of the state of the stock over the entire area and this should be considered when reviewing the results.

The distribution of the bulk of the stock within the Hebrides target area is consistent with previous years. Although the stock was located in the southern end on the border with the Porcupine target area indicating spawning occurred later than in 2013. During recent surveys the bulk of the stock was located further north to the west of the Hebrides. The westward continuation of spawning/post spawning aggregations extending into the Rockall Trough, which was more pronounced in 2014 than in 2013, would indicate favourable spawning habitat in the mid Rockall Trough. Hydrographic data indicates a stable water mass dominating the main body of the survey area in terms of temperature and salinity. Such conditions are indicative of a weaker sub polar gyre which allow for more stable conditions to develop on the Rockall Bank and through the Rockall Trough. During strong gyre conditions spawning aggregation are most often observed in close proximity to the shelf edge.

The stock appears to be in the forth year of positive recruitment after a prolonged period of poor recruitment. Although episodic, periods of positive recruitment can have a strong influence on the stock within a relatively short time frame. The 3 and 4-year old fish (strong 2010 & 2011 year classes) continue to be observed within the survey and are now considered fully recruited to the spawning stock. A sign of a potentially strong emerging 2013 year class was observed during the international survey. However, it is too early to predict the magnitude of that year class yet with any degree of accuracy until it can be confirmed in the coming 2-3 years.

Acknowledgements

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

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Table 1. Survey settings and calibration report for the Simrad ER60 echosounder.

Echo Sounder System Calibration

Vessel :	RV Celtic Explorer	Date :	23.03.14
Echo sounder :	EK60 PC	Locality :	Dunmnaus Bay
Type of Sphere :	Cu-60.1mm	TS_{Sphere}: -33.50 dB (Corrected for soundvelocity)	Depth(Sea floor) 31 m

Calibration Version 2.1.0.11

Comments:
CE14005.BWAS. Dunmanus Bay

Reference Target:

TS	-33.5 dB	Min. Distance	16.00 m
TS Deviation	5.0 dB	Max. Distance	20.00 m

Transducer: ES38B Serial No. 30227

Frequency	38000 Hz	Beamtype	Split
Gain	26.5 dB	Two Way Beam Angle	-20.6 dB
Athw. Angle Sens.	21.90	Along. Angle Sens.	21.90
Athw. Beam Angle	7.10 deg	Along. Beam Angle	7.10 deg
Athw. Offset Angle	- 0.00 deg	Along. Offset Angl	-0.00 deg
SaCorrection	-0.00 dB	Depth	8.8 m

Transceiver: GPT 38 kHz 009072033933 1 ES38B

Pulse Duration	1.024 ms	Sample Interval	0.191 m
Power	2000 W	Receiver Bandwidth	2.43 kHz

Sounder Type:
ER60 Version 2.4.3

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.	9.8 dB/km	Sound Velocity	1486.4 m/s

Beam Model results:

Transducer Gain =	25.98 dB	SaCorrection =	-0.69 dB
Athw. Beam Angle =	7.00 deg	Along. Beam Angle =	6.93 deg
Athw. Offset Angle =	-0.03 deg	Along. Offset Angle=	-0.06 deg

Data deviation from beam model:
RMS = 0.10 dB
Max = 0.27 dB No. = 31 Athw. = -3.1 deg Along = -1.9 deg
Min = -0.26 dB No. = 123 Athw. = -3.6 deg Along = 2.4 deg

Data deviation from polynomial model:
RMS = 0.05 dB
Max = 0.13 dB No. = 128 Athw. = -2.2 deg Along = 2.8 deg
Min = -0.21 dB No. = 123 Athw. = -3.6 deg Along = 2.4 deg

Comments :

Wind Force : 2 **Wind Direction** W
Raw Data File: \\C\EK60_Data\BWAS_2014\RAW ER60 Files\Calibration\BWAS_2014
Calibration File: \\C\EK60_Data\BWAS_2014\RAW ER60 Files\Calibration\BWAS_2014

Calibration : Ciaran O'Donnell

Table 2. Catch composition, time and location of trawl hauls.

No.	Date	Lat. N	Lon. W	Time	Bottom (m)	Target (m)	Bulk Catch (Kg)	Sampled (Kg)	Blue Whiting %	Mackerel %	Meso %	Herring %	Others %
1	27.03.14	53 25.24	014 31.01	08:30	800	537	5,500.0	191.0	99.9		0.1		
2	28.03.14	54 17.78	013 02.75	05:02	880	500	4,000.0	120.2	99.9		0.1		
3	28.03.14	54 17.71	011 49.81	14:29	2220	500	5,000.0	122.9	100.0				
4	30.03.14	55 18.37	012 50.02	04:10	2871	500	1,200.0	182.6	99.9		0.1		
5	30.03.14	55 48.31	009 35.22	22:55	850	477	300.0	145.9	99.7		0.3		
6	31.03.14	55 48.16	010 57.70	06:40	2505	450	3,500.0	183.6	99.7		0.3		
7	01.04.14	56 18.16	009 13.48	08:48	800	430	1,500.0	184.8	99.8		0.2		
8	02.04.14	57 18.07	009 31.35	16:15	1000	420	700.0	176.2	100.0				
9	04.04.14	58 48.17	007 52.05	08:12	940	420	1,000.0	191.4	98.8		1.3		
10	04.04.14	58 47.98	010 40.01	21:22	1871	500	6,000.0	199.9	99.9		0.1		
11	06.04.14	59 18.07	007 08.12	02:02	730	250	400.0	196.2	97.2		2.8		

Note: “Others” was used to represent fish and non-fish species occurring in the catch.

Table 3. Length frequency distribution of blue whiting from trawl samples.

Haul	1	2	3	4	5	6	7	8	9	10	11	
length (cm)												Total
17								2				2
17.5								9				9
18								10				10
18.5							1	7				8
19							2	5				7
19.5							2	8				10
20							3	2				5
20.5								7				7
21							2	1				3
21.5				1				4				5
22								1				1
22.5								2				2
23	1						2	4				7
23.5		1		2			4					7
24	3		2		1	1	7	4	5		2	25
24.5	5	6	6	6	3	5	25	7	3	1	4	71
25	20	18	8	10	4	9	23	8	5		3	108
25.5	9	14	26	10	14	13	17	12	9	5	2	131
26	16	10	18	12	14	19	15	9	5	1	5	124
26.5	13	35	18	15	12	16	9	15	4	1	3	141
27	17	9	13	7	8	15	11	5	8	2	3	98
27.5	15	12	16	12	16	19	9	7	8	4	5	123
28	5	12	10	9	9	9	8	2	2	3	6	75
28.5	6	8	5	7	7	9	4	1	7	1	7	62
29	6	5	9	4	10	9	2	4	3	4	6	62
29.5	4	4	2	2	8	5	1		2		5	33
30	6	2	3	7	10	4		5	6	2	11	56
30.5	3	4	4		7	2			2	1	6	29
31	7	3	1	4	6	5	1	3	7	6	7	50
31.5	2	1		2	2	1		1	6	5	13	33
32	1		1	6	4	2			10	1	5	30
32.5	3		3	10	2			2	10	7	6	43
33		3	2	3	2	1		1	6	12	15	45
33.5	4	1	2	6	2	1		1	7	17	6	47
34	2	1		1	2		1		10	13	3	33
34.5	1	1		4	1				8	14	3	32
35			1	1	1	2		1	3	12	5	26
35.5				4	3	1	1		7	15	9	40
36	1			1	2	2			3	9	2	20
36.5				1					3	5	1	10
37				2						3	2	7
37.5										2	2	4
38										1	2	3
38.5												
39				1					1	2		4
39.5												
40												
40.5												
41												
41.5												
42												
42.5												
43												
43.5												
44												
44.5										1		1
45											1	1
Total	150	150	150	150	150	150	150	150	150	150	150	1650

Table 4. Blue whiting length at age (years) as abundance (millions) and biomass (000's tonnes).

Length (cm)	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	Abund (mils)	Biomass 000's t	Mn wt (g)
17	19.36	-	-	-	-	-	-	-	-	-	-	-	-	-	19.36	0.45	23.2
17.5	87.1	-	-	-	-	-	-	-	-	-	-	-	-	-	87.1	2.2	25.4
18	96.8	-	-	-	-	-	-	-	-	-	-	-	-	-	96.8	2.7	27.9
18.5	80.6	-	-	-	-	-	-	-	-	-	-	-	-	-	80.6	2.5	30.5
19	74.0	-	-	-	-	-	-	-	-	-	-	-	-	-	74.0	2.5	33.2
19.5	103.0	-	-	-	-	-	-	-	-	-	-	-	-	-	103.0	3.7	36.1
20	57.7	-	-	-	-	-	-	-	-	-	-	-	-	-	57.7	2.3	39.2
20.5	67.8	-	-	-	-	-	-	-	-	-	-	-	-	-	67.8	2.9	42.5
21	35.3	-	-	-	-	-	-	-	-	-	-	-	-	-	35.3	1.6	46.0
21.5	-	47.0	-	-	-	-	-	-	-	-	-	-	-	-	47.0	2.3	49.6
22	-	9.7	-	-	-	-	-	-	-	-	-	-	-	-	9.7	0.5	53.5
22.5	-	19.4	-	-	-	-	-	-	-	-	-	-	-	-	19.4	1.1	57.5
23	-	77.7	-	-	-	-	-	-	-	-	-	-	-	-	77.7	4.8	61.8
23.5	-	-	69.5	-	-	-	-	-	-	-	-	-	-	-	69.5	4.6	66.3
24	-	37.2	185.6	-	-	-	-	-	-	-	-	-	-	-	222.8	15.8	71.0
24.5	-	111.9	363.8	167.9	56.0	-	-	-	-	-	-	-	-	-	699.6	53.1	75.9
25	-	88.5	352.9	558.6	29.8	-	-	-	-	-	-	-	-	-	1029.8	83.5	81.1
25.5	-	105.5	448.6	368.6	263.1	26.7	-	-	-	-	-	-	-	-	1212.5	104.9	86.5
26	-	-	259.5	778.6	259.5	-	-	-	-	-	-	-	-	-	1297.6	119.5	92.1
26.5	-	-	271.1	587.5	316.3	45.2	-	-	-	-	-	-	-	-	1220.2	119.6	98.0
27	-	-	215.4	404.6	323.1	27.2	-	-	-	-	-	-	-	-	970.4	101.1	104.2
27.5	-	-	244.5	733.6	244.5	-	-	-	-	-	-	-	-	-	1222.7	135.2	110.6
28	-	-	48.1	265.9	338.4	24.4	-	-	-	-	-	-	-	-	676.7	79.4	117.3
28.5	-	-	57.4	268.2	134.1	76.7	-	-	-	-	-	-	-	-	536.3	66.6	124.2
29	-	-	68.3	22.6	342.6	159.7	-	-	-	-	-	-	-	-	593.2	78.0	131.5
29.5	-	-	57.0	170.8	57.0	57.0	-	-	-	-	-	-	-	-	341.9	47.5	139.0
30	-	-	-	93.2	256.9	140.2	-	-	-	-	-	-	-	-	490.3	72.0	146.9
30.5	-	-	-	56.0	56.0	28.0	28.0	28.0	-	28.0	-	28.0	-	-	252.0	39.1	155.0
31	-	-	-	-	85.6	171.6	-	28.4	57.2	28.4	28.4	-	-	-	399.7	65.3	163.4
31.5	-	-	-	-	10.6	32.0	21.4	10.6	42.7	10.6	21.4	-	-	-	149.2	25.7	172.2
32	-	-	-	21.5	-	21.5	-	21.5	21.5	21.5	64.4	21.5	-	-	193.3	35.0	181.3
32.5	-	-	-	11.5	23.1	23.1	11.5	34.6	23.1	11.5	69.3	23.1	-	-	230.8	44.0	190.7
33	-	-	-	-	25.3	12.6	-	37.9	50.6	12.6	12.6	12.6	-	-	164.3	32.9	200.4
33.5	-	-	-	-	-	18.9	38.1	38.1	38.1	-	75.9	18.9	-	-	228.0	48.0	210.5
34	-	-	-	-	-	9.4	-	9.4	28.2	37.5	28.2	9.4	-	-	122.0	27.0	220.9
34.5	-	-	-	-	-	-	-	-	32.4	-	32.4	13.0	-	-	77.8	18.0	231.7
35	-	-	-	-	-	16.6	16.6	-	16.6	16.6	49.8	16.6	-	-	132.7	32.2	242.9
35.5	-	-	-	-	-	-	-	8.9	53.7	44.7	26.9	8.9	-	-	143.0	36.4	254.4
36	-	-	-	-	-	-	-	-	19.5	39.0	58.5	19.5	-	-	136.4	36.3	266.3
36.5	-	-	-	-	-	-	-	-	5.2	-	15.7	-	-	-	20.9	5.8	278.6
37	-	-	-	-	-	-	-	-	8.8	8.8	8.8	-	-	-	26.4	7.7	291.2
37.5	-	-	-	-	-	-	-	-	-	-	8.1	-	-	-	8.1	2.5	304.3
38	-	-	-	-	-	-	-	-	-	-	6.3	-	-	-	6.3	2.0	317.7
38.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
39	-	-	-	-	-	-	-	-	-	-	12.3	-	-	-	12.3	4.3	345.9
39.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
40.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
41.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
42.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
43.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
44.5	-	-	-	-	-	-	-	-	-	-	-	-	-	1.8	1.8	0.9	532.4
45	-	-	-	-	-	-	-	-	-	-	-	-	2.3	-	2.3	1.3	552.2
Total															13,666.3	1,574.8	-
SSN (mil)	364.1	429.0	2,340.7	4,253.9	2,756.0	888.4	115.6	217.4	397.5	259.3	519.0	171.4	2.3	1.8	12,716.2	-	-
SSB ('000s t)	12.1	31.0	218.8	440.6	320.3	130.1	22.3	41.3	83.8	56.1	115.6	35.7	1.3	0.9	-	1,509.8	-
Mn Wt (g)	33.4	72.9	91.8	102.5	115.5	146.3	192.6	189.8	210.8	216.3	222.8	208.3	552.2	532.4	-	-	-
Mn length (cm)	19.2	24.4	26.1	27.0	28.0	30.1	32.8	32.6	33.7	33.9	34.2	33.5	45.2	44.8	-	-	-

Table 5. Total blue whiting biomass at age.

Target area	Strata	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
S Porc	5112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S Porc	5114	0	0	0.1	0.5	1	0.6	0.3	0	0.1	0.1	0.1	0.2	0.1	0	0	3
N Porc	5314	0	0	4.8	37.5	75.2	49.3	21.2	3.6	5.8	9.5	5.6	12.7	4.1	0	0	229.3
N Porc	5312	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N Porc	5414	0	0	0	0	0.1	0.1	0	0	0	0	0	0	0	0	0	0.3
N Porc	5412	0	0	1	9.4	19.5	13.2	5	1.1	2.1	3.8	2.3	6.3	1.8	0	0	65.5
N Porc	5410	0	0	2.3	20.5	38.4	27.2	7.2	1.3	2.3	2.1	1.3	3.3	1.6	0	0	107.5
Heb	5510	0	0	4.4	53.6	118.1	84.6	32.4	3.8	6.7	14	11.4	18.6	6.7	0	0	354.3
Heb	5508	0	0	2.6	32.3	76.2	63.5	29.2	4.1	8.4	16.1	12.7	18.4	7.5	0	0	271
Heb	5610	0	0	0.1	0.7	1.6	1.1	0.4	0	0.1	0.1	0.1	0.2	0.1	0	0	4.4
Heb	5608	0	10.8	13.4	57.6	74.1	38.8	7.9	0.4	1.2	3.2	2.4	2.7	0.8	0	0	213.3
Heb	5710	0	0.6	0.3	0.7	1.1	0.8	0.3	0.1	0.1	0.2	0.1	0.3	0.1	0	0	4.7
Heb	5708	0	9.4	5.1	11.2	17.2	12.5	4.7	0.6	1.1	1.6	0.6	2	0.6	0	0	66.5
Heb	5810	0	0	0	0.4	0.8	1.4	1.6	0.9	1.5	5.2	3	7.6	1.8	0	0.4	24.6
Heb	5808	0	0	0	0.2	0.5	0.6	0.7	0.3	0.6	1.8	1.1	2.7	0.7	0	0.1	9.3
Heb	5806	0	0	0.1	0.7	1.3	1.1	0.9	0.3	0.6	1.6	0.9	2.1	0.6	0	0	10.1
Heb	5910	0	0	0	0.4	0.7	1.3	1.6	0.9	1.5	5	2.9	7.3	1.8	0	0.4	23.8
Heb	5908	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Heb	5906	0	0	0.2	2.5	6.6	8.3	6.4	1.9	3.9	9	4.9	11.2	2.7	1.3	0	59.1
Rock	5514	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock	5612	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock	5512	0	0	1.7	14	29.8	21.7	10.6	2.9	5.3	10.3	6.8	20	5	0	0	128.1
Total		0	20.8	36.2	242.4	462.2	326.1	130.3	22.3	41.3	83.8	56.1	115.6	35.7	1.3	0.9	1574.8
%		0	1.3	2.3	15.4	29.3	20.7	8.3	1.4	2.6	5.3	3.6	7.3	2.3	0.1	0.1	100.0

Table 6. Total blue whiting abundance at age.

Target area	Strata	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
S Porc	5112	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S Porc	5114	0	0	0.8	5.2	9.6	5.5	1.9	0.2	0.4	0.6	0.4	0.8	0.3	0	0	25.7
N Porc	5314	0	0	63.7	404.8	743.1	425.3	144.1	19.1	31.3	48.8	28.3	61.8	20.4	0	0	1990.7
N Porc	5312	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
N Porc	5414	0	0	59.0	0.5	1.0	0.6	0.1	12.0	26.0	39.0	2.0	25.0	16.0	0	0	2.4
N Porc	5412	0	0	13.2	101.5	190.5	114.7	34.1	5.4	10.8	18.0	10.6	27.9	8.4	0	0	535.3
N Porc	5410	0	0	27.9	22091.0	379.4	244.9	52.8	6.9	12.3	10.7	6.9	16.4	8.6	0	0	987.0
Heb	5510	0	0	23.0	152.4	286.0	183.4	67.9	14.1	27.2	47.7	29.3	87.5	23.2	0	0	941.7
Heb	5508	0	0	54.4	552.2	1125.6	731.5	226.7	20.1	36.6	67.3	52.9	84.7	31.8	0	0	2983.8
Heb	5610	0	0	31.1	327.0	698.4	523.9	199.9	22.8	45.4	76.5	60.4	86.3	37.4	0	0	2109.0
Heb	5608	0	0.1	0.8	7.6	15.0	9.3	2.6	0.2	0.3	0.7	0.5	0.8	0.3	0	0	38.3
Heb	5710	0	312.6	188.4	690.4	785.9	373.0	60.0	1.9	6.2	15.1	11.0	12.6	3.5	0	0	2460.7
Heb	5708	0	18.1	5.2	8.1	11.2	7.1	2.2	0.3	0.5	1.0	0.5	1.3	0.4	0	18.0	55.8
Heb	5810	0	290.8	82.8	128.3	177.1	110.6	32.3	3.1	5.6	8.6	3.3	9.9	2.8	0	0	855.3
Heb	5808	0	0	0.5	3.7	6.9	9.7	8.9	4.3	7.4	22.5	12.4	30.9	8.0	0	0.8	116.0
Heb	5806	0	0	0.4	2.6	4.5	4.7	3.8	1.5	2.8	8.1	4.5	11.0	2.9	0	0.2	47.1
Heb	5910	0	0	1.0	7.2	11.5	8.6	5.5	1.3	3.1	7.3	4.0	9.5	2.8	0	0	61.8
Heb	5908	0	0	0.4	3.6	6.7	9.4	8.6	4.1	7.2	21.8	12.0	29.8	7.7	0	0.7	112.1
Heb	5906	0	0	1.0	7.0	12.0	17.0	16.0	8.0	13.0	4.0	22.0	55.0	14.0	0	1.0	0.2
Rock	5514	0	0	3.2	26.4	56.7	59.7	39.3	10.2	20.1	42.7	22.2	47.5	13.0	2.3	0.0	343.3
Rock	5612	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rock	5512	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total			621.6	496.9	2641.8	4509.1	2822.0	890.8	115.6	217.4	397.5	259.2	519.0	171.4	2.3	1.8	13666.3
%			4.5	3.6	19.3	33.0	20.7	6.5	0.8	1.6	2.9	1.9	3.8	1.3	17.0	13.0	100.0
CV			35	13	17	18	19	17	13	13	13	14	14	14	0	43	NA

Table 7. Total blue whiting biomass at maturity.

Target area	Strata	Imm	Mature	Spent	Total
S Porc	5112	0	0	0	0
S Porc	5114	0.1	1.3	1.5	3
N Porc	5314	9.6	99.9	119.9	229.3
N Porc	5312	0	0	0	0
N Porc	5414	0	0.1	0.1	0.3
N Porc	5412	1.8	28.8	34.9	65.5
N Porc	5410	4.3	44.6	58.6	107.5
Heb	5510	9.8	147.1	197.4	354.3
Heb	5508	5.3	121.8	143.9	271
Heb	5610	0.1	1.8	2.5	4.4
Heb	5608	23	94.6	95.7	213.3
Heb	5710	0.4	2.2	2	4.7
Heb	5708	6.8	31.2	28.5	66.5
Heb	5810	0	13.2	11.3	24.6
Heb	5808	0.1	4.9	4.4	9.3
Heb	5806	0.2	5	4.9	10.1
Heb	5910	0	12.8	10.9	23.8
Heb	5908	0	0	0	0
Heb	5906	0.6	34	24.6	59.1
Rock	5514	0	0	0	0
Rock	5612	0	0	0	0
Rock	5512	2.8	57	68.4	128.1
Total		65.0	700.2	809.6	1,574.8
%		4.1	44.5	51.4	100.0

Table 8. Total blue whiting abundance at maturity.

Target area	Strata	Imm	Mature	Spent	Total
S Porc	5112	0	0	0	0
S Porc	5114	1.5	10.9	13.3	25.7
N Porc	5314	117.9	845.1	1027.8	1990.7
N Porc	5312	0	0	0	0
N Porc	5414	0.1	1.0	1.3	2.4
N Porc	5412	22.0	229.5	283.8	535.3
N Porc	5410	51.7	396.2	539.1	987.0
Heb	5510	117.0	1202.7	1664.1	2983.8
Heb	5508	63.5	901.7	1143.8	2109.0
Heb	5610	1.8	15.2	21.4	38.3
Heb	5608	367.0	1142.1	951.6	2460.7
Heb	5710	9.6	28.9	17.4	55.8
Heb	5708	153.6	441.8	259.8	855.3
Heb	5810	0.6	61.1	54.3	116.0
Heb	5808	0.6	24.2	22.2	47.1
Heb	5806	2.2	29.9	29.7	61.8
Heb	5910	0.5	59.0	52.5	112.1
Heb	5908	0.0	0.1	0.1	0.2
Heb	5906	7.0	184.5	151.7	343.3
Rock	5514	0	0	0	0
Rock	5612	0	0	0	0
Rock	5512	33.3	413.4	495.0	941.7
Total		950.1	5,987.3	6,728.9	13,666.3
%		7.0	43.8	49.2	100.0

Table 9. Blue whiting biomass and abundance by strata.

Target area	Strata	No. transects	No. schools	Def schools	Mix schools	Prob schools	% zeros	Def Biomass	Mix Biomass	Prob Biomass	Biomass ('000t)	SSB ('000t)	Abundance millions
S Porc	5112	1	0	0	0	0	100	0.0	0	0	0.0	0.0	0.0
S Porc	5114	1	4	4	0	0	0	3.0	0	0	3.0	2.8	25.7
N Porc	5314	1	27	27	0	0	0	229.3	0	0	229.3	219.7	1,990.7
N Porc	5312	1	0	0	0	0	100	0.0	0	0	0.0	0.0	0.0
N Porc	5414	2	5	5	0	0	0	0.3	0	0	0.3	0.2	2.4
N Porc	5412	2	134	134	0	0	0	65.5	0	0	65.5	63.7	535.3
N Porc	5410	2	84	84	0	0	0	107.5	0	0	107.5	103.2	987.0
Heb	5510	2	132	132	0	0	0	354.3	0	0	354.3	344.5	2,983.8
Heb	5508	2	16	16	0	0	0	271.0	0	0	271.0	265.6	2,109.0
Heb	5610	2	16	16	0	0	0	4.4	0	0	4.4	4.2	38.3
Heb	5608	2	52	52	0	0	0	213.3	0	0	213.3	190.3	2,460.7
Heb	5710	2	22	22	0	0	0	4.7	0	0	4.7	4.3	55.8
Heb	5708	2	38	38	0	0	0	66.5	0	0	66.5	59.7	855.3
Heb	5810	2	8	8	0	0	0	24.6	0	0	24.6	24.5	116.0
Heb	5808	2	28	28	0	0	0	9.3	0	0	9.3	9.3	47.1
Heb	5806	1	13	13	0	0	0	10.1	0	0	10.1	9.9	61.8
Heb	5910	1	11	11	0	0	0	23.8	0	0	23.8	23.7	112.1
Heb	5908	1	2	2	0	0	0	0.0	0	0	0.0	0.0	0.2
Heb	5906	1	30	30	0	0	0	59.1	0	0	59.1	58.6	343.3
Rock	5514	1	0	0	0	0	100	0.0	0	0	0.0	0.0	0.0
Rock	5612	1	0	0	0	0	100	0.0	0	0	0.0	0.0	0.0
Rock	5512	2	80	80	0	0	0	128.2	0	0	128.2	125.4	941.7
Total		34	702	702	0	0	12	1,574.8	0	0.0	1,574.8	1,509.8	13,666.3
Cv (%)		-	-	-	-	-	-	-	-	-	16.0	NA	16

Table 10. Species occurrence from trawl stations.

Category	Common Name	Scientific Name	Occurrence
Pelagic	Blue Whiting	*Micromesistius poutassou*	11
	Mackerel	*Scomber scombrus*	0
	Horse mackerel	*Trachurus trachurus*	0
	Hake	*Merluccius merluccius*	0
Mesopelagics		Arctozenus rissoi	3
	Greater Argentine	*Argentina silus*	3
	Hatchet Fish (small)	*Argyropelecus hemigymnus*	4
	Myctophidae(combined)		0
	Hatchet Fish (large)	*Argyropelecus olfersi*	2
	None	*Astronethus gemmifer*	0
	Myctophidae	*Benthosema glaciale*	0
	Alfonsino	*Beryx decadactylus*	0
	Ray's bream	*Brama brama*	0
	Blackfish	*Centrophagus niger*	0
	Sloanes Viper fish	*Chauliodus sloani*	0
	Myctophidae	*Diaphus raffinesqui*	0
	Myctophidae	*Diaphus metapoclampus*	0
	None	*Diretmus argentus*	0
	None	*Echiostoma barbatum*	0
	Myctophidae	*Electrona rissoi*	0
	Pipefish	*Entelurus aequoreus*	0
	Balbo sabretooth	*Evermanella balbo*	0
	None	*Gonastoma elongatum*	0
	None	*Howella sherborni*	0
	None	*Lampadena speculigera*	0
	Myctophidae	*Lampanyctus crocodilus*	3
	Myctophidae	*Lobianchia gemallari*	0
	Searsids	*Maulisia*	0
	Pearlside	*Maurolicus muelleri*	2
		Melanostomias tentaculatus	
	Myctophidae	*Myctophum punctatum*	0
	Greenland Argentine	*Nansenia groenlandica*	0
	Forgotten argentine	*Nansenia oblita*	0
	Slender snipe-eel	*Nemichthys scolopaceous*	1
	Multipore Searside	*Normichthys operosus*	1
	None	*Notolepis rissoi*	0
	Myctophidae	*Notoscopelus krokeyeri*	7
	None	*Opisthoproctus soleatus*	0
	Shrimps	*Pandalidae*	5
	Silver Pomfret	*Pterycombus brama*	0
	Schnakenbeck's searside	*Sagamichthys schnakenbecki*	0
	None	*Scopelosaurus lepidus*	0
	None	*Searsia koefoedi*	0
	Bean's saw toothed eel	*Serrivomer beani*	0
	None	*Sternoptyx diaphana*	0
	Scaly dragonfish	*Stomias boa*	0
	Myctophidae	*Symbolophoros veranyi*	0
	Greater Pipefish	*Syngnathus acus*	0
	Dealfish	*Trachipterus arcticus*	0
	Bluntsnout smooth-head	*Xenodermichthys copei*	2
	None	*Pseudoscopelus altipinnis*	0
Demersal	Grey Gurnard	*Eutrigla gurnardus*	0
	Silvery Pout	*Gadiculus argentus*	0
	Norway Pout		0
	saithe	*Pollachius Virens*	0
Squid	Lesser flying squid	*Todaropsis elbanae*	0
	Northern flying squid	*Todarodes sagittatus*	0
	Short finned squid	*Omnastrephidae*	0
	Unknown squid		4
Other	Jellyfish		0
	Octopus		1
		Total Number of Trawls	**11**
		Total number of Species:	**14**

Table 11. Irish blue whiting survey time series.

Year	2004	2005	2006	2007	2008	2009	2010	2011	2011	2012	2013	2014
Target	2a	1	2b	1	1	1	1	Survey 1	Survey 2	1	1	1
areas	2b, 2c	2a, 2b		2a, 2b	2a, 2b	2b	2b	1, 2b	1, 2b	2b	2a, 2c	2a-b, 3a
Age												
1	3.0	37.4	4.4	2.4	13.9	2.2	2.5	21.2	1.0	19.8	53.7	20.8
2	108.3	64.0	43.2	31.0	12.5	66.7	1.5	28.9	3.7	4.2	113.2	36.2
3	346.4	500.0	242.5	585.0	128.7	49.9	3.3	35.8	12.6	282.3	346.6	242.4
4	524.0	911.1	636.7	1681.0	1148.0	236.3	8.6	41.8	19.4	124.3	298.5	462.4
5	211.5	1010.0	342.6	1424.0	1445.7	1126.8	15.0	15.0	15.5	79.9	472.6	326.1
6	154.5	311.0	144.7	639.2	762.9	1444.3	81.7	107.3	23.3	155.3	243.4	130.1
7	72.8	111.0	50.4	219.3	200.0	563.6	143.3	255.3	26.8	86.7	39.4	22.3
8	34.7	69.9	18.0	126.2	33.1	117.6	104.2	489.5	85.6	212.3	103.8	41.3
9	4.1	20.5	0.0	14.6	0.0	31.4	19.2	319.2	41.2	514.9	122.8	83.8
10+	15.6	7.9	0.0	5.4	0.0	12.9	5.6	80.7	5.6	745.9	916.9	209.6
TSB ("000 t)	1,474.9	3,042.8	1,482.4	4,727.6	3,744.7	3,651.7	385.0	1,394.7	234.6	2,225.5	2,710.9	1574.8
TSN (millions)	16,029.3	34,268.0	16,344.0	48,746.1	34,179.6	28,512.2	2,365.3	9,057.1	1,590.5	15,530.0	21,577.0	13,666.00
SSB ("000 t)	1,471.9	3,001.0	1,478.1	4,725.2	3,726.4	3,647.9	382.6	1,373.5	233.6	2,203.4	2,464.3	1509.8

*Note: 2012 onwards survey estimate calculated using the new TS-length relationship.
Target area 1: Hebrides; Target area 2a: north Porcupine Bank; Target area 2b: Rockall; Target area 2c Faroe/Shetland. 3a south Porcupine Bank.

Table 12. Sightings, counts and group size ranges for cetacean species recorded during the survey.

Species	nr. sightings	nr. individuals	nr. calves - Juveniles	range of group-size
Grey seal	1	1		1
Common dolphin	3	10	2 - 0	2 - 6
Long-finned pilot whale	16	97	7 - 6	2 - 25
Bottlenose dolphin	1	10		6
Sperm whale	6	7		1 - 2
Unidentified beaked whale	1	1		1
Unidentified dolphin	2	11		5 - 6
Unidentified small whale	1	1		1
Total	31	138		

Table 13. Details of daily effort, species richness and location throughout the survey period.

Date	Start	End	Effort (mins)	Species	Platform	Area
25/03/2014	08:00	11:15	240	9	Bridge	Inshore West Cork
26/03/2014	08:00	18:00	360	7	Bridge Deck	Porcupine Bank
27/03/2014	10:10	18:00	300	9	Bridge Deck	Porcupine Bank
28/03/2014	08:03	18:05	277	6	Bridge Deck	Rockall Trough
29/03/2014	08:00	17:56	357	7	Bridge Deck	Rockall Trough
30/03/2014	13:00	17:45	240	8	Bridge Deck	Rockall Trough
31/03/2014	08:23	17:55	350	6	Bridge Deck	Rockall Trough
01/04/2014	09:25	18:00	360	9	Bridge Deck	Rockall Trough
02/04/2014	07:59	15:10	229	8	Bridge Deck	Rockall Trough
03/04/2014	08:11	18:00	350	7	Bridge Deck	Rockall Trough
04/04/2014	13:00	18:02	180	10	Bridge Deck	Rockall Trough
05/04/2014	11:16	18:05	300	8	Bridge Deck	Rockall Trough
06/04/2014	09:50	17:35	240	10	Bridge Deck	Outer Hebrides
07/04/2014	08:39	15:50	220	11	Bridge Deck	Outer Hebrides/West Donegal
Total			4003	15		

Table 14. Daily totals for all seabird species recorded between 25th March and 7th April 2014. Species codes: F. = Fulmar; Blue F. = Blue Fulmar; MX = Manx Shearwater; OT = Sooty Shearwater; GX = Gannet; SA = Shag; NX = Great Skua; BH = Black-headed Gull; KI = Kittiwake; LB = Lesser Black-backed Gull; YG = Yellow-legged Gull; HG = Herring Gull; GZ = Glaucous Gull; GB = Great Black-backed Gull; RA = Razorbill; GU = Guillemot; RAGU = unidentified Razorbill/Guillemot; PU = Puffin. Figures in *italics* represent totals of birds recorded as 'off survey', i.e. in association with the survey vessel or outside of dedicated survey time, thus separate to 'on survey' totals (non-italics) which are to be used for abundance and density estimates.

	25th Mar	26th Mar	27th Mar	28th Mar	29th Mar	30th Mar	31st Mar	1st Apr	2nd Apr	3rd Apr	4th Apr	5th Apr	6th Apr	7th Apr	Total
F.	74	28	233	428	901	240	333	201	214	45	538	190	163	68	3656
							5	*33*	*361*		*7*	*10*	*6*	*1*	*423*
Blue F.	1		5	1	6		2	5	1		2	2			25
	1		*3*	*5*	*11*			*3*	*2*		*3*				*28*
OT															0
			1										*1*		*2*
MX	20	3	2	1				1				1		5	33
	5	*2*	*2*												*9*
GX	82	24	136	164	127	178	54	295	186	39	54	62	88	167	1656
			1					*200*	*509*	*4*			*2*	*1*	*717*
SA													1		1
															0
NX		17	12		5	1	6	3	3	1	2	5			55
		20	*5*		*4*				*1*		*3*	*1*		*2*	*36*
BH										1			1		2
											1				*1*
KI	9	60	150	56	95	32	29	30	25	30	12	35	10	53	626
		24	*13*		*3*	*2*	*6*			*3*		*2*			*53*
LB	1		5		5	12	2	2	1	6	1	2		1	38
	3	*1*	*18*	*3*		*10*	*2*	*4*	*3*	*5*	*15*	*15*	*6*	*10*	*95*
YG															0
											1				1
HG	5														5
	6										*4*		*9*	*2*	*21*
GZ					1										1
															0
GB	2			1		1	2								6
	1		1	4	1			3	1		25		7	4	47
GU	4					35		19	6	1	7	4	7	72	155
						1					*6*				*7*
RA	19					1		2				1		2	25
									1						1
RAGU	1								2			2	1	13	19
															0
PU		1												3	4
			1												1
Total	218	133	543	651	1140	500	428	558	438	123	616	304	271	384	6307
	16	*47*	*45*	*12*	*19*	*13*	*13*	*243*	*878*	*12*	*65*	*28*	*31*	*20*	*1442*

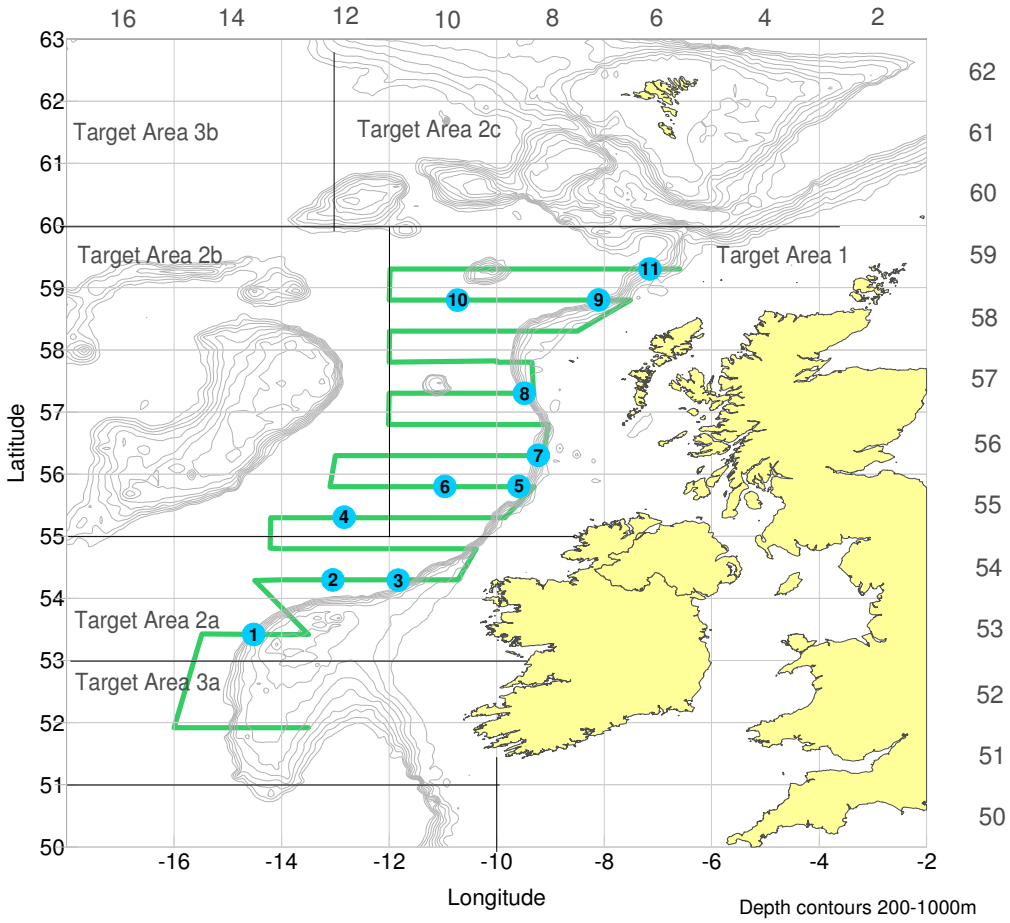


Figure 1. Cruise track and trawl station positions and stratified target areas.

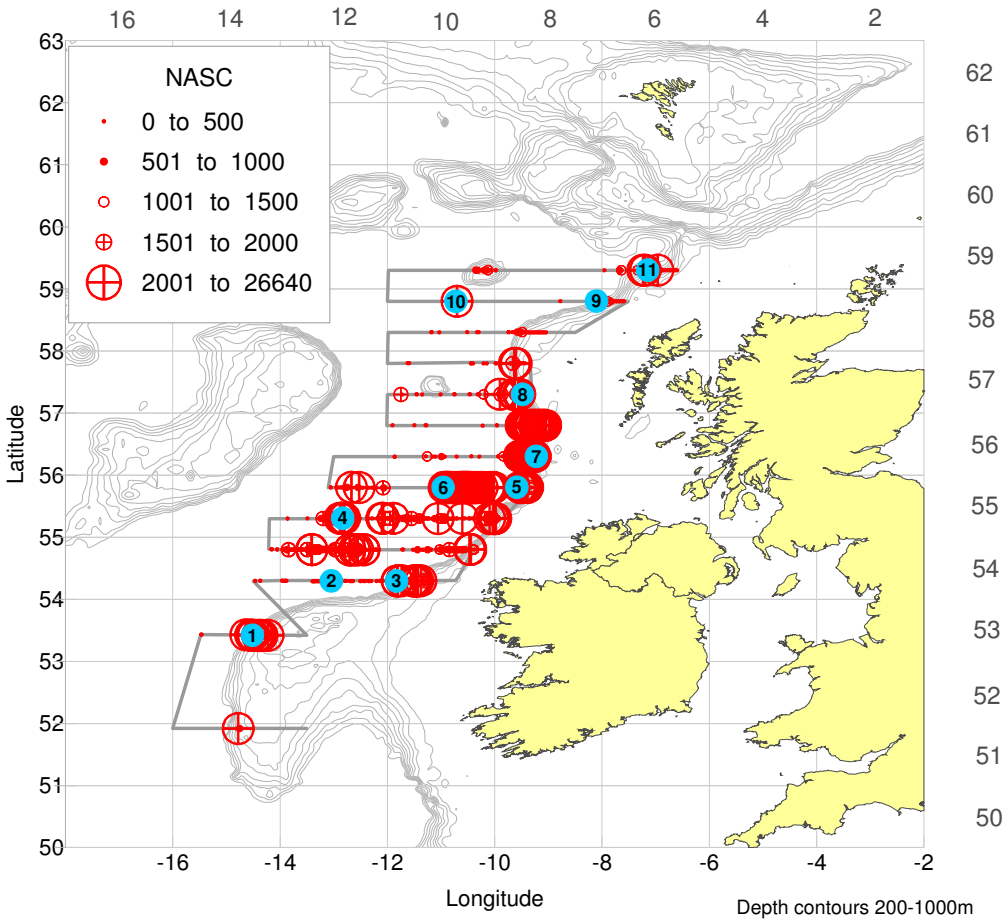
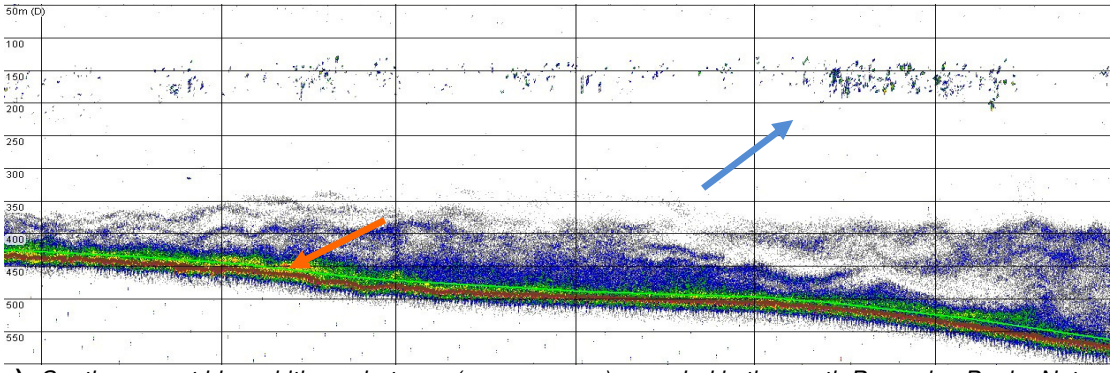
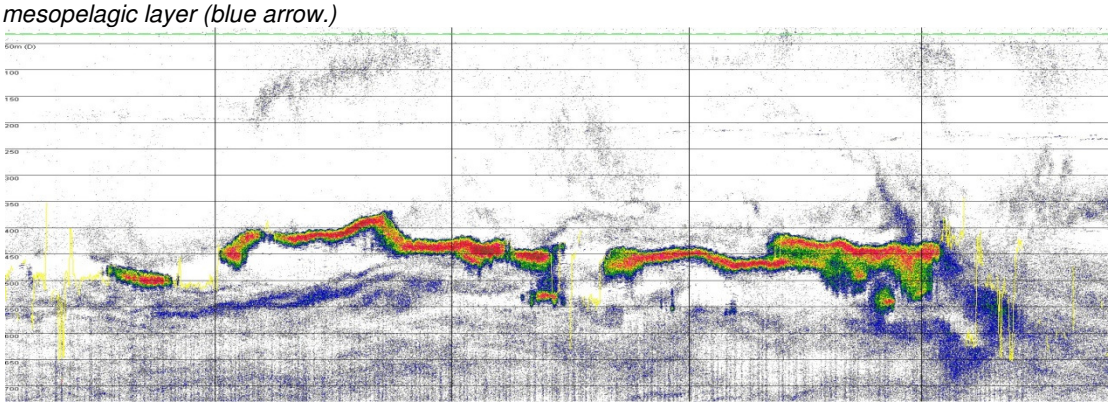


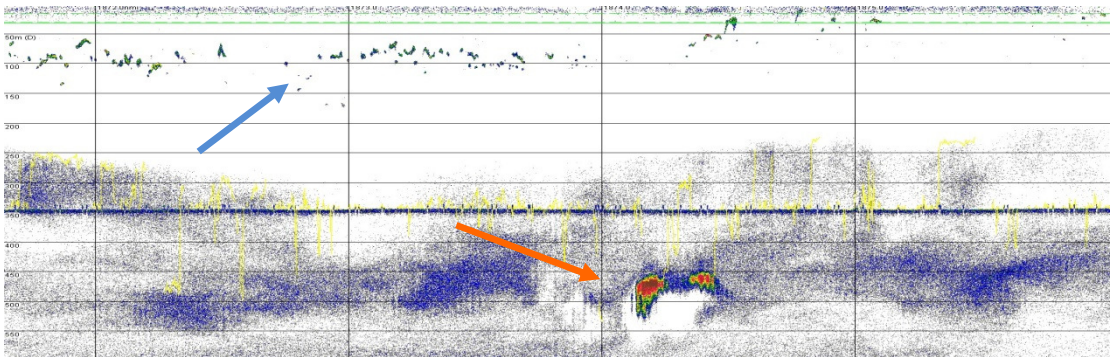
Figure 2. Blue whiting distribution as determined from survey data (NASC values).



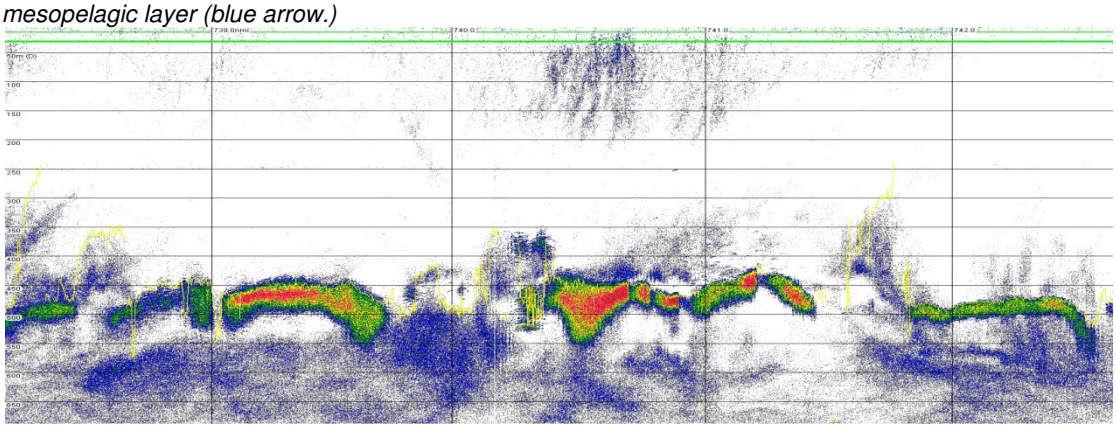
a). *Southern most blue whiting echotraces(orange arrow) recorded in the south Porcupine Bank . Note mesopelagic layer (blue arrow.)*



b). *The highest density blue whiting echotrace observed during the survey, recorded prior to Haul 05 on the shelf edge at 56ºN.*



c). *A high density echotrace containing large blue whiting layer (orange arrow) sampled during Haul 10 south of the Rosemary Bank. This sample contained the highest mean length of survey trawls. Note mesopelagic layer (blue arrow.)*



d). *Western most blue whiting echotraces recorded in the Rockall Trough prior to Haul 04 at 13ºW.*

Figures 3 a-d. Echotraces recorded on an EK60 echosounder (38 kHz) with images captured from Echoview. Note: Vertical bands on echogram represent 1nmi (nautical mile) intervals. Depth scale is shown in 50m intervals.

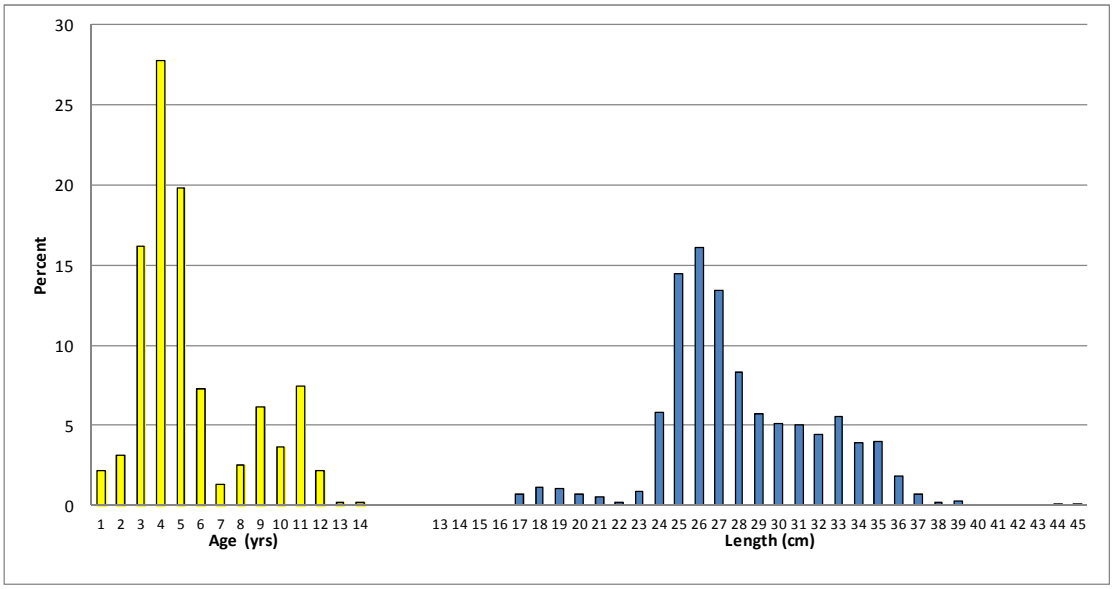


Figure 4. Combined age (left) and length (right) composition of blue whiting trawl samples.

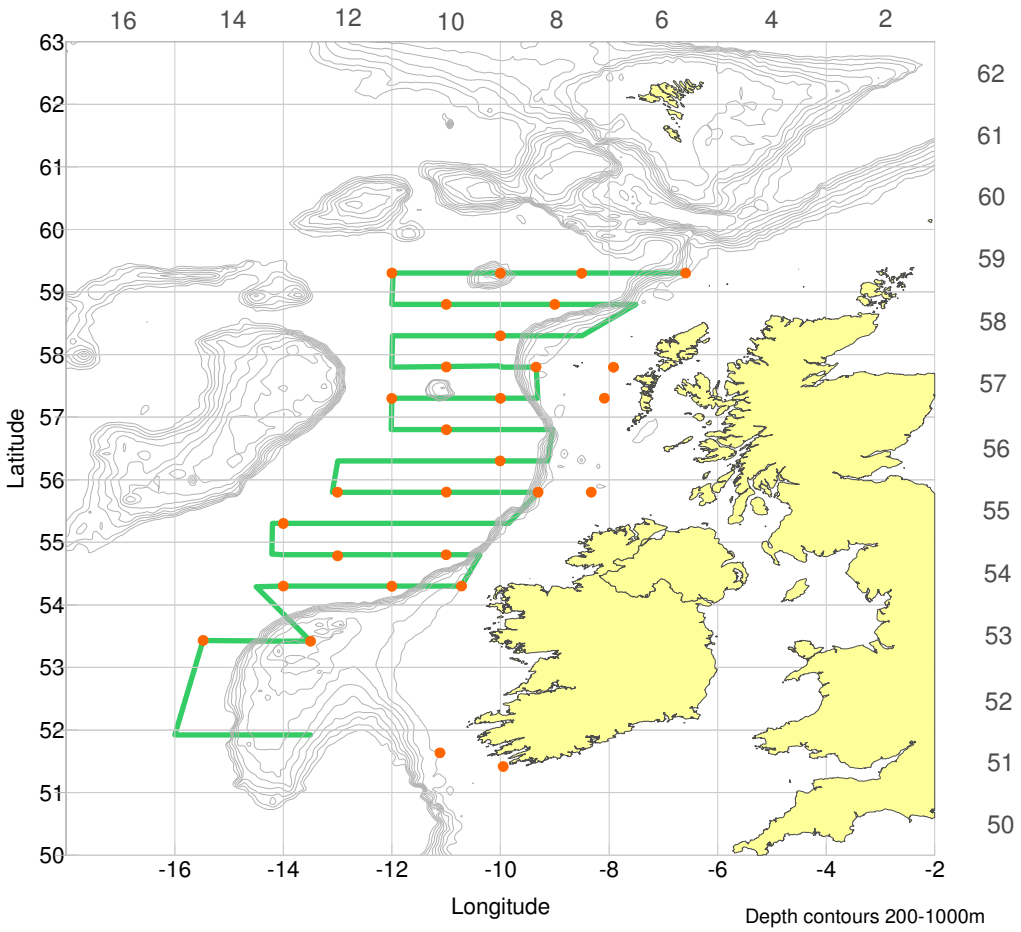


Figure 5. Position of hydrographic stations (orange points). Note: Open water stations were carried out to a maximum depth of 1000m.

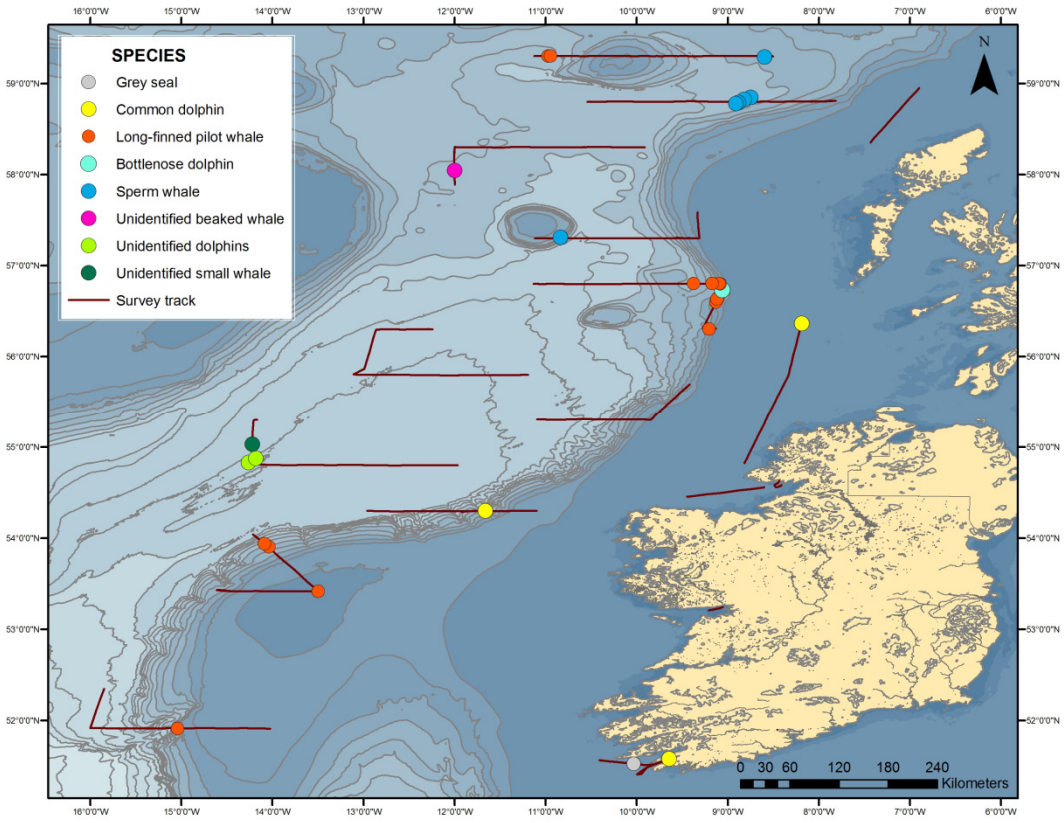


Figure 6. Geographical map of the visual survey effort (survey track), and the sighting locations of the marine mammals recorded between 22 March and 10 April 2014.

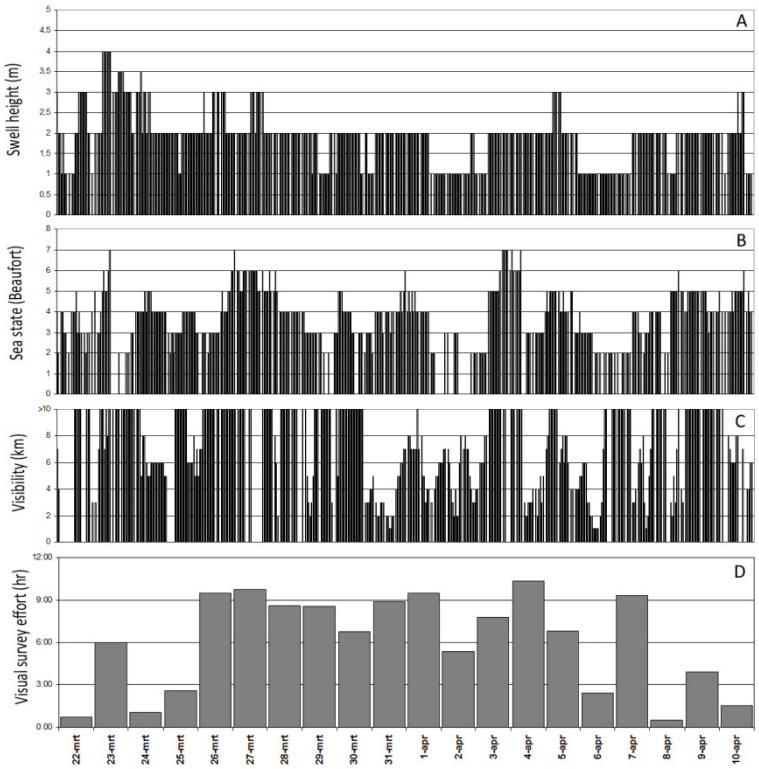


Figure 7. Summary of the environmental conditions and survey effort recorded between 22 March and 10 April 2014. A) swell height (m); B) Beaufort sea state; C) visibility (km); and D), visual survey effort (hr).

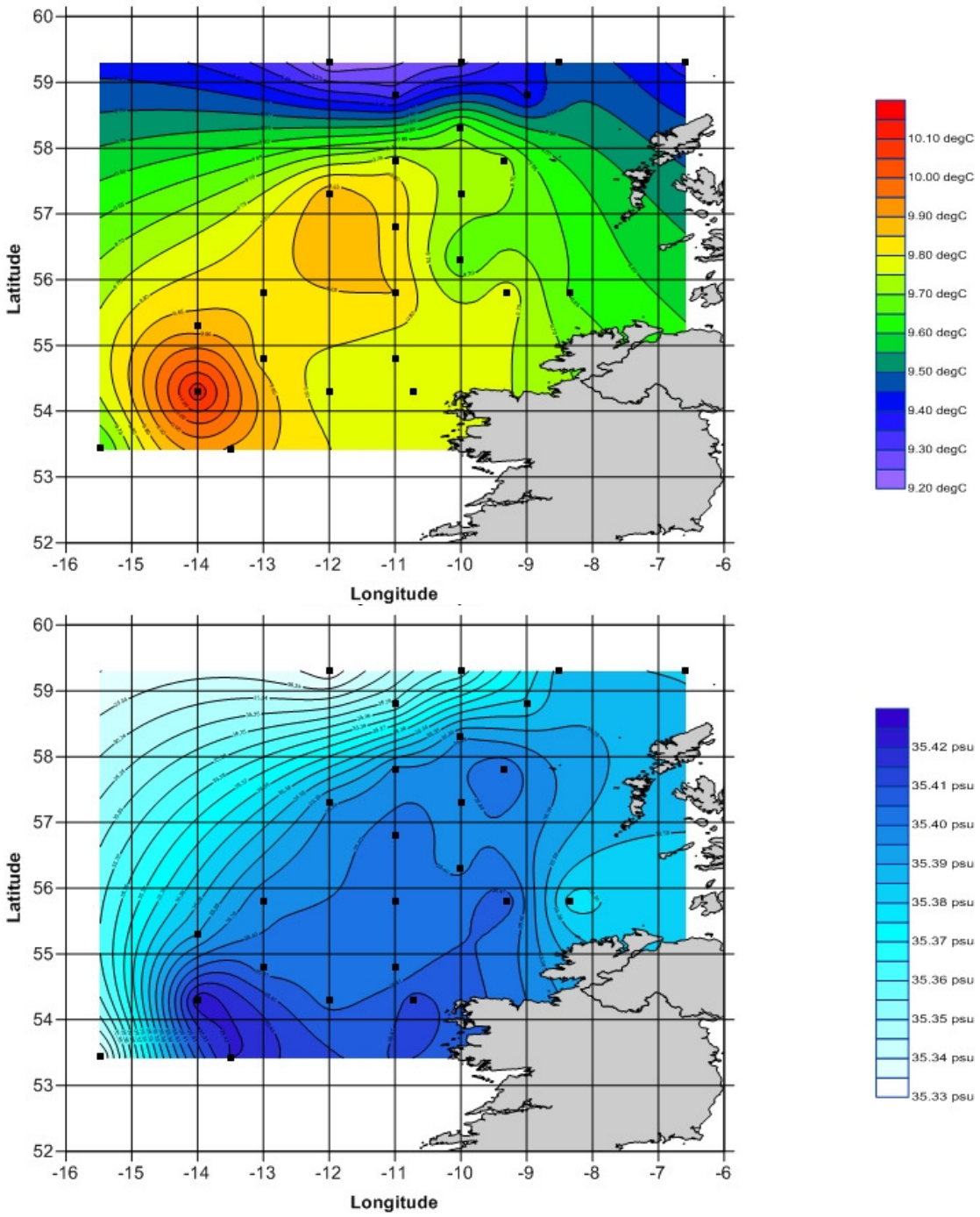


Figure 8. Horizontal temperature (top) and salinity (bottom) at 10m as compiled from Irish CTD stations (black dots).

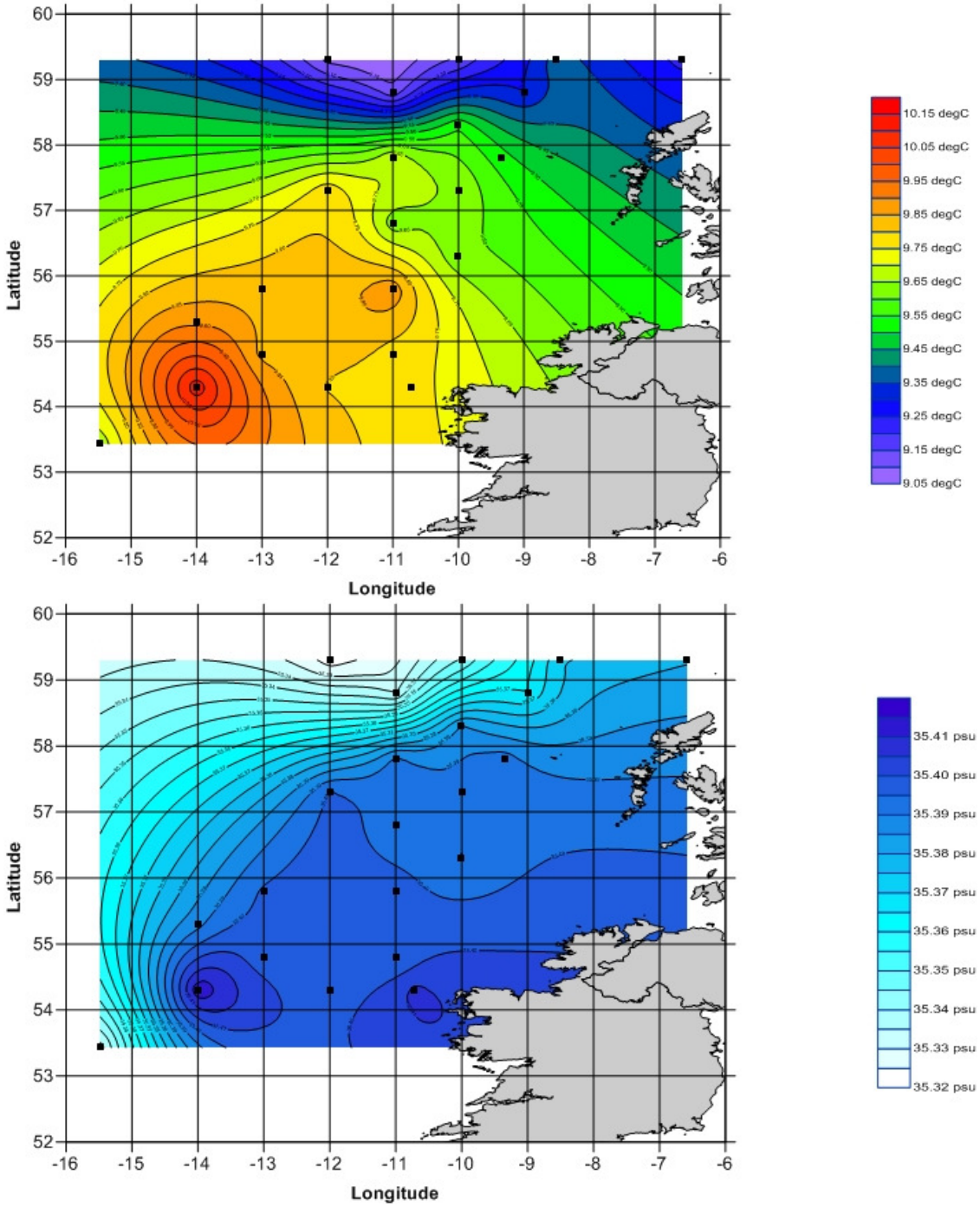


Figure 9. Horizontal temperature (top) and salinity (bottom) at 200m as compiled from Irish CTD stations (black dots).

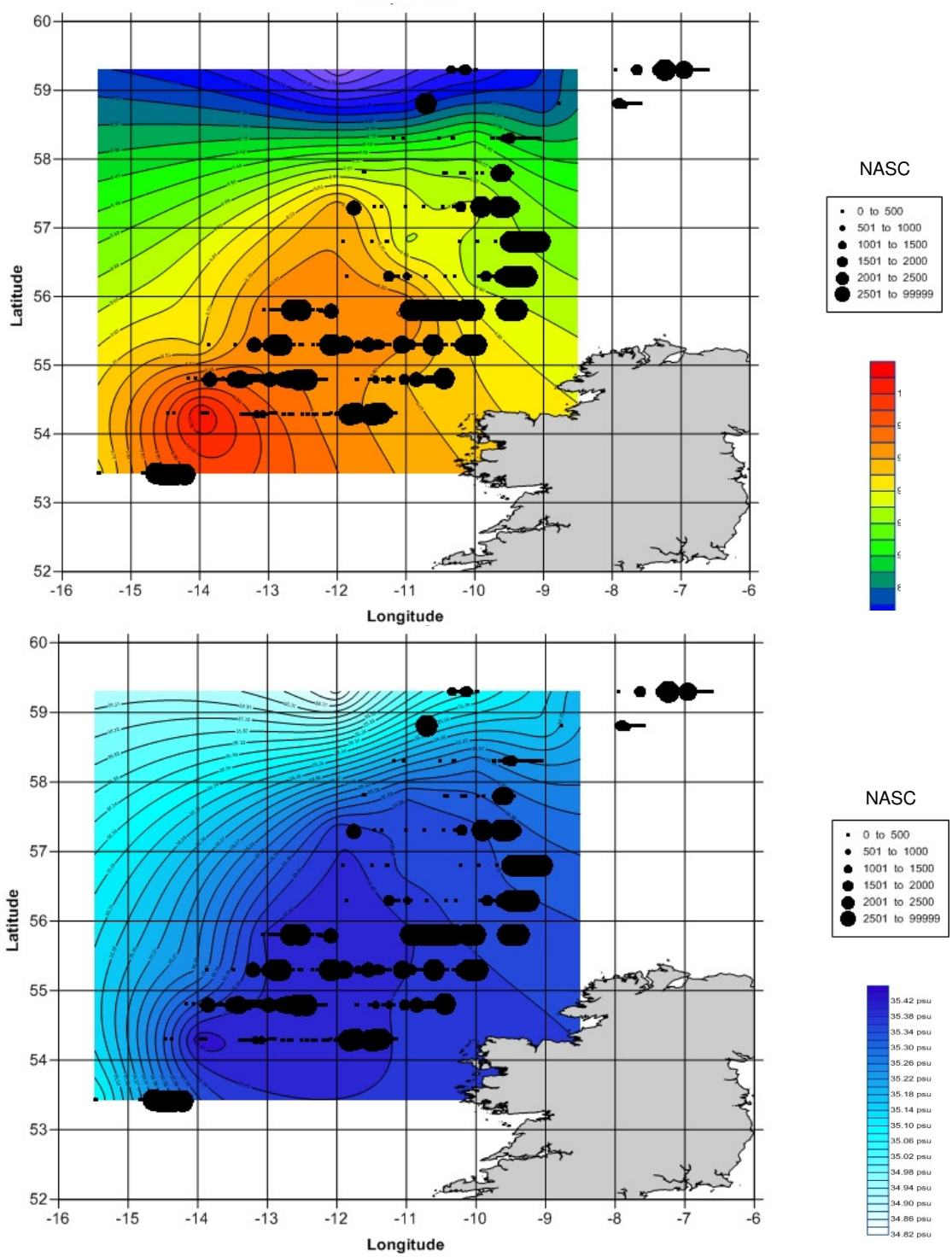


Figure 10. Habitat plot of horizontal temperature (top) and salinity (bottom) at 400m overlaid proportional NASC values from acoustic observations (black circles). NASC observations outside of temp/sal profiles are due to rejected/compromised CTD data.

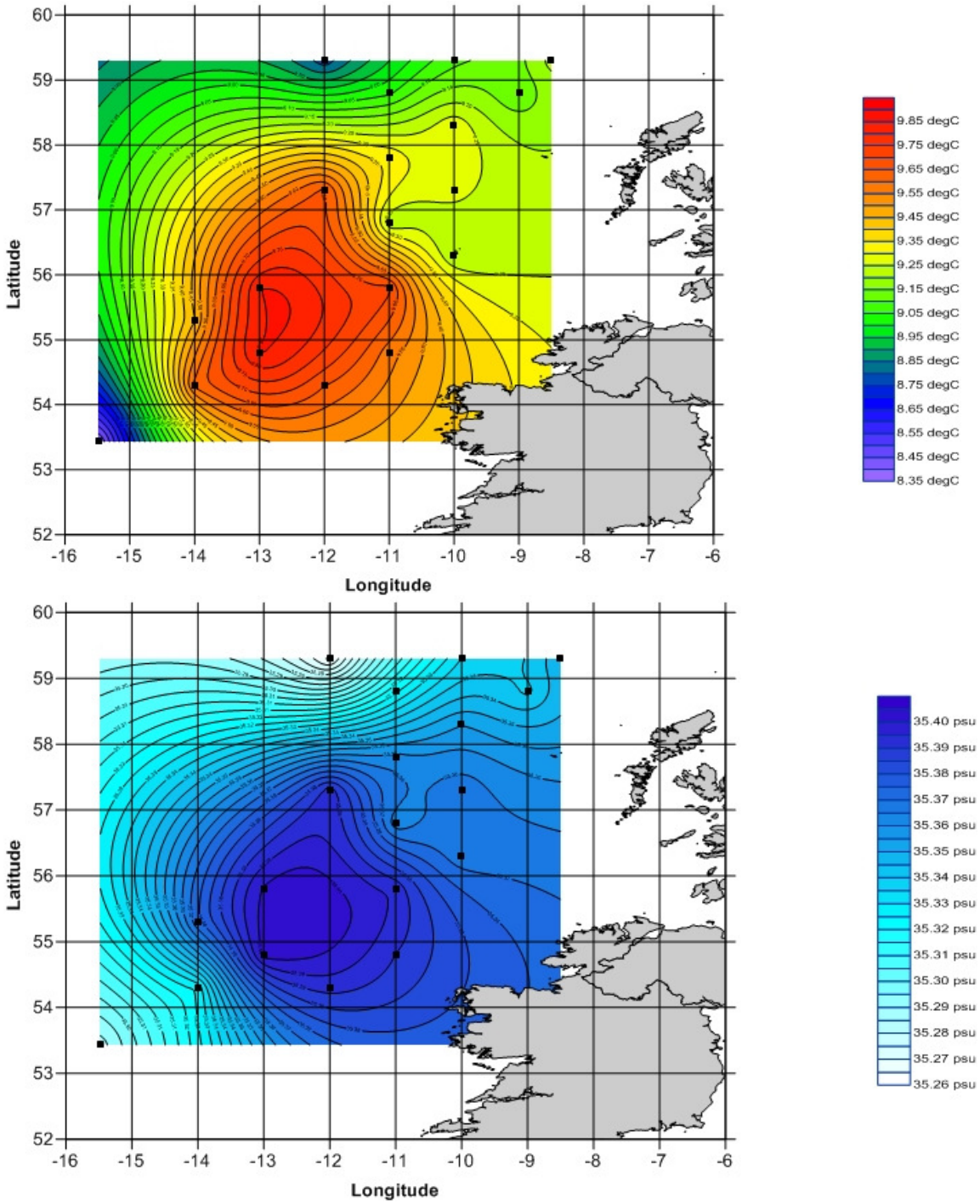
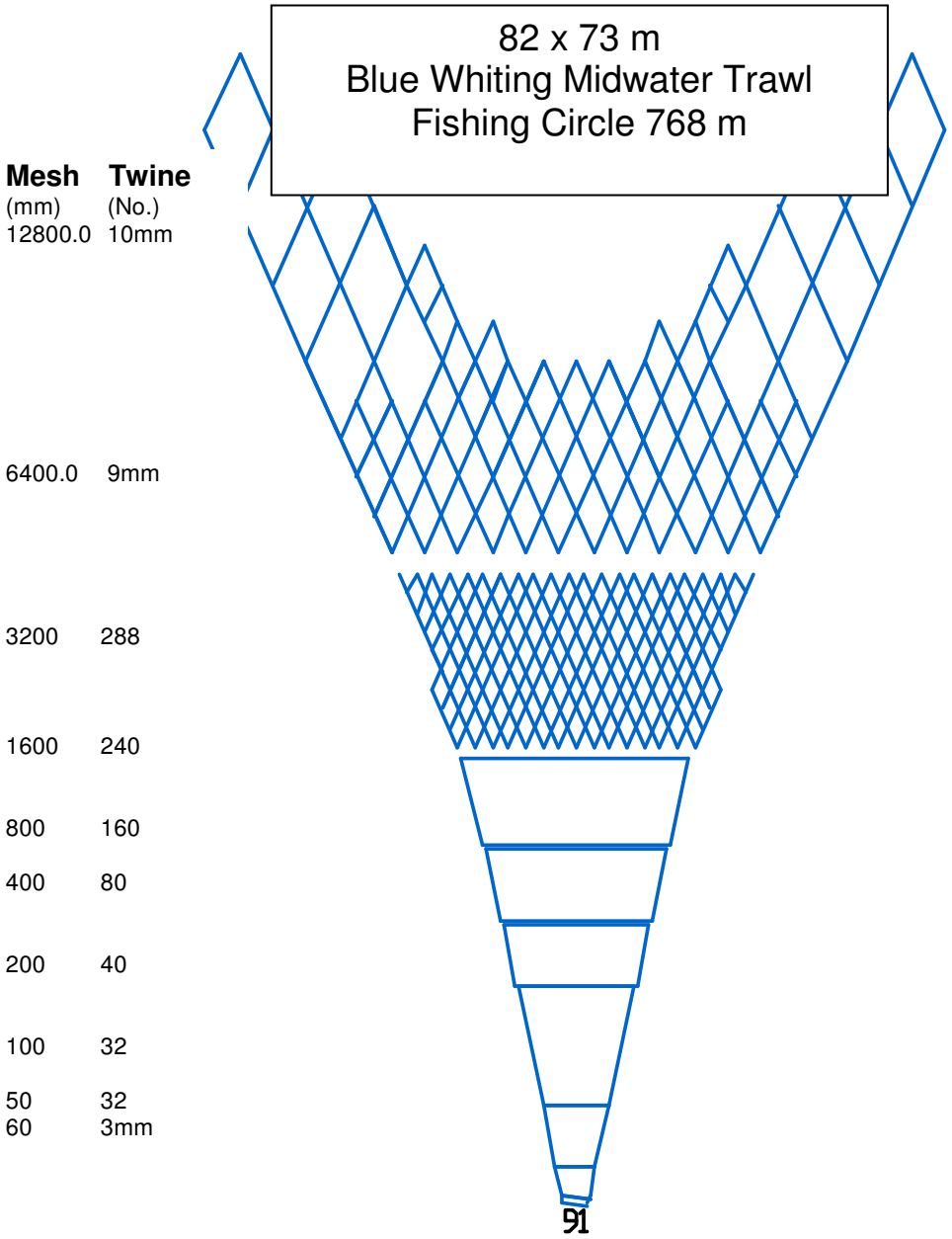


Figure 11. Horizontal temperature (top) and salinity (bottom) at 600m as compiled from Irish CTD stations (black dots).



Net specifics	
Clump weights:	1000 Kg per side
Trawl doors:	Polyice pelagic 6m^2 (750Kg weight in air)
Bridle length:	80m
Door spread:	170m
Vertical net opening:	50m

Figure 12. Pelagic midwater trawl employed during the survey.

Appendix

SEABIRD SPECIES ACCOUNT

Fulmar *(Fulmarus glacialis)*
The most abundant seabird observed with a corrected total of 3656 individuals recorded during survey periods. The highest single day total relates to 901 birds on 29th March over the Rockall Trough, West of Malin More, Co. Donegal. Over 360 birds were recorded in association with the survey vessel during sample trawls for fish on 2nd April.

A maximum, uncorrected total of 53 'blue' fulmars were recorded throughout the survey period. These darker colour morphs represent individuals from the High Arctic breeding range of the species. The majority of 'blue' fulmars recorded were of the 'Light' (L) or 'Dark' (D) type. A single 'Double Dark' (DD) bird was noted on 29th March.

'Blue' fulmar © Machiel Oudejans

Sooty Shearwater (*Puffinus griseus*)
Two seen. Singles noted on the Porcupine Bank shelf edge, West of Co. Mayo on 27th March and near the Flannan Isles, Outer Hebrides on 6th April.

Manx Shearwater *(Puffinus puffinus)*
Seen infrequently and in small numbers during the survey with a maximum, uncorrected total of 42 birds recorded, 25 of which were on 25th March along inshore waters off West Cork. The most Northerly record of manx shearwater during the survey related to a single bird seen on 5th April, approximately 80 nautical miles West-Northwest of Sula Sgeir, Outer Hebrides.

Gannet *(Morus bassanus)*
Gannet was the second most frequently observed species during the survey, with a corrected total of 1656 individuals recorded during survey periods. Up to 500 gannets were sometimes found in association with the survey vessel during sample trawls for fish. The large majority of birds observed were adults or 5th calendar year birds. Only of handful of immature birds were noted.

Gannets foraging during a sample trawl © Machiel Oudejans

Shag (*Phalacrocorax aristotelis*)
A single shag was seen near the Flannan Isles, Outer Hebrides on 6th April.

Great Skua (*Stercorarius skua*)
Present throughout the survey period with small numbers of birds regularly recorded following the survey vessel. A maximum, uncorrected total of 91 birds were recorded. The highest single day count of 37 was noted over the Southern end of the Porcupine Bank on 26th March.

Great skua © Macheil Oudejans

Puffin *(Fratercula arctica)*
A total of 5 birds were seen on three dates during the survey.

Razorbill (*Alca torda*)
A maximum, uncorrected total of 26 razorbills were recorded along inshore waters or over the top of the Eastern Rockall Trough shelf edge break closest to land.

Guillemot (*Uria aalge*)
A maximum, uncorrected total of 162 guillemots were recorded along inshore waters or over the top of the Eastern Rockall Trough shelf edge break closest to land. Individuals showing plumage characteristics of Northern (*aalge*) and Southern (*albionis*) populations were identified.

Kittiwake *(Rissa tridactyla)*
Kittiwake was the third most frequently observed species during the survey, with a corrected total of 626 individuals recorded. The single highest day total was of 150 birds seen over the Western edge of the Porcupine Bank on 27th March.

Black-headed Gull (*Chroicocephalus ridibundus*)
A total of three single adult birds were recorded migrating North, far out to sea over the Rockall Trough on 3rd, 4th and 6th April respectively. It is likely that these birds were on their way to breeding grounds in Iceland.

Black-headed Gull © Machiel Oudejans

Lesser Black-backed Gull (*Larus fuscus graellsii*)
Present throughout the survey, with a maximum, uncorrected total of 133 birds recorded, most often associating with the survey vessel. The majority of birds observed were adults, with only a small number of near-adult or immature birds seen.

Herring Gull (*Larus argentatus*)
Seen infrequently in small numbers, associating with the survey vessel. A maximum, uncorrected total of 26 birds were recorded along inshore waters.

Yellow-legged Gull (*Larus michaellis*)
A single adult was identified on 4th April, approximately 60 nautical miles Northwest of St. Kilda, Outer Hebrides, associating with the survey vessel during sample trawls for fish. Yellow-legged gull is classified as a rarity in Scotland by the Scottish Rare Birds Committee. As such, a full description and series of pictures has been submitted for assessment.

Yellow-legged gull © Machiel Oudejans

Glaucous Gull (*Larus hyperboreus*)
A single 1st winter bird was noted in association with the survey vessel on 29th March.

Glaucous gull © Machiel Oudejans

Great Black-backed Gull (*Larus marinus*)
Seen frequently throughout the survey period in small numbers, associating with the survey vessel. A maximum, uncorrected total of 53 birds was recorded with the highest single day count of 25 on 4th April.

SPECIES ACCOUNTS: TERRESTRIAL AND COASTAL BIRDS

Oystercatcher (*Haematopus ostralegus*)
Two records of single birds flying around the survey vessel, each on 1st and 4th April.

Collared Dove (*Streptopelia decaocto*)
A single bird landed on the deck of the survey vessel on 6th April, approximately 33 nautical miles West of the Butt of Lewis, Outer Hebrides.

Collared Dove © Machiel Oudejans

Skylark (*Alauda arvensis*)
A single bird circling the survey vessel early on the morning of 1st April associated with a period of heavy sea mist and light South-easterly winds, approximately 80 nautical miles West of Tiree, Outer Hebrides.

Redwing (*Turdus iliacus*)
A single flock of c.500 birds circling the survey vessel early on the morning of 1st April associated with a period of heavy sea mist and light South-easterly winds, approximately 80 nautical miles West of Tiree, Inner Hebrides. Followed by records of 9 on 2nd April, 5 on 3rd April and 1 on 4th April.

Redwing © Niall Keogh

Robin (*Erithacus rubecula*)
One caught inside the dry laboratory of the survey vessel early on the morning of 1st April associated with a period of heavy sea mist and light South-easterly winds, approximately 80 nautical miles West of Tiree, Outer Hebrides.

Robin © Niall Keogh

Wheatear (*Oenanthe oenanthe*)
A male and female seen circling and landing on the survey vessel early on the morning of 1st April associated with a period of heavy sea mist and light South-easterly winds, approximately 80 nautical miles West of Tiree, Outer Hebrides.

Wheatear © Niall Keogh

Meadow Pipit (*Anthus pratensis*)
A single bird flying around the survey vessel on 28th March, approximately 150km West the Mullet Peninsula, Co. Mayo.