FSS Survey Series: 2012/01

Blue Whiting Acoustic Survey Cruise Report

March 21- April 11, 2012

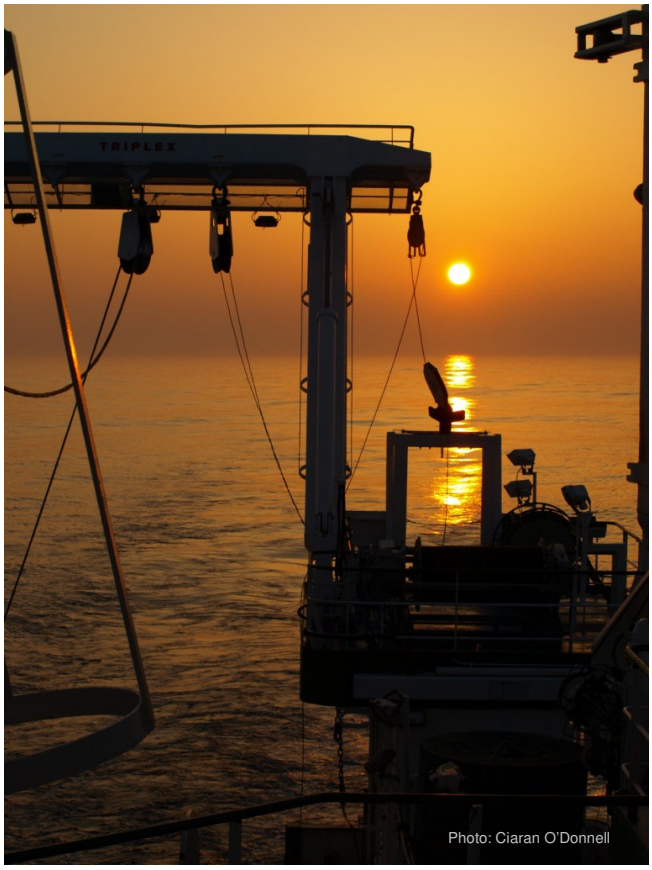

Photo: Ciaran O'Donnell

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1 Introduction

Acoustic surveys on blue whiting (*Micromesistius poutassou*) 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 break 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 2012 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 Brennholm (Norway). 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 and biomass index the blue whiting spawning stock in western waters. The combined survey report is presented annually at the WGIPS meeting held in December. The information presented here relates to the Irish survey.

2 Materials and Methods

2.1 Scientific Personnel

Name	Institute	Capacity
Ciaran O'Donnell (SIC)	FSS	Acoustics
Cormac Nolan	FSS	Acoustics
Graham Johnston	FSS	Acoustics
Matthias Shaber	VTI-FS	Acoustics
Eugene Mullins	FSS	Biologist
Thomas Moeller	DTU	Biologist
John Power	GMIT	MMO

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 2011
- 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
- Collected ichthyoplankton samples to determine presence/absence of mackerel and horse mackerel eggs on the Rockall Bank and shelf edge
- 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 Scotland and the Western Isles (Figure 1). Coverage extended from the shelf slopes (250 m) westward to the western flanks of the Rockall Bank. The survey was carried out in continuity from south to north.

Transect design and effort allocation was pre-agreed for each vessel at the l WGIPS meeting in 2011. A parallel transect design was used to allow transect interlacing in co-surveyed target areas (east-west orientation). Offshore, transects extended to the 19° W. Transect spacing was set at 30 nmi for individual vessels and maintained throughout the survey.

In total, the Irish survey covered 57,960 nmi² using 2,119 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 ER60 was calibrated in Donegal Bay on March 22 at the start of the survey and again in Killary Harbour 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.

2.3.4 Acoustic data acquisition

EK60 "RAW files" were logged via a continuous Ethernet connection as "EK5" files to the vessels server and the ER60 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.

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

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)

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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 10). 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 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 (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 (NASC) per nautical mile were averaged over one nautical mile, 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 (ρ_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 TS= 20 $\log_{10}$ – 65.2 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.

3 Results

3.1 Blue whiting abundance and distribution

A total of 15 directed trawls were carried out during the survey (Figure 1, Table 2). All hauls contained blue whiting as the dominant species both by weight and numbers.

In total 1,051 schools were positively identified as blue whiting during the analysis (Table 9). Blue whiting behaviour during the spawning season allows for ease of identification as they are by far the most abundant species in the area and also due to their presence in a defined depth layer (350-550m) as homogeneous schools. This combined with the positive identification from trawl samples allowed for 100% allocation of schools in the definitely blue whiting category.

The second most frequently encountered species was the Myctophid *Benthosema glaciale* present in 93% of hauls (Table 10). The presence of mesopelagic species within trawl catches is regarded as an incidental by-catch, a consequence of the passage of the trawl through the mesopelagic layer (70-200 m) to the target blue whiting layer (350-550 m).

Mackerel were encountered in 7 trawls along the shelf slopes. The presence of mackerel in trawl catches is not unusual along the shelf slopes in the mid Hebrides area.

3.1.2 Blue whiting biomass and abundance

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	15,530	2,225,279	100.0
Mixture	0	0	0.0
Probably	0	0	0.0
Total estimate	15,530	2,225,279	100
Possibly	0	0	
Possible estimate			
SSB Estimate			
Definitely	14834	2,203,438	100.0
Probably	0	0	0.0
Mixture	0	0	0.0
SSB estimate	14834	2,203,438	100

3.1.3 Blue whiting distribution

In the Rockall target area a small number (n=17) of low density blue whiting schools were observed (Figure 2 & 3a). The overall contribution to the total estimate was low accounting for 0.1% to the total stock biomass (TSB) and total stock numbers (TSN) respectively. Samples taken from this area were composed of larger mature individuals and contained no immature fish as compared to core spawning areas along the shelf edge (Table 3). This is most likely related to the open water location (>550m) of these particular trawl samples. Immature blue whiting are commonly observed on the Rockall Bank itself (<350m depth) year round.

In the Hebrides area and further south blue whiting schools were predominantly concentrated in a narrow band along the shelf edge and composed of numerous (n=761) high density schools. The bulk of the biomass observed during the survey was located within the Hebrides area and contributed over 94% to the TSB and TSN respectively. The individual school with the highest acoustic value was located in the Hebrides area along the shelf edge at 57°N (Figure 3c).

The northern part of the Porcupine target area was also covered by the survey. This area contributed over 5% to the TSB and TSN respectively. As only the northern Porcupine area was covered during this survey it is not possible to accurately report abundance in this area due to incomplete coverage. However, this area was comprehensively covered by the other participants in the survey, namely the Dutch vessel the RV *Tridens.*

3.1.4 Blue whiting stock structure

During the survey 680 fish were aged with length, weight, sex, maturity and stomach fullness data recorded. A further 1,433 fish were measured and weighed. Age analyses of otiliths showed individuals from 1 to 13-years old from trawl samples.

The age structure of survey stock was dominated by 3 strong year classes namely the 10, 9 and 3-year old fish respectively. Together these year classes represented 64% of the TSB and 62% of the TSN.

In terms of biomass this breaks down as; 10-year old fish 28% (623,900t), 9-year old fish 23% (514,900t) and 3-year old fish 13% (282,200t). In terms of abundance: 10-year old fish 23% (3,603 million individuals), 9-year old fish 20% (3,109 million individuals) and 3-year old fish 19% (2,956 million individuals).

The stock age structure within the survey area was consistent with commercial landing sampled in Killybegs before the start of the survey by landings from the international fleet, namely Norway.

Maturity analysis of samples (international data) revealed that 25% 1-year old fish were mature, 59% of 2-year old fish and 99% of 3-year old fish. Of the mature fish sampled a high proportion were actively spawning or spent indicating the spawning was still underway.

The input of the newly recruited 3-year old fish changes the dynamic from older fish which have dominated the age structure of the stock for several years. The first signal of this year class (2009 year class) was first observed during the 2011 survey as 2-year old pre-recruits. However, as this survey is not a good indicator of immature biomass and it wasn't until this year class was almost fully recruited to the spawning stock (97% maturity international data) that it could be confidently included as part of the SSB.

Immature fish were found in the highest concentrations within the Hebrides area, where the bulk of the stock was located. Immature fish were generally taken mixed with mature blue whiting. Observations made during the survey identified an area where low density schools of immature blue whiting were located above denser schools containing spawning fish (Figure 3b).

3.2 Oceanography

Overall 19 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 were compiled using international data from 150 individual casts (Figures 6-9).

3.2 Inter-vessel calibration

An acoustic and fishing intercalibration exercise was carried out with the RV Tridens (Netherlands) on April 5 to the north of the Hebrides (Figure 1). The result of the exercise are presented in Appendix 1.

4 Discussion and Conclusions

4.1 Discussion

Overall, the survey objectives were carried out as planned and no time was lost due to bad weather. Exceptional weather conditions allowed for complete track coverage including the southern Rockall Bank and an additional acoustic calibration at the end of the survey.

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 as robust as the stock was considered well contained within the survey area (international coverage), the survey was carried out in a short time period (14 days in total) and comprehensive trawl sampling was undertaken.

Close agreement of the age structure of blue whiting from commercial landings and trawl samples was achieved and this will help to increase the precision of the stock estimates.

4.2 Conclusions

As this survey forms part of larger cooperative survey covering the entire spawning range of the stock it is difficult to take the results from this survey as an indicator of the state of the stock over the entire area.

The presence of immature fish (1-2 years old) within the survey area is encouraging, although the estimates of abundance of young fish from this survey cannot be used for quantitative assessment as they are not considered reliable. The presence of young fish on the survey grounds are thought to be part of the residual nursery stock and not yet a component of the recruiting/recruited migratory stock. That said indications of a strong year class may be visible due to the increased numbers on the grounds. Such was the case of the current 3-year old fish which were tracked through from one-year olds in the Faroes/Shetland during the international survey.

Work currently being undertaken on the sub-polar gyre indicates that we may now be entering a positive phase in the cycle which in the past has been linked to strong blue whiting year classes. However, it is very early and it is not possible to predict what effect this will have on current blue whiting spawning success and recruitment. What does appear evident is that the blue whiting stock is prone to episodic recruitment interspersed with strong year classes.

The presence of mackerel in trawl catches is not unusual as there is a degree of overlap between the blue whiting spawning season and on the onset of mackerel spawning. Preliminary results from GULF net stations used to determine mackerel egg presence/absence in this area would indicate mackerel spawning is underway and this would account for the increased occurrence within the survey area.

Acknowledgements

We would like to express our thanks and gratitude to Anthony Hobin (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. Matthias Schaber (VTI_FS, Germany) and Thomas Moller (DTU Aqua, Denmark) for there help and expertise during the survey.

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Table 1. Survey settings and calibration report for the Simrad ER60 echosounder. Blue whiting survey, March-April 2012.

Echo Sounder System Calibration

Vessel :	R/V Celtic Explorer	Date :	23/3/2012
Echo sounder :	ER60 PC	Locality :	Donegal Bay
Type of Sphere :	WC-38,1	TS_{Sphere}: -33.50 dB (Corrected for soundvelocity or t,S)	Depth(Sea floor) : 30 m

Calibration Version 2.1.0.11

Comments:
CE11005.BWAS.Stornaway. 27.03.11. 38 khz

Reference Target:

TS	-33.50 dB	Min. Distance	15.00 m
TS Deviation	5.0 dB	Max. Distance	25.00 m

Transducer: ES38B Serial No. 30227

Frequency	38000 Hz	Beamtype	Split
Gain	25.93 dB	Two Way Beam Angle	-20.6 dB
Athw. Angle Sens.	21.90	Along. Angle Sens.	21.90
Athw. Beam Angle	6.92 deg	Along. Beam Angle	6.91 deg
Athw. Offset Angle	- 0.06 deg	Along. Offset Angl	-0.09 deg
SaCorrection	-0.62 dB	Depth	5.5 m

Transceiver: GPT 38 kHz 009072033933 1 ES38B

Pulse Duration	1.024 ms	Sample Interval	0.190 m
Power	2000 W	Receiver Bandwidth	2.43 kHz

Sounder Type:
ER60 Version 2.2.0

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.	9.7 dB/km	Sound Velocity	1490.5 m/s

Beam Model results:

Transducer Gain =	25.89 dB	SaCorrection =	-0.66 dB
Athw. Beam Angle =	6.98 deg	Along. Beam Angle =	7.03 deg
Athw. Offset Angle =	-0.06 deg	Along. Offset Angle=	-0.07 deg

Data deviation from beam model:
RMS = 0.17 dB
Max = 0.70 dB No. = 226 Athw. = -3.1 deg Along = -4.1 deg
Min = -0.94 dB No. = 242 Athw. = 4.6 deg Along = -1.0 deg

Data deviation from polynomial model:
RMS = 0.14 dB
Max = 0.52 dB No. = 226 Athw. = -3.1 deg Along = -4.1 deg
Min = -0.62 dB No. = 217 Athw. = 4.4 deg Along = -1.4 deg

Comments :

Wind Force : **Wind Direction :**
Raw Data File: \\Expfiledstr\ER-60_Data\BWAS_2011\RAW ER60 Files\Calibration\BWAS_2012
Calibration File: \\Expfiledstr\ER-60_Data\ER-60\Calibrations_2012\BWAS 2012\38 kHz

Calibration : Ciaran O'Donnell

Table 2. Catch composition, time and location of trawl hauls. Blue whiting survey, March-April 2012.

No.	Date	Lat. N	Lon. W	Time	Bottom (m)	Target (m)	Bulk Catch (Kg)	Sampled (Kg)	Blue Whiting %	Mackerel %	Meso %	Herring %	Others %
1	27.03.12	54 56.11	016 03.71	07:53	1765	520	80.3	80.3	85.3		13.8		0.9
2	28.03.12	54 53.79	015 03.99	00:01	>2000	500	83.3	83.3	90.4		9.6		
3	29.03.12	54 22.00	011 58.15	00:28	2000	400	240.0	92.2	96.5		3.5		
4	29.03.12	54.51.82	010.29.11	16:15	600	400	139.5	139.5	99.0		1.0		
5	30.03.12	55 21.89	011 37.17	12:54	>2000	500	400.0	118.8	98.9		1.1		
6	30.03.12	55 19.25	010 04.87	22:11	868	400	750.0	119.2	99.4	0.4	0.2		
7	01.04.12	56 21.66	009 18.31	00:17	876	400	500.0	77.6	99.3		0.7		
8	01.04.12	56 51.76	009 11.73	09:42	1000	380	2,500.0	165.0	96.4	3.3	0.2		0.1
9	02.04.12	57 21.99	010 25.73	02:37	>1000	420	350.0	117.4	98.4		1.6		
10	02.04.12	57 21.78	009 24.50	09:20	900	400	5,000.0	147.4	96.6	1.4			2.0
11	03.04.12	58 21.78	009 23.66	13:14	700	450	1,500.0	122.5	99.4	0.2	0.4		
12	04.04.12	58 51.60	007 58.29	04:54	1000	370	2,500.0	117.8	99.5	0.4	0.1		
13	05.04.12	59 21.03	008 37.13	05:03	>1000	410	2,200.0	117.9	98.9		1.1		
14*	05.04.12	59 35.66	006 39.34	19:36	730	335	500.0	30.0					
15	05.04.12	59 21.26	006 50.26	22:58	680	310	350.0						

* Inter-calibration trawl with RV Tridens

Note: "Others" was used to represent fish and non-fish species occurring in the catch see Table 6.

Table 3. Length frequency distribution of blue whiting from trawl samples. Blue whiting survey, March-April 2012.

Haul	1	2	3	4	5	6	7	8	9	10	11	12	13	15	
length (cm)															Total
13				1											1
13.5						1									1
14															0
14.5						1									1
15				2		1									3
15.5						1								1	2
16				3								1		4	8
16.5						1								1	2
17				2								1	1	3	7
17.5														2	2
18				3		1			1	2	1		1	7	16
18.5						1								2	3
19				1							1			2	4
19.5											1				1
20						1					1				2
20.5															0
21											1				1
21.5															0
22														1	1
22.5															0
23				2				1			1			1	5
23.5	1		1								1		1		4
24		2	5	3	1	1	1	3			1	2	1	2	22
24.5			5		1	3		4	1	9	1	3	2	3	32
25	1		1	1	1	1	1	1	1	1	1	1	1	1	13
25.5	2	2	2		2	2	2	2	2	2	2	2	2	2	26
26	3	3	3	3	3	3	3	3	3	3	3	3	3	2	41
26.5	2	2	2		2	2	2	2			2	2	2	2	22
27	3	3	3	3	3	3	3	3	3	3	3		3	2	38
27.5	4	4	5		4	4	4	4	4	4	4	4	4	3	52
28	4	4	5	5	4	4	4	4	4	4	4	4	4	3	57
28.5	2		2		2	2	2	2	2	2		2	2		20
29	7	7	8	9	7	7	7	7	7	6	7	7	6	5	97
29.5	3	3	3		3	3	3	3	3	3	3	3	3	2	38
30	6	6	7	8	6	6	6	6	6	6	6	6	6	5	86
30.5	3	3			3	3	3	3	3	3	4	3	3	3	37
31	13	14	16	17	14	14	13	13	14	13	14	13	13	10	191
31.5	6	6	7		6	6	6	6	6	6	6	6	6	5	78
32	12	12	14	16	12	12	12	12	13	11	13	12	12	9	172
32.5	6	6			6	6	6	6	6	6	6	6	6	5	71
33	5	5	5	6	5	5	5	5	5	4	5	5	5	4	69
33.5	3	3	4		3		3	3	3	3	4	3	3	3	38
34	4	4		5	4	4	4	4	4	4	4	4	4	3	52
34.5	2	2			2		2	2	2	2		2	2	2	20
35	3	3		3	3		3	3	3	3		3	3	2	32
35.5	2	2	2		2		2		2	2		2	2	2	20
36	3	3		3		3	3					3	3	2	23
36.5		1											1		2
37		1		3					1	1				1	7
37.5	1						1		1	1				1	5
38	1			1										1	3
38.5															0
39				1											1
39.5															0
40					1										1
40.5															0
41	1							1							2
41.5															0
42															0
42.5															0
43											1				1
Total	103	101	100	101	100	102	101	103	100	104	101	103	105	109	1,433

Table 4. Blue whiting length at age (years) as abundance (millions) and biomass (000's tonnes).. Blue whiting survey, March-April 2012.

Length (cm)	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	Abund (mils)	Biomass 000's t	Mn wt (g)
13	1.7													1.7	0.0	11.8
13.5	9.2													9.2	0.1	13.2
14														0.0	0.0	0.0
14.5	9.2													9.2	0.2	16.2
15	8.0													8.0	0.1	17.9
15.5	14.1													14.1	0.3	19.7
16	85.6													85.6	1.9	21.7
16.5	28.2													28.2	0.7	23.7
17	79.4													79.4	2.1	25.9
17.5	37.9													37.9	1.1	28.2
18	225.6													225.6	6.9	30.6
18.5	33.0													33.0	1.1	33.2
19	62.8													62.8	2.3	35.9
19.5	23.3													23.3	0.9	38.8
20	27.9													27.9	1.2	41.8
20.5														0.0	0.0	0.0
21	23.3													23.3	1.1	48.2
21.5														0.0	0.0	0.0
22			9.5											9.5	0.5	55.3
22.5														0.0	0.0	0.0
23			45.2											45.2	2.9	63.0
23.5			36.8											36.8	2.5	67.1
24		26.7	160.1											186.8	13.4	71.4
24.5		26.8	374.2	53.6										454.6	34.5	75.9
25		2.9	95.7	2.9										101.6	8.2	80.6
25.5			302.5											302.5	25.8	85.4
26			362.5	47.6										410.1	37.1	90.5
26.5			195.9	39.3										235.2	22.5	95.7
27			288.2	92.7	10.2									391.1	39.6	101.1
27.5			439.9	165.2										605.0	64.6	106.8
28			398.0	144.6	36.3	36.3								615.2	69.3	112.6
28.5			67.1	89.5		22.4		22.4						201.4	23.9	118.6
29			180.3	361.6	120.9	120.9	120.9		60.4	60.4				1025.3	128.1	124.9
29.5				64.5	16.1	112.9	48.4	32.3	48.4	80.7				403.4	53.0	131.4
30					41.6	209.9	125.7	84.1	125.7	294.0	41.6			922.7	127.4	138.1
30.5					67.0	50.0	33.5	67.0	117.0	150.6				485.2	70.3	145.0
31					67.6	135.2	135.2	268.4	940.2	471.1	32.8			2050.5	311.9	152.1
31.5				27.3	27.3	82.7	27.3	165.3	275.3	275.3	27.3			907.5	144.7	159.5
32					164.3	164.3		245.4	573.9	657.0		40.6		1845.5	308.3	167.1
32.5						28.9	28.9	116.3	262.3	320.8	116.3			873.3	152.8	174.9
33						61.0	30.9	61.0	274.9	274.9	15.1			717.7	131.3	183.0
33.5								90.5	120.3	240.6			29.8	481.1	92.0	191.3
34						24.9		24.9	172.8	345.0		24.9		592.3	118.4	199.9
34.5								16.0	32.0	127.6	16.0	16.0		207.5	43.3	208.7
35							20.1	40.5	60.7	121.6	40.5			283.4	61.7	217.8
35.5									32.0	95.7	32.0	32.0		191.5	43.5	227.1
36							12.7	12.7	12.7	50.7	25.3	25.3		139.3	33.0	236.7
36.5										5.8	5.8			11.6	2.9	246.6
37								25.3			12.6			38.0	9.7	256.7
37.5										23.8			11.9	35.6	9.5	267.1
38										7.5			3.8	11.3	3.1	277.8
38.5														0.0	0.0	0.0
39								1.7						1.7	0.5	300.0
39.5														0.0	0.0	0.0
40												9.1		9.1	2.9	323.3
40.5														0.0	0.0	0.0
41											4.6	4.6		9.3	3.2	347.9
41.5														0.0	0.0	0.0
42														0.0	0.0	0.0
42.5														0.0	0.0	0.0
43												23.3		23.3	9.3	400.6
Total														15,529.8	2,225.3	
SSN (mil)	-	54.9	2,933.9	1,085.5	551.2	1,049.2	583.5	1,273.7	3,108.5	3,602.8	369.8	175.7	45.4	14,834.0		
SSB ('000s t)	-	4.1	280.5	124.0	79.9	155.3	86.7	212.3	514.9	623.9	69.9	42.2	9.9		2,203.4	
Mn Wt (g)	29.6	74.0	95.5	114.1	144.9	148.0	148.5	166.7	165.6	173.2	188.9	240.2	218.2			
Mn length (cm)	17.9	24.5	26.6	28.3	30.7	30.9	30.9	32.2	32.1	32.6	33.5	36.1	35.2			

Table 5. Total blue whiting biomass at age. Blue whiting survey, March-April 2012.

Target area	Strata	0	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
Porc N	5410	0	0.5	0.3	12.9	5.3	3.2	6.1	3.4	8.5	18.7	20.6	2.1	1.1	0.3	83.2
	5412	0	0	0.1	3.1	1.2	0.6	1.3	0.6	1.4	3.7	3.8	0.3	0.2	0.1	16.3
	5414	0	0	0	2.2	1	0.7	1.4	0.9	2.1	4.9	6.4	1.1	0.4	0.1	21.1
	5416	0	0	0	0.1	0.1	0	0.1	0	0.1	0.3	0.4	0.1	0	0	1.2
	5418	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rockall	5518	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5516	0	0	0	0.2	0.1	0.1	0.1	0.1	0.1	0.4	0.5	0.1	0	0	1.6
	5616	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5618	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	5514	0	0	0	0.1	0	0	0.1	0	0.1	0.2	0.3	0	0	0	0.8
Hebrides	5510	0	1.1	0.5	35.7	16.7	10.3	20.2	11.1	26	65.7	77.8	8.3	6.5	0.5	280.4
	5508	0	0.1	0	2.6	1.3	0.8	1.5	0.9	2.1	5.1	6.5	0.8	0.4	0.1	22.2
	5608	0	0	0.7	34.5	14.9	9.1	17.8	9.9	24.1	59.1	71.4	8.7	4.2	0.9	255.2
	5610	0	0	0	1.1	0.5	0.3	0.6	0.4	0.9	2.1	2.7	0.3	0.2	0.1	9.2
	5708	0	1.4	1	57.5	26.4	16.1	31.6	17.3	46.1	106.5	133.8	15.5	5.7	3	461.8
	5710	0	0.1	0.1	5.2	2.4	1.5	3	1.6	4.3	9.9	12.5	1.4	0.5	0.3	42.9
	5808	0	4.7	0.6	67.8	29.4	20.7	39.8	21.2	50.4	128.7	144.2	11.9	13.4	1.6	534.3
	5810	0	0.1	0	1.6	0.7	0.5	0.9	0.5	1.2	3	3.3	0.2	0.3	0	12.3
	5806	0	0.1	0.1	2.7	1.3	0.8	1.6	1	2.3	5.6	7.1	0.9	0.5	0.1	23.8
	5908	0	0.4	0.2	19.5	9	5.6	10.9	6.6	15.3	37.5	48.3	6.9	3.2	0.4	163.8
	5910	0	0.1	0.1	6.9	3.2	2	3.9	2.3	5.4	13.3	17.1	2.4	1.1	0.1	58
	5906	0	11.2	0.6	28.3	10.7	7.4	14.2	8.8	21.7	50	66.8	8.8	4.3	2.3	235.1
	5512	0	0	0	0.2	0.1	0.1	0.1	0.1	0.2	0.5	0.6	0.1	0.1	0	2
Total		0	19.8	4.2	282.2	124.3	79.9	155.3	86.7	212.3	514.9	623.9	69.9	42.2	9.9	2,225.5
%		0	0.9	0.2	12.7	5.6	3.6	7	3.9	9.5	23.1	28	3.1	1.9	0.4	100

Table 6. Total blue whiting abundance at age. Blue whiting survey, March-April 2012.

Target area	Strata	0	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
Porc N	5410	0	20.3	4.6	139.4	46.7	22.2	41.8	23.0	48.7	114.6	120.9	10.9	5.5	1.5	600.2
	5412	0	0	1.2	33.2	10.7	4.4	8.7	4.5	9.0	22.6	23.1	1.6	0.8	0.3	120.1
	5414	0	0	0.4	22.6	8.6	5.0	9.3	5.6	12.2	29.0	35.9	5.2	1.9	0.3	135.9
	5416	0	0	0	1.3	0.6	0.3	0.5	0.3	0.7	1.6	2.0	0.3	0.1	0.1	7.7
	5418	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
Rockall	5518	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	5516	0	0	0	1.7	0.7	0.4	0.7	0.4	0.9	2.1	2.6	0.3	0.2	0.1	10.0
	5616	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	5618	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0
	5514	0	0	0	0.9	0.3	0.2	0.4	0.2	0.5	1.2	1.4	0.2	0.1	0.0	5.4
Hebrides	5510	0	48.2	6.2	364.9	145.2	71.1	136.8	75.1	159.2	397.2	452.8	45.3	26.8	2.7	1931.4
	5508	0	2.6	0.4	26.5	10.9	5.4	10.4	6.0	12.6	30.9	36.8	4.1	1.9	0.5	149.0
	5608	0	0	9.4	365.0	130.5	62.5	120.3	66.6	146.2	356.1	413.3	43.8	17.7	4.4	1735.8
	5610	0	0	0.2	10.8	4.4	2.2	4.2	2.4	5.2	12.7	15.4	1.7	0.8	0.2	60.3
	5708	0	46.4	12.5	605.4	234.1	111.2	213.8	116.9	272.0	639.6	763.5	81.5	28.3	13.2	3138.4
	5710	0	3.9	1.0	54.3	21.5	10.4	20.0	10.9	25.4	59.7	71.3	7.6	2.6	1.2	290.0
	5808	0	124.6	7.8	704.3	255.1	143.0	268.2	145.6	308.7	784.9	857.8	69.5	45.3	8.2	3723.1
	5810	0	2.9	0.1	16.2	5.9	3.3	6.2	3.3	7.1	18.1	19.6	1.5	1.0	0.2	85.6
	5806	0	3.2	0.7	28.3	10.8	5.6	11.0	6.4	13.7	33.3	40.1	4.6	2.2	0.3	160.2
	5908	0	14.2	2.5	200.4	78.8	38.5	74.0	43.0	92.0	223.9	273.3	34.6	14.9	2.2	1092.3
	5910	0	5.0	0.9	70.9	27.9	13.6	26.2	15.2	32.6	79.3	96.8	12.2	5.3	0.8	386.7
	5906	0	397.7	8.5	307.5	94.8	51.4	95.6	57.4	125.9	298.9	372.8	44.5	19.9	9.2	1884.3
	5512	0	0.0	0.0	2.5	1.0	0.5	1.0	0.5	1.2	2.9	3.4	0.3	0.2	0.0	13.6
Total		0	669.0	56.5	2,956.0	1,088.7	551.2	1,049.2	583.5	1,273.7	3,108.5	3,602.8	369.8	175.6	45.4	15,529.8
%		0	4.3	0.4	19.0	7.0	3.5	6.8	3.8	8.2	20.0	23.2	2.4	1.1	0.3	100
Cv (%)		NA	18.0	28.0	25.0	24.0	25.0	24.0	23.0	23.0	24.0	22.0	18.0	23.0	18.0	NA

Table 7. Total blue whiting biomass at maturity. Blue whiting survey, March-April 2012.

Target area	Strata	Imm	Mature	Spent	Total
Porc N	5410	0.6	0.8	81.8	83.2
	5412	0.0	0.2	16.1	16.3
	5414	0.0	0.2	20.9	21.1
	5416	0.0	0.0	1.2	1.2
	5418	0.0	0.0	0.0	0.0
Rockall	5518	0.0	0.0	0.0	0.0
	5516	0.0	0.0	1.5	1.6
	5616	0.0	0.0	0.0	0.0
	5618	0.0	0.0	0.0	0.0
	5514	0.0	0.0	0.8	0.8
Hebrides	5510	1.2	2.4	276.7	280.4
	5508	0.1	0.2	21.9	22.2
	5608	0.2	2.3	252.6	255.2
	5610	0.0	0.1	9.1	9.2
	5708	2.3	3.4	456.1	461.8
	5710	0.2	0.3	42.4	42.9
	5808	4.9	4.7	524.7	534.3
	5810	0.1	0.1	12.0	12.3
	5806	0.1	0.2	23.5	23.8
	5908	0.5	1.2	162.1	163.8
	5910	0.2	0.4	57.4	58.0
	5906	11.4	2.0	221.8	235.1
	5512	0.0	0.0	2.0	2.0
Total		21.8	18.6	2,184.8	2,225.3
%		1.0	0.8	98.2	100.0

Table 8. Total blue whiting abundance at maturity. Blue whiting survey, March-April 2012.

Target area	Strata	Imm	Mature	Spent	Total
Porc N	5410	21.5	7.9	570.9	600.2
	5412	0.4	1.7	118.1	120.1
	5414	0.0	1.5	134.4	135.9
	5416	0.0	0.1	7.6	7.7
	5418	0.0	0.0	0.0	0.0
Rockall	5518	0.0	0.0	0.0	0.0
	5516	0.0	0.1	9.9	10.0
	5616	0.0	0.0	0.0	0.0
	5618	0.0	0.0	0.0	0.0
	5514	0.0	0.1	5.3	5.4
Hebrides	5510	50.2	20.0	1,861.1	1,931.4
	5508	2.7	1.5	144.8	149.0
	5608	3.2	20.2	1,712.4	1,735.8
	5610	0.0	0.6	59.7	60.3
	5708	58.3	25.4	3,054.6	3,138.4
	5710	4.9	2.4	282.7	290.0
	5808	126.8	37.6	3,558.7	3,723.1
	5810	3.0	0.8	81.8	85.6
	5806	3.4	1.8	155.0	160.2
	5908	15.4	9.8	1,067.0	1,092.3
	5910	5.5	3.5	377.7	386.7
	5906	400.5	17.2	1,466.6	1,884.3
	5512	0.0	0.1	13.4	13.6
Total		695.8	152.3	14,681.6	15,529.8
%		4.5	1.0	94.5	100.0

Table 8. Species occurrence from trawl stations. Blue whiting survey, March-April 2012.

Common Name	Scientific Name	Occurrence
Blue Whiting	*Micromesistius poutassou*	15
Mackerel	*Scomber scombrus*	7
Horse mackerel	*Trachurus trachurus*	0
Hake	*Merluccius merluccius*	1
Greater Argentine	*Argentina silus*	0
Hatchet Fish (small)	*Argyropelecus hemigymnus*	3
Hatchet Fish (large)	*Argyropelecus olfersi*	2
None	*Astronethus gemmifer*	0
Myctophidae	*Benthosema glaciale*	14
Alfonsino	*Beryx decadactylus*	0
Ray's bream	*Brama brama*	0
Blackfish	*Centrophagus niger*	1
Sloanes Viper fish	*Chauliodus sloani*	5
Myctophidae	*Diaphus raffinesqui*	0
Myctophidae	*Diaphus metapoclampus*	0
None	*Diretmus argentus*	1
None	*Echiostoma barbatum*	0
Myctophidae	*Electrona rissoi*	0
Pipefish	*Entelurus aequoreus*	0
Balbo sabretooth	*Evermanella balbo*	0
None	*Gonastoma elongatum*	3
None	*Howella sherborni*	1
None	*Lampadena speculigera*	0
Myctophidae	*Lampanyctus crocodilus*	0
Myctophidae	*Lobianchia gemallari*	0
Searsids	*Maulisia*	0
Pearlside	*Maurolicus muelleri*	8
Myctophidae	*Myctophum punctatum*	0
Greenland Argentine	*Nansenia groenlandica*	8
Forgotten argentine	*Nansenia oblita*	1
Slender snipe-eel	*Nemichthys scolopaceous*	1
Multipore Searside	*Normichthys operosus*	2
None	*Notolepis rissoi*	10
Myctophidae	*Notoscopelus krokeyeri*	0
None	*Opisthoproctus soleatus*	0
Shrimps	*Pandalidae*	9
Silver Pomfret	*Pterycombus brama*	1
Schnakenbeck's searside	*Sagamichthys schnakenbecki*	0
None	*Scopelosaurus lepidus*	1
None	*Searsia koefoedi*	0
Bean's sawtoothed 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*	2
Bluntsnout smooth-head	*Xenodermichthys copei*	6
None	*Pseudoscopelus altipinnis*	1
Grey Gurnard	*Eutrigla gurnardus*	2
Silvery Pout	*Gadiculus argentus*	0
Norway Pout		0
Lesser flying squid	*Todaropsis elbanae*	0
Northern flying squid	*Todarodes sagittatus*	0
Short finned squid	*Omnastrephidae*	0
Unknown squid		0
Jellyfish		6
Octopus		5
	Total Number of Trawls	**15**
	Total number of Species:	**25**

Table 9. Irish blue whiting survey time series. Blue whiting survey, March-April 2012.
*Note: 2012 survey estimate calculated using the new TS-length relationship for blue whiting.

Year	2004	2005	2006	2007	2008	2009	2010	2011	2011	2012
Target	2a	1	2b	1	1	1	1	Survey 1	Survey 2	1
areas	2b, 2c	2a, 2b		2a, 2b	2a, 2b	2b	2b	1, 2b	1, 2b	2b
Age										
1	3.0	37.4	4.4	2.4	13.9	2.2	2.5	21.2	1.0	19.8
2	108.3	64.0	43.2	31.0	12.5	66.7	1.5	28.9	3.7	4.2
3	346.4	500.0	242.5	585.0	128.7	49.9	3.3	35.8	12.6	282.3
4	524.0	911.1	636.7	1681.0	1148.0	236.3	8.6	41.8	19.4	124.3
5	211.5	1010.0	342.6	1424.0	1445.7	1126.8	15.0	15.0	15.5	79.9
6	154.5	311.0	144.7	639.2	762.9	1444.3	81.7	107.3	23.3	155.3
7	72.8	111.0	50.4	219.3	200.0	563.6	143.3	255.3	26.8	86.7
8	34.7	69.9	18.0	126.2	33.1	117.6	104.2	489.5	85.6	212.3
9	4.1	20.5	0.0	14.6	0.0	31.4	19.2	319.2	41.2	514.9
10+	15.6	7.9	0.0	5.4	0.0	12.9	5.6	80.7	5.6	745.9
11										
12										
13										
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
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
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	14,834.0

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

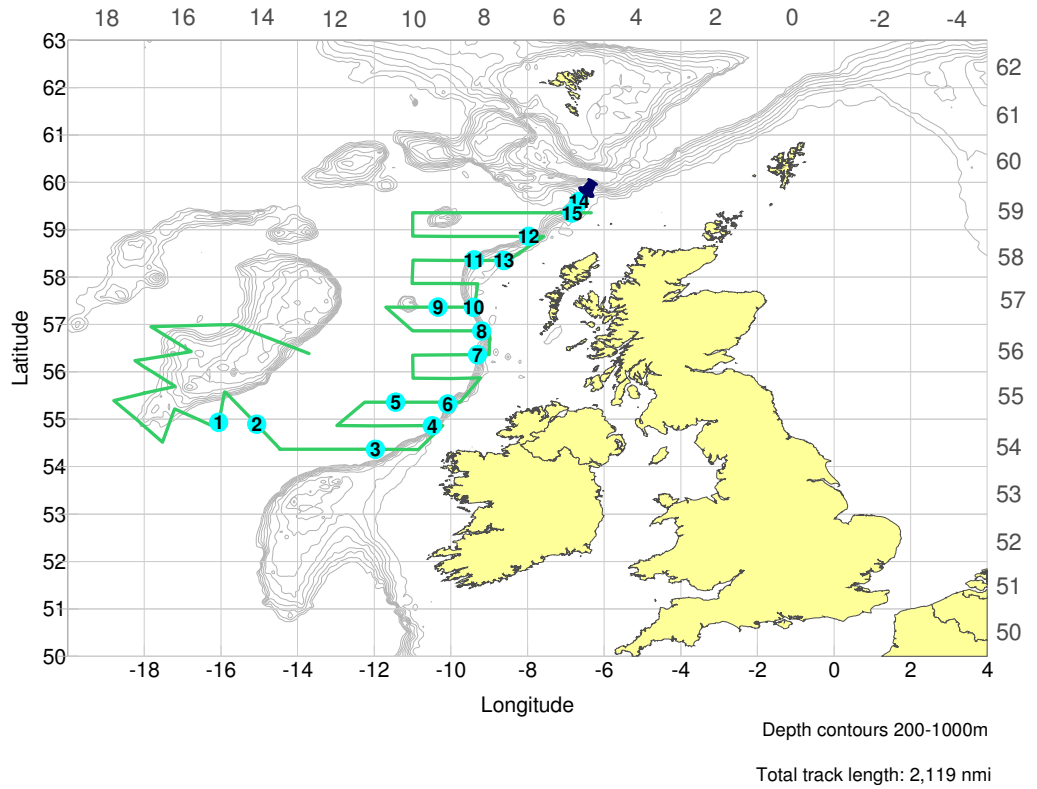


Figure 1. RV Celtic Explorer cruise track showing position of trawl stations. Blue pin indicates intercalibration site with RV *Tridens*. Blue whiting survey, March-April 2011.

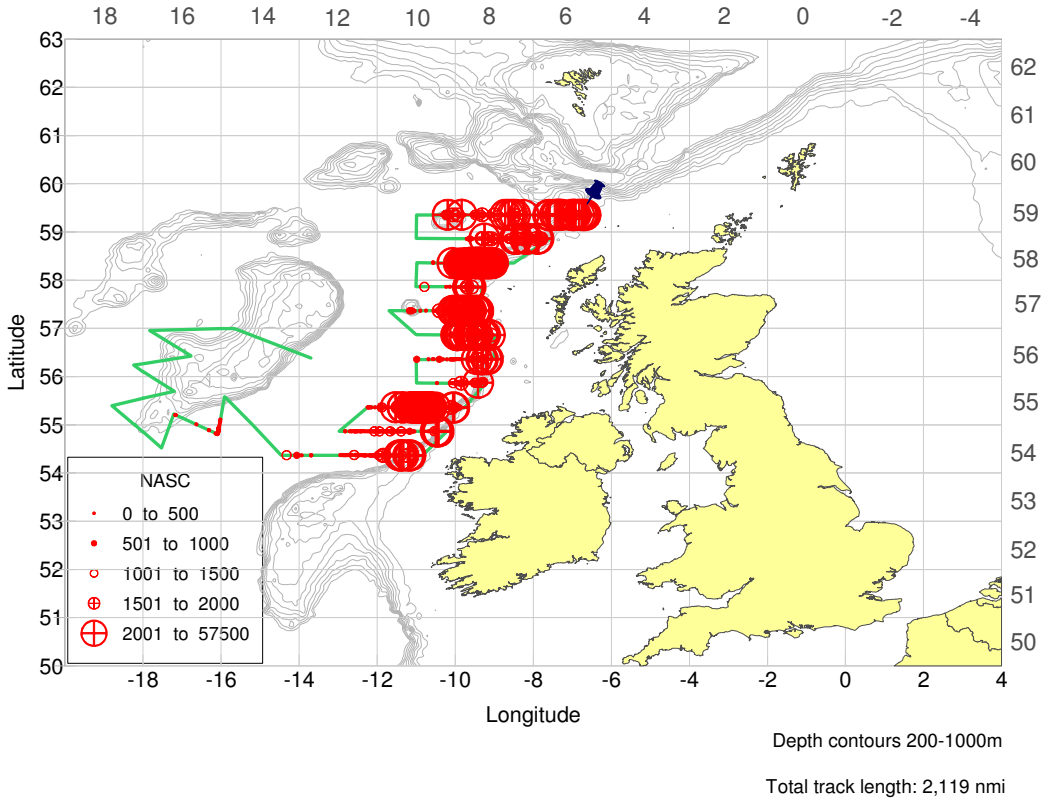
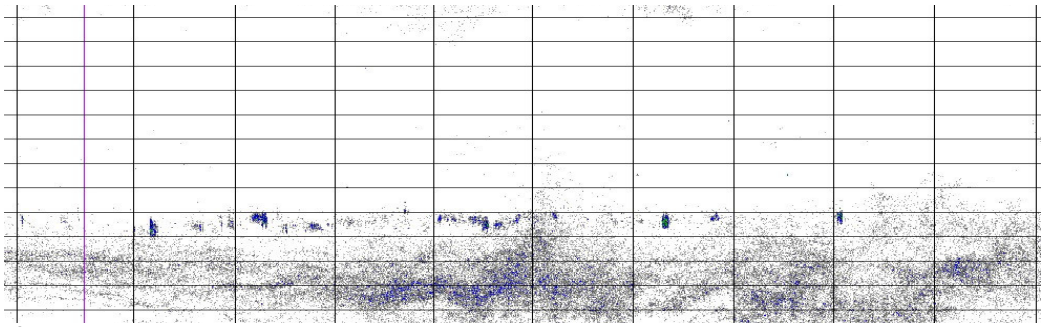
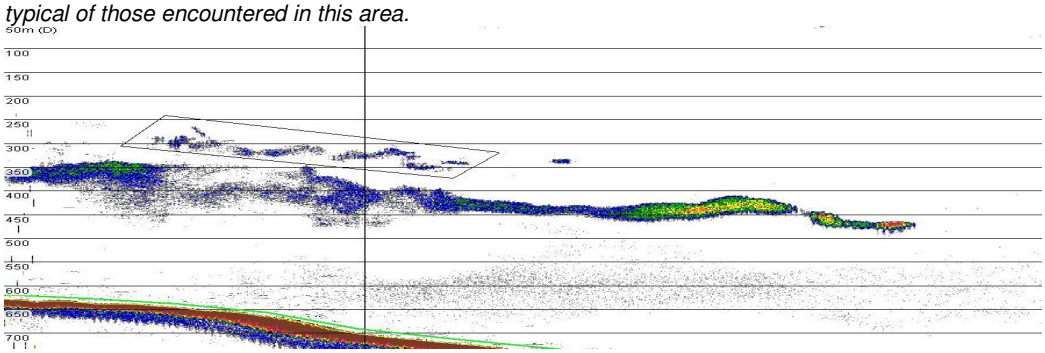


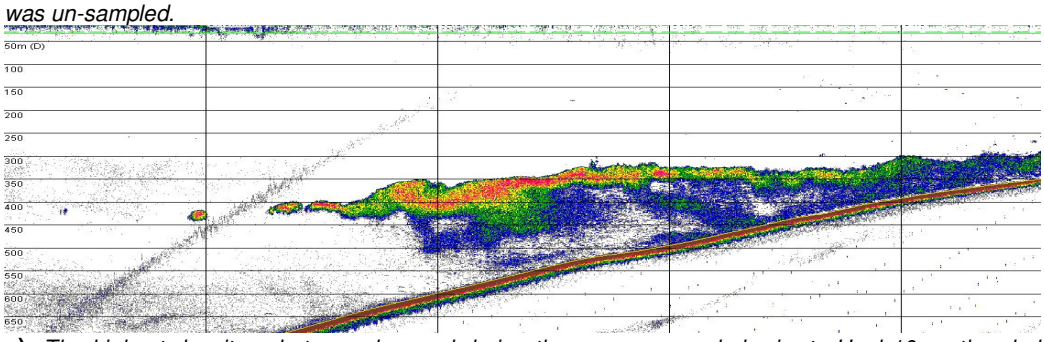
Figure 2. Blue whiting distribution as determined from survey data (NASC values). Blue whiting survey, March-April 2012.



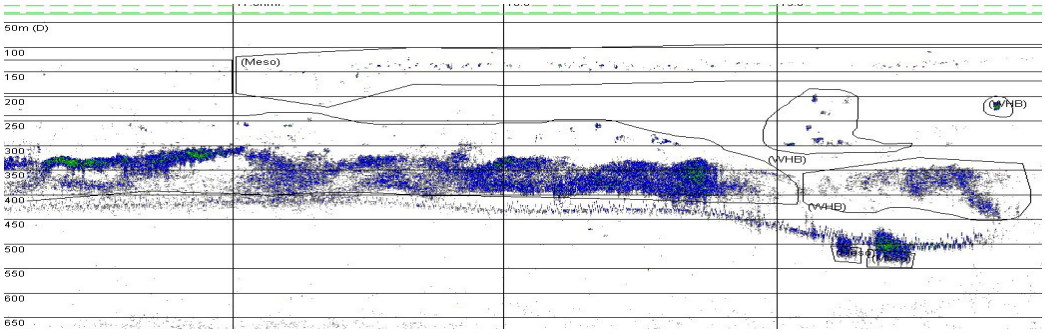
a). *Low density blue whiting echotraces recorded to the southwest of the Rockall Bank during Haul 01, typical of those encountered in this area.*



b). *High density shelf edge echotrace recorded prior to Haul 04. The haul targeted the upper schools as outlined by the black box and yielded almost 100% 1-year old fish while the main body of the echotrace was un-sampled.*



c). *The highest density echotrace observed during the survey, recorded prior to Haul 10 on the shelf edge to the south of 57°N.*



d). *Medium density echotrace of blue whiting located off the shelf edge north of 59° 30'N prior to haul 14 during the intercalibration exercise with the RV Tridens.*

Figures 3a-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 bands.

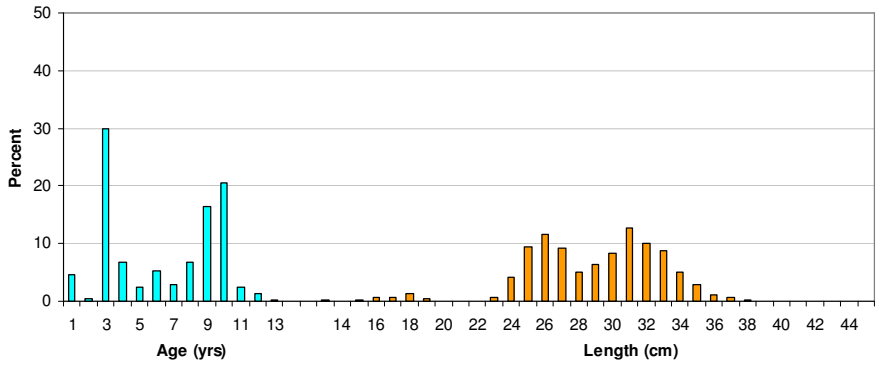


Figure 4. Combined age (left) and length (right) composition of trawl samples. Blue whiting survey, March-April 2012.

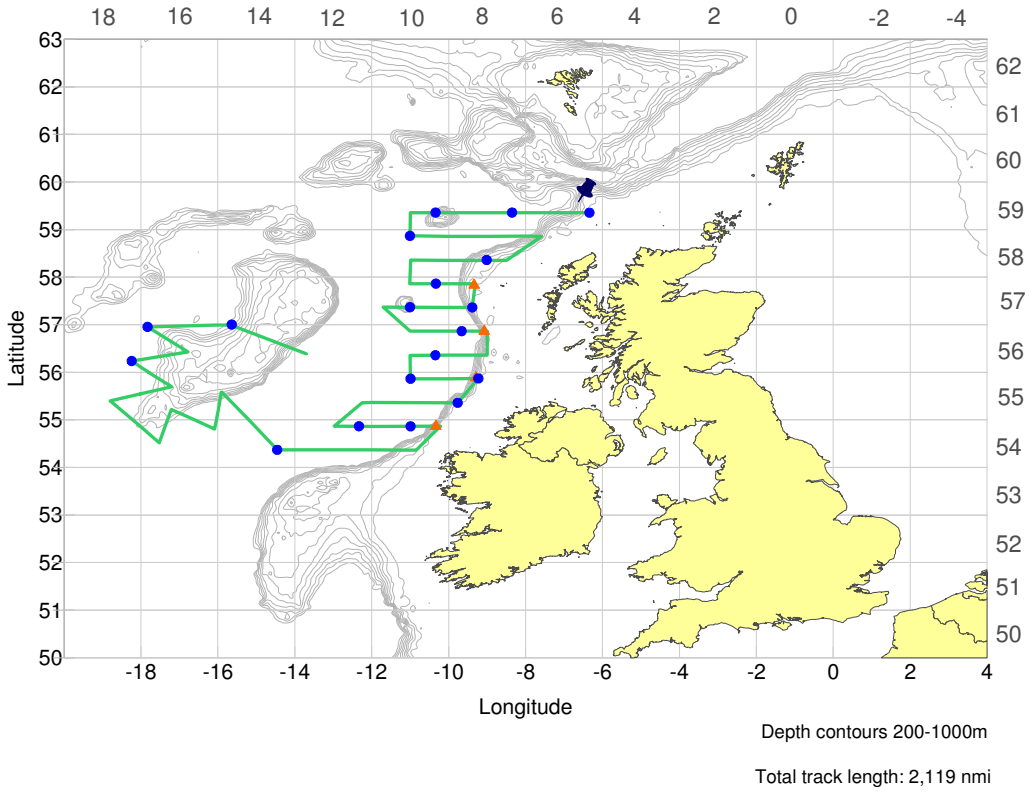


Figure 5. Position of hydrographic stations (blue points) and GULF sampling station (orange points). Note: Open water stations were carried out to a maximum depth of 1000m. Blue whiting survey, March-April 2012.

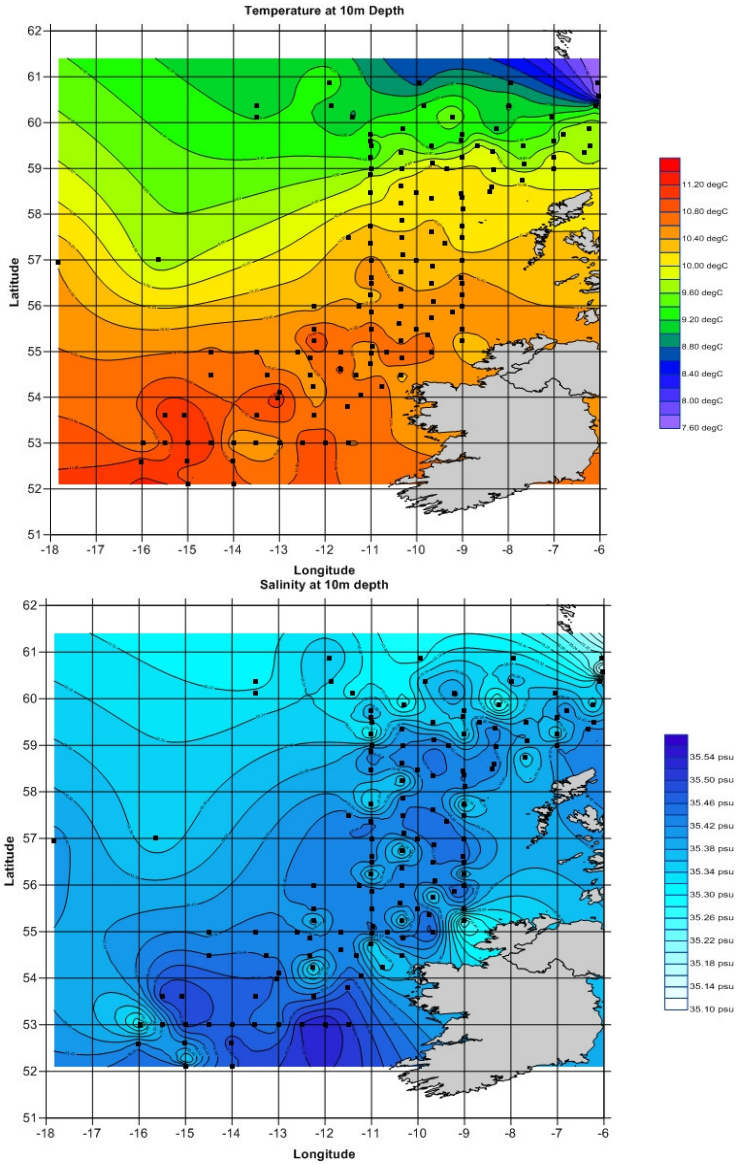


Figure 6. Horizontal temperature and salinity at 10m as compiled from international CTD stations (black dots). Blue whiting survey, March-April 2012.

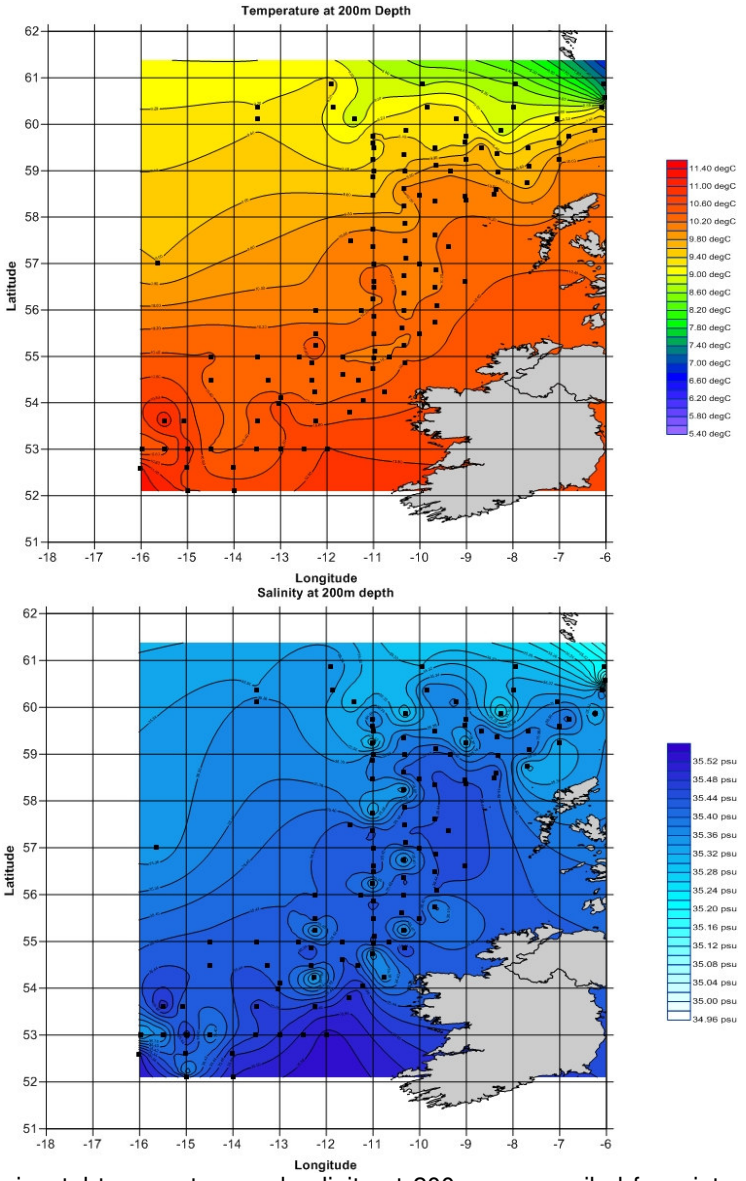


Figure 7. Horizontal temperature and salinity at 200m as compiled from international CTD stations (black dots). Blue whiting survey, March-April 2012.

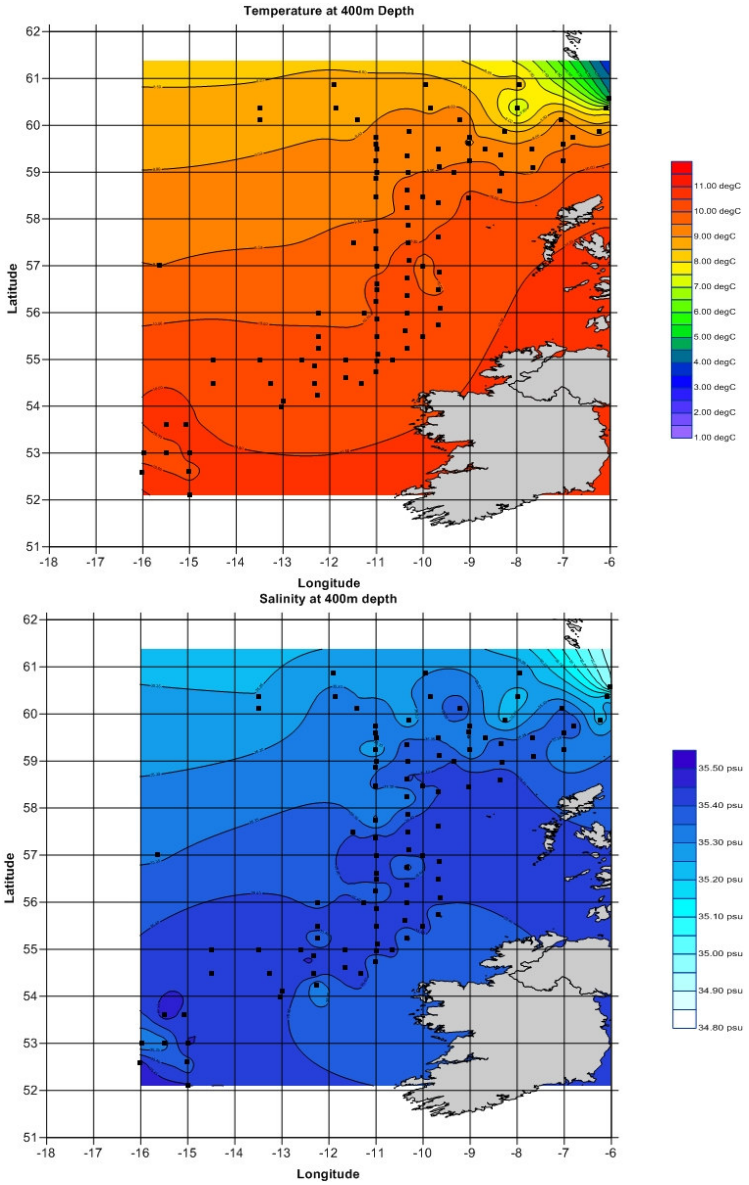


Figure 8. Horizontal temperature and salinity at 400m as compiled from international CTD stations (black dots). Blue whiting survey, March-April 2012.

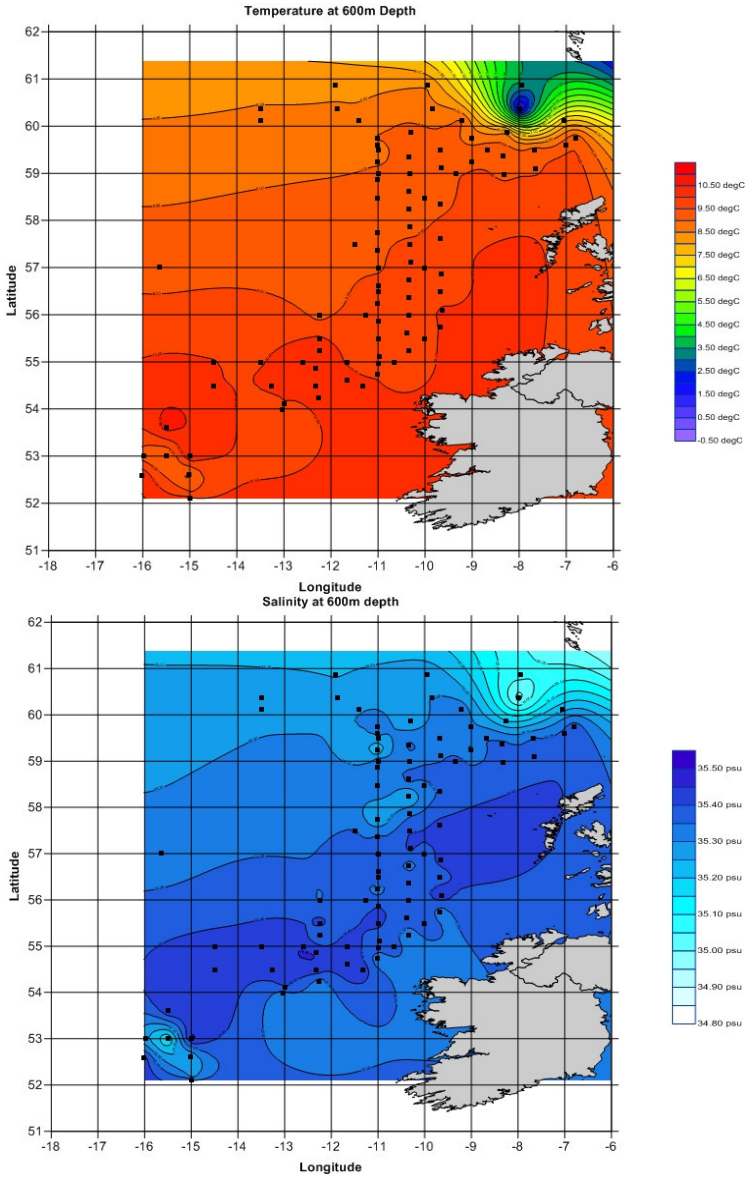
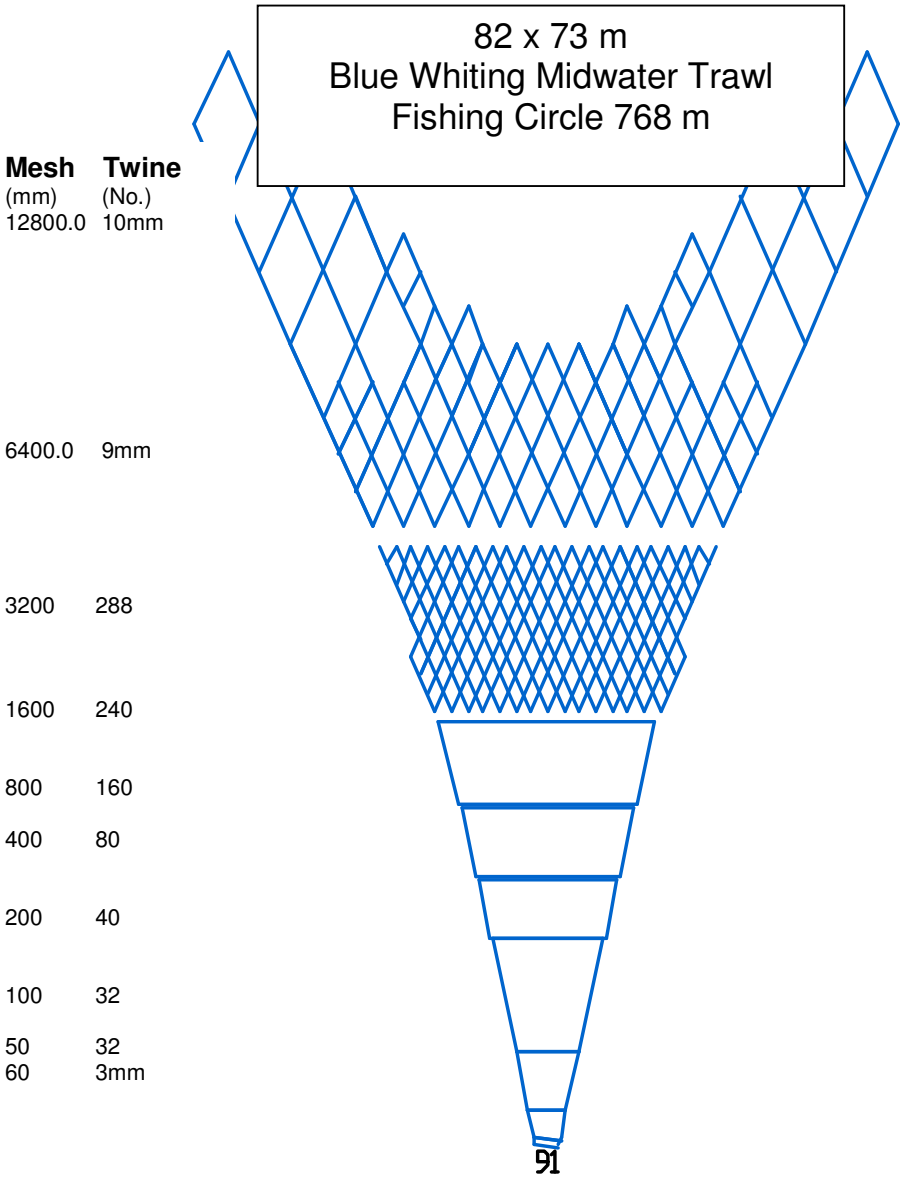


Figure 9. Horizontal temperature and salinity at 600m as compiled from international CTD stations (black dots). Blue whiting survey, March-April 2012.



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 10. Pelagic midwater trawl employed during the Blue whiting Acoustic Survey, March-April 2011.

Appendix 1

Inter-calibration exercise between the RV Celtic Explorer and RV Tridens

Acoustic inter-calibration between R/V *Celtic Explorer* and R/V *Tridens* was conducted on 5 April between 16:00 and 21:00 close to the shelf slope in depths from 600-850 m. The exercise was centred on 59º 35'N & 006º 39'W. Two 10 nmi transects were undertaken. The first transect was conducted with the *Tridens* acting as the lead vessel cruising at approximately 10 Kts while the C. Explorer maintained a position of 0.5nmi astern and 0.5nmi off *Tridens* starboard quarter. A second 10nmi transect was then carried out with the *C. Explorer* as the lead vessel and *Tridens* following with the same approximate distance and position. Weather conditions were good with light NE winds of 10-15 knots and a northerly swell of 1-2 m.

The main acoustic features in the area were (1) a relatively constant area of blue whiting schools with variable density in depths between 250 and 520 m, (2) a layer of presumed macro-zooplankton from depths over 400 m, partly mixed with the blue whiting layer in some areas, and (3) mesopelagic fish, in the uppermost of the echogram at 100 to 240 m and a plankton layer to the surface.

Data analysis focused on acoustic densities (c, m^2/nmi^2) allocated to blue whiting (Figure 1). On both vessels the routine procedures were followed for scrutinizing the data. Recordings show variable agreement, as is to be expected from experience of previous exercises. The *Tridens* tended to record much higher acoustic densities during the first 1-12 nmi than the Explorer, for distances of 12-20 nmi acoustic densities are more comparable in value (Figure 2). However, it should be noted that this is more likely a result of the geographical distance between the ships on both transects and thus the density of schools observed rather than actual differences in recording capability. When comparing portions of the track which were more closely aligned *Tridens* appears to record higher acoustic densities than the *C Explorer* for similar observations. Again this may be accounted for by the spatial heterogeneity of the patchy schools encountered.

At the end of the acoustic inter-calibration a comparative trawl exercise was undertaken. Both vessels turned and towed in parallel over the reciprocal course at a distance of about 0.8 nmi apart. Both vessels actively towed for 20 minutes with the trawl headline at c.320 m. *Celtic Explorers'* total catch was 500 kg and composed of blue whiting, *Tridens* had a very similar catch of 490 Kg.

Comparing the size distribution of catches both vessels recorded 15 different length groups (14.5-40 cm). However, *C Explorer* was observed to catch a more varied profile with 3 modal groups dominated by a larger mode of older fish (Figure 3). Mean length of blue whiting was 25.4 for *Tridens* and 29.3 for *C. Explorer. Tridens* catch was dominated by one mode of smaller, younger fish. Comparing trawl gear *Tridens* has a net with a vertical opening of c.90 m as compared to c.45 m for the *C Explorer.* Differences in catchability and of the schools encountered by the trawl are the most likely explanations for the differences in catch profile.

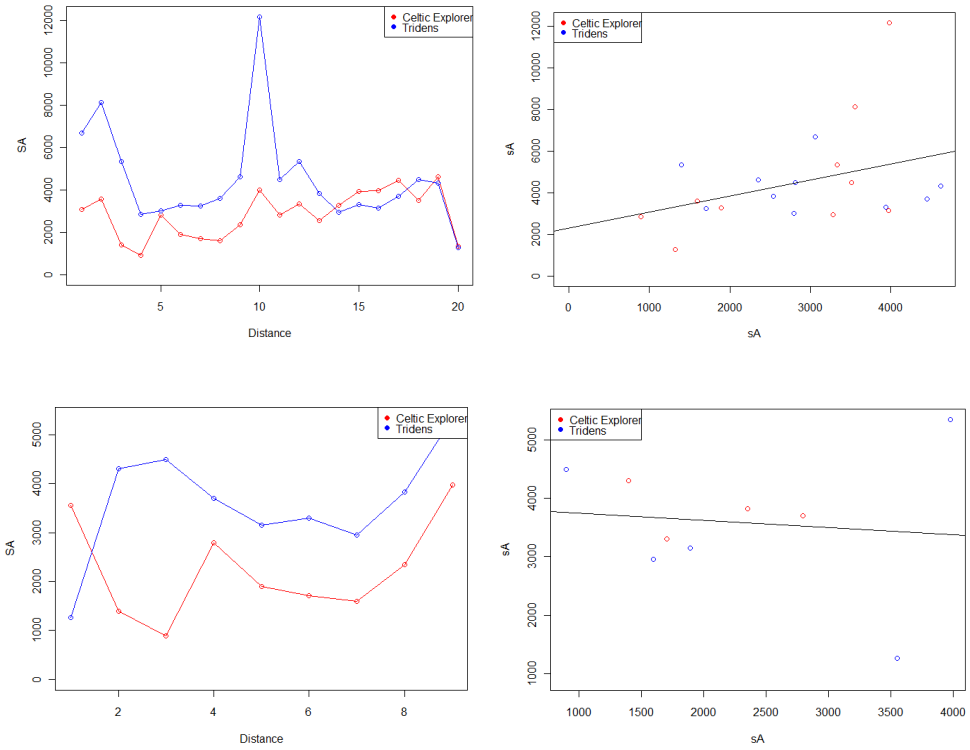


Figure 1. Comparison of blue whiting acoustic densities recorded by vessel for the entire exercise (upper panels) and for those most geographically aligned (lower panels).

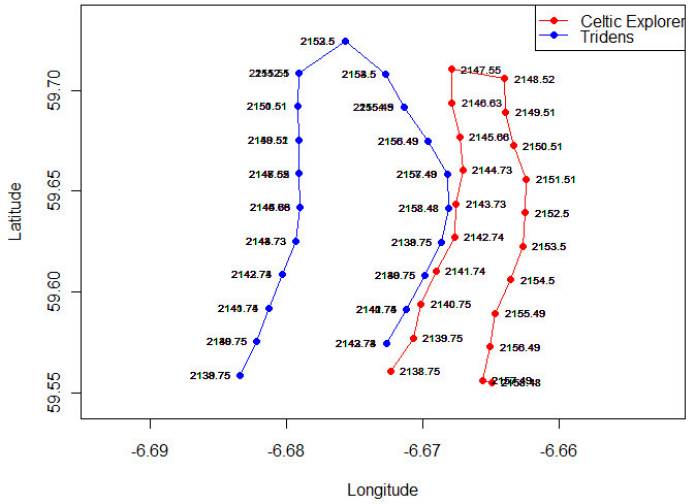


Figure 2. Plot of geographical positions by 1 nmi log intervals during the inter-calibration track for the entire exercise

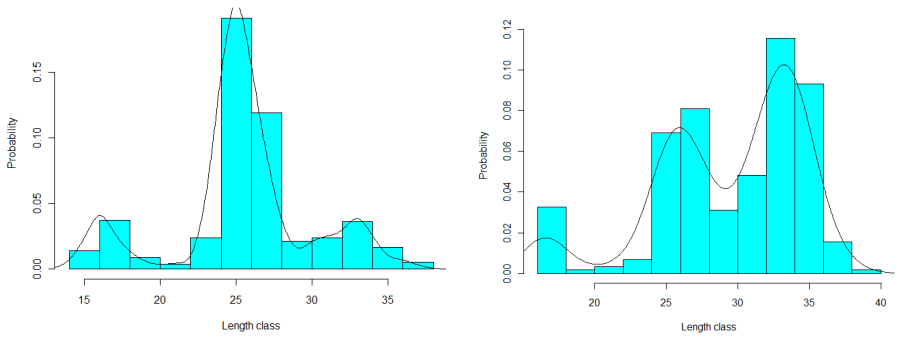


Figure 3. Length distributions from the trawls hauls by *Tridens* (left panel) and *Celtic Explorer* (right panel). Smoothing is obtained by normal kernel density estimates.