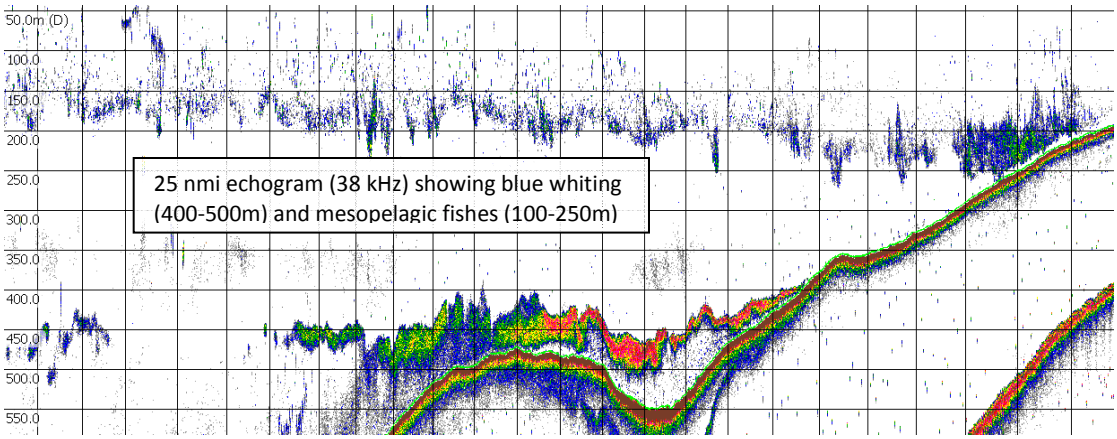
FSS Survey Series: 2018/01

Blue Whiting Acoustic Survey Cruise Report

March 20- April 06, 2018



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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 2018 survey was part of an international collaborative survey using the vessels RV *Celtic Explorer* (Ireland), RV *Tridens* (Netherlands), FV *Kings Bay* (Norway) 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 (51° N), with east -west extension from 1°-18° W. To the south of 51°N the Spanish research vessel the RV *Miguel Oliver* conducted a survey, complimentary to, but separate to the IBWSS survey, as part of their annual PELACUS survey program.

International survey participants met 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 unless otherwise stated.

2 Materials and Methods

2.1 Scientific Personnel

Name	Organisation	Role
Graham Johnston	FEAS	SIC/Acoustics
Eugene Mullins	FEAS	Acoustics
Marcin Blaszkowski	FEAS	Acoustics
John Enright	FEAS	Acoustics
Meadhbh Quinn	Contractor	Wetlab
Jan Pedersen	DTU Aqua	Wetlab
Sally O'Meara	GMIT	Seabird Observer
Sibeal Regan	GMIT	Seabird Observer
John Power*	NPWS	M Mammal Obs
Catherine O'Sullivan*	NPWS	M Mammal Obs

*Contract observers

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 2017
- 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 visual abundance surveys of marine mammals and seabirds.

2.2.2 Survey design and area coverage

The survey covered core spawning areas of blue whiting to the southwest and 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 2017. A parallel transect design was used to allow transect interlacing in co-surveyed target areas. Offshore, transects extended to 18° W. Transect spacing was set at 30 nmi for individual vessels and maintained throughout the survey.

In total, the Irish survey covered 90,751 nmi² using 2,213 nmi of transects. Survey design and methodology adheres to the methods laid out in the WGIPS acoustic survey manual (ICES 2015).

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 EK60 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 one 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 two engine operations were employed to provide sufficient power to tow the net.

2.3.2 Calibration of acoustic equipment

The EK60 was calibrated in Tobermory, Scotland at the end of the survey. Tidal conditions in Galway Bay meant that calibration could not be completed there at the start of the survey. Calibration procedure followed methods laid out in Demer *et al.* (2015). The results of the 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 and MacLennan 2007.

No inter-calibration exercise was carried out in 2018.

2.3.4 Acoustic data acquisition

EK60 "RAW files" were logged via a continuous Ethernet connection to the vessel's server and the EK60 hard drive as a backup. Sonar Data's Echoview® Echolog (Version 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 continuously monitored the equipment. 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 vessel's 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
b). Mesopelagic fish (daylight)
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 11). 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 Simrad FS70 (120 & 200 kHz). The net was fitted with a MarPort depth sensor. Spread between the trawl doors was monitored using Scanmar distance sensors and all sensors were 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 also taken. All blue whiting were aged during the survey. 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 6). Data on temperature, depth and salinity were collected using a calibrated 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

Acoustic data were analysed using the StoX software package (V 2.6), as the standard adopted for WGIPS coordinated surveys. A description of StoX can be found here:
http://www.imr.no/forskning /prosjekter/stox/nb-no.

Estimation of abundance from acoustic surveys with StoX is carried out according to the stratified transect design model developed by Jolly and Hampton (1990). Baseline survey strata, established in 2017, were adjusted based on survey effort and observations in 2018. Strata and transects used are shown in Figure 1. Length and weight data from trawl samples were equally weighted and applied across all transects within a given stratum.

Following the decisions made at the Workshop on implementing a new TS relationship for blue whiting abundance estimates (WKTSBLUES) (ICES 2012), the following target strength (TS)-to-fish length (L) relationship (Pedersen et al. 2011) used is:

$$TS = 20 \log10 (L) - 65.2$$

In StoX a super-individual table is produced where abundance is linked to population parameters like age, length, weight, sex, maturity etc. This table is used to split the total abundance estimate by any combination of population parameters. The International StoX project folder for 2018 is available on request through WGIPS.

2.5 Marine mammal and seabirds

2.5.1 Marine mammal sighting

2.5.1.1 Visual surveys

The cetacean survey was conducted using a team of two marine mammal observers (MMOs) working on rotating shifts. To prevent MMO fatigue and optimise the validity of the data,

survey effort was carried out in two-hour shifts, with a minimum break of one hour between shifts.

Cetacean watches were conducted using a standard single platform line transect survey design while the vessel was travelling at a consistent speed and heading. When the vessel was stationary at oceanographic stations, cetacean watches were conducted using a standard single platform point sampling survey design. Visual watches were undertaken from the vessel's crow's nest, located 17.45 m above sea level during all daylight hours, when weather conditions permitted. During periods of unfavourable weather conditions, observations were carried out from the bridge (10.63 m above sea level).

Survey effort was concentrated in periods of sea state 6 or less, and in moderate or good visibility. Survey effort conducted outside of these parameters was conducted at the discretion of the observers. Survey effort for cetaceans was concentrated within an arc of 60° either side (i.e., to port and to starboard) of the vessel's track-line but all sightings to 90° both side of the track-line and further aft were also recorded. Searching for cetaceans was predominantly done with the naked eye, however, Nikon Prostaff 7 8x42 binoculars and a Canon EOS 7D DSLR camera with a Sigma 100-400 mm zoom lens was used to confirm species identification and group size, and assess behaviour. Survey effort was also carried out during hauls and when at CTD stations.

The IFAW Logger 2000™ (IFAW, 2000) data collection software package was used to collect all positional, environmental and sightings data, and save it to a Microsoft Access database. Positional data was collected using a portable GPS receiver with a USB connection and recorded every 10 seconds.

Environmental data was recorded at least every 15-30 minutes or sooner if there was a change in environmental conditions. Environmental data recorded included; wind speed, wind direction, sea state, swell, visibility, cloud cover and precipitation. All data entry was time stamped by Logger and saved in the Access database.

The distance of each sighting from the ship was estimated using a fixed interval range finder, while the bearing from the ship was estimated with an angle board. This data, along with data such as species identification, group size, composition, heading, sighting cues, surfacing interval, behaviour and any associations with birds or other cetaceans was also recorded on the time stamped Logger sighting record page. Where species identification could not be confirmed, sightings were recorded at an appropriate taxonomic/confidence level (i.e. probable, possible, unidentified whale, unidentified dolphin etc.). Auxiliary and incidental sightings were also recorded.

Ancillary data such as line changes, changes in survey activity (e.g. fishing/CTD cast) and fishing vessel activity were also recorded.

2.5.2 Seabirds

Surveys of seabirds at sea were conducted from RV *Celtic Explorer* across thirteen days between 21st March and 7th April 2018. While on transect, the ship travelled at an average speed of 10 knots, except when increased swell prohibited this. 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) surveyed while the ship was travelling along transect lines during daylight hours, between 08:00 to 20:30 each day. Surveying ceased when the ship broke track during sample tows, deployment of CTD etc. Environmental conditions, including wind force and direction, sea state, swell height, visibility, precipitation and cloud cover as well as the ship's speed and heading were noted at the start of each survey period and when significant changes occurred thereafter. No surveys were conducted out on deck in conditions greater than sea state six, when high swell made working on deck unsafe. During such periods of inclement weather or

heavy seas, surveying was conducted from inside the bridge. Survey effort was also stopped when visibility was reduced to less than 300m due to heavy rain or sea fog.

The seabird observation platform was the bridge deck, which is 10m above the waterline and provided a good 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 300 m ahead of the ship. This survey band was sub- divided (A = 0-50 m from the ship, B = 50-100 m, C = 100-200 m, D = 200-300 m, E = >300 m) 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 check distance estimates for birds sitting on the water or those flying birds which were recorded during 'snapshot' counts. The area was scanned by eye, with binoculars used only to confirm species identification or count the number of birds present in a flock. All birds seen within the survey area were counted, and those recorded sitting on the water in survey bands A to D 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 when the ship passed from one survey area to the next (every 300m). Any bird recorded within the survey area that was regarded as being associated 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 ad hoc counts of birds not occurring in the survey area were also recorded and added to the database for the research cruise, but are not included in abundance or density analysis.

During the 2018 survey, a series of point counts were made of seabirds associating with the vessel during fishing operations. These began as soon as the towed net began to appear near the surface of the water and finished once the fishing operation was complete, with the net back on board and any surplus fish cleared from the deck. Date, time, location and details of the haul (gross tonnage, species present etc.) were noted for each of these point counts.
In this report, we present our daily total count data for each species along with the daily survey effort. It is envisaged that this data will be analysed in the future and the seabird abundance (birds per km travelled), and seabird density (birds per km²) will be mapped per ¼ ICES square (15˚ latitude x 30˚ longitude), allowing comparison to the results of previous seabird surveys in Irish waters (e.g. Hall et al. in press, Mackey et al. 2004, Pollock et al. 1997). Through further analysis, species-specific correction factors will be applied to birds observed on the water. The binomial species names for the birds recorded are presented in the results section, for which taxonomy and nomenclature follows that of the Irish Rare Birds Committee (2015).

3 Results

3.1 Blue whiting distribution and age structure

No independent estimate of abundance has been calculated for this survey. This survey forms part of a coordinated multi vessel effort and as a result a single vessel estimate is not considered a representative measure of the stock.

The combined survey estimate of biomass and abundance for the IBWSS survey 2018 is available here: http://hdl.handle.net/10793/1349

3.1.2 Blue whiting distribution

In total 2,443 echotraces were positively identified as blue whiting over the 3 strata surveyed (Figures 1 & 2). Blue whiting aggregations were most frequently encountered between 350-550 m with a range extending from 250 to 750 m (Figure 3f). Aggregations of blue whiting were observed below 750 m (data acquisition floor) in a small area around the northern Porcupine Bank. However, these aggregations, although significant, were localised and not thought to adversely downgrade the overall International estimate of abundance. The Porcupine Bank (stratum 1) was characterised by high density aggregations made up of primarily mature fish (Figures 3a & 4). Further north, along the northern flank of the Porcupine Bank, (stratum 3, southern boundary) fewer aggregations were encountered (Figures 3b). Northwards still, within stratum 3 (Rockall Trough) another high density area of distribution was noted, exceeding that observed in strata 2 in terms of acoustic density and spatial extent. (Figures 3c-e). Within this stratum, aggregations were observed in continuity westwards to 14°W indicating a high density of fish based on previous observations.

3.1.4 Blue whiting stock structure

A total of 14 directed blue whiting trawls were carried out during the Irish survey (Figures 1 & Table 2). During the survey 1,700 individual lengths and weights recorded for blue whiting and 600 fish were aged. Age analyses of otiliths showed individuals from 1 to 14-years old from trawl samples (Figure 4 & 5). From combined survey effort, 49 trawls were undertaken resulting in 5, 315 length measurements and 2,619 aged fish (1-18 years) contributing to the analysis.

From combined survey data, the age groups 3, 4 and 5 represented 86% of SSB. Four year olds (2014 year-class) being most abundant (50%), followed by the 2013 year-class (21%) and 2015 year-class (15%). In all stratum, with the exception of strata 4 (south Faroes), 4 year olds dominated the age profile (Figure 4).

The second most frequently encountered group of species were the Myctophidae present in all survey hauls (Table 2 & 3). High density mesopelagic echotraces were observed in a number of areas during daylight hours (Figure 3b-e). 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).

3.2 Oceanography

A total of 34 CTD casts were carried out during the survey, including the standardised hydrographic transect containing 10 full depth stations along the 53° 30N line of latitude (Figure 6). Horizontal profiles of temperature and salinity compiled from international effort (n=110 stations) from 50 m subsurface to 500 m are shown in Figures 7-10.

3.3 Marine mammal and seabirds

3.3.1 Marine mammals

3.3.1.1 Environmental data and survey effort

In total, 159 hours and 17 minutes of survey effort was conducted over the course of the survey. Of which, 147 hours and 45 minutes of survey effort were conducted using a line transect methodology and the remaining 11 hours and 31 minutes of effort were conducted using the point sampling methodology. Environmental data was collected a total of 799 times during the survey.

In total, 53 marine mammal sightings, consisting of 253 individuals, were recorded throughout the survey. This includes six sightings recorded as auxiliary sightings and 12 sightings recorded as incidental sightings. The sightings included; three whale species, three dolphin species, one porpoise species, two seal species, and a number of sightings which could not be identified to species level. Of the 53 marine mammal sightings, 50 were recorded while conducting line transects, while three were recorded while conducting point sampling. A list of the species encountered is shown in Table 4, and the distribution of the sightings is presented in Figures 12-14.

Common dolphins (*Delphinus delphis*) were the most frequently encountered and abundant species accounting for 20 sightings (38%), comprising of 152 individuals (60% of all individuals counted). Sperm whales (*Physeter macrocephalus*) were the second most frequently observed species, accounting for 17% of all sightings, with nine sightings consisting of 11 individuals. Pilot whales (*Globicephala melas*) were the second most abundant species encountered, accounting for 24% of all individuals counted (62 individuals), and the third most frequently encountered species, accounting for six sightings (11%).One species of marine megafauna, a single basking shark (*Cetorhinus maximus*), was recorded during the survey.

3.3.2 Seabirds

3.3.2.1 Effort

A total of 58 hours and 38 minutes (3, 518 minutes) of dedicated seabird surveys was conducted across thirteen days between 21st March and 7th April 2018. Casual observations from the bridge during rough weather on 27th and 28th March amounted to 2 hours and 35 minutes of effort bringing the total effort for the survey period to 61 hours and 13 minutes (3, 673 minutes). Inclement weather conditions meant that no surveys were conducted on 2nd and 3rd April and no surveys were conducted on 6th April while the ship was docked at Tobermory, Isle of Mull. A total of three point counts were made during fishing tow operations during the survey.

3.3.2.2 Sightings

A cumulative total of 4,068 individual seabirds of 17 species was recorded, of which 1,361 were noted as 'off survey' (outside of dedicated survey time or associating with the vessel, including during fishing operations point counts) and as such will be excluded from future analysis of abundance and density. A synopsis of daily totals for all seabird species recorded is presented in Table 5. In addition, daily totals for three species of migrant terrestrial birds recorded on or around the vessel are also presented (Table 6).

4 Discussion and Conclusions

4.1 Discussion

Overall, the survey objectives were carried out as planned, with bad weather resulting in reduced survey speed as opposed to actual downtime. Communication between vessels was good and close temporal alignment was achieved.

Global TSB (combined survey effort) report an increase of abundance of 29% (3.1 mt and 4.0 mt respectively) and 15% in abundance when compared to 2017. This can be accounted for by the significant contribution of the 2014 year class (4 year old fish) that are now fully recruited to the SSB. This year class alone accounted for over 50% (2 mt) any represents the largest on record for this survey. The 2018 TSB estimate is also the highest in the survey time series.

The large biomass observed was attributed to the size and geographical extent of aggregations. High density aggregations extended from the Porcupine Bank northwards to west of the Hebrides, with an extension up to 70 nmi into the Rockall Trough.

Immature fish (1 year old) were observed in the northern strata and this follows on from previous observations. The strength of any emerging years classes is somewhat masked by the strength of the extremely large 2014 year class.

4.2 Conclusions

The spatial distribution and acoustic density of observations of the stock is represented in the large biomass observed. The strong 2014 year class has been successfully tracked through the survey time series since recruiting the spawning stock. The 2018 estimate of abundance is considered robust due to the close temporal alignment of survey vessels, good spatial coverage and comprehensive trawling undertaken.

The 2018 international survey was considered a good representation of the stock with the dominant year classes represented. The survey was carried out during the same time and with comparable survey effort and geographical coverage.

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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 :	06.04.18
Echo sounder :	EK60 PC	Locality :	Tobermory
Type of Sphere :	Cu-60.1mm	TS_{Sphere}: -33.50 dB (Corrected for soundvelocity)	Depth(Sea floor) : 35 m

Calibration Version 2.1.0.11

Comments:
Tobermory 06.04.18. 2nd attempt

Reference Target:

TS	-33.5 dB	Min. Distance	25.00 m
TS Deviation	5.0 dB	Max. Distance	32.00 m

Transducer: ES38B Serial No. 30227

Frequency	38000 Hz	Beamtype	Split
Gain	25.73 dB	Two Way Beam Angle	-20.6 dB
Athw. Angle Sens.	21.90	Along. Angle Sens.	21.90
Athw. Beam Angle	7.00 deg	Along. Beam Angle	6.93 deg
Athw. Offset Angle	- 0.04 deg	Along. Offset Angl	-0.04 deg
SaCorrection	-0.68 dB	Depth	8.8 m

Transceiver: GPT 38 kHz 009072033933 1 ES38B

Pulse Duration	1.024 ms	Sample Interval	0.189 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.	10.1 dB/km	Sound Velocity	1476.7 m/s

Beam Model results:

Transducer Gain =	25.65 dB	SaCorrection =	-0.58 dB
Athw. Beam Angle =	7.09 deg	Along. Beam Angle =	7.03 deg
Athw. Offset Angle =	-0.01 deg	Along. Offset Angle=	-0.05 deg

Data deviation from beam model:
RMS = 0.17 dB
Max = 0.54 dB No. = 190 Athw. = -2.0 deg Along = -1.9 deg
Min = -0.66 dB No. = 202 Athw. = 4.5 deg Along = -1.5 deg

Data deviation from polynomial model:
RMS = 0.14 dB
Max = 0.43 dB No. = 190 Athw. = -2.0 deg Along = -1.9 deg
Min = -0.63 dB No. = 224 Athw. = -4.5 deg Along = -1.6 deg

Comments :

Wind Force : 4 **Wind Direction :** W
Raw Data File: \\C\EK60_Data\BWAS_2017\RAW ER60 Files\Calibration\BWAS_2018
Calibration File: \\C\EK60_Data\BWAS_2017\RAW ER60 Files\Calibration\BWAS_2018

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	22/03/2018	51.666	-15.775	12:35	3000	200	0.0						
2	23/03/2018	52.409	-14.712	03:18	420	350	900.0	145.0	100.0		0.0		
3	25/03/2018	53.857	-13.815	18:16	840	500	5,000.0	130.9	98.9	0.7	0.4		
4	26/03/2018	55.087	-10.173	14:11	600	500	10.0	10.0	69.1		31.0		
5	26/03/2018	55.146	-10.121	16:09	850	500	1,100.0	123.1	100.0				
6	27/03/2018	55.082	-11.462	02:09	3000	450	15.3	15.3	97.6		2.4		
7	28/03/2018	55.406	-16.769	19:42	720	280	1.4	1.4			100.0		
8	30/03/2018	56.448	-12.740	12:04	2185	450	700.0	109.7	99.8		0.2		
9	30/03/2018	56.401	-11.831	19:23	2700	480	900.0	115.9	99.3		0.7		
10	31/03/2018	56.401	-9.307	07:48	966	480	4,000.0	114.9	99.8		0.2		
11	04/01/2018	58.054	-9.758	00:09	1400	400	600.0	119.8	94.9		5.1		
12	04/01/2018	58.016	-12.201	11:32	1700	500	600.0	111.4	98.2		1.8		
13	04/01/2018	59.043	-9.738	08:23	1800	450	6,000.0	128.2	99.5		0.5		
14	04/01/2018	59.045	-7.560	18:20	1300	500	1,300.0	117.5	98.3		0.3		1.4

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

Table 3. Species occurrence from trawl stations.

Category	Common Name	Scientific Name	Occurrence
Pelagic	Blue Whiting	*Micromesistius poutassou*	12
	Mackerel	*Scomber scombrus*	1
	Horse mackerel	*Trachurus trachurus*	0
	Hake	*Merluccius merluccius*	0
Mesopelagics	Barracudina	Arctozenus rissoi	3
	Greater Argentine	*Argentina silus*	0
	Hatchet Fish (small)	*Argyropelecus hemigymnus*	7
	Myctophidae(combined)		11
	Hatchet Fish (large)	*Argyropelecus olfersi*	7
	None	*Astronethus gemmifer*	0
	Myctophidae	*Benthosema glaciale*	0
	Alfonsino	*Beryx decadactylus*	0
	Ray's bream	*Brama brama*	0
	None	*Bathylagus euryops*	0
	Blackfish	*Centrophagus niger*	0
	Sloanes Viper fish	*Chauliodus sloani*	4
	Myctophidae	*Diaphus raffinesqui*	0
	Myctophidae	*Diaphus metapoclampus*	0
	Myctophidae	*Diaphus effulgens*	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*	1
	None	*Howella sherborni*	1
	None	*Lampadena speculigera*	0
	Myctophidae	*Lampanyctus crocodilus*	0
	Myctophidae	*Lobianchia gemallari*	0
	Searsids	*Maulisia*	0
	Pearlside	*Maurolicus muelleri*	11
	None	*Melanostomias tentaculatus*	0
	Myctophidae	*Myctophum punctatum*	0
	None	*Maulisia microlepis*	0
	None	*Melamphaes longivelis*	0
	None	*Melanstomias bartonbeani*	0
	Greenland Argentine	*Nansenia groenlandica*	0
	Forgotten argentine	*Nansenia oblita*	8
	Slender snipe-eel	*Nemichthys scolopaceous*	0
	Multipore Searside	*Normichthys operosus*	1
	None	*Notolepis rissoi*	0
	Myctophidae	*Notoscopelus krokeyeri*	0
	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 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*	0
	Bluntsnout smooth-head	*Xenodermichthys copei*	0
	None	*Pseudoscopelus altipinnis*	0
	None	*Argyropelecus olfersi*	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		2
	Boarfish	Capros aper	1
	Barracudina		
Other	Jellyfish		4
	Octopus		1
	Unidentified a		1
	Unidentified b		1
		Total Number of Trawls	**14**
		Total number of Species:	**17**

Table 4. Sightings, counts and group size ranges for cetacean species recorded during the survey.

Common name	Species name	No. of Sightings	No. of individuals	Group size range
Common Dolphin	*Delphinus delphis*	20	152	1-50
Common Seal	*Phoca vitulina*	1	1	1
Cuvier's Beaked Whale	*Ziphius cavirostris*	1	1	1
Grey Seal	*Halichoerus grypus*	2	2	1
Harbour Porpoise	*Phocoena phocoena*	1	1	1
Minke Whale	*Balaenoptera acutorostrata*	3	3	1
Pilot Whale	*Globicephala melas*	6	62	5-25
Risso's Dolphin	*Grampus griseus*	1	1	1
Sperm Whale	*Physeter macrocephalus*	9	11	1-2
Unidentified Beaked Whale		1	2	2
Unidentified Cetacean		2	2	1
Unidentified Dolphin		5	14	1-8
Unidentified Large Baleen Whale		1	1	1
	Total	**53**	**253**	

Other Marine Megafauna

Common name	Species name	No. of Sightings	Total No. of individuals	Group size range
Basking Shark	*Cetorhinus maximus*	1	1	1
	Total	**1**	**1**	

Table 5. Total for all seabird species.

Vernacular Name	Scientific Name	On Survey	Off Survey	Total
Fulmar	*Fulmarus glacialis*	899	859	1758
Manx Shearwater	*Puffinus puffinus*	84	35	119
Gannet	*Morus bassanus*	1148	176	1324
Shag	*Phalacrocorax aristotelis*	23	0	23
Kittiwake	*Rissa tridactyla*	390	181	571
Black-headed Gull	*Chroicocephalus ridibundus*	1	0	1
Common Gull	*Larus canus*	1	0	1
Great Black-backed Gull	*Larus marinus*	27	2	29
Glaucous Gull	*Larus hyperboreus*	1	0	1
Herring Gull	*Larus argentatus*	n/c	n/c	n/c
Lesser Black-backed Gull	*Larus fuscus graellsii*	17	15	32
Unidentified large gull sp.	*Larus sp.*	2	0	2
Great Skua	*Stercorarius skua*	27	6	33
Little Auk	*Alle alle*	33	0	33
Guillemot	*Uria aalge*	87	1	88
Razorbill	*Alca torda*	27	0	27
Guillemot/Razorbill		19	0	19
Black Guillemot	*Cepphus grylle*	7	0	7
Puffin	*Fratercula arctica*	1	0	1

Table 6. Totals of migrant terrestrial bird species.

Vernacular Name	Scientific Name	Total
Whooper Swan	*Cygnus cygnus*	27
Oystercatcher	*Haematopus ostralegus*	2
Redwing	*Turdus iliacus*	12
Unidentified passerine		7
Total		58

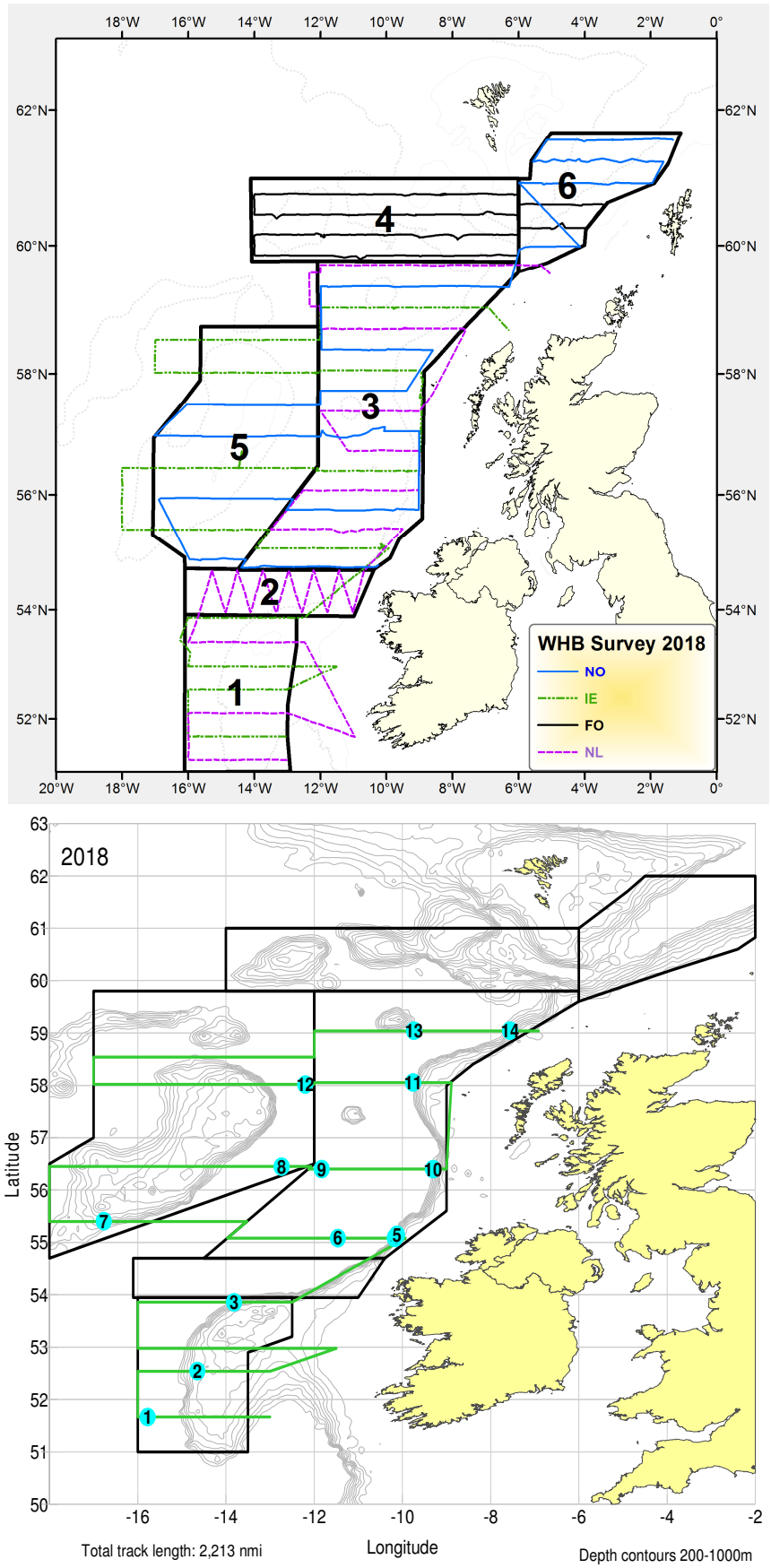


Figure 1. International survey effort (top panel) and Irish effort with trawl station positions (bottom panel).

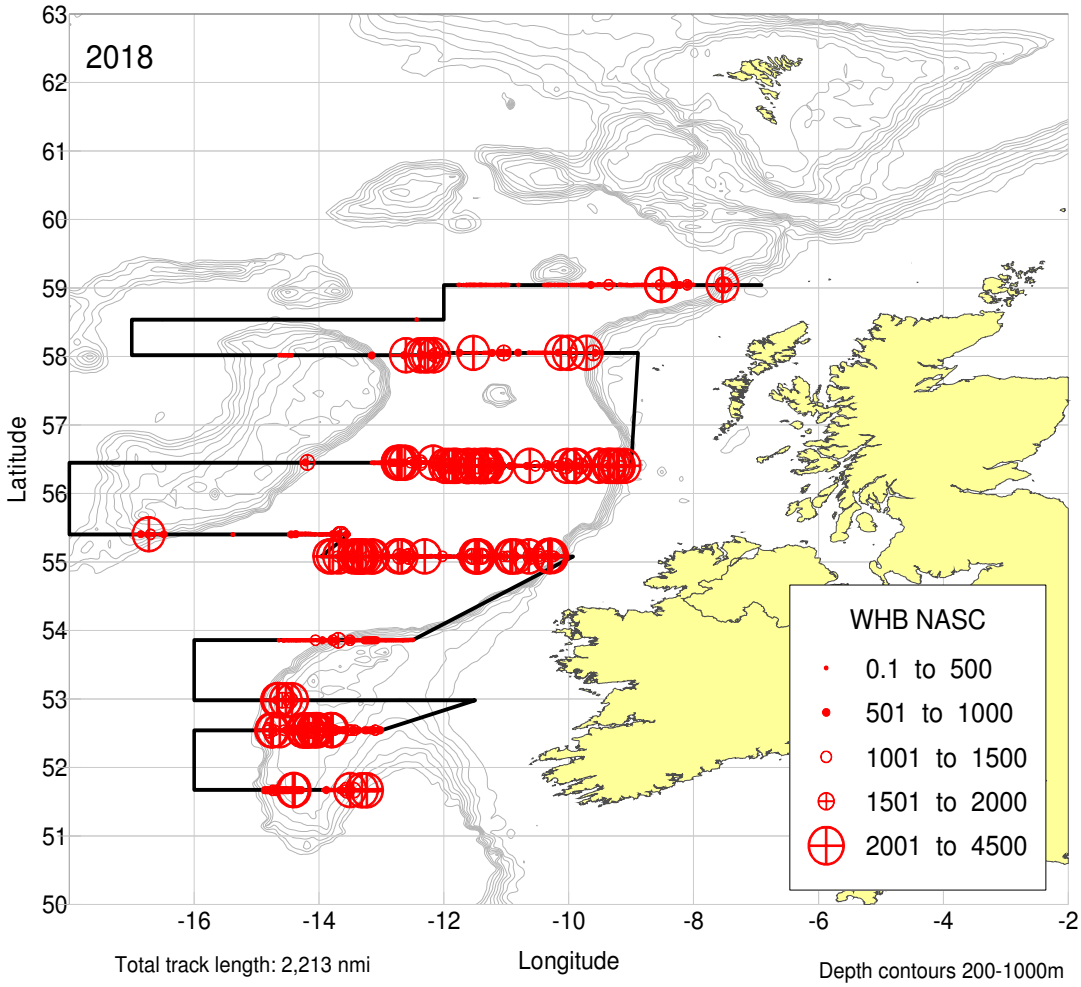
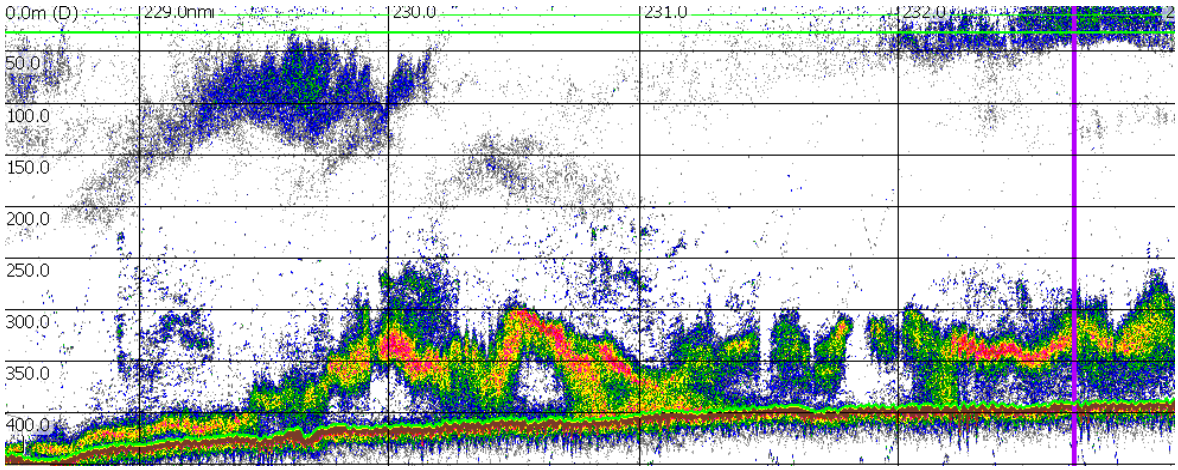
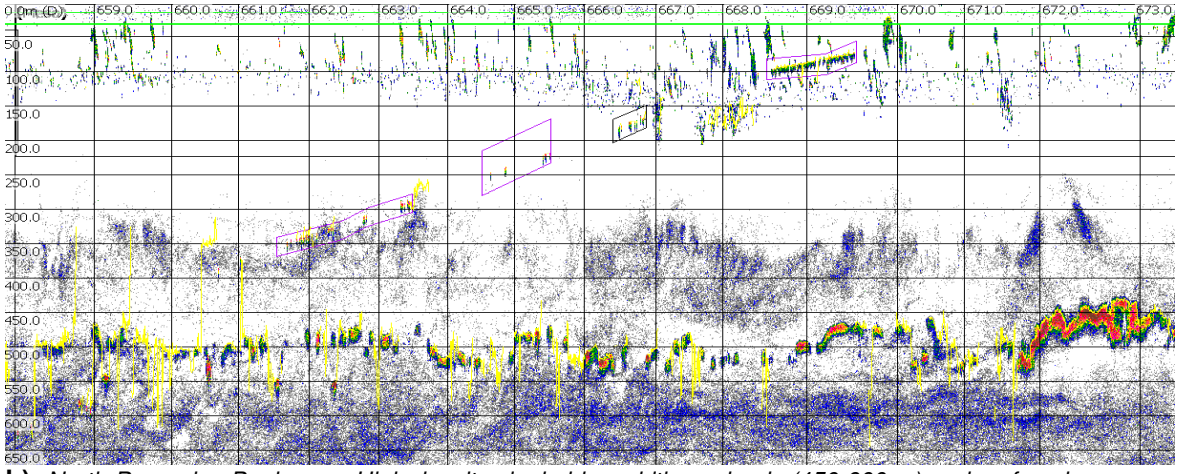


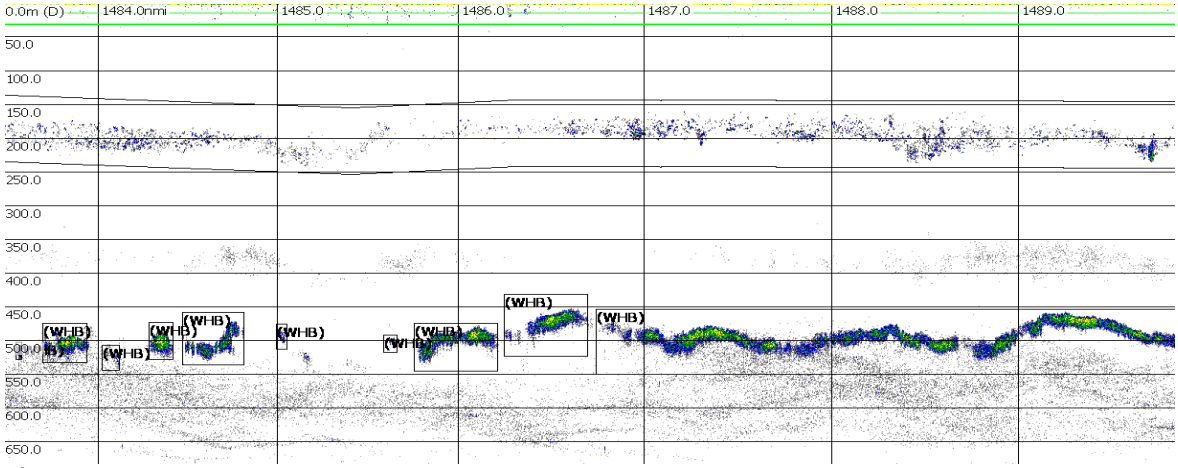
Figure 2. Blue whiting distribution determined from acoustic observations (NASC values).



a). *High density blue whiting aggregation in the southern the Porcupine Bank area. Haul 02.*

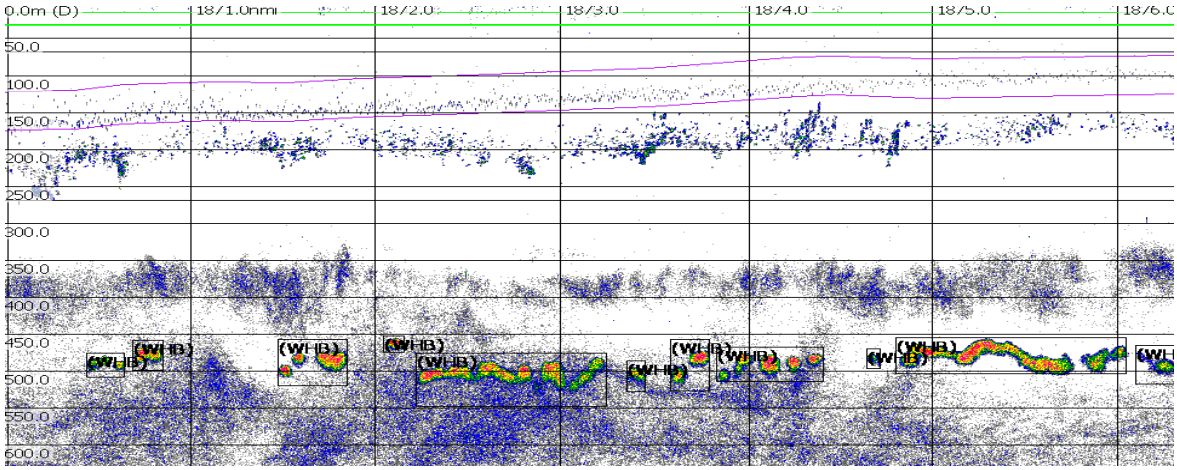


b). *North Porcupine Bank area. High density single blue whiting schools (450-600 m) and surface layer containing mesopelagic fish (25-200 m).*



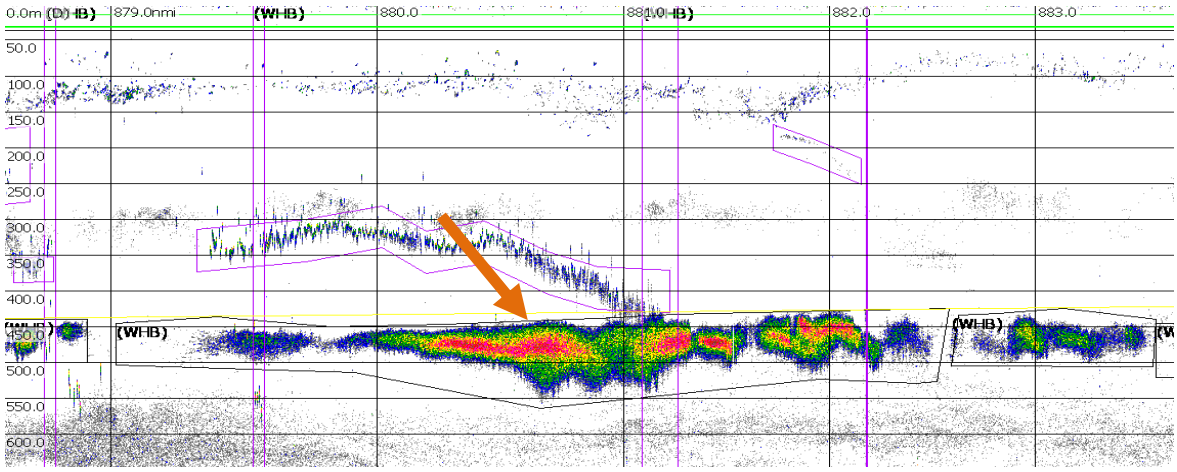
c). *Mid Rockall Trough. Open water blue whiting aggregation Haul 08.*

Figures 3 a-e. 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.

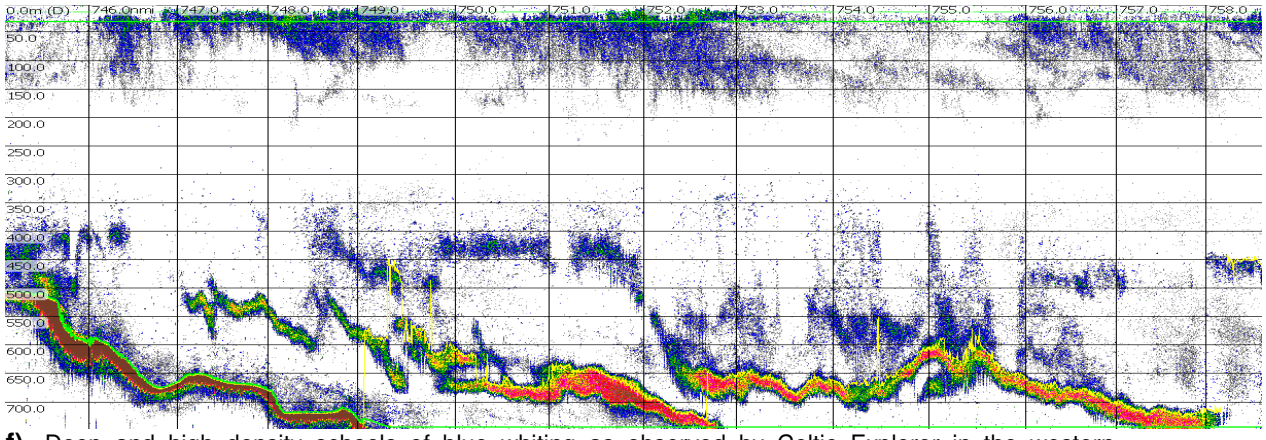


d). *Western Rockall Trough. Open water blue whiting aggregation Haul 12.*

.



e). *Highest density single aggregation of blue whiting per sampling distance unit (1 nmi sampling interval and 50m vertical depth channel) observed during the survey. Recorded in open water northwest Ireland.*



f). Deep and high density schools of blue whiting as observed by Celtic Explorer in the western Porcupine Bank area, strata 2. Note schools extended below the current 750m data acquisition floor.

Figures 3 a-f. continued.

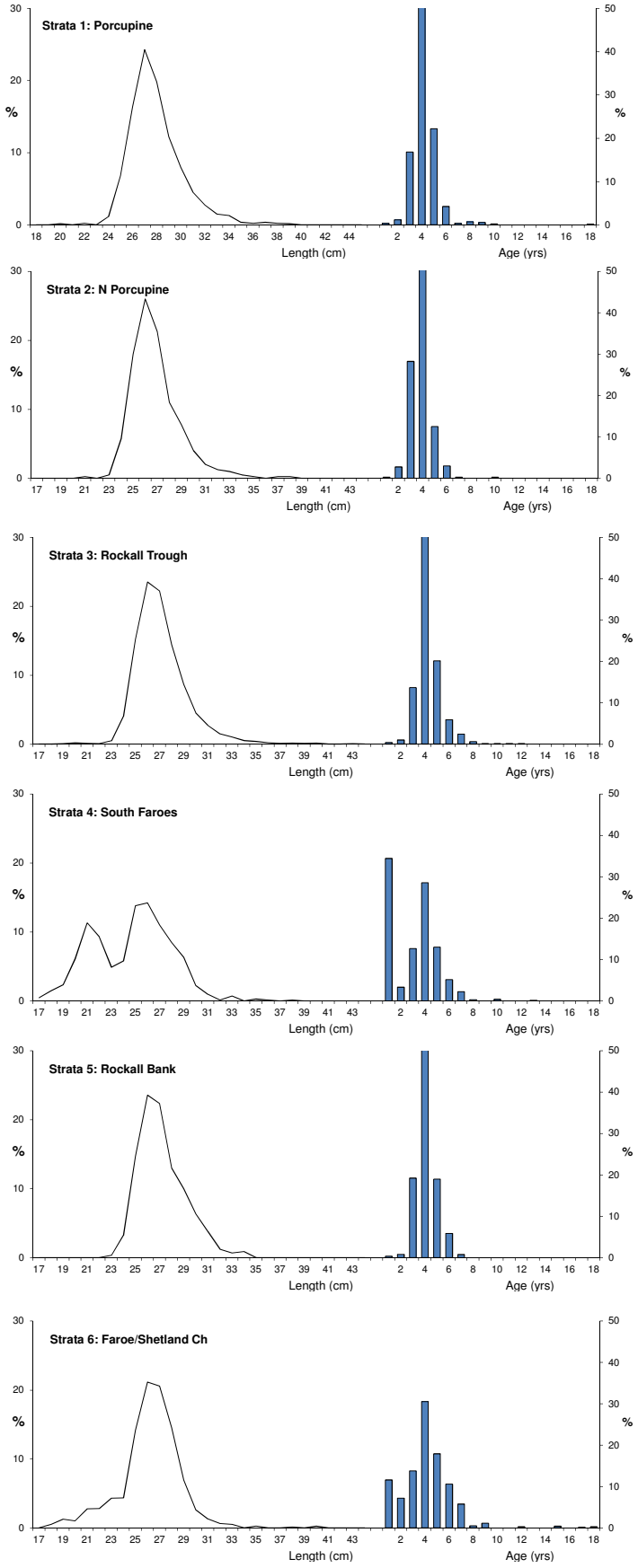


Figure 4. Length and age composition of blue whiting from trawl samples (all nations) presented by stratum.

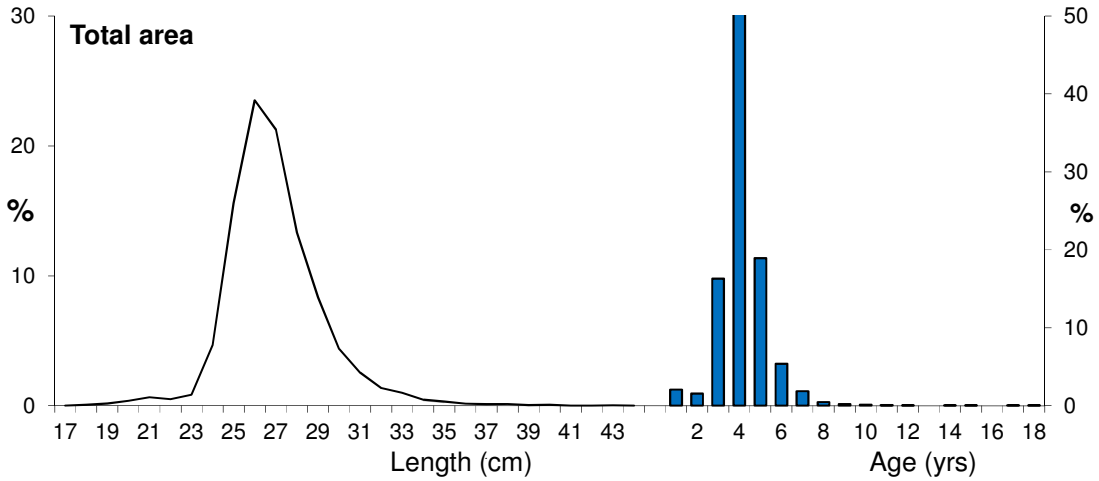


Figure 5. Length (n= 5,315) and age (n=2,619) composition of blue whiting from combined trawl samples (all nations) presented for the total area surveyed.

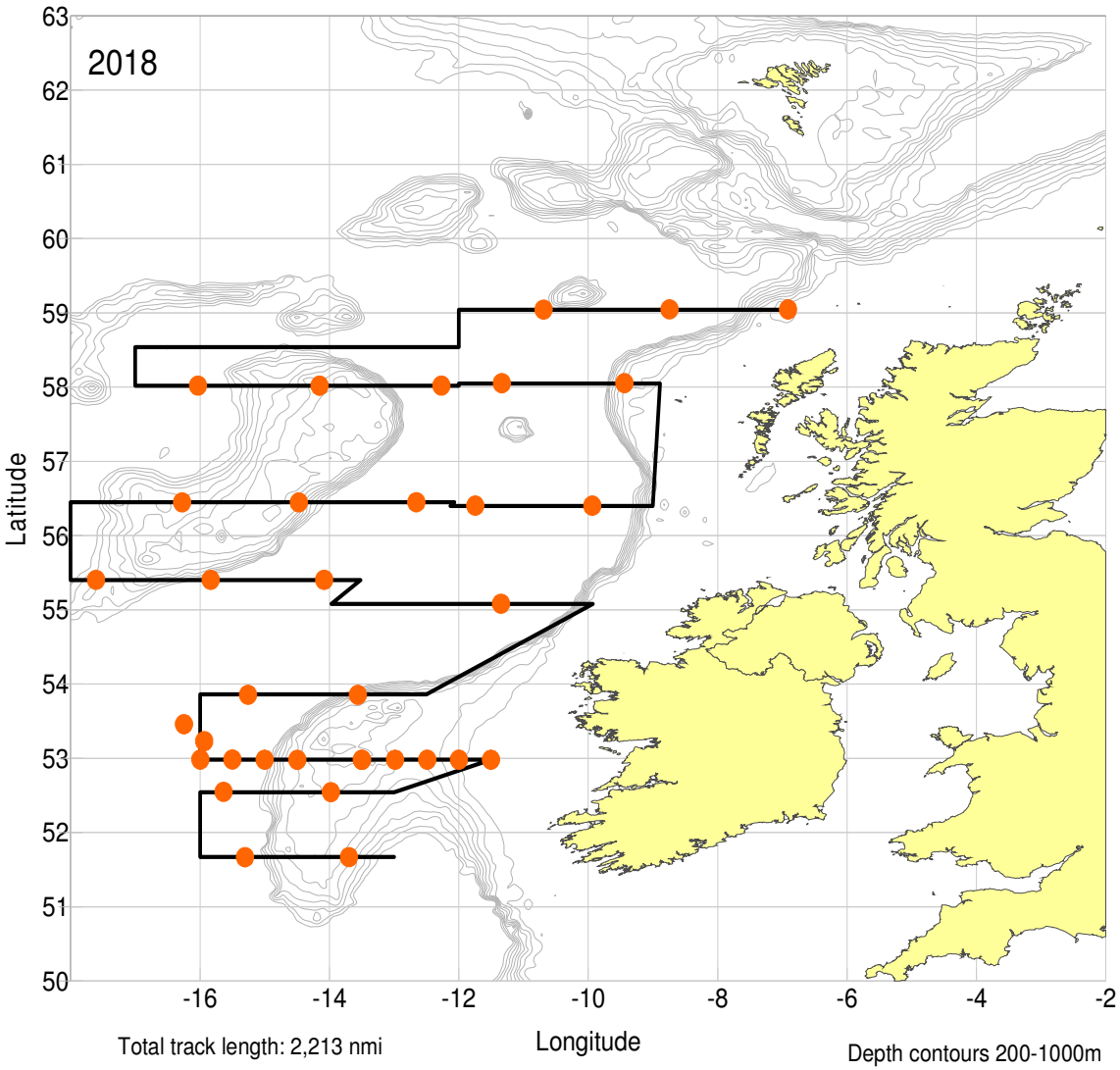


Figure 6. Position of Irish hydrographic stations (orange dots). Note: Open water stations were carried out to a maximum depth of 1000m with the exception of the stations occurring on the 53°N line of latitude.

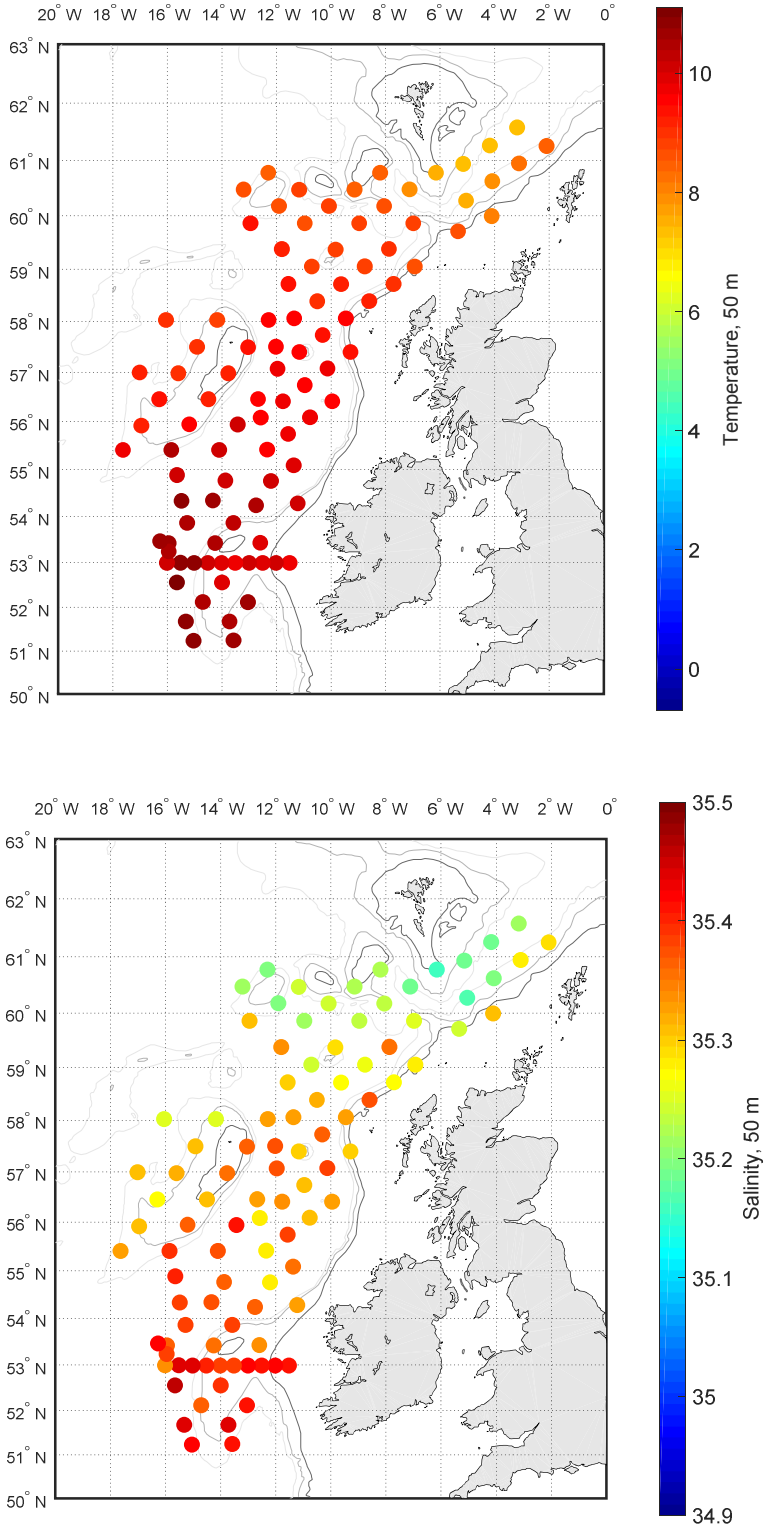


Figure 7. Horizontal temperature (top) and salinity (bottom) at 50m as compiled from combined international data.

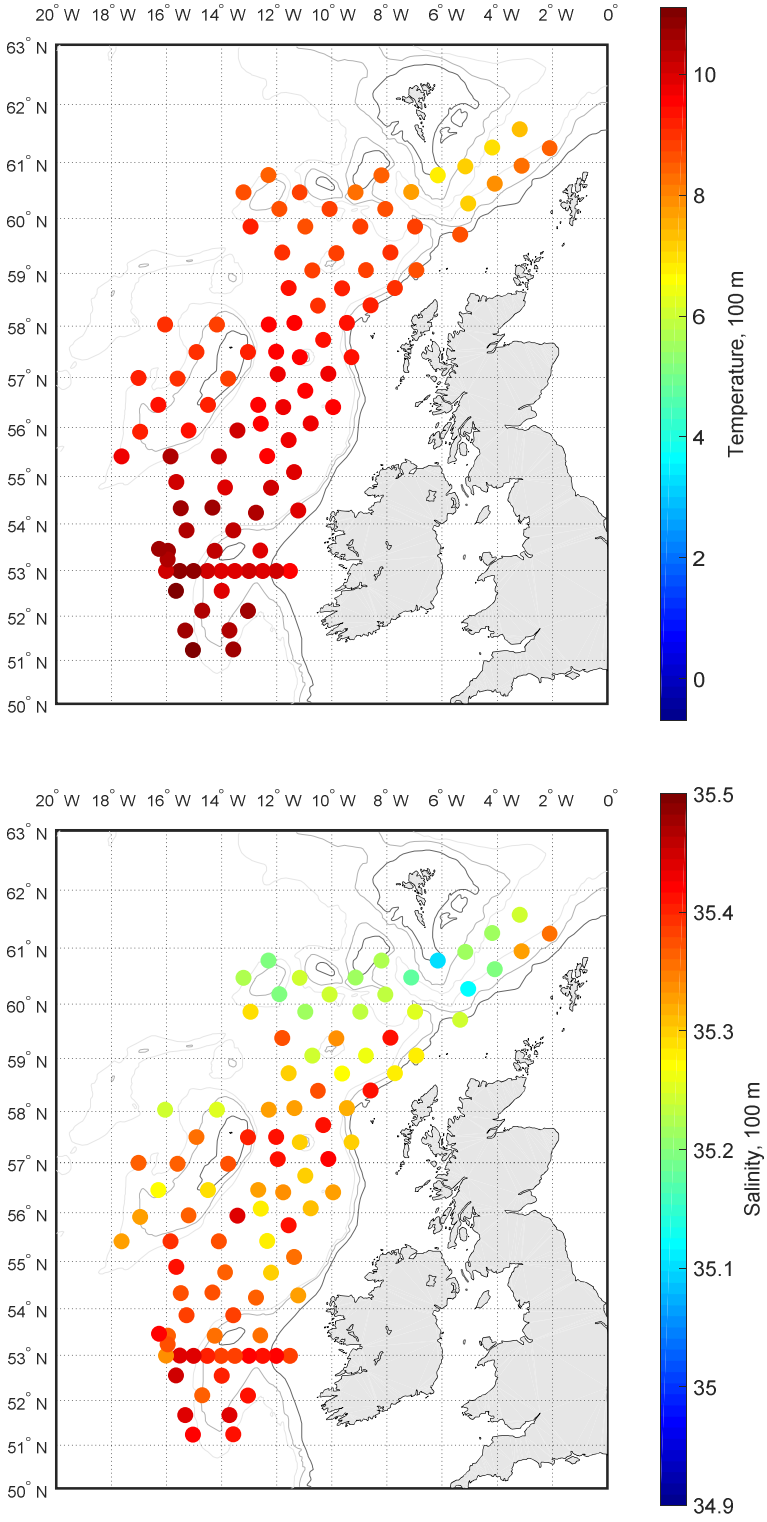


Figure 8. Horizontal temperature (top) and salinity (bottom) at 100m as compiled from combined international data.

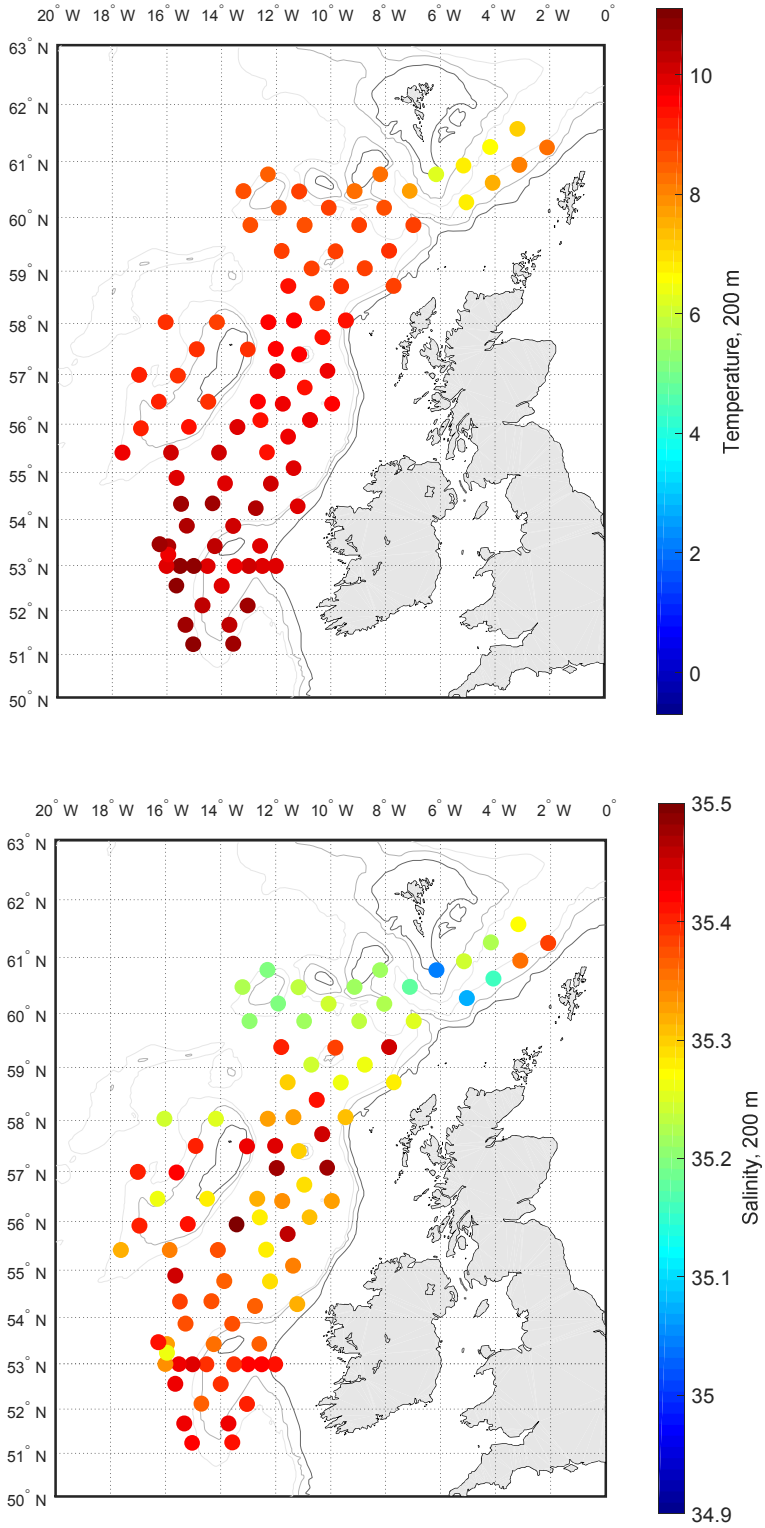


Figure 9. Horizontal temperature (top) and salinity (bottom) at 200m as compiled from combined international data.

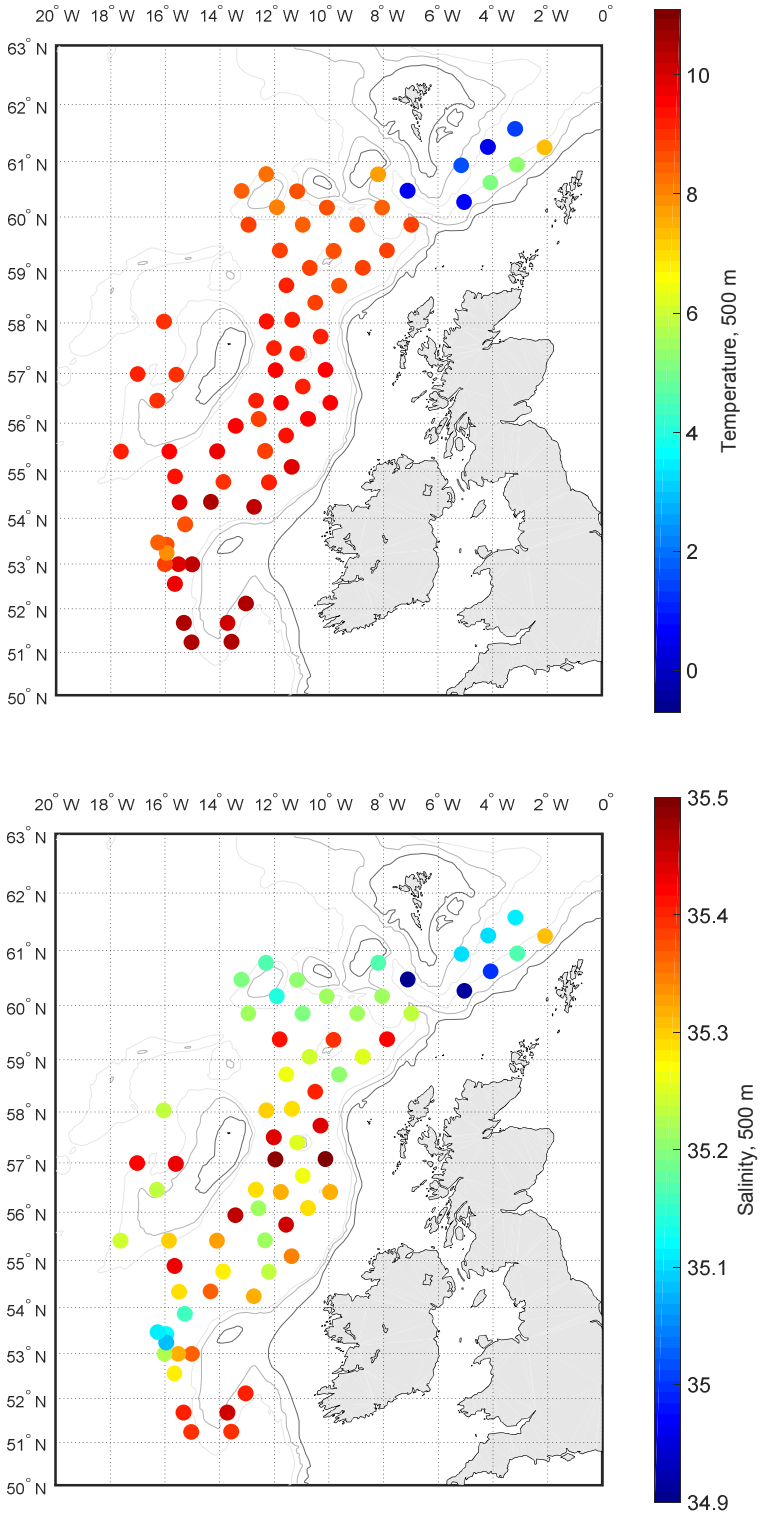
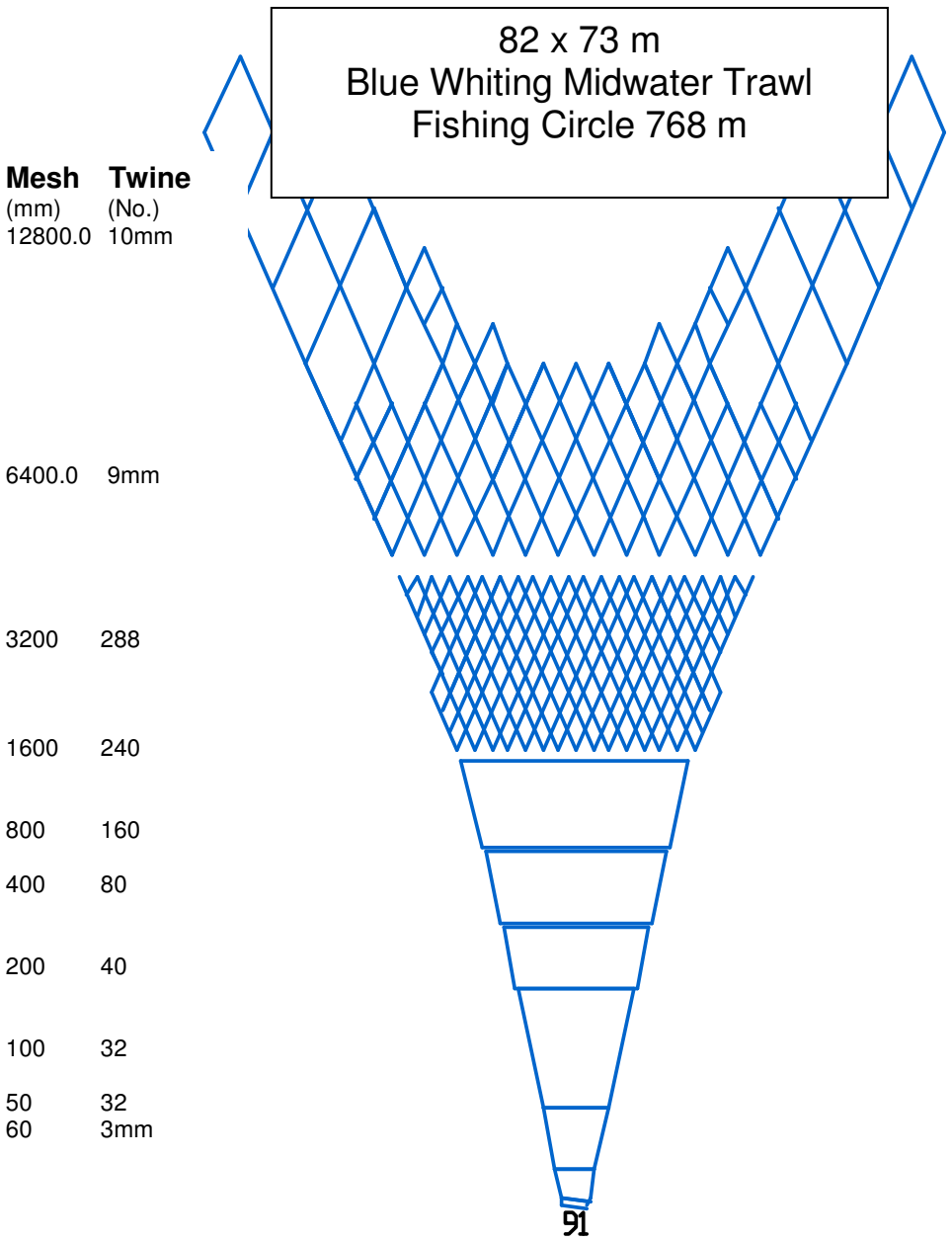


Figure 10. Horizontal temperature (top) and salinity (bottom) at 500m as compiled from combined international data.



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

Figure 11. Pelagic midwater trawl employed during the survey.

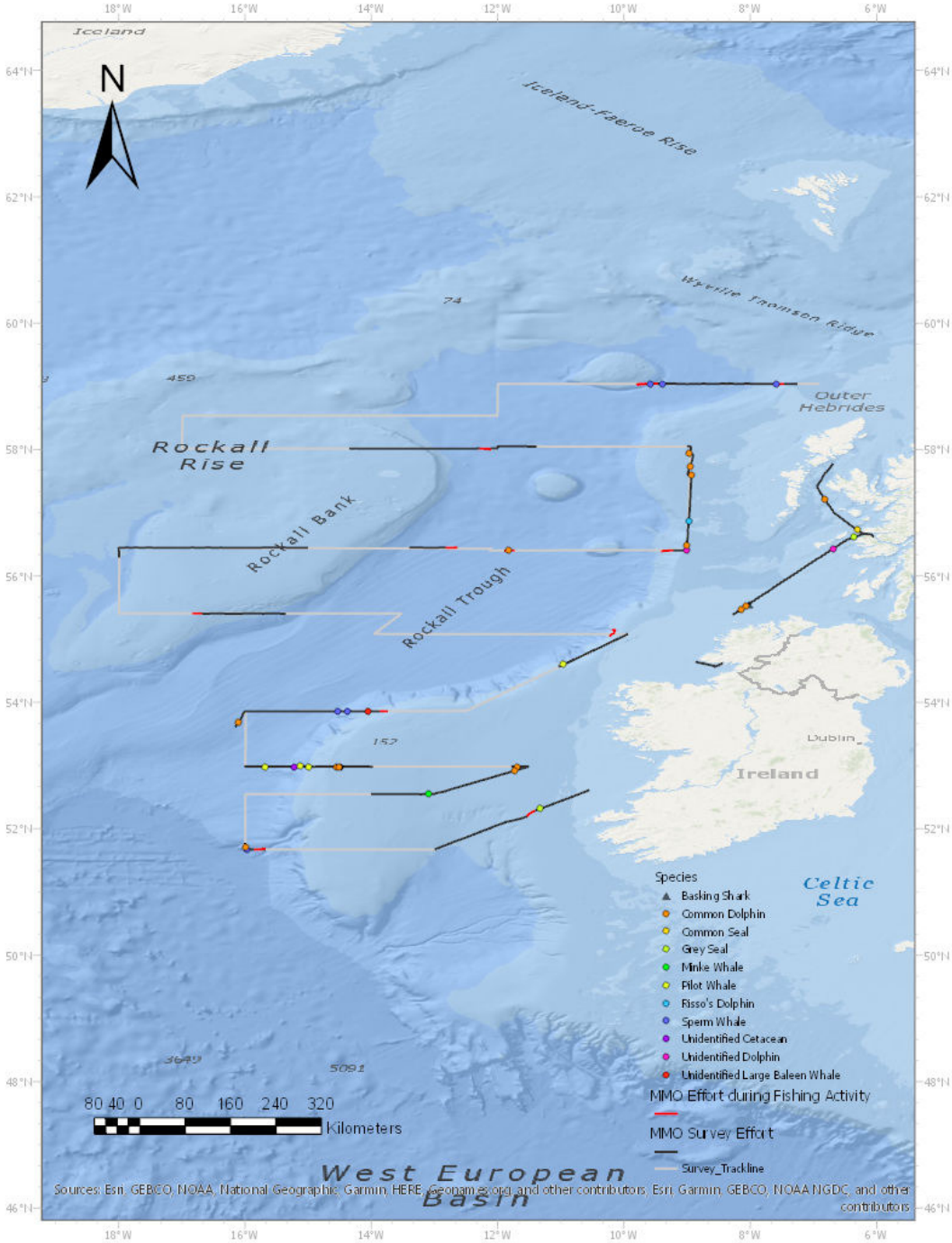


Figure 12. Distribution of primary sightings while on effort during the survey profiled with observer effort

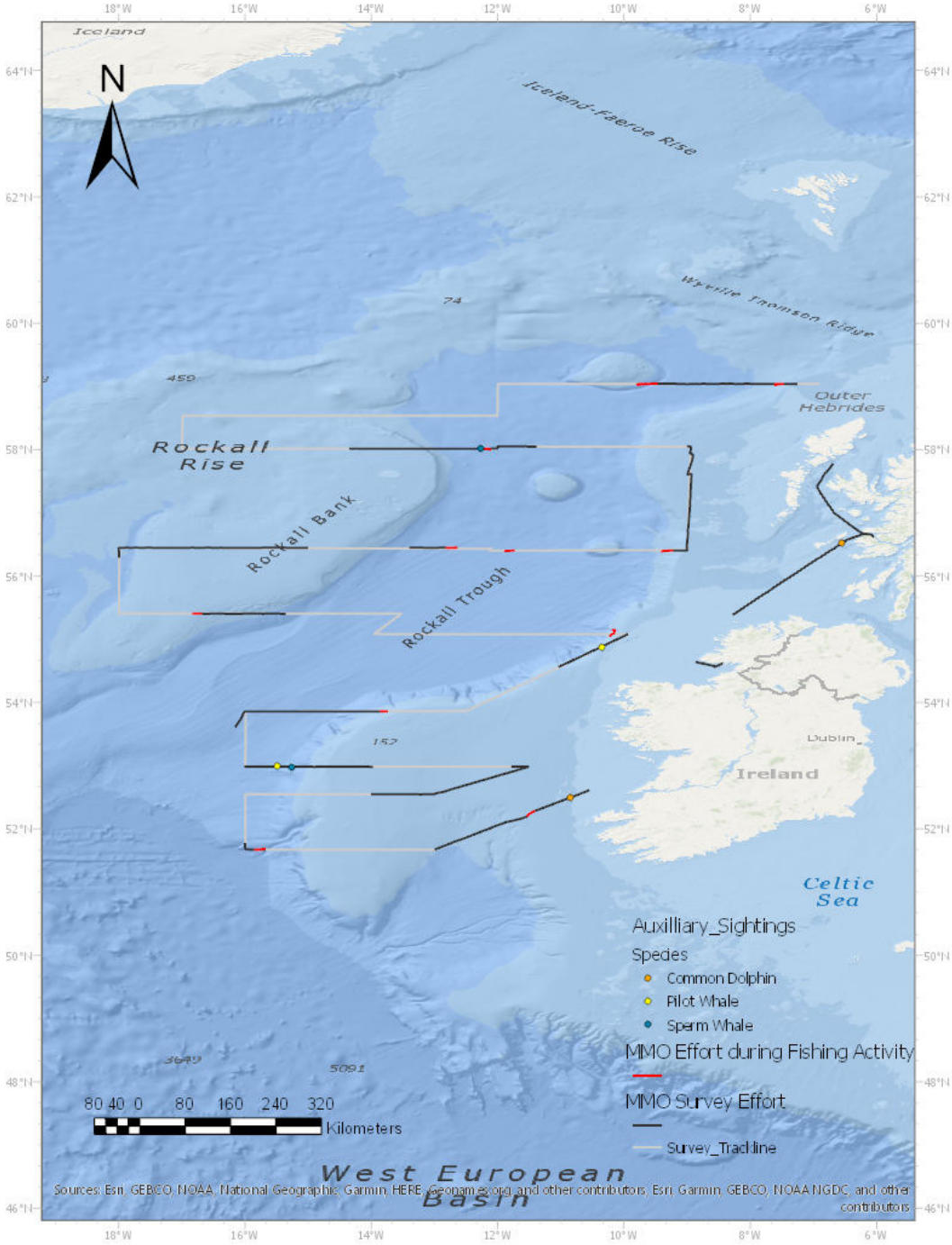


Figure 13. Distribution of auxiliary sightings during the survey profiled with observer effort

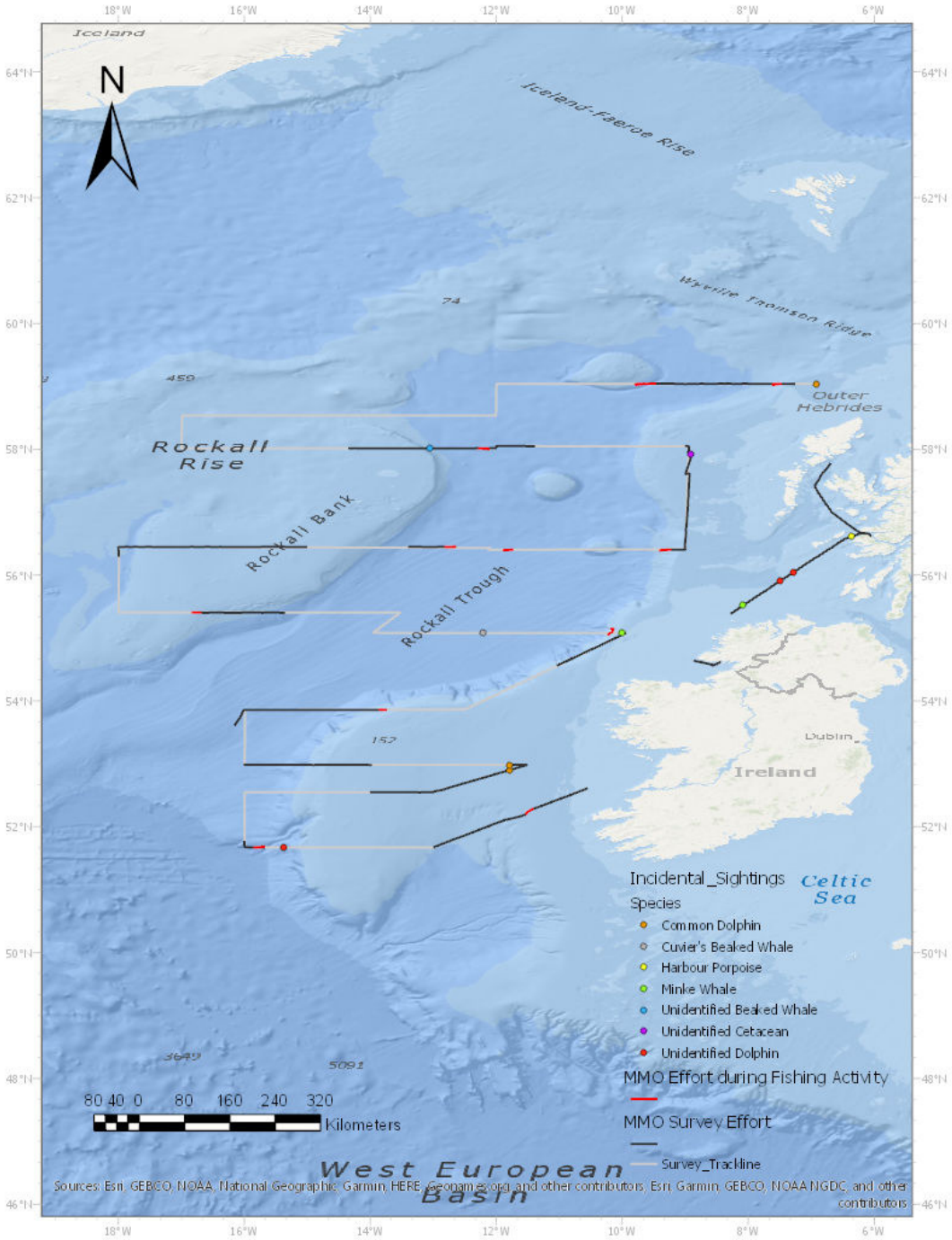


Figure 14. Distribution of incidental sightings during the survey profiled with observer effort