

A large white three-bladed wind turbine stands on a yellow and black steel jacket foundation in the middle of the sea. The sky is a clear, deep blue. In the foreground, a large splash of white water is visible, likely from a boat. In the background, another smaller offshore structure is visible on the horizon.

Beatrice Offshore Windfarm

Pre-construction Baseline Cod Spawning Survey – Technical Report

February 2015


Beatrice
Offshore Windfarm Ltd

Project Title/ Location	Beatrice Offshore Windfarm
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Beatrice Offshore Windfarm

Cod Spawning Survey Results – Technical Report

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1 Executive Summary

This pre-construction Monitoring Report has been prepared for Beatrice Offshore Windfarm Ltd (BOWL) as part of the Project Environmental Monitoring Programme (PEMP) required as part of the Section 36 Consent. This report describes the pre-construction element of condition 27 of the PEMP in relation to cod spawning and satisfies the pre-construction element of condition 35 of BOWL's section 36 consent.

The North Sea cod (*Gadus morhua*) stock is assessed as a single unit however there is evidence of sub-stock structuring (Fox *et al.*, 2008 and ICES, 2007). The Moray Firth cod stock is reproductively isolated from other North Sea stocks. Spawning grounds for this species have been defined in the area of the BOWL development (i.e. Coull *et al.*, 1998 and Ellis *et al.*, 2010) however, the degree of spawning activity currently taking place in this area is unknown. The objective of this survey was to sample and analyse adult cod within the 90 dB_{ht} noise ranges modelled for the BOWL Development Area in order to characterise cod spawning occurring within the defined area. The survey methodology was designed in consultation with Marine Scotland Science (MSS) and Marine Scotland Licensing and Operations Team (MS-LOT).

The survey was carried out in two trips between 20th February and 13th March 2014 (Trip 1 from 20th February to 25th February, and Trip 2 from 9th March to 13th March) coinciding with the peak spawning season. Sampling was undertaken using a commercial rock-hopper otter trawl with a 120 mm mesh cod-end, fitted with a 20 mm blinder (provided by MSS). Out of a planned 42 sampling locations a total of 40 tows of 30 minutes duration were undertaken within and adjacent to the BOWL site to cover areas of the cod spawning grounds defined by Coull *et al.* (1998). Two stations were omitted on the first trip due to weather and time constraints.

The catch from each otter trawl was emptied into the hopper, photographed, and sorted into baskets by species. The length, sex and spawning condition of each cod was identified and recorded. The gonads of each individual were photographed.

Cod were caught in 34 out of 40 stations sampled, with a maximum of 13 individuals recorded at a single station (OT05, Trip 2). A total of 47 spawning cod were caught in the survey, 25 in Trip 1 and 22 in Trip 2.

In line with previous cod spawning surveys in the same area, cod catch rates were calculated using the Scanmar outputs (swept area per tow). MSS guidance (derived from Wright *et al.*, 2006) defining spawning areas based on Catch Per Unit Effort (CPUE) has been used to determine whether significant cod spawning occurred at any sampling stations during the survey. Three categories were assigned based on the values provided by MSS:

- Not important for spawning cod (≤ 15 spawning cod/km²),
- May be important for spawning cod (>15 to ≤ 75 spawning cod/km²), and
- Spawning area (>75 spawning cod/km²).

Of the 19 stations undertaken during Trip 1, three stations had spawning cod catch rates that are considered to indicate a "spawning area" (>75 spawning cod/km²). Eight stations had spawning cod catch rates within the threshold "may be important" to spawning cod (>15 to ≤ 75 spawning cod/km²) with the remaining eight stations defined as "not important" for spawning cod (≤ 15 spawning cod/km²).

During Trip 2, four of the 21 stations sampled had spawning cod catch rates that are considered to indicate a "spawning area" (>75 spawning cod/km²). Five stations had spawning cod catch rates within the category "may be important" to spawning cod (>15 to

≤75 spawning cod/km²) with the remaining 12 stations categorised as “not important” for spawning cod (≤15 spawning cod/km²).

All fish and commercial shellfish species caught were identified, counted, measured and returned to the sea. Sub-sampling by species was carried out at sea when necessary. A total of 39 species were caught in the survey. Dab (*Limanda limanda*), plaice (*Pleuronectes platessa*), haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*) were the principal by-catch species found.

2 Introduction

This pre-construction monitoring report has been prepared for Beatrice Offshore Windfarm Ltd (BOWL) as part of the Project Environmental Monitoring Programme (PEMP) required as part of the Section 36 Consent.

This report describes the pre-construction element of condition 27 PEMP in relation to cod spawning. The completion of this survey also satisfies the pre-construction element of condition 35 of BOWL's Section 36 consent in that a baseline cod survey was undertaken in February and March 2014 prior to commencement of the development. The report complies with the Section 36 conditions and potential marine licence conditions. This report has been written by Brown and May Marine Ltd (BMM).

The following report details the findings of the cod spawning survey undertaken between the 20th February and 13th March 2014 within the BOWL development site and adjacent areas. The aim of this survey was to sample and analyse adult cod within the 90 dB_{ht} noise ranges modelled for the BOWL development area in order to characterise cod spawning occurring within the defined area.

BOWL committed to undertake the cod surveys, based on recommendations by Marine Scotland Science (MSS) and in consultation with Marine Scotland Licensing and Operations Team (MS-LOT). The objective of the surveys are to substantiate the baseline presence of cod so that results can be compared post-construction in compliance with S36 condition 35. BOWL, in consultation with MSS and other stakeholders, ensured that the survey methodology, rationale and approach were consistent and that surveys were undertaken at the appropriate time of year.

The survey methodology (LF000005-REP-060 - BOWL Cod_Sandeel_Survey_Methodology) was submitted to MSS and MS-LOT in January 2014 for consultation and agreement (Pers. com. G. Jones, 29/01/2014 & 5/02/2014; G. Holland 24/02/2014). Following consultation with MSS it was agreed that the survey could be undertaken from the last two weeks of February and the first two weeks of March. In line with MSS requests two cod surveys were conducted with at least a week's separation.

A dispensation from MSS, in accordance with the terms of Section 9 of the Sea Fish Conservation Act 1967 and Article 43 of Council Regulation No. 850/98, to fish in Area IVab, related to days at sea, was obtained prior to commencement of this survey.

A summary of the Health and Safety performance of the survey is provided in Section 9.1 - Appendix 1.

3 Background Information

Cod spawn throughout much of the northern North Sea however there is evidence of sub-stock structuring (Fox *et al.*, 2008; ICES, 2007). In the Moray Firth, the cod population has been found to be genetically distinct from other North Sea cod (Hutchinson *et al.*, 2001).

Cod spawn between January and April, with peak spawning taking place from February to March (Coull *et al.*, 1998). Eggs are pelagic and hatch over a period of two to three weeks, depending on water temperature (Wright *et al.*, 2003).

There is little available information on cod spawning in the central Moray Firth. The assessment of construction noise presented in the Beatrice Environmental Statement (BMM, 2012) used the grounds depicted in Coull *et al.* (1998) and Ellis *et al.* (2010) as primary sources of information in respect to cod spawning and nursery areas. According to these publications the BOWL site falls within a low intensity spawning and a high intensity nursery ground for cod (Coull *et al.*, 1998; Ellis *et al.*, 2010). The cod spawning and nursery areas as defined in Coull *et al.* (1998) and Ellis *et al.* (2010) are shown in Figure 3.1. Other sources of information (i.e. Gibbs *et al.*, 2008) were also used to further characterise the current state of knowledge in relation to the potential for the BOWL site to support spawning and juvenile cod.

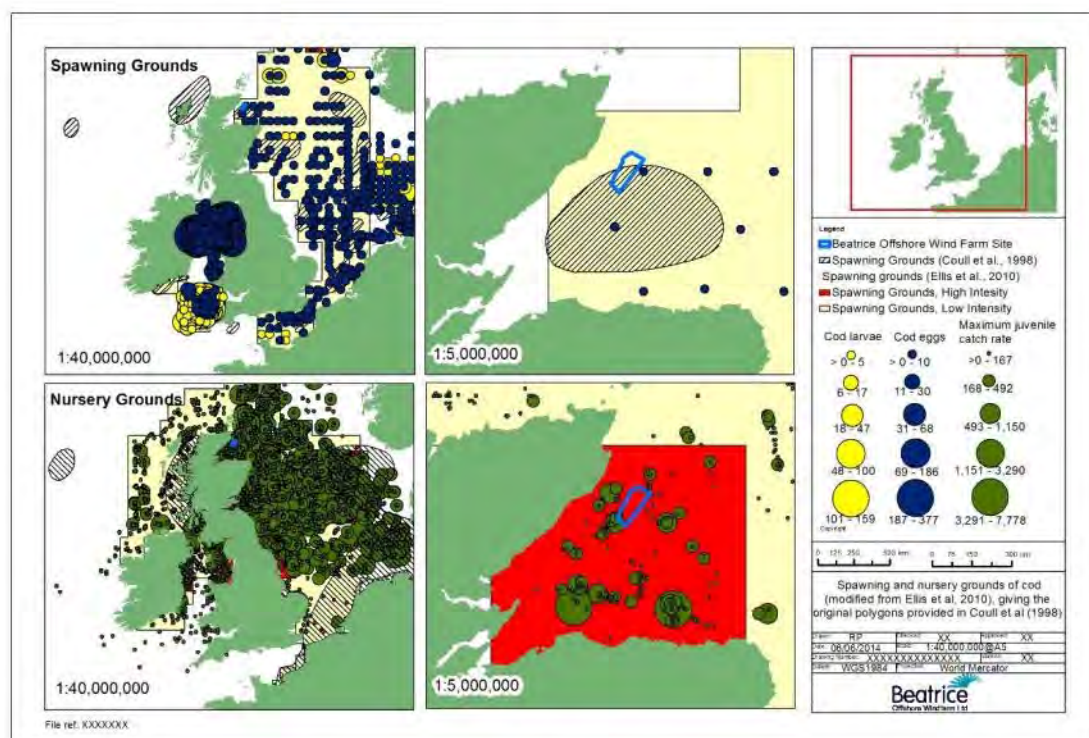


Figure 3.1 Cod spawning and nursery grounds (modified from Ellis *et al.*, 2010)

4 Scope of Works

The scope of works for the cod spawning survey is detailed below. The sampling stations are illustrated in Figure 4.1. Sampling locations were stratified spatially and by depth to provide a comprehensive coverage of the identified cod spawning grounds (Coull *et al.*, 1998), and the areas expected to be affected by piling noise during the construction phase at the 90dB_{ht}1 (*G. morhua*) level from two locations within the BOWL site.

The noise impact ranges used for selection of sampling stations are as presented in the Beatrice Environmental Statement (BMM, 2012).

- Otter Trawl – 21 stations
 - Trip 1: 21 tows of 30 minutes duration within the 3rd week of February 2014
 - Trip 2: 21 replicate tows of 30 minutes duration within the 2nd week of March 2014
- Sample Analysis – Cod
 - Number of individuals, catch rate and density
 - Length distribution (nearest 0.5 cm below)
 - Maturity analysis – Bucholtz *et al.*, (Draft manual) maturity key
- Sample Analysis – By-catch species
 - Number of individuals and catch rate by species
 - Length distribution by species
 - Finfish and sharks (except herring and sprat): individual lengths (nearest cm below)
 - Herring and sprat: individual lengths (nearest 0.5cm below)
 - Rays: individual length and wing-width (nearest cm below)
- Cod Spawning Analysis by Catch per Unit Effort (CPUE)
 - MSS guidance (derived from Wright *et al.*, 2006) defining spawning areas based on CPUE (Pers.com A. Kafas 7th April 2014) was used to determine if significant cod spawning occurred at any sampling stations during the survey. Three categories were assigned based on the values provided in the MSS guidance: (i) Not important for spawning cod (≤ 15 spawning cod/km²), (ii) May be important for spawning cod (>15 to ≤ 75 spawning cod/km²) and (iii) Spawning area (>75 spawning cod/km²).

¹ The dB_{ht} (*Species*) metric takes account of the hearing ability and expected response to underwater noise on a species specific basis. The noise impact ranges defined at the 90dB_{ht} (*Gadus morhua*) level represent sea areas where the majority of cod would be expected to exhibit strong avoidance reactions.

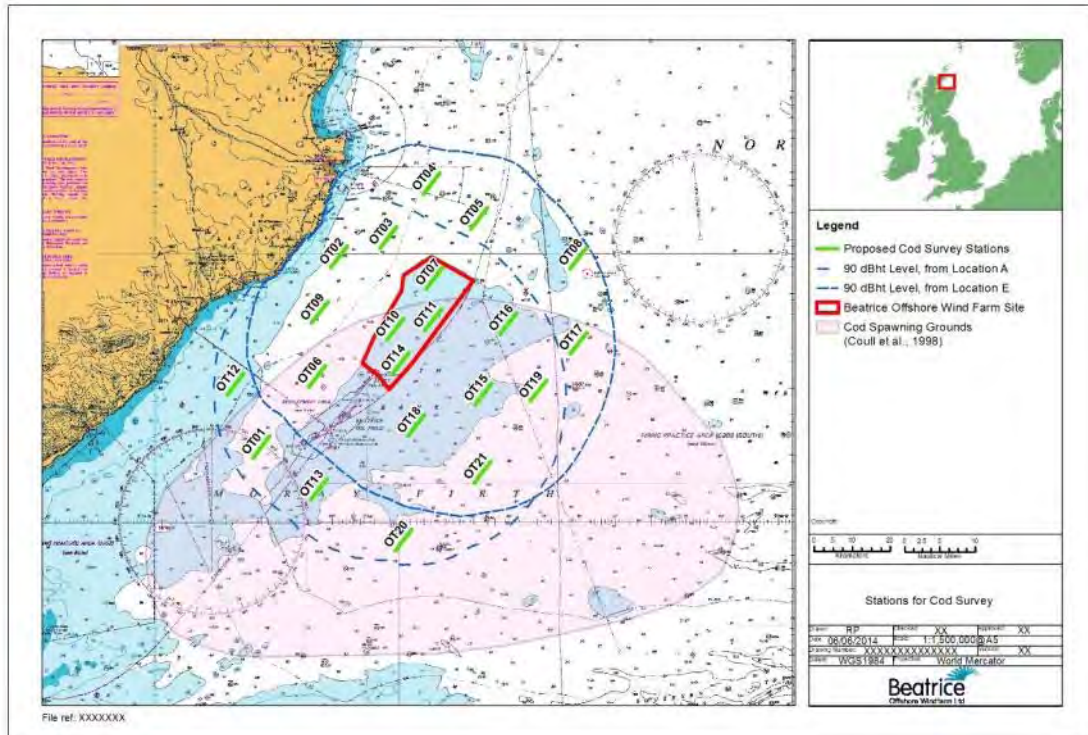


Figure 4.1 Sampling stations

5 Survey Methodology

The survey was undertaken between 20th February and 13th March 2014 in order to cover the peak spawning period of this species.

Two sampling trips were undertaken: Trip 1 from 20th February to 25th February, and Trip 2 from 9th March to 13th March. During these, a total of 40 stations were sampled using a commercial rock-hopper otter trawl with a 120 mm mesh cod end, fitted with a 20 mm blinder. A summarised log of events is given in Section 9.2 - Appendix 2.

5.1 Survey Vessel

The vessel chartered for the survey, the Marine Fishing Vessel "Seagull" (Figure 5.1), is a Fraserburgh-based commercial trawler. The specifications of the vessel are given in Table 5.1.



Figure 5.1 Survey vessel "Seagull"

Table 5.1 Survey vessel specifications

Survey Vessel Specifications	
Length	27.41m
Beam	8.52m
Draft	4.9m
Main Engine	Deutz MWM Marine TBD620 V12, 1,340 kW
Gearbox	Hemidal HG47OF 7.07:1 reduction
Propeller	4 Blade Variable Pitch 2.9m diameter with a Kort Nozzle
GPS	1 x Dassault Sercel NR51, 1 x Furuno
Plotters	Sodena Plotter with Electronic Charts x 2
Sounder	Atlas 783 Colour
Scanmar	RX400 and Scanmate

5.2 Sampling Gear

A commercial rock-hopper otter trawl (Figure 5.2) with a 120 mm mesh cod end, fitted with a 20 mm blinder provided by MSS, was used for cod sampling; the specifications of which are detailed below in Table 5.2.

In order to calculate trawl swept areas during each tow, a receiver and data processing unit (Scanmar RX400) was used to receive data from three Scanmar S400 sensors, two of which were fitted at the wing-ends and one on the headline.



Figure 5.2 Rock-hopper otter trawl used

Table 5.2 Rock-hopper otter trawl specifications

Rock-hopper Otter Trawl Specifications	
Towing Warp	Steel core diaform 24 mm, 1,463 m on each of three winches
Sweep Length	109.7 m with 27.43 m of split chain
Depth: Payout Ratio	3:1
Trawl Doors	Thyboron, 1 tonne, single tow point, 3 back attachments
Net	Seaway net with 120mm mesh bag and cod end (fitted with a 20 mm blinder)
Groundline	5,121 cm, rock-hopper with 31 and 35.6 cm bobbins
Estimated Headline Height	6.4 m
Distance between Trawl Doors (est.)	73.1 m

5.3 Sampling Procedures

5.3.1 Positioning and Navigation

The position of the vessel was tracked at all times using a Garmin GPSMap 278 with an EGNOS differential connected to an external Garmin GA30 antenna. Otter trawl start times and positions were taken when the winch stopped paying out the gear. Otter trawl end times and positions were taken when hauling of the gear commenced.

5.3.2 Otter Trawl Sampling

The catch from each otter trawl was emptied into the hopper, photographed, and sorted into baskets by species. The length, sex and spawning condition of each cod was identified and recorded. The gonads of each individual were photographed.

The gonadal maturity key used was as provided by MSS (Bucholtz *et al.*, Draft manual). The maturity stages used are described in Table 5.3. As shown, stage III cod is considered to be in spawning condition. Examples of spawning and spent individuals are provided in Section 9.4 - Appendix 4.

By-catch species were identified, counted, measured and returned to the sea. Sub-sampling by species was carried out at sea where necessary.

5.3.3 Cod Analysis by CPUE

Following the methodology provided in Wright *et al.* (2006) the numbers of individuals caught at each station were multiplied up using the Scanmar data to produce the number of cod per km² for each station. MSS have produced a guideline on defining cod spawning areas based on CPUE based on the findings in Wright *et al.* (2006). MSS have stated that the presence of >15 spawning cod per km² indicates that the area “may be important” to spawning cod. The presence of >75 spawning cod per km² should provide a clear indication of a “spawning area”.

Table 5.3 Cod maturity key (adapted from Bucholtz *et al.*, Draft manual)

Stage		Description of Appearance	
		Female	Male
I	Juvenile/immature	Ovaries small but easily distinguishable posterior in body cavity, soft with smooth surface, blurred translucent, reddish-orange	Testes small, but distinguishable along air bladder. Lobules small, blurred translucent reddish-white
II	Maturing	Ovaries occupy between half and 2/3 of the body cavity, plump and firm with prominent blood vessels, opaque, orange to creamy yellow. Oocytes clearly visible and densely packed	Testes enlarged and prominent dorsal in body cavity; lobules plump and brittle; reddish-white. Empty transparent spermatoducts with prominent blood vessels; no sperm release
III	Spawning	Ovaries fill most of body cavity; very distended and soft; appear granulated orange- to reddish-grey from mixture of opaque and glassy oocytes. Lumen containing viscous fluid in excess or hydrated eggs	Testes large and prominent in body cavity. Lobules still plump, but soft; completely opaque, whitish. Spermatoducts filled with fluid, milky semen that easily flows from vent
IV	Spent	Ovaries contracted; slack with greyish cast; rich in blood vessels; dim translucent reddish-grey. Vitellogenic oocytes absent but single hydrated eggs or atretic oocytes (opaque irregular granules) may occur	Testes contracted, close to air bladder; rich in blood vessels. Lobules empty, flabby, reddish potentially with a greyish cast. Spermatoducts with signs of previous distension, often with visible remains of semen
V	Resting/Skip of spawning	Ovaries small as in stage I but with signs of previous spawning; e.g. greyish cast and somewhat uneven walls; blurred translucent, reddish-grey, but more granulated and opaque than in stage I	Testes small but with signs of previous spawning; e.g. lobules slightly larger than in stage I; spermatoducts often with a greyish cast
VI	Abnormal	Stone roe. Ovary has a thick wall, grey-whitish cast and hard parts	Testes with adipose tissue formation; affected parts undeveloped, hard and yellowish

5.4 Trip 1

A total of 19 tows of 30 minutes duration were undertaken within and adjacent to the BOWL site. In order to maintain the survey programme, stations OT05 and OT08 were omitted from the survey due to weather and time constraints after approval from MSS.

The otter trawl tow tracks of Trip 1 are given in Figure 5.3. The start and end times, co-ordinates, depths and durations of each otter trawl tow are given in Section 9.3 - Appendix 3.

5.5 Trip 2

A total of 21 tows of 30 minutes duration were undertaken, replicating the tows carried out during Trip 1. No stations were omitted as weather conditions were favourable.

The otter trawl tow tracks of Trip 2 are given in Figure 5.4. The start and end times, co-ordinates, depths and durations of each otter trawl are given in 9.3 - Appendix 3.

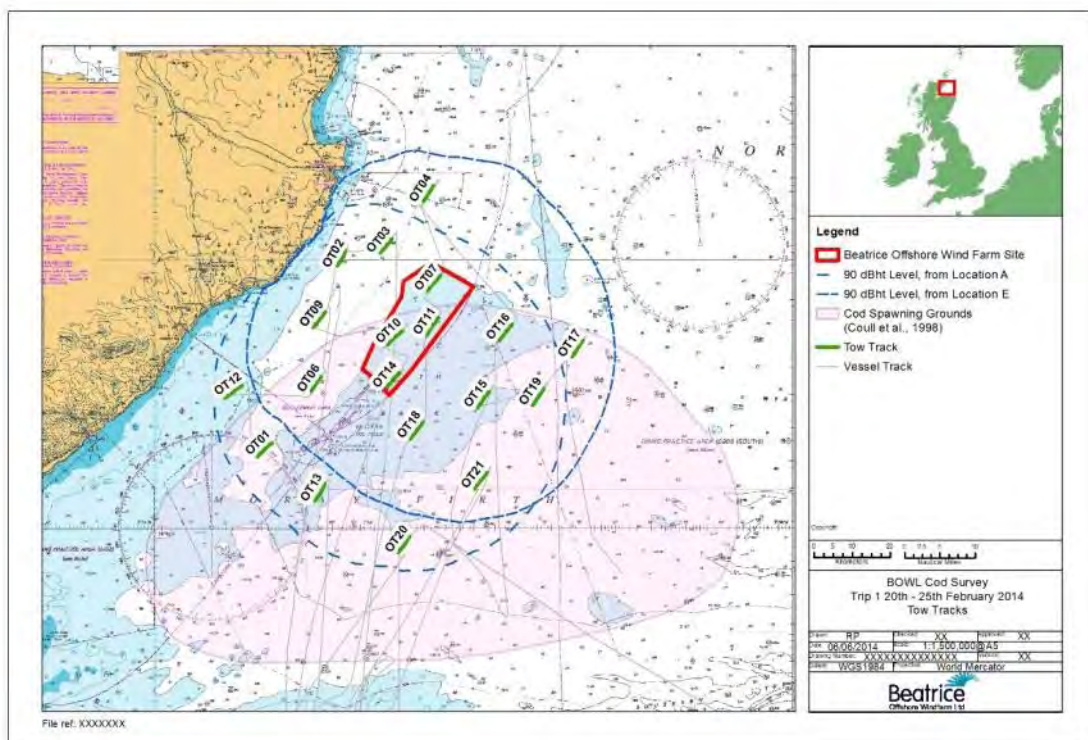


Figure 5.3 Trip 1 - Vessel tracks whilst towing the otter trawl

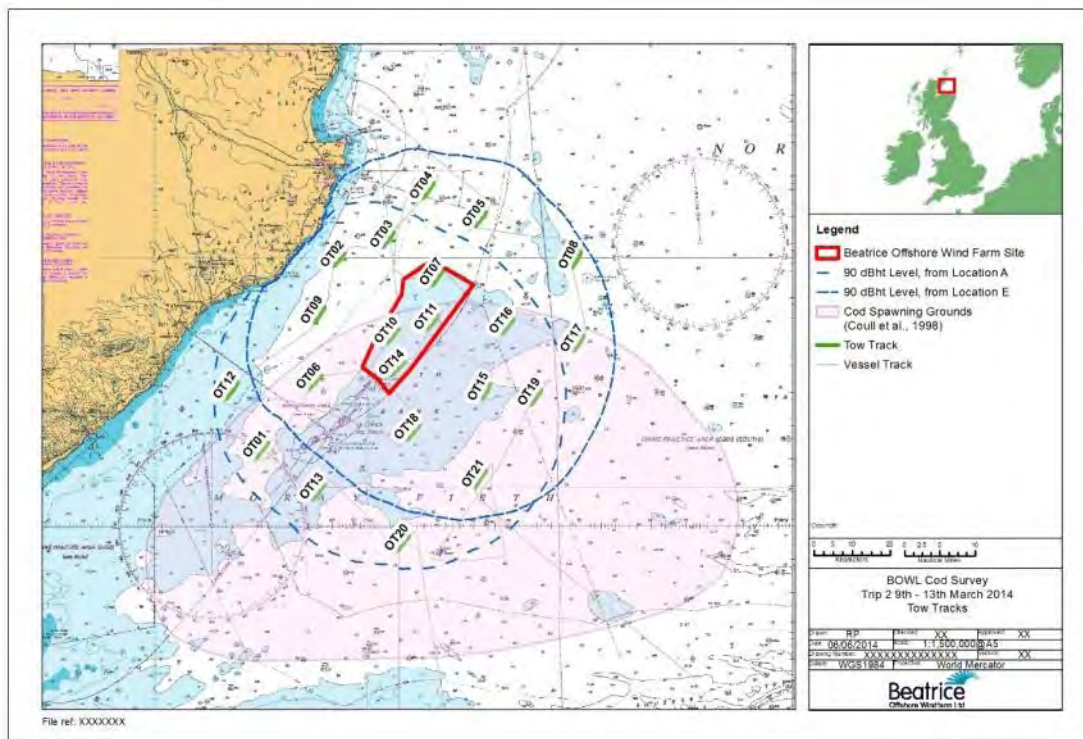


Figure 5.4 Trip 2 – Vessel tracks whilst towing the otter trawl

6 Otter Trawl Results

6.1 Cod Survey Overview

Cod were caught in 34 of the 40 stations sampled, with a maximum of 13 individuals recorded in a single station (OT05, Trip 2). In general terms, cod were found in low numbers with a total of 131 individuals being caught during both survey trips (Trip 1 and Trip 2).

A total of 72 juvenile (maturity stage I) and 59 adult (maturity stages II, III and IV) cod were caught during the survey. The majority of adult cod caught were spawning (stage III; 47 individuals), with 11 maturing cod (stage II) and one spent individual (stage IV).

During Trip 1 a total of 25 spawning cod were recorded whereas 22 spawning cod were recorded in Trip 2. A maximum of five spawning individuals were recorded at three stations (Trip 1, OT09; Trip 2, OT04 and OT05).

A greater number of males were caught than females (66 and 51, respectively). The majority of spawning cod caught were male. 21 male spawning cod and 4 female were caught during Trip 1, with 19 male spawning cod and 3 female recorded during Trip 2. Sex-specific behaviours have been observed in cod during spawning; male dominated and female dominated shoals have been recorded and males have also been reported to aggregate on spawning grounds with females distributed more on the periphery (Michalsen *et al.*, 2008; Skjaeraasen *et al.*, 2011).

The numbers of cod caught by station are shown in Table 6.1 and Table 6.3 for Trip 1 and Trip 2, respectively.

Scanmar outputs (swept area per tow) were used to calculate cod catch rates (no. of cod per km²). The MSS guidance (section 9.5 - Appendix 5) on defining cod spawning by CPUE were applied to these data in order to determine whether significant cod spawning is taking place within the BOWL site and/or in adjacent locations. The full dataset used to calculate catch rates from the Scanmar outputs is given in section 9.6 (Appendix 6).

Three categories to define cod spawning by CPUE were established based on the MSS guidance:

- Not important for spawning cod (≤ 15 spawning cod/km²),
- May be important for spawning cod (> 15 to ≤ 75 spawning cod/km²), and
- Spawning area (> 75 spawning cod/km²).

Of the 19 stations undertaken during Trip 1, three stations had spawning cod catch rates that are considered to indicate a "spawning area" (> 75 spawning cod/km²). Eight stations had spawning cod catch rates within the threshold "may be important" to spawning cod (> 15 to ≤ 75 spawning cod/km²) with the remaining eight stations defined as "not important" for spawning cod (≤ 15 spawning cod/km²).

During Trip 2, four of the 21 stations sampled had spawning cod catch rates that are considered to indicate a "spawning area" (> 75 spawning cod/km²). Five stations had spawning cod catch rates within the category "may be important" to spawning cod (> 15 to ≤ 75 spawning cod/km²) with the remaining 12 stations categorised as "not important" for spawning cod (≤ 15 spawning cod/km²).

6.1.1 Trip 1

The numbers of cod caught by station during Trip 1 together with the length, sex and maturity stage of each individual is shown in Table 6.1. Figure 6.1 and Figure 6.2 give the

spatial distribution of cod caught during Trip 1 by spawning state (spawning/not spawning) and maturity stages (I to IV) respectively. The percentage contribution of spawning cod (maturity stage III) to the total catch in each sampling station is also shown.

Table 6.1 Number of cod, sex and maturity stage by sampling station – Trip 1

Station	Length (cm)	Sex	Maturity Stage	Total No. Individuals	Total No. Spawning Cod	Percentage of Spawning Cod
OT01	11.0	F	I	3	0	0.0%
	14.0	F	I			
	17.5	F	I			
OT02	17.0	F	I	5	1	20.0%
	18.0	F	I			
	25.5	F	I			
	29.5	M	I			
	38.5	M	III			
OT03	14.0	F	I	7	4	57.1%
	14.5	M	I			
	16.0	U	I			
	39.0	M	III			
	40.0	M	III			
	42.0	M	III			
	44.0	F	III			
OT04	17.5	M	I	5	3	60.0%
	29.5	M	III			
	34.5	M	II			
	46.0	M	III			
	58.0	M	III			
OT06	11.0	F	I	5	2	40.0%
	13.0	U	I			
	14.0	F	I			
	50.5	M	III			
	59.5	F	III			
OT07	13.5	F	I	3	1	33.3%
	17.5	M	I			
	45.0	M	III			
OT09	14.0	F	I	7	5	71.4%
	30.0	M	II			
	35.0	M	III			
	36.0	M	III			
	37.0	M	III			
	47.0	M	III			
	47.0	M	III			
OT10	15.0	F	I	2	0	0.0%
	22.0	F	I			

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Station	Length (cm)	Sex	Maturity Stage	Total No. Individuals	Total No. Spawning Cod	Percentage of Spawning Cod
OT11	16.0	U	I	2	0	0.0%
	16.0	U	I			
OT12	12.0	U	I	5	4	80.0%
	32.5	M	III			
	59.5	M	III			
	61.0	F	III			
	62.0	F	III			
OT13	17.5	U	I	4	2	50.0%
	19.0	F	I			
	36.5	M	III			
	42.0	M	III			
OT14	43.0	M	III	1	1	100.0%
OT15	45.5	M	III	1	1	100.0%
OT16	27.0	M	I	3	1	33.3%
	34.0	M	II			
	37.0	M	III			
OT17	17.0	F	I	1	0	0.0%
OT18	15.5	F	I	3	0	0.0%
	18.0	F	I			
	18.0	M	I			
OT19	13.0	F	I	1	0	0.0%
OT20	14.5	M	I	1	0	0.0%
OT21	13.0	M	I	2	0	0.0%
	19.0	F	I			
Grand Total				61	25	41.0%

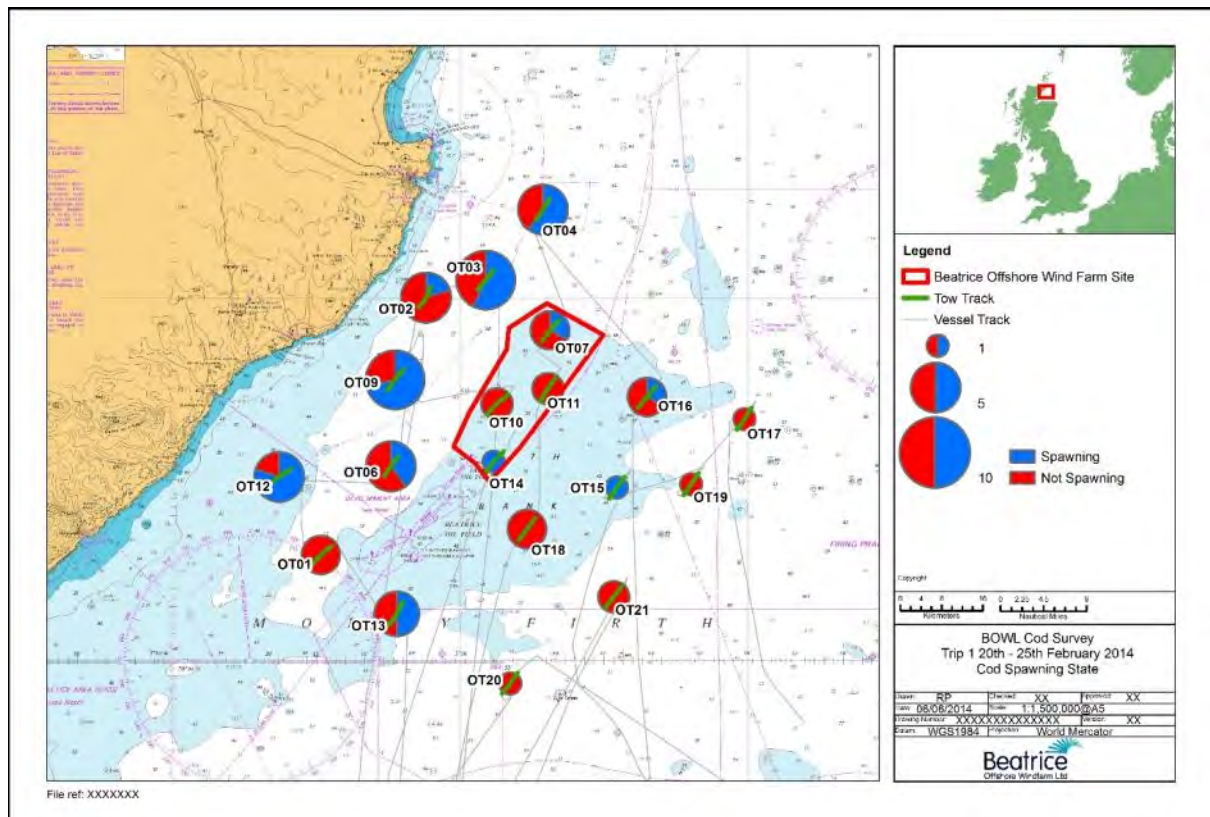


Figure 6.1 Cod catch by spawning state (spawning/not spawning) recorded by station - Trip 1

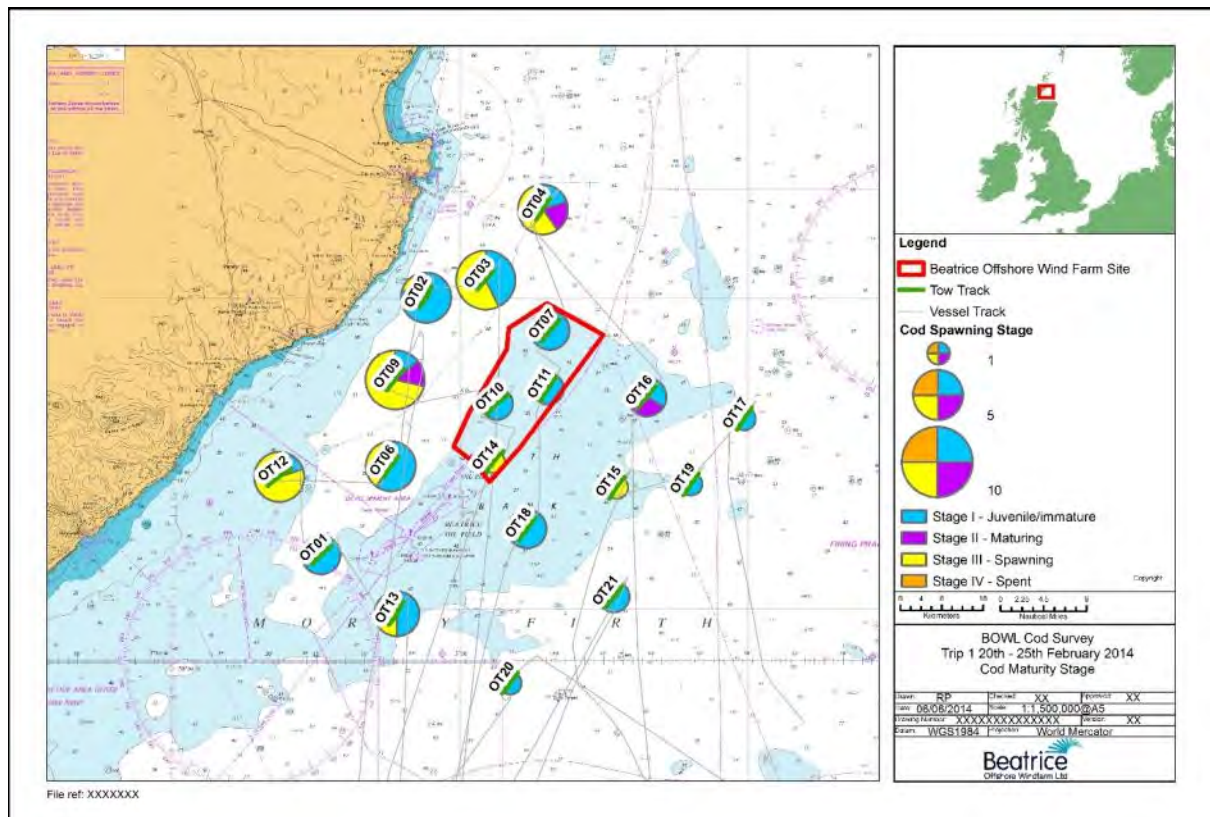


Figure 6.2 Cod catch by maturity stage (I to IV) recorded by station - Trip 1

6.1.1.1 Cod Spawning by CPUE

Scanmar outputs (swept area per tow) were used to calculate cod catch rates (no. of cod per km²). These data are given in Table 6.2 and shown in Figure 6.3. Stations that fall within the category “spawning area” (>75 spawning cod/km²) are highlighted in green (Figure 6.4).

Stations with catch rates classified as a “spawning area” for cod were observed at the sample locations along the coastline.

Table 6.2 Total number of cod and number of spawning cod per km² with spawning status assigned for each station during Trip 1

Station	Total No. Cod per km ²	No. Spawning Cod per km ²	Spawning Status Based on MSS Guidance
OT01	88	0	Not significant
OT02	142	28	May be important
OT03	195	111	Spawning area
OT04	118	71	May be important
OT06	165	66	May be important
OT07	80	27	May be important
OT09	190	136	Spawning area
OT10	50	0	Not significant
OT11	54	0	Not significant
OT12	139	111	Spawning area
OT13	121	61	May be important
OT14	21	21	May be important
OT15	29	29	May be important
OT16	75	25	May be important
OT17	30	0	Not significant
OT18	85	0	Not significant
OT19	30	0	Not significant
OT20	30	0	Not significant
OT21	57	0	Not significant

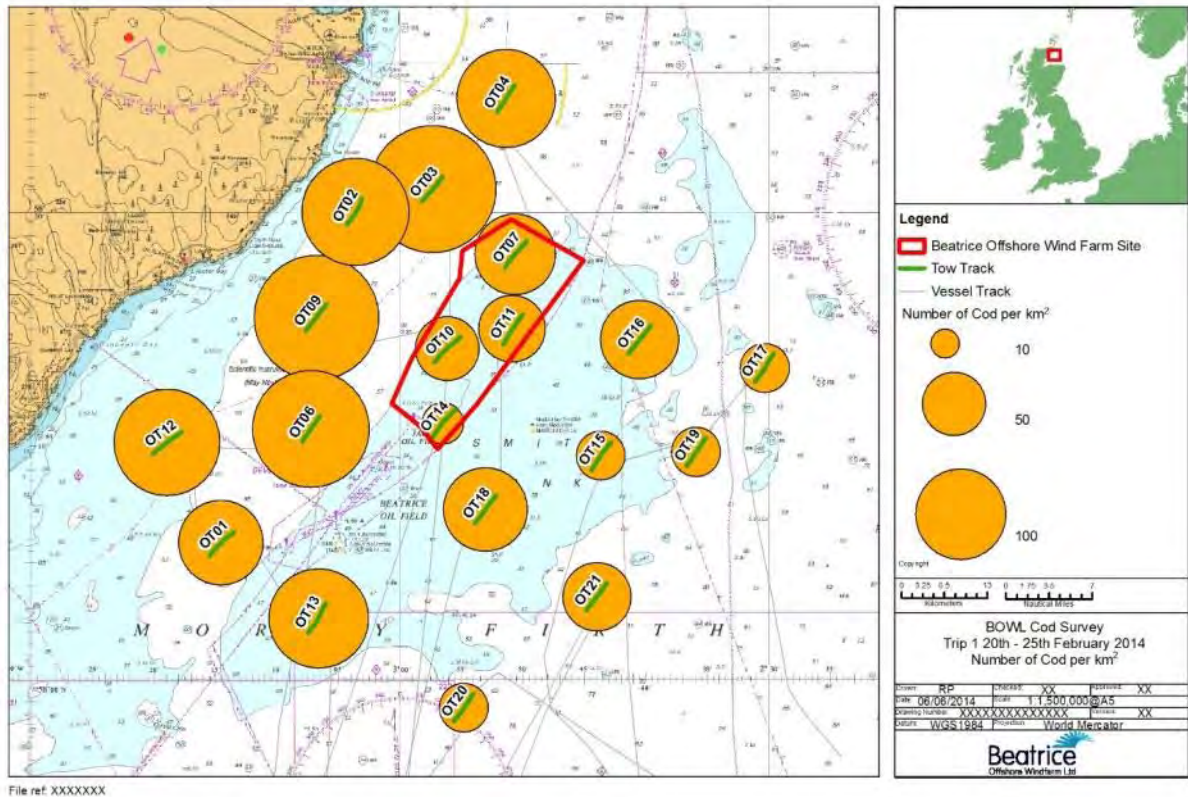


Figure 6.3 Cod catch rates by CPUE (no. cod/km²) for Trip 1

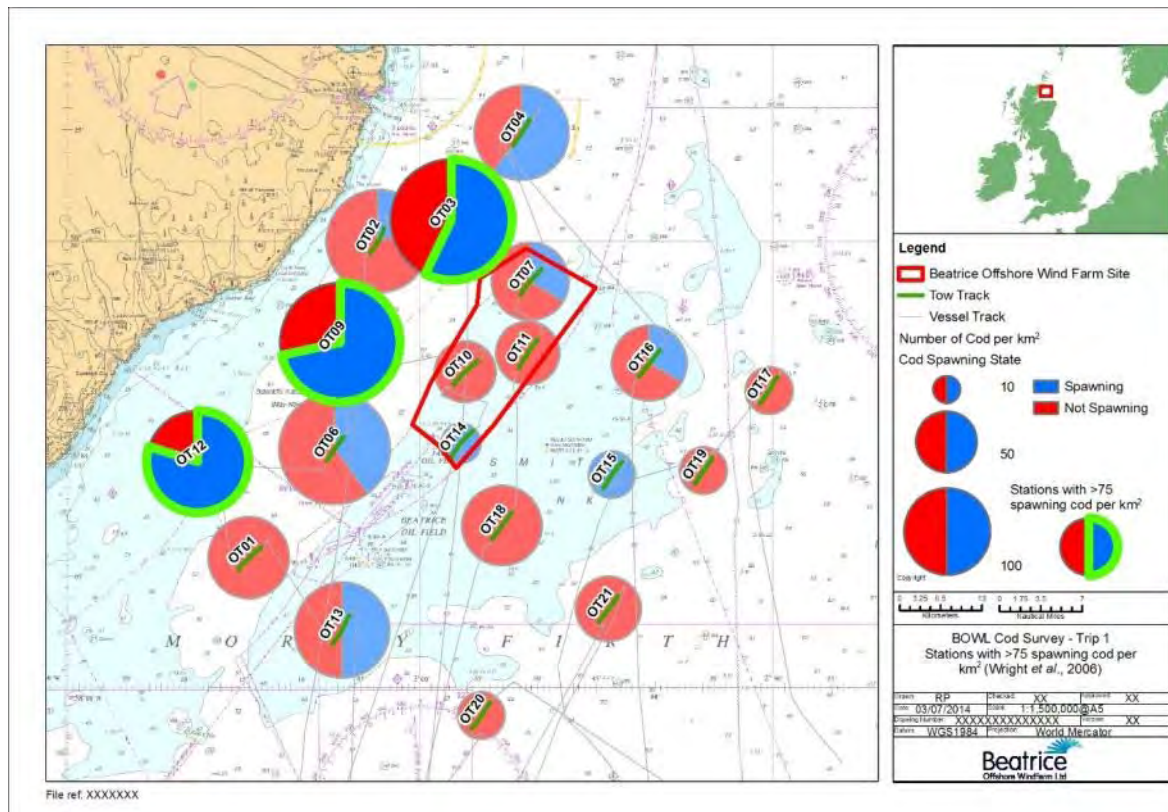


Figure 6.4 Cod catch rates by CPUE (no. cod/km²) for Trip 1 with stations showing >75 spawning cod/km² highlighted in green

6.1.2 Trip 2

The numbers of cod caught by station during Trip 2 together with the length, sex and maturity stage of each individual is shown in Table 6.3.

Figure 6.5 and Figure 6.6 give the spatial distribution of cod caught during Trip 2 by spawning state (spawning/not spawning) and maturity stages (I to IV) respectively. The percentage contribution of spawning cod (maturity stage III) to the total catch in each sampling station is also shown.

Table 6.3 Number of cod, sex and maturity stage by sampling station – Trip 2

Station	Length (cm)	Sex	Maturity Stage	Total No. Individuals	Total No. Spawning Cod	Percentage of Spawning Cod
OT02	14.0	M	I	11	0	0.0%
	14.0	M	I			
	14.5	M	I			
	14.5	U	I			
	15.0	F	I			
	15.0	F	I			
	15.0	F	I			
	15.0	M	I			
	15.5	F	I			
	16.5	F	I			
	17.0	F	I			
OT03	15.5	U	I	4	3	75.0%
	40.5	M	III			
	42.0	M	III			
	45.5	M	III			
OT04	21.5	M	I	7	5	71.4%
	30.0	M	III			
	34.5	M	II			
	34.5		III			
	35.0	M	III			
	35.5	M	III			
	52.0	M	III			
OT05	16.0	F	I	13	5	38.5%
	16.5	F	I			
	30.0	F	II			
	30.5	M	II			
	31.0	M	II			
	33.5	M	II			
	34.0	M	II			
	36.0	M	II			
	36.5	M	III			
	39.0	M	III			
	39.0	M	III			
	39.5	M	III			
	53.5	M	III			
OT07	14.5	F	I	5	2	40.0%
	15.5	F	I			
	16.5	F	I			
	27.5	M	III			
	43.5	M	III			
OT09	13.5	M	I	2	0	0.0%

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Station	Length (cm)	Sex	Maturity Stage	Total No. Individuals	Total No. Spawning Cod	Percentage of Spawning Cod
	26.0	F	I			
OT10	46.5	F	III	1	1	100.0%
OT11	14.0	F	I	2	0	0.0%
	15.0	F	I			
OT12	11.5	U	I	12	1	8.3%
	12.0	U	I			
	12.5	U	I			
	13.0	F	I			
	13.5	F	I			
	14.0	M	I			
	14.0	U	I			
	15.0	F	I			
	15.5	F	I			
	16.0	U	I			
	18.5	F	I			
	29.0	M	III			
OT13	38.0	M	III	3	3	100.0%
	39.0	F	III			
	43.0	M	III			
OT15	15.0	M	I	2	1	50.0%
	54.0	F	III			
OT16	60.0	F	IV	1	0	0.0%
OT17	14.5	F	I	3	0	0.0%
	15.0	F	I			
	16.0	F	I			
OT18	9.5	U	I	3	1	33.3%
	32.5	M	II			
	52.0	M	III			
OT19	13.0	F	I	1	0	0.0%
Grand Total				70	22	31.4%

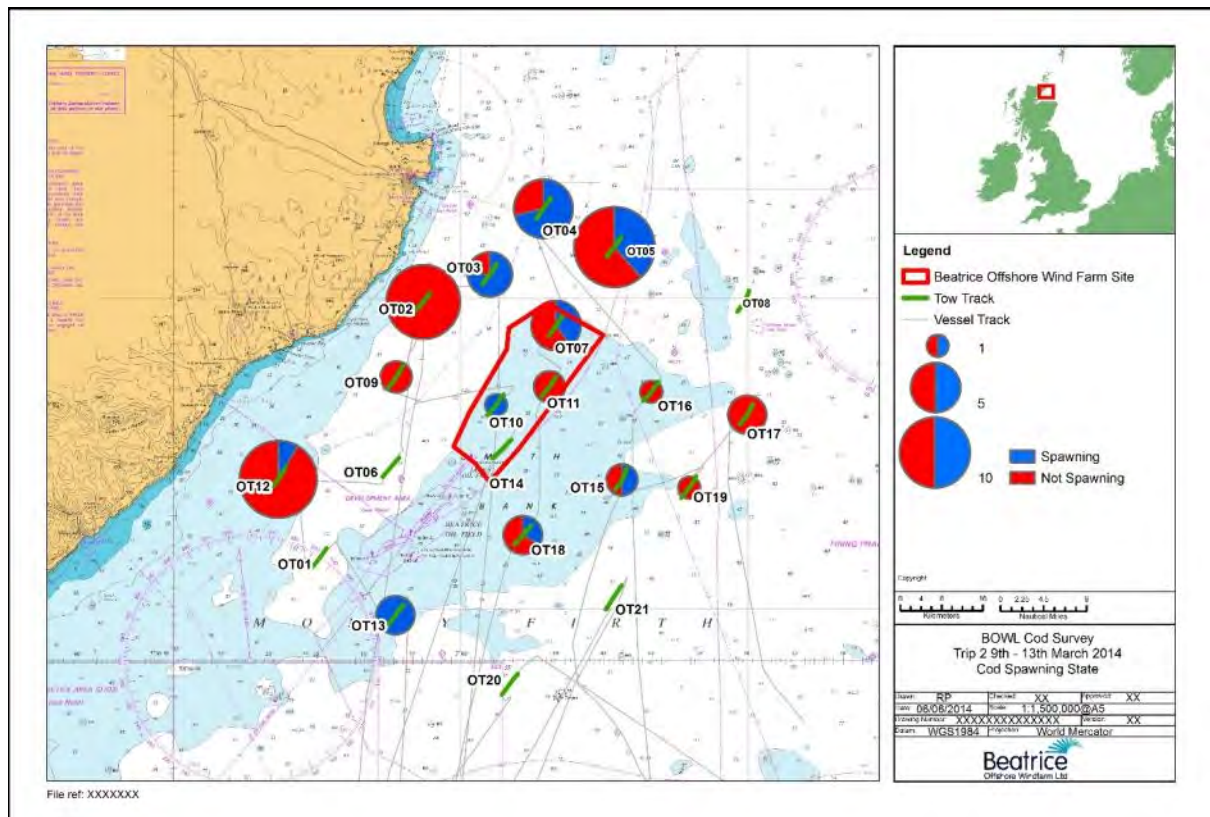


Figure 6.5 Cod catch by spawning state (spawning/not spawning) recorded by station - Trip 2

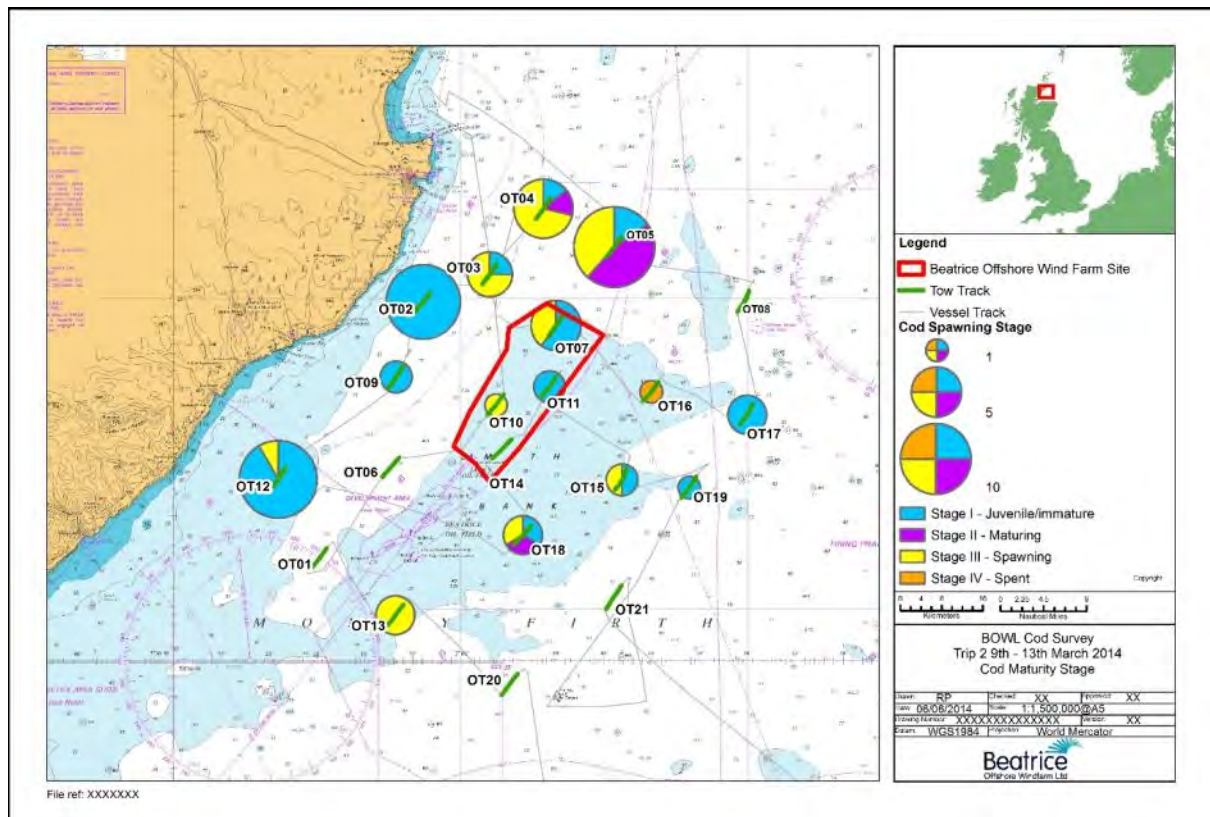


Figure 6.6 Cod catch by maturity stage (I to IV) recorded by station - Trip 2

6.1.2.1 Cod Spawning by CPUE

Scanmar outputs (swept area per tow) were used to calculate cod catch rates (no. of cod per km²). These data is given in Table 6.4 and shown in Figure 6.7. Stations that fall within the threshold defined as a “spawning area” for cod (>75 spawning cod/km²) are highlighted in green (Figure 6.8).

Higher catch rates were observed at stations along the coastline. Stations with catch rates classified as a “spawning area” for cod show a patchy distribution, however, the majority of stations were observed in the north of the survey area.

Table 6.4 Total number of cod and number of spawning cod per km² with spawning status assigned for each station during Trip 2

Station	Total No. Cod per km ²	No. Spawning Cod per km ²	Spawning Status Based on MSS Guidance
OT01	85	0	Not significant
OT02	329	0	Not significant
OT03	109	82	Spawning area
OT04	166	119	Spawning area
OT05	357	137	Spawning area
OT06	89	0	Not significant
OT07	138	55	May be important
OT08	91	0	Not significant
OT09	53	0	Not significant
OT10	29	29	May be important
OT11	55	0	Not significant
OT12	292	24	May be important
OT13	87	87	Spawning area
OT14	82	0	Not significant
OT15	63	31	May be important
OT16	31	0	Not significant
OT17	94	0	Not significant
OT18	87	29	May be important
OT19	29	0	Not significant
OT20	87	0	Not significant
OT21	76	0	Not significant

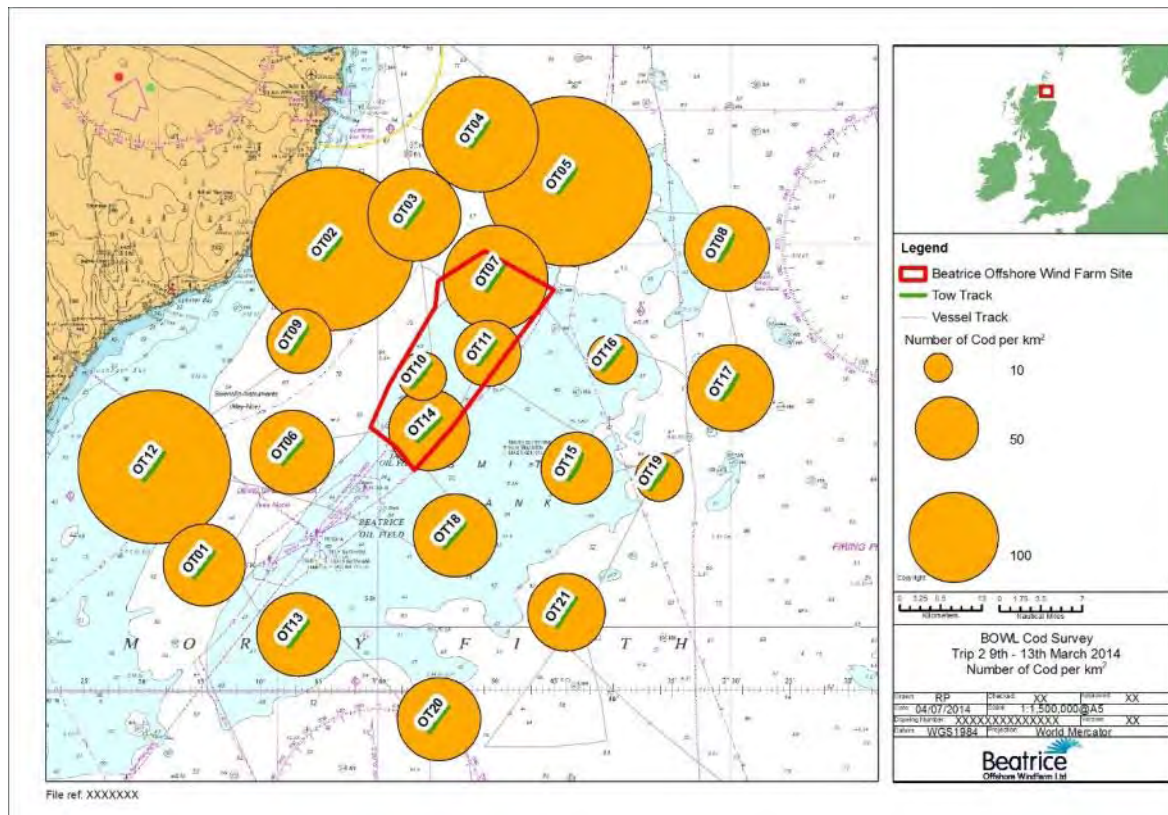


Figure 6.7 Cod catch rates by CPUE (no. cod/km²) for Trip 2

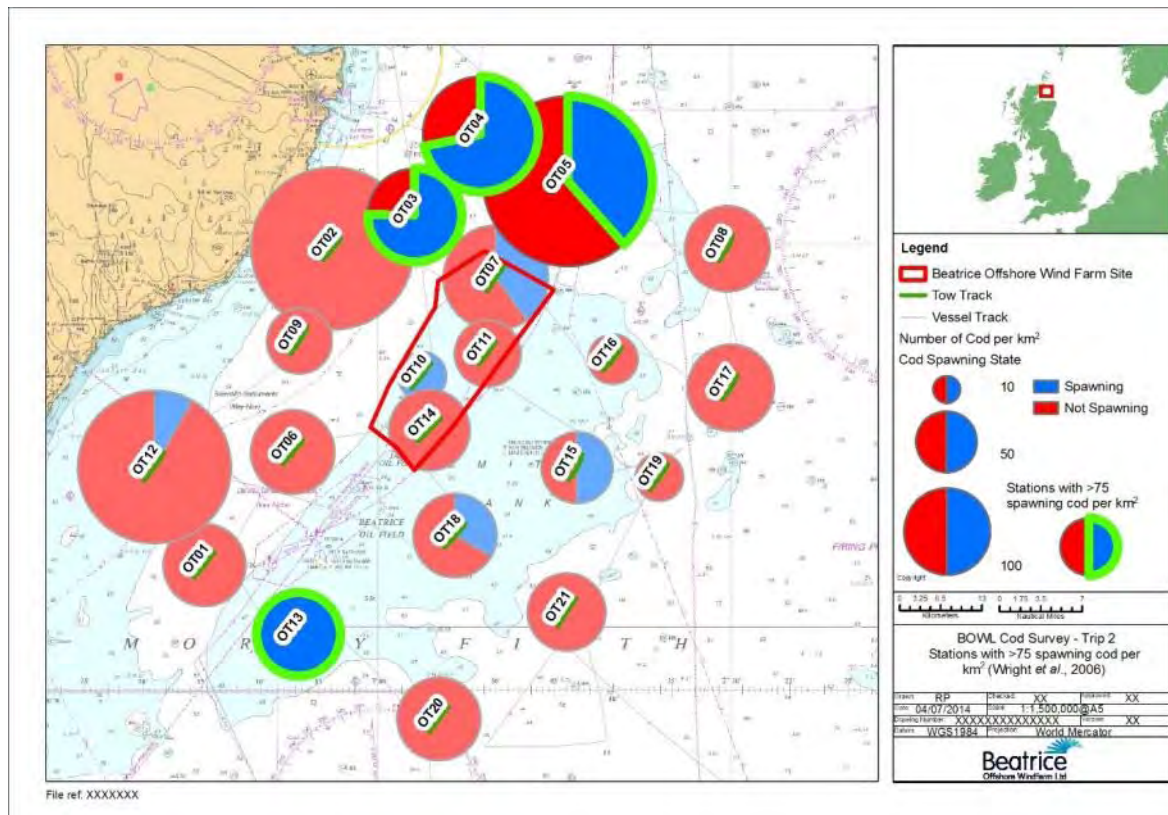


Figure 6.8 Cod catch rates by CPUE (no. cod/km²) for Trip 2 with stations showing >75 spawning cod/km² highlighted in green

6.2 Total Catch

A total of 59,944 individuals of 39 fish and commercial shellfish species were caught in the survey. The species recorded in Trip 1 and Trip 2 are given in Table 6.5 and Table 6.6, respectively.

Dab (*Limanda limanda*), plaice (*Pleuronectes platessa*), Norway pout (*Trisopterus esmarkii*), haddock (*Melanogrammus aeglefinus*), whiting (*Merlangius merlangus*) and grey gurnard (*Eutrigla gurnardus*) were the principal by-catch species found during the survey. The spatial distribution of the principal by-catch species are given in Figure 6.9 to Figure 6.18 by survey trip. It should be noted however that Norway pout was only caught in large numbers during Trip 1 and grey gurnard during Trip 2.

Greater numbers of the most abundant by-catch were recorded in the deeper waters to the north and west of the site for the majority of species. Norway pout and whiting from trip 1 showed higher abundances to the south-west of the site.

Table 6.5 Number of individuals caught - Trip 1

Species		Total No. of Individuals Caught
Common Name	Scientific Name	
Dab	<i>Limanda limanda</i>	12,309
Plaice	<i>Pleuronectes platessa</i>	5,620
Norway Pout	<i>Trisopterus esmarkii</i>	5,087
Haddock	<i>Melanogrammus aeglefinus</i>	1,966
Whiting	<i>Merlangius merlangus</i>	1,706
Sprat	<i>Sprattus sprattus</i>	873
Long Rough Dab	<i>Hippoglossoides platessoides</i>	723
Grey Gurnard	<i>Eutrigla gurnardus</i>	332
Herring	<i>Clupea harengus</i>	215
Lemon Sole	<i>Microstomus kitt</i>	168
Poor Cod	<i>Trisopterus minutus</i>	132
Bullrout	<i>Myoxocephalus scorpius</i>	130
Cod	<i>Gadus morhua</i>	61
Queen Scallop	<i>Aequipecten opercularis</i>	12
Lesser Spotted Dogfish	<i>Scyliorhinus canicula</i>	10
Greater Sandeel	<i>Hyperoplus lanceolatus</i>	9
Horse Mackerel	<i>Trachurus</i>	8
Pogge	<i>Agonus cataphractus</i>	7
Thickback Sole	<i>Microchirus variegatus</i>	7
Common Dragonet	<i>Callionymus lyra</i>	6
Monkfish	<i>Lophius piscatorius</i>	5
Flounder	<i>Platichthys flesus</i>	4
John Dory	<i>Zeus faber</i>	4
Spotted Dragonet	<i>Callionymus maculatus</i>	3
Whelk	<i>Buccinum undatum</i>	3
Argentine	<i>Argentina sphyraena</i>	2
Scaldfish	<i>Arnoglossus laterna</i>	2
Spotted Ray	<i>Raja montagui</i>	2
Striped Red Mullet	<i>Mullus surmuletus</i>	2
Nephrops	<i>Nephrops norvegicus</i>	2
Common Skate	<i>Dipturus batis</i>	1
Ling	<i>Molva</i>	1
Lumpsucker	<i>Cyclopterus lumpus</i>	1
Sandeel sp.	Ammodytidae	1
Total No. of Individuals		29,414

Table 6.6 Number of individuals caught - Trip 2

Species		Total No. of Individuals Caught
Common Name	Scientific Name	
Dab	<i>Limanda</i>	19,768
Plaice	<i>Pleuronectes platessa</i>	5,532
Haddock	<i>Melanogrammus aeglefinus</i>	2,340
Whiting	<i>Merlangius merlangus</i>	1,229
Grey Gurnard	<i>Eutrigla gurnardus</i>	504
Long Rough Dab	<i>Hippoglossoides platessoides</i>	269
Sprat	<i>Sprattus</i>	227
Lemon Sole	<i>Microstomus kitt</i>	216
Bullrout	<i>Myoxocephalus scorpius</i>	91
Herring	<i>Clupea harengus</i>	76
Cod	<i>Gadus morhua</i>	70
Poor Cod	<i>Trisopterus minutus</i>	61
Queen Scallop	<i>Aequipecten opercularis</i>	28
Norway Pout	<i>Trisopterus esmarkii</i>	27
Greater Sandeel	<i>Hyperoplus lanceolatus</i>	27
Common Dragonet	<i>Callionymus lyra</i>	12
Sandeel sp.	<i>Ammodytidae</i>	7
Raitt's Sandeel	<i>Ammodytes marinus</i>	7
Lesser Spotted Dogfish	<i>Scyliorhinus canicula</i>	6
Red Gurnard	<i>Aspitrigla cuculus</i>	5
Monkfish	<i>Lophius piscatorius</i>	4
Cuckoo Ray	<i>Raja naevus</i>	3
Flounder	<i>Platichthys flesus</i>	3
Pogge	<i>Agonus cataphractus</i>	3
Thickback Sole	<i>Microchirus variegatus</i>	2
Whelk	<i>Buccinum undatum</i>	2
Argentine	<i>Argentina sphyraena</i>	1
Common Skate	<i>Dipturus batis</i>	1
Horse Mackerel	<i>Trachurus</i>	1
John Dory	<i>Zeus faber</i>	1
Ling	<i>Molva</i>	1
Lumpsucker	<i>Cyclopterus lumpus</i>	1
Saithe	<i>Pollachius virens</i>	2
Spotted Ray	<i>Raja montagui</i>	1
Striped Red Mullet	<i>Mullus surmuletus</i>	1
Nephrops	<i>Nephrops norvegicus</i>	1
Total No. of Individuals		30,530

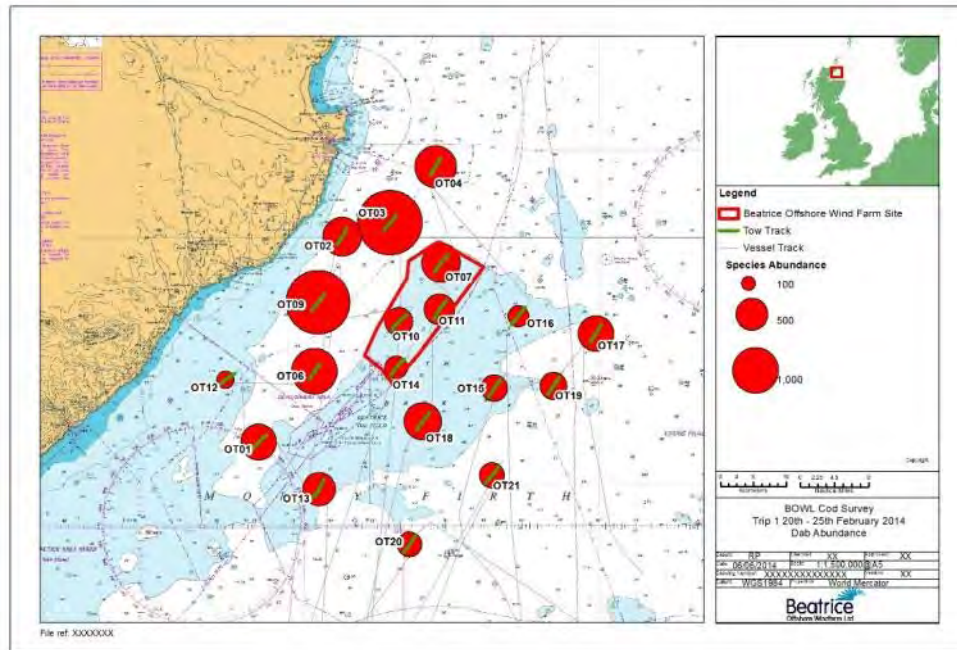


Figure 6.9 Spatial distribution of dab - Trip 1

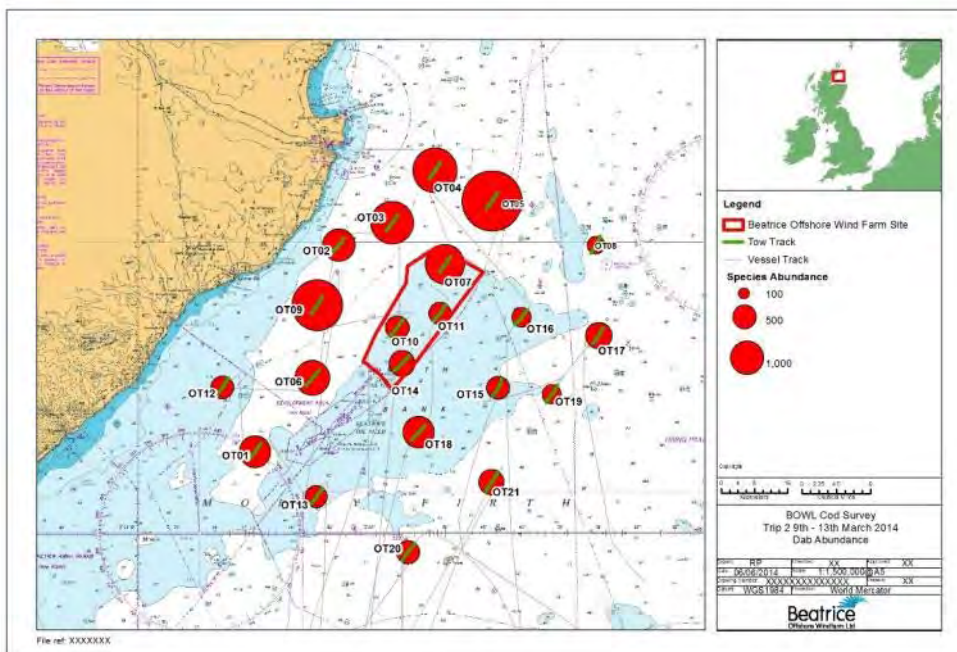


Figure 6.10 Spatial distribution of dab - Trip 2

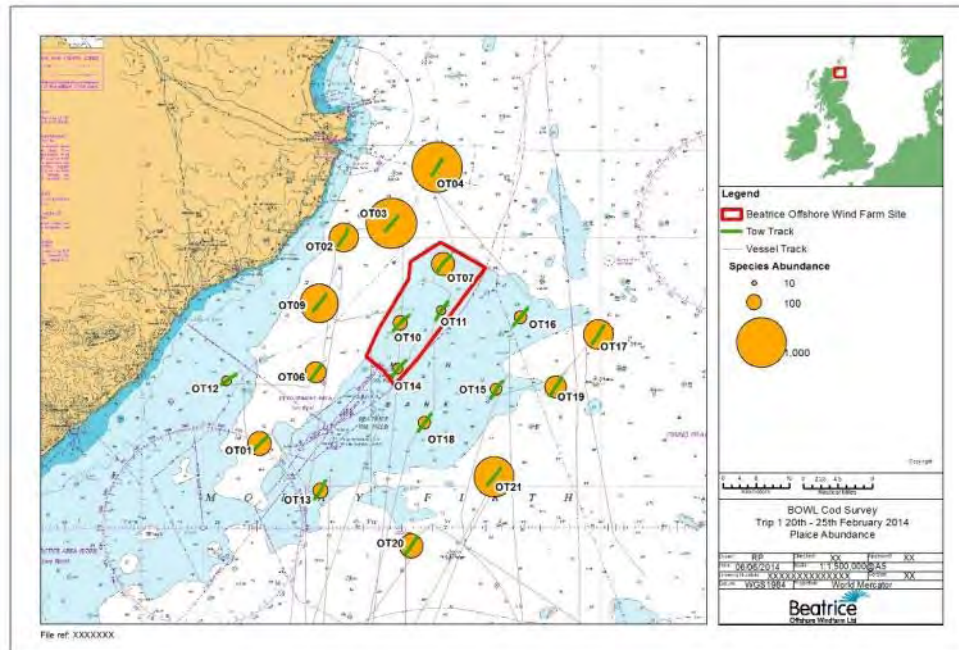


Figure 6.11 Spatial distribution of plaice - Trip 1

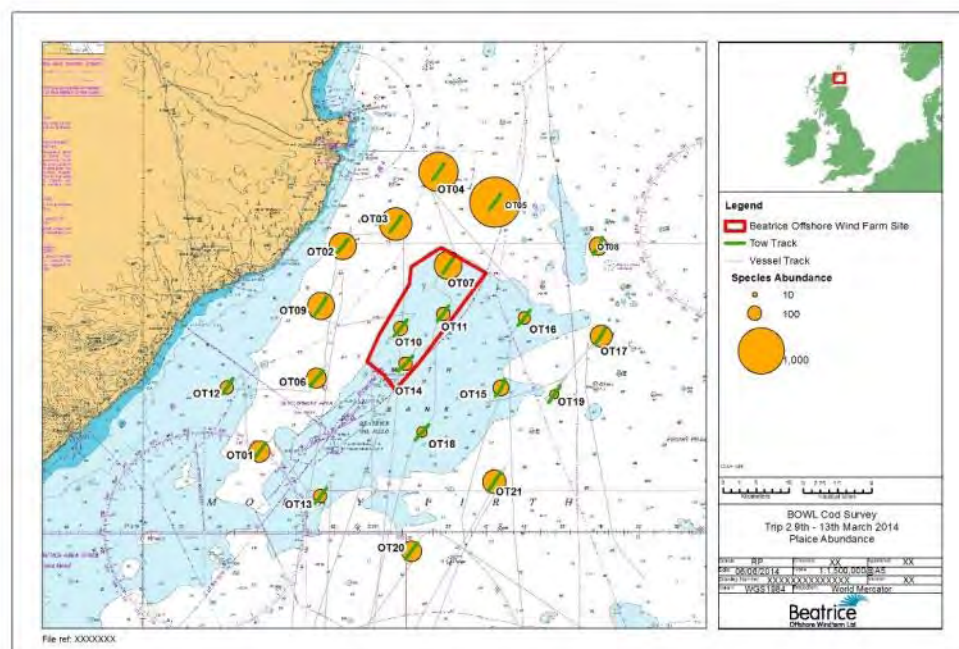


Figure 6.12 Spatial distribution of plaice - Trip 2

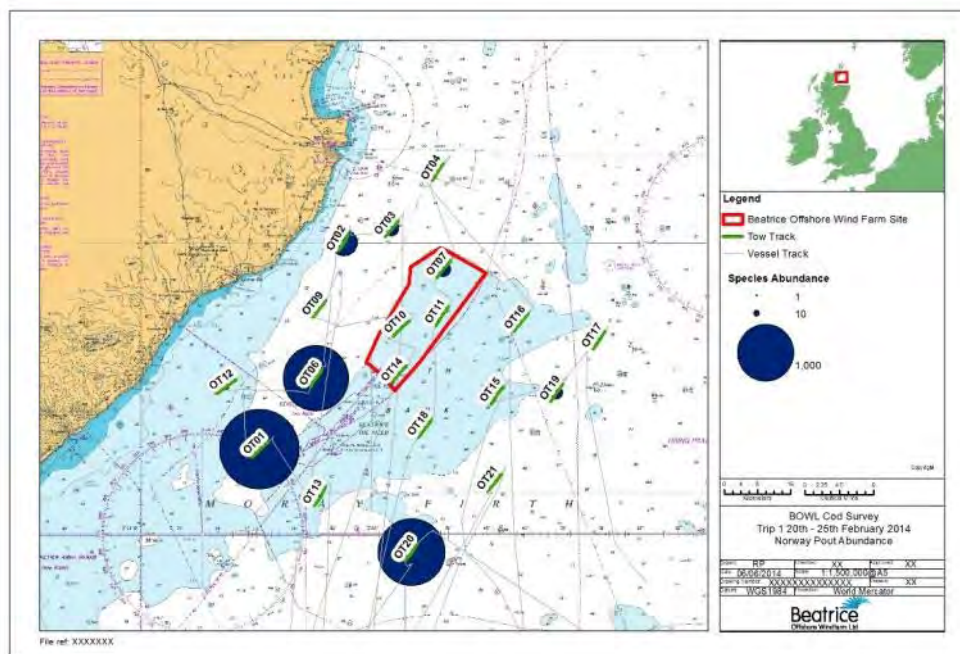


Figure 6.13 Spatial distribution of Norway pout - Trip 1

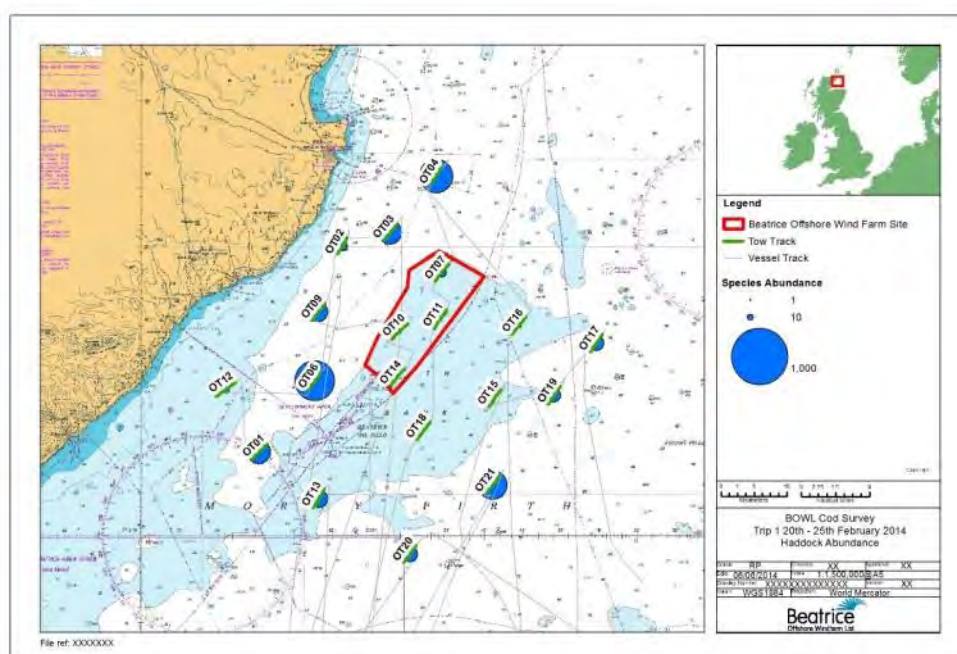


Figure 6.14 Spatial distribution of haddock - Trip 1

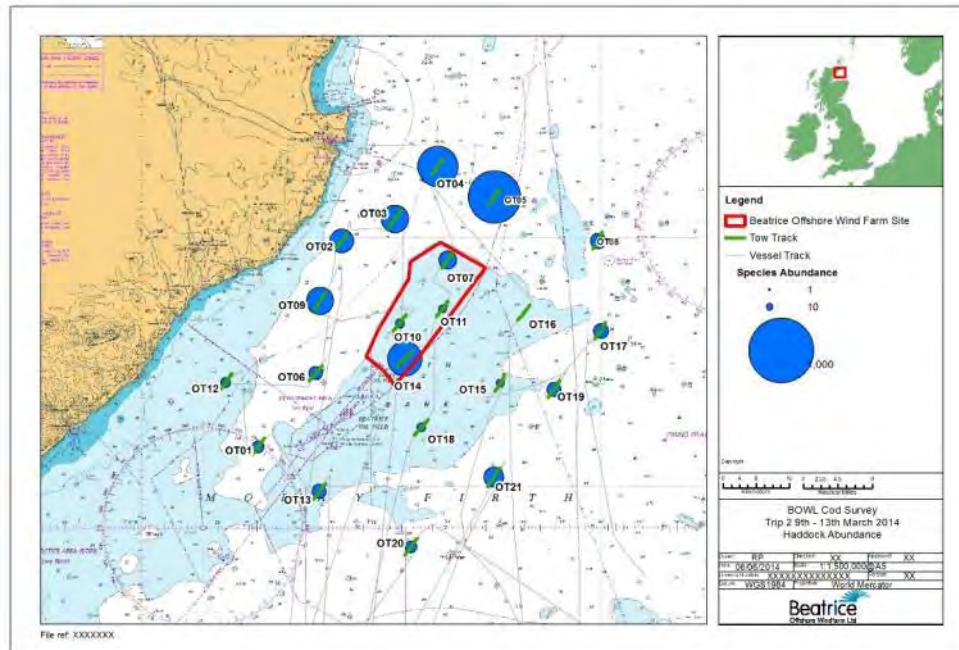


Figure 6.15 Spatial distribution of haddock - Trip 2

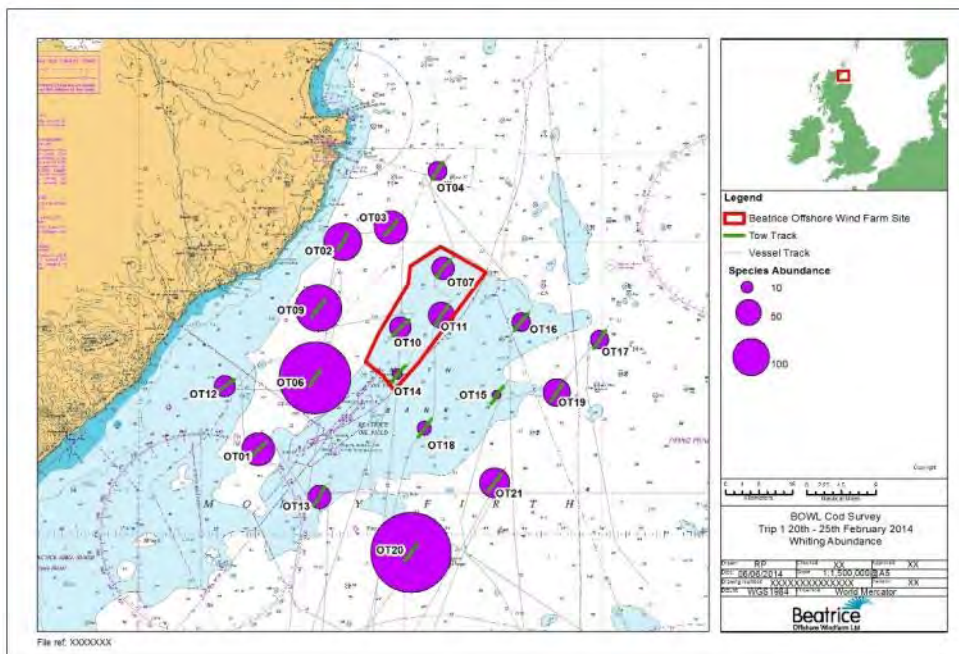


Figure 6.16 Spatial distribution of whiting - Trip 1

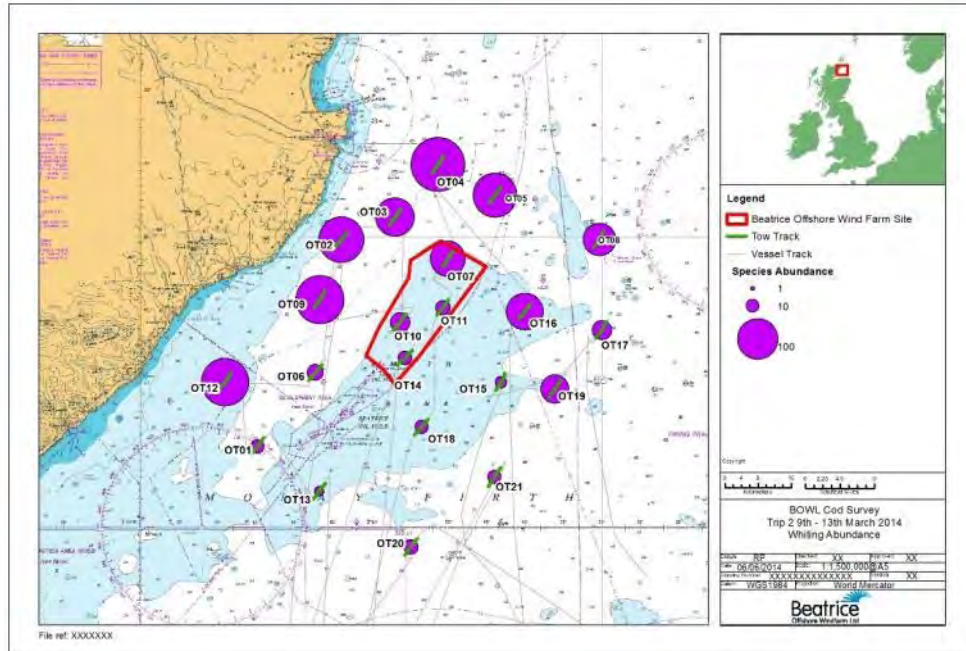


Figure 6.17 Spatial distribution of whiting - Trip 2

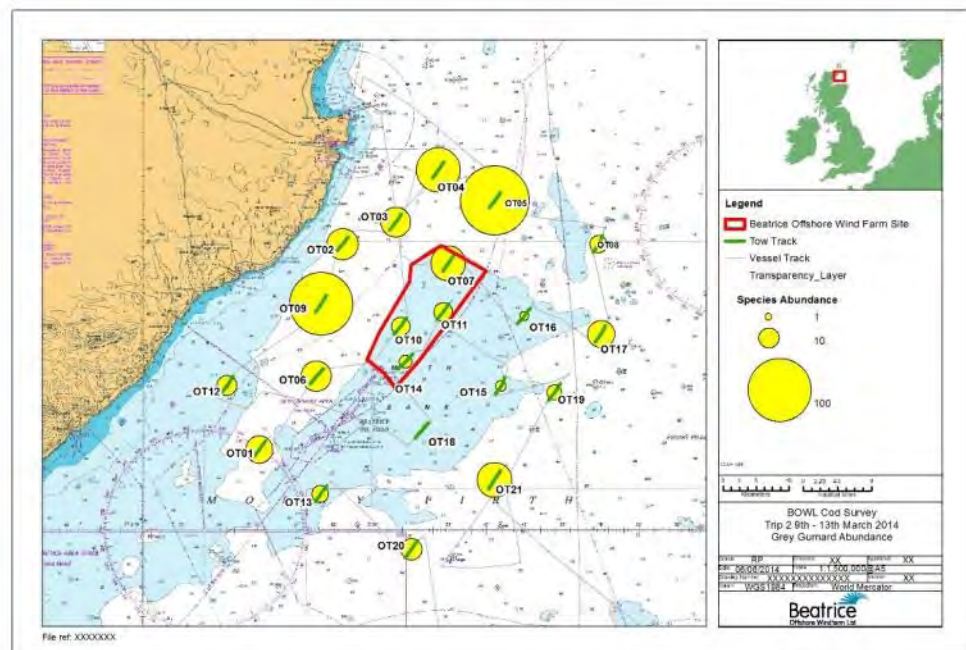


Figure 6.18 Spatial distribution of grey gurnard - Trip 2

7 Observations

The survey results presented in this report provide the pre-construction element of condition 27 PEMP in relation to cod spawning. Survey completion and presentation of the results also satisfies the pre-construction element of condition 35 of BOWL's Section 36 consent requiring a baseline cod survey to be undertaken prior to commencement of the development. Specific observations on the survey results are provided below.

7.1 Cod spawning analysis by number of individuals

Cod were caught in 34 of the 40 stations sampled. In comparison to the total catch, cod were found in low numbers with a total of 131 individuals being caught during both survey trips (Trip 1 and Trip 2).

A total of 72 juvenile (maturity stage I) and 59 adult (maturity stages II, III and IV) cod were caught during the survey. The majority of the 59 adult cod caught were spawning (stage III; 47 individuals), with 11 maturing cod (stage II) and one spent individual (stage IV).

During Trip 1 a total of 25 spawning cod were recorded whereas 22 spawning cod were recorded in Trip 2. A maximum of five spawning individuals were recorded at three stations (Trip 1, OT09; Trip 2, OT04 and OT05).

A greater number of males were caught than females (66 and 51, respectively). The majority of spawning cod caught were male. 21 male spawning cod and four female were caught during Trip 1, with 19 male spawning cod and three female recorded during Trip 2.

Higher catches of cod were observed at stations nearest to the coastline, to the west and north of the proposed BOWL site in both Trip 1 and Trip 2. There was a general trend of a decrease in the proportion of spawning cod observed at the stations along the coastline from Trip 1 to Trip 2.

7.2 Cod spawning analysis by CPUE

Calculations provided by MSS were used to multiply up the number of cod caught per station to the projected number of cod caught per km². Based on MSS guidance, three categories were provided in order to define the importance criteria for cod spawning:

- Not important for spawning cod (≤ 15 spawning cod/km²),
- May be important for spawning cod (> 15 to ≤ 75 spawning cod/km²), and
- Spawning area (> 75 spawning cod/km²).

Of the 19 stations undertaken during Trip 1, three stations had spawning cod catch rates that are considered to indicate a "spawning area" (> 75 spawning cod/km²). Eight stations had spawning cod catch rates within the threshold "may be important" to spawning cod (> 15 to ≤ 75 spawning cod/km²) with the remaining eight stations defined as "not important" for spawning cod (≤ 15 spawning cod/km²).

During Trip 2, four of the 21 stations sampled had spawning cod catch rates that are considered to indicate a "spawning area" (> 75 spawning cod/km²). Five stations had spawning cod catch rates within the category "may be important" to spawning cod (> 15 to ≤ 75 spawning cod/km²) with the remaining 12 stations categorised as "not important" for spawning cod (≤ 15 spawning cod/km²).

Over the two survey trips six stations were categorised as a "spawning area" for spawning cod, as defined by the MSS guidance, and 11 stations of the 21 were categorised as "may be important" for spawning cod. The remaining 14 stations were defined as "not important"

for spawning cod. There appears to be a shift in stations classified as a “spawning area” for cod from stations along the coastline in Trip 1 to stations to the north of the survey area in Trip 2.

8 References

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9 Appendices

9.1 Appendix 1 – Health and Safety

9.1.1 *Personnel*

Brown and May Marine (BMM) staff followed the standard health and safety protocol outlined in the BMM “Offshore Operational Procedures for Surveys using Commercial Fishing Vessels”.

All BMM staff have completed a Sea Survival course approved by the Maritime and Coastguard Agency, meeting the requirements laid down in: **STCW 95 Regulation VI/1 para 2.1.1 and STCW Code section A- VI/1** before boarding any vessel conducting works for the company. Employees are also required to have valid medical certificates (ENG1), Safety Awareness, Basic Fire Fighting and Basic First Aid certificates before participating in offshore works.

9.1.2 *Vessel Induction*

Before boarding the survey team were shown how to safely board and disembark the vessel. Prior to departure the skipper briefed surveyors on the whereabouts of the safety equipment, including the life raft, emergency flares and fire extinguishers, and the location of the emergency muster point. The safe deck areas, man-overboard procedures and emergency alarms were also discussed. The survey team was warned about the possible hazards, such as slippery decks and obstructions whilst aboard. Surveyors were briefed about trawling operations and the need to keep clear of all winches when operational. All hazards were assessed prior to the survey in the BMM health and safety risk assessment.

9.1.3 *Daily Safety Checks*

The condition of the life jackets, EPIRB's, and life raft were inspected daily. Also checked were the survey team working areas, including the fish room and the wheelhouse to ensure these areas were clear of hazards such as clutter and obstructions.

9.1.4 *Post Trip Survey Review*

Upon completion of the survey a “Post Trip Survey Review” was filled, see Table 9.1 below.

Table 9.1 Post trip survey review

Project: BOWL Cod Survey February/March 2014	Vessel: Seagull
Surveyors: Alex Winrow-Giffin / Richard Preston	Skipper: Gary Mutch
Survey Area: Moray Firth	Total Time at Sea: 10 Days
Dates at Sea: 20/02/14 – 25/02/14 and 9/03/14 – 13/03/14	

	Comments	Actions
Did vessel comply with pre trip safety audits?	Yes (audited by Noble Denton 12/02/14)	N/A
Skipper and crew attitude to safety?	Good	N/A
Vessel machinery failures?	Yes – Engine problems encountered on the steam out to the site.	Returned to port and engineer called to resolve the issue. Incident Report 001
Safety equipment failures?	None	N/A
Accidents?	Yes – Slip/trip/fall Skipper slipped going up the ladder into the wheelhouse, falling forward and knocking the side of his face on the back of chair. Two small cuts on face.	Washed and dried cut and applied cold pack to face to ease swelling. Incident Report 002 (Accident Report 001)
Injuries?	Two small cuts – see above	None – Incident report produced

9.2 Appendix 2 - Log of Events

A summarised log of events is given below in Table 9.2 for Trip 1 and in Table 9.3 overleaf for Trip 2.

Table 9.2 Summarised log of events for Trip 1: 12th to 25th February 2014

Wednesday 12th February 2014
Vessel audit completed by Noble Denton
Monday 17th February 2014
Surveyors depart BMM, travel to North Queensferry, Edinburgh
Tuesday 18th February 2014
Surveyors travel to Aberdeen to pick up 20mm blinder and dissection equipment from Marine Scotland, then continue on to Fraserburgh to meet vessel. Unload van, load vessel.
Wednesday 19th February 2014
Mobilisation Day: Kick off meeting (representatives from SSE, BOWL, SFF and BMM in attendance)
Vessel departs port at 23:30 to begin steam to survey area
Weather: BF 5, moderate
Overnight at sea
Thursday 20th February 2014
During the steam out, vessel encountered engine problems and had to return to port, arriving in port at 01:15
Engineer arrived at vessel at 0800 and issue resolved by 1030. Vessel departed port at 1050 to steam to survey area, arriving onsite at 1530.
Otter Trawl: OT20 (1 x cod M I)
Weather: BF4-6, moderate to rough
Overnight at sea
Friday 21st February 2014
Otter Trawls: OT13 (4 x cod; 2 x M III, 1 x F I, 1 x U I), OT01 (3 x cod; 3x F I), OT12 (5 x cod; 2 x F III, 2 x M III, 1 x U I), OT06 (5 x cod; 1 x F III, 1 x M III, 2 x F I, 1 x U I).
Unable to undertake 5 th station due to worsening weather conditions and vessel steamed inshore at 1530 to shelter under the land.
Weather: BF 4 – 7/8, moderate increasing to rough/very rough
Overnight at sea
Saturday 22nd February 2014
Poor weather conditions delay sampling until 1530.
Otter Trawls: OT21 (2 x cod; 1 x F I, 1 x M I)
Weather: BF 7/8 – 5, very rough/rough decreasing to moderate
Overnight at sea
Sunday 23rd February 2014
Otter Trawls: OT03 (7 x cod; 1 x F III, 3 x M III, 1 x F I, 1 x M I, 1 x U I), OT02 (5 x cod; 1 x M III, 3 x F I, 1 x M I), OT09 (7 x cod; 5 x M III, 1 x M II, 1 x F I), OT10 (2 x cod; 2 x F I), OT14 (1 x cod; M III)
Weather: BF 5/6 – 7/8, moderate to rough/very rough
Overnight at sea
Monday 24th February 2014
Otter Trawls: OT18 (3 x cod; 2 x F I, 1 x M I), OT11 (2 x cod; 2 x U I), OT07 (3 x cod; 1 x M III, 1 x M I, 1 x F I), OT04 (5 x cod; 3 x M III, 1 x M II, 1 x M I), OT16 (3 x cod; 1 x M III, 1 x M II, 1 x M I)

Weather: BF 4/5, moderate
Overnight at sea
Tuesday 25th February 2014
Otter Trawls: OT15 (1 x cod; M III), OT19 (1 x cod; F I), OT17 (1 x cod; F I)
Ceased sampling when weather conditions worsened after OT17. Cod survey completed with 2 stations omitted (05 and 08). Steamed to Fraserburgh, arrived at 1900 hrs.
24 hour downtime between day working and night working starts at 1900.
Weather: BF 5 – 7/8, moderate to rough/very rough

Table 9.3 Summarised log of events for Trip 2: 8th to 14th March 2014

Saturday 8th March 2014
Depart Fraserburgh at 2300 to steam overnight to survey site
Weather: BF 4 – 6, moderate to rough
Overnight at sea
Sunday 9th March 2014
Otter trawls: OT20 (0 x cod), OT13 (3 x cod; 2 x M III, 1 x F II), OT01 (0 x cod), OT06 (0 x cod), OT10 (1 x cod; F III)
Weather: BF 4-5, slight to moderate
Overnight at sea
Monday 10th March 2014
Otter Trawl: OT05 (13 x cod; 5 x M III, 5 x M II, 1 x F II, 2 x F I), OT08 (0 x cod), OT17 (3 x cod; 3 x F I), OT16 (1 x cod; F IV), OT07 (5 x cod; 2 x M III, 3 x F I)
Weather: BF 3 – 4, slight to moderate
Overnight at sea
Tuesday 11th March 2014
Otter Trawls: OT04 (7 x cod; 5 x M III, 1 x M II, 1 x M I), OT03 (4 x cod; 3 x M III, 1 x U I), OT02 (11 x cod; 6 x F I, 4 x M I, 1 x U I), OT09 (2 x cod; 1 x F I, 1 x M I), OT12 (12 x cod; 1 x M III, 5 x F I, 1 x M I, 5 x U I)
Weather: BF 3, slight
Overnight at sea
Wednesday 12th March 2014
Otter Trawls: OT18 (3 x cod; 1 x M III, 1 x M II, 1 x U I), OT14 (0 x cod), OT11 (2 x cod; 2 x F I), OT15 (2 x cod; 1 x F III, 1 x M I), OT19 (1 x F I)
Weather: BF 2 – 3, slight
Overnight at sea
Thursday 13th March 2014
Otter Trawls: OT21 (0 x cod). Cod spawning survey (trip 2) completed.
Steamed to Fraserburgh for demobilisation, arrived in port at 1100. Unloaded vessel and loaded van. Courtesy visit by SSE for survey debrief at 1330.
Weather: BF 3, slight
BMM surveyors departed Fraserburgh at 1430, travelled to Aberdeen to return 20mm blinder and cod samples and dissection kit to Marine Scotland. Surveyors travelled to Musselburgh, arrived 2100.
Friday 14th March 2014
BMM surveyors returned to BMM office, arrived 1930.

9.3 Appendix 3 – Times and Coordinates

The date, times, coordinates and depth for each station is given below in Table 9.4 for Trip 1 and in Table 9.5 overleaf for Trip 2.

Table 9.4 Start and end times, coordinates and duration of each otter trawl - Trip 1

Cod Survey Trip 1										
Station	Date	Otter Trawl Start				Otter Trawl End				Duration (mm:ss)
		Time (GMT)	UTM30N		Depth (m)	Time (GMT)	UTM30N		Depth (m)	
			Latitude	Longitude			Latitude	Longitude		
OT01	21/02/2014	10:11:09	58° 06.338	-3° 13.528	60.9	10:41:45	58° 05.314	-3° 15.546	62.1	30:36
OT02	23/02/2014	09:57:16	58° 20.647	-3° 03.127	72.7	10:27:16	58° 19.522	-3° 04.330	74.0	30:00
OT03		07:36:38	58° 21.555	-2° 56.549	70.6	08:06:40	58° 20.494	-2° 58.238	77.7	30:02
OT04	24/02/2014	14:39:49	58° 25.470	-2° 50.704	69.3	15:09:52	58° 24.314	-2° 52.139	71.1	30:03
OT06	21/02/2014	14:41:55	58° 10.207	-3° 07.958	68.7	15:11:57	58° 11.292	-3° 06.550	70.9	30:02
OT07	24/02/2014	11:07:23	58° 17.641	-2° 51.502	55.6	11:37:23	58° 18.819	-2° 49.706	55.7	30:00
OT09	23/02/2014	12:03:24	58° 16.108	-3° 05.977	69.6	12:33:36	58° 14.955	-3° 07.708	67.6	30:12
OT10		14:52:44	58° 14.702	-2° 55.076	48.8	15:22:50	58° 13.633	-2° 57.202	45.1	30:06
OT11	24/02/2014	09:32:51	58° 14.366	-2° 51.615	44.8	10:02:57	58° 15.678	-2° 50.022	47.3	30:06
OT12	21/02/2014	12:25:00	58° 10.633	-3° 17.704	55.2	12:54:59	58° 09.687	-3° 20.158	55.2	29:59
OT13		07:55:46	58° 03.274	-3° 06.048	49.9	08:25:49	58° 02.001	-3° 07.501	50.4	30:03
OT14	23/02/2014	16:43:32	58° 11.579	-2° 55.499	43.7	17:13:44	58° 10.348	-2° 57.386	42.4	30:12
OT15	25/02/2014	07:37:19	58° 10.172	-2° 42.838	49.7	08:07:24	58° 08.979	-2° 44.460	50.1	30:05
OT16	24/02/2014	16:49:28	58° 15.189	-2° 39.628	49.2	17:19:34	58° 13.982	-2° 41.446	53.5	30:06
OT17	25/02/2014	11:06:18	58° 13.977	-2° 29.609	56.7	11:36:22	58° 12.777	-2° 31.150	56.8	30:04
OT18	24/02/2014	07:35:51	58° 06.676	-2° 53.937	42.9	08:06:01	58° 07.911	-2° 52.198	43.1	30:10
OT19	25/02/2014	09:19:01	58° 10.374	-2° 35.140	57.6	09:49:03	58° 09.160	-2° 36.723	56.3	30:02
OT20	20/02/2014	16:16:50	57° 59.343	-2° 54.046	75.1	16:47:03	57° 58.174	-2° 55.658	81.2	30:13
OT21	22/02/2014	15:55:34	58° 04.141	-2° 43.187	61.8	16:25:37	58° 02.966	-2° 44.875	66.7	30:03

Table 9.5 Start and end times, coordinates and duration of each otter trawl - Trip 2

Cod Survey Trip 2										
Station	Date	Otter Trawl Start				Otter Trawl End				Duration (mm:ss)
		Time (GMT)	UTM30N		Depth (m)	Time (GMT)	UTM30N		Depth (m)	
			Latitude	Longitude			Latitude	Longitude		
OT01	09/03/2014	11:48:47	58° 06.233	-3° 13.999	62.7	12:18:48	58° 05.071	-3° 15.712	62.9	30:01
OT02	11/03/2014	11:59:38	58° 20.299	-3° 03.208	73.8	12:29:44	58° 19.335	-3° 04.704	73.3	30:06
OT03		10:07:15	58° 21.910	-2° 56.243	70.7	10:37:17	58° 20.783	-2° 57.747	76.6	30:02
OT04		07:40:45	58° 25.504	-2° 50.598	69.1	08:10:47	58° 24.373	-2° 52.107	71.1	30:02
OT05	10/03/2014	07:34:49	58° 23.391	-2° 43.211	68.7	08:04:52	58° 22.304	-2° 44.736	62.7	30:03
OT06	09/03/2014	14:19:23	58° 10.171	-3° 08.155	67.3	14:49:23	58° 11.235	-3° 06.431	70.4	30:00
OT07	10/03/2014	17:11:49	58° 17.932	-2° 50.783	54.3	17:41:53	58° 19.097	-2° 49.267	57.4	30:04
OT08		10:18:42	58° 20.430	-2° 29.864	60.7	10:48:46	58° 19.273	-2° 31.060	55.7	30:04
OT09	11/03/2014	14:38:47	58° 16.301	-3° 06.044	68.7	15:08:50	58° 15.111	-3° 07.514	67.1	30:03
OT10	09/03/2014	16:13:34	58° 13.594	-2° 57.193	45.5	16:43:38	58° 14.717	-2° 55.510	48.8	30:04
OT11	12/03/2014	11:35:50	58° 15.689	-2° 50.017	47.0	12:05:51	58° 14.639	-2° 51.527	42.9	30:01
OT12	11/03/2014	16:38:39	58° 10.707	-3° 18.265	53.0	17:08:44	58° 09.443	-3° 20.012	54.1	30:05
OT13	09/03/2014	09:52:32	58° 03.094	-3° 05.976	51.2	10:22:34	58° 01.957	-3° 07.648	51.4	30:02
OT14	12/03/2014	09:37:32	58° 11.200	-2° 56.678	42.6	10:07:37	58° 12.234	-2° 54.707	42.8	30:05
OT15		14:04:15	58° 10.623	-2° 42.671	52.3	14:34:20	58° 09.479	-2° 43.848	47.7	30:05
OT16	10/03/2014	14:29:25	58° 15.414	-2° 39.324	51.0	14:59:30	58° 14.375	-2° 40.933	51.2	30:05
OT17		12:04:16	58° 14.199	-2° 29.474	55.9	12:34:19	58° 13.072	-2° 30.812	56.5	30:03
OT18	12/03/2014	07:37:45	58° 06.425	-2° 54.397	42.0	08:07:50	58° 07.494	-2° 52.610	43.1	30:05
OT19		16:24:08	58° 10.193	-2° 35.388	56.3	16:54:06	58° 09.011	-2° 36.936	55.6	29:58
OT20	09/03/2014	07:44:55	57° 59.255	-2° 54.026	76.2	08:15:23	57° 58.116	-2° 55.680	80.8	30:28
OT21	13/03/2014	06:34:17	58° 04.154	-2° 43.190	61.0	07:04:51	58° 02.862	-2° 44.791	66.0	30:34

9.4 Appendix 4 - Examples of Cod Maturity Stages

9.4.1 Trip 1

9.4.1.1 Stage I – Immature



Figure 9.1 OT06 Female 14cm Stage I



Figure 9.2 OT06 Female 14cm Stage I

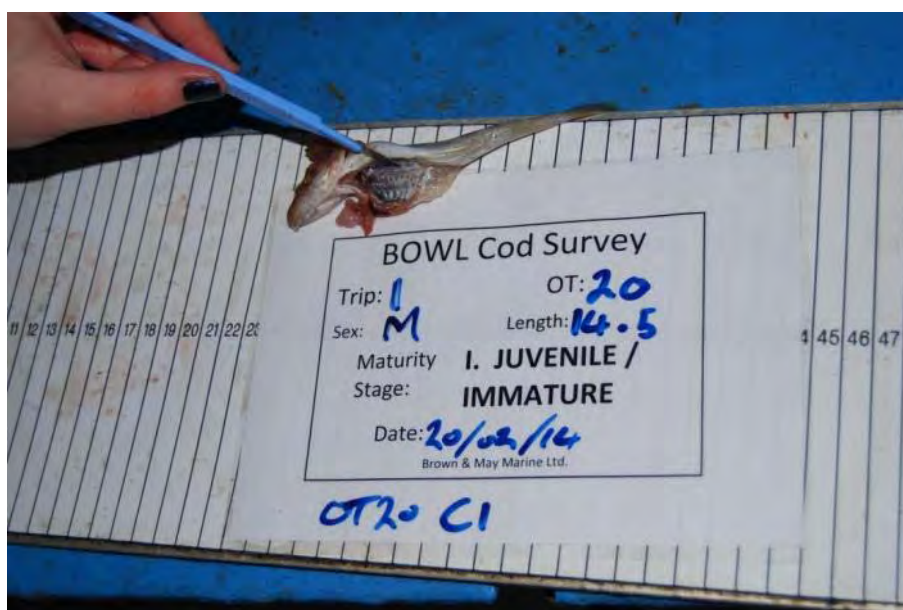


Figure 9.3 OT20 Male 14.5cm Stage I



Figure 9.4 OT20 Male 14.5cm Stage I

9.4.1.2 Stage II – Maturing



Figure 9.5 OT04 Male 34.5cm Stage II

9.4.1.3 Stage III – Spawning



Figure 9.6 OT12 Female 61cm Stage III



Figure 9.7 OT13 Male 42cm Stage III

9.4.2 Trip 2

9.4.2.1 Stage II – Maturing



Figure 9.8 OT13 Female 39cm Stage II



Figure 9.9 OT13 Female 39cm Stage II



Figure 9.10 OT05 Male 31cm Stage II



Figure 9.11 OT05 Male 31cm Stage II

9.4.2.2 Stage III – Spawning



Figure 9.12 OT10 Female 46.5cm Stage III



Figure 9.13 OT13 Male 43cm Stage III

9.4.2.3 Stage IV – Spent



Figure 9.14 OT16 Female 60cm Stage IV

9.5 Appendix 5 - MSS Guidance for Defining Cod Spawning

Defining cod spawning areas based on CPUE (pers.com A. Kafas (MSS) 7th April 2014)

Wright et al. (2006) used a variety of approaches to define general areas of cod spawning, including the number of spawning cod caught per hour by MRV Scotia in the GOV. The threshold for defining spawning areas in that paper was CPUE values > 2 spawning cod per hour, although > 10 spawning cod per hour provides a more definitive evidence of spawning. The average swept area (wing spread x distance travelled) of 1,330 hauls conducted on Scotia during Q1 and Q4 west coast surveys, 2000-2011 was estimated to be 66039.14 m², for a 30 minute tow. The following averages were used to standardise the gear raising factors: Headline height = 5 m and wing spread = 20 m. On average then the GOV covers 0.132 km² in 1 hour. So for the GOV, 2 running cod per hour is approximately equal to 15 spawning cod per km² swept (i.e. $2 \times (1/0.132)$) and 10 running cod per hour is approximately equal to 75 spawning cod per km² swept. Three other trawl surveys targeted at cod in early spring caught mature cod in 55 out of 207 stations. Of these 55 stations with mature cod, 25 contained spawning cod ranging from 5 - 360 spawning cod per km² swept. Of the 25 spawning cod stations, 16 had >15 spawning cod per km² swept with only 2 stations > 75 spawning cod per km² swept.

So, as a guideline **the presence of >15 spawning cod per km² should give some concern that the area may be important to spawning cod. Whereas > 75 spawning cod per km² swept should provide a clear indication of a spawning area.** It should also be noted that spawning cod generally represent a small percentage of the mature cod in a haul (on average 9%) and so we would expect that swept area estimates of mature cod numbers would be higher than this but the presence of spawning (running cod) gives the clearest indication of a spawning site.

Wright, P.J., Galley, E., Gibb, I.M. & Neat, F.C. (2006) Fidelity of adult cod to spawning grounds in Scottish waters. *Fisheries Research*, **77**, 148-158.

9.6 Appendix 6 - Calculations Using Scanmar Tow Data

Scanmar tow data were used to multiply up the number of cod caught at each station to the number of cod caught per km² for Trip 1 (Table 9.6) and Trip 2 (Table 9.7). Using the MSS guidance spawning status was allocated in the below tables as L = not important for spawning cod, M= may be important to spawning cod and S = spawning area.

Table 9.6 Trip 1 Scanmar and cod abundance data used to calculate no. of spawning cod per km²

Station	Date	Tow Duration (hr)	Av. Headline Height (m)	Av. Wing Spread (m)	Swept Distance (km)	Swept Area (km ²)	No. Cod	No. Spawning Cod	% Spawning Cod	No. Cod/km ²	No. Spawning Cod/km ²	Spawning Status
OT01	21/02/2014	0.5094	5.481	12.55	2.704	0.03395	3	0	0.0%	88	0	L
OT02	23/02/2014	0.4986	6.395	14.23	2.472	0.03515	5	1	20.0%	142	28	M
OT03	23/02/2014	0.5	5.13	13.75	2.615	0.03595	7	4	57.1%	195	111	S
OT04	24/02/2014	0.5014	6.377	16.23	2.638	0.04252	5	3	60.0%	118	71	M
OT06	21/02/2014	0.5	5.299	12.8	2.364	0.0303	5	2	40.0%	165	66	M
OT07	24/02/2014	0.5	6.078	13.11	2.868	0.03751	3	1	33.3%	80	27	M
OT09	23/02/2014	0.5028	6.055	13.33	2.763	0.03684	7	5	71.4%	190	136	S
OT10	23/02/2014	0.5014	5.953	13.47	2.949	0.03973	2	0	0.0%	50	0	L
OT11	24/02/2014	0.5014	5.755	12.65	2.958	0.03724	2	0	0.0%	54	0	L
OT12	21/02/2014	0.4986	5.614	12.45	2.899	0.03608	5	4	80.0%	139	111	S
OT13	21/02/2014	0.5	5.283	12.08	2.731	0.03302	4	2	50.0%	121	61	M
OT14	23/02/2014	0.7431	5.843	12.45	4.037	0.04676	1	1	100.0%	21	21	M
OT15	25/02/2014	0.5014	6.074	12.5	2.758	0.03442	1	1	100.0%	29	29	M
OT16	24/02/2014	0.5014	5.969	13.76	2.907	0.03998	3	1	33.3%	75	25	M
OT17	25/02/2014	0.5014	5.937	12.34	2.732	0.03367	1	0	0.0%	30	0	L
OT18	24/02/2014	0.5014	4.655	12.24	2.879	0.03524	3	0	0.0%	85	0	L
OT19	25/02/2014	0.5	5.66	12.23	2.77	0.03385	1	0	0.0%	30	0	L
OT20	20/02/2014	0.5028	5.614	12.94	2.621	0.0339	1	0	0.0%	30	0	L
OT21	22/02/2014	0.5014	5.859	12.76	2.753	0.03511	2	0	0.0%	57	0	L

Table 9.7 Trip 2 Scanmar and cod abundance data used to calculate no. of spawning cod per km²

Station	Date	Tow Duration (hr)	Av. Headline Height (m)	Av. Wing Spread (m)	Swept Distance (km)	Swept Area (km ²)	No. Cod	No. Spawning Cod	% Spawning Cod	No. Cod/km ²	No. Spawning Cod/km ²	Spawning Status
OT01	09/03/2014	0.5	5.591	12.78	2.748	0.03514	3	0	0.0%	85	0	L
OT02	11/03/2014	0.5014	6.048	14.45	2.316	0.03346	11	0	0.0%	329	0	L
OT03	11/03/2014	0.5	5.6	14.29	2.563	0.03664	4	3	75.0%	109	82	S
OT04	11/03/2014	0.5	5.923	16.51	2.564	0.04219	7	5	71.4%	166	119	S
OT05	10/03/2014	0.5014	6.01	14.46	2.518	0.03641	13	5	38.5%	357	137	S
OT06	09/03/2014	0.5	5.729	12.98	2.604	0.03386	3	0	0.0%	89	0	L
OT07	10/03/2014	0.5014	5.548	13.78	2.624	0.03617	5	2	40.0%	138	55	M
OT08	10/03/2014	0.5014	5.808	13.34	2.475	0.03301	3	0	0.0%	91	0	L
OT09	11/03/2014	0.5	5.629	14.41	2.636	0.03797	2	0	0.0%	53	0	L
OT10	09/03/2014	0.5014	5.586	12.92	2.681	0.03466	1	1	100.0%	29	29	M
OT11	12/03/2014	0.5	5.394	14.76	2.447	0.03615	2	0	0.0%	55	0	L
OT12	11/03/2014	0.5014	5.543	13.91	2.916	0.04103	12	1	8.3%	292	24	M
OT13	09/03/2014	0.4972	5.441	12.89	2.681	0.03461	3	3	100.0%	87	87	S
OT14	12/03/2014	0.4986	5.537	13.47	2.718	0.03667	3	0	0.0%	82	0	L
OT15	12/03/2014	0.5	5.854	13.1	2.442	0.03198	2	1	50.0%	63	31	M
OT16	10/03/2014	0.5	5.809	13.13	2.492	0.03273	1	0	0.0%	31	0	L
OT17	10/03/2014	0.5	5.714	12.88	2.482	0.03197	3	0	0.0%	94	0	L
OT18	12/03/2014	0.5	5.644	13.07	2.642	0.03457	3	1	33.3%	87	29	M
OT19	12/03/2014	0.4917	5.638	13.35	2.624	0.03505	1	0	0.0%	29	0	L
OT20	09/03/2014	0.5069	6.486	12.92	2.678	0.03463	3	0	0.0%	87	0	L
OT21	13/03/2014	0.5097	5.935	13.42	2.949	0.03949	3	0	0.0%	76	0	L