moray offshore renewables ltd

Developing Wind Energy In The Outer Moray Firth

Environmental Statement

Modified Transmission Infrastructure for Telford, Stevenson and MacColl Wind Farms

Technical Appendix 4.2 A

Fish and Shellfish Ecology

renewables

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1 Introduction

This technical report provides site specific information regarding the ecology and distribution of fish and shellfish species in areas relevant to the modified offshore transmission infrastructure (modified TI) of the Telford, Stevenson and MacColl offshore wind farms. Further detail regarding the ecology, life cycle and behaviour of the key species identified can be found within the relevant sections of the Fish and Shellfish Ecology Technical Report (Appendix 9.3A) submitted as part of the previous Environmental Statement (ES) detailing the Telford, Stevenson and MacColl Offshore Wind Farms in August 2012.

For the purposes of this report fish and shellfish species have been described within four broad categories:

- Species of commercial interest;
- Species potentially using the development area as a spawning or nursery ground;
- Key prey species; and
- Species of conservation importance, including diadromous and elasmobranch species.

Given the socio-economic and conservation status importance of salmon and sea trout in Scotland, their ecology and fisheries have been described separately in a standalone document (Appendix 4.2B).

2 Methodology

2.1 Guidance

The following documents have provided guidance for the undertaking of the Fish and Shellfish Ecology baseline assessment:

- Strategic Environmental Assessment (SEA) of Draft Plan for Offshore Wind Energy in Scottish Territorial Waters: Volume I: Environmental Report (Marine Scotland, 2010);
- Habitats Regulations Appraisal of Draft Plan for Offshore Wind Energy in Scottish Territorial Waters. Appropriate Assessment Information Review (Marine Scotland, 2011);
- CEFAS Guidance Note for Environmental Impact Assessment in Respect of the FEPA and CPA Requirements (CEFAS 2004);
- Marine Scotland Science (MSS) Scoping Opinion; and
- Scottish Natural Heritage (SNH) and Joint Nature Conservation Committee (JNCC) Scoping Opinion.

2.2 Sources of Data and Information

Establishing an ecological baseline for fish and shellfish species requires an approach that incorporates a number of different data and information sources. The principal sources of data and information used to inform the report were as follows:

- Marine Management Organisation (MMO) Landings Data by ICES rectangle for the period 2003-2013;
- Fisheries Sensitivity Maps in British Waters (Coull *et al*., 1998);
- Mapping spawning and nursery areas of species to be considered in Marine Protected Areas (Marine Conservation Zones). Report No 1 (Ellis *et al*., 2010a);
- Marine Scotland Science (MSS) publications;
- International Council for the Exploration of the Sea (ICES) publications;
- Centre for Environment, Fisheries and Aquaculture (CEFAS) publications;
- Results of Benthic Surveys undertaken in the area (Fugro EMU, 2011 and 2014??XXX); and
- Other relevant research publications.

2.3 Data sensitivities, Gaps and Limitations

2.3.1 MMO Landings Data

ICES statistical rectangles are the smallest spatial unit used for the collation of fisheries statistics by the European Commission (EC) and Member States. The boundaries of ICES rectangles align to 1° of longitude and 30' of latitude and are large in relation to the area occupied by the modified TI. In addition, fishing activity is rarely evenly distributed throughout the area of a rectangle. The analysis of the fisheries statistics provided below should therefore be taken in the context of the spatial limitations of the dataset.

Whilst landings data provide a good indication of the commercial species present by ICES rectangle, in some cases their relative abundance and importance may be misrepresented as a result of factors such as: low quota allocations, fluctuations in fishing effort, fisheries closures, changes in market demand, etc. In addition, the presence and distribution of fish and shellfish species are dependent on a number of biological and environmental factors that interact with each other in direct and indirect ways, and are subject to seasonal and annual variation.

2.3.2 Spawning and Nursery Grounds

The assessment of the area of the proposed modified TI as potential spawning and nursery grounds has primarily been undertaken using the charts provided in Coull *et al*. (1998) and Ellis *et al*. (2010a). It is acknowledged that whilst these are useful sources to identify broad scale spawning and nursery grounds, they do not delineate the exact location of grounds, especially in relation to discrete areas such as that occupied by the modified TI. In light of this limitation, alternative publications have been used to help define the extent of the grounds on a site specific basis where available.

2.3.3 Gaps in Current Knowledge

It is recognised that there are gaps in the understanding of the distribution, behaviour and ecology of certain species. This is particularly true for migratory species of conservation importance, such as Atlantic salmon (*Salmo salar*), sea trout (*Salmo trutta*), lamprey (*Lampetra fluviatilis*) sea lamprey, (*Petromyzon marinus)* and European eel (*Anguilla anguilla*). An absence of information in relation to specific migration routes, location of feeding grounds and the use of coastal/inshore areas by these species means that it is not possible to quantify the extent to which they may access areas occupied by the proposed modified TI.

2.4 Study Area

The study area used for this assessment has been defined by the ICES rectangles within which the modified TI is located (45E7 and 44E7) and is shown in Figure 2.1. Rivers designated as Special Areas of Conservation (SACs) in the Moray Firth and the wider area are also shown.

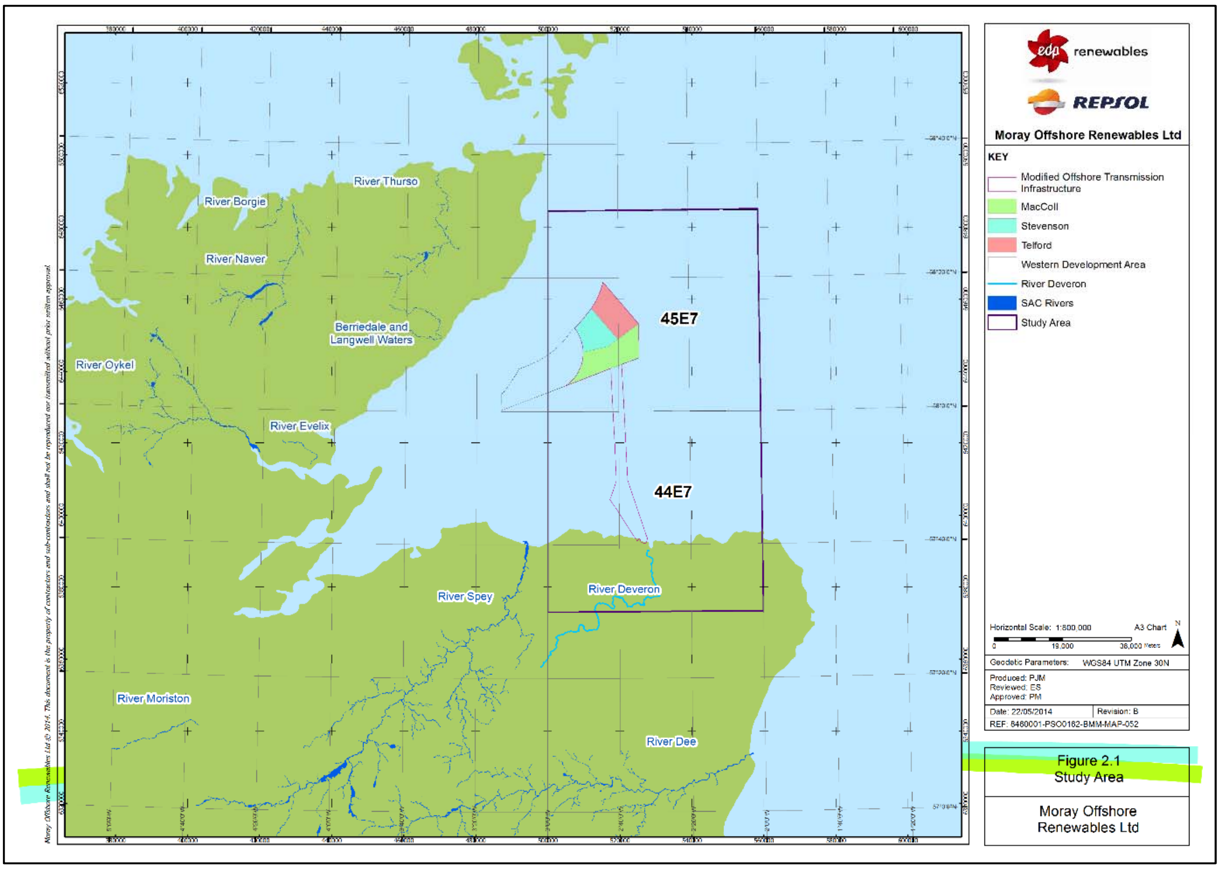

Figure 2.1 Modified Transmission Infrastructure study area

3 Baseline Characterisation

3.1 Substrate Types

In addition to factors such as water depth, temperature and salinity, substrate type can also determine the location and extent of feeding and spawning grounds for species such as *Nephrops (Nephrops norvegicus)*, king and queen scallops (*Pecten maximus, Aequipecten opercularis*), sandeels (Ammodytidae spp.) and herring (*Clupea harengus*).

The distribution of substrate types in the Moray Firth based on British Geological Survey (BGS) data is given in Figure 3.1. Muddy substrates dominate in the inner and southern area, whilst sand, gravelly sand and to a lesser extent sandy gravel and slightly gravelly sand, dominate in the northern and central areas.

The northern and southern sections of the modified TI are located in areas of coarser substrate, such as sandy gravel and gravelly sand, whilst the substrate in the middle section of the modified TI is characterised by the presence of muddy sand and sand.

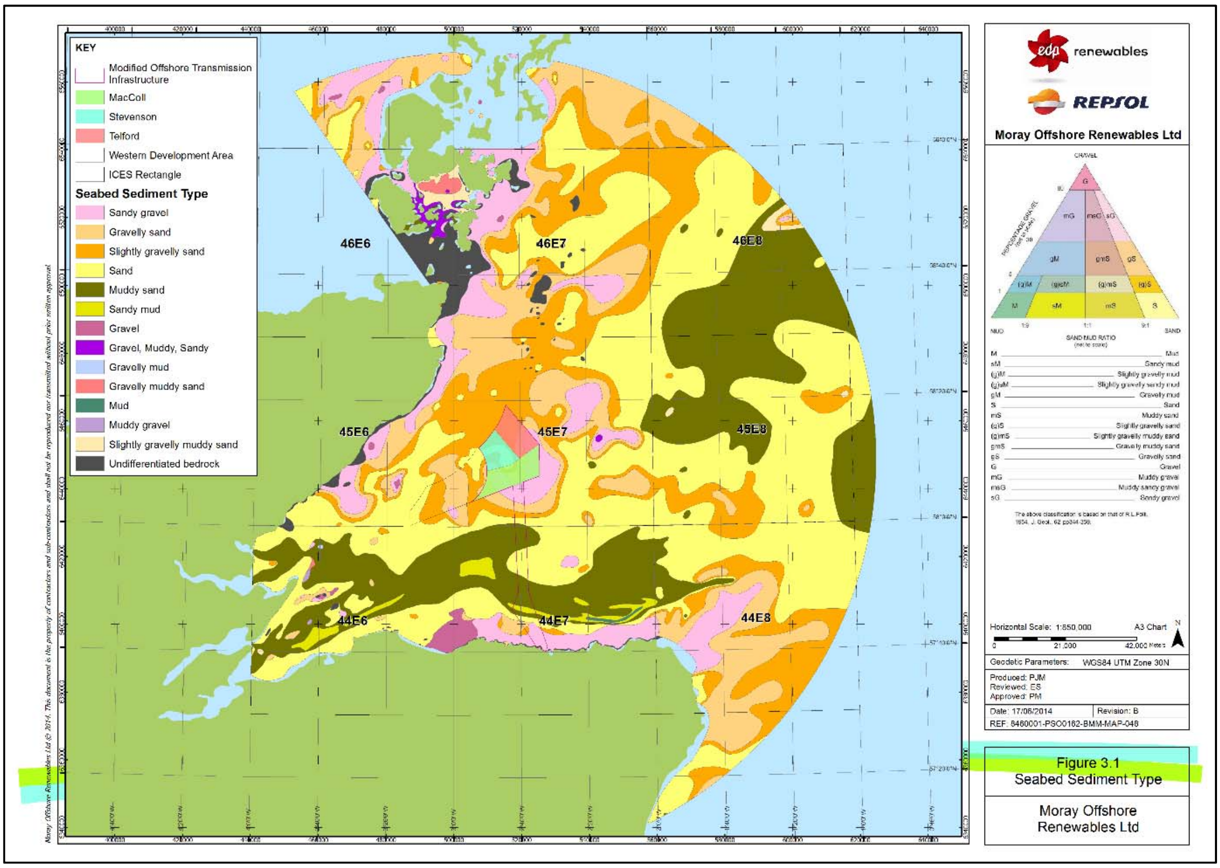

Figure 3.1 BGS (British Geological Survey) seabed sediment chart with ground type

3.2 Species of Commercial Interest

The Moray Firth supports a number of commercially targeted fish and shellfish species. An indication of the relative importance of these within the modified TI study area is given in Figure 3.2, based on annual average (2003 to 2012) landings weights (tonnes) by species and ICES rectangle.

The principal shellfish and cephalopod species landed are *Nephrops*, scallops and squid. With respect to fish, haddock, herring, whiting, monkfish, mackerel and cod constitute the majority of landings. The relative importance of each of these species to the total landings weights varies depending on the ICES rectangle under consideration.

In the case of scallops, landings weights are particularly high in rectangle 45E7, representing almost 50% of the total. In rectangle 44E7 *Nephrops* and squid account for higher proportions of total average weights. In both rectangles constituting the modified TI study area, haddock represents a considerably higher proportion of total landings than all other fish species. Landings weights for monkfish, cod and herring are comparatively low. Elasmobranch species (sharks and rays) comprise a minimal percentage of the landings weights in the study area being included under the category "other" in Figure 3.2 .

The annual average landings weights (2003 to 2012) by species and the proportion each contributes to the total are shown in Table 3.1 and Table 3.2 for shellfish and fish species respectively.

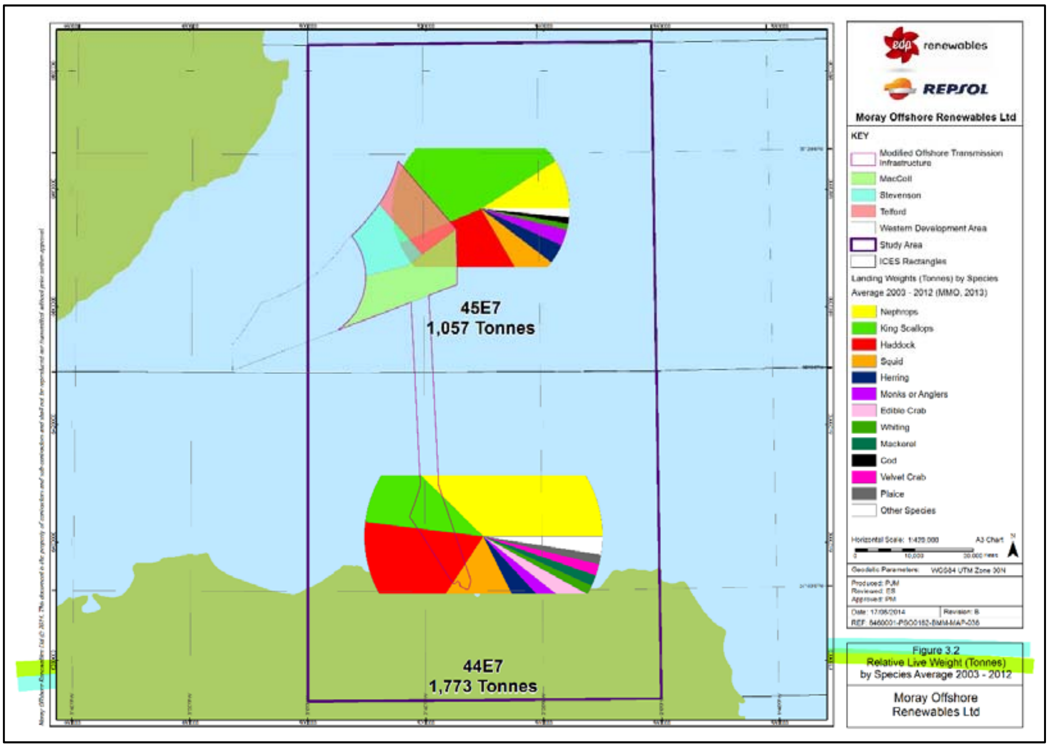

Figure 3.2 Live weight (tonnes) by species by ICES rectangle in the Study Area (2003-2012) (Source: MMO, 2013)

Table 3.1 Annual average landings weights (2003 to 2012) of principal commercial shellfish species in the study area (Source: MMO, 2013)

Common Name	Latin Name	Average (2003 - 2012) Landings Weight (t)	Percentage of Total Shellfish Landings Weight in 44E7 & 45E7	Percentage of Total Landings Weight (all fish and shellfish species combines) in 44E7 & 45E7
Nephrops	*Nephrops norvegicus*	756.7	40.4%	26.7%
King Scallops	*Pecten maximus*	678.2	36.2%	24.0%
Squid	*Loligo forbesi*	356.3	19.0%	12.6%
Edible Crab	*Cancer pagurus*	48.7	2.6%	1.7%
Velvet Crab	*Necora puber*	27.1	1.4%	1.0%
Lobsters	*Homarus gammarus*	3.8	0.2%	0.1%
Queen Scallops	*Aequipecten opercularis*	1.3	0.1%	< 0.1%
Octopus	n/a	1.1	0.1%	< 0.1%
Mixed Crabs	n/a	0.3	< 0.1%	< 0.1%
Whelks	*Buccinum undatum*	0.1	< 0.01%	< 0.01%
Green Crab	*Carcinus maenas*	0.1	< 0.01%	< 0.01%
Razor Clam	*Ensis* spp.	0.0	< 0.01%	< 0.01%
Periwinkles	*Littorina littorea*	0.0	< 0.01%	< 0.001%
Brown Shrimps	*Crangon crangon*	0.0	< 0.001%	< 0.0001%

Table 3.2 Annual average landings weights (2003 to 2012) of principal commercial fish species in the study area (Source: MMO, 2013)

Common Name	Latin Name	Average (2003 - 2012) Landings Weight (t)	Percentage of Total Fish Landings Weight in 44E7 & 45E7	Percentage of Total Landings Weight (all fish and shellfish species combines) in 44E7 & 45E7
Haddock	*Melanogrammus aeglefinus*	592.2	61.9%	20.9%
Herring	*Clupea harengus*	117.1	12.2%	4.1%
Monks or Anglers	*Lophius piscatorius / L. budegassa*	74.8	7.8%	2.6%
Whiting	*Merlangius merlangus*	34.0	3.6%	1.2%
Mackerel	*Scomber scombrus*	29.2	3.1%	1.0%
Cod	*Gadus morhua*	28.8	3.0%	1.0%
Plaice	*Pleuronectes platessa*	26.6	2.8%	0.9%
Witch	*Glyptocephalus cynoglossus*	9.4	1.0%	0.3%
Skates and Rays	n/a	6.5	0.7%	0.2%
Lemon Sole	*Microstomus kitt*	6.3	0.7%	0.2%
Hake	*Merluccius merluccius*	5.3	0.6%	0.2%
Megrim	*Lepidorhombus whiffiagonis*	4.1	0.4%	0.1%
Ling	*Molva molva*	3.4	0.4%	0.1%
Saithe	*Pollachius virens*	2.6	0.3%	0.1%
Halibut	*Hippoglossus hippoglossus*	1.7	0.2%	0.1%
Other Species	n/a	14.3	1.5%	0.5%

3.3 Spawning and Nursery Grounds

The modified TI falls within, or is in close proximity to, the spawning and nursery grounds of a number of species (Coull *et al*., 1998; Ellis *et al*., 2010). These are listed in Table 3.3, together with the spawning times and intensity of spawning (where defined). The spawning times given in Table 3.3 are as provided in Coull *et al*. (1998) and the intensity of the spawning/nursery intensity as described in Ellis *et al*. (2010).

Sandeel, *Nephrops*, cod, plaice, lemon sole, sprat and whiting spawning grounds have all been defined within the vicinity of the three consented wind farms. The modified TI does not cross the spawning grounds of either the Orkney/Shetland or the Buchan herring stocks (the two stocks known to have spawning grounds in the vicinity of the Moray Firth; see Figure 3.6).

In addition to the species listed in Table 3.3, king scallop may also use areas in the vicinity of the modified TI as spawning and nursery grounds. Post-planktonic stages of this species are generally associated with coarse sand gravel substrates and bryozoans/hydroid communities. Similarly, squid are known to spawn in inshore areas from December to June, with peak spawning having been reported from December to March, laying eggs onto biogenic or manmade structures and surfaces. Fishermen have reported finding squid eggs off Burghead and Buckie in May and June in water depths of 5-6 m and eggs have also been found on lobster creels shot on hard ground in the Moray Firth. It is therefore considered that some degree of spawning may take place in the vicinity of the modified TI.

Table 3.3 Species with spawning and nursery areas within/in close proximity to the Modified TI, together with spawning times and intensity (Coull *et al*., 1998; Ellis *et al*., 2010).

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Nursery
Sandeel													
Nephrops				*	*	*							
Cod		*	*										
Plaice	*	*											
Lemon Sole													
Sprat					*	*							
Whiting													
Herring													
Spurdog	n/a												
Thornback Ray	n/a												
Spotted Ray	n/a												
Blue Whiting	n/a												
Ling	n/a												
Hake	n/a												
Anglerfish	n/a												
Mackerel	n/a												
Haddock	n/a												
Saithe	n/a												

Colour key: (red) = high intensity spawning/nursery ground, (yellow) = low intensity spawning/nursery ground, (green) = unknown spawning/nursery intensity, (*) = peak spawning

A review of the species identified as having spawning and nursery grounds in the general area of the modified TI is given in the following sections.

3.3.1 Sandeels

For the purposes of fisheries management, the North Sea sandeel stock has been classified into seven reproductively isolated sub-stocks. The sandeel population of the Moray Firth is part of the Central Western North Sea sub-stock (ICES, 2009).

Sandeels have a prolonged dormant overwintering period (September to March) during which they are buried in benthic substrates (Winslade, 1974b; Wright & Bailey, 1993). This overwintering phase is interrupted by spawning which usually occurs during December and January (Winslade, 1974b; Gauld & Hutcheon, 1990; Bergstad *et al*., 2001). Females lay demersal eggs which hatch as planktonic larvae several weeks after spawning during February and March (Macer, 1965; Langham, 1971; Wright & Bailey, 1996). Following spawning, overwintering resumes until April which marks the start of an extended period of pelagic feeding through spring and summer (Winslade, 1974b; Van der Kooij *et al*., 2008).

Spawning grounds are shown in Figure 3.4 together with the results of recent egg and larval surveys, as presented in Ellis *et al*. (2010a). The modified TI is located in high intensity spawning grounds and a low intensity nursery ground for sandeels (Ellis *et al*., 2010a).

Sandeels are highly substrate specific and as such broad scale patterns of distribution show a high degree of heterogeneity (Wright, 1999a). Sandeels create temporary burrows in the substrate and ventilate their gills with interstitial water. The presence of fine particles of silt rich sediments potentially clogs the gills and inhibits respiration. Therefore, preferred habitats typically comprise a high proportion of medium and coarse sands (particle size 0.25-< 2 mm) with low silt content (Holland *et al*., 2005).

Based on the analysis of 2,885 grab-samples Holland *et al*. (2005) demonstrated that lesser sandeel is likely to be rare in sediments where the silt content (particle size < 0.63 µm) is greater than 4 % and absent where the silt content is greater than 10% (Holland *et al*., 2005; Wright *et al*., 2000). Holland *et al*. (2005) further defined sediment characteristics for suitable and unsuitable habitats for sandeels. A habitat was defined as unsuitable for sandeels if all of the four sediment characteristics described below are present:

- >1% Medium silt AND
- ≤55% Medium sand AND
- >2% Coarse silt AND
- ≤15% Coarse sand

Suitable habitat was only broadly defined requiring one or more of the characteristics:

- >55% Medium sand OR
- >15% Coarse sand OR
- ≤2% Coarse silt OR

In light of the highly specific habitat requirements of sandeels it is expected that the distribution of adults, juveniles, larvae and spawning grounds will occupy discrete ‘patches’ as opposed to being distributed homogenously throughout the Moray Firth and the area occupied by the modified TI. The benthic particle size distribution (PSD) data indicates that stations KPA2, KPA50 and KPA58 contain substrates suitable for sandeels (Fugro, 2014; Figure 3.3).

Based on the BGS data presented in Figure 3.1 the areas of suitable sandeel habitat are the relatively small discrete areas of slightly gravelly sand and sand located in the north, central and southern areas of the modified TI.

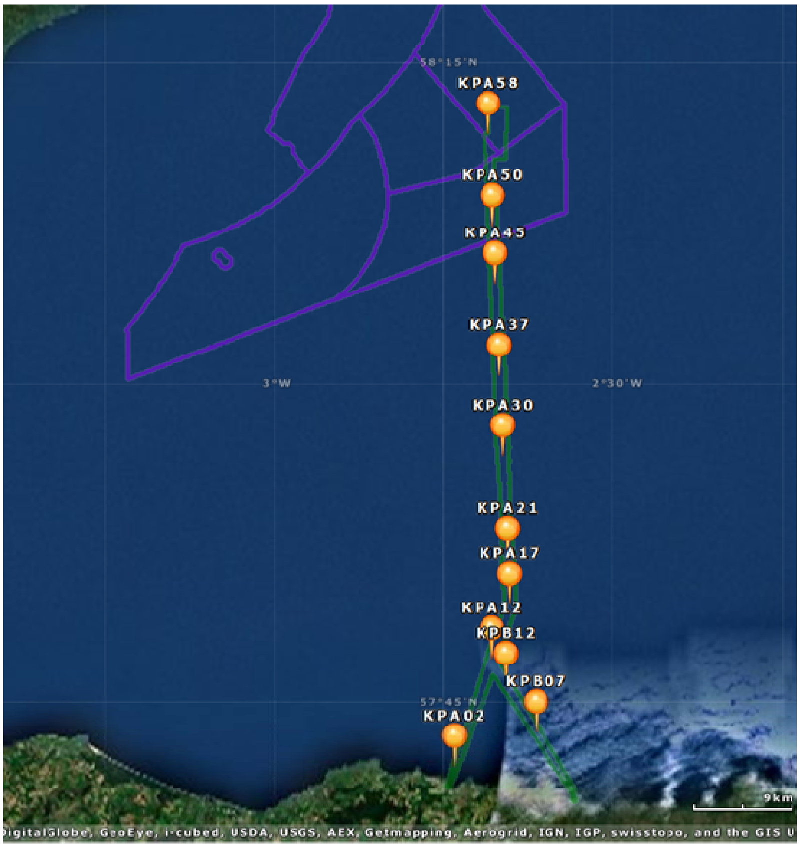

Figure 3.3 Benthic Particle Size Distribution (PSD) sample stations (Fugro, 2014)

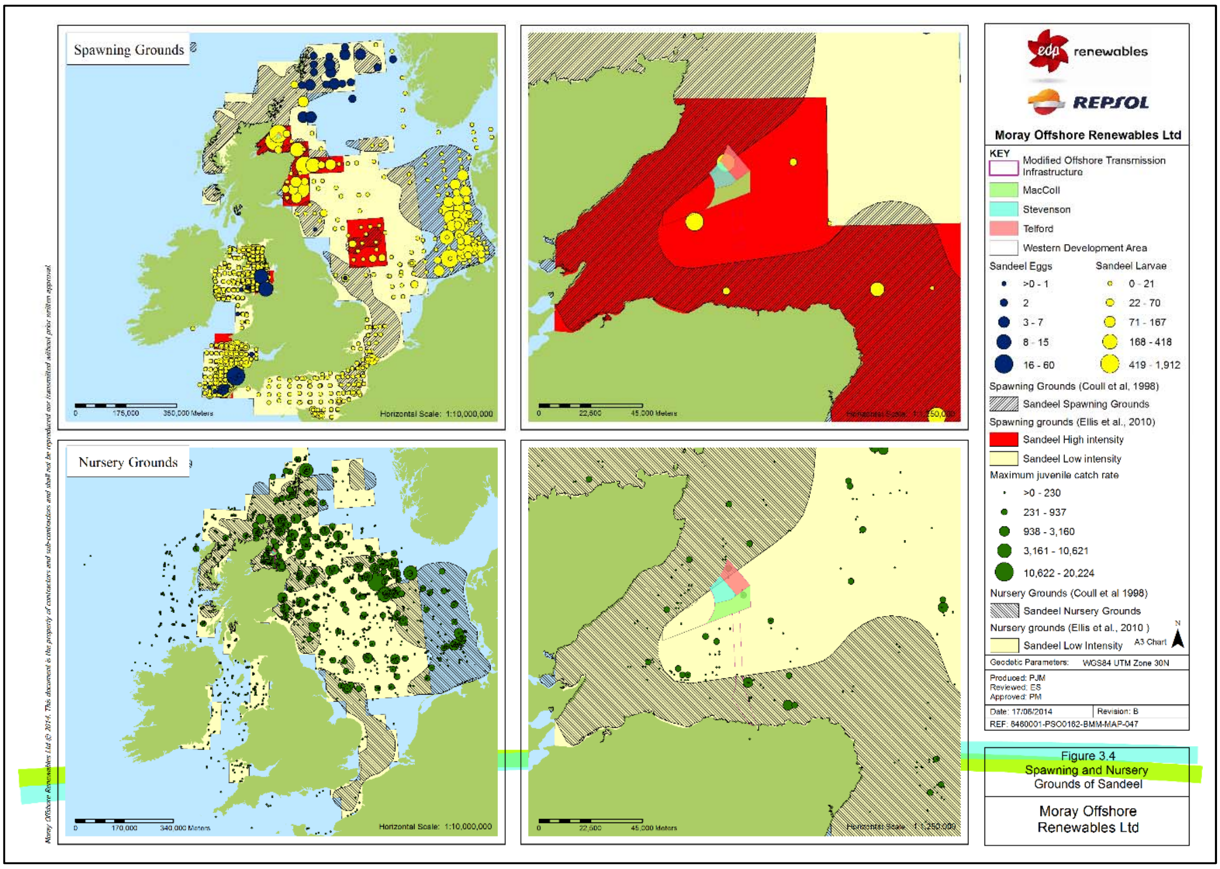

Figure 3.4 Sandeel spawning and nursery grounds (Modified from Ellis *et al.*, 2010)

3.3.2 Nephrops

Nephrops are a burrowing species which spend a high proportion of their life cycle in burrows, leaving only when feeding and searching for a mate (Barreto & Bailey, 2013). In Scottish waters, spawning occurs from August to November (Howard 1989; Barreto & Bailey, 2013). Following fertilisation females incubate the eggs exogenously under the abdomen ('berried') for 8-9 months until they hatch as pelagic larvae from late April to August (Howard, 1989). Berried females remain in the burrow throughout the incubation period. Post hatch larval stages develop in the plankton before settling to the seabed six to eight weeks later as juveniles (Barreto & Bailey, 2013). The juveniles then enter burrows, remaining there for approximately one year (Howard, 1989).

Nephrops distribution is dependent upon the availability of substrates composed of fine cohesive mud within which they can construct burrows. Sediment type appears to affect the structure of *Nephrops* populations, with areas of fine sediment being characterised by the presence of large *Nephrops* and low population densities. Conversely, areas of coarser sediment may support higher population densities of smaller sized individuals (Howard, 1989). The benthic PSD data shows that "muddy sand" (BGS classification) was found at stations KPA12, KPA17 and KPB12, which are considered suitable sediments for *Nephrops* (Fugro, 2014; Figure 3.3).

Figure 3.5 shows that the location of the modified TI falls within the *Nephrops* spawning and nursery grounds defined by Coull *et al*. (1998). Based on the presence of significant fisheries in those ICES rectangles occupied by the modified TI, (particularly 44E7) and the presence of suitable habitats (muddy sand and sandy mud, see Figure 3.1) in central areas of its offshore route, it is likely that spawning and nursery grounds could occur in these locations.

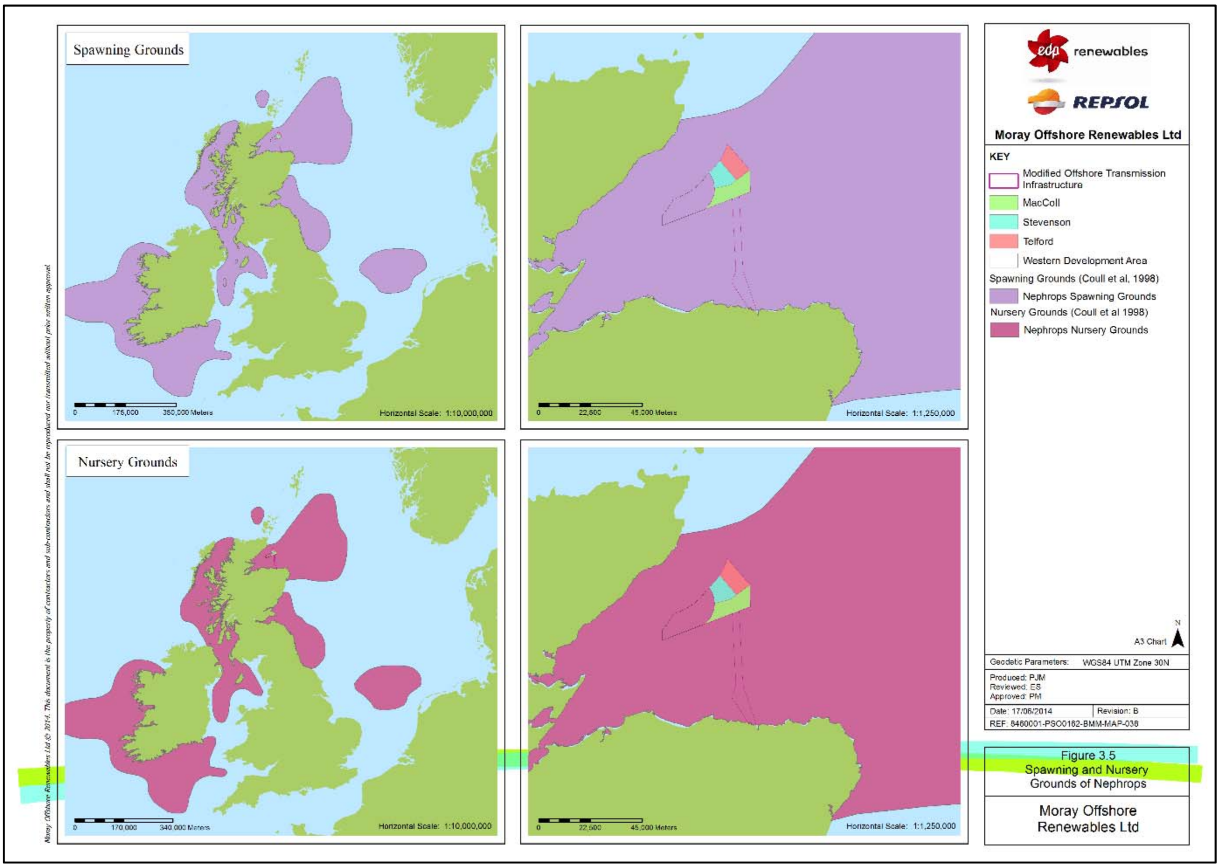

Figure 3.5 Nephrops spawning and nursery grounds (Modified from Coull *et al*., 1998)

3.3.3 Herring

North Sea herring is divided into four sub-stocks on the basis of areas used for spawning. The spatial limits of these sub-stocks are shown in Figure 3.6. The sub-stocks most relevant to the modified TI are the Orkney-Shetland stock and the Buchan stock. The Orkney-Shetland stock spawns off the Scottish east coast and in Shetland/Orkney waters and the Buchan stock spawns outside the Moray Firth off Fraserburgh and south as far as the Firth of Forth.

Herring are demersal spawners and show a strong preference for coarse grounds and high energy environments when selecting spawning grounds (Maucorps, 1969; de Groot, 1980; Blaxter, 1985; Munro *et al*., 1998; Barreto & Bailey, 2013). Females deposit sticky eggs in single batches directly onto the seabed in areas of coarse sand, gravel, small stones or rocks (Hodgson, 1957; Munro *et al*., 1998; Barreto & Bailey, 2013;).

Spawning of the Shetland-Orkney and Buchan sub-stocks occurs between August and September (Coull *et al*., 1998; Barreto & Bailey, 2013) and shoals of herring arrive at traditional spawning grounds in a series of waves, where they congregate (Lambert, 1987). The composition of herring spawning schools changes over time as new fish arrive at spawning grounds and spent fish leave (Geffen, 2009).

It is generally thought that herring larvae hatch after approximately three weeks, depending on sea temperature (Maucorps, 1969; de Groot, 1980; Blaxter, 1985; Munro *et al*., 1998; Barreto & Bailey, 2013). Morley & Batty (1996) found that herring larvae hatch between 6 and 10 days following fertilisation at water temperatures of 14.5°C. Hatched larvae measure between 7 and 10mm and depend on their yolk-sac until first feeding (Hodgson, 1957; ICES, 2013). Once this has been absorbed larvae become pelagic and feed on plankton. They are then passively carried by prevailing currents before arriving at nursery grounds (Munro *et al*., 1998; Barreto & Bailey, 2013). After hatching, herring larvae can travel up to 100 km in the first 15 days (Dickey-Collas *et al*., 2009).

Herring larvae from the Orkney-Shetland stock drift south into nursery grounds in the Moray Firth and east into nursery grounds in the Skagerrak and Kattegat. Larvae of the Buchan stock drift south into nursery grounds in the Firth of Forth and east to Skagerrak and Kattegat.

Herring spawning grounds as presented in Coull *et al*. (1998), including larval densities recorded in the 2008 International Herring Larvae Survey (IHLS) are given in Figure 3.6 (Ellis *et al*., 2010). The extent of herring nursery grounds, together with juvenile catch rates recorded in groundfish surveys are also shown (Ellis *et al*., 2010a). The modified TI does not pass through spawning grounds of either the Orkney-Shetland or Buchan herring stocks (Coull *et al*., 1998) but is located within high intensity nursery grounds as defined by Ellis *et al*. (2010a). Maximum juvenile catch rates were highest west of the central section of the modified TI.

The definition of herring spawning grounds is principally based on the results of the IHLS, which has been undertaken since 1967. A time series of larval densities of the Orkney-Shetland stock (larvae from which are the most likely to drift south into areas occupied by the modified TI) based on data from the IHLS (MSS, 2011a) is provided in Figure 3.7 and Figure 3.8. These show newly hatched larvae (<10 mm) densities from 1973-1994 (1-15 September) and from 1973 to 2004 (16-30 September), respectively. The distribution of larval densities in recent years (2005, 2006, 2008, and 2009) is illustrated in Figure 3.9, as provided in Rohlf & Gröger (2006, 2009, and 2010) and Schmidt *et al*. (2007, 2008).

Based on the data shown it appears that the highest larval densities occur in the north of the Moray Firth, off the coast of Caithness as opposed to central and southern areas relevant to the modified TI. It should be noted that not all stations are sampled each year during the IHLS survey, therefore the lack of larvae in some locations for a particular year does not necessarily imply that spawning did not occur. However, given the long time series for which data is shown it is expected to be broadly representative of the distribution and density of herring larvae within the Moray Firth.

Based on the BGS data presented previously in Figure 3.1, areas of suitable spawning habitat constitute a small proportion of the area covered by the modified TI and are located within the northern and southern sections.

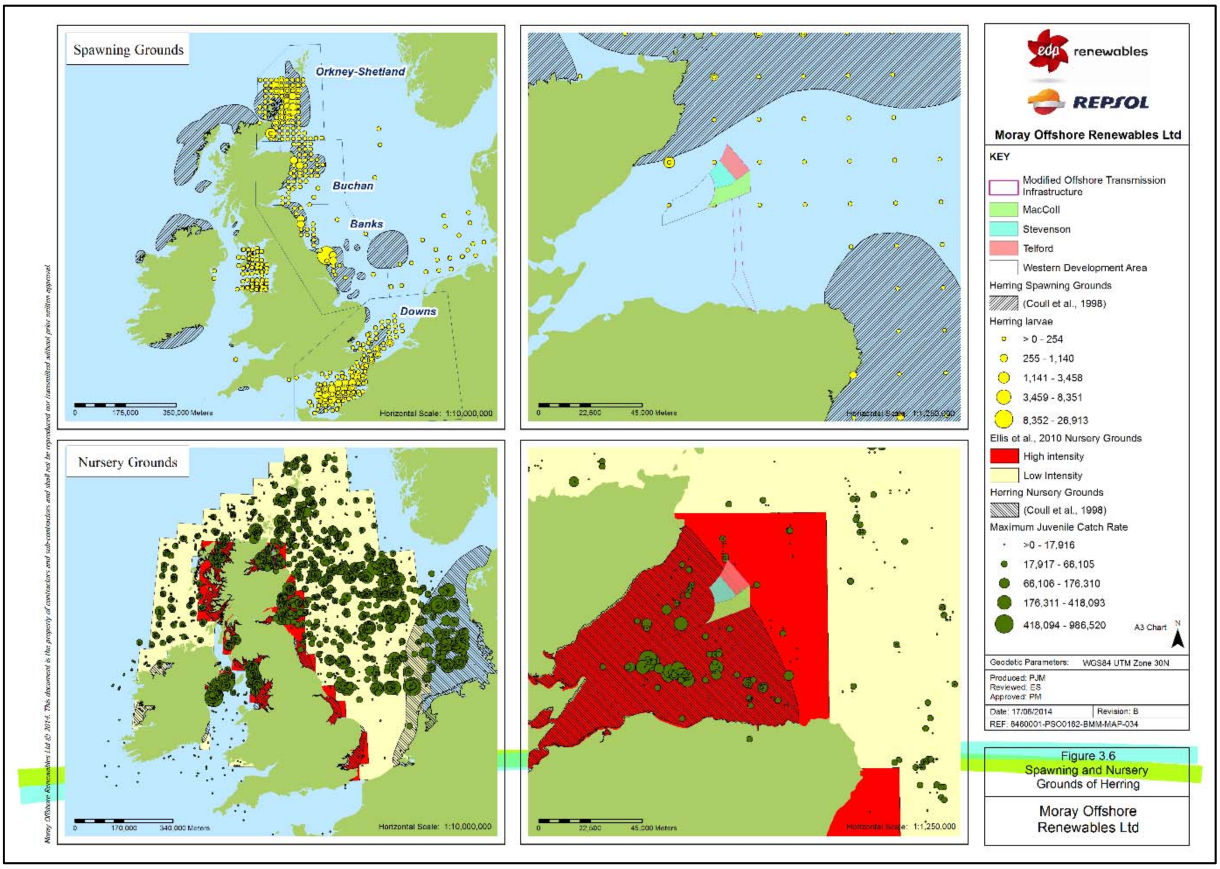

Figure 3.6 Herring spawning and nursery grounds (Modified from Ellis *et al.*, 2010)

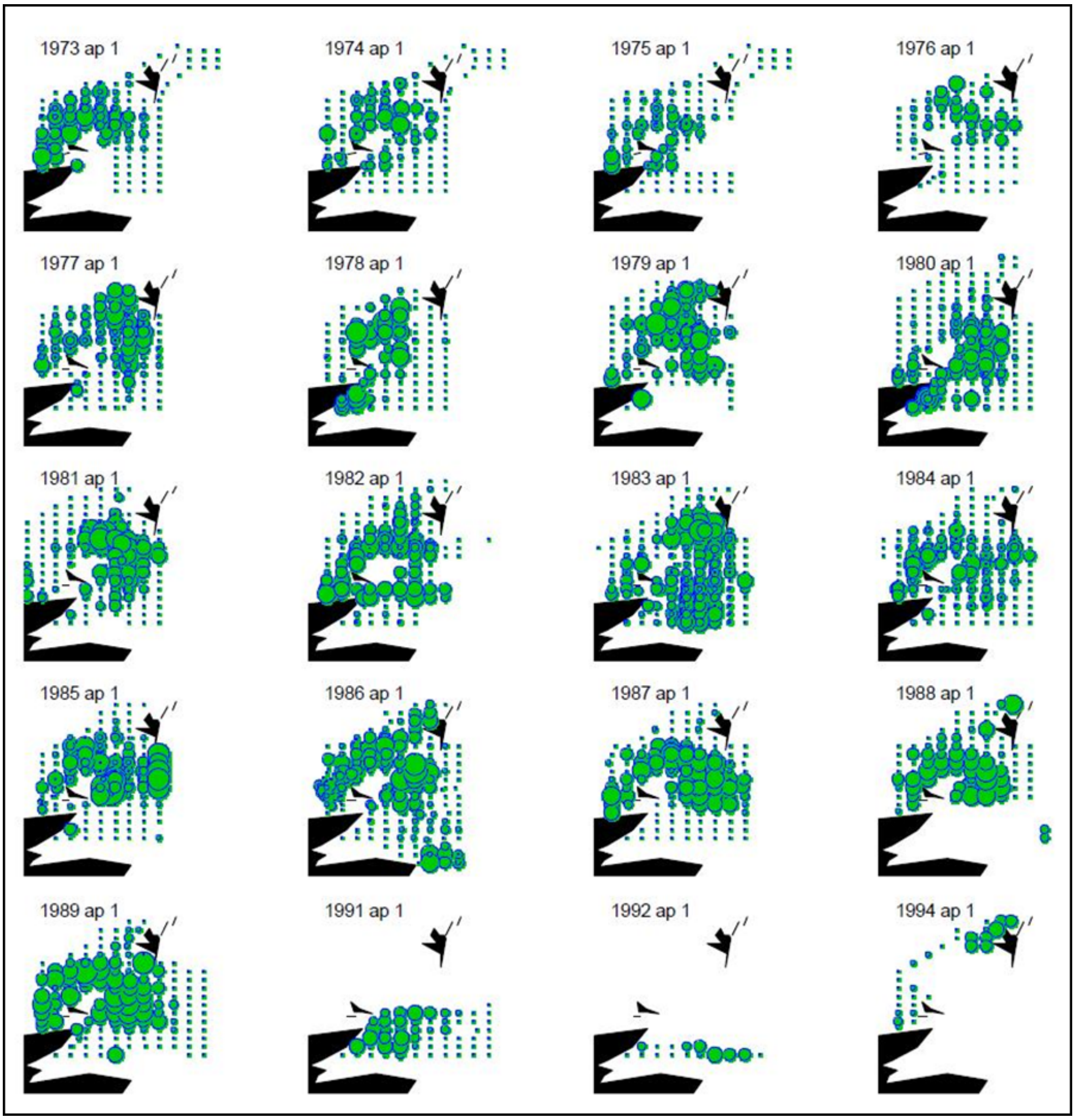

Figure 3.7 International Herring Larvae Surveys charts (1973-1994) of the Orkney/Shetland stock for the period 1 (1-15 September) (Source: Data MSS, 2011a)

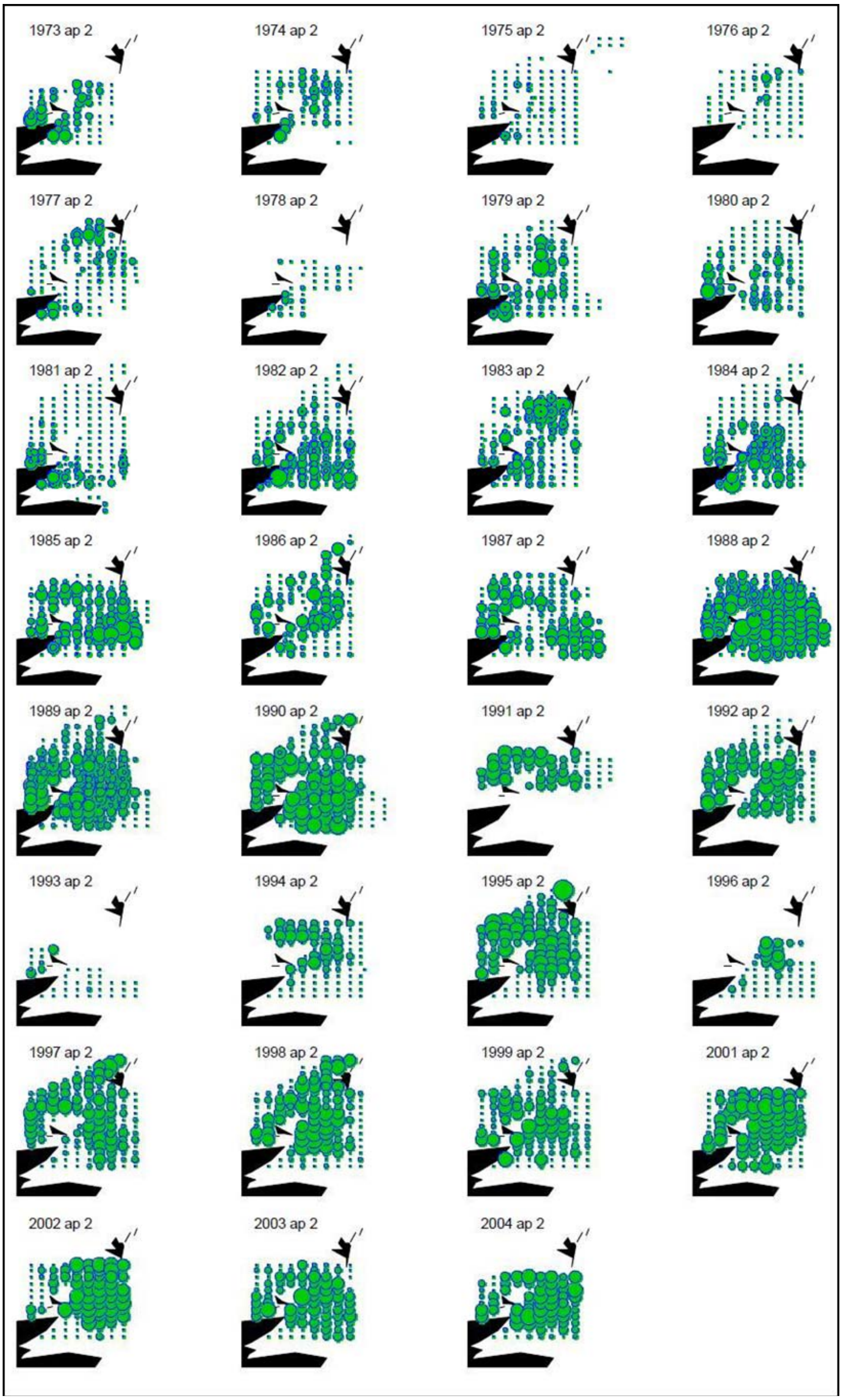

Figure 3.8 International Herring Larvae Surveys charts (1973-2004) of the Orkney/Shetland stock for the period 2 (16-30 September) (Source: Data MSS, 2011)

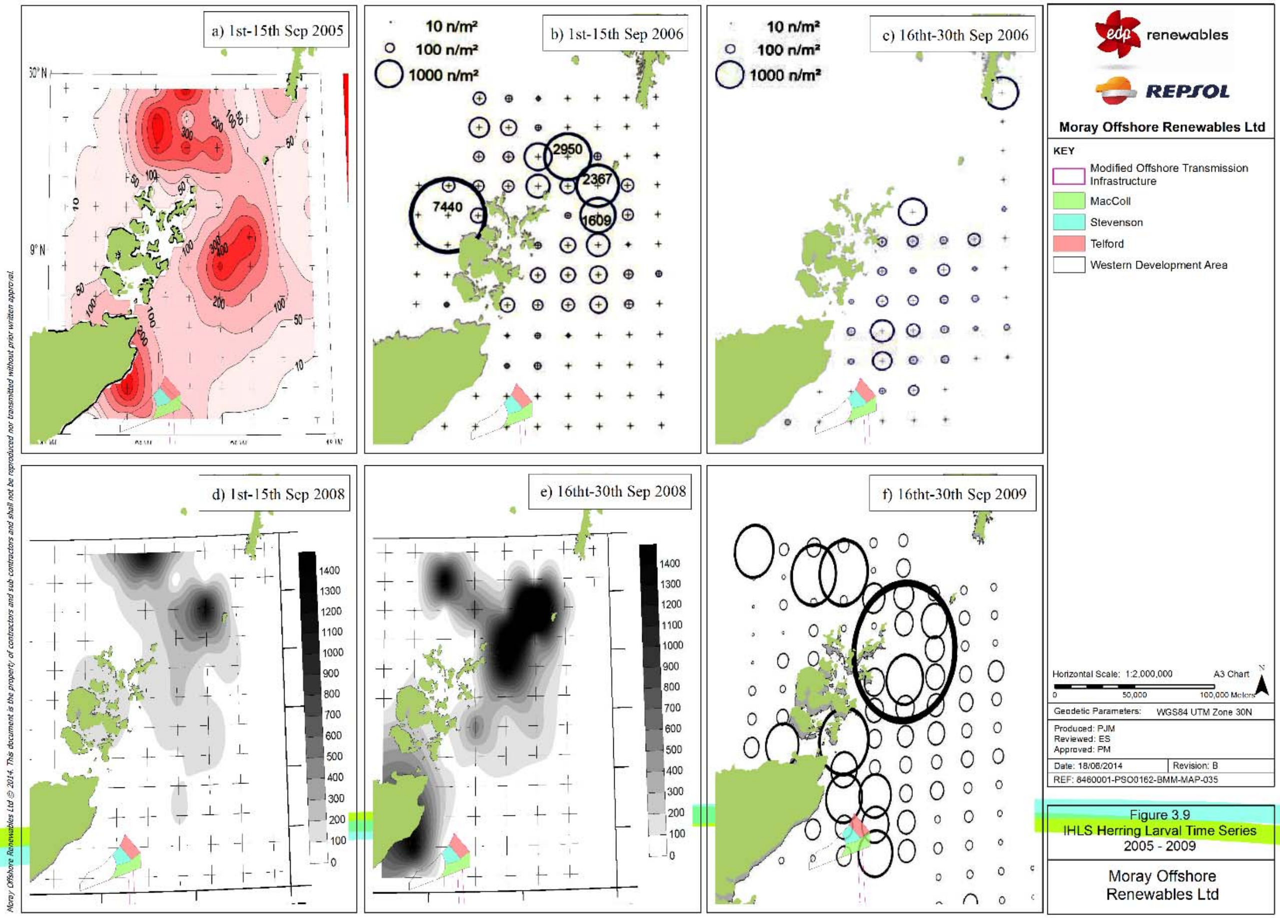

Figure 3.9 International Herring Larval Surveys charts (2005, 2006, 2008, 2009) of the Orkney/Shetland stock (Rohlf & Gröger, 2006, 2009, 2010; Schmidt *et al*., 2007, 2008)

3.3.4 Cod

The cod population of the Moray Firth is genetically distinct from other North Sea populations (Hutchinson *et al.*, 2001). Spawning occurs between January and April, generally during hours of darkness and is at its highest intensity from February to March (ICES, 2005a; Coull *et al.*, 1998). Spawning occurs within the water column and eggs remain pelagic hatching over a period of two to three weeks, dependant on water temperature (Wright *et al.*, 2003). Male cod are known to produce a drumming sound during the spawning season (Nordeide & Kjellsby, 1999; Fudge and Rose, 2009) and it has been suggested that the sounds are used to defend territories and attract females during spawning (Brawn, 1961).

Figure 3.10 shows the extent of cod spawning and nursery grounds. Figure 3.10 also depicts egg and larval densities and juvenile catch rates recorded in ground fish surveys (Ellis *et al.*, 2010a). As shown, the proposed location of the modified TI falls within a low intensity cod spawning area.

The Moray Firth has been defined as a high intensity nursery ground for cod. During the North Sea Egg Survey (2004), significant numbers of eggs were found off the Moray Firth and to the east of the Shetland Islands (Fox *et al.*, 2008). It has been suggested that passive transport of early life history stages could lead to a substantial advection of cod eggs and larvae from Shetland south to the Scottish east coast (Heath & Gallego, 1997).

Potentially significant impacts on spawning cod were identified as a result of piling noise associated with the installation of the wid farms sites in the EIA submitted as part of the Environmental Statement (ES) detailing the Telford, Stevenson and MacColl Offshore Wind Farms in August 2012 (Chapter 7.2 - Biological Environment). The impact assessment took a precautionary approach, where conservative assumptions were applied due to the uncertainty regarding how cod may utilise the Moray Firth area. In consultation with MSS, MORL committed to undertake additional survey work and monitoring with the objective of increasing the confidence in the impact assessment and identifying whether further mitigation would be required.

Results of the survey are shown in Figure 3.11 and Figure 3.12. Cod were recorded in low numbers at 35 out of 58 stations with a maximum of 9 individuals caught at a single station (0T38, Trip B). A total of 23 spawning cod were caught throughout the survey, 12 in Trip A and 11 in Trip B. Further detail is provided in Appendix 1 (Cod Survey Report).

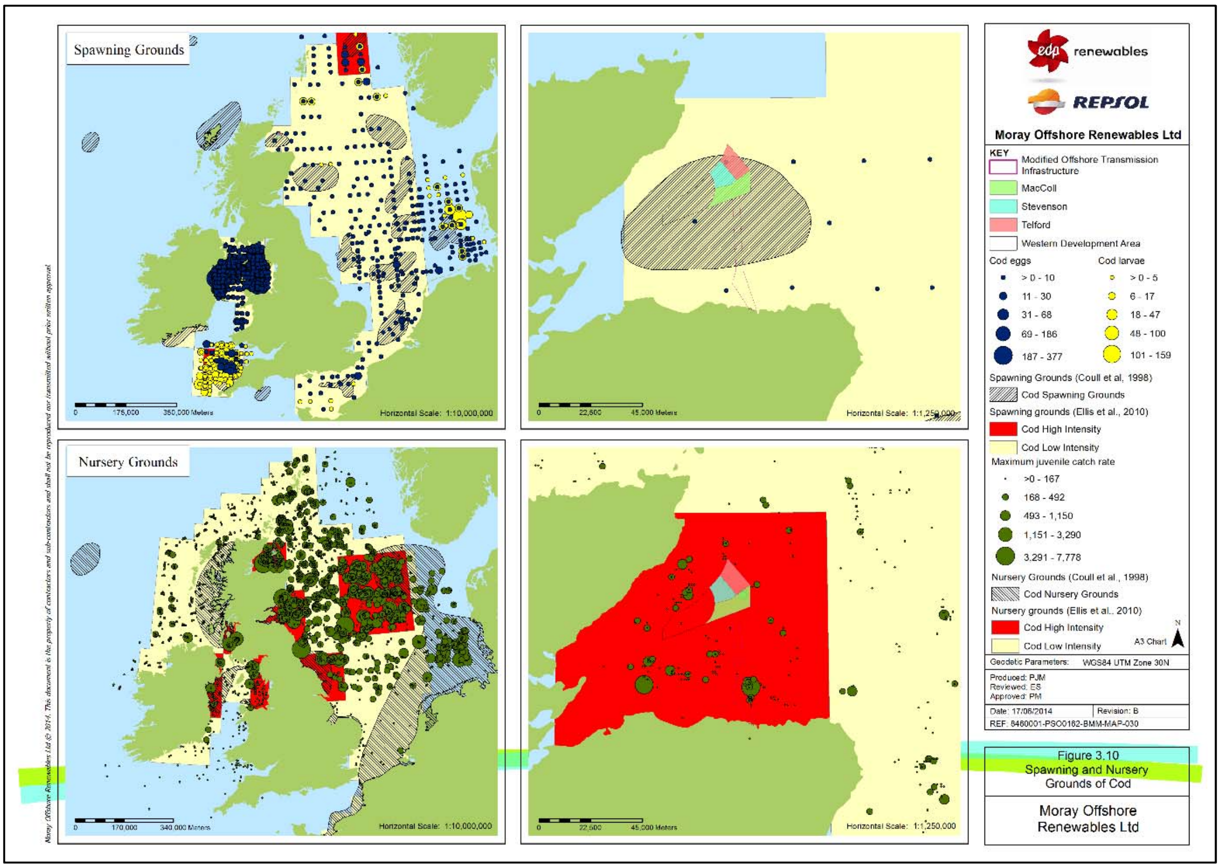

Figure 3.10 Cod spawning and nursery grounds (Modified from Ellis *et al.*, 2010)

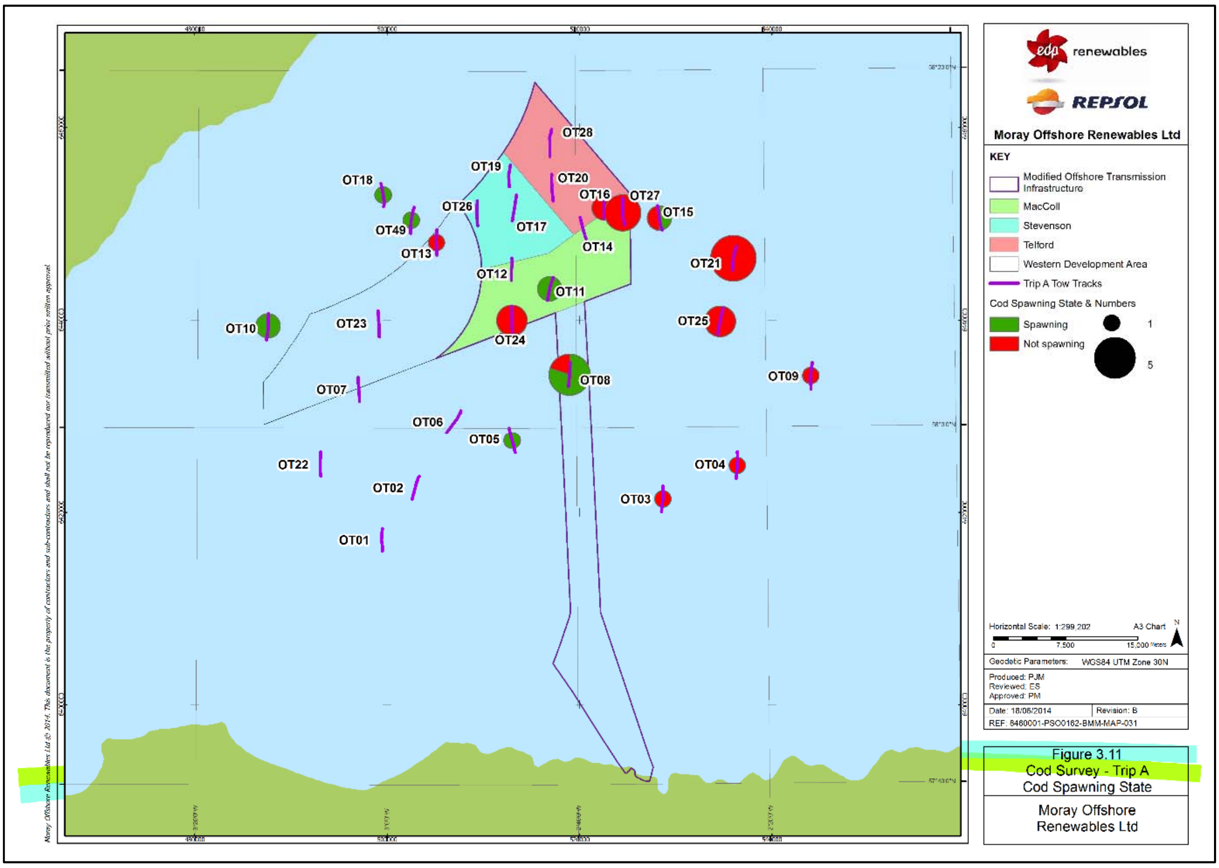

Figure 3.11 Cod survey (trip A) cod spawning state

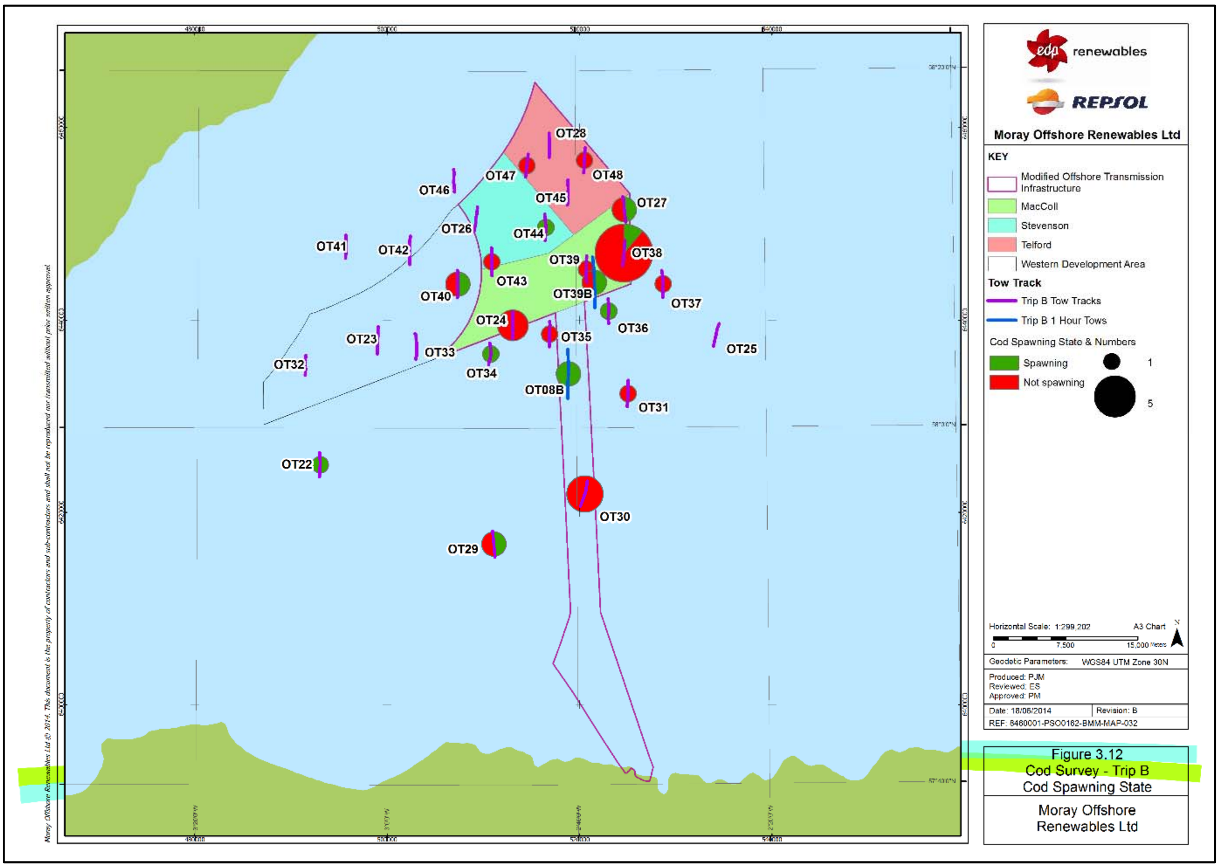

Figure 3.12 Cod survey (trip B) cod spawning state

3.3.5 Plaice

Figure 3.13 shows the distribution of plaice spawning grounds as defined by Coull *et al*. (1998). Figure 3.12 also provides larvae and egg densities as provided in Ellis *et al*. (2010a). A small area to the northwest and an area to the south of the plaice spawning grounds defined by Coull *et al*. (1998) are crossed by the modified TI. The area occupied by the modified TI has also been identified as a low intensity nursery ground.

Plaice spawn between December and March with a peak usually occurring in February/March (Harding *et al*., 1978; Simpson, 1959; Rijnsdorp, 1989;;). Plaice are pelagic spawners and rarely spawn beyond the 50 m depth contour (Harding *et al*., 1978; Rijnsdorp, 1989; Armstrong *et al*., 2001; Murua & Saborido-Rey, 2003). Females spawn over a period of 4-6 weeks (Rijnsdorp, 1989). Eggs hatch into pelagic larvae between 7 and 21 days dependant on water temperature (Fox *et al*., 2003).

The results of the North Sea Egg Survey (2004) showed that plaice eggs showed a patchy distribution with higher abundances in the areas of Flamborough Head, the Firth of Forth, the Moray Firth and to the east of the Shetland Isles (ICES, 2005b). Assuming spawning is relatively continuous, the centres of density of stage I eggs should be close to the sites of spawning although up to three days drift and dispersion may have occurred (ICES, 2005b).

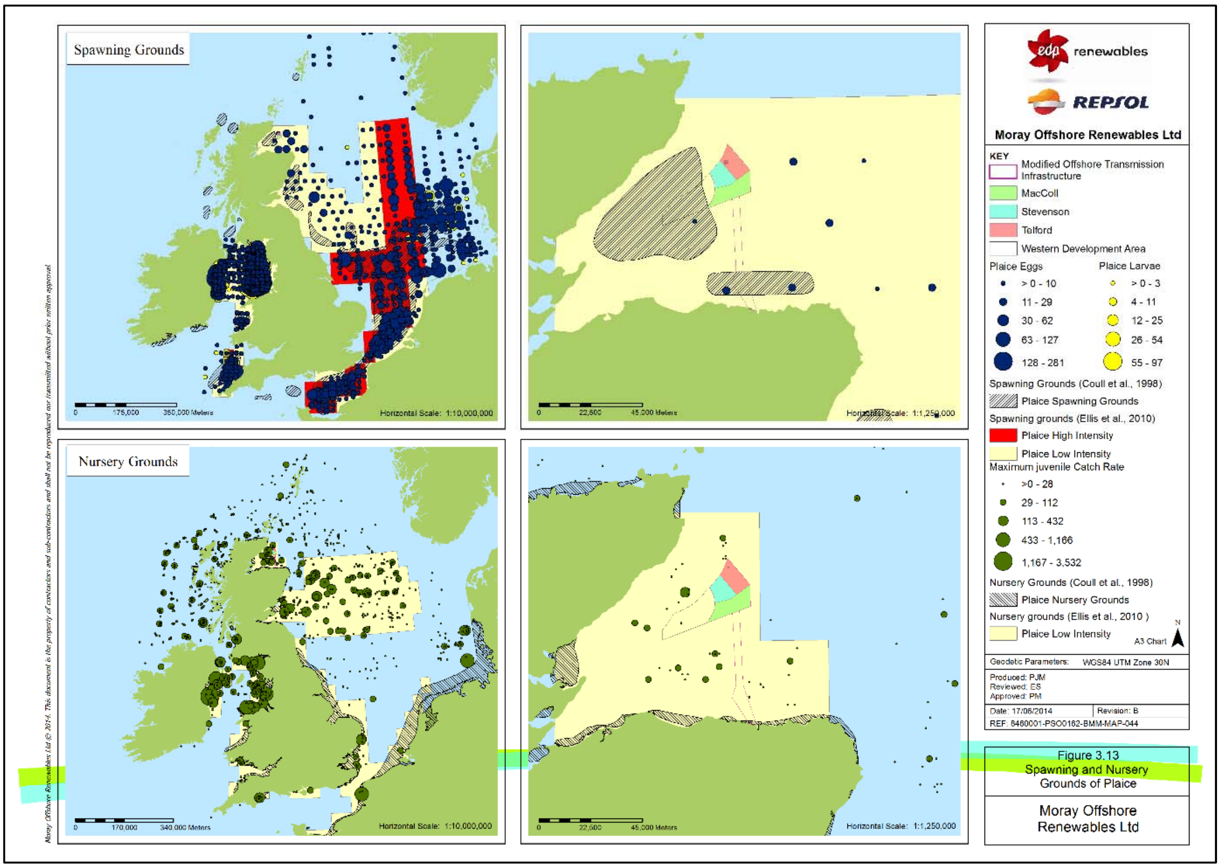

Figure 3.13 Plaice spawning and nursery grounds (Modified from Ellis *et al*., 2010)

3.3.6 Lemon sole

Figure 3.14 shows that the modified TI is situated within lemon sole spawning grounds defined by Coull *et al*. (1998). Lemon sole is widely distributed throughout the North Sea and is thought to spawn where it is found (Rogers & Stocks, 2001). Spawning occurs from April until September (Coull *et al*., 1998). Figure 3.14 shows that nursery grounds have been identified within the vicinity of the modified TI (Coull *et al*., 1998).

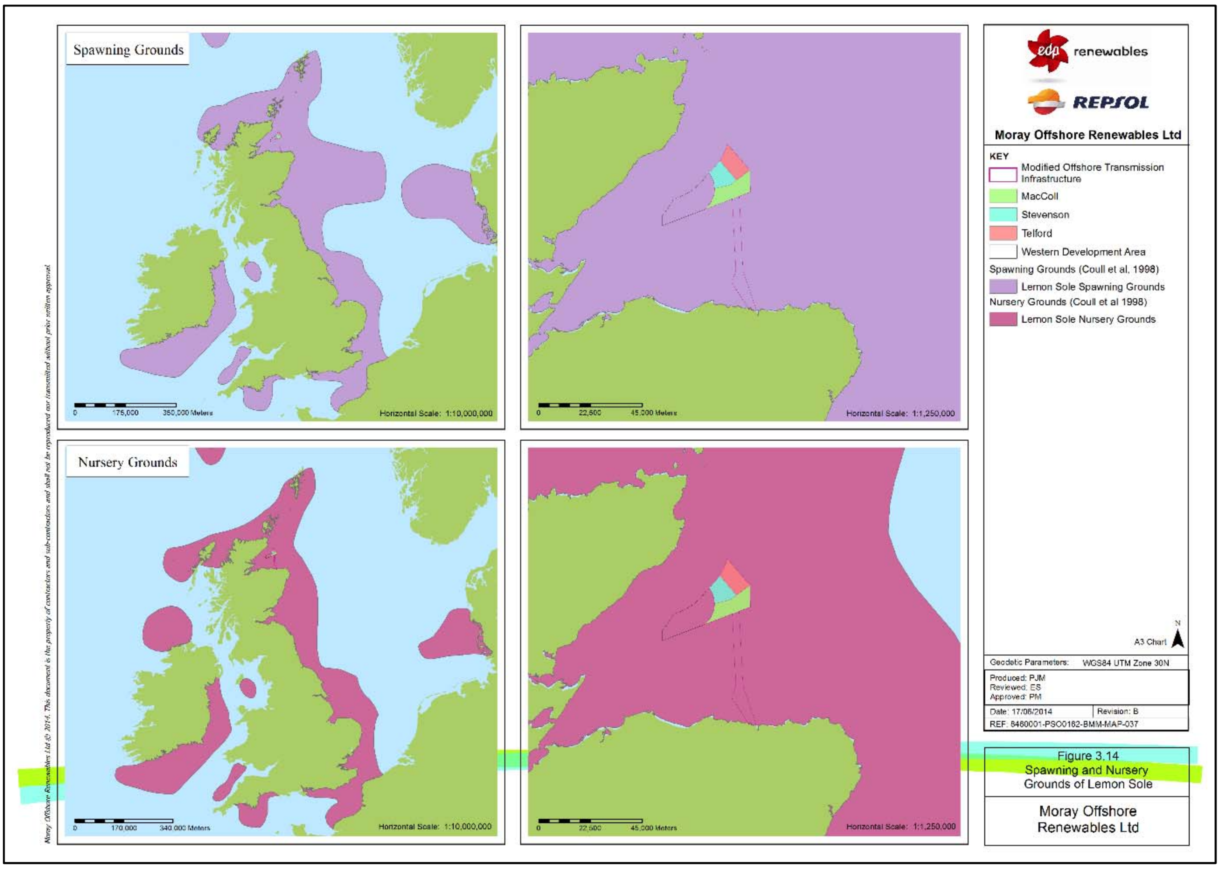

Figure 3.14 Lemon sole spawning and nursery grounds (Modified from Coull *et al*., 1998)

3.3.7 Sprat

Figure 3.15 shows that the modified TI falls within sprat spawning and nursery grounds defined by Coull *et al*. (1998). As shown, the spawning grounds of this species are widely distributed around the British Isles. Spawning takes place from May to August (Coull *et al*., 1998), peaking in May to early July (Kraus & Köster, 2001). Spawning occurs in both coastal and offshore waters up to 100 km from the shore (Whitehead, 1986; Nissling *et al*., 2003; FAO, 2011). Females spawn repeatedly in batches throughout the spawning season (Milligan, 1986). Eggs and larvae of sprat are pelagic and subject to larval drift, often moving into coastal nursery areas (Nissling *et al*., 2003; Hinrichsen *et al*., 2005). Feeding larvae are mainly found in the upper layers of the water column (Nissling *et al*., 2003).

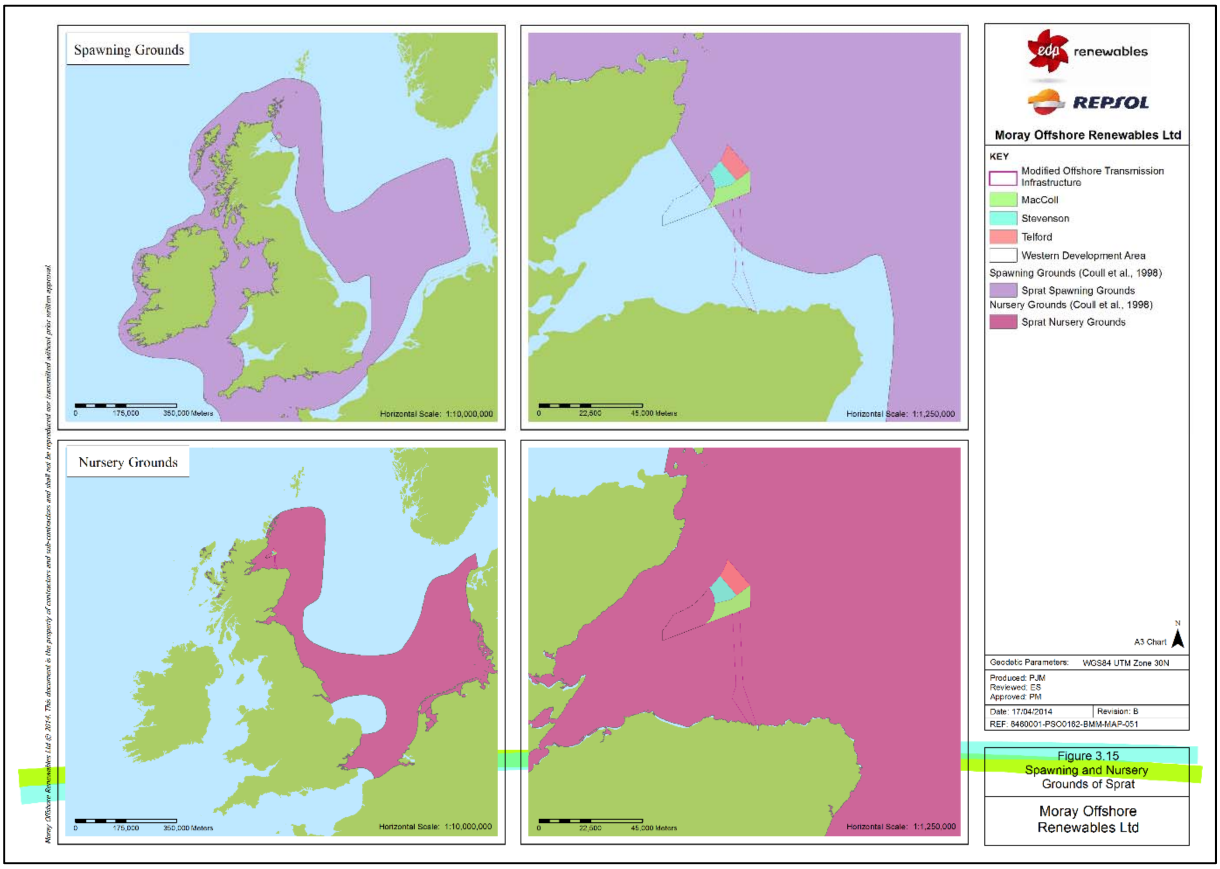

Figure 3.15 Sprat spawning and nursery grounds (Modified from Coull *et al.*, 1998)

3.3.8 Haddock

Figure 3.16 shows that the modified TI does not overlap with haddock spawning grounds as defined by Coull *et al*. (1998) although a more recent publication (Barreto & Bailey, 2013) shows that spawning occurs in an additional location to the east of the Moray Firth. However, these grounds are located some distance away from the location of the modified TI. The modified TI does however fall within the haddock nursery grounds as defined by Coull *et al*. (1998).

Results of international ichthyoplankton surveys carried out in 2004 found high concentrations of haddock stage I eggs in and off the Moray Firth (ICES, 2005b) and surveys conducted by the Fisheries Research Services (FRS) in 1999 found haddock spawning in both coastal and offshore areas (Gibb *et al*., 2004). The highest densities of mature and spawning haddock were found in depths of around 100 m and most fish were associated with areas of mud or sand with abundance apparently reduced over areas of harder substrate (Gibb *et al*., 2004).

Haddock spawn between February and May (Coull *et al*., 1998), at depths of 50-150-m (Fillina *et al*., 2009; FAO, 2011), with the peak spawning occurring in March and April (Coull *et al*., 1998; Fillina *et al*., 2009). Haddock are serial spawners, releasing their eggs in batches over the spawning season (Gibb *et al*., 2004; Fillina *et al*., 2009). Haddock eggs are laid demersally and rise into the water column following fertilisation and develop into pelagic larvae (Page & Frank, 1989). Haddock are capable of producing a wide range of sounds (Wahlberg & Westerberg, 2005) and those produced by males during the spawning season are thought to serve to bring male and female fish together. In addition, it has been suggested that the sounds play a role in synchronising the reproductive behaviour of males and females (Hawkins & Amorim, 2000).

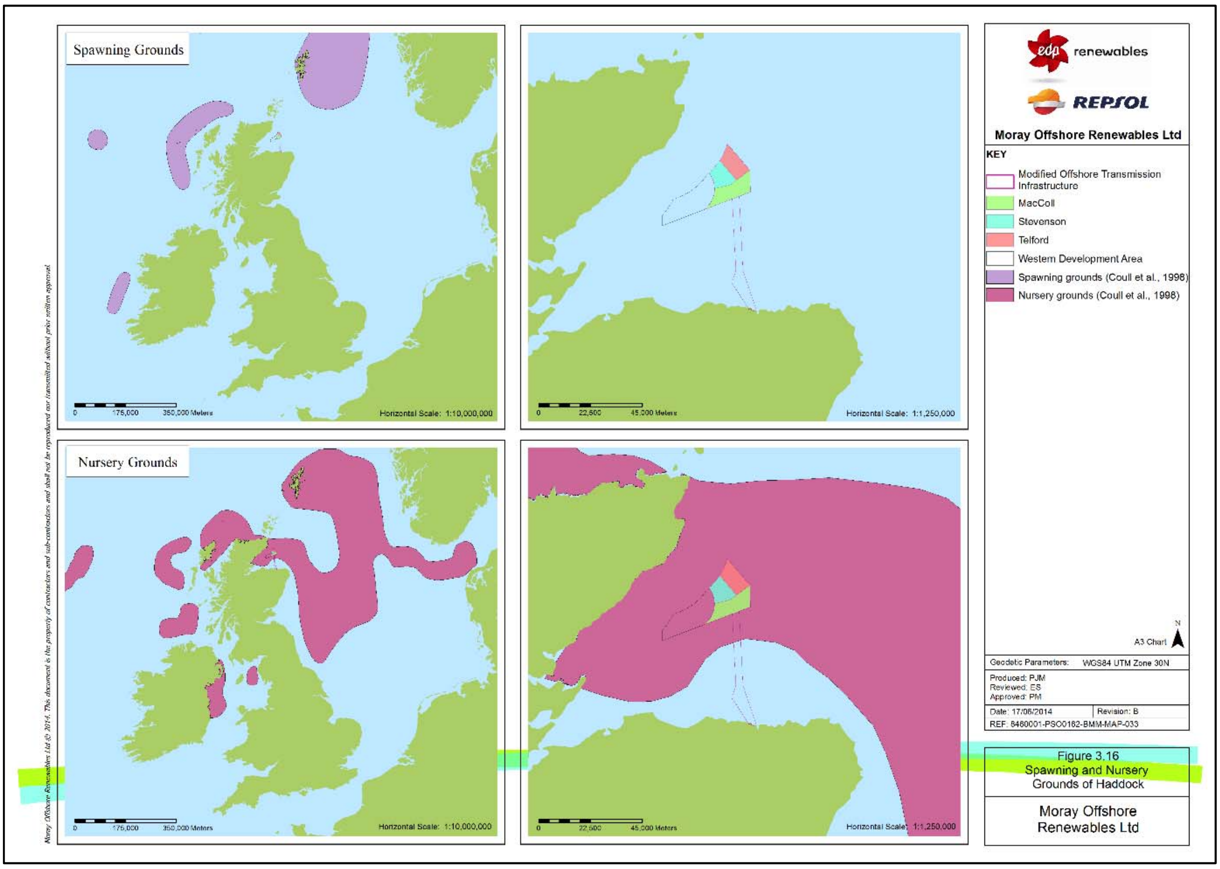

Figure 3.16 Haddock spawning and nursery grounds (Modified from Coull *et al*., 1998)

3.3.9 Whiting

Figure 3.17 shows that the modified TI occupies a small area of the whiting spawning grounds defined by Coull *et al*. (1998) along their western extent. The modified TI is defined as a low intensity spawning ground and high intensity nursery ground by Ellis *et al*. (2010a).

Whiting spawn between February and June with females releasing their eggs in numerous batches for up to fourteen weeks (Teal *et al*., 2009). Eggs are pelagic and take approximately ten days to hatch (Russel, 1976).

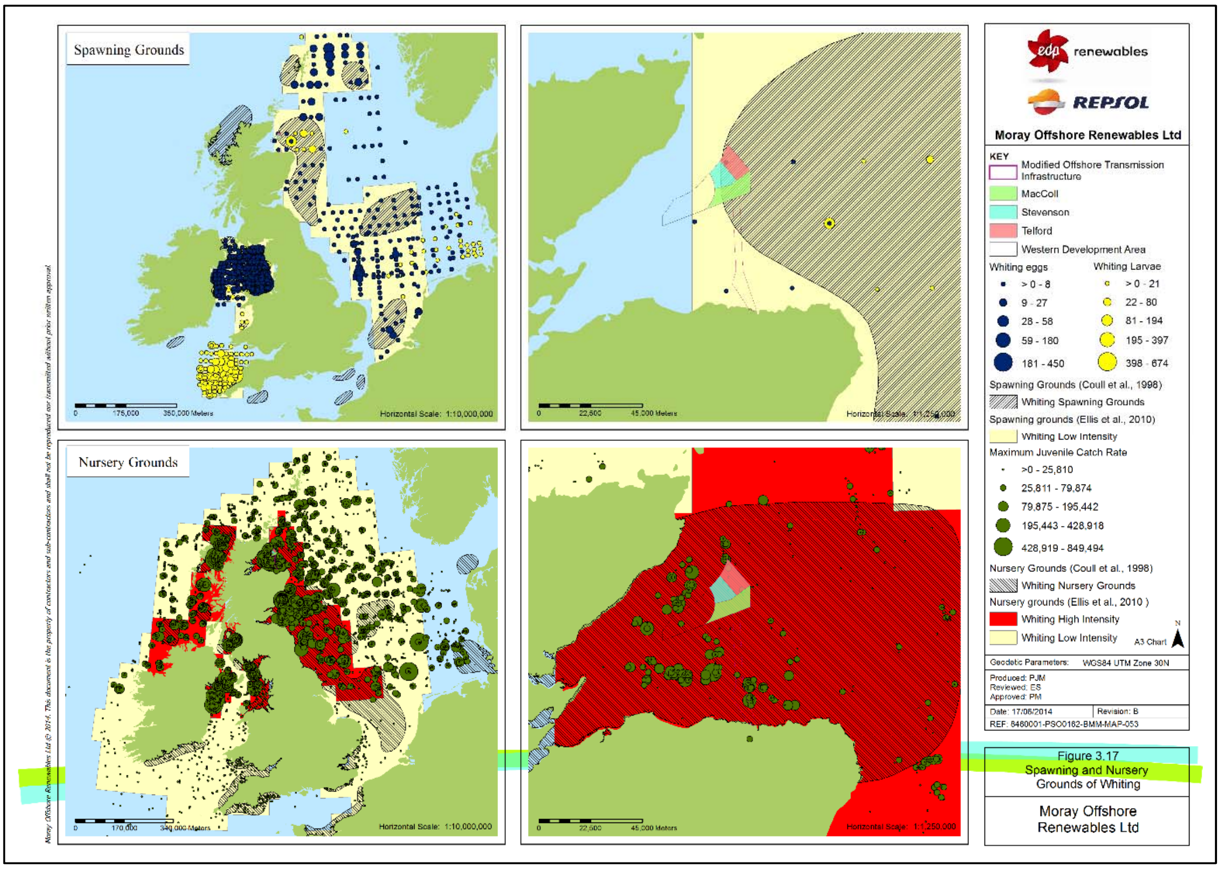

Figure 3.17 Whiting spawning and nursery grounds (Modified from Ellis *et al.*, 2010)

3.3.10 Other Species with Nursery Grounds

Nursery grounds have been defined in the vicinty of the modified TI for a number of other species in addition to those described in the sections above (See Table 3.3). These are shown in Figure 3.18 and Figure 3.19 as defined by Coull *et al*. (1998) and Ellis *et al*. (2010a). Nursery grounds have not been identified in the vicinity of the modified TI for tope or ling (Figure 3.18 and Figure 3.19).

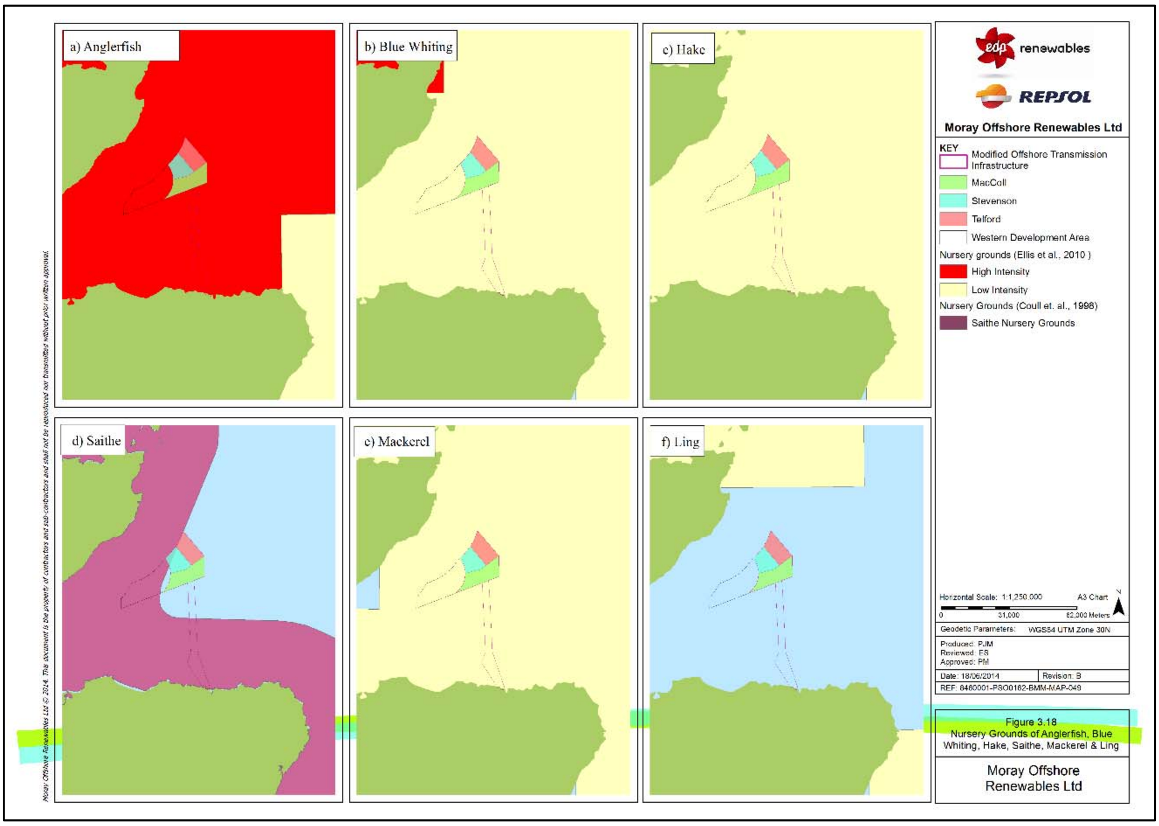

Figure 3.18 Nursery grounds of anglerfish, blue whiting, hake, saithe, mackerel and ling (Modified from Ellis *et al.*, 2010 and Coull *et al.*, 1998)

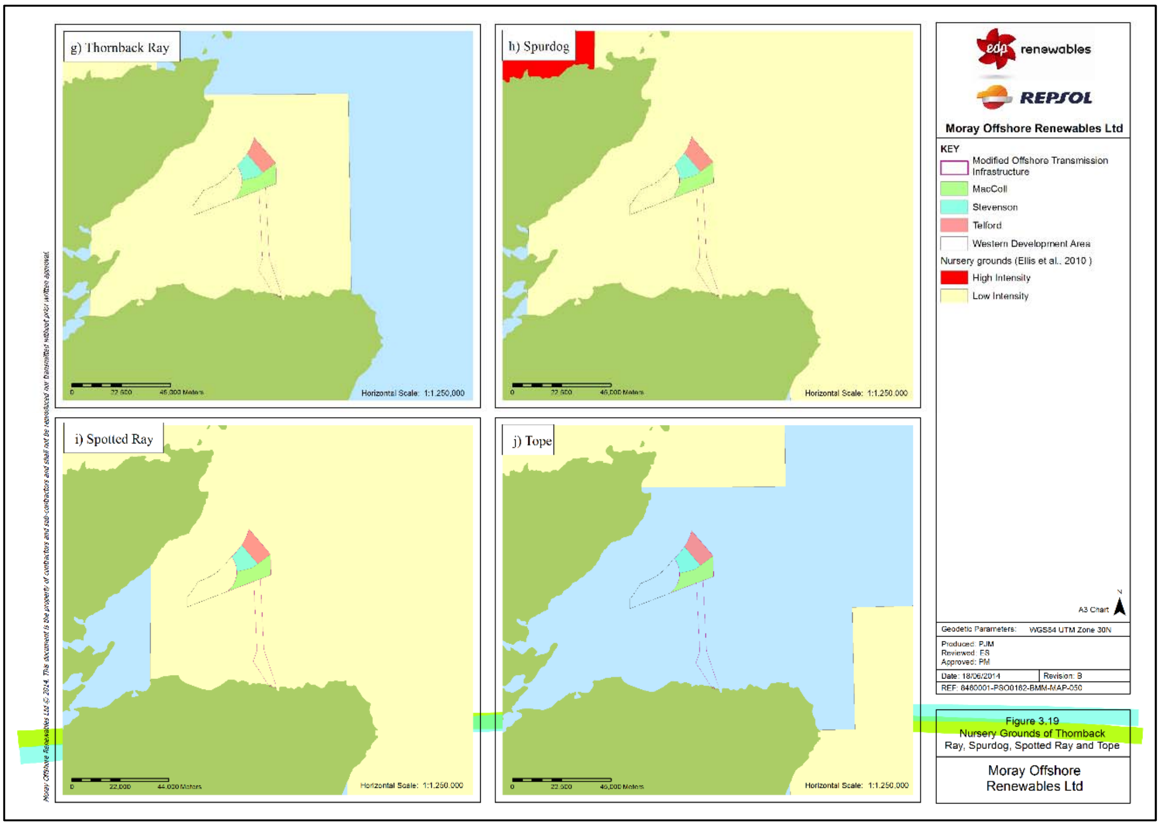

Figure 3.19 Nursery grounds of thornback ray, spurdog, spotted ray and tope (Modified from Ellis *et al.*, 2010 and Coull *et al.*, 1998)

3.4 Key Species in the Food-web

Abundant species with high biomass such as sandeels and clupeids (e.g. herring and sprat) play an important functional role in North Sea food web dynamics. These species occupy intermediate trophic levels, are significant predators of zooplankton and represent a key dietary component for a variety of aquatic predators.

Species of sandeels and Clupeidae are important prey for piscivorous fish such as elasmobranchs, gadoids, bass, mackerel, and diadromous salmonids, amongst others (ICES, 2005a; ICES, 2005b; ICES, 2006; ICES, 2008; ICES, 2009). Studies conducted by Greenstreet *et al*. (1998) in the inner Moray Firth showed that sandeels comprised the majority of the diet for whiting and haddock (all size classes) in June, whilst from October to January, the proportion of sandeels in the diet of whiting and haddock was gradually replaced by sprat.

In addition, the demersal egg mats of herring are known to aggregate fish predators (Richardson *et al*., 2011). The diets of marine mammals such as seals, harbour porpoise and Minke whales are also subsidised by sandeels and clupeids (Olsen & Holst, 2001; Santos and Pierce, 2003; Pierce *et al*., 2004). Sandeels and clupeids are also an important resource for seabirds (Wanless *et al*., 2005).

3.5 Species of Conservation Importance

A number of species of conservation importance have been identified as potentially present in the Moray Firth and the wider area. These include diadromous migratory species, elasmobranchs and a number of fish species which are targeted commercially.

Diadromous migratory species potentially present in the vicinity of the modified TI and their conservation status are given in Table 3.4. Species include European eel, allis and twaite shad, sea and river lamprey, smelt, salmon and sea trout.

Elasmobranchs have slow growth rates and low reproductive output compared to other species groups (Camhi *et al*., 1998). As a result, stock resilience to fishing mortality is low (Smith *et al*., 1998) and recovery rates are likely to be slow where directed fisheries have depleted abundance (Holden, 1974; Bonfil, 1994; Musick, 2005). A summary of the principal species with conservation status and /or declining stocks potentially present in the vicinity of the modified TI is provided in Table 3.5.

In addition to the above, a number of other fish species with conservation status may be present in the area of the modified TI. The majority of these are commercially exploited in the Moray Firth having been recorded in landings data within the study area and are given in Table 3.6.

Table 3.4 Diadromous species of conservation importance in the Moray Firth

Common Name	Scientific Name	Conservation Status								
		OSPAR	IUCN Red List	Bern Convention	Habitats Directive	The Wildlife & Countryside Act 1981	The Conservation (Natural Habitats, &c.) Regulations 1994	UK BAP species	Scottish Priority Marine Feature (PMF)	The Nature Conservation (Scotland) Act 2004
European eel	*Anguilla anguilla*	✓	Critically endangered	-	-	-	-	✓	✓	-
Allis shad	*Alosa alosa*	✓	Least concern	✓	✓	✓	✓	✓	-	-
Twaite shad	*Alosa fallax*	-	Least concern	✓	✓	✓	✓	✓	-	-
Sea Lamprey	*Petromyzon marinus*	✓	Least concern	✓	✓	-	-	✓	✓	-
River Lamprey	*Lampetra fluviatilis*	-	Least concern	✓	✓	-	✓	✓	✓	-
Smelt	*Osmerus eperlanus*	-	Least concern	-	-	-	-	✓	✓*	-
Salmon	*Salmo salar*	✓	Lower Risk/least concern	✓	✓	-	✓	✓	✓	-
Sea Trout	*Salmo trutta*	-	Least concern	-	-	-	-	✓	✓	-

Table 3.5 Principal elasmobranch species with conservation status recorded in the Moray Firth

Common Name	Latin Name	MMO Landings Data	Recorded in the Moray Firth (Ellis *et al.*, 2005)	Conservation Status						
				OSPAR	IUCN Red List	The Wildlife & Countryside Act 1981	The Conservation (Natural Habitats, &c.) Regulations 1994	UK BAP species	Scottish Priority Marine Feature (PMF)	The Nature Conservation (Scotland) Act 2004
Sharks										
Basking shark	*Cetorhinus maximus*	-	-	✓	Vulnerable	✓	-	✓	✓	✓
Blue shark	*Prionace glauca*	-	-	-	Near threatened	-	-	✓	-	-
Leafscale gulper shark	*Centrophorus squamosus*	✓	-	✓	Vulnerable	-	-	✓	-	-
Porbeagle	*Lamna nasus*	-	-	✓	Vulnerable	-	-	✓	-	-
Portuguese dogfish	*Centroscymnus coelolepis*	✓	-	✓	Near threatened	-	-	✓	-	-
Spurdog	*Squalus acanthias*	✓	✓	✓	Vulnerable	-	-	✓	✓	-
Skates and Rays										
Sandy ray	*Leucoraja circularis*	-	-	-	Vulnerable	-	-	✓	-	-
Spotted ray	*Raja montagui*	-	✓	✓	Least concern	-	-	-	-	-
Thornback ray	*Raja clavata*	✓	✓	✓	Near Threatened	-	-	-	-	-

Table 3.6 Conservation status of fish species recorded in landings data (2000 to 2009) of the study area

Common Name	Latin name	Scottish Priority Marine Feature	UK BAP Species	OSPAR	IUCN Red List
Anglerfish	*Lophius piscatorius*	✓ (juveniles)	✓	-	-
Atlantic halibut	*Hippoglossus hippoglossus*	-	✓	-	Endangered
Atlantic mackerel	*Scomber scombrus*	✓	✓	-	-
Black scabbardfish	*Aphanopus carbo*	-	✓	-	-
Blue ling	*Molva dypterygia*	-	✓	-	-
Cod	*Gadus morhua*	✓	✓	✓	Vulnerable
Greenland halibut	*Reinhardtius hippoglossoides*	-	✓	-	-
Hake	*Merluccius merluccius*	-	✓	-	-
Herring	*Clupea harengus*	✓ (juveniles and spawning adults)	✓	-	Least concern
Horse mackerel	*Trachurus trachurus*	-	✓	-	-
Ling	*Molva molva*	✓	✓	-	-
Plaice	*Peluronectes platessa*	-	✓	-	Least concern
Roundnose Grenadier	*Coryphaenoides rupestris*	-	✓	-	-
Saithe	*Pollachius virens*	✓ (juveniles)	-	-	-
Sandeels	*Ammodytes marinus*	✓	✓	-	-
	Ammodytes tobianus	✓	-	-	-
Whiting	*Merlangius merlangus*	✓ (juveniles)	✓	-	-

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Appendices

Appendix 1 – Cod Survey Report

Summary

The North Sea cod stock is assessed as a single unit however there is evidence of sub-stock structuring (ICES 2007; Fox *et al.,* 2008). 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 MORL development (i.e. Coull *et al.,* 1998; 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 determine whether significant cod spawning currently takes place in the area of the Moray Firth Round 3 and its vicinity.

The survey was carried out in two trips between 17th February and 19th March 2013 (Trip A from 17th February to 26th February and Trip B from 10th March to 19th March) coinciding with the peak spawning season. Sampling was undertaking using a commercial rock-hopper otter trawl with a 120 mm mesh cod end, fitted with a 20 mm blinder (provided by Marine Scotland Science, hereinafter referred to as MSS). Fifty-six tows of 30 minutes duration were undertaken within and adjacent to the MORL Round 3 Area to cover areas of the cod spawning grounds defined by Coull *et al.* (1998) where noise levels at which cod may exhibit strong avoidance reactions during the construction phase may occur ($90dB_{ht}$ (*Gadus morhua*) level). Two tows of 60 minutes duration were also carried at the request of MSS to determine whether larger cod were out-swimming the net in the 30 minute tows.

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 all cod was identified and recorded. The gonads of each individual were photographed. In Trip A up to three male gonads and five female gonads of each maturity stage were fixed with 4% seawater buffered formalin solution. Gonad samples were delivered to MSS at the end of Trip A to verify the maturity stage analysis carried out at sea.

Cod were recorded in 35 out of 58 stations in relatively low numbers, with a maximum of nine individuals caught at a single station (0T38, Trip B). A total of 23 spawning cod were caught in the survey, 12 in Trip A and 11 in Trip B.

Cod catch rates will be calculated by MSS using the Scanmar outputs (swept area per tow) and used to determine whether significant cod spawning is taking place in the Moray Firth Round 3 Area and/or in adjacent locations.

All by-catch fish and commercial shellfish species were identified, counted, measured and returned to the sea; where necessary sub-sampling was carried out at sea by species. A total of 45 by-catch species were caught in the survey. Dab (*Limanda limanda*), plaice (*Pleuronectes platessa*), haddock (*Melanogrammus aeglefinus*) and whiting (*Merlangius merlangus*), to a lesser extent, were the principal species found during the survey. Introduction

The following report details the findings of the cod spawning survey undertaken between the 17th February and 19th March 2013 in the Moray Firth Round 3 Area which includes the following four development areas:

- The Telford wind farm;
- The MacColl wind farm;
- The Stevenson wind farm; and
- The Western development area (WDA).

The aim of this survey was to establish the potential degree of cod spawning activity currently taking place in the Moray Firth Round 3 Zone and in adjacent locations. As presented in MORL's Offshore

Generating Station Impact Assessment (Chapter 7.2 - Biological Environment), construction noise was identified as having potential to result in a significant effect on cod, particularly during the spawning season.

The impact assessment on this species, however, took a precautionary approach, where conservative assumptions had to be applied as a result of the uncertainty surrounding available information on the use that this species currently makes of the Moray Firth area. In order to mitigate this uncertainty, MORL committed, in consultation with MSS to undertake additional survey work and monitoring with the objective of increasing the confidence in the impact assessment and identifying whether mitigation is required, and if so, to define feasible measures in order to reduce the significance of the likely effects.

The survey methodology was designed in consultation with MSS. 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 0 -Appendix 1.

Background Information

Cod spawn throughout much of the northern North Sea however there is evidence of sub-stock structuring (ICES 2007; Fox *et al* 2008). In the particular case of 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).

Recent information in relation to the potential use of the central Moray Firth for cod spawning is currently lacking. The assessment of construction noise presented in MORL's Offshore Generating Station Impact Assessment (Chapter 7.2 - Biological Environment) used the grounds depicted in Coull *et al.* (1998) and Ellis *et al.* (2010) in respect to cod spawning and nursery areas, as primary sources of information. According to these publications the Moray Firth Round 3 Area 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 4.1. In addition to the above, other sources of information (i.e Gibbs *et al.,* 2008) were used to further characterise the current state of knowledge in relation to the potential for the Moray Firth Round 3 Area to support spawning and juvenile cod.

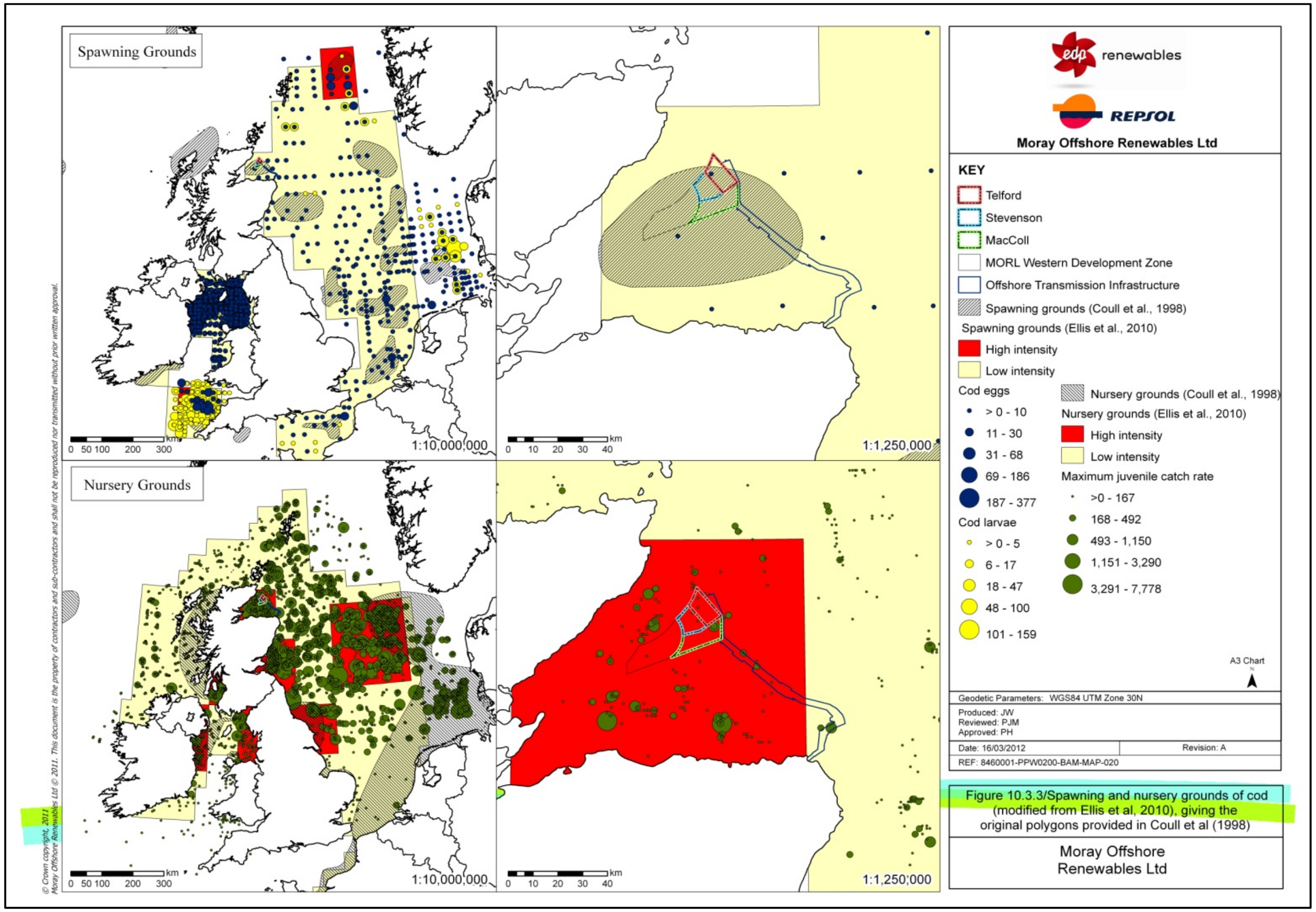

Figure 4.1 Cod Spawning and Nursery Grounds (Modified from Ellis *et al.,* 2010)

Survey Methodology

The survey was undertaken between 17th February and 19th March 2013 in order to cover the peak spawning period of this species. As previously mentioned cod spawning occurs between January and April, with peak spawning taking place from February to March.

Two sampling trips were undertaken: Trip A from 17th February to 26th February and Trip B from 10th March to 19th March. During these, a total of 58 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 0- Appendix 2.

The sampling stations were located within the Moray Firth Round 3 Area and at adjacent locations overlapping both the cod spawning grounds defined in Coull *et al.* (1998) and areas expected to be affected by piling noise during the construction phase at the 90dB_{ht}[1](*Gadus morhua*) level).

The noise impact ranges used for selection of sampling stations are as presented in MORL's Offshore Generating Station Impact Assessment (Chapter 7.2 - Biological Environment).

Trip A

A total of 29 tows of 30 minutes duration were undertaken within and adjacent to the MORL Round 3 Area. OT49 was an additional tow to the north east of the Jackie oil field undertaken at the request of MSS.

The otter trawl tow tracks of Trip A are given in Figure 4.2. The start and end times, co-ordinates, depths and durations of each otter trawl tow are given in Section 0- Appendix 3.

Trip B

A total of 29 tows were undertaken, seven of which were repeated from Trip A (OT22-OT28). As in Trip A the tow duration was of 30 minutes with the exception of the tows undertaken at station OT08 and station OT39, which were of 60 minutes duration. These were carried out to determine whether larger cod were out-swimming the net in the 30 minute tows at the request of MSS.

The otter trawl tow tracks of Trip B are given in Figure 4.3. The start and end times, co-ordinates, depths and durations of each otter trawl are given in Section 0- Appendix 3.

[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.

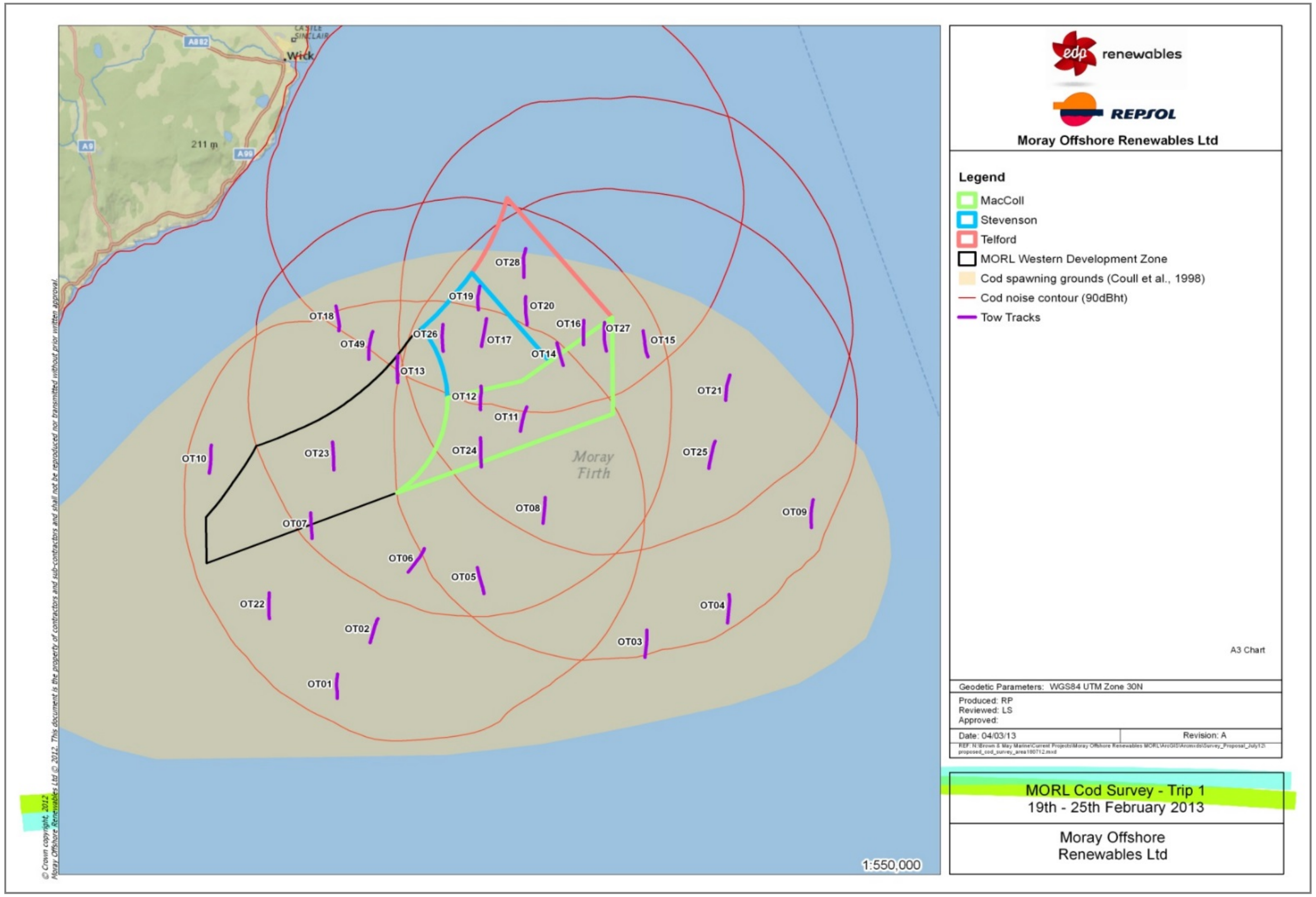

Figure 4.2 Trip A - Vessel Tracks whilst Towing the Otter Trawl

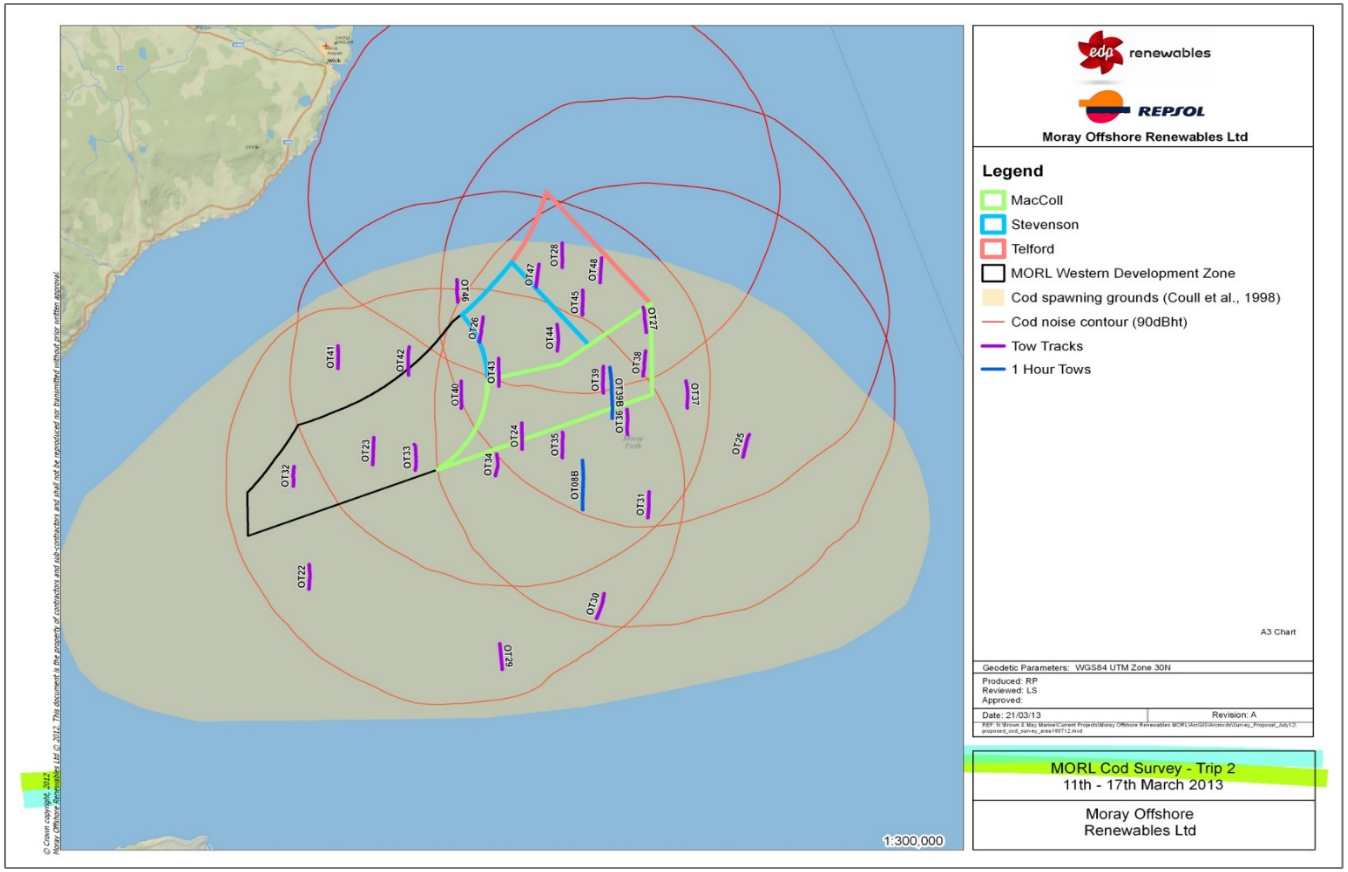

Figure 4.3 Trip B – Vessel Tracks whilst Towing the Otter Trawl

Survey Vessel

The vessel chartered for the survey (Figure 4.4), the "Seagull", is a Peterhead-based commercial trawler. The specifications of the vessel are given below in Table 4.1.

Figure 4.4 Survey Vessel "Seagull"

Table 4.1 Survey Vessel Specifications

Survey Vessel Specifications	
Length	27.41 m
Beam	8.52 m
Draft	4.9 m
Main engine	Deutz MWM Marine TBD620 V12, 1340 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

Sampling Gear

A commercial rock-hopper otter trawl (Figure 4.5) 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 4.2.

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 in the headline.

Figure 4.5 Rock-hopper Otter Trawl Used

Table 4.2 Rock-hopper Otter Trawl Specifications

Rock-hopper Otter Trawl Specifications	
Towing warp	Steel core diaform 24 mm, 1463 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	5121 cm, rock-hopper with 31 and 35.6 cm bobbins
Estimated headline height	6.4 m
Distance between trawl doors (est.)	73.1 m

Sampling Procedures

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 skipper advised that the gear was settled (i.e. the headline and wing end

Scanmar sensors showed little movement and had reached the appropriate spread). Otter trawl end times and positions were taken when hauling of the gear commenced.

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 all cod was identified and recorded. The gonads of each individual were photographed. In Trip A up to 3 male gonads and 5 female gonads of each maturity stage were fixed with 4% seawater buffered formalin solution. Gonad samples were delivered to MSS at the end of Trip A to verify the maturity stage analysis carried out at sea.

The gonadal maturity key used was as provided by MSS (Bucholtz *et al.*-Draft Manual to determine gonadal maturity of North Sea cod (*Gadus morhua L*)). The maturity stages used are described in Table 4.3 below. As shown, stage III cod is considered to be in spawning condition. Examples of spawning and spent individuals are provided in Section 0- Appendix 4.

Table 4.3 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. Vitollogenic 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 if 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

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

Otter Trawl Results

Cod

Cod were caught in 35 of the 58 stations sampled, with a maximum of nine individuals recorded in a single station (OT38, trip B). In general terms, cod were found in very low numbers with a total of 73 individuals being caught during the survey (Trip A + Trip B).

A total of 48 juveniles (stage I) and 25 adults (23 of which were spawning -stage III and two spent - stage IV) were caught. Twelve spawning cod were recorded in Trip A and 11 in Trip B. A maximum of four spawning individuals were found at a single station (Trip A, OT08). The number of males and females was approximately even (36 females and 34 males).

The numbers of cod caught by station are shown in Table 4.4 and Table 4.5 for Trip A and Trip B, respectively. Catch rates will be calculated by MSS using the Scanmar outputs (swept area per tow) and used to determine whether significant cod spawning is taking place in the Moray Firth Round 3 Area and/or in adjacent locations.

Trip A

The numbers of cod caught by station during Trip A together with the length, sex and maturity stage of each individual is shown in Table 4.4.

The spatial distribution of the cod catch recorded in Trip A is given in Figure 4.6. The percentage contribution of spawning cod (maturity stage III) to the total catch in each sampling station is also shown.

Table 4.4 Numbers of Cod, Sex and Spawning Condition by Sampling Station (30 min duration tows) – Trip A

Trip A Station	Length (cm)	Sex	Spawning Condition	Total No. of Individuals	Total No. of Spawning Cod
OT03	22	F	I	1	0
OT04	17	F	I	1	0
OT05	46	M	III	1	1
OT08	18	M	I	5	4
	33	M	III		
	36	M	III		
	46	M	III		
	50	F	III		
OT09	37	F	I	1	0
OT10	54	M	III	2	2
	67	M	III		
OT11	46	F	III	2	2
	68	M	III		
OT13	56	M	I	1	
OT15	13	U	I	2	1
	42	M	III		
OT16	19	F	I	2	0
	20	F	I		
OT18	46	M	III	1	1
OT21	17	F	I	6	0
	18	F	I		
	19	F	I		
	19	U	I		
	21	M	I		
	26	U	I		
OT24	14	F	I	3	0
	15	F	I		
	15	M	I		
OT25	16	M	I	3	0
	18	F	I		
	22	F	I		

Trip A Station	Length (cm)	Sex	Spawning Condition	Total No. of Individuals	Total No. of Spawning Cod
OT27	20	M	I	4	0
	20	F	I		
	22	M	I		
	22	F	I		
OT49	49	M	III	1	1
Total No. of Individuals				**36**	**12**

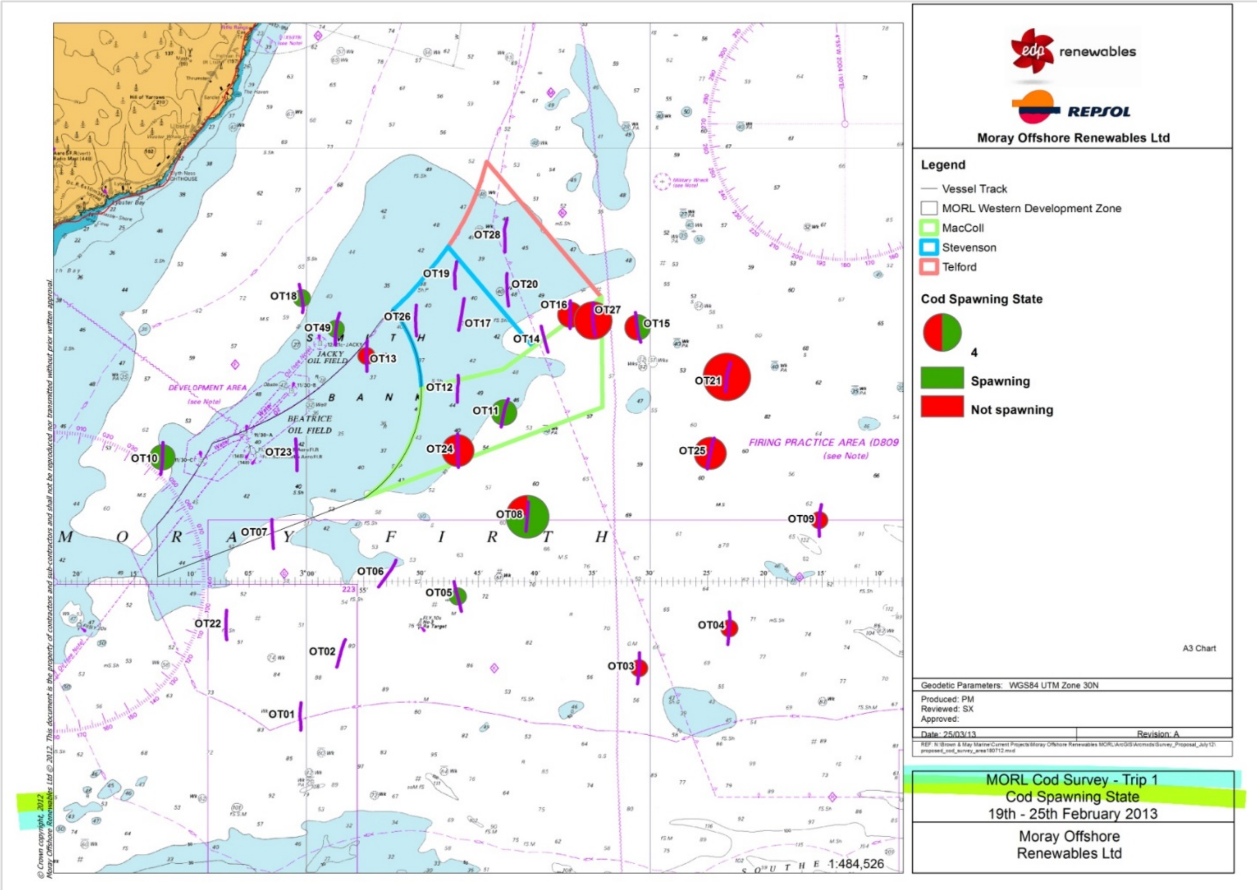

Figure 4.6 Cod catch by maturity stage (spawning/not spawning) recorded by stations during Trip A

Trip B

The number of cod caught by station during Trip B together with the length, sex and maturity stage of each individual is shown in Table 4.5. The spatial distribution of the cod catch recorded in Trip B is given in Figure 4.7. The percentage contribution of spawning cod (maturity stage III) to the total catch in each sampling station is also shown.

Table 4.5 Total Numbers of Cod, Sex and Spawning Condition by Sampling Station (30 min duration tows) – Trip B

Trip B Station	Length (cm)	Sex	Spawning Condition	Total No. of Individuals	Total No. of Spawning Cod
OT22	49	M	III	1	1
OT24	13	F	I	3	0
	14	F	I		
	16	M	I		
OT27	15	F	I	2	1
	43	M	III		
OT29	50	F	III	2	1
	55	F	IV		
OT30	16	M	I	4	0
	16	M	I		
	18	M	I		
	22	M	I		
OT31	21	M	I	1	0
OT34	37	F	III	1	1
OT35	18	M	I	1	0
OT36	43	F	III	1	1
OT37	25	F	I	1	0
OT38	14	F	I	9	1
	14	M	I		
	16	F	I		
	17	F	I		
	17	M	I		
	18	F	I		
	18	M	I		
	20	M	I		
	45	M	III		
OT39	17	M	I	1	0
OT40	39	M	I	2	1
	41	F	III		
OT43	43	F	I	1	0
OT44	74	F	III	1	1
OT47	55	F	IV	1	0
OT48	20	F	I	1	0
OT08_1hour	49	F	III	2	2
	57	M	III		
OT39_1hour	20	F	I	2	1
	54	F	III		
Total No. of Individuals				**37**	**11**

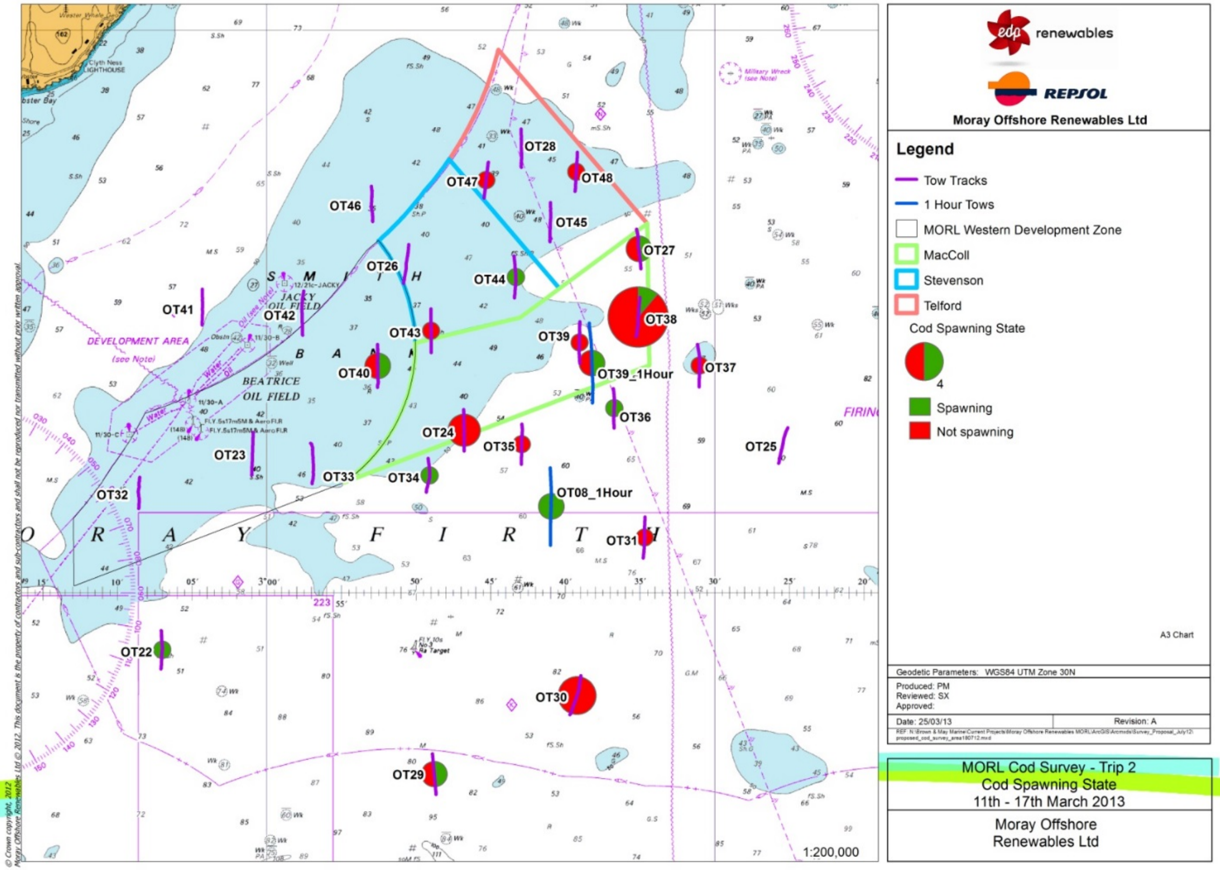

Figure 4.7 Cod catch by maturity stage (spawning/not spawning) recorded by stations during Trip B

By-catch

A total of 49,583 individuals of 45 fish and commercial shellfish species were caught in the survey.

The by-catch recorded in Trip A and Trip B is given by species in Table 4.6 and Table 4.7, respectively.

Dab, plaice, haddock, and whiting, to a lesser extent, were the principal species found during the survey.

Table 4.6 Numbers of Individuals Caught (By-Catch) in Trip A

Species		Total No. of Individuals Caught
Common Name	Scientific Name	
Dab	*Limanda limanda*	9,692
Plaice	*Pleuronectes platessa*	8,196
Haddock	*Melanogrammus aeglefinus*	6,230
Herring	*Clupea harengus*	1,449
Whiting	*Merlangius merlangus*	449
Long Rough Dab	*Hippoglossoides platessoides*	353
Grey Gurnard	*Eutrigla gurnardus*	203
Lemon Sole	*Microstomus kitt*	203
Poor Cod	*Trisopterus minutus*	202
Sprat	*Sprattus sprattus*	160
Saithe	*Pollachius virens*	133
Bullrout	*Myoxocephalus scorpius*	93
Queen Scallop	*Aequipecten opercularis*	86
Sandeel (indet.)	*Ammodytidae sp.*	51
Greater Sandeel	*Hyperoplus lanceolatus*	21
John Dory	*Zeus faber*	18
Sea Scorpion	*Taurulus bubalis*	17
Hake	*Merluccius merluccius*	14
Lesser Spotted Dogfish	*Scyliorhinus canicula*	12
Long-finned Squid	*Loligo forbesii*	10
Common Dragonet	*Callionymus lyra*	8
Nephrops	*Nephrops norvegicus*	6
Thickback Sole	*Microchirus variegatus*	5
Pogge	*Agonus cataphractus*	4
Mackerel	*Scomber scombrus*	3
Red Gurnard	*Aspitrigla cuculus*	3
Brill	*Scophthalmus rhombus*	2
Cuckoo Ray	*Raja naevus*	2
Flounder	*Platichthys flesus*	2
Ling	*Molva molva*	2
Edible Crab	*Cancer pagurus*	1
Fifteen Spined Stickleback	*Spinachia spinachia*	1
Lesser Weever	*Echiichthys vipera*	1
Lumpsucker	*Cyclopterus lumpus*	1
Norway Pout	*Trisopterus esmarkii*	1
Whelk	*Buccinum undatum*	1
Witch	*Glyptocephalus cynoglossus*	1
Juvenile Gadoid	Gadidae sp.	P
Total No. of Individuals		**27,636**

Table 4.7 Numbers of Individuals Caught (By-Catch) in Trip B

Species		Total No. of Individuals Caught
Common Name	Scientific Name	
Dab	*Limanda limanda*	7,295
Haddock	*Melanogrammus aeglefinus*	6,016
Plaice	*Pleuronectes platessa*	4,990
Whiting	*Merlangius merlangus*	988
Sprat	*Sprattus sprattus*	603
Long Rough Dab	*Hippoglossoides platessoides*	509
Lemon Sole	*Microstomus kitt*	369
Grey Gurnard	*Eutrigla gurnardus*	285
Nephrops	*Nephrops norvegicus*	254
Poor Cod	*Trisopterus minutus*	155
Bullrout	*Myoxocephalus scorpius*	125
Queen Scallop	*Aequipecten opercularis*	82
Greater Sandeel	*Hyperoplus lanceolatus*	41
Herring	*Clupea harengus*	37
Sandeel (indet.)	*Ammodytidae sp.*	30
Sea Scorpion	*Taurulus bubalis*	27
Common Dragonet	*Callionymus lyra*	26
Saithe	*Pollachius virens*	25
Long-finned Squid	*Loligo forbesii*	15
Lesser Spotted Dogfish	*Scyliorhinus canicula*	10
Pollack	*Pollachius pollachius*	9
Red Gurnard	*Aspitrigla cuculus*	9
John Dory	*Zeus faber*	8
Thickback Sole	*Microchirus variegatus*	7
Ling	*Molva molva*	6
Pogge	*Agonus cataphractus*	4
Spotted Dragonet	*Callionymus maculatus*	4
Hake	*Merluccius merluccius*	3
Lumpsucker	*Cyclopterus lumpus*	3
Anchovy	*Engraulis encrasicolus*	2
Norway Pout	*Trisopterus esmarkii*	2
Bib	*Trisopterus luscus*	1
Blue Mouth	*Helicolenus dactylopterus*	1
Brill	*Scophthalmus rhombus*	1
Cuckoo Ray	*Raja naevus*	1
Mackerel	*Scomber scombrus*	1
Scaldfish	*Arnoglossus laterna*	1
Starry Smoothhound	*Mustelus asterias*	1
Witch	*Glyptocephalus cynoglossus*	1
Juvenile Whiting	*Merlangius merlangus*	P
Total No. of Individuals		**21,947**

The spatial distribution of the catch of the principal species found in the survey (dab, plaice, haddock and whiting) is given in Figure 4.8 to Figure 4.15 below by survey trip.

In addition to the above, the spatial distribution of the sandeel and herring catch recorded in the survey is also shown (Figure 4.16 to Figure 4.19) as concerns in relation to these two species were raised during the EIA process. The limitations of the catch records for these two species are however fully recognised (i.e catchability in demersal trawls and timing of the survey).

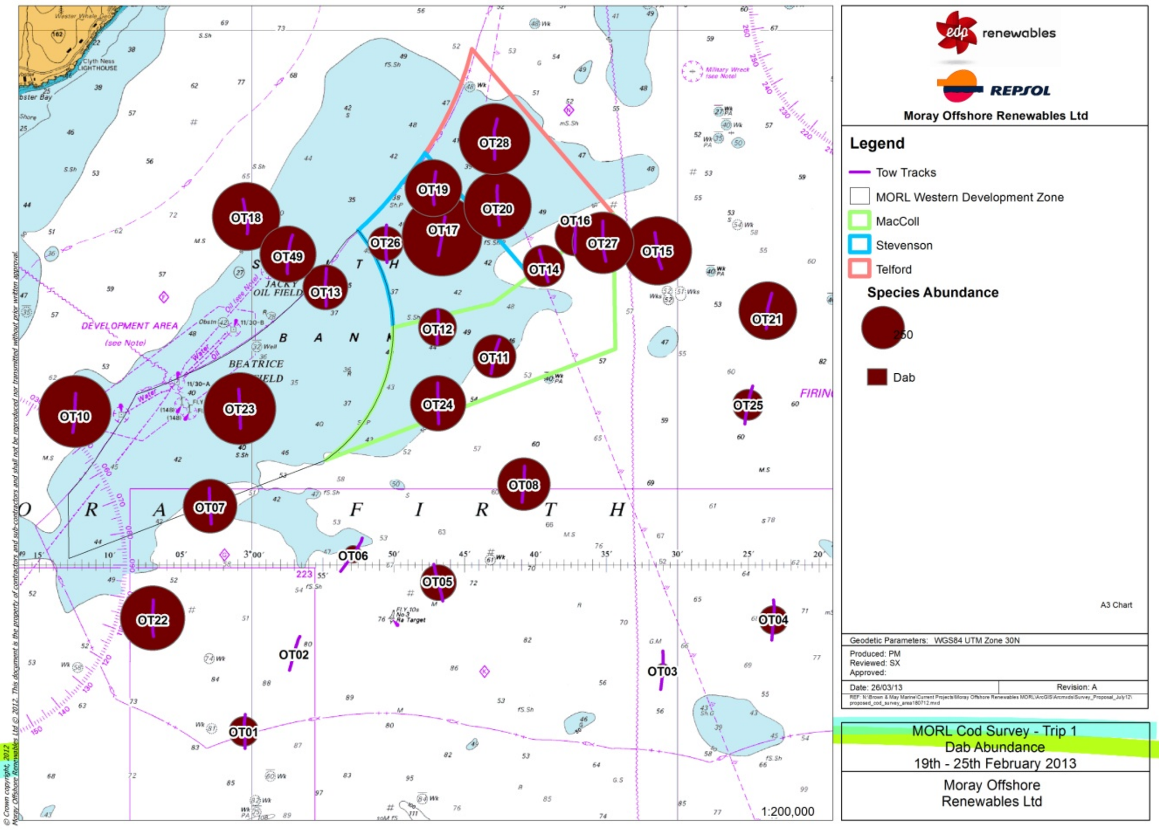

Figure 4.8 Spatial Distribution of Dab caught during Trip A

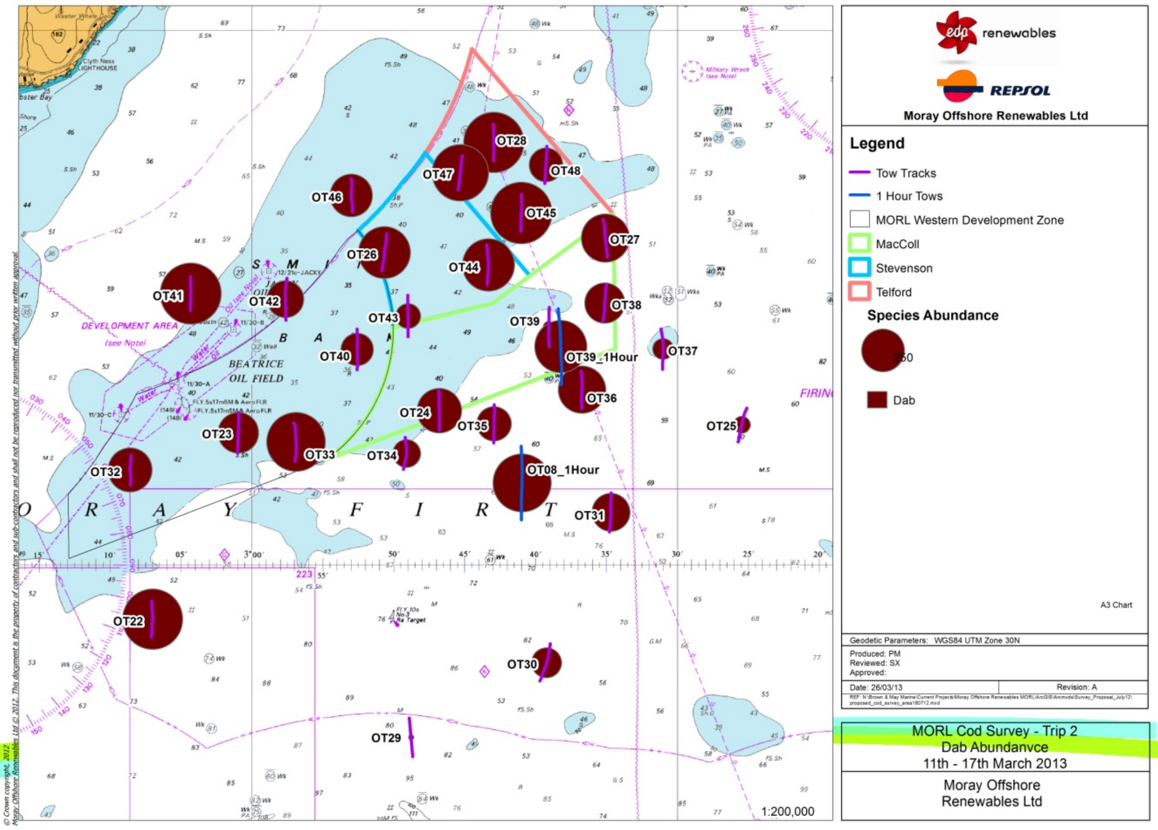

Figure 4.9 Spatial Distribution of Dab caught during Trip B

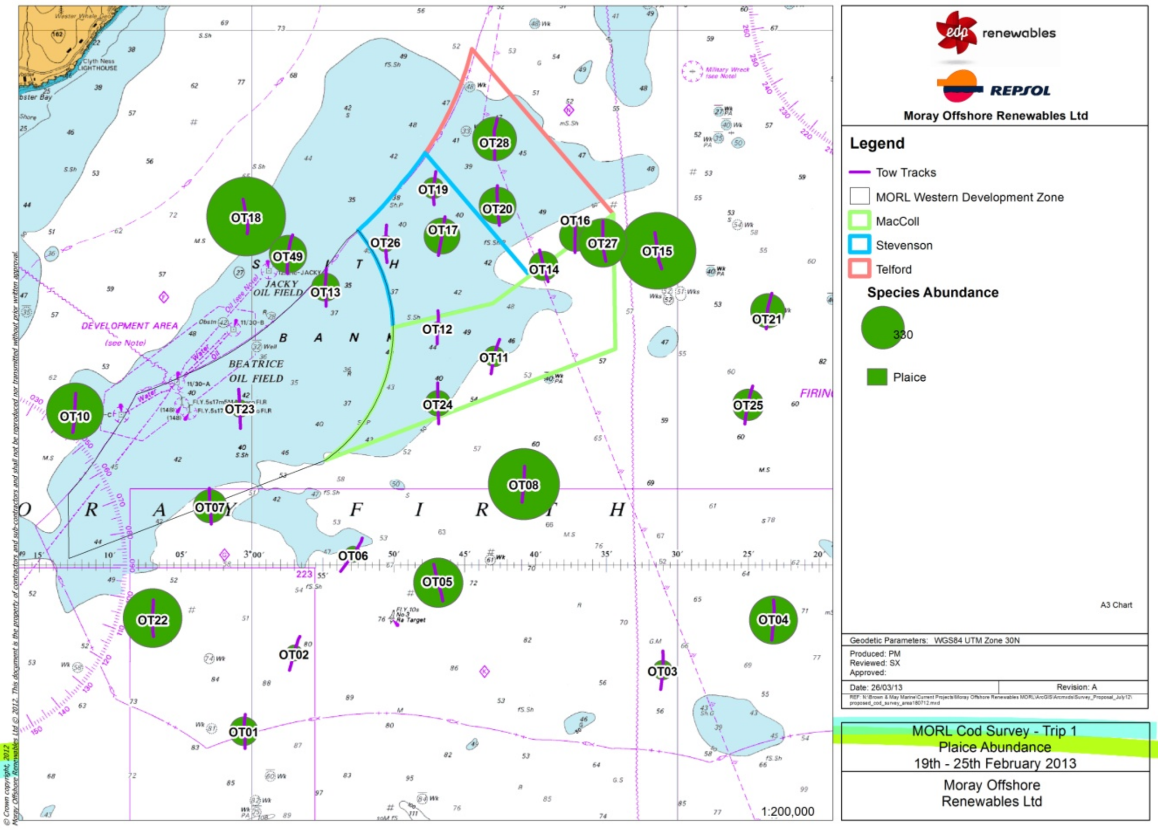

Figure 4.10 Spatial Distribution of Plaice caught during Trip A

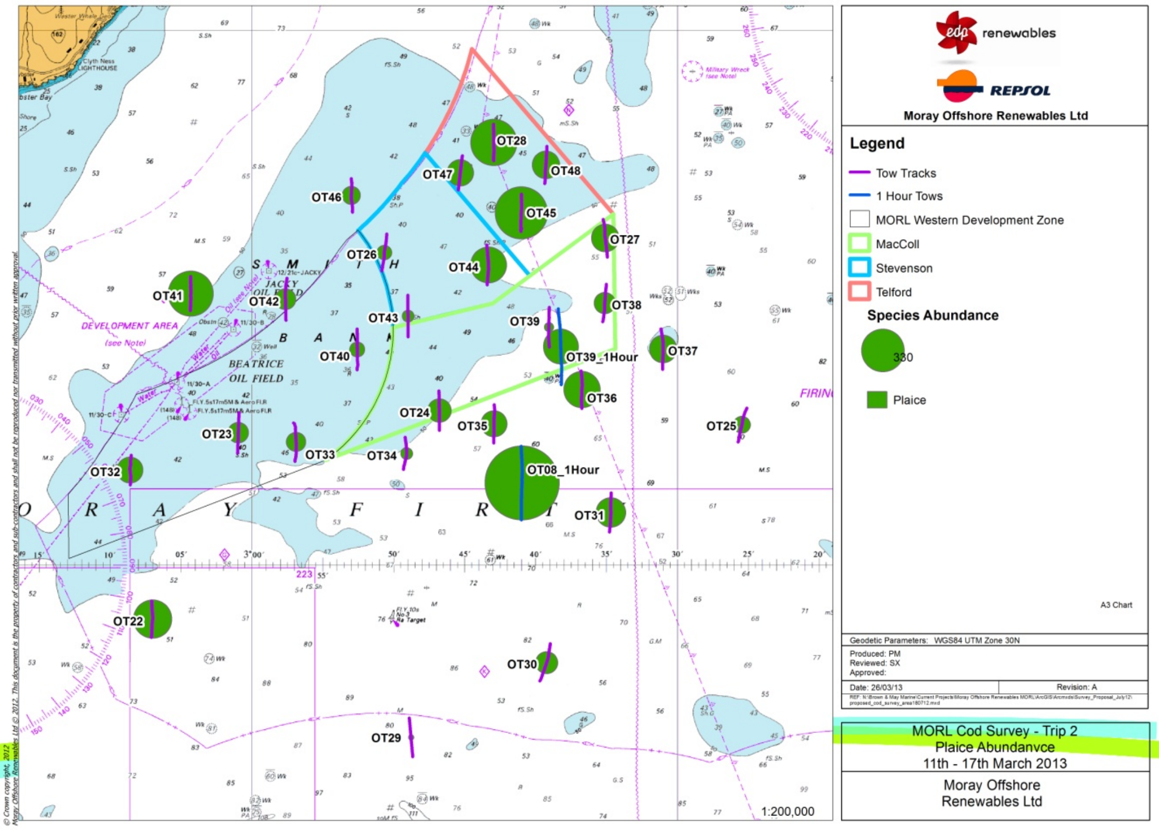

Figure 4.11 Spatial Distribution of Plaice caught during Trip B

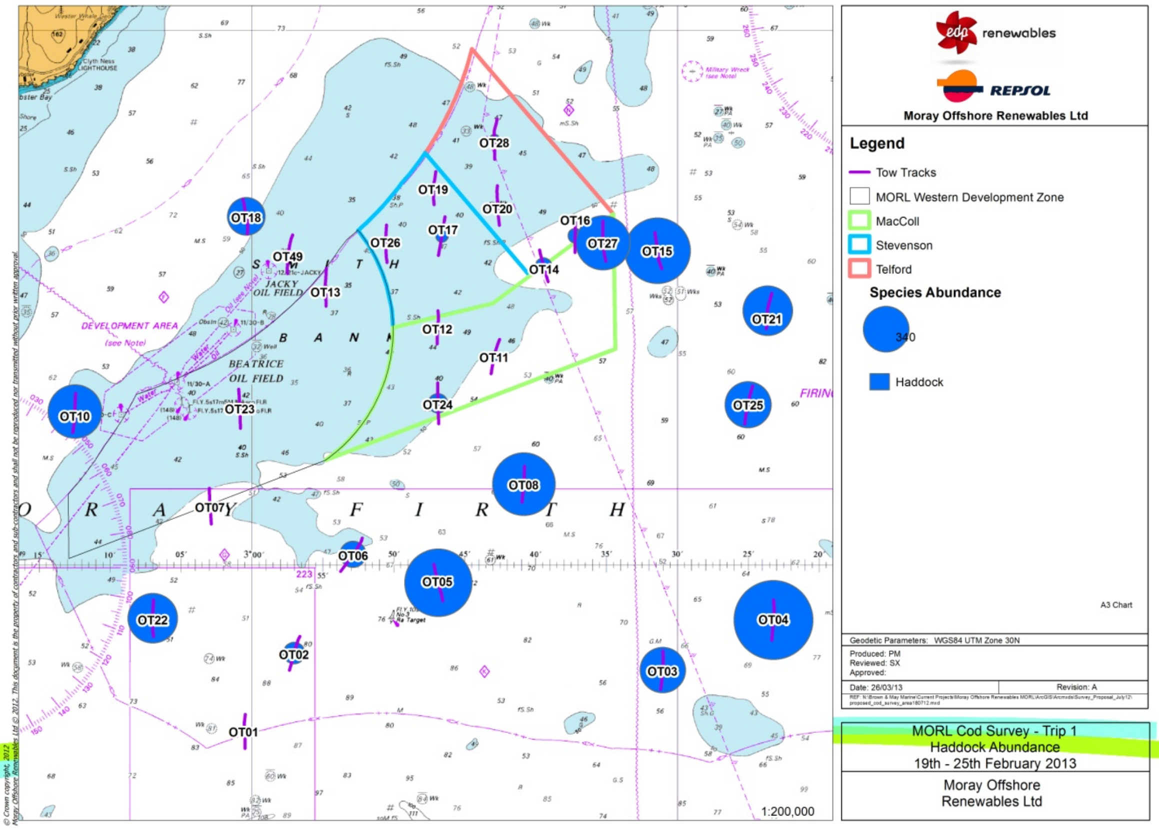

Figure 4.12 Spatial Distribution of Haddock caught during Trip A

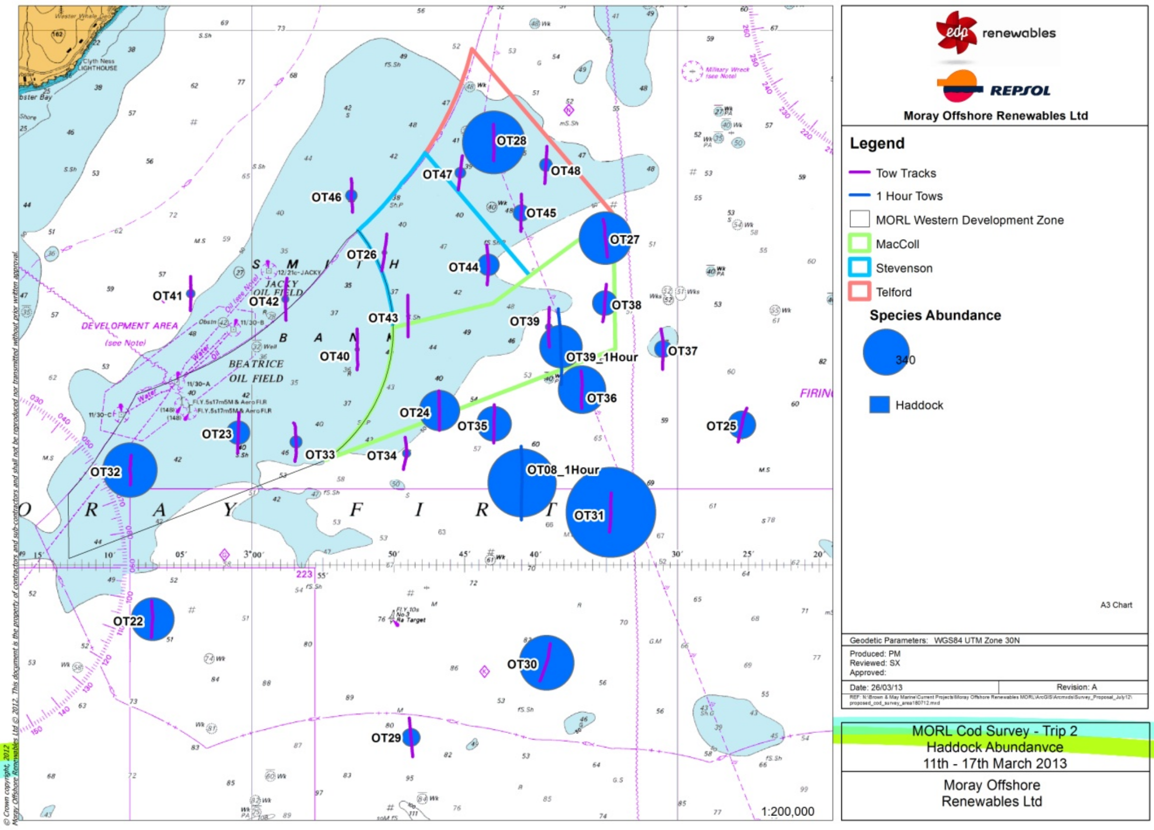

Figure 4.13 Spatial Distribution of Haddock caught during Trip B

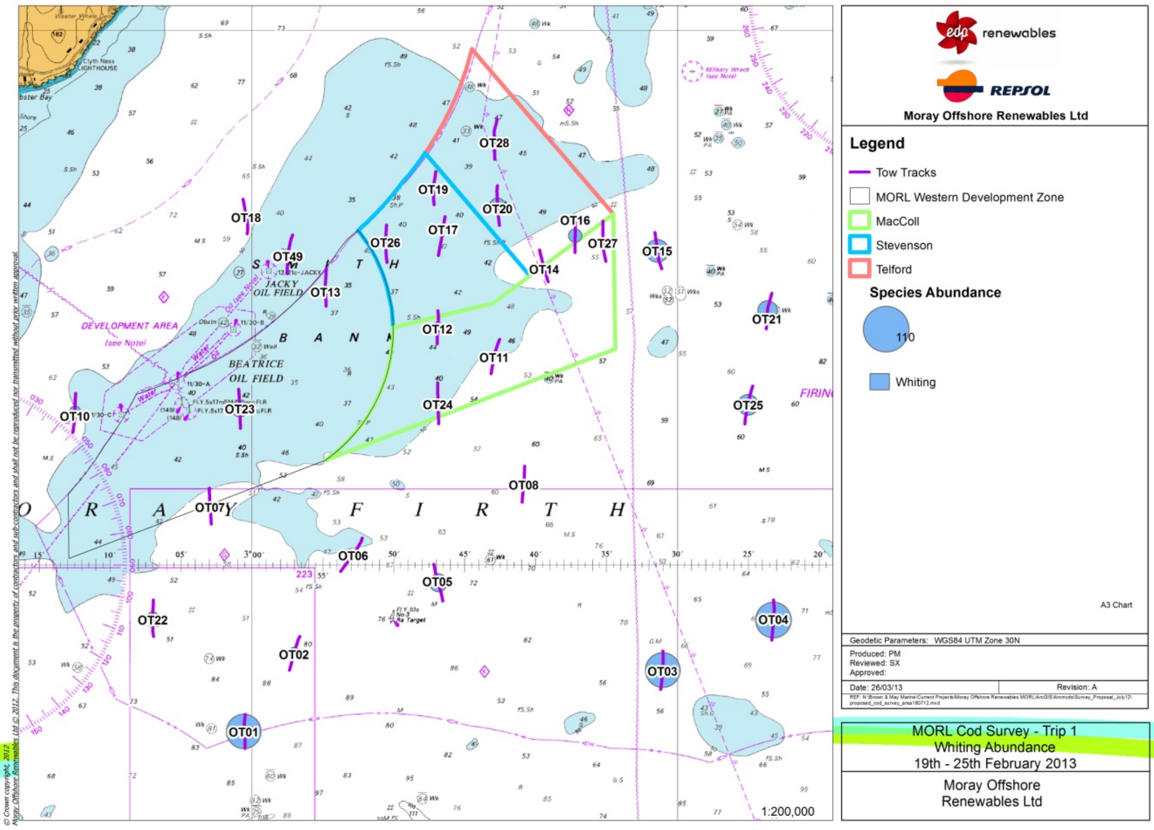

Figure 4.14 Spatial Distribution of Whiting caught during Trip A

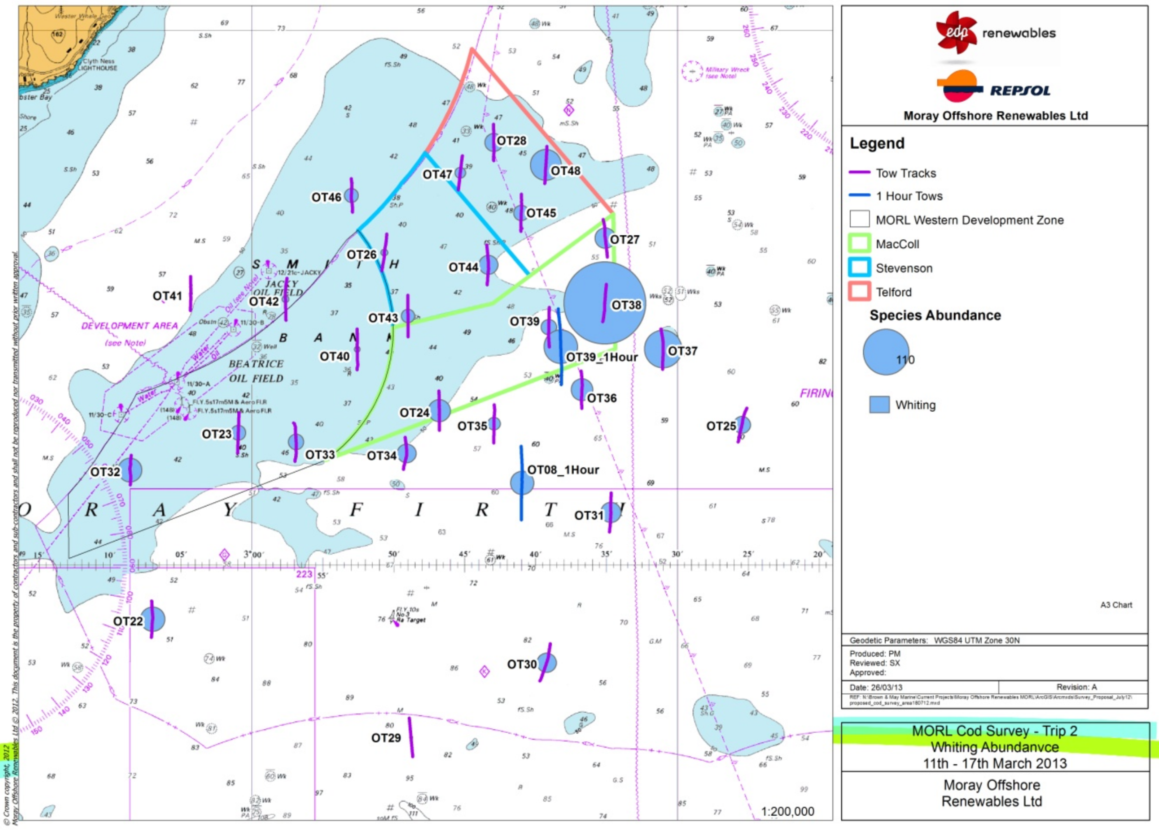

Figure 4.15 Spatial Distribution of Whiting caught during Trip B

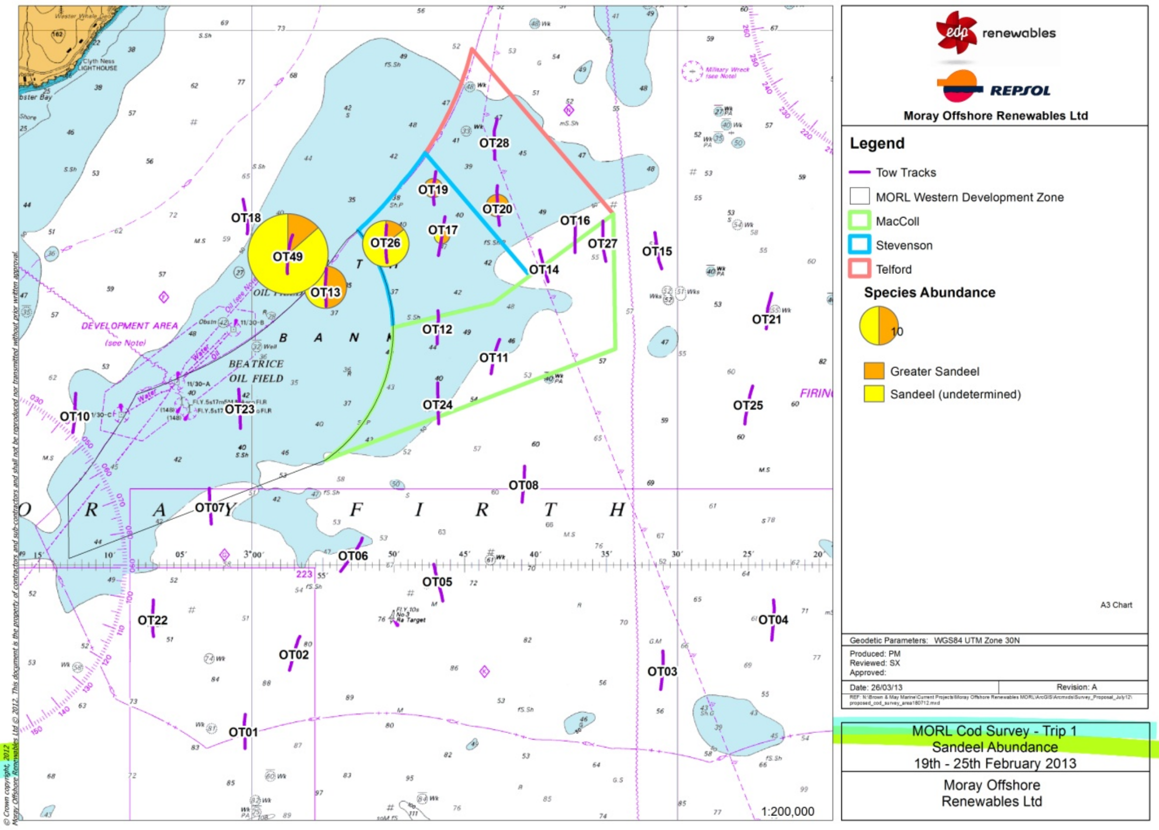

Figure 4.16 Spatial Distribution of Sandeels caught during Trip A

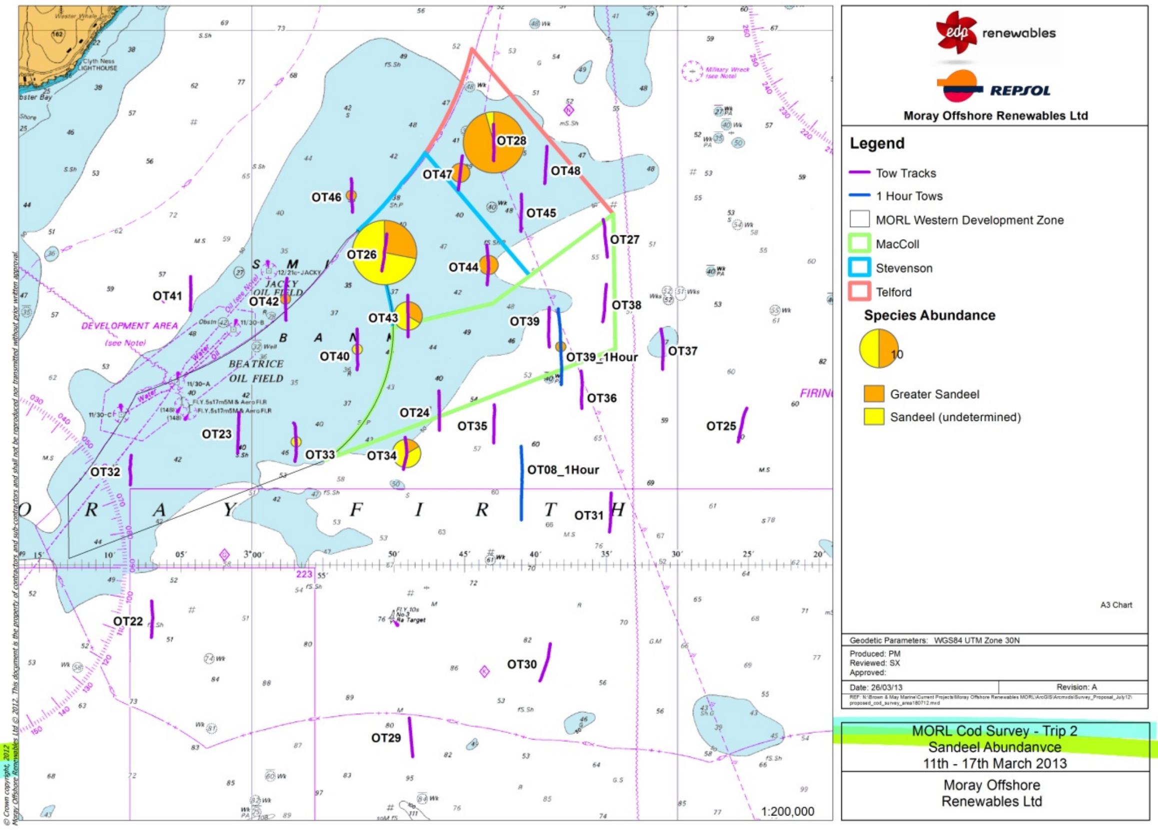

Figure 4.17 Spatial Distribution of Sandeels caught during Trip B

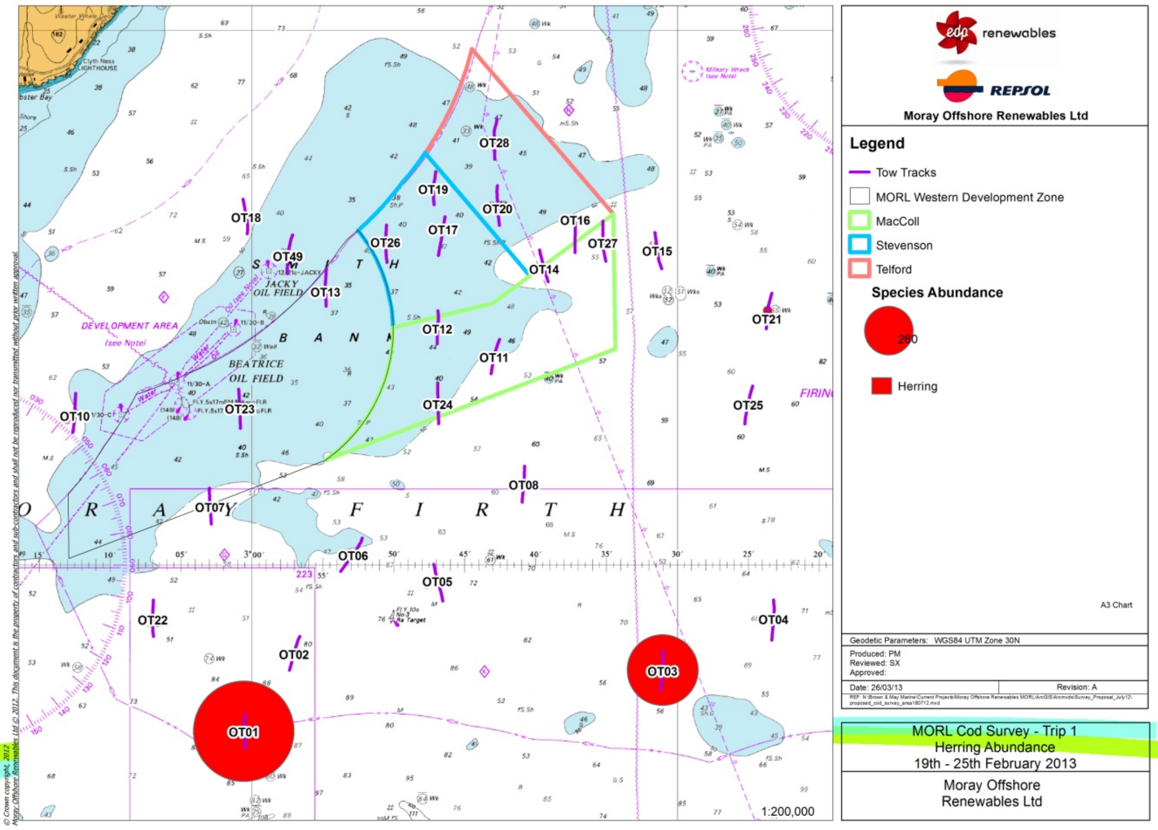

Figure 4.18 Spatial Distribution of Herring caught during Trip A

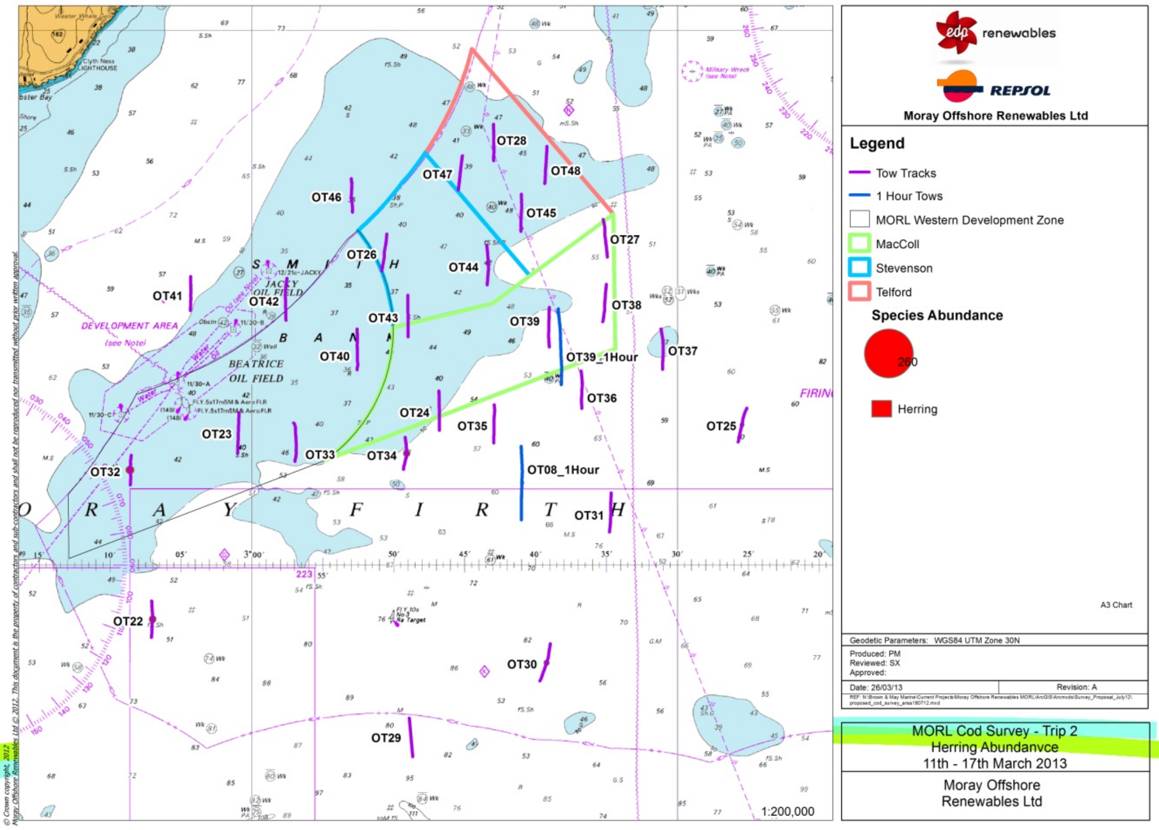

Figure 4.19 Spatial Distribution of Herring caught during Trip B

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Appendix 2 – Health and Safety

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.

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.

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.

Post Trip Survey Review

Upon completion of the survey a "Post Trip Survey Review" was filled, see Table 4.8 below.

Table 4.8 Post Trip Survey Review

Project: MORL Cod Survey February/March 2013	**Vessel:** Seagull
Surveyors: Lucy Shuff, Jose Peiro	**Skipper:** Gary Mutch
Survey Area: Moray Firth	**Total Time at Sea:** 16 Days
Dates at Sea: 18/02/13 – 25/02/13, 11/03/13 – 18/03/13	

	Comments	Actions
Did vessel comply with pre trip safety audits?	Yes (audited by Noble Denton 15/02/13)	N/A
Skipper and crew attitude to safety?	Good	N/A
Vessel machinery failures?	None	N/A
Safety equipment failures?	None	N/A
Accidents?	None	N/A
Injuries?	None	N/A

Appendix 3 – Survey Log

A summarized log of events is given below in Table 4.9 for Trip A and in Table 7.3 overleaf for Trip B.

Table 4.9 Summarised Log of Events for Trip A, 17th to 26th February 2013

Friday 15th February 2013
Vessel audit completed by Noble Denton
Sunday 17th February 2013
Surveyors depart BMM, travel to South Queensferry, Edinburgh
Monday 18th February 2013
Travel to Peterhead, mobilise vessel (Gareth Jones, Phil (MSS), John Watt, Stephen Appleby and Peter Moore in attendance)
Depart Peterhead at 2315 hrs, steam to survey area overnight
Overnight at sea
Tuesday 19th February 2013
Otter Trawls: OT09 (1 x stage I cod), OT25 (3 x stage I cod), OT21 (6 x stage I cod), OT15 (1 x stage I and 1 x stage III cod), OT27 (4 x stage I cod)
Weather:BF1-3, smooth/slight
Overnight at sea
Wednesday 20th February 2013
Otter Trawls: OT05 (1 x stage III cod), OT06, OT02, OT01
Steam inshore at 1530 hrs to shelter under the land
Weather: BF6/7, moderate to rough
Overnight at sea
Thursday 21st February 2013
Otter Trawls: OT22, OT07, OT23, OT10 (2 x stage III cod), OT18 (1 x stage III cod)
Weather: BF5/6, moderate
Overnight at sea
Friday 22nd February 2013
Otter Trawls: OT49 (1 x stage III cod, 37 x sandeel), OT13 (1 x stage I cod, 12 x sandeel), OT26 (14 x sandeel), OT17 (2 x sandeel), OT19 (3 x sandeel)
Weather: BF3/4, slight
Overnight at sea
Saturday 23rd February 2013
Otter Trawls: OT28, OT20 (4 x sandeel), OT16 (2 x stage I cod), OT14, OT11 (2 x stage III cod, 1 x sandeel)
Weather: BF3/4, slight
Overnight at sea
Sunday 24th February 2013
Otter Trawls: OT12, OT24 (3 x stage I cod), OT08 (1 x stage I and 4 x stage III cod), OT03 (1 x stage I cod)
Weather: BF2/3, slight
Overnight at sea
Monday 25th February 2013
Otter Trawls: OT04 (1 x stage I cod)
Steam to Peterhead, arrive at 1230 hrs
Land samples and take to Marine Scotland, surveyors travel to South Queensferry, Edinburgh
Weather: BF2, slight
Tuesday 26th February 2013
Demobilise survey vessel
Surveyors return to BMM

Table 4.3 Summarised Log of Events for Trip B, 10th to 19th March 2013

Sunday 10th March 2013
Surveyors depart BMM, travel to South Queensferry, Edinburgh
Monday 11th March 2013
Travel to Peterhead, collect survey equipment from Marine Scotland, mobilise vessel
Client Representative arrived at vessel at approximately 2300 hrs
Depart Peterhead at 0000 hrs, steam to survey area overnight
Overnight at sea
Tuesday 12th March 2013
Otter Trawls: OT34 (1 x stage III cod), OT33 (repeated due to Scanmar error, OT32, OT22 (1 x stage III cod)
Weather:BF4/5, moderate
Overnight at sea
Wednesday 13th March 2013
Otter Trawls: OT41, OT23, OT40 (1 x stage I and 1 x stage III cod, 1 x sandeel), OT42, OT46
Weather: BF3-5, moderate, decreasing
Overnight at sea
Thursday 14th March 2013
Otter Trawls: OT26 (25 x sandeel), OT43 (1 x stage I cod, 6 x sandeel), OT24 (3 x stage I cod), OT35 (1 x stage I cod), OT08B (1 hour, 2 x stage III cod)
Weather: BF2/3, slight
Steam into Macduff, arrive at 2330 hrs, client representative disembarked vessel
Return to survey area
Overnight at sea
Friday 15th March 2013
Otter Trawls: OT30 (4 x stage I cod), OT31, OT36 (1 x stage III cod), OT39 (1 x stage I cod), OT39B (1 hour, 1 x stage III and 1 x stage I cod, 1 x sandeel)
Weather: BF2-4, slight
Overnight at sea
Saturday 16th March 2013
Otter Trawls: OT44 (1 x stage III cod, 3 x sandeel), OT45, OT47 (1 x stage IV cod, 3 x sandeel), OT28 (24 x sandeel), OT48 (1 x stage I cod)
Weather: BF2/3, slight
Overnight at sea
Sunday 17th March 2013
Otter Trawls: OT27 (1 x stage I and 1 x stage III cod) OT38 (8 x stage I and 1 x stage III cod), OT37 (1 x stage I cod), OT25
Weather: BF5/6, moderate
Overnight at sea
Monday 18th March 2013
Otter Trawls: OT29 (1 x stage III and 1 x stage IV cod)
Steam to Macduff due to poor weather conditions, arrive at 1530 hrs
Take survey equipment to Marine Scotland, surveyors travel to South Queensferry, Edinburgh
Weather: BF6-8, moderate to rough
Tuesday 19th March 2013
Demobilise survey vessel
Surveyors return to BMM

Appendix 4 – Times and Coordinates

Trip A Otter Trawls

Table 4.10 Start and End Times, Co-ordinates and Duration of Each Otter Trawl during Trip A

Station	Date	Start				End				Duration (hh:mm:ss)
		Time (GMT)	UTM30N		Depth (m)	Time (GMT)	UTM30N		Depth (m)	
			Easting	Northing			Easting	Northing		
OT01	20/02/2013	13:18:57	499,521.7	6,418,304.5	91.6	13:48:58	499,499.3	6,415,935.1	89.4	00:30:01
OT02	20/02/2013	11:41:58	503,323.4	6,423,729.6	84.5	12:12:11	502,594.9	6,421,373.7	90.5	00:30:13
OT03	24/02/2013	15:33:26	528,664.2	6,422,689.7	74.0	16:03:26	528,506.5	6,420,044.7	68.4	00:30:00
OT04	25/02/2013	07:35:26	536,381.1	6,426,277.9	83.4	08:05:37	536,259.7	6,423,494.1	85.4	00:30:11
OT05	20/02/2013	07:58:27	513,305.9	6,426,202.5	80.4	08:28:30	512,669.7	6,428,759.5	74.4	00:30:03
OT06	20/02/2013	09:58:05	507,677.6	6,430,593.0	54.1	10:28:31	506,175.3	6,428,280.7	71.5	00:30:26
OT07	21/02/2013	09:40:00	497,136.3	6,431,578.6	55.7	10:10:01	497,019.6	6,434,062.6	53.4	00:30:01
OT08	24/02/2013	12:14:29	519,013.1	6,435,606.6	68.4	12:44:29	518,830.4	6,433,099.6	71.3	00:30:00
OT09	19/02/2013	08:09:03	544,193.7	6,435,600.7	68.2	08:39:04	544,045.0	6,432,866.7	116.5	00:30:01
OT10	21/02/2013	13:51:12	487,475.3	6,437,960.6	56.1	14:21:12	487,679.6	6,440,666.3	58.7	00:30:00
OT11	23/02/2013	16:13:42	517,261.1	6,444,438.7	52.8	16:43:42	516,668.9	6,442,056.7	54.1	00:30:00
OT12	24/02/2013	08:13:42	512,910.4	6,444,138.6	49.9	08:43:42	512,953.8	6,446,439.7	44.6	00:30:00
OT13	22/02/2013	09:14:13	505,158.2	6,446,769.4	44.2	09:44:12	505,165.5	6,449,396.2	46.8	00:29:59
OT14	23/02/2013	14:40:35	520,058.8	6,450,681.2	57.0	15:10:35	520,650.3	6,448,477.2	55.6	00:30:00
OT15	19/02/2013	14:36:51	528,580.4	6,449,377.0	56.5	15:06:51	528,106.9	6,451,899.5	57.6	00:30:00
OT16	23/02/2013	12:11:01	522,543.6	6,452,860.7	59.4	12:41:01	522,532.6	6,450,511.5	59.0	00:30:00
OT17	22/02/2013	12:15:42	512,993.4	6,450,305.9	48.4	12:45:42	513,449.0	6,452,992.7	49.5	00:30:00
OT18	21/02/2013	16:05:36	499,644.0	6,451,808.1	64.2	16:34:35	499,367.5	6,454,206.8	67.6	00:28:59
OT19	22/02/2013	14:44:39	512,801.0	6,456,148.6	48.4	15:14:38	512,694.2	6,453,851.6	49.5	00:29:59
OT20	23/02/2013	09:51:18	517,105.7	6,455,164.3	47.3	10:21:18	517,251.1	6,452,401.1	55.7	00:30:00
OT21	19/02/2013	12:09:53	535,875.9	6,445,196.4	72.6	12:39:54	536,259.0	6,447,667.4	61.0	00:30:01
OT22	21/02/2013	07:52:24	493,117.5	6,423,738.7	57.8	08:22:23	493,093.8	6,426,261.6	58.8	00:29:59
OT23	21/02/2013	11:13:35	499,169.4	6,438,253.5	51.4	11:43:36	499,055.0	6,440,976.5	47.9	00:30:01
OT24	24/02/2013	09:40:22	512,936.6	6,441,422.2	52.6	10:10:22	513,015.2	6,438,586.8	58.5	00:30:00
OT25	19/02/2013	10:09:49	534,375.2	6,438,567.0	73.7	10:39:50	534,922.9	6,441,182.3	67.3	00:30:01
OT26	22/02/2013	10:45:17	509,406.3	6,449,816.9	45.0	11:15:16	509,367.5	6,452,431.4	42.4	00:29:59
OT27	19/02/2013	16:00:45	524,628.4	6,450,126.9	55.4	16:30:45	524,481.7	6,452,679.0	58.8	00:30:00
OT28	23/02/2013	08:14:29	517,092.7	6,459,821.5	51.9	08:44:30	516,922.0	6,457,021.5	50.3	00:30:01
OT49	22/02/2013	07:43:47	502,815.7	6,451,726.9	43.7	08:13:48	502,448.7	6,449,028.3	42.0	00:30:01

Trip B Otter Trawls

Table 4.11 Start and End Times, Co-ordinates and Duration of Each Otter Trawl during Trip B

Station	Date	Start				End				Duration (hh:mm:ss)
		Time (GMT)	UTM30N		Depth (m)	Time (GMT)	UTM30N		Depth (m)	
			Easting	Northing			Easting	Northing		
OT22	12/03/2013	17:32:51	492,985.1	6,426,215.2	57.0	18:02:52	492,957.4	6,423,665.3	54.8	00:30:01
OT23	13/03/2013	10:37:59	499,076.5	6,439,357.5	49.5	11:07:59	498,976.5	6,436,519.3	54.6	00:30:00
OT24	14/03/2013	12:06:43	513,032.1	6,440,858.4	53.4	12:36:43	513,061.7	6,438,105.0	59.0	00:30:00
OT25	17/03/2013	17:16:55	534,515.0	6,439,651.4	67.6	17:46:55	533,917.3	6,437,299.9	65.1	00:30:00
OT26	14/03/2013	09:23:33	509,041.1	6,449,217.1	42.6	09:53:33	509,396.7	6,451,790.5	44.2	00:30:00
OT27	17/03/2013	09:11:31	524,492.7	6,452,818.9	57.9	09:41:31	524,784.3	6,450,194.6	54.6	00:30:00
OT28	16/03/2013	14:15:47	516,846.6	6,456,911.7	51.0	14:45:53	516,838.7	6,459,448.6	52.6	00:30:06
OT29	18/03/2013	08:14:58	511,006.1	6,417,994.0	100.0	08:44:58	511,196.4	6,415,350.2	96.0	00:30:00
OT30	15/03/2013	09:39:10	520,803.6	6,423,232.1	88.8	10:09:12	520,074.9	6,420,632.7	71.7	00:30:02
OT31	15/03/2013	11:50:00	524,931.1	6,431,025.2	75.7	12:22:40	525,052.9	6,433,745.1	76.2	00:32:40
OT32	12/03/2013	15:36:48	491,487.5	6,434,298.6	49.2	16:06:50	491,580.4	6,436,431.4	47.7	00:30:02
OT33	12/03/2013	13:03:39	502,981.3	6,435,951.8	54.6	13:33:40	502,884.9	6,438,632.6	53.0	00:30:01
OT34	12/03/2013	09:24:54	510,560.4	6,435,378.3	53.4	09:55:09	510,666.6	6,437,626.5	52.1	00:30:15
OT35	14/03/2013	14:24:14	516,886.2	6,439,890.1	58.1	14:54:13	516,859.7	6,437,238.4	59.9	00:29:59
OT36	15/03/2013	14:32:52	523,010.1	6,439,642.6	61.0	15:03:01	522,958.4	6,442,241.2	60.1	00:30:09
OT37	17/03/2013	13:30:46	528,533.4	6,445,191.6	56.3	14:00:44	528,649.3	6,442,365.6	61.8	00:29:58
OT38	17/03/2013	10:40:19	524,714.0	6,448,293.3	55.7	11:10:20	524,464.9	6,445,676.2	55.9	00:30:01
OT39	15/03/2013	16:10:59	520,730.3	6,443,925.8	55.9	16:40:58	520,731.9	6,446,683.6	55.0	00:29:59
OT40	13/03/2013	13:14:31	507,321.8	6,442,338.3	44.6	13:44:32	507,316.3	6,445,167.7	44.6	00:30:01
OT41	13/03/2013	08:37:15	495,693.3	6,446,458.2	55.0	09:07:18	495,703.8	6,448,833.0	64.7	00:30:03
OT42	13/03/2013	14:44:26	502,348.5	6,445,777.3	42.0	15:14:26	502,421.6	6,448,716.0	41.3	00:30:00
OT43	14/03/2013	10:46:05	510,863.8	6,447,528.5	44.8	11:16:06	510,880.0	6,444,625.5	47.9	00:30:01
OT44	16/03/2013	08:30:18	516,393.1	6,448,261.1	51.4	09:00:47	516,369.4	6,451,028.8	52.3	00:30:29
OT45	16/03/2013	10:08:16	518,747.2	6,451,986.8	51.7	10:38:16	518,789.8	6,454,576.2	53.4	00:30:00
OT46	13/03/2013	16:30:25	506,915.6	6,455,662.7	42.6	17:00:35	507,004.3	6,453,318.5	40.7	00:30:10
OT47	16/03/2013	11:40:45	514,378.0	6,454,876.4	49.5	12:10:45	514,662.1	6,457,250.1	44.8	00:30:00
OT48	16/03/2013	16:39:08	520,569.6	6,457,908.1	53.4	17:09:10	520,415.9	6,455,319.6	54.8	00:30:02
OT08 1 Hour	14/03/2013	15:48:53	518,762.0	6,436,998.2	65.4	16:48:53	518,790.6	6,431,869.9	70.9	01:00:00
OT39 1 Hour	15/03/2013	17:05:47	521,352.7	6,446,580.4	55.6	18:05:46	521,568.1	6,441,309.5	58.7	00:59:59

Appendix 5 – Examples of Spawning and Spent Cod

Stage III Spawning

Trip A

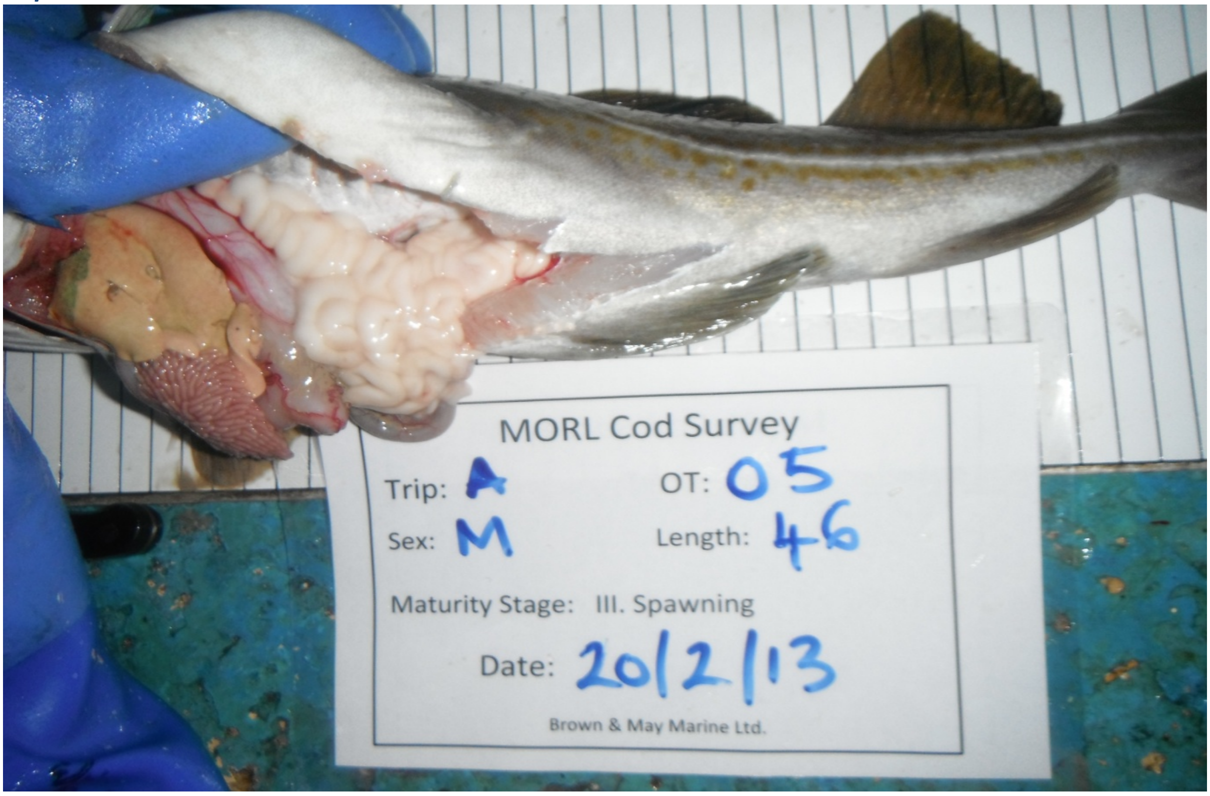

Figure 4.20 OT05 Male 46 cm

Figure 4.21 OT10 Male 54 cm

Figure 4.22 OT10 Male 67 cm

Figure 4.23 OT18 Male Length 45 cm

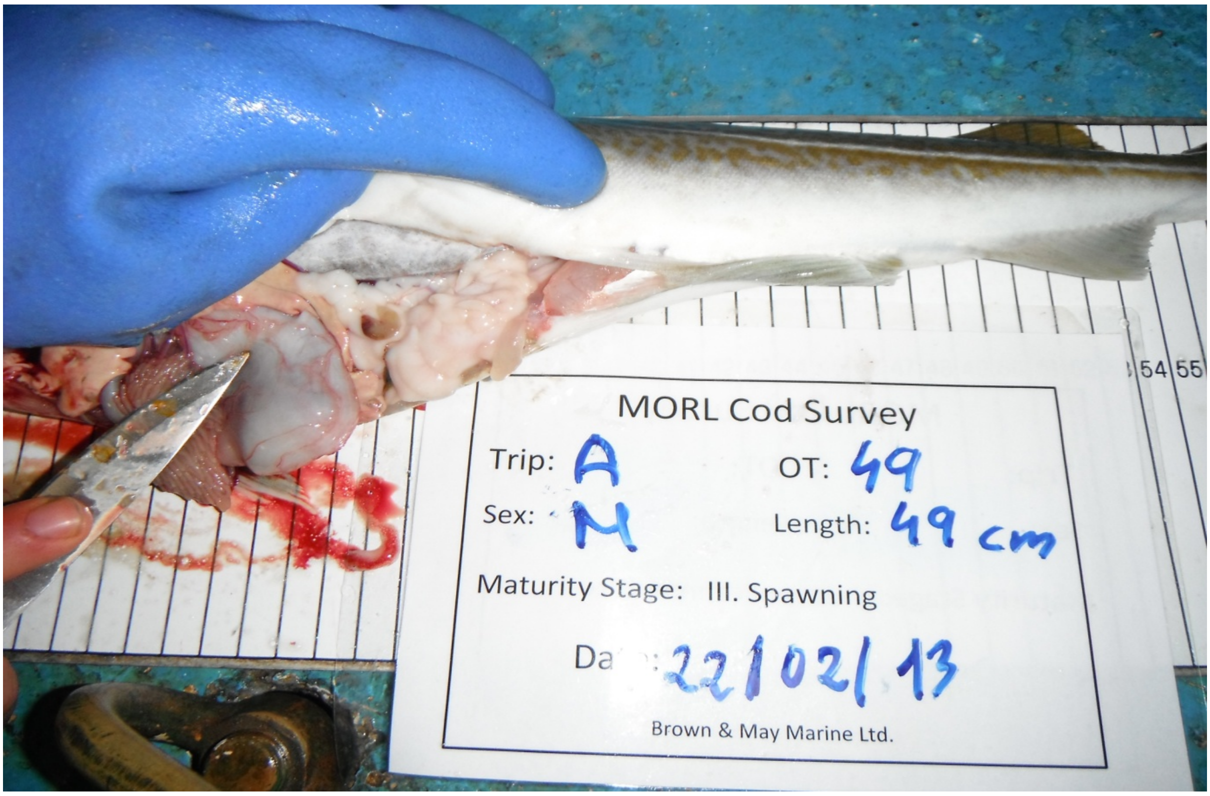

Figure 4.24 OT49 Male Length 49 cm

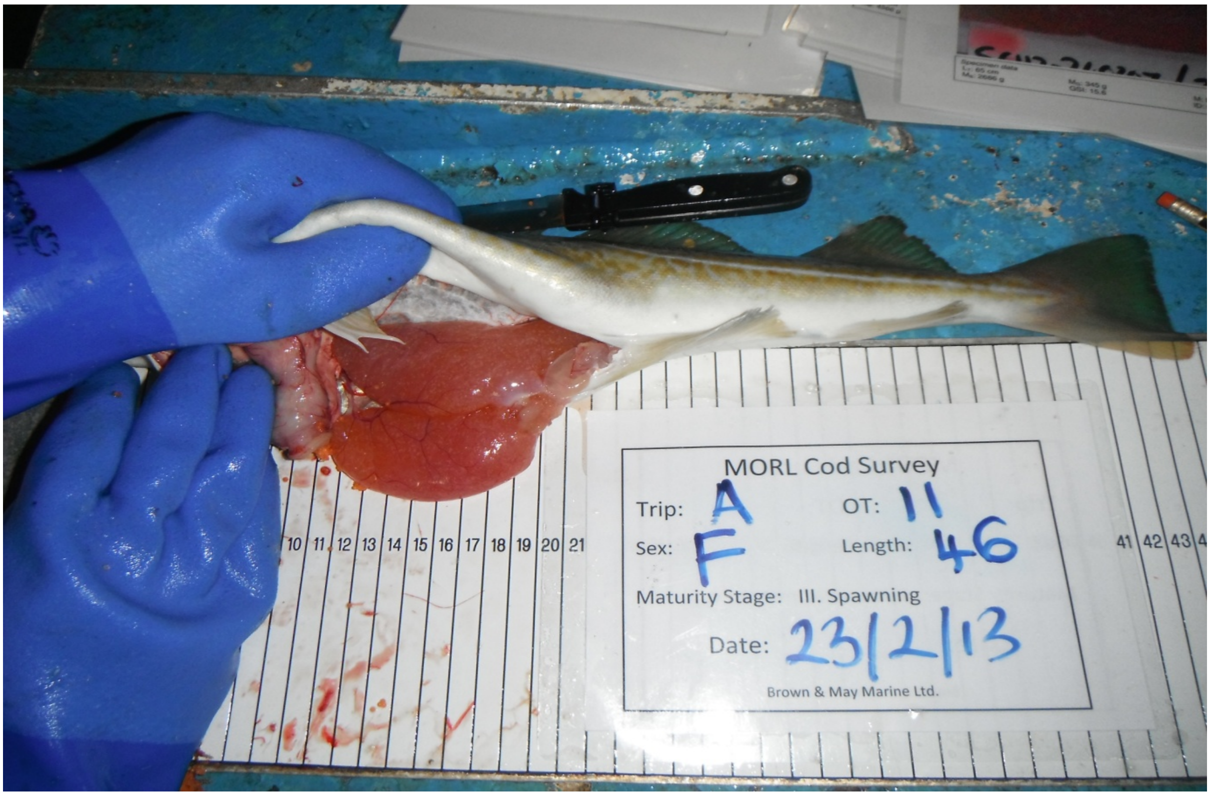

Figure 4.25 OT11 Female 46 cm

Figure 4.26 OT11 Male 68 cm

Figure 4.27 OT08 Male 33 cm

Figure 4.28 OT08 Male 46 cm

Figure 4.29 OT08 Female 50 cm

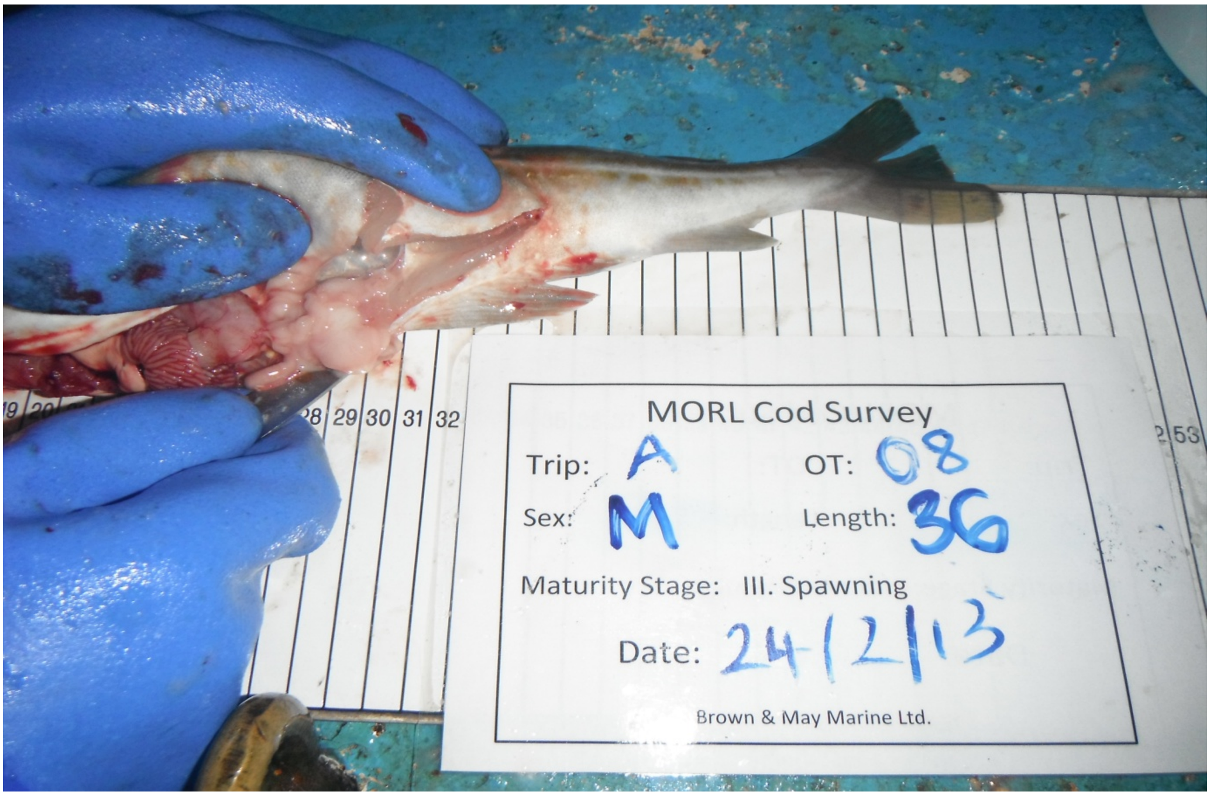

Figure 4.30 OT08 Male 36 cm

Trip B

Figure 4.31 OT34 Female 34 cm

Figure 4.32 OT22 male 49 cm

Figure 4.33 OT40 Female 41 cm

Figure 4.34 OT08 58 cm_1hour

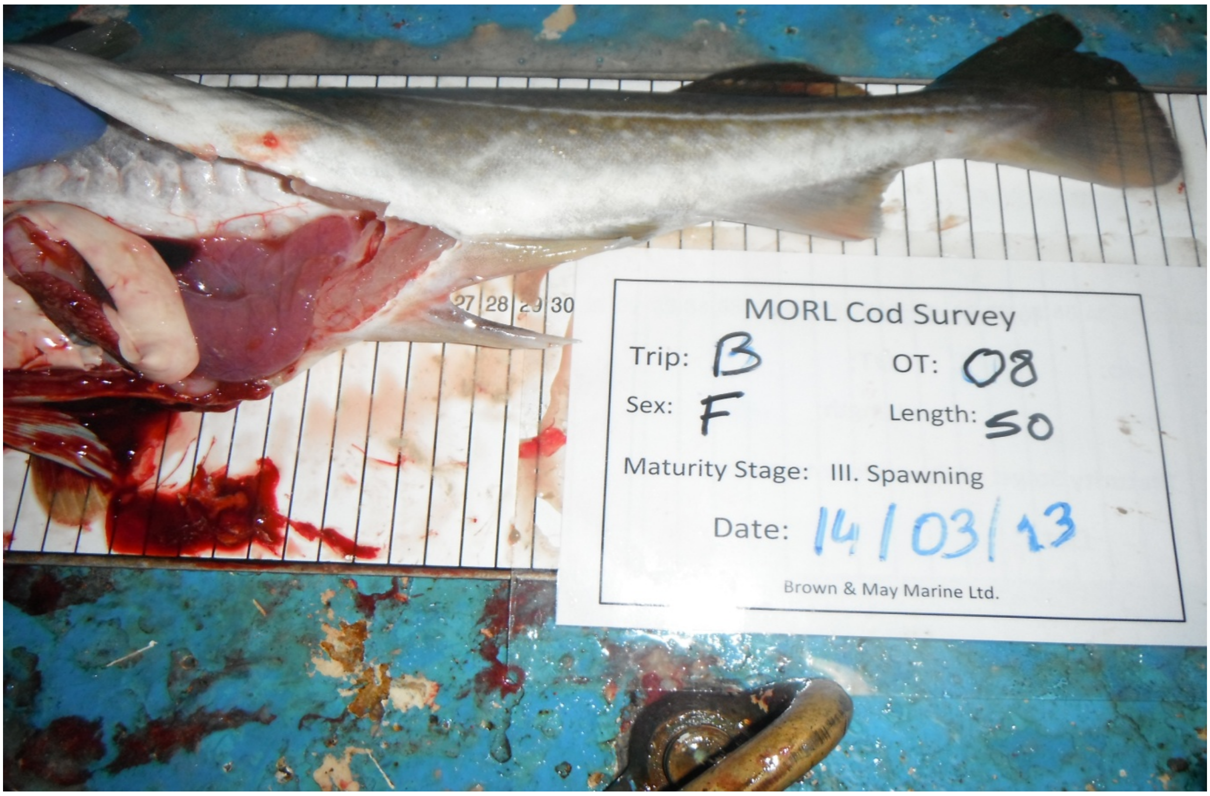

Figure 4.35 OT08_1hour Female 50 cm

Figure 4.36 OT36 female 43 cm

Figure 4.37 OT39_1hour Female 54 cm

Figure 4.38 OT27 male 43 cm

Figure 4.39 OT38 Male 45 cm

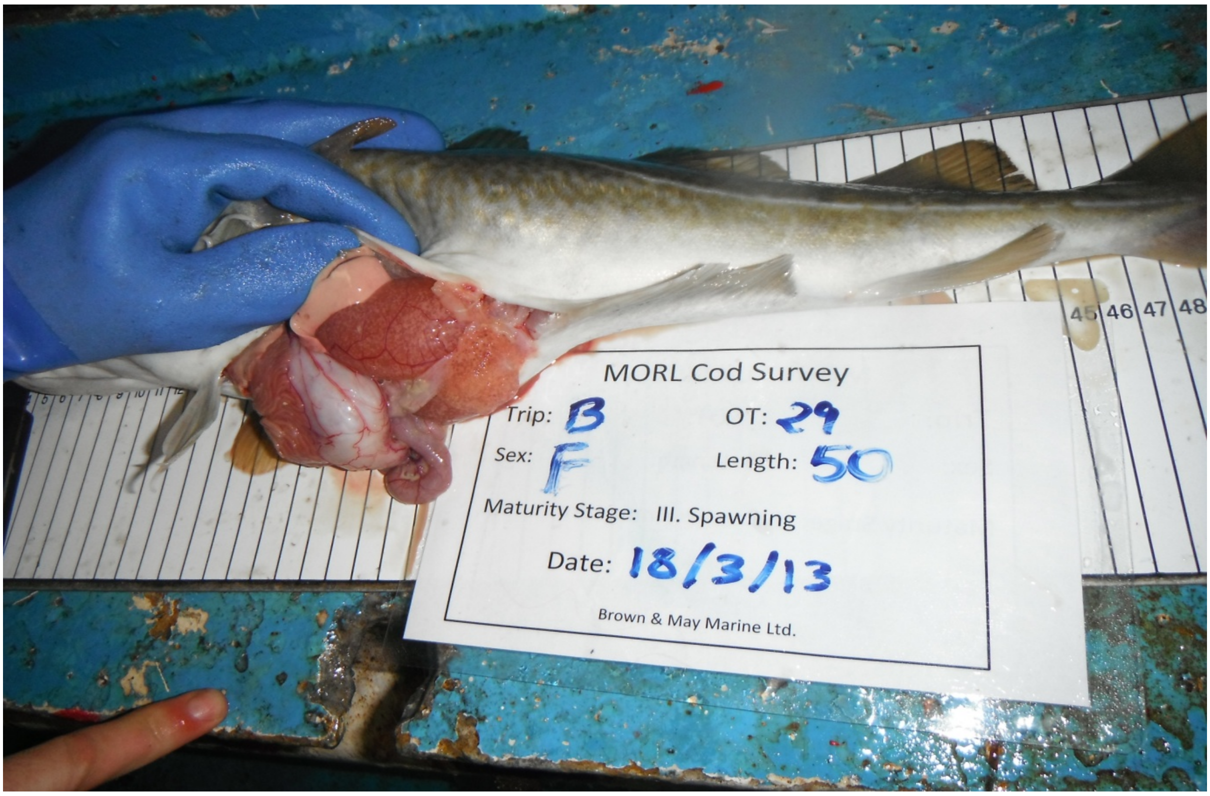

Figure 4.40 OT29 Female 50 cm

Stage IV spent
Trip B

Figure 4.41 OT29 Female 55 cm

Figure 4.42 OT47 Female 55 cm