BURBO BANK EXTENSION OFFSHORE WIND FARM

DONG Energy Burbo Extension (UK) Ltd.

Environmental Statement
Volume 2 - Chapter 13: Fish and Shellfish Ecology

Document reference: 5.1.2.13

APFP 5(2)(a)

March 2013

DONG energy

Burbo Bank Extension offshore wind farm
DONG Energy Burbo Extension (UK) Ltd

Environmental Statement
Volume 2 – Offshore, Biological & Physical Technical Chapters 8-16

Document reference: 5.1.2

Pursuant to: APFP 5(2)(a)

Prepared by: Stuart Livesey (Consents Project Manager, DONG Energy), Jennifer Brack (Applications Lead, DONG Energy), Allen Risby (Environmental Lead, DONG Energy), Bronagh Byrne (Environmental Lead, DONG Energy), Julian Carolan (Environmental Lead, DONG Energy), David King (Assistant Environmental Manager, DONG Energy), Rasmus Juncher (Geoscience Manager, DONG Energy), Gardline Geosurvey Ltd., ABP Marine Environmental Research, Subacoustech Ltd., CMACS Ltd., Brown & May Marine Ltd., NIRAS Consulting Ltd., Natural Power Ltd., NIRAS Consulting Ltd.

Checked by: Stuart Livesey (Consents Project Manager, DONG Energy), Jennifer Brack (Applications Lead, DONG Energy), Andrew Prior (Senior Environmental Manager, DONG Energy), Bond Pearce LLP, James Deeble (NIRAS Consulting Ltd.), David King (Assistant Environmental Manager, DONG Energy)

Accepted by: Stuart Livesey (Consents Project Manager, DONG Energy)

Approved by: Ferdinando Giammichele (Project Development Manager, DONG Energy)

Date: March 2013

Status: Final

Burbo Bank Extension offshore wind farm
c/o DONG Energy Burbo Extension (UK) Ltd.
33 Grosvenor Place
Belgravia
London
SW1X 7HY
United Kingdom

Tel: (+44) 020 7811 5235

Website: www.burbobankextension.co.uk
Email: burbobankextension@dongenergy.co.uk

DONG energy

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13. Fish and Shellfish Ecology

13.1 Introduction

13.1.1 The purpose of this chapter in the Burbo Bank Extension offshore wind farm ("the Project") Environmental Statement is to identify and assess the likely significant effects of the Project on Fish & Shellfish Ecology. The Project for which development consent is sought consists of an extension westwards of the existing Burbo Bsnk offshore wind farm. The proposed offshore Project site covers an area of 40 km² which lies approximately 7 km north off the North Wirral coast. The maximum capacity of the wind farm will be up to 258 MW, consisting of offshore wind turbines and foundations, an offshore substation, buried inter-array and export cable(s), buried onshore cable(s) from the cable landfall in North Wales between Rhyl and Prestatyn to a new onshore substation next to the Bodelwyddan substation near St Asaph in Denbighshire where the cable will connect with the National Grid. Further details on the Project infrastructure, installation methodologies and timelines can be found in ES Chapter 6 'Project Description'.

13.1.2 This chapter of the Environmental Statement (ES) presents the details of the Environmental Impact Assessment (EIA) for the potential impacts of the Project on Fish and Shellfish Ecology.

13.1.3 This chapter summarises information from technical reports which are included in the ES Annex 5.1.5.13:

- In addition to the aforementioned technical reports, the following chapters support this assessment: ES Chapter 10 'MetOcean and Coastal Processes';
- ES Chapter 11 'Offshore Noise';
- ES Chapter 12 'Subtidal and Intertidal Benthic Ecology';
- ES Chapter 18 'Commercial Fisheries'.

13.2 Planning policy context

13.2.1 Planning policy on offshore renewable energy Nationally Significant Infrastructure Project (NSIP) is contained in the National Policy Statements (NPS) for Renewable Energy Infrastructure (EN-3, Department of Energy and Climate Change (DECC, 2011).

13.2.2 The NPSs identify a number of issues relevant to this chapter. These are summarised in Table 13.1 below.

Table 13.1: Summary of NPS EN-3 provisions relevant to this chapter.

Summary of NPS provision	Consideration in ES
There is the potential for the construction and decommissioning phases, including activities occurring both above and below the seabed, to interact with seabed sediments and therefore have the potential to impact fish communities, migration routes, spawning activities and nursery areas of particular species. In addition, there are potential noise impacts, which could affect fish during construction and decommissioning and to a lesser extent during operation.	Predictions of impacts for the construction and decommissioning phases on fish species are provided in this chapter.
The applicant should identify fish species that are the most likely receptors of impacts with respect to: • Spawning grounds; • Nursery grounds; • Feeding grounds; • Over-wintering areas for crustaceans; and • Migration routes.	Key fish and shellfish receptors have been identified. These are detailed in Table 13.11
Electromagnetic fields (EMFs) during operation may be mitigated by use of armoured cable for inter-array and export cables which should be buried at a sufficient depth. Some research has shown that where cables are buried at depths greater than 1.5 m below the sea bed impacts are likely to be negligible. However sufficient depth to mitigate impacts will depend on the geology of the seabed.	Armoured cables will be sought to be buried to a target depth 1-2 m and 10% of inter-array and export cables are assumed on a likely maximum adverse scenario to be protected by rock dumping where target burial depth cannot be achieved. This has been included as embedded mitigation.
During construction, 24 hour working practices may be employed so that the overall construction programme and the potential for impacts to fish communities is reduced in overall time.	Included in embedded mitigation.

13.3 Consultation

13.3.1 The ES Chapter 7 'Consultation' outlines the consultation activities which have been undertaken in respect of the Project, this is also described in the Consultation Report (document 4.1).

13.3.2 Consultation was undertaken with representatives of a number of stakeholder groups including the Centre for Environment, Fisheries and Aquaculture Science (Cefas), the Marine Management Organisation (MMO), the Environment Agency, Natural England, Wales Government Marine Consents Unit (WG MCU) and Countryside Council for Wales (CCW). Consultation was also undertaken with bodies with salmon and sea trout interests, including representatives of the Welsh Rivers Trusts and salmon and sea trout fisheries stakeholders. The information and feedback obtained through consultation and stakeholders' responses has been used to inform this chapter.

13.3.3 A list of the stakeholder consultation meetings and of stakeholders' responses is provided below:

- IPC Scoping Opinion: Proposed Burbo Bank Extension Offshore Wind Farm, Liverpool Bay: 17.08.2010;
- Information (relevant to salmon, sea trout, river and sea lamprey) provided by the Environment Agency during consultation: 26.01.2012 (Wales);
- Meeting with MMO and Cefas: Consultation regarding spawning areas and the potential impact from noise: 15.02.2012;
- MMO/Cefas review of Institute for Marine Resources and Ecosystem Studies (IMARES) report on the effect of piling noise on the survival of fish larvae: 20.04.2012;
- MMO/Cefas comments to draft fish and shellfish resources technical report: 13.06.2012; and
- Key stakeholder (MMO, Countryside Council for Wales (CCW), Natural England and Cefas) workshop to discuss the Preliminary Environmental Information Technical Report (PEI) and additional Technical Reports: 14.06.2012.
- MMO/Cefas/Natural England Workshop: 14.06.2012;
- MMO comments on draft salmon and sea trout ecology and fisheries technical report. 12.06.2012;
- Consultation with MMO, Cefas, CCW, Environment Agency (Wales), Natural England, Welsh Government Marine Consent Unit regarding potential noise impact on fish ecology (salmon and sole) 22.10.2012;
- Consultation with Natural England, Environment Agency, Cefas regarding potential noise impact on salmon and sea trout (EIA and Habitats Regulations Assessments (HRA)) 21.11.2012; and
- Consultation with Environment Agency Wales regarding potential impact of construction noise on salmon and sea trout noise 08.01.2013.

Table 13.2: Consultation responses relevant to this chapter

Date	Consultee and type of response	Issues Raised	How/where addressed
13th June 2012	MMO and Cefas Responses to Technical Reports	It is noted that MMO landings data between 2001 and 2010 has been included in the Fish and Shellfish and Commercial Fisheries Technical Reports, the inclusion of 2011 data requires to be added as part of the assessment.	The most up to date data available from the MMO at the current time has been used throughout the assessment. Due to the confidentiality constraints of the 2011 data provided by the MMO, it is not compatible with previous year's data and does not provide sufficient method or species specific information for it to be used in this assessment.
		The potential impacts to fisheries and commercial fisheries are not discussed in either of the reports so we presume that these and the cumulative / in-combination impacts will be discussed in a separate chapter or added to the reports.	The full assessment of potential impacts on fish and shellfish ecology is provided in this chapter. The assessment of impact on commercial fishing is addressed in ES Chapter 18 'Commercial Fisheries'.
		Appropriate evidence, data and information is included within the reports. However, given the proximity to the Burbo Bank offshore wind farm, conclusions and potential impacts identified from pre and post construction survey data require inclusion in the reports.	Available data from the existing Burbo offshore wind farm has been incorporated into this chapter and ES Annex '5.1.2.13.2'.
		Surveys for fisheries to inform the pre-construction characterisation have been undertaken in consultation with fisheries advisors at Cefas and they are appropriate with regard to methodologies and use standard practice. Previous advice given in	The epibenthos was sampled as part of the benthic and intertidal characterisation survey undertaken by CMACS Ltd. (See ES Chapter 12 'Subtidal and Intertidal Benthic Ecology'). The outputs of which have been included in the ES Annex '5.1.5.13.2'.

Table 13.2: continued

Date	Consultee and type of response	Issues Raised	How/where addressed
		July 2010 (scoping advice) highlighted the importance of the area for shellfisheries: 'Given the importance of some shell fisheries e.g. Whelks, in surrounding areas we suggest that the survey design ensures adequate sampling of the epibenthos to assess the area.' It is not evident from the Fish and Shellfish Technical Report whether this has been undertaken and should be clarified within the report.	Based on knowledge of commercial fishery for whelks in the area, no surveys were undertaken as it was not expected to catch more than a few whelks (see ES Chapter 18 'Commercial Fisheries').
		In the presentation of the fisheries survey results, for data comparability between individual survey stations and actual surveys, this tabulated data must be presented in Tables 4.1 and 4.2 of the Fish and Shellfish Technical Report as standardised data for example as Catch Per Unit Effort (CPUE) as shown in most Brown and May Marine Ltd. (BMM) survey reports.	Changes have been made to the relevant tables.
		Section 4.2: Commercial species are discussed. In order to avoid repetition of information the information on species in the teleost, pelagic and elasmobranch sections must be combined with the relevant information from the spawning and nursery ground section. This will aid the flow of the document and ease of understanding of the information presented.	Changes to the report structure have been undertaken.

Table 13.2: continued

Date	Consultee and type of response	Issues Raised	How/where addressed
		Queen Scallops are known to be more mobile than King Scallops and may carry out larger scale movements at times. This should be noted within the report.	Clarifications added to the text.
		The inclusion of species of conservation importance within the Fish and Shellfish Technical Report is appropriate and covers the relevant species. The common skate Dipturus batis has been identified as two different species upon careful re-examination of its taxonomy and we welcome this acknowledgement within the Fish and Shellfish Technical Report. The noticeable phenotypic differences within the species, morphology, genetics and life history have shown that the two species have been confused since 1920's. The common skate species-complex is split into two nominal species Dipturus intermedia and Dipturus flossada and they are commonly named the flapper skate and blue skate respectively, however it is not sure if these will become widely accepted. This information is compiled from Iglésias *et al.*, 2010 and Shark Trust, 2009.	Clarifications added to in the report.

Table 13.2: continued

Date	Consultee and type of response	Issues Raised	How/where addressed
		The Fish and Shellfish and draft Commercial Fisheries Technical Reports are well constructed with all the salient points and issues included, however we have made some points above that will improve the assessment and which we expect to see implemented within the technical reports and subsequent ES.	Recommended changes have been addressed .
		Identify the specific life-stages that might be affected by the proposed development and to provide a critical review of the possible effects (e.g. noise from piling/operation, Electro Magnetic Field (EMF), suspended sediment) both in terms of timing and likely extent of different aspects of the project (construction/ operation).	Addressed in the impact assessment.
		The Report Summary states that there are four principle salmon rivers in the vicinity of the Burbo Bank Extension area, indicating that these rivers only should be described. However, care should be taken to include the River Mersey; this is a recovering salmon river and we acknowledge that this is pointed out on page 29 of the report. The River Mersey is in close proximity to the wind farm, impacts may be relevant to potential recovery and it should be included as part of the assessment, even if conservation limits are not currently applied.	The River Mersey has been included in the ES chapter and the impacts on salmon and sea trout originating from the River Mersey have been addressed on a site specific basis within this chapter.

Table 13.2: continued

Date	Consultee and type of response	Issues Raised	How/where addressed
		The report requires further detail with regards to the need to identify the particular aspects of the salmon/sea trout life-cycle that might be affected by the proposed development or on the possible effects, if any, of the wind farm on fish behaviour and mortality. For example, there is no information on the possible effects of noise or electromagnetic fields on fish, an indication of the stages in the life-cycle that might be affected, or information on the possible impacts that might occur, as a result of the construction and operation of the proposed wind farm development.	Addressed in impact assessment.

13.4 Study area

13.4.1 The study area used for the assessment of fish and shellfish ecology is shown in Figure 13.1. The Project is located in Liverpool Bay, between the estuaries of the Dee and Mersey, and falls almost entirely within International Council for the Exploration of the Sea (ICES) rectangle 35E6. The export cable is also located in rectangle 35E6.

13.4.2 For the purposes of the salmon and sea trout assessment the study area comprises the principal five rivers which flow into the Liverpool Bay in the vicinity of the Project (Figure 13.1). These are as follows:

- The Rivers Conwy and Clwyd both located within the Environment Agency West Wales River Basin District;
- The River Dee, which flows through both North West England and North Wales and is located in the Environment Agency Dee River Basin District. In addition, the Dee is part of a designated SAC (The River Dee and Bala Lake SAC) for which Atlantic salmon is a primary reason for selection of the site (Joint Nature Conservation Committee (JNCC), 2010); and
- The River Ribble and the River Mersey, located within the Environment Agency North West River Basin District.

13.4.3 All the rivers included for assessment, with the exception of the River Mersey, are listed as principal salmon rivers and support important salmon and sea trout recreational fisheries. Following the extinction of migratory salmonids from the Mersey system during the Industrial Revolution, salmon and sea trout have recently been confirmed as returning to the Mersey (APEM, 2007).

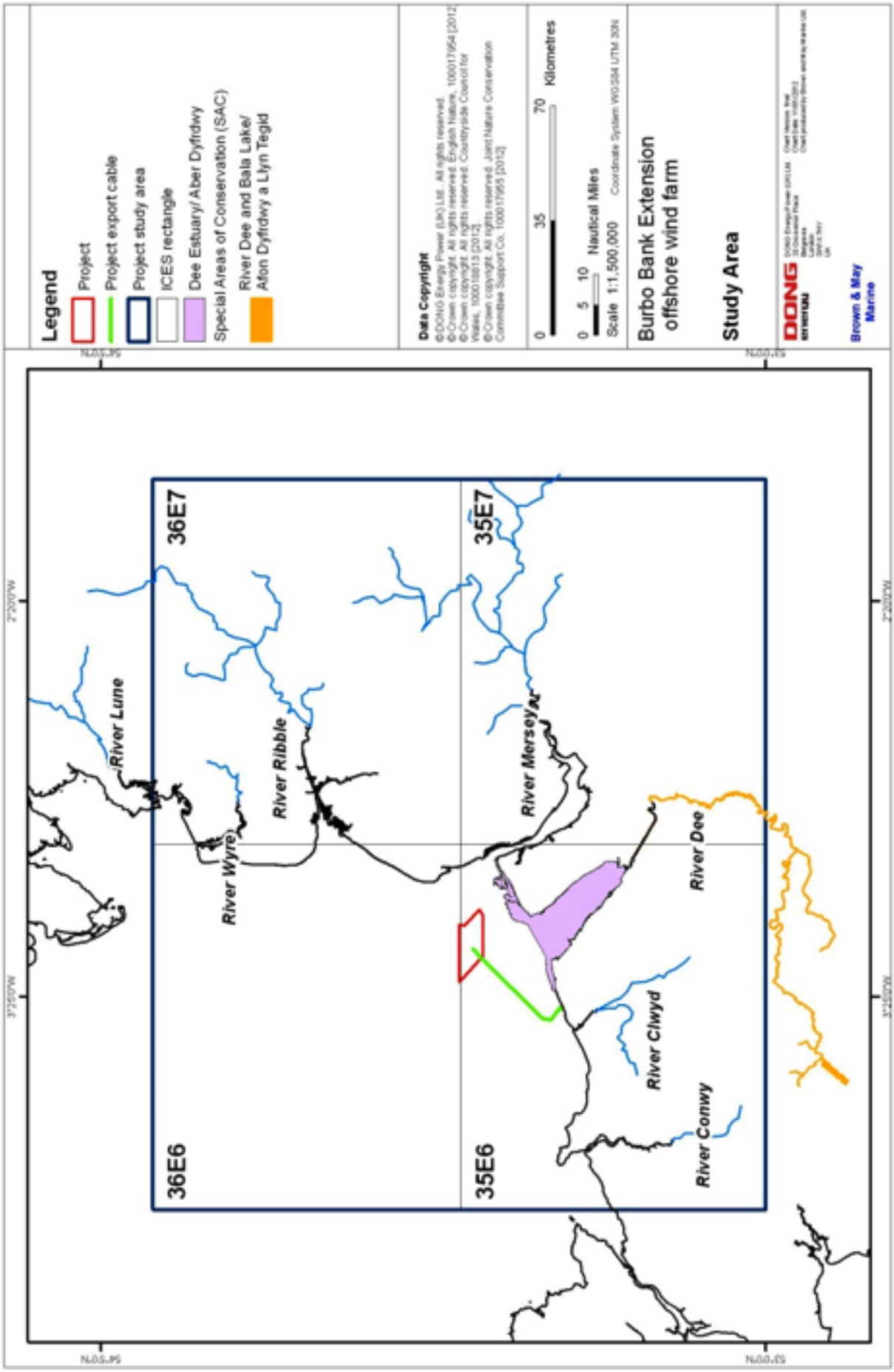

Figure 13.1: Project assessment study area

13.5 Methodology

13.5.1 In order to inform the EIA the survey data summarised at Table 13.3 were collected for the Project area.

Table 13.3: Summary of survey data

Title	Source	Year	Reference
Burbo Bank Extension Adult and Juvenile Fish Characterisation surveys	BMM	May and September 2011	Technical Report Annex 5.1.5.13
Burbo Bank Extension Monitoring Surveys Report	CMACS	2010	ES Annex '5.1.5.12.1'

13.5.2 In addition to these Project-specific surveys, other data and literature were collected and reviewed. The principal sources of data and information are detailed below.

Sources of data and information

13.5.3 The principal sources of data and information used are as follows:

- Burbo Bank Extension offshore wind farm Salmon and Sea Trout Baseline Characterisation Report (ES Annex '5.1.5.13.1');
- Burbo Bank Extension offshore wind farm Fish and Shellfish Ecology Baseline Characterisation Report (ES Annex '5.1.5.13.2');
- Results of the epibenthic survey conducted within the Project in 2011 (ES Annex '5.1.5.12.1');
- Burbo Bank Extension offshore wind farm Commercial Fisheries Technical Report (ES Annex '5.1.5.18.1');
- MMO Landings Data by ICES rectangle for the period 2001 to 2010 (MMO, 2011);
- Fisheries Sensitivity Maps in British Waters (Coull *et al.*, 1998);
- Spawning and nursery grounds of selected fish species in UK waters (Ellis *et al.*, 2012);
- Results of monitoring work undertaken in the operational Burbo Bank offshore wind farm (CMACS, 2010);
- Cefas publications;
- ICES publications;
- Environment Agency Fisheries Statistics Reports (Environment Agency 2001 to 2009);
- North Atlantic Salmon Conservation Organisation (NASCO);
- Joint Nature Conservation Committee (JNCC);
- The Welsh Dee River Trust (WDRT);
- The Clwyd and Conwy River Trust (CCRT);
- The Ribble Catchment Conservation Trust (RCCT);
- The Celtic Sea Trout Project (CSTP);

- Seasonal Data from the Environment Agency Chester Weir Fish Trap; and
- Scientific manuscripts and other relevant publications.

13.6 Baseline environment

Data limitations

MMO landings data

13.6.1 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, being large in relation to the area of the Project. 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 data set.

13.6.2 Furthermore, 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 the specific targeting of species, economic factors, quota allocations and stock conservation measures. In addition, the presence and distribution of fish and shellfish species are dependent on a number of biological and environmental factors, which interact in direct and indirect ways, and are subject to seasonal and annual variations.

Spawning and nursery grounds

13.6.3 The assessment of the potential for the Project area to be used as a spawning or nursery ground has primarily been undertaken using the charts provided in Coull *et al.* (1998) and Ellis *et al.* (2012). Whilst these are useful sources to identify spawning and nursery grounds, the broad areas defined in these publications do not allow for the exact definition of the boundaries of grounds, especially in relation to discrete areas such as the Project area.

13.6.4 In addition, spawning times are given using the maximum duration of spawning periods recorded in British waters as defined by Coull *et al.* (1998) and Ellis *et al.* (2012). However, spawning durations might be more contracted on a site specific basis. Where available, other research publications have also been referenced, to provide Irish Sea specific information on spawning times.

Current knowledge and data gaps

13.6.5 It is recognised that there are gaps in the understanding of the distribution, behaviour and ecology of certain species. This is particularly evident for a number of migratory species and species of conservation importance.

13.6.6 In the particular case of salmon and sea trout, there is insufficient information available to date to allow migratory routes and patterns of salmon and sea trout to be defined at the spatial resolution required in this assessment. The available data and information do not allow for the numbers and the origin of the fish potentially migrating through or near the Project to be estimated or otherwise quantified. In addition to data gaps relating to migratory patterns and behaviour, there is no detailed information on the potential for the area of the Project to be used by these species in other ways. This is particularly relevant for sea trout as they generally do not undertake long distance migrations and could potentially use the Project area and its vicinity for other purposes during extended periods of time (e.g. marine feeding).

13.6.7 As described in ES Annex '5.1.5.13.1', following a ~200 year absence, populations of migratory salmon have only relatively recently started returning to the Mersey catchment (APEM, 2007). Despite the availability of fish counter infrastructure at Woolston Weir, this trap has typically only been operated for limited periods of time since 2001 (between 4 and 48 days annually). Accordingly, data pertaining to the temporal distribution and annual size of salmon/ sea trout runs have not been available for inclusion in the annual assessment of salmon stocks and fisheries reports published by the EA (Environment Agency & Cefas, 2012).

13.6.8 The lack of current knowledge described for salmon and sea trout above, also applies to a number of other species of conservation importance potentially present in the area (e.g. European eel, river and sea lamprey) for which little is known in relation to migration routes and the use they may make of coastal areas.

Fish and shellfish baseline environment

13.6.9 The following section provides a summary of the fish and shellfish resources present within the area of the Project and its export cable. A summary of baseline information on salmon and sea trout is provided separately in section 13.6.3 below.

13.6.10 For the purposes of defining the fish and shellfish ecology baseline four main aspects have been taken into account:

- Commercial importance of fish and shellfish species;
- Distribution of spawning, nursery grounds;
- Importance of species in the food web; and
- Conservation importance.

13.6.11 Site specific information on the fish community of the Project gathered during fish surveys undertaken in the Project has also been integrated in order to establish the fish and shellfish fish ecology baseline (see ES Annex '5.1.5.13.2'). Similarly, the results of relevant pre and post- construction monitoring work undertaken in the adjacent operational Burbo Bank offshore wind farm have also been integrated for assessment (see ES Annex '5.1.5.13.2').

Commercial fisheries landings data (MMO, 2011)

13.6.12 An indication of the principal commercial species present in the study area is given in Figure 13.2, based on ten years averaged (2001 to 2010) landings weights (tonnes) by species (MMO, 2011).

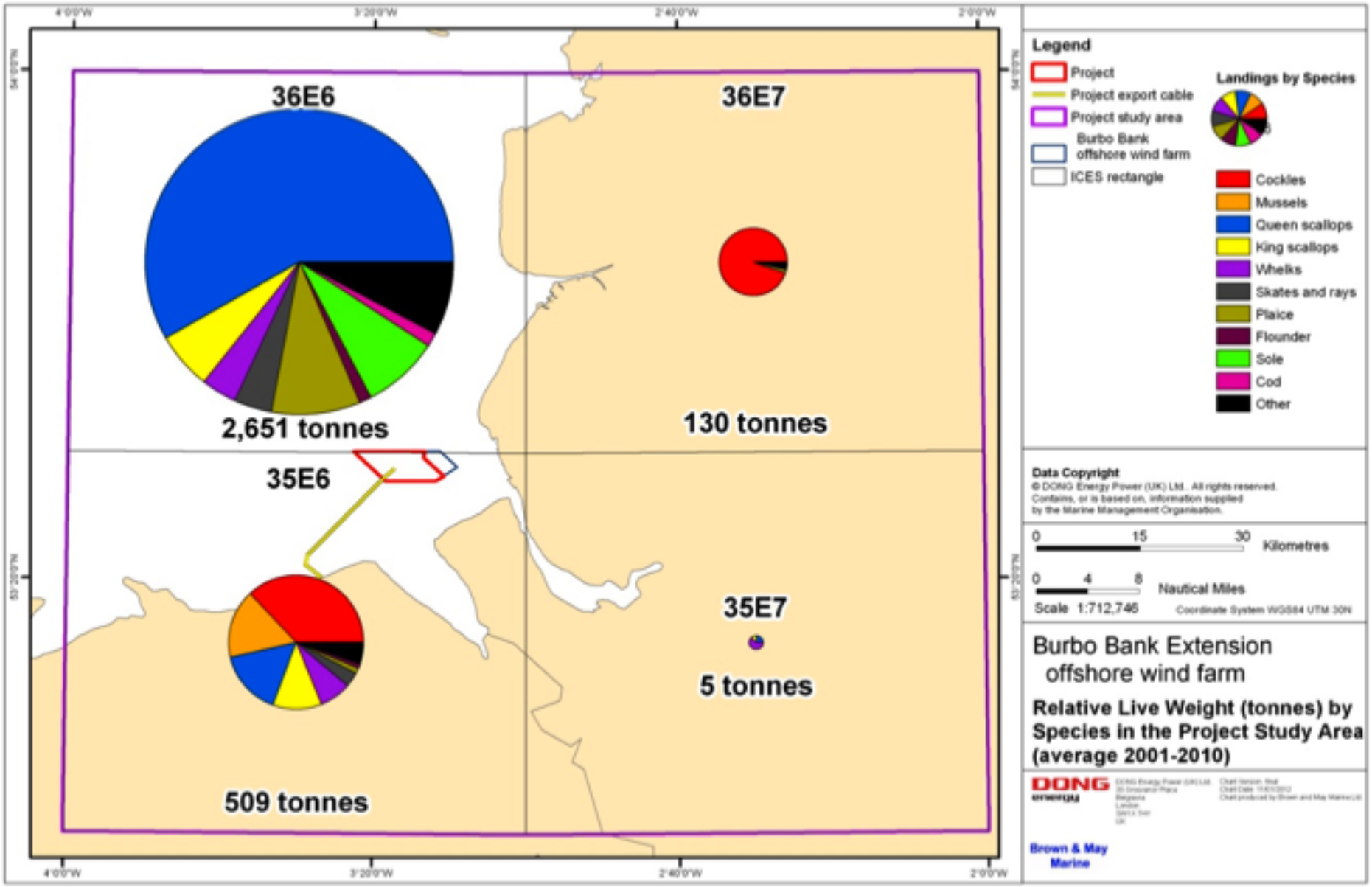

Figure 13.2: Average (2001-2010) live weight (tonnes) by species in the study area (MMO, 2011)

13.6.13 Shellfish comprise the majority of landings by weight from the study area, representing 73.5% of total landings (shellfish, teleosts and elasmobranchs combined). Queen scallop (*Aequipecten opercularis*) is the principal shellfish species landed by weight, accounting for 66.9% of total shellfish landings, followed by cockles (*Cerastoderma edule*, 12.6%), king scallops (*Pecten maximus*, 9.1%), whelks (*Buccinum undatum*, 5.9%) and mussels (*Mytilus edulis*, 3.8%). The majority of queen scallops (92.3%) are landed from rectangle 36E6. Cockle landings are highest in rectangle 35E6 and 36E7, where they are targeted in the estuaries of major rivers. Mussels are also mainly targeted in inshore waters, with the majority (90.6%) being landed from rectangle 35E6. The majority of whelk potting activity occurs in rectangle 35E6 and the highest values are landed into Holyhead. Potting for whelks takes place year round within the 6 nm limit (ES Chapter 18 'Commercial Fisheries').

13.6.14 Teleost landings account for 20.8% of total landings in the study area. Demersal flatfish species, in particular plaice (*Pleuronectes platessa*) and sole (*Solea solea*), constitute the majority of teleost landings at 37.3% and 32.0% respectively. Within the Project boundary, there is a small, discrete, seasonal fishery for sole, plaice and cod (*Gadus morhua*); species generally targeted by vessels operating beam trawls during the spring. Consultation with fishermen has also identified occasional otter trawling for plaice and sole throughout the site. The cable route transects seasonal gillnet fisheries for seabass (*Dicentrarchus labrax*) and flatfish (ES Chapter 18 'Commercial Fisheries').

13.6.15 Landings of elasmobranch species are comparatively low, representing 5.7% of the total landings by weight in the study area, of which 65.9% are from the grouped category "skates and rays". At the species level, thornback ray (*Raja clavata*), lesser spotted dogfish (*Scyliorhinus canicula*) and spurdog (*Squalus acanthias*) are the principal species landed from the study area accounting for 12.6%, 11.2% and 6.6% respectively of elasmobranch landings. Consultation with fishermen has identified a small thornback ray gillnet fishery in the north-west of the Project site and occasional otter trawling for thornback ray throughout the site. The cable route transects seasonal gillnet fisheries for tope (*Galeorhinus galeus*) and smoothhound (*Mustelus spp.*) (ES Chapter 18 'Commercial Fisheries').

Species with spawning and nursery grounds

13.6.16 The Project falls within the spawning and nursery grounds of a number of species (Coull *et al.*, 1998; Ellis *et al.*, 2012[1]). These are given in Table 13.4 together with spawning times and intensity of spawning (where it has been defined). The spawning periods are given as provided in Coull *et al.* (1998) and Ellis *et al.* (2012), and the spawning/nursery intensity are as described in Ellis *et al.* (2012).

13.6.17 Spawning grounds for sole, plaice, cod, whiting (*Merlangius merlangus*), sandeels (*Ammodytidae spp.*), sprat (*Sprattus sprattus*) and mackerel (*Scomber scombrus*) have all been defined within the Project area and its export cable.

13.6.18 Nursery grounds for all the above species (with the exception of sprat) as well as for herring (*Clupea harengus*), thornback ray, tope, spotted ray (*Raja montagui*) and anglerfish (*Lophius budegassa/Lophius piscatorius*) have also been identified in the area of the Project and its export cable (Table 13.4). In addition, nursery grounds of spurdog are located in the vicinity of the Project approximately 8 km to the northwest.

[1] Ellis *et al.* (2012) provides the available field data which provides supporting evidence for the nominal nursery and spawning grounds identified. These grounds are mapped by rectangles (updated spawning ground layer based on half ICES statistical rectangles, with sites of higher importance noted for selected species), as the polygons provided by Coull *et al.* (1998) were often viewed as exact boundaries, despite the fact that there can be subtle shifts in the use of such grounds. Where possible, sites that may be of "greater" importance have been identified (high intensity), as indicated by a higher density of the relevant life-history stage (e.g. eggs, larvae and juveniles).

13.6.19 The distribution of the spawning and nursery grounds of the species listed in Table 13.4 together with further information on the relative importance of the area of the Project in terms of spawning/nursery grounds is included in the Technical Report 5.1.5.13 Fish and Shellfish Ecology.

Table 13.4: Species with spawning and nursery grounds within the Project and its vicinity, together with spawning times and intensity (Coull et al., 1998; Ellis et al., 2012)

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Nursery
Sole				*									
Plaice	*	*											
Cod		*	*										
Whiting													
Sandeels													
Sprat					*	*							n/a
Mackerel (Western)					*	*							
Thornback ray				*	*	*	*						
Spotted ray				?	*	*	*	?					
Tope shark	Viviparous species (gravid females can be found all year)												
Spurdog	Viviparous species (gravid females can be found all year)												●
Anglerfish	n/a												
Herring	n/a												

Colour/symbol key: (red) = high intensity spawning/nursery ground, (yellow) = low intensity spawning/nursery ground, (grey) = unknown spawning/nursery intensity, (*) = peak spawning, (n/a) = no overlap with spawning/nursery ground, (●) = nursery ground in vicinity

rectangles, with sites of higher importance noted for selected species), as the polygons provided by Coull *et al.* (1998) were often viewed as exact boundaries, despite the fact that there can be subtle shifts in the use of such grounds. Where possible, sites that may be of "greater" importance have been identified (high intensity), as indicated by a higher density of the relevant life-history stage (e.g. eggs, larvae and juveniles).

Species of conservation importance

Diadromous migratory species

13.6.20 A number of diadromous[2] species could potentially transit the study area during certain phases of their life cycles. These are listed in Table 13.5 below, together with their conservation status.

Table 13.5: Diadromous species of conservation importance (OSPAR, 2008)

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

Elasmobranchs

13.6.21 Sharks and rays have slow growth rates and low reproductive output compared to other species groups (Camhi *et al*., 1998). This results in slow rates of stock increase (Smith *et al*., 1998) and low resilience to fishing mortality (Holden, 1974). Directed fisheries have caused stock

[2] Diadromous: Migratory fish which migrate between the sea and fresh water.

collapse for many species (Musick, 2005), although mortality in mixed-species and by-catch fisheries seems to be a more significant threat (Bonfil, 1994). The principal elasmobranch species of conservation interest, potentially transiting or inhabiting areas relevant to the Project together with their conservation status are given in Table 13.6.

Table 13.6: Principal elasmobranch species with conservation status recorded in the Project area and its vicinity (MMO, 2011; Ellis et al., 2005; BMM 2011, a and b; OSPAR, 2008; The Wildlife & Countryside Act 1981; UKBAP, 2012)

Common Name	Latin Name				Conservation status		
					OSPAR List	The Wildlife & Countryside Act 1981	UK BAP species
Sharks							
Basking shark	*Cetorhinus maximus*	-	-	-	✓	✓	✓
Spurdog	*Squalus acanthias*	✓	✓	-	✓	-	✓
Tope	*Galeorhinus galeus*	✓	✓	-	-	-	✓
Skates and Rays							
Spotted ray	*Raja montagui*	✓	✓	✓	✓	-	-
Common skate complex[3] (flapper skate/blue skate)	*Dipturus intermedia/ Dipturus flossada*	-	-	-	✓	-	✓

13.6.22 It should be noted that the common skate complex (listed in Table 13.6 above) are now thought to be extirpated from large parts of their range, including habitats within the Mediterranean Sea, North Sea, Irish Sea and English Channel (Dulvy and Reynolds, 2002; Reynolds *et al*., 2005). The last remaining strongholds of the common skate complex include continental shelf edge habitat off the western coast of Scotland, the western waters of the Celtic Sea (Ellis *et al*., 2005), and along the Norwegian coast (Dolgov *et al*., 2005). Landing of these species has been banned within the European Union while species management plans are considered (Clarke, 2009).

[3] A recent study by Iglésias *et al.* (2010) has revealed that common skate actually comprises two species: Dipturus intermedia and Dipturus flossada. Common names already in use for these species are the flapper skate and blue skate respectively, although it remains to be seen if these become widely accepted (Iglésias *et al*., 2010; Shark Trust, 2009).

Other species of conservation interest

13.6.23 In addition to the diadromous migratory species and elasmobranchs mentioned above, there are a number of other fish species of conservation interest. The majority of these are commercially exploited in the wider area of the Project having been recorded in landings data (2001 to 2010) and/or during fish characterisation surveys within the study area. These are given in Table 13.7.

Table 13.7: Conservation status of fish species recorded in landings data (2001-2010) and/or during fish characterisation surveys within the study area (UK BAP, 2012; OSPAR, 2008)

Common Name	Latin Name	UK BAP Species	OSPAR List
Anglerfish	*Lophius piscatorius*	✓	-
Atlantic Halibut	*Hippoglossus hippoglossus*	✓	-
Cod	*Gadus morhua*	✓	✓
Hake	*Merluccius merluccius*	✓	-
Herring	*Clupea harengus*	✓	-
Horse mackerel	*Trachurus trachurus*	✓	-
Ling	*Molva molva*	✓	-
Mackerel	*Scomber scombrus*	✓	-
Plaice	*Peluronectes platessa*	✓	-
Raitt's Sandeel	*Ammodytes marinus*	✓	-
Roundnose Grenadier	*Coryphaenoides rupestris*	✓	-
Sole	*Solea solea*	✓	-
Whiting	*Merlangius merlangus*	✓	-

Prey species

13.6.24 Mid-trophic level species such as herring, sprat and sandeels, amongst others, play an important role in the Irish Sea's food-web. They are major predators of zooplankton and the principal prey of many top predators such as birds, marine mammals and piscivorous fish. In addition, whiting, especially juveniles, are an important prey for larger gadoids (including whiting itself) and other demersal fish (Hislop *et al*., 1991). They also constitute an important prey for a number of birds and marine mammals (ICES 2005a, ICES 2008).

Adult and juvenile fish characterisation surveys results

13.6.25 Site specific adult and juvenile fish characterisation surveys were conducted in May and September 2011 within the Project area and at adjacent control locations. Otter and beam trawl sampling was used to assess juvenile and adult fish populations within and in the immediate vicinity of the Project.

Otter trawl surveys

13.6.26 Demersal teleost species such as dab (*Limanda limanda*), plaice, flounder (*Platichthys flesus*), whiting and tub gurnard (*Trigla lucerna*) were the most abundant species caught during both surveys. The majority of dab, flounder and sole were above their set Minimum Landing Size (MLS), whilst most of the plaice were below their set MLS.

13.6.27 Thornback ray was the most abundant elasmobranch species caught during both surveys, followed by lesser spotted dogfish. Most thornback rays (>90%) were caught within the Project and below their set MLS. Other elasmobranch species, such as starry smoothhound (*Mustelus asterias*), spotted ray, blonde ray (*Bathyraja brachyurops*) and nursehound (*Scyliorhinus stellaris*) were also recorded. However, spotted ray, blonde ray and nursehound were only recorded in trawls carried out in September.

13.6.28 Pelagic species such as sprat and herring were also caught during the surveys. Sprat catches were highest in May, with the majority caught at a single station (OT09). High numbers of juvenile herring (1,850 individuals) were caught within the Project at station OT01 during the September survey.

Beam trawl surveys

13.6.29 Dab was the most abundant species caught during beam trawl surveys undertaken in May. Raitt's sandeel (*Ammodytes marinus*) and lesser sandeel (*Ammodytes tobianus*), were the second most abundant species caught in May, with the majority being caught at two control stations (BT08 and BT09). Solenette (*Buglossidium luteum*), plaice and whiting were also caught in high numbers, followed by scaldfish (*Arnoglossus laterna*), sand gobies (*Pomatoschistus minutus*) and lesser weever (*Echiichthys vipera*).

13.6.30 In September, whiting was the most abundant species caught during the survey, followed by dab, sand gobies, lesser weever, solenette, plaice and lesser sandeel. The majority of sandeels was caught at control stations.

Results of monitoring surveys undertaken in the existing Burbo Bank offshore wind farm (CMACS, 2010)

13.6.31 A 4 m beam trawl survey programme commenced in early May 2006 (before wind farm construction) following methodological agreement with the main statutory agency (Cefas). This survey collected baseline data describing the presence and abundance of demersal fish species within and around the existing Burbo Bank offshore wind farm during the pre-construction phase. The third survey (the first post-construction) took place in May 2008, and the fourth in June 2010 is the second post-construction survey after a gap in the monitoring in 2009 that was agreed with consultees. Results of the 2010 survey have been compared with pre-construction, during-construction and first pre-construction surveys in preceding years.

13.6.32 Despite some small scale effects it was concluded that, in general, the construction and operation of the wind farm has had no major impact on fish diversity or abundance (ES Annex '5.1.5.13.2').

Salmon and sea trout baseline ecology

13.6.33 The following section provides a summary of the baseline ecology of salmon and sea trout in the study area. Focus is directed at aspects of ecology and life history that have the potential to interact with the Project, as follows:

- Migration;
- Feeding Ecology; and
- Navigation and orientation.

13.6.34 There is limited information available on the migration and feeding of Atlantic salmon and sea trout, both in the context of the Irish Sea and on a river specific basis. Where available, information relating to stocks from the study rivers has been included. Such information is, however, relatively scarce and it has therefore been necessary to access the wider literature in order to establish common trends. Detailed information on all following sections can be found in the ES Annex '5.1.5.13.1'.

Salmon and sea trout life cycle overview

13.6.35 Atlantic salmon and sea trout are anadromous species of the family Salmonidae. Sea trout are anadromous brown trout and migratory and non-migratory forms are recognised as a single species. The mechanisms controlling anadromy in brown trout are not fully understood but involve both genetic and environmental components (Malcolm et al, 2010). The life cycles of salmon and sea trout are broadly similar with the exception of differences in the temporal scale of marine feeding migration. A more detailed description of salmon and sea trout life histories is provided in ES Annex '5.1.5.13.1'.

13.6.36 An overview of salmon and sea trout life history stage terminology is provided in Table 13.8 below.

Table 13.8 : Basic salmon and sea trout life-stage terminology (modified after Hendry and Cragg- Hine, 2003)

Developmental stage	Description
Alevin	From hatching to end of dependence on yolk sac for primary nutrition
Fry	From independence of yolk sac to end of first summer
Parr	From end of first summer to migration as smolt
Smoltification	Physiological and morphological processes which prepare salmon and sea trout for marine migration
Smolt	Fully silvered juvenile salmon or sea trout migrating to sea
Post - smolt	From river departure to middle of first winter in the sea (in sea trout the end of first sea winter)
Whitling	Immature sea trout returning to freshwater to overwinter after short period at sea

Table 13.8 : continued

Developmental stage	Description
1SW	Adult salmon or sea trout after first winter at sea. Sea trout may also be referred to as 'Maidens'
MSW	Adult salmon or sea trout after more than one winter in sea. Salmon commonly referred to as "spring" run fish when entering river before June
Kelt	Spawned adult salmon or sea trout

Migration

Atlantic salmon

Smolts and post-smolts

13.6.37 Smolting is size dependent (Potter & O' Maoileidigh, 2005) and parr that have not attained the size threshold may fail to undergo smolting despite the onset of environmental cues which stimulate the process (McCormick *et al.*, 1998).

13.6.38 Increases in temperature and water flow during spring often correlate with the initiation of smolt migration although the importance of each may vary between both river systems and years. In the River Conwy, migration of radio tagged smolts coincided with temperatures above 10°C (Moore *et al.*, 1995). Similar results have been observed in other rivers where a significant proportion of the variance in timing of the smolt run may be explained by temperature as opposed to flow rate (e.g. the River Test, UK; Moore *et al.*, 1998a; River Imsa, Norway; Jonssen and Ruud Hansen, 1985).

13.6.39 Tagging and radio telemetry of smolts indicates that seaward migration is mainly nocturnal in the freshwater and tidal reaches of rivers (Moore *et al.*, 1995; Aarestrup *et al.*, 2002). In estuaries, migration can occur throughout the diurnal cycle but may be slower during daylight hours (Moore *et al.*, 1995; 1998a). During this phase smolts have been recorded swimming in the upper layers of the water column with selective use of the ebbing tide to move seaward (Moore and Potter, 1994; Moore *et al.*, 1995; 1998a). Residence times in estuarine environments are generally short (e.g. in the order of hours or days) with smolts reported to move rapidly into the marine environment, typically at depths between 1 m and 6 m (Moore *et al.*, 1995; Lacroix and McCurdy, 1996; Marschall *et al.*, 1998; Davidsen *et al.*, 2008).

13.6.40 Selective timing of migration over the diurnal cycle may influence the levels of predation experienced by smolts which can be significant, particularly from avian sources (Larsson 1985; Kennedy and Greer, 1988; Moore *et al.*, 1995; Jepsen *et al.*, 1998; Ibbotson *et al.*, 2006). The timing of ocean entry is also critical as parameters such as temperature and prey availability influence early post-smolt growth and survival rates (Freidland *et al.*, 2000; 2009; Potter and Dare, 2003). Use of the ebbing tide for seaward migration may therefore be advantageous if it increases the speed of transit through the estuary ensuring that the optimum 'window' for ocean entry is met (Moore *et al.*, 1995; Klemetsen *et al.*, 2003).

13.6.41 Directed research examining migrations of post-smolts in the first months of oceanic feeding is scarce because salmon are relatively uncommon in the ocean and difficult to locate in areas outside directed fisheries (Shelton *et al.*, 1997; Haugland *et al.*, 2006). To date no research has examined the migration routes of post- smolts in the Irish Sea. In light of these limitations

it has not been possible to adequately define the migration routes of post-smolts leaving rivers in the study area with reference to the Project.

13.6.42 The timings of smolt runs in the Clwyd, Conwy and Dee have been identified through meetings with fisheries stakeholders and statutory bodies (see Section 13.3). Runs occur throughout late March to June. The timings of the runs in each river are provided in Table 13.9, below.

Table 13.9: Timing of river specific smolt runs defined at stakeholder meetings

River	Timing of Smolt Run
Conwy	May - June
Clwyd	April - May
Dee	Late March – early June, peak in May

Adult spawning migration

13.6.43 There is currently a lack of information relating to return migration routes of adult Atlantic salmon from their feeding grounds to inshore habitats of the Liverpool Bay area of the Irish Sea. In light of this limitation it has not been possible to make conclusive judgement on the position of the Project with respect to spawning migration routes. However, based on data provided by the Environment Agency, and information gathered through meetings with fisheries stakeholders, salmon could be expected to be in the vicinity of the Project between March to October. The number of fish potentially transiting the area is not possible to determine, although is likely to increase through spring and summer as the peak of river entry (August and September) is approached.

13.6.44 Swimming behaviour during homeward migration is reported as similar to that of outward post-smolt migration. It is an active, directed, process often occurring with the tide, close to the surface (1 m to 6 m in depth) with occasional dives between 20 m and 100 m (Hawkins *et al*., 1979; Sturlaugsson and Thorisson, 1997; Malcolm *et al*., 2010; Aas *et al*., 2011). Considerable distances can be covered over short time scales when homing to the natal stream, and swimming speeds between 50 km/day and 100km/day have been recorded (Hansen *et al*., 1993). Slower swimming speeds are observed in inshore areas, presumably relating to the search for the natal stream (e.g. 2.4 km/day to 43.2 km/day; Sturlaugsson and Thorisson, 1997).

13.6.45 A number of studies indicate that returning adults can migrate close to the shoreline (Hawkins *et al*., 1979; Smith *et al*., 1981; Sturlaugsson *et al*., 2009). In telemetry studies adults have been observed to utilise the near shore extensively during the final phases of migration and tracked individuals have been retrieved from commercial nets set close to shore (Sturlaugsson *et al*., 2009). Homing adults have also been observed entering non- natal rivers and estuaries while searching for natal streams in Iceland (Sturlaugsson and Thorisson, 1997) and similar behaviour has been observed in the Ribble Estuary (Priede *et al*., 1998). The tendency for salmon (and sea trout) to migrate close to the shoreline in the study area was reported during baseline information gathering meetings with fisheries stakeholders and statutory bodies.

13.6.46 Atlantic salmon can begin entering coastal home waters and natal rivers several months prior to spawning (Thorstad *et al*., 2008). Entry into larger estuaries (e.g. the Dee) can

occur throughout the diurnal and tidal cycles, although some selective use of the flooding tide may occur (ES Annex '5.1.5.13.1') River flow conditions play an important role in the control of upstream migration (Thorstad *et al*., 2008). A number of studies demonstrate the importance of freshets (periods of high flow) in stimulating spawning adults to enter rivers from the sea (Huntsman, 1948; Thorstad *et al*., 1998) and salmon may wait for substantial periods of time until flow conditions are optimal before river entry (Thorstad *et al*., 2008). Changes in hydrological regime may also have implications for the success of migration, as low flows make ascending physical obstructions such as weirs more difficult (APEM, 1998) and potentially increase the risk of predation (Thorstad *et al*., 2008).

Adult Atlantic salmon run timings in the study area

13.6.47 The run timings for adult salmon spawning in the Conwy, Clwyd and Dee were defined during meetings with statutory bodies and fisheries stakeholders (see Section 13.3). The majority of salmon enter the rivers between June and October, with the peak occurring in late summer to early autumn. The timing of runs for the Conwy, Clwyd and Dee are provided in Table 13.10.

Table 13.10: Timing of adult Atlantic salmon runs in the study area

River	Timing of adult Atlantic Salmon Run
Conwy	June - November
Clwyd	MSW, May – October. 1SW, June - October
Dee	MSW- occasional fish as early as January. Main run June - October. Peak August -September

13.6.48 Data collected from the Environment Agency fish trap allows for some quantification of the seasonal distribution of river entry for adult salmon on the Dee. Monthly run size estimates based on these data are presented in detail in the Technical Report of the ES Annex '5.1.5.13.1'.

Sea trout

Smolts and post-smolts

13.6.49 The environmental parameters initiating migration in sea trout are similar to those of Atlantic salmon; (with a number of studies identifying water temperature and flow rate as key determinants (Elliot 1975; Egglishaw and Shackley, 1977; Solomon, 1978).

13.6.50 The behaviour of sea trout smolts and post-smolts during seaward migration is potentially more variable than that of Atlantic salmon (Malcolm *et al*., 2010). This is due to a greater range of migratory strategies that include estuary residence, localised coastal movements, and long distance ocean migration (Kallilo-Nyberg *et al*., 2001; Solomon, 2007).

13.6.51 Despite these differences, which relate primarily to longer term migration, similarities are apparent during seaward migration. For example, during freshwater and estuarine phases movement is reported to occur mainly nocturnally, within the upper 10 m of the water column (Lyse *et al*., 1998; Moore *et al*., 1998b; Aarestrup *et al*., 2002). As with salmon smolts in the same river (Moore *et al*., 1995), tracking of sea trout smolts in the Conwy recorded selective use of the ebbing tide and short estuary residence times (Moore *et al*., 1998b).

13.6.52 Information gathered during meetings with statutory bodies and fisheries stakeholders indicates that the seasonal timing of sea trout smolt runs in the study area are broadly similar to those of Atlantic salmon (see Table 13.10), although the run may be initiated up to two weeks earlier.

Adult spawning migration

13.6.53 As previously discussed marine feeding migration in sea trout is less extensive than for salmon although patterns may vary both within and between populations (Kallilo-Nyberg *et al*., 2001; Solomon, 2007).

13.6.54 Research conducted in the Irish Sea under the CSTP indicates that most sea trout migration within the Irish Sea is relatively local, with a smaller number of tagged individuals recorded in Northern Irish waters (N. Milner, pers. comm.). Similar results are reported in telemetry and tagging experiments that have demonstrated that the majority of sea trout remain in relatively local coastal areas. A smaller proportion of the population may migrate distances in the order of hundreds of kilometres (Nall, 1935; Pratten and Shearer, 1983; Kallilo-Nyberg *et al*., 2001).

13.6.55 The duration and routes of homeward migration prior to freshwater entry are likely to vary according to migratory strategy. As with Atlantic salmon, sea trout returning to rivers to spawn may begin their freshwater migration several months prior to spawning (Klemetsen *et al*., 2003).

13.6.56 Radio telemetry of sea trout in the Afon Glaslyn (Wales) indicated rapid migration through the estuary and tidal reaches. Once fish had reached the confluences of the spawning tributaries they were observed to hold station for between 3 and 79 days (Le Cren, 1985). Movement in the earlier stages of migration is often directed and rapid (e.g. 3 km to 5 km each night: Le Cren, 1985; Armstrong and Herbert, 1997; Ovidio *et al*., 1998) slowing as the spawning areas are approached (Le Cren, 1985; Ovidio *et al*., 1998).

Sea trout run timings in the study area

13.6.57 During meetings with fisheries stakeholders and statutory bodies it was stated that the timing of the adult sea trout runs in the study rivers are broadly similar to adult salmon (see Table 13.10). However, as with smolts, the peak of the adult sea trout return migration tends to occur earlier than for salmon, typically during June and July.

13.6.58 Data collected from the Environment Agency fish trap allows for some quantification of the seasonal distribution of river entry for adult sea trout on the Dee. Monthly run size estimates based on these data are presented in detail in the Technical Report of the ES Annex' 5.1.5.13.1'.

13.6.59 As with Atlantic salmon, little information is available on the migration patterns of sea trout post-smolts and adults within the vicinity of the Project. Given the generally shorter scale migrations of sea trout it is considered likely that some components of the population may access the area of the Project during time spent feeding at sea and when returning to rivers to spawn.

Feeding ecology

13.6.60 There is currently a lack of information relating to the diets of Atlantic salmon and sea trout in the Irish Sea and UK waters in general. In light of this, a summary of the relevant literature is provided below.

Atlantic salmon

13.6.61 Prior to ocean migration Atlantic salmon smolts are reported to prey opportunistically on a variety of prey including freshwater and intertidal invertebrates, adult terrestrial insects, copepods, eauphausiids and fish larvae (Andreassen *et al*., 2001; Dutil and Coutu, 1988; Levings, 1994).

13.6.62 Following ocean entry juvenile fish represent an important dietary component of Atlantic salmon post–smolts (Shelton *et al*., 1997). Species such as herring and sand eel have been reported to occur frequently in the diets of post–smolts feeding in the North East Atlantic (Haugland *et al*., 2006).

13.6.63 Fish are also important in the diets of maturing Atlantic salmon adults, including, clupeids, gadoids and particularly sandeels (Fraser, 1987; Reddin, 1985; Hislop and Webb, 1992; Karlsson *et al*., 1999; Jacobsen & Hansen, 2001). Results from Fraser (1987) indicated that feeding ceased after a cut-off point during June and early July, as all salmon sampled after these months had not fed and yielded no prey items from stomach content analyses.

13.6.64 Seasonal differences in prey selectivity may also be apparent in Atlantic salmon diet. In the Baltic Sea, sprat were the principal prey species during the winter with herring and three spined stickleback (*Gasterosteus aculeatus*) becoming more important as the season progressed into spring (Karlsson *et al*., 1999).

Sea Trout

13.6.65 As with Atlantic salmon, the feeding ecology of sea trout varies in response to habitat, season, body size and age (Pemberton, 1976a; Fahy, 1985; Rikardsen *et al*., 2006).

13.6.66 The most marked differences between sea trout and Atlantic salmon diet is an increased occurrence of benthic prey such as polycheates and annelids (Pemberton, 1976b; Fahy, 1985; Rikardsen *et al*., 2006). Benthic crustaceans and annelids occurred frequently in the winter diet of Scottish sea trout (Pemberton, 1976b). Similarly, polycheates and crustaceans were a common feature in the stomachs of sea trout sampled during winter from two Norwegian fjords (Rikardsen *et al*., 2006). In fish of three sea ages (whitling, maiden and 2SW) captured from coastal waters of the Irish Sea molluscs were recorded in addition to polycheates and crustaceans (Fahy, 1987).

13.6.67 During the summer months, fish became a more important dietary component in both Scottish and Norwegian sea trout, characterised by the consumption of high numbers of juvenile herring, sprat and sandeel (Pemberton, 1976b; Rikardsen *et al*., 2006). In sea trout from the Irish sea, sprats and sandeel were also found to form an important component of the diet (Fahy, 1985), though this was primarily related to size rather than season. In all cases piscivory correlated positively with fork length with larger sea trout having consumed more fish than smaller conspecifics (Pemberton, 1976a; Fahy, 1985; Rikardsen *et al*., 2006). Preliminary data from the CSTP has also identified juvenile cluepids and sandeels are the principal prey species of sea trout in the Irish Sea (N. Milner, pers. comm.).

Salmon and sea trout feeding in the Liverpool Bay

13.6.68 As discussed previously, there is currently insufficient information available to determine the extent to which salmon and sea trout may utilise the area of the Project during marine feeding. In the literature cited above, species such as sprat, herring and sandeel were a common feature of salmon and sea trout diet both as post-smolts and adults.

13.6.69 The presence of these species in the vicinity of the Project (section 13.6.4 and the ES Annex '5.1.5.13.1') suggests the potential for use as a feeding ground during some life history stages. This may be particularly pertinent to sea trout, as recent research indicates that sandeels and cluepids are principal prey species in the Irish Sea. The benthic surveys indicated high annelid abundance in the vicinity of the Project (see ES Chapter 12 'Subtidal and Intertidal Benthic Ecology') which represents an additional potential prey resource for sea trout.

13.6.70 In addition to increased potential prey availability the limited migratory range of sea trout means it is possible that sea trout may make greater use of the Project area for feeding compared to salmon. The long distances associated with salmon migration suggest potential use of the area is less likely and would probably be temporally limited to periods spanning either outward and/or return migration (as post smolts and adults, respectively).

Salmon and sea trout navigation and orientation

13.6.71 Navigation and orientation at sea is probably the least well understood aspect of salmon and sea trout ecology. This is particularly true for Atlantic salmon which undertakes ocean migrations over extensive spatial and temporal scales yet exhibit fidelity to their natal streams with minimal stray to non natal rivers (Stabell, 1984).

13.6.72 Olfaction is believed particularly important for the precise homing needed to locate the natal river during the final stages of spawning migration (Stabell, 1984; Hansen *et al*., 1993; Sturlaugsson *et al*., 2009). However, the chemical cues involved in this phase of homeward migration (e.g. those that originate from the natal river) do not extend far enough in to the ocean to direct open sea migration (Lohmann *et al*., 2008a; 2008b). In light of this, other mechanisms must operate that facilitate navigation in the open ocean.

13.6.73 Salmon and sea trout are known to be responsive to magnetic fields (Formicki *et al*., 2004; Tanski *et al*., 2005; Formicki and Winnicki, 2009). Biomagnetic particles of a size suitable for magnetoreception are present in the lateral line of Atlantic salmon (Moore *et al*., 1990; Potter & Dare, 2003) and the species has been reported to respond to electric fields (Rommel and McLeave, 1973). It has been hypothesised that this geomagnetic capability is utilised to orientate to the earth's magnetic field during oceanic migration, with olfaction increasingly important during the final stages when locating the natal stream (Sturlaugsson *et al*., 2009; Lohmann *et al*., 2008a, 2008b; Hansen *et al*., 1993).

Key fish and shellfish receptors identified

13.6.74 The key fish and shellfish species considered for the purposes of the impact assessment are given in Table 13.11. These have been selected taking account of their ecological, commercial and conservation importance in the area of the Project. As previously mentioned, detailed information on the key fish and shellfish receptors identified is given in the ES Annex '5.1.5.13.2'.

Table 13.11: Key fish and shellfish receptors identified

Key Receptor Species			
Teleosts	**Elasmobranchs**	**Shellfish**	**Diadromous Species**
Sole	Basking shark	Scallops	Atlantic salmon
Plaice	Spotted ray	Cockle	Sea trout
Brill	Thornback ray	Mussel	River and sea lamprey
Turbot	Spurdog	Common whelk	Smelt
Cod	Tope	Lobsters and edible crab	Allis shad and twaite shad
Seabass		Brown shrimp	European eel
Herring			
Whiting			
Sandeel			
Sprat			

13.6.75 It should be noted that in the particular case of salmon and sea trout, the populations from the five main rivers located in the vicinity of the Project (See section 13.4, above) have been considered key receptors for assessment. It is however recognised that salmon and sea trout originating in other rivers may also potentially transit the area of the Project and the Export Cable. It should also be noted that both the baseline information and the assessment of impacts on salmon and sea trout is focused on the juvenile (smolt) and adult life stages. Where relevant, differentiation has been made between whitling and older sea trout, as the use they make of the area of the Project may be substantially different.

13.7 Key parameters for assessment

13.7.1 The assessment of impacts on fish and shellfish ecology has been undertaken taking into account relevant guidance and policies including:

- The NPS for Renewable Infrastructure (EN-3) (DECC, 2011);
- Cefas Guidance note for EIAs in respect of Food and Environment Protection Act (FEPA) and Coast Protection Act (CPA) Requirements for offshore wind farms (Cefas, 2004);
- IEEM's (Institute of Ecology and Environmental Management) guidelines for ecological impact assessment in Britain and Ireland (marine and coastal) (IEEM, 2010); and
- Highways Agency Design Manual for Roads and Bridges (DMRB, 2008).

13.7.2 The Rochdale Envelope (or Design Envelope) approach is being used in this chapter (as with other sections of the environmental statement), to ensure that the maximum adverse scenario/worst likely case scenario is assessed in relation to effects on the environmentally sensitive receptor which is in this case fish and shellfish. The potential impacts of the Project on fish and shellfish ecology have been assessed separately for the construction, operational and decommissioning phase. The potential impacts considered for the assessment on fish and shellfish ecology are given in Table 13.12.

Table 13.12: Potential impacts upon fish and shellfish from the Project

Construction
Temporary disturbance of the seabed
Underwater noise
Operation
Loss of habitat
Introduction of hard substrate
EMF's
Operational noise
Changes to fishing activity
Decommissioning
Temporary disturbance of the seabed
Underwater noise

13.7.3 Of the potential impact listed above, the following have been assessed separately for salmon and sea trout:

- Temporary disturbance of seabed;
- Underwater noise; and
- EMFs

13.7.4 The potential impacts assessed separately for salmon and sea trout, take account of the principal concerns in relation to the Project and export cable raised by salmon and sea trout fisheries stakeholders and statutory bodies during baseline information gathering, including the following consultation documents and meetings:

- MMO comments on draft salmon and sea trout ecology and fisheries technical report. 12.06.2012.
- Consultation with MMO, Cefas, CCW, Environment Agency (Wales), Natural England, Welsh Government Marine Consent Unit regarding potential noise impact on fish ecology (salmon and sole) 22.10.2012

- Consultation with Natural England, Environment Agency, Cefas regarding potential noise impact on salmon and sea trout (EIA and Habitats Regulations Assessments (HRA)) 21.11.2012

13.7.5 It is however recognised, that during the operational phase salmon and sea trout, likewise the remaining fish and shellfish receptors, may be subject to indirect impacts associated with loss of seabed, introduction of hard substrate and potential changes to commercial fishing activity. Similarly, they may also be subject to the potential impact of operational noise. These potential impacts are not considered salmon and sea trout specific and are therefore not discussed separately for these receptors. The assumption has been made that the assessment undertaken for fish in general, also applies to salmon and sea trout.

13.7.6 Cumulative impacts arising from multiple marine developments or multiple impacts from the Project on fish and shellfish ecology (including salmon and sea trout) are discussed separately in section 13.9.4.

Maximum adverse scenario

13.7.7 A likely maximum adverse scenario, taking account of the engineering parameters with potential to result in the greatest impact upon fish and shellfish resources (including salmon and sea trout) is described below.

13.7.8 In general terms it is considered that the installation of the maximum number of turbines (using 69 x 3.6 MW turbines) will constitute the maximum adverse scenario for all fish and shellfish receptors, as this would result in the greatest total footprint and number of construction related operations.

13.7.9 Further identification of the maximum adverse scenario based on more detailed parameters of wind farm design is complicated as it varies depending on the potential impact being considered. The likely maximum adverse scenarios for the construction, operational and decommissioning phase are presented in Table 13.13.

Table 13.13: Maximum adverse scenario considered for the assessment of potential impacts on fish and shellfish ecology.

Potential impact	Maximum adverse scenario	Justification
Construction phase		
Temporary disturbance of seabed in relation to increased suspended sediment concentrations (SSCs) and sediment re-deposition	• Dredging associated with seabed preparation for installation of gravity base structure (GBS) – both wind turbine generators (WTG) and offshore substation have 35 m diameter, total estimated seabed volume for WTG is 382,500 m^3 and offshore substation is 81,000 m^3);	Resulting in the greatest area impacted

Table 13.13: continued

Potential impact	Maximum adverse scenario	Justification
Construction phase		
	• Drilling to facilitate installation of monopile foundations, if required (maximum drill depth is 50 m based on a maximum 8 m wide monopile); and • Trenching by energetic means (e.g. jetting) as a result of inter-array cable burial and export cable burial activities.	
Noise from construction activities	Two worst case scenarios have been defined based on maximum construction noise and duration, respectively Single Steel Monopile Foundations (largest impact ranges) • Maximum number of foundations (69); • Maximum pile diameter (8 m); • Maximum hammer size (2,700 kJ); • Maximum simultaneous piling events (2); and • Number of monopiles installed in a 24 hour period (4). Jacket Foundations on Pin Piles (longest impact duration) • Maximum number of foundations (69); • Maximum pile diameter (3 m); • Maximum number of piles per foundation (4);	Resulting in the greatest area impacted by construction noise and maximum construction duration

Table 13.13: continued

Potential impact	Maximum adverse scenario	Justification
Construction phase		
	• Maximum hammer energy (1,500 kJ); • Maximum simultaneous piling events (2); and • Maximum number of pin piles installed in a 24 hours period (6).	
Operation phase		
Loss of seabed habitat and introduction of hard substrate habitat	Installation of 69 gravity base foundations and associated scour protection (15 m extent): • Total seabed loss of 0.229 km^2 (0.57% of Project area). • An offshore substation will add to these figures, but only minimally, since its maximum dimensions are 35 x 35 m. • Similarly, cable protection where required will further contribute to habitat loss (assumed to be a maximum of 10% of total cabling length)	Resulting in the greatest Project footprint on the seabed and associated habitat loss and introduction or hard substrate
EMFs	Installation of the following cabling: Inter-array cables (AC): • Maximum rating - 66 kV; and • Maximum total length - 65 km. Export cables (HVAC): • Maximum rating - 275 kV; • Maximum length approx. 29 km each cable; and	Resulting in the greatest area impacted

Table 13.13: continued

Potential impact	Maximum adverse scenario	Justification
Operation phase		
	• Maximum number of export cables - 2. Cables will be buried to a target depth of 2 m (+/ –1 m) with 10% of the export and inter-array cables assumed to be protected by rock dumping where target burial depth cannot be achieved.	
Operational noise	• Installation of 69 monopile turbines; and • 24 hours a day for operational wind turbines.	Resulting in the greatest area impacted and maximum duration
Changes to fishing activities	See ES Chapter 18 'Commercial Fisheries'	
Decommissioning phase		
Temporary disturbance of seabed in relation to increased SSCs and sediment re-deposition)	• Assumed to be decommissioning of maximum number of foundations - 69.	
Noise from decommissioning activities	• Assumed to be decommissioning of maximum number of foundations - 69	

13.8 Assessment criteria and assignment of significance

13.8.1 This section describes the criteria applied in this chapter to assign values to the sensitivity of receptors and the magnitude of potential impacts. Unless stated otherwise the values are those used in the DMBR methodology described in more detailed in ES Chapter 3 'Environmental Impact Assessment Process'.

13.8.2 The criteria for sensitivity used in this chapter are outlined in Table 13.14 below. The sensitivity of the receptor has been assigned taking account of the following:

- **Vulnerability** (depending on adaptability and tolerance) **and recoverability of the receptor** to the potential impact;
- **Timing of the impact**: referring to whether impacts are caused during critical life-stages or seasons (e.g. spawning season and migration); and
- **Value**: referring to conservation status of the receptor (e.g. protected to the European level and/or national level) and its importance in the area (e.g. species of importance as prey to other marine organisms and species of commercial importance).

- **Degree of receptor-impact interaction**, which considers both the ecology of the receptor (e.g. distribution range, location of spawning and nursery grounds and migration routes) and the spatial and temporal extent of the impact.

Table 13.14: Sensitivity Criteria used in this chapter

Sensitivity	Criteria used in this chapter
Negligible	Receptors with no defined spawning/nursery/feeding/overwintering grounds and/or migratory routes in the area of the development, which are not of conservation or commercial importance and not restricted in terms of habitat suitability/mobility, for which there may be a small or medium degree of interaction with the potential effect at the stock/population level.
Low	Receptors with spawning/nursery/feeding/overwintering grounds and/or migratory routes in the area of the development, which may be of conservation and commercial importance and/or restricted in terms of habitat suitability/mobility for which there will be a small degree of interaction with the potential effect at the stock/ population level.
Medium	Receptors with spawning/nursery/feeding/overwintering grounds and/or migratory routes in the area of the development, which may be of conservation and commercial importance and/or restricted in terms of habitat suitability/mobility, for which there will be a medium degree of interaction with the potential effect at the stock/ population level.
High	Receptors with spawning/nursery/feeding/overwintering grounds and/or migratory routes in the area of the development, which may be of conservation and commercial importance and/or restricted in terms of habitat suitability /mobility for which there will be a medium/ high degree of interaction with the potential effect at the stock/population level.
Very High	Receptors with spawning/nursery/feeding/overwintering grounds and/or migratory routes in the area of the development, which may be of conservation and commercial importance and/or restricted in terms of habitat suitability /mobility for which there will be a high degree of interaction with the potential effect at the stock/ population level.

13.8.3 The criteria for magnitude used in this chapter are outlined in Table 13.15 below. The magnitude of the impact has been assigned taking account of the following:

- **Geographical extent of the impact: referring to the full area over which the impact occurs;**
- **Duration of the impact**: referring to the duration over which the impact is expected to last;
- **Frequency of the impact**; and
- **Degree of change in relation to baseline levels.**

Table 13.15 Magnitude criteria used in this assessment

Magnitude of Impact	Definition
No Change	Very localised effects, of very short term duration, low or high frequency resulting in non-discernible changes to baseline levels.
Negligible	Very localised effects, of very short term duration, low or high frequency resulting in small or medium changes to baseline levels.
Minor	Localised effects, of short or long term duration, low or high frequency resulting in small changes relative to baseline levels; or
Effects occurring over larger areas but short term and low frequency resulting in small or medium changes to baseline levels.	Receptors with spawning/nursery/feeding/overwintering grounds and/or migratory routes in the area of the development, which may be of conservation and commercial importance and/or restricted in terms of habitat suitability /mobility for which there will be a medium/ high degree of interaction with the potential effect at the stock/population level.
Moderate	Effects occurring over large areas, short term and high frequency resulting in medium changes to baseline levels.
Major	Effects occurring over large areas, long term and high frequency resulting in medium to high changes to baseline levels.

13.8.4 Taking the magnitude of the impact and the sensitivity of the receptor, the significance of an impact is then defined as "neutral", "slight", "moderate", "large" or "very large". The matrix used to define significance in this assessment is given in Table 13.16. This is as set out in ES Chapter 3 'Environmental Impact Assessment Process'. Impacts assessed to be above slight (similar to a negligible rating in other chapters of the environmental statement) are significant in terms of EIA regulations and are considered of sufficient importance to call for consideration of mitigating (if moderate) or of changes to the Project (if large or very large) (DMRB, 2008). In addition to the significance ratings, whether the predicted impact is considered **beneficial** or **adverse** has also been described.

Table 13.16 Assessment matrix (DMRB, 2008)

		Magnitude of Impact				
		No change	**Negligible**	**Minor**	**Moderate**	**Major**
Environmental Sensitivity	**Very high**	Neutral	Slight	Moderate or large	Large or Very Large	Very Large
	High	Neutral	Slight	Slight or Moderate	Moderate or large	Large or Very Large
	Medium	Neutral	Neutral or Slight	Slight	Moderate	Moderate or large
	Low	Neutral	Neutral or Slight	Neutral or Slight	Slight	Slight or Moderate
	Negligible	Neutral	Neutral	Neutral or Slight	Neutral or Slight	Slight

13.8.5 The impact assessment given below is subject to a number of limitations as a result of the lack of current knowledge on the sensitivity of particular species/species groups to certain potential impacts. Where required, surrogates (similar species/species groups for which information is available), have been used to inform the assessment.

13.8.6 In addition, the limited information available to date in relation to some effects and species specific sensitivities make defining magnitudes of impact and identification of receptors and their sensitivity difficult. In those instances, the impact assessment has been based on a literature review of current knowledge of the particular impact and the receptors under consideration and on indirect evidence from monitoring studies carried out in operational wind farms, including the adjacent operational Burbo Bank offshore wind farm.

13.8.7 As a result of uncertainties in relation to the distribution of some fish and shellfish species and the use that they may make of the area of the Project and its export cable, conservative assumptions have had to be made in some instances. Where applied, these are detailed in the following sections.

13.8.8 In the particular case of salmon and sea trout the following assumptions have had to be made:

- Salmon and sea trout smolts transit the Project, or its vicinity, on their seaward migration;
- Adult salmon and sea trout transit the Project, or its vicinity, on their return migration; and
- Salmon (adults and smolts) and potentially with greater frequency, sea trout transit the Project as part of their foraging activity. This may be particularly pertinent with reference to whitling which undertake small scale estuarine migrations.

13.8.9 In addition, as a result of the limited information available on the movement of Atlantic salmon and sea trout in coastal areas (both in general and on a river specific basis) at the spatial resolution required in this assessment, probability ratings have been assigned to the assessed potential impacts. These are as defined in the IEEM Guidelines for Ecological Impact Assessment in Britain and Ireland, Marine and Coastal (IEEM, 2010). These are as follows:

- **Certain/near certain**: probability estimated at 95% or higher;
- **Probable**: probability estimated above 50% but below 95%;
- **Unlikely**: Probability estimated above 5% but less than 50%; and
- **Extremely unlikely**: Probability estimated at less than 5 %.

13.8.10 The probability ratings above provide an indication of the degree of confidence in the assessment by means of estimating the likelihood for an impact of the assigned significance to occur. This primarily takes account of the location of the rivers included for assessment relative to the Project and the potential for salmon and sea trout from these rivers to transit the area affected by each specific potential impact considered for assessment.

Mitigation measures adopted as part of the project

13.8.11 In order to minimise the potential effects of the Project on fish ecology, DONG Energy have committed to the following:

- The inter-array and export cables will be armoured and buried to a target depth of 2 m (+/– 1 m). A worst case scenario of 10% of inter-array and export cabling is assumed to be protected by rock dumping/matressing where target burial depth cannot be achieved.
- During construction, overnight working practices will be employed so that construction activities will be 24 hours, thus reducing the overall period of time for potential impacts to fish communities in the vicinity of the Project.
- Where pile driving activity is required, soft start procedures will be implemented. This involves reducing the piling hammer pressure and the subsequent sound level starting at a lower level, gradually increasing to full piling pressure. This enables fish in the area disturbed by the sound levels to move away from the piling before any adverse physiological impacts are caused. This method has been agreed with statutory consultees and implemented for other UK offshore wind farms. In addition, piling will be carried out for a maximum of 12 hours during a 24 hour period.

13.9 Assessment of significance

13.9.1 The methodology for determining the significance of an impact, and therefore the significance of an effect for EIA purposes, is discussed in ES Chapter 3 'Environmental Impact Assessment Process'. The assessment has been undertaken to identify whether any of the predicted interactions of the project with the marine environment during the Project phases (construction, operation or decommissioning) have the potential to impact fish and shellfish ecology (directly or indirectly), and also to determine the significance where this occurs.

Construction phase

13.9.2 The impacts of the construction of the Project have been assessed on fish and shellfish ecology (including salmon and sea trout) in the offshore study area. The environmental effects arising from the construction of the Project site are listed Table 13.13 above along with the Design Envelope criteria against which each construction phase impact has been assessed.

13.9.3 A description of the potential changes on fish and shellfish ecology receptors caused by each identified impact is given below. In general the environmental effects arising from the construction of the Project are temporary, as they occur during the construction phase and encompass the effects associated with turbine foundation and cable installation.

Temporary disturbance of the seabed

13.9.4 Construction activities, particularly dredging as part of bed preparation for installation of gravity base foundations, drilling to facilitate monopile installation (if required) and cable trenching by energetic means (e.g. jetting) will result in re-suspension and dispersion of sediment into the water column and subsequent re-deposition of sediment. The expected SSCs and sediment re-deposition associated with these activities are described in detail in ES Chapter 10 'MetOcean and Coastal Processes' and summarised below.

13.9.5 SSCs vary with proximity to the seabed, coastline and are also dependent upon meteorological conditions. It is considered that mean "normal" (non-surge/storm events) SSC background levels in The Project are in the range of 5 to 20 mg/l within surface waters, increasing to circa 150 mg/l near the seabed. During storm events SSCs are expected to increase to values in the order of hundreds of milligrams. These values increase inshore towards the Mersey and Dee estuaries, with SSCs in the Mersey estuary (at Sandon Dock) reaching values in the range of 30 to 450 mg/l near surface waters and 70 to 1,500 mg/l near the seabed.

13.9.6 Drilling and dredging for foundation installation within the Project is expected to result in an increase of SSCs in the order of hundreds of milligrams per litre, affecting an area 50 to 200 m downstream from where dredging/drilling is taking place for a non-continuous duration of approximately 12 to 48 hours. If multiple simultaneous operations occur, it is unlikely that significantly further elevated SSC values will be reached. In addition to foundation installation, cable burial is also expected to result in an increase in SSCs.

13.9.7 Monitoring undertaken in the operational Burbo Bank offshore wind farm, demonstrated that the local effect on suspended sediments over a relatively fine seabed sediment area (which is likely to represent close to a "maximum adverse" scenario for cable installation at the Project) was in the region of 250 to 300 mg/l within 200 m from the operation, falling to the measured baseline level (100 mg/l) by 700 m downstream. Considering the similarities between the operational Burbo Bank offshore wind farm and the Project in terms of bathymetry, sediments and likely cable burial methods, the increase in SSCs associated to cable burial in the area of The Project and its export cable is expected be of similar low levels (within the range of natural variability), localised and short term.

13.9.8 In light of the non-continuous, localised and short-term nature of the expected increases in SSCs, associated with both foundation installation and cable burial, the **magnitude** of the effect of **increased SSCs** is considered to be **minor**.

13.9.9 Subsequent to the increase in SSCs and the dispersion of sediments, re-deposition of sediments on the seabed will take place. Drilling and dredging will result in sediment being re-deposited at varying levels, depending on the type of sediment under consideration. The greatest accumulations are expected from sand and coarser sediments. This will typically be within the order of tens of metres but up to 260 m from each foundation. The deposition thickness will typically be less than 0.5 m. This is of a similar order of magnitude to the short-term natural variability in the seabed level observed in the adjacent operational wind farm site (0.3 to 0.4 m). Such deposits would therefore be rapidly incorporated into the local sedimentary environment. Larger thicknesses are also predicted in the shallowest locations; however, this is expected to be less than 1 m in all cases. Sediment re-deposition associated with cable burial, is similarly expected to be very localised and short-term. At the adjacent operational Burbo Bank offshore

wind farm no measurable surface signature of cable burial was apparent, approximately three months following the end of construction (ES Chapter 10 'MetOcean and Coastal Processes').

13.9.10 Taking the localised and short-term and non-continuous nature of sediment accumulation associated with both foundation installation and cable burial, **sediment re-deposition** is considered an impact of **minor magnitude**.

13.9.11 Further to indirect impacts through increased SSCs and sediment re-deposition, disturbance of the seabed associated with construction works may result in direct impacts on species of limited mobility (e.g. if unable to avoid construction machinery) and in a localised temporary loss of habitat (e.g. due to the physical presence of jack up vessel legs on the substrata). At a given time, only localised areas will however be disturbed and disturbance will be short term. Potential impacts associated with direct seabed disturbance and temporary loss of habitat during construction, have therefore been scoped out of the assessment on fish and shellfish resources. An assessment of the temporary impacts associated with direct seabed disturbance and temporary loss of habitat is provided in ES Chapter 12 'Subtidal and Intertidal Benthic Ecology'.

13.9.12 It should be noted that the particular case of salmon and sea trout, given their pelagic and highly mobile nature, the potential for sediment re-deposition, is not considered relevant for assessment. The assessment of the potential impacts of temporary disturbance of the seabed on salmon and sea trout is therefore only focused on potential impacts associated with increased SSCs.

Likely environmental effects without mitigation

Fish and shellfish

13.9.13 An assessment of the sensitivity of fish and shellfish receptors to the expected increased SSCs and sediment re-deposition and the likely significance of the effect is given below by receptor/receptor group.

Eggs and Larvae

13.9.14 Early life stages such as eggs and larvae are less tolerant to suspended sediments than adults, with larvae being generally considered to be more sensitive than eggs (Appleby and Scarratt, 1989). Being of limited mobility, eggs and larvae may not be able to avoid areas disturbed by increased SSCs as they passively drift through (if pelagic) or remain (if demersal) in areas where construction works are taking place.

13.9.15 The survival of pelagic eggs is dependent upon their ability to remain in the upper layers of the water column where abiotic[4] parameters such as oxygen concentration, are ideal for survival and development of eggs. The settlement of sediment particles might cause pelagic eggs to sink to deeper depths increasing the risk of oxygen deficiency. In addition, if eggs sink to the bottom, a high mortality may be expected primarily due to benthic predation or mechanical or physiological stress (Engell-Sørensen and Skyt, 2001).

13.9.16 Eggs and larvae of six species of anadromous and estuarine fish indigenous to the Chesapeake Bay (United States) were exposed to concentrations of suspended sediment ranging from a few mg/l to 1000 mg/l to determine the effects of different concentrations on hatching success and short term survival. The egg experiments indicated that concentrations of up to 1000 mg/l did not significantly affect the hatching success of yellow perch (*Perca flavescens*),

[4] Abiotic factor. Non-living physical and chemical attribute of a system, for example light, temperature, wind patterns, rocks, soil, pH, pressure, etc. in an environment.

blueback herring (*Alosa aestivalis*), alewife (*Alosa pseudoharengus*) or American shad (*Alosa sapidissima*) eggs. Concentrations of 1000 mg/l significantly reduced the hatching success of white perch (*Morone americana*) and striped bass (*Morone saxatilis*), but lower concentrations did not. Experiments with larvae indicated that concentrations of 500 mg/l significantly reduced the survival of striped bass and yellow perch larvae exposed for 48–96 hours. American shad larvae appeared to be less tolerant than the other two species tested. Concentrations of 100 mg/l significantly reduced the survival of shad larvae continuously exposed for 96 hours (Auld and Schubel, 1978). Messieh *et al*. (1981) were unable to detect any deleterious effect on herring eggs hatching at SSCs as high as 7,000 mg/l, whilst Griffin *et al*. (2009) suggest that the attachment of sediment particles on herring eggs may lead to retarded development and reduced larval survival rates at sediment concentrations as low as 250 mg/l. Sandeel eggs have an adhesive surface, and material released as a result of construction activities may stick to the eggs and thus reduce the diffusion of oxygen into the eggs, and potentially increasing mortality (Engell-Sørensen and Skyt, 2001).

13.9.17 In many species of fish, larvae use sight to locate prey. There is therefore potential for increased SSCs to result in disturbance to larval feeding. Larvae of species such as herring, plaice, sole, turbot, and cod sight their prey at a distance of only a few millimetres (Bone and Moore, 2008). Herring and plaice larvae, can survive for about a week without food when they are small and plaice can withstand starvation for as long as three weeks as they approach metamorphosis (Bone and Moore, 2008). Johnston and Wildish (1982) investigated the effect of increased levels of suspended sediment on the feeding rate of larval herring of different ages. Larval herring consumed significantly fewer food items at concentrations of 20 mg/l and smaller larvae were more affected by increased levels of suspended sediment than were larger larvae. Boehlert & Morgan (1985) found that maximum feeding incidence and intensity of Pacific herring larvae, which were exposed to suspensions of estuarine sediment and volcanic ash at concentrations ranging from 0 to 8000 mg/l, occurred at levels of suspension of either 500 mg/l for sediment or 1000 mg/l for volcanic ash. Feeding decreased at greater concentrations. It was suggested that suspensions may have enhanced feeding by providing visual contrast of prey items on the small perceptive scale used by the larvae. Boehlert & Morgan (1985) also suggested that larval residence in turbid environments such as estuaries may serve to reduce predation from larger visual planktivores, while searching ability in the small larval perceptive field is not decreased (Boehlert & Morgan, 1985).

13.9.18 In addition, as the water becomes more turbid fine silt may adhere to the gills of larvae and cause suffocation (De Groot, 1980). Rönnbäck and Westerberg (1996) found that yolk sac cod larvae had a higher mortality than cod eggs, when exposed to suspended sediment and suggested that this could be due to blocking of the gills of the yolk sac larvae.

13.9.19 As described in section: Species with spawning and nursery grounds, a number of fish species have defined spawning grounds in the area of the Project and its export cable, hence their eggs and larvae are may be present in areas where construction works are taking place and/or in their vicinity, and therefore be subject to the expected increased SSCs. The extent of their spawning grounds is however large (ES Annex '5.1.5.13.2') in comparison to the areas that may be affected by increased SSCs. The degree of interaction between eggs and larvae and increased SSCs may be from small to medium, subject to the timing of construction operations and the spawning periods of different species.

13.9.20 In addition to the above, eggs and larvae may be subject to smothering as a result of sediment re-deposition. This is of particular relevance for fish species potentially spawning in the area of the Project and its export cable which lay their eggs/egg cases on the seabed, such as sandeels, spotted ray and thornback ray and shellfish species, such as whelks. The spawning

grounds of these species are large in comparison to the localised areas where sediment re-deposition is expected to occur. The degree of interaction between eggs and sediment re-deposition may be from small to medium, subject to the timing of construction operations and the spawning periods of different species.

13.9.21 Taking the above into account **eggs and larvae** are considered receptors of **medium sensitivity**. As previously described the **magnitude** of the impact of **increased SSCs and sediment re-deposition** is deemed to be **minor**, the effect will, therefore, be of **slight adverse** significance, which is not significant in EIA terms.

Juvenile and Adult Fish

13.9.22 The effect of increased SSCs on juvenile and adult fish varies depending on anatomical parameters such as gill dimensions and on the size and shape of the sediment particles (Engell-Sørensen and Skyt, 2001; Appleby and Scarratt, 1989). Potential effects of suspended sediments on fish include the following:

- Clogging of gills;
- Abrasion of the body surface;
- Reduced sight;
- Avoidance; and/or
- Death.

13.9.23 In general terms, concentrations of suspended material have to be on the scale of milligram per litre (mg/l) to cause avoidance reactions in juvenile and adult fish. For lethal effects to occur, concentrations of suspended sediment have to be on the scale of grams per litre (g/l) (Engell-Sørensen and Skyt, 2001).

13.9.24 For assessment of effects of suspended concentrations, not only the level of SSCs to which an organism is exposed is of relevance but also the duration of the exposure time to a given concentration. Newcombe (1986) defined the intensity of suspended sediment concentrations as the product of concentration of suspended sediment multiplied by the duration (hours) of exposure of the organisms.

13.9.25 Although not all fish avoid turbid waters, elevated turbidity or levels of suspended solids often induce avoidance reactions and may modify natural movement and migration of fish (Kerr, 1995). The effect is expected to be limited to localised, temporary, intermittent and short term disturbance. The juvenile and adult fish present in the area of The Project and its export cable are likely to avoid localised areas where significant SSCs are reached and expected to move to adjacent undisturbed areas within their normal distribution range. Similarly, in the particular case of diadromous migratory species, there is potential for disturbance to occur during migration resulting in localised and short term avoidance reactions. The comparatively high "normal" (non-surge/storm events) SSC background levels present at the mouth of the estuaries in the vicinity of The Project (e.g. Dee and Mersey), and hence the likely increased tolerance of diadromous species to expected SSCs should be noted. In terms of sediment re-deposition, the majority of adult and juvenile fish (including diadromous migratory species) will be able to flee localised areas where sediment re-deposition is expected to occur, with potential for smothering being therefore unlikely to occur. Taking the mobility of adult and juvenile fish together with their wide distribution ranges the potential degree of interaction with increased SSCs will be small.

13.9.26 In light of the above, **adult and juvenile fish** are considered receptors of **low sensitivity**. As previously described, the **magnitude** of the impact is deemed to be **minor** and

the effect of increased SSCs and sediment re-deposition will, therefore, be of **neutral or slight adverse** significance, which is not significant in EIA terms.

Shellfish

13.9.27 The principal shellfish species present in the study area are either sedentary (e.g. cockles and mussels) or of limited mobility compared to most fish species (e.g. queen scallops, lobster and whelks). It is therefore likely that these will remain in areas disturbed by increased SSCs whilst construction works are taking place. In addition, they could be affected by smothering as a result of sediment re-deposition.

13.9.28 The largest single cause of mortality in invertebrates associated with sediments is attributable to the effects of sediment deposition, and not from suspended solids per se. The most obvious effect of deposited sediments is that of smothering non-motile species (Appleby and Scarratt, 1989). However, the ability of filter feeders (e.g. scallops, cockles and mussels) to feed may be affected by increased SSCs. Experiments carried out in New Zealand with the scallop *Pecten novaezelandiae* found, that for a period of time less than a week, this species coped with SSCs below 250 mg/l, whilst for periods greater than a week SSCs above 50 mg/l may have led to decreased growth (Nicholls *et al.*, 2003). Studies undertaken by Navarro and Widdows (1997) found a significant negative relationship between the clearance rate of C. *edule* and suspended sediment concentrations. Filtration rates increased until 300 mg/l at which filtration rates abruptly declined to very low values at 570 mg/l.

13.9.29 Commercially exploited scallop, mussel and cockle beds have not been identified within the area of The Project and its export cable (ES Chapter 18 'Commercial Fisheries'). Other shellfish species which may be present in the area, particularly edible crabs and lobsters, are expected to be more prevalent in other areas, for example, off Anglesey and the Great Orme (Lockwood, 2005; ES Chapter 18 'Commercial Fisheries'). The degree of interaction between shellfish species and increased SSCS and sediment re-deposition is therefore expected to be small.

13.9.30 Examples of the degree of sensitivity[5] to smothering, increased SSCs and displacement of relevant shellfish species for which the Marine Life Information Network (MarLIN) provides species specific information is given in Table 13.17 (MarLIN, 2012).

[5] The sensitivities provided are described by MarLIN. See http://www.marlin.ac.uk/sensitivityrationale.php for further information on rationale.

Table 13.17 Sensitivity to smothering, increased SSCs and displacement (Source: MarLIN, 2012)

Receptor		Smothering	Increased SSCs	Displacement
Common Name	Latin Name			
Cockle	*Cerastoderma edule*	Low	Not sensitive	Low
Mussel	*Mytilus edulis*	Low	Not sensitive	Low
King scallop	*Pecten maximus*	Low	Low	Not sensitive
Brown shrimp	*Crangon crangon*	Low	Not sensitive	Not sensitive
Edible crab	*Cancer pagurus*	Very Low	Low	Not sensitive
European spiny lobster	*Palimurus elephas*	No sensitive	Not sensitive	Not sensitive

13.9.31 Taking the above into account shellfish species are considered receptors of **low sensitivity**. As previously described the **magnitude** of the impact is deemed to be minor. The **effect** of **increased SSCs and sediment re-deposition** will, therefore, be of **neutral or slight adverse** significance, which is not significant in EIA terms.

Salmon and sea trout

13.9.32 A wide range of studies have assessed the effect of turbidity above natural background levels on the physiology and behaviour of salmonids. Research indicates that high levels of suspended sediment may be fatal while lower levels of suspended sediment and turbidity may cause chronic sub-lethal effects such as loss or reduction of foraging capability, reduced growth, resistance to disease, increased stress and interference with cues necessary for orientation in homing and migration (Bash and Bernman, 2001). It should be considered that the majority of these studies have been conducted in laboratory, as opposed to field settings and are based on early freshwater life stages rather than migratory phases in the marine environment.

13.9.33 Lethal levels of sediment in fish typically range from hundreds to thousands mg/l whilst sub-lethal effects may manifest at significantly lower levels, ranging from tens to hundreds mg/l depending on species specific tolerance (Birtwell, 1999). As previously noted in the fish and shellfish section above, not only the level of SSCs to which an organism is exposed is of relevance but also the duration of the exposure time to a given concentration.

13.9.34 Newcombe and MacDonald (1991) identified three main categories of effect of suspended sediment on salmonids as behavioural, sublethal and lethal.

- **Lethal effects** kill individual fish, cause overall population reductions, and damage the capacity of the system to produce future populations. This category includes reductions caused by sublethal or behavioural effects.
- **Sublethal effects** relate to tissue injury or alteration of the physiology of an organism.

Effects are chronic in nature and while not leading to immediate death, may produce mortalities and population decline over time.

- **Behavioural effects** are described by any effect that results in a change of activity usually associated with an organism in an undisturbed environment. These changes may lead to immediate death or population decline or mortality over time.

13.9.35 The potential for lethal/sublethal and behavioural (in terms of migration and feeding) effects to occur on salmon and sea trout are assessed separately in the following sections.

Lethal and Sublethal Effects

13.9.36 Salmonids are able to cope with some levels of turbidity at certain life stages (Gregory and Northcote, 1993); as evidenced by the presence of juvenile salmonids in turbid estuaries prior to starting their marine migration and in natal streams characterised by high natural turbidity (Gregory and Northcote, 1993). As indicated in ES Chapter 10 'MetOcean and Coastal Processes', background SSC levels around the Project and the export cable are comparatively higher at the mouth of the Dee and Mersey estuaries. It is therefore expected that salmon and sea trout entering and exiting rivers in the study area will, under normal circumstances, be exposed to relatively high SSCs. It should be noted that for the most part, the expected increases in SSCs fall within the natural range of variability in the area (see ES Chapter 10 'Metocean and Coastal Processes').

13.9.37 Adult and juvenile salmon and sea trout are highly mobile. In the marine environment, where not restricted by geographical features, they will be able to avoid the localised areas where the highest increased SSCs are reached. As a result, they would only be exposed to lethal/sublethal SSCs during very short periods of time resulting in a small degree of interaction between the impact and the receptors.

13.9.38 Taking the above into account salmon and sea trout (both smolts and adults) are considered receptors of **low sensitivity**. As previously mentioned, the **magnitude** of the impact is deemed to be **minor**. The effect of **increased SSC** will, therefore, be of **neutral or slight adverse** significance, which is not significant in EIA terms. This is considered to be the case for fish originating from the five rivers under consideration in this assessment, although it is recognised that fish originating in the **Clwyd, Dee and Mersey** will more likely be exposed to the expected increased SSCs given the proximity of these to the Project and Export cable. On this basis it is considered that the **neutral or slight adverse effect** is **probable** for fish originating in the **rivers Clwyd, Dee and Mersey**.

13.9.39 Salmon and sea trout originating from the **Conwy and Ribble**, would only encounter increased SSCs associated with construction works assuming they transit the area of the Project and the Export cable as part of their normal migration/foraging activity. They will not, however, be subject to increased SSCs immediately prior to or after leaving the rivers, both stages which are considered of key importance in the life cycle of salmonids (ES Annex '5.1.5.13.1' and references therein). The assessed effect of **neutral or slight adverse** significance is therefore considered to be **unlikely** in the case of fish originating in the **rivers Conwy and Ribble**.

Behavioural Effects

13.9.40 Although not all fish avoid turbid waters, elevated turbidity or levels of suspended solids often induce avoidance reactions and may modify natural movement and migration of fish (Kerr, 1995). Wilber and Clark's (2001) review of the biological responses of juvenile and adult salmonids to SSCs suggests for that levels of SSCs typically associated with dredging,

most responses in salmonids are behavioural as opposed to sub-lethal or lethal, with avoidance being a frequent response.

13.9.41 Avoidance reactions triggered in salmon and sea trout by increased SSCs in the proximity of the Project and the Export Cable may cause disturbance to migration and feeding. The potential effects on salmon and sea trout migration and feeding are separately discussed in the sections below for the five rivers included in this assessment.

Migration

13.9.42 **River Ribble and River Conwy**: Given the location of these rivers (at considerable distance from the Project and Export cable) the migration of salmon and sea trout smolts and adults will not be affected immediately prior to river entry or after leaving the rivers. Assuming fish originating in these rivers transit the Project and the export cable as part of their normal migration, there is however potential for localised short term disturbance to migration. If displaced, fish will be able to move to adjacent undisturbed areas. The degree of interaction between increased SSCs and salmon and sea trout from these rivers will therefore be small. **Salmon and sea trout (both smolts and adults)** originating in the Ribble and the Conwy are therefore considered receptors of **low sensitivity**. As previously mentioned, the magnitude of the impact is deemed to be minor. The effect of **increased SSCs** will, therefore, be of **neutral or slight adverse** significance, which is not significant in EIA terms. Taking the distance from these rivers to the Project and export cable, the assessed effect is considered to be **unlikely**.

13.9.43 **River Dee and River Mersey**: Given the location of the rivers in relation to the Project it is considered that there is potential for salmon and sea trout adults and smolts to be disturbed during migration immediately prior to river entry and after leaving natal rivers. In the particular case of these rivers, given the tendency for whitling to undertake only local estuarine migrations, they may be disturbed during migration. The degree of interaction between these receptors and the potential impact will therefore be from small to medium, subject to the timing of construction works and degree of overlap with the movement of the receptors. Taking this into account, **salmon and sea trout (including both smolts and adults and, in the case of sea trout, whitling)** originating in the River Dee and the River Mersey are considered receptors of **medium sensitivity**. As previously described, the **magnitude** of the impact is deemed to be **minor**. The effect of **increased SSCs** on their migration will, therefore, be of **slight and adverse** significance, which is not significant in EIA terms. Given the proximity of the Project to these rivers, the assessed effect is considered to be **probable**.

13.9.44 **River Clwyd**: The River Clwyd is in the vicinity of the proposed export cable landfall, there is therefore potential for increased SSCs associated with cable installation activities to disturb salmon and sea trout adults and smolts originating from this river prior to river entry and immediately after exit. It should be noted, however, that this would only be the case whilst cable installation takes place along a small section of the cable in the proximity to the river mouth. In addition, fish originating in this river may be disturbed during their seaward and return migrations assuming they transit the area of the Project as part of their normal migration. The degree of interaction between these receptors and the potential impact will therefore be from small to medium, subject to the timing of construction works and degree of overlap with the movement of the receptors. Taking the above into account, **salmon and sea trout (both smolts and adults)** originating in the Clwyd are considered receptors of medium sensitivity. As previously described, the magnitude of the impact is deemed to be **minor**. The effect of increased SSCs will, therefore, be of **slight adverse** significance, which is not significant in EIA terms. Given the relative proximity of the Clwyd to the Project and the Export Cable, the assessed effect is considered **probable**.

Feeding

13.9.45 Increased turbidity may reduce visual acuity, potentially decreasing foraging rates (Barrett et al, 1992) and can increase vulnerability to predation if avoidance reactions are reduced (Gregory, 1993; Robertson et al, 2007). Research examining the behaviour of juvenile Atlantic salmon has found that initial introduction of sediment (20 mg/l) increases foraging activity, however this subsequently declined at sediment levels greater than 180 mg/l (Robertson et al, 2007). Short term pulses of suspended sediment have been shown to disrupt feeding behaviour in juvenile coho salmon and elicit alarm reactions that may cause fish to relocate downstream to undisturbed areas (Berg and Northcote, 1985). In contrast, increased SSCs can also have the opposite effect, reducing the risk of predation and increasing foraging rates as has been demonstrated in both coho salmon (*Onchyrnchus tshawytscha*; Gregory and Northcote, 1993) and Atlantic salmon (Robertson *et al*, 2007). Similarly, Gregory and Levings (1998) suggest that seaward migrating pacific salmon are less likely to encounter and be consumed by piscivorous fish in turbid water than in clear water.

13.9.46 As described in the ES Annex '5.1.5.13.1', species of importance as prey to salmon and sea trout in the marine environment such as sandeels, herring and sprat have wide distribution ranges. Benthic invertebrates such as polychaetes and crustaceans represent a potential prey source to sea trout and have also been demonstrated to have high abundance and wide distribution ranges (see ES Chapter 12 'Subtidal and Intertidal Benthic Ecology'). Salmon and sea trout, if disturbed during feeding as a result of increased SSCs, will find alternative equally suitable feeding grounds in adjacent locations. It should be noted in this context that no significant impacts (above neutral or slight) on important prey species to salmon and sea trout (e.g. sandeels, sprat and herring) associated with the construction, operational and decommissioning phase of the Project have been identified (Table 13.26). The degree of interaction between the receptors and the impact is therefore considered to be small. In light of the above, **salmon and sea trout (including smolts, adults and whitling)** are considered receptors of **low sensitivity**. As previously described, the **magnitude** of the impact is deemed to be **minor**. The effect will, therefore, be of **neutral or slight adverse** significance which is not considered significant in EIA terms.

13.9.47 Given the relative proximity of the five rivers to the Project and Export Cable and the migratory nature of these species it is considered that the assessed adverse and neutral or slight effect is **probable** for the salmon and sea trout populations of all the rivers under assessment.

Construction noise

13.9.48 There are a number of wind farm construction related activities which generate underwater noise, including suction dredging, drilling, impact piling, cable laying, rock dumping, trenching, vessel noise and vibropiling. As described in Chapter 11 'Offshore Noise', piling is the construction related activity with potential to result in the most detrimental effect on fish with other activities resulting in comparatively negligible impact ranges. The impact assessment for construction noise is therefore focused on this noise generating activity.

13.9.49 In order to assess the magnitude of the impact of piling, modelling was undertaken using the dB_{ht} (Species) metric which allows impact ranges to be defined taking account of species specific sensitivities. Noise modelling was undertaken for dab, salmon, cod, and herring, species for which there is detailed information on their hearing ability and that represent different ranges of hearing capabilities and sensitivities to noise. For those species for which noise modelling was not undertaken and surrogates not defined, the magnitude of behavioural impacts associated with construction noise has been defined by approximation, using the

outputs of the noise modelling undertaken for the modelled species and taking account of their potential hearing ability.

13.9.50 Different fish species have different auditory capabilities due to the diversity in hearing structures. For classification purposes the terms hearing specialist and hearing generalist are commonly used. This classification is independent of taxonomic grouping but based on a species' hearing capability. Hearing specialists have specialised coupling mechanisms between the swim bladder and the inner ear. As a result they have high sound pressure sensitivities and low hearing thresholds when compared to generalists. Generalists hear primarily via the direct pathway (that is particle motion via the otoliths) and have relatively poor sensitivity. Hearing generalists may be further divided into those species lacking swim bladders and those species possessing a swim bladder but lacking specialised coupling mechanisms (Thomsen *et al.*, 2006).

13.9.51 A summary of the hearing specialisation of the fish species for which modelling was undertaken is given below:

- **Dab** does not possess a swim bladder and is generally chosen in order to represent other fish species of low sensitivity to noise. For the purposes of this assessment dab has therefore been used as a **surrogate for flatfish species including sole, plaice, flounder, brill and turbot** (ES Chapter 11 'Offshore Noise').
- **Atlantic salmon** possess a swim bladder, which is not always completely filled. Hawkins and Johnstone (1978) concluded that the swim bladder plays no part in hearing of the species. For the purposes of this assessment salmon has been used as a (conservative) **surrogate for sea trout** (ES Chapter 11 'Offshore Noise').
- **Cod** has a gas-filled swim bladder. Although, there is no direct connection between the swim bladder and the ear, the anterior of the swim bladder is in close proximity to the inner ear. This species is therefore considered to be more sensitive to sound than dab. For the purposes of this assessment cod has been used as a **surrogate for elasmobranchs** (ES Chapter 11 'Offshore Noise').
- **Herring**, like all members of the order Clupeiformes, has a swim bladder and inner ear structures which are responsible for the species' increased hearing capabilities. Structural specialisations include an extension of the swim bladder which terminates within the inner ear.

13.9.52 The criteria for assessment of noise impacts on fish (including salmon and sea trout), is summarised in Table 13.18 below.

Table 13.18: Assessment criteria used to assess the potential behavioural impact of underwater noise on marine species (ES Chapter 11 'Offshore Noise')

Level dB_{ht} (Species)	Effect
>75 dB_{ht}	Significant avoidance. At this level about 85% of individuals will react to the noise, although the effect will probably be limited by habituation
≥90 dB_{ht}	Strong avoidance reaction by virtually all individuals
>110 dB_{ht}	Tolerance limit of sound; unbearably loud
>130 dB_{ht}	Possibility of traumatic hearing damage from single event

13.9.53 As mentioned in Table 13.13, two maximum adverse scenarios have been taken into account for assessment of construction noise:

- Installation of 69, 8 m diameter monopiles: this will result in the largest spatial effect by a single piling operation as the hammer energy required (2,700 kJ) is significantly greater than that required for installation of pin piles. The total piling duration associated with installation of monopile foundations is estimated at 34.5 days taking account of a total of 69 piling events.
- Installation of 69 jacket foundations on 3 m diameter pin piles: This will result in the highest potential total number of piling events (276), as each jacket foundation may be supported by up to 4 piles. The total piling duration is estimated to be 92 days. It should be noted, however, that the hammer energy required for installation of 3 m diameter piles (1,500 kJ) will result in substantially smaller noise impact ranges associated with each piling event in comparison to those expected for piling of 8 m monopiles.

13.9.54 It should be noted that in both cases piling will only be undertaken during a maximum of 12 hours in any 24 hour period.

13.9.55 Three positions were modelled to account for different propagation ranges that would be expected from these positions:

- One to the north-west of the Project construction area;
- One to the south-east of the Project construction area; and
- One to the south-west of the Project construction area.

13.9.56 In addition, locations at a distance of 1,500 m have been modelled for each location described above. It should be noted that simultaneous piling occurring in adjacent locations will result in only slightly larger sea areas being affected by construction noise, whilst reducing the total piling duration (see Figure 13.3 to Figure 13.28).

13.9.57 Taking the outputs of the modelling, the assessment of the effect of construction noise has been assessed in term of lethal effects and traumatic hearing damage and behavioural effects.

13.9.58 Given that the spatial magnitude of the impact varies depending on the species under consideration (using the dB_{ht} (Species) metric), the magnitude of noise impacts has, where possible, been defined on a species specific basis. In the particular case of shellfish, given

the lack of current knowledge on their hearing ability, the conservative approach has been taken that the magnitude of impact assigned to fish receptors may also apply to shellfish species.

Magnitude of Lethal and Traumatic Hearing Impacts

Adult and Juvenile Fish

13.9.59 The ranges at which lethal effects and physical injury are expected in marine species are given in Table 13.19. The impact ranges at the 130 dB_{ht} (Species) level (corresponding to the onset level for traumatic hearing damage) for the fish species modelled, are shown in Table 13.20 (ES Chapter 11 'Offshore Noise'). As it can be seen, lethal effects, physical injury and traumatic hearing damage are only expected to occur in the immediate vicinity of where piling is taking place.

Table 13.19 Summary of maximum ranges out to which lethal effect and physical injury are expected to occur in marine species using the 240 and 220 dB criteria for a 3 and 8 m diameter piles

Modelled Location	Range to 240 dB re. 1 µPa (Lethal Effect) (m)		Range to 220 dB re. 1 µPa (Physical Injury) (m)	
	3 m Pile	8 m Pile	3 m Pile	8 m Pile
South East	2	4	47	75
South West	2	4	50	80
North West	2	4	50	80

Table 13.20 Summary of the maximum ranges out to which traumatic hearing damage are expected to occur in marine species using the 130dBht (Species) criteria for 3 and 8 m diameter piles

Species	Range to 130dB_{ht} (m)					
	South East Position		South West Position		North West Position	
	3 m Pile	8 m Pile	3 m Pile	8 m Pile	3 m Pile	8 m Pile
Dab	30	60	40	70	40	70
Salmon	20	40	20	40	20	40
Cod	140	420	170	540	170	550
Herring	250	510	290	610	290	620

13.9.60 Taking the impact ranges identified in Table 13.19 and Table 13.20, any effect is expected to be very localised. As previously mentioned in section 13.8.1, where pile driving activity is required, soft start procedures will be implemented. This involves reducing the piling hammer pressure and the subsequent sound level starting at a lower level, gradually increasing to full piling pressure. This enables fish in the area disturbed by the sound levels to move away from the piling before any adverse physiological impacts are caused. Furthermore, the temporary, intermittent and short term nature of piling activity should be noted in this context. Taking the above into account the **magnitude** of lethal/injury noise related impacts is considered to be **negligible**, for both the 3 m pin pile and 8 m monopile maximum adverse scenarios.

Shellfish

13.9.61 As previously mentioned, it has been assumed that the magnitude of impact assigned to fish species also applies to shellfish species. The **magnitude** of the impact is therefore considered to be **negligible** for both the 3 m pin pile and 8 m monopile maximum adverse scenarios.

Early life stages of limited mobility

13.9.62 In the particular case of life stages of limited mobility, such as eggs and larvae, there is a lack of current knowledge for precise impact ranges and hence magnitude of the impact of lethal effects to be defined. Research has however been recently carried out by the Dutch Institute for Marine Resources and Ecosystem Studies (IMARES) (Bolle *et al.*, 2011). Bolle *et al.* (2011) found no significant effects in sole larvae at the highest exposure level (cumulative SEL= 206 dB re 1μPa2s) which represented 100 pulses at a distance of 100 m from piling. Based on these findings, it has been suggested that the assumption of 100% of larvae mortality within a radius of 1000 m around a piling site (used in the Appropriate Assessment of Dutch offshore wind farms) is too conservative. It is recognised that these results, based on sole larvae, should not be extrapolated to fish larvae in general as inter-specific differences in vulnerability to sound exposure may exist. In addition, it should be noted that this study was focused on the potential lethal effects of sound exposure and not on any physiological, behavioural or morphological effects or on determining the likelihood of survival in the long term.

13.9.63 Taking the uncertainty in relation to the exact ranges at which lethal impacts may occur on early life stages, together with the temporary, intermittent and short term nature of piling the magnitude of impact is considered to be minor.

Magnitude of Behavioural Impacts

13.9.64 A comparative indication of the expected 90 and 75 dB_{ht} (Species) noise impact ranges for the species modelled is given in ES Chapter 11 'Offshore Noise', Dab and salmon are expected to exhibit strong avoidance reactions only in proximity to the foundations, whilst cod and herring are expected to avoid wider areas.

13.9.65 The main focus of the assessment of behavioural impacts relates to the outputs of the noise modelling undertaken at the 90 dB_{ht} (Species) level as it is at this level that strong avoidance by virtually all individuals is expected to occur. Consideration has however also been given to the 75 dB_{ht} (Species) level at which milder behavioural responses are expected.

13.9.66 Taking the expected noise impact ranges associated with piling of both 8 m monopile and 3 m pin piles but also considering the substantial difference in terms of the total duration of piling associated with each scenario, it is considered that the magnitude of the impact will remain consistent for both scenarios. The magnitude of the impact has been defined taking both the expected impact ranges and total duration of piling together with the short term and

intermittent nature of piling. This is described below for individual receptors/receptor groups.

13.9.67 For species for which modelling was undertaken the magnitude of noise behavioural impacts has been defined as follows:

- **Dab** (surrogate for flatfish species): The magnitude of the impact is considered to be **minor**;
- **Salmon** (surrogate for sea trout): The magnitude of the impact is considered to be **minor**.
- **Cod** (surrogate for elasmobranchs): The magnitude of the impact is considered to be **moderate**; and
- **Herring**: The magnitude of the impact is considered to be **moderate**.

13.9.68 For those species for which noise modelling was not undertaken and surrogates have not been defined in ES Chapter 11 'Offshore Noise', the magnitude of behavioural impacts associated with construction noise has been defined by approximation, using the outputs of the noise modelling undertaken for the modelled species and taking account of their potential hearing ability. It should be noted that data on hearing ability exists for a limited number of species and extrapolation of hearing capabilities between different species, and especially those that are taxonomically distant, should be undertaken with the greatest caution (Hastings and Popper, 2005). The limitations and the qualitative nature of the noise assessment for species which have not been modelled should therefore be recognised and be taken only as an indication of potential impacts.

- For species which lack a swim bladder; namely **sandeels, river lamprey and sea lamprey**, the magnitude of the impact is considered to be similar to that assigned to the noise contours for dab (**minor**);
- For species with a swim bladder but no connection to the ear, namely **smelt, seabass and European eel**, the magnitude of impact may be between that assigned to the noise contours of dab (minor) and cod (**moderate**);
- For species with a connection between the swim bladder and the ear such as **shad and sprat**, the potential magnitude of impact may be similar to that assigned to the noise contours for herring (**moderate**). In addition, a precautionary approach was taken in the case of **whiting**, which considers the magnitude of impact similar to that assigned to herring (**moderate**); and
- In the particular case of shellfish species, as previously mentioned, the conservative approach has been taken which assumes that the magnitude of the impact of noise defined for fish species also applies. The magnitude of the impact for **shellfish** species is therefore considered to be from **minor to moderate**.

Likely environmental effects without mitigation

Fish and Shellfish

Lethal and Traumatic Hearing Effects

Juvenile and adult fish

13.9.69 Juvenile and adult fish are expected to be able to flee the areas where the highest noise levels are reached. In addition, soft start piling will be used with the aim that fish leave the areas in the proximity of the foundations before the highest noise levels are reached. In the particular case of adult and juvenile fish, this will minimise the potential for fish to be

exposed to the highest noise levels. Being mobile, the degree of interaction between adult and juvenile fish with the potential impact, is considered to be small. **Juvenile and adult fish** are therefore considered receptors of **low sensitivity**. As previously described, the **magnitude** of the impact is deemed to be negligible. The effect of construction noise in terms of lethal and traumatic hearing effects will, therefore, be of **neutral or slight adverse** significance, which is not significant in EIA terms.

Life stages of limited mobility

13.9.70 Life stages of limited mobility such as eggs, larvae and glass eels will not be able to avoid areas where the highest noise levels are reached during construction, assuming they drift with currents through the area of the Project whilst piling activities are taking place.

13.9.71 Taking account of the uncertainty in relation to the exact spatial extent of lethal effects on early life stages associated with construction, the degree of interaction between the impact and the receptor is considered to be small to medium. The relative large areas over which fish eggs and larvae distribute should however be noted in this context (see ES Annex '5.1.5.13.2'). Taking the above into account **early life stages of limited mobility** are considered receptors of **medium sensitivity**. As previously described, the **magnitude** of the impact is deemed to be **minor**. The **effect** of construction noise in terms of lethal and traumatic hearing effects will, therefore, be of **slight adverse** significance, which is not significant in EIA terms.

Shellfish

13.9.72 The hearing mechanism of invertebrate species is currently not well understood. They are generally assumed to be less sensitive to noise than fish due to the lack of a swim bladder. Recent studies, however, have found that species such as the shrimp (*Palaemus serratus*) and the longfin squid (*Loligo pealeii*) are sensitive to acoustic stimuli and it has been suggested that these species may be able to detect sound similarly to most fish, via their statocysts (Lovell *et al*., 2005; Mooney *et al*., 2010).

13.9.73 Crabs and lobsters are expected to be present in areas relevant to the Project in relatively low numbers being more prevalent off Anglesey and Great Orme. Cockle, mussel and scallop beds are located off the Wirral Peninsula and not within The Project. Potting for whelks takes place year round within the 6 nm limit with the majority of activity occurring in rectangle 35E6 (ES Chapter 18 'Commercial Fisheries'). Taking the above into account, together with the short term and intermittent nature of piling activity the degree of interaction between shellfish species and the impact is expected to be small. In light of the above, **shellfish** are considered receptors of **low sensitivity**. As previously described, the **magnitude** of the impact is deemed to be **negligible**. The effect will, therefore, be of **neutral or slight adverse** significance, which is not significant in EIA terms.

Behavioural Effects

Juvenile and Adult Fish

Sole

13.9.74 The western section of The Project falls within high intensity sole spawning grounds, whilst the eastern section overlaps low intensity spawning grounds. In addition, high intensity sole nursery grounds overlap with the Project (see Figure 13.3 and Figure 13.4). Areas of high intensity spawning may be disturbed at the 90 dB_{ht} (*Limanda limanda*) level, principally whilst piling operations take place at locations in the western section of the Project. The overall spawning and nursery grounds of sole in the Irish Sea are large in comparison to the areas

which may be impacted at the 90 dB_{ht} (*Limanda limanda*) level. High concentrations of sole eggs have however been recorded in the western section of the Project and to the north and west of it (Figure 13.3 and Figure 13.4). In addition, as indicated in ES Chapter 18 'Commercial Fisheries', sole is one of the main target species in the area of the Project where it is caught by a seasonal beam trawl fishery during the spring. Sole is also of conservation interest, being listed as a UK BAP species. Whilst the intermittent and short nature of piling is recognised, assuming piling takes place during the peak spawning period of sole the degree of interaction between the impact and the receptor is considered to be very high.

13.9.75 Taking the above into account, **sole** is considered a receptor of **very high sensitivity**. As previously described, the **magnitude** of the impact is deemed to be **minor**. The effect will, therefore, be of **moderate or large adverse** significance which is significant in EIA terms.

Plaice

13.9.76 The Project falls within low intensity plaice spawning and nursery grounds (Ellis *et al*., 2012). Plaice is commercially exploited within the Project and its vicinity and is listed as a UK BAP species. The extent of the 90 dB_{ht} (*Limanda limanda*) impact ranges is however small compared to the overall distribution of plaice spawning and nursery grounds in the Irish Sea. In addition, the highest egg concentrations have been recorded to the west of the Project, outside areas potentially impacted by the 90 dB_{ht} (*Limanda limanda*) level (Figure 13.5 and Figure 13.6). Taking the above into account together with the short term and intermittent nature of piling activity, the degree of interaction between the impact and the receptor is expected to be small.

13.9.77 In light of the above, plaice is considered a receptor of **low sensitivity**. As previously described, the **magnitude** of the impact is deemed to be minor. The effect will therefore be of **neutral or slight adverse** significance, which is not significant in EIA terms.

Other flatfish species

13.9.78 Flatfish species such as flounder, turbot and brill are all known to be present within the Project. Of these, turbot and brill are commercially targeted within the Project and its vicinity. The distribution of spawning and nursery grounds has not yet been defined for these species. The extent of the 90 dB_{ht} (*Limanda limanda*) impact ranges are however small in comparison to the distribution of these species. Taking the above into account, together with the short term and intermittent nature of piling activity, the degree of interaction between the impact and the receptors, is excepted to be small. **Flat fish species** are considered receptors of **low sensitivity**. As previously described, the **magnitude** of the impact is deemed to be **minor**. The effect will, therefore, be of **neutral or slight adverse** significance, which is not significant in EIA terms.

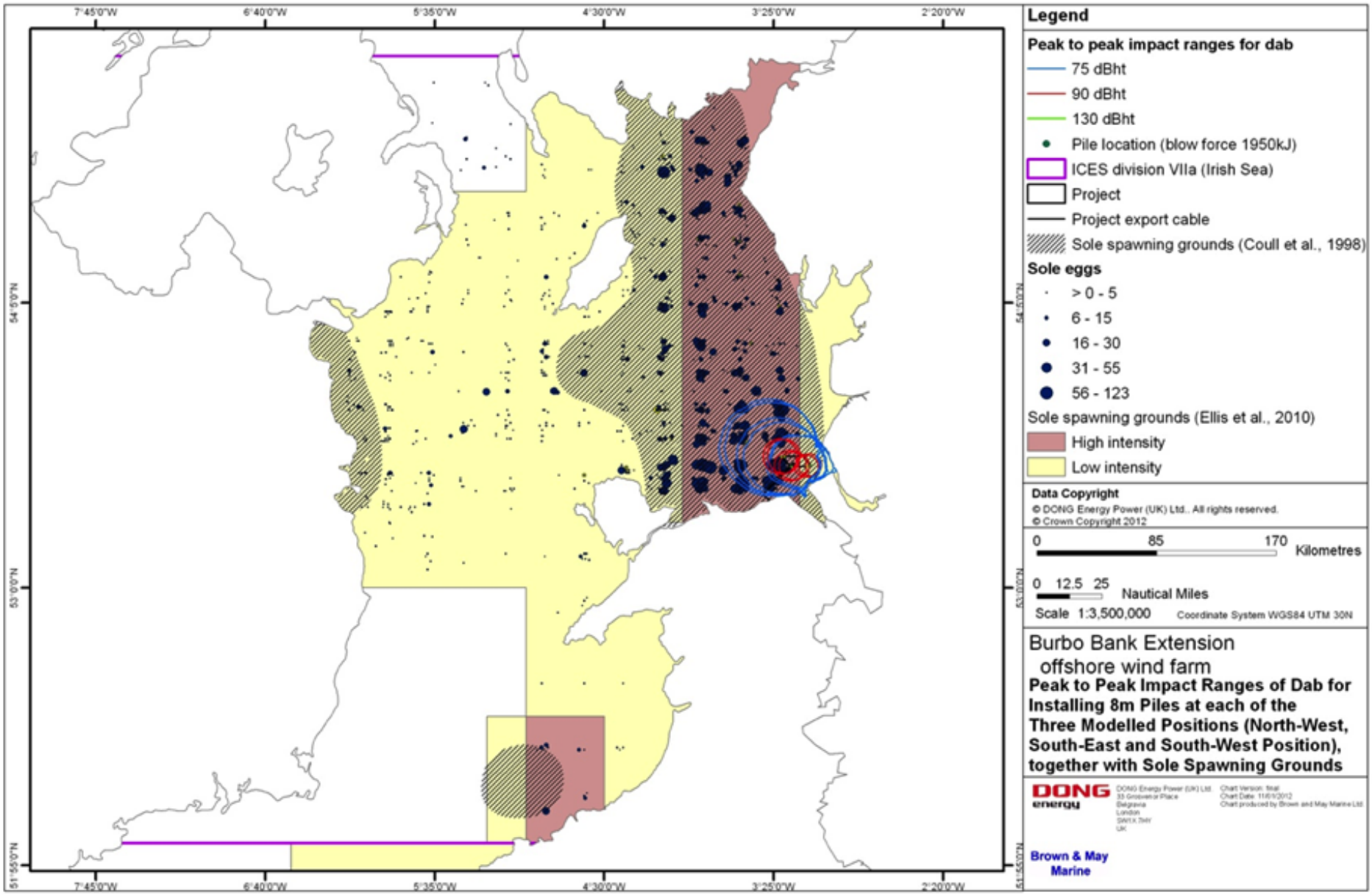

Figure 13.3: Estimated 75, 90 and 130 dB_{ht} (Limanda limanda) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at each of the three piling modelled locations together with sole spawning grounds as provided in Ellis et al., (2012)

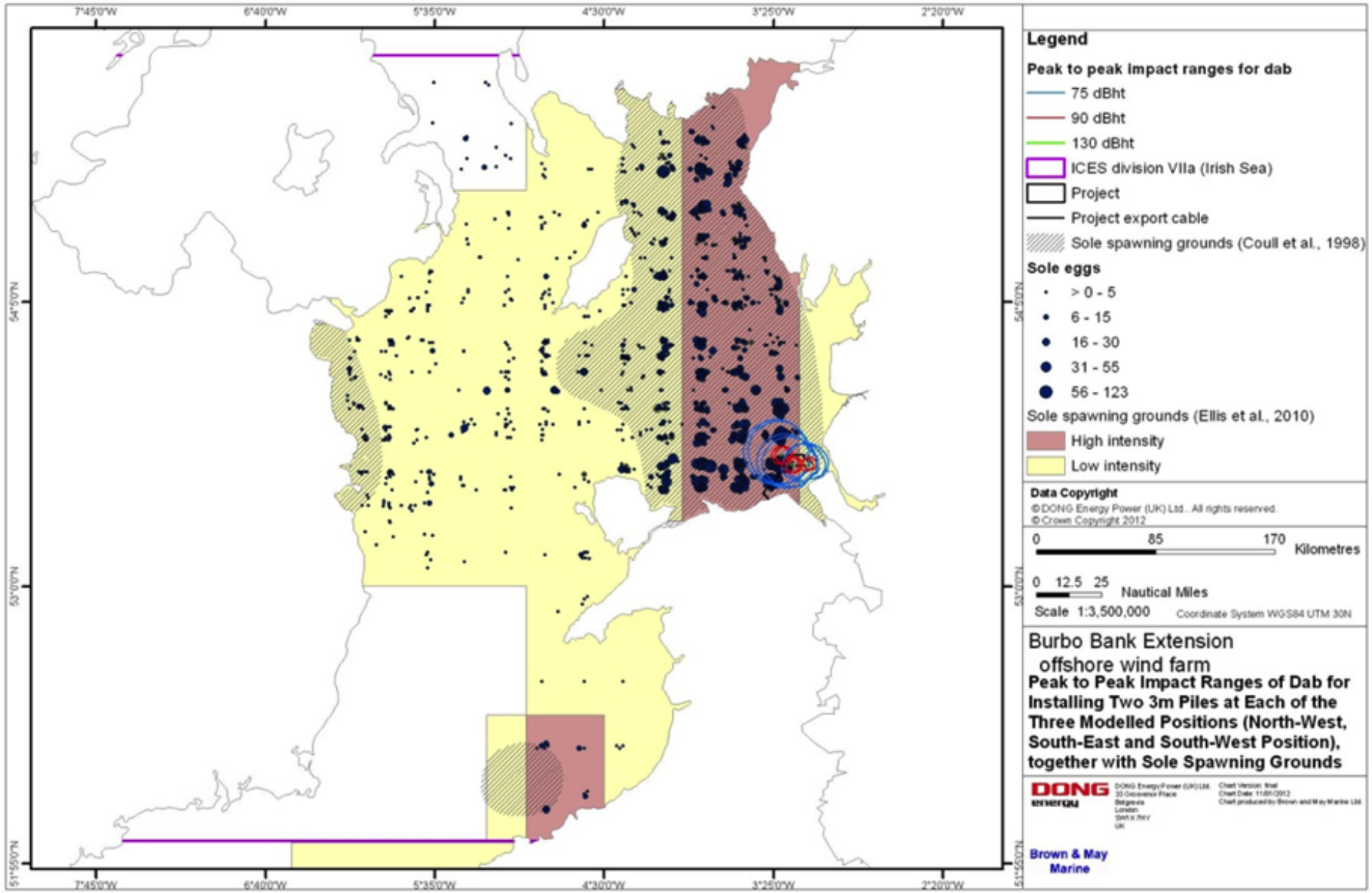

Figure 13.4: Estimated 75, 90 and 130 dB_{ht} (Limanda limanda) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at each of the three piling modelled locations together with sole spawning grounds as provided in Ellis et al., (2012)

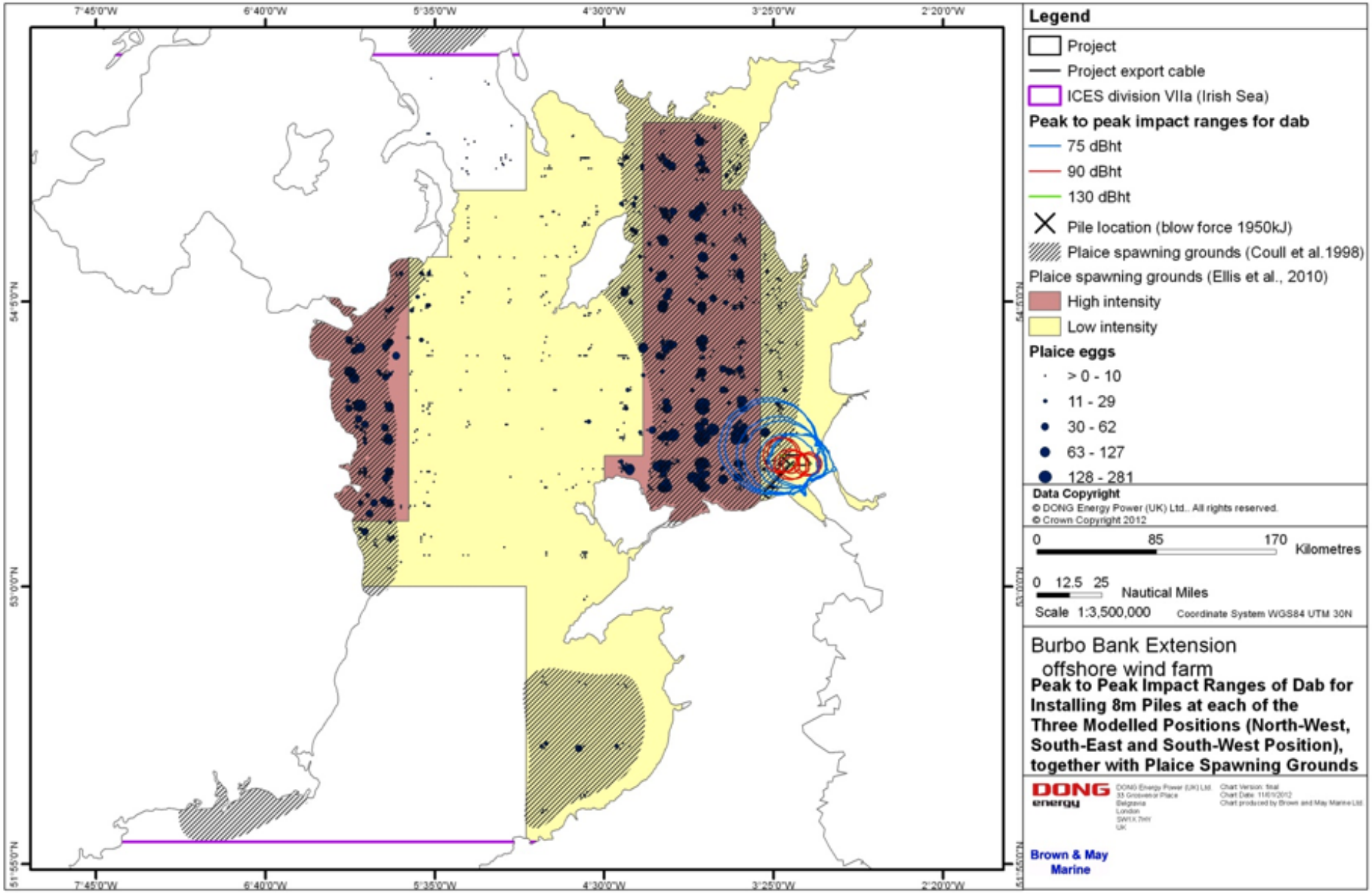

Figure 13.5: Estimated 75, 90 and 130 dB_{ht} (Limanda limanda) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at each of the three modelled locations together with plaice spawning grounds as provided in Ellis et al., (2012)

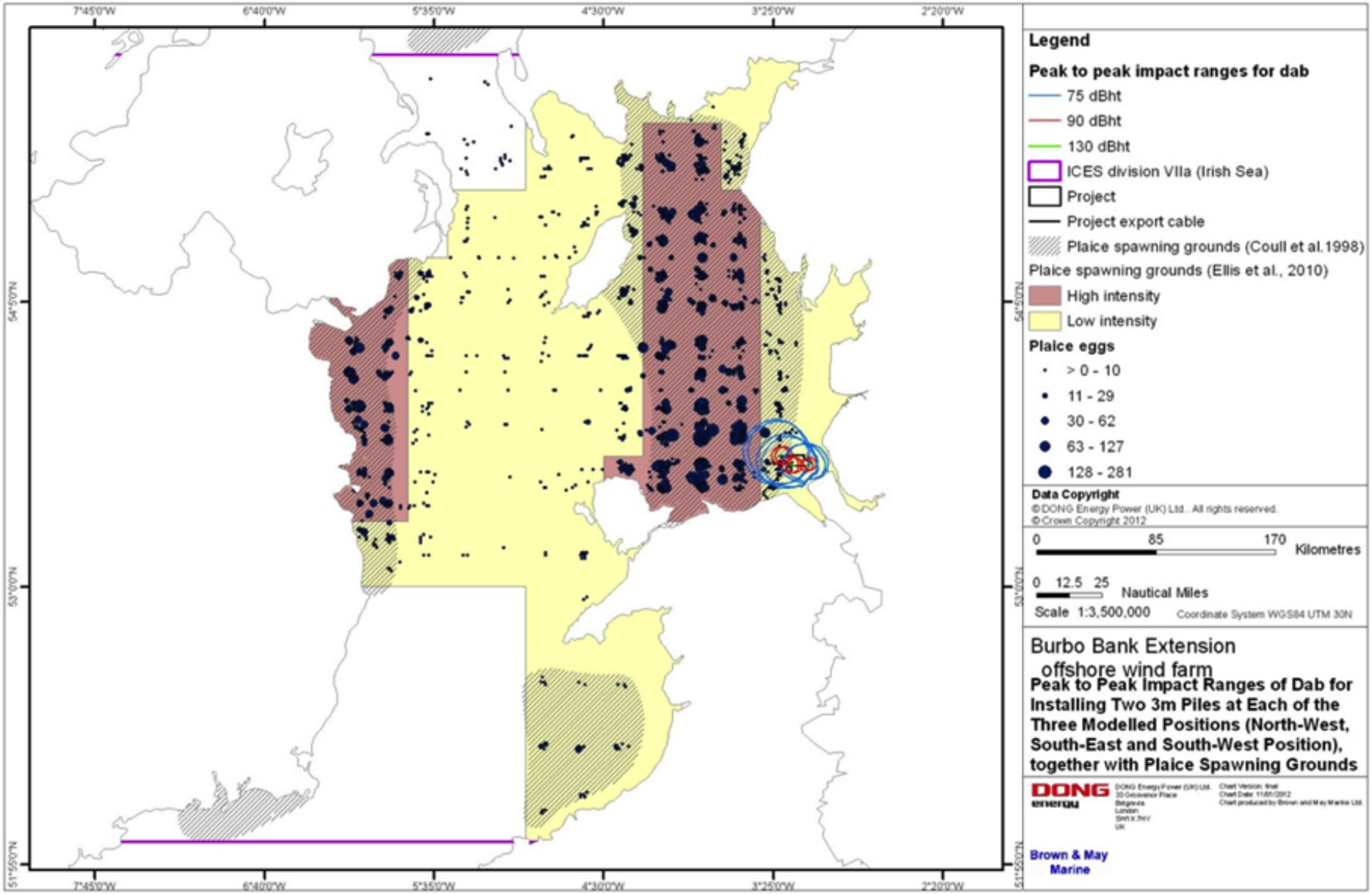

Figure 13.6: Estimated 75, 90 and 130 dB_{ht} (Limanda limanda) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at each of the three modelled locations together with plaice spawning grounds as provided in Ellis et al., (2012)

Cod

13.9.79 The Project falls within low intensity cod spawning grounds and high intensity nursery grounds (Ellis *et al*., 2012). Cod is caught within the Project in spring by a seasonal beam trawl fishery. Overall cod catches are however low due to low quota allocations. Cod is also considered to be of conservation interest, being listed as UK BAP species. There is potential for high intensity cod spawning grounds to be disturbed at the 90 dB_{ht} (*Gadus morhua*) level, principally when piling is taking place in the western section of the Project (see Figure 13.7 and Figure 13.8). The areas potentially disturbed are however small in the context to the overall extent of cod spawning grounds in the Eastern Irish Sea. In addition, as illustrated in Figure 13.7 and Figure 13.8, highest egg concentrations have been reported in areas located outside the Project, to the west and north of the site. Taking account of the intermittent and short term nature of piling together with the information provided above, the degree of interaction between the receptor and the impact is expected to be small.

13.9.80 In light of the above, **cod** is considered a receptor of **low sensitivity** and the **magnitude** of the impact is deemed to be moderate. The effect will, therefore, be of **slight adverse** significance, which is not significant in EIA terms.

Herring

13.9.81 There are no defined herring spawning grounds in the vicinity of the Project, with the closest being located approximately 135 km to the north of the site, off the Isle of Man (see ES Annex '5.1.5.13.2'). The Project, however, falls within defined high intensity herring nursery grounds (Ellis *et al*., 2012). Herring is listed as UK BAP species and constitutes an important prey for a number of fish, birds and marine mammals. There is currently no commercial herring fishery operational within the Project, due to an all year fishing closure. High intensity herring nursery grounds may be disturbed at the 90 dB_{ht} (*Clupea harengus*) level during piling; these areas are however small in comparison to the overall distribution of herring nursery grounds in the Irish Sea (see Figure 13.9 and Figure 13.10). In addition, it should be noted that highest juvenile catch rates have principally been recorded in areas located to the north of the modelled 90 dB_{ht} (*Clupea harengus*) levels (see Figure 13.9 and Figure 13.10). Taking the above into account, together with the intermittent and short term nature of piling activity, the degree of interaction between the impact and the receptor is expected to be small. In light of the above, **herring** is considered a receptor of **low sensitivity**. As previously described, the **magnitude** of the impact is deemed to be **moderate**. The effect will, therefore, be of **slight adverse** significance, which is not significant in EIA terms.

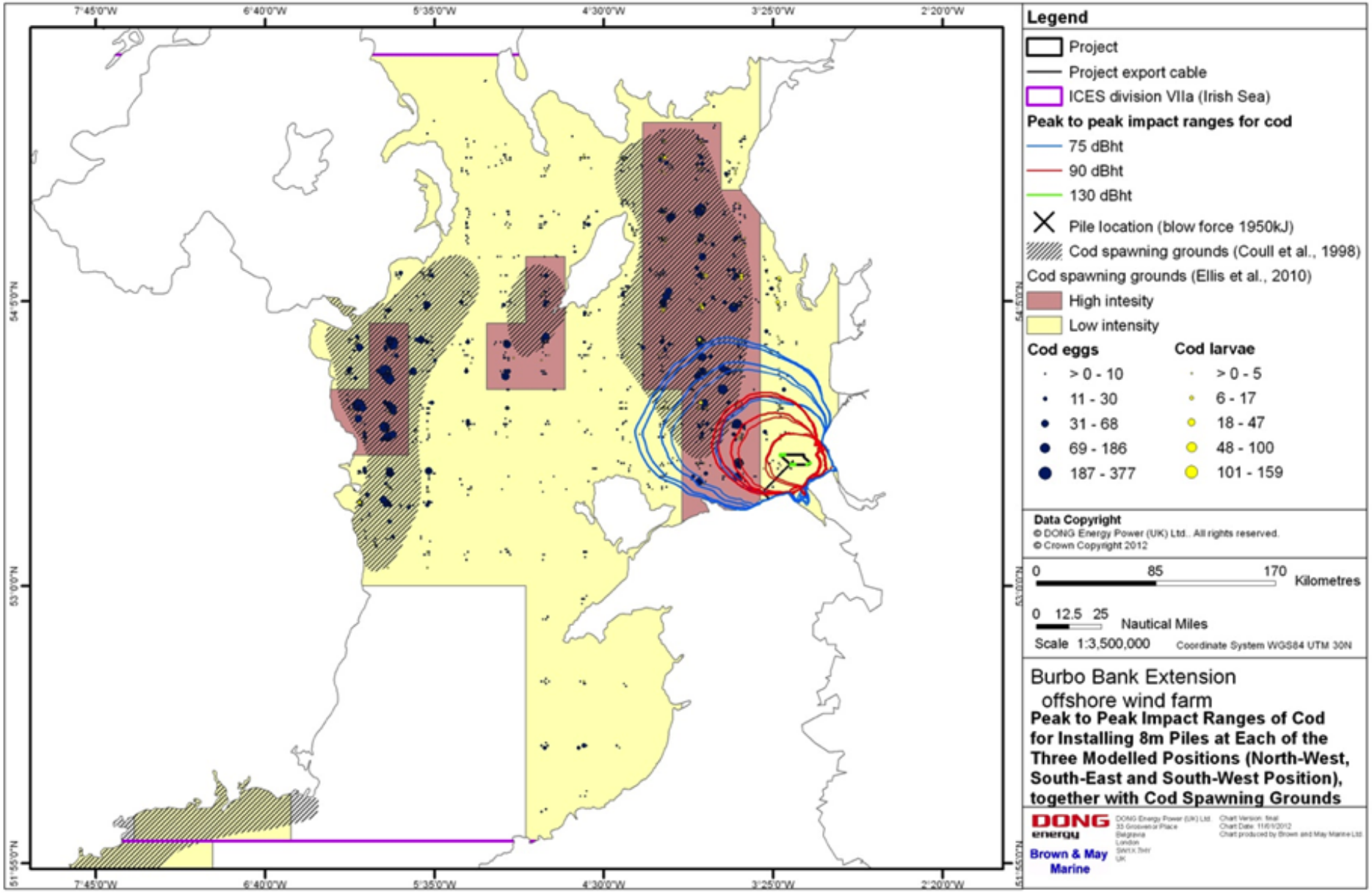

Figure 13.7: Estimated 75, 90 and 130 dB_{ht} (Gadus morhua) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at each of the three modelled locations, together with cod spawning grounds as provided in Ellis et al. (2012)

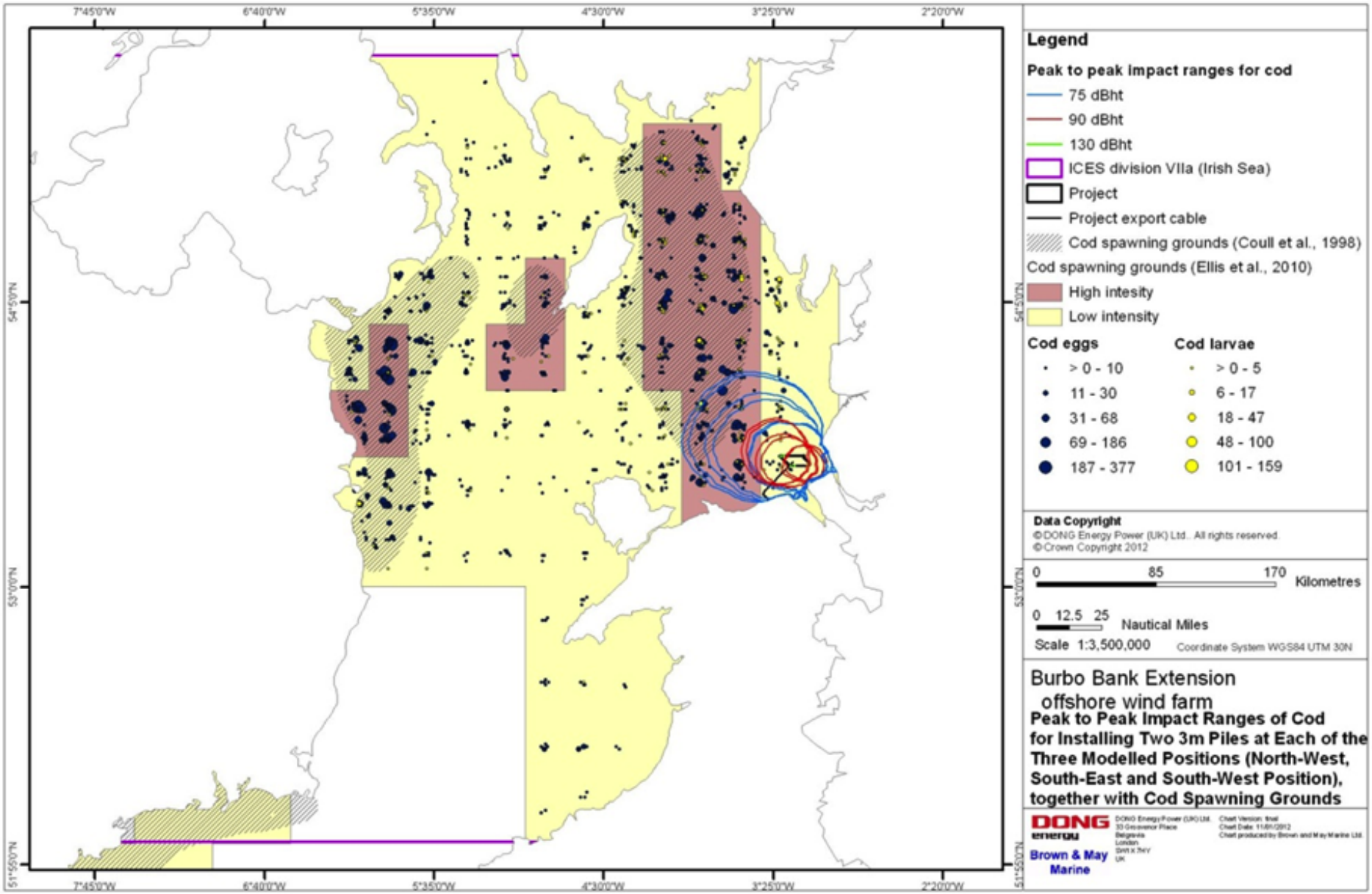

Figure 13.8: Estimated 75, 90 and 130 dB_{ht} (Gadus morhua) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at each of the three modelled locations, together with cod spawning grounds as provided in Ellis et al. (2012)

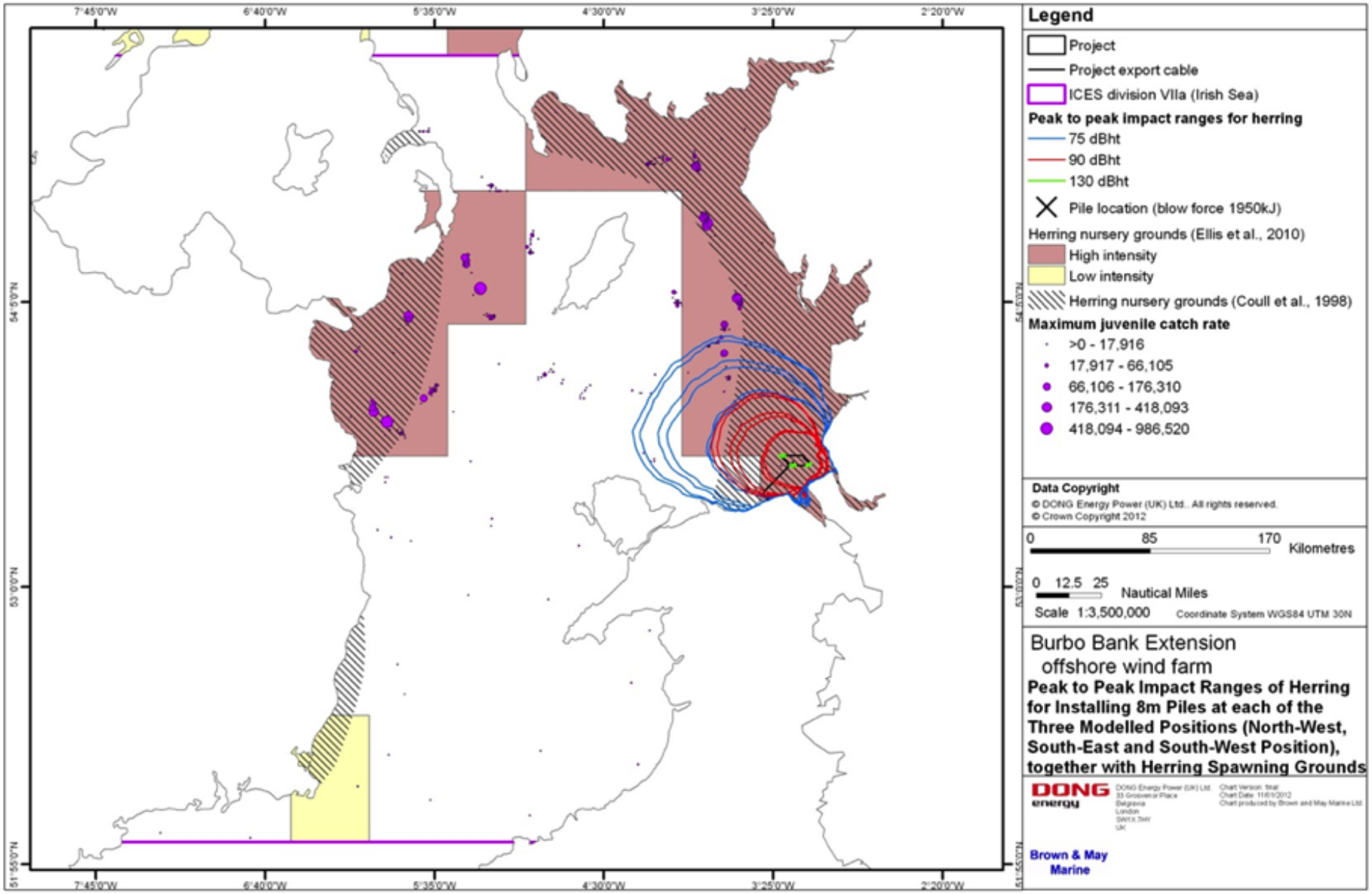

Figure 13.9: Estimated 75, 90 and 130 dB_{ht} (Clupea harengus) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at each of the three modelled locations, together with herring nursery grounds as provided in Ellis et al. (2012)

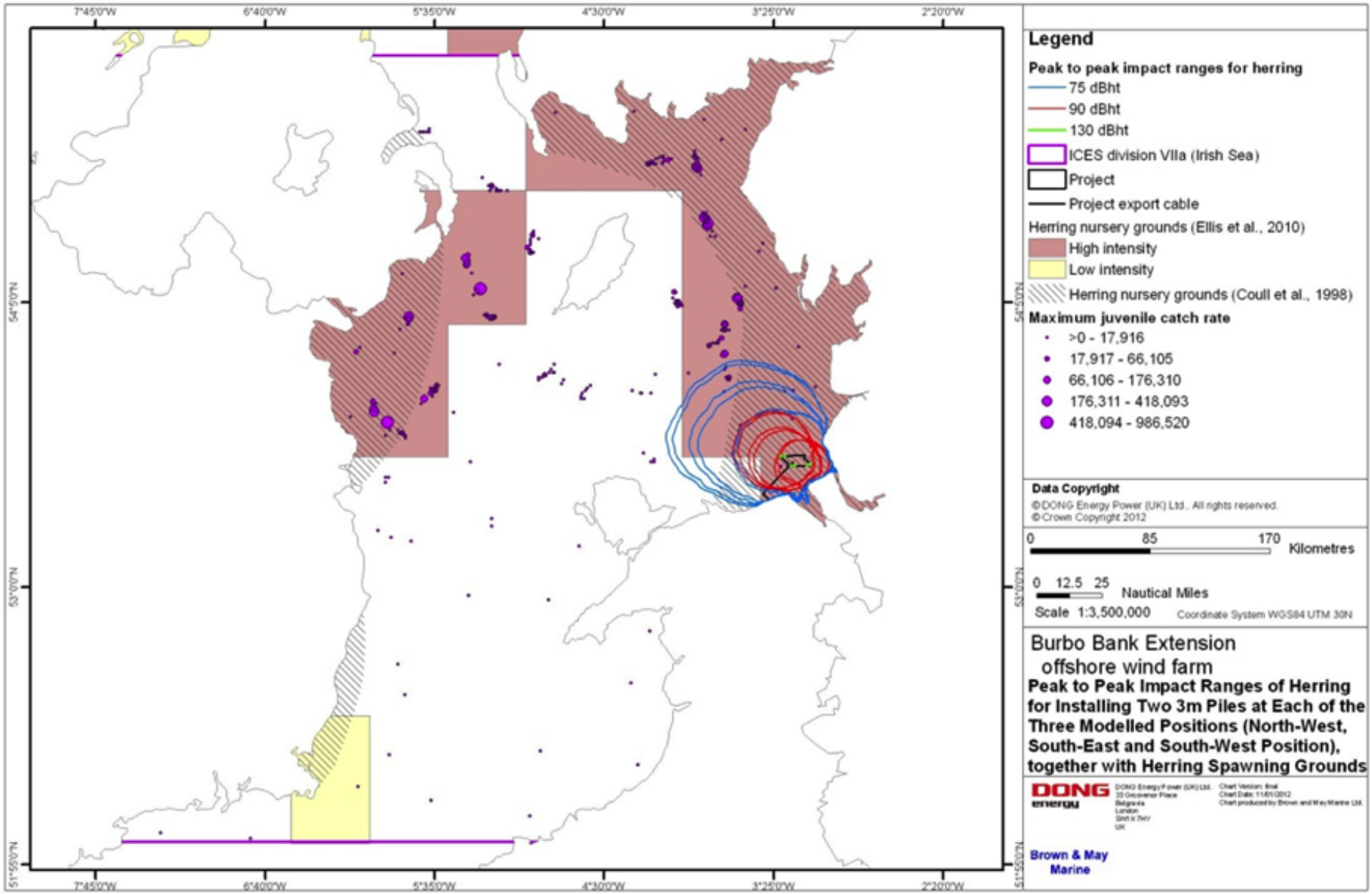

Figure 13.10: Estimated 75, 90 and 130 dB_{ht} (Clupea harengus) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at each of the three modelled locations, together with herring nursery grounds as provided in Ellis et al. (2012)

Sprat

13.9.82 The Project falls within the wide spawning grounds defined for sprat (Coull *et al.*, 1998). Sprat is not commercially targeted within the Project but is considered to be an important prey species for a number of fish, birds and marine mammals. The extent of the 90 dB_{ht} (*Clupea harengus*) impact ranges is, however, small compared to the overall distribution of sprat spawning grounds in the Irish Sea (see Figure 13.11 and Figure 13.12). Taking this into account, together with the short term and intermittent nature of piling activity, the degree of interaction between the impact and the receptor is expected to be small. In light of the above, **sprat** is considered a receptor of **low sensitivity**. As previously described, the **magnitude** of the impact is deemed to be **moderate**. The **effect** will, therefore, be of **slight adverse** significance which is not significant in EIA terms.

Whiting

13.9.83 Low intensity whiting spawning grounds and high intensity nursery grounds overlap with The Project (Ellis *et al.*, 2012). Whiting is not commercially targeted within the Project but is considered to be an important prey (in particular juvenile whiting) for a number of fish, birds and marine mammals. In addition, whiting is listed as a UK BAP species. Spawning and nursery areas which may be disturbed at the 90 dB_{ht} (*Clupea harengus*) levels are small in comparison to the overall distribution of whiting spawning and nursery grounds (see Figure 13.13 and Figure 13.14). Based on the above, and taking the short term and intermittent nature of piling activity, the degree of interaction between the impact and the receptor is expected to be small. In light of the above **whiting** is considered to be a receptor of **low sensitivity**. As previously described, the **magnitude** of the impact is deemed to be **moderate**. The **effect** will, therefore, be of **slight adverse** significance, which is not significant in EIA terms.

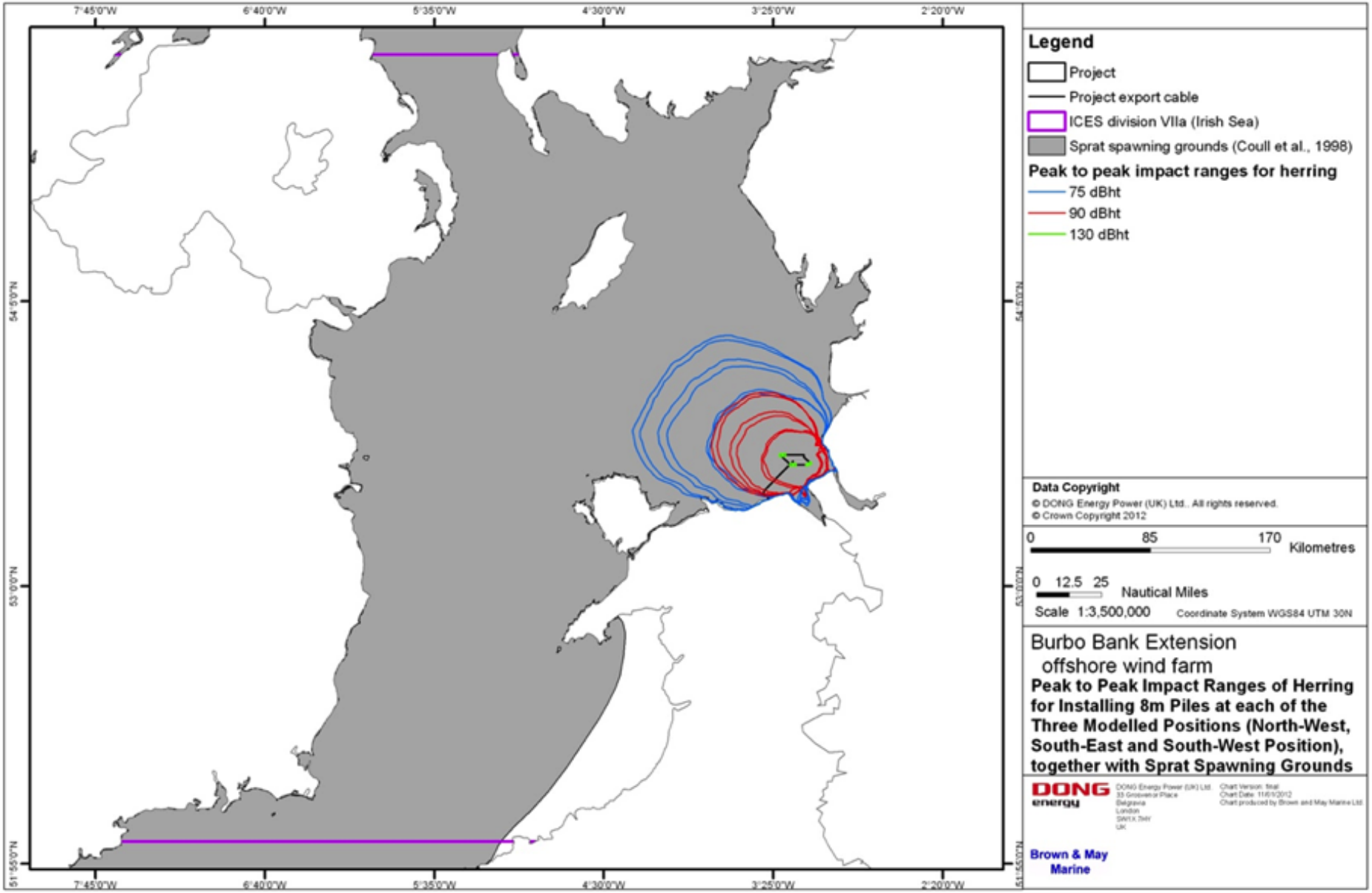

Figure 13.11: Estimated 75, 90 and 130 dB_{ht} (Clupea harengus) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at each of the three modelled locations together with sprat spawning grounds as provided in Coull et al. (1998)

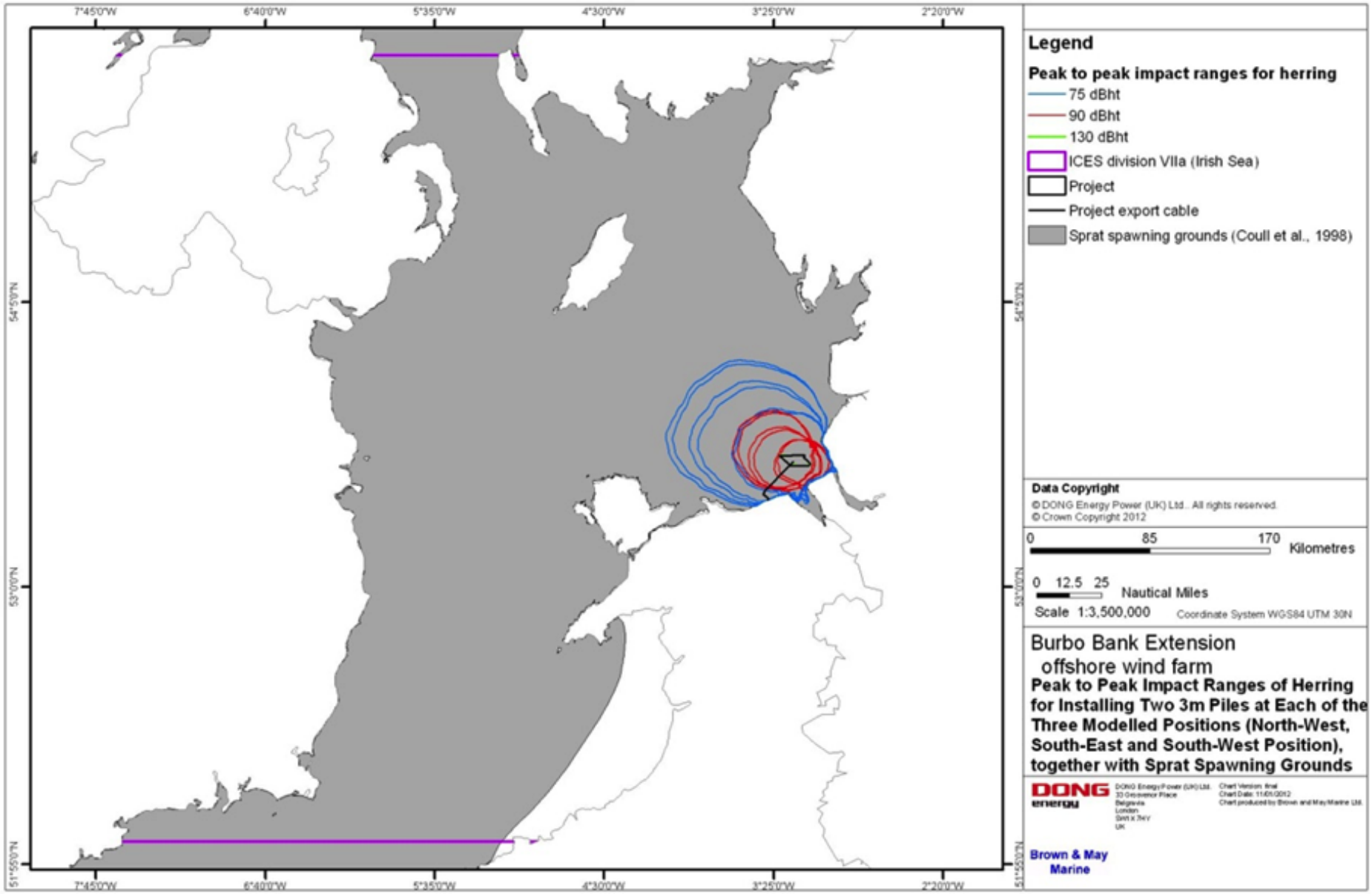

Figure 13.12: Estimated 75, 90 and 130 dB_{ht} (Clupea harengus) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at each of the three modelled locations together with sprat spawning grounds as provided in Coull et al. (1998)

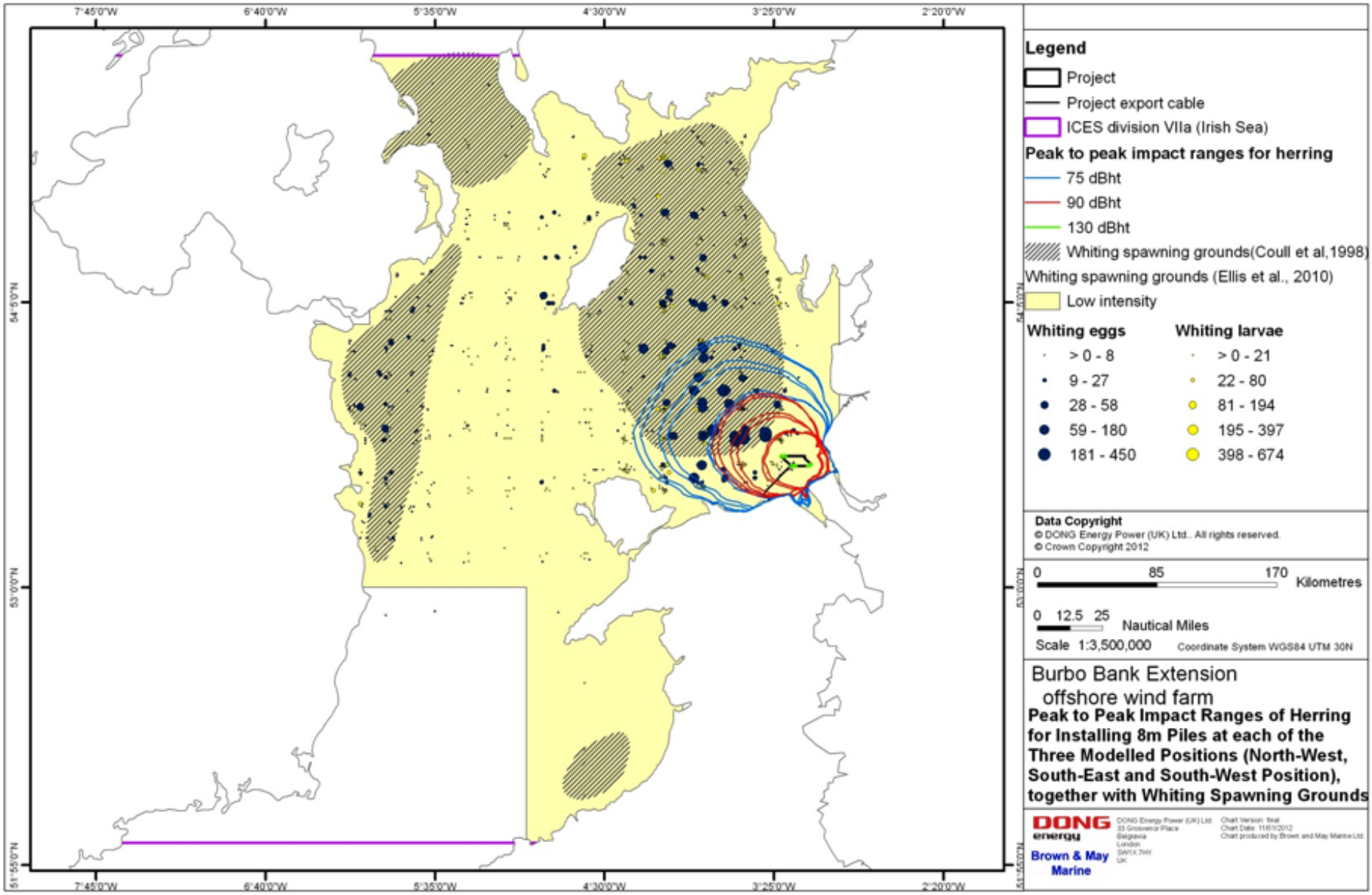

Figure 13.13: Estimated 75, 90 and 130 dB_{ht} (Clupea harengus) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at each of the three modelled locations (together with whiting spawning grounds as provided in Ellis et al. (2012)

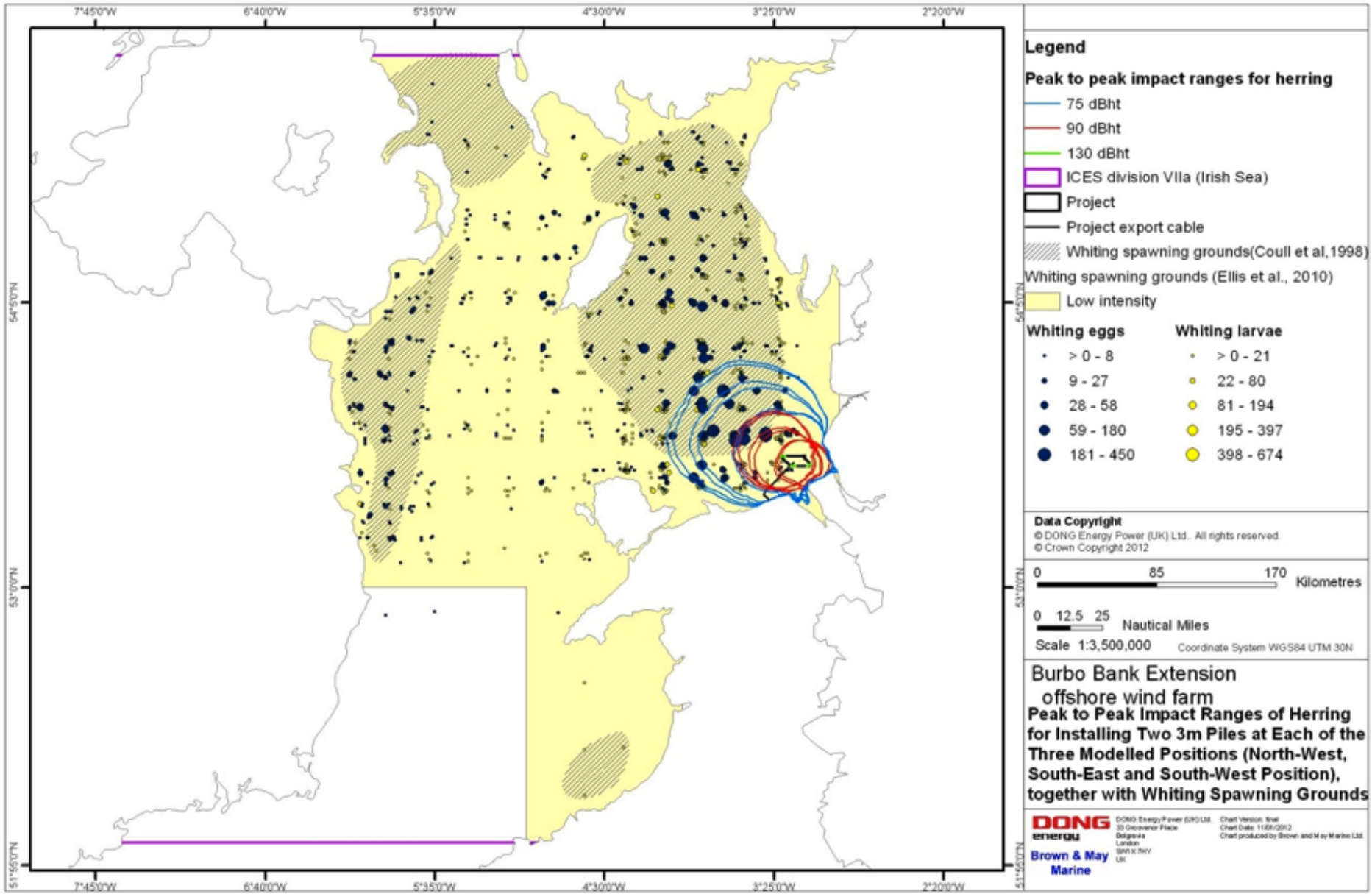

Figure 13.14: Estimated 75, 90 and 130 dB_{ht} (Clupea harengus) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at each of the three modelled locations (together with whiting spawning grounds as provided in Ellis et al. (2012)

Sandeels

13.9.84 The Project falls within high intensity sandeel spawning grounds and low intensity nursery grounds (Ellis *et al.*, 2012). Sandeels are an important prey for a number of fish, birds and marine mammals. Raitt's sandeel is listed as a UK BAP species. There is no commercial sandeel fishery within the Project and its vicinity. Given the lack of species specific information on sandeel's hearing ability, peak to peak impact ranges have not been modelled for this species. As previously mentioned, sandeels, lack a swim bladder and it has been assumed that the noise impact ranges may be similar to the noise contours for dab. High intensity sandeel spawning grounds may be disturbed at the 90 dB_{ht} (*Limanda limanda*) level (see Figure 13.15 and Figure 13.16). These areas are, however, small compared to the overall spawning grounds and the distribution of sandeels in the Irish Sea. The patchiness of sandeel distribution given their substrate specificity should however be noted in this context. In addition, as previously mentioned, sandeels were recorded in relatively high numbers during beam trawl surveys carried out in the Wind Farm. Taking the above into account together with the short term and intermittent nature of piling the degree of interaction between the impact and the receptor is considered to be small to medium. In light of the above, **sandeels** are considered receptors of **medium sensitivity**. As previously described, the **magnitude** of the impact is deemed to be **minor. The effect** will, therefore, be of **slight adverse** significance, which is not significant in EIA terms.

Seabass

13.9.85 As described in the Technical Report ES Annex '5.1.5.13.2', post-spawning seabass migrate northwards in May/June to coastal summer feeding areas of the coasts of north Devon to north Wales and northwest England- a range which includes areas relevant to the Project. From September onwards they then migrate south during autumn and return to winter pre-spawning areas. Seabass are targeted in the study area by a gill net fishery from May until October. In addition, the estuaries of the Dee and Conwy rivers are designated seabass nursery areas.

13.9.86 As previously mentioned, seabass lack a specialised coupling mechanisms between the swim bladder and the inner ear. The **magnitude** of the impact of construction noise on this species has therefore been assumed to be **between** that assigned for dab (**minor**) and cod (**moderate**). The modelled noise contours at the 90 dBht (Species) level for dab are limited to the immediate vicinity of the Project. Noise contours at the 90 dBht (Species) level for cod are however comparatively large and may reach shore in the vicinity of the Dee estuary. There is therefore potential for juvenile seabass using the Dee estuary as a nursery area to be subject to noise levels at which avoidance reactions at the 90 dB_{ht} (*Species*) level may occur. The designated nursery area of the Conwy estuary is however at a considerable distance from the Project. Juvenile seabass using this nursery area are therefore not expected to be affected by construction noise. Taking the above into account together with the short term and intermittent nature of piling activity and year round presence of juvenile seabass, the degree of interaction between the receptor and the impact is expected to be small. In light of the above, seabass is considered to be a receptor of low sensitivity. As previously described, the magnitude of the impact is deemed to be between minor and moderate. The effect will, therefore, be slight adverse at worst, which is not significant in EIA terms.

Elasmobranchs

13.9.87 As indicated in ES Chapter 11 'Offshore Noise', the outputs of the noise modelling undertaken for cod have been taken as representative of a conservative worst case for assessment of construction noise on elasmobranchs.

13.9.88 A number of elasmobranch species are known to be present in the Project and

its vicinity. Among these, thornback ray, tope and spotted ray have defined low intensity nursery grounds within the Project, whilst high intensity spurdog nursery grounds are located approximately 8 km to the north-west of the site (Ellis *et al.*, 2012). In addition, spurdog, tope and spotted ray are considered to be of conservation interest, with thornback ray being commercially exploited within the Project and its surroundings. The outputs of the noise modelling for cod are shown in Figure 13.17 to Figure 13.24, together with the nursery grounds (Ellis *et al.*, 2012) for thornback ray, spotted ray, tope and spurdog respectively. Areas which may be disturbed by the 90 dB_{ht} (*Gadus morhua*) level are comparatively small in the context of the overall distribution of these species' nursery grounds. Taking the above into account together with the short terms intermittent nature of piling activity the interaction between the impact and the receptors is expected to be small. In light of the above, **thornback ray, spotted ray, tope** and **spurdog** are considered receptors of **low sensitivity**. As previously described, the **magnitude** of the impact is deemed to be **moderate**. The **effect** will, therefore, be of **slight adverse** significance, which is not significant in EIA terms.

13.9.89 In addition to the elasmobranch species mentioned above, basking sharks, a species of importance from a conservation point of view (protected under the Wildlife and Countryside Act, 1981) may potentially transit the vicinity of the Project during their migration. As mentioned above, cod has been used as a surrogate for elasmobranchs, including basking sharks. Recorded sightings of basking sharks for the period (1987-2006) are given in Figure 13.25 and Figure 13.26 together with the 75 and 90 dB_{ht} (*Gadus morhua*) modelled noise impact ranges. As shown, sighting of this species in areas potentially disturbed by construction noise are very rare with basking sharks being more typically observed towards the southern tip of the Isle of Man, around the Calf of Man, up the southwest coast of the island predominantly at Niarbyl Bay and Peel. Taking the above into account, together with the short term and intermittent nature of piling activity, the degree of interaction between the impact and the receptor is expected to be small. In light of the above, **basking sharks** are considered receptors of **low sensitivity**. As previously described, the **magnitude** of the impact is deemed to be **moderate**. The **effect** will, therefore, be of **slight adverse** significance, which is not significant in EIA terms.

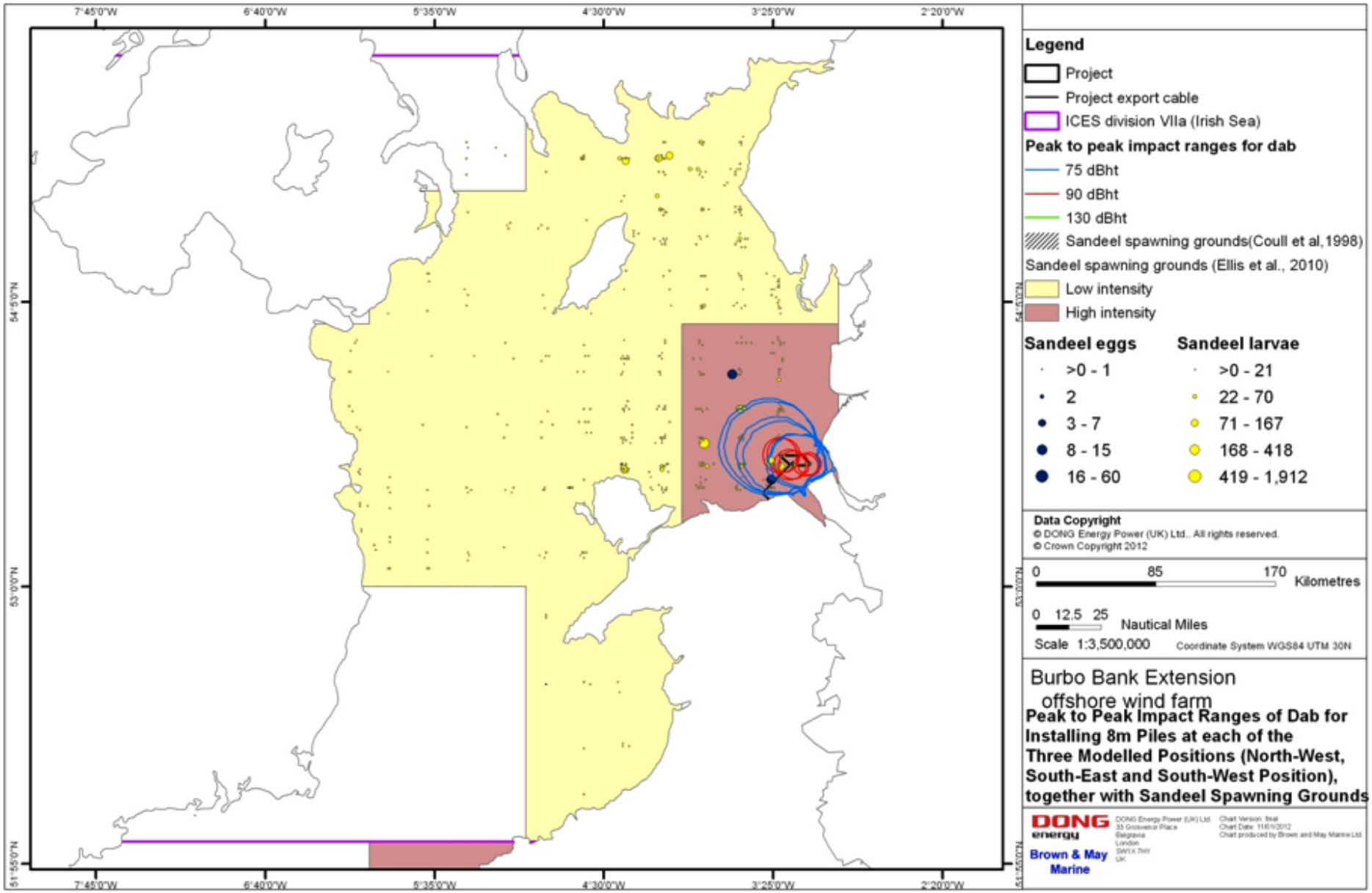

Figure 13.15: Estimated 75, 90 and 130 dB_{ht} (Limanda limanda) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at each of the three modelled locations together with sandeel spawning grounds as provided in Ellis et al. (2012)

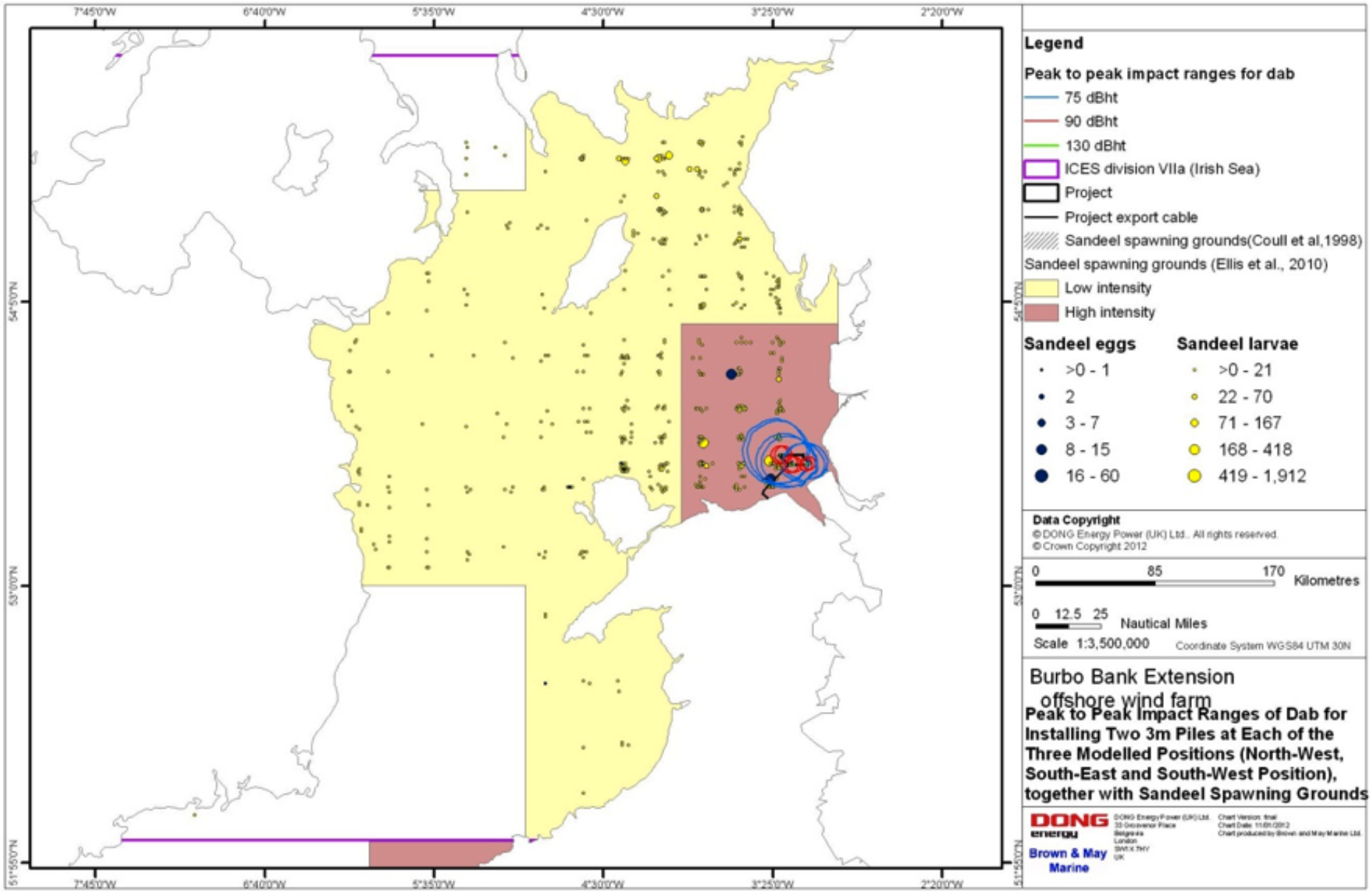

Figure 13.16: Estimated 75, 90 and 130 dB_{ht} (Limanda limanda) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at each of the three modelled locations together with sandeel spawning grounds as provided in Ellis et al. (2012)

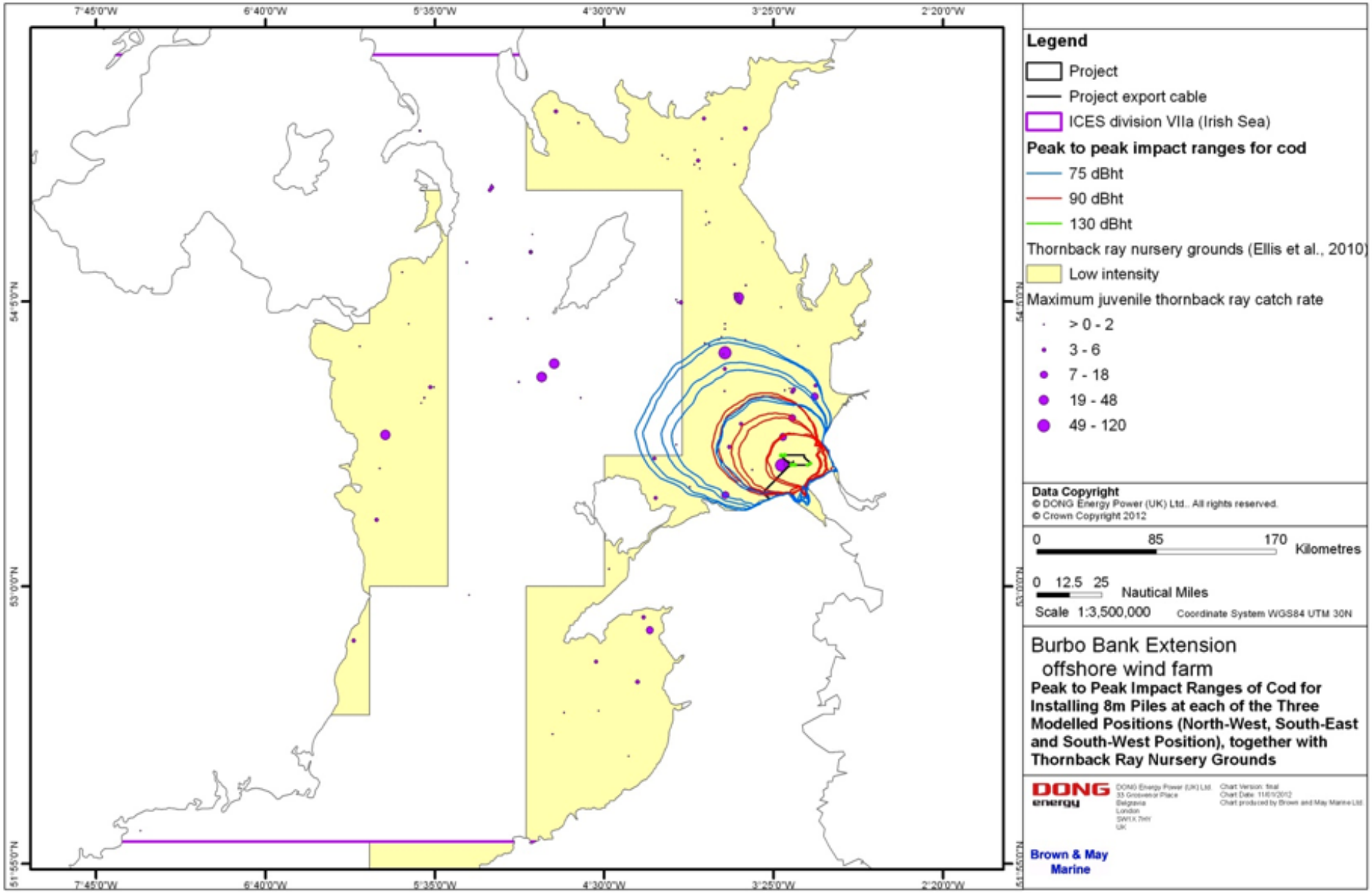

Figure 13.17: Estimated 75, 90 and 130 dB_{ht} (Gadus morhua) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at each of the three modelled locations together with thornback ray nursery grounds as provided in Ellis et al., (2012)

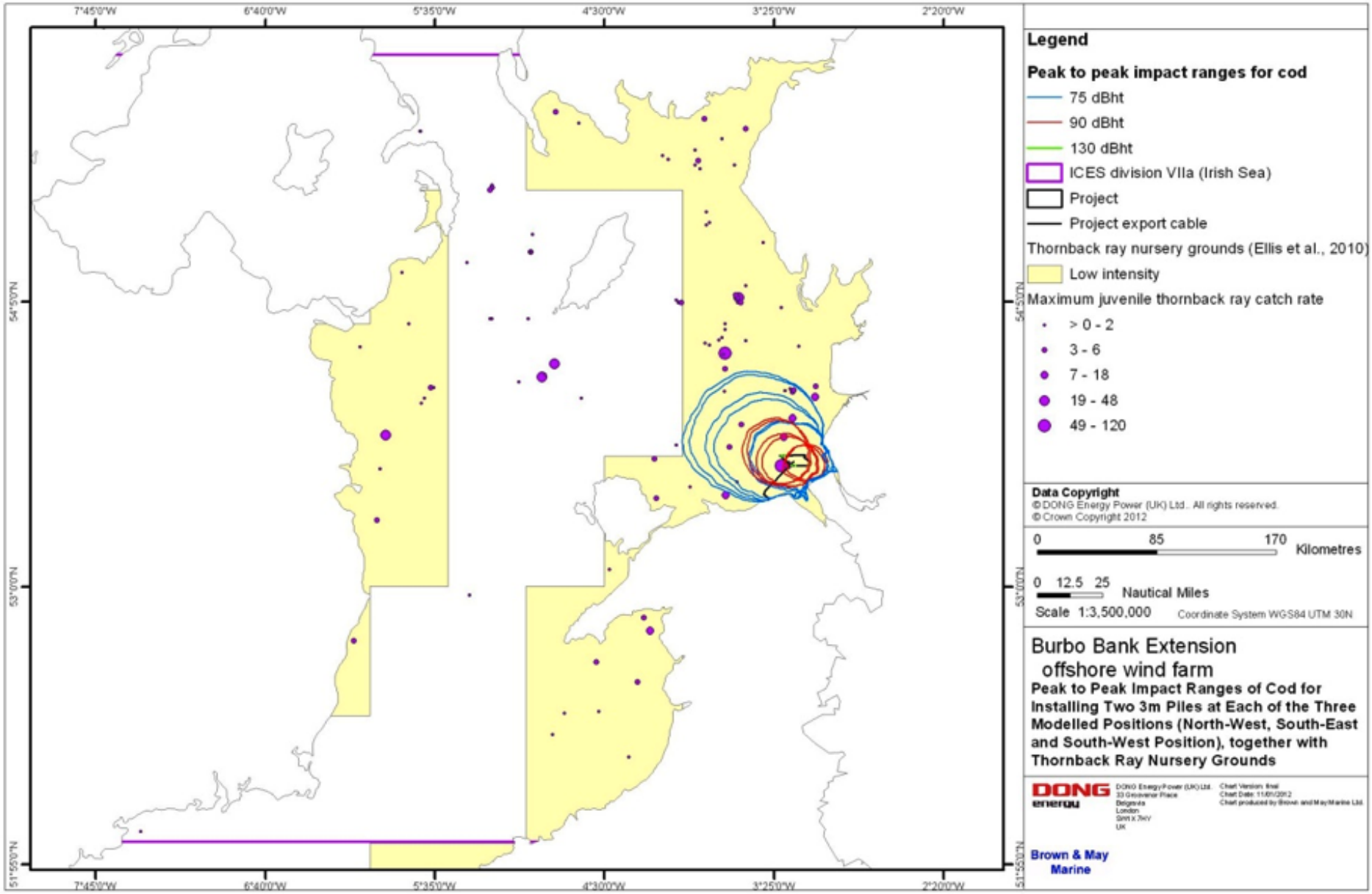

Figure 13.18: Estimated 75, 90 and 130 dB_{ht} (Gadus morhua) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at each of the three modelled locations together with thornback ray nursery grounds as provided in Ellis et al., (2012)

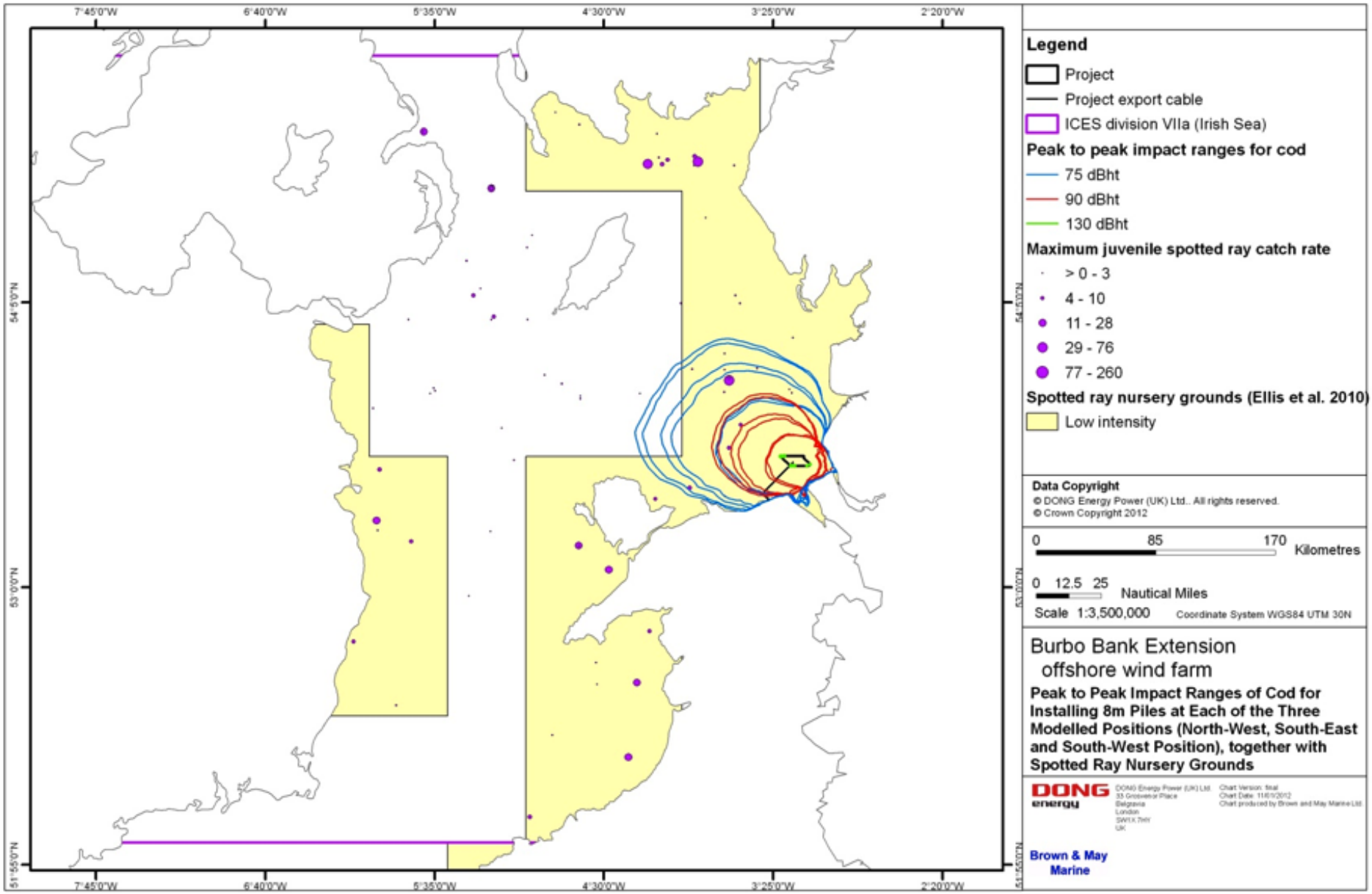

Figure 13.19: Estimated 75, 90 and 130 dB_{ht} (Gadus morhua) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at each of the three modelled locations together with spotted ray nursery grounds as provided in Ellis et al., (2012)

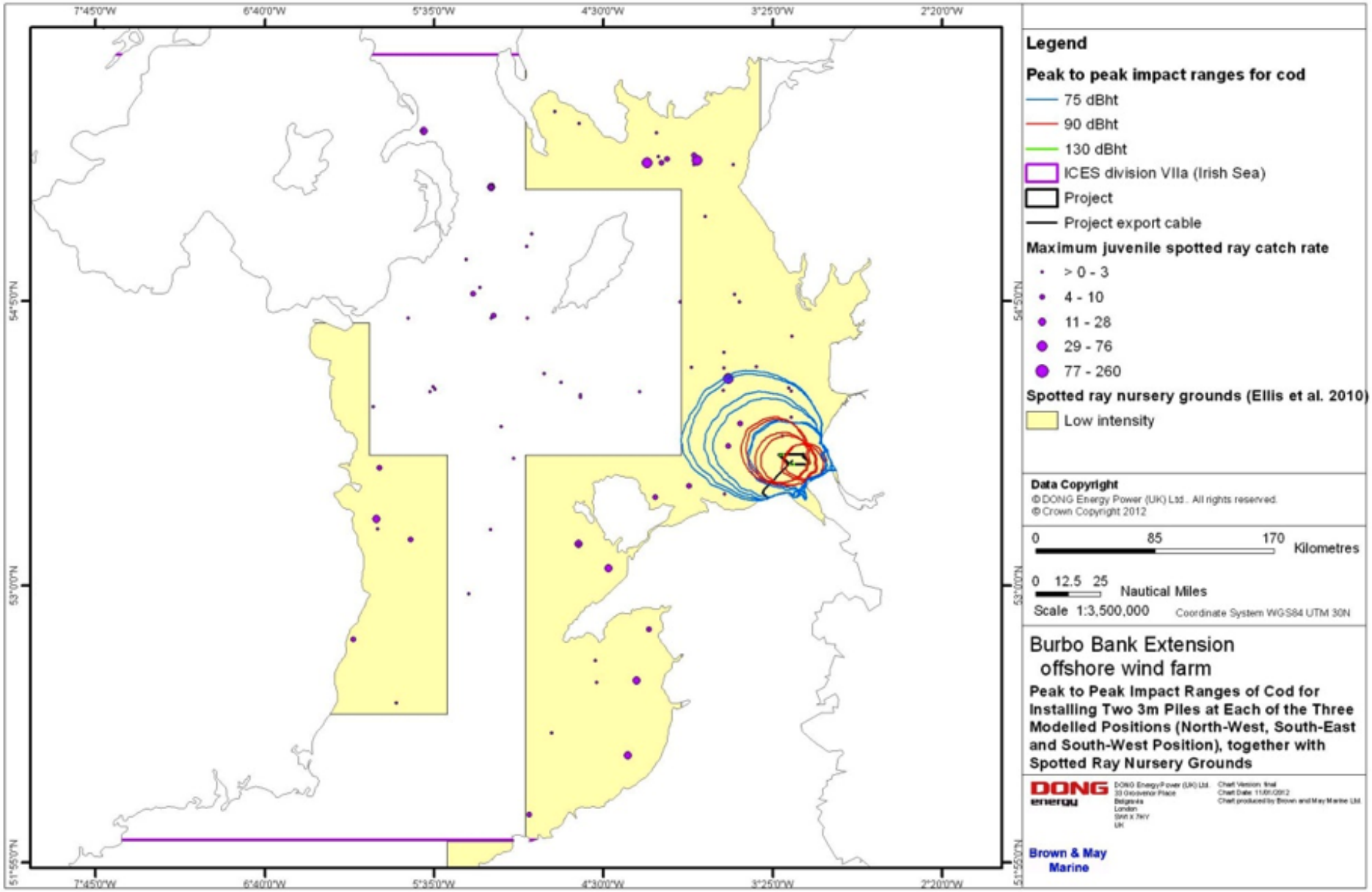

Figure 13.20: Estimated 75, 90 and 130 dB_{ht} (Gadus morhua) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at each of the three modelled locations together with spotted ray nursery grounds as provided in Ellis et al., (2012)

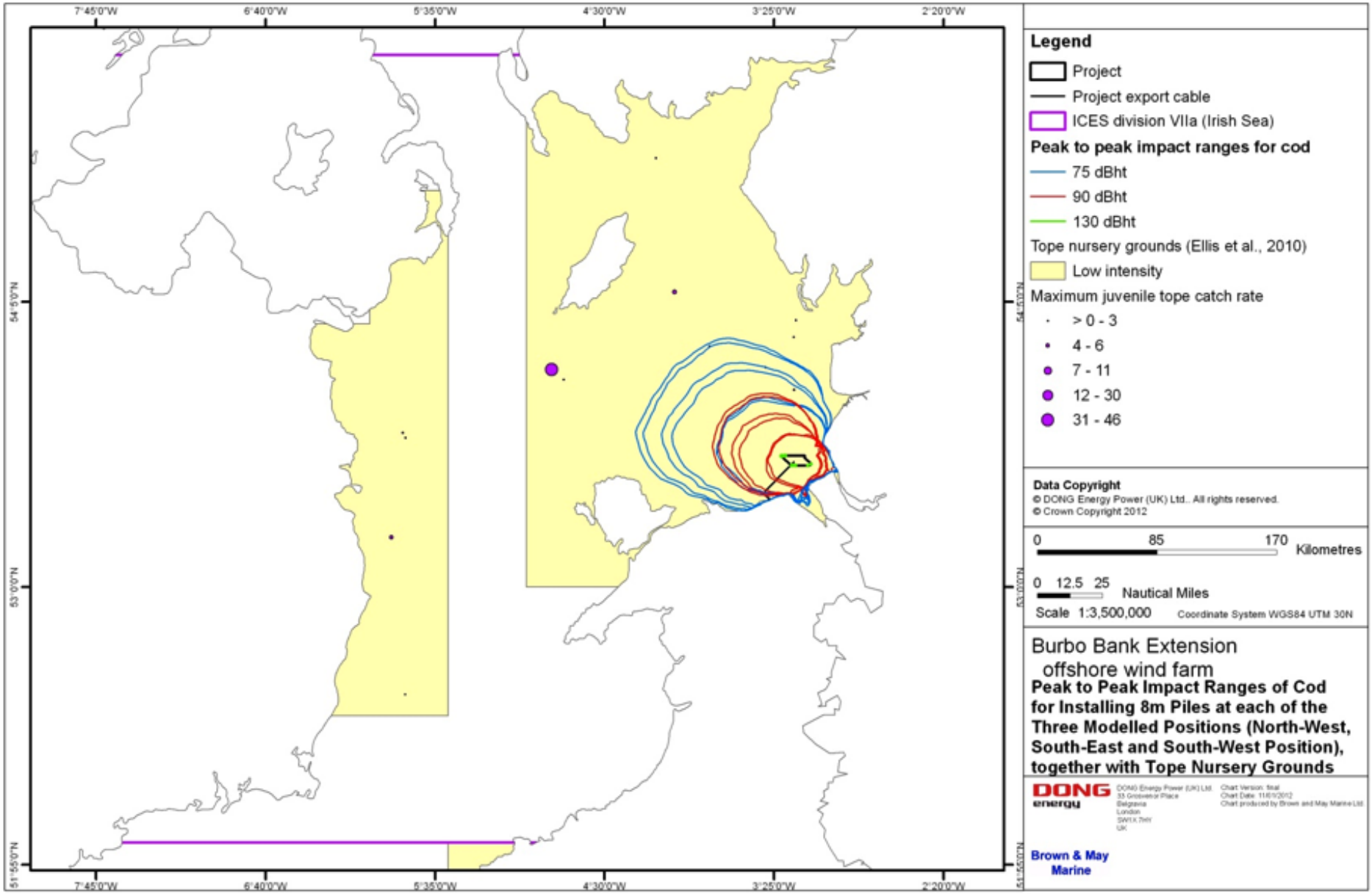

Figure 13.21: Estimated 75, 90 and 130 dB_{ht} (Gadus morhua) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at the three modelled locations together with tope shark nursery grounds as provided in Ellis et al., (2012)

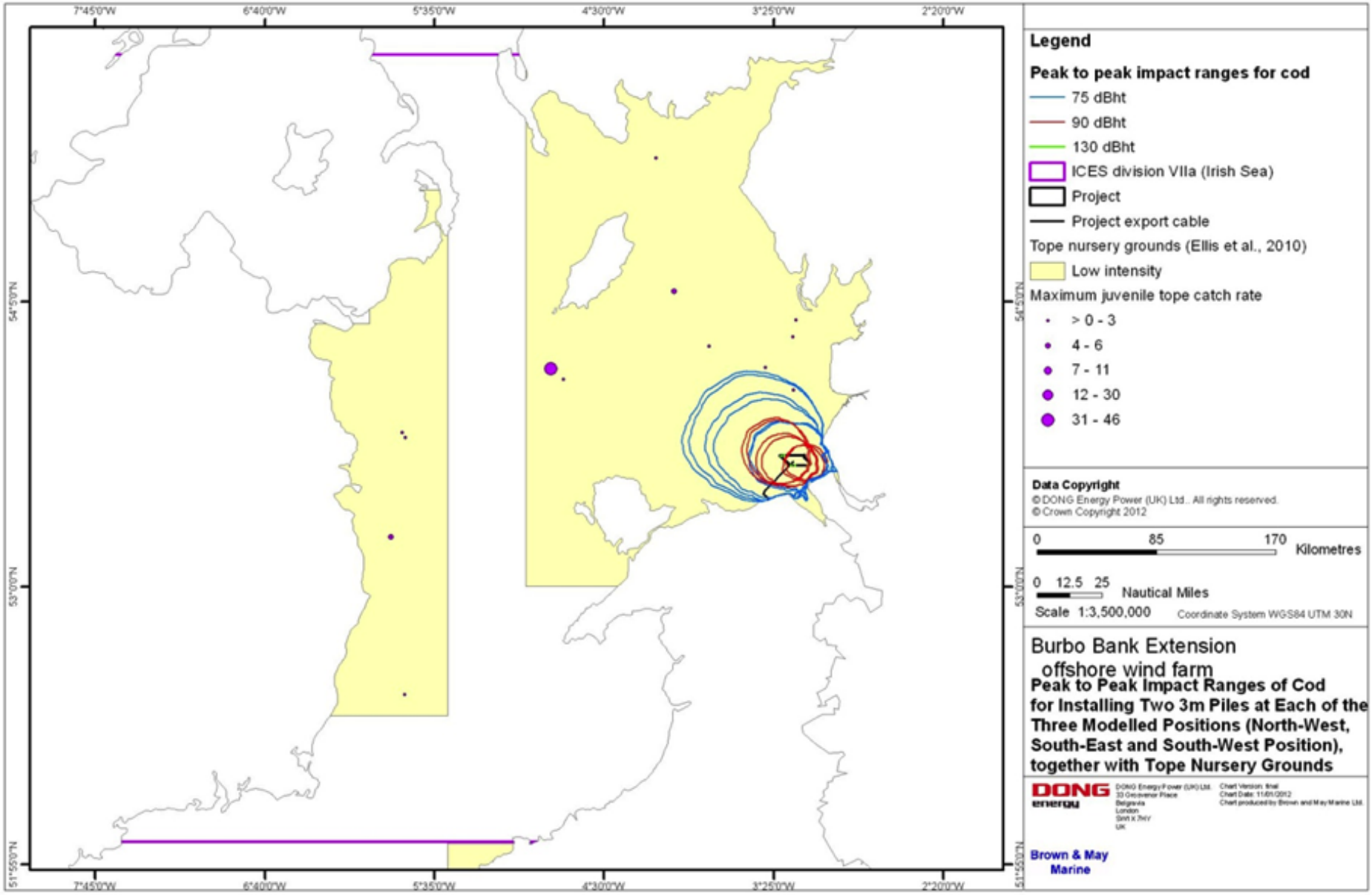

Figure 13.22: Estimated 75, 90 and 130 dB_{ht} (Gadus morhua) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at the three modelled locations together with tope shark nursery grounds as provided in Ellis et al., (2012)

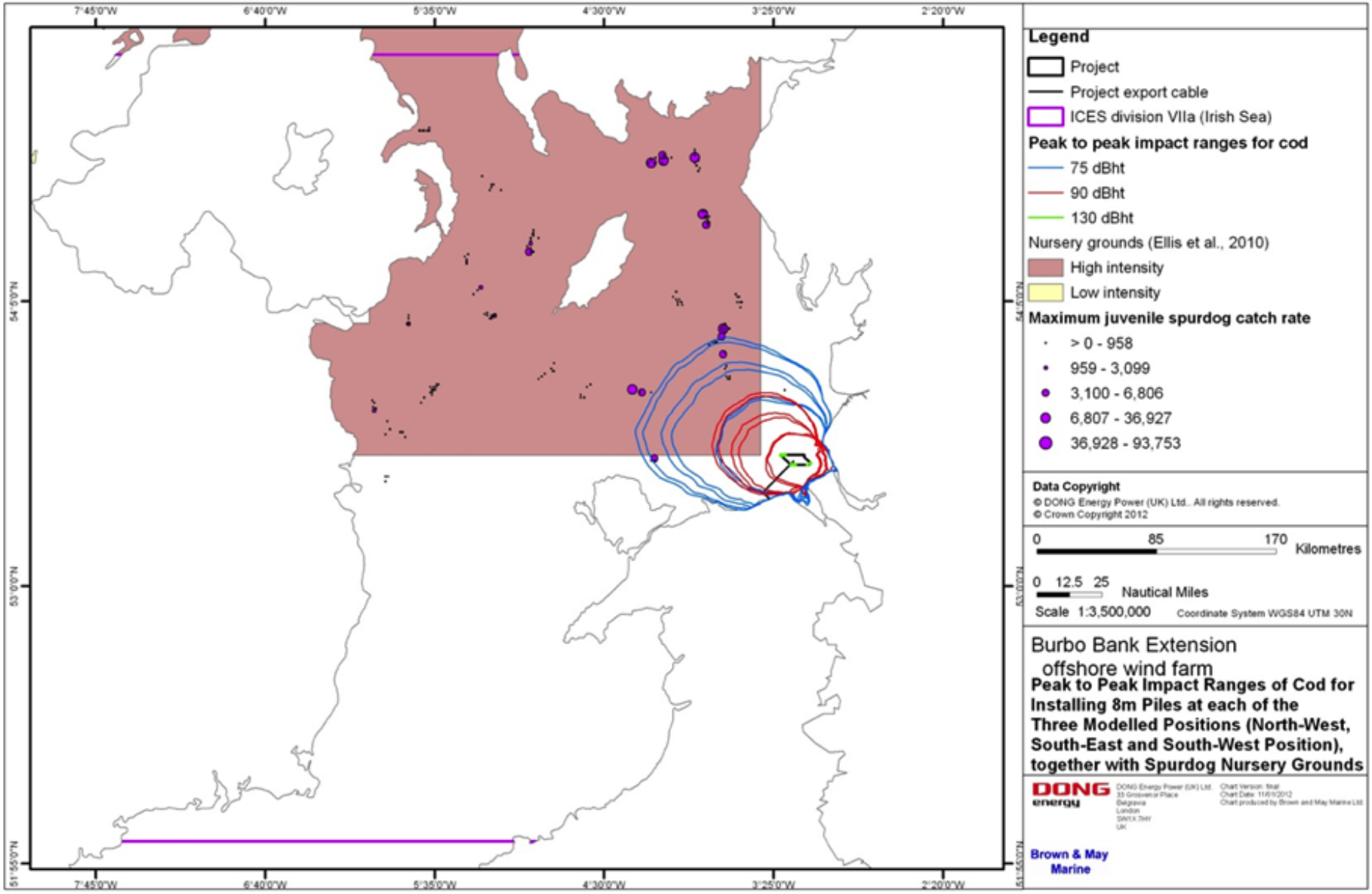

Figure 13.23: Estimated 75, 90 and 130 dB_{ht} (Gadus morhua) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, the three modelled locations together with spurdog nursery grounds as provided in Ellis et al., (2012)

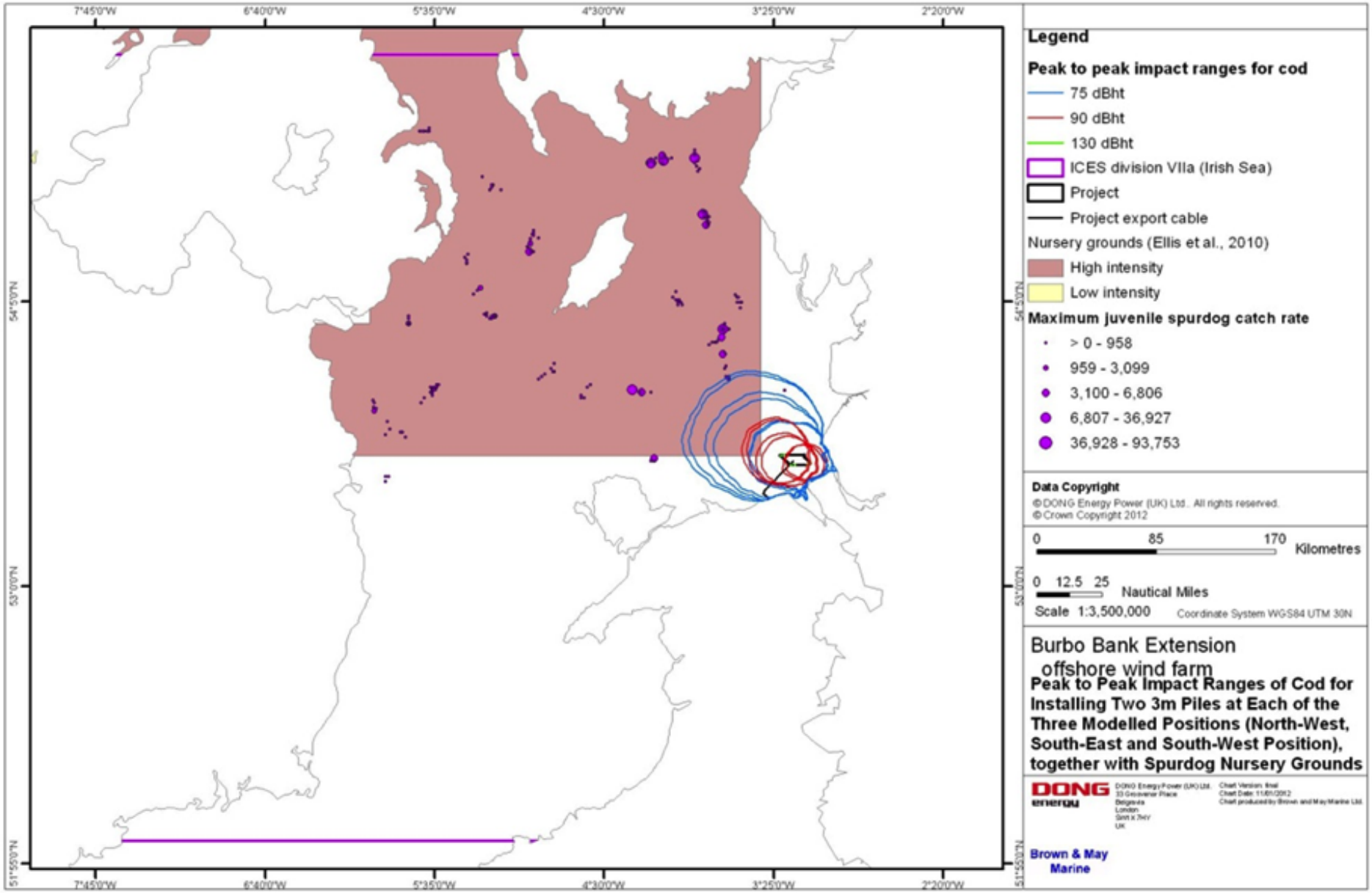

Figure 13.24: Estimated 75, 90 and 130 dB_{ht} (Gadus morhua) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, the three modelled locations together with spurdog nursery grounds as provided in Ellis et al., (2012)

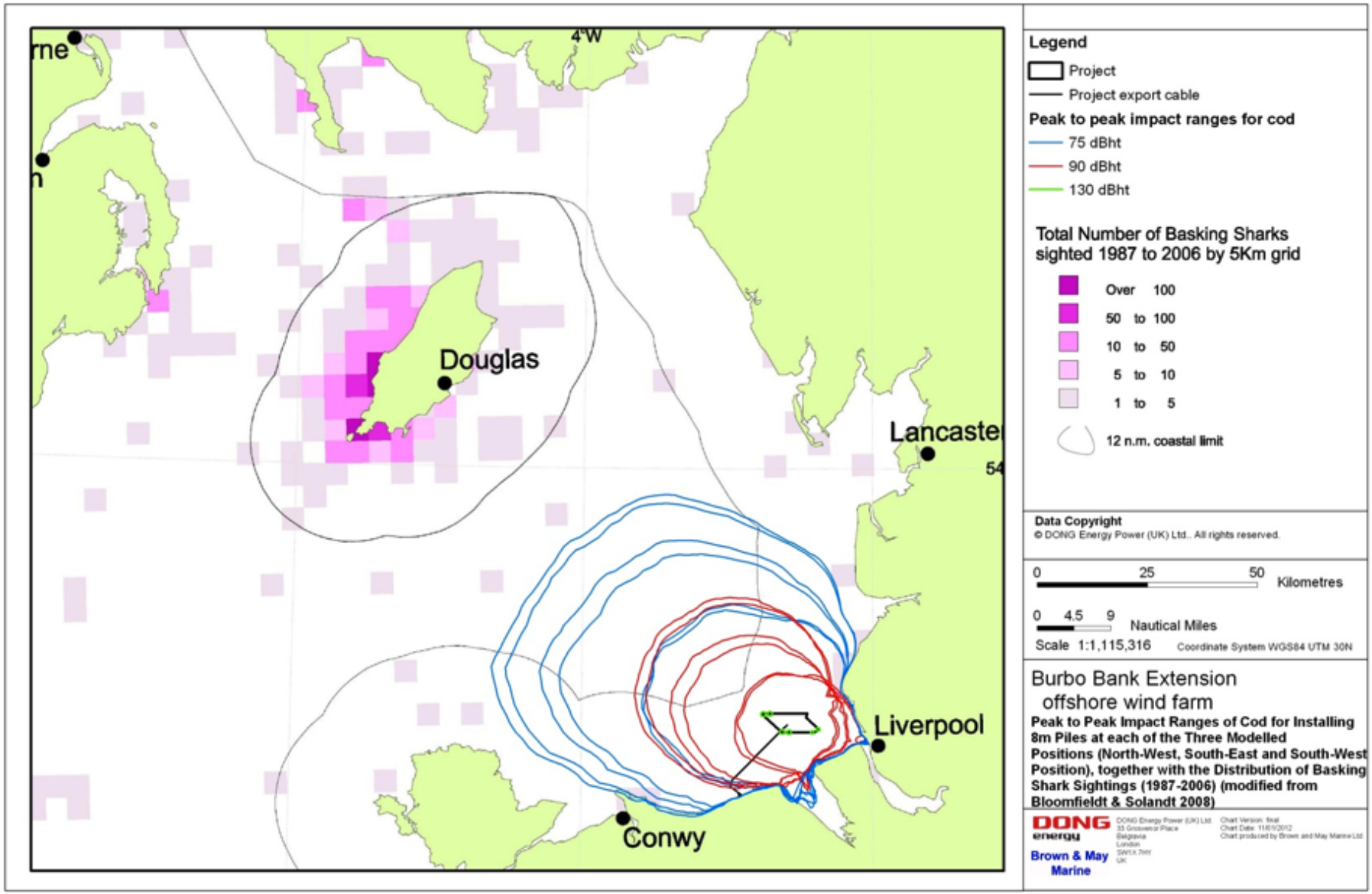

Figure 13.25: Estimated 75, 90 and 130 dB_{ht} (Gadus morhua) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, the three modelled locations together with the number of basking shark sightings (by 5 km^2 cell) from Irish Sea/ Isle of Man waters (modified from Bloomfield & Solandt, 2008)

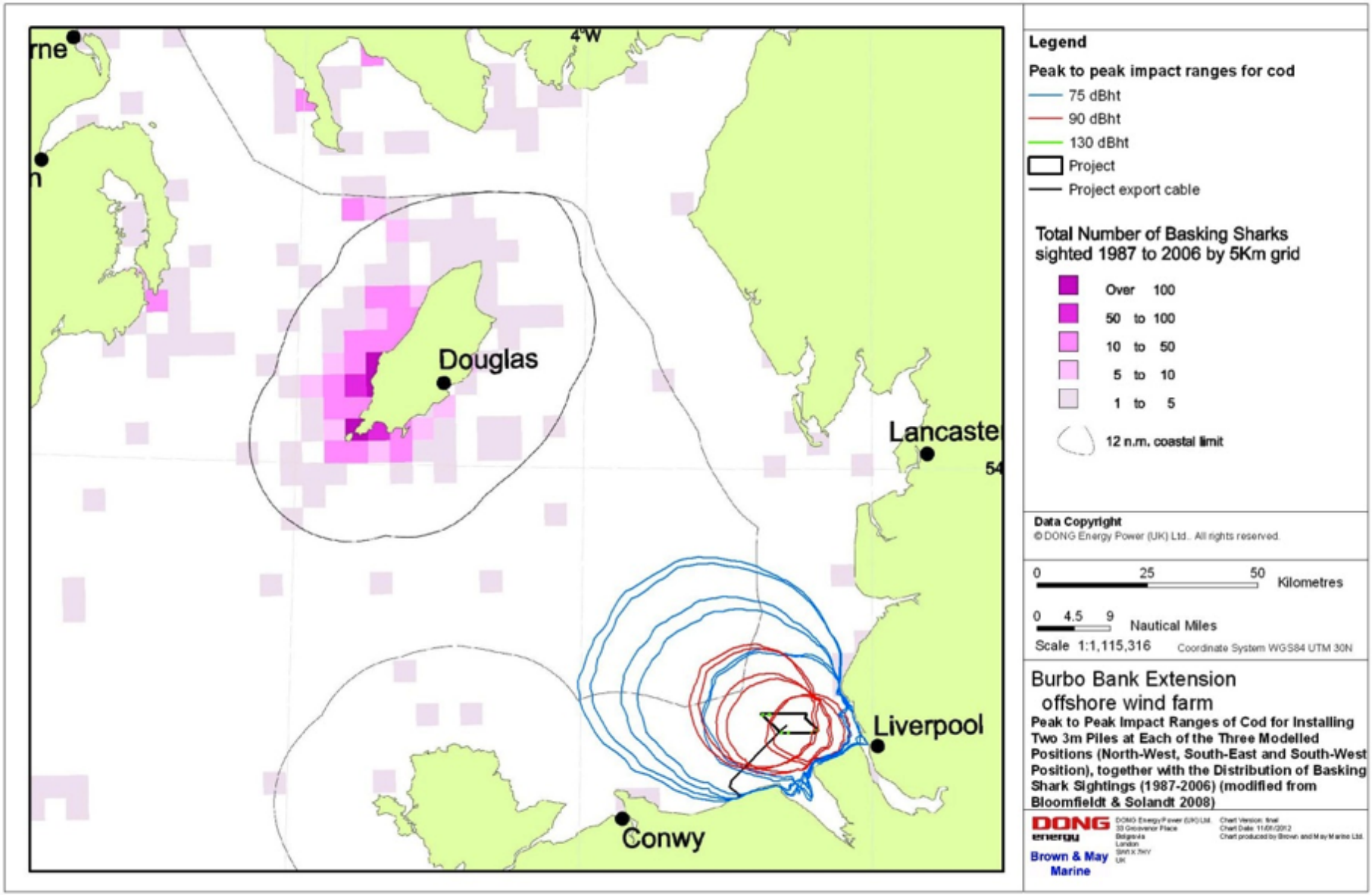

Figure 13.26: Estimated 75, 90 and 130 dB_{ht} (Gadus morhua) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, the three modelled locations together with the number of basking shark sightings (by 5 km^2 cell) from Irish Sea/ Isle of Man waters (modified from Bloomfield & Solandt, 2008)

Diadromous migratory species

13.9.90 A number of diadromous migratory species may use areas of the Project during migration (see ES Annex '5.1.5.13.2') and may therefore be exposed to noise levels at which behavioural responses are expected in fish.

13.9.91 Of these, river and sea lamprey are of particular conservation importance in the study area, being qualifying features of some of the Special Areas of Conservation (Dee estuary SAC and river Dee and Bala Lake SAC) located in the vicinity of the Project (See Figure 13.1).

13.9.92 For the purposes of this assessment and in the absence of species specific hearing ability data, the **magnitude** of potential impact of noise on **river and sea lamprey** has been assumed to be similar to that modelled for dab (**minor**) as this species also lack a swim bladder.

13.9.93 The principal rivers and those SACs for which river and sea lamprey are qualifying features are shown in Figure 13.27 and Figure 13.28 together with the noise contours modelled for dab. As shown, the areas where river and sea lamprey may be affected at the 90 dB_{ht} (*Limanda limanda*) level are comparatively small. These do not overlap the immediate vicinity of the Mersey and Dee estuaries and therefore river and sea lamprey are not expected to exhibit strong avoidance reactions immediately prior to entering or after leaving the Mersey and the Dee. Noise contours at the 75 dB_{ht} (*Limanda limanda*) level are however expected to reach the shore having potential to result in milder disturbance to river and sea lamprey. Taking the above into account together with short term and intermittent nature of piling activity the degree of interaction between the receptor and the impact is expected to be medium. In light of the above **river and sea lamprey** are considered receptors of **medium sensitivity**. As previously described the **magnitude** of the impact is deemed to be **minor**. The effect will, therefore, be of **adverse and slight significance** which is not significant in EIA terms.

13.9.94 European eel and smelt may also transit the area of the Project during migration and enter/exit rivers in the vicinity of the Project. Taking the lack of any specialised coupling mechanisms between the swim bladder and the inner ear, the **magnitude** of the impact on these species has been assumed to be **between** that assigned for dab (**minor**) and cod (**moderate**).

13.9.95 The modelled noise contours at the 90 dB_{ht} (Species) level for dab are comparatively small being limited to the immediate vicinity of the Project. The noise contours at the 90 dB_{ht} (Species) level for cod are however comparatively large and expected to reach the shore in the vicinity of the Mersey and Dee estuaries. There is potential for smelt and European eel to be disturbed at the 90 dB_{ht} (Species) level when migrating into and out of these rivers. Both species are considered to be of conservation importance and are known to be present in the wider area of the Irish Sea. Taking the above into account together with the short term and intermittent nature of piling activity, the degree of interaction between these receptors and the potential impact is expected to be small. In light of the above, **European eel** and **smelt** are considered receptors of **low sensitivity**. As previously described the **magnitude** of the impact is considered to be **between minor and moderate** and therefore the **effect** is assessed to be, at worst, adverse and slight. This is not significant in EIA terms.

13.9.96 **Allis and twaite shad** are deemed to be hearing specialists due to the presence of specialised coupling mechanisms between the swim bladder and the inner ear, therefore the **magnitude** of the impact has been assumed to be similar to that assessed for herring (**moderate**). Both species are considered to be of conservation importance (see Table 13.5). Shads are however considered to be neither abundant nor regularly recorded in the Irish Sea, being most likely to be encountered in the Solway area in the Cree estuary- located to the north of the Project (see ES Annex '5.1.5.13.2'). Taking the above into account together with short

terms and intermittent nature of piling activity, the degree of interaction between the receptors and the impact is expected to be small.

13.9.97 In light of above, **allis and twaite shad** are considered receptors of **low sensitivity**. As previously described the **magnitude** of the impact is considered to be **moderate**. The **effect** will, therefore, be of **slight adverse** significance, which is not significant in EIA terms.

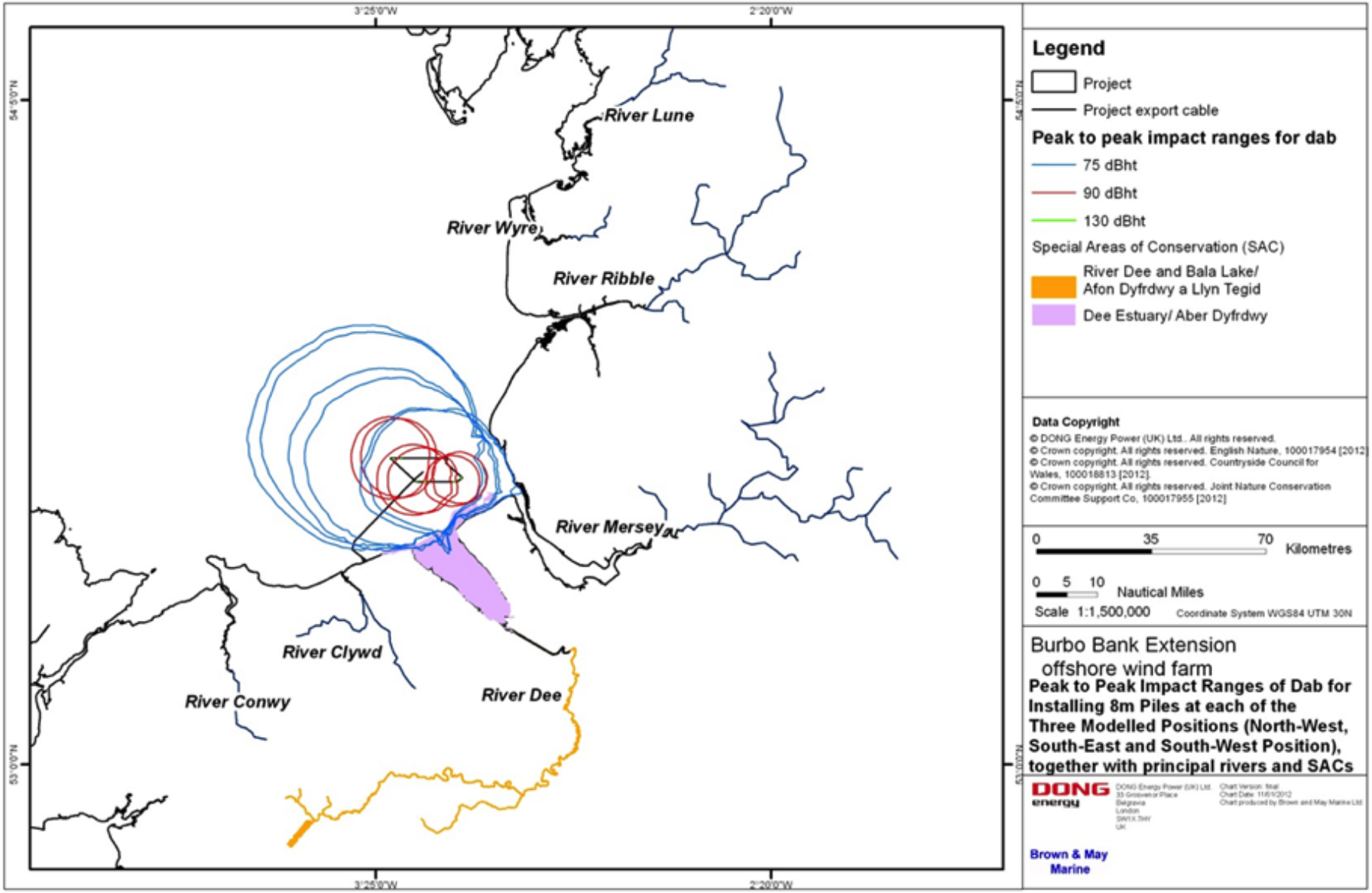

Figure 13.27: Estimated 75, 90 and 130 dB_{ht} (Limanda limanda) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at the three modelled locations ,together with principal rivers and Special Areas of Conservation (SACs), where river and sea lamprey are qualifying features for the site selection of the SAC

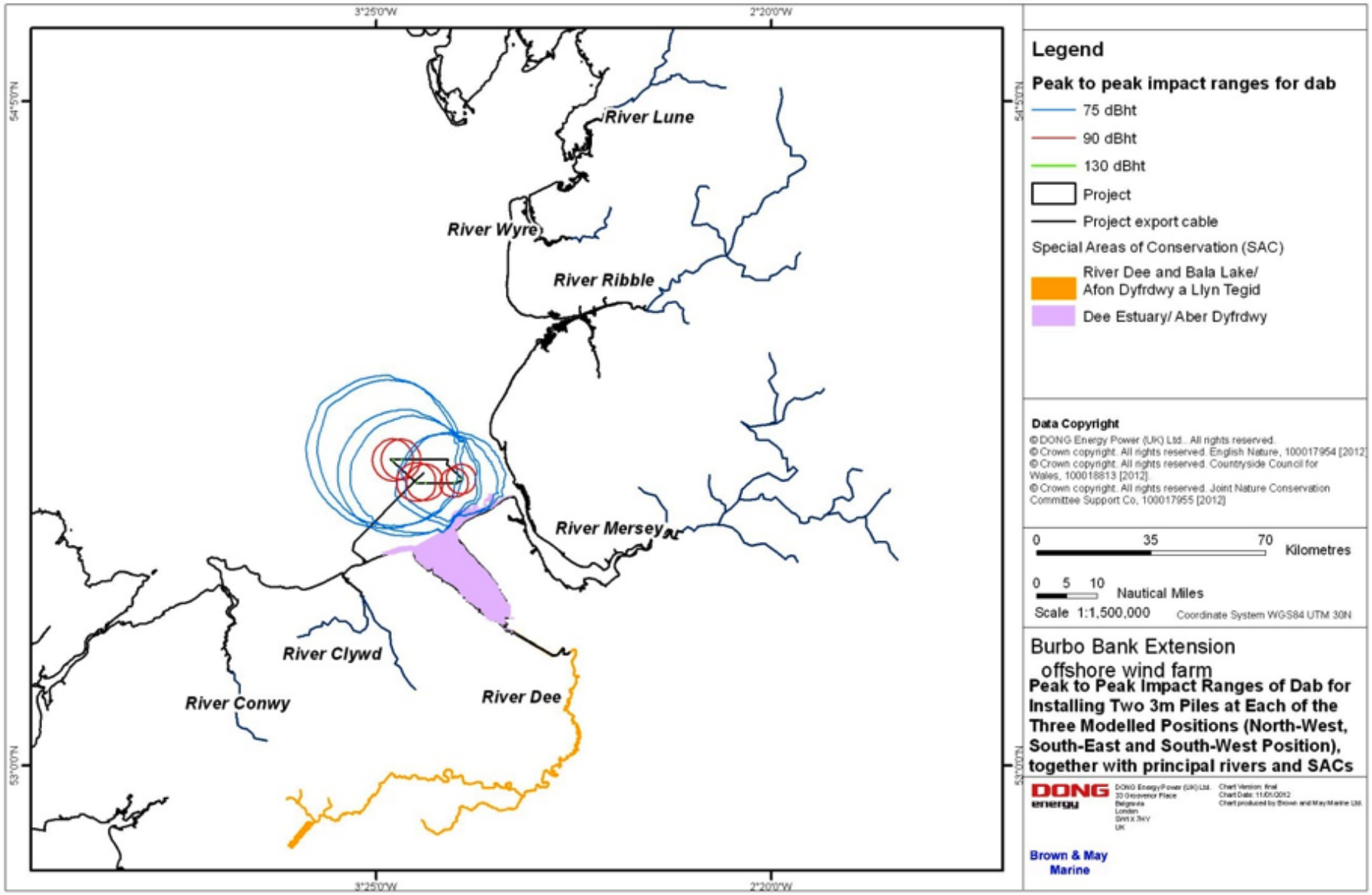

Figure 13.28: Estimated 75, 90 and 130 dB_{ht} (Limanda limanda) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at the three modelled locations ,together with principal rivers and Special Areas of Conservation (SACs), where river and sea lamprey are qualifying features for the site selection of the SAC

Shellfish

13.9.98 The majority of shellfish species present in areas relevant to the Project, are sedentary or have limited mobility in comparison to most fish species, hence they may not be able to avoid areas in close proximity to piling operations.

13.9.99 The hearing mechanism of invertebrate species is currently not well understood. They are generally assumed to be less sensitive to noise than fish due to the lack of a swim bladder. Recent studies, however, have found that species such as the shrimp (*Palaemus serratus*) and the longfin squid (*Loligo pealeii*) are sensitive to acoustic stimuli and it has been suggested that these species may be able to detect sound similarly to most fish, via their statocysts (Lovell *et al.*, 2005; Mooney *et al.*, 2010).

13.9.100 Crabs and lobsters are expected to be present in areas relevant to the Project in relatively low numbers being more prevalent off Anglesey and Great Orme. Cockle, mussel and scallop beds are located off the Wirral Peninsula and not within the Project. Potting for whelks takes place year round within the 6 nm limit with the majority of whelk potting activity occurring in rectangle 35E6 (ES Chapter 18 'Commercial Fisheries). Taking the above into account together with the short term and intermittent nature of piling activity the degree of interaction between **shellfish** species and the impact is expected to be small. In light of the above, shellfish species are considered receptors of **low sensitivity**. As previously described, the **magnitude** of the effect is considered to be between **minor** to **moderate** and therefore the effect is assessed to, at worst, be of **adverse and slight** significance. This is not significant in EIA terms.

Salmon and sea trout

Lethal and Traumatic Hearing Effects

13.9.101 The area in which salmon may be exposed to lethal and traumatic hearing effects (See Table 13.19 and Table 13.20) is very small relative to the area available for foraging and migration. Juvenile and adult salmon and sea trout, due to their mobility, would be expected to flee the areas where lethal/hearing damage effects may occur. As previously mentioned, soft start piling will be used allowing salmon and sea trout to flee the vicinity of the foundations before the highest noise levels are reached. The degree of interaction between **salmon and sea trout** and the impact will therefore be small. In light of the above, **salmon and sea trout (including smolts and adults and in the particular case of sea trout whitling)** are considered receptors of **low sensitivity**. As previously described, **the magnitude** of the impact is deemed to be **negligible**. **The effect** will, therefore, be of **neutral or slight adverse** significance, which is not significant in EIA terms. Given the uncertainties in relation to the migratory patterns of salmon and sea trout from different rivers the assessed effect is considered to be **probable**.

Behavioural Effects

13.9.102 The 90 and 75 dB_{ht} (*Salmo salar*) impact ranges at the three modelled locations (and adjacent locations located 1,500 m apart) are shown in Figure 13.29 and Figure 13.30 for installation of 8 m diameter monopiles and 3 m diameter pin piles, respectively. As illustrated in the charts, simultaneous piling using two vessels in close proximity would result in a minimal increase in the spatial extent whilst reducing the total duration of noise disturbance associated with piling.

13.9.103 The assessment of behavioural impacts in relation to noise on salmon and sea trout is given below separately in relation to the following aspects:

- Disturbance/barrier to migration and;
- Indirect impacts upon feeding/prey species.

13.9.104 In addition to these two potential impacts of noise in the offshore environment, there may be potential for salmon and sea trout to be disturbed as a result of noise associated with the installation of the onshore section of the export cable (where it crosses under the River Clwyd). As stated in ES Chapter 6 'Project Description', Horizontal Directional Drilling (HDD) may be necessary to pass large structures, including rivers. As previously mentioned, piling is the noise generating activity considered to have potential to result in the greatest impact on fish receptors. Other noise generating activities, including drilling, are considered to result in comparatively negligible noise levels. As shown in ES Chapter 11 'Offshore Noise', the impact range of drilling at which salmon would be affected at the 90 dB_{ht} and 75 dB_{ht} (*Salmo salar*) levels is not considered to exceed 1 m. As a consequence, no significant effects on salmon and sea trout as a result of noise derived from installation of the onshore section of the export cable.

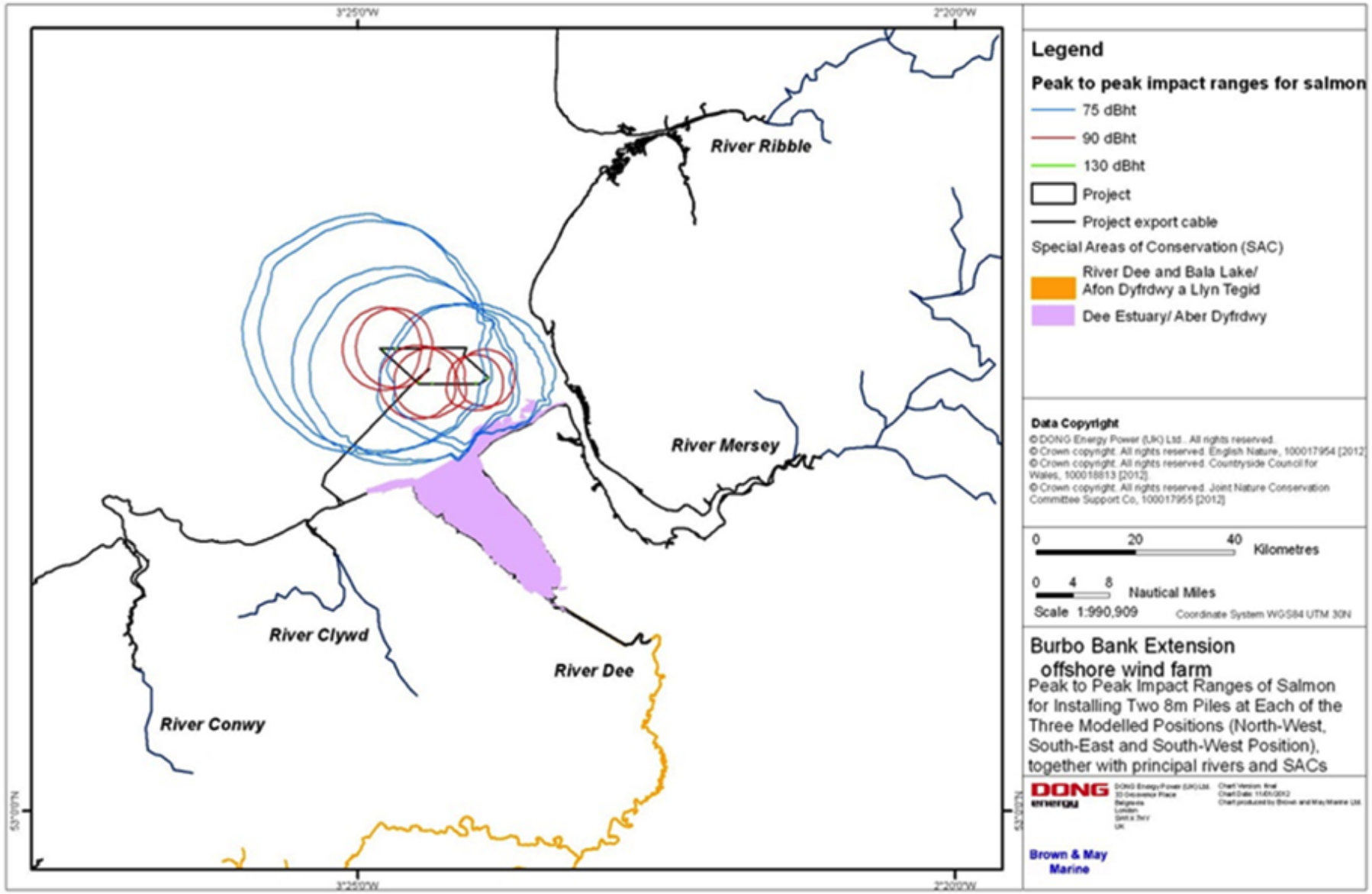

Figure 13.29: Estimated 75, 90 and 130 dB_{ht} (Salmo salar) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at the three modelled locations together with principal rivers and Special Areas of Conservation (SACs), where salmon are qualifying features for the site selection of the SAC

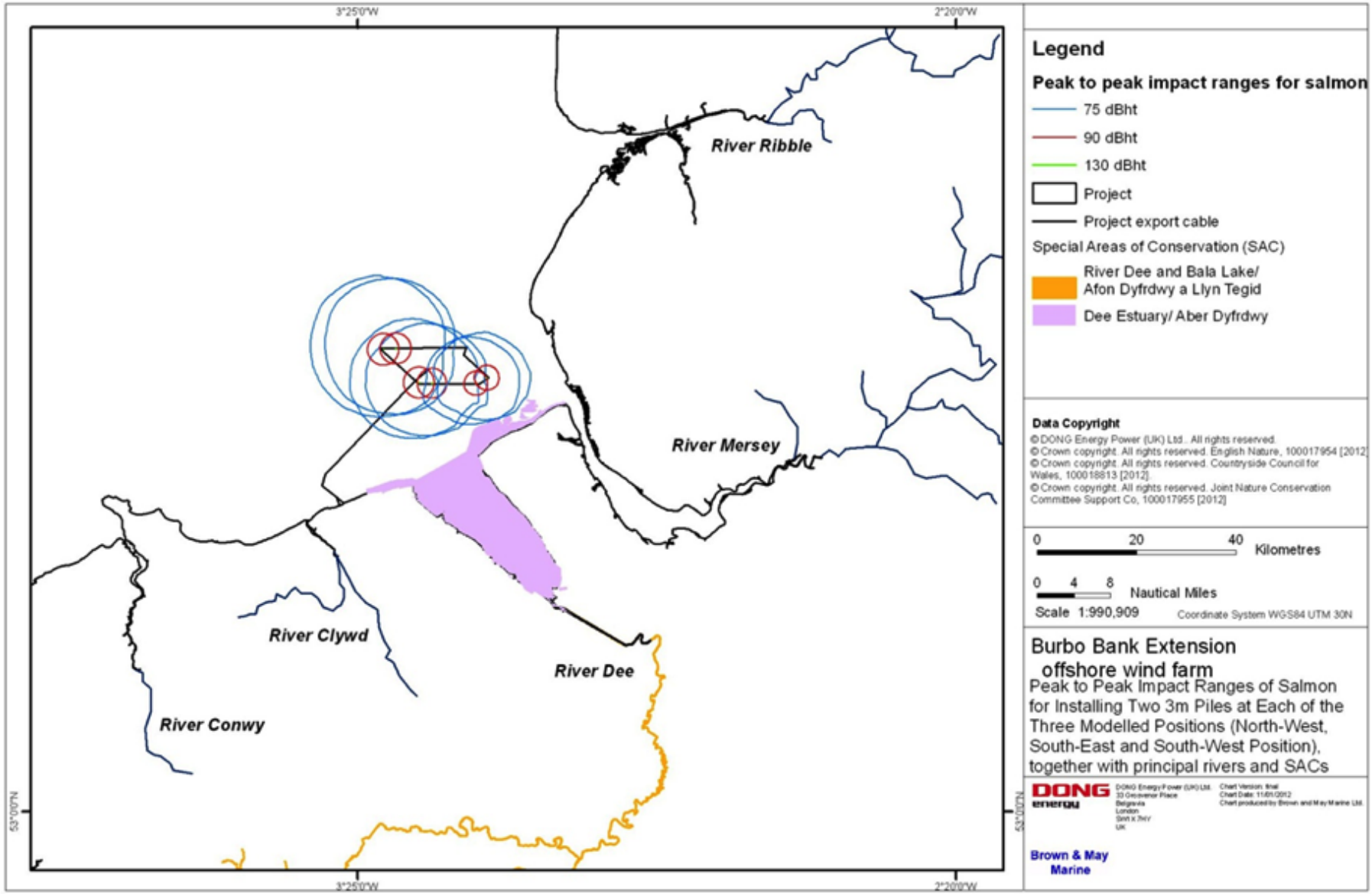

Figure 13.30: Estimated 75, 90 and 130 dB_{ht} (Salmo salar) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at the three modelled locations together with principal rivers and Special Areas of Conservation (SACs), where salmon are qualifying features for the site selection of the SAC

Disturbance to migration

13.9.105 **River Ribble and River Conwy**: Noise levels at which behavioural responses are expected in salmon and sea trout will not reach the vicinity of the Ribble and the Conwy (Figure 13.29 and Figure 13.30). Salmon and sea trout (adults and smolts) will therefore not be disturbed immediately prior to entering or leaving these rivers. They may, however, transit the area of the Project at earlier or later stages during migration. This would be expected to result in limited disturbance to migration with salmon and sea trout being able to use adjacent undisturbed areas. The degree of interaction between the receptors and the impacts is considered to be medium. Taking the above into account, **salmon and sea trout (adults and smolts)** are considered to be of **medium sensitivity**. As previously described, the **magnitude** of the impact is deemed to be **minor**. The **effect** will, therefore, be of **slight adverse** significance, which is not significant in EIA terms. The assessed effect is however considered to be **unlikely** given the distance from these rivers to the areas disturbed by construction noise.

13.9.106 **River Clwyd**: Levels of noise which could be expected to elicit behavioural responses in salmon and sea trout will not reach shore in the vicinity of the River Clwyd estuary mouth (Figure 13.29 and Figure 13.30). As suggested for the Ribble and Conwy, salmon and sea trout adults and smolts will not be subject to construction noise prior to or immediately after leaving the river, however, they may transit the area of the Project at earlier or later stages during migration. Salmon and sea trout are expected to be able to use undisturbed adjacent areas during migration. The degree of interaction between the receptors and the impact is considered to be medium. Taking the above into account, **salmon and sea trout adults and smolts** originating from the Clwyd are considered to be receptors of **medium sensitivity**. The effect will, therefore, be of **slight adverse** significance, which is not significant in EIA terms. The assessed effect is considered **probable** given the relative proximity of the river to areas potentially impacted by construction noise.

13.9.107 **River Dee and River Mersey**: As shown in Figure 13.29 and Figure 13.30 noise levels at which strong avoidance reactions may occur (90 dB_{ht} (*Salmo salar*) contours will reach the proximity of the Dee Estuary and the mouth of the River Mersey. Noise contours at the 75 dB_{ht} (*Salmo salar*) level, particularly if 8m diameter pin piles are used, will reach the shore in the immediate vicinity of the Dee Estuary and the River Mersey mouth. There is therefore potential for construction noise to result in a barrier to migration to salmon and sea trout from these rivers. It should be noted in this context that, given the intermittent and short nature of piling any barrier effect that may occur will be necessarily short term (in the order of hours or days).

13.9.108 The peak migration of salmon and sea trout smolts is temporally restricted. In addition, the smolt run may be highly synchronised in relatively large proportions of the population (Stewart *et al*, 2006). Assuming that piling occurs concomitantly with the peak of outward migration then significant numbers of smolts could be exposed to piling noise prior to the outward migration. At this life stage, the timing of marine entrance is believed to influence survival rates (Kennedy & Greer, 1988; Moore et al, 1995; Klemetsen *et al*, 2003). The degree of interaction between the receptor and the potential impact is therefore considered to be very high. In light of the above, salmon and sea trout smolts originating in the river Dee and Mersey are considered receptors of **very high sensitivity**. As previously described, the **magnitude** of the impact is deemed to be **minor**. The effect will, therefore, be of **moderate or large adverse** significance which is significant in EIA terms.

13.9.109 In the case of **adult fish**, based on consultation, fisheries statistics and the literature, adult migration into rivers is likely to be more staggered, with fish entering the river Dee as early as January and as late as December. The general pattern is one of low numbers entering in the first quarter increasing through spring with August and September recording 27% and

35% of the annual run, respectively. Numbers then decline markedly in October, November and December (ES Annex '5.1.5.13.1'). For sea trout, the majority of river entry occurs from May through to August. For mature adults, June represents the peak of migration (65%) occurring later in July the case of **whitling** (69%). The degree of interaction between the impact and salmon and sea trout adults and whitling originating in the rivers Dee and Mersey is considered to be medium/high. Taking the above into account, the above receptors (**adult salmon and sea trout and whitling**) are considered of **high sensitivity**. As previously described the **magnitude** of the impact is deemed to be minor. The effect will, therefore, be of **slight or moderate adverse** significance which is significant in EIA terms.

13.9.110 Given the proximity of the rivers Dee and Mersey to the areas impacted by construction noise, the effects assessed above are in all cases considered to be **probable**.

Feeding

13.9.111 A number of prey species which feature in the diets of both salmon and sea trout (both as post - smolts and adults) are found within the vicinity of the Project (see ES Annex '5.1.5.13.1'). These include herring, sprat and sandeel with benthic invertebrates such as polychaetes and crustaceans which represent an additional prey source. As shown in ES Annex '5.1.5.13.2' and ES Chapter 12 'Subtidal and Intertidal Benthic Ecology', both polychaetes and crustaceans have wide distribution ranges and are generally abundant in the study area. Salmon and sea trout would therefore be able to access alternative feeding grounds in adjacent locations. It should be noted in this context that significant impacts on salmon and sea trout fish prey have not been identified in any phase of the Project. Sea trout generally migrate less extensively during marine feeding and natal rivers are in close proximity to the Project. Whilst it is generally accepted that salmon post-smolts and adult feeding grounds are located long distances from natal rivers (see ES Annex '5.1.5.13.1'), feeding in the vicinity of the Project cannot be ruled out. The degree of interaction between the impact and the receptors is however expected to be, at worst, medium. Taking the above into account, adult and juvenile sea trout from all the rivers included for assessment are considered receptors of **medium sensitivity**. As previously described, the magnitude of the impact is deemed to be **minor**. The effect will, therefore, be of **slight adverse** significance, which is not significant in EIA terms.

13.9.112 In the particular case of whitling, given that they undertake local estuarine migrations, and taking account of the potential overlap between construction noise and areas at the mouth of the River Dee and Mersey, the degree of interaction between the receptor and the impact is considered to be medium/high. Taking the above into account, whitling originating in these rivers are considered receptors of **high sensitivity**. As previously described the **magnitude** of the effect is deemed to be **minor**. The effect will, therefore, be of **slight or moderate adverse significance**, which is significant in EIA terms.

13.9.113 Taking the migratory nature of salmon and sea trout and sea trout effects assessed above are considered to be **probable**.

Further mitigation and future monitoring

13.9.114 As presented in the assessment given above in general terms the potential impacts associated with the construction phase will result in effects of neutral or slight significance on fish and shellfish receptors, and therefore not significant in EIA terms.

13.9.115 Exceptions to these are the predicted effects of construction noise on the following receptors, which are of a significance above slight and therefore significant in EIA terms:

- **Sole**: Construction noise is expected to result in an effect of moderate or large adverse significance in particular relation to spawning activity.

- **Salmon and sea trout smolts originating in the River Dee and Mersey**: Construction noise is expected to result in an effect of moderate or large adverse significance on **migration**.
- **Adult salmon, adult sea trout and whitling originating in the River Dee and Mersey**: Construction noise is expected to result in an effect of slight or moderate adverse significance on their **migration**. In addition, in the particular case of **whitling** originating in the **River Dee**, construction noise is expected to result in an effect of slight or moderate adverse significance in terms of disturbance to **feeding**. These effects are significant in EIA terms.

13.9.116 Concern was expressed with regards to the potential noise impacts on the peak periods of sole spawning and the salmon and sea trout smolt seaward migration during the consultation meeting/teleconference held on 21st November 2012. It was therefore agreed that a piling restriction between 1st April and 31st May would effectively mitigate the noise effect so that there would not be a significant adverse impact on spawning sole nor on salmon and sea trout smolts.

13.9.117 As a result of the Applicant's commitment to avoid piling activity between the 1st April and 31st May, the **residual effect of construction noise on sole and salmon and sea trout smolts** it is considered to be of **slight adverse significance**, and therefore not significant in EIA terms.

13.9.118 In the particular case of adult salmon and sea trout and the Dee whitling population, the applicant is engaged in on-going consultation with relevant statutory stakeholders with the aim of exploring the potential for effective mitigation and/or monitoring measures be implemented and potential adverse effects minimised.

Operational phase

13.9.119 The impacts of the operation and maintenance of the Project have been assessed on fish and shellfish ecology in the offshore study area. The environmental effects arising from the operation and maintenance of the Project are listed in Table 13.13 along with the Design Envelope criteria against which operation and maintenance phase impact has been assessed. A description of the potential changes on fish and shellfish ecology receptors caused by each identified impact is given below.

Loss of habitat

13.9.120 The installation of 69 x 3.6 MW turbines using gravity base foundations together with the use of scour protection (usually dumped rocks or concrete blocks extending up to 15 m) will result in the maximum adverse scenario in terms of loss of habitat, resulting in a loss of seabed of 0.229 km^2 (0.0664 km^2 excluding scour protection), equalling 0.57% (0.166% excluding scour protection) of the total Project area (see ES Chapter 12 'Subtidal and Intertidal Benthic Ecology'). Offshore sub stations will add to these figures, but negligibly when compared with the number of turbines. Similarly, cable protection, where required, will further contribute to seabed loss. Whilst the long term and constant nature of the potential impact is recognised, taking the very small expected loss of seabed habitat (0.0664 km^2, excluding scour protection) and hence the small change to baseline conditions, the magnitude of the impact is considered to be **minor**.

Likely environmental effects without mitigation

Fish and shellfish (including salmon and sea trout)

13.9.121 **Fish and shellfish** species present in the area of the Project have wide distribution ranges (see Fish and Shellfish Ecology and Salmon and Sea Trout Technical Reports ES Annexes '5.1.5.13'). These may vary depending on the species under consideration but are consistently very large (whether in the context of spawning, nursery and/or feeding grounds) relative to the predicted loss of seabed habitat. The degree of interaction between the impact and the receptor will therefore be small. In light of the above, fish and shellfish species are considered receptors of **low sensitivity**. As previously described the magnitude of the impact is deemed to be **minor**. The effect will, therefore, be of **neutral or slight adverse** significance, which is not significant in EIA terms.

13.9.122 An exception to the above are sandeels which are highly substrate specific requiring the presence of an adequate substrate in which to bury. Sandeels are key prey to a number of marine mammals, seabirds and other fish species. In addition, the Project is located within defined sandeel high intensity spawning grounds and they were recorded in relatively high numbers during site specific beam trawl surveys (ES Annex '5.1.5.13.2'). Taking the information above into account, it is assumed that there is potential for turbine foundations to be placed in areas where sandeels may be present. It should be noted that the highest numbers of sandeels caught in beam trawl samples during fish characterisation surveys were found at control stations outside the Project (ES Annex '5.1.5.13.2'). The wider distribution of these species in the Eastern Irish Sea and in the vicinity of Project should be recognised in this context. Taking the above into account, the degree of interaction between the receptor and the impact is considered to be medium.

13.9.123 Sandeels are considered receptors of **medium sensitivity** and as previously described, the **magnitude** of the impact is deemed to be minor. The effect will, therefore, be of **slight adverse** significance, which is not significant in EIA terms.

Introduction of hard substrate habitat

13.9.124 The sub-surface sections of turbine towers, gravity base foundations and rock dumping (0.229 km^2, equalling 0.57% of the total Project area) will result in the introduction of hard substrate which will potentially be colonised by a number of organisms such as mussels, tubeworms, barnacles, hydroids, sponges, soft corals, amphipods, anemones and other sessile invertebrates (ES Chapter 12 'Subtidal and Intertidal Benthic Ecology'). The overall effect of installing gravity base foundations and rock-based scour protection will be the replacement of areas of the existing predominantly sandy and slightly gravelly or silty biotopes with communities typical of harder substrates (ES Chapter 12 'Subtidal and Intertidal Benthic Ecology'). Whilst the constant and long term duration of the potential impact is recognised, taking the small expected introduction of hard substrate together with the relatively small area over which effect associated with this may occur (limited to the area of the Project and its immediate vicinity), the **magnitude** of the impact is considered to be **minor**.

Likely environmental effects without mitigation

Fish and shellfish (including salmon and sea trout)

13.9.125 The increase in diversity and productivity of seabed communities expected may have an impact on fish resulting in either attraction or increased productivity (Hoffman *et al*., 2000). The potential for marine structures, whether man-made or natural, to attract and concentrate

fish is well documented (Sayer *et al*., 2005; Bohnsack, 1989; Bohnsack and Sutherland,1985), however, whether these structures act only to attract and aggregate fish or actually increase biomass is currently unclear. The assessment of the impact of introduction of hard substrate has, therefore, been largely supported by a review of existing literature.

13.9.126 Studies carried out in Sweden in operational wind farms suggest that the structures may function as combined artificial reefs and fish aggregation devices (FADs) for demersal and semi-pelagic fish (Wilhelmsson *et al*., 2006). This was concluded on the basis of the greater abundance of fish found on and near monopiles. Wilhelmsson *et al.* (2006) pointed out that added structures on the monopiles may attract species that would not have been present otherwise and suggested that the changes in abundance of some species could result in positive local effects on commercial species, provided local increases on the species that they prey upon also occur.

13.9.127 Monitoring of fish communities was conducted in 2009 at the C-Power wind farm at Thorntonbank (6 operational turbines at the time of the survey, GBS and scour protection). Scuba diving operated visual surveys and line and gillnet surveys were undertaken to assess fish communities near hard substrata, whilst beam trawl surveys were used to assess fish abundances on soft sediments (Reubens *et al*., 2010, Vandendriessche *et al*., 2009). Compared to the soft sediments, densities were highly enhanced for cod, pouting (*Trisopterus luscus*) and horse mackerel near the artificial hard substrata of the wind turbines, indicating the aggregation effect of the turbines (Reubens *et al*., 2010). In addition the results of stomach analysis of pouting caught near the artificial hard substrata supported the prime importance of the hard substratum prey species *Jassa herdmani* (amphipod) and *Pisidia longicornis* (porcelain crab) (Reubens *et al*., 2010, Kerckhof *et al*., 2010). The biofouling organisms on the artificial hard substrates, as well as the enriched sandy sediment macrobenthic communities, in their turn, represent increased food availability for cod and pouting. Their actually observed feeding on dominant hard substrate fouling organisms, clearly hints towards the fact that wind farms are major feeding grounds for bentho-pelagic fish species (Degraer *et al*., 2011). In addition, Reubens *et al.* (2011) confirmed cod to be attracted to offshore wind farms and their surrounding erosion protection layers, as shown by the high residency (62-100% of the days: max. 85 days) of some tagged cod specimens. Individual cod further seemed to profit from the variety of habitat, and hence probably also food resources, as demonstrated by their small-scale spatial distribution patterns nearby the wind farm, where they occupy the erosion protection layer with its rich biofouling community (preferred habitat during night), as well as the nearby biologically enriched sandy sediments (Degraer *et al*., 2011; Reubens *et al*., 2011). Monitoring of fish communities conducted in 2010 at Thorntonbank found larger individuals of the swimming crab (*Liocarcinus holsatus*) and the brown shrimp within the wind farm, suggesting either increased growth due to a high food availability or increased predation pressure eliminating smaller individuals. Furthermore, small whiting were detected in higher densities within the wind farm than at the reference stations in autumn 2010 (Degraer *et al*., 2011).

13.9.128 A review on the short term ecological effects of the offshore wind farm Egmond aan Zee (OWEZ) in the Netherlands, based on two year post-construction monitoring (Lindeboom *et al*., 2011), found only minor effects upon fish assemblages, especially near the monopiles, and it was suggested that species such as cod may find shelter within the wind farm. Data collected by pelagic and demersal surveys indicated the presence of a highly dynamic fish community with large differences observed for pre-construction catches compared to those after the wind farm was operational. A switch in the dominance of pelagic species from herring to sandeels, and an increase in the species richness of demersal species in the first year after construction was recorded. Those changes were, however, also observed in reference areas and it was concluded that it was unlikely to be caused by the presence of the wind farm. At OEWZ, an exclusive

significant increase inside the wind farm was found for sole, whiting and striped red mullet (*Mullus surmuletus*) during summer, whereas a significant decrease was found for lesser weever (*Echiinchthys vipera*), both in summer and in winter. No clear explanation was however found for the change in abundance of these species (Lindeboom *et al*., 2011).

13.9.129 During post-construction monitoring work at the operational wind farm "Horns Rev" in Denmark, it was estimated that the loss of infaunal habitat derived from the introduction of hard substrate habitat provided 60 times increased food availability for fish and other organisms in the wind farm area compared to the native infaunal biomass (Leonhard and Pedersen, 2005). A succession in the number of fish species was observed when comparing the results of surveys undertaken in March and September, and it was suggested that it could be a result of seasonal migrations of fish species to the turbine site for foraging. Pouting was observed presumably partly feeding on crustaceans on the scour protection together with schools of cod. Other species such as rock gunnel (*Pholis gunnellus*) and dragonet (*Callionymus spp.*) were commonly found inhabiting caves and crevices between the stones. In addition, pelagic and semi-pelagic fish such as sprat, mackerel and lesser sandeel were recorded more frequently than previously (Leonhard and Pedersen, 2005). The recently published Horns Rev monitoring follow-up report (Stenberg *et al*., 2011) which examined the changes in the fish community seven years after construction, indicates that the introduction of hard substrate resulted in minor changes in the fish community and species diversity. Fish community changes were observed due to changes in densities of the most commonly occurring fish (whiting and dab), however, this reflected the general trend of these fish population in the North Sea. The introduction of hard substrate was however found to result in higher species diversity close to each turbine with a clear (horizontal) distribution, which was most pronounced in the autumn, when most species were registered. New reef habitat fish such as goldsinny wrasse (*Ctenolabrus rupestris*), viviparous eelpout (*Zoarces viviparous*) and lumpsucker (*Cyclopterus lumpus*) were found to establish themselves on the introduced reef area (Stenberg *et al*., 2011). Specific monitoring of sandeel populations carried out in Horns Rev suggests that the construction of the windfarm has not had a detrimental long-term effect on the overall occurrence of sandeels in the area (Stenberg *et al*., 2011).

13.9.130 Research carried out at Lysekil, a test wave power park off the Swedish west coast, found significantly higher abundance of fish and crabs on the foundations compared to the surrounding soft bottoms. Fish numbers were however not found to be influenced by increased habitat complexity (Langhamer and Wihelmsson, 2009).

13.9.131 The results of fish monitoring programmes carried out in operational wind farms in the UK do not suggest that major changes in fish species composition, abundance or distribution have occurred. At North Hoyle, changes in the diversity of organism or the species composition of the benthic and demersal community were not found. The annual post-construction beam trawl survey indicated that most of the fish species were broadly comparable to previous years and within the long-term range, with some species showing recent increases and decreases but broadly mirroring regional trends (Cefas, 2009). At Barrow, pre and post-construction otter trawl survey results from the wind farm area showed similar patterns of abundance, with the most frequently caught fish being dab, plaice, whiting and lesser spotted dogfish. Results from control locations showed a similar pattern and found no significant differences between the catches of the two most abundant species (dab and plaice) before and after installation of the wind farm, or between the numbers caught at control locations and within the wind farm area after the wind farm was constructed (Cefas, 2009). Similarly as described in ES Annex '5.1.5.13.1' at the operational Burbo Bank offshore wind farm, pre and post-construction 4 m beam trawl survey results showed that the construction and operation of the wind farm had no major impact on fish diversity or abundance.

13.9.132 It has been suggested by Linley *et al*. (2007) that the introduction of wind farm related structures could extend the distribution of some mobile species such as crabs, lobsters and fin fish, as a result of increased habitat opportunities. At Horns Rev for example, it was found during post construction monitoring that the wind farm site was being used as a nursery area by juvenile edible crabs (Leonhard and Pedersen, 2005). Colonisation of structures by commercial shellfish species has also been reported at the artificial reef constructed in Poole Bay in 1989, where attraction and loyalty was demonstrated for European lobster and edible crabs within three weeks of deposition (Collins *et al*., 1992; Jensen *et al*., 1994). In addition, evidence of reproductive activity for a number of shellfish species such as spider crabs, velvet crabs and presence of berried females of lobster was also found (Jensen *et al*., 1992).

13.9.133 As suggested by the information provided above, the degree of interaction between fish and shellfish and the impact is expected to be small. Fish and shellfish species are considered to be receptors of **low sensitivity**. As previously described the **magnitude** of the effect is deemed to be minor. The effect will, therefore, be of **neutral or slight** significance which is not significant in EIA terms. Whether the assessed effect is **beneficial or adverse** will depend on the species under consideration (e.g. beneficial for species for which feeding opportunities are increased and/or shelter is found within the Project and adverse for other species if subject to increased predation or competition for food resources within the Project).

EMFs

13.9.134 Inter-array and export cables will be buried to a target depth of 2 m (+/– 1 m) and a maximum of 10% of inter-array and export cables is assumed to be protected by rock dumping where target burial depth cannot be achieved (section 13.8.1). As described in Table 13.1, the effects of EMF during operation on sensitive species are not likely to be significant where mitigation measures such as the use of armoured cables for inter array and export cables and cable burial at sufficient depths is applied (Department of Energy and Climate Change, 2011).

13.9.135 The maximum adverse scenario takes account of the above mitigation and assumes the maximum length of cabling and the use of the highest rating for inter-array and export cables. As the ES Chapter 6 'Project Description', inter-array cables will be AC XLPE cables of a voltage between 33 and 66 kV and up to two HVAC export cables will be running offshore with a voltage of between 75/132 kV and 127/275 kV. The maximum length of cabling is considered to 65 km of inter-array cables and 29 km for each export cable.

13.9.136 During the operational phase inter-array and export cables will generate an electric field (E) and a magnetic field (B). The total E field cancels itself out to a large extent and the remaining E field is shielded by the metallic sheath and the cable armour. The varying magnetic field (B) however, produces an associated induced electric field (Ei), therefore both B and Ei fields will be generated by inter-array and export cables during the operational phase of the Project.

13.9.137 Normandeau *et al.* (2011) modelled expected magnetic fields using design characteristics of 24 undersea cable projects and found that for eight out of ten modelled AC cables intensity of the field was roughly a direct function of voltage (ranging from 33 kV to 345 kV) although separation between the cables and burial depth also influenced field strengths. The predicted magnetic fields were strongest directly over the cables and decreased rapidly with vertical and horizontal distance from the cables. The averaged values of the magnetic field strengths from AC cables, assuming 1 m depth cable burial, modelled by Normandeau *et al*. (2011) are given in Table 13.21.

Table 13.21 Averaged magnetic field strength values from AC cables buried 1 m (Normandeau et al., 2011)

Distance (m) above seabed	Magnetic Field Strength (μT)		
	Horizontal distance (m) from cable		
	0	4	10
0	7.85	1.47	0.22
5	0.35	0.29	0.14
10	0.13	0.12	0.08

13.9.138 Since the strength of the magnetic field decreases with distance from the source, the potential effects of EMFs on fish and shellfish species will likely be influenced by the position of particular species in the water column and by water depth. Cable burial does not effectively mitigate B or Ei fields, although it reduces exposure of electromagnetically sensitive species to the strongest EMFs which exist at the "skin" of the cable owing to the physical barrier of the substratum (OSPAR, 2008). The localised impact of EMFs on fish and shellfish resources will persist throughout the operational life-time of the Project. As previously mentioned, 90% of inter-array and export cables will be buried to a target depth of 1 to 2 m or protected where target burial depths and therefore fish and shellfish species will not be directly exposed to the strongest EMFs. Furthermore, given the rapid decrease of EMFs with both horizontal and vertical distance from the source EMF related impacts on fish and shellfish species are expected to be very localised, being limited to cables and their immediate vicinity.

13.9.139 Whilst the long term and constant nature associated with EMFs is recognised, given the localised nature the potential impact and the relatively small change to baseline conditions, the **magnitude** of the impact of EMFs is considered to be **minor**.

Likely environmental effects without mitigation

13.9.140 The information related to the sensitivity of marine species to EMFs and the implications of EMF related effects is limited to date. Evidence of a response to E fields and B fields has however been described for a number of species in UK waters. These given in Table 13.22 and Table 13.23, respectively as provided in Gill *et al*., (2005).

Table 13.22: Species for which there is evidence of a response to E fields in UK waters (Gill et al., 2005)

Species/Species Group	Latin Name
Elasmobranchs	
Lesser Spotted Dogfish	*Scyliorhinus canicula*
Blue shark	*Prionace glauca*
Thornback ray	*Raja clavata*
Round Ray	*Rajella fyllae*
Agnatha	
River lamprey	*Lampetra fluviatilis*
Sea lamprey	*Petromyzon marinus*
Teleosts	
European eel	*Anguilla anguilla*
Cod	*Gadus morhua*
Plaice	*Pleuronectes platessa*
Atlantic salmon	*Salmo salar*

Table 13.23: Species for which there is evidence of a response to B fields in UK waters (Gill et al., 2005)

Species/Species Group	Latin Name
Elasmobranchs	
All elasmobranch possess the ability to detect magnetic fields	
Agnatha	
River lamprey	*Lampetra fluviatilis*
Sea lamprey	*Petromyzon marinus*
Teleosts	
European eel	*Anguilla anguilla*
Plaice	*Pleuronectes platessa*
Atlantic salmon	*Salmo salar*

Table 13.23: continued

Species/Species Group	Latin Name
Teleosts	
Sea Trout	*Salmo trutta*
Yellowfin tuna	*Thunnus albacores*
Crustaceans	
e.g. lobster, crabs, shrimps and prawns	Specific cases non-UK: *Decapoda: Crancon crangon* ((ICES, 2003) *Isopoda: Idotea baltica* (Ugolini and Pezzani, 1995) Amphipoda: Talorchestia *martensii* (Ugolini, 1993) and *Talitrus saltator* (Ugolini and Macchi, 1988)
Molluscs	
e.g. snails, bivalves and squid	Specific case non-UK Nudibranch: *Tritonia diomedea* (Willows, 1999)

Fish and shellfish

Elasmobranchs

13.9.141 Elasmobranchs possess specialised electroreceptors called Ampullae of Lorenzini, which allow them to detect bioelectric emissions from prey, conspecifics and potential predators/competitors (Gill *et al*., 2005). In addition, they detect magnetic fields using their electrosensory systems or through a yet-to-be described magnetite receptor system (Normandeau *et al*., 2011). It is generally accepted that elasmobranchs use magnetic field detection as a means of orientation, however, scientific evidence for this is limited (Meyer *et al*., 2005) and there is debate on the actual mechanisms used (Johnsen and Lohmann, 2005).

13.9.142 Both attraction and repulsion reactions associated with E-fields have been observed in elasmobranchs. Gill and Taylor (2001) found limited laboratory based evidence that the lesser spotted dogfish avoids DC E-fields at emission intensities similar to those predicted from offshore wind farm AC cables. The same fish were attracted to DC emissions at levels predicted to emanate from their prey. Marra (1989) found evidence of a communication cable being damaged by elasmobranchs (Carcharhinis spp. and Pseudocarcharias kamoharai). Further research on EMFs and elasmobranchs (Gill *et al*., 2009) found that two benthic species, lesser spotted dogfish and thornback ray, were able to respond to the EMFs of the type and intensity associated with sub-sea cables. The responses found were however not predictable and did not always occur; when there was a response this was species dependent and individual specific, meaning that some species and their individuals are more likely to respond by moving more or less within the zone of EMFs (Gill *et al*., 2009).

13.9.143 Information gathered as part of the monitoring programme undertaken at the operational Burbo Bank offshore wind farm suggested that certain elasmobranch species (sharks, skates and rays) do feed inside the wind farm and demonstrated that they are not

excluded during periods of low power generation (CMACS, 2010, Cefas, 2009; ES Annex '5.1.5.12.1'). Monitoring at Kentish Flats found an increase in thornback rays, smoothhounds and other elasmobranchs during post construction surveys in comparison to surveys before construction. There did not, however, appear to be any discernible difference between the data for the wind farm site and reference areas, including population structure changes, and it was concluded that the population increase observed was unlikely to be related to the operation of the wind farm (Cefas, 2009).

13.9.144 As suggested above, elasmobranch EMFs may result in limited behavioural effects on elasmobranch species transiting of feeding in the area of the Project. In addition, the Project falls within defined nursery grounds for a number of elasmobranch species including, thornback ray, spotted ray and tope (section 13.6.2.2). Taking the above into account, the degree of potential interaction between EMFs and elasmobranchs is considered to be medium. In light of the above, elasmobranchs are considered receptors of **medium sensitivity**. As previously described, the magnitude of the effect is deemed to be minor. The effect will, therefore, be of **slight adverse** significance, which is not significant in EIA terms.

River and Sea Lamprey

13.9.145 Lampreys possess ampullary electroreceptors that are sensitive to weak, low-frequency electric fields (Bodznick and Northcutt, 1981; Bodznick and Preston, 1983). Whilst responses to E fields have been reported for these species, information on the use that they make of the electric sense is limited. It is likely however that they use it in a similar way as elasmobranchs to detect prey, predators or conspecifics and potentially for orientation or navigation (Normadeau *et al*., 2011). Chung-Davidson *et al.* (2008) found, based on experiments carried out on sea lamprey, that electric fields may play a role in their reproduction and it was suggested that electrical stimuli mediate different behaviours in feeding-stage and spawning-stage of sea lampreys.

13.9.146 River and sea lamprey are both qualifying features of the Dee estuary SAC and the river Dee and Bala Lake SAC. Two river lampreys were caught within the Project during the fish characterisation survey undertaken in May 2011 (ES Annex '5.1.5.13.2'). Whilst the behaviour and distribution of both species in the marine environment is poorly understood there is potential for both to transit the Project and the export cable during migration. Assuming they use the electric sense for navigation, EMFs generated by the inter-array and export cables may result in behavioural effects on these species and limited disturbance during migration. The degree of interaction between the impact and the receptors is therefore considered to be medium. In light of the above, **river and sea lamprey** are considered receptors of **medium sensitivity**. As previously described, the **magnitude** of the impact is deemed to be **minor**. The effect will, therefore, be of **slight adverse** significance which is not significant in EIA terms.

<u>European Eel</u>

13.9.147 European eel are known to possess magnetic material of biogenic origin of a size suitable for magnetoreception (Hanson *et al*., 1984; Hanson and Walker, 1987; Moore and Riley, 2009) and are thought to use the geomagnetic field for orientation (Karlsson, 1985). In addition, their lateral line has been found to be slightly sensitive to electric currents (Berge, 1979; Vriens and Bretschneider, 1979).

13.9.148 A number of studies have been carried out in relation to the migration of eels and the potential impact of EMFs derived from offshore wind farm cables. Experiments undertaken at the operational wind farm of Nysted detected barrier effects, however correlation analysis between catch data and data on power production showed no indication that the observed

effects were attributable to EMFs. Furthermore, mark and recapture experiments showed that eels did cross the export cable (Hvidt *et al*., 2005). Similarly research carried out on HVDC cables and eel migration by Westerberg (1999) found that some effects associated to the magnetic disturbance were likely to occur on eel migration, although the consequences appeared to be small. In addition, no indication was found that cables constituted a permanent obstacle to migration, either for adult eels or for elvers.

13.9.149 Further research, where 60 migrating silver eels were tagged with ultrasonic tags and released north of a 130 kV AC cable, found swimming speeds were significantly lower around the cable than in areas to the north and south (Westerberg and Lagenfelt, 2008). It was noted that no details on the behaviour during passage over the cable were recorded and possible physiological mechanisms explaining the phenomenon were unknown. Based on the results of Westerberg and Lagenfelt (2008) before publication, Öhman *et al*. (2007) suggested that even if an effect on migration was demonstrated the impact was small and pointed out that on average the delay caused by the passage was about 30 minutes.

13.9.150 European eel are of conservation importance. In addition, they are assumed to occur in all the rivers of the eastern Irish Sea and small eel fisheries exist in the Dee and Conwy rivers (see ES Annex '5.1.5.13.2'). Whilst the behaviour and distribution of European eel in the marine environment is poorly understood there is potential for them to transit the area of the Project and its export cable during migration. Taking the above into account a medium degree of interaction between the receptor and the impact is expected. European eel is considered are receptor of **medium sensitivity**. As previously described, the **magnitude** of the impact is deemed to be **minor**. The effect will, therefore, be of **slight adverse** significance which is not significant in EIA terms.

Other Fish Species

13.9.151 As indicated in Table 13.22 and Table 13.23, further to the species described above, there is some evidence of a response to EMFs in other teleost species such as cod and plaice. The results of monitoring programmes carried out in operational wind farms do not, however, suggest that EMFs have resulted in a detrimental impact on these species. Lindeboom *et al*. (2011) suggest that the presence of the foundations and scour protection and potential changes in the fisheries related to offshore wind farm development are expected to have the most impact upon fish species and that noise from the turbines and EMFs from cabling do not seem to have a major impact on fish and other mobile organisms attracted to the hard bottom substrates for foraging, shelter and protection (Leonhard and Pedersen, 2006). In line with this, research carried out at the Nysted offshore wind farm (Denmark), focused on detecting and assessing possible effects of EMFs on fish during power transmission (Hvidt *et al*., 2005), found no differences in the fish community composition after the wind farm was operational. Whilst effects on the distribution and migration of four species were observed (European eel, flounder, cod and Baltic herring), it was recognised that the results were likely to be valid on a very local scale and only on the individual level and that an impact on a population or community level was likely to be very limited. The degree of interaction between **fish species other than those previously assessed (with the exception of salmon and sea trout)** is expected to be small. In light of the above, these species are considered receptors of **low sensitivity**. As previously described, the **magnitude** of the impact is deemed to be **minor**. The effect will, therefore, be of **neutral or slight adverse** significance which is not significant in EIA terms.

Shellfish

13.9.152 Limited research has been carried out to date on the ability of marine invertebrates

to detect EMFs. Whilst there is to date no direct evidence of impacts to invertebrates from undersea cable EMFs (Normandeau *et al*., 2011) the ability to detect magnetic fields has been studied for some species and there is evidence of a response to magnetic fields in some of them, including molluscs and crustaceans (Table 13.23). Research undertaken by Bochert and Zettler (2004), where a number of species including crustaceans such as brown shrimp and molluscs such as mussels (*Mytilus edulis*), were exposed to a static magnetic field of 3.7 mT for several weeks, found no differences in survival between experimental and control animals. The functional role of the magnetic sense in invertebrates is hypothesized to be for orientation, navigation and homing using geomagnetic cues (Cain *et al*., 2005; Lohmann *et al*., 2007).

13.9.153 Research undertaken on the Caribbean spiny lobster (Panulirus argus) (Boles and Lohmann, 2003) suggest that this species derive positional information from the Earth's magnetic field. Limited research undertaken with the European lobster, however, found no neurological response to magnetic field strengths considerably higher than those expected directly over an average buried power cable (Ueno *et al*., 1986; Normandeau *et al*., 2011).

13.9.154 Indirect evidence from monitoring programmes undertaken in operational wind farms do not suggest that the distribution of potentially magnetically sensitive species of crustaceans or molluscs have been affected by the presence of submarine power cables and associated magnetic fields. In this context, however, the lack of shellfish specific EMFs monitoring programmes should be recognised.

13.9.155 As suggested by fisheries data (ES Chapter 18 'Commercial Fisheries'), most shellfish species are found in coastal areas off the Wirral Peninsula (cockles and mussels), off Anglesey and Great Orme (edible crabs and lobsters), to the north-west of the Project (scallops) and not within The Project. The degree of interaction between the receptor and the potential impact is therefore considered to be small. In light of the above, shellfish species are considered to be receptors of **low sensitivity**. As previously described, the **magnitude** of the impact is deemed to be minor. The effect will, therefore, be of **neutral or slight adverse** significance which is not significant in EIA terms.

Salmon and sea trout

13.9.156 Salmon and sea trout are known to be responsive to magnetic fields (Formicki *et al*, 2004; Tanski *et al*, 2005; Formicki and Winnicki, 2009). Biomagnetic particles of a size suitable for magnetoreception are present in the lateral line of Atlantic salmon (Moore et al, 1990; Potter & Dare, 2003) and the species has been reported to respond to electric fields (Rommel and McLeave, 1973). It has been hypothesised that this geomagnetic capability is utilised to orientate during oceanic migration, with olfaction increasingly important during the final stages when locating the natal stream (Sturlaugsson *et al*, 2009; Lohmann *et al*, 2008a, 2008b; Hansen *et al*, 1993)

13.9.157 The majority of research examining this subject in salmonids has centred on laboratory studies which demonstrate physiological responses to EMFs in both salmon and sea trout (McCleave *et al*, 1976; Vriens and Bretschneider, 1979; Formicki *et al*, 1997, 2004). It should be noted however that laboratory studies do not necessarily represent conditions at sea and that the same behavioural responses may be modified under naturally occurring conditions. Furthermore, magnetic field detection is not the only mechanism used for orientation in salmonids; vision, hearing, olfaction and hydrographic information may also be employed during migration (Öhman *et al*, 2007; Stabell, 1984).

13.9.158 Atlantic salmon migration in and out of the Baltic Sea for example, seems to have continued unaffected despite fish migrating over a number operational sub-sea HVDC cables

(Walker et al, 2001).

13.9.159 The potential impacts of EMFs on the behaviour of salmonids are likely to be closely linked to the position of fish in the water column relevant to the EMF source. In addition to water depth, the proximity of the project site to natal rivers will also have a significant bearing on the exposure of salmon and sea trout exposure to EMFs (Gill and Bartlett, 2010). In the case of the export cable, the direction/route of migration to and from rivers will determine the likelihood of exposure to EMFs emanating from this source. As migration routes to and from natal rivers are undefined, it is assumed that salmon and sea trout will be exposed to EMFs either as a result of traversing the wind farm or crossing the export cable both as part of their normal migration and/or foraging activity.

13.9.160 The literature suggests that salmon and sea trout adults and smolts generally migrate in the upper layers of the water column with more infrequent dives to deeper depths (Hawkins *et al*., 1979; Sturlaugsson & Thorisson, 1997; Aas *et al*., 2011; Malcolm *et al*., 2010).

13.9.161 It should be noted, that as suggested in Table 13.21 above, EMFs produced by wind farm cables assuming 1 m burial, are expected to be below the Earth's magnetic field (approx. 50 μT) even in the immediate vicinity of the cables, both vertically and horizontally.

13.9.162 The assessment of behavioural impacts associated with EMFs on salmon and sea trout is given below separately in relation to the following aspects:

- Disturbance/barrier to migration and;
- Indirect impacts upon feeding/prey species.

13.9.163 It should be noted, that in addition to offshore cabling, salmon and sea trout originating in the River Clwyd are likely to transit the vicinity of the onshore section of the export cable (where it crosses under the River Clwyd). When crossing rivers the depth of cable burial is expected to be 1.5 m under the riverbed (as specified by the Environment Agency Wales guidance) but most likely 3 m. The effect of EMFs associated with this will, therefore, be at worst, of the same significance as assessed below for the salmon and sea trout in the offshore environment. It should be noted in this context that, during the freshwater stages, mechanisms other than magnetic field detection are expected to be employed for spatial orientation (ES Annex '5.1.5.13.1').

Migration

13.9.164 **River Ribble and River Conwy**: Given the distance from the development, adults and smolts either entering or leaving natal rivers would not be exposed to EMFs. It is assumed however, that wider migration beyond the immediate area of these rivers would result in exposure to EMF either from export or inter array cables. Typical depths along the export cable route range from 4.5 m in near shore areas to 16.5 m closer to the turbine field. Considering this, in addition to the likely position of salmonids in the water column and the target burial depth of 1-2 m and rock dumping where burial is not possible, the strength and degree of EMF exposure is expected to be small. Any disturbance to migration would therefore likely be of a temporary and short term nature. **Salmon and sea trout smolts and adults** are considered receptors of **low sensitivity**. As previously described, the **magnitude** of the impact is deemed to be minor. The effect will, therefore, be of **neutral or slight adverse** significance which is not significant in EIA terms.

13.9.165 **River Clwyd and River Mersey**: Due to the position of the both the Clwyd and Mersey relative to the Project and its export cable route there is little potential for disturbance to migration of salmon and sea trout smolts in areas encountered shortly before or after river

entry or exit. Despite this, as with the Ribble and Conwy it is assumed that fish will transit areas where they may be exposed to EMFs. These are expected to be of low field strength due to cable burial and position in the water column. The degree of interaction between the impact and the receptors is considered to be small. Taking the factors outlined previously, **salmon and sea trout smolts and adults** are considered receptors of **low sensitivity**. As previously described, the **magnitude** of the impact is deemed to be **minor**. The effect will, therefore, be of **neutral or slight adverse** significance which is not significant in EIA terms.

13.9.166 **River Dee**: As with other rivers in the study area, there is no potential for exposure to EMFs immediately pre or post river entry for Dee salmon and sea trout populations. However, due to the position of the export cable route relative to the mouth of the estuary it is considered that potential exposure to EMFs is slightly increased in the case of the Dee. The degree of interaction between the impact and the effect is therefore considered to be medium. Salmon and sea trout are expected to be exposed to EMFs of low strength for short durations. As previously described, this is due to position in the water column combined with cable burial and armouring. In light of the above, **salmon and sea trout** are considered receptors of **medium sensitivity**. As previously described, the **magnitude** of the impact is deemed to be **minor**. The effect will, therefore, be of **slight adverse** significance which is not significant in EIA terms.

13.9.167 The assessed effect is considered to be **probable** for the five rivers included for assessment given their relative proximity to the project and export cable in the context of the migratory nature of these species.

Disturbance to Feeding

13.9.168 As described in ES Annex '5.1.5.13.2', species of importance as prey to salmon and sea trout in the marine environment such as sandeels, herring and sprat have wide distribution ranges. These species are primarily preyed upon in the water column and therefore, as previously described for migration, salmon and sea trout would not be expected to be frequently exposed to the strongest EMFs during foraging activity. It should be noted in this context that significant impacts (above slight) associated with the construction/decommissioning and operational phase of the Project and the export cable have not been identified for key salmon and sea trout prey species. The degree of interaction between the potential impact and the receptors is therefore considered to be small.

13.9.169 Taking the above into account adult and juvenile salmon and sea trout are considered receptors of **low sensitivity**. As previously described, the **magnitude** of the impact is deemed to be **minor**. The effect will, therefore, be of **neutral or slight adverse** significance, which is not significant in EIA terms. Given the relative proximity of the five rivers to the project and export cable in the context of the migratory nature of these species, it is considered that the assessed effect is **probable** for the salmon and sea trout populations of all five rivers considered for assessment.

Operational noise

13.9.170 During the operational phase of a wind farm, noise is principally generated by the turbine's gear boxes and transferred into the water and sediment through the towers and foundations (Lindell, 2003). As indicated in Table 13.13 the maximum adverse scenario for operational noise assumes 24 hours a day for operational turbines and the use of the maximum number of turbines (69 turbines). Sound emissions during this period are expected especially in the low-frequency range (Westerberg, 1994; Degn, 2000; Lindell, 2003). Detailed information on the potential impacts of operational noise on fish and shellfish is limited to date, it is however generally accepted that the impacts of operational noise are restricted to masking of

communication and orientation signals, rather than causing damage or consistent avoidance reactions (Wahlberg and Westerberg, 2005). The implications of these depend on the ecology and use that particular species make of the Project and its vicinity and on the hearing ability of different species.

13.9.171 As described in ES Chapter 11 'Offshore Noise', in general, the measured underwater noise level of operational wind farms has been found to be low. An estimate of the likely operational underwater noise level for The Project was made using a similar site for comparison. The level of noise is expected to be insufficient to cause physical injury or deafness. In addition, using the 90 dB_{ht} criterion level for strong avoidance, the expected noise is also insufficient to cause avoidance by most marine species at any significant distance (ES Chapter 11 'Offshore Noise'). In light of this, whilst the long term and continuous duration of the impact is acknowledged, taking the small areas potentially affected (limited to the vicinity of the turbines and in the context of the area of the Project and its immediate vicinity) and the small expected changes to baseline levels, the **magnitude** of the impact is considered to be **minor**.

Likely environmental effects without mitigation

Fish and Shellfish (including salmon and sea trout)

13.9.172 Given the lack of species/species group specific information in relation to the impact of operational noise, the impact assessment and assignment of receptor sensitivity has been based on a literature review of current knowledge and on indirect evidence derived from the results of monitoring programmes carried out in operational wind farms.

13.9.173 Walhberg and Westerberg (2005) studied the responses of three species representing various hearing capabilities (cod, Atlantic salmon and goldfish (*Carassius auratus*)) to operational wind farm noise and found that noise was detected at a distance between 0.4-25 km at wind speeds of 8-13 m/s. Operational noise was found not to have any destructive effects upon the hearing ability of fish, even within distances of a few metres and it was estimated that fish would only be consistently scared away from wind turbines at ranges shorter than about 4 m, and only at high wind speeds (higher than 13 m/s).

13.9.174 Based on operational noise data measurements at the Svante wind farm in Sweden (estimated to peak at 120 dB at 16 Hz), Vella *et al*. (2001) concluded that noise levels appeared to be outside the behavioural reaction sensitivities of most species for which data was available. However, the authors noted that some effect could be apparent in species such as cod. Cod and other gadoids, such as haddock, are known to be able to produce low frequency sounds during spawning (Hawkins and Chapman, 1966; Hawkins and Rasmussen, 1978; Nordeiede and Kjellsby, 1999; Fudge and Rose, 2009). Hawkins and Amorim (2000) suggest that the sound produced by haddock serves to bring male and female fish together and that sound also plays a role in synchronising the reproductive behaviour of the male and the female. Similarly, Brawn (1961) suggests that sounds produced by cod are used to attract females during spawning. Studies undertaken by Westerberg (1994) found the catchability of cod and roach (*Rutilus rutilus*) increased by a factor of two within 100 m of a wind turbine when the rotor was stopped under otherwise similar conditions. In addition, Westerberg (1994) did not find significant changes in the swimming behaviour of European eel when passing at a distance of 0.5 km from a small (200 kW single-unit) offshore wind turbine.

13.9.175 Post construction monitoring of hard bottom communities at Horns Rev (Leonhard and Pedersen, 2005) found that based on comparisons with fish fauna on shipwrecks in other parts of the North Sea, there was great similarity in the species observed including benthic species and pointed out that there was no indication that noise or vibrations from the turbine

generators had any impacts on the fish community. In line with this, as previously described in the introduction of hard substrate section, post construction monitoring undertaken in operational wind farms does not suggest that major changes in the distribution and abundance of fish and shellfish species have occurred, hence if operational noise is having any effect this is expected to be very limited.

13.9.176 The fish and shellfish receptors present within the Project have wide distribution ranges in comparison to the area where potential impacts associated to operation noise may take place. The degree of interaction between the receptors and the impact is therefore expected to be small. Taking the above into account **fish and shellfish** species are considered receptors of **low sensitivity**. As previously described the **magnitude** of the impact is deemed minor. The effect will, therefore, be of **neutral or slight adverse** significance, which is not significant in EIA terms.

Changes to fishing activity

13.9.177 Within the Project boundary, there is a small, discrete, seasonal fishery for sole, plaice and cod, generally targeted by vessels operating beam trawls during the spring. Consultation with fishermen has also identified a small thornback ray gillnet fishery in the north-west of the Project site and occasional otter trawling for plaice, sole and thornback ray throughout the site. The cable route transects seasonal gillnet fisheries for bass, tope, smoothhound and flatfish. It should be noted, that during the operational phase, it is not expected that fishing will be excluded from the Project (ES Chapter 18 'Commercial Fisheries'). There may be potential, however, for a reduction in the fishing effort currently sustained in the area of the Project and/or potential displacement to other areas.

13.9.178 Taking the relatively low levels of fishing activity occurring within the Project, however, the **magnitude** of the impact of changes to fishing activity is considered to be **negligible**. This takes account of the long term and continuous nature of the potential impact as well as the small change in relation to baseline levels and the small area affected (limited to the Project site and its immediate vicinity).

Likely environmental effects without mitigation

Fish and shellfish (including salmon and sea trout)

13.9.179 Changes to fishing activity as a result of the installation of the development could potentially directly or indirectly have an impact on fish and shellfish species. Primarily this would be species commercially targeted and/or caught as by-catch. Whilst the potential for displacement of fishing activity to other areas is recognised, the degree of interaction between the impact and the receptor is expected to be very small, given the limited fishing activity occurring in the Project. Based on the above, fish and shellfish species are considered receptors of **low sensitivity**. As previously described, the **magnitude** of the impact is deemed **negligible**. The effect will, therefore, be of **neutral or slight** significance which is not significant in EIA terms.

13.9.180 Whether the assessed effect is **adverse or beneficial** would depend on the degree and nature of the fishing activity potentially reduced and on the particular area where fishing effort is increased (assuming some degree of fishing activity is displaced).

Further mitigation and future monitoring

13.9.181 As described above, significant effects in EIA terms have not been identified in the impact assessment for the operational phase of the Project. No mitigation measures further to those adopted as part of the Project in respect to the EMFs (see section 13.8.1) is therefore considered necessary.

Decommissioning phase

13.9.182 The impacts of the decommissioning of the Project have been assessed on fish and shellfish ecology in the offshore study area. The environmental effects arising from the decommissioning of the Project are listed in Table 13.13 along with the Design Envelope criteria against which each decommissioning phase impact has been assessed.

13.9.183 The lifetime of the Project is considered to be around 25 years which is equivalent to the expected lifetime of the turbines. The potential impacts identified that might arise during the decommissioning phase are:

- Temporary disturbance of seabed in relation to increased SSCs and sediment re-deposition; and
- Noise from decommissioning activities.

13.9.184 In the absence of detailed decommissioning schedules and methodologies, it is assumed that the potential impacts on fish and shellfish, including salmon and sea trout, during this phase will at worst be as those assessed above for the construction phase. It should be noted that piling is not envisaged to be required during decommissioning, and hence noise related impacts associated with this phase are expected to be considerably below those assessed for the construction phase. In addition, it is likely that inter-array and export cables will be left in situ, hence, disturbance to the seabed associated with cable removal is not expected to take place. in this respect.

Cumulative impact assessment

13.9.185 The cumulative impacts of the Project have been assessed on fish and shellfish ecology receptors in the offshore area. Other projects taken into account as part of the cumulative impact assessment are listed in Table 13.24.

13.9.186 The cumulative impacts of the Project have been assessed on fish and shellfish ecology (including salmon and sea trout) receptors in the offshore study area. Other projects taken into account as part of cumulative impact assessment are listed in Table 13.24, below. Further details of these projects are provided in the ES Chapter 36 'In-combination and Cumulative Impacts'.

Table 13.24: Projects being considered with potential cumulative effects in relation to fish and shellfish resources

Project	Construction Timeline		Operational
	Start*	Finish*	
Burbo Bank Extension offshore wind farm	Q1 2015	Q1 2016	No
Burbo Bank Operational offshore wind farm	n/a	n/a	Yes
Walney Extension offshore wind farm	2016	2017	No
Gwynt y Môr offshore wind farm	2012	2014	No
North Hoyle offshore wind farm	n/a	n/a	Yes
Rhyl Flats offshore wind farm	n/a	n/a	Yes
Irish Sea Zone Round 3 Development (Celtic Array South East)	2017	2020	No
Irish Sea Zone Round 3 Development (Celtic Array North)	2021	2023	No
West of Duddon Sands offshore wind farm	Q1 2013	Q3 2014	No
Eigrid interconnector	2011	2012	No
SP HVCD Western link	?	2015	No
Existing and proposed aggregate licence areas	-	-	Yes/ No

Temporary disturbance of the seabed

13.9.187 Increases in SSCs due to interaction of sediment plumes as a result of construction works being carried out simultaneously in adjacent areas may cumulatively affect fish and shellfish species.

13.9.188 As described in ES Chapter 10 'MetOcean and Coastal Processes', sediment re-suspension events at developments more than one mean spring tidal excursion distance from the wind farm site or cable corridor have limited or no potential to interact directly with any of the proposed activities within the Project site extent and export cable corridor. Only the operational Burbo Bank offshore wind farm, where construction activity has been completed, is within one spring tidal excursion of the Project site.

13.9.189 Temporary disturbance of the seabed is therefore considered to result in a cumulative impact of **neutral** significance on fish and shellfish ecology.

Construction noise

13.9.190 Cumulative impacts due to multiple noise sources, taking into account other nearby wind farms in various stages of construction as well as those fully commissioned and operational, installation of interconnector cables across the Southern Irish Sea, oil and gas platforms and dredging operations, are described in ES Chapter 11 'Offshore Noise' and summarised below.

13.9.191 There is potential for two noise sources, if they are close enough, to result in an increased cumulative spatial impact range. The closest wind farm potentially under construction at the same time as the Project is the Gwynt y Môr wind farm, located approximately 7.7 km to the west of the Project. The Project is expected to be constructed from 2014 to 2016, whereas Gwynt y Môr, (currently under construction), is expected to be fully operational by summer 2014. It is therefore unlikely that significant simultaneous piling operations will occur at the Project and Gwynt y Môr.

13.9.192 Noise associated with construction activities in wind farms located further afield, (e.g. the Irish Sea Round 3 Wind Farm projects, the West of Duddon Sands Wind Farm and the Walney Extension Wind Farm), may result in cumulative impacts on fish and shellfish ecology. Spawning, nursery and feeding grounds may be affected during sensitive periods over wider areas than those identified in association with the Project itself. In the particular case of salmon and sea trout, and other species of conservation importance (e.g. European eel, sea lamprey) and given the long distance nature of their migrations, they may be subject to construction noise cumulatively at different stages as they migrate. Taking the above into account together with the mitigation options in relation to construction noise to be implemented by the Applicant during construction, the cumulative impact of construction noise on fish and shellfish is considered to be of **slight adverse** significance. In this context, the relatively small likely contribution of the Project to any cumulative impact associated with construction noise in the wider Irish Sea should be noted.

13.9.193 Other noise generating operations which may occur at the same time as the construction of the Project are listed below (ES Chapter 11 'Offshore Noise'):

- The construction of HVDC or interconnector cables;
- Dredging operations in areas 392 and 393 to the west of the Project, the Douglas, Hamilton and Lennox oil and gas platforms to the north; and
- Other shipping that could happen during the construction of the Project.

13.9.194 These are however, likely to be of such a low level that will not contribute to the identified cumulative impact.

Loss of Habitat

13.9.195 As mentioned above, the installation of 69 turbines using gravity base foundations and scour protection will result in the worst case scenario in terms of seabed loss of 0.229 km^2 representing 0.57% of the total Project (excluding scour protection, this is reduced to 0.0664 km^2 and 0.166% respectively).

13.9.196 Although the total loss of habitat associated with the construction of all operational and planned developments in the Irish Sea is currently unknown, the combined loss of area will likely be small in comparison to the wide distribution range of fish and shellfish species.

Cumulative loss of habitat is considered to result in a cumulative impact of **neutral or slight adverse** (subject to species specific sensitivities and the degree of overlap of sensitive habitats with other wind farm projects' infrastructure). In this context, the small likely contribution of the Project to any cumulative impact associated with loss of habitat in the wider Irish Sea should be noted.

Introduction of Hard Substrate

13.9.197 Post-construction monitoring undertaken in operational wind farms does not suggest that introduction of hard substrate has had a significant detrimental impact on fish and shellfish species (see section 13.9.2.2 above) The cumulative introduction of hard substrate is therefore expected to result in **neutral or slight adverse/beneficial** cumulative impacts. The comparatively small area of the Project, and likely small contribution to cumulative impacts should be noted in this context.

EMFs

13.9.198 Post-construction monitoring undertaken in operational wind farms does not suggest that EMFs have had a significant detrimental impact on fish and shellfish species. The comparatively large spatial extent of the impact associated to the interconnector cables, inter-array cables and export cables of other developments during operation may cumulatively add to the impacts incurred by the inter-array and export cable of the Project, should be noted in this context. This may be of particularly relevant to migratory species which may encounter EMFs repeatedly at various stages of their migration. Assuming cable armouring and burial to adequate depths (and cable protection where target burial depths cannot be achieved) is applied in the other developments considered for assessment, the cumulative impact associated with EMFs is expected to be of **neutral or slight adverse** significance.

Operational Noise

13.9.199 There are a number of fully operational wind farms near the Project; these are the operational Burbo Bank offshore wind farm, North Hoyle and Rhyl Flats. As indicated in ES Chapter 11 'Offshore Noise', noise from operational wind turbines is expected to be very low, falling below background noise within 200 m ranges. Operational noise is therefore considered to result in a **neutral cumulative impact** on fish and shellfish ecology.

Changes to Fishing Activity

13.9.200 In respect of the cumulative impacts on restricted access to or loss of fishing area only vessels identified as fishing within the Project site can be subject to a cumulative effect. As discussed in ES Chapter 18 'Commercial Fisheries', only a limited number of small, inshore vessels, with comparatively limited range, have a history of fishing within the Project site. It appears that there is negligible activity in both the Project site and the adjacent Burbo Bank, Gwynt y Môr, Rhyl Flats and North Hoyle sites (ES Chapter 18 'Commercial Fisheries').

13.9.201 As previously stated, during the operational phases, it is not expected that fishing will be excluded from the Project or from adjacent sites. Taking the above into account it is expected that there will be no, or at worst a minor, cumulative impact on loss of fishing area (ES Chapter 18 'Commercial Fisheries'). Taking the above into account, changes to fishing activity are expected to result in a cumulative impact of **neutral significance** on fish and shellfish ecology.

Residual impacts

Fish and shellfish (including salmon and sea trout)

13.9.202 Taking the mitigation described above, the impacts on fish and shellfish species (including salmon and sea trout) are not expected to be significant.

Trans-boundary effects

13.9.203 The distribution of fish and shellfish species is independent of national geographical boundaries. The impact assessment presented in this chapter has therefore been undertaken taking account of the distribution of fish and shellfish stocks/populations irrespective of political limits. As a result it is considered that the assessment of trans-boundary effects is already integrated in the assessment given above.

Inter-related effects

13.9.204 Inter-relationships between fish and shellfish ecology are expected principally with the following chapters:

- ES Chapter 10 'MetOcean and Coastal Processes' - Changes in SSCs are likely to result in indirect impacts on fish and shellfish species;
- ES Chapter 12 'Subtidal and Intertidal Benthic Ecology' - Changes in seabed communities are likely to result in indirect impacts on fish and shellfish species;
- ES Chapter 18 'Commercial Fisheries' - A number of the species included in this assessment are of commercial importance. Any impacts on these species may therefore potentially result in indirect impacts on their fisheries;
- ES Chapter 11 'Offshore Noise' - Potential impacts can arise on the species included in this assessment as a result of underwater noise.
- ES Chapter 15 'Ornithology' and ES Chapter 14 'Marine Mammals' - A number of fish species are of importance as prey to seabirds and marine mammals. Any impacts on key prey species (e.g. sandeels) may therefore result in indirect impacts on seabirds and marine mammals; and
- ES Chapter 33 'Socio-economic Impact Assessment' - Potential impacts of the Project on salmon and sea trout could potentially indirectly impact recreational salmon and sea trout fisheries, which are of significant socio-economic importance.

13.9.205 Table 13.25 provides details of where linkages occur in this assessment.

Table 13.25: Summary of inter-relationships

Fish and Shellfish Ecology – inter-related effects					
Impact type and phase	**Source of impact**	**Nature of inter-related effect**	**Source chapter**	**Relevant chapters to be cross referenced**	**Notes**
Temporary disturbance of the seabed during construction	Construction and decommissioning of the Project	Impacts on fish and shellfish species (including salmon and sea trout) due to SSCs	ES Chapter 10 'MetOcean and Coastal Processes'	ES Annex '5.1.5.10.1' ES Chapter 10 'MetOcean and Coastal Processes'	Impacts discussed in detail in ES Chapter 10 'MetOcean and Coastal Processes' and assessed in this chapter.
	The construction and decommissioning of the Project may increase SSCs and potentially impact fish and shellfish species (including salmon and sea trout).				
Construction noise	Construction of the Project	Impacts on fish and shellfish species (including salmon and sea trout) due to underwater noise	ES Chapter 11 'Offshore Noise'	ES Annex '5.1.5.11.1' ES Chapter 11 'Offshore Noise'	Impacts discussed in detail in ES Chapter 11 'Offshore Noise' and assessed in this chapter.
	The construction of the Project may increase underwater noise and potentially impact fish and shellfish species (including salmon and sea trout).				

Table 13.25: continued

Fish and Shellfish Ecology – inter-related effects					
Impact type and phase	**Source of impact**	**Nature of inter-related effect**	**Source chapter**	**Relevant chapters to be cross referenced**	**Notes**
Loss of habitat during operation	Operation of the Project	Impacts on fish and shellfish species (including salmon and sea trout) due to loss of habitat	ES Chapter 12 'Subtidal and Intertidal Benthic Ecology'	ES Annex '5.1.2.12.1' ES Chapter 12 'Subtidal and Intertidal Benthic Ecology'	Impacts discussed in detail in ES Chapter 12 'Subtidal and Intertidal Benthic Ecology' and assessed in this chapter.
	Changes in the seabed communities are likely to result in indirect impacts on fish and shellfish species.				
Introduction of hard substrate habitat during operation	Operation of the Project	Impacts on fish and shellfish species (including salmon and sea trout) due to introduction of hard substrate habitat	ES Chapter 12 'Subtidal and Intertidal Benthic Ecology'	ES Annex '5.1.5.12.1' ES Chapter 12 'Subtidal and Intertidal Benthic Ecology'	Impacts discussed in detail in ES Chapter 12 'Subtidal and Intertidal Benthic Ecology' and assessed in this chapter.
	Changes in the seabed communities are likely to result in indirect impacts on fish and shellfish species.				

Table 13.25: continued

Fish and Shellfish Ecology – inter-related effects					
Impact type and phase	**Source of impact**	**Nature of inter-related effect**	**Source chapter**	**Relevant chapters to be cross referenced**	**Notes**
Changes to fishing activity during operation	Operation of the Project	Impacts on fish and shellfish species (including salmon and sea trout) due to changes in fishing activity	ES Chapter 18 'Commercial Fisheries'	ES Annex' 5.1.5.18.1' ES Chapter 18 'Commercial Fisheries'	Impacts discussed in detail in ES Chapter 18 'Commercial Fisheries' and assessed in this chapter.
	A number of the species included in this assessment are of commercial importance. Any impacts on these may therefore potentially result in indirect impacts on their fisheries.				

13.10 Summary table

13.10.1 Table 13.26 below provides a summary of the impacts on fish and shellfish (including salmon and sea trout) arising from the construction, operation and decommissioning of the Project.

Table 13.26: Summary of significance, mitigation and monitoring

Summary tables – Fish and shellfish ecology (including salmon and sea trout)								
Description of impact	**Receptor**	**Magnitude of impact**	**Sensitivity of receptor**	**Significance of effect**	**Probability Rating (where applicable)**	**Potential Mitigation Measures**	**Residual Effect**	**Proposed monitoring**
Construction Phase								
Temporary disturbance of the seabed (increased SSCs and sediment re-deposition)	Eggs and larvae	Minor	Medium	Adverse, slight	N/A	None required	Adverse, slight	None proposed
	Juvenile and adult fish	Minor	Low	Adverse, neutral or slight	N/A	None required	Adverse, neutral or slight	None proposed
	Shellfish	Minor	Low	Adverse, neutral or slight	N/A	None required	Adverse, neutral or slight	None proposed
Increased SSCs: Lethal and sublethal effects	Salmon and sea trout (adults and smolts) -Rivers Clwyd , Dee and Mersey	Minor	Low	Adverse, neutral or slight	Probable	None required	Adverse, neutral or slight	None proposed
	Salmon and sea trout (adults and smolts) - Rivers Conwy and Ribble	Minor	Low	Adverse, neutral or slight	Unlikely	None required	Adverse, neutral or slight	None proposed

Table 13.26: continued

Summary tables – Fish and shellfish ecology (including salmon and sea trout)								
Description of impact	**Receptor**	**Magnitude of impact**	**Sensitivity of receptor**	**Significance of effect**	**Probability Rating (where applicable)**	**Potential Mitigation Measures**	**Residual Effect**	**Proposed monitoring**
Construction Phase								
Increased SSCs: Behavioural effects during migration	Salmon and sea trout (adults and smolts) - Rivers Ribble and Conwy	Minor	Low	Adverse, neutral or slight	Unlikely	None required	Adverse, neutral or slight	None proposed
	Salmon and sea trout (adults and smolts) - Rivers Dee, Mersey and Clwyd	Minor	Medium	Adverse, slight	Probable	None required	Adverse, slight	None proposed
Increased SSCs: Behavioural effects during feeding	Salmon and sea trout (adults and smolts, all rivers)	Minor	Low	Adverse, neutral or slight	Probable	None required	Adverse, neutral or slight	None proposed

Table 13.26: continued

Summary tables – Fish and shellfish ecology (including salmon and sea trout)								
Description of impact	**Receptor**	**Magnitude of impact**	**Sensitivity of receptor**	**Significance of effect**	**Probability Rating (where applicable)**	**Potential Mitigation Measures**	**Residual Effect**	**Proposed monitoring**
Construction Phase								
Construction noise: Lethal effects and traumatic hearing damage	Adult and juvenile fish	Minor	Low	Adverse, neutral or slight	N/A	None required	Adverse, neutral or slight	None proposed
	Life stages of limited mobility (e.g. eggs, larvae and glass eels)	Minor	Medium	Adverse, slight	N/A	None required	Adverse, slight	None proposed
	Shellfish	Negligible	Low	Adverse, neutral or slight	N/A	None required	Adverse, neutral or slight	None proposed
	Salmon and sea trout (adults and smolts, all rivers)	Negligible	Low	Adverse, neutral or slight	Probable	None required	Adverse, neutral or slight	None proposed

Table 13.26: continued

Summary tables – Fish and shellfish ecology (including salmon and sea trout)								
Description of impact	**Receptor**	**Magnitude of impact**	**Sensitivity of receptor**	**Significance of effect**	**Probability Rating (where applicable)**	**Potential Mitigation Measures**	**Residual Effect**	**Proposed monitoring**
Construction Phase								
Construction noise: Behavioural effects	Sole	Minor	Very high	Adverse, moderate or large	N/A	Piling restriction	Adverse, slight	None proposed
	Plaice	Minor	Low	Adverse, neutral or slight	N/A	None required	Adverse, neutral or slight	None proposed
	Other flatfish species (including turbot, brill and flounder)	Minor	Low	Adverse, neutral or slight	N/A	None required	Adverse, neutral or slight	None proposed
	Cod	Moderate	Low	Adverse, slight	N/A	None required	Adverse, slight	None proposed
	Herring	Moderate	Low	Adverse, slight	N/A	None required	Adverse, slight	None proposed
	Sprat	Moderate	Low	Adverse, slight	N/A	None required	Adverse, slight	None proposed

Table 13.26: continued

Summary tables – Fish and shellfish ecology (including salmon and sea trout)								
Description of impact	**Receptor**	**Magnitude of impact**	**Sensitivity of receptor**	**Significance of effect**	**Probability Rating (where applicable)**	**Potential Mitigation Measures**	**Residual Effect**	**Proposed monitoring**
Construction Phase								
	Whiting	Moderate	Low	Adverse, slight	N/A	None required	Adverse, slight	None proposed
	Sandeels	Minor	Medium	Adverse, slight	N/A	None required	Adverse, slight	None proposed
	Seabass	Minor to moderate	Low	Adverse, slight	N/A	None	Adverse, slight	None proposed
	Elasmobranchs: Thornback ray, spotted ray, tope and spurdog	Moderate	Low	Adverse, slight	N/A	None required	Adverse, slight	None proposed
	Basking shark	Moderate	Low	Adverse, slight	N/A	None required	Adverse, slight	None proposed
	River and sea lamprey	Minor	Medium	Adverse, slight	N/A	None required	Adverse, slight	None proposed
	European eel and smelt	Minor to moderate	Low	Adverse, slight	N/A	None	Adverse, slight	None proposed

Table 13.26: continued

Summary tables – Fish and shellfish ecology (including salmon and sea trout)								
Description of impact	**Receptor**	**Magnitude of impact**	**Sensitivity of receptor**	**Significance of effect**	**Probability Rating (where applicable)**	**Potential Mitigation Measures**	**Residual Effect**	**Proposed monitoring**
Construction Phase								
	Allis and twaite shad	Moderate	Low	Adverse, slight	N/A	None required	Adverse, slight	None proposed
	Shellfish	Minor to moderate	Low	Adverse, slight	N/A	None required	Adverse, slight	None proposed
	Salmon and sea trout adults and smolts - Rivers Ribble and Conwy	Minor	Medium	Adverse, slight	Unlikely	None required	Adverse, slight	None proposed
	Salmon and sea trout adults and smolts - River Clwyd	Minor	Medium	Adverse, slight	Probable	None required	Adverse, slight	None proposed
	Salmon and sea trout smolts originating in the Rivers Dee and Mersey	Minor	Very high	Adverse, moderate or large	Probable	Piling restriction	Adverse, slight	None proposed

Table 13.26: continued

Summary tables – Fish and shellfish ecology (including salmon and sea trout)								
Description of impact	**Receptor**	**Magnitude of impact**	**Sensitivity of receptor**	**Significance of effect**	**Probability Rating (where applicable)**	**Potential Mitigation Measures**	**Residual Effect**	**Proposed monitoring**
Construction Phase								
	Salmon and sea trout adults migrating to the Rivers Dee and Mersey	Minor	High	Adverse, slight or moderate	Probable	DONG Energy is engaged in on-going consultation with relevant statutory stakeholders with the aim of exploring the potential for effective mitigation and or/ monitoring measures be implemented and potential adverse effects minimised	Adverse, slight or moderate	Additional research, consultation, and data to be undertaken and data investigated and consultation undertaken
	Salmon and sea trout feeding	Minor	Medium	Adverse, slight	Probable	None required	Adverse, slight	None proposed

Table 13.26: continued

Summary tables – Fish and shellfish ecology (including salmon and sea trout)								
Description of impact	**Receptor**	**Magnitude of impact**	**Sensitivity of receptor**	**Significance of effect**	**Probability Rating (where applicable)**	**Potential Mitigation Measures**	**Residual Effect**	**Proposed monitoring**
Construction Phase								
	(adults and smolts, all rivers)							
	Whitling migrating and feeding (Rivers Dee and Mersey)	Minor	High	Adverse, slight to moderate	Probable	DONG Energy is engaged in on-going consultation with relevant statutory stakeholders with the aim of exploring the potential for effective mitigation and or/ monitoring measures be implemented and potential adverse effects minimised	Adverse, slight to moderate	Additional research, and data investigated and consultation undertaken

Table 13.26: continued

Summary tables – Fish and shellfish ecology (including salmon and sea trout)								
Description of impact	**Receptor**	**Magnitude of impact**	**Sensitivity of receptor**	**Significance of effect**	**Probability Rating (where applicable)**	**Potential Mitigation Measures**	**Residual Effect**	**Proposed monitoring**
Operation Phase								
Loss of habitat	Fish and shellfish species	Minor	Low	Adverse, neutral to slight	N/A	None required	Adverse, slight	None proposed
	Sandeels	Minor	Medium	Adverse, slight	N/A	None required	Adverse, slight	None proposed
Introduction of hard substrate habitat	Fish and shellfish species	Minor	Low	Beneficial or adverse (depending on the species under consideration), neutral or slight	N/A	None required	Beneficial or adverse (depending on the species under consideration), neutral or slight	None proposed
EMFs	Elasmobranchs	Minor	Medium	Adverse, slight	N/A	None required	Adverse, slight	None proposed
	River and sea lamprey	Minor	Medium	Adverse, slight	N/A	None required	Adverse, slight	None proposed
	European eel	Minor	Medium	Adverse, slight	N/A	None required	Adverse, slight	None proposed

Table 13.26: continued

Summary tables – Fish and shellfish ecology (including salmon and sea trout)								
Description of impact	**Receptor**	**Magnitude of impact**	**Sensitivity of receptor**	**Significance of effect**	**Probability Rating (where applicable)**	**Potential Mitigation Measures**	**Residual Effect**	**Proposed monitoring**
Operation Phase								
	Other fish species	Minor	Low	Adverse, neutral or slight	N/A	None required	Adverse, neutral or slight	None proposed
	Shellfish	Minor	Low	Adverse, neutral or slight	N/A	None required	Adverse, neutral or slight	None proposed
EMFs: Disturbance to Migration	Salmon and sea trout (adults and smolts) -Rivers Mersey, Clwyd, Ribble and Conwy	Minor	Low	Adverse, neutral or slight	Probable	None required	Adverse, neutral or slight	None required
	Salmon and sea trout (adults and smolts) - River Dee	Minor	Medium	Adverse, slight	Probable	None required	Adverse, slight	None required

Table 13.26: continued

Summary tables – Fish and shellfish ecology (including salmon and sea trout)								
Description of impact	**Receptor**	**Magnitude of impact**	**Sensitivity of receptor**	**Significance of effect**	**Probability Rating (where applicable)**	**Potential Mitigation Measures**	**Residual Effect**	**Proposed monitoring**
Operation Phase								
EMFs: Disturbance to Feeding	Salmon and sea trout (adults and smolts, all rivers)	Minor	Low	Adverse, neutral or slight	Probable	None required	Adverse, neutral or slight	None required
Operational noise	Fish and shellfish species	Minor	Low	Adverse, neutral or slight	N/A	None required	Adverse, neutral or slight	None required
Changes to fishing activity	Fish and shellfish species	Negligible	Low	Adverse/ beneficial, neutral or slight	N/A	None required	Adverse/ beneficial, neutral or slight	None required
Decommissioning Phase								
In the absence of detailed decommissioning schedules and methodologies, it is assumed that the potential impacts on fish and shellfish, including salmon and sea trout, during this phase will at worst be as those assessed for the construction phase.								

Glossary

Alevin	From hatching to end of dependence on yolk sac for primary nutrition
Anadromy	Fish which spend significant proportion of their life in marine habitats, returning to fresh water to spawn
BAP	Biodiversity Action Plan
BMM	Brown and May Marine Ltd.
CCRT	Clwyd and Conwy River Trust
CCW	Countryside Council for Wales
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CMACS	Centre for Marine and Coastal Studies Ltd
CPA	Coastal Protection Act
CPUE	catch per unit effort
CSTP	Celtic Sea Trout Project
dBht	(Species) - decibels referenced to hearing threshold (as a measure of underwater noise)
DECC	Department for Energy and Climate Change
DMRB	Design Manual for Roads and Bridges
EC	European Commission
EIA	environmental impact assessment
EMF	electro-magnetic field
ES	environmental statement
FEPA	Food and Environment Protection Act
Fry	From independence of yolk sac to end of first summer
GBS	gravity base structure
HRA	habitats regulations assessments
ICES	International Council for the Exploration of the Sea
IEEM	Institute of Ecology and Environmental Management
IMARES	Institute for Marine Resources and Ecosystem Studies
IPC	Infrastructure Planning Commission
JNCC	Joint Nature Conservation Committee
Kelt	Spawned adult salmon or sea trout
kV	kilovolt (electrical potential)
kW	kilowatt (power)
Maidens	Sea trout which has spent at least one year at sea prior to spawning
MCZ	Marine Conservation Zone

MLS	minimum landing size
MMO	Marine Management Organisation
MSW	multi-sea-winter; adult salmon or sea trout after more than one winter in sea. Salmon commonly referred to as "spring" run fish when entering river before June
MW	megawatt (power)
NASCO	North Atlantic Salmon Conservation Organisation
nm	nautical mile (distance; 1 nm = 1.852 km)
NPS	National Policy Statement
NSIP	Nationally Significant Infrastructure Project
OSPAR	Oslo/Paris convention (for the Protection of the Marine Environment of the North-East Atlantic)
Parr	From end of first summer to migration as smolt
PEI	Preliminary Environmental Information Technical Report Version 2 (April 2012)
Post-smolt	From river departure to middle of first winter in the sea (in sea trout the end of first sea winter)
RCCT	Ribble Catchment Conservation Trust
Redds	Nests cut in the gravel prior to spawning
SAC	special area of conservation
SPA	special protection area
SSC	suspended sediment concentrations
Smolt	Fully silvered juvenile salmon or sea trout migrating to sea
Smolting	Physiological and morphological processes which prepare salmon and sea trout for marine migration
WDRT	Welsh Dee River Trust
Whitling	Immature sea trout returning to freshwater to overwinter after short period at sea
1SW	One-Sea-Winter; adult salmon or sea trout after first winter at sea. Sea trout may also be referred to as 'Maidens'

References

Aarestrup, K. Nielsen C., Koed, A. (2002) Net ground speed of downstream migrating radio – tagged Atlantic Salmon (Salmo salar) and brown trout (Salmo trutta) smolts in relation to environmental factors. Hydrobiologia 483: 95-102.

Aas, Ø., Einum, S., Klemetsen, A., and Skurdal, J., (2011) Atlantic Salmon Ecology. Wiley-Blackwell, 467 pp.

Andreassen, P.M.R., Martinussen, M.B., Hvidsten, N.A and Sefansson, S.O. (2001) Feeding and prey selection of wild Atlantic salmon post – smolts. Journal of Fish Biology 58: 1667-1679

Armstrong, J.D. and Herbert, N.A., (1997) Homing movements of displaced stream- dwelling brown trout. Journal of Fish Biology 50: 445-449.

APEM., (1998) An Investigation into the Impact of Flow Regulation on Fisheries in the River Dee. Environment Agency, Bristol.

APEM., (2007) Manchester Ship Canal: Strategic Review of Fish Populations. Report to United Utilities. APEM Scientific Report 410039. 130pp.

Appleby, J.P. and Scarratt., (1989) Physical effects of suspended solids on marine an estuarine fish and shellfish with special reference to ocean dumping: a literature review. Canadian Technical Report of Fisheries and Aquatic Science No.1681.

Auld., A.H. and Schubel, J.R., (1978) Effects of suspended sediment on fish eggs and larvae: A laboratory assessment. Estuarine and Coastal Marine Science. 6(2): 153-164.

Barret., J.C., Grossmand, G.D. and Rosenfeld, J., (1992) Turbidity-induced Changes in Reactive distance of Rainbow Trout. Transaction of the American Fisheries Society 121(4): 437-443.

Bash, J. and Bernman, C., (2001) Effects of Turbidity and Suspended Solids on Salmonids. A report prepared for Washington State Transportation Commission, Department of Transportation and in cooperation with U.S Department of Transportation, Federal Highway Administration.

Berge, J.A., (1979) The perception of weak electric A.C. currents by the European eel, Anguilla anguillla. Comparative Biochemistry and Phsyiology. Part A. Physiology. 62(4): 915-919.

Birtwell, I.K. (1999) The Effects of Sediment on Fish and their Habitat. Fisheries and Oceans Canada. Canadian Stock Assessment Secretariat. Research Document 99/139.

Bloomfield, A., and Solandt, J-L., (2008) The Marine Conservation Society Basking Shark Watch Project: 20 year report (1987-2006). Marine Conservation Society, Ross on Wye, UK.

Brown and May Marine Ltd (BMM) (2011a), Burbo Bank Extension Offshore wind farm: Adult and Juvenile Fish Characterisation Survey, 13th to 17th May 2011.

Brown and May Marine Ltd (BMM) (2011b), Burbo Bank Extension Offshore wind farm: Adult and Juvenile Fish Characterisation Survey, 7th to 11th September 2011.

Bochert, R., and Zettler, M.L., (2004) Long -Term exposure of several marine benthic animals to static magnetic fields. Bioelectromagnetics 25:498-502.

Boehlert, G.W., and Morgan, J. B., (1985) Turbidity enhances feeding abilities of larval Pacific herring, Clupea harengus pallasi. Hydrobiologia 123, 161-170 (1985).

Bodznick, D. and Northcutt, R.G., (1981) Electroreception in lampreys: evidence that the earliest vertebrates were electroreceptive. Science. 212: 465-467.

Bodznick, D. and Preston, D.G., (1983) Physiological characterization of electroreceptors in the lampreys Ichthyomyzon uniscuspis and Petromyzon marinus Journal of Comparative Physiology 152: 209-217.

Boles, L.C. and Lohmann, K.J., (2003) True navigation and magnetic maps in spiny lobsters. Nature. 421.

Bohnsack, J.A. and Sutherland, D.L., (1985) Artificial reef research: a review with recommendations for future priorities. Bull. Mar. Sci. 37, 11-39.

Bohnsack, J.A., (1989) Are high densities of fishes at artificial reefs the result of habitat limitation or behavioural preference? Bull. Mar. Sci. 44, 631-645.

Bone, Q., and Moore, R.,H., (2008) Biology of fish. Third edition. Taylor and Francis Group

Bonfil, R., (1994) Overview of world elasmobranch fisheries. FAO Fisheries Technical Paper No 341: 119pp.

Cain, S.D., Boles, L.C., Wang, J.H. and Lohmann, K.J., (2005) Magnetic orientation and navigation in marine turtles, lobsters and molluscs: Concepts and conundrums. Integrative and Comparative Biology 45: 539-546.

Camhi, M., Fowler, S., Musick, J., Brautigam A. and Fordham S., (1998) Sharks and their relatives: Ecology and Conservation. Occasional Paper of the IUCN Species Survival Commission Occas. Pap. No. 20.

Chung-Davidson., Y., Bryan, M.B., Teeter, J., Bedore, C.N., and Li, W., (2008) Neuroendocrine and behavioural responses to weak electric fields in adult sea lampreys (Petromyzon marinus). Hormones and Behaviour. 54 (1): 34-40.

CEFAS, (2004) offshore wind farms: Guidance Note for Environmental Impact Assessment in Respect of FEPA and CPA Requirements. Version 2 - June 2004.

Clarke, M. W., (2009) Sharks, skates and rays in the northeast Atlantic: population status advice and management. J. Appl. Ichthyol. 25, 3–8.

Centre for Marine and Coastal Studies Ltd (CMACS) (2010), Burbo Bank offshore wind farm. Post-construction 2010 (Year 3) Commercial Fish Survey (4m trawl)-Draft report. CMACS ref: J3071 (Burbo 2010 Commercial Fish Survey) v3.

Collins, K.J., Jensen, A.C. and Lockwood, A.P.M., (1992) Stability of a coal waste artificial reef. Chemical Ecology 6: 79-93. Cited in- Pickering, H. and Whitmarsh, D. (1997). Artificial Rreefs and fisheries exploitation: a review of the attraction versus production debate, the influence of design and its significance for policy. Fisheries Research 31, 39-59.

Coull, K. A., Johnstone, R. and Rogers, S.I., (1998) Fisheries Sensitivity Maps in British Waters. UKO. OA Ltd.

Davidsen, J.G., Plantalech Manel-la, N., Økland, F., Diserud, O.H., Thorstad, E.B., Finstad, B. Sivertsgård, R., McKinley, R.S., Rikardsen, A.H., (2008) Changes in swimming depths of Atlantic salmon (Salmo salar) post-smolts relative to light intensity. Journal of Fish Biology 73: 1065-1074.

DECC, (2011) Department of Energy and Climate Change. National Policy Statement for Renewable Energy Infrastructure (EN-3).

Degn, U., (2000) Ødegaard and Danneskiold-Samsoe A/S offshore wind turbines –VVM underwater noise measurements, analysis, and predictions. Report no. 00.792 rev.1 to SEAS Distribution, Haslev: 29 p.

Degraer,S., Brabant, R. and Rumes, B. (Eds.), (2011) Offshore wind farms in the Belgian part of the North Sea: Selected findings from the baseline and targeted monitoring. Royal Belgian Institute of Natural Sciences, Management Unit of North Sea Mathematical Models. Marine ecosystem management unit. 157 pp. + annexes.

De Groot, S.J., (1980) The consequences of marine gravel extraction on the spawning of herring, Clupea harengus Linné. J. Fish Biol. 16: 605-611.

Design Manual for Roads and Bridges (DMRB), (2008) Volume II, Environmental Assessment. Section 2, Environmental Impact Assessment. Part 5, HA 205/08. Assessment and Management of Environmental Effects.

Dolgov, A. V., Drevetnyak, K. V. and Gusev, E. V., (2005) The status of skate stocks in the Barents Sea. J. Northw. Atlantic Fish. Sci. 35, 249–260. (doi:10.2960/J.v35. m522).

Dulvy, N. K. and Reynolds, J. D., (2002) Predicting extinction vulnerability in skates. Conserv. Biol. 16, 440–450. (doi:10.1046/j.1523-1739.2002.00416.x).

Dutil, J.D. and Coutou, J.M. (1988) Early marine life of Atlantic salmon (Salmo salar) postsmolts in the northern Gulf of St. Lawrence. Fishery Bulletin 86: 197-212.

Egglishaw, H.J. and Shackley, P.E. (1977) Growth, survival and production of juvenile salmon and trout in a Scottish stream. Journal of Fish Biology 11: 647-672.

Ellis, J. R., Cruz-Martínez, A., Rackham, B. D. and Rogers. S. I., (2005) The distribution of chondrichthyan fishes around the British Isles and implications for conservation. J. Northw. Atl. Fish. Sci., 35: 195-213. doi:10.2960/J.v35.m485.

Ellis, J.R., Milligan, S.P., Readdy, L., Taylor, N. and Brown, M.J. (2012) Spawning and nursery grounds of selected fish species in UK waters. Sci. Ser. Tech. Rep., Cefas Lowestoft, 147: 56 pp.

Elliot, J.M. (1975) The growth rate of brown trout (Salmo trutta L.) fed on maximum ratios. Journal of Animal Ecology 44: 805-821.

Engell-Sørensen, K. and Skyt, P.H., (2001) Evaluation of the Effect of Sediment Spill from offshore wind farm Construction on Marine Fish. – Report to SEAS, Denmark: 18 p

Environment Agency, (2001) Fisheries statistics report 2000, freshwater fisheries statistics for England, Wales and the Border Esk. Environment Agency, Bristol.

Environment Agency, (2002) Fisheries statistics report 2001, freshwater fisheries statistics for England, Wales and the Border Esk. Environment Agency, Bristol.

Environment Agency, (2003) Fisheries statistics report 2002, freshwater fisheries statistics for England, Wales and the Border Esk. Environment Agency, Bristol.

Environment Agency, (2004) Fisheries statistics report 2003, freshwater fisheries statistics for England, Wales and the Border Esk. Environment Agency, Bristol.

Environment Agency, (2005) Fisheries statistics report 2004, freshwater fisheries statistics for England, Wales and the Border Esk. Environment Agency, Bristol

Environment Agency, (2006) Fisheries statistics report 2005, freshwater fisheries statistics for England, Wales and the Border Esk. Environment Agency, Bristol.

Environment Agency, (2008) Fisheries statistics report 2006, freshwater fisheries statistics for England, Wales and the Border Esk. Environment Agency, Bristol

Environment Agency, (2009) Fisheries statistics report 2007, freshwater fisheries statistics for England, Wales and the Border Esk. Environment Agency, Bristol.

Environment Agency, (2008) Fisheries statistics report 2008, freshwater fisheries statistics for England, Wales and the Border Esk. Environment Agency, Bristol.

Environment Agency, (2010) Fisheries statistics report 2009, freshwater fisheries statistics for England, Wales and the Border Esk. Environment Agency, Bristol.

Environment Agency & Cefas (2012) Annual Assessment of Salmon Stocks and Fisheries in England and Wales 2011. Preliminary assessment prepared for ICES, March 2012. Environment Agency, Bristol.

Fahy, E. (1987) Feeding, growth and parasites of trout Salmo trutta L. from Mulroy Bay, an Irish Sea Lough. No. 25. Department of Fisheries and Forestry. Dublin.

Fraser, P.J. (1987) Salmo salar L. Feeding in Scottish coastal waters. Aquaculture Research 18: 243-247.

Formicki, K., Bonislawska, M. and Jasinski, M., (1997) Spatial orientation of trout (Salmo trutta L.) and rainbow trout (Onchorhynchus mykiss Walb.) embryos in natural and artificial magnetic fields. Acta Ichthyologica et Piscatoria 27: 92 -100.

Formicki, K., Sadowski, M., Tański, A., Korzelecka-Orkisz, A. and Winnicki, A., (2004) Behaviour of trout (Salmo trutta L.) larvae and fry in a constant magnetic field. Acta Ichthyologica et Piscatoria (27): 77- 83 Formicki, K., and Winnicki, A. 2009. Reactions of fish embryos and larvae to constant magnetic fields. Italian Journal of Zoology. 65: 479-482.

Friedland, K.D., MacLean, J.C., Hansen, L.P., Peyronnet, A.J., Karlsson, L., Reddin, D.G., O Maoileidigh, N. and McCarthy, J.L., (2009) The recruitment of Atlantic salmon in Europe. ICES Journal of Marine Science, 66: 289-304.

Friedland, K.D., Hansen, L.P., Dunkley, D.A. and MacLean, J.C., (2000) Linkage between ocean climate, post-smolt growth, and survival of Atlantic salmon (Salmo salar L.) in the North Sea area. ICES Journal Marine Science 57: 419-429.

Gill, A.B. and Taylor, H., (2001) The potential effects of electromagnetic fields generated by cabling between offshore wind turbines upon elasmobranch fishes, Countryside Council for Wales, Contract Science Report 488

Gill, A.B., Gloyne-Phillips, I., Neal, K.J. and Kimber, J.A., (2005) The potential effects of electromagnetic fields generated by sub-sea power cables associated with offshore wind farm development on electrically and magnetically sensitive marine organism - a review. COWRIE 1.5 Electromagnetic Fields Review. Final Report. COWRIE-EM FIELD 2-06-2004.

Gill, A.B., Huang, Y., Gloyne-Philips, I., Metcalfe, J., Quayle, V., Spencer, J. and Wearmouth, V., (2009) COWRIE 2.0 Electromagnetic Fields (EMF) Phase 2: EMF-sensitive fish response to EM emissions from sub-sea electricity cables of the type used by the offshore renewable energy industry. Commissioned by COWRIE Ltd (project reference COWRIE-EMF-1-06).

Gregory, R.S., (1993) Effect of Turbidity on the Predator Avoidance Behaviour of Juvenile Chinook Salmon (Oncorhynchus tshawytscha). Canadian Journal of Fisheries and Aquatic Science. 50: 241-246.

Gregory, R. S., and Northcote, T. G., (1993) Surface, planktonic, and benthic foraging by juvenile Chinook salmon (Oncorhynchus tshawytscha) in turbid laboratory conditions. Canadian Journal of Fisheries and Aquatic Sciences 50: 233-240.

Griffin, F.J., Sith, E. H., Vines, C.A. and Cherr, G.A., (2009) Impacts of suspended sediments on fertilization embryonic development, and early larval life stages of the Pacific herring, Clupea pallasi. Biological Bulletin 216: 175-187.

Hansen, L.P., Jonsson, N. and Jonsson, B., (1993) Oceanic migration in homing Atlantic salmon. Animal Behaviour 45: 927-941.

Hanson, M., Karlsson, l., Westerberg, H., (1984) Magnetic material in European eel (Anguilla anguillla L.) Comparative Biochemistry and Physiology Part A. Physiology 77(2):221-224.

Hanson, M., and Walker, M.A., (1987) Magnetic particles in European eel (Anguilla anguilla) and carp (Cyprinus carpio). Magnetic susceptibility and remanence. Journal of Magnetism and Magnetic Materials. 66(1): 1-7.

Hastings, M.C. and Popper, A.N., (2005) Effects of sound on fish. California Department of Transportation Contract 43A0139 Task Order, 1.

Haugland, M., Holst J.C., Holm, M. and Hansen, L.P., (2006) Feeding of Atlantic salmon (Salmo salar L.) post-smolts in the Northeast Atlantic. ICES Journal of Marine Science 63:1488-1500.

Hawkins, A.D., Urquhart, G.G. and Shearer, W.M., (1979) The coastal movements of returning Atlantic salmon, Salmo salar L. Scottish Fisheries Research Report, 15, 14pp.

Hawkins, A.D. and Johnstone, A.D.F., (1978) The hearing of Atlantic salmon Salmo salar. Journal of Fish Biology, 13: 655 -673.

Hendry, K. and Cragg-Hine, D. (2003) Ecology of the Atlantic Salmon. Conserving Natura 2000 Rivers Ecology Series no.7. English Nature. Peterborough.

Hislop, J.R.G., Robb, A.P., Bell, M.A. and Armstrong, D.W., (1991) The diet and food consumption of whiting (Merlangius merlangus) in the North Sea. ICES Journal of Marine Science 48:139-156. Cited in ICES, 2012.

Hislop, J.R.G and Webb, J.H., (1992) Escaped farmed Atlantic salmon, Salmo salar L., feeding in Scottish coastal waters. Aquaculture Research 23: 721-723.

Hoffman, E., Astrup, J., Larsen, F. and Munch-Petersen, S., (2000) Effects of Marine Windfarms on the distribution of fish, shellfish and marine mammals in the Horns Rev area. Baggrundsrapport nr 24 to ELSAMPROJEKT A/S: 42p.

Holden, M.J., (1974) Problems in the rational exploitation of elasmobranch populations and some suggested solutions. Sea Fisheries Research (F. R. Harden Jones, ed). Elek: London 117-137.

Huntsman, A.G., (1948) Freshets and Fish. Transactions of the American Fisheries Society 75: 257-266.

Hvidt, C.B., Kaustrup, M., Leonhard, S.B., and Pedersen, J., (2005) Fish along the Cable Trace. Nysted offshore wind farm. Final Report 2004.

Ibbotson, A, T., Beaumont, W.R.C, Pinder, A.C., Welton, J.S and Ladle, M., (2006) Diel migration patterns of Atlantic salmon smolts with particular reference to the absence of crepuscular migration. Ecology of Freshwater Fish, 15: 544-551.

ICES, (2005a), Report of the Study Group on Multispecies Assessment in the North Sea (SGMSNS), 5–8 April 2005, ICES Headquarters. ICES CM 2005/D:06. 163 pp.

ICES, (2008) Report of the Working Group on Multispecies Assessment Methods (WGSAM), 6–10 October 2008, ICES Headquarters, Copenhagen. ICES CM 2008/RMC: 06,113 pp.

IEEM (2010) Institute of Ecology and Environmental Management. Guidelines for Ecological Impact Assessment in Britain and Ireland. Marine and Coastal. Final Document.

Iglésias, S.P., Toulho at, L. and Sellos, D.Y., (2010) Taxonomic confusion and market mislabelling of threatened skates: important consequences for their conservation status.

Aquatic Conservation: Marine and Freshwater Ecosystems, 20: 319–333.

Jacobsen, J.H. and Hansen, L.P. (2001) Feeding habits of wild and escaped farmed Atlantic salmon, Salmo salar L., in the North East Atlantic. ICES Journal of Marine Science. 58:916-933.

Jensen, A.C., Collins, K.L., Free, E.K. and Bannister, R.C.A., (1994) Lobster (Homarus gammarus) movement on an artificial reef: the potential use of artificial reefs for stock enhancement. Proceedings of the Fourth International Workshop on Lobster Biology and Management, 1993. Crustaceana 67 (2). 1994.

Jepsen, N., Aarestrup, K. Oland, F. and Rasmussen, G., (1998) Survival of radio tagged Atlantic (Salmo salar L.) and trout (Salmo trutta L.) smolts passing a reservoir during seaward migration. Hydrobiolgia 10: 371-372.

JNCC, 2010. Atlantic salmon. Available through [online] <http://www.jncc.gov.uk/ProtectedSites/SAC selection/species.asp>. [January 2012]

Johnsen, S., and Lohmann, K. J., (2005) The Physics and Neurobiology of Magnetoreception. Nature Reviews Neuroscience 6:703-712.

Johnston, D.W. and Wildish, D.J., (1981) Avoidance of dredge spoil by herring (Clupea harengus harengus). Bulletin of Environmental Contamination and Toxicology, vol. 26, 307-314. Cited in Engell-Sørensen 2001.

Jonsson, B. and Ruud – Hansen, J., (1985) Water Temperature as the primary influence on timing of seaward migrations of Atlantic salmon (Salmo salar) post smolts. Canadian Journal of Fisheries and Aquatic Science 42: 593-595.

Kallilo- Nyberg, I. Saura, A and Ahlfors, C., (2001) Sea migration patterns of two sea trout (Salmo trutta) stocks released in the Gulf of Finland. Ann. Zool. Fennichi. 39: 221- 235.

Karlsson, L., (1985) Behavioural responses of European silver eels (Anguilla anguilla) to the geomagnetic field. Helgolander Meeresuntersuchungen 39:71-8.

Karlsson L., Ikonen E., Mitans A. and Hansson, S., (1999) The Diet of Salmon (Salmo salar) in the Baltic Sea and Connections with the M74 Syndrome. Ambio. Vol.28.No.1. Reproductive Disturbances in Baltic Sea Fish: An International Perspective. Pp. 37-42.

Kennedy G.J.A. and Greer, J.E., (1988) Predation by cormorants Phalacrocorax carbo (L.) on the salmonid populations of an Irish river. Aquaculture and Fisheries Management 19: 159-170.

Kerckhof, F., Rumes, B., Norro, A., Jacques, T.G., and Degraer, S., (2010) Seasonal variation and vertical zonation of the marine biofouling on a concrete offshore windmill foundation on the Thornton Bank (southern North Sea). Cited in Degraer *et al.* 2010.

Kerr, S.J., (1995) Silt, turbidity and suspended sediments in the aquatic environment: an annotated bibliography and literature review. Ontario Ministry of Natural Resources, Southern Region Science and Technology Transfer Unit Technical Report TR-008. 277 pp.

Klemetsen, A., Amundsen, P-A., Dempson, J.B., Jonsson, B., Jonsson, N., O' Connell, M.F. and Mortensen, E., (2003) Atlantic salmon Salmo salar L., brown trout Salmo trutta L. And Arctic charr Salvelinus alpinus (L): a review of aspects of their life histories. Ecology of Freshwater Fish 12: 1-59.

Lacroix, G. L. and McCurdy, P., (1996) Migratory behaviour of post-smolt Atlantic salmon during initial stages of seaward migration. Journal of Fish Biology (49): 1086-1101.

Langhamer, O. and Wihelmsson, D., (2009) Colonisation of fish and crabs of wave energy foundations and the effects of manufactured holes - a field experiment. Marine Environmental

Research. 68 (4): 151-157.

Larsson, P.O., (1985) Predation on migrating smolts as a regulating factor in Baltic salmon, Salmo salar populations. Journal of Fish Biology 26: 391-397.

Leonhard, S.B, and Pedersen, J., (2005) Hard Bottom Substrate Monitoring Horns Rev offshore wind farm. Annual Status Report 2004.

Le Cren, E.D. The biology of the sea trout. Pitlochry: Atlantic Salmon Trust. 44pp.

Levings, C. D., (1994) Feeding behaviour of juvenile salmon and significance of habitat during estuary and early sea phase. Nordic Journal of Freshwater Research, 69: 7–16

Lindell, H., (2003) Utgrunden offshore wind farm. Measurements of underwater noise. Project 11-00329. Report 11-00329-03012700.

Linley, E.A.S., Wilding, T.A., Hawkins, A. J.S., and Mangi, S., (2007) Review of the Reef Effects of offshore wind farm Structures and their Potential for Enhancement and Mitigation. Report from PML Applications Ltd and the Scottish Association for Marine Science to the Department for Business, Enterprise and Regulatory Reform (BERR), Contract No. RFA/005/0029P.

Lindeboom, H.J., Kouwenhoven, H.J., Bergman, M.J.N. Bouma, S., Brasseur, S., Daan, R.,Fijn, R.C., de Haan, D., Dirksen, S., van Hal, R., Lambers, R.H.R., ter Hofsted, R., Krijgsveld, K.L., Leopold, M. and Scheidat, M., (2011) Short-term ecological effects of an offshore wind farm in the Dutch coastal zone: a compilation. Environ. Res. Lett. 6.

Lockwood, S. J., 2005. A strategic Environmental Assessment of the Fish and Shellfish Resources with respect to Proposed offshore wind farms in the Eastern Irish Sea. Coastal Fisheries Conservation and Management Colwyn Bay.

Lohmann, K.J., Lohmann, M.F. and Putman, N.F., (2007) Magnetic maps in animals: nature GPS's. The Journal of Experimental Biology. 210:3697-3705.

Lohmann, K.J., Lohmann, M.F. and Endres, C.S., (2008a) The sensory ecology of ocean navigation. Journal of Experimental Biology 211:1719-1728.

Lohmann, K.J., Putman, N.F. and Lohmann, M.F., (2008b) Geomagnetic imprinting: A unifying hypothesis of long-distance natal homing in salmon and sea turtles. PNAS 105: 19096-19101.

Lovell, J. M., Findlay, M.M., Moate, R.M. and Yan, H.Y., (2005) The Hearing Abilities of the Prawn Palaemon serratus. Comparative Biochemistry and Physiology.

Lyse, A.A., Stefansson, O. Ferno A., (1998) Behaviour and diet of sea trout smolts in a Norwegian fjord system. Journal of Fish Biology 52: 923-936.

Malcolm, I.A., Godfrey, J. and Youngson, A.F (2010) Review of migratory routes and behaviour of Atlantic salmon, sea trout and European eel in Scotland's coastal environment: Implications for the development of marine renewable. Environmental Research Institute, Thurso. Published by Marine Scotland Science. ISSN:2043-7722.

MarLIN, (2012) Available through [online] at <http://www.marlin.ac.uk/> [Accessed June 2012]

Marra, L.J., (1989) Sharkbite on the SL Submarine Lightwave Cable System: History, Causes and Resolution, IEEE Journal of Oceanic Engineering, 14 (3): 230-237. Cited in- Gill, A.B., Gloyne-Phillips, I., Neal, K.J. and Kimber, J.A., (2005) The Potential Effects of Electromagnetic Fields generated by Sub-Sea Power Cables associated with offshore wind farm Development on Electrically and Magnetically Sensitive Marine Organism- a review. COWRIE 1.5 Electromagnetic Fields Review. Final Report. COWRIE-EM FIELD 2-06-2004

Marschall, E., Quinn, T. Roff, D., Hutchings, J., Metcalfe, N., Bakke, T., Saunders, R. & Poff, N.,

(1998) A framework for understanding Atlantic salmon (Salmo salar) life history. Canadian Journal of Fisheries and Aquatic Science 55:48-58.

McCormick S., Hansen L., Quinn T. and Saunders R., (1998) Movement, migration, and smolting of Atlantic salmon (Salmo salar). Canadian Journal of Fisheries Aquatic Science 55:77-92.

Messieh, S. N., Wildish, D. J., and Peterson, R. H., (1981) Possible Impact from Dredging and Soil Disposal on the Miramichi Bay Herring Fishery. Can. Tech. Rep. Fish. Aquat. Sci., 1008: 33 p. Cited in- Engel-Sørensen, K., and Skyt, P.H., (2001) Evaluation of the Effect of Sediment Spill from offshore wind farm Construction on Marine Fish. Report to SEAS, Denmark: 18 pp.

Meyer, C. G., Holland, K. N., and Papastamatiou, Y. P., (2005) Sharks can detect changes in the Geomagnetic Field. Journal of the Royal Society Interface 2:129-13.

Milner, N. (2012) Personal communication with Brown and May Marine on 6th February

MMO, (2011) Marine Management Organisation landings data (2001-2010).

Mooney, T.A., Hanlon, R.T., Christensen-Dalsgaard, J., Madsen, P.T. Ketten, D.R. and Nachtigall, P.E., (2010) Sound Detection by the Longfin Squid (Loligo pealeii) studied with Auditory Evoked Potentials: Sensitivity to low-Frequency Particle Motion and not Pressure. The Journal of Experimental Biology 213: 3748-3759.

Moore, A., Freake, S.M and Thomas, I.M., (1990) Magnetic particles in the lateral line of the Atlantic Salmon (Salmo salar L.). Philosophical Transactions: Biological Sciences. 329 (1252): 11-15. Moore A., and Potter, E.C.E., 1994. The movements of sea trout (Salmo trutta L) smolts through the estuary of the River Avon, Southern England. Fisheries Management and Ecology 1: 1-14

Moore, A., Potter, E.C.E., Milner, N.J., Milner, and Bamber., S. 1995. The migratory behaviour of wild Atlantic salmon (Salmo salar) smolts in the estuary of the River Conwy, North Wales. Canadian Journal of Fisheries and Aquatic Science 52: 1923-1935.

Moore A., Ives S., Mead T.A. and Talks L., (1998a).The migratory behaviour of wild Atlantic salmon (Salmo salar L.) smolts in the River Test and Southampton Water, southern England. Hydrobiologia 371/372: 295-304

Moore, A. and Riley, W.D., (2009) Magnetic particles associated with the lateral line of the European eel Anguilla anguilla. Journal of Fish Biology. 74 (7): 1629-1634.

Moore A., Ives M., Scott M. and Bamber A., (1998b) The migratory behaviour of wild sea trout (Salmo trutta L.) smolts in the estuary of the River Conwy, North Wales. Aquaculture (168): 57-68.

Musick, J.A., (2005) Management Techniques for elasmobranch fisheries. FAO Fisheries Technical paper 474.

Nall, G.H. (1935) Sea-trout of the Montrose District. Part III – The migrations of Sea-Trout. Fisheries, Scotland, 1935, No.III. In- Malcolm, I.A., Godfrey, J. and Youngson, A.F. 2010. Review of migratory routes and behaviour of Atlantic salmon, sea trout and European eel in Scotland's coastal environment: Implications for the development of marine renewable. Environmental Research Institute, Thurso. Published by Marine Scotland Science. ISSN:2043-7722.NASCO. 2012.

The Atlantic Salmon. Available through: [online] <http://www.nasco.int/atlanticsalmon.html> [Accessed February 2012]

Navarro, J.M., and Widdows, J., (1997) Feeding physiology of Cerastoderma edule (L.) in response to a wide range of seston concentrations. Marine Ecology Progress Series 152: 175-

186.

Nedwell, J.R., Turnpenny, A.W.H., Lovell, J., Parvin, S.J., Workman, R., Spinks, J.A.L. and Howell, D., (2007) A validation of the dBht as a measure of the behavioural and auditory effects of underwater noise. Subacoustech Report No. 534R1231, 74pp.

Newcombe, C. P., 1986. Suspended sediments in aquatic ecosystems: A guide to impact assessment. Waste Management Branch, British Columbia Ministry of the Environment and Parks, Victoria, British Columbia. Cited in Kerr, 1995.

Newcombe, C.P and Macdonald, D.D., (1991) Effects of Suspended Sediments on Aquatic Ecosystems. North American Journal of Fisheries Management. 11(1): 72-82.

Nicholls, P., Hewitt, J. and Haliday, J., (2003) Effects of Suspended Sediment Concentrations on Suspension and Deposit Feeding Marine Macrofauna. NIWA Client Report ARC03267.

Normandeau, Exponent, Tricas, T. and Gill, A., (2011) Effects of EMFs from Undersea Power Cables on Elasmobranchs and Other Marine Species. U.S. Depart. of the Interior, Bureau of Ocean Energy Management, Regulation and Enforcement, Pacific OCS Region, Camarillo, CA. OCS Study BOEMRE 2011-09.

Öhman, C., Sigray, P. and Westerberg, H., (2007) Offshore Windmills and the effects of Electromagnetic Fields on Fish. Ambio Vol.36 No 8. Royal Swedish Academy of Science 2007.

OSPAR, (2008) OSPAR List of Threatened and/or Declining Species and Habitats (Reference Number:2008-6). Available through: [online] <http://jncc.defra.gov.uk/pdf/08 06e_OSPAR%20 List%20species%20and%20habitats.pdf.> [Accessed April 2012].

Ovidio, M., Baras, E., Goffaux, D., Birtles, C and Philipart, J.C. 1998. Environmental unpredictability rules the autumn migration of downstream migration of brown trout (Salmo trutta L.) in the Belgian Ardennes. Hydrobiologia 371/372: 263-274

Potter, E.C., and Dare, P.J., (2003) Research on migratory salmonids, eel and freshwater fish stocks and fisheries. Sci. Ser. Tech Rep., CEFAS, 119: 64pp.

Potter, E.C., and Ó Maoiléidigh, N., (2005) Review of Mixed Stock Fisheries for Atlantic Salmon in European Community Waters, excluding the Baltic Sea.

Pemberton, R. (1976a), Sea trout in North Argyll Sea lochs, population, distribution and movements. Journal of Fish Biology 9: 157-179

Pemberton, R., (1976b) Sea trout in North Argyll Sea lochs.II. diet. Journal of Fish Biology 9: 179-185

Pratten, D. J., and Shearer, W. M., (1983) The Migrations of North Esk Sea Trout. Aquaculture Research 14: 99–113.

Priede, I.G., de L, J.F., Solbe, G., Nott, J.E., O' Grady, and, Cragg-Hine, D, (1998) Behaviour of adult Atlantic salmon Salmo salar, L., in the estuary of the River Ribble in relation to variations in dissolved oxygen and tidal flow. Journal of Fish Biology, 33: 133-139

Reddin, D.G., (1988) Atlantic salmon (Salmo salar) On and East of the Grand Bank. 1988. Journal of the Northwestern Atlantic Fisheries Society 96: 157-164.

Reynolds, J. D., Dulvy, N. K., Goodwin, N. B. and Hutchings, J. A., (2005) Biology of extinction risk in marine fishes. Proc. R. Soc. B 272, 2337–2344. (doi:10.1098/rspb. 2005.3281).

Rikardsen, A.H., Amundsen, P.A., Knudsen, R. and Sandring, S., (2006) Seasonal marine feeding and body condition of sea trout (Salmo trutta) at its northern distribution. ICES Journal of Marine Science 63:466-475.

Robertson, M.J., Scruton, A.D. and Clarke, K.D., (2007) Seasonal Effects of Suspended Sediment on the Behaviour of Juvenile Atlantic Salmon. Transactions of the American Fisheries Society. 136(3):822-828.

Rommel, S.A. and McCleave, J.D., (1973) Prediction of Oceanic Electric Fields in relation to fish migration. ICES Journal of Marine Science. 35: 27-31.

Rönnbäck, P., and Westerberg, H., (1996) Sedimenteffekter på pelagiska fiskägg och gulesäckslarver. Fiskeriverket, Kustlaboratiriet, Frölunda, Sweden. Cited in Engell-Sørensen and Skyt (2001).

Reubens, J.T., Degraer, S., and Vincx, M., (2010) The importance of marine wind farms, as artificial hard substrata, for the ecology of the ichtyofauna. Cited in Degraer *et al.*, 2010

Reubens, J., Degraer, S., and Vincx, M., 2011. Spatial and temporal movements of cod (Gadus morhua) in a wind farm in the Belgian part of the North Sea using acoustic telemetry, a VPS study. Cited in Degraer *et al.*, 2011

Shark Trust, (2009) Common Skate Factsheet. Available through: [online] <http://www.sharktrust.org/content.asp?did=33255.> [Accessed June 2012].

Sayer, M. D. J., Magill, S., H., Pitcher, T. J., Morisette, L. and Ainsworth,C., 2005. Simulation-based investigations of fishery changes as affected by the scale and design of artificial habitats. Journal of Fish Biology (2005) 67 (Supplement B), 218–243

Shelton, R.G.J, Holst, W.R., Turrel, W.R., MacLean, J.C., McLaren, I.S. and Nicoll, N.T., (1997) Records of post-smolt Atlantic salmon, Salmo salar L., in the Faroe-Shetland Channel in June 1996. Fisheries Research 31:159-162.

Smith, S.E., Au. D.W. and Show, C., (1998) Intrinsic rebound potentials of 26 species of Pacific sharks. Mar. Freshwater. Res., 41:663-678.

Smith, G.W., Hawkins, A.D., Urquhart G.G., and Shearer, W.M., (1981) Orientation and energetic efficiency in the offshore movements of returning Atlantic salmon (Salmo salar L.). Scottish Fisheries Research Report 21. 22pp.

Solomon, D., (1978) Migration of Atlantic salmon (Salmo salar) and brown trout (Salmo trutta) in a chalk stream. Environmental Biology of Fishes 3: 223-230

Solomon, D., (2007) Migration as a Life-History Strategy for the Sea Trout, in Sea Trout: Biology, Conservation and Management (eds G. Harris and N. Milner), Blackwell Publishing Ltd, Oxford, UK.

Stabell, O.B., (1984) Homing and olfaction in salmonids: a critical review with reference to the Atlantic salmon. Biological Reviews 59: 333-388.

Stenberg, C., van Deurs, M., Stottrup, J., Mosegaard, H, Grome, T., Dinesen, G., Christensen, A., Jensen, H, Kaspersen, M., Berg, C.W., Leonhard, S.B., Skov, H., Pedersen, J., Hvidt, C.B. and Kaustrup, M., (2011) Effect of the Hors Rev 1 offshore wind farm on Fish Communities. Follow-up Seven Years after Construction. DTU Aqua Report NO 246-2011.

Sturlaugsson, J. and Thorisson, K., (1997) Migratory pattern of homing Atlantic salmon (Salmo salar L.) in coastal waters of W-Iceland, recorded by data storage tags. ICES. C.M. 1997/CC:09. 23pp.

Sturlaugsson J., Gudbjornsson, S. and Stockhausen, H., (2009) Orientation of homing Atlantic salmon (Salmo salar L.) mapped in relation to geomagnetic field. International Council for the Exploration of the Sea. C.M. 2009/B:05.

Stewart, D. C., Middlemas, S. J. and Youngson, A. F. (2006) Population structuring in Atlantic salmon (Salmo salar): evidence of genetic influence on the timing of smolt migration in sub-catchment stocks. Ecology of Freshwater Fish, 15: 552–558.

Tanski, A., Formicki, k. Korzelecka-Orkisz, A. and Winnicki, A., (2005) Spatial orientation of fish embryos in magnetic field. Electronic Journal of Ichthyology 1:14.

The Wildlife and Countryside Act, 1981. Available through: [online] <http://www.legislation.gov.uk/ukpga/1981/69.> [Accessed April 2012].

Thomsen, F., Lüdemann, K., Kafemann, R. and Piper, W., (2006) Effects of offshore wind farm noise on marine mammals and fish, biola, Hamburg, Germany on behalf of COWRIE Ltd.

Thorstad, E.B., Heggberget, T.H. and ØKland, F., (1998) Migratory behaviour of adult wild and escaped farmed Atlantic salmon, Salmo salar L., before, during and after spawning in a Norwegian river. Aquaculture Research 29:419-428.

Thorstad, E.B., ØKland, F., Heggberget, T.H. and Aarestrup, K., (2008) Factors affecting the within-river spawning migration of Atlantic salmon, with emphasis on human impacts. Rev Fish Biol Fisheries 18: 345-371.

Ueno, S.P., Lovsund, P. and Ober, P.A., (1986) Effect of time-varying magnetic fields on the action potential in lobster giant axon. Medical and Biological Engineering and Computing 24.

UKBAP, 2012. UK BAP priority fish species full list. Available through: [online] < http://jncc.defra.gov.uk/page-5164.> [Accessed February 2012].

Vandendriessche, S., Hostens, K. and Wittoeck, J., (2009) Monitoring of the effects of the Thorntonbank and Bligh Bank windmill parks on the epifauna and demersal fish fauna of soft-bottom sediments. In Degraer *et al.*, 2009.

Vella, G., Rushforth, I., Mason, E., Hough, A., England, R., Styles, P., Holt, P. and Thorne, P., (2001) Assessment of the Effects of Noise and Vibration from offshore wind farms on Marine Wildlife. ETSU W/13/00566/REP. DTI/Pub URN 01/1341

Vriens, A.M. and Bretschneider, F., (1979) The electrosensitivity of the lateral line of the European eels, Anguillla anguillla L. Journal of Physiology. 75: 341-342.

Wahlberg, M. and Westerberg, H., (2005) Hearing in fish and their reactions to sounds from offshore wind farms. Marine Ecology Progress Series. 288:295-309.

Westerberg, H., (1994) Fiskeriundersokningar vid havsbaserat vindkraftvert 1990-1993. Rapport 5 - 1994. pp. 44 Jonkoping: Goteborgsfilialen, Utredningskontoret i Jonkoping. Sweden National Board of Fisheries Cited in Vella *et al.*, 2001.

Westerberg, H., (1999) Impact Studies of Sea-Based Windpower in Sweden. "Technische Eingriffe in marine Lebensräume". Cited in Vella, G., Rushforth, I., Mason, E., Hough, A., England, R., Styles, P., Holt, P. And Thorne, P., (2001) Assessment of the Effects of Noise and Vibration from offshore wind farms on Marine Wildlife. ETSU W/13/00566/REP. DTI/Pub URN 01/1341.

Westerberg, H. and Lagenfelt, I. (2008) Sub-Sea Power Cables and the Migration Behaviour of the European Eel. Fisheries Management and Ecology 15 (1-5): 369-375.

Wilber, D.H. and Clark, D.G., (2001) Biological Effects of Suspended Sediments: A review of Suspended Sediment Impacts on Fish and Shellfish in Relation to Dredging Activities in Estuaries. North American Journal of Fisheries Management 21: 855-875.

Wilhelmsson, D., Malm. And Ohman, M.C., (2006) The influence of Offshore Wind Power on demersal fish. ICES Journal of Marine Science. 63: 775-784.

BURBO BANK EXTENSION OFFSHORE WIND FARM

DONG Energy Burbo Extension (UK) Ltd.

Environmental Statement
Volume 2 - Chapter 14: Marine Mammals

Document reference: 5.1.2.14
APFP 5(2)(a)

March 2013

DONG energy

Burbo Bank Extension offshore wind farm
DONG Energy Burbo Extension (UK) Ltd

Environmental Statement
Volume 2 – Offshore, Biological & Physical Technical Chapters 8-16

Document reference: 5.1.2

Pursuant to: APFP 5(2)(a)

Prepared by: Stuart Livesey (Consents Project Manager, DONG Energy), Jennifer Brack (Applications Lead, DONG Energy), Allen Risby (Environmental Lead, DONG Energy), Bronagh Byrne (Environmental Lead, DONG Energy), Julian Carolan (Environmental Lead, DONG Energy), David King (Assistant Environmental Manager, DONG Energy), Rasmus Juncher (Geoscience Manager, DONG Energy), Gardline Geosurvey Ltd., ABP Marine Environmental Research, Subacoustech Ltd., CMACS Ltd., Brown & May Marine Ltd., NIRAS Consulting Ltd., Natural Power Ltd., NIRAS Consulting Ltd.

Checked by: Stuart Livesey (Consents Project Manager, DONG Energy), Jennifer Brack (Applications Lead, DONG Energy), Andrew Prior (Senior Environmental Manager, DONG Energy), Bond Pearce LLP, James Deeble (NIRAS Consulting Ltd.), David King (Assistant Environmental Manager, DONG Energy)

Accepted by: Stuart Livesey (Consents Project Manager, DONG Energy)

Approved by: Ferdinando Giammichele (Project Development Manager, DONG Energy)

Date: March 2013

Status: Final

Burbo Bank Extension offshore wind farm
c/o DONG Energy Burbo Extension (UK) Ltd.
33 Grosvenor Place
Belgravia
London
SW1X 7HY
United Kingdom

Tel: (+44) 020 7811 5235

Website: www.burbobankextension.co.uk
Email: burbobankextension@dongenergy.co.uk

DONG energy

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14. Marine Mammals

14.1 Introduction

14.1.1 The purpose of this chapter in the Burbo Bank Extension offshore wind farm ("the Project") Environmental Statement (ES) is to identify and assess the likely significant effects of the Project on Marine Mammals. The Project for which development consent is sought consists of an extension westwards of the existing Burbo Bank offshore wind farm. The proposed offshore Project site covers an area of 40 km^2 which lies approximately 7 km north off the North Wirral coast. The maximum capacity of the wind farm will be up to 258 MW, consisting of offshore wind turbines and foundations, an offshore substation, buried inter-array and export cable(s), buried onshore cable(s) from the cable landfall in North Wales between Rhyl and Prestatyn to a new onshore substation next to the Bodelwyddan substation near St Asaph in Denbighshire where the cable will connect with the National Grid. Further details on the Project infrastructure, installation methodologies and timelines can be found in ES Chapter 6 'Project Description'.

14.1.2 This assessment will concentrate on the following species which were highlighted in the marine mammal desk study report (Centre for Marine and Coastal Studies Ltd (CMACS), May 2012) (ES Technical Annex '5.1.5.14.1') as key species due to their abundance in the Study Area and/or conservation importance:

- Harbour porpoise (*Phocoena phocoena*);
- Bottlenose dolphin (*Tursiops truncatus*); and
- Grey seal (*Halichoerus grypus*).

14.1.3 It is acknowledged that additional species have been recorded within Liverpool Bay and, for the purpose of this assessment, it is assumed that all conclusions made will also apply to these rarely occurring species such as minke whale, Risso's dolphin, common dolphin, white-beaked dolphins (see Table 14.5). This chapter summarises information from technical reports which are included at ES Technical Annex '5.1.5.14.1'.

14.2 Planning Policy Context

14.2.1 Planning policy on offshore renewable energy NSIPs is contained in the National Policy Statements (NPSs) for Overarching Energy (EN-1; DECC, 2011a) and Renewable Energy Infrastructure (EN-3, DECC, 2011b).

14.2.2 The NPSs identify a number of issues relevant to this chapter. Generic biodiversity impacts that are set out in Section 5.3 of EN-1 sets out the policy for the IPC in relation to generic biodiversity impacts and paragraphs 2.6.58 to 2.6.71 sets out offshore wind-specific biodiversity policy. In addition, EN-3 outlines specific considerations which apply to the effect of offshore wind energy development proposals on marine mammals. The specific considerations with respect of marine mammals are summarised in Table 14.1 below.

Table 14.1: Summary of NPS EN-3 provisions relevant to this chapter.

Summary of NPS provision	Consideration in ES
Section 2.6.92 and 2.6.93	
Where necessary, assessment of the effects on marine mammals should include details of: • likely feeding areas; • known birthing areas/haul out sites; • nursery grounds; • known migration or commuting routes; • duration of the potentially disturbing activity including cumulative/ incombination effects with other plans or projects; • baseline noise levels; • predicted noise levels in relation to mortality, permanent threshold shift (PTS) and temporary threshold shift (TTS); • soft-start noise levels according to proposed hammer and pile design; and • operational noise.	An assessment of the effects on marine mammals including these issues where appropriate/applicable are considered in Section 14.8. No assessment on likely feeding areas, nursery grounds or known migration /commuting routes has been possible as not data exists for the relevant species. Seal haul out sites, where data is available, has been assessed.
The applicant should discuss any proposed piling activities with the relevant body. Where assessment shows that noise from offshore piling may reach noise levels likely to lead to an offence as described in 2.6.9 above, the applicant should look at possible alternatives or appropriate mitigation before applying for a licence. Offshore piling may reach noise levels which are high enough to cause injury, or even death, to marine mammals. If piling associated with an offshore wind farm is likely to lead to the commission of an offence (which would include deliberately disturbing, killing or capturing a European Protected Species), an application may have to be made for a wildlife licence to allow the activity to take place.	The use of piling activities has been considered and assessed in Section 14.8 (Construction Phase). Mitigation measures have also been considered in Section 14.8 (Decommissioning Phase).

14.3 Consultation

14.3.1 ES Chapter 7 'Consultation' outlines the consultation activities which have been undertaken in respect of the Project.

14.3.2 Table 14.2 below summarises the issues relevant to this chapter which have been highlighted by the consultees and indicates how, if possible, these issues have been addressed within this ES. Scoping Opinion and Preliminary Environmental Information Technical Report Version 2 (PEI) responses have focused on marine mammal interests as European Protected Species (EPS).

Table 14.2: Consultation responses to scoping document and PEI relevant to this chapter

Date	Consultee and type of response	Issues Raised	How/where addressed
August 2010	The Planning Inspectorate (PINS; formerly the Infrastructure Planning Commission)	The ES should set out in full the potential risk to European Protected Species (EPS) and confirm if any EPS licence will be required. Ensure that the data required for the purpose of consenting and granting any EPS licences is collected. Need to consider in the ES the potential environmental impacts of the decommissioning phase on marine mammals.	A preliminary EPS assessment in included within this chapter. Impacts from decommissioning of the project are discussed in Section 14.8 (Decommissioning Phase).
August 2010	Welsh Assembly Government (WAG)	Possible requirement for a marine EPS license.	A preliminary EPS assessment in included within this chapter.
August 2010	Natural England	EPS likely to be required for harbour porpoise. Approved of proposed baseline i.e. desk study supported by observations and mitigation.	A preliminary EPS assessment is included within this chapter.
June 2012	Marine Management Organisation (MMO)	Reference should be made to densities of specific species when assessing the effects of noise.	Details of densities used in assessment can be found in Table 14.5.

Table 14.2: continued

Date	Consultee and type of response	Issues Raised	How/where addressed
June 2012	Natural England	An EPS licence to disturb harbour porpoises will likely be required. Mitigation (re. injury) will need to be implemented prior to each piling event. A small desk study presenting evidence of the post construction usage of wind farm sites by marine mammals would support an investigation into whether the Project would have any impact on the distribution of marine mammals in the east Irish sea. Other projects, namely piling activities, that are likely to be creating high levels of noise during the period of construction at the Project should be identified and cumulative assessment undertaken.	A preliminary EPS assessment in included within this chapter. A discussion of marine mammal behavior around operational wind farms can be found in Section 14.8 (Operational and Maintenance Phase). Cumulative impacts of piling at neighboring wind farms can be found in Section 14.9.
June 2012	National Trust	Suggest mitigation measures to avoid marine mammals being affected by boat propellers.	It is noted that the SNCBs are developing guidance on this matter.
June 2012	Countryside Council for Wales (CCW)	Advise that impacts during breeding seasons are likely to be greater than those to individuals solely feeding. Highlight that impacts on harbour seal need careful consideration due to the current declining trend in many UK populations. Recommend need for discussion regarding requirement for EPS license.	Noted and points highlighted in baseline section.

14.4 Study Area

14.4.1 Given the level of legal protection afforded by all of the marine mammals likely to be encountered within Liverpool Bay and the wide-ranging foraging and migratory behaviour exhibited by these species, the study area for this assessment has been taken to be the entire Irish Sea zone.

14.5 Methodology

14.5.1 The potential impacts of the Project on marine mammal populations have been examined via desk-based studies.

14.5.2 In order to inform the EIA, the survey data detailed below in Table 14.3 were collected for the Project area.

Table 14.3: Summary of survey data

Title	Source	Year	Reference
Subtidal and Intertidal Benthic Ecology	DONG Energy	2012	Burbo Bank Extension ES Chapter 12
Fish and Shellfish Ecology	DONG Energy	2012	Burbo Bank Extension ES Chapter 13
Shipping and Navigation	DONG Energy	2012	Burbo Bank Extension ES Chapter 17
Marine Mammal Desk Study Report	CMACS	2012	Burbo Bank Extension ES Annex '5.1.5.14.1'

14.5.3 In addition to these Project-specific surveys, other data and literature was collected and reviewed. Suitable density estimates for the species under investigation at a scale appropriate for this assessment are not readily available. A review of available abundance estimates was undertaken and the most robust chosen and used to calculate density estimates per km (divide the abundance estimate by the area investigated). Details of data used to calculate densities for the purpose of this assessment are summarised at Table 14.4 below.

Table 14.4: Summary of key reports

Title	Source	Year	Reference
SCANS II	http://biology.st-andrews.ac.uk/scans2	2008	Final Report to the European Commission under project LIFE04NAT/GB/00245
EISDG	Marine mammal desk study	2005	East Irish Sea Developers Group (EISDG) (2005), Desktop Review of Marine Mammal Distribution in the NW3 Area. Revision:01, Ormond Project. Prepared by Rudall Blanchard Associates Ltd., London.
SCOS	http://www.smru.st-andrews.ac.uk/pageset.aspx?psr=411	2012	Scientific Advice on Matters Related to the Management of Seal Populations
Background information on marine mammals for Strategic Environmental Assessment 6	http://www.offshore-sea.org.uk/site/scripts/category_info.php?categoryID=11	2005	Hammond, P.S., Northridge, S.P., Thompson, D., Gordon, J.C.D., Hall, A.J., Aarts, G. and Matthiopoulos, J. 2005. Background information on marine mammals for Strategic Environmental Assessment 6. SMRU report.
Maritime INTERREG Series	http://oar.marine.ie/handle/10793/561	2000	Kiely *et al.*, 2000

14.6 Baseline Environment

14.6.1 Existing information on marine mammals occurring in the vicinity of the Project is presented in the CMACS (2012) marine mammal desk study report (ES Annex '5.1.5.14.1').

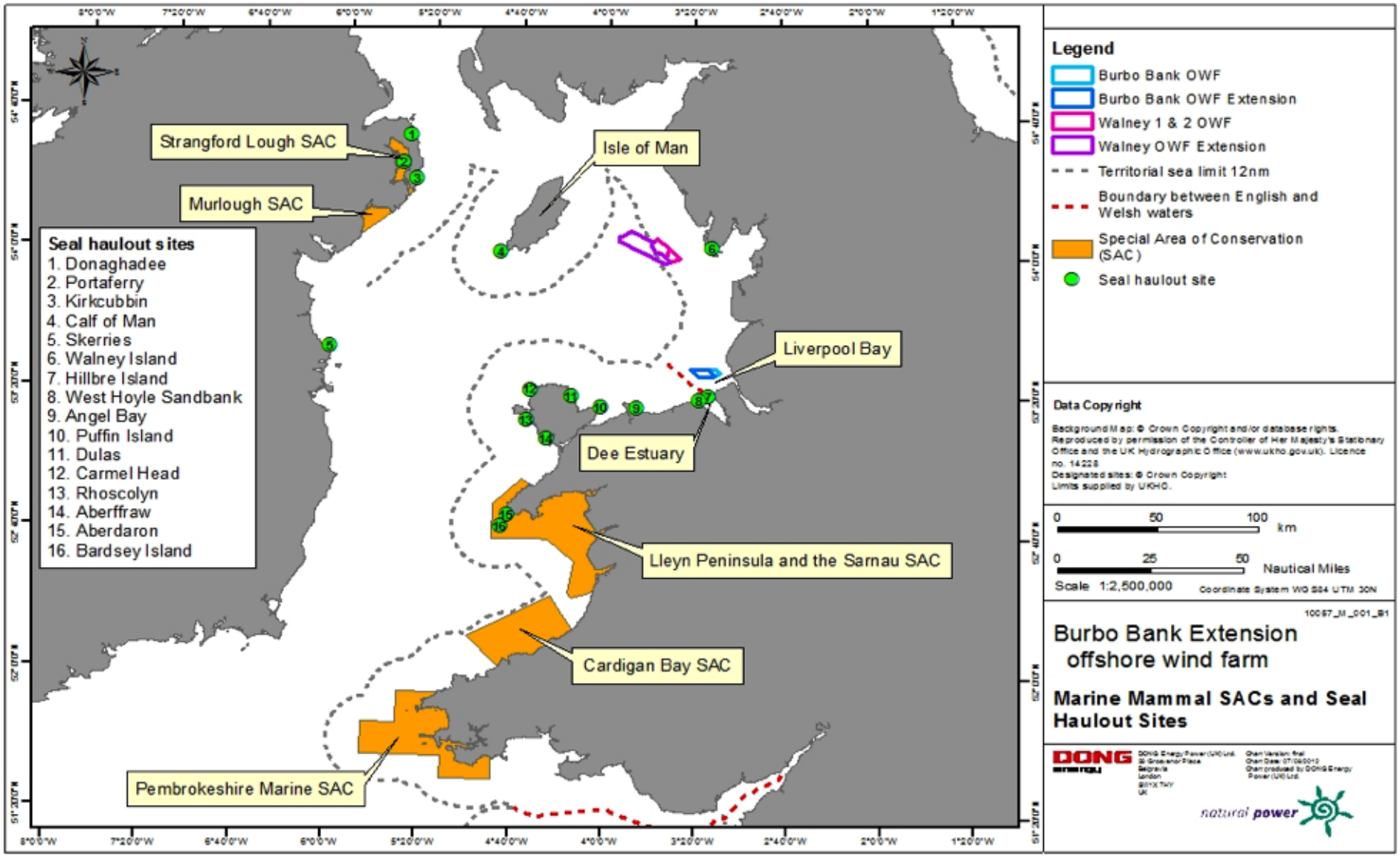

Figure 14.1: Marine mammal SACs and seal haul-out sites

14.6.2 For the purpose of this assessment, relevant information on the occurrence, density and abundance of the key species occurring in the Liverpool Bay/Irish Sea area has been summarised in Table 14.5 below. The overall study area has been assumed to be the Irish Sea zone (see Section 14.4) but the scale relevant for different species varies depending on their mobility. The location of SACs discussed in Table 14.5 can be found in Figure 14.1. Additional information illustrating grey seal at-sea usage and harbour porpoise density is shown in Figure 14.2 and Figure 14.3 respectively.

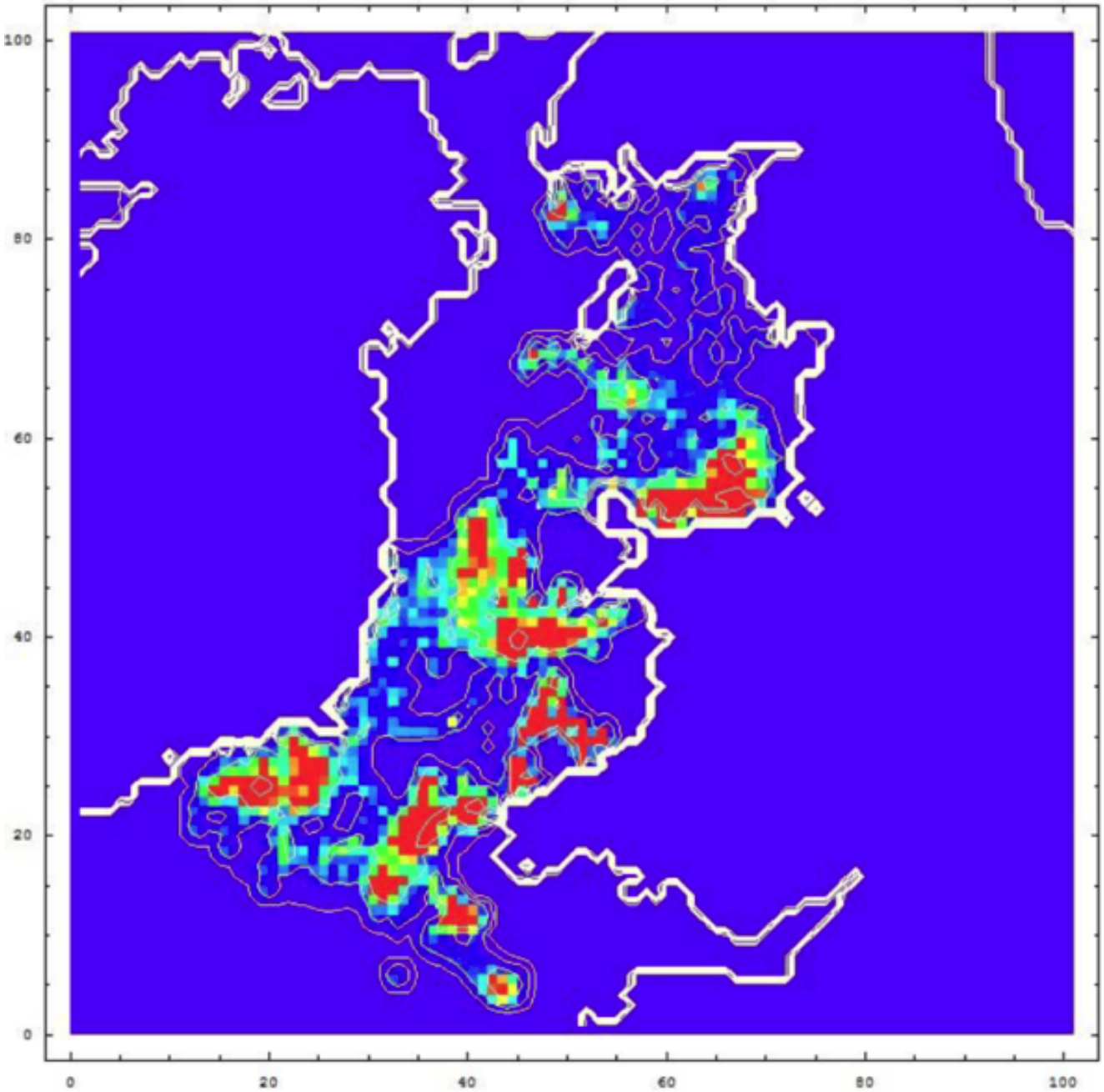

Figure 14.2: Estimated at-sea usage of the Irish Sea by 19 grey seals tagged in Wales (Hammond et al., 2005). Warm colours indicate higher usage

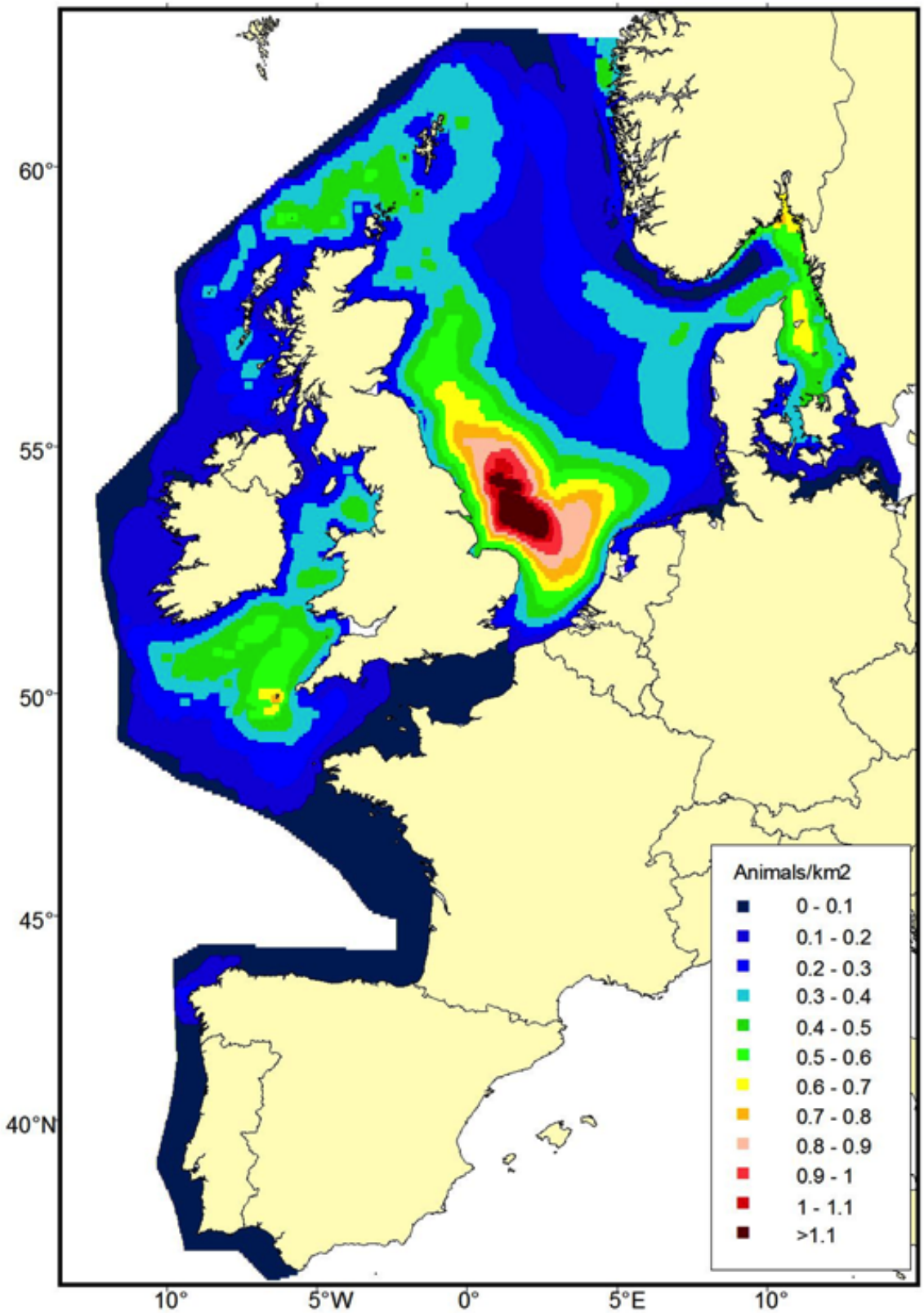

Figure 14.3: Estimated density of harbour porpoises calculated using the SCANS II data (redrawn from SCANS II, 2008)

14.6.3 It should be noted that although young bottlenose dolphins and harbour porpoise have been observed off the coast of Anglesey, no specific calving locations have been identified.

Table 14.5: Information on the key species recorded in the Liverpool Bay area. (CV = coefficient of variance)

Taxonomy	Species	Relevant SACs	Abundance (CV)	Density (animals per km²) (CV)	Area estimated and Source	Other information
Order Cetacea	Harbour porpoise (*Phocoena phocoena*)	The UK has not identified any SACs with harbour porpoise as a qualifying feature, but 26 SACs where it is included as a non-qualifying feature have been identified. These include Cardigan Bay, Lleyn Peninsula and the Sarnau and Pembrokeshire Marine (Figure 14.1).	15,230 (0.35)	0.335 (0.35)	Irish Sea SCANS II, Block O	Harbour porpoises are the most abundant and widespread species in Liverpool Bay. Although they are resident, peak sightings (in the Irish Sea) occur between July and September. The SCANS II density estimate has been used when assessing impacts because it is applicable to the wider area.
			-	0.01-0.09	Morecambe Bay (EISDG, 2005, cited in CMACS, 2012)	
			-	0.2	Cardigan Bay SAC Pesante *et al.*, 2008, (cited in CMACS, 2012)	
			122 (95% CI 90-165) for May to October 2001	-	Cardigan Bay SAC Baines *et al.* 2002, (cited in Hammond *et al.*, 2005)	

Table 14.5: continued

Taxonomy	Species	Relevant SACs	Abundance (CV)	Density (animals per km²) (CV)	Area estimated and Source	Other information
Order Cetacea	Bottlenose dolphin (*Tursiops truncatus*)	Cardigan Bay Lleyn Peninsula and the Sarnau (qualifying feature but not the primary reason for site selection)	235 (0.75)	0.0052 (0.75)	Irish Sea SCANS II, Block O	Although resident off the west coast of Wales, bottlenose dolphins are relatively rare in Liverpool Bay (Baines ***et al.***, 2012); the north coast of Anglesey has relatively high predicted densities but Liverpool Bay estimates are very low (Paxton *et al.*, 2011). Peak sightings occur during the autumn and winter (November to March). The SCANS II density estimate has been used when assessing impacts because it is applicable to the wider area.
			213 (95% CI 183-279)	0.2-0.3 (calculated by dividing the abundance estimate by the area of the SAC which is 958.6036 km²)	Cardigan Bay SAC Baines *et al.*, 2002 (cited in Hammond *et al.*, 2005)	

Table 14.5: continued

Taxonomy	Species	Relevant SACs	Abundance (CV)	Density (animals per km²) (CV)	Area estimated and Source	Other information
Order Cetacea	Minke whale (*Balaenoptera acutorostrata*)	-	1,073 (0.89)	0.0236 (0.89)	Irish Sea SCANS II Block O	Minke whales are occasional visitors to the Irish Sea (Baines *et al.*, 2012) where they occur annually in small numbers, mainly in July and August. They are rarely recorded east of the Isle of Man (Figure 14.1) and are rare in Liverpool Bay.
	Risso's dolphin (*Grampus griseus*)	-	-	-	-	Peak Risso's dolphin sightings off the Lleyn Peninsula and the Isle of Man (Baines *et al.*, 2012) occur between July and September. Sightings in Liverpool Bay are rare.
	Common dolphin (*Delphinus delphis*)	-	366 (0.73)	0.0081 (0.73)	Irish Sea SCANS II Block O	Although rare, common dolphin sightings are most likely to occur during the summer (June to September).

Table 14.5: continued

Taxonomy	Species	Relevant SACs	Abundance (CV)	Density (animals per km²) (CV)	Area estimated and Source	Other information
Order Cetacea	White-beaked dolphin (*Lageno-rhynchus albirostris*)	-	75 (0.8)	0.0016 (0.8)	Irish Sea SCANS II Block O	White-beaked dolphins are relatively rare in the Irish Sea. No sightings records in Liverpool Bay have been found.
Order Pinnipedia	Grey seal (*Halichoerus grypus*)	Pembrokeshire Marine Cardigan Bay (qualifying feature but not the primary reason for site selection) Lleyn Peninsula and the Sarnau (qualifying feature but not the primary reason for site selection)	A co-ordinated transnational study in the central and southern Irish Sea was conducted between 1996 and 1998 (Kiely *et al.*, 2000). The pup census data collected in Ireland and Wales yielded a minimum all-age population estimate for the Irish Sea of 5,198-6,976 individuals.	The Irish Sea (International Hydrographic Organisation, 1,971) covers an area of 47,612 km². Telemetry data show that 33% of grey seals are hauled out during August surveys (95% bootstrap confidence interval 29-37%; Lonergan *et al.*, 2011). Using the Irish Sea surface area,	Irish Sea Density estimate calculated using information from Kiely *et al.*, (2000), Lonergan ***et al.***, (2011) and International Hydrographic Organisation (1971)	Grey seals are resident in the Liverpool Bay area. The closest haul-out (of up to 500 animals) is at Hilbre Island in the Dee estuary, approximately 12 km (6.5 nm) south west of the Project. A second haul-out, on south Walney Island, is used by up to 100 grey seals (Figure 14.1). There are also a number of grey seal haul-out sites around Anglesey and north-west Wales (Figure 14.1) however these are considered to be at too great a distance from

Table 14.5: continued

Taxonomy	Species	Relevant SACs	Abundance (CV)	Density (animals per km²) (CV)	Area estimated and Source	Other information
Order Pinnipedia			This estimate was supported by photo-identification mark-recapture data which delivered an estimate of 5,613 seals (0.2% CV).	the photo-identification mark-recapture population estimate, and the proportion of the population likely to be at-sea in August gives an at-sea density estimate of 0.074-0.084 grey seals per km².	Irish Sea Density estimate calculated using information from Kiely *et al.*, (2000), Lonergan ***et al.***, (2011) and International Hydrographic Organisation (1971)	the development site to be impacted on so are not considered any further. The closest breeding colony to the Project is on the west coast of Anglesey. There are no known breeding colonies in the Liverpool Bay area. At-sea distribution in the SEA6 area is limited to Liverpool Bay, the southern Irish Sea and northern St George's Channel (Hammond *et al.*, 2005)

Table 14.5: continued

Taxonomy	Species	Relevant SACs	Abundance (CV)	Density (animals per km²) (CV)	Area estimated and Source	Other information
Order Pinnipedia	Harbour seal (*Phoca vitulina*)	The closest SACs (where harbour seals have been included as a non-qualifying feature) are Strangford Lough and Murlough, both in County Down, Northern Ireland (Figure 14.1).	-	-	-	Harbour seal sightings in the east Irish Sea are relatively rare, with few reports in or around Liverpool Bay. A number of UK populations have been declining in recent years for example Shetland (down 50%), Orkney (down 68%) and Firth of Ray (down 85% compared to the mid 1990's; SCOS, 2011). Due to the low number of harbour seals associated with the Project, the area is not regularly surveyed making determination of trends difficult.

14.7 Key Parameters for Assessment

14.7.1 The following assessment for marine mammals has been made using parameters detailed in the Design Envelope (see ES Chapter 6 'Project Description') and assessments are made for each of the three main phases of the projects lifetime: construction operation and decommissioning. Table 14.6 below details the design envelope scenarios considered for each potential impact assessed in this chapter.

14.7.2 Impacts from electromagnetic fields associated with offshore cables have not been included in this assessment. Guidance document EN-3 states that the operational EMF impacts are unlikely to be of sufficient range or strength to create a barrier to fish movement, should the cables be insulated and buried at depth. Although information on marine mammal sensitivity to EMF is scarcer than for fish, it is considered that the same conclusions can be applied to marine mammals. As a result impacts from EMF have been scoped out of this assessment.

Table 14.6: Design envelope scenario considered for the assessment of potential impacts on marine mammals.

Potential impact	Maximum adverse scenario	Justification
Construction phase		
Collision risk associated with increased vessel movement	Construction activity will involve approximately 3,650 single trips to the ports within the Irish Sea (potentially Mostyn, Liverpool, Barrow or Belfast) per annum. Transits from Belfast are considered to represent the maximum adverse scenario.	Maximum vessel traffic movements will be associated with the greatest turbine numbers (and associated infrastructure).
Increased noise associated with vessel movement	Construction activity will involve approximately 3,650 single trips to the ports within the Irish Sea (potentially Mostyn, Liverpool, Barrow or Belfast) per annum. Transits from Belfast are considered to represent the maximum adverse scenario.	Maximum vessel traffic movements will be associated with the greatest turbine numbers (and associated infrastructure).

Table 14.6: continued

Potential impact	Maximum adverse scenario	Justification
Construction phase		
Increased noise associated with Trenching/Cable laying	Up to two export cables of 29 km each (total length of 58 km). 65 km of intra array cabling (total length of 65 km).	Maximum cable length for export cable and intra array cabling associated with the greatest turbine numbers (and associated infrastructure).
Increased noise associated with piling: Lethality/ physical trauma	69 x 8 m diameter monopile foundations, installed via pile driving using a maximum hammer energy of 2,700 kJ. Two foundation vessels, each installing 2 x 8 m monopiles over a 24 hr period (four in total). Three positions considered.	Piling is accepted as being the noisiest activity during the construction process (see Figure 14.4). Maximum noise associated with largest pile diameter and hammer size. The greatest number of foundations will increase the duration of the impact. The greatest number of simultaneous foundation installations will increase the footprint of the noise impact during pile installation. Modelling undertaken to represent the location of piling events which would have the greatest effect on marine mammal species. NW position modelled for seals and harbour porpoise and SW position modelled for Bottlenose dolphins.
Increased noise associated with piling: Hearing damage i.e. Permanent Threshold Shift (PTS)		
Increased noise associated with piling: Disturbance/ displacement		

Table 14.6: continued

Potential impact	Maximum adverse scenario	Justification
Operation phase		
Displacement/disturbance associated with turbine operating noise	Layout of largest number of foundations (plus associated substations, meteorological masts and accommodation platforms) spaced evenly across the development site.	Maximum area of noise emitted from operational turbines (and associated infrastructure).
Increased collision risk associated with maintenance vessels	Maximum scenario of six service vessels per day, each departing and returning each day. The location of the O&M base could be has yet to be determined.	Maximum vessel traffic movements will be associated with greatest turbine numbers (and associated infrastructure).
Loss of prey species associated changes in habitat or abundance and distribution of prey	Layout of largest number of foundations with greatest footprint (plus associated substations, and accommodation platforms) spaced evenly across the development site. Resulting in loss of approximately 0.229 km^2 seabed habit within the Project site boundary.	Maximum loss of habitat of prey species will be associated with the greatest number of turbines with greatest footprint (and associated infrastructure).
Decommissioning phase		
Noise associated with the use of cutting and crushing tools	Decommissioning plan yet to be confirmed so preliminary assessment based on information provided in the Project Description.	Maximum noise from decommissioning will be associated with greatest turbine numbers (and associated infrastructure) required to be decommissioned and method used for decommissioning.

Table 14.6: continued

Potential impact	Maximum adverse scenario	Justification
Decommissioning phase		
Increased vessel use associated with demolition	Decommissioning plan yet to be confirmed so preliminary assessment based on information provided in the Project Description.	Maximum vessel traffic will be associated with greatest turbine numbers (and associated infrastructure) required to be decommissioned.
Cumulative effects		
Increased vessel activity	Full development of other proposed or existing marine projects in the region, including: other offshore wind farms; subsea cables, and marine aggregates.	Outcome of the cumulative impact assessment would be greatest when the greatest number of other schemes, present or planned, are considered.
Impacts of piling occurring at multiple developments simultaneously	The maximum adverse scenario for construction during the Project occurring simultaneously with the loudest scenario at southernmost point of the Walney Extension offshore wind farm, where construction timescales are likely to overlap	The maximum adverse scenarios for impact piling at the Project and the Walney Extension offshore wind farm would result in the greatest area of the Irish Sea to be insonified. Other noise sources are either unlikely to overlap with the construction period or are of a significantly lower level of noise than impact piling.
Loss of prey species associated changes in habitat or abundance and distribution of prey	Full development of other proposed or existing marine projects in the region, including: other offshore wind farms; and marine aggregates.	Outcome of the cumulative impact assessment would be greatest when the greatest number of other schemes, present or planned, are considered.
Displacement/disturbance associated with turbine operating noise	Full development of other proposed or existing offshore wind farms.	Outcome of the cumulative impact assessment would be greatest when the greatest number of other schemes, present or planned, are considered.

Table 14.6: continued

Potential impact	Maximum adverse scenario	Justification
Cumulative effects		
Noise associated with decommissioning	Simultaneous occurrence of decommissioning activities at nearby locations.	Outcome of the cumulative impact assessment would be greatest when the greatest number of other schemes, present or planned, are required to be decommissioned.

14.7.3 In addition to the generic biodiversity impacts described in Section 5.3 of EN-1, Section 2.6.9 of EN-3 highlights that specific considerations need to be given to piling noise with regard to marine mammals, stating *"where assessment shows that piling noise may lead to an offence, the applicant should look at possible alternatives or appropriate mitigation before applying for a licence"*. To reflect this guidance, the impact assessment has focused on noise as the primary potential impact.

14.7.4 As part of the assessment process, noise from nine different construction related activities (suction dredging, drilling, impact piling, operational noise, cable laying, rock dumping, trenching, vessel noise and vibropiling) was modelled by Subacoustech using the SPEAR model to determine their impact on marine species in the vicinity of the Project (see ES Chapter 11 'Offshore Noise' for full details of modelling undertaken and the parameters used). Figure 14.4 illustrates the ranges at which noise from the different construction related activities reaches 90 dB_{ht} from the noise source for harbour porpoises. 90 dB_{ht} is the level at which the perceived noise level is deemed 'unbearably loud' and will therefore elicit strong avoidance behaviour. Piling, should it be required, would not be constant (i.e. will be down time while vessels reposition and due to weather) and are only required to install the turbine foundations. When piling is not occurring, other construction activities should be considered e.g. rock dumping, trenching and vibropiling. Because piling is one of the construction activities taking place at the Project, it has been considered as the main construction related activity because it has by far the greatest impact on marine mammals.

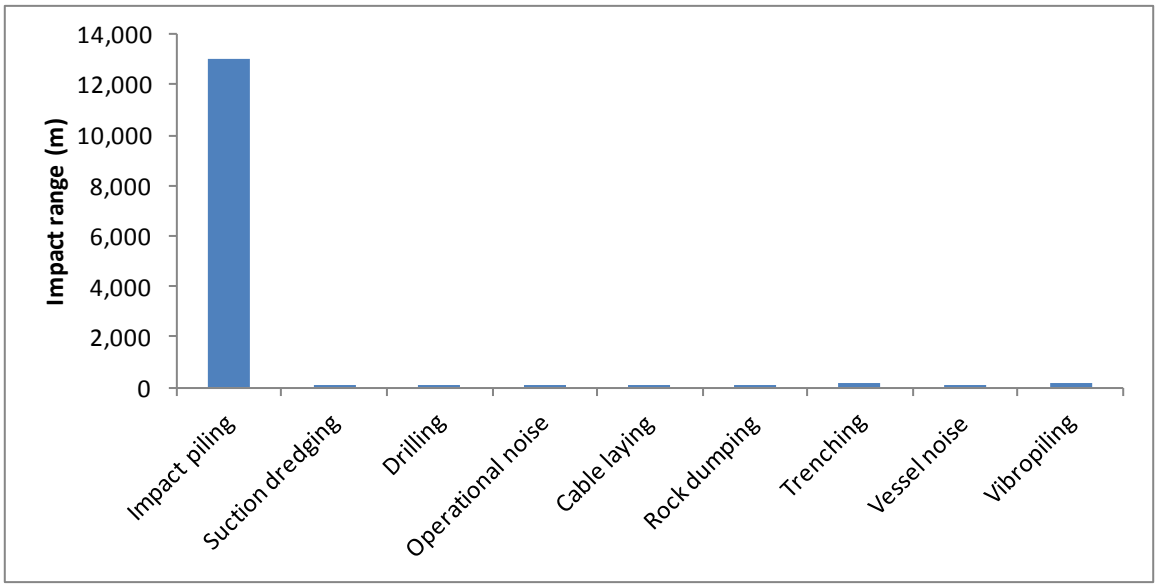

Figure 14.4: A summary of impact ranges for harbour porpoise for various modelled offshore activities using the 90 dB_{ht} criteria (redrawn using data from Hughes et al., 2012)

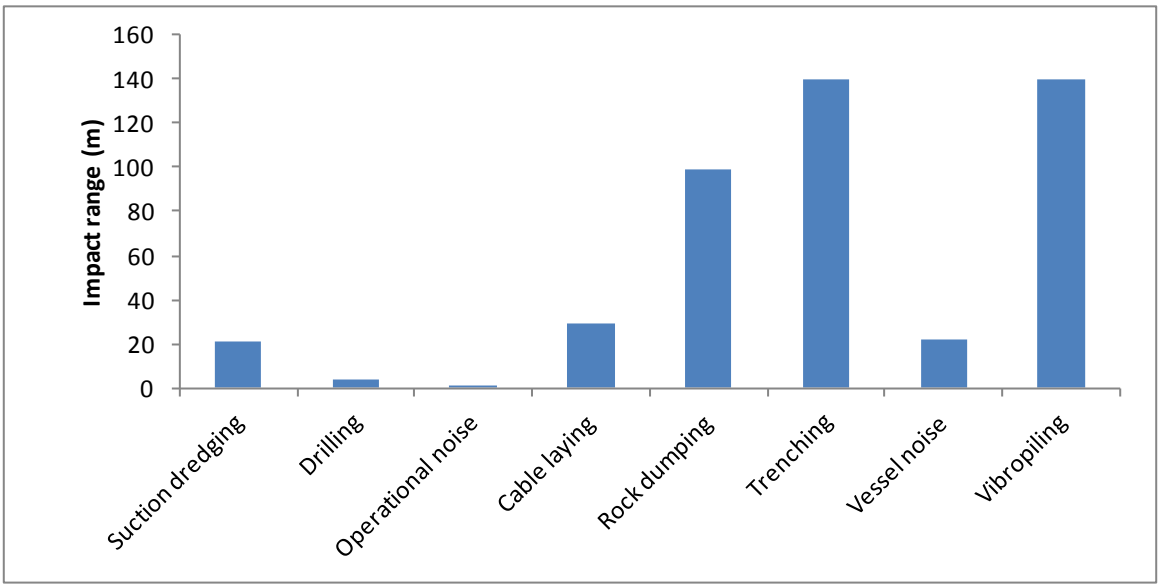

Figure 14.5: A summary of impact ranges for harbour porpoise for various modelled offshore activities excluding piling using the 90 dB_{ht} criteria (redrawn using data from Hughes et al., 2012)

14.8 Assessment Criteria and Assignment of Significance

14.8.1 This section describes the criteria applied in this chapter to assign values to the sensitivity of receptors and the magnitude of potential impacts. Unless stated otherwise the values are those used in the Design Manual for Roads and Bridges (DMRB, 2008) methodology described in more detail in ES Chapter 3 'Environmental Impact Assessment Process'.

14.8.2 The criteria for sensitivity used in this chapter are outlined in Table 14.7 below. Given the level of legal protection afforded all of the marine mammals likely to be encountered within Liverpool Bay, all species of marine mammal are considered to be of very high sensitivity in this assessment. The criteria for magnitude used in this chapter are outlined in Table 14.8 below.

Table 14.7: Environmental value (Sensitivity)

Value (Sensitivity)	DMRB description	Criteria used in this chapter
Very High	Very high importance and rarity, international scale and very limited potential for substitution.	Species are a European Protected Species (EPS) or a feature of a European designated site i.e. Special Area of Conservation (SAC).
High	High importance and rarity, national scale and limited potential for substitution.	Species are a feature of a UK designated site i.e. Site of Special Scientific Interest (SSSI), UK Biodiversity Action Plan (UKBAP) or Priority Marine Feature (PMF).
Medium	High or medium importance and rarity, regional scale, limited potential for substitution.	Species present in regionally important numbers.
Low (or lower)	Low or medium importance and rarity, local scale.	Species present in locally important numbers.
Negligible	Very low importance and rarity, local scale.	Species rarely present.

Table 14.8: Magnitude of environmental impacts

Magnitude of impact	Description	Criteria used in this chapter
Major	Loss of resource and/or quality and integrity of resource; severe damage to key characteristics, features or elements (adverse).	Greater than 20% of the population will be impacted.
Moderate	Loss of resource, but not adversely affecting integrity of resource; partial loss of/damage to key characteristics, features or elements (adverse).	Between 10 and 20% of the population will be impacted in the medium to long term.
Minor	Some measureable change in attributes, quality or vulnerability, minor loss or, alteration to, one (maybe more) key characteristics, features or elements (adverse).	Between 10 and 20% of the population will be impacted in the short term. Less than 10% of the population will be impacted in the medium to long term.
Negligible	Very minor loss or detrimental alteration to one or more characteristics, features or elements (adverse).	Less than 10% of the population will be impacted in the short term.
No change	No loss or alteration or characteristics, features or elements; no observable impact in either direction.	No change

14.8.3 Significance is assessed by correlating the magnitude (spatial extent or size) of the impact and the sensitivity of the receptor, see Table 14.9 below.

Table 14.9: Assessment of significance matrix

		Magnitude of Impact				
		No change	**Negligible**	**Minor**	**Moderate**	**Major**
Environmental Sensitivity	**Very high**	Neutral	Slight	Moderate or large	Large or Very Large	Very Large
	High	Neutral	Slight	Slight or Moderate	Moderate or large	Large or Very Large
	Medium	Neutral	Neutral or Slight	Slight	Moderate	Moderate or large
	Low	Neutral	Neutral or Slight	Neutral or Slight	Slight	Slight or Moderate
	Negligible	Neutral	Neutral	Neutral or Slight	Neutral or Slight	Slight

14.8.4 Certainties in predictions for this assessment are based on IEEM guidance (IEEM, 2010) and follow the criteria described in Table 14.10 below.

Table 14.10: Criteria used for predicting certainty in predictions during the assessment

Term	Definition
Certain	Interactions are well understood and documented, i.e. receptor sensitivity investigated in relation to potential impact, data have comprehensive spatial coverage/resolution and predictions relating to effect magnitude modelled and/or quantified. Probability estimated at >95%.
Probable	Interactions are understood using some documented evidence, i.e. receptor sensitivity is derived from sources that consider the likely effects of the potential impact, data have a relatively moderate spatial coverage/ resolution, and predictions relating to effect magnitude have been modelled but not validated. Probability estimated at 50-95%.
Uncertain	Interactions are poorly understood and not documented, i.e. predictions relating to effect magnitude have not been modelled and are based on expert interpretation using little or no quantitative data. Probability estimated at <50%.

14.9 Assessment of Significance

Mitigation Measures Adopted as Part of the Project

14.9.1 Incorporated into the foundation installation methodology is a "soft start" procedure for piling activities, in accordance with JNCC mitigation guidance (JNCC, 2010). This involves ramping up of hammer energy over a period of time until full power is achieved. This process is expected to act as a "warning" to marine mammals, allowing them time to leave the area prior to the hammer achieving full power and therefore reduce the risk of injury. This process has been incorporated into the noise modelling process presented within this assessment, full details of which can be found in ES Chapter 11 'Offshore Noise'.

Construction Phase

14.9.2 The impacts of construction during the Project have been assessed on marine mammals in the offshore study area. The environmental effects arising from the construction of the Project are listed in Table 14.6 above along with the Design Envelope criteria against which each construction phase impact has been assessed.

14.9.3 A description of the potential changes on marine mammals receptors caused by each identified impact is given below. In general however, the environmental effects arising from the construction of the Project are temporary, as they only occur during the construction phase and encompass the effects associated with turbine foundation and cable installation.

Collision Risk associated with Increased Vessel Movement

14.9.4 Ship strikes are known to be a cause of mortality for marine mammals (Pace *et al.*, 2006; Laist *et al.*, 2001) however the extent of mortality due to ship strikes is likely to be under-recorded (David, 2006). A review of studies on stranded carcases reported that ship strikes accounted for between 12 and 47% of the deaths reported (Carter, 2007).

14.9.5 The number and severity of strikes is likely to be influenced by vessel type, speed and the underwater noise environment. Vessels travelling at a speed of 14 knots or over appear to cause the most severe injuries, with sick or juvenile animals being the most vulnerable (Laist *et al.*, 2001). Some behaviour (i.e. social interaction or foraging) may increase the risk of collision by reducing an animal's perception of risk (IWC, 2006).

14.9.6 A number of behavioural responses to vessel traffic have been reported in marine mammal species including avoidance, displacement and changes in vocalisation. Whales however, may become habituated to vessel noise (Richardson *et al.*, 1985; Terhune and Verboom, 1999; Laist *et al.*, 2001; Norwack *et al.*, 2004), only responding once the vessel is very close. Experiments using alerting devices found right whales responded strongly but the nature of the response (swimming towards the vessel or remaining at the surface) had the potential to put the animals at an increased risk from ship strikes (Norwack *et al.*, 2004).

14.9.7 The precise nature of the vessels to be used during construction of the Project is still to be determined. Options being considered include jack-up platforms, barges, dredgers, cable laying vessels and tugs.

14.9.8 During construction there will be an increased level of vessel activity within the Project and along the export cable route which will be associated with the temporary construction activity. For example, installation of the substation would last approximately one month and use one heavy lift vessel with a large anchor spread (radius up to 1.2 km) and two to three tugs, one transport barge (30 x 100 m), a mammal observer boat and crew vessels. The small vessels

will be more active, approximately five trips per day, and will require a local base (e.g. Liverpool or Mostyn). The tugs, heavy lift vessel and barge will not be as active and may come from further afield (e.g. Belfast or Barrow).

14.9.9 Installation vessel for turbines and foundations are predicted to travel at a speed of approximately 10 knots and use relatively regular transit routes from port to site.

Likely environmental effects

14.9.10 Vessel traffic associated with the construction of the wind farm will use defined commuting corridors that will, where possible, maintain maximum distance from known seal haul-outs and low speeds.

14.9.11 Vessel traffic associated with construction of the wind farm will therefore be slow moving and predictable and pose little risk to marine mammals that are already used to a high level of vessel movement. Impacts associated with vessel traffic are considered to be direct and intermittent.

14.9.12 All marine mammal species likely to be encountered are of **very high** sensitivity. The impact of increased vessel movement on marine mammals is considered to be negative, intermittent, short in duration and **negligible** magnitude and therefore of overall **slight** (adverse) significance, which is not significant in EIA terms.

Further mitigation and future monitoring

14.9.13 No mitigation required.

Corkscrew Injury from Ducted Propellers

14.9.14 Ducted propellers are propellers with non-rotating nozzles which are encircled by a duct or passageway. Their use is prevalent in the shipping industry and they have been in use since 1931.

14.9.15 Recently, concern has been raised by Statutory Nature Conservation Bodies (SNCBs) about the potential impacts on seals from vessels with ducted propellers in particular those using their thrusters for dynamic positioning. Since 2008, a number of carcasses have been found with a characteristic single smooth edge spiral cut down the length of the body on beaches in south-eastern Scotland, the north Norfolk coast (England) and around Strangford Lough (Northern Ireland; Thompson *et al.*, 2010). In all cases examined, the wound was fatal. Injuries were consistent with the animals being pulled through a ducted propeller common to a wide range of vessels including tugs, self-propelled barges, rigs, offshore support vessels and research boats. Seals with similar injuries have been reported in Canada for at least 15 years (Thompson *et al.*, 2010).

14.9.16 The precise nature of the vessels to be used during construction of the Project is still to be determined. Options being considered include jack-up platforms, barges, dredgers, cable laying vessels and tugs. A likely worst case scenario for this impact assessment would be that a number of vessels would be commuting between the site and the shore on a daily basis.

14.9.17 It is highly likely that a number of vessels used in construction and operation of the wind farm will have and utilise ducted propellers.

Likely environmental effects

14.9.18 Vessel traffic associated with the construction of the wind farm will use defined commuting corridors that will, where possible, maintain maximum distance from known seal haul-outs and low speeds.

14.9.19 Vessel traffic associated with construction of the wind farm will therefore be slow moving and predictable and therefore pose little risk to marine mammals that are already used to a high level of vessel movement.

14.9.20 It can be assumed that a large proportion of the Project construction and support vessels will be equipped with ducted propellers, and will utilise these propellers for propulsion and dynamic positioning. The potential for seals to be at risk of corkscrew injury due to the use of ducted propellers for dynamic positioning has been raised by regulators as a primary concern.

14.9.21 Based on previous stranding data (Thompson *et al.*, 2010), seals, particularly breeding females, are considered to be at greatest risk from ducted propellers. However, there is uncertainty over the precise nature of the risk to seals. As the proposed development is out with the range of concern from any SAC for which grey or harbour seal are a notified interest (SNCB Internal Advice – Guidance for staff advising on the potential risk of seal corkscrew injuries April 2012), the potential for seals to be at risk of corkscrew injury is considered to be low.

14.9.22 All pinniped species likely to be encountered are of **very high** sensitivity. Considering the uncertainty of the potential for injury, and the small additional incremental risk when considered in the context of wider regional activities (in particular piling), the impact of ducted propellers is considered to be direct, short in duration, intermittent and of **negligible** magnitude and therefore of overall **slight** (adverse) significance, which is not significant in EIA terms.

Further mitigation and future monitoring

14.9.23 No mitigation required.

Increased noise associated with Vessel Movement

14.9.24 Construction of an offshore wind farm will involve an increase in shipping traffic for the transportation of materials and installation activities. The frequency and sound levels produced will depend on ship size and speed, and the potential impact to differing marine mammal species will be dependent upon transport routes taken. Potential construction ports are thought to include Belfast, Liverpool, Mostyn and Barrow. Vessels coming out of Belfast have been identified as the likely maximum adverse scenario therefore this has been assessed.

14.9.25 Coastal species such as bottlenose dolphins have been shown to use (Sini *et al.*, 2005) and avoid (Polacheck and Thorpe, 1990; Bristow, 2004) areas with a high frequency of boat traffic. Their response to boats vary according to boat size, activity and speed (Sini *et al.*, 2005). Harbour porpoise responses include vessel avoidance (Palka and Hammond, 2001) and increased dive times. It is possible therefore, that marine mammals have the potential to be excluded from important supporting habitat, although acclimatisation to boat presence and noise has been observed in some species (Koschinski and Culik, 1997; Richardson *et al.*, 1995; Laist *et al.*, 2001; Sini *et al.*, 2005 (bottlenose dolphins); Leung and Leung, 2003).

14.9.26 SPEAR modelling was undertaken as part of the noise assessment on a number of activities associated with construction including vessel noise (see ES Chapter 11 'Offshore Noise' and associated ES Annex '5.1.5.11.1'). The model outputs for harbour porpoise and harbour seal are been presented using the dB_{ht} species metric (Nedwell *et al.*, 2007) and summarised in Table

14.11 below (see also Figure 14.4 and Figure 14.5). 90 dB_{ht} is the level at which the perceived noise level is deemed 'unbearably loud' and will therefore elicit strong avoidance behaviour.

Table 14.11: Summary of the dB_{ht} (species) impact ranges predicted for vessel noise.

	90 dB_{ht}		75 dB_{ht}	
	Impact range (m)	**Area of affected sea (km^2/hour)**	**Impact range (m)**	**Area of affected sea (km^2/hour)**
Harbour porpoise	22	<1	200	3
Harbour seal	<1	<1	11	<1

Likely environmental effects

14.9.27 All marine mammal species likely to be encountered are of **very high** sensitivity. Impacts associated with vessel traffic are considered to be direct and intermittent. The range at which vessel noise will elicit a strong behavioural response in either harbour porpoise or harbour seal is 22 m and less than 1 m respectively (from the vessel). Given these small ranges and the movement constraints discussed above, the impact of increased noise due to vessel movement on marine mammals is considered to be negative, short in duration and **negligible** magnitude and therefore of overall **slight** (adverse) significance, which is not significant in EIA terms.

Further mitigation and future monitoring

14.9.28 No mitigation required.

Increased noise associated with Trenching/cable laying

14.9.29 The laying of cables, including trenching and rock armouring for example, can cause an increase in anthropogenic noise through a combination of engine noise and the action of trenching/rock armouring which may have the potential to affect marine mammal species.

14.9.30 The general impacts of engine noise are discussed above. There is presently no publicly available information on marine mammal responses to trenching and cable burying. The impacts in vessel noise are discussed above. Trenching/cable laying was also included in SPEAR modelling conducted by Subacoustech Environmental Ltd (see ES Chapter 11 'Offshore Noise' and ES Annex '5.1.5.11.1') the results of this are presented in Table 14.12 below.

Table 14.12: Summary of the dB_{ht} (species) impact ranges predicted for trenching, cable laying and rock.

Cable laying	90 dB_{ht}		75 dB_{ht}	
	Impact range (m)	Area of affected sea (km^2/hour)	Impact range (m)	Area of affected sea (km^2/hour)
Harbour porpoise	29	<1	220	4
Harbour Seal (same as Grey Seal response)	2	<1	29	<1

Rock dumping	90 dB_{ht}		75 dB_{ht}	
	Impact range (m)	Area of affected sea (km^2/hour)	Impact range (m)	Area of affected sea (km^2/hour)
Harbour porpoise	99	1	550	23
Harbour Seal (same as Grey Seal response)	17	<1	99	1

Rock dumping	90 dB_{ht}		75 dB_{ht}	
	Impact range (m)	Area of affected sea (km^2/hour)	Impact range (m)	Area of affected sea (km^2/hour)
Harbour porpoise	140	1	640	31
Harbour Seal (same as Grey Seal response)	12	<1	87	1

Likely environmental effects

14.9.31 Taken in isolation, the laying of cables is predicted to produce a strong behavioural response up to 140 m from the source, with impact ranges for harbour porpoise being greater than those predicted for harbour seal and trenching having the greatest range.

14.9.32 The laying of cables is likely to take place at the same time as construction of the offshore wind farm, which includes piling. Piling is widely accepted as being the major source of anthropogenic noise associated with the construction of an offshore wind farm, therefore it is predicted that any impacts from cable laying/trenching will be indistinguishable from those for piling, should the activities occur concurrently.

14.9.33 Marine mammal species likely to be encountered are of **very high** sensitivity. Impacts associated with cable laying are considered to be direct and intermittent. The predicted impact of trenching/cable laying on marine mammals is therefore considered to be probable, of short duration and range, reversible in nature and of **negligible** magnitude. Therefore overall significance of cable laying in marine mammals is considered to be **slight** (adverse), which is not significant in EIA terms.

Further mitigation and future monitoring

14.9.34 No mitigation required.

Increased Noise from Piling

14.9.35 The piling process involves driving piles into the sea bed using an impulse pile driving technique for several hours at a time. The level of noise produced is related to the blow energies required to pile the foundation, with the required blow energy dependent upon various factors including pile design and diameter, seabed characteristics and water depth (Diederichs *et al.*, 2008). The propagation of noise produced through the water column is also dependent on a number of factors including the depth of the water, suspended sediment load etc. The piling process, as currently proposed in the Project Design Statement, is likely to produce noise levels which have the potential to impact marine mammals within the vicinity of the pile location (Richardson *et al.*, 1985).

14.9.36 Marine mammals have very good underwater hearing and as a consequence are sensitive to increased underwater noise (Koschinski *et al.*, 2003; Thomsen *et al.*, 2006; Madsen *et al.*, 2006). Cetaceans rely heavily on sound to feed, navigate and to interact socially. Sound travels much further underwater than in air, resulting in anthropogenic noise potentially affecting marine mammals at relatively large distances from the source.

14.9.37 Reported responses by marine mammals to anthropogenic noise (Weilgart, 2007) include:

- Changes in foraging/diving behaviour, swim speed, respiration or vocalisation, stress;
- Displacement/avoidance;
- Hearing damage (temporary and permanent); and
- Stranding/death.

14.9.38 Some of these responses can be subtle and difficult to detect, and there are many documented cases of apparent tolerance to anthropogenic noise (Richardson *et al.*, 1985; Richardson *et al.*, 1999; Madsen *et al.*, 2002; Croll *et al.*, 2001). Although the consequences of the more direct impacts (such as mortality) are relatively clear, it is more difficult to assess the biological consequences of behavioural responses and auditory injury. Nevertheless, these impacts have the potential to lead to higher energetic demands on the individual, higher predation risk, and decreased reproduction, potentially impacting both the individual and the population as a whole.

14.9.39 Research on harbour porpoises and harbour seals carried out in Germany (Thomsen *et al.*, 2006) suggests individuals may respond to piling noise up to 20 km away, with the potential for masking of communication signals occurring well beyond 80 km. Similar predictions have been reported by a number of other studies in the North and Baltic Seas (Tougaard *et al.*, 2003; Tougaard *et al.*, 2005; Madsen *et al.*, 2006; Tougaard *et al.*, 2009). Animals close to the source of a high level of noise may also be physically injured (Thomsen *et al.*, 2006; Madsen *et al.*, 2006).

14.9.40 For the purposes of this section, noise modelling has been carried out by Subacoustech Environmental Ltd to predict the exposure of marine mammals to piling noise and reported in both metrics, dB_{ht} and SEL.

14.9.41 Table 14.13 describes the criteria which have been used to describe the levels of noise likely to cause physical and behavioural effects in marine mammals. The predicted SELs were modelled assuming a level of noise exposure produced within a 24 hour period, and represent the SEL which has the potential to cause the onset of PTS in the species considered (see ES Chapter 11 'Offshore Noise' for more details).

Table 14.13: Simple definition of metrics used in noise propagation modelling (Hughes et al., 2012)

Metric	Definition
M-weighted SEL	Sound is frequency weighted for four functional groups of marine mammals (high, mid and low frequency cetaceans and pinnipeds) by effectively removing frequencies outside the hearing ranges of each group (Southall *et al.*, 2007).
dB_{ht}	Developed as a means for quantifying the likelihood of behavioural impacts of a sound on a particular species. It takes into account species differences in hearing sensitivity at different frequencies (Nedwell *et al.*, 2007).

14.9.42 Noise modelling (using the Impulse Noise Sound Propagation and Impact Range Estimator, INSPIRE, model) was carried out for worst case locations for marine mammals. The position of the pile used varied between species groups/species and is shown in Table 14.14 below along with an explanation as to why this pile position was used.

Table 14.14: Worst case modelling locations for the different marine mammal species groups/ species (8 m diameter piles were used throughout)

Species group/ species	Pile position used	Reason
Pinnipeds/seals	Northwest (53.5008°N, 3.3697°W)	Contours from all 3 pile positions encompassed the main grey seal haul-out site (Hilbre Island; Figure 14.1). Contours from the northwest position are most similar to the area where grey seals are likely to occur when they are at sea (Figure 14.2). The northwest position also provides the biggest contours which, because a point estimate rather than a density surface has been used, represent the worst case.
Low frequency cetacean	Northwest (53.5008°N, 3.3697°W)	Low frequency cetaceans are more likely to be found offshore rather than close to the coast.
Mid frequency cetacean/ bottlenose dolphin	Southwest (53.4652°N, 3.3049°W)	Bottlenose dolphins have a coastal distribution and are more likely to be present to the west than the east of the site.
High frequency cetacean/ harbour porpoise	Northwest (53.5008°N, 3.3697°W)	The northwest position gives the largest contours (mainly due to water depth) and thus represents the worst case.

14.9.43 The full noise modelling report is presented in the ES Annex '5.1.5.11.1'.

14.9.44 The approach to assessing impacts from piling that has been followed in this impact assessment is set out below:

- Phase 1: Predicted noise propagation from piling modelled using the INSPIRE model. This model was used to predict received noise levels dB_{ht} (species) in Liverpool Bay. As there are differences in biological impacts predicted by dB_{ht} and M-weighted SEL thresholds, two sets of contours were modelled for each species – dB_{ht} and M-weighted SEL. The dB_{ht} contours were generated at 75 and 90 dB_{ht}. The SELs were generated for 198 dB for cetacean species and 186 for pinnipeds based on the Southall *et al.* (2007) criteria.
- Phase 2: Numbers of animals that could receive PTS or elicit behavioural responses at 90 or 75 dB_{ht} have been calculated from density estimates presented in the baseline section of this assessment (see ES Annex '5.1.5.11.1') and received dose contours from the INSPIRE modelling.

14.9.45 The predicted SELs are modelled assuming a level of noise produced within a 24 hour period. As such, installation of one, two or more piles in a 24 hour window will impact the SEL and therefore the PTS predictions.

14.9.46 This assessment has focussed on increased levels of anthropogenic noise due to piling, the main impact on marine mammal species during construction (Figure 14.4). During

periods when no piling is occurring, animals may react to other sources of anthropogenic noise should they be occurring.

Lethal and physical injury - All marine mammals

14.9.47 The ranges provided in Table 14.15 below give details of the predicted distances for lethal effects (240 dB) and physical injury (220 dB) for all marine mammals, assuming an animal fleeing speed of 1.5 m/s.

14.9.48 All marine mammals are predicted to have the potential to experience lethal effects up to 4 m from piling, and physical injury up to 80 m from piling, using the maximum adverse scenario (8 m diameter pile and either the southwest or the northwest pile position) scenario.

Likely environmental effects

14.9.49 Marine mammal species likely to be encountered are of very high sensitivity. Impacts associated with piling are considered to be direct, intermittent and occurring in the medium term. On the individual animal, should they be affected the magnitude of impact is considered to be major and the significance is deemed very large (adverse) and significant in EIA terms. However, at the population level, given the predicted range within which impact may occur and the very small number of individuals this may affect, the overall magnitude is considered to be negligible. A detailed mitigation protocol will be developed in consultation with the advisory bodies prior to construction commencing, taking into account best practices at that time. Present recommendations (JNCC, 2010) include the presence of a marine mammal observer implementing a standard marine mammal observation protocol during piling activities, coupled with a ramp up of piling energy which should allow all marine mammal species to move out with the range of lethal or physical injury. Therefore the likelihood of marine mammals experiencing lethal effects or physical injury at the population level is deemed of slight (adverse) significance, which is not significant in EIA terms.

Table 14.15: Ranges at which lethal effects and physical injury are predicted for an 8 m pile installed at either the SW or NW position

Unweighted (all marine mammals)	Lethal effects (240 dB)	Physical injury (220 dB)
Range (m)	4	80

Auditory injury and behavioural response - Pinnipeds

14.9.50 An averaged generic audiogram using data from three pinniped species (harbour, grey and harp seal) was used for the dB_{ht} (species) modelling to provide an indication of the impact ranges for seals during impact piling at the Project. Because these data are fairly generic, having been constructed from several seal audiograms, results may be expected to be appropriate for grey and harbour seals (Hughes *et al.*, 2012).

Auditory injury

14.9.51 Using the M-weighted SEL criteria of 186 dB, seals are predicted to have the potential to experience the onset of PTS up to 20 km from the piling event under the maximum adverse scenario (8 m diameter pile, northwest pile position) (Table 14.16; Figure 14.6). The 186 dB criteria have been used for pinnipeds (as opposed to the 198 dB criteria which have been used

for cetaceans) because (1) although likely to be overly conservative, current evidence suggests that they are more appropriate for seals than the 198 dB criteria and (2) the 186 dB criteria has been accepted by the regulatory community on other developments and is considered current industry best practise. It is acknowledged that this is likely to result in an overestimate, and that the most appropriate value for pinnipeds lies somewhere between 186 and 198 dB.

Table 14.16: Ranges at, and areas over, which onset of auditory injury (PTS) is predicted to occur in pinnipeds using the M-weighted SEL criteria of 186 dB (8 m pile)

Pinnipeds – SEL (186 dB)	NW pile position
Min range (km)	7
Max range (km)	20
Mean range (km)	12
Area (km^2)	490

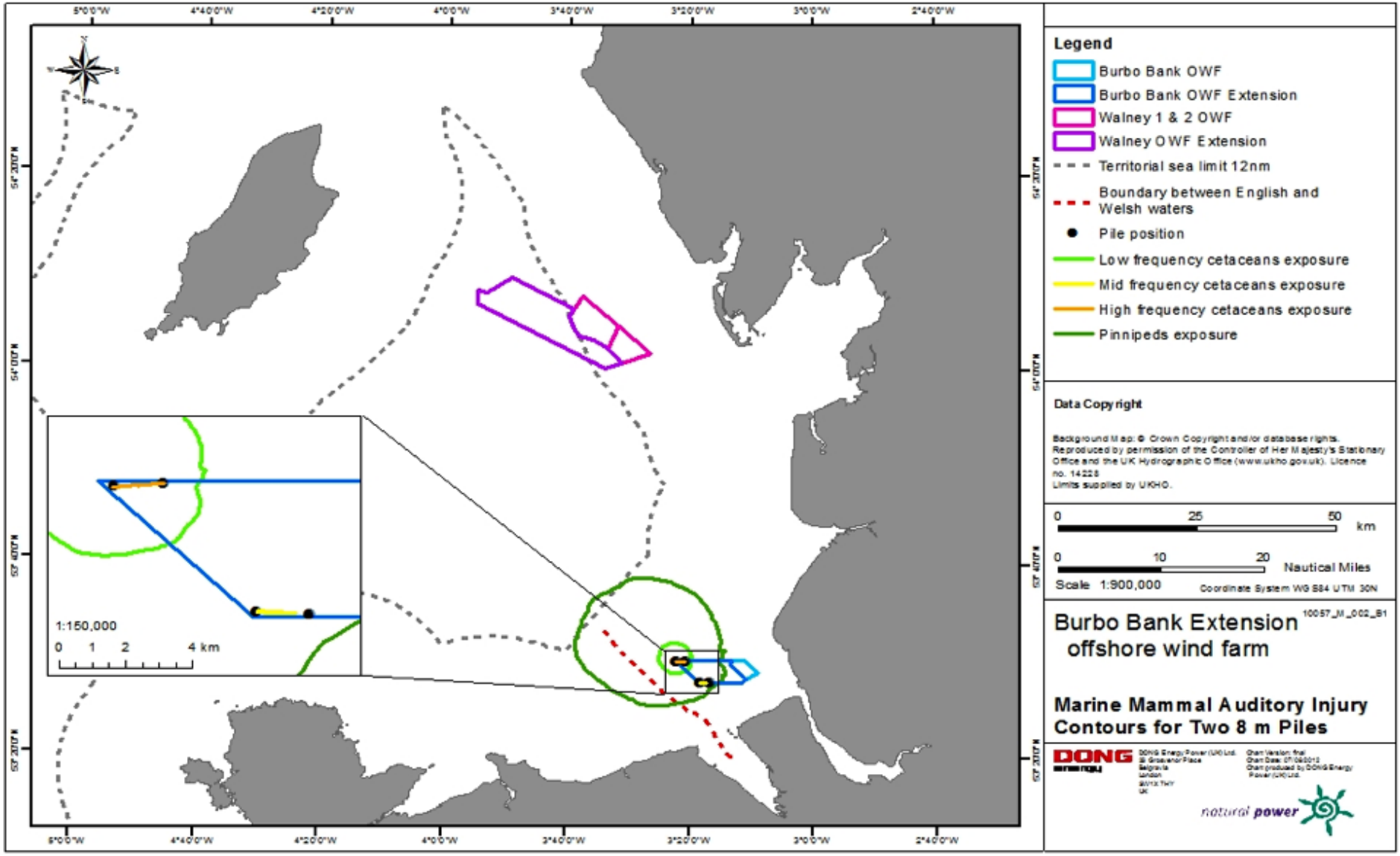

Figure 14.6: Marine mammal auditory injury contours

Behavioural response

14.9.52 Grey seals are predicted to display strong (90 dB_{ht}) behavioural avoidance up to 13 km from the piling event, and mild (75 dB_{ht}) behavioural avoidance up to 34 km from the piling event, under the maximum adverse scenario (8 m diameter pile, northwest pile position) scenario (Table 14.17; Figure 14.7). The maximum distance from the piling event for strong behavioural avoidance (13 km; Table 14.17; Figure 14.7) is smaller than the maximum distance from the piling event for PTS (20 km; Table 14.16; Figure 14.6). This is because the dB_{ht} criteria (behavioural impact) is based on an event occurring at a single point in time while SEL (auditory injury impact) is based on sound exposure levels over time (24 hour period) and therefore a multiple pulse scenario.

Table 14.17: Ranges at, and areas over, which strong (90 dB_{ht}) and mild (75 dB_{ht}) behavioural responses are predicted in grey seals (8 m diameter pile, NW position)

Grey seal – behaviour	90 dB_{ht}	75 dB_{ht}
Min range (km)	9.5	15
Max range (km)	13	34
Mean range (km)	10	19
Area (km^2)	390	1900

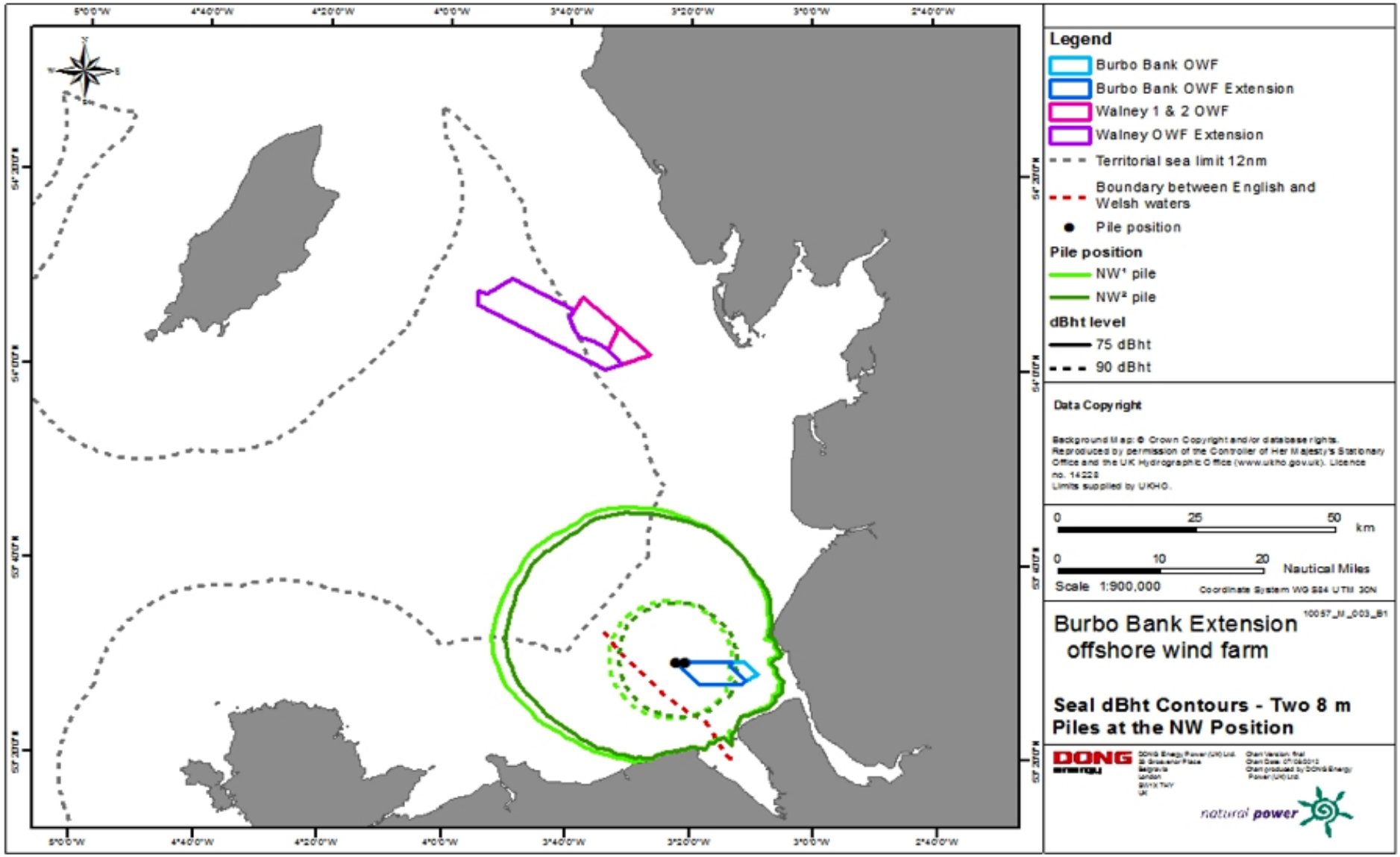

Figure 14.7: Seal behavioural impact contours

Likely environmental effects

14.9.53 Although the ranges over which seals are predicted to have the potential to experience the onset of PTS are large (Table 14.16; Figure 14.6), the number of grey seals predicted to experience the onset of PTS is low (36-41 individuals; Table 14.18) due to the relatively low density of grey seals in the Irish Sea (Table 14.5). When expressed as a percentage of the total Irish Sea population of 5,613 grey seals (Kiely *et al*., 2000), the number of grey seals predicted to experience the onset of PTS represents less than 1% of the total Irish Sea population (Table 14.18).

14.9.54 The number of grey seals predicted to display behavioural avoidance has also been presented in Table 14.18. While the number predicted to display mild behavioural avoidance (75 dB_{ht}; 141-160 individuals) is larger than the number predicted to experience the onset of PTS, the percentage of the Irish Sea population affected (3%) remains low (Table 14.18).

14.9.55 When the predicted seal behavioural impact contours (Figure 14.7) are compared with the estimated at-sea usage of Liverpool Bay by grey seals, there is some overlap, particularly in south east Liverpool Bay. Although displacement is likely to occur from this area of foraging habitat during periods of piling activity, it is unlikely to have impacts on the viability of the population due to the short time periods, and relatively small numbers of animals, involved. Animals hauled out (for example at Hilbre Island) will not be affected as only animals in the water will experience impacts from underwater noise. Animals foraging, as discussed above, will therefore be the main consideration.

14.9.56 Marine mammal species likely to be encountered are **very high** sensitivity. Impacts associated with piling are considered to be direct and intermittent. The prediction of impact on grey seals with regard to both PTS and behavioural displacement is therefore considered to be likely for the duration of piling activity (i.e. medium term), of **minor** magnitude (based on an estimate of less than 10% of the population being effected), and therefore of **moderate** (adverse) significance, which is significant in EIA terms.

Table 14.18: Number of grey seals predicted to experience the onset of PTS and behavioural effects calculated using the proportion of the Kiely et al. (2000) abundance estimate for grey seals in the Irish Sea that will be in the water divided by the surface area of the Irish Sea (which gives a density estimate of 0.074-0.084 grey seals per km^2). These numbers have also been expressed as percentages of the Kiely et al. (2000) abundance estimate for the Irish Sea of 5613

Grey seal	PTS (186 dB)	Behaviour	
		90 dB_{ht}	75 dB_{ht}
Number of animals	36-41	29-33	141-160
% of Irish Sea abundance	< 1%	< 1%	3%

Auditory injury and behavioural response - Cetaceans

Auditory injury

14.9.57 Using the M-weighted SEL criteria of 198 dB, low frequency cetaceans (e.g. minke whales) are predicted to have the potential to experience the onset of PTS up to 4.3 km from the piling event under the maximum adverse scenario (8 m diameter pile, northwest pile position; Table 14.19; Figure 14.6). Both mid and high frequency cetaceans would need to be within 1 km of the piling event in order to have the potential to experience the onset of PTS (Table 14.19; Figure 14.6).

Table 14.19: Ranges at, and areas over, which onset of auditory injury (PTS) is predicted in low, mid and high frequency cetaceans using the M-weighted SEL criteria of 198 dB (8 m diameter pile)

Species group	Low Frequency Cetacean e.g. minke whale	Mid Frequency Cetacean e.g. bottlenose dolphin	High Frequency Cetacean e.g. harbour porpoise
Pile position	**Northwest**	**Southwest**	**Northwest**
Min range (km)	1.7	0.01	0.01
Max range (km)	4.3	0.77	0.76
Mean range (km)	2.8	0.032	0.018
Area (km^2)	26	0.03	< 0.01

Behavioural response

14.9.58 Table 14.20 and Table 14.21 below provide details of the ranges at, and areas over, which harbour porpoises and bottlenose dolphins, if they are within those ranges/areas from the piling event, have the potential to display behavioural avoidance. Figure 14.8 and Figure 14.9 show the behavioural impact contours for these species (harbour porpoise and bottlenose dolphin, respectively). The 90 dB_{ht} criteria were used for strong behavioural avoidance, and the dB_{ht} criteria for milder behavioural avoidance.

14.9.59 If harbour porpoises are within 18 km of the piling event they are likely to show strong behavioural responses. Milder behavioural responses are likely to be shown if porpoises are within 44 km of the piling event (Table 14.20; Figure 14.8).

14.9.60 The comparable distances from the piling event for bottlenose dolphins are 11 km (strong behavioural response) and 28 km (milder behavioural response; Table 14.21; Figure 14.9).

Table 14.20: Ranges at, and areas over, which strong (90 dB_{ht}) and mild (75 dB_{ht}) behavioural responses are predicted in harbour porpoises (8 m diameter pile, northwest position)

Harbour porpoise – behaviour	90 dB_{ht}	75 dB_{ht}
Min range (km)	13	16
Max range (km)	18	44
Mean range (km)	14	22
Area (km^2)	740	2900

Table 14.21: Ranges at, and areas over, which strong (90 dB_{ht}) and mild (75 dB_{ht}) behavioural responses are predicted in bottlenose dolphins (8 m diameter pile, southwest position)

Bottlenose dolphin – behaviour	90 dB_{ht}	75 dB_{ht}
Min range (km)	8	8.9
Max range (km)	11	28
Mean range (km)	9.7	19
Area (km^2)	300	1200

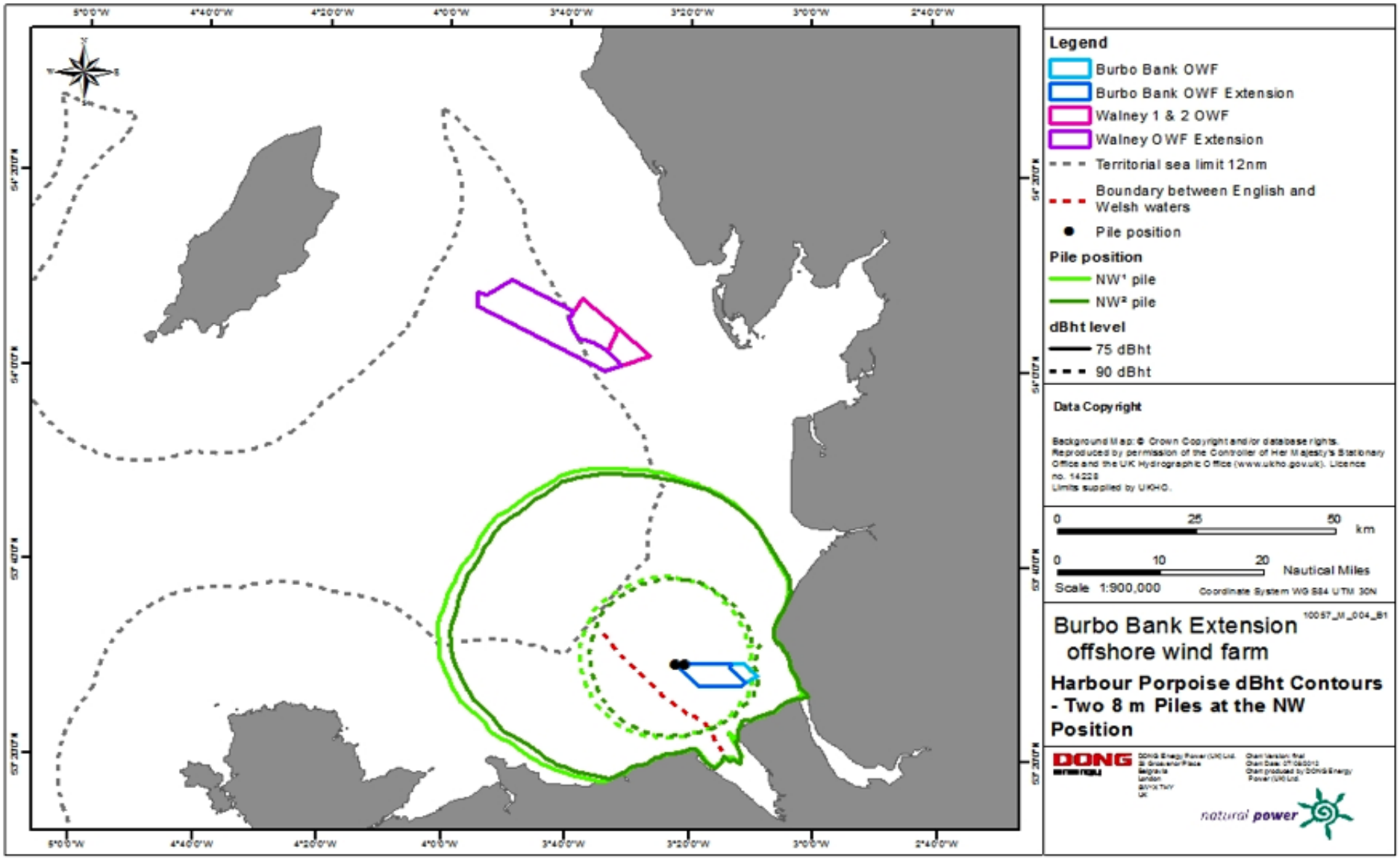

Figure 14.8: Harbour porpoise behavioural impact contours

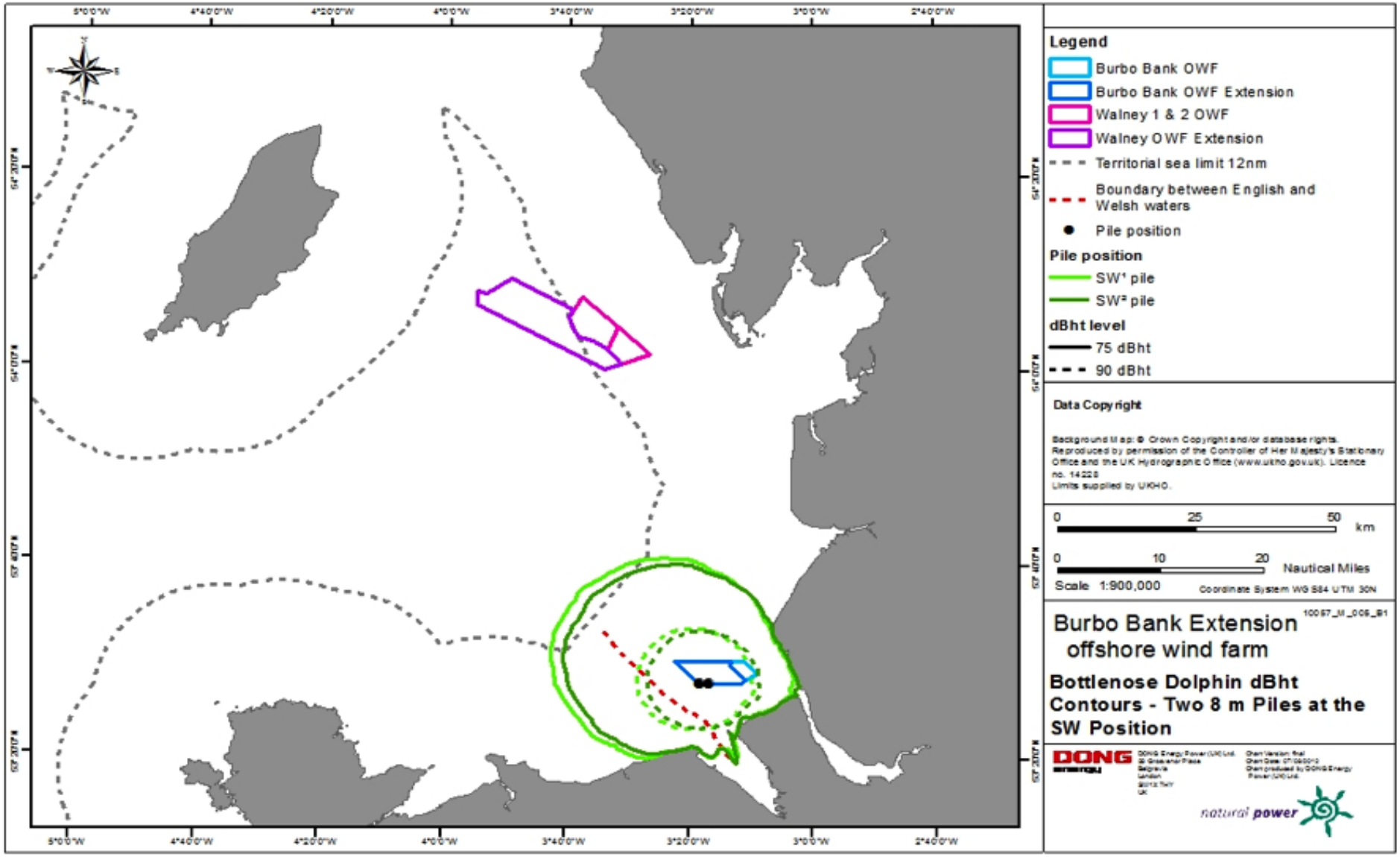

Figure 14.9: Bottlenose dolphin behavioural impact contours

14.9.61 The ranges from the piling event over which both harbour porpoises and bottlenose dolphins are predicted to have the potential to experience the onset of PTS are small (< 800 m in each case; Table 14.19; Figure 14.6). This, combined with the density estimates for each species, means that the numbers of animals predicted to experience the onset of PTS are also low (less than 1 individual of each species; Table 14.22 and Table 14.23).

14.9.62 When expressed as percentages of the respective SCANS II Block O (Irish Sea) abundance estimates, the numbers of both harbour porpoises and bottlenose dolphins predicted to experience the onset of PTS represents less than 1% in each case (Table 14.22 and Table 14.23).

14.9.63 The number of harbour porpoises predicted to display behavioural avoidance is also shown in Table 14.22. A larger number are predicted to display milder (972) than strong (248) behavioural avoidance. These numbers equate to 6 and 2% of the SCANS II Block O (Irish Sea) abundance estimate respectively.

14.9.64 One of the proposed installation methodologies (piling) is likely to have an impact on harbour porpoises in the Liverpool Bay area due to the large distances over which behavioural responses are predicted to occur (Figure 14.8) and the density of the animals themselves (Figure 14.3). However, while potential impacts may be significant during piling they are likely to be reversible in nature (based on information from other areas) and thus not significant in the long term i.e. impacts will be solely for the duration of piling operations.

14.9.65 Marine mammal species likely to be encountered are very high sensitivity. Impacts associated with piling are considered to be direct and intermittent. The prediction of impact on harbour porpoises with regard to both PTS and behavioural displacement is therefore considered to be likely, of minor to moderate magnitude (see Table 14.22 below) and moderate significance in EIA terms for the duration of piling activity.

14.9.66 The number of bottlenose dolphins predicted to display behavioural avoidance is shown in Table 14.23. A larger number are predicted to display milder (6) than strong (2) behavioural avoidance. These numbers equate to 3 and < 1% of the SCANS II Block O (Irish Sea) abundance estimate respectively.

14.9.67 The proposed installation methodology (piling) is likely to have a negligible impact on the bottlenose dolphin population which uses the Liverpool Bay area because, although resident off the west coast of Wales, bottlenose dolphin density in Liverpool Bay is very low. Any behavioural response impacts during piling are likely to be reversible in nature.

14.9.68 Marine mammal species likely to be encountered are **very high** sensitivity. Impacts associated with piling are considered to be direct and intermittent. The prediction of impact on bottlenose dolphins is therefore considered to be medium term, of **minor** magnitude (see Table 14.28 below) and therefore of **moderate** (adverse) significance, which is significant in EIA terms for the duration of piling activity (see discussion below regarding long-term impacts).

Table 14.22: Number of harbour porpoises predicted to experience the onset of PTS and behavioural effects calculated using the SCANS II density estimate for the Irish Sea (Block O) of 0.335. These numbers have also been expressed as percentages of the SCANS II abundance estimate for the Irish Sea (Block O) of 15230

Harbour porpoise	PTS (186 dB)	Behaviour	
		90 dB_{ht}	75 dB_{ht}
Number of animals	< 1	248	972
% of SCANS II abundance	< 1%	2%	6%

Table 14.23: Number of bottlenose dolphins predicted to experience the onset of PTS and behavioural effects calculated using the SCANS II density estimate for the Irish Sea (Block O) of 0.0052. These numbers have also been expressed as percentages of the SCANS II abundance estimate for the Irish Sea (Block O) of 235

Bottlenose dolphin	PTS (186 dB)	Behaviour	
		90 dB_{ht}	75 dB_{ht}
Number of animals	< 1	2	6
% of SCANS II abundance	< 1%	< 1%	3%

Further mitigation and future monitoring

14.9.69 Mitigation measures incorporated into the Project design are discussed in Section 14.8.1. This will be reviewed prior to construction commencing once the construction program has been finalised and in line with best practice at the time.

Impacts from piling in context of long-term population viability

14.9.70 Under the Habitats Directive, there is a requirement to assess the Favourable Conservation Status (FCS) of protected species and, in doing so, consider whether populations are maintaining themselves in the "long-term" (Annex II, EU 2010), i.e. do data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable element of its habitats?

14.9.71 As a result, it is important to place impacts such as those associated with piling in the context of the long-term viability of the population, in other words, what happens once the piling has stopped. When considering this in the context of potential impacts from piling, Thompson *et al.*, (2012) have suggested a period of 25 years as being appropriate when considering the long-term viability of long-lived species such as marine mammals.

14.9.72 The length of time required to install foundations for the Project will depend on a number of factors including foundation type (i.e. gravity base, mono-pile or jacket pin-piles), number of installation vessels operating at the same time, and the weather. Assuming the maximum adverse scenario of 276 pins for 69 jacket foundations, and assuming 2 pins are piled

per day (not the maximum number of piling events in a 24 hour period which equates to 6 pins per day) this would require 138 days to install all the foundations, not accounting for down time. When taken in the context of a 25 year life span, the duration of this potential impact is short i.e. one breeding season.

14.9.73 Current research from constructed wind farms suggest that marine mammals are primarily impacted whilst construction (in particular piling) is occurring, with little negative effects observed once the wind farms are operational. For example, the seal population at Rødsand, the haul-out site near Nysted wind farm, increased during the operational years 2004 and 2005 (Teilmann *et al.*, 2006), although it is unclear whether this was related to the presence of the wind farm. Harbour seals have also been observed within Horns Rev wind farm with no evidence of avoidance or changes in dive behaviour (Tougaard *et al.*, 2006).

14.9.74 An increase in harbour porpoises within and around the Egmond aan Zee wind farm (Holland) during the first two years of operation was observed. Although a general increase has been observed in Dutch waters during the last decade (Hammond *et al.*, 2002; SCANS II, 2008; Scheidat *et al.*, 2011), the increase within the wind farm was more pronounced compared to reference areas. The reasons for this are again unclear, with two possible causes (increased food availability inside the wind farm (reef effect) and/or the absence of vessels in an otherwise heavily trafficked part of the North Sea (sheltering effect) being examined (Scheidat *et al.*, 2011).

14.9.75 Taking into account the short period of time during which piling will occur (less than one year) in the context of the life span of the species in question, magnitude of impacts of piling activities on marine mammals, is considered to be no change and therefore of neutral significance, which is not significant in EIA terms.

Operational and Maintenance Phase

14.9.76 The impacts of the operation and maintenance of the Project have been assessed on marine mammals in the offshore study area. The environmental effects arising from the operation and maintenance of Project are listed in Table 14.6 along with the Design Envelope criteria against which each operation and maintenance phase impact has been assessed.

14.9.77 A description of the potential changes on marine mammals receptors caused by each identified impact is given below.

Displacement or disturbance due to turbine operating noise

14.9.78 Offshore wind turbines, once operational, produce low frequency noise that pass into the water column. This noise, which is only expected to exceed ambient levels at very low frequencies, has the potential to impact wildlife including marine mammals.

14.9.79 Noise from turbines may affect marine mammal behaviour but will not cause hearing damage (Betke *et al.*, 2004; Koschinski *et al.*, 2003; Tougaard *et al.*, 2009). Responses include avoidance and increased echolocation (Koschinski *et al.*, 2003) although avoidance by harbour porpoises was less than that observed during pinger experiments (Culik *et al.*, 2001). Harbour porpoises can appear cautious when confronted with a new stimulus (in this case the noise from the turbine foundation), exploring the sound source loss of prey species associated changes in habitat or abundance and distribution of prey with their sonar (Koschinski *et al.*, 2003). Masking of communication cues by turbine noise is thought to be insignificant for both harbour seals and harbour porpoises (Tougaard *et al.*, 2009). It is possible that these conclusions can be extended to bottlenose dolphins and grey seals as these species are known to be more robust than harbour seals and harbour porpoises.

14.9.80 Recordings at Barrow wind farm (eastern Irish Sea, Cumbria) indicated a marginal increase in low frequency noise compared to background from 3 MW turbines (Edwards *et al.*, 2007). The increase was distinguishable up to a distance of 600 m from the turbines. Marine mammals observed in the area included harbour seal, harbour porpoise and bottlenose dolphin. From measurements taken at 5 m from the turbines, it was concluded that operational noise was unlikely to cause a behavioural response. Unweighted noise measurements were of a sufficiently low level that direct physical injury (i.e. auditory damage, injury or death) was also considered unlikely.

14.9.81 Larger turbines have the potential to produce louder noise or peak energies at higher frequencies. Harbour porpoises have poor hearing capabilities within the noise frequency range produced by a 2 MW turbine, but a higher frequency noise may result in an increased response zone (Tougaard *et al.*, 2009).

Likely environmental effects

14.9.82 Evidence from existing wind farms suggests that physical injury or behavioural responses by marine mammals to turbine operating noise are unlikely. Marine mammals have been observed in close proximity to other fixed, noisy features such as drilling rigs and oil platforms.

14.9.83 It is expected that marine mammals will not suffer adversely from turbine operating noise. Behavioural reactions are likely to occur only in the immediate vicinity of the foundations. Harbour porpoises have relatively poor hearing in the frequency ranges previously recorded from offshore wind turbines (Tougaard *et al.*, 2009) and while seals have better hearing, they are more tolerant to underwater noise (Southall *et al.*, 2007).

14.9.84 Marine mammal species likely to be encountered are **very high** sensitivity. Impacts associated with turbine operating noise are considered to be direct and continuous. Although the impact of turbine operating noise is uncertain, given the information available to date, its impacts are predicted to be of very low impact and the magnitude of the impact is **no change**, only having the potential to affect marine mammals in very close proximity to the turbines. It is predicted that marine mammals will quickly habituate to the presence of turbines in the water, and that there will be sufficient distance between turbines to allow movement between foundations. The impact is therefore considered to be of **neutral** significance, which is not significant in EIA terms.

Further mitigation and future monitoring

14.9.85 None required.

Increased vessel use (collision)

14.9.86 Increase in local traffic associated with operation and maintenance of the Project has the potential to increase the risk of collision of marine mammals with vessels above that currently encountered within the Liverpool Bay area.

14.9.87 Maintenance programs are yet to be finalised but, depending on weather windows, the Applicant proposes to typically have six support vessels transiting between the shore and operational wind farm.

Likely environmental effects

14.9.88 It is considered unlikely that vessel use during the operational phase of the wind

farm for maintenance activities will significantly increase the number of vessels already utilising the Liverpool Bay area.

14.9.89 Vessel traffic associated with the operational phase of the wind farm will, when possible, use defined commuting corridors and maintain maximum distance from known seal haul-outs and low speeds (service vessels typically maintain a speed of 20 knots).

14.9.90 Vessel traffic associated with operation of the wind farm will therefore be predictable and pose little risk to marine mammals that are already used to a high level of vessel movement.

14.9.91 Marine mammal species likely to be encountered are **very highly** sensitive. Impacts associated with maintenance vessels are considered to be direct and intermittent. The impact of increased vessel traffic during operation of the offshore wind farm on marine mammals is considered to be probable, of short duration (i.e. only when vessel is present), reversible and **negligible** magnitude. The overall significance is therefore considered to be **slight** (adverse), which is not significant in EIA terms.

Further mitigation and future monitoring

14.9.92 None required.

Loss of prey species associated changes in habitat or abundance and distribution of prey

14.9.93 The physical presence of turbines has the potential to result in increased noise and habitat loss which could lead to changes (positive or negative) in marine mammal prey availability (secondary impact). This may in turn affect marine mammal at-sea usage/foraging distribution.

14.9.94 The installation of 69 x 3.6 MW turbines, using GBS foundations together with the use of scour protection (usually dumped rocks or concrete blocks, 15 m extent), will result in the maximum adverse scenario in terms of loss of habitat, resulting in a loss of seabed of 0.229 km^2 (0.0664 km^2 foundation only), equalling 0.57% (0.166% foundation only) of the total Project area (ES Chapter 12 'Subtidal and Intertidal Benthic Ecology'). Characterisation of noise produced by operating turbines is discussed in the preceding section (operating noise).

14.9.95 For the operational phase, loss of habitat and operational noise were both assessed as having a negative impact of negligible or minor significance for fish/shellfish and salmon/sea trout (ES Chapter 13 'Fish and Shellfish Ecology').

14.9.96 It is generally considered that offshore wind farms are unlikely to result in significant loss of habitat, although inappropriate positioning of developments may impact certain species (Inger *et al.*, 2009). Habitat loss will vary depending on the type and size of the installation, the location, whether it is situated in degraded or pristine habitat, and the stage of the life cycle of the installation (Inger *et al.*, 2009). Infrastructure on the seabed such as turbine foundations has the potential to act as an artificial reef (Linley *et al.*, 2007), thus increasing the amount of available habitat for some taxa (for example prey species of marine mammals). Man-made structures positioned on the sea bed attract many marine organisms and are often used to enhance fisheries and rehabilitate local habitat (Clark and Edwards, 1999; Jensen, 2002). The presence of such structures has the potential to create new habitat capable of supporting epibiota and fish, and has been shown to increase density and biomass of fish compared to surrounding areas (Bohnsack *et al.*, 1994; Wilhelmsson *et al.*, 1998; Wilhelmsson and Malm, 2008). Greater abundances of fish have been found in the vicinity of wind turbines compared to surrounding areas (Wilhelmsson *et al.*, 2006). Marine organisms can also be attracted to light sources that may be present on the structure (Marchesan *et al.*, 2006; Harewood and Horrocks, 2008).

Likely environmental effects

14.9.97 There are few data on marine mammal diet in the Liverpool Bay area. In other areas where diet has been assessed, sandeels have been found to make up a significant proportion of the diet of grey seals (using analysis of prey hard parts recovered from scats collected at haul-out sites) although many other fish species (particularly gadoids and flatfish) and cephalopods also contribute. Because they do not spend time ashore, cetacean diet is more difficult to assess and studies have often been based on the stomach contents of stranded animals (which may not be representative of the population). These data do, however, indicate that cetaceans consume a wide variety of fish species and cephalopods.

14.9.98 The current Project Design Envelope (see ES Chapter 6 'Project Description') includes single steel monopile, steel jacket and concrete gravity foundation installation technology. Piling is unlikely to cause substantial habitat loss. The dimensions of the gravity base foundation are likely to vary but this loss of habitat is not expected to be significant across the Project footprint for fish species (i.e. potential prey). Coupled with the fact that marine mammals have a varied diet and are highly mobile, no significant secondary impacts on any marine mammal populations are expected to result (neutral significance).

14.9.99 Marine mammal species likely to be encountered have a **very high** sensitivity to secondary impacts on prey species. The direct impacts of operational noise on fish species are discussed in ES Chapter 13 'Fish and Shellfish Ecology' and predicted to be of negligible significance. Impacts are considered to be indirect, continuous and of **negligible** magnitude. Given the assessment for prey species (fish) it is considered that the indirect impacts of operational noise on marine mammals is also considered to be of **slight** (adverse) significance, which is not significant in EIA terms.

Further mitigation and future monitoring

14.9.100 None required.

Change in marine mammal activity due to the presence of electromagnetic fields

14.9.101 Transmission of electricity through subsea cables can lead to the generation of electric and magnetic fields, both of which have been associated with the main feeder cables to shore from offshore wind farms (Gill *et al.*, 2009).

14.9.102 A large number of animals are thought able to detect geomagnetic fields, including cetacean species, with a number suspected to respond to magnetic fields (CMACS, 2005). A number of live cetacean standings have been linked to local geomagnetic anomalies (Kirschvink *et al.*, 1986), suggesting that cetaceans are capable of sensing geomagnetism and using these cues for navigation. There is no suggestion that seals are sensitive to magnetic fields.

14.9.103 An electric field is largely kept within the cable; therefore the assessment of significance is focussed around magnetic fields, which are not.

Likely environmental effects

14.9.104 There is no evidence to date suggesting a change (positive or negative) in marine mammal activity related to magnetic fields from cables associated with offshore wind farms. It is thought that magnetic fields from cables are likely to be detected by cetaceans as a new localised addition to a heterogeneous pattern of geomagnetic anomalies in the surrounding area (Basslink, 2001).

14.9.105 Where possible, cables associated with the offshore development area will be buried to a depth of 1 m. Evidence suggests that magnetic fields may only be detectable above

background levels in the immediate vicinity of the cable (up to 1m in fish), and will dissipate rapidly with distance from the cable.

14.9.106 Therefore, the impact of electromagnetic fields on marine mammals (both within the site and along the offshore export cable) is considered to be direct, long term, **low** magnitude and continuous. All marine mammal species likely to be encountered are of a **very high** sensitivity. The impact is of overall **slight** (adverse) significance, which is not significant in EIA terms.

Further mitigation and future monitoring

14.9.107 None required.

Changes in prey availability due to electromagnetic fields associated with offshore cabling

14.9.108 Changes in the distribution and abundance of fish species may occur in very close vicinity to offshore wind farm transmission cabling; this may result in the displacement of fish species during the operational phase of the wind farm. This has the potential to have indirect implications for foraging marine mammals.

Likely Environmental Effects

14.9.109 The greatest likely impact of EMF on marine mammals is on potential impacts on prey species. Electromagnetic effects on fish species will likely be limited to marine habitats in close vicinity to cabling corridors, therefore it is expected that although of a long-term nature, impacts will affect only a localised area and a very small proportion of available marine mammal prey species, with a negligible indirect impact on marine mammals.

14.9.110 Given the very small potential impact range predicted, the impact is considered to be indirect, long term, **low** magnitude and continuous. All marine mammal species likely to be encountered have a **very high** sensitivity. The impact is considered to be of **slight** (adverse) significance, which is not significant in EIA terms.

Further mitigation and future monitoring

14.9.111 None required.

Decommissioning Phase

14.9.112 The impacts of the decommissioning of the Project have been assessed on marine mammals in the offshore study area. The environmental effects arising from the decommissioning of the Project are listed in Table 14.6 along with the Design Envelope criteria against which each decommissioning phase impact has been assessed.

14.9.113 The decommissioning plan will be finalised prior to construction and will depend on the choice of turbine structure therefore a detailed assessment is not possible at this stage. The decommissioning of offshore wind farms may involve the use of cutting tools and/or other methodologies which have yet to be identified.

14.9.114 Current cutting techniques include mechanical and abrasive cutting. Both would generate noise near the turbine foundations. No data on noise levels produced by cutting mechanisms underwater are available at this time, but it would be expected that such noise would be at substantially lower levels than noise created during the construction phase. For the purpose of this preliminary assessment, based on limited available information, the sensitivity of the receptor is **very high**, the magnitude of impact is considered to be **negligible** with **slight** significance, which is considered not significant in EIA terms.

14.9.115 There may also be disturbance from vessels associated with decommissioning but, as with the construction phase, the associated impacts are considered to be of negligible magnitude.

Further mitigation and future monitoring

14.9.116 Will be determined once decommissioning plan finalised.

14.10 Cumulative Impact Assessment

14.10.1 The cumulative impacts of the Project have been assessed on marine mammal receptors in the offshore study area. Other projects taken into account as part of cumulative impact assessment are listed in Table 14.24 below. Further details of these projects are provided at ES Chapter 36 'In-combination and Cumulative Impacts'.

Table 14.24: List of other projects assessed for cumulative impact

Other projects considered as part of cumulative impact assessment
Burbo Bank OWF
North Hoyle OWF
Gwynt Mor OWF
Celtic Array OWF
Walney 1 & 2 OWF
Walney Extension OWF
Gwynt y Môr OWF
Douglas, Hamilton and Lennox O&G Platforms
Three gas pipelines owned by BHP
EirGrid subsea cable between Ireland and North Wales
Scottish Power HVDC western link
Emerald Express Cable
Existing aggregate licenses
Proposed aggregate licenses
Underground coal gasification project

14.10.2 A description of the potential changes on marine mammals receptors caused by each identified cumulative impact is given below. The primary cumulative impact on marine mammals during construction of the Project will be from piling from the Project itself or other

offshore projects that incorporate piling activities. The cumulative and interactive effects assessment has therefore focussed on piling with all other impacts discussed collectively.

Non-piling cumulative assessment

14.10.3 The cumulative and interactive effects of offshore activities other than piling, including other wind farm developments and planned and existing infrastructure, have been outlined descriptively in Table 14.25 below:

Table 14.25: Qualitative cumulative impact assessment

Development/ Infrastructure	Status	Potential effects	Cumulative impact/ interactive effect assessment
Offshore wind farms and associated infrastructure			
Burbo Bank	Operational	The impact range of operational noise from offshore wind farms is very small and evidence suggests that physical injury to or behavioural responses by marine mammals to turbine operating noise are unlikely.	Not significant in EIA terms
North Hoyle			
Rhyl Flats			
Walney 1 & 2			
Gwynt y Môr	Currently under construction and is due to be fully operational in 2014 so will not overlap with the Project	Operation	
		The impact range of operational noise from offshore wind farms is very small and evidence suggests that physical injury to or behavioural responses by marine mammals to turbine operating noise are unlikely. Marine mammals may also be affected indirectly by changes in prey availability or distribution (either positively or negatively) due to either decrease in prey availability due to increased auditory injury or by aggregation of fish around man-made structures such as piles.	Not significant in EIA terms

Table 14.25 continued

Development/ Infrastructure	Status	Potential effects	Cumulative impact/ interactive effect assessment
Offshore wind farms and associated infrastructure			
Walney Extension offshore wind farm	Construction proposed 2015 which has the potential to overlap with the Project	Construction	
		The main impact of construction will be impact piling which leads to potentially high levels of underwater noise.	Not significant in EIA terms
		Operation	
		The impact range of operational noise from offshore wind farms is very small and evidence suggests that physical injury to or behavioural responses by marine mammals to turbine operating noise are unlikely. Marine mammals may also be affected indirectly by changes in prey availability or distribution (either positively or negatively) due to either decrease in prey availability due to increased auditory injury or by aggregation of fish around man-made structures such as piles.	Not significant in EIA terms
		Decommissioning	
		Likely to generate noise near turbine foundations. No data on noise levels produced by underwater cutting mechanisms are available at this time. It is expected that decommissioning noise will occur at substantially lower levels than construction noise.	Not significant in EIA terms

Table 14.25: continued

Development/ Infrastructure	Status	Potential effects	Cumulative impact/ interactive effect assessment
Offshore wind farms and associated infrastructure			
Celtic Array (Round 3 Irish Sea Zone 9)	Construction proposed to commence in 2017	Construction	
		Cumulative noise modelling has not been carried out for the Celtic Array as it is deemed to be of sufficient distance as to be unlikely to have overlapping modelled noise impact contours for the furthest reaching potential impact (mild behavioural avoidance). In addition, the proposed construction periods for Celtic array are unlikely to overlap with those of the Project. Project Animals are therefore likely to be able to move between feeding areas.	Not significant in EIA terms
		Operation	
		The impact range of operational noise from offshore wind farms is very small and evidence suggests that physical injury to or behavioural responses by marine mammals to turbine operating noise are unlikely. Marine mammals may also be affected indirectly by effects on their prey.	Not significant in EIA terms
		Decommissioning	
		Likely to generate noise near turbine foundations. No data on noise levels produced by underwater cutting mechanisms are available at this time. It is expected that decommissioning noise will occur at substantially lower levels than construction noise.	Not significant in EIA terms

Table 14.25: continued

Development/ Infrastructure	Status	Potential effects	Cumulative impact/ interactive effect assessment
Offshore oil and gas platforms, pipelines and associated infrastructure			
Three gas pipelines in one bundle (gas, chemical and mixed hydrocarbons) owned by BHP	In place since the mid 1990s	The main impact is likely to come from maintenance vessels carrying out routine work.	Not significant in EIA terms – maintenance vessels are likely to be slow moving and predictable and therefore pose little risk to marine mammals that are already used to high levels of vessel movement.
Subsea cables			
Scottish Power HVDC Western link running from west coast of Scotland down to the Wirral in northwest England	*Main construction of the cable is planned to start in early 2013 and be complete and operational by the end of 2015*	Construction	
		The main impact of construction will be increased vessel traffic (including cable laying and associated vessels).	Not significant in EIA terms – cable laying and associated vessels will be slow moving and present in the Project area for a relatively short period only.

Table 14.25: continued

Development/ Infrastructure	Status	Potential effects	Cumulative impact/ interactive effect assessment
Subsea cables			
Emerald Express Cable System (tel-ecommunica-tions cable located 12 nm north of The Project)	The system is scheduled to be ready for service by Autumn 2013	Construction	
		The main impact of construction will be increased vessel traffic (including cable laying and associated vessels).	Not significant in EIA terms – cable laying and associated vessels will be slow moving and present in the Project area for a relatively short period only.
Other offshore activities			
Existing aggregate licences (392/393 to the west of the proposed wind farm and 175-1&2)	Existing	The main impact of dredging/ aggregate extraction on marine mammals is disturbance due to vessel and dredging activity. Marine mammals may also be affected indirectly effects on their prey.	Uncertain but considered to be not significant in EIA terms because the areas involved are relatively small.
Proposed aggregate licence areas (to the west of the proposed wind farm)	Proposed	The main impact of dredging/ aggregate extraction on marine mammals is disturbance due to vessel and dredging activity. Marine mammals may also be affected indirectly by effects on their prey.	Uncertain but considered to be not significant in EIA terms because the areas involved are relatively small.

Table 14.25: continued

Development/ Infrastructure	Status	Potential effects	Cumulative impact/ interactive effect assessment
Other offshore activities			
Underground Coal Gasification project (Riverside)	Proposed	Underground coal gasification converts coal to gas while still in the coal seam. The gas is then extracted through wells. Noise-related effects of construction are most likely for marine mammals.	Uncertain

Piling cumulative assessment

14.10.4 The Walney Extension offshore wind farm is the only other wind farm project in the Irish Sea that is likely to have an overlapping construction schedule with the Project. As such, the cumulative effects of simultaneous piling at the Project and the Walney Extension offshore wind farm have been assessed. The maximum adverse cumulative scenario has been modelled by Subacoustech as follows:

- An 8 m diameter pile in the northwest corner of the Project and an 8 m diameter pile in the southeast corner of Walney Extension offshore wind farm.
- Modelling was undertaken for seals (Figure 14.10), harbour porpoise (Figure 14.11) and bottlenose dolphin (Figure 14.12).

14.10.5 Table 14.26 below provides details of the areas over which behavioural responses are predicted for the different species should piling be occurring simultaneously at both sites. Numbers of animals occurring in these areas were estimated using the densities shown in Table 14.5 (baseline). The populations against which they were assessed (% of population column) are also detailed in Table 14.5.

14.10.6 The number of grey seals and harbour porpoises predicted to have the potential to experience behavioural disturbance in the cumulative scenario (Table 14.26) is approximately 2.5 times the number predicted in the Project only scenario (Table 14.18 and Table 14.22) for both strong and mild behavioural disturbance.

14.10.7 The number of bottlenose dolphins predicted to have the potential to experience strong behavioural disturbance in the cumulative scenario (Table 14.26) is also 2.5 times the number predicted in the Project only scenario (Table 14.22). However, the number predicted to have the potential to experience mild behavioural disturbance in the cumulative scenario is 3.7 times the number predicted in the Project only scenario (Table 14.23). This is because, unlike the other species, the 75 dB_{ht} contours for bottlenose dolphins do not overlap (Figure 14.12).

14.10.8 When expressed as percentages of Irish Sea population or abundance estimates (Table 14.5), up to 7% of the grey seal, 9% of the bottlenose dolphin, and 15% of the harbour porpoise abundance estimates are predicted to experience mild behavioural disturbance (Table 14.26).

Table 14.26: Areas over which strong (90 dB_{ht}) and milder (75 dB_{ht}) behavioural responses are predicted for different species when piling is occurring simultaneously at the Project and Walney Extension offshore wind farm

Level of behavioural response	Species	Area (km^2)	Number of animals	% of population
Strong (90 dB_{ht})	Grey seal	943	70-79	1%
	Harbour porpoise	1778	595	4%
	Bottlenose dolphin	871	5	2%
Milder (75 dB_{ht})	Grey seal	4819	357-405	6-7%
	Harbour porpoise	6635	2223	15%
	Bottlenose dolphin	4135	22	9%

14.10.9 It should be noted that bottlenose dolphins differ from the other marine mammal species occurring in Liverpool Bay for which there are density estimates in that they are either absent from an area, or present there as part of a group. This means that the number of bottlenose dolphins predicted to experience behavioural disturbance is likely to be an overestimate if they are absent, or an underestimate if they are present, because the density estimate (number of individuals per km^2) does not take into account behaviour i.e. group size. Because grey seals and harbour porpoises are likely to occur in the area more often than bottlenose dolphins, but singly (i.e. a single density estimate applied across an area is more likely to reflect reality), the numbers predicted to experience behavioural disturbance are less likely to be an over or an underestimate.

Likely significant effect

14.10.10 Impacts from piling are considered to be direct and intermittent. Marine mammal species likely to be encountered are of very high sensitivity.

14.10.11 The potential cumulative impact of simultaneous piling at the Project and the Walney Extension offshore wind farm on grey seals is assessed as likely and of **minor to moderate** magnitude in the short term and reversible once piling has ceased. The significance of cumulative piling on grey seal is therefore considered to be **moderate** for the duration of the impact but of **slight** significance in the long term, which is not significant in EIA terms.

14.10.12 The potential cumulative impact on bottlenose dolphins is assessed as likely and of **minor to moderate** magnitude in the short term (i.e. duration of the piling), and reversible once piling has ceased. The significance of cumulative piling on bottlenose dolphins is therefore considered to be **moderate** for the duration of the impact but of **slight** significance in the long term, which is not significant in EIA terms.

14.10.13 The potential cumulative impact on harbour porpoises is assessed as likely and of **moderate** magnitude in the short term (i.e. duration of the piling), and reversible once piling has ceased. The significance of cumulative piling on harbour porpoise is therefore considered to be **moderate** to large for the duration of the impact but of **slight** significance in the long term, which is not significant in EIA terms.

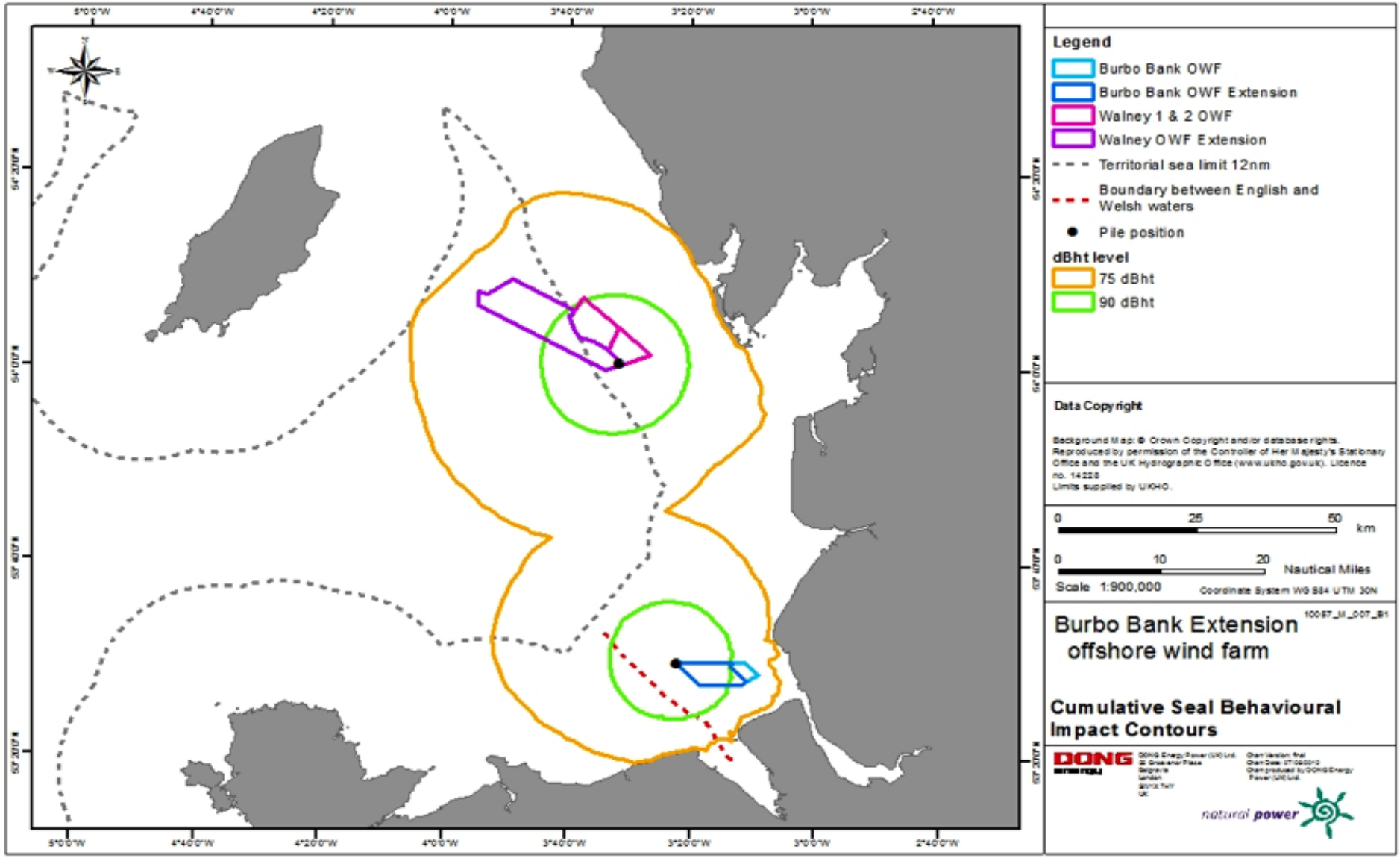

Figure 14.10: Cumulative seal behavioural impact contours

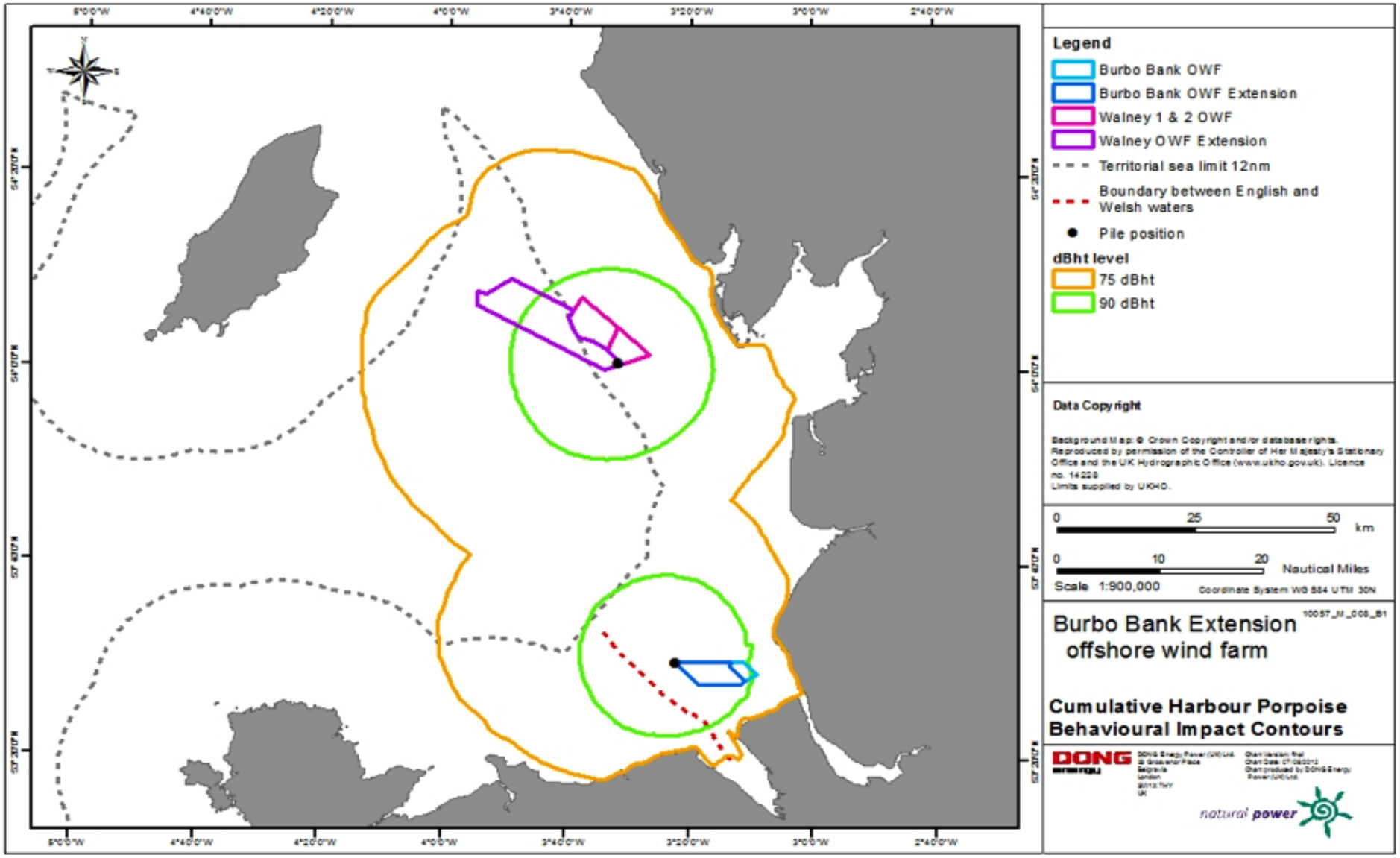

Figure 14.11: Cumulative harbour porpoise behavioural impact contours

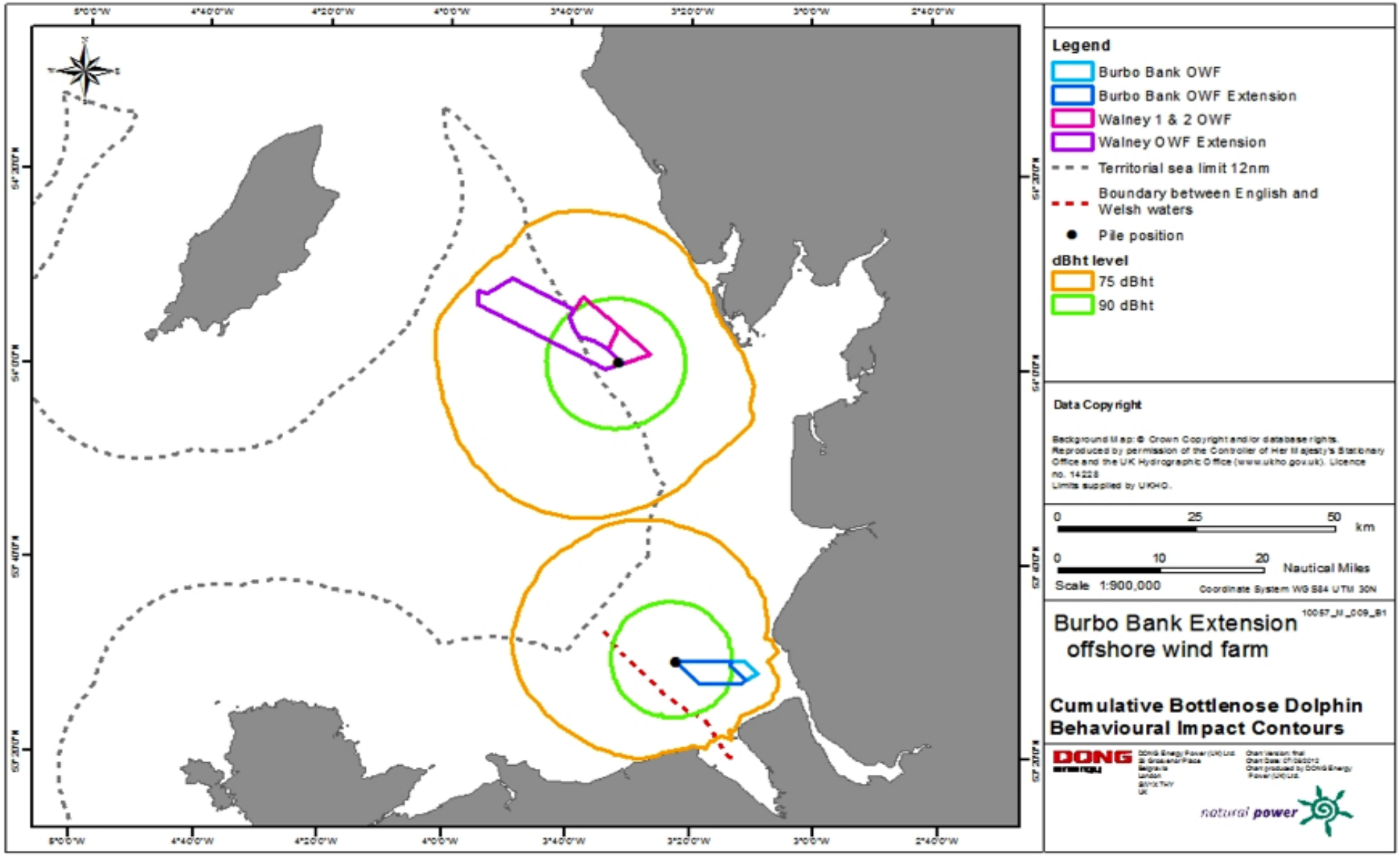

Figure 14.12: Cumulative bottlenose dolphin behavioural impact contours)

Further mitigation and future monitoring

14.10.14 As no significant impacts in the long term have been identified either alone or cumulatively/in-combination, no additional mitigation has been identified other than that currently embedded within the Project engineering parameters.

14.11 Trans-boundary Effects

14.11.1 The United Nations Economic Commission for Europe (UNECE) convention in environmental impact assessment requires that assessments are extended across borders between neighbouring members of the convention when a planned activity may cause a significant trans-boundary impact. Of all the potential impacts discussed within this marine mammal assessment, the activity which may cause the greatest potential impact to marine mammals is considered to be impact piling associated with the installation of turbine foundations.

14.11.2 There are a number of potential impacts that are associated with impact piling, with varying degrees of severity. The most severe (to the individual) is physical injury or lethality. Noise propagation modelling predicts that this may only occur within 80 m of a piling event and it is considered that standard mitigation protocols (as recommended by the JNCC) make this an unlikely occurrence. Another potential impact is hearing damage, which may impact marine mammals' ability to forage or communicate with other members of the species. Noise propagation models predict that this may occur within 20 km of a piling event for seal species and within 4.5 km for cetacean species. The final impact considered within this assessment was behavioural displacement which may result in a loss of foraging or breeding grounds. A strong behavioural response (i.e. displacement) has been predicted to occur within 13 km of a piling event for seal species and within 18 km for cetacean species.

14.11.3 Therefore no population level effect is predicted on any marine mammal species considered therefore there is no potential for a significant effect on any marine mammal species from distant populations.

14.11.4 Although the marine mammal species under investigation within this assessment have the potential to range over large areas, including areas out with UK territorial waters, the potential impact ranges within which impacts from piling may occur, do not extend into areas governed by other member states of the UNECE and therefore there are no predicted trans-boundary effects on marine mammals from the proposed development.

14.12 Inter-Related Effects

14.12.1 Details of inter-relationships involving marine mammals can be found in Table 14.27 below and are discussed further in ES Chapter 34 'Inter-relationships'.

Table 14.27: Summary of inter-relationships

Marine Mammals – inter-related effects					
Impact type and phase	**Source of impact**	**Nature of inter-related effect**	**Source chapter**	**Relevant chapters to be cross referenced**	**Notes**
Construction noise impacts on fish ecology, construction phase	Installation of foundations	Impacts on marine mammal foraging (prey species)	ES Chapter 13 'Fish and Shellfish Ecology'	ES Chapter 14 'Marine Mammals'	Assessment of significance provided in ES Chapter 34 'Inter-relationships'
	Impacts on fish ecology arising from the installation of large driven piles may affect the abundance or distribution of prey species for marine mammals (fish). The impact on prey species is considered in ES chapter 13. The associated impact on marine mammals is considered in ES chapter 14 (as detailed above). The potential for impacts on marine mammals associated with a change in prey availability are considered unlikely. The sensitivity of the receptor (marine mammals) is considered to be **high** and the magnitude of the impact is deemed to be **negligible**. The effect will, therefore, be of **slight** significance in EIA terms.				
Habitat loss impacts on fish ecology, operational phase	Presence of foundations	Impacts on marine mammal foraging (prey species)	ES Chapter 13 'Fish and Shellfish Ecology'	ES Chapter 14 'Marine Mammals'	Assessment of significance provided in ES Chapter 34 'Inter-relationships'
	Impacts on fish ecology arising from the presence of turbine foundations may affect the abundance or distribution of prey species for marine mammals (fish). The impact on prey species is considered in ES Chapter 13. The associated impact on marine mammals is considered in ES Chapter 14 (as detailed above). The potential for impacts on marine mammals associated with a change in prey availability are considered unlikely. The sensitivity of the receptor (marine mammals) is considered to be **high** and the magnitude of the impact is deemed to be **negligible**. The effect will, therefore, be of **slight** significance in EIA terms.				

14.13 Conclusion and summary tables

Table 14.28: Summary of significance, mitigation and monitoring

Summary tables – marine mammals						
Description of impact	**Magnitude of impact**	**Sensitivity of receptor**	**Significance of effect**	**Potential Mitigation Measures**	**Residual Effect**	**Proposed monitoring**
Construction Phase						
Collision risk associated with increased vessel movement	Negligible	Very high	Slight	None required	Not applicable	None required
Increased noise associated with vessel movement	Negligible	Very high	Slight	None required	Not applicable	None required
Increased noise associated with Trenching/ Cable laying	Negligible	Very high	Slight	None required	Not applicable	None required

Table 14.28: continued

Summary tables – marine mammals						
Description of impact	**Magnitude of impact**	**Sensitivity of receptor**	**Significance of effect**	**Potential Mitigation Measures**	**Residual Effect**	**Proposed monitoring**
Construction Phase						
Increased noise associated with piling: Lethality/ physical trauma all marine mammals long term	Minor	Very high	Slight	Included in Project design	Not applicable	None required
Increased noise associated with piling: Hearing damage i.e. Permanent Threshold Shift (PTS) on seals short term	Minor	Very high	Moderate	Included in Project design	Not applicable	None required

Table 14.28 continued

Summary tables – marine mammals						
Description of impact	**Magnitude of impact**	**Sensitivity of receptor**	**Significance of effect**	**Potential Mitigation Measures**	**Residual Effect**	**Proposed monitoring**
Construction Phase						
Increased noise associated with piling: Disturbance/ displacement on seals short term	Minor	Very high	Moderate	Included in Project design	Not applicable	None required
Increased noise associated with piling: Hearing damage i.e. Permanent Threshold Shift (PTS) on harbour porpoise short term	Minor	Very high	Moderate	Included in Project design	Not applicable	None required

Table 14.28: continued

Summary tables – marine mammals						
Description of impact	**Magnitude of impact**	**Sensitivity of receptor**	**Significance of effect**	**Potential Mitigation Measures**	**Residual Effect**	**Proposed monitoring**
Construction Phase						
Increased noise associated with piling: Disturbance/ displacement on harbour porpoise short term	Minor	Very high	Moderate	Included in Project design	Not applicable	None required
Increased noise associated with piling: Hearing damage i.e. Permanent Threshold Shift (PTS) on bottlenose dolphins short term	Minor	Very high	Moderate for duration of impact; not significant in long term	Included in Project design	Not applicable	None required

Table 14.28: continued

Summary tables – marine mammals						
Description of impact	**Magnitude of impact**	**Sensitivity of receptor**	**Significance of effect**	**Potential Mitigation Measures**	**Residual Effect**	**Proposed monitoring**
Construction Phase						
Increased noise associated with piling: Disturbance/ displacement on bottlenose dolphins short term	Minor	Very high	Moderate for duration of impact; not significant in long term	Included in Project design	Not applicable	None required
Increased noise associated with piling: Hearing damage i.e. Permanent Threshold Shift (PTS) and disturbance/ displacement on marine mammals long term	Negligible	Very high	Slight	None required	Not applicable	None required

Table 14.28: continued

Summary tables – marine mammals						
Description of impact	**Magnitude of impact**	**Sensitivity of receptor**	**Significance of effect**	**Potential Mitigation Measures**	**Residual Effect**	**Proposed monitoring**
Operation Phase						
Displacement/ disturbance associated with turbine operating noise	No change	Very high	Neutral	None required	Not applicable	None required
Increased collision risk associated with maintenance vessels	Negligible	Very high	Slight	None required	Not applicable	None required
Secondary impact: reduction in prey availability	Negligible	Very high	Slight	None required	Not applicable	None required

Table 14.28: continued

Summary tables – marine mammals						
Description of impact	**Magnitude of impact**	**Sensitivity of receptor**	**Significance of effect**	**Potential Mitigation Measures**	**Residual Effect**	**Proposed monitoring**
Decommissioning Phase						
Noise associated with the use of cutting and crushing tools?	Negligible	Very high	Slight	None required	Not applicable	None required
Increased vessel use associated with demolition	Negligible	Very high	Slight	None required	Not applicable	None required

14.14 EPS risk assessment

14.14.1 An EPS risk assessment is presented here to accompany the Marine Licence application (under the Marine and Coastal Access Act 2009) and to be used for application for an EPS licence to disturb.

14.14.2 The EU council directive 92/43/EEC on the Conservation of natural habitats and wild flora and fauna (the Habitats Directive) requires member states to implement management measures to maintain or restore natural habitats and wild species listed on the Annexes of the directive. The following regulations transpose these requirements of the Habitats Directive into UK law:

- The Wildlife and Countryside Act 1981 (as amended), effective from 0-12 nautical miles (nm);
- The Conservation of Habitats and Species Regulations 2010 (Habitats Regulations 2010), effective from 0-12 nm in respect of England and Wales
- The Offshore Marine Conservation (Natural Habitats, & c.) Regulations 2007 (as amended), effective within UK offshore waters beyond 12 nm.

14.14.3 The Directive states for species listed on Annex IV of the Habitats Directive that member states will establish a "system of strict protection for the animal species listed". As such, regulation 40 of the Habitats Regulation 2010 and regulation 39 of the Offshore Marine Conservation Regulations 2007 (as amended), respectively, make it an offence to:

- deliberately capture, injure or kill a wild animal of a European Protected Species (EPS);
- deliberately disturb wild animals of any such EPS species;
- damage or destroy a resting site or breeding place of such an EPS animal.

14.14.4 Draft guidance entitled '*The Protection of Marine European Protected Species from Injury and Disturbance*' was first published in March 2010, with a subsequent revision dated June 2010, by the JNCC, Natural England and the Countryside Council for Wales (JNCC *et al.*, 2010). This document and the Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling (2010) have been used as resources, when a view is needed as to whether there is potential for an offence of deliberately disturbing or injuring/killing a marine EPS to occur, or to have occurred, as a result of an activity.

14.14.5 As previously discussed within this ES, the greatest potential impact on marine mammals will come from piling noise. The guidance above considers certain activities that produce loud noises in areas where an EPS could be present to have the potential to result in an injury or disturbance offence, unless appropriate mitigation measures are implemented. The risk of an offence being committed is dependent on a number of factors including:

- Duration of noise associated with the activity;
- Presence/absence of semi-resident populations of EPS;
- Frequency of occurrence of EPS;
- Density of occurrence of EPS; and
- Length of stay of individuals in a given area.

14.14.6 The JNCC *et al.* (2010) report considers that the potential for disturbance from some activities can be considered trivia when the activity leads to "*sporadic disturbances without any likely negative impact on the species*".

14.14.7 For an activity to be considered non-trivial, the report states that "*The disturbance to marine EPS would need to be likely to at least increase the risk of a certain negative impact on the species Favourable Conservation Status (FCS)*".

14.14.8 Favourable Conservation Status (FCS) is defined in the Habitats Directive by the following:

- Population dynamics data on the species concerned indicate that it is maintaining itself on a long term basis as a viable element of its natural habitats.
- The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future.
- There is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long term basis.

14.14.9 All dolphins, porpoise and whales are considered EPS. 15 species of cetacean have been recorded in the Liverpool Bay area but only one has been identified by SNCBs as requiring consideration as a European Protected Species (EPS). This species is harbour porpoise. It is assumed that any mitigation put in place for this species will afford similar mitigation for any other cetacean species that may be present in the Liverpool Bay area during potentially disturbing activities.

Harbour porpoise baseline

14.14.10 Harbour porpoise is the most commonly recorded cetacean species in the Liverpool Bay area.

14.14.11 Harbour porpoises are found throughout the temperate shelf waters of the northern hemisphere (Read, 1999) and they are the most abundant cetacean recorded in British and Irish waters (Evans, 1992; Hammond *et al.*, 2002; Reid *et al.*, 2003) with sightings being widely distributed all around the coast. The species is limited to the waters of the continental shelf by its foraging behaviour and diving capacity (Read, 1999) and they are seldom found in waters warmer than 17°C (Gaskin *et al.*, 1993).

14.14.12 Although generally described as a coastal species (Evans, 1992; Carwardine, 1995), harbour porpoises have been sighted throughout the North Sea, in the deep waters between the Faeroe Islands and Iceland, and at depths of up to 1,500 m off the west coast of Scotland (Northridge *et al.*, 1995; Hammond *et al.*, 2002; Macleod *et al.*, 2003). Satellite telemetry studies suggest that porpoises are highly mobile and capable of covering large distances in short time periods, with daily distances travelled in the Bay of Fundy varying from 14 to 58 km (Read and Westgate, 1997). Their distribution across the North Sea is not uniform (Hammond *et al.*, 2002; Reid *et al.*, 2003). Sightings were considered rare in the southern parts and the English Channel although recent work (i.e. Camphuysen, 2004; Hammond, 2007) suggest this is variable.

14.14.13 Harbour porpoises feed on small, schooling fish usually between 10 and 30 cm in length (Read, 1999). Timing of breeding varies with geographical location but it generally occurs in the spring or summer (Jefferson *et al.*, 2008) with a peak around June and July (Lockyer, 2007).

EPS assessment

14.14.14 Harbour porpoise are considered a high frequency cetacean under the Southall *et al.* (2007) criteria. Based on the high frequency cetacean SEL data, it was predicted that harbour porpoises potentially risk auditory injury (PTS) up to 760 m from the Project, assuming a fleeing speed of 1.5 m/s. Based upon the predicted area of impact and the porpoise density estimates presented in Table 14.5 above (0.335), it is predicted that less than one porpoise (0.255) could be affected by auditory injury. Mitigation in the form of a monitoring zone of 500 m and a soft start lasting 30 minutes ramping up from 20-80% blow energy (see ES Chapter 11 'Offshore Noise' for details of ramp up included in noise modelling) should provide porpoises travelling at 1.5 m/s sufficient time to move out of the auditory injury range.

14.14.15 Harbour porpoises are predicted to have the potential to exhibit a strong avoidance reaction (90 dB_{ht}) up to 18 km from the operation and a mild avoidance reaction (75 dB_{ht}) up to 44 km from the operation. Not all animals within these distances will exhibit these effects. Table 14.29 below illustrates the maximum numbers of harbour porpoises that have the potential to experience these behaviours, based on the SCANS II density estimate.

Table 14.29: The maximum number of harbour porpoises that have the potential to experience traumatic hearing loss, strong avoidance or mild avoidance as a result of the proposed piling operation. Numbers calculated based on Irish Sea estimates produced for the SCANS II survey

dB_{ht} level	No. animals
90	248
75	972

14.14.16 While some animals have the potential to experience a strong (n = 248) or mild (n = 972) avoidance reaction, the piling operation is likely to last for a maximum adverse scenario of 40 days, therefore animals have the potential to be affected for a short period of time.

14.14.17 Harbour porpoises are most frequently recorded between July and September in the Liverpool Bay area.

14.14.18 A gradual ramp up of piling (as set out in Table 14.30 below) will allow most animals to move out of the zone of potential disturbance, however, it is likely that some animals will be temporarily displaced from the area whilst piling operations are taking place.

Table 14.30: Proposed ramp up of piling

Duration	Blow Energy (100% = 2700 kJ)	Strike rate
7.5 minutes	20%	1 every 6 seconds
7.5 minutes	40%	1 every 6 seconds
7.5 minutes	60%	1 every 4 seconds
7.5 minutes	80%	1 every 4 seconds

14.14.19 Given that the JNCC guidance advises that a "sporadic disturbance without any likely negative impact on the species" can be considered a "trivial" impact, we conclude that the proposed piling operation cannot be considered trivial due to the potential to disturb harbour porpoises resident in the Liverpool Bay area for the period of piling.

14.14.20 However, due to the short duration of piling and the use of soft start and ramp up procedures to allow most animals to move out with the range of significant behavioural disturbance (90 dB_{ht}), it is considered unlikely that construction operations will have an adverse effect on Favourable Conservation Status (FCS) of harbour porpoises as defined in the Habitats Directive.

14.14.21 It is therefore concluded that a licence to disturb harbour porpoises as a European Protected Species (EPS) is required, however the long term population dynamics and natural range or habitat of the species are unlikely to be affected, particularly when considered in context of the wide distribution of the species around the British and Irish coasts.

Conclusions

14.14.22 Drawing on the information presented in the JNCC (2010) guidance document and the noise assessment presented in ES Chapter 11 'Offshore Noise', together with suitable mitigation and taking into account the localised, transient nature (duration and frequency) of the operations, it is concluded that an EPS licence to disturb is likely to be required for harbour porpoises but that there is unlikely to be an adverse effect on their favourable conservation status.

Glossary

dB_{ht}	Developed as a means for quantifying the likelihood of behavioural impacts of a sound on a particular species. It takes into account species differences in hearing sensitivity at different frequencies (Nedwell *et al.*, 2007).
CCW	Countryside Council for Wales
CI	confidence interval; an interval in which a measurement falls corresponding to a given probability
CMACS	Centre for Marine and Coastal Studies
CV	coefficient of variation (a statistical measure of the dispersion of data points around the mean)
DCO	Development Consent Order
EIA	environmental impact assessment
EMF	electromagnetic fields
EPS	European Protected Species
ES	environmental statement
IPC	Infrastructure Planning Commission
JNCC	Joint Nature Conservation Committee
M-weighted SEL	sound is frequency weighted for four functional groups of marine mammals (high, mid and low frequency cetaceans and pinnipeds) by effectively removing frequencies outside the hearing ranges of each group (Southall *et al.*, 2007).
MMO	Marine Management Organisation or marine mammal observer
NPS	National Policy Statement
NSIP	Nationally Significant Infrastructure Project
PDS	project design statement
PEI	Preliminary Environmental Information Technical Report Version 2 (April 2012)
PTS	permanent threshold shift
SAC	special area of conservation
SCANS	small cetaceans in the european Atlantic and North Sea
SEA	strategic environmental assessment
SEL	sound exposure level
SNCB	Statutory Nature Conservation Body
SoCC	statement of community consultation
TCE	The Crown Estate
TTS	temporary threshold shift
WAG	Welsh Assembly Government

References

Highways Agency (2008) Design Manual for Roads and Bridges. London, DFT.

Baines, M.E., Reichelt, M., Evans, P.G.H. and Shepherd, B. 2002. Comparison of the abundance and distribution of harbour porpoises and bottlenose dolphins in Cardigan Bay, UK. In Abstracts of the 16th Annual Conference of the European Cetacean Society, 7-11 April, Liège, Belgium.

Baines, M.E. and Evans, P.G.H. 2012. Atlas of Marine Mammals of Wales. CCW Monitoring Report No. 68. 2nd edition. 139pp.

Betke, K., Schultz-von Glahn, M. and Matuschek, R. 2004. Underwater noise emissions from offshore wind turbines. Paper presented on CFA/DAGA 2004, 2 pp. (http://www.Itap.de/Itap.htm)

Bohnsack, J.A., Harper, D.E., McClellan, D.B. and Hulsbeck, M. 1994. Effects of reef size on colonisation and assemblage structure of fishes at artificial reefs off south-eastern Florida, USA. Bulletin of Marine Science, 55, 796–823.

Bristow, T. 2004. Changes in coastal site usage by bottlenose dolphin (Tursiops truncatus) in Cardigan Bay, Wales. Aquatic Mammals, 30, 398 – 404.

Camphuysen, K. 2004. The return of the harbour porpoise (Phocoena phocoena) in Dutch coastal waters. Lutra, 47, 135–144.

Carter, C. 2007. Marine renewable energy devices: a collision risk for marine mammals? MSc Thesis, University of Aberdeen.

Carwardine, M. 1995. Whales, dolphins and porpoises. Ed: P. Evans and M. Weinrich. Dorling Kindersley Ltd, London. pp256.

Clark, S. & Edwards, A.J. 1999. An evaluation of artificial reef structures as tools for marine habitat rehabilitation in the Maldives. Aquatic Conservation: Marine and Freshwater Ecosystems, 9, 5–21.

CMACS. 2012. Burbo Bank Extension offshore wind farm Marine Mammal Desk Study Report. Ref: J3162 Marine Mammals v3. Prepared for: DONG Energy.

Croll, D.A., Clark, C.W., Calambokidis, J., Ellison, W.T. and Tershy, B.R. 2001. Effect of anthropogenic low-frequency noise on the foraging ecology of *Balaenoptera* whales. Animal Conservation, 4, 13-27.

Culik, B.M., Koschinski, S., Tregenza, N. and Ellis, G. 2001. Reactions of harbour porpoises (*Phocoena phocoena*) and herring (*Clupea harengus*) to acoustic alarms. Mar Ecol Pr g Ser 211, 255–260.

David, L. 2006. Risks of collision for fin whales in the north-western Mediterranean Sea in summer. Fins, p16-18.

Diederichs, A., Nehls, G., Dähne, M., Adler, S., Koschinski, S. &and Verfuß, U. 2008. Methodologies for measuring and assessing potential changes in marine mammal behaviour, abundance or distribution arising from the construction, operation and decommissioning of offshore wind farms. Commissioned by COWRIE Ltd. 90 pp.

Edwards B., Brooker, A., Workman, R., Parvin, S.J. and Nedwell, J.R. 2007. Subsea operational noise assessment at the Barrow offshore wind farm site. Subacoustech Report No. 753R0109. Subacoustech Ltd., Bishops Waltham, Hants.

EISDG. 2005. Desktop Review of Marine Mammal Distribution in the NW3 Area. Revision:01, Ormond Project. Prepared by Rudall Blanchard Associates Ltd., London.

Evans, P.G.H. 1992. Status review of cetaceans in British and Irish waters. UK Mammal Society, Cetacean Group, Oxford.

Gaskin, D.E., Yamamoto, S. and Kawamura, A. 1993. Phocoena phocoena (L.) in the coastal waters of northern Japan. Fisheries Bulletin, 91, 440-454.

Gould, J.L. 2008. Animal navigation: the evolution of magnetic orientation. Current Biology, 18, 482–484.

Hammond, P.S., Berggren, P., Benke, H., Borchers, D.L., Collet, A., Heide-Jørgensen, M.P., Heimlich, S., Hiby, A.R. and Leopold, M.F. 2002. Abundance of harbour porpoise and other cetaceans in the North Sea and adjacent waters. Journal of Applied Ecology, 39, 361-376.

Hammond, P.S., Northridge, S.P., Thompson, D., Gordon, J.C.D., Hall, A.J., Aarts, G. and Matthiopoulos, J. 2005. Background information on marine mammals for Strategic Environmental Assessment 6. SMRU report which can be downloaded from http://www.offshore-sea.org.uk/site/scripts/category_info.php?categoryID=11

Hammond, P.S. 2007. Small cetaceans in the European Atlantic and North Sea (SCANS II). Life Project Number: LIFE04NAT/GB/000245.

Harewood, A. and Horrocks, J. 2008. Impacts of coastal development on hawksbill hatching survival and swimming success during initial offshore migration. Biological Conservation, 141, 394–401.

Hughes, D., Barham, R. and Cheeseman, S. 2012. Noise assessment for the proposed Burbo Bank Extension wind farm. Subacoustech Environmental Report No. E341R0205.

IEEM. 2010. Guidelines for ecological impact assessment in Britain and Ireland, marine and coastal. Institute of Ecology and Environmental Management.

Inger, R., Attrill, M.J., Bearhop, S., Broderick, A.C., Grecian, W.J., Hodgson, D.J., Mills, C., Sheehan, E, Votier, S.C., Witt, M.J. and Godley, B.J. 2009. Marine renewable energy: potential benefits to biodiversity? An urgent call for research. Journal of Applied Ecology 2009, 46, 1145–1153.

International Hydrographic Organization. 1971. Limits of oceans and seas. Special Publication No. 23. 3rd edition which can be found at http://www.iho-ohi.net/iho_pubs/standard/S-23/S23_1953.pdf

IWC. 2006. 58th Annual Meeting of the International Whaling Commission. Ship strikes working group. First progress report to the conservation committee. Report No. IWC/58/CC3.

Jefferson, T.A., Webber, M.A. and Pitman, R.L. 2008. Marine mammals of the world, A comprehensive guide to their identification. Academic Press.

Jensen, A. 2002. Artificial reefs in Europe: perspectives and future. ICES Journal of Marine Science, 59, 3–13.

JNCC. 2010. Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise. Joint Nature Conservation Committee, Peterborough, UK.

JNCC, Natural England and Countryside Council for Wales. 2010. The protection of marine European Protected Species from injury and disturbance; guidance for the marine area in England and Wales and the UK offshore marine area.

Kiely, O., Lidgard, D., McKibben, M., Connolly, N. and Baines, M. 2000. Grey seals: status and monitoring in the Irish and Celtic Seas. Maritime Ireland/Wales INTERREG Report No. 3. 85pp.

Koschinski, S. and Culik, B.M. 1997. Deterring harbour porpoises (*Phocoena phocoena*) from gillnets: observed reactions to passive reflectors and pingers. Reports of the International Whaling Commission, 47, 659-668.

Koschinski, S. Culik, B.M., Damsgaard Henriksen, O., Tregenza, N., Ellis, G., Jansen, C. and Kathe, G. 2003. Behavioural reactions of free-ranging porpoises and seals to the noise of a simulated 2MW windpower generator. Marine Ecology Progress Series, 265, 263-273.

Laist, D.W., Knowlton, A.R., Mead, J.G., Collet, A.S. and Podesta, M. 2001. Collisions between ships and whales. Marine Mammal Science, 17: 35-75.

Leung Ng, S. and Leung, S. 2003. Behavioural response of Indo-pacific humpback dolphin (*Sousa chinensis*) to vessel traffic. Marine Environmental Research, 56, 555-567.

Lockyer, C. 2007. All creatures great and smaller: a study in cetacean life history energetics. Journal of the Marine Biological Association of the UK, 98: 1035-1045.

Lonergan, M., McConnell, B., Duck, C. and Thompson, D. 2011. An estimate of the size of the British grey seal population based on summer haulout counts and telemetry data. SCOS Briefing Paper 11/06 which can be downloaded from http://www.smru.st-andrews.ac.uk/pageset.aspx?psr=411.

Macleod, K., Simmonds, M.P. and Murray, E. 2003. Summer distribution and relative abundance of cetacean populations of north-west Scotland. Journal of the Marine Biological Association of the UK, 83, 1187–1192.

Madsen, P.T., Møhl, B., Nielsen, B.K., and Wahlberg, M. 2002. Male sperm whale behaviour during exposures to distant seismic survey pulses. Aquatic Mammals, 28, 231-240.

Madsen, P.T., Wahlberg, M., Tougaard, J., Lucke, K. and Tyack, P. 2006. Wind turbine underwater noise and marine mammals: implication of current knowledge and data needs. Marine Ecology Progress Series, 309, 279-295.

Marchesan, M., Spoto, M., Verginella, L. and Ferrero, E.A. 2006. Behavioural effects of artificial light on fish species of commercial interest. Fisheries Research, 73, 171–185.

Nedwell, J.R., Turnpenny, A.W.H., Lovell, J., Parvin, S.J., Workman, R., Spinks, J.A.L. and Howell, D. 2007. A validation of the dB_{ht} as a measure of the behavioural and auditory effects of underwater noise. Subacoustech Report Reference 534R1231. Published by the Department for Business, Enterprise and Regulatory Reform.

Northridge, S.P., Tasker, M.L., Webb. A. and Williams, J.M. 1995. Distribution and relative abundance of harbour porpoise (Phocoena phocoena L.), white-beaked dolphins (Lagenorhynchus albirostris Gray) and minke whales (Balaenoptera acutorostrata Lacepède) around the British Isles. ICES Journal of Marine Science, 52, 55 - 66.

Norwack, D.P., Johnson, M.P. and Tyack, P.L. 2004. North Atlantic right whales (Eubalaena glacialis) ignore ships but respond to alerting stimuli. Proceedings of the Royal Society of London, B, 271, 227-231.

Pace, D.S., Miragliuolo, A. and Mussi, B. 2006. Vessels and dolphins: scars that tell stories. Fins: 19-20.

Palka, D.L. and Hammond, P.S. 2001. Accounting for responsive movement in line transect estimates of abundance. Canadian Journal of Fisheries and Aquatic Sciences 58, 777-787.

Paxton, C.G.M., Mackenzie, M., Burt, M.L., Rexstad, E. and Thomas, L. 2011. Phase II data analysis of Joint Cetacean Protocol data resource. Report to JNCC Contract number C11-0207-0421.

Pesante, G., Evans, P.G.H., Baines, M.E. and McMath, M. 2008. Abundance and Life History Parameters of Bottlenose Dolphin in Cardigan Bay: Monitoring 2005-2007. Countryside Council for Wales Marine Monitoring Report No. 61. Report to the Sea Watch Foundation. Eds. Sanderson, B. & McMath, M.

Polacheck, T. and Thorpe, L. 1990. The swimming direction of harbor porpoise in relationship to a survey vessel. Report of the International Whaling Commission, 40, 463-470.

Read, A.J. 1999. Harbour porpoise Phocoena phocoena (Linnaeus, 1758). In Handbook of marine mammals, volume 6. Academic Press. p323–355.

Read, A.J. and Westgate, A.J. 1997. Monitoring the movements of harbour porpoise (Phocoena phocoena) with satellite telemetry. Marine Biology, 130, 315–322.

Reid, J.B., Evans, P.G.H., and Northridge, S.P. 2003. Atlas of Cetacean Distribution in North-west European Waters. Joint Nature Conservation Committee, Peterborough. 76pp.

Richardson, W.J., Fraker, M.A., Würsig, B. and Wells, R.S. 1985. Behaviour of bowhead whales, *Balaena mysticetus*, summering in the Beaufort Sea: Reactions to industrial activities. Biological Conservation, 32, 195-230.

Richardson, W.J., Miller, G.W. and Greene, C.R. 1999. Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea. Journal of the Acoustical Society of America, 106, 2281.

SCANS II. 2008. Final report to the European Commission under project LIFE04NAT/GB/000245.

Scheidat, M., Tougaard, J., Brasseur, S., Carstensen, J., van Polanen Petel, T., Teilmann, J. and Reijnders, P. 2011. Harbour porpoises (*Phocoena phocoena*) and wind farms: a case study in the Dutch Norst Sea. Environmental Research Letters, 6: 025102 (10pp).

Sini, M.I., Canning, S.J., Stockin, K.A. and Pierce, G.J. 2005. Bottlenose dolphins around Aberdeen harbour, north-east Scotland: a short study of habitat utilization and the potential effects of boat traffic. J Mar Biol Assoc UK 85, 1547–1554.

Southall, B.L., Bowles, A.E., Ellison, W.T., Finneran, J.J., Gentry, R.L., Greene Jr. C.R., Kastak, D., Ketten, D.R., Miller, J.H., Nachtigall, P.E., Richardson, W.J., Thomas, J.A. and Tyack, P. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. Aquatic Mammals 33, 411-521.

Teilmann, J., Carstensen, J., Dietz, R., Edrén, S.M.C. and Andersen, S.M. 2006. Final report on aerial monitoring of seals near Nysted offshore wind farm. Technical report to Energi E2 A/S.

Terhune, J.M. and Verboom, W.C. 1999. Right whales and ship noise. Marine Mammal Science, 15, 256–258.

Thompson, P., Hastie, G., Nedwell, J., Barham, R., Brooker, A., Brookes, K., Cordes, LO., Bailey., H & McLean, N. 2012. Moray Offshore Renewables Limited - Environmental Statement: Technical Appendix 7.3 B - Framework for assessing the impacts of pile-driving noise from offshore wind farm construction on Moray Firth harbour seal populations.

Thomsen, F., Lüdemann, K., Kafemann, R. and Piper, W. 2006. Effects of offshore wind farm noise on marine mammals and fish. Biola, Hamburg, Germany on behalf of COWRIE Ltd.

Tougaard, J., Carstensen, J., Henriksen, O.H., Skov, H. & Teilmann, J. 2003. Short-term effects of the construction of wind turbines on harbour porpoises at Horns Rev. Technical report to Techwise A/S. Hedeselskabet.

Tougaard, Carstensen, J., Teilmann, J., Bech, N.I., Skov, H. and Henriksen, O.D. 2005. Effects of the Nysted offshore wind farm on harbour porpoises. Technical report to Energi E2 A/S. NERI, Roskilde.

Tougaard, J., Tougaard, S., Jensen, R.C., Jensen, T., Teilman, J., Adelung, D., Liebsch, N. and Müller, G. 2006. Harbour seals at Horns Reef before, during and after construction of Horns Rev offshore wind farm. Final report to Vattenfall A/S.

Tougaard, J., Henriksen, O.D. and Miller, L.A., 2009. Underwater noise from three types of offshore wind turbines: Estimation of impact zones for harbour porpoises and harbour seals. Journal of the Acoustical Society of America, 125, 3766-3773.

Wilhelmsson, D. and Malm, T. 2008. Fouling assemblages on offshore wind power plants and adjacent substrata. Estuarine Coastal and Shelf Science, 79, 459–466.

Wilhelmsson, D., Öhman, M.C., Stáhl, H. and Shlesinger, Y. 1998. Artificial reefs and dive ecotourism in Eilat, Isreal. Ambio, 27, 764–766.

Wilhelmsson, D., Malm, T. and O¨ hman, M.C. 2006. The influence of offshore wind power on demersal fish. ICES Journal of Marine Science, 63, 775–784.

BURBO BANK EXTENSION OFFSHORE WIND FARM

DONG Energy Burbo Extension (UK) Ltd.

Environmental Statement
Annex 15 – Ornithology

Document reference: 5.1.5.15
APFP 5(2)(a)

March 2013

DONG energy

Burbo Bank Extension offshore wind farm
DONG Energy Burbo Extension (UK) Ltd.

Environmental Statement
Annex 15 – Ornithology

Document reference: 5.1.5.15

Pursuant to: APFP 5(2)(a)

Prepared by: NIRAS Consulting Ltd., CMACS Ltd., National Environmental Research Institute (NERI)

Checked by: Jennifer Brack (Applications Lead, DONG Energy), Allen Risby (Environmental Lead, DONG Energy)

Accepted by: Stuart Livesey (Consents Project Manager, DONG Energy)

Approved by: Ferdinando Giammichele (Project Development Manager, DONG Energy)

Date: March 2013

Status: Final

Burbo Bank Extension offshore wind farm
c/o DONG Energy Burbo Extension (UK) Ltd.
33 Grosvenor Place
Belgravia
London
SW1X 7HY
United Kingdom

Tel: (+44) 020 7811 5235

Website: www.burbobankextension.co.uk
Email: burbobankextension@dongenergy.co.uk

DONG energy

REPORT

Ornithological Technical Report: Burbo Bank Extension Offshore Wind Farm

Prepared	IEL
Checked	TNO
Accepted	TNO

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1 Executive Summary

1.1.1 This report presents ornithological information gathered to assess the potential impacts of the proposed Burbo Bank Extension Offshore Wind Farm 'the Project'.

1.1.2 The site lies within Liverpool Bay SPA, which is designated due to the Presence of populations of European importance of red-throated divers and common scoter. Several additional European sites exist to the south and east of the Project, with interest features comprising both breeding seabirds and wintering waterbirds.

1.1.3 Survey data comprised substantial information sourced from wider surveys of the Irish Sea and the operational Burbo Bank Wind Farm in addition to aerial and boat-based surveys undertaken specifically on Burbo Bank Extension Offshore Wind Farm.

1.1.4 This report identifies the importance of bird species recorded, taking into consideration their conservation status and the significance of the populations present. A wide selection of bird species were recorded during the surveys comprising true seabirds such as Manx shearwater and gannet, a numbers of species of gulls and terns and seaduck. Waders and migratory wildfowl (away from seaduck) were generally absent during both boat-based and aerial work.

1.1.5 It is evident that bird densities were generally low within the area of interest. Within and around the Project, it can be said the area is unexceptional in terms of the ornithological community it supports. Bird densities were notably lower than found in surrounding areas and this is particularly the case for red-throated diver and common scoter, with both of these species present in low densities only. No species occurred in numbers approaching thresholds for international importance, although both lesser black-backed gull and common tern occurred in numbers of national importance.

1.1.6 This technical report has been updated in light of valuable comments received from Natural England and the Countryside Council for Wales in August 2012. The additional information included in this report is as follows:

- Distance analysis of boat-based survey data;
- Further discussion and details of designated sites for Manx shearwater within foraging range;
- Seasonal presentation of historic baseline data;
- Revision of population estimate data;
- Further insight in to boat-based survey behavioural data; and
- Update of data interpretation in systematic list of species.

2 Introduction

2.1 The Burbo Bank Extension

2.1.1 Burbo Bank Offshore Wind Farm is a twenty-five turbine, 90MW development that has been operational since August 2007. This report assesses a proposed extension to the wind farm Burbo Bank Extension Offshore Wind Farm, 'the Project' from which DONG Energy plans provide up to 258MW of additional capacity from up to sixty-nine installed wind turbines.

2.1.2 The Burbo Bank study area is located in Liverpool Bay, in the east Irish Sea. This is approximately 7 km north of the North Wirral coast (at the village of Meols), 8.5 km from Crosby beach, and 12.2 km from the Point of Ayr on the North Wales coast (DONG Energy, 2011). The extension lies to the immediate west of the existing operational turbine array of Burbo Bank and to the east and north east of the consented Gwynt y Môr and operational North Hoyle Offshore Wind Farms (Figure 1).

2.2 Technical Report objectives

2.2.1 This report is part of the analytical assessment of the potential ornithological impacts of the Project. Its purpose is to:

- Determine the regional context in which the Burbo Bank Extension Offshore Wind Farm can be assessed;
- Collate all ornithological data gathered for the site and surrounding areas;
- Establish the ornithological significance of the proposed OWF (offshore wind farm) application site for breeding, wintering and migratory birds; and
- Predict potential ornithological impacts of the construction, operational and decommissioning phases that may require further assessment as part of an Environmental Statement.

Legend

- Export Cable Options
- Burbo Bank Extension
- UK Offshore Wind Farms (Round 1)
- UK Offshore Wind Farms (Round 2)

* Export cable routes are indicative and subject to change

Data Copyright:

Round 1 & 2 Offshore Wind Farms: Crown Estate, September 2009
Background Map: OS 1:250,000: Raster Tile from OS OpenData; contains Ordnance Survey data © Crown copyright and database rights, 2010.

0 3 6 Kilometres

0 1.5 3 Nautical Miles

Scale 1:150,000 Coordinate System: OSGB 36 BNG

Burbo Bank Extension offshore wind farm

Site and indicative cable route

DONG energy
DONG Energy Power (UK) Ltd.
33 Grosvenor Place
Belgravia
London
SW1X 7HY
UK

Chart Version: final
Chart Date: 27/06/2011
Chart produced by DONG Energy Power (UK) Ltd.
Ref: BBW025011

Figure 1: Location of Burbo Bank Extension offshore wind farm.

3 Existing baseline

3.1 Overview of the avifauna of the east Irish Sea and Liverpool Bay

3.1.1 The proposed Burbo Bank Extension Offshore Wind Farm lies in the vicinity of several designated European sites, including the Liverpool Bay Special Protection Area (SPA), which extends across the boundaries of the development site. Figure 2 presents the location of each designated site in relation to Burbo Bank Extension Offshore Wind Farm, while Table 1 presents a summary of each site in terms of key designated features and distance from Burbo Bank Extension Offshore Wind Farm.

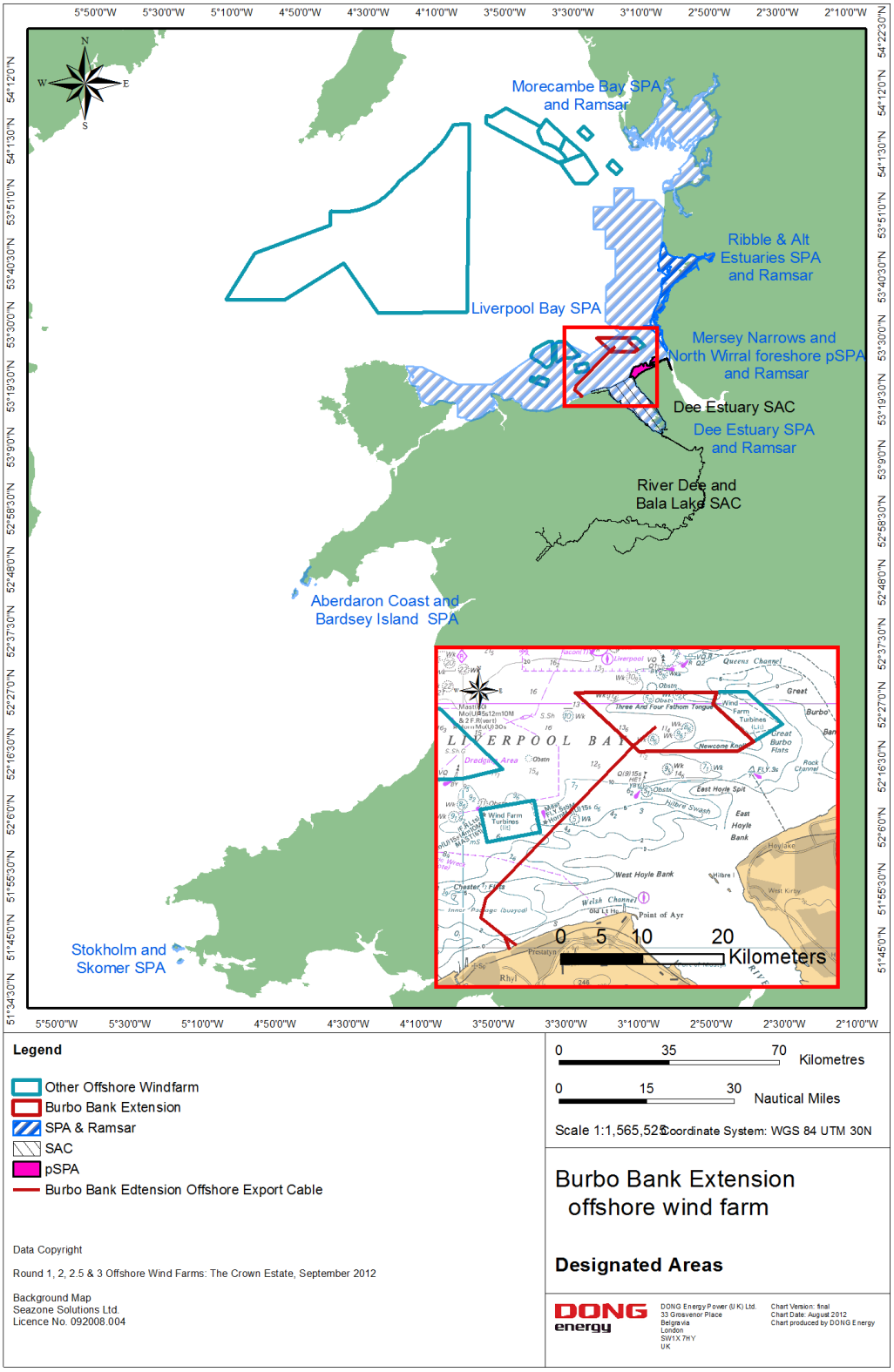

Figure 2: Location of European designated sites in the proximity of Burbo Bank Extension Offshore Wind Farm.

Table 1: Interest features of internationally designated sites within proximity of Burbo Bank Extension Offshore Wind Farm.

Site/designation	Distance (km)	Breeding season	Wintering season	On passage	Assemblage
Liverpool Bay / SPA	0 (site intersects the SPA)	n/a	Red-throated diver; common scoter	n/a	55,597 waterbirds.
Mersey Narrows and North Wirral Foreshore / pSPA and pRamsar	6	Common tern	Bar-tailed godwit; knot.	Little gull; common tern	32,366 individual waterbirds. Additional species: cormorant, oystercatcher, grey plover, sanderling, dunlin, redshank.
Ribble and Alt Estuaries / SPA	6.5	Ruff; common tern; lesser black-backed gull; black-headed gull.	Bewick's swan; whooper swan; bar-tailed godwit; golden plover; pintail; teal; wigeon; pink-footed goose; scaup; sanderling; dunlin; knot; oystercatcher; black-tailed godwit; common scoter; curlew; cormorant; grey plover; shelduck; lapwing.	Sanderling; ringed plover; whimbrel; redshank.	29,236 seabirds in the breeding season 323,861 waterbirds in the wintering season.
Ribble and Alt Estuaries / Ramsar	6.5	Lesser black-backed gull; *black-headed gull; common tern*	Bewick's swan; whooper swan; pink-footed goose; shelduck; wigeon; teal; pintail; oystercatcher; bar-tailed godwit; *red-throated diver; cormorant; shoveler;*	Ringed plover; grey plover; knot; sanderling; dunlin; black-tailed godwit; redshank; lesser black-backed gull; *ruff; curlew; greenshank.*	222,038 waterfowl during winter

Site/designation	Distance (km)	Breeding season	Wintering season	On passage	Assemblage
			common scoter; golden plover; spotted redshank; black-headed gull;		
Dee Estuary / SPA	8.2	Common tern; little tern	Bar-tailed godwit; redshank; black-tailed godwit; curlew, dunlin; grey plover; knot; oystercatcher; pintail; shelduck; teal.	Sandwich tern; redshank	130,408 waterbirds. Additional species: sanderling; cormorant; wigeon; mallard; lapwing.
Dee Estuary / Ramsar	8.2	*Little tern*[1]*; common tern; redshank*	Redshank; teal; shelduck; oystercatcher; curlew; pintail; grey plover; knot; dunlin; black-tailed godwit; bar-tailed godwit; *wigeon; sanderling; cormorant; great crested grebe;*	Redshank; *Sandwich tern; ringed plover*	120,726 individual water birds

[1] Ramsar species in italics refer to 'noteworthy' species only i.e. species not attaining status as internationally important, although present in nationally important numbers.

Site/designation	Distance (km)	Breeding season	Wintering season	On passage	Assemblage
Mersey Estuary / SPA	18	n/a	Golden Plover; pintail; wigeon; dunlin; black-tailed godwit; curlew; grey plover; great crested grebe; shelduck; redshank; lapwing.	Redshank; ringed plover.	20,269 individual waterbirds. Additional species: knot; oystercatcher; cormorant; turnstone.
Mersey Estuary / Ramsar	18	n/a	Teal; pintail; dunlin; *wigeon;*	Shelduck; black-tailed godwit; redshank; *ringed plover; curlew; spotted redshank; greenshank.*	n/a
Morecambe Bay SPA	52	Little tern; Sandwich tern; herring gull; lesser black-backed gull.	Bar-tailed godwit; golden plover; curlew; dunlin; grey plover; knot; oystercatcher; pink-footed goose; pintail; redshank; shelduck; turnstone.	Ringed plover; sanderling.	61,858 seabirds in the breeding season. 210,688 wintering waterfowl with additional species: great crested grebe; cormorant; teal; mallard; eider; goldeneye; red-breasted merganser; lapwing.
Morecambe Bay Ramsar	52	Lesser black-backed gull; herring gull; Sandwich tern; *black-headed gull*;	Great crested grebe; pink-footed goose; wigeon; goldeneye; red-breasted merganser; golden plover; lapwing; knot; dunlin; bar-tailed godwit; *teal; black-tailed godwit.*	Cormorant; shelduck; pintail; eider; oystercatcher; ringed plover; grey plover; sanderling; curlew; redshank; turnstone; *ruff*; *whimbrel; spotted redshank; greenshank*.	n/a

Site/designation	Distance (km)	Breeding season	Wintering season	On passage	Assemblage
Bowland Fells SPA	55	Lesser black-backed gull	n/a	n/a	n/a
Copeland Islands SPA	191	Arctic tern. Manx shearwater	n/a	n/a	n/a
Aberdaron Coast and Bardsey Island SPA	185	Manx shearwater, chough[2]	Chough[2]	n/a	n/a
Skokholm and Skomer SPA	309	Chough[2], short-eared owl[2], storm petrel, lesser black-backed gull, Manx shearwater, puffin	n/a	n/a	67,278 breeding seabirds including razorbill, guillemot and kittiwake.

[2] Terrestrial species that will not interact with Burbo Bank Extension Offshore Windfarm.

3.2 Liverpool Bay SPA

Qualifying features

3.2.1 Liverpool Bay SPA was formally designated in August 2010 due to its importance for wintering populations of seabirds, particularly common scoter and red-throated diver.

3.2.2 The site supports over 1% of the Great Britain population of the Annex1 listed (on the EC directive on the Conservation of Wild Birds 79/409/EEC) red-throated diver, with a mean peak count of 922 individuals recorded over the period 2001/02 – 2005/06. This accounts for 5.4% of the total estimated British winter population. Liverpool Bay also supports over 1% of the biogeographical population (Siberia/ Western and Northern Europe) of common scoter. The mean peak overwintering population of this species between 2001/02 and 2005/06 was 54,675 individuals, which represents 58% of the Great Britain population. In addition, the site supports an assemblage of over 20,000 waterbirds.

Conservation Objectives

3.2.3 With respect to red-throated divers, the conservation objective for the SPA is to maintain the population and its supporting habitats in favourable condition whereby:

- The 5 year peak mean population size for this species is no less than 922 individuals;
- The overall presence and abundance of prey species within the site is maintained; and
- Red-throated divers are not subject to significant human-induced mortality, and areas where they congregate in higher densities are not subject to significant disturbance.

3.2.4 For common scoter, the conservation objective is to maintain the species population in favourable condition whereby:

- The 5 year peak mean population size for this species is no less than 54,675 individuals;
- The overall presence and abundance of benthic prey species within the site is maintained, along with its associated features;
- Common scoters are not exposed to significant human-induced mortality, and their aggregations are not subject to significant disturbance; and
- The movement of common scoters between feeding and resting areas is not significantly impeded.

3.2.5 With regard to the overall waterbird assemblage, the Conservation Objectives are to maintain its size and its habitat in favourable condition whereby:

- The peak mean population size for the waterfowl assemblage is no less than 55,597 birds; and
- Aggregations of waterfowl and seabirds at feeding and resting sites are not subject to significant disturbance.

3.3 Mersey Narrows and North Wirral Foreshore pSPA/pRamsar

Qualifying features

3.3.1 English Nature (now Natural England) identified the Mersey Narrows and North Wirral Foreshore pSPA/pRamsar as potentially qualifying as a Special Protection Area and Ramsar site in October 2000. English Nature consulted owners, occupiers, statutory authorities and other interested parties on the proposal to designate the SPA and Ramsar site at the Mersey Narrows and North Wirral Foreshore in 2001. English Nature submitted its report to DEFRA in 2004, but no decision was made at that time to designate the sites.

3.3.2 A new consultation was undertaken in late 2011 due to the pSPA and pRamsar site supporting more than 1% of the GB populations of three species listed in Annex 1 (bar-tailed godwit, little gull and common tern. The site regularly supports more than 1% of the biogeographical population of one regularly occurring migratory species (knot), and supports an assemblage of more than 20,000 (i.e. 32,366) waterbirds during the non-breeding season.

Conservation Objectives

3.3.3 No Conservation Objectives have been formally set for this site at the present time.

3.4 Ribble and Alt Estuaries SPA

Qualifying features

3.4.1 The Ribble and Alt Estuaries (of which the Ribble is by far the larger) along an extensive area of sandy foreshore along the Sefton Coast, form this SPA. The SPA's intertidal mudflats, saltmarshes and coastal grazing marshes support important populations of wintering and migrating waterbirds. The areas of saltmarsh also support large concentrations of breeding gulls and terns. The SPA includes the component SSSI's of Ribble Estuary and Sefton Coast., with the former site's designation noting the internationally important numbers of waterfowl that it supports.

3.4.2 During the breeding season the Ribble and Alt Estuaries support populations of European importance of two Annex 1 listed species; ruff and common tern. The site also supports populations of European importance of four further Annex 1 listed species: Bewick's swan, whooper swan, golden plover and bar-tailed godwit. The site supports a suite of further species that occurs during winter in populations of European importance, including pintail, teal, wigeon, pink-footed goose, scaup, sanderling, dunlin, knot, oystercatcher, black-tailed godwit, common scoter, curlew, cormorant, grey plover, shelduck and lapwing. During the breeding season, lesser black-backed gull and black-headed gull are both present in numbers of European importance, while sanderling, ringed plover, whimbrel, and redshank also exceed this threshold during passage periods.

Conservation Objectives

3.4.3 The Conservation Objectives for the SPA are to maintain in favourable condition:

- The habitats for the populations of regularly occurring Annex 1 species of European importance, in particular intertidal sand and mudflats and saltmarsh.
- The habitats for the populations of regularly occurring migratory bird species of European importance, in particular intertidal sand and mudflats and saltmarsh.

- The habitats for the populations of waterfowl that contribute to the wintering waterfowl assemblage of European importance, with particular reference to intertidal sand and mudflats, marshy grassland and saltmarsh.

3.5 Ribble and Alt Estuaries Ramsar

3.5.1 The Ribble and Alt Estuaries are also a designated Ramsar site with cited species similar to those included for the SPA (Table 1).

3.6 Dee Estuary SPA

Qualifying features

3.6.1 The Dee Estuary, on the boundary between England and Wales on the north-west coast of Britain, is a large, funnel-shaped, sheltered estuary that supports extensive areas of intertidal sand-flats, mudflats and saltmarsh. During the winter, the intertidal flats and saltmarshes provide feeding and roosting sites for large populations of ducks and waders. The site is also important during migration periods, particularly for wader populations moving along the west coast of Britain. The Dee Estuary SPA includes a suite of component SSSI's (Sites of Special Scientific Interest) comprising Inner Marsh Farm, Shotton Lagoons and Reedbeds (which supports a breeding colony of common tern), Dee Estuary and Gronant Dunes, and Talacre Warren.

3.6.2 During the breeding season, the Dee Estuary supports populations of European importance of two Annex 1 listed species: little and common tern. The site also supports populations of European importance of two further Annex 1 listed species: black-tailed godwit during winter and Sandwich tern during passage. The site supports a suite of further species that occurs during winter in populations of European importance, including pintail, teal, dunlin, knot, oystercatcher, curlew, grey plover, shelduck and redshank. Redshank also occurs in numbers of European importance during passage periods. In addition, the site supports an assemblage of over 20,000 (i.e.130,408 birds) waterbirds.

Conservation Objectives

3.6.3 The Conservation Objectives for species considered likely to occur at Burbo Bank Extension Offshore Wind Farm include common tern, little tern and Sandwich tern.

3.6.4 For breeding common tern, the interest feature will be considered to be in favourable condition when:

- The five year mean population is no less than 392 breeding pairs;
- The five year mean productivity is no less than 1.34 chicks fledging per breeding pair per year;
- The abundance of prey species in the estuary is maintained;
- Common terns are able to pass freely between the Estuary and their breeding site at Shotton Lagoons without obstruction; and
- Aggregations roosting on the upper shore over high tide are not subject to significant disturbance.

3.6.5 For breeding little tern the interest feature will be considered to be in favourable condition when:

- The five year mean population is no less than 69 breeding pairs;

- The five year mean productivity is no less than 0.80 chicks fledging per breeding pair per year;
- The breeding site is not subject to significant disturbance;
- The extent of shingle habitat at Gronant is maintained; and
- Aggregations roosting on the beach at Gronant or Point of Ayr are not subject to significant disturbance.

3.6.6 For passage Sandwich tern the interest feature will be considered to be in favourable condition when:

- The five year mean population is no less than 957 individuals during autumn passage; and
- Aggregations roosting on the upper shore over high tide are not subject to significant disturbance.

3.7 Dee Estuary Ramsar Site

3.7.1 The Dee Estuary is also a designated Ramsar (with an identical area extent) site with cited species similar to those included for the SPA (Table 1). Breeding and passage tern species are however considered 'noteworthy species' for the Ramsar site rather than interest features in their own right.

3.8 Mersey Estuary SPA

Qualifying features

3.8.1 The Mersey is a large, sheltered estuary, which comprises large areas of saltmarsh and extensive intertidal sand and mudflats, with limited areas of brackish marsh, rocky shoreline and boulder clay cliffs. The intertidal flats and saltmarshes provide feeding and roosting sites for large and internationally important populations of waterfowl. The site is important during winter, and during spring and autumn migration periods.

3.8.2 During the wintering season, the Mersey Estuary supports a population of European importance of one Annex 1 listed species, Golden Plover. The site supports a suite of further species that occurs during winter in populations of European importance, including pintail, teal, wigeon, dunlin, black-tailed godwit, curlew, grey plover, great crested grebe, shelduck, redshank and lapwing. Ringed plover and redshank also occur in numbers of European importance during passage periods. In addition, the site supports an assemblage of over 20,000 waterbirds.

Conservation Objectives

3.8.3 The Conservation Objectives for the Mersey Estuary SPA focus on maintaining habitats for interest features in favourable condition subject to natural change (English Nature, 2001). Habitats include intertidal sediments, rocky shores and saltmarsh.

3.9 Mersey Estuary Ramsar Site

3.9.1 The Mersey Estuary is also a designated Ramsar site (where their extents are identical) with cited species similar to those included for the SPA (Table 1). Morecambe Bay SPA

Qualifying features

3.9.2 Morecambe Bay is one of the largest estuarine systems in the UK and is fed by five main river channels which drain through the intertidal flats of sand and mud. These habitats support a rich invertebrate fauna which in turn supports large numbers of waterbirds during both wintering and passage periods. Associated habitats also important for birds include freshwater wetlands, fringing saltmarshes and saline lagoons. Shingle banks and dock structures provide important and secure roost sites at high tide. In summer, areas of sand and shingle support breeding colonies of terns.

3.9.3 During the breeding season Morecambe Bay supports populations of European Importance of two Annex 1 species, little tern and Sandwich tern. Annex 1 species that occur in population of European importance in the winter months are bar-tailed godwit and golden plover.

3.9.4 A number of migratory species occur in numbers of European importance. During the breeding season such species are herring gull and lesser black-backed gull while on passage ringed plover and sanderling qualify. Over winter periods such interest features are curlew, dunlin, grey plover, knot, oystercatcher, pink-footed goose, pintail, redshank, shelduck and turnstone. In addition, the site supports an assemblage of over 20,000 waterbirds (210,688 birds 1991/92-1995/96).

Conservation Objectives

3.9.5 The conservation objectives for Morecambe Bay SPA are broad sweeping and take the form of the following:

- Subject to natural change, to maintain in favourable condition the habitats of the internationally important populations of regularly occurring bird species listed on Annex 1 of the Birds Directive, in particular:
  - Shingle areas.
- Subject to natural change, to maintain in favourable condition the habitats of the internationally important populations of regularly occurring migratory species, in particular:
  - Intertidal mudflat and sandflat communities
  - Intertidal and subtidal boulder and cobble skear communities
  - Saltmarsh communities
  - Coastal lagoon communities.

3.10 Bowland Fells SPA

Qualifying features

3.10.1 The Bowland Fells are an extensive upland area in Lancashire, in north-west England. It forms a western outlier of the Pennines, with summits mostly in the range 450-550 m. The geology is millstone grit-capped fells overlying softer Bowland shales, resulting in predominantly acidic vegetation types. The major habitats are heather-dominated moorland and blanket mire. The SPA supports a large breeding population of lesser black-backed gull numbering 13,900 pairs representing up to 11.2% of the breeding Western Europe / Mediterranean / Western Africa population (Stroud et al., 2001).

Conservation Objectives

3.10.2 The conservation objectives for the Bowland Fells SPA are: subject to natural change, to maintain or restore:

- The extent and distribution of the habitats of the qualifying features;
- The structure and function of the habitats of the qualifying features;
- The supporting processes on which the habitats of the qualifying features rely;
- The populations of the qualifying features; and
- The distribution of the qualifying features within the site.

3.11 Copeland Islands SPA

Qualifying features

3.11.1 The Copeland Islands SPA is located off the north-east coast of County Down, Northern Ireland and covers an area of 201.52 ha. The SPA comprises three islands (Big Copeland, Light House Island and Mew Island) together with a number of associated islets. The site includes rocky shores together with small areas of sand/mud and cobble/boulder beaches. Terrestrially, the site is composed of saltmarsh, freshwater marsh, maritime grassland and a limited extent of inland cliff and semi-improved agricultural grassland.

3.11.2 The site is designated under Article 4.1 of the EU Birds Directive for supporting nationally important numbers of Arctic tern (566 pairs representing 22.6% of the Irish population) and under Article 4.2 of the EU Birds Directive for supporting internationally important numbers of Manx shearwater (4800 pairs representing 1.7% of the world population). The islands also support a number of non-qualifying species including a nationally important breeding population of Eider (200 individuals representing 10% of the Irish population), a nationally important population of common gull (250 pairs representing 7% of the Irish population) and Northern Ireland's first breeding pair of Mediterranean gull.

3.12 Aberdaron Coast and Bardsey Island / Glannau Aberdaron & Ynys Enlii SPA

Qualifying features

3.12.1 The Aberdaron Coast and Bardsey Island is located at the end of the Lleyn Peninsula in far north-west Wales. The SPA coastline is rocky with frequent crags, screes and low cliffs. This borders heather-covered hills separated by valleys occupied by pastures.

3.12.2 The site is designated for its resident population of chough and for breeding Manx shearwater. The former species has a restricted distribution in Britain tied to coastal areas of low intensity agriculture and short-grass (Cramp & Simmons, 1977). Within the region is found only in north-west Wales and the Isle of Man; the SPA supports 12 breeding pairs. Choughs are noted to be essentially sedentary in the UK (Cramp and Simmons, 1977) and are not likely to occur in the Walney Extension Offshore Wind Farm zone of influence.

3.12.3 The Manx shearwater colony on Bardsey is large and the SPA designation cites a population of European Importance of 6930 pairs which represents at least 2.6% of the species breeding population (Stroud et al., 2001).

Conservation Objectives

3.12.4 The conservation objectives for breeding Manx shearwater are to maintain the population in favourable conservation status, where all of the following conditions are satisfied:

- Breeding population of Manx shearwater (confined to Bardsey) is stable or increasing (lower limit 10,000 pairs);
- Reproductive rates remain stable (lowest tolerable limit of >0.5 fledged chicks per pair for 3 consecutive years);
- Deaths from the lighthouse attractions, fencing and other infrastructure are minimal (upper limit of 35 fatalities per year);
- No ground predators are introduced;
- Nesting birds are not disturbed by restoration works on boundary walls or recreational activities; and
- All factors affecting the achievement of these conditions are under control.

3.13 Skomer and Skokholm SPA

Qualifying features

3.13.1 Skomer, Skokholm and Middleholm are three islands lying off the extreme south-west tip of Pembrokeshire in south-west Wales. They are bounded by cliffs that reach 70m on Skomer (Stroud et al, 2001). Of principal importance are the large number of breeding seabirds, especially petrels, gulls and auks. Especially notable is the high proportion (over half; 150,968 pairs) of the world population of Manx shearwater that nest here. The nesting seabirds using the site feed outside the SPA in surrounding marine areas, as well as more distantly. The SPA is a substantial distance from Burbo Bank Offshore Windfarm (over 310 kilometres) and of the qualifying breeding seabirds only Manx shearwater, which has a large foraging range (Thaxter et al., 2012), has the potential to interact with the Project site.

Conservation Objectives

3.13.2 The conservation objectives for breeding Manx shearwater are to maintain the population in favourable conservation status, where all of the following conditions are satisfied:

- During the breeding season the population of Manx shearwater will be at least 150,000 pairs within the SPA;
- Breeding success will be at least 0.5 chicks per egg laid; and
- The factors affecting the feature[3] are under control.

Defining population importance

[3] Disturbance, predators, soil erosion, bracken distribution, food availability and oil spills (CCW, 2008)

3.13.3 The significance of an impact on any particular species can be determined as a combination of the importance of the species' population affected, and the sensitivity of the species to that particular impact. This section provides a summary of population thresholds used to define regional, national and international importance.

3.13.4 The importance of species present in the Walney Extension site plus 4 km buffer area (taken to be the spatial limit of possible effects caused by the Project) was defined in relation to estimated international, national and regional populations through the use of the 1% threshold criterion. The 1% criterion, whilst not necessarily of biological relevance, has been previously used as a standard for designating areas of conservation interest (Skov et al. 2007) and has since been used as a convenient threshold figure to indicate potential significance of effects (be it through proportions of relevant populations affected or through changes in background mortality). The 1% criterion should there be interpreted as guidance on potential impact significance only.

International and national populations

3.13.5 Threshold values for international populations were derived from figures provided by Burfield & Van Bommel (2004), which represents the most up to date synthesis of international population data. National populations thresholds were derived from the BTO Bird Facts online species database and national wintering thresholds were derived from the most current WeBS report (Holt et al. 2012), Musgrove et al. (2011), Banks et al., (2007) and Burton et al. (2012). Appropriate numbers for both breeding and wintering populations were determined for each species from the most recent literature, taking into account seasonal patterns of movement.

3.13.6 Table 2 presents threshold values for international and national importance for species likely to be significant in the east Irish Sea.

Table 2: International and national population thresholds for key species in the east Irish Sea.

Species	**International Biogeographic**		**National wintering**		**National breeding**	
	Population	**1%**	**Population**	**1%**	**Population**	**1%**
Common scoter	550,000	5,500	100,000	1000	n/a	n/a
Red-throated diver	54,000	540	17,000	170	2310	23[4]
Fulmar	3,600,000	30,600	n/a	n/a	998,000	9980
Manx shearwater	740,000	7400	n/a	n/a	590,000	5900
Gannet	610,000	6100	n/a	n/a	438,000	4380
Arctic skua	60,000	600	n/a	n/a	4200	42[2]
Great skua	32,000	320	n/a	n/a	19,200	192
Kittiwake	4,500,000	45,000	n/a	n/a	724,000	7240
Black-headed Gull	3,000,000	30,000	2,200,000	22,000	256,000	2560
Common gull	2,000,000	20,000	700,000	7000	96,000	960
Lesser black-backed gull	550,000	5500	120,000	1200	220,00	2200

[4] A minimum of 50 birds as a threshold is generally implemented.

Herring gull	1,560,000	15,600	730,000	7300	262,000	2620
Great black-backed gull	440,000	4400	76,000	760	34,000	340
Sandwich tern	167,000	1670	n/a	n/a	22,000	220
Common tern	540,000	5400	n/a	n/a	20,000	200
Arctic tern	1,330,000	13,300	n/a	n/a	106,000	1060
Common guillemot	4,700,000	47,000	n/a	n/a	1,300,000	13,000
Razorbill	1,190,000	11,900	n/a	n/a	164,000	1640
Puffin	13,000,000	130,000	n/a	n/a	579,000	5790

Regional populations

3.13.7 Regional populations are presented in Table 3 as densities for the Irish Sea, based on data in Stone et al. (1995) and as a wider scale west coast regional population (that can be applied to the wintering period), derived from Mitchell et al. (2004). For the purposes of Walney Extension Offshore Wind Farm, the west coast regional population was calculated as the total UK west coast breeding population from the north-west coast of Sutherland to the Isles of Scilly (including Ireland). For those species for which information was presented as the number of Apparently Occupied Nests/Sites (AON/AOS) count data was doubled to provide an estimate of the number of individuals.

Table 3: The Irish Sea densities and west coast population sizes of a bird species associated with Walney Extension.

Species	**Irish Sea density (Stone *et al.,* 1995)**		**West coast regional population (Mitchell *et al.,* 2004)**	**1% threshold of West coast regional population**
	Max	**Mean**		
Common scoter	1.68	0.25	n/a	n/a
Red-throated diver	n/a	n/a	n/a	n/a
Fulmar	1.43	0.58	414,872	4149
Manx shearwater	16.42	3.28	448,502	4485
Gannet	1.39	0.38	327,526	3275
Arctic skua	0	0	450	5[5]
Great skua	0.01	0	1,150	12[3]
Kittiwake	1.40	0.79	239,380	2394
Common gull	1.22	0.23	13,036	130
Lesser black-backed gull	0.79	0.36	138,474	1385
Herring gull	3.27	0.90	178,444	1784
Great black-backed gull	0.34	0.12	20,644	206
Sandwich tern	0.02	0	9,052	91
Common tern	0.36[6]	0.05[1]	15,010	150

[5] A minimum of 50 birds as a threshold is generally implemented

[6] Data taken for 'commic' terns i.e. unidentified common / Arctic terns

Arctic tern	0.36[1]	0.05[1]	23,764	238
Common guillemot	6.47	2.45	664,836	6648
Razorbill	1.69	0.69	139,772	1398
Puffin	2.54	0.26	558,704	5587

3.14 Summary of existing baseline

3.14.1 Of principal significance to the assessment of Burbo Bank Extension are the interest features of Liverpool Bay SPA (wintering red-throated diver and common scoter), within which the site is situated. A suite of European sites exists on the adjacent Wirral, Merseyside and North Wales coasts and the interest features of these sites are of high relevance to the assessment. Features from the Dee Estuary, Mersey Estuary, Ribble and Alt Estuaries and Mersey Narrows Aberdaron Coast and Skomer / Skokholm SPA/Ramsar sites include both breeding seabird colonies and wintering/passage waterfowl. Considering the location of Burbo Bank Extension, c.6km from the Wirral Coastline, it is likely that breeding seabirds will be more affected than wildfowl and wader species. Breeding seabird interest features of these European sites include lesser black-backed and black-headed gulls, common, little and Sandwich terns.

3.14.2 Puffin Island SPA lies 46 km west of Burbo Bank Extension and the does not support any qualifying species likely to interact with the Project site. The island is however, also designated as a Site of Special Scientific Interest (SSSI) with the citation for the site detailing the presence of puffin, guillemot and razorbill although no populations are given. All three of these species have the potential to interact with Burbo Bank Extension.

4 Data and information sources

4.1 Ornithological surveys

4.1.1 Extensive ornithological surveys have been undertaken in the Irish Sea area in which Burbo Bank Extension is situated. Aerial survey work in the area has been some of most comprehensive around the UK coastline, and has been on-going since 2001 (Webb *et al*, 2006). Boat-based surveys were undertaken to support the EIA of the original Burbo Bank Offshore Wind Farm, with monitoring surveys required by FEPA of the construction and post-construction periods also completed.

4.1.2 Due to the high level of biological data available for the Burbo Bank Extension Offshore Wind Farm site, an additional single year of surveys to inform the EIA for Burbo Bank Extension Offshore Wind Farm was proposed (detailed in DONG Energy, 2010) and discussed with Natural England and CCW in December 2011. Figure 3 presents the extent of surveys that have been undertaken with relevance to Burbo Bank Extension shown by season. Included are the baseline surveys carried out for this assessment.

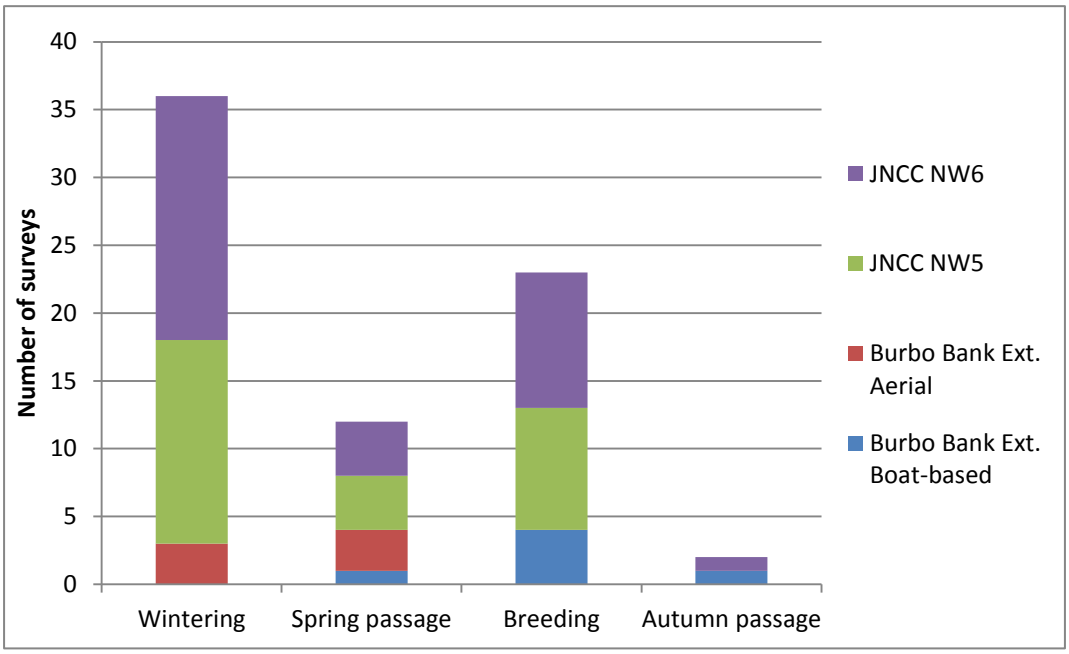

Figure 3: Survey effort undertaken for Burbo Bank Extension and the wider Project area

4.2 Boat based survey of Burbo Bank existing site

Survey design

4.2.1 Hyder Consulting carried out surveys during the construction and post-construction of Burbo Bank Offshore Wind Farm, on behalf of the Centre for Marine and Coastal Studies (Hyder Consulting, 2008; 2009). Surveys were undertaken from May 2006 to July 2007, and from November 2007 to April 2009.

4.2.2 During the construction period of the wind farm, monthly surveys were undertaken, with the exception of December 2006, from May 2006 to July 2007. The survey methodology implemented was based on Camphuysen *et al*. (2004) and agreed through consultation with English Nature (now Natural England), the Royal Society for the Protection of Birds (RSPB) and the Countryside Council for Wales (CCW). The survey area encompassed the wind farm area, 1km buffer and an adjacent reference area. The reference area in these surveys and a portion of the buffer area areas are found within the area of study for the Burbo Bank Extension (Figure 4).

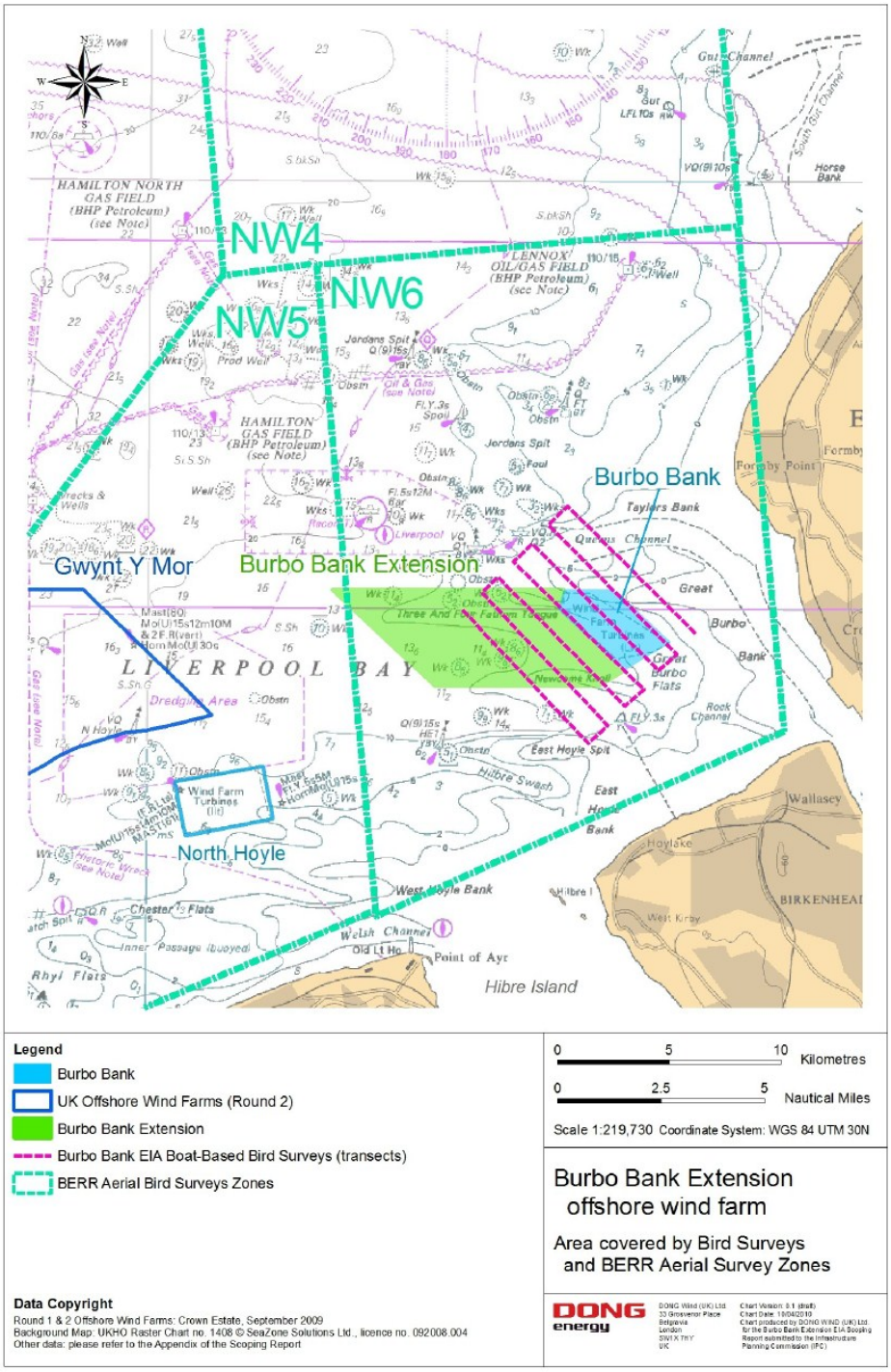

Figure 4: Boat-based survey area of Burbo Bank Operational Wind Farm

Data collection

4.2.3 The wind farm area, buffer and adjacent reference area were crossed by seven evenly distributed transect routes approximately 1km apart. Two ornithologists surveyed from the vessel on a purpose built

observation platform approximately 5m above sea level. The observers viewed from both sides of the vessel and scanned the area perpendicular to the boat using binoculars. This also included sweeps ahead of the boat, to ensure that no under-counting of divers occurred, as they are known to be susceptible to disturbance from on-coming vessels. Approximate height and direction were also recorded for birds observed in flight.

4.2.4 Target bird species were restricted to those identified in pre-construction studies: common scoter, red-throated diver, cormorant and common tern. With the exception of commoner gull species, all other observed bird species were recorded.

Data analysis

4.2.5 The reports by Hyder Consulting provide numerical data for the species recorded, but do not provide population or density estimates. For the purposes of the assessment of Burbo Bank Extension Offshore Wind Farm, interpretation of this information is therefore limited to simple comparisons of raw numbers of birds and distributional information.

4.3 Boat –based survey at Burbo Bank Extension Offshore Wind Farm site (2011)

Survey design

4.3.1 Six ornithological surveys were carried out by CMACS in each calendar month between April and September 2011 inclusive with at least two weeks between surveys (CMACS, 2012). The 39.65km^2 Burbo Bank Extension site was surveyed along with a 4km buffer, giving a total surveyed area of 76.8km^2. With regards to the buffer zone, impacts are considered to have the potential to occur to within 1 km of this area.

4.3.2 The surveys were carried out from the survey vessel Halcyon Days, which closely followed COWRIE recommendations (Camphuysen et al., 2004) in being greater than 20m in length and with an eye height of more than 5m. The viewing platform was built according to CMSC specifications, allowing for unrestricted visibility. Two observers, including at least one JNCC accredited Marine Mammal Observer (MMO) were present in each survey.

4.3.3 Transects followed eight pre-determined transect lines totalling 128 km at a spacing of 2 km agreed between DONG Energy and statutory consultees.

Data collection

4.3.4 Methods implemented for the surveys followed the recommendations of Camphuysen et al. (2004) for assessment of ornithological of potential wind farms. In addition, the methods also considered the British Trust for Ornithology (BTO) review of those recommendations (Maclean et al., 2009). The following were key components of the methodology:

- Survey bands subdivided into 0-50m, 50-100m, 100-200m, 200-300m and 300+m;
- Vessel speed 10 knots (range 5-15kt);
- Viewing height >5m above sea level;
- No observations at sea state five or more used in data analysis;
- Registration of tidal status (low, medium or high tidal);
- Qualified (i.e. experienced) observers for each survey;
- Observations on both sides of the vessel; and

- Registration of weather conditions including sea state, wind speed and wind direction.

4.3.5 The surveys recorded birds sitting on the sea and those in flight. In the first two months of survey snapshot counts of birds in flight were attempted every 300m (as per the recommendation of Maclean et al., 2009) but it became evident after the first survey that continuous recording of birds in flight (i.e. alongside birds on the water) could be undertaken owing to the low numbers of birds seen (CMACS, 2012).

4.3.6 The following information was recorded for each bird observation,: observation time; position; species; numbers; age classes (where possible); distance band from the vessel; flight height; flight direction; behaviour; association (e.g. with fishing vessels). Notes on prevailing meteorological conditions, sea state and visibility were made periodically throughout each survey.

4.3.7 All individual birds were assigned to a distance band category with the transects parallel to the boat (A: 0-50m; B: 50-100m; C: 100-200m; D: 200-300m and E: >300m). Birds recorded in transects A to D were taken as being within the transect, which assumes that all birds, no matter what size, were recorded within this 300m distance. All birds were also assigned to a height category when first seen, with this category maintained even if the bird altered its flight height. The three categories comprised 0-30m (below turbine blade height), 31-140m (within the sweep of turbine blades) and greater than 130m (above turbine height). The direction of flying birds was recorded according to eight compass directions.

4.3.8 A hand-held GPS recorded the vessel's position every 10 seconds and thus real-time positions of observations were available after the survey. Observers were present on each side of the vessel swapping sides at the end of every other transect to account for observer bias. Each observer was equipped with binoculars and a dictaphone (voice recorder) to make audio records of sightings.

Data analysis

4.3.9 The aim of analysis of boat-based survey is to estimate the density of each species (as birds per km^2). This can then be extrapolated to the size of the site and/or the site plus the 4km buffer. These results are designed to allow direct comparison with those recorded in wider areas in the Irish Sea and against relevant population levels for key species (be they of international, national or regional contexts).

4.3.10 To provide appropriate population estimates, Distance sampling (Buckland et al., 2001) was undertaken on boat-based data, for those species where it was considered that the results could potentially be valuable to the assessment. It was not possible to carry out this analysis for all species recorded during the surveys due to the low number of observations (I.K. Petersen pers comm.). The models were run with hazard rate and half normal key functions. One model with each of the two key functions were run without inclusion of any covariates. Thereafter covariates "cluster size" (= flock size) and behaviour were considered.

4.3.11 The results generated from the analyses were, with the exception of guillemot, found to have very large confidence intervals and thus be of limited value for the assessment.

4.3.12 Where Distance analysis results were disregarded due to confidence interval issues (as agreed with Natural England in August 2012 (M. Busch via email), a standard correction factor was applied to the data. In this analysis the following assumptions were made:

- Observations of birds in flight within 300m do not require correction for distance related detection errors.

- That all birds on the sea surface are recorded within 100m of the vessel but that beyond this there is a distance related detection error that must be corrected for.

4.3.13 The second assumption means that the proportion of birds observed in bands 'c' and 'd' is less than 100% of the population present and that a correction factor is required to estimate the total number of birds on the sea in the surveyed area. This was achieved for each species separately using the following formula[7]:

- Correction factor = $\frac{(a+b)*3}{(a+b+c+d)}$

Where a, b, c and d are the number of individual birds in band a, b, c and d.

4.3.14 When a correction factor of less than one was calculated, it was assumed that all birds had been recorded. Where there were too few sightings to calculate a correction factor, a factor from a similar species was used.

4.3.15 The correction factor was calculated using pooled data from all six surveys and followed by the calculation of population and density estimates for each species in each month. Population estimates were calculated for the total surveyed area with the following formula:

- Estimated bird population = corrected bird count * $\frac{\text{Area of interest}}{\text{Total surveyed area}}$

4.4 Aerial survey at Burbo Bank Extension Offshore Wind Farm (2010-11)

Survey design

4.4.1 Six aerial surveys of the Burbo Bank Extension Offshore Wind Farm site during the period November 2010 to April 2011 were undertaken by Aarhus University (Petersen et al., 2011). The objective was to map bird distributions within the study area by monthly aerial image surveys. The surveys were conducted along 10 pre-defined transect lines over an image survey area of the wind farm site and a 4km buffer, which therefore leads to a total survey area of 210.5 km^2. The length of the image track lines for each survey had a total length of around 109km per survey.

Data collection

4.4.2 Five of the six surveys utilised a VexcelUltracam XP camera. The resulting XP images cover a width of 520m and a ground resolution of 3cm. The survey undertaken on 8th December 2010 was carried out using a VexcelUltracam D camera. This camera had an image width of 430m and a ground resolution of 4cm. The XP camera resulted in 788 images per survey while the D camera resulted in 904 images.

4.4.3 The camera was operated from a twin-engine aircraft, either a Cessna 402B or a Cessna 404. Images were obtained from an altitude of 475m and a speed of 140 knots.

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[7] The formula firstly assumes that all the density of birds recorded in the first 100m is extrapolated to the full 300 metres then this total is divided by birds recorded in all distance bands.

Data analysis

4.4.4 Birds were identified manually by experienced ornithologists in 20% of the images produced by the surveys. An automated pattern recognition algorithm was also used on the images, and was found to be implemented accurately. In a similar way to that presented for boat-based survey data, population sizes were determined through calculation of density values in line transects which are applied to the wider area.

4.4.5 The analysis assumed that all birds are stationary in time and space. Species identification from aerial image survey takes a precautionary approach and only those individuals seen clearly were assigned to species level. Consequently, birds were assigned to taxonomic groups such as such as ‘grey gull’ (common or herring gull), ‘gull sp.', ‘tern sp.’ and ‘razorbill/guillemot.

4.5 WWT/ESAS/CCW aerial survey

Survey design

4.5.1 In order to provide data on the numbers and distribution of waterbirds and seabirds for the Strategic Environmental Assessment (SEA) of offshore windfarm development, The Department of Trade and Industry (DTI, now Department of Energy and Climate Change DECC) commissioned large-scale aerial surveys of strategic inshore waters.

4.5.2 The first comprehensive survey was undertaken in 2004/5 (DTI, 2006), with subsequent surveys from winter 2005/6 through to summer 2006 (BERR, 2007), January to March 2007 (WWT Consulting, 2007) and October 2007 to August 2008 (WWT Consulting, 2009).

4.5.3 Of most relevance to Burbo Bank Extension are the survey zones NW5 and NW6a (Figure 5). Data from these surveys have been extracted to provide comparative bird densities for the Burbo Bank Extension area plus a 1km buffer. Each survey of NW5 or NW6a was conducted over four hours flight time centred on midday (GMT) of one day, in selected good weather conditions with wind speeds of less than 15 knots.

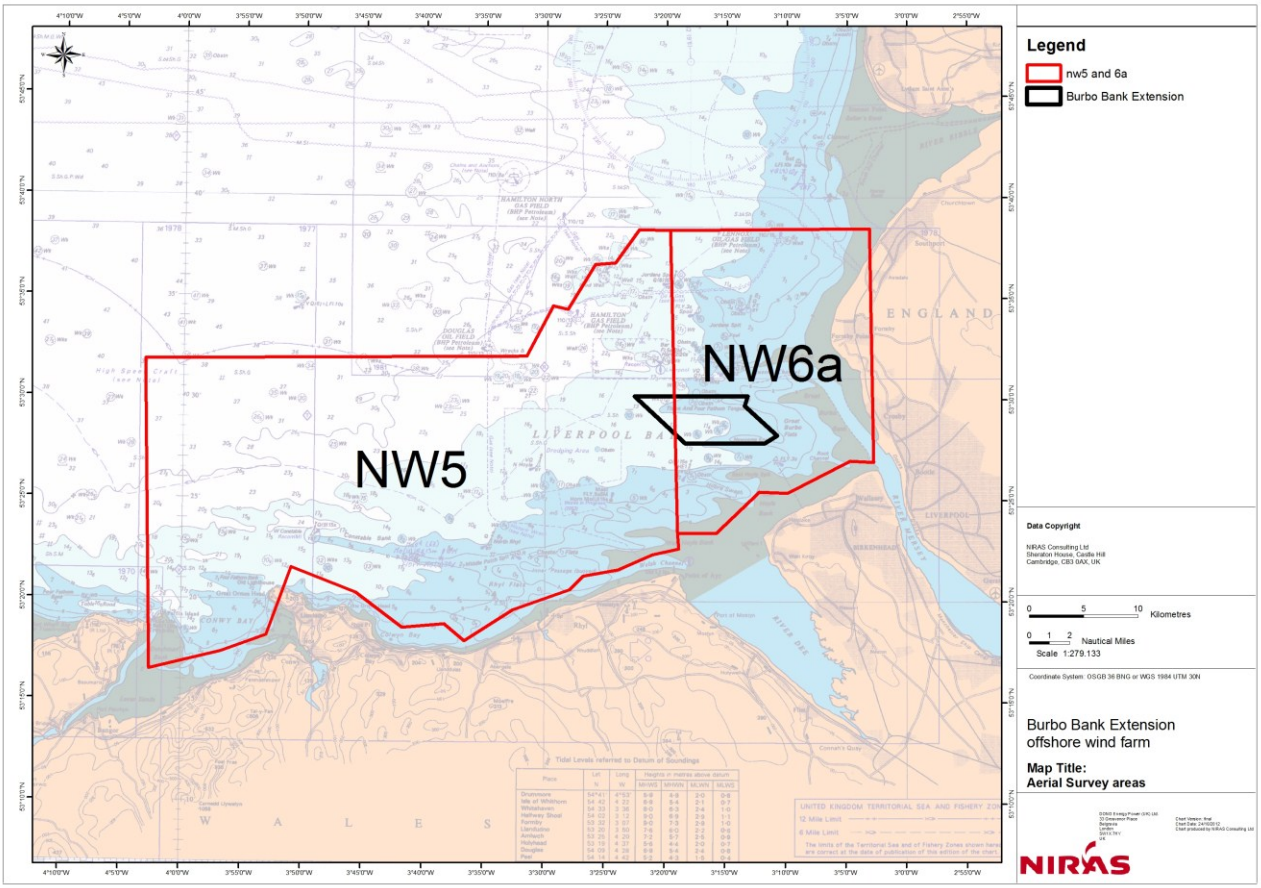


Figure 5: Aerial survey areas for WWT/ESAS surveys in relation to Burbo Bank Extension.

4.5.4 Surveys of NW5 were undertaken at various time of year; relevant to the following periods of birds annual cycles:

- Five surveys in early winter (2 and 30 November 2004, 16 October 2005, 10 and 22 November 2005).
- Five surveys in mid-winter (23 January 2005, 16 February 2005, 8 December 2005, 10 February 2006 and 23 January 2007.
- Two late winter surveys (6 March 2006 and 24 February 2007)
- One breeding (incubation) period survey (11 May 2005)
- Two breeding (chick rearing) period surveys (16 June 2005, 27 June 2006)
- Two post-breeding/moult period surveys (21 July 2005, 4 August 2005)

Data collection

4.5.5 The DTI commissioned aerial surveys were undertaken using the methodology developed by the National Environment Research Institute in Denmark (Kahlert et al., 2000). The methods utilised were based on physical observations rather than digital imaging although are directly comparable to those used for the Burbo Bank Extension Offshore Wind Farm.

4.5.6 A number of Partenavia PN68 aircraft were used, flying at an altitude of 76m and a speed of approximately 185km^{-1}. A series of north-south transects were spaced 2 km apart to cover nearshore waters. For each bird or flock of birds, the species, number, behaviour, distance band and the time at which it was perpendicular to the flight path of the aircraft was recorded. As with the 2010-2011 Burbo Bank Extension Offshore Wind Farm surveys, a precautionary approach to species identification was taken.

Data analysis

4.5.7 In the same way as for boat-based based surveys, population sizes were determined for all species by the calculation of line transect density values, which could then be extrapolated to the wider area.

4.5.8 The Countryside Council for Wales (CCW) compiled a database using the DTI commissioned data with those found in the Joint Nature Conservation Committee's (JNCC) European Seabirds at Sea (ESAS) database and any other relevant data available (WWT Consulting, 2010). The compiled CCW database provides GIS layers of the abundance and distribution of seabirds in Welsh waters and indicates the density of flying and sitting species on a 3km grid scale. This data, therefore, is designed to demonstrate relative risk to seabird species around the Welsh coast and provide important context against aerial and boat –based site-specific data for the Burbo Bank Extension Offshore Wind Farm site.

4.5.9 The database was analysed to provide maximum densities of birds for various areas relevant to Burbo Bank Extension Offshore Wind Farm:

- Burbo Bank Extension Offshore Wind Farm
- Burbo Bank Offshore Windfarm
- NW5 Count Area
- NW6a Count Area

4.5.10 The database provided by CCW provides the most appropriate data set for use in supporting the site specific data for Burbo Bank Extension. However, the database does not provide insight into seasonal shifts in abundance. As such, JNCC separately supplied the aerial data from 2001-2007 (which is incorporated into the CCW database); this data was analysed separately to explore seasonal abundances.

4.6 Hi-Def/ WWT aerial surveys of Liverpool Bay SPA 2011

4.6.1 The objectives of these aerial surveys were to conduct two digital aerial surveys of inshore waterbirds to give the distribution and population size within the Liverpool Bay SPA. It was aimed to gain population estimates for common eider, red-breasted merganser, all divers, cormorant, shag, little gull and auks in addition to the two qualifying species for the SPA, red-throated diver and common scoter (Hi-Def/WWT, 2011).

4.6.2 The total survey area in Liverpool Bay (2034 km^2) was divided into two blocks and both blocks were surveyed twice. Transects were placed 3 km apart in wider areas, with 1 km spacing in higher intensity areas (Figure 6).

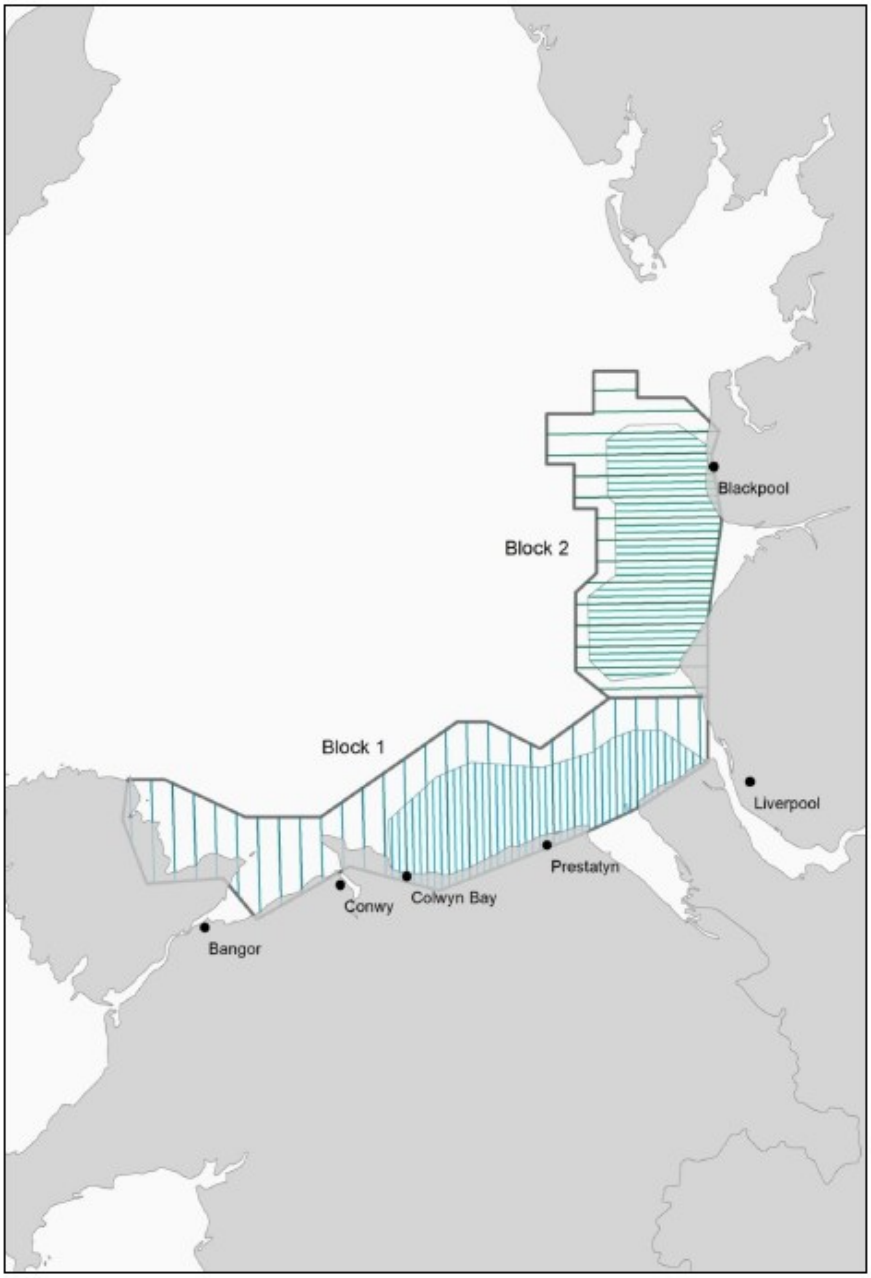


Figure 6: Aerial survey areas for Hi-Def/WWT surveys in 2011 (Source: Hi-Def/WWT, 2011).

4.7 Foraging ranges

4.7.1 In order to provide important context on the potential effects of offshore wind farms on bird species, it is appropriate to determine the foraging range of breeding seabirds and establish whether such ranges from designated sites overlap with the extent of the proposed development (Thaxter *et. al*., 2012). Representative foraging ranges can therefore assist in highlighting sensitive ornithological receptors at the Burbo bank Extension Offshore Wind Farm site.

4.7.2 Of most significance is the distance at which most foraging flights occur, rather than extreme distances (either maximum or minimum) as the overall flight activity of a species is likely to be most significant in determining the risk associated to each species' population (Langston, 2010). Therefore the mean-maximum foraging ranges presented by Thaxter *et. al.* (2012) are considered to offer the most realistic measure of the potential of an overlap of foraging ranges from a designated site and the extent of the proposed wind farm. This data is presented in Table 4, which also shows mean foraging ranges (which are deemed insufficiently precautionary in terms of considering the extent of foraging behaviour is likely to be exhibited by species at adjacent seabird colonies).

4.7.3 The mean-maximum foraging ranges given in Table 4 can then be compared to the distance Burbo Bank Extension Offshore Wind Farm site lies from the highlighted designated sites in Table 1. For species with extensive foraging ranges (e.g. gannet and gull species) designated sites outside of the region of immediate interest may need to be taken in to consideration. When small differences occur between the mean-maximum foraging ranges of individual species and the distance from Burbo Bank Extension Offshore Wind Farm, a precautionary approach is applied when identifying potential sensitive receptors.

Table 4: Foraging ranges of selected species, (taken from Thaxter *et al.* 2012)

Species	Foraging range (km)			Assessment confidence	European site where interest feature
	Max	Mean-max	Mean		
Fulmar	580	**400**	48	Low	None
Manx shearwater	330	**330**	-	Moderate	Aberdaron Coast & Bardsey Island SPA (185 km); Skomer & Skokholm SPA (309 km); Copeland Islands SPA (191 km)
Gannet	590	**282**	126	Highest	None
Cormorant	35	**25**	5	Moderate	None
Shag	17	**15**	6	Moderate	None
Black-headed gull	40	**22**	11	Uncertain	Ribble & Alt Estuaries SPA (6.5 km)
Common gull	50	**50**	25	Poor	None
Herring gull	92	**61**	11	Moderate	Morecambe Bay SPA (52 km)
Lesser black-backed gull	181	**132**	65	Moderate	Ribble & Alt Estuaries SPA and Ramsar (6.5 km); Morecambe Bay SPA (52 km); Bowland Fells SPA (55 km)
Kittiwake	120	**62**	27	Highest	None
Sandwich tern	54	**32**	11	Moderate	None (although interest feature on passage for Dee Estuary 8.2km distant)
Common tern	30	**15**	5	Moderate	Mersey Narrows pSPA (6 km); Ribble & Alt Estuaries SPA (6.5 km); Dee Estuary SPA (8.2 km).
Arctic tern	30	**24**	7.1	Moderate	None
Little tern	11	**6**	2	Low	None
Guillemot	135	**71**	20	Highest	None
Razorbill	100	**58**	24	Moderate	None
Puffin	200	**87**	4	Low	None

5 Survey results

5.1 Boat based surveys

2011 surveys of Burbo Bank Extension Offshore Wind Farm

5.1.1 Thirty-seven bird taxa were recorded during the surveys, of which twenty-eight were identified to species level. The majority of species involved were true seabirds including Manx shearwater, gannet, three species of auk, eight species of gull, three species of tern and two species of skua.

5.1.2 In addition several coastal (e.g. curlew) or migrating terrestrial (e.g. meadow pipit, common swift) species were recorded in low numbers. These species were present in insignificant numbers and/or of no conservation significance and are not discussed further in this report.

5.1.3 Figure 7 presents the total number of bird observations in each survey month. Bird numbers were clearly lowest in April and May, with a large post-breeding influx occurring in July involving numbers of Manx shearwater and guillemot in addition to kittiwake and gannet.

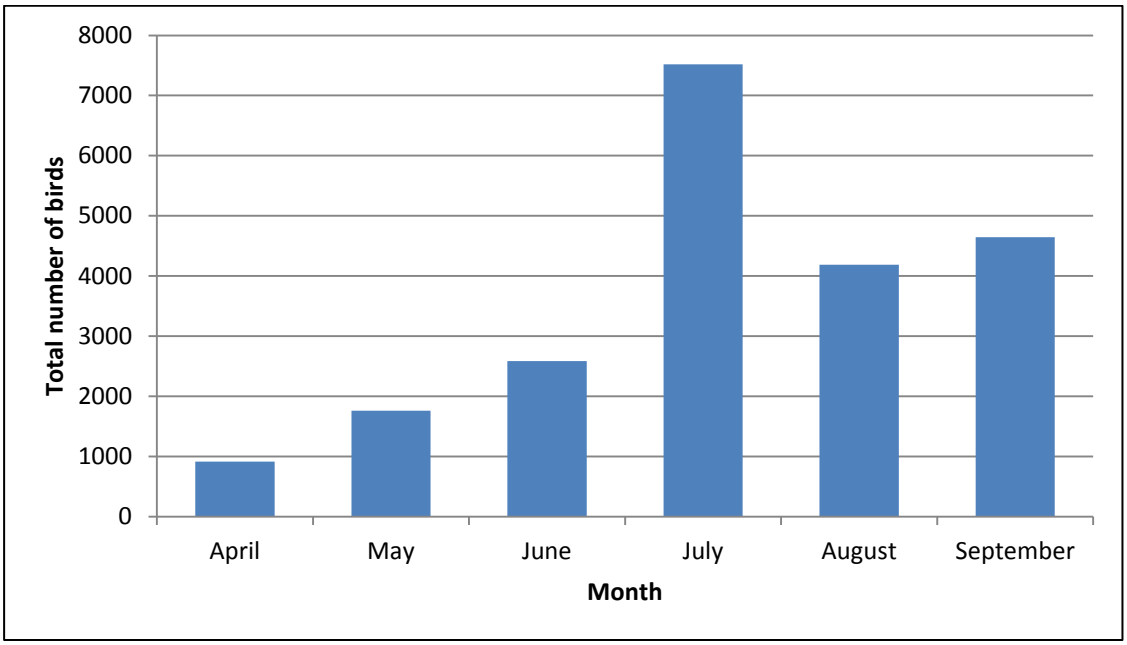


Figure 7: Counts of all bird species during 2011 boat-based surveys

5.1.4 Tables 6 and 7 provide maximum and mean data respectively, on population size estimates and density of relevant bird species recorded during the 2011 boat-based surveys. Data is presented for the Burbo Bank Extension Offshore Wind Farm area plus this area including a 4km buffer. The data of the wind farm area plus buffer zone are carried forward in this assessment; this area includes the area of the original Burbo Bank Offshore windfarm.

5.1.5 Distance sampling was found to have limited value for all species with the exception of guillemot. Models were also run for herring gull, lesser black-backed gull, Sandwich tern and common tern, with confidence intervals found to be of a large magnitude for all of these species (Table 5 indicates population estimates). Tables 6 and 7 present data on densities and populations based on a manual correction factor

and these values are taken forward to the assessment with the exception of guillemot, where results from Distance sampling are used.

Table 5: Population estimates derived from Distance sampling for key bird species, where sufficient were available (with lower and upper confidence limits).

	April	May	June	July	August	Sept
Guillemot	75 (18-303)	1,823 (1,131-2,954)	2,131 (1,136-3,999)	4,219 (2,431-7,323)	2,684 (1,778-4,052)	1,638 (676-3,970)
Common tern	230 (88-605)	-	462 (173-1,233)	116 (50-663)	599 (164-2,187)	-
Herring gull	835 (246-2,828)	-	205 (5-8,577)	383 (71-2,070)	357 (89-1,435)	334 (83-1352)
Lesser black-backed gull	418 (57-3,090)	290 (107-785)	1,155 (650-2,052)	469 (244-901)	1,335 (571-3,122)	661 (110-3,957)
Sandwich tern	-	-	-	1,563 (15-158,830)	1,243 (141-10,962)	293 (160-536)

Table 6: Maximum population estimates and densities for species recorded on boat-based surveys 2011

Common Name	WF population	WF + 1 km buffer population	WF + 4 km buffer population	Burbo Ext. Density inds./km^2	WF +1km Density inds./km^2	WF +4km density inds./km^2
Red-throated diver	0	0	0	0	0	**0**
Great crested grebe	3	3	40	0.07	0.04	**0.19**
Manx Shearwater	908	1425	2937	22.90	16.78	**13.96**
Fulmar	0	0	6	0	0	**0.03**
Gannet	121	187	429	3.04	2.20	**2.04**
Cormorant	94	314	555	2.38	3.70	**2.64**
Common scoter	6	156	166	0.14	1.84	**0.79**
Red-breasted merganser	0	0	13	0	0	**0.06**
Great skua	4	8	6	0.09	0.09	**0.03**
Arctic skua	6	11	34	0.14	0.13	**0.16**
Arctic/long-tailed skua	0	0	2	0	0	**0.01**
Skua sp.	11	17	23	0.27	0.20	**0.11**
Great black-backed gull	18	32	160	0.45	0.38	**0.76**
Lesser black-backed gull	400	626	606	10.09	7.37	**2.88**
Black-backed gull sp.	0	14	15	0	0.17	**0.07**
Herring gull	132	310	400	3.32	3.65	**1.90**
Common gull	3	49	40	0.07	0.58	**0.19**
Black-headed gull	8	7	13	0.20	0.08	**0.06**

Kittiwake	252	437	707	6.35	5.15	**3.36**
Little gull	3	7	13	0.07	0.08	**0.06**
Gull sp.	34	78	97	0.86	0.92	**0.46**
Sandwich tern	86	126	177	2.17	1.48	**0.84**
Arctic tern	0	0	8	0	0	**0.04**
Common tern	59	334	402	1.49	3.93	**1.91**
Common/Arctic tern	101	134	246	2.54	1.58	**1.17**
Tern sp.	16	92	2	0.41	1.08	**0.01**
Guillemot	1249	1966	3448	31.49	23.15	**16.39**
Razorbill	46	114	360	1.17	1.34	**1.71**
Auk sp.	7	9	23	0.17	0.11	**0.11**

Table 7: Mean population estimates and densities for species recorded on boat-based surveys 2011

Common Name	WF population	WF plus 1 km buffer population	WF + 4 km Buffer population	Burbo Ext. Density inds./km^2	WF +1km Density inds./km^2	WF +4km density inds./km^2
Red-throated diver	0	0	0	0	0	**0**
Great crested grebe	0	1	6	0.01	<0.01	**0.03**
Manx Shearwater	153	239	572	3.86	2.82	**2.72**
Fulmar	0	0	2	0	0	**0.01**
Gannet	42	68	210	1.05	0.80	**1.00**
Cormorant	22	107	318	0.56	1.26	**1.51**
Common scoter	2	31	36	0.04	0.37	**0.17**
Red-breasted merganser	0	0	2	0	0	**0.01**
Great skua	1	3	2	0.03	0.03	**0.01**
Arctic skua	2	3	8	0.04	0.04	**0.04**
Arctic/long-tailed skua	0	0	0	0	0	**<0.01**
Skua sp.	2	3	4	0.05	0.03	**0.02**
Great black-backed gull	8	18	50	0.19	0.21	**0.24**
Lesser black-backed gull	118	247	320	2.97	2.91	**1.52**
Black-backed gull sp.	0	3	2	0	0.03	**0.01**
Herring gull	36	127	227	0.91	1.49	**1.08**
Common gull	1	11	11	0.02	0.13	**0.05**
Black-headed gull	1	1	2	0.03	0.01	**0.01**
Kittiwake	110	189	429	2.78	2.23	**2.04**
Little gull	0	2	4	0.01	0.02	**0.02**
Gull sp.	8	17	46	0.21	0.20	**0.22**
Sandwich tern	19	43	55	0.49	0.51	**0.26**

Arctic tern	0	0	1	0	0	**<0.01**
Common tern	16	90	145	0.40	1.06	**0.69**
Common/Arctic tern	17	22	42	0.42	0.26	**0.20**
Tern sp.	3	15	20	0.07	0.18	**<0.01**
Guillemot	519	1123	1660	13.09	13.23	**7.89**
Razorbill	8	19	61	0.20	0.22	**0.29**
Auk sp.	1	2	4	0.03	0.02	**0.02**

5.1.6 The recorded behavioural activity of each bird seen in the boat-based surveys was analysed, with the Table 8 indicating the proportion of each spent undertaking four behavioural categories (foraging, resting. Associating with structures and transiting).

Table 8: Behavioural analysis of species recorded during boat-based surveys of Walney Extension

Common Name	Foraging	Resting	Associating with structures	Transiting
Manx Shearwater	28.2	18.7	**0**	53.1
Gannet	22.8	18.4	**0**	58.8
Cormorant	0	1.3	**42.5**	56.2
Common scoter	0	0	**0**	100
Great skua	0	50	**0**	50
Arctic skua	27.3	18.2	**0**	54.5
Great black-backed gull	5.3	26.3	**0**	68.4
Lesser black-backed gull	3.5	32.0	**0**	64.5
Black-backed gull sp.	0	0	**0**	100
Herring gull	0	15.4	**30.2**	54.4
Common gull	0	0	**0**	100
Black-headed gull	0	0	**0**	100
Kittiwake	7.8	32.0	**0**	60.2
Little gull	50	0	**0**	50
Gull sp.	1.8	31.6	**3.5**	63.1
Sandwich tern	21.4	0	**0**	78.6
Common tern	8.7	29.4	**0**	61.9
Common/Arctic tern	14.6	24.4	**4.9**	56.1
Tern sp.	44.2	0	**0**	56.8
Guillemot	0.4	32.6	**0**	67.0
Razorbill	0	48	**0**	52
Auk sp.	0	47	**0**	53

5.1.7 Foraging behaviour was most commonly observed for tern species, gannet, Manx shearwater and Arctic skua, although the representative sample size for the latter species is low. Auk species were most commonly recorded during the surveys (Tables 6 and 7) were rarely observed foraging and were almost entirely found to be resting or transiting the site. The association with structures (e.g. buoys) was restricted to cormorants and gull species (with a small number of common tern). Several species were recorded as transiting the site only, with these being common scoter, common gull and black-headed gull with a large proportion of Sandwich tern (78%) also recorded transiting.

2006-2009 monitoring surveys of Burbo Bank Operational Wind Farm

Overview

5.1.8 Table 9 presents raw count data of the construction and post-construction monitoring boat-based surveys at Burbo Bank Offshore Wind farm. The annual monitoring reports did not provide population size or density estimations (Hyder Consulting, 2008) and as such data presented here are indicative only, although it provides significant information on the abundance of key species in the vicinity of Burbo Bank Extension Offshore Wind Farm.

5.1.9 Species composition was broadly similar to that seen in the 2011 surveys of Burbo Bank Extension Offshore Wind Farm, with numbers of common scoter, red-throated diver, common tern and little gull present, in albeit small numbers. Notably, Manx shearwater was rare and gannet also uncommon. The number of birds recorded during the monitoring surveys was notably low, indicating that the operational wind farm site is of lower value to other areas of Liverpool Bay. It is considered that an influence on bird numbers may be the presence of the busy Queens Channel shipping lane directly to the east of the Burbo Bank site, which may create significant levels of background disturbance.

Results and relevance to Burbo Bank Extension

5.1.10 No significant change in bird numbers was noted during and after the construction of the operational wind farm (Table 9), suggesting that impacts on the insignificant numbers of birds present was minimal. The highest counts of red-throated diver were in April 2007 (9 birds) and February 2008 (10 birds). Common scoters were present in low numbers, with a peak of 47 birds in January 2008. This species is known to aggregate in sizeable flocks when foraging (Cramp & Simmons, 1977, Webb et al., 2006) and the numbers seen during the surveys were considered to indicate a low level of commuting behaviour rather than foraging with the Burbo Bank area.

5.1.11 These results, while not providing quantitative supporting data for potential impacts such as collision, do provide valuable baseline information on the importance (or lack thereof) of Burbo Bank Extension for the two species for which Liverpool Bay SPA is designated.

Table 9: Raw count boat-based data from during and post-construction boat based ornithological surveys carried out as part of Burbo Bank Offshore Wind Farm FEPA monitoring

Species	May 06	Jun 06	Jul 06	Aug 06	Sep 06	Oct 06	Nov 06	Jan 07	Feb 07	Mar 07	Apr 07	Jun 07	Jul 07	Nov 07	Dec 07	Jan 08	Feb 08	Apr 08	May 08	Jul 08	Sep 08	Nov 08	Jan 09	Feb 09	Apr 09
Cormorant	9	16	29	13	33	11	11	16	79	17	2	18	11	34	48	52	37	62	10	32	39	42	41	55	59
Great northern Diver	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0
Red-throated Diver	3	0	0	3	0	4	3	7	1	3	9	0	0	0	6	4	10	0	1	1	0	3	3	3	1
Great crested Grebe	0	0	0	0	0	0	2	1	0	0	2	0	0	0	1	0	0	0	0	0	1	0	0	1	1
Kittiwake	4	1	10	1	3	0	1	1	0	1	0	2	0	0	0	4	0	2	21	2	2	1	1	1	2
Med. Gull	0	1	1	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Little Gull	0	0	0	0	1	0	0	0	0	0	0	0	7	0	0	0	0	1	0	0	0	0	2	0	0
auk sp.	9	12	50	6	15	11	13	13	1	12	24	3	13	34	48	52	37	76	20	36	29	38	36	41	42
Gannet	0	0	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	2	1	1	2
Manx Shearwater	0	0	0	00	0	0	0	0	0	0	0	6	0	0	0	0	0	1	0	0	0	0	0	0	0
Common Scoter	0	0	0	7	12	0	0	9	8	10	0	0	0	16	34	47	25	0	0	0	18	21	5	19	11

Common Tern	4	0	0	18	2	0	0	0	0	0	0	6	19	0	0	0	0	14	10	4	1	0	0	0	0
Sandwich Tern	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0
Wader sp.	0	0	0	0	0	2	0	0	1	0	0	0	4	0	30	0	0	0	0	0	0	0	0	0	0

5.2 Aerial surveys

2010-2011 surveys at Burbo Bank Extension Offshore Wind Farm

5.2.1 A total of fourteen bird species and six taxonomic groups were identified from the images. Gulls and guillemot/razorbill were the two species groups that were recorded most frequently in the analysis of all six surveys. Other frequently recorded species were red-throated/black-throated divers, cormorant, shag and puffin. Table 10 presents the number of each species detected from the images for each survey.

Table 10: Raw count data from aerial surveys of Burbo Bank Extension 2010-2011

Species/Group	10th Nov 2010	8th Dec 2010	24th Feb 2011	3rd Mar 2011	18th Mar 2011	8th Apr 2011	**Total**
Diver sp.	10	3	13	25	10	5	**66**
Gannet	4	-	3	-	1	-	**8**
Cormorant	-	1	-	2	5	-	**8**
Shag	-	1	-	-	-	-	**1**
Cormorant/shag	8	3	20	18	8	1	**58**
Scaup	-	-	33	-	-	-	**33**
Common scoter		6	-	32	5	-	**43**
Red-breasted merganser	-	-	2	-	-	-	**2**
Common gull	59	9	41	38	20	5	**172**
Herring gull	78	1	41	69	16	14	**219**
Lesser black-backed gull	1	-	3	8	1	3	**16**
Great Black-backed gull	21	2	17	4	-	1	**45**
Black-headed gull	3	-	1	5	1	3	**13**
Little gull	1	-	-	-	4	7	**12**
Kittiwake	5	1	20	3	6	9	**44**
Grey gull sp.	78	51	196	44	-	68	**437**
Gull sp.	-	142	43	45	129	18	**377**
Tern sp.	-	-	-	5	-	18	**23**
Razorbill/guillemot	163	114	503	106	152	155	**1193**
Puffin	34	-	106	2	-	3	**145**

5.2.2 For each bird species or species group the overall density was calculated, which was then extrapolated to provide an estimate for the total population within the 210.5km^2 study area (Table 11).

Table 11: Density (D) and population size (N) estimates for aerial surveys at Burbo Bank Extension 2010-2011

Species/Group	10th Nov 2010		8th Dec 2010		24th Feb 2011		3rd Mar 2011		18th Mar 2011		8th Apr 2011		**MAX**	
	D	N	D	N	D	N	D	N	D	N	D	N	**D**	**N**
Diver sp.	0.20	43	0.07	14	0.29	60	0.61	129	0.22	46	0.15	32	**0.61**	**129**
Gannet	0.08	17	0.00	0	0.07	14	0.00	0	0.02	5	0.00	0	**0.08**	**17**
Cormorant	0.00	0	0.02	5	0.00	0	0.05	10	0.11	23	0.00	0	**0.11**	**23**
Shag	0.00	0	0.02	5	0.00	0	0.00	0	0.00	0	0.00	0	**0.02**	**5**
Cormorant/shag	0.16	34	0.07	14	0.44	93	0.44	93	0.17	37	0.03	6	**0.44**	**93**
Scaup	0.00	0	0.00	0	0.73	153	0.00	0	0.00	0	0.00	0	**0.73**	**153**
Common scoter	0.12	26	0.00	0	0.71	149	0.12	26	0.00	0	0.00	0	**0.71**	**149**
Red-breasted merganser	0.00	0	0.00	0	0.04	9	0.00	0	0.00	0	0.00	0	**0.04**	**9**
Common gull	1.21	254	0.20	41	0.91	191	0.93	196	0.43	91	0.15	32	**1.21**	**254**
Herring gull	1.59	336	0.02	5	0.91	191	1.69	357	0.35	73	0.43	90	**1.69**	**357**
Lesser black-backed gull	0.02	4	0.00	0	0.07	14	0.20	41	0.02	5	0.09	19	**0.20**	**41**
Great Black-backed gull	0.43	90	0.04	9	0.38	79	0.10	21	0.00	0	0.03	6	**0.43**	**90**
Black-headed gull	0.06	13	0.00	0	0.02	5	0.12	26	0.02	5	0.09	19	**0.12**	**26**
Little gull	0.02	4	0.00	0	0.00	0	0.00	0	0.09	18	0.21	45	**0.21**	**45**
Kittiwake	0.10	22	0.02	5	0.44	93	0.07	16	0.13	27	0.28	58	**0.44**	**93**
Grey gull sp.	1.59	336	1.12	235	4.33	911	1.08	227	0.00	0	2.08	438	**4.33**	**911**
Gull sp.	0.00	0	3.11	654	0.95	200	1.10	233	2.63	589	0.55	116	**3.11**	**654**
Tern sp.	0.00	0	0.00	0	0.00	0	0.12	26	0.00	0	0.55	116	**0.55**	**116**
Razorbill/guillemot	3.33	702	2.49	525	11.11	2338	2.60	548	1.91	694	4.74	998	**11.11**	**2338**
Puffin	0.70	146	0.00	0	2.34	493	0.05	10	0.00	0	0.09	19	**2.34**	**493**

WWT/ESAS/BERR surveys

5.2.3 The database provided by CCW was analysed to provide maximum and mean densities of bird species at various zones within the northern Irish Sea. Table 12 summarises this data, where it is combined for sitting and flying birds and for relevant zones i.e. NW5 and NW6.

Table 12: Species densities (km^2) for Burbo Bank Extension in addition to NW5 and NW6 count areas extracted from aerial survey data 2001 - 2009.

Species	NW5	NW6a	Burbo Bank Extension Offshore Wind Farm
Red-throated diver	0.36	0.79	0.19
Great northern diver	0.04	0.06	0.06
Diver sp.	1.33	1.33	0.58
Fulmar	1.78	0.96	0.01
Manx shearwater	2.84	0.35	0.35
Gannet	2.75	1.96	0.43
Cormorant	0	0.01	0
Shag	3.50	0.18	0
Cormorant/shag	6.09	9.02	2.31
Common scoter	38.10	22.07	0.24
Red-breasted merganser	0.93	0.31	0
Black-headed gull	0.69	0.50	0.03
Common gull	3.73	0.44	1.09
Herring gull	6.88	3.44	1.33
Lesser black-backed gull	2.43	2.88	2.88
Great black-backed gull	1.33	2.69	2.69
Kittiwake	5.30	1.78	1.69
Common/Arctic tern	2.85	2.85	1.55
Sandwich tern	0.67	0.20	0.44
Guillemot	3.57	3.57	1.08
Razorbill	1.09	0.12	1.09
Auk sp.	10.40	3.57	1.98
Puffin	0	0	0

5.2.4 Data for key species was analysed in order to present seasonal shifts in abundance. Appendix 3 presents data for common scoter, red-throated diver, Manx shearwater and auk species from the 2001 - 2006 extent of the surveys.

5.2.5 Common scoter abundance was consistently high throughout the winter months within NW5, with peaks occurring in November and January. A smaller post-breeding occurrence of the species was noted to occur during July and August, with the species being virtually absent in May and June. Similar patterns of occurrence occurred in NW6, although levels of abundance were notably lower in this count sector. Counts extracted from the aerial surveys within Burbo Bank Extension were extremely low, with numbers in double figures occurring in January only. Mean counts were of 4 individuals or below in each month of the year.

5.2.6 Red-throated divers were present in all months from November to April in NW5. The peak count occurred in January (of 13 birds), with this month also supporting the highest mean count. Within Burbo Bank Extension a maximum count of just 2 birds occurred (in January), with other records being from February, March and December.

5.2.7 Manx shearwaters were present in peak numbers in July within NW5 (both maximum and mean counts) with a very limited number of individuals of this species recorded in any other months. Within NW6, lower numbers were recorded although the peak was again in July, with moderate numbers also seen in May.

5.2.8 Auks were predictably widespread in the aerial surveys and occurred in consistent numbers in NW5 from December – July. A peak count occurred in November, while there is evidence when examining mean counts of an early spring peak. Auk abundance within NW6 were considerably lower, although a peak in November also occurred within this zone. Auks within Burbo Bank Extension also reached somewhat of a peak during November, with another peak occurring in March. Auks were found to be present throughout the yearly cycle within the wind farm foot print.

Hi-Def/WWT aerial surveys

5.2.9 Results for key species from the Hi-Def / WWT surveys of Liverpool Bay SPA in February and March 2011 are given in Table 13 for what were deemed to be key species (common scoter, red-throated diver, cormorant and auk species).

Table 13: Hi-Def / WWT aerial survey results 2011

Species	Population estimate	Density (km^2)
Common scoter	35,643	17.52
Red-throated diver	715 (+1188 diver sp.)	0.35 (0.58)
Cormorant	171 (point estimate)	0.08
Auks	7992	3.92

5.2.10 Red-throated diver density was similar to that estimated for the NW5 and NW6 count sectors during previous survey work. Common scoter density was notably lower than these surveys, although this is unsurprising due to surveys considering the whole of Liverpool Bay. NW5 incorporates the core North Wales coastal area of the SPA for this species, where peak densities occur.

5.2.11 Appendix 4 presents figures indicating the distribution of red-throated diver and common scoters during the two surveys undertaken in 2011. In February 2011, red-throated diver density was concentrated off Formby Point on the Lancashire coastline with the species also widespread along the North Wales Coastline. In March 2011, areas of Gwynedd and Clwyd held the highest concentrations, although notable numbers were still present off Formby Point. Common scoters were found to be present in three discreet core areas within both February and March 2011 surveys. These occurred off the Lancashire coast near Blackpool, off Formby Point and the north Wales Coast. Few scoters were again found to be present in the vicinity of Burbo Bank Extension.

Summary

5.2.12 Appendix 5 shows the results of the site specific boat-based and aerial surveys at Burbo Bank Extension in terms of densities and compares this with maximum densities derived from the historic data (CCW database) and other surveys (e.g. the Hi-Def/JNCC survey in 2011). This data is also presented graphically in Appendix 6a, where mean and maximum densities are compared. The majority of species densities recorded at Burbo Bank Extension are in range of those recorded in Nw5 and NW6a with notable exceptions including common scoter (higher densities in NW5 / NW6a) whereas Manx Shearwater maximum densities were considerably higher in the Burbo Bank Extension boat-based surveys.

5.2.13 Appendix 3 indicates raw count data by month recorded in the aerial survey data provided by JNCC. Appendix 6b shows densities recorded in the aerial surveys, with the majority species recording lower densities than recorded at Burbo Bank Extension. It is considered that this is a reflection on the survey technique rather than displaying any population increases within the site specific surveys. The CCW database provides a more appropriate comparison and therefore supporting information for the assessment.

6 Identification of important ornithological receptors

6.1 Defining species importance

6.1.1 As part of the EIA process, an importance or sensitivity estimate needs to be assigned to relevant species recorded during the surveys as occurring within Burbo Bank Extension or adjacent areas. Guidance on assigning appropriate values is taken from IEEM (2010) with reference also made to Percival (1999). The value of a species is derived from a series of given criteria (Table 14) which takes into account the significance of the numbers of the species recorded at the site and the species conservation status.

6.1.2 The criteria for species value take the form of a geographic frame of reference (IEEM 2010). With regards to the Burbo Bank Extension Offshore Wind Farm the following categories are deemed appropriate:

- International
- National
- Regional
- Local / within zone of influence only

6.1.3 The conservation status of each species incorporates whether it is cited as an interest feature in a site of international (i.e. SPA, Ramsar) or national (i.e. SSSI, NNR) significance. The foraging range of species provides key guidance on the likely origin of species recorded within any survey area, and as such whether there is the potential to affect the integrity of designated sites

6.1.4 Species listed on Annex 1 of the EU Birds Directive or Schedule 1 of the wildlife and Countryside Act (1981, as amended) are deemed to be of national significance. Additional guidance is sought from Birds of Conservation Concern (BoCC; Eaton et. al., 2009) and the UK Biodiversity Action Plan (BAP). Species detailed on the Red list of BoCC are considered to be of regional significance, with all other species (Amber and Green lists) being of local value only.

6.1.5 The population size of individual species recorded at Burbo Bank Extension Offshore Wind Farm is compared to 1% threshold levels for international, national and regional importance in order to provide

further evidence of the value of the species involved. Threshold levels were taken from Stone et al. (1995), Wetlands International (2006) and Baker et al. (2006) with further guidance and BirdLife International (2004), Mitchell et al. (2004), Banks et al. (2007) and Burton et al. (2012).

6.1.6 The seemingly arbitrary 1% threshold level signifying importance has in fact been used extensively for site designation and in assessing potential impacts of proposed developments (Skov *et al*. 2007) and its use here is considered appropriate. Where possible, thresholds are taken from temporally appropriate population levels, with particular attention given to breeding, wintering and passage populations. The density of species recorded at Burbo Bank also provides important context in presenting data that are directly comparable to wider studies of the Irish Sea, thus giving further indication of the importance of populations occurring at Burbo Bank extension Offshore Wind Farm.

Table 14: Criteria for establishing importance of species recorded at Burbo Bank Extension

Importance	Criteria
International	- Population present within survey area exceeds 1% threshold of international importance - Cited interest feature of connected SPA[8] or Ramsar
National	- Cited interest feature of a connected SSSI - Species listed on Annex 1 of the EU Birds Directive - Species listed on Schedule 1 of the Wildlife & Countryside Act - Population present within survey area exceeds 1% threshold for national importance. - Species that contributes to the assemblage of an SPA/Ramsar
Regional	- Species listed on the BoCC Red list[9] - UK Bap Priority Species[10] - Species considered to be of regional significance due to population size or distribution restrictions - Regularly occurring migratory species which are either rare or vulnerable, or warrant special consideration on account of the proximity of migration routes, or breeding, moulting, wintering or staging areas in relation to the proposed development
Local / Within zone of influence only	- All other species of conservation interest i.e. those species on the BoCC Amber and Green lists[2].

[8] Including species listed in original SPA citation and/or those included in the 2001 review (Stroud *et al*., 2001)

[9] Eaton *et al*. (2009)

[10] http://jncc.defra.gov.uk/page-5163

6.2 Species accounts

Red-throated diver

6.2.1 Red-throated divers that winter in north-west Europe breed in Scandinavia, Russia and Greenland and to a lesser extent northern Scotland, Orkney and Shetland (Forrester et al., 2008). In the UK, the breeding population is estimated at 1255 pairs (Dillon et al., 2009). They are almost entirely marine in the winter months, with the vast majority of the population wintering in the North Sea and Baltic Seas (Brown & Grice, 2005).

6.2.2 The British wintering population is aggregated in notable numbers in several areas, from the Moray Firth in the north to Norfolk and the Thames Estuary off Kent and Essex. They are generally less abundant (although still common) on the west coast. Red-throated divers do not generally arrive in English (or Welsh) waters until mid to late September, with numbers peaking in December, January or early February. Numbers subsequently fall in late February to early March as birds depart for their breeding grounds (Brown & Grice, 2005). The British winter population is currently estimated at 17,166 individuals (O'Brien et al., 2008) which represents between 10 and 19% of the north-west Europe biogeographical non-breeding population. Offshore surveys (particularly for wind farm developments) have led to the identification of much larger numbers of this species than previously known.

6.2.3 In the UK, wintering red-throated divers are associated with shallow (between 0-20m deep and less frequently in depths of around 30m) inshore waters (Skov et al., 1995). Their diet is principally small fish of a variety of species particularly of the cod family, herring and sprats (Cramp & Simmons, 1977).

6.2.4 In a review of the sensitivity of seabird species to offshore wind farms, Garthe and Hüppop (2004) found that red-throated divers had the second highest sensitivity score. Potential effects on the species include displacement due to disturbance from the turbines or from maintenance activities.

6.2.5 Red-throated divers are one of the two species for which Liverpool Bay SPA is designated. The species occurs throughout the SPA with highest densities occurring off the Ribble Estuary, North Wales and the North Wirral Foreshore (Webb et al., 2006). A population of 922 individuals occurs, which accounts for 5.4% of the British population and is of European importance.

6.2.6 Table 15 summarises the conservation and Liverpool Bay/Burbo Bank Extension status of red-throated diver.

Table 15: Red-throated diver status at Burbo Bank Extension Offshore Wind Farm

	Red–throated diver
Conservation status	Cited for Liverpool Bay SPA (winter) Annex 1 of the EU Birds Directive Schedule 1 of the WCA BoCC Amber
International threshold	540
National threshold	170
Regional threshold	50
BBW02 Aerial (2011) population	129 (March)
BBW02 Aerial (2011) density	0.61/km^2

BBW02 Boat-based (2011) population	-
BBW02 Boat-based (2011) density	-
BBW02 Aerial (2001-2009) density	0.77/km^2
NW5 Aerial density (2001-2009)	1.69/km^2
NW6a Aerial density (2001-2009)	2.12/km^2
Hi-Def/WWT Aerial density (2011)	0.35/km^2

6.2.7 In addition to its status as an interest feature of Liverpool Bay SPA, red-throated divers are also listed on Annex 1 of the EU Birds Directive and Schedule 1 of the Wildlife & Countryside Act.

6.2.8 In terms of the population densities estimated at Burbo Bank Extension Offshore Wind Farm, the 2011 aerial surveys include all records of 'diver sp.' as most observed divers could not be identified to species. In reality, the vast majority of divers are likely to be red-throated, although small numbers of black-throated and great northern may also be present. The highest number of divers detected was on 3rd March when 26 divers were observed. This accounted for a population estimate of 129 and a density of 0.61 individuals / km^2. In contrast, estimates from December 2010 were of 14 individuals and 0.07 individuals / km^2. Unsurprisingly, the 2011 boat-based surveys did not record any red-throated divers as they were outside of the key season for this species. The aerial survey data taken from the CCW database suggests a maximum density of 0.77 individuals / km^2 (records including unidentified divers).

6.2.9 To provide context, the data for Burbo Bank Extension Offshore Wind Farm can be compared to aerial survey data for the wider NW5 and NW6a. All densities recorded in Burbo Bank Extension Offshore Wind Farm were less than 50% of those found in the wider zones, suggesting that the development site is not significant for the species. Hi-Def / WWT surveys in 2011 further highlight the reduced importance of the Burbo Bank areas for this species, with highest aggregations occurring to the west along the North Wales Coast and to the north off Formby Point (Appendix 4).

6.2.10 As red-throated diver is included as interest feature of Liverpool Bay SPA it is considered to be of **International importance** for the purposes of this assessment.

Great northern diver

6.2.11 Great northern divers are winter visitors to the UK, with these birds originating from breeding areas in Iceland and Greenland. They are generally scarce around all coasts with Musgrove et al. (2011) calculating the latest estimate of the Great Britain (GB) population at 2,500 individuals. The majority occur in Shetland, Orkney, west Highland, Argyll and the Outer Hebrides, with the English population considered unlikely to exceed 1000 individuals at any one time (Brown & Grice, 2005). However, the European wintering population of this species is small (5000 individuals), so any aggregations in English waters may be significant (Skov et al., 1995).

6.2.12 The threshold for SPA qualification for a given species is set at 1% of the GB wintering population occurring regularly in any given season. However, where a GB population of non-breeding waterbirds is sufficiently small, such as 2,500 for great northern diver, the threshold is set at 50 individuals (JNCC, 1999). No SPA for this species exists within the vicinity of Burbo Bank Extension and no regular aggregations of international significance occur in English or Welsh waters. Great northern divers are, however, listed on both Annex 1 of the EU Birds Directive and Schedule 1 of the Wildlife and Countryside Act.

6.2.13 Table 16 summarises the conservation and Liverpool Bay/Burbo Bank Extension Offshore Wind Farm status great northern diver.

Table 16: Great northern diver status at Burbo Bank Extension Offshore Wind Farm

	Great northern diver
Conservation status	Annex 1 of the EU Birds Directive Schedule 1 of the WCA BoCC Amber
International threshold	50
National threshold	50
Regional threshold	50
BBW02 Aerial (2011) population	-
BBW02 Aerial (2011) density	-
BBW02 Boat-based (2011) population	-
BBW02 Boat-based (2011) density	-
BBW02 Aerial (2001-2009) density	0.06/km^2
NW5 Aerial density (2001-2009)	0.04/km^2
NW6a Aerial density (2001-2009)	0.06/km^2

6.2.14 Great northern divers may occur in very small numbers offshore at any time of year, although notable numbers occur from late October onwards, and remain until early April when birds return to breeding grounds (Brown & Grice, 2005). This species was unrecorded in the 2010-2011 aerial surveys, although a small number may have been absorbed into the 'diver sp.' observations. The 2011 boat-based surveys also did not record the species, although the timing of these surveys is outside of the non-breeding season when it is likely to occur. The aerial survey data from the CCW database suggests a very low maximum density for this species within the Burbo Bank Extension Offshore Wind Farm area, which is approximately equivalent to the densities recorded for the wider count areas.

6.2.15 As great northern diver is not cited as an interest feature of any local designated site nor is it present in numbers of international significance, it is deemed to be **of National Importance** for the purposes of this assessment. This is due to the species being listed on both Annex 1 of the EU Birds Directive and Schedule 1 of the Wildlife and Countryside Act.

Great crested grebe

6.2.16 Great crested grebes are currently a common breeding resident in the UK, with the population having recovered from near-extirpation in the early 19th Century. Most breeding pairs are found on inland gravel pits, lakes and reservoirs and also, locally, on coastal lagoons. The British winter population is estimated at around 15,900 birds (Baker et al., 2006), which is insignificant in terms of the regional biogeographical population. No sites in England support numbers of international significance, although 12 sites hold numbers of national importance (including four estuarine sites). These include both the Dee and Mersey Estuaries.

6.2.17 Table 17 summarises the conservation and Liverpool Bay/Burbo Bank Extension status of great crested grebe.

Table 17: Great crested grebe status at Burbo Bank Extension Offshore Wind Farm

	Great crested grebe
Conservation status	Cited for Mersey Estuary SPA (winter) Noteworthy species for Dee Estuary SPA (winter) BoCC Green
International threshold	3600
National threshold	159 (winter)
Regional threshold	n/a
Aerial (2011) population	-
Aerial (2011) density	-
BBW02 Boat-based + 1 km buffer (2011) population	3 (August)
BBW02 Boat-based + 1 km buffer (2011) density	0.04/km^2
BBW02 Boat-based + 4 km buffer (2011) population	40 (Sept)
BBW02 Boat-based + 4 km buffer (2011) density	0.19/km^2
BBW02 Aerial (2001-2009) density	-
NW5 Aerial (2001-2009) density	-
NW6a Aerial (2001-2009) density	-

6.2.18 Aside from their citation on the Mersey Estuary SPA and as a noteworthy species in the Dee Estuary Ramsar, great crested grebes are not subject to any further legislative conservation protection. No great crested grebes were recorded in the aerial surveys of 2010-2011, although small numbers were recorded during the 2011 boat surveys. For the entire study area of the wind farm and 4 km buffer, a maximum population size of 40 birds was recorded in September 2011, which represents an estimated density of 0.19 individuals / km^2. The Burbo Bank Extension Offshore Wind Farm site does not, therefore, carry any importance for this species.

6.2.19 For the purposes of this assessment Great Crested Grebe is, however, considered to be of **International Importance** due to its inclusion as an interest feature of the Mersey Estuary SPA.

Fulmar

6.2.20 Fulmars are one of the most abundant true seabirds found in British waters, with an estimated population of over 504,000 breeding pairs (Mitchell et al., 2004). The European population is also substantial, with 2.8-4.4 million pairs estimated (BirdLife International, 2004). The majority of British breeding fulmars occur in Scotland, with the English population estimated at 6000 pairs (Brown & Grice 2005). No breeding colonies are found on the coast of Northwest England south of St Bees Head in Cumbria. Several colonies occur on the northwest Wales coast, particularly on Anglesey, with 555 pairs estimated (Mitchell et al., 2004).

6.2.21 Fulmars are present year-round in UK waters, with dispersal from breeding colonies occurring after the breeding season and a return early the following year. Non-breeding densities are highest around the northern isles, at the edge of the continental shelf off northwest Scotland and on the Dogger Bank in the North Sea. Densities in the Irish Sea are relatively low (Stone et al., 1995).

6.2.22 Table 18 summarises the conservation and Liverpool Bay/Burbo Bank Extension Offshore Wind Farm status of fulmar.

Table 18: Fulmar status at Burbo Bank Extension Offshore Wind Farm

	Fulmar
Conservation status	BoCC Amber
International threshold	36,000
National threshold	9980
Regional threshold	4149
Aerial (2011) population	-
Aerial (2011) density	-
BBW02 Boat-based + 1 km buffer (2011) population	0
BBW02 Boat-based + 1 km buffer (2011) density	0/km^2
BBW02 Boat-based + 4 km buffer (2011) population	6
BBW02 Boat-based + 4 km buffer (2011) density	0.03/km^2
BBW02 Aerial (2001-2009) density	0.96/km^2
NW5 Aerial (2001-2009) density	1.78/km^2
NW6a Aerial (2001-2009) density	0.96/km^2

6.2.23 Although fulmars have a large and increasing British breeding population, they are still considered to be of conservation concern (Amber listed on BoCC) on account of over 50% of its population occurring at ten or fewer sites (Eaton et al., 2009).

6.2.24 Fulmars were unrecorded in both the 2010-2011 aerial and within the site and 1 km buffer during the 2011 boat-based surveys. Fulmars were also present in very small densities within Burbo Bank Extension as extracted from the historic aerial data (2001 – 2009). Densities of fulmar were notably higher in the wider aerial survey zones with densities of up to 1.78 individuals / km^2 within NW5.

6.2.25 For the purposes of this assessment, fulmar is considered to be of **Regional Importance** due to its inclusion on the Amber list of BoCC.

Manx shearwater

6.2.26 Manx shearwaters are highly oceanic seabirds that make nocturnal visits to breeding colonies on land only. The majority of the world population occurs in the UK – 300,000 out of 338,000-411,000 pairs, with the remainder breeding in Iceland, France, the Faeroes, the Atlantic islands and a small population in North-eastern North America. Over 90% of the British population are found on the islands of Rum in the Inner Hebrides and the Pembrokeshire islands of Skomer, Skokholm and Middleholm.

6.2.27 Manx shearwaters return to British seas from their wintering quarters in early March, remaining in the vicinity until early October (Brown & Grice, 2005). Foraging ranges for this species can be large (Table 4) and as such high densities are found in the Celtic and Irish Seas can occur between May and August. Within the Irish Sea, birds from the breeding colony at Skomer island have been recorded foraging within Cardigan Bay and further north at Dundalk Bay and the Mull of Galloway. Some birds have also been observed on foraging

excursions, passing around the Isle of Man, down through Liverpool Bay and past Anglesey on their way back to Skomer island (Guilford et al., 2008). During September and October, high densities can still be found in the Irish Sea, though the population is more widespread during this period (Brown and Grice, 2005). The species is rarely encountered in British waters between late November and late February, with the majority of the population having moved to areas off the east coast of South America.

6.2.28 Table 19 summarises the conservation and Liverpool Bay/Burbo Bank Extension Offshore Wind Farm status of Manx shearwater.

Table 19: Manx shearwater status at Burbo Bank Extension Offshore Wind Farm

	Manx shearwater
Conservation status	Cited on Aberdaron Coast and Bardsey Island SPA Cited on Skokholm & Skomer SPA Cited on Copeland Islands SPA BoCC Amber
International threshold	7400
National threshold	5900
Regional threshold	4485
Aerial (2011) population	-
Aerial (2011) density	-
BBW02 Boat-based + 1 km buffer (2011) population	1425 (July)
BBW02 Boat-based + 1 km buffer (2011) density	16.78/km^2
BBW02 Boat-based + 4 km buffer (2011) population	2937 (July)
BBW02 Boat-based + 4 km buffer (2011) density	13.96/km^2
BBW02 Aerial (2001-2009) density	0.35/km^2
NW5 Aerial density (2001-2009)	2.84/km^2
NW6a Aerial density (2001-2009)	0.35/km^2

6.2.29 Manx shearwaters are not cited in any designated sites adjacent to Burbo Bank Extension, although the large foraging range of this species requires breeding colonies from extensive distances away to be considered. The Skokholm and Skomer SPA is beyond the maximum foraging distance of this species, although the Aberdaron Coast and Bardsey Island SPA is within this range (at around 185km). This SPA supports 6930 pairs, which represents 3.2% of the British population (and 2.6% of the biogeographic population). Manx shearwaters are also listed on the amber list of BoCC on account of over 50% of its population occurring at ten or fewer sites (Eaton et al., 2009).

6.2.30 No Manx shearwaters were recorded during the 2010-2011 aerial surveys, although notable numbers were recorded in the 2011 boat-based surveys, which took place within months likely encompassing the likely peak occurrence of the species within the Irish Sea (Stone et al., 1995). Within the entire study area a maximum population estimate of 2937 birds occurred in July 2011, which represents a density of 13.96 individuals / km^2 . The maximum density within the wind farm and 1 km buffer was slightly larger at 16.78 individuals / km^2 with a population of 1425 birds. These numbers do not, however, approach the threshold

for national or regional importance and the species was absent or present in low numbers during all other months of survey.

6.2.31 Figure 8 presents the abundance of Manx shearwater during the 2011 boat-based surveys and further highlights the restriction to July of notable numbers.

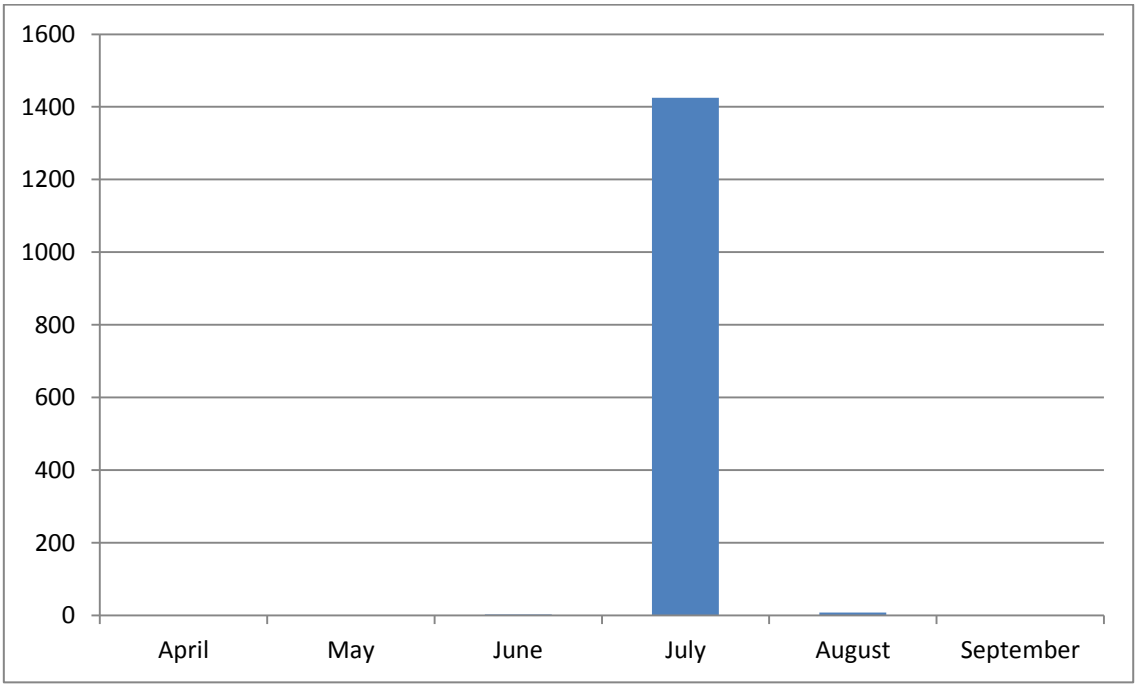


Figure 8: Manx shearwater abundance during 2011 boat-based surveys (Wind farm area and 1 km buffer)

6.2.32 Densities recorded from historic aerial survey data did not approach the peak density seen during the July 2011 boat-based survey. The historic data indicates higher densities within the wider NW5 count zone compared with Burbo Bank Extension.

6.2.33 For the purposes of this assessment, Manx shearwater is considered to be of **International Importance** due to being designated at the Aberdaron Coast and Bardsey Island SPA and Skomer and Skokholm SPA.

Gannet

6.2.34 Gannets breed in substantial numbers in Great Britain, with over 50% of the global population being supported in these colonies. The British population is estimated at 218,546 breeding pairs and as such is recognised as being of conservation concern in a British and European context. The majority of British breeding gannets are found at colonies in Scotland, the largest being on St Kilda (Mitchell et al., 2004). The closest colony to Burbo Bank Extension Offshore Wind Farm is at Ailsa Craig SPA, which supports approximately 3,600 breeding pairs. This site however lies beyond the mean-maximum foraging range from Burbo Bank Extension Offshore Wind Farm.

6.2.35 Gannets are wide ranging seabirds and occur around the British coasts during all times of years (although at low densities during winter months) (Nelson, 2002). Adult birds disperse into waters outside of breeding colonies and as far as the Bay of Biscay and the Mediterranean Sea (Brown & Grice, 2005). Younger birds are known to travel much further, to areas such as off the West coast of Africa. Birds return to breeding colonies in January (although young birds do not generally breed until their sixth year), with the breeding season falling between March and August.

6.2.36 Table 20 summarises the conservation and Liverpool Bay/Burbo Bank Extension Offshore Wind Farm status of gannet.

Table 20: Gannet status at Burbo Bank Extension Offshore Wind Farm

	Gannet
Conservation status	BoCC Amber
International threshold	6100
National threshold	4380
Regional threshold	3275
Aerial (2011) population	17
Aerial (2011) density	0.08/km^2
BBW02 Boat-based + 1 km buffer (2011) population	187 (May)
BBW02 Boat-based + 1 km buffer (2011) density	2.20/km^2
BBW02 Boat-based + 4 km buffer (2011) population	429 (May)
BBW02 Boat-based + 4 km buffer (2011) density	2.04/km^2
BBW02 Aerial (2001-2009) density	157 (July)
NW5 Aerial density (2001-2009)	2.75/km^2
NW6a Aerial density (2001-2009)	1.96/km^2

6.2.37 During the 2011 boat-based surveys gannets were recorded at maximum density of 2.20 individuals / km^2 within Burbo Bank Extension and a 1 km buffer, which represents a population size of 187 individuals. Numbers were inconsistent with the peak occurring in July 2011 and similar densities also found in May 2011 (when peak numbers for the wind farm and 1km buffer occurred). Significantly lower numbers were found in all other survey months. The aerial surveys in 2010-2011 were carried out during autumn and winter months and found a comparatively low density of this species with just 0.08 individuals / km^2. It is, however, notable that the boat-based surveys undertaken in April and September 2011 also observed a low number of this species. The peak population sizes recorded in all surveys do not approach the threshold for regional importance.

6.2.38 Densities of gannet taken from aerial survey data extracted from the CCW database were low for Burbo Bank Extension Offshore Wind Farm (although higher than the recorded in the site specific surveys in 2010-2011). The densities recorded for NW5 and NW6a were similar to that recorded in the 2011 boat-based surveys.

6.2.39 For the purposes of this assessment gannets are considered to be of **Regional Importance** due to being included on the Amber list of BoCC.

Cormorant

6.2.40 Cormorants are historically known as coastal breeding seabirds, although in recent years, substantial colonies primarily of the continental subspecies sinensis have occurred at inland waterbodies. Cormorants are common breeders on the north west Wales coast with 1,366 pairs recorded in Gwynedd in 2000 (Mitchell et al., 2004), although very few are present on the English Irish Sea coast. Puffin Island SPA on the Gwynedd coast supports 776 pairs of cormorants, which are an interest feature of the SPA (the site supports at least 1.9% of the breeding northwest Europe population). This site lies 31km to the west of Burbo Bank Extension and is therefore beyond the mean-maximum foraging range of this species.

Table 21: Cormorant status at Burbo Bank Extension Offshore Wind Farm

	Cormorant
Conservation status	Cited on assemblage for Dee Estuary SPA (winter) Cited on assemblage for Mersey Estuary SPA (winter) Cited on assemblage for Mersey Narrows & North Wirral Foreshore pSPA (winter) Noteworthy species for Ribble & Alt Estuaries Ramsar BoCC Green
International threshold	5850
National threshold	350 (winter)
Regional threshold	n/a
Aerial (2011) population	93 (February)
Aerial (2011) density	0.55/km^2
BBW02 Boat-based + 1 km buffer (2011) population	314 (August)
BBW02 Boat-based + 1 km buffer (2011) density	3.70/km^2
BBW02 Boat-based + 4 km buffer (2011) population	555 (September)
BBW02 Boat-based + 4 km buffer (2011) density	2.64/km^2
BBW02 Aerial (2001-2009) density	2.31/km^2
NW5 Aerial density (2001-2009)	6.09/km^2
NW6a Aerial density (2001-2009)	9.02/km^2

6.2.41 During winter, cormorants are widespread, with large gatherings notable off the Cumbrian coast (Brown & Grice, 2005). Cormorants are included in the majority of the assemblages for SPAs in the vicinity of Burbo Bank Extension Offshore Wind Farm, with respect to winter months. The boat-based surveys undertaken in 2011 confirmed that cormorants are widespread in the area with a maximum population estimate within the entire study area of 555 birds recorded (in September 2011) which represents a density of 2.64 individuals / km^2 (Table 21). Such a population exceeds the threshold for national importance.

6.2.42 Figure 9 shows the distribution of cormorant observations during the 2011 boat-based surveys. There is a clear bias to records in the eastern side of the survey area, with the species being largely absent from the majority of the proposed development area. Cormorants were noted to be attracted to roosting/resting on turbine transition pieces or buoys and this heavily influenced their distribution to the eastern half of the survey area.

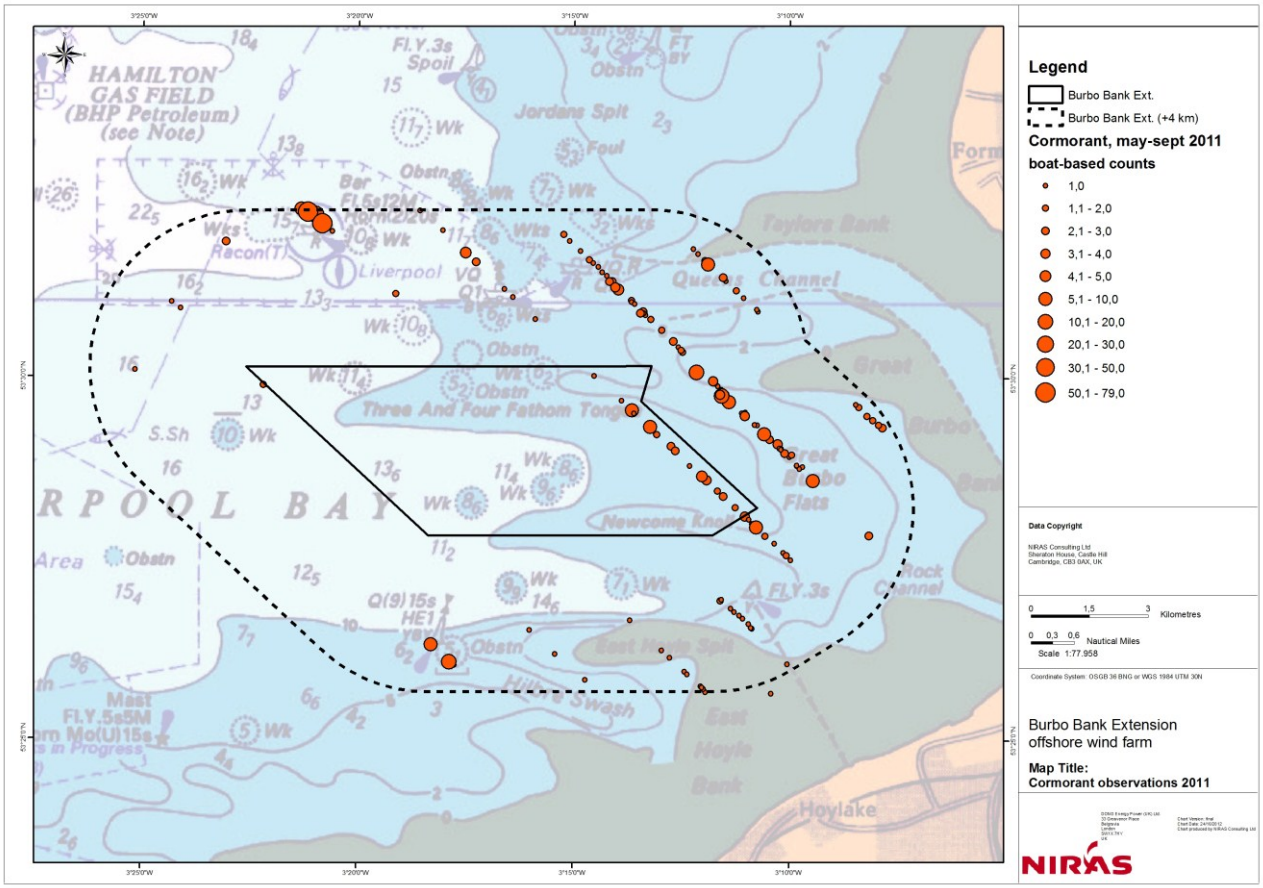


Figure 9: Cormorant observations during 2011 boat-based surveys.

6.2.43 Aerial surveys often did not discriminate between cormorants and shags and as such the maximum count from the pooled birds is given in Table 21 above. Cormorants are likely to be substantially more common in the southern Irish Sea. The aerial surveys recorded a maximum population size of 93 birds which constitutes a density of 0.55 individuals / km^2. The timing of the 2010-2011 aerial surveys was outside of the likely peak months for this species and the discrepancy between this and the boat-based survey results is therefore not surprising.

6.2.44 Densities derived from aerial survey data extracted from the CCW database indicate high densities occurring in the NW5 and NW6a count zones. NW6a was particularly high (being closer to estuarine habitat) with up to 9.02 individuals / km^2 recorded.

6.2.45 For the purposes of this assessment cormorants are considered to be of **National Importance** due to being included on the assemblages of Dee Estuary, Mersey Estuary and Mersey Narrows and North Wirral Foreshore SPAs.

Shag

6.2.46 The (European) shag is endemic to the northeast Atlantic and the Mediterranean. The British population of 27,176 pairs (Mitchell et al., 2004) compares to the northeast Atlantic population of 66,000 – 73,000 pairs. Shag breed on ledges of steep mainland and island cliffs and disperse widely along the coast during the autumn.

6.2.47 No designated sites where this species is included as an interest feature are in the vicinity of Burbo Bank Extension Offshore Wind Farm. Table 22 summarises the conservation and Liverpool Bay/Burbo Bank Extension Offshore Wind Farm status of shag.

Table 22: Shag status at Burbo Bank Extension Offshore Wind Farm

	Shag
Conservation status	BoCC Amber
International threshold	2000
National threshold	272
Regional threshold	n/a
BBW02 Aerial (2011) population	5 (December)
BBW02 Aerial (2011) density	0.02/km^2
BBW02 Boat-based (2011) population	-
BBW02 Boat-based (2011) density	-
BBW02 Aerial (2001-2009) density	-
NW5 Aerial density (2001-2009)	3.50/km^2
NW6a Aerial density (2001-2009)	0.18/km^2

6.2.48 No shags were recorded during the 2011 boat-based surveys, while a small number were identified during the 2010-2011 aerial surveys. Shag is substantially less common off the Lancashire and North Merseyside coast (White et al., 2008) than cormorant and all unidentified birds are likely to be the latter species. Shags were not identified in the Burbo Bank Extension Offshore Wind Farm area during the aerial surveys carried out in 2001-2009 (data extracted from the CCW database). Densities were also very low for NW6a, although a peak density of 3.50 individuals / km^2 occurred in NW5.

6.2.49 For the purposes of this assessment, shag is considered to be of **Regional Importance** due to inclusion on the BoCC Amber List.

Scaup

6.2.50 Scaup is exclusively a winter visitor to the region, with its status on Schedule 1 of the Wildlife and Countryside Act being due to occasional breeding records in northern Scotland. In the non-breeding season scaup show a preference for shallow coastal waters and are widespread, although scarce in English waters. The species is not noted in the assemblage for any designated site in the region, although historically the Dee Estuary has been favoured by notable numbers (Brown & Grice, 2005). Table 23 summarises the conservation and Liverpool Bay/Burbo Bank Extension Offshore Wind Farm status of scaup.

Table 23: Scaup status at Burbo Bank Extension Offshore Wind Farm

	Scaup
Conservation status	Schedule 1 of the WCA BoCC Red UK BAP Priority Species
International threshold	3100
National threshold	52
Regional threshold	n/a
BBW02 Aerial (2011) population	153 (February)
BBW02 Aerial (2011) density	0.73/km^2
BBW02 Boat-based (2011) population	-
BBW02 Boat-based (2011) density	-
BBW02 Aerial (2001-2009) density	-
NW5 Aerial density (2001-2009)	-
NW6a Aerial density (2001-2009)	-

6.2.51 Scaup were unrecorded in both the 2011 and 2006-2009 boat-based surveys, and recorded on a single occasion during the 2010-2011 aerial surveys. This observation involved an aggregation of 33 birds on 24th February 2011. This accounts for a potential population size of 153 birds at a density of 0.73 individuals / km^2. This estimated population size exceeds the threshold for national importance, although it should be noted that this is derived from the single observation and likely overstates the significance of Burbo Bank Extension Offshore Wind Farm for this species. In addition, no data for the Burbo Bank Extension Offshore Wind Farm site or surrounding count zones is held within the CCW database for this species.

6.2.52 For the purposes of this assessment, scaup is considered to be of **Regional Importance** due to its inclusion on the BoCC Red List, and as a UK BAP Priority Species due to declining winter populations. Scaup is listed as a Schedule 1 (Wildlife and Countryside Act) species although this is in response to the occasional small breeding population in northern Scotland and not relevant to this assessment.

Common scoter

6.2.53 Common scoters are the most commonly observed seaduck in English and Welsh waters. A small population of this species breeds in northern Scotland (Forrester et al., 2007), while much larger (and significant in an international context) numbers winter around the coasts of the UK. The most important areas for this species include the Moray Firth in Scotland, Carmarthen Bay in South Wales and Liverpool Bay.

6.2.54 Common scoter is an interest feature of both Liverpool Bay and Ribble and Alt Estuaries SPAs. Liverpool Bay supports a population of 54,765 individuals, which far exceeds the threshold for international importance (Table 24). Within the SPA, the most important areas are Shell Flat to Formby (off Blackpool), Colwyn Bay and Conwy Bay (NE & CCW, 2006). Therefore, common scoters are known to aggregate to the north (at densities of up to 50 individuals / km^2) and to the south west of Burbo Bank Extension Offshore Wind Farm (at lower densities of up to 13 individuals / km^2). The species is known to winter in aggregations on a water depth of 2-20m with a mean depth of 10-12m (Kaiser et al., 2005). Distribution is also influenced by benthic prey, with food items including cockles, clams, other bivalves, molluscs and crustaceans. They are present in Liverpool Bay from August to May with the most significant numbers present during August to

March. Male and female scoters have been noted to arrive at different times, with females arriving later in the winter (NE & CCW, 2009).

6.2.55 Common scoters are also cited as an interest feature of the Ribble and Alt Estuaries SPA, with the species qualifying through Article 4.2 of the Directive in supporting a population of European importance of this migratory species (746 birds, 2.7% of the British wintering population).

Table 24: Common scoter status at Burbo Bank Extension Offshore Wind Farm

	Common scoter
Conservation status	Cited for Liverpool Bay SPA (winter) Cited for Ribble & Alt Estuaries SPA (winter) Schedule 1 of the WCA BoCC Red
International threshold	5500
National threshold	1000
Regional threshold	n/a
Aerial (2011) population	149 (March)
Aerial (2011) density	0.71/km^2
BBW02 Boat-based + 1 km buffer (2011) population	156 (July)
BBW02 Boat-based + 1 km buffer (2011) density	1.84/km^2
BBW02 Boat-based + 4 km buffer (2011) population	166 (July)
BBW02 Boat-based + 4 km buffer (2011) density	0.79/km^2
BBW02 Aerial (2001-2009) density	0.24/km^2
NW5 Aerial density (2001-2009)	38.10/km^2
NW6a Aerial density (2001-2009)	22.07/km^2
Hi-Def/WWT Aerial density (2011)	17.52/ km^2

6.2.56 Common scoters were observed in three of the 2010-2011 aerial surveys, with a peak count of 32 birds on 3rd March 2011. This count represented a predicted population size of 149 birds at a density of 0.71 individuals / km^2. The 2011 boat-based surveys were undertaken outside of the peak season for this species, although a notable maximum population size occurred on the early date of July 2011 where 166 birds were estimated in the entire study area at a density of 0.79 individuals / km^2. These birds were all noted to be transiting through the site (i.e. no birds were seen on the water within the site boundary; Table 6). Aside from the survey in July, common scoters were scarce or absent in all other surveys.

6.2.57 Aerial data extracted from the CCW database indicate that densities for this species were extremely large for both the NW5 and NW6a count zones. Notably, the density for Burbo Bank Extension Offshore Wind Farm from this data is low and therefore further suggests the limited importance of the site area for this species.

6.2.58 Observations from the 2011 boat-based survey are shown in Figure 10, which indicate a wide scattering of observations with no obvious aggregations. The 2011 aerial surveys also indicated few records from the Burbo Bank Extension Offshore Wind Farm area, with the majority of records from the south eastern buffer area (Petersen et al., 2011 ; Figure 14). Counts undertaken during the Burbo Bank boat-based

surveys in 2006-2009 provide further information on the numbers of this species present within the area; a peak count of 47 birds in January 2008 is also notably low when compared to adjacent areas within Liverpool Bay.

6.2.59 Appendix 4 presents maps of the Liverpool Bay SPA area and records of common scoter made during 2011 (Hi-Def / WWT, 2011). Notable aggregations were present off Blackpool and Formby Point to the north of Burbo Bank Extension and also the north Wales coast to the west (and so mirroring the results given by NE & CCW, 2006). Records of common scoter in the vicinity of Burbo Bank Extension were again sparse, adding further supporting evidence to the conclusion that the zone of the SPA within which the Project site is situated, does not provide significant habitat for the species.

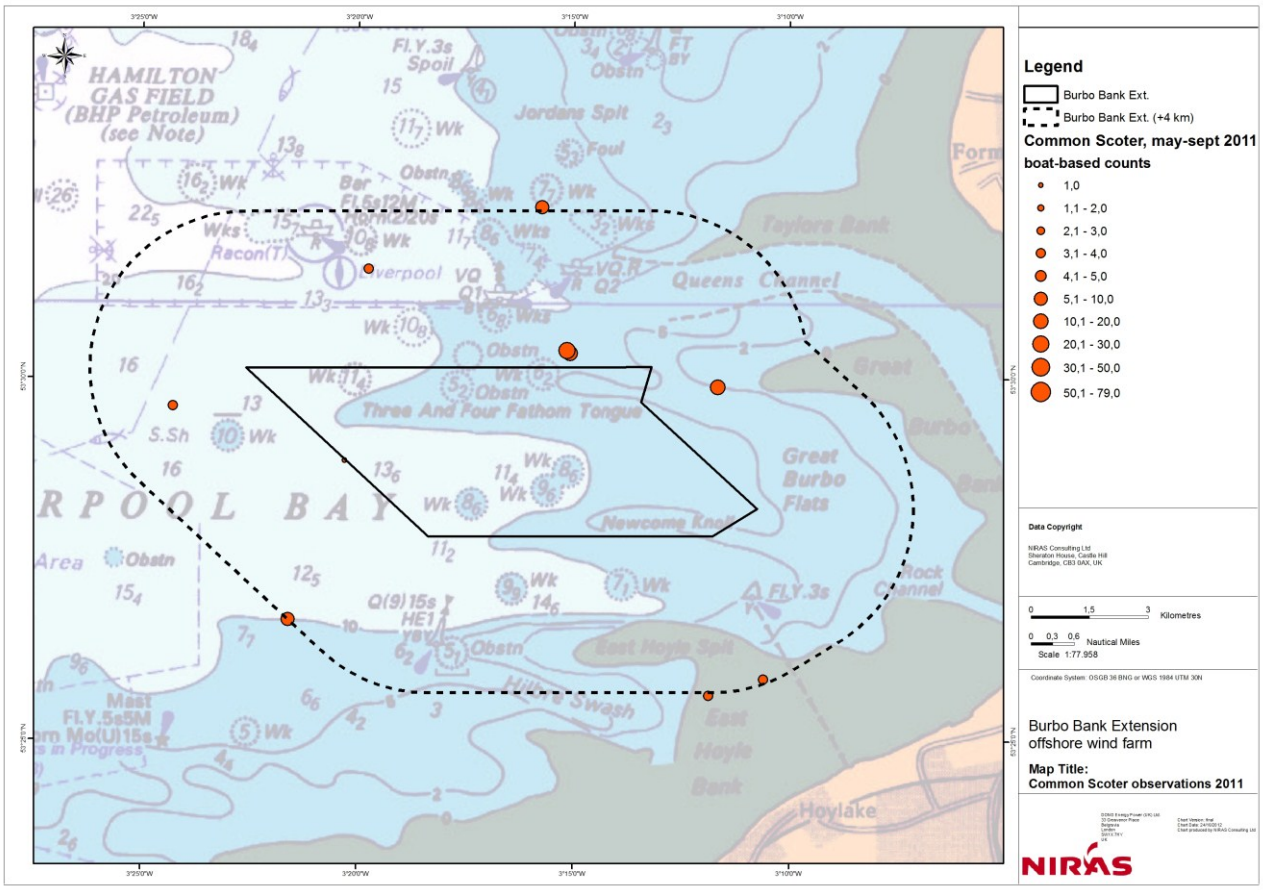


Figure 10: Common scoter observations during 2011 boat-based surveys.

6.2.60 For the purposes of this assessment, common scoter is considered to be of **International Importance** due to its inclusion as an interest feature of both Liverpool Bay and Ribble and Alt Estuaries SPAs.

Red-breasted merganser

6.2.61 Red-breasted mergansers are locally numerous winter visitors to the Irish Sea. Most of these wintering birds are considered to be British breeding birds, although a small proportion may originate from Iceland or Fennoscandia. No British site supports numbers of international importance although sites of national importance for this species are widespread in the UK, with Morecambe Bay (176 birds in 2009-2010;

Holt et al., 2011) being in closest proximity to Burbo Bank Extension Offshore Wind Farm. Non-breeding birds tend to arrive from mid-October, departing again during March and early April. Table 25 summarises the conservation and Liverpool Bay/Burbo Bank Extension Offshore Wind Farm status of red-breasted merganser.

Table 25: Red-breasted merganser status at Burbo Bank Extension Offshore Wind Farm

	Red-breasted merganser
Conservation status	BoCC Green
International threshold	1700
National threshold	84 (winter)
Regional threshold	n/a
Aerial (2011) population	9 (February)
Aerial (2011) density	0.04 / km^2
BBW02 Boat-based + 1 km buffer (2011) population	0
BBW02 Boat-based + 1 km buffer (2011) density	0/km^2
BBW02 Boat-based + 4 km buffer (2011) population	13 (April)
BBW02 Boat-based + 4 km buffer (2011) density	0.06/km^2
BBW02 Aerial (2001-2009) density	-
NW5 Aerial density (2001-2009)	0.93/km^2
NW6a Aerial density (2001-2009)	0.31/km^2

6.2.62 Red-breasted merganser is not an interest feature of designated sites in the proximity of Burbo Bank Extension Offshore Wind Farm, nor is it featured in the assemblages. This species was only encountered in the 2011 boat-based surveys within the 4km buffer on a single occasion, while the 2010-2011 aerial surveys recorded them on just a single occasion. The aerial surveys in 2010-2011 recorded 2 birds on 24th February 2011. This represents a population estimate of 9 birds at a density of 0.04 individuals / km^2.

6.2.63 Densities of this species were also low from the aerial survey data extracted from the CCW database. No birds occurred within Burbo Bank Extension Offshore Wind Farm while maximum densities for both NW5 and NW6a were below one ind./km^2.

6.2.64 For the purposes of this assessment, red-breasted merganser is considered to be of **Local Importance**.

Arctic skua

6.2.65 Arctic skuas are localised breeders in Britain and confined to areas of northern and Western Scotland. The species has a world population of up to 335,000 pairs with the Scottish population being 2,100 pairs. This therefore represents a small proportion of the world population but a moderately significant part of the north-eastern Atlantic biogeographic population (6-14%; Mitchell et al., 2004). The Scottish population has undergone recent declines and the species is currently Red listed within BoCC (Eaton et al., 2009) and is also a UK BAP Priority Species (Table 26).

6.2.66 Arctic skuas winter primarily in the southern oceans and as such are seen within the Irish Sea during passage periods. The distribution during these species is often linked to foraging opportunities; the species is

kleptoparasitic and attacks other seabirds, such as Sandwich tern, to steal prey. Spring migration is rapid, with birds returning to colonies in April and early May, mainly passing along the west coast of the UK. Autumn migration is more protracted and can be extensive off both east and west coasts (Forrester et al., 2007). Table 26 summarises the conservation and Liverpool Bay/Burbo Bank Extension Offshore Wind Farm status of Arctic skua.

Table 26: Arctic skua status at Burbo Bank Extension Offshore Wind Farm

	Arctic skua
Conservation status	BoCC Red UK BAP Priority Species
International threshold	600
National threshold	50
Regional threshold	50
Aerial (2011) population	-
Aerial (2011) density	-
BBW02 Boat-based + 1 km buffer (2011) population	11 (May)
BBW02 Boat-based + 1 km buffer (2011) density	0.13/km^2
BBW02 Boat-based + 4 km buffer (2011) population	34 (September)
BBW02 Boat-based + 4 km buffer (2011) density	0.16/km^2
BBW02 Aerial (2001-2009) density	-
NW5 Aerial density (2001-2009)	-
NW6a Aerial density (2001-2009)	-

6.2.67 Arctic skuas were unrecorded during the 2010-2011 aerial surveys, which took place outside of the peak passage periods for this species. The 2011 boat-based surveys recorded Arctic skuas on two months of survey (May and September) within Burbo Bank Extension Offshore Wind Farm. The peak count occurred in September 2011 where a population size of 34 birds was estimated within the entire study area (representing a density of 0.16 individuals / km^2). This population approaches but does not pass the threshold for national or regional importance

6.2.68 There is no evidence of nationally important numbers of this species occurring at Burbo Bank Extension Offshore Wind Farm (or in surrounding areas). As Arctic skua is however is included on the Red List of BoCC for the purposes of this assessment it is considered to be of **Regional Importance**.

Great skua

6.2.69 Great skuas have a small global population of just 16,000 pairs, with northern and north-west Scotland supporting 60% of this total (Mitchell et al., 2004). Great skuas winter distribution ranges from the Celtic Sea to the Atlantic Ocean of West Africa, although some birds remain in the North Sea. The Irish Sea is therefore most significant for this species during passage periods. Spring migration occurs mainly in April and is generally rapid and direct to the colonies (Forrester et al., 2007). In autumn, dispersal is widespread with most birds travelling through the Atlantic and the North Sea, although some migrate down the west coast. Table 27 summarises the conservation and Liverpool Bay/Burbo Bank Extension Offshore Wind Farm status of great skua.

Table 27: Great skua status at Burbo Bank Extension Offshore Wind Farm

	Great skua
Conservation status	BoCC Amber
International threshold	320
National threshold	192
Regional threshold	50
Aerial (2011) population	-
Aerial (2011) density	-
BBW02 Boat-based + 1 km buffer (2011) population	8 (June / September)
BBW02 Boat-based + 1 km buffer (2011) density	0.09/km^2
BBW02 Boat-based + 4 km buffer (2011) population	6 (June / September)
BBW02 Boat-based + 4 km buffer (2011) density	0.03/km^2
BBW02 Aerial (2001-2009) density	-
NW5 Aerial density (2001-2009)	-
NW6a Aerial density (2001-2009)	-

6.2.70 Great skuas were unrecorded during the 2010-2011 aerial surveys, although the survey period lay outside of key passage periods for this species. The 2011 boat-based surveys recorded the species on two occasions (in June and September) with a population estimated at 6 birds being present (density of 0.03 individuals / km^2) within the entire study area. This population does not exceed the threshold for regional importance.

6.2.71 There is no evidence of nationally important numbers of this species occurring at Burbo Bank Extension Offshore Wind Farm (or in surrounding areas). As Great skua is however is included on the Amber List of BoCC for the purposes of this assessment it is considered to be of **Regional Importance**.

Kittiwake

6.2.72 Kittiwakes are the most numerous gull in the world, with the North Atlantic biogeographic population providing up to 3,000,000 of the total c.5,200,000 pairs. Kittiwakes are highly pelagic and rarely seen inland, breeding on coastlines of the North Atlantic, North Pacific and Arctic Oceans. The British population is estimated at 415,995 (Mitchell et al., 2004), although recent downward trends at key colonies have led to the species being Amber listed on BoCC (Eaton et al., 2009). The Joint Nature Conservation Committee Seabirds Monitoring Programme (SMP) database reports a 40% decline of this species between 1999 and 2009, with the more northerly colonies declining more rapidly. Kittiwakes in these areas are heavily dependent on sandeels (Ammodytes spp.) which have shown population fluctuations and redistribution (Coulson, 2011; Furness & Tasker, 2000).

6.2.73 Colonies of this species are widespread around the British coasts, with the nearest to Burbo Bank Extension Offshore Wind Farm being along the north-west Wales coast (Puffin Island and Anglesey). However, only kittiwake colonies distant to Burbo Bank Extension Offshore Wind Farm are cited as interest features of SPAs (closest being Ailsa Craig in the north and the Skomer and Skokholm to the south-west. Despite the species relatively large foraging range, there are no functional linkages from these SPAs to the Burbo Bank Extension Offshore Wind Farm area.

6.2.74 Kittiwakes return to their colonies in late February to March, often forming flocks on the sea before settling on the cliff. After breeding, they disperse in to the North Atlantic, North Sea and the Baltic, with some mostly immature birds crossing the Atlantic (Wernham et al. 2002). Non-breeding birds in British waters may also originate from colonies elsewhere in Northern Europe.

6.2.75 Table 28 summarises the conservation and Liverpool Bay/Burbo Bank Extension Offshore Wind Farm status of kittiwake.

Table 28: Kittiwake status at Burbo Bank Extension Offshore Wind Farm

	Kittiwake
Conservation status	BoCC Amber
International threshold	45,000
National threshold	7240
Regional threshold	2394
Aerial (2011) population	93 (February)
Aerial (2011) density	0.44/km^2
BBW02 Boat-based + 1 km buffer (2011) population	437 (June)
BBW02 Boat-based + 1 km buffer (2011) density	5.15/km^2
BBW02 Boat-based + 4 km buffer (2011) population	707 (June)
BBW02 Boat-based + 4 km buffer (2011) density	3.36/km^2
BBW02 Aerial (2001-2009) density	1.69/km^2
NW5 Aerial density (2001-2009)	5.30/km^2
NW6a Aerial density (2001-2009)	1.78/km^2

6.2.76 Kittiwakes were present in all aerial surveys carried out in 2010-2011. Peak numbers occurred in February 2011 where 20 individuals were identified, which accounts for a population estimate of 93 birds at a density of 0.44 individuals / km^2. Kittiwakes were also ever present in the 2011 boat-based surveys, with notable peaks in mid-summer; lesser numbers were present in April and September. The highest population estimate was 707 birds in July 2011 at a density of 3.36 individuals / km^2 within the entire study area. These population sizes do not exceed the threshold for regional importance.

6.2.77 The density of kittiwakes recorded in 2011 is similar to that recorded in the wider count zone NW5, although higher than that seen in NW6a. The aerial survey data for Burbo Bank Extension Offshore Wind Farm extracted from the CCW database showed a lower figure of 1.69 individuals / km^2.

6.2.78 For the purposes of this assessment, kittiwake is considered to be of **Regional Importance**. There is no evidence of nationally important numbers occurring at Burbo Bank Extension Offshore Wind Farm (or in surrounding areas) although kittiwake is included on the Amber List of BoCC.

Little gull

6.2.79 Little gulls are year round visitors to British waters, with the numbers passing through the country on spring and autumn passage having increased enormously in the last 50 years (Brown & Grice, 2005). The

European population of little gull is 24,000 – 58,000 pairs (BirdLife International, 2004), with colonies found from the Baltic eastwards to north-west Russia.

6.2.80 Spring passage of little gulls has become recently significant in Liverpool Bay, with 300-400 birds seen to roost at Seaforth Reserve during mid-April from the late 1980's onwards (Messenger, 1993). Little gull is therefore included as an interest feature of Mersey Narrows and North Wirral Foreshore pSPA, which cites 213 individuals on passage. Table 29 summarises the conservation and Liverpool Bay/Burbo Bank Extension Offshore Wind Farm status of little gull.

Table 29: Little gull status at Burbo Bank Extension Offshore Wind Farm

	Little gull
Conservation status	Cited for Mersey Narrows & North Wirral Foreshore pSPA (passage) Annex 1 of the EU Birds Directive Schedule 1 of the WCA BoCC Amber
International threshold	420
National threshold	50
Regional threshold	n/a
Aerial (2011) population	45
Aerial (2011) density	0.21 / km^2
BBW02 Boat-based + 1 km buffer (2011) population	7 (April)
BBW02 Boat-based + 1 km buffer (2011) density	0.08/km^2
BBW02 Boat-based + 4 km buffer (2011) population	13 (September)
BBW02 Boat-based + 4 km buffer (2011) density	0.05/km^2
BBW02 Aerial (2001-2009) density	-
NW5 Aerial density (2001-2009)	-
NW6a Aerial density (2001-2009)	-

6.2.81 Little gull has additional conservation status by being listed on Annex 1 of the EU Birds Directive (a recovery from a moderate decline in the European population has not yet been achieved).

6.2.82 Little gulls were observed in three aerial surveys in 2010-2011, with peak numbers in April (and thus coinciding with known passage movement in Liverpool Bay). During this survey a population size of 45 birds was estimated at a density of 0.21 individuals / km^2. A boat-based survey was also undertaken in April 2011 and in contrast to other species the overall density of this species was higher for aerial surveys. In fact, only a population of 7 little gulls were considered to be present during April, with marginally more records being made in September 2011, where a population of 13 birds was estimated at a density of 0.06 individuals / km^2. Little Gulls were also scarce in the boat-based surveys in 2006-2009 where they were recorded in low numbers during three surveys only.

6.2.83 Figure 11 presents the distribution of the limited little gull observations during the 2011 boat based surveys, with records outside of Burbo Bank Extension Offshore Wind Farm to the east (and therefore towards Seaforth Reserve).

6.2.84 For the purposes of this assessment little gull is considered to be of **International Importance**. Nationally important numbers did not occur in the Burbo Bank Extension area (although the April 2011 aerial population estimate approached the threshold). However, little gull is included as an interest feature of the Mersey Narrows and North Wirral Foreshore pSPA.

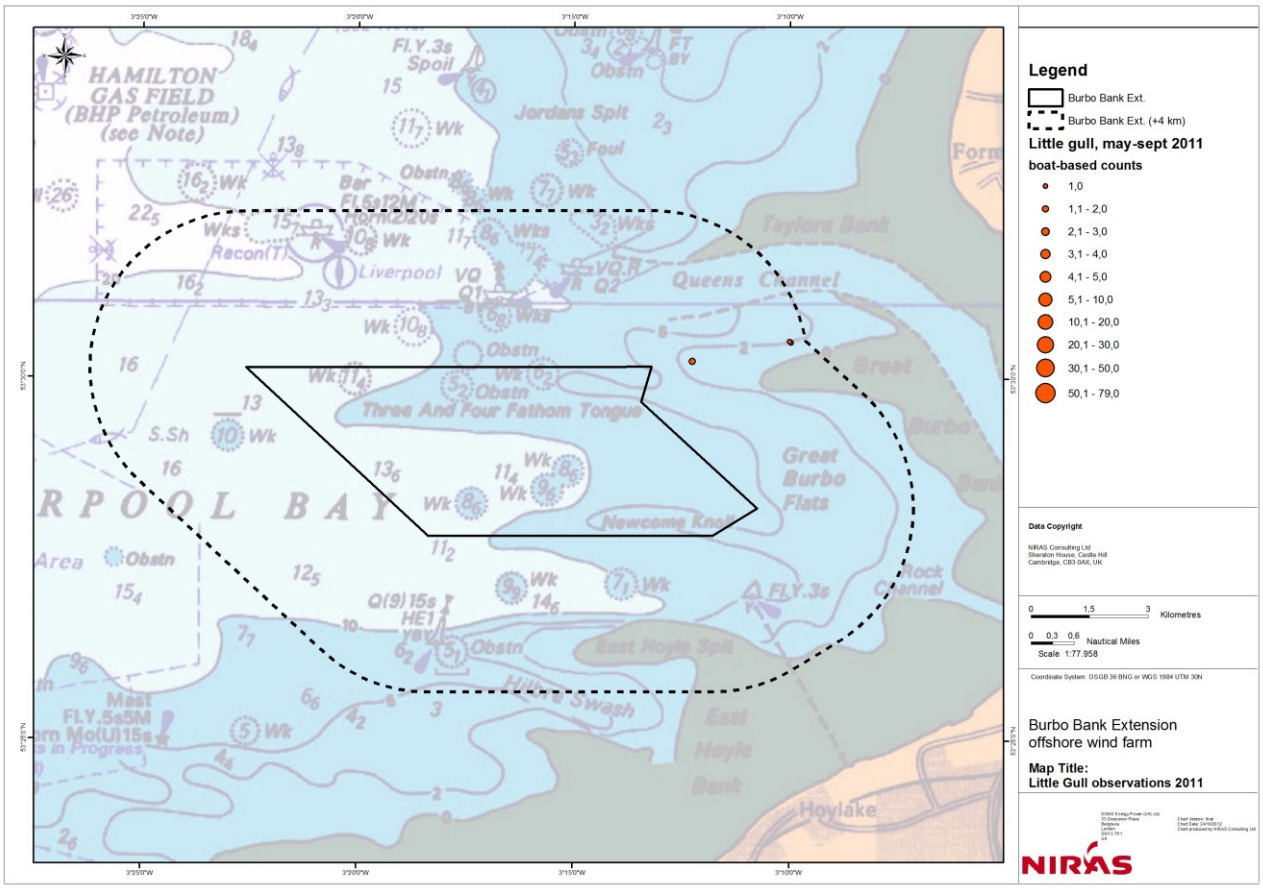


Figure 11: Little gull observations during 2011 boat-based surveys.

Black-headed gull

6.2.85 Black-headed gulls are the most common and ubiquitous gull species in Britain, found on a wide variety of inland costal and marine habitats. The global population is estimated at between 2.1 and 2.8 million pairs, with 138,000 estimated to breed in Britain (Mitchell et al., 2004). Colonies are found at both inland and coastal sites. The Ribble and Alt Estuaries SPA supports a breeding colony of this species, and is cited to have 11,900 pairs or 7.1% of the British population.

6.2.86 Most British birds disperse within the country and they are joined by large numbers from northern and eastern Europe. An estimated 1.7 million birds winter in Britain (Baker et. al, 2006) although this total may be something of an underestimate (Brown & Grice, 2005). Table 30 summarises the conservation and Liverpool Bay/Burbo Bank Extension Offshore Wind Farm status of black-headed gull.

Table 30: Black-headed gull status at Burbo Bank Extension Offshore Wind Farm

	Black-headed gull
Conservation status	Cited for Ribble & Alt Estuaries SPA (breeding) BoCC Amber
International threshold	30,000
National threshold	22,000 (wintering) 2560 (breeding)
Regional threshold	n/a
Aerial (2011) population	-
Aerial (2011) density	-
BBW02 Boat-based + 1 km buffer (2011) population	7 (June)
BBW02 Boat-based + 1 km buffer (2011) density	0.08/km^2
BBW02 Boat-based + 4 km buffer (2011) population	13 (June)
BBW02 Boat-based + 4 km buffer (2011) density	0.06/km^2
BBW02 Aerial (2001-2009) density	0.03/km^2
NW5 Aerial density (2001-2009)	0.69/km^2
NW6a Aerial density (2001-2009)	0.50/km^2

6.2.87 Black-headed gulls were not specifically observed in the 2010-2011 aerial surveys, although this species is likely to have been subsumed in records of unidentified gulls. The 2011 boat-based surveys recorded very few individuals of this species, with a maximum population of13 birds at a density of 0.06 individuals / km^2 recorded in the entire study area during June 2011. These birds were scattered over the eastern half of the survey area, with limited number of records within the Burbo Bank Extension Offshore Wind Farm area (Figure 12).

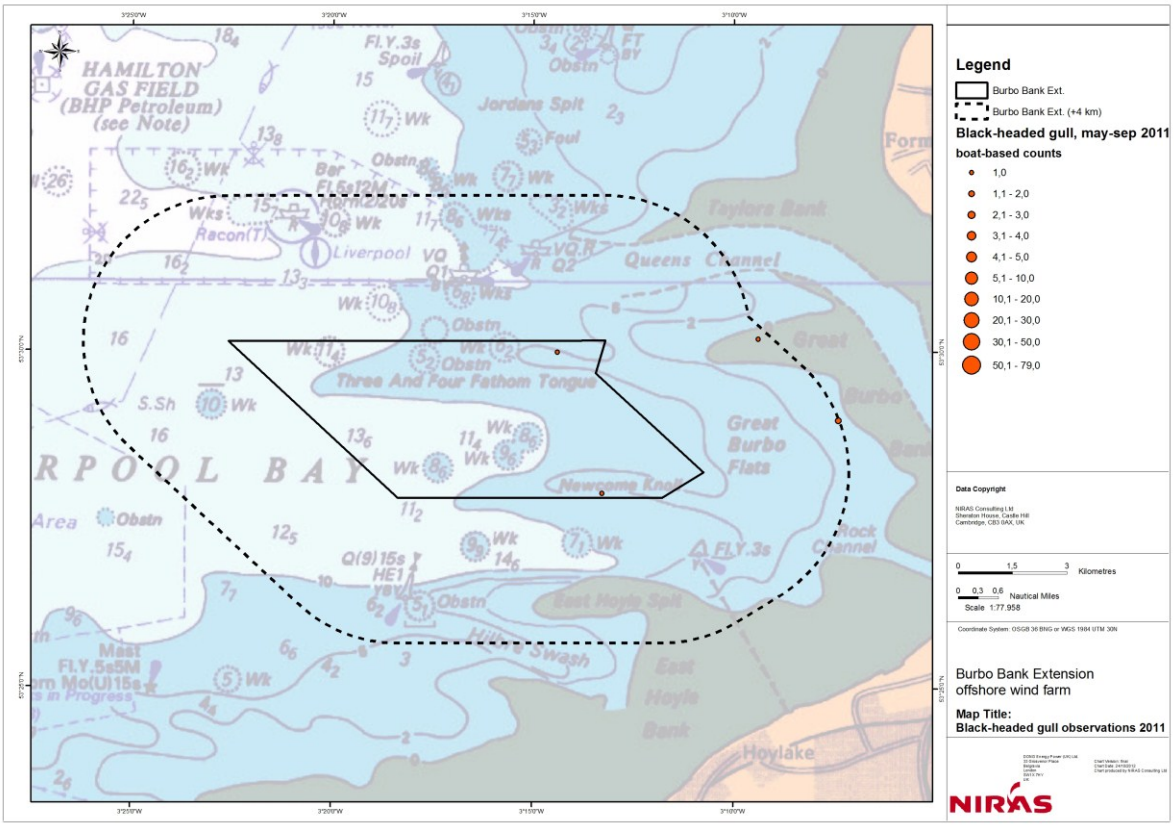


Figure 12: Black-headed gull observations during 2011 boat-based surveys.

6.2.88 Densities of black-headed gull within Burbo Bank Extension were similarly low when the aerial survey data extracted from the CCW database was analysed. Densities were greater for the wider count zones of NW5 and NW6a, although they were still notably small.

6.2.89 For the purposes of this assessment, black-headed gull is considered to be of **International Importance.** Nationally important numbers did not occur in the Burbo Bank Extension area and numbers overall were extremely small. However, black-headed gull is included as an interest feature of the Ribble and Alt Estuaries SPA. This species is notably abundant in coastal areas throughout the year and a very limited proportion of these birds will originate from the SPA.

Common gull

6.2.90 Common gull breeds across the Palearctic and North America, with the north-west Europe population being up to 650,000 pairs (Mitchell et al., 2004), which accounts for over 90% of the world population. An estimated 48,000 pairs breed in Britain, with vast majority found in colonies in Northern Scotland. Common gulls are more abundant in winter and widespread throughout Britain; a minimum population of 430,000 is present. Highest numbers are found in the English Channel with Liverpool and Morecambe Bays also holding significant aggregations (Stone et al., 1995).

6.2.91 Table 31 summarises the conservation and Liverpool Bay/Burbo Bank Extension Offshore Wind Farm status of common gull.

Table 31: Common gull status at Burbo Bank Extension Offshore Wind Farm

	Common gull
Conservation status	BoCC Amber
International threshold	20,000
National threshold	7,000
Regional threshold	130
Aerial (2011) population	254 (November)
Aerial (2011) density	1.21/km^2
BBW02 Boat-based + 1 km buffer (2011) population	49
BBW02 Boat-based + 1 km buffer (2011) density	0.58/km^2
BBW02 Boat-based + 4 km buffer (2011) population	40 (April)
BBW02 Boat-based + 4 km buffer (2011) density	0.19/km^2
BBW02 Aerial (2001-2009) density	1.09/km^2
NW5 Aerial density (2001-2009)	3.73/km^2
NW6a Aerial density (2001-2009)	0.44/km^2

6.2.92 Common gulls are not included as interest features or in assemblage qualifications of any designated sites adjacent to Burbo Bank Extension.

6.2.93 The 2011 boat-based surveys recorded very limited numbers of this species, which is unsurprising considering the timing of the surveys. The 2010-2011 aerial surveys took place in winter months when this species is more likely to be present in numbers in Liverpool Bay, and as such recorded a minimum population estimate of 254 individuals at a density of 1.21 individuals / km^2. This estimate included specifically identified common gulls only, with the true population size likely to be higher (if for example all 'grey gulls' recorded during the surveys were this species). Densities calculated for Burbo Bank Extension from the aerial survey data extracted from the CCWQ database shows a similar low density to the 2010-2011 surveys. Data for NW5 shows a distinctly higher density in this wider area.

6.2.94 Population estimates of this species do not, however, approach thresholds for international or national importance. Therefore, for the purposes of this assessment, common gull is considered to be of **Regional Importance.**

Herring gull

6.2.95 Herring gulls are a widespread breeding species in Britain, although they have undergone a recent population decline leading to their inclusion on the BoCC Red List (Eaton et al., 2009) and being a UK BAP Priority Species. As a breeding bird, herring gulls are distributed throughout the Holarctic with a global population of over 1 million pairs (Mitchell et al., 2004). It is a taxonomically complicated 'species', with British breeding birds belonging to the subspecies argenteus, with 131,500 pairs present.

6.2.96 Colonies are widespread around the British coastline, including Liverpool Bay on both the North Wales and Lancashire sections. British breeding birds are known to be rather sedentary, with many making an early return to their breeding grounds in February or early March. During the non-breeding season the population is supplemented by a substantial number of European birds of the nominate subspecies argentatus. The

winter population is estimated at 378,748 birds (Baker et al., 2006). Table 32 summarises the conservation and Liverpool Bay/Burbo Bank Extension status of herring gull.

Table 32: Herring gull status at Burbo Bank Extension Offshore Wind Farm

	Herring gull
Conservation status	Cited for Morecambe Bay SPA (breeding) BoCC Red UK BAP Priority Species
International threshold	15,600
National threshold	2620 (breeding) 7300 (winter)
Regional threshold	1784
Aerial (2011) population	357 (or 659 including 'grey gull species') (March)
Aerial (2011) density	1.69 / km^2 (or 6.02 / km^2 including 'grey gull')
BBW02 Boat-based + 1 km buffer (2011) population	310 (April)
BBW02 Boat-based + 1 km buffer (2011) density	3.65/km^2
BBW02 Boat-based + 4 km buffer (2011) population	400 (April)
BBW02 Boat-based + 4 km buffer (2011) density	1.9/km^2
BBW02 Aerial (2001-2009) density	1.33/km^2
NW5 Aerial density (2001-2009)	6.88/km^2
NW6a Aerial density (2001-2009)	3.44/km^2

6.2.97 Herring gulls are included as interest features for Morecambe Bay SPA (11,000 breeding pairs) which lies approximately 55km to the north of Burbo Bank Extension Offshore Wind Farm. The site is therefore within the mean-maximum foraging range of this species (61km).Herring gulls were recorded during all aerial surveys in 2010-2011, with a peak occurring in March 2011 when 69 birds were counted. This accounts for a population size estimate of 357 birds at a density of 1.69 individuals / km^2. This density is comparable to the density estimate from aerial survey data extracted from the CCW database and is considerably lower than that recorded for the NW5 and NW6a count zones. Numbers during the 2011 boat-based survey were variable, with few individuals present during May to July. Larger numbers were present during April 2011 with a population size of 400 birds estimated (1.9 individuals / km^2), suggesting that the study area is utilised on a more regular basis by wintering birds. These population sizes to not exceed the threshold for regional importance.

6.2.98 Population sizes during either survey did not approach national or international thresholds. Therefore, for the purposes of this assessment, herring gull is considered to be of **International Importance** due to its inclusion as an interests feature of Morecambe Bay SPA.

Lesser black-backed gull

6.2.99 Lesser black-backed gulls have a more restricted global distribution than either herring or great black-backed gulls and as such, breeding colonies in Britain have increased significance. The species breeds from Iceland to Western Siberia and southwards to northern Iberia. All birds breeding in Britain are of the graellsii

subspecies and number 110,000 pairs (Mitchell et al., 2004). This compares with a European population of 300,000 – 350,000 pairs (Birdlife International, 2004).

6.2.100 Lesser black-backed gull is listed on the Amber list of BoCC due to the presence of over 20% of the European population and the fact that over 50% breed at ten or fewer sites (Eaton et al., 2009). Large colonies are principally found along the west coast of Britain, including the colony within the Ribble and Alt Estuaries SPA. The SPA citation states 1,800 pairs are present, representing 1.5% of the West Europe population (Stroud et al, 2001), although more recent data puts the colony at 4100 birds (Mitchell et al., 2004). A breeding population of 22,000 pairs is an interest feature of Morecambe Bay SPA, which is found 42km to the north of Burbo Bank Extension Offshore Wind Farm.

6.2.101 At sea, lesser black-backed gulls' distribution reflects the location of breeding colonies with highest densities in the Irish Sea. Between March and April birds become more widespread, although again high densities are found in the Irish and Celtic Seas in addition to the south-western Approaches. These areas are on the northern edge of the species' winter range with substantial numbers moving southwards to the Bay of Biscay (Wernham et al., 2002).

6.2.102 Table 33 summarises the conservation and Liverpool Bay/Burbo Bank Extension Offshore Wind Farm status of lesser black-backed gull.

Table 33: Lesser black-backed gull status at Burbo Bank Extension Offshore Wind Farm

	Lesser black-backed gull
Conservation status	Cited for Ribble & Alt Estuaries SPA & Ramsar (breeding) Cited for Morecambe Bay SPA (breeding) BoCC Amber
International threshold	5500
National threshold	2200 (breeding) 1200 (winter)
Regional threshold	1385
Aerial (2011) population	41 (March)
Aerial (2011) density	0.20/km^2
BBW02 Boat-based + 1 km buffer (2011) population	626 (August)
BBW02 Boat-based + 1 km buffer (2011) density	7.37/km^2
BBW02 Boat-based + 4 km buffer (2011) population	606 (June)
BBW02 Boat-based + 4 km buffer (2011) density	2.88/km^2
BBW02 Aerial (2001-2009) density	2.88/km^2
NW5 Aerial density (2001-2009)	2.43/km^2
NW6a Aerial density (2001-2009)	2.88/km^2

6.2.103 Lesser black-backed gulls were present in low numbers during the 2010-2011 aerial surveys, which were undertaken primarily in winter months. A peak count occurred in March 2011 when a population estimate of 41 birds was present at a density of 0.20 individuals / km^2. This density is lower than estimates from the data extracted from the CCW database, where Burbo Bank Extension, NW5 and NW6a had broadly

equal densities (albeit fairly low). The 2011 boat-based surveys recorded low densities during April and May, with a build-up of numbers during the summer reaching with a peak in June. At this point densities were highest within the wind farm site and 1 km buffer and reached 7.37 individuals / km^2 (population of 626). These numbers are likely to involve both breeding adult and non-breeding immature birds and the population estimate should be assessed against the national threshold for breeding lesser black-backed gulls (which it does not exceed).

6.2.104 Figure 13 presents the abundance of lesser black-backed gulls during the 2011 boat-based surveys, highlighting the low numbers present in April, May and September and peak populations in June and August.

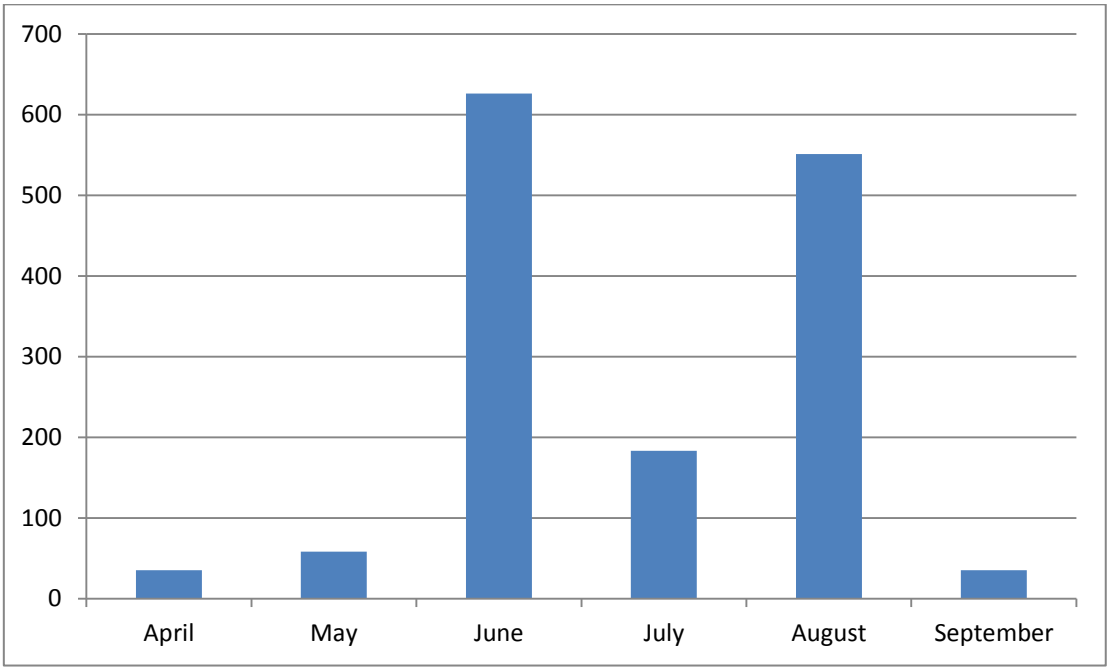


Figure 13: Lesser black-backed gull abundance during 2011 boat-based surveys (Wind farm area and 1 km buffer).

6.2.105 Figure 14 shows the distribution of lesser black-backed gull observations during the 2011 boat-based surveys. Observations were widespread, although few records were made in the north-west of the survey area. Peak densities occurred in the south-east of the survey area closest to the Wirral coastline.

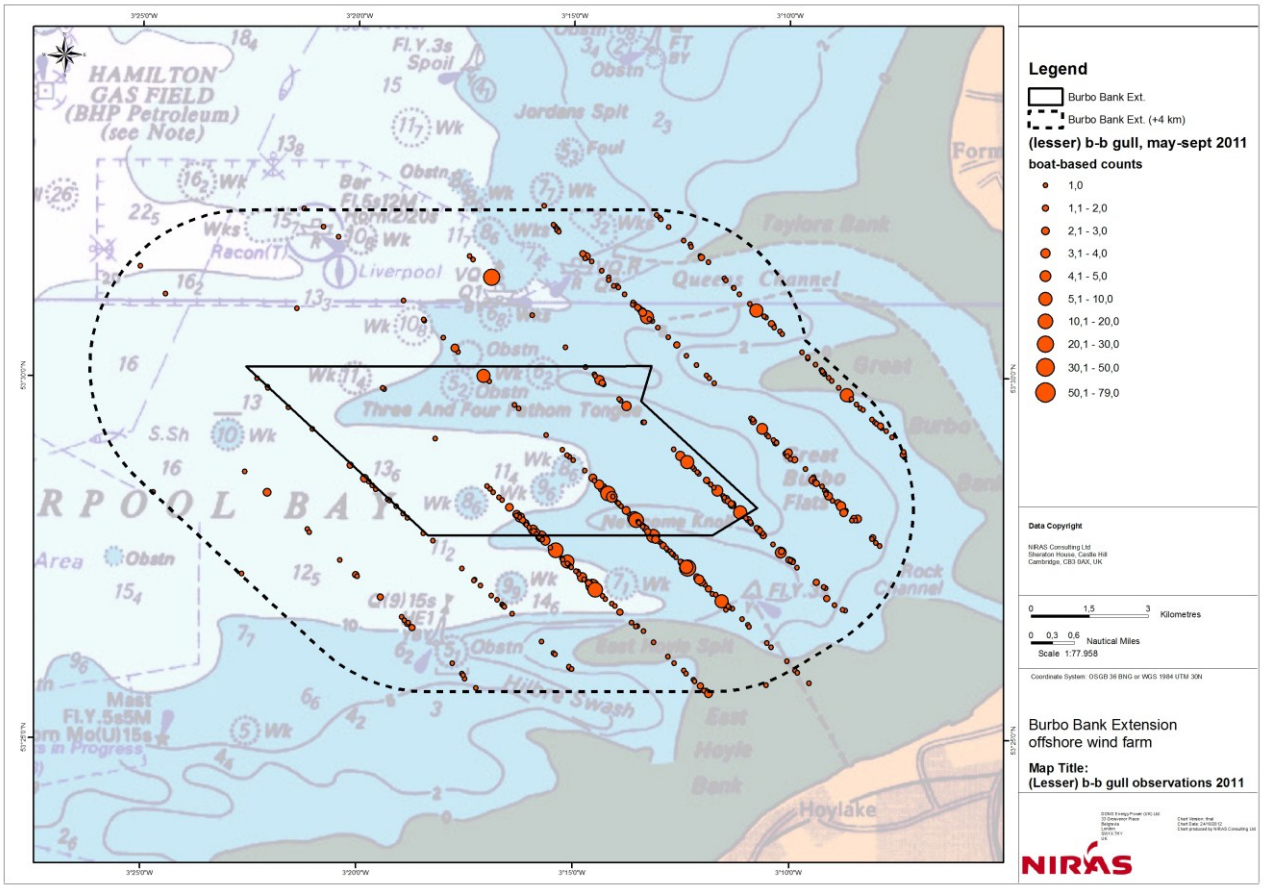


Figure 14: Lesser black-backed gull observations during 2011 boat-based surveys.

6.2.106 For the purposes of this assessment, lesser black-backed gull is considered to be of **International Importance** as it is included as an interest feature of the Ribble and Alt Estuaries SPA.

Great black-backed gull

6.2.107 Great black-backed gulls have a large range within the North Atlantic and have a global population of 170,000 – 180,000 pairs. Within Britain, the majority are found in northern and western Scotland, where they nest on rocky coastlines with stacks and cliffs. Numbers breeding around the northern Irish Sea are limited, with 101 pairs present in Gwynedd during the Seabird 2000 survey (Mitchell et al., 2004). British breeding birds disperse relatively short distances after breeding, with these individuals joined by large numbers of birds from northern Europe between July and October. A large proportion of these birds over- winter on the east coast of England.

6.2.108 Table 34 summarises the conservation and Liverpool Bay/Burbo Bank Extension Offshore Wind Farm status of great black-backed gull.

Table 34: Great black-backed gull status at Burbo Bank Extension Offshore Wind Farm

	Great black-backed gull
Conservation status	BoCC Amber
International threshold	4400
National threshold	340 (breeding) 760 (winter)
Regional threshold	206
Aerial (2011) population	90 (November)
Aerial (2011) density	0.40/km^2
BBW02 Boat-based + 1 km buffer (2011) population	32 (September)
BBW02 Boat-based + 1 km buffer (2011) density	0.38/km^2
BBW02 Boat-based + 4 km buffer (2011) population	160 (September)
BBW02 Boat-based + 4 km buffer (2011) density	0.76/km^2
BBW02 Aerial (2001-2009) density	2.69/km^2
NW5 Aerial density (2001-2009)	1.33/km^2
NW6a Aerial density (2001-2009)	2.69/km^2

6.2.109 The 2011 boat-based surveys found that great black-backed gulls were absent during spring, with low numbers arriving from June onwards. A peak count occurred in September, when a population of 160 birds (at a density of 0.76 individuals / km^2) was present within the entire study area. Numbers were similarly low during the 2010-2011 aerial surveys, with a peak count of 21 birds on 10th November 2010 (population estimate of 90 at a density of 0.43 individuals / km^2). Unidentified gulls reached a peak in December 2010 during the aerial surveys, with a population estimate of 654 birds present. A proportion of these birds are likely to be great black-backed gulls, although it is considered very unlikely that the total of this species would approach the threshold for national or regional importance. Densities derived from the aerial survey data extracted from the CCW database were higher than the 2010-2011 surveys. Burbo Bank Extension had an equivalent density to NW6a, while NW5 was 50% lower.

6.2.110 Great black-backed gull is not included as an interest feature of any European sites adjacent to Burbo Bank Extension nor is there evidence that significant populations occur. For the purposes of this assessment, great black-backed gull is considered to be of **Regional Importance**.

Common tern

6.2.111 Common terns are the most widely distributed breeding tern species in Britain. Colonies occur around most coastlines and also inland on lakes and gravel pits. Common terns have a large worldwide breeding distribution being present throughout Eurasia, North America and North Africa, with a global population of 460,000-620,000 pairs. Britain supports 10,100 pairs which represents 3-5% of the European population (Mitchell et al., 2004).

6.2.112 Common tern is listed on Annex 1 of the EU Birds Directive and as such, notable colonies in the region contribute as interest features to several designated sites (Table 32). Common tern is an interest feature for the Dee Estuary SPA (277 pairs; 2.3% of the British population), Ribble and Alt Estuaries SPA (182 pairs; 1.5% of the British population) and Mersey Narrows and North Wirral Foreshore pSPA (177 pairs; 1.8%

of the British population). Common terns are also cited as a passage interest feature for the Mersey Narrows pSPA (1475 birds).

Table 35: Common tern status at Burbo Bank Extension

	Common tern
Conservation status	Cited for Dee Estuary SPA (breeding) Cited for Mersey Narrows & North Wirral Foreshore pSPA (breeding and passage) Cited for Ribble & Alt Estuaries SPA (breeding) Noteworthy species for Dee Estuary Ramsar Annex 1 of the EU Birds Directive BoCC Amber
International threshold	5400
National threshold	200 (breeding)
Regional threshold	150
Aerial (2011) population	0
Aerial (2011) density	0
BBW02 Boat-based + 1 km buffer (2011) population	334 (August)
BBW02 Boat-based + 1 km buffer (2011) density	3.93/km^2
BBW02 Boat-based + 4 km buffer (2011) population	402 (August)
BBW02 Boat-based + 4 km buffer (2011) density	1.91/km^2
BBW02 Aerial (2001-2009) density	1.55/km^2
NW5 Aerial density (2001-2009)	2.85/km^2
NW6a Aerial density (2001-2009)	2.85/km^2

6.2.113 No Common terns were specifically identified during the 2010-2011 aerial surveys, which in any case were outside of key periods for this species. A small number of unidentified terns were recorded in April 2011. Aerial survey data extracted from the CCW database included densities for unidentified common/Arctic terns, which are most likely to concern the majority of the former species. NW5 and NW6a had identical densities of 2.85 individuals / km^2, while within the Burbo Bank Extension site the maximum density was lower at 1.55 individuals / km^2.

6.2.114 The 2011 boat-based surveys recorded moderate numbers of common terns during May and June, with low numbers of birds recorded in July. Large numbers were present in August with a population of 402 estimated at a density of 1.91 individuals / km^2. The population present in August exceeds the threshold for national and regional importance (for breeding birds at least, although in August these birds are likely to be on passage). Most terns recorded in September were unidentified and noted as common/Arctic, with up to 101 birds present at a density of 2.54 individuals / km^2 within the wind farm area.

6.2.115 Figure 15 presents the abundance of common terns during the 2011 boat-based surveys. The figure further highlights the post-breeding peak in August and the limited numbers recorded during the main breeding period of June and July.

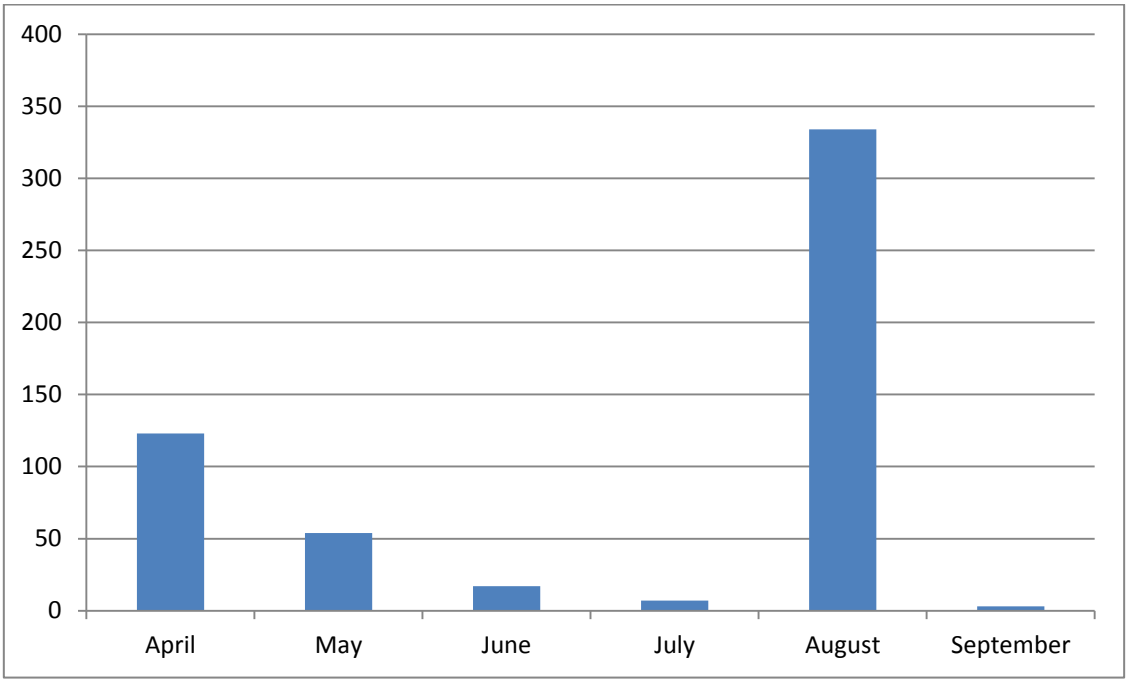


Figure 15: Common tern abundance during 2011 boat-based surveys (Wind farm area and 1 km buffer area).

6.2.116 Figure 16 shows the distribution of all common tern records during the boat-based surveys. Records were widespread, although few birds were recorded in the west of the survey area. Largest numbers occurred in the south-east.

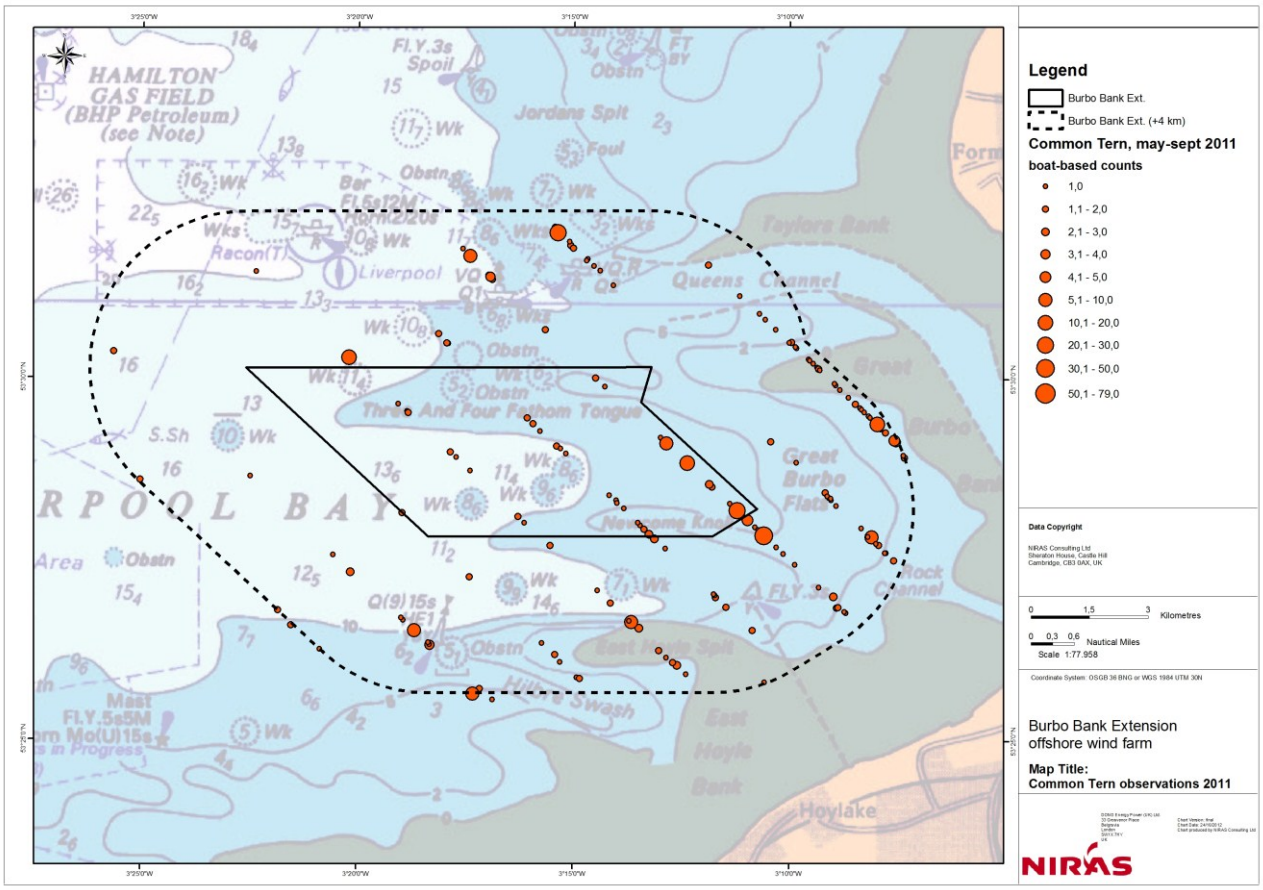


Figure 16: Common tern observations during 2011 boat-based surveys.

6.2.117 Common tern is included as an interest feature of three European sites adjacent to Burbo Bank Extension Offshore Wind Farm, while a population of national importance was seen to occur on one occasion in the boat-based survey of 2011. For the purposes of this assessment common tern is considered to be of **International Importance**.

Arctic tern

6.2.118 Arctic terns are the most abundant tern species in the UK, although they have a distinctly northern breeding distribution (73% occur in the Northern Isles). Arctic terns have a wide circumpolar distribution, with the total population estimated at between 800,000 – 2.7 million pairs (Mitchell et al., 2004). Britain supports 52,600 pairs which represents 3-11% of the European/North Atlantic population.

6.2.119 No colonies exist in the near vicinity of Burbo Bank Extension Offshore Wind Farm, with the closest being large colonies on Anglesey and moderate numbers at Walney, Cumbria. Burbo Bank Extension Offshore Wind Farm lies beyond the maximum foraging range of this species. Table 36 summarises the conservation and Liverpool Bay/Burbo Bank Extension Offshore Wind Farm status of Arctic tern.

Table 36: Arctic tern status at Burbo Bank Extension Offshore Wind Farm

	Arctic tern
Conservation status	Annex 1 of the EU Birds Directive BoCC Amber
International threshold	13,300
National threshold	1060
Regional threshold	238
Aerial (2011) population	0
Aerial (2011) density	0
BBW02 Boat-based + 1 km buffer (2011) population	0
BBW02 Boat-based + 1 km buffer (2011) density	0/km^2
BBW02 Boat-based + 4 km buffer (2011) population	8 (September)
BBW02 Boat-based + 4 km buffer (2011) density	0.04/km^2
BBW02 Aerial (2001-2009) density	-
NW5 Aerial density (2001-2009)	-
NW6a Aerial density (2001-2009)	-

6.2.120 No Arctic terns were specifically identified during either the 2011 aerial survey, while a very limited number were recorded in the 4km buffer during the boat-based surveys (population of 8 birds in September 2011). Unidentified common/Arctic terns see on passage during the boat-based surveys in August and September 2011 may have included a proportion of the latter species although numbers would be well below thresholds for international, national and regional importance. It is also assumed that all common/Arctic terns recorded in the 2001- 2009 aerial surveys (extracted from the CCW database) refer to the former species, although a small proportion may refer to Arctic terns during passage periods.

6.2.121 Arctic tern is not included as an interest feature of any European sites adjacent to Burbo Bank Extension Offshore Wind Farm. It is considered extremely unlikely that populations of international or national importance of this species occur within the survey area during passage periods. For the purposes of this assessment, Arctic tern is considered to be of **National Importance** due to its status as being included on Annex 1 of the EU Birds Directive.

Sandwich tern

6.2.122 Sandwich tern has an estimated global population of 160,000-170,000 pairs, of which 69,000-79,000 breed in Europe (Mitchell et al., 2004). The British population is estimated to be at 11,000 pairs, which therefore contributes between 14 and 16% of the European population. The population is patchily distributed along British coasts, with the majority divided between a handful of large colonies. The most significant of these colonies lies on the English east coast, although colonies do exist on Anglesey and in Cumbria. Burbo Bank Extension Offshore Wind Farm lies outside the mean-maximum foraging range from these colonies.

6.2.123 Sandwich terns do not breed until at least three years of age, with young birds known to remain in their West African wintering grounds (Wernham et al., 2002). They are one of the first migrants to reappear for the breeding season (often by mid-March), with the majority having left British waters by late September.

6.2.124 Sandwich tern is cited as an interest feature of the Dee Estuary SPA, with 818 birds during passage periods (which represents 5.8% of the British population). The species are also breeding interest features for Morecambe Bay SPA (42km from Burbo Bank) and Duddon Estuary SPA (50km from Burbo Bank). Burbo Bank Extension Offshore Wind Farm lies outside of the mean-maximum foraging range for both of these sites.

6.2.125 Table 37 summarises the conservation and Liverpool Bay/Burbo Bank Extension Offshore Wind Farm status of Sandwich tern.

Table 37: Sandwich tern status at Burbo Bank Extension Offshore Wind Farm

	Sandwich tern
Conservation status	Cited for Dee Estuary SPA (passage) Noteworthy species for Dee Estuary Ramsar Annex 1 of the EU Birds Directive BoCC Amber
International threshold	1670
National threshold	220
Regional threshold	91
Aerial (2011) population	0 (116 if including all 'tern sp.' records)
Aerial (2011) density	0 (0.55/km^2 if including all tern sp. records)
BBW02 Boat-based + 1 km buffer (2011) population	126
BBW02 Boat-based + 1 km buffer (2011) density	1.48/km^2
BBW02 Boat-based + 4 km buffer (2011) population	177
BBW02 Boat-based + 4 km buffer (2011) density	0.84/km
BBW02 Aerial (2001-2009) density	0.44/km^2
NW5 Aerial density (2001-2009)	0.20/km^2
NW6a Aerial density (2001-2009)	0.67/km^2

6.2.126 Sandwich terns were not specifically recorded during the 2010-2011 aerial surveys, although 5 unidentified terns on 3rd March 2011 were almost certainly this species. No significant spring passage was noted during the 2011 boat-based surveys, with moderate numbers not present until August when a maximum population of 86 birds was present at a density of 2.17 individuals / km^2 which approaches the threshold for regional importance but does not exceed it..

6.2.127 Figure 17 presents the distribution of all Sandwich tern records during the boat-based surveys. Records were widespread although it is notable that relatively few birds were recorded within the Burbo Bank Extension Offshore Wind Farm site. Highest densities occurred in the eastern half of the survey area.

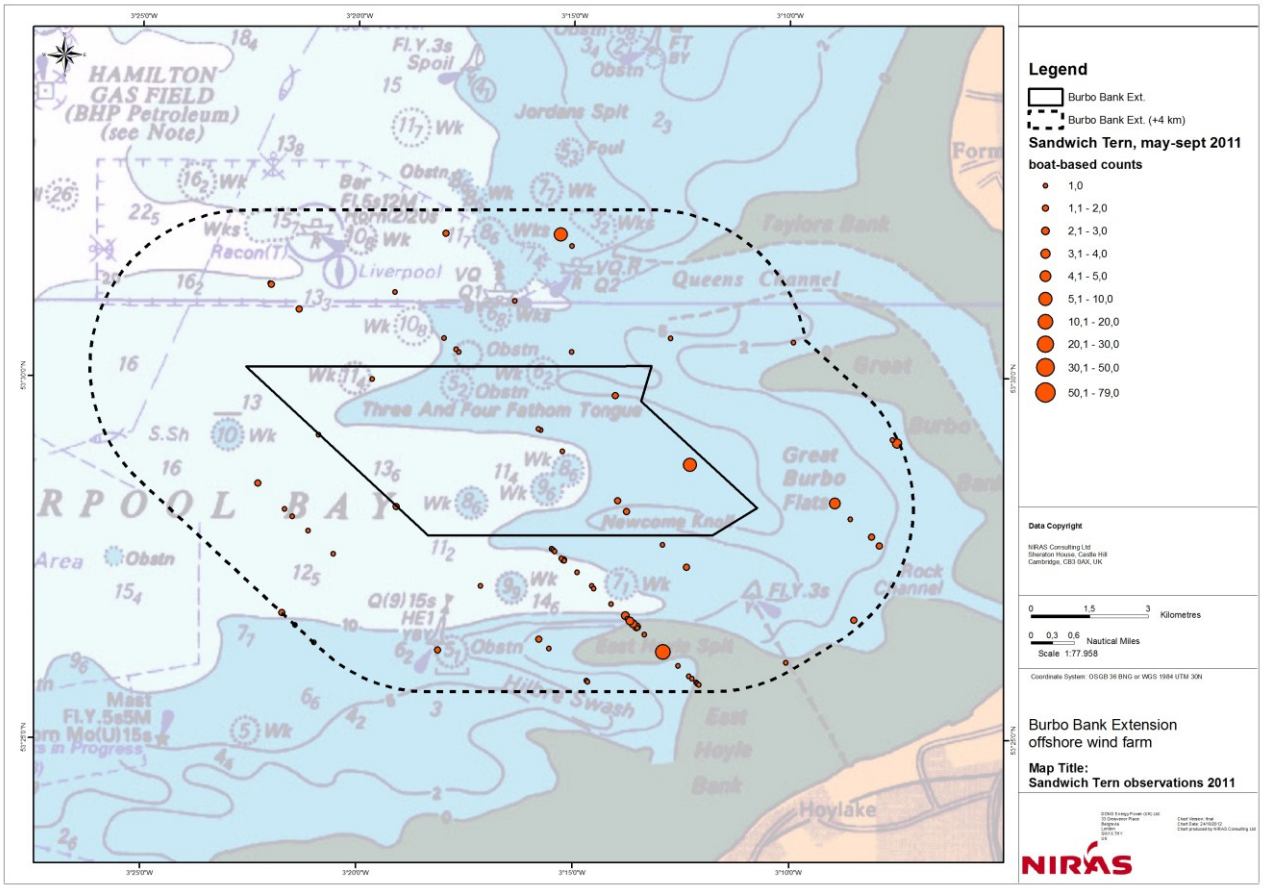


Figure 17: Sandwich tern observations during 2011 boat-based surveys.

6.2.128 Aerial survey data extracted from the CCW database indicated that the Burbo Bank Extension Offshore Wind Farm area had approximately equivalent importance for Sandwich tern to the wide count areas. Maximum densities were low with Burbo Bank Extension Offshore Wind Farm lower than that seen for NW6a but greater than NW5.

6.2.129 Sandwich tern is included as an interest feature of the Dee Estuary SPA (for a passage population), although population estimates of this species from boat-based surveys at Burbo Bank Extension Offshore Wind Farm did not exceed thresholds of international or national importance. For the purposes of this assessment, common tern is considered to be of **International Importance**.

Guillemot

6.2.130 Guillemots are abundant seabirds that have a breeding population of 1.32 million individuals (with the European and world populations being 2.8 and 7.3 million respectively. Guillemots are widely distributed across the North Atlantic and Pacific Oceans. Guillemots nest in most places around the coastline where there is suitable cliff habitat; as such, the majority of the British population nest in Scottish colonies.

6.2.131 Many adults remain in the vicinity of their colonies year-round, although they begin to visit the nesting ledge in January and February, and by March and April large congregations gather in the waters surrounding colonies. Adults disperse in July and moult, hence becoming flightless for a period of 6-7 weeks.

By August, large concentrations are found in several areas including the Irish Sea. Between November and February they become more widespread and can occur in all inshore waters from Norway south to Iberia.

6.2.132 Within the proximity of Burbo Bank Extension Offshore Wind Farm, no breeding colonies are present. The closest occur in north-west Wales (Puffin Island and Anglesey), while a further notable colony occurs at St Bees Head in Cumbria. Guillemots have an extensive foraging range and Burbo Bank Extension Offshore Wind Farm is in reach of these colonies, although the species is not cited as an interest feature of any SPA site in the region. The nearest European sites including guillemot as an interest feature are Ailsa Craig SPA to the north and Skokholm and Skomer SPA to the south-west. Both of these sites are greater than 200km distant from Burbo Bank Extension Offshore Wind Farm.

6.2.133 Table 38 summarises the conservation and Liverpool Bay/Burbo Bank Extension Offshore Wind Farm status of guillemot.

Table 38: Guillemot status at Burbo Bank Extension Offshore Wind Farm

	Guillemot
Conservation status	BoCC Amber
International threshold	47,000
National threshold	13,000
Regional threshold	6648
Aerial (2011) population	2198 (partitioned unidentified auks (February)
Aerial (2011) density	10.44/km^2
BBW02 Boat-based + 1 km buffer (2011) population	1966
BBW02 Boat-based + 1 km buffer (2011) density	23.15/km^2
BBW02 Boat-based + 4 km buffer (2011) population	3448
BBW02 Boat-based + 4 km buffer (2011) density	16.39/km^2
BBW02 Aerial (2001-2009) density	3.07/km^2
NW5 Aerial density (2001-2009)	13.97/km^2
NW6a Aerial density (2001-2009)	7.14/km^2

6.2.134 Guillemots and razorbills were not separately identified during the 2010-2011 aerial surveys, although it is highly likely that the vast majority are guillemot. Auks were common in each survey reaching a peak maximum population estimate of 2338 birds (at a density of 11.11 individuals / km^2) in February 2011. The 2011 boat-based survey allowed positive identification of most auks seen and guillemot was vastly more abundant than razorbill, present in substantial numbers in all surveys except April. A peak population occurred in July when 3448 birds were estimated at a density of16.39 individuals / km^2. This population does not exceed the threshold for regional importance.

6.2.135 Figure 18 presents the abundance of guillemots during the 2011 boat-based surveys and highlighting the build of numbers from virtual absence in April.

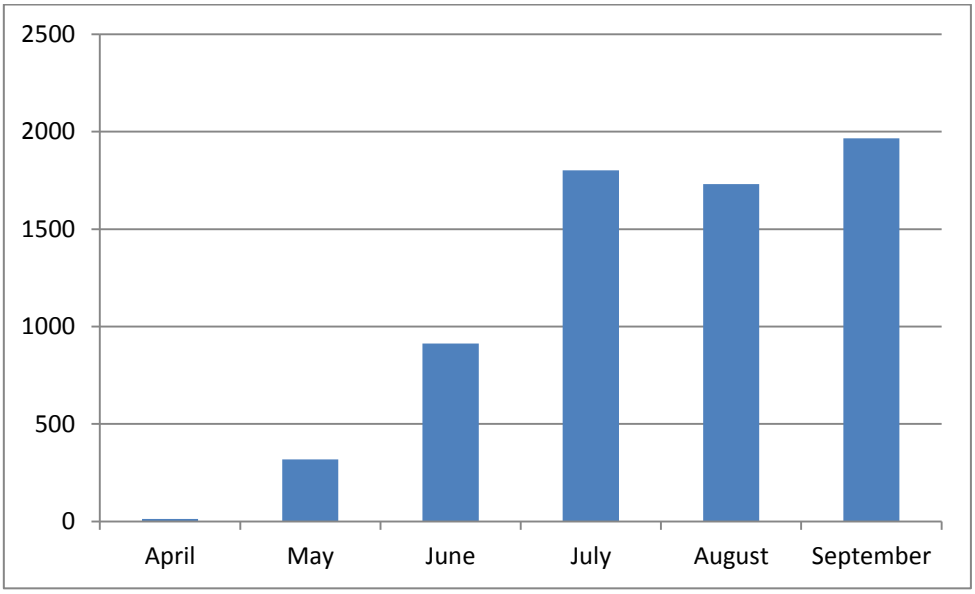


Figure 18: Guillemot abundance during 2011 boat-based surveys (Wind farm area and 1 km buffer).

6.2.136 The aerial survey data extracted from the CCW database suggests a variable density of guillemots in the area in and around Burbo Bank Extension Offshore Wind Farm. Density within the site was low (considerably lower than seen in the both boat-based surveys and the 2010-2011 aerial surveys). Densities in the wider survey areas of NW5 and NW6a were broadly equivalent to the peak density recorded in the 2010-2001 aerial survey.

6.2.137 Guillemot is not included as an interest feature of any European sites adjacent to Burbo Bank Extension Offshore Wind Farm. Guillemots were abundant in the Burbo Bank Extension Offshore Wind Farm site and surrounding area, although maximum population estimates suggest that international or nationally important numbers are not present. For the purposes of this assessment guillemot is considered to be of **Regional Importance** due to its status as being included on Amber list of BoCC.

Razorbill

6.2.138 As a breeding bird, razorbills are restricted to the North Atlantic, where there is a population of 610,000-630,000 pairs (Mitchell et al., 2004). Britain supports an estimated 110,000 pairs, which is approximately 18% of the world population. Razorbill is therefore regarded as of conservation concern in a British and European perspective.

6.2.139 Razorbills nest on small ledges or in cracks on rocky cliffs, and most in Britain are found on the Northern Isles and in Northwest Scotland. Within the northern Irish Sea their breeding distribution mirrors that of guillemot with colonies occurring at St Bees Head in Cumbria and in north-west Wales and Anglesey. Birds from northern colonies move southwards in winter and between October and March they are well dispersed in the North Sea, English Channel and the central Irish Sea (Brown & Grice, 2005).

6.2.140 Table 39 summarises the conservation and Liverpool Bay/Burbo Bank Extension Offshore Wind Farm status of razorbill. Razorbill is not an interest feature of any designated site within the region.

Table 39: Razorbill status at Burbo Bank Extension Offshore Wind Farm

	Razorbill
Conservation status	BoCC Amber
International threshold	11,900
National threshold	1640
Regional threshold	1398
Aerial (2011) population	140 (partitioned unidentified auks)
Aerial (2011) density	0.67/km^2 (guillemot and unidentified auks combined)
BBW02 Boat-based + 1 km buffer (2011) population	114
BBW02 Boat-based + 1 km buffer (2011) density	1.34/km^2
BBW02 Boat-based + 4 km buffer (2011) population	360 (September)
BBW02 Boat-based + 4 km buffer (2011) density	1.71/km^2
BBW02 Aerial (2001-2009) density	1.09/km^2
NW5 Aerial density (2001-2009)	1.09/km^2
NW6a Aerial density (2001-2009)	0.12/km^2

6.2.141 No razorbills were specifically identified in the 2010-2011 aerial surveys although the population estimates for unidentified auks was large. The vast majority of these birds were, however, likely to be guillemots, with razorbills in the distinct minority. This suggestion is confirmed by the 2011 boat-based surveys which were able to distinguish most observed auks. . Using a proportional approach is it estimated that the peak population of razorbills in the aerial surveys was 140 birds. Razorbills were absent within the wind farm area in all months except September when a maximum population of 360 individuals was present (at a density of 1.71 individuals / km^2). Densities were similarly low in the aerial data extracted from the CCW database, although again there would be limited positive identification of this species from the techniques implemented.

6.2.142 Razorbill is not included as an interest feature of any European sites adjacent to Burbo Bank Extension Offshore Wind Farm. Razorbills were moderately common in the Burbo Bank Extension Offshore Wind Farm site and surrounding area, although maximum population estimates suggest that internationally, nationally or regionally important numbers are not present. For the purposes of this assessment, razorbill is considered to be of **Regional Importance** due to its Amber list BoCC status.

Puffin

6.2.143 Puffins breed on both sides of the North Atlantic, although 95% of the global population of 5.5-6.6 million pairs is found in the European north-east Atlantic. An estimated 580,000 breeds in Britain, largely in northern Scotland and in Northumberland. Within the northern Irish Sea, small colonies exist on Anglesey, the Isle of Man and at St Bees Head in Cumbria.

6.2.144 During the non-breeding season puffins are widespread throughout the North Atlantic, occurring at low densities, and are considered to be scarce in the Irish Sea during this period (Skov et al., 1995; Harris & Wanless, 2011). Puffins return to breeding colonies in late March to early April, with much time spent feeding some distance offshore.

6.2.145 Table 40 summarises the conservation and Liverpool Bay/Burbo Bank Extension Offshore Wind Farm status of puffin. Puffin is not an interest feature of any designated site within the region.

Table 40: Puffin status at Burbo Bank Extension Offshore Wind Farm

	Puffin
Conservation status	BoCC Amber
International threshold	130,000
National threshold	5790
Regional threshold	5587
Aerial (2011) population	493 (November)
Aerial (2011) density	2.34/km^2
BBW02 Boat-based + 1 km buffer (2011) population	-
BBW02 Boat-based + 1 km buffer (2011) density	-
BBW02 Boat-based + 4 km buffer (2011) population	-
BBW02 Boat-based + 4 km buffer (2011) density	-
BBW02 Aerial (2001-2009) density	-

6.2.146 Puffins were not recorded during the 2011 boat-based surveys, although occasional numbers were recorded during the 2010-2011 aerial surveys. A peak of 493 birds (at a density of 2.34 individuals / km^2) occurred in February 2011, with moderate numbers also present in November 2010.

6.2.147 Puffin is not included as an interest feature of any European sites adjacent to Burbo Bank Extension Offshore Wind Farm. Puffins were recorded within the 2010-2011 aerial survey only, where maximum population estimates did not approach thresholds for national or regional importance. For the purposes of this assessment puffin is considered to be of **Regional Importance** due to its Amber list of BoCC status.

6.3 Additional species of relevance to the Project

Migratory waders and wildfowl

6.3.1 It is recognised that migratory waders and wildfowl are unlikely to be recorded in realistic numbers during the baseline survey work due to the often short periods of time species may interact with the wind farm area and the predilection for certain species to migrate at night. Recently published guidance from the British Trust for Ornithology (BTO) (Wright and Austin, 2012) presents the SOSS Migration Assessment Tool (MAT) which was designed in order to address this problem. The MAT utilises 251,599 lines of connectivity which were constructed as line of sight crossings for migrants transiting UK waters. Those lines of connectivity which interacted with the Project site were identified, resulting in a total of 1,178 lines of connectivity.

6.3.2 Those sea crossings pertinent to the Project were identified according to the descriptions provided in Wright and Austin (2012):

- England and Wales Bristol Channel to England and Wales Irish Sea;
- England and Wales Irish Sea to England and Wales Irish Sea;

- England and Wales Irish Sea to Northern Ireland Celtic Seas coast;
- England and Wales Irish Sea to Scottish mainland Celtic Seas coast;
- Republic of Ireland – Celtic Seas Eastern coast to England and Wales Irish Sea; and
- Spanish North coast to England and Wales Irish Sea.

6.3.3 Key species potentially interacting with the Project site were identified from the SPA review citations (Stroud et al., 2001) for sites to the south or east. Sites to the north (e.g. Morecambe Bay SPA) were not included as connectivity between northern breeding grounds (Cramp and Simmons (1977); Cramp and Simmons (1983)) and the SPA would not include interaction with the Project site. SPAs considered in the analysis were:

- Dee Estuary SPA;
- Mersey Estuary SPA; and
- Mersey Narrows and North Wirral Foreshore.

6.3.4 The percentage of the UK population of each species predicted to be potentially transiting the sea crossings identified above was calculated using the data presented in Wright et al. (2012) and Stroud et al.(2001). These percentage values were then used as the population correction factor as required in the MAT.

6.3.5 Table 41 presents the results obtained from the MAT in terms number of annual movements potentially interacting with the Project site. These figures are incorporated in to a collision risk model (Band, 2012) within the EIA for Burbo Bank Extension although preliminary guidance is given in Table 41 in terms of applying a 98% avoidance rate (SNH, 2010). This implies a very low proportion of each species relevant regional population likely to interact with Burbo Bank Extension.

Table 41: The number of movements of wading and wildfowl species predicted across the Project site

Species	Number of movements across wind farm footprint	98% avoidance
Shelduck	283	5.66
Teal	141	2.82
Pintail	221	4.42
Oystercatcher	680	13.6
Ringed plover	35	0.7
Golden plover	74	1.48
Grey plover	52	1.04
Knot	770	15.4
Dunlin	2318	46.36
Black-tailed godwit	41	0.82
Bar-tailed godwit	138	2.76
Curlew	96	1.92
Redshank	316	6.32

6.4 Identified receptors at Burbo Bank Extension

6.4.1 Table 42 presents all bird species of interest at Burbo Bank Extension and details their importance and thus the relevant population or populations of this species that require further assessment.

6.4.2 Ten species of international importance were identified: red-throated diver, great crested grebe, Manx shearwater, common scoter, little gull, black-headed gull, lesser black-backed gull, common tern, little tern and Sandwich tern. All of these species, in varying densities, occurred within Burbo Bank Extension with the exception of little tern. No significant numbers of waders or wildfowl which are interest features of several adjacent European sites to Burbo Bank Extension Offshore Wind Farm were recorded during the surveys.

6.4.3 Three species were considered to be of national importance: great northern diver, cormorant and Arctic tern. Cormorant was recorded in all surveys, while great northern diver was found in the 2001-2009 aerial surveys of the Irish Sea only. Arctic terns were not specifically identified, although a proportion of unidentified terns during passage periods may have referred to this species.

6.4.4 Twelve remaining species are considered to be of regional importance; while a single species (red-breasted merganser) is of local importance.

6.4.5 The suite of European sites in the vicinity of Burbo Bank Extension include several wildfowl and wader species as interest features (Table 1). With the exception of common scoter and red-breasted merganser (both sea ducks) no wildfowl were recorded during the boat-based surveys of Burbo Bank Extension or during the monitoring surveys of the operational Burbo Bank.

6.4.6 Wader species were limited to a sighting of a single curlew during the 2011 surveys. Numbers of waders recorded during both pre and during construction of Burbo Bank were extremely low and considered to be insignificant in the context of the Scheme and populations of adjacent European sites (Hyder Consulting, 2008). These species are therefore not carried forward in the assessment and not included in Table 38.

Table 42: Importance of bird species recorded within or adjacent to Burbo Bank Extension

Importance	Species	Populations	Usage of site
International	Red-throated diver	Liverpool Bay SPA (winter)	Present during winter at a low density, higher densities occur in surrounding areas.
	Great crested grebe	Mersey Estuary SPA (winter)	Present during winter in very low densities.
	Manx shearwater	Aberdaron Coast & Bardsey Island SPA (breeding)	Present during summer months in variable densities; highest densities occurred in July 2011 boat-based surveys which were higher than recorded in aerial surveys of surrounding areas.
	Common scoter	Liverpool Bay SPA (winter) Ribble & Alt Estuaries SPA (winter)	Present from early autumn through winter months at low densities. Substantially higher densities occur in areas elsewhere in Liverpool Bay.
	Little gull	Mersey Narrows & North Wirral Foreshore SPA (passage)	Present during passage periods at a low density
	Black-headed gull	Ribble and Alt Estuaries SPA (breeding)	Seen sporadically throughout the year, although in very low densities.
	Herring gull	Morecambe Bay SPA (breeding)	Present throughout the year and fairly common. Densities recorded in aerial surveys were however somewhat lower than recorded in surrounding areas.
	Lesser black-backed gull	Ribble and Alt Estuaries SPA (breeding) Morecambe Bay SPA (breeding)	Present throughout the year, with highest densities occurring in late summer; relatively uncommon in winter.
	Common tern	Dee Estuary SPA (breeding) Mersey Narrows & North Wirral Foreshore pSPA (breeding) Mersey Narrows & North Wirral Foreshore pSPA (passage) Ribble & Alt Estuaries SPA (breeding)	Summer visitor, when present in low densities from May-July. Higher densities involving post-breeding/passage birds recorded in August 2011.
	Sandwich tern	Dee Estuary SPA (passage)	Seen during passage periods in low-moderate densities, peak numbers recorded early autumn.

National	Great northern diver	British wintering population	Scarce-rare winter visitor, very low densities recorded.
	Cormorant	British wintering population	Fairly common throughout the year, although densities substantially lower in Burbo Bank Extension Offshore Wind Farm site than surrounding areas.
	Arctic tern	British breeding population	No identified within Burbo Bank Extension Offshore Wind Farm site (reference area only); likely to be a scarce-rare passage visitor.
	Guillemot	British breeding population	Common throughout the year, with a peak noted in late summer boat-based survey (when higher density noted than recorded for surrounding areas).
	Razorbill	British breeding population	Uncommon during winter months
	Puffin	British breeding population	Identified in two aerial surveys only (November 2010 and February 2011).
Regional	Fulmar	British breeding population	Rarely recorded within site, larger densities (although still low) recorded elsewhere in Liverpool Bay.
	Gannet	British breeding population	Present in variable numbers primarily during passage periods; scarce during winter. Site population estimates not significant.
	Shag	British breeding population	Present in low densities during winter only.
	Scaup	British wintering population.	Present in winter, when recorded on a single aerial survey only.
	Arctic skua	British breeding population	Scarce passage migrant, low densities recorded.
	Great skua	British breeding population	Rare passage migrant, very low densities recorded.
	Kittiwake	British breeding population	Present throughout the year, low densities during winter months to moderate levels in mid-summer. Densities broadly equivalent to surrounding areas.
Local	Red-breasted Merganser	British wintering population	Recorded on a single aerial survey only; low densities present in surrounding areas.
	Common gull	British wintering population	Fairly common winter visitor, with few present during summer months. Densities broadly equivalent to surrounding areas.
	Great black-backed gull	British wintering population	Widespread during winter and passage periods, scarce in summer.

			Lower densities present within site than surrounding areas.

7 Potential impacts

7.1 Impacts of offshore wind farms on birds

7.1.1 Wind turbines have the potential to present risks to birds through collision, disturbance/displacement, barriers to movement, habitat change and the cumulative/in-combination effects across multiple schemes (Langston, 2010).

7.1.2 Seabirds, in general, are longer lived and consequently a lower annual reproductive output is characteristic of several species. Such species may therefore be more susceptible to effects of increased mortality above background levels by, for example, collision with turbine rotors. The effects of disturbance and displacement are in comparison, more difficult to quantify, although both seabirds and migratory species are potentially vulnerable to such effects.

7.1.3 Barriers to movement can affect migratory birds on their annual flyways and as disruption to functional links, such as between feeding and breeding areas. Habitat loss has the potential to affect birds at different times of their life cycle with foraging, roosting and moulting areas requiring consideration, although such effects are limited to seabirds.

7.1.4 The forthcoming impact assessment of Burbo Bank Extension Offshore Wind Farm will provide detailed focus on the potential negative impacts of such effects on the identified ornithological receptors highlighted in this report. As a summary however, this section provides a preliminary overview of the possible key impacts considered to require such further assessment.

7.2 Burbo Bank Extension Offshore Wind Farm

7.2.1 Table 43 presents all species identified as being of regional importance and above, with their potential sensitivity to effects from offshore wind farms. Sensitivity ratings are given for collision, displacement, barrier effects and indirect effects on habitat and prey, and are based on the reviews by Langston (2010), Furness and Wade (2012) and Garthe and Hüppop (2004). Species are assigned as being of high (***), moderate (**) or low (*) risk from operational wind farms.

7.2.2 Table 43 therefore provides guidance, taken alongside survey results detailed in this report,, to focus the assessment of the potential ornithological effects of Burbo Bank Extension Offshore Wind Farm.

Table 43: Sensitivity of bird species recorded at Burbo Bank Extension Offshore Wind Farm to operational wind farms (based on Langston, 2010)

Importance	Species	Collision	Displacement	Barrier	Habitat/prey
International	Red-throated diver	*	***	**	**
	Great crested grebe	*	**	**	**
	Manx shearwater	*	*		**
	Common scoter	*	**	**	**
	Little gull	*	*	*	*
	Black-headed gull	*	*	*	*
	Herring gull	**	*	*	*
	Lesser black-backed gull	**	*	*	*
	Common tern	**	*	*	**
	Sandwich tern	**	*	*	**
National	Great northern diver	*	***	**	**
	Cormorant	**	*	**	**
	Arctic tern	**	*	*	**
	Guillemot	*	**	**	**
	Razorbill	*	**	**	**
	Puffin	*	**	**	**
Regional	Fulmar	*	*	*	**
	Gannet	**	*	*	*
	Shag	*	**	**	**
	Scaup	*	**	**	**
	Arctic skua	**	*	*	*
	Great skua	**	*	*	*
	Kittiwake	**	*	*	*

Local	Red-breasted Merganser	*	*	**	**
	Common gull	*	*	*	*
	Great black-backed gull	**	*	*	*

7.2.3 The accompanying Environmental Impact Assessment has been prepared in accordance with guidance provided in the National Policy Statements, EN-1 and EN-3, issued by DECC in 2011. This guidance suggests that there are five potential impacts of offshore wind farms on birds (in line with those given by Langston, 2010; Table 39):

- Collision with rotating blades;
- Direct habitat loss;
- Disturbance from construction activities such as the movement of construction/decommissioning vessels and piling;
- Displacement during the operational phase, resulting in loss of foraging/roosting area and:
- Impacts on bird flight lines (i.e. barrier effect) and associated increased energy use by birds for commuting flights between roosting and foraging areas.

7.2.4 Each of these effects is assessed within the EIA for each sensitive receptor for the three stages of the proposed wind farm development (construction, operation and decommissioning).

8 References

Baker, H., Stroud, D. A., Aebischer, N. J., Cranswick, P. A., Gregory, R. D., McSorley, C. A. , Noble, D. G. and Rehfisch, M. M. (2006). Population estimates of birds in Great Britain and the United Kingdom. *British Birds*, 99, 25-44.

Banks, A.N., Burton, N.H.K., Calladine, J.R. & Austin, G.E. 2007.Winter gulls in the UK: population estimates from the 2003/04-2005/06 Winter Gull Roost Survey. BTO Research Report No. 456 to English Nature (now Natural England), the Countryside Council for Wales, Scottish Natural Heritage, the Environment & Heritage Service (Northern Ireland), the Joint Nature Conservation Committee and Northumbrian Water Ltd. BTO, Thetford.

BirdLife International (2004). *Birds in Europe; population trends and conservation status.* BirdLife Conservation Series No. 12. Birdlife International, Cambridge, UK; 374pp.

Brown, A. and Grice, P. (2005). *Birds in England*. T & AD Poyser, London, UK: 694pp. ISBN 07136 6530 0.

Burton, N.H.K., Banks, A.N., Calladine, J.R. and Austin, G.E. (2012). The importance of the United Kingdom for wintering gulls: population estimates and conservation requirements. Bird Study, pp. 1-15.

Camphuysen, C. J., Fox, A. D. and Leopold, M. F. (2004). *Towards standardised seabirds at sea census techniques in connection with environmental impact assessments for offshore wind farms in the UK: A comparison of ship and aerial sampling for marine birds, and their applicability to offshore wind farm assessments*. Report commissioned by COWRIE. Available at: www.offshorewindfarms.co.uk.

CMACS. (2012). Burbo Extension Ornithology Report. A report to: DONG Energy. Centre for Marine and Coastal Studies Ltd, Eastham, Wirral.

Coulson, J.C. (2011). *The Kittiwake*. T & AD Poyser, London, UK.

Cramp, S. and Simmons, K.E.L. (1977) *The Birds of the Western Palearctic,* Volume I. Oxford University Press, Oxford, New York, 722 p.

Cramp, S. and Simmons, K.E.L. (1983) *The Birds of the Western Palearctic,* Volume III. Oxford University Press, Oxford, New York, 913 p.

Delany, S. & Scott, D. (2006). Waterfowl Population Estimates – Fourth Edition. Wetlands International, Wageningen, Netherlands.

BERR (2007). Aerial Surveys of Waterbirds in Strategic Wind Farm Areas: 2004/05 Final Report. Department for Business Enterprise & Regulatory Reform.

CCW (2008). Core Management Plan including Conservation Objectives for Skomer and Skokholm SPA. Countryside Council for Wales.

Dillon, I.A., Smith, T.D., Williams, S.J., Haysom, S. & Eaton, M.A. (2009) Status of Red-throated Divers *Gavia stellata* in Britain in 2006. *Bird Study* 56: 147–157.

DONG Energy (2010) Burbo Bank Extension Offshore Wind Farm: Environmental Impact Assessment Scoping Report. DONG Energy, London.

DTI (2006). Aerial Surveys of Waterbirds in Strategic Wind Farm Areas: 2004/05 Final Report. Department of Trade and Industry.

Eaton M.A, Brown, A.F., Noble, D.G., Musgrove, A.J., Hearn, R., Aebischer, N.J., Gibbons, D.W., Evans, A. & Gregory, R.D.(2009). Birds of Conservation Concern 3: the population status of birds in the United Kingdom, Channel Islands and the Isle of Man. *British Birds* 102:296-341.

English Nature. (2001). *The Mersey Estuary European Marine Site. English Nature's advice given under Regulation 33(2) of the Conservation (Natural Habitats &c.) Regulations 1994, as amended.* English Nature, Peterborough.

Forrester R.W., Andrews I.J., McInerny C.J., Murray R.D., McGowan R.Y., Zonfrillo B., Betts M.W., Jardine D.C. & Grundy D.S. (eds) 2007. The Birds of Scotland. The Scottish Ornithologists' Club, Aberlady.

Furness, R.W. & Tasker, M.L. 2000. Seabird-fishery interactions: quantifying the sensitivity of seabirds to reductions in sandeel abundance, and identification of key areas for sensitive seabirds in the North Sea. Marine Ecology Progress Series 202: 253-264.

Garthe, S. and Hüppop, O. (2004). Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index. *Journal of Applied Ecology*, 41(4), 724-734.

Hi-Def / WWT Consulting (2011). *Digital aerial surveillance of inshore waterbirds in Liverpool Bay Special Protection Area*. Report to JNCC.

Holt, C.A., Austin, G.E., Calbrade, N.A., Mellan, H.J., Mitchell, C., Stroud, D.A., Wotton, S.R., Musgrove, A.J. 2011. Waterbirds in the UK 2009/10: The Wetland Bird Survey. BTO/RSPB/JNCC, Thetford.

Hyder Consulting. (2008) Burbo Bank Offshore Wind Farm: Ornithological Survey – Construction period. Report to CMACS. Hyder Consulting (UK) Limited, Warrington.

Institute of Ecology and Environmental Assessment (IEEM) (2010). *Guidelines for ecological impact assessment in Britain and Ireland: Marine and Coastal*. August 2010 IEEM, Winchester, UK: 62pp.

JNCC (1999). The Birds Directive: selection guidelines for Special Protection Areas. Joint Nature Conservation Committee, Peterborough.

Kaiser, M. Elliot, A,. Galanidi, M., Rees, E.I.S., Caldow, R., Stillman, R., Sutherland, W. & Showler, D. (2005). *Predicting the displacement of Common Scoter* Melanitta nigra *from benthic feeding areas due to offshore windfarms*. Report Cowrie-BEN-03-2002. University of Wales, Bangor.

Langston, R. H.W. (2010). *Offshore wind farms and birds: Round 3 zones, extensions to Round 1 & Round 2 sites & Scottish Territorial Waters*. RSPB Research Report No.39, RSPB, Sandy.

Maclean, I.M.D., Wright, L.J., Showler, D.A. & Rehfisch, M.M. (2009). A Review of Assessment Methodologies for Offshore Windfarms. COWRIE METH-08-08.

Mitchell, P. I., Newton, S., Ratcliffe, N. and Dunn, T. E. (2004). *Seabird populations of Britain and Ireland (Results of the Seabird 2000 Census 1998-2000*). T&AD Poyser, London, UK: 511pp.

Musgrove, A.J., Austin, G.E., Hearn, R.D., Holt, C.A., Stroud, D.A. & Wotton, S.R. (2011). Overwinter population estimates of British waterbirds. *British Birds* 104: 364-397

Natural England and Countryside Council for Wales. (2009). *Liverpool Bay / Bae Lerpwl pSPA Draft Conservation Objectives and Advice on Operations.* NE & CCW.

Nelson, B. (2001) *The Atlantic Gannet*. Was Fenix Books, UK.

O'Brien, S.H., Wilson, L.J., Webb, A. & Cranswick, P.A. (2008) Revised estimate of numbers of wintering red-throated divers *Gavia stellata* in Great Britain. *Bird Study* 55; 152-160.

Percival, S. M., Band, B. and Leeming, T. (1999). *Assessing the ornithological effects of wind farms: developing a standard methodology*. Proceedings of the 21st British Wind Energy Association Conference, pp161-166.

Petersen, I.K., Grrom, G., Stjenholm, M. & Nielsen, R.D. (2011). *Ornithological Surveys of the Burbo Bank Extension Offshore Wind Farm area November 2010 to April 201*. Report commissioned by DONG Energy A/S. Aarhus University, DCE – Danish Centre for Environment and Energy. 29pp.

Skov. H. Durinck, J., Leopold, M.F. & Tasker, M.L. (1995). *Important Bird Areas for Seabirds in the North Sea including the Channel and the Kattegat.* BirdLife International, Cambridge.

Skov, H., J. Durinck, M. F. Leopold, and M. L. Tasker. (2007). A quantitative method for evaluating the importance of marine areas for conservation of birds. *Biological Conservation*, 136:262-371.

SNH. (2010). Use of Avoidance Rates in the SNH Wind Farm Collision Risk Model. Scottish Natural Heritage, Edinburgh.

Stroud, DA, Chambers, D, Cook, S, Buxton, N, Fraser, B, Clement, P, Lewis, P, McLean, I, Baker, H & Whitehead, S (eds).(2001). *The UK SPA network: its scope and content.* JNCC, Peterborough

Stone, C. J., Webb, A., Barton, C., Ratcliffe, N., Reed, T. C., Tasker, M. L., Camphuysen, C. J. and Pienkowski, M. W. (1995). *An atlas of seabird distribution in north-west European waters*. Joint Nature Conservation Committee, Peterborough, UK: 326pp.

Thaxter, C. B., Lascelles, B., Sugar, K., Cook, A. S. C. P., Roos, S., Bolton, M., Langston, H. W. and Burton N. H. K. (In press). Seabird Foraging Ranges as a Tool for Identifying Candidate Marine Protected Areas. *Biological Conservation*.

Webb, A, McSorley, C.A., Dean, B.J., Reid, J.B., Cranswick, P.A, Smith, L. & Hall, C. (2006). *An assessment of the numbers and distribution of inshore aggregations of waterbirds using Liverpool Bay during the non-breeding season in support of possible SPA identification.* JNCC Report 373.

Wernham, C.V., Toms M.P., Marchant, J.H., Clark, J.A., Siriwardena, G.M. & Baillie, S.R. (eds). (2002). *The Migration Atlas: movements of the birds of Britain and Ireland*. T. & A.D. Poyser, London.

Wright, L. and Austin, G. (2012) *SOSS Migration Assessment Tool Instructions.* Report to Strategic Ornithological Support Services.

Wright, L.J., Ross-Smith, V.H., Austin, G.E., Massimino, D., Dadam, D., Cook, A.S.C.P., Calbrade, N.A. and Burton, N.H.K. (2012) *SOSS-05 Assessing the risk of offshore wind farm development to migratory birds designated as features of UK Special Protection Areas (and other Annex 1 species).* Report to Strategic Ornithological Support Services.

WWT Consulting. (2007). Aerial Surveys of Waterbirds in the in South-west England and Wales: 2007 Final Report. Report to: BERR. WWT Consulting, Glos.

WWT Consulting. (2009). Aerial Surveys of Waterbirds in the UK: 2007/08 Final Report. Report to: Department of Energy and Climate Change. WWT Consulting, Glos.

9 Appendices

9.1 Appendix 1 – Monthly boat-based raw data 2011

9.1.1 April 2011

Common Name	Burbo Ext Total Pop. of Birds	Burbo Ext plus 1km buffer population	Both Sites + 4km Buffer Total Pop. of Birds	Burbo Ext. Density individuals/km	WF +1kmDensity individuals/km	WF +4km density individuals/km
Auk sp.	0	0	0	0	0	0.00
Common gull	0	49	40	0	0.58	0.19
Common scoter	0	14	11	0	0.16	0.05
Common tern	0	123	99	0	1.45	0.47
Cormorant	94	166	389	2.38	1.96	1.85
Gannet	0	3	8	0	0.04	0.04
Great black-backed gull	0	28	17	0	0.33	0.08
Guillemot	10	13	61	0.25	0.15	0.29
Gull sp.	0	0	44	0	0	0.21
Herring gull	132	310	400	3.32	3.65	1.90
Kittiwake	13	12	57	0.32	0.14	0.27
Lesser black-backed gull	6	35	118	0.14	0.41	0.56
Little gull	0	7	6	0	0.08	0.03
Manx shearwater	0	0	6	0	0	0.03
Razorbill	0	0	8	0	0	0.04
Red-breasted merganser	0	0	13	0	0	0.06
Tern sp.	0	0	19	0	0	0.09
Wader sp.	0	0	6	0	0	0.03

9.1.2 May 2011

Common Name	Burbo Ext Site Total Pop. of Birds	Burbo Ext plus 1km buffer population	Both Sites + 4km Buffer Total Pop. of Birds	Burbo Ext. Density individuals/km	WF +1kmDensity individuals/km	WF +4km density individuals/km
Arctic skua	6	11	8	0.14	0.13	0.04
Auk sp.	0	0	0	0.00	0.00	0.00
Common gull	3	14	23	0.07	0.16	0.11
Common scoter	3	7	4	0.07	0.08	0.02
Common tern	24	54	50	0.61	0.64	0.24
Cormorant	0	8	107	0.00	0.09	0.51
Fulmar	0	0	6	0.00	0.00	0.03
Gannet	106	187	246	2.68	2.20	1.17
Great black-backed gull	0	0	4	0.00	0.00	0.02
Guillemot	116	319	299	2.92	3.76	1.42
Gull sp.	3	7	95	0.07	0.08	0.45
Herring gull	11	23	63	0.27	0.27	0.30
Kittiwake	28	48	130	0.70	0.57	0.62
Lesser black-backed gull	16	58	80	0.41	0.68	0.38
Manx shearwater	3	0	2	0.07	0.00	0.01
Puffin	3	3	2	0.07	0.04	0.01
Razorbill	0	0	27	0.00	0.00	0.13
Sandwich tern	6	10	13	0.14	0.12	0.06
Yellow-legged gull	0	3	2	0.00	0.04	0.01

9.1.3 June 2011

Common Name	Burbo Ext Site Total Pop. of Birds	Burbo Ext plus 1km buffer population	Both Sites + 4km Buffer Total Pop. of Birds	Burbo Ext. Density individuals/km	WF +1kmDensity individuals/km	WF +4km density individuals/km
Black-headed gull	8	7	13	0.20	0.08	0.06
Common gull	0	0	2	0.00	0.00	0.01
Common tern	8	17	255	0.20	0.20	1.21
Cormorant	7	77	114	0.18	0.91	0.54
Curlew	3	3	2	0.07	0.04	0.01
Gannet	7	13	305	0.18	0.15	1.45
Great black-backed gull	13	24	32	0.34	0.28	0.15
Great skua	4	4	6	0.09	0.05	0.03
Guillemot	492	913	850	12.41	10.75	4.04
Gull sp.	0	0	6	0.00	0.00	0.03
Herring gull	10	65	137	0.26	0.76	0.65
Kittiwake	252	437	873	6.35	5.15	4.15
Lesser black-backed gull	160	626	606	4.03	7.37	2.88
Manx shearwater	0	3	112	0.00	0.04	0.53
Sandwich tern	6	7	13	0.14	0.08	0.06

9.1.4 July 2011

Common Name	Burbo Ext Site Total Pop. of Birds	Burbo Ext plus 1km buffer population	Both Sites + 4km Buffer Total Pop. of Birds	Burbo Ext. Density individuals/km	WF +1kmDensity individuals/km	WF +4km density individuals/km
Arctic skua	0	0	2	0.00	0.00	0.01
Auk sp.	0	0	0	0.00	0.00	0.00
Black-headed gull	0	0	2	0.00	0.00	0.01
Common gull	3	3	2	0.07	0.04	0.01
Common scoter	0	156	166	0.00	1.84	0.79
Common tern	0	7	55	0.00	0.08	0.26
Cormorant	0	76	398	0.00	0.90	1.89
Gannet	121	174	429	3.04	2.05	2.04
Great black-backed gull	2	13	29	0.04	0.15	0.14
Guillemot	849	1801	3448	21.42	21.21	16.39
Gull sp.	0	7	13	0.00	0.08	0.06
Herring gull	6	166	156	0.16	1.96	0.74
Kittiwake	221	347	707	5.57	4.09	3.36
Lesser black-backed gull	103	183	286	2.61	2.15	1.36
Little gull	0	0	6	0.00	0.00	0.03
Manx shearwater	908	1425	2937	22.90	16.78	13.96
Sandwich tern	3	14	55	0.07	0.16	0.26
Wader sp.	0	0	2	0.00	0.00	0.01

9.1.5 August 2011

Common Name	Burbo Ext Site Total Pop. of Birds	Burbo Ext plus 1km buffer population	Both Sites + 4km Buffer Total Pop. of Birds	Burbo Ext. Density individuals/km	WF +1kmDensity individuals/km	WF +4km density individuals/km
Arctic skua	0	0	8	0.00	0.00	0.04
Common tern	59	334	402	1.49	3.93	1.91
Common/Arctic tern	0	0	6	0.00	0.00	0.03
Cormorant	22	314	343	0.56	3.70	1.63
Gannet	0	0	202	0.00	0.00	0.96
Great black-backed gull	18	12	57	0.45	0.14	0.27
Great crested grebe	3	3	2	0.07	0.04	0.01
Guillemot	1249	1731	2880	31.49	20.38	13.69
Gull sp.	12	8	21	0.30	0.10	0.10
Herring gull	46	158	284	1.17	1.86	1.35
Kittiwake	125	217	526	3.16	2.56	2.50
Lesser black-backed gull	400	551	551	10.09	6.49	2.62
Manx shearwater	6	8	259	0.16	0.10	1.23
Razorbill	0	0	15	0.00	0.00	0.07
Sandwich tern	86	126	177	2.17	1.48	0.84

9.1.6 September 2011

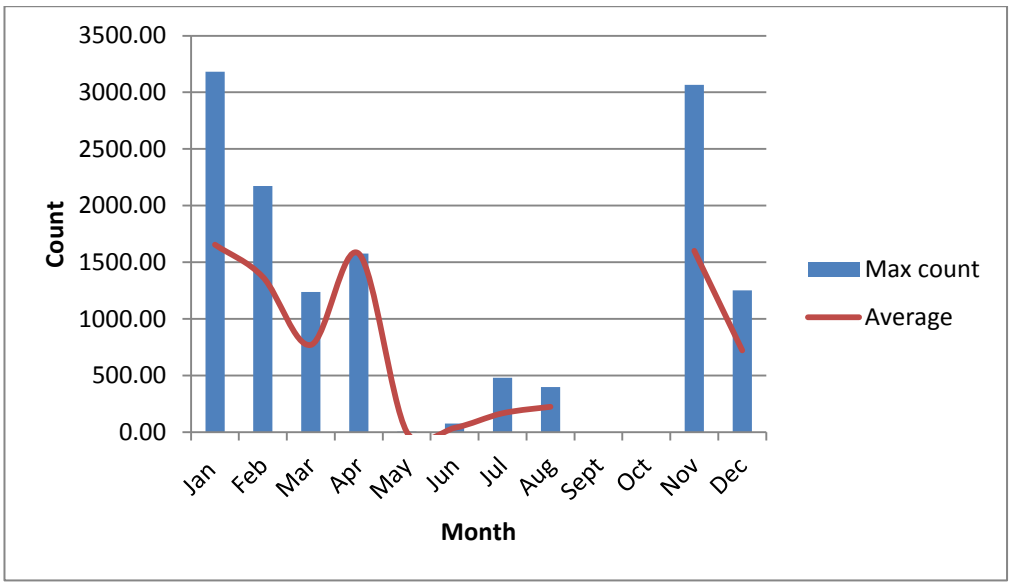
Common Name	Burbo Ext Site Total Pop. of Birds	Burbo Ext plus 1km buffer population	Both Sites + 4km Buffer Total Pop. of Birds	Burbo Ext. Density individuals/km	WF +1kmDensity individuals/km	WF +4km density individuals/km
Arctic skua	6	8	34	0.16	0.09	0.16
Arctic tern	0	0	8	0.00	0.00	0.04
Arctic/long-tailed skua	0	0	2	0.00	0.00	0.01
Auk sp.	7	9	23	0.17	0.11	0.11
Black-backed gull sp.	0	14	15	0.00	0.17	0.07
Common scoter	6	10	29	0.14	0.12	0.14
Common tern	3	3	8	0.07	0.04	0.04
Common/Arctic tern	101	134	246	2.54	1.58	1.17
Cormorant	9	151	555	0.22	1.78	2.64
Fulmar	0	0	2	0.00	0.00	0.01
Gannet	16	28	65	0.41	0.33	0.31
Great black-backed gull	12	32	160	0.31	0.38	0.76
Great crested grebe	0	0	40	0.00	0.00	0.19
Great skua	4	4	6	0.09	0.05	0.03
Guillemot	399	1966	2424	10.07	23.15	11.52
Gull sp.	34	78	97	0.86	0.92	0.46
Herring gull	11	37	318	0.28	0.44	1.51
Kittiwake	22	133	183	0.55	1.57	0.87
Lesser black-backed gull	11	35	278	0.27	0.41	1.32
Little gull	3	3	13	0.07	0.04	0.06
Meadow pipit	6	7	11	0.14	0.08	0.05
Passerine sp.	0	0	6	0.00	0.00	0.03
Razorbill	46	114	360	1.17	1.34	1.71
Red-throated diver	0	0	13	0.00	0.00	0.06
Sandwich tern	11	20	67	0.27	0.24	0.32
Skua sp.	11	17	23	0.27	0.20	0.11
Swift	0	3	2	0.00	0.04	0.01
Tern sp.	16	92	2	0.41	1.08	0.01

9.2 Appendix 2 – Scientific names of species included in report

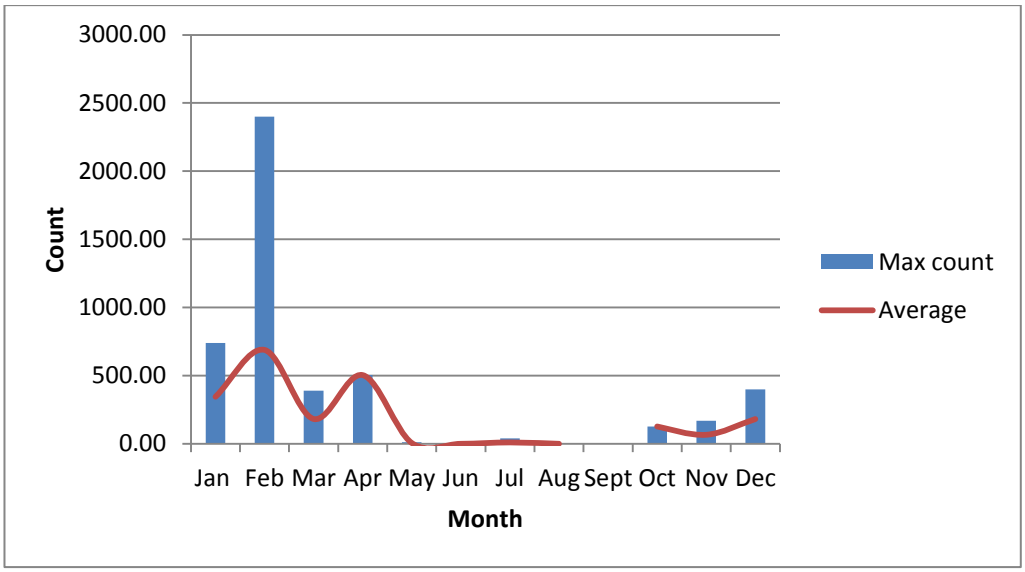
Species	Scientific name
Red-throated diver	*Gavia stellata*
Great northern diver	*Gavia immer*
Great crested grebe	*Podiceps cristatus*
Fulmar	*Fulmarus glacialis*
Manx shearwater	*Puffinus puffinus*
Gannet	*Morus bassanus*
Cormorant	*Phalacrocorax carbo*
Shag	*Phalacrocorax arisotelis*
Bewick's swan	*Cygnus columbianus*
Whooper swan	*Cygnus cygnus*
Pink-footed goose	*Anser brachyrhynchus*
Shelduck	*Tadorna tadorna*
Wigeon	*Anas penelope*
Teal	*Anas crecca*
Mallard	*Anas platyrhynchos*
Pintail	*Anas acuta*
Shoveler	*Anas clypeata*
Common scoter	*Melanitta nigra*
Red-breasted merganser	*Mergus serrator*
Oystercatcher	*Haemotopus ostralegus*
Ringed plover	*Charadrius hiaticula*
Golden plover	*Pluvialis apricaria*
Grey plover	*Pluvialis squatarola*
Lapwing	*Vanellus vanellus*
Knot	*Calidris cautus*
Sanderling	*Calidris alba*
Dunlin	*Calidris alpina*
Ruff	*Philomachus pugnax*
Black-tailed godwit	*Limosa limosa*
Bar-tailed godwit	*Limosa lapponica*
Whimbrel	*Numenius phaeopus*
Curlew	*Numenius arquata*
Spotted redshank	*Tringa erythropus*
Redshank	*Tringa totanus*
Greenshank	*Tringa nebularia*
Turnstone	*Aremaria interpres*
Little gull	*Hydrocoloeus minutus*
Black-headed gull	*Chroicocephalus ridibundus*
Common gull	*Larus canus*
Herring gull	*Larus argentatus*

Species	Scientific name
Lesser black-backed gull	*Larus fuscus*
Great black-backed gull	*Larus marinus*
Kittiwake	*Rissa tridactyla*
Common tern	*Sterna hirundo*
Arctic tern	*Sterna paradisaea*
Little tern	*Sterna albifrons*
Sandwich tern	*Sterna sandvicensis*
Guillemot	*Uria aalge*
Razorbill	*Alca torda*
Puffin	*Fratercula arctica*

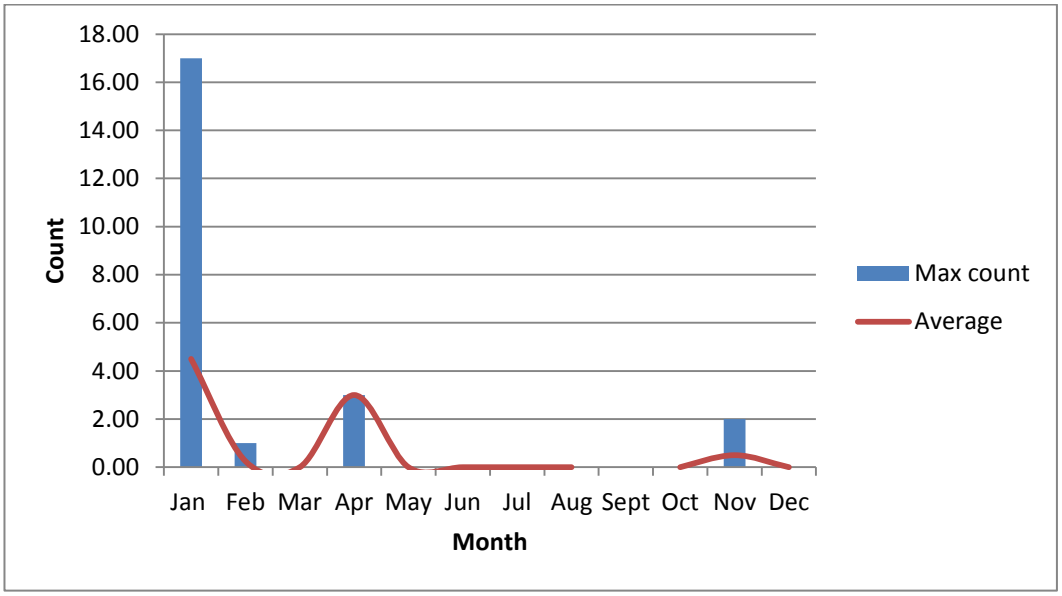
9.3 Appendix 3 – WWT/ESAS/BERR aerial survey seasonal data analysis of species raw counts



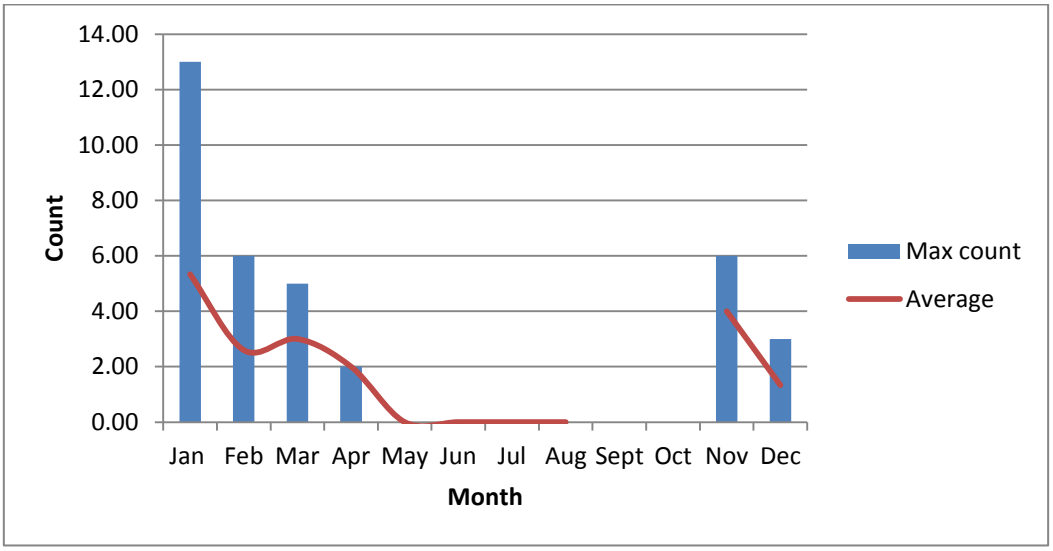
9.3.1 Common scoter abundance within NW5 aerial surveys 2001-2006.



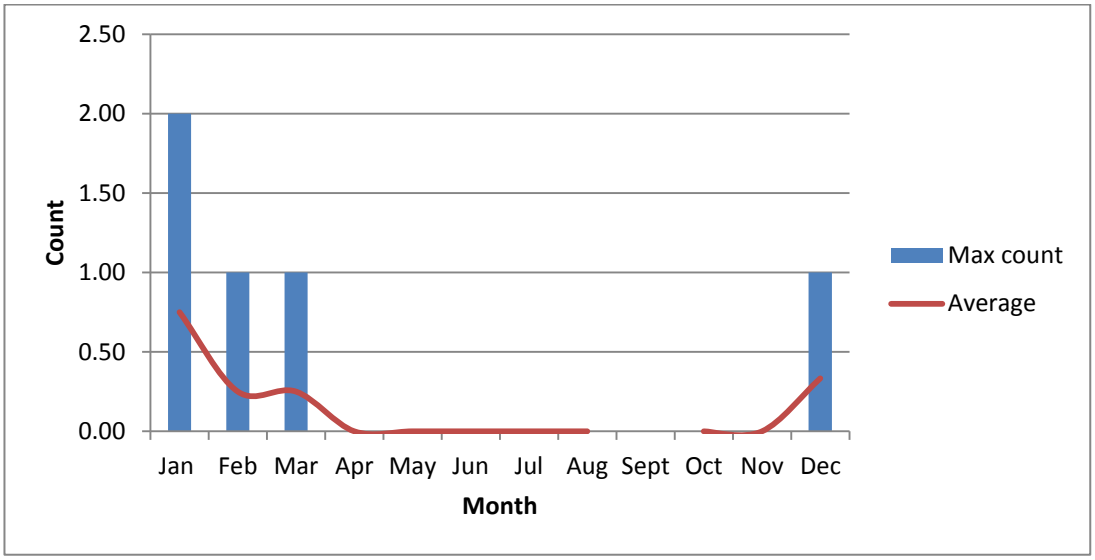
9.3.2 Common scoter abundance within NW6 aerial surveys 2001-2006.



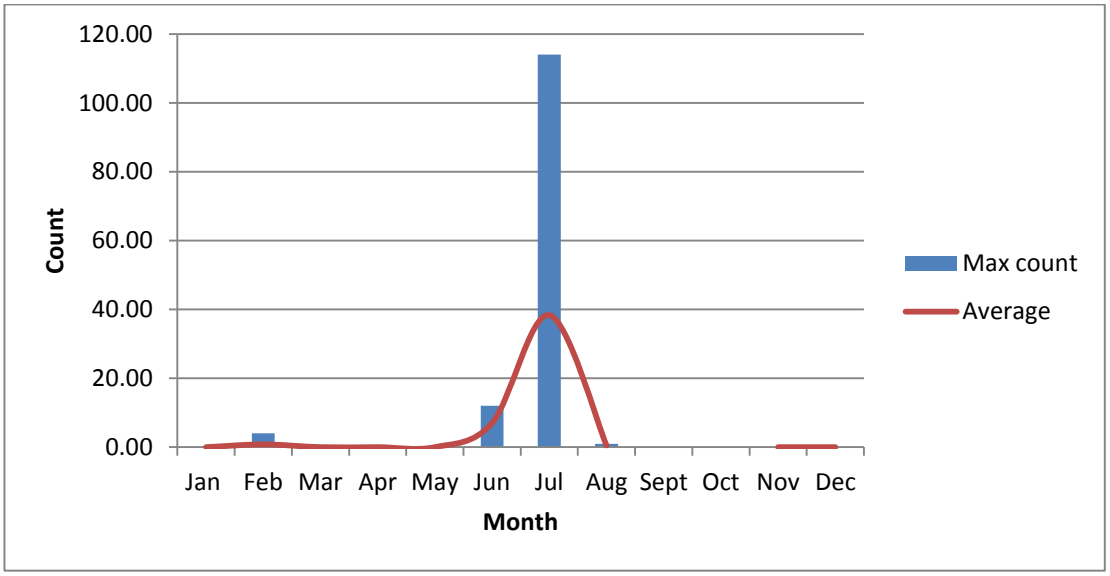
9.3.3 Common scoter abundance within Burbo Bank Extension aerial surveys 2001-2006.



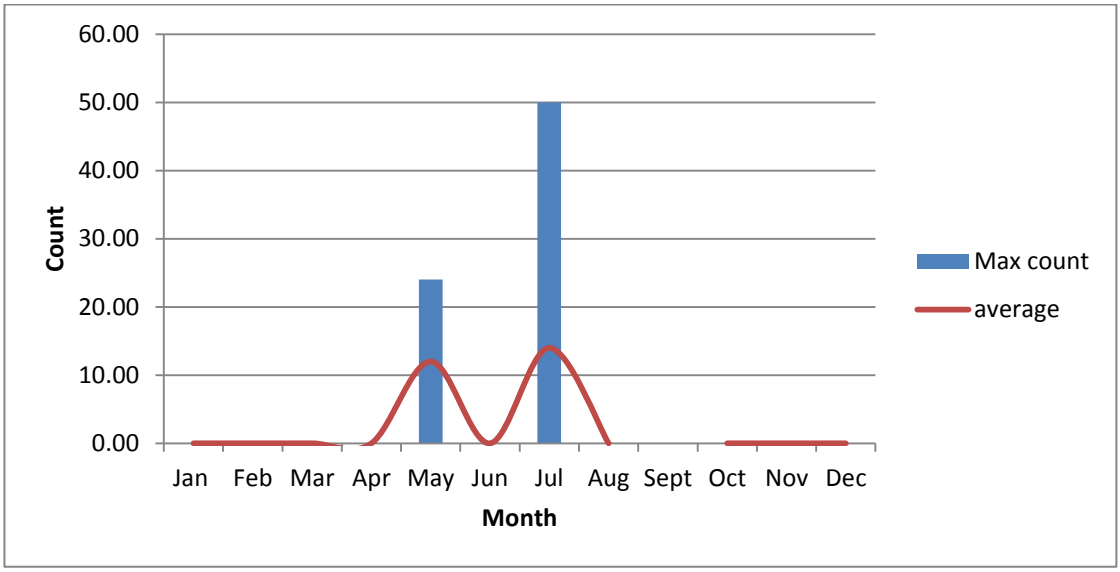
9.3.4 Red-throated diver abundance within NW5 aerial surveys 2001-2006.



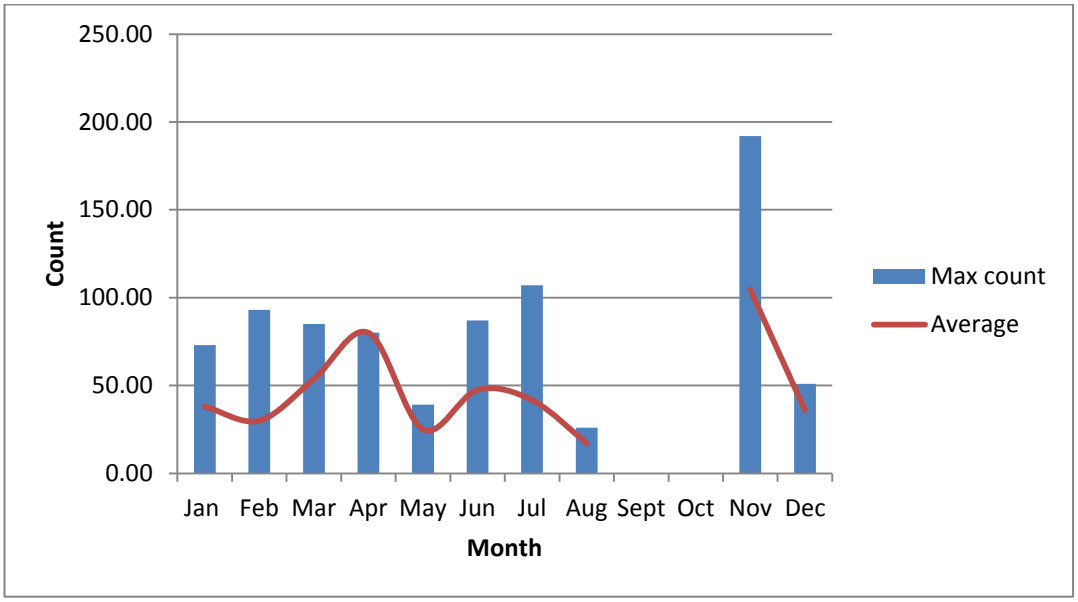
9.3.5 Red-throated diver abundance within Burbo Bank Extension aerial surveys 2001-2006.



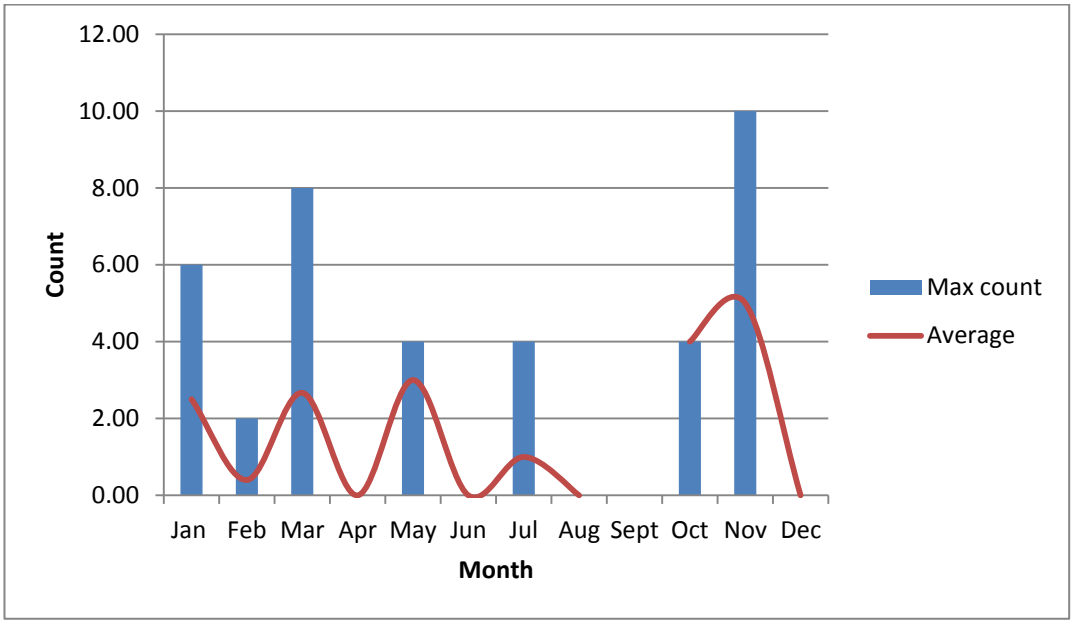
9.3.6 Manx shearwater abundance within NW5 aerial surveys 2001-2006.



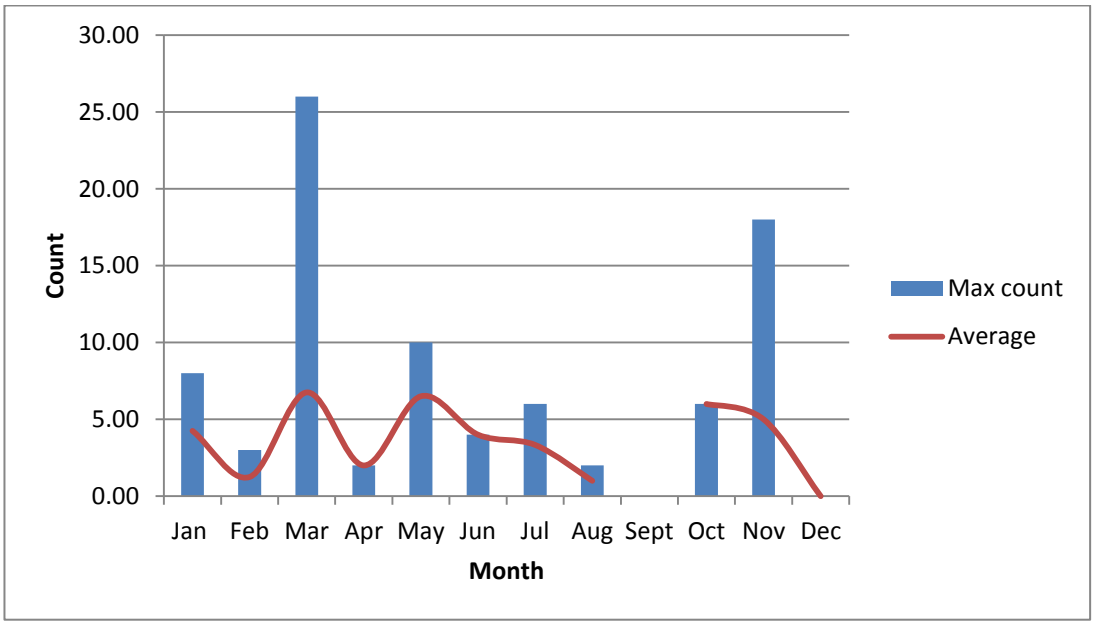
9.3.7 Manx shearwater abundance within NW6 aerial surveys 2001-2006.



9.3.8 Auk species abundance within NW5 aerial surveys 2001-2006.

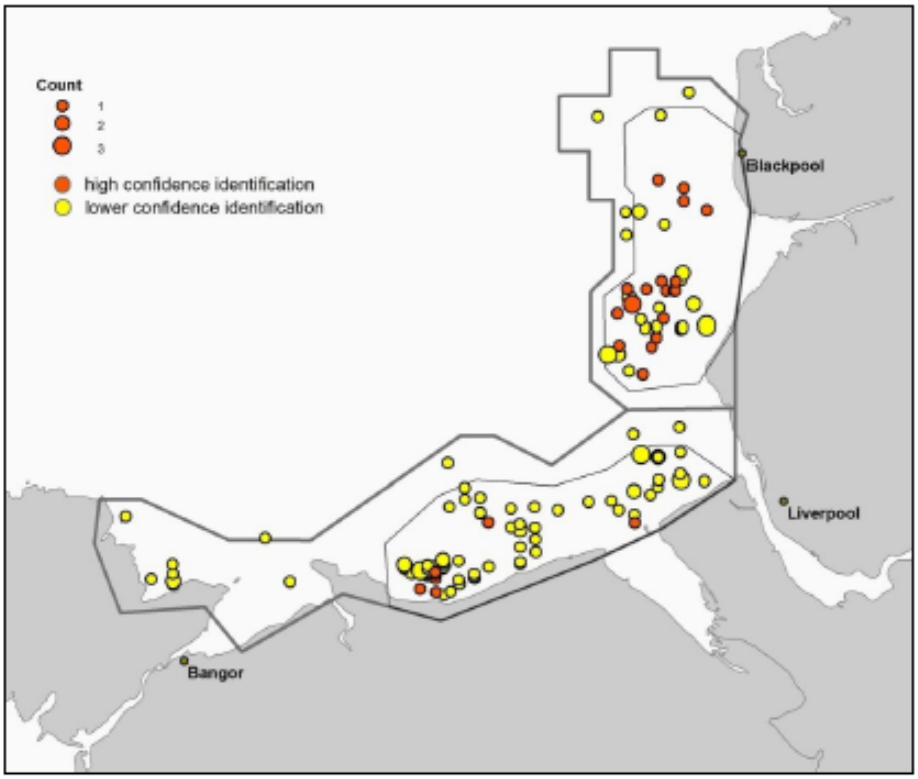


9.3.9 Auk species abundance within NW6 aerial surveys 2001-2006.

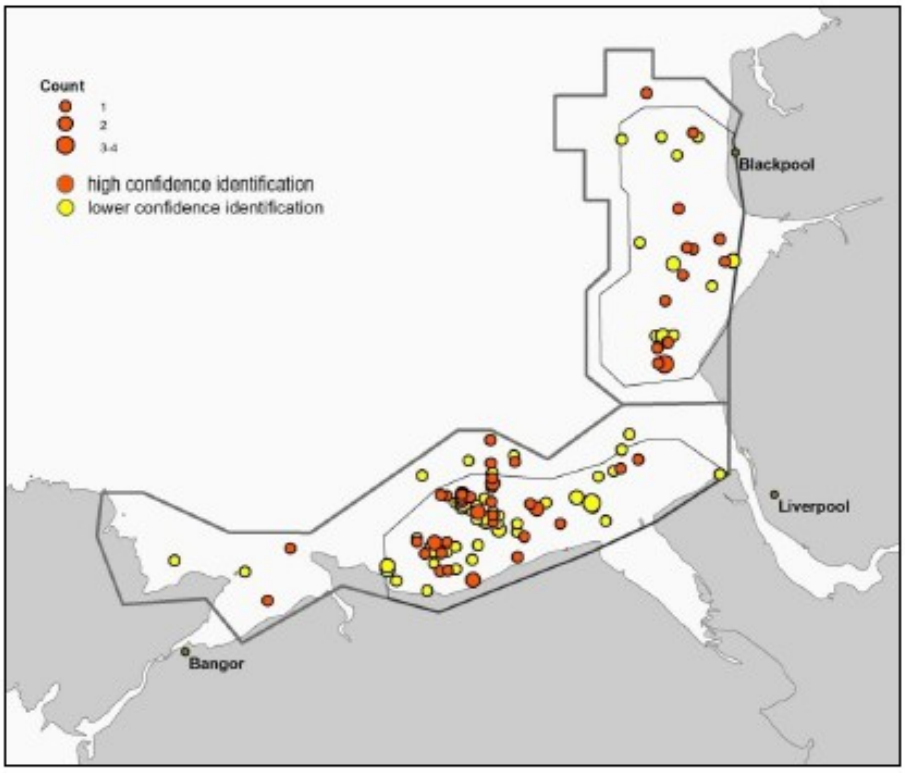


9.3.10 Auk species abundance within Burbo Bank Extension aerial surveys 2001-2006.

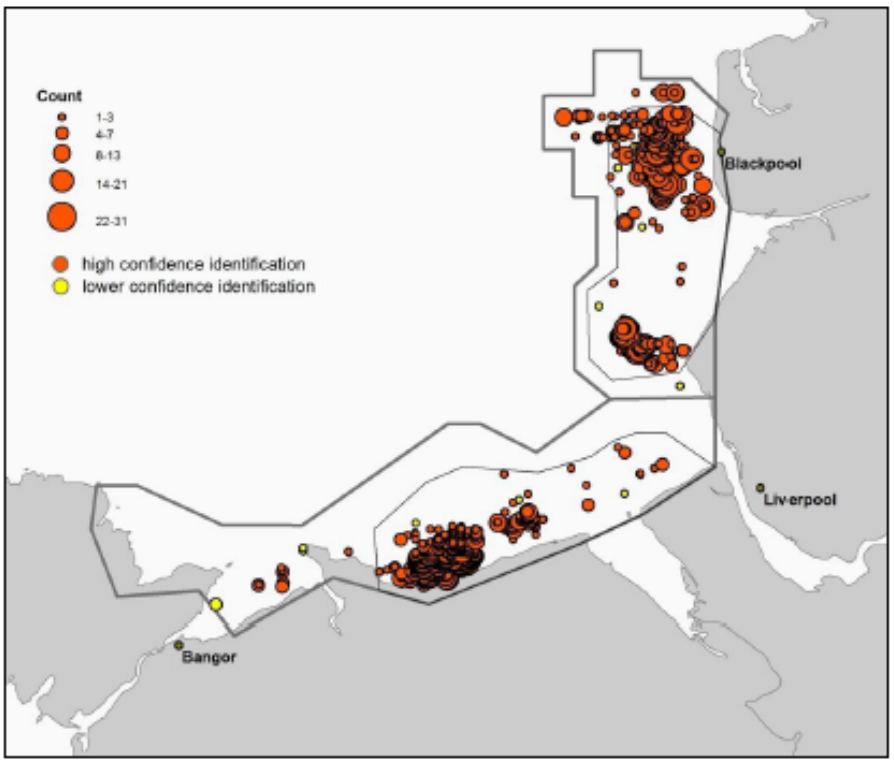
9.4 Appendix 4 – Hi-Def / WWT red-throated diver and common scoter results



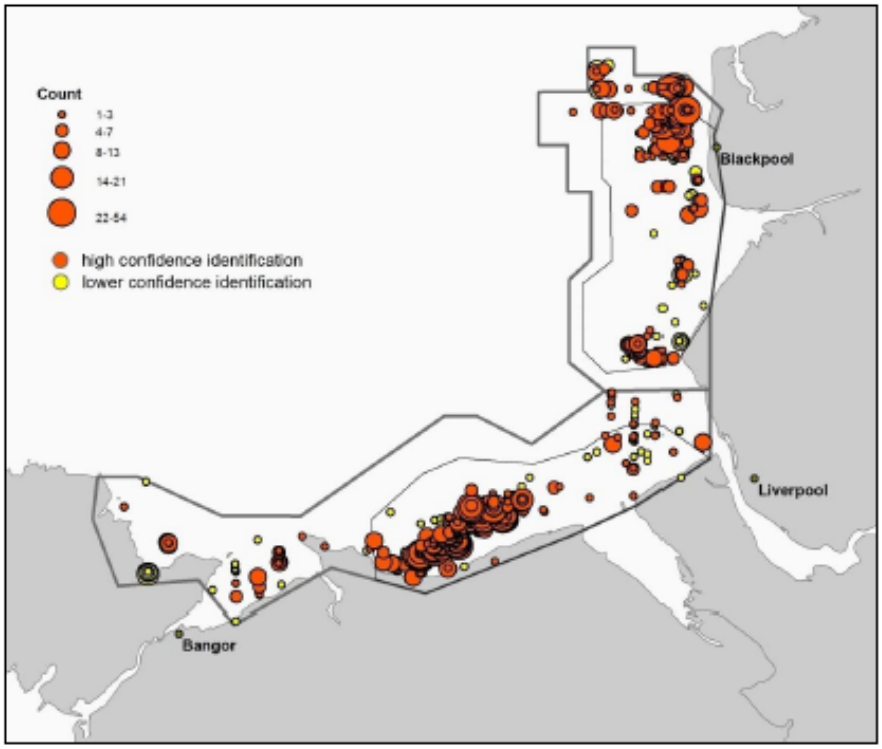
9.4.1 Distribution of Red-throated divers during Flight 1 (February 2011). Source: Hi—Def / WWT (2011).



9.4.2 Distribution of red-throated divers during Flight 2 (March 2011). Source: Hi—Def / WWT (2011).



9.4.3 Distribution of common scoters during Flight 1 (February 2011). Source: Hi—Def / WWT (2011).



9.4.3 Distribution of common scoters during Flight 2 (March 2011). Source: Hi—Def / WWT (2011).

9.5 Appendix 5 – Densities of seabird species recorded throughout all surveys

Table 9.5.1 Maximum densities of seabird species recorded throughout all surveys

	Survey						
Species	**Aerial 2011***	**Boat+1 km 2011****	**Boat+4 km 2011****	**Aerial 2001-9**	**NW5 Aerial 2001-9**	**NW6a Aerial 2001-9**	**Hi-Def/WWT Aerial 2011**
Red-throated diver	0.61	-	-	0.77	1.69	2.12	0.35
Great northern diver	-	-	-	0.06	0.04	0.06	
Great crested grebe	-	0.04	0.19	-	-	-	
Fulmar	-	0	0.03	0.96	1.78	0.96	
Manx shearwater		16.78	13.96	0.35	2.84	0.35	
Gannet	0.08	2.2	2.04	1.96	2.75	1.96	
Cormorant	0.55	3.7	2.64	2.31	6.09	9.02	
Shag	0.02	-	-	-	3.5	0.18	
Scaup	0.73	-	-	-	-	-	
Common scoter	0.71	1.84	0.79	0.24	38.1	22.07	17.52
Red-breasted merganser	0.04	0	0.06	-	0.93	0.31	
Arctic skua	-	0.13	0.16	-	-	-	
Great skua	-	0.09	0.03	-	-	-	
Kittiwake	0.44	5.15	3.36	1.69	5.3	1.78	
Little gull	0.21	0.08	0.05	-	-	-	
Black-headed gull	-	0.08	0.06	0.03	0.69	0.5	
Common gull	1.21	0.58	0.19	1.09	3.73	0.44	
Herring gull	1.69	3.65	1.9	1.33	6.88	3.44	
Lesser black-backed gull	0.2	7.37	2.88	2.88	2.43	2.88	
Great black-backed gull	0.4	0.38	0.76	2.69	1.33	2.69	
Common tern	0	3.93	1.91	1.55	2.85	2.85	

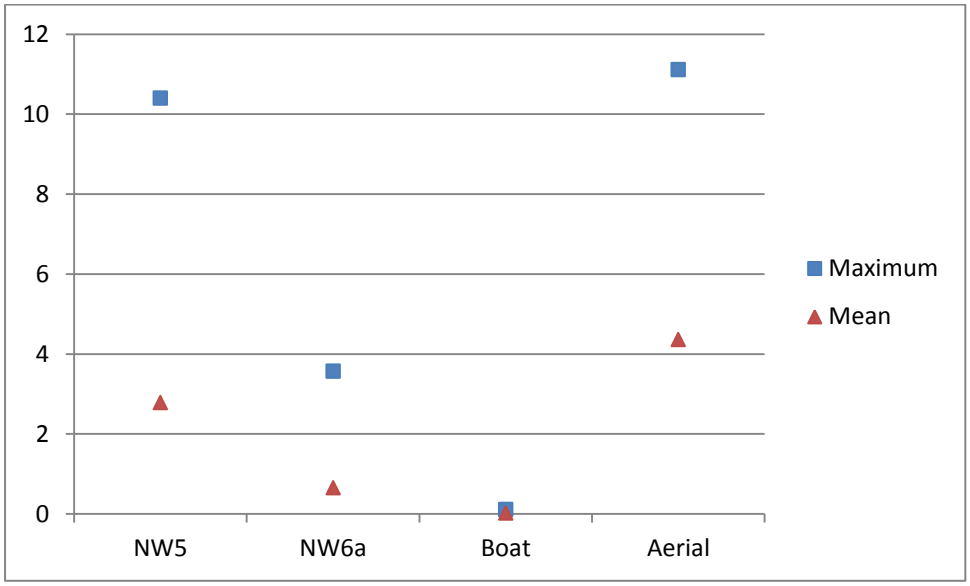
Arctic tern	0	-	0.04	-	-	-	
Sandwich tern	0	1.48	0.84	0.44	0.2	0.67	
Guillemot	10.44	23.15	16.39	3.07	13.97	7.14	
Razorbill	0.67	1.34	1.71	1.09	1.09	0.12	
Puffin	2.34	-	-	-	-	-	

* Data collected in six surveys between November 2010 and April 2011

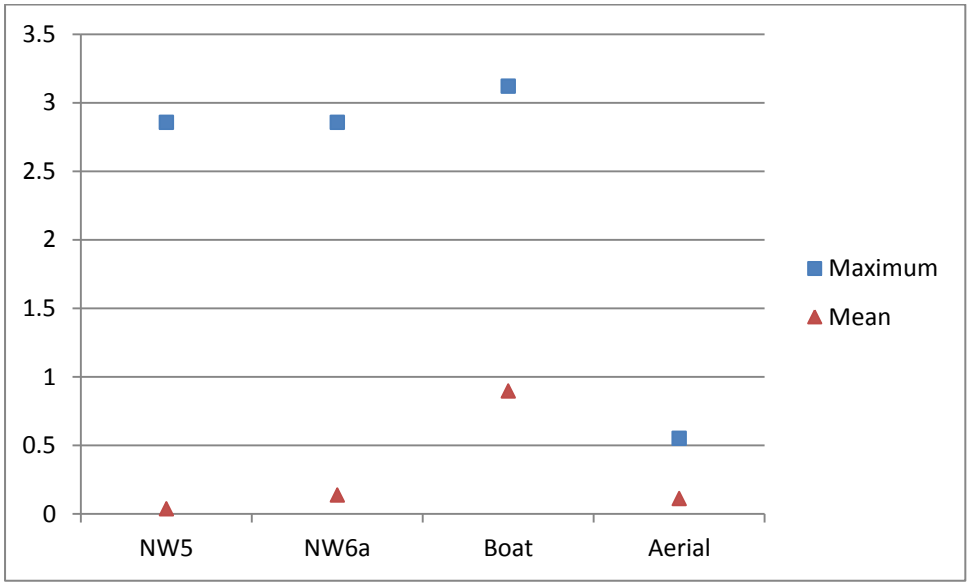
** Data collected in six surveys between April and September 2011

9.6 Appendix 6 – Graphical comparisons of historical data within Liverpool Bay with site data from Burbo Bank Extension

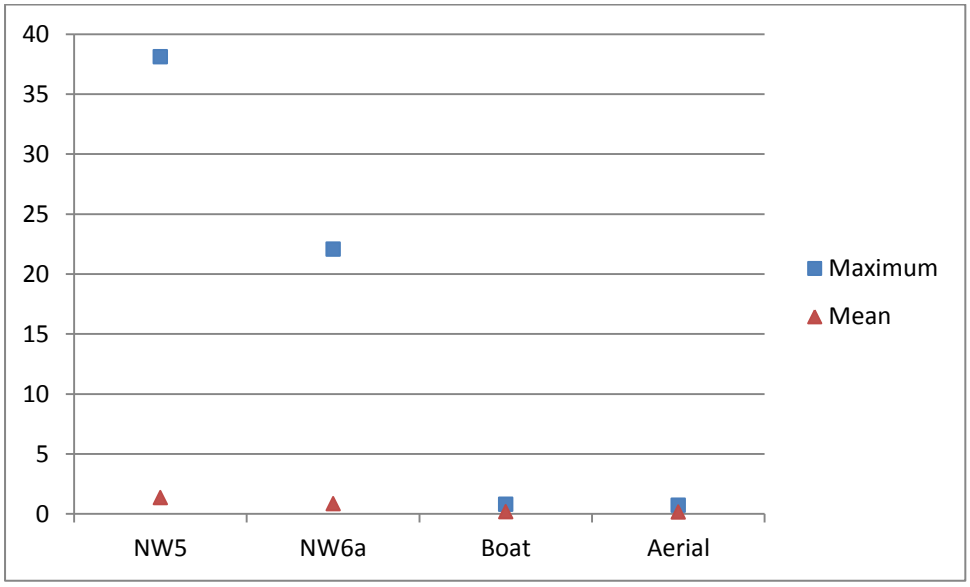
9.6.1 6a – Densities derived from the CCW database for NW5 and NW6a



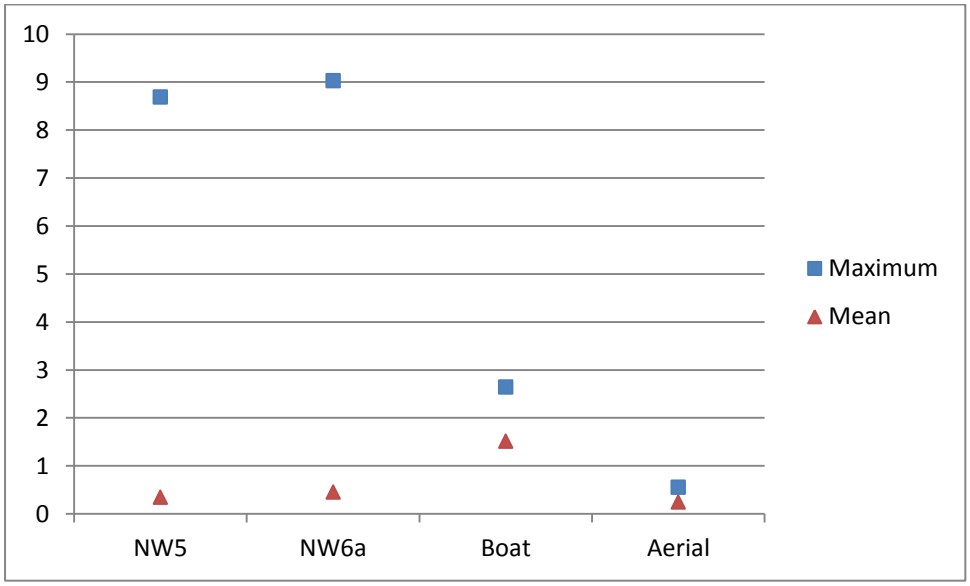
9.6.2 Auk sp.



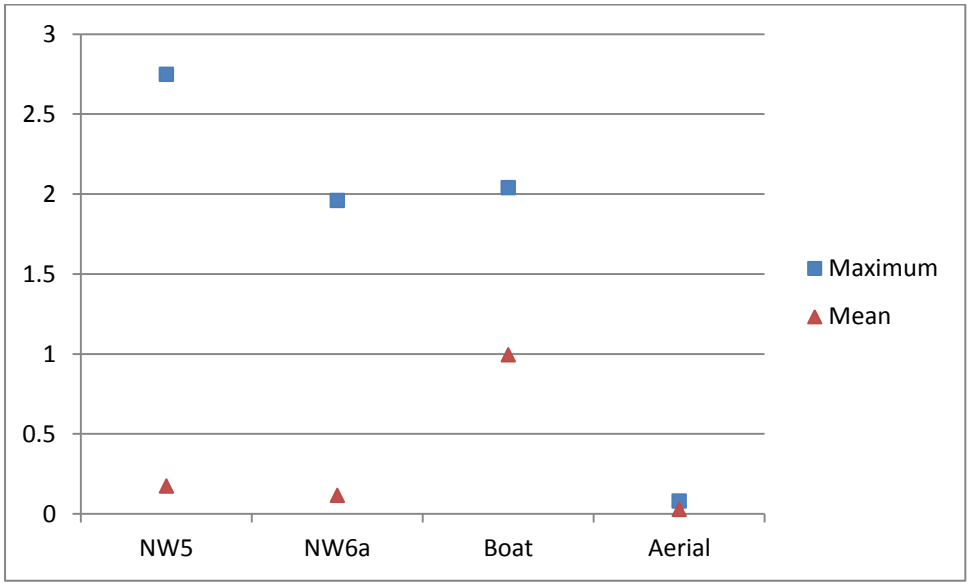
9.6.3 Common / Arctic tern



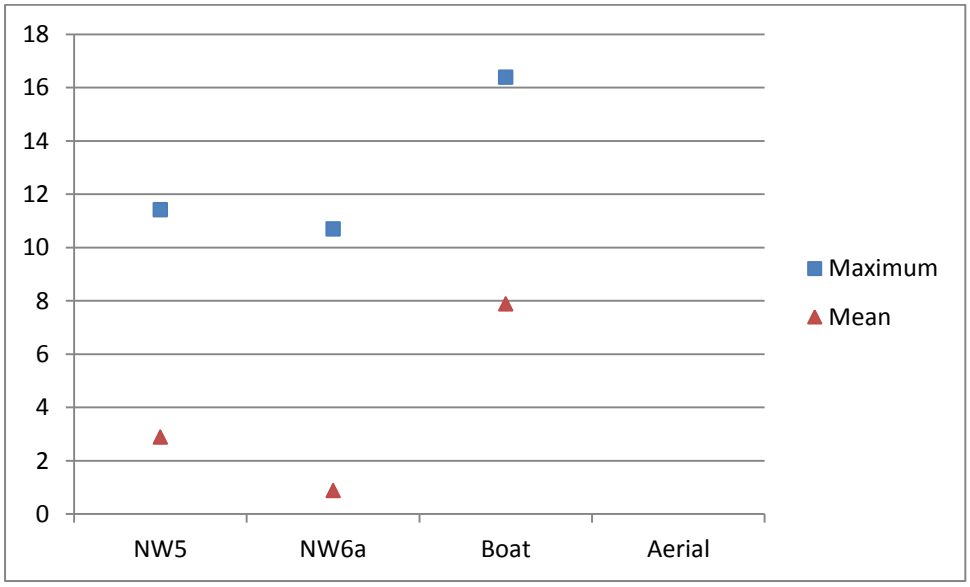
9.6.4 Common scoter



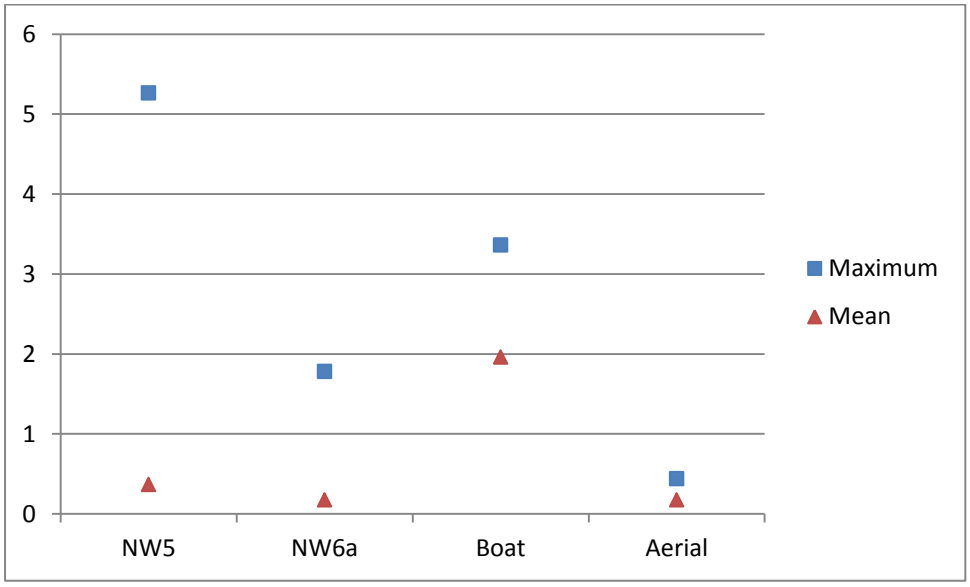
9.6.5 Cormorant



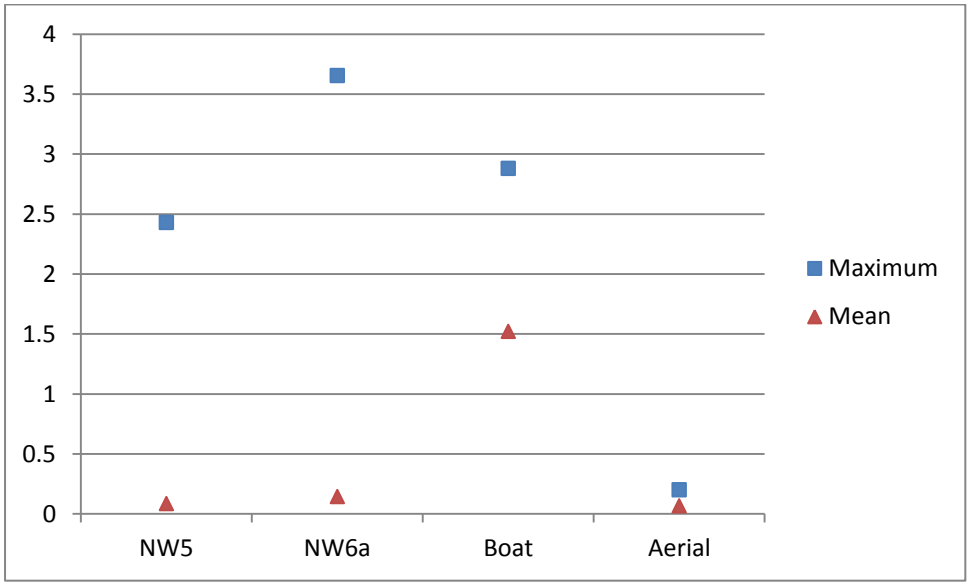
9.6.6 Gannet



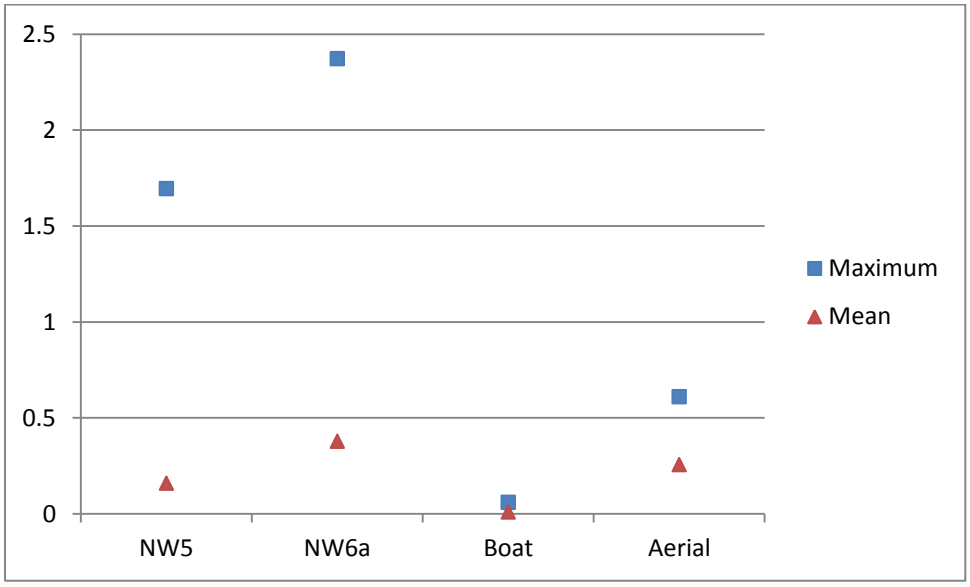
9.6.7 Guillemot



9.6.8 Kittiwake

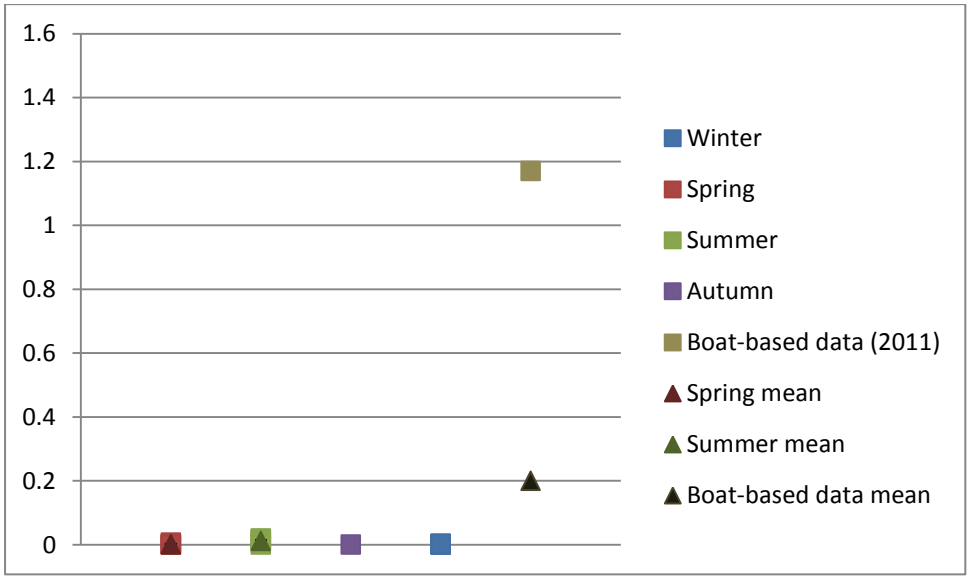


9.6.9 Lesser black-backed gull

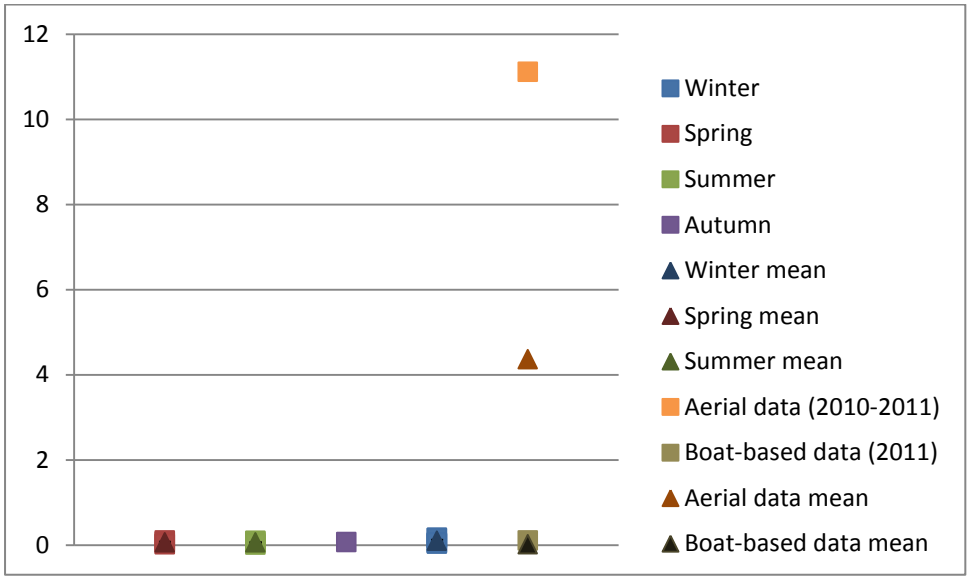


9.6.10 Red-throated diver

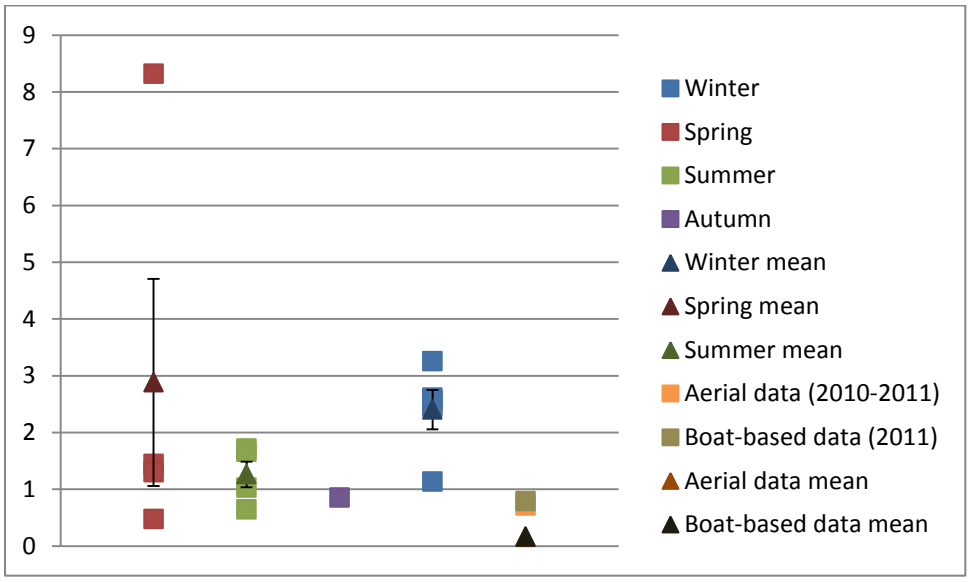
9.7 6b – Densities derived from the JNCC aerial survey data for NW5 and NW6a



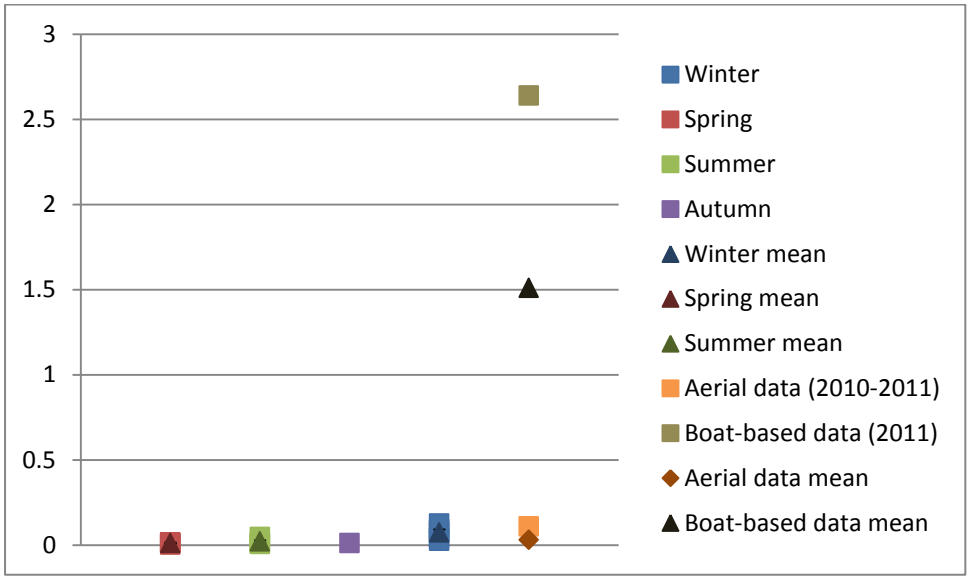
9.7.1 Arctic / Common tern



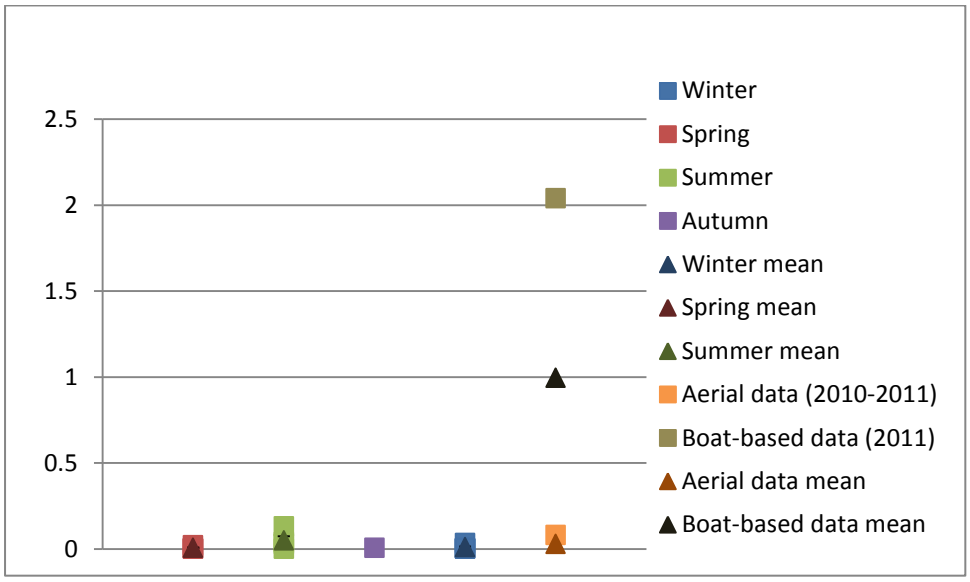
9.7.2 Auk sp.



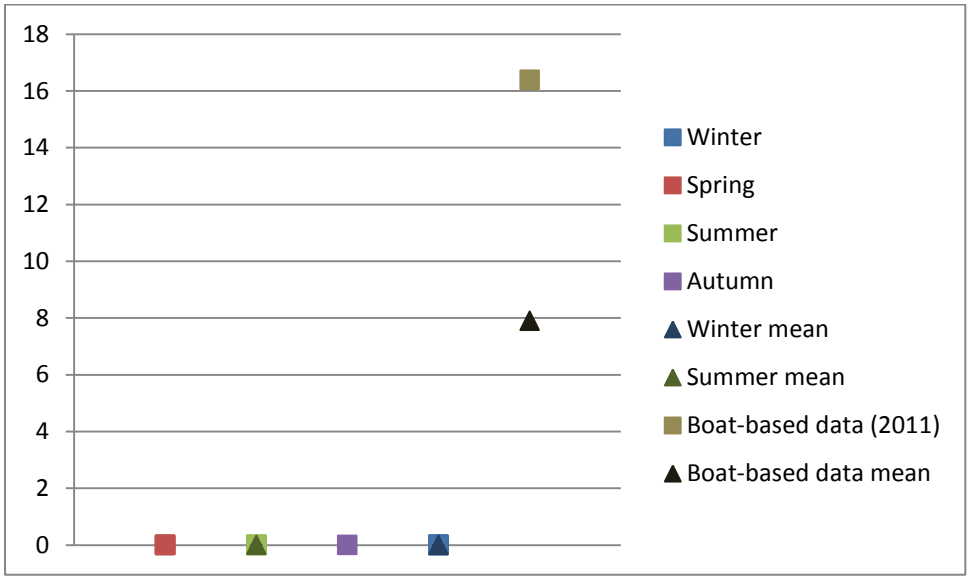
9.7.3 Common scoter



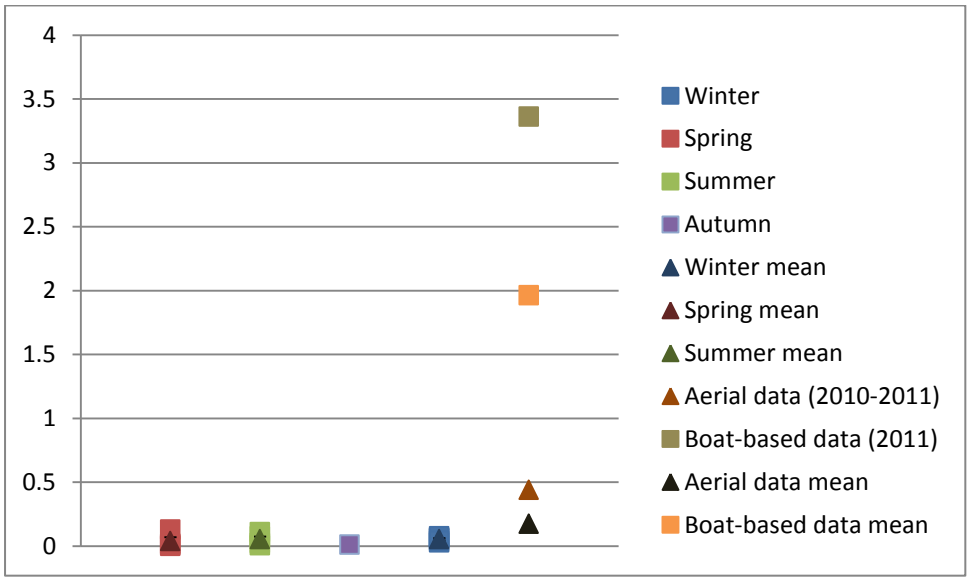
9.7.4 Cormorant



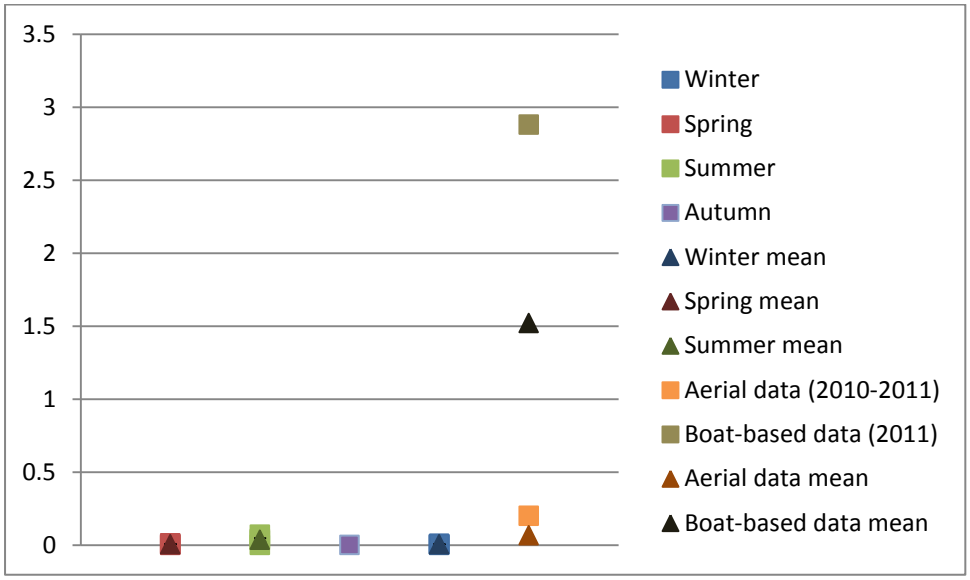
9.7.5 Gannet



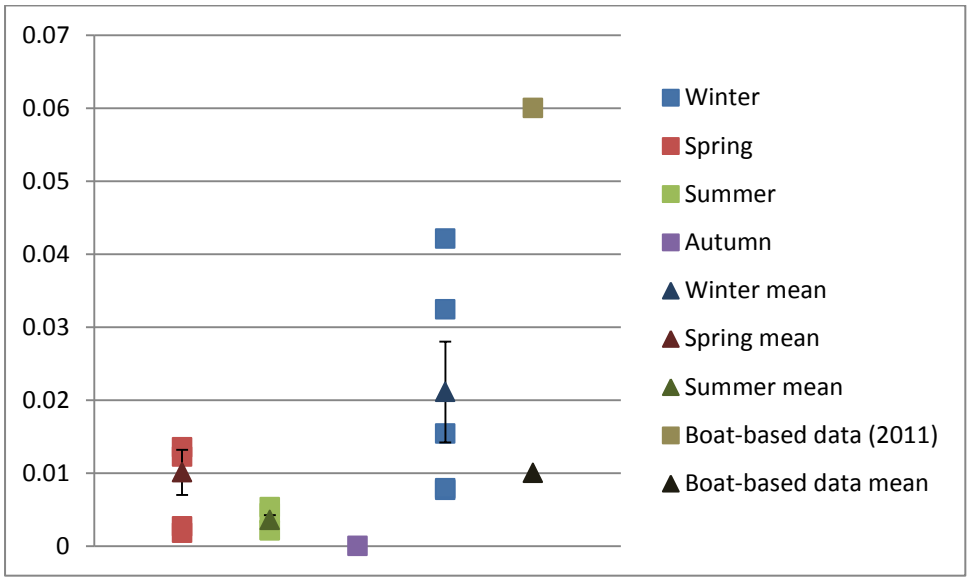
9.7.6 Guillemot



9.7.7 Kittiwake



9.7.8 Lesser black-backed gull



9.7.9 Red-throated diver

Burbo Bank Extension Offshore Wind Farm
Ornithology Report

Technical Report
March 2012

CMACS ref: J3164/03/2012/v3

A report to: DONG Energy

Version	Date	Description	Prepared	Checked	Approved
1	1/2012	First Draft	KN	GR	IGP
2	2/2012	Draft Final	KN	IGP	IGP
3	3/2012	Final	KN	IGP	IGP

Cover image: Northern fulmar *Fulmarus glacialis*

Centre for Marine and Coastal Studies Ltd

Head Office:
CMACS Ltd.
80 Eastham Village Road
Eastham
Wirral CH62 0AW

Tel 0151 327 7177
Fax 0151 327 6344

CMACS Ltd.
Asahi House
10 Church Road, Port Erin
Isle of Man, IM9 6AQ

CMACS Ltd (Cymru).
Woodland View
Pen-y-Worlod Lane, Penhow
Newport NP26 3AJ

Centre for Marine and Coastal Studies Ltd.
Registered in England No. 4883990

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3.2 Marine mammals 16

Appendices

Appendix 1. Monthly counts of each bird species (raw data in the first column and adjusted count to estimate populations for entire survey area in the second column)

Appendix 2. Flight height categories for each species recorded in the surveys

1 Introduction

1.1.1 The proposed Burbo Bank Extension offshore wind farm site is located west of the existing Burbo Bank site (25 x 3.6 MW turbines; operational since August 2007) in the Liverpool Bay, approximately 7.5 km north of Hoylake, Wirral and 12.6 km from Point of Ayr, Wales. It is bordered by the Queens Channel navigation channel into the Port of Liverpool to the northeast. The proposed Burbo Bank Extension Offshore Wind Farm project is planned to provide a total installed capacity upper boundary in the region of 250 MW from up to 69 turbines and will depend on the range of wind turbine types that can be employed at the offshore site (Figure 1).

1.1.2 There are several Special Protection Areas (SPA) in the area: the existing wind farm is inside the Liverpool Bay SPA and the extension proposed will extend across its boundary, and there are also the Dee Estuary SPA (also a Ramsar site), Mersey Estuary SPA (also a Ramsar site) and the North Wirral Foreshore SPA to the south of the proposed development and Sefton Coast SPA to the east (Figure 1). Therefore, to inform an environmental impact assessment, estimates of bird populations in the area are required and DONG Energy contracted Centre for Marine and Coastal Studies Ltd (CMACS) to carry out vessel-based ornithological surveys.

1.1.3 Six ornithological surveys were carried out in each calendar month between April and September 2011 with at least two weeks between surveys. This report details the findings of the surveys and presents statistical analysis of the data to provide estimates of bird populations.

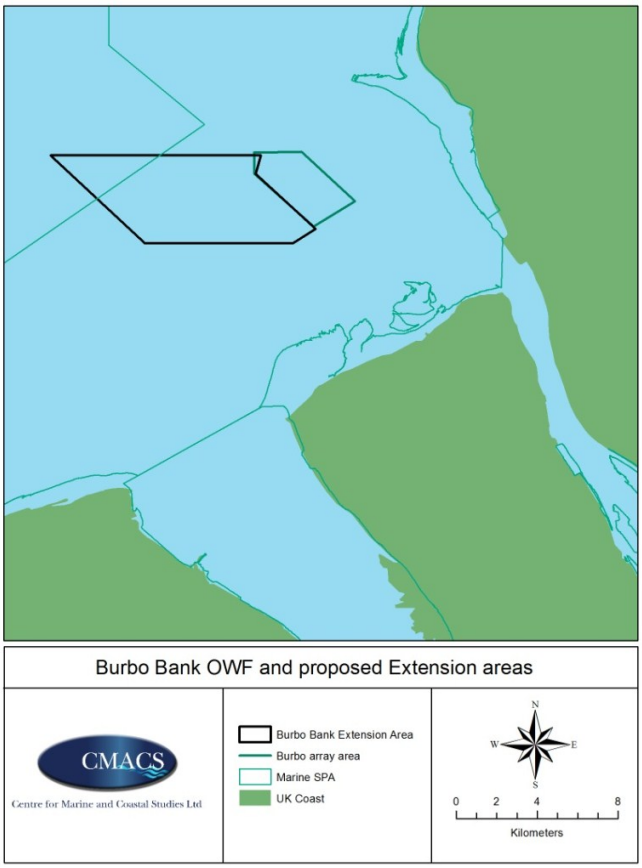

Figure 1. Location of Burbo Bank Extension Offshore Wind Farm in respect to the British mainland and marine Special Protection Areas (SPA)

2 Methodology

2.1 Survey

2.1.1 Surveys were carried out from the survey vessel; *Halcyon Days* which followed eight pre-determined transect lines agreed between DONG Energy and statutory consultees (Figure 2).

2.1.2 The transects totalled 128km at a spacing of 2km, with a total surveyed area of 76.8km^2 (transect width 0.6km)and were arranged so that the proposed wind farm area was in a central location. The total survey area was 207km^2 which was subdivided into the following three areas; existing Burbo Bank wind farm, Burbo Bank Extension Offshore Wind Farm area and reference area (this was defined as any part of a transect that was not within either of the wind farm areas). Methods followed the recommendations of Camphuysen *et al.* (2004) but also considered the British Trust for Ornithology (BTO) review of those recommendations (Maclean *et al.* 2009):

- Survey bands shall be subdivided into 0-50m, 50-100m, 100-200m, 200-300m and 300+m
- Vessel speed 10 knots (range 5-15kt)
- Viewing height shall be >5m above sea level.
- No observations at sea state 5 or more to be used in data analysis.
- Registration of tidal status (low, medium or high tidal).
- Qualified (i.e. experienced) observers for each survey.
- Observations on both sides of the vessel
- Registration of weather conditions including sea state, wind speed and wind direction.

2.1.3 For each bird observation, the following was recorded: observation time; position; species; numbers; age classes (where possible); distance band from the vessel; flight height; flight direction; behaviour; association (e.g. with fishing vessels).

2.1.4 For birds in flight, three height bands were used; 0-30m 30-140m and 140+ thus estimating birds flying below the rotor sweep, those within the rotor sweep and those above it. These flight heights were based on previous wind farms (figures supplied by DONG Energy) as the specific rotor sweep for Burbo Bank Extension Offshore Wind Farm was unknown at the beginning of the surveys.

2.1.5 For each marine mammal observation, the following was recorded: observation time; position; species; numbers; age classes (if possible); direction; behaviour.

2.1.6 Notes on prevailing meteorological conditions, sea state and visibility were also made periodically throughout each survey.

2.1.7 Two observers, including at least one JNCC accredited Marine Mammal Observer (MMO) were present in each survey with one on each side of the vessel swapping sides at the end of every other transect to account for observer bias. Each observer was equipped with binoculars and a dictaphone (voice recorder) to make audio records of sightings. The dictaphones allowed observation to continue while records were being made and reduced the problem of 'swamping' when large numbers of birds were recorded at once.

2.1.8 Birds were recorded continuously as they were encountered by the surveyors; experience of previous bird surveys has shown that recording birds continuously rather than at specific intervals is easier to manage at sea. A hand-held GPS recorded the vessel's position every 10 seconds and thus real-time positions of observations were available after the survey.

2.1.9 In the first two months of survey snapshot counts of birds in flight were attempted every 300m (as per the recommendation of Maclean *et al.* 2009) but it soon became obvious that continuous recording of birds in flight was more accurate and with a low risk of double counting owing to the low numbers of birds seen. This adjustment of the method meant that the bird in flight data was treated in the same way as birds on the sea i.e. as a density per transect area rather than as a series of densities in consecutive snapshot 'boxes'.

2.1.10 The survey vessel for all six surveys was the *Halcyon Days* (Figure 3) with observers surveying from a viewing platform that was built to CMACS's specification for our previous surveys and allowed for unrestricted visibility. Observers scanned for birds principally by eye over a transect width of 300m either side of the vessel but also scanned forward of the vessel using binoculars to aid detection of sea ducks and divers.

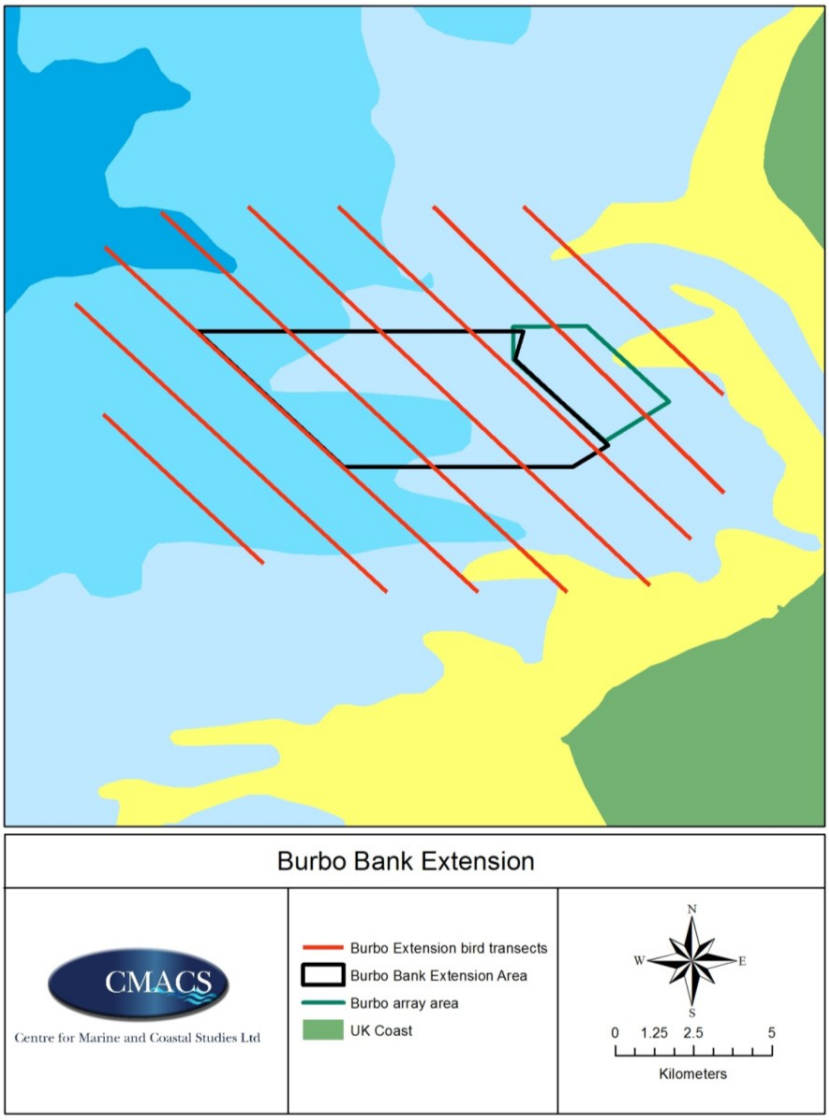

Figure 2. Location of survey transects on Burbo Bank Extension Offshore Wind Farm area. Also shown are 10m isobaths in Liverpool Bay.

Figure 3. Survey vessel, *Halcyon Days*.

2.2 Population Estimation

2.2.1 To calculate the population density for each species the following assumptions were made:

a. Observations of birds in flight within 300m (or within band d) do not require correction for distance related detection errors.

b. That all birds on the sea surface are recorded within 100m of the vessel but that beyond this there is a distance related detection error that must be corrected for

2.2.2 The second assumption means that the proportion of birds observed in bands 'c' and 'd' is less than 100% of the population present and that a correction factor is required to estimate the total number of birds on the sea in the surveyed area. This was achieved for each species separately using the following formula:

$$\text{Correction factor} = \frac{(a+b)*3}{(a+b+c+d)}$$

Where a, b, c and d are the number of birds in band a, b, c and d.

2.2.3 When a correction factor was calculated as less than 1, it was assumed that all birds had been recorded and a correction factor of 1 was used. Where there were too few sightings to calculate a correction factor, one was used from a similar species.

2.2.4 The correction factor was calculated from pooled data from all six surveys but then population and density estimates were calculated for each species in each month separately. Population estimates were calculated for the total surveyed area with the following formula:

$$\text{Estimated bird population} = \text{corrected bird count} * \frac{\text{Area of interest}}{\text{Total surveyed area}}$$

2.2.5 The total surveyed area is derived from the transect width; 300m either side of the vessel and therefore a total width of 0.6km (see Figure 4) which is a proportion of the total area of interest (see figure 5)

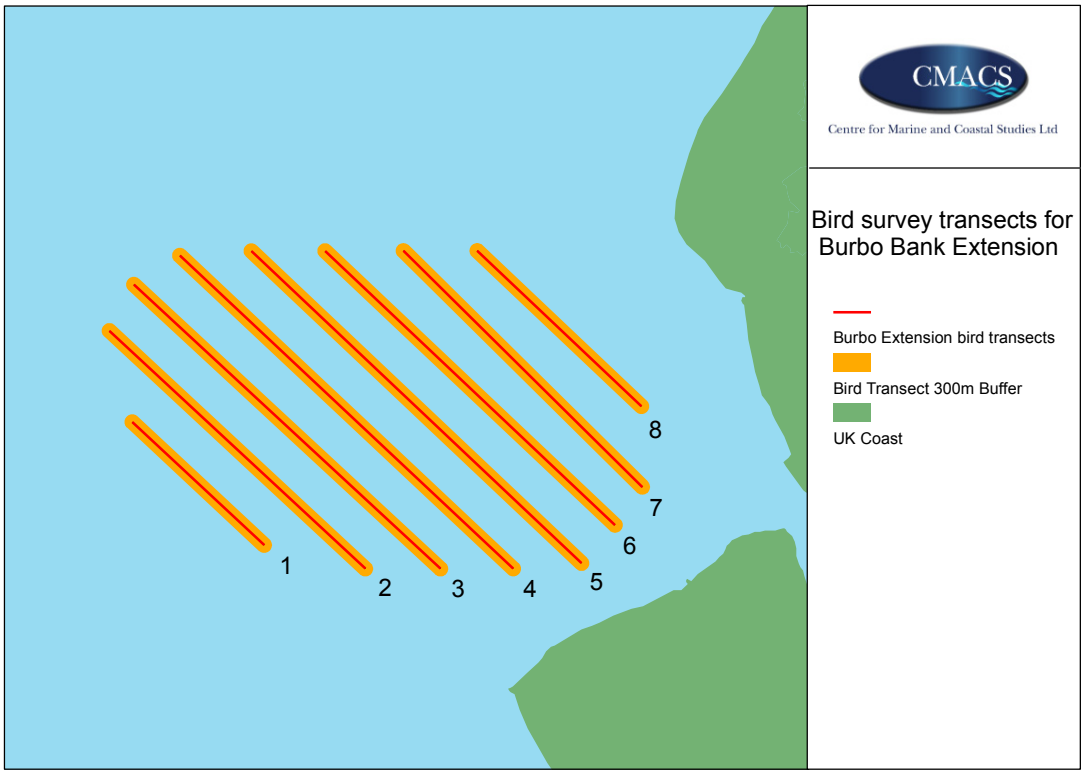

Figure 4. Numbered survey transects for the 2011 Burbo Bank Extension Offshore Wind Farm ornithology survey showing line followed by the vessel (red) and the surveyed area (orange).

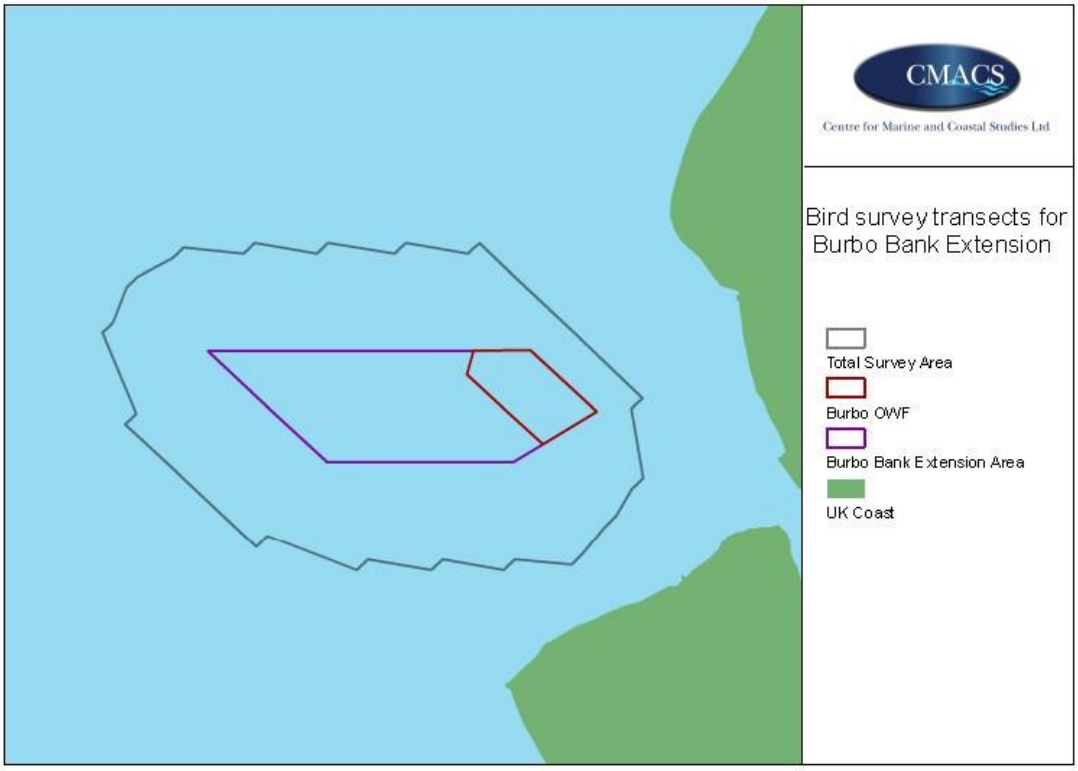

Figure 5. Areas of interest; total survey area, Burbo Bank Extension Offshore Wind Farm area, Burbo Bank OWF area.

3 Results & Discussion

3.1.1 Total bird population estimates from each survey area totalled 7,807 from the wind farm areas and 21,611 from the reference area. While it appears that there is a large discrepancy between areas, the wind farm area was less than a third of the size of the reference area and density of birds per km^2 were comparable for most species. A total of 37 taxa were recorded, 28 of which were identified to species level, which are detailed in a list with the raw monthly count as well as the distance and area adjusted figure in Appendix 1. Bird numbers were lowest in April and May with a large influx to the area in July (Figure 6), probably as fledged offspring from local breeding colonies moved offshore.

3.1.2 The birds recorded in the survey were mostly true seabirds including 8 species of gull, 3 species of auk, gannet, 3 species of tern and two species of skua. However, coastal species were also recorded (e.g. curlew) , terrestrial species (meadow pipit and swift) which were probably on migration and some species which spend a proportion of their lives on freshwater but overwinter at sea (red breasted merganser and red throated diver).

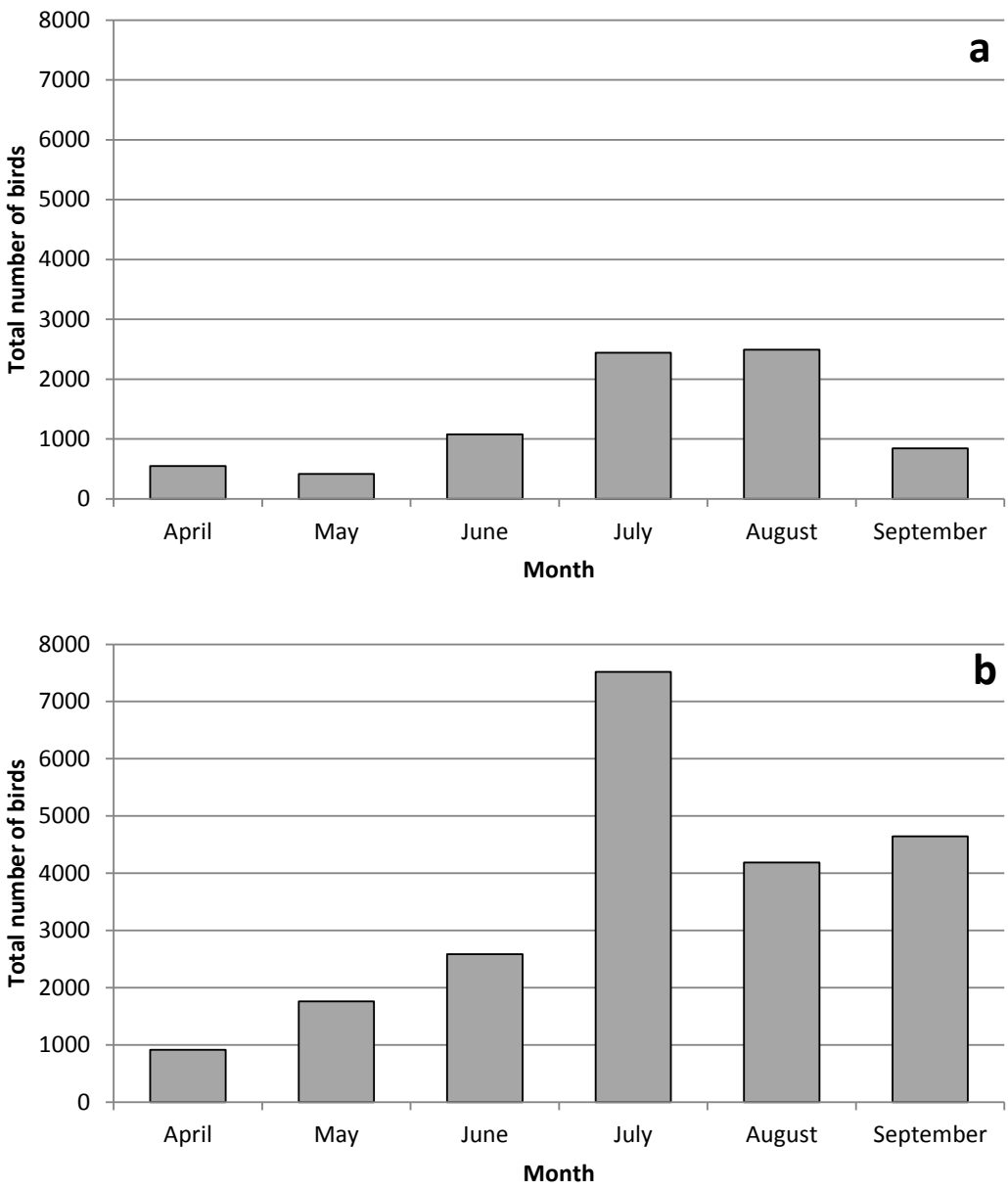

Figure 6. Total number of birds in the wind farm areas (a) and reference area (b) in each monthly survey, Burbo Bank Extension Offshore Wind Farm. Plots are based on data corrected for distance and area.

3.1.3 Distribution plots of the principal species are provided in Figure 7 to Figure 10 and indicate that guillemot and kittiwake were distributed throughout the survey area but with lower numbers towards the Burbo Bank. The greatest numbers of gannet and Manx shearwater were recorded to the north and west of the survey area and there were no records of either species from the existing wind farm area. Both of these species were often observed in feeding aggregations of tens of birds. Cormorant appeared more unevenly distributed than other species probably because many records were from these birds resting on turbine transition pieces or buoys which not only concentrated their numbers but also made them easier to spot.

3.1.4 Gulls were mainly recorded inshore of the wind farm areas and was the main group found in the existing wind farm in any numbers; herring gull in particular were observed perched on transition pieces or foraging around the bases of them. Common tern were also mainly recorded inshore of the wind farm areas whereas sandwich tern had a more even distribution across the survey area.

3.1.5 The large majority of birds in flight were recorded in the lowest height band (see table in Appendix 2) with Manx shearwater and guillemot never recorded higher than thirty metres.

3.1.6 It was predominantly gulls and skuas that were seen in the higher height categories probably because these birds are scavengers as well as predators and may be flying high in order to spot feeding aggregations of other birds (such as gannets and terns).

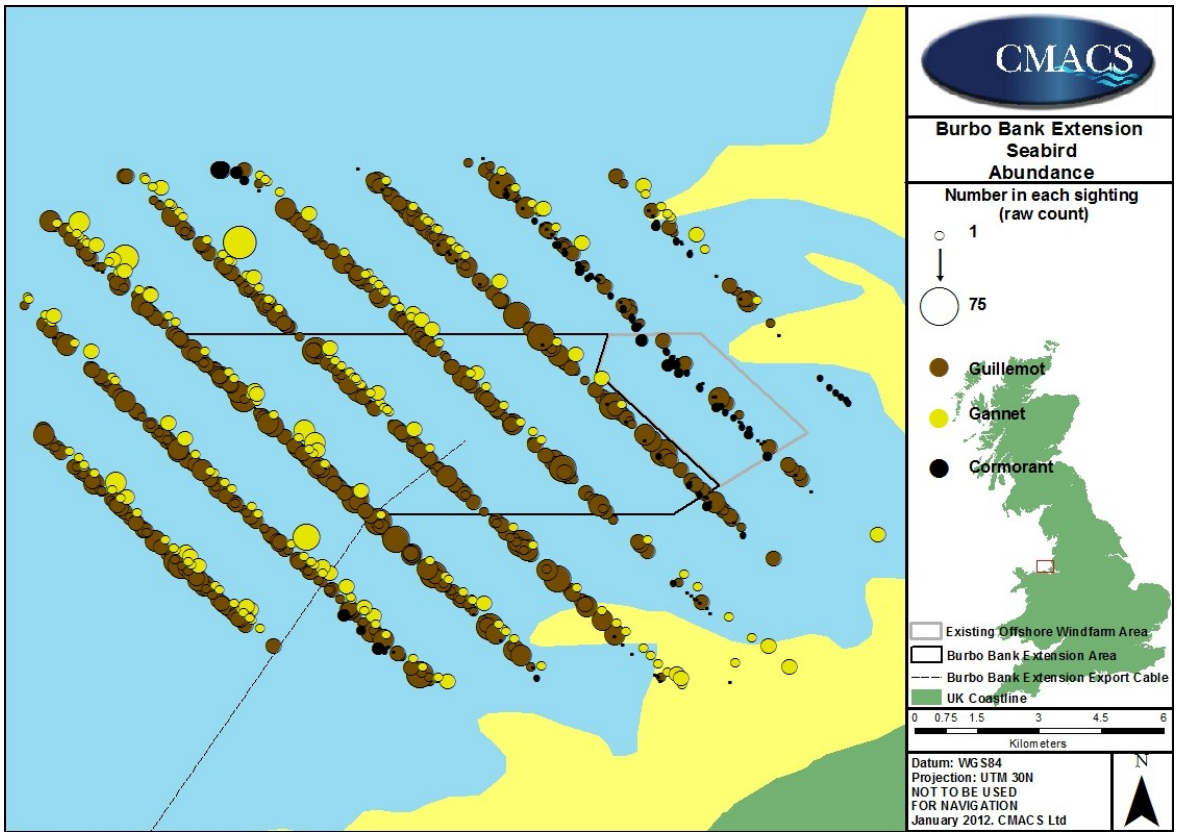

Figure 7. Distribution and abundance of seabirds on the Burbo Bank Extension Offshore Wind Farm survey area. Data combined from all months and uncorrected for distance.

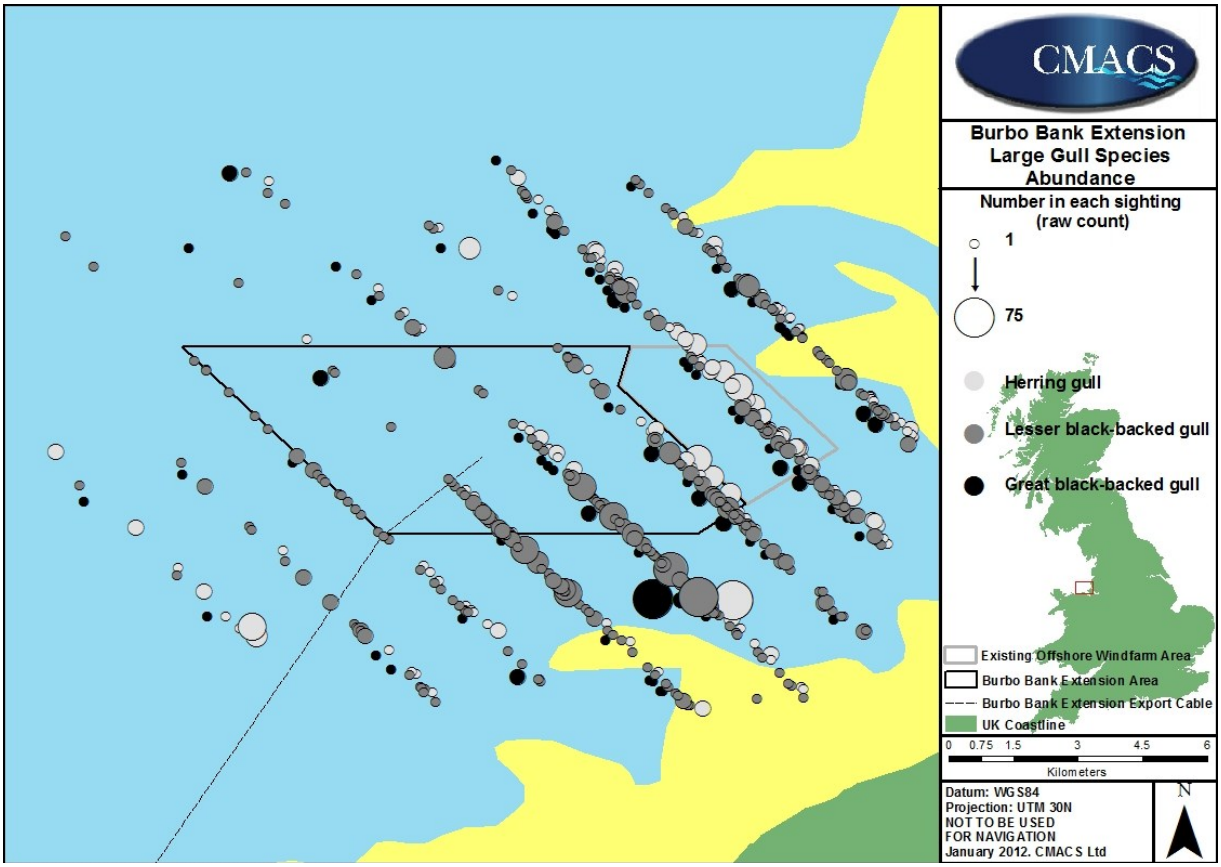

Figure 8. Distribution and abundance of large gull species on the Burbo Bank Extension Offshore Wind Farm area. Data combined for all months and uncorrected for distance.

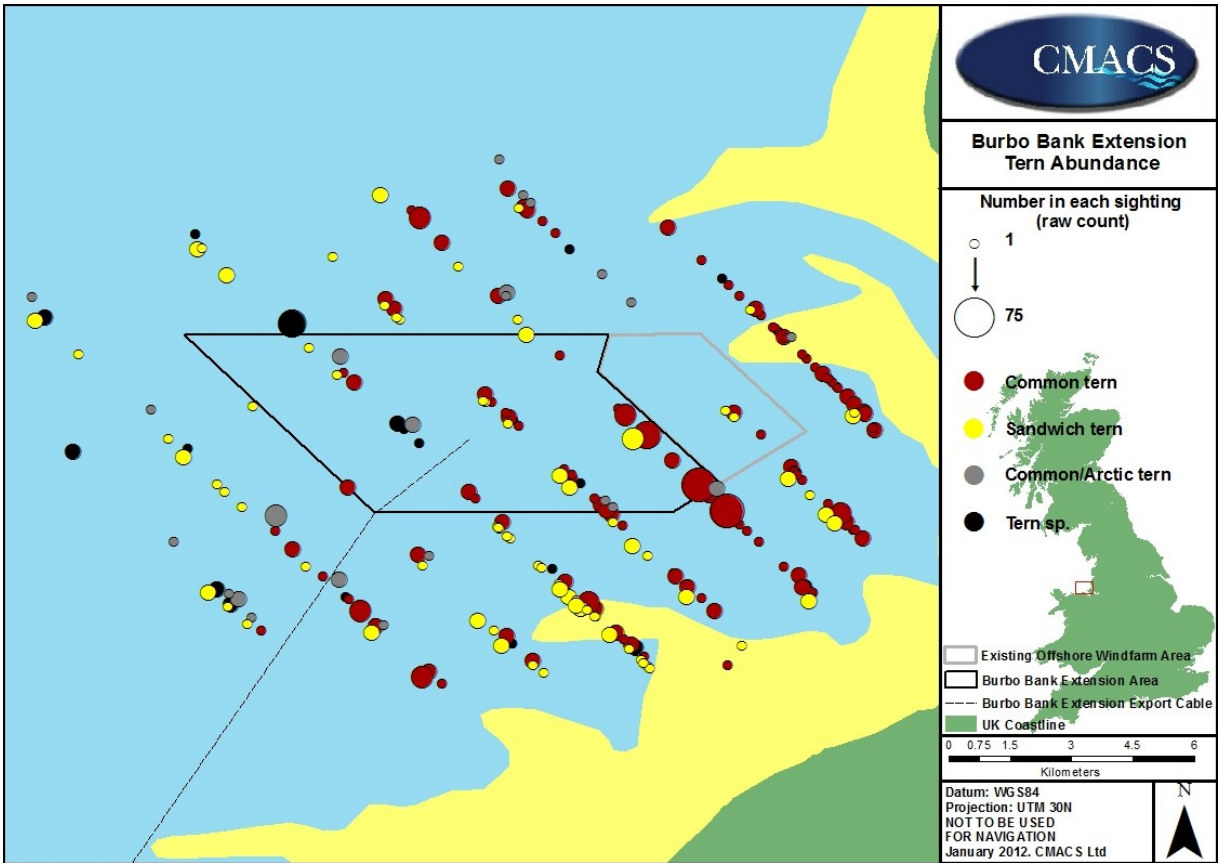

Figure 9. Distribution and abundance of tern species on the Burbo Bank Extension Offshore Wind Farm area. Data combined from all moths and uncorrected for distance.

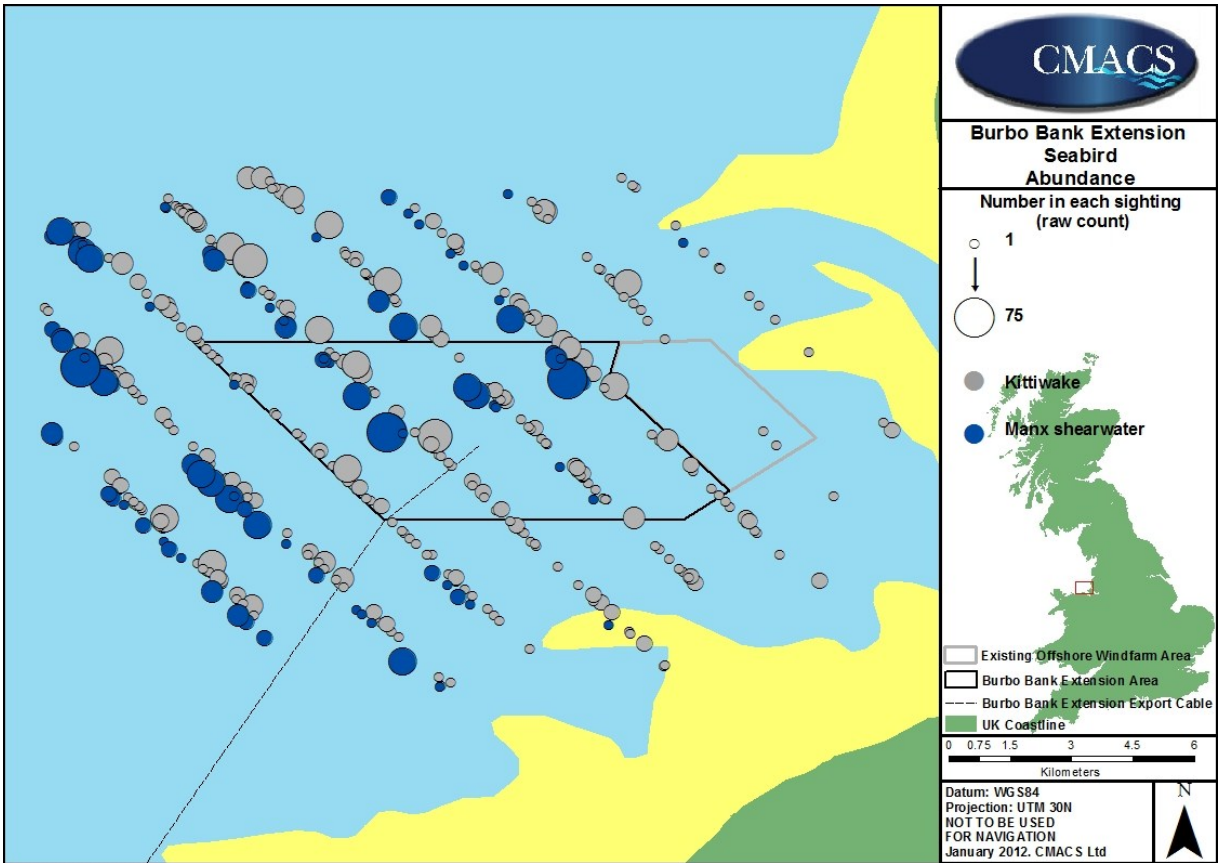

Figure 10. Distribution and abundance of kittiwake and Manx shearwater on the Burbo Bank Extension Offshore Wind Farm area. Data combined for all months and uncorrected for distance.

3.1. Migrant species

3.1.7 The principal migratory species recorded in the surveys were terns and shearwaters but there were also records of skua, common scoter and passerines. The distribution and abundance of these groups (with the exception of passerines which were only present in low numbers) are presented in Figure 11 to Figure 13.

3.1.8 Terns were distributed throughout the survey area with no particularly prevalent flight direction but appeared to be concentrated to the southern and eastern sides, where there was shallow water around sand banks (Figure 11). It is interesting to note that while there are numerous sightings of terns immediately to the south and east of the existing Burbo Bank Offshore wind farm, there were only three records (two common tern and one sandwich tern) from with the existing wind farm area itself suggesting that there may be avoidance.

3.1.9 Manx shearwater were recorded predominantly from the northern and western side of the survey area, mainly over the relatively deep water but there was one record of a large feeding flock within the proposed extension area in July (Figure 12). There was no particular trend of flight direction of Manx shearwater within the survey area as a whole but birds were often recorded in feeding aggregations.

3.1.10 Common scoter were recorded infrequently in the survey area and therefore inferences of overall distribution cannot be made but most records were of birds flying in either a north easterly or south westerly direction (Figure 12). Most of the sightings were outside the wind farm areas with just a single record from each of the extension area and existing Burbo OWF. Liverpool Bay is an important area for common scoter and the records suggest that these birds were making local movements and transiting the survey area, especially as there were no records of birds on the sea.

3.1.11 Skuas were relatively scarce in the surveys, recorded mainly to the west of the extension area, but were often observed in aerial pursuit of gulls and terns suggesting that their presence was influenced by feeding flocks of those taxa.

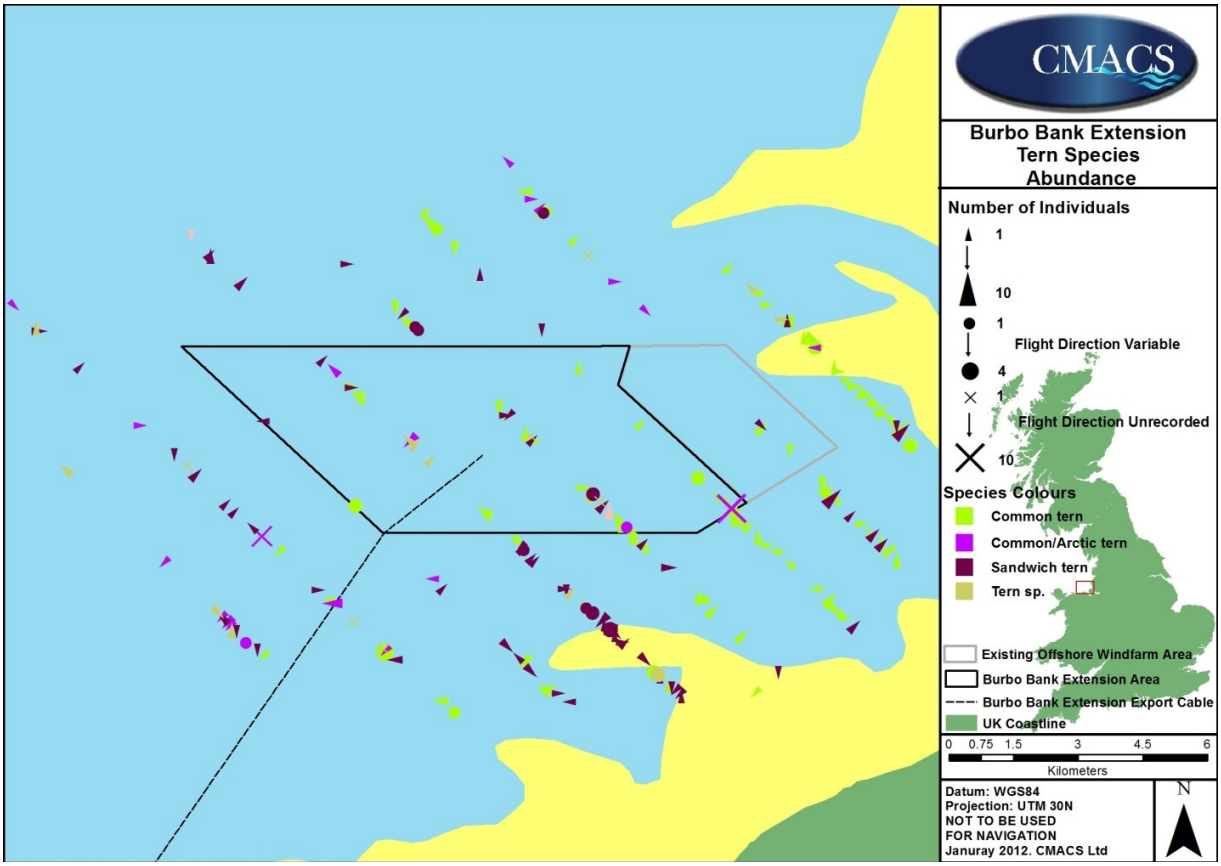

Figure 11. Abundance and indicative flight direction of all tern species. Based on pooled data from all survey months.

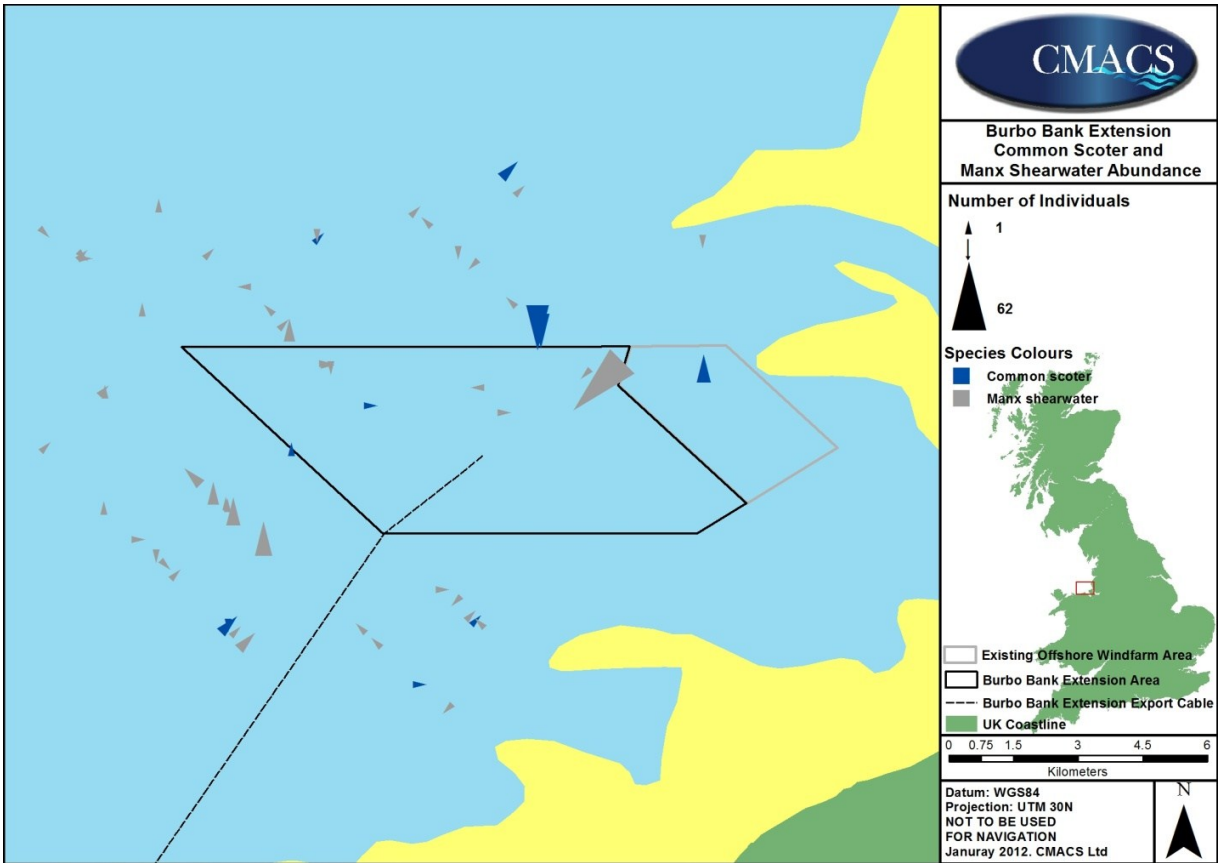

Figure 12. Abundance and indicative flight direction of common scoter and Manx shearwater. Based on pooled data from all survey months.

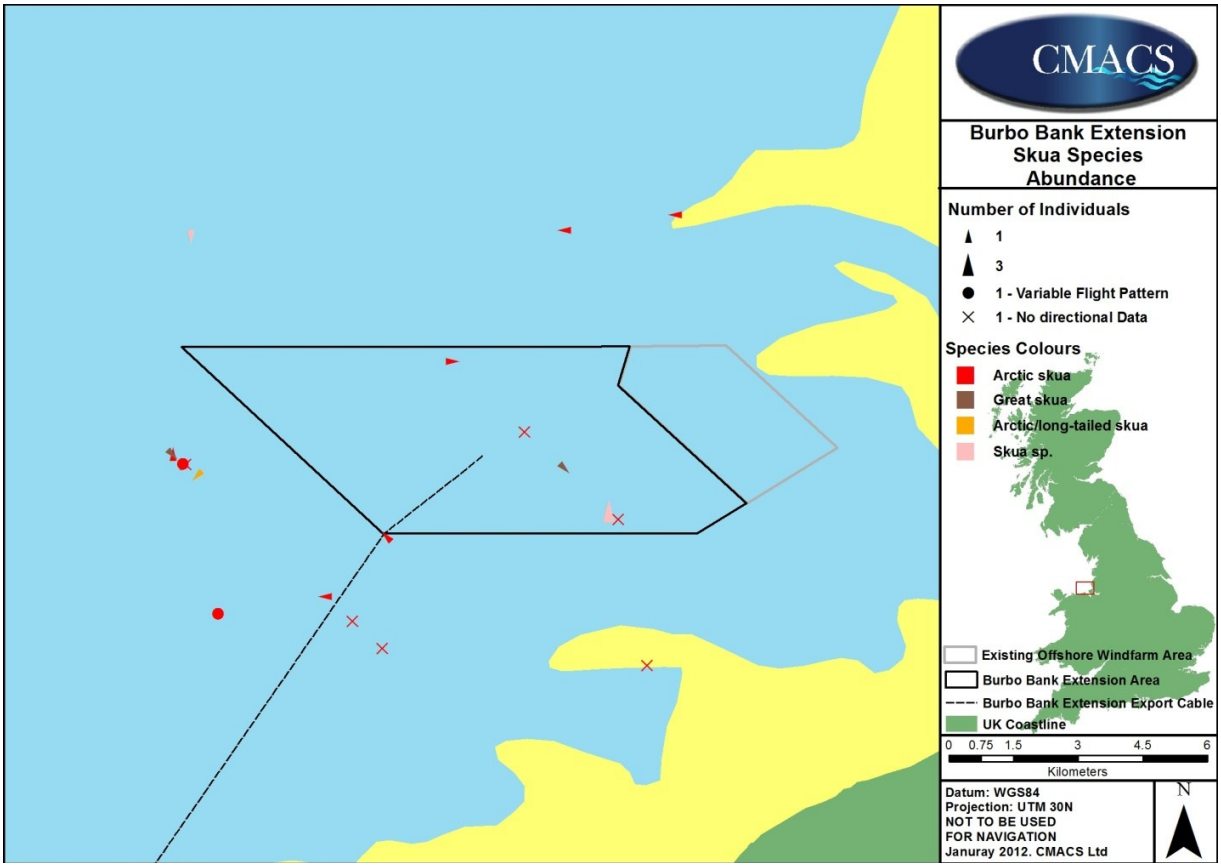

Figure 13. Abundance and indicative flight direction of all species of skua. Based on pooled data from all survey months.

3.2 Marine mammals

3.2.1 Three species of marine mammal were recorded in the surveys; grey seal, harbour porpoise and harbour seal. Grey seal were evenly distributed across the survey area and were the only marine mammal recorded within the existing wind farm (Figure 14) and were often observed loafing at the sea surface or observing the survey vessel.

3.2.2 Harbour porpoise were mainly recorded to the north and south of the wind farm areas although there was a single record of one individual in the extension area. Sightings of harbour porpoise were often fleeting but several records were of individuals apparently pursuing prey.

3.2.3 A single sighting of a harbour seal was made from the northern end of the Burbo Bank although the sandbank was submerged at the time and the seal was loafing at the surface of the sea.

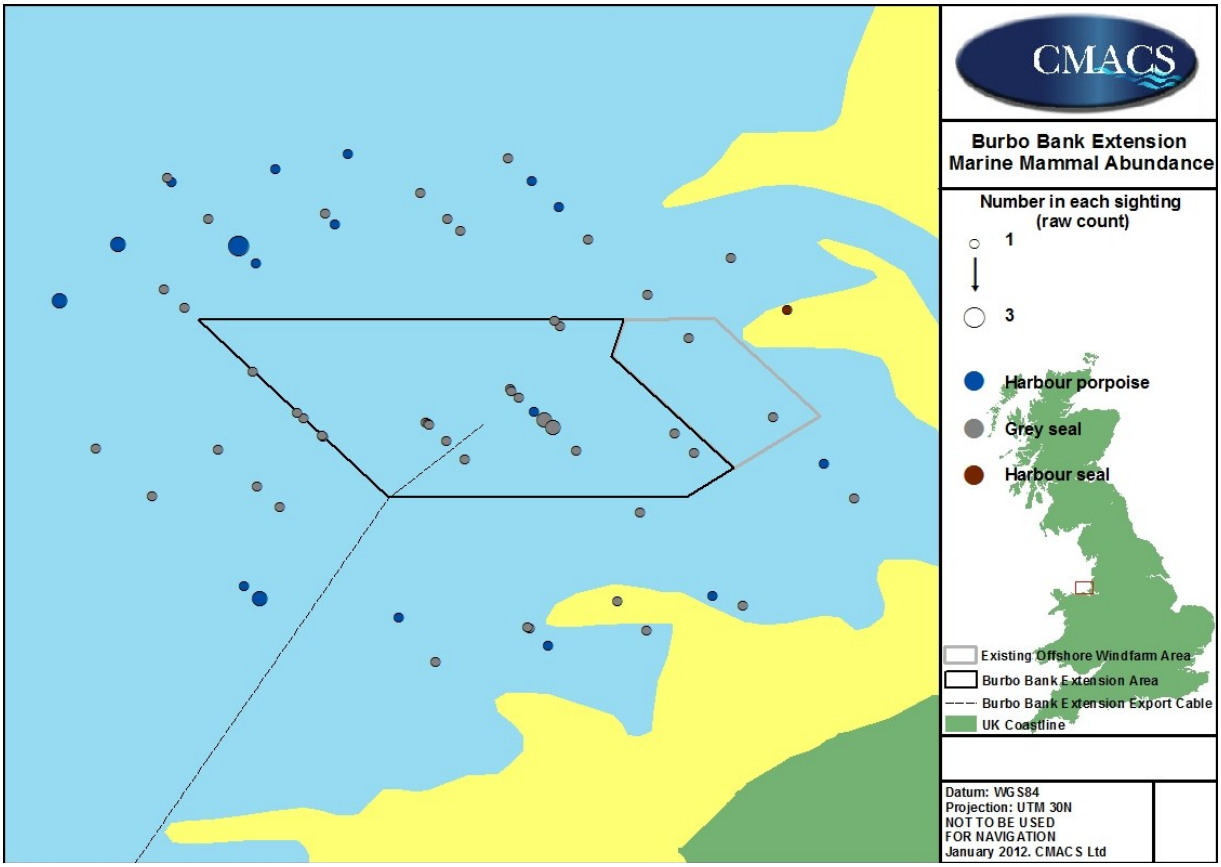

Figure 14. Distribution and abundance of marine mammals in the Burbo Bank Extension Offshore Wind Farm survey area. Based on raw data, uncorrected for seastate.

4 Appendices

4.1 Appendix 1. Monthly counts of each bird species (raw data in the first column and adjusted count to estimate populations for entire survey area in the second column)

Common Name	Species	April		May		June	
		Raw	Adjusted	Raw	Adjusted	Raw	Adjusted
Arctic skua	*Stercorarius parasiticus*	0	0	4	13	0	0
Arctic tern	*Sterna paradisaea*	0	0	0	0	0	0
Arctic/long-tailed skua	*Stercorarius parasitica/longicauda*	0	0	0	0	0	0
Auk sp	Alcidae	2	3	5	3*	10	0*
Black-backed gull sp.	*Larus* sp.	0	0	0	0	0	0
Black-headed gull	*Larus ridibundus*	0	0	0	0	4	15
Common gull	*Larus canus*	12	47	13	44	1	3
Common scoter	*Melanitta nigra*	4	13	16	7*	4	0*
Common tern	*Sterna hirundo*	23	118	30	93	62	302
Common/Arctic tern	*Sterna hirundo/paradisaea*	0	0	0	0	0	0
Cormorant	*Phalacrocorax carbo*	55	420	59	204	39	139
Curlew	*Numenius arquata*	0	0	0	0	1	3
Fulmar	*Fulmaris glacialis*	0	0	2	12	0	0
Gannet	*Morus bassanus*	4	10	161	448	105	363
Great black-backed gull	*Larus canus*	10	29	4	10	17	37
Great crested grebe	*Podiceps cristatus*	0	0	0	0	0	0
Great skua	*Catharacta skua*	0	0	0	0	2	7
Guillemot	*Uria aalge*	12	71	173	549	354	911
Gull sp.	Laridae	120	53*	548+	181*	105	8*
Herring gull	*Larus argentatus*	117	468	29	121	44	170
Kittiwake	*Rissa tridactyla*	27	66	70	242	293	990
Lesser black-backed gull	*Larus fuscus*	47	143	48	155	312	567
Little gull	*Larus minutus*	2	7	0	0	0	0
Manx shearwater	*Puffinus puffinus*	2	7	1	3	24	132
Meadow pipit	*Anthus pratensis*	0	0	0	0	0	0
Passerine sp.		0	0	0	0	0	0

Common Name	Species	April		May		June	
Puffin	*Fratercula arctica*	0	0	1	3	0	0
Razorbill	*Alca torda*	1	9	6	53	0	0
Red-breasted merganser	*Mergus serrato*	5	16	0	0	0	0
Red-throated diver	*Gavia stellata*	0	0	0	0	0	0
Sandwich tern	*Sterna sandivicensis*	0	0	7	22	5	15
Skua sp	*Stercorarius* sp.	0	0	0	0	0	0
Sooty shearwater(?)	*Puffinus griseus*	0	0	0	0	0	0
Swift	*Apus apus*	0	0	0	0	0	0
Tern sp.	Sternidae	8	23	3	0	0	0
Wader sp.	Charadriiformes	2	7	0	0	0	0
Yellow-legged gull	*Larus michahellis*	0	0	1	4	0	0

Common Name	Species	July		August		September	
		Raw	Adjusted	Raw	Adjusted	Raw	Adjusted
Arctic skua	*Stercorarius parasiticus*	1	3	4	11	11	38
Arctic tern	*Sterna paradisaea*	0	0	0	0	1	10
Arctic/long-tailed skua	*Stercorarius parasitica/longicauda*	0	0	0	0	1	3
Auk sp	Alcidae	1	3	32	0*	165	467
Black-backed gull sp.	*Larus* sp.	2	0*	0	0	7	17
Black-headed gull	*Larus ridibundus*	1	3	0	0	0	0
Common gull	*Larus canus*	3	3	0	0	0	0
Common scoter	*Melanitta nigra*	65	199	0	0	11	35
Common tern	*Sterna hirundo*	51	65	191	674	3	9
Common/Arctic tern	*Sterna hirundo/paradisaea*	0	0	5	7	55	272
Cormorant	*Phalacrocorax carbo*	121	482	214	404	181	660
Curlew	*Numenius arquata*	0	0	0	0	0	0
Fulmar	*Fulmaris glacialis*	0	0	0	0	1	3
Gannet	*Morus bassanus*	174	487	98	241	25	74
Great black-backed gull	*Larus canus*	14	47	32	85	95	306
Great crested grebe	*Podiceps cristatus*	0	0	1	3	5	49
Great skua	*Catharacta skua*	0	0	0	0	2	7
Guillemot	*Uria aalge*	762	3939	643	3178	308	1796
Gull sp.	Laridae	7	16	12	23	39	108
Herring gull	*Larus argentatus*	58	201	81	359	86	377

Common Name	Species	July		August		September	
Kittiwake	*Rissa tridactyla*	274	798	252	601	60	213
Lesser black-backed gull	*Larus fuscus*	128	324	239	574	98	330
Little gull	*Larus minutus*	2	7	0	0	5	16
Manx shearwater	*Puffinus puffinus*	639	3312	65	306	0	0
Meadow pipit	*Anthus pratensis*	0	0	0	0	4	12
Passerine sp.		0	0	0	0	2	7
Puffin	*Fratercula arctica*	0	0	0	0	0	0
Razorbill	*Alca torda*	0	0	2	18	53	419
Red-breasted merganser	*Mergus serrato*	0	0	0	0	0	0
Red-throated diver	*Gavia stellata*	0	0	0	0	5	16
Sandwich tern	*Sterna sandivicensis*	31	65	93	194	25	79
Skua sp	*Stercorarius* sp.	0	0	0	0	9	26
Sooty shearwater(?)	*Puffinus griseus*	0	0	0	0	1	3
Swift	*Apus apus*	0	0	0	0	1	3
Tern sp.	Sternidae	0	0	0	0	43	137
Wader sp.	Charadriiformes	1	3	20	0*	0	0
Yellow-legged gull	*Larus michahellis*	0	0	0	0	0	0

*Because population estimates are based on counts from distance bands A-D, those groups with raw counts that include high band E counts will have a population estimate lower than the raw count. This assumed, however, to be accounted for in the population estimate of related taxa: lower counts of 'gull sp.' in the population estimate are accounted for in the estimates for herring gull, lesser black-backed gull etc

4.2 Appendix 2. Flight height categories for each species recorded in the surveys

Species	Flight height category (m)		
	0-30	31-140	140+
Arctic skua	8	5	0
Arctic/long-tailed skua	1	0	0
Black-backed gull sp.	1	3	0
Black-headed gull	1	3	1
Common gull	13	1	0
Common scoter	81	7	0
Common tern	139	21	0
Common/Arctic term	31	4	0
Cormorant	87	7	0
Curlew	1	0	0
Fulmar	2	0	0
Gannet	79	51	0
Great black-backed gull	16	22	4
Great skua	2	0	0
Great crested grebe	1	0	0
Guillemot	57	0	0
Gull sp.	30	14	0
Herring gull	56	37	2
Kittiwake	169	118	1
Lesser black-backed gull	195	179	1
Little gull	3	0	0
Meadow pipit	2	2	0
Passerine sp.	1	1	0
Manx shearwater	173	0	0
Puffin	1	0	0
Razorbill	2	0	0
Red-breasted merganser	5	0	0
Red-throated diver	3	2	0
Sandwich tern	85	16	0
Skua sp.	1	2	0
Swift	1	0	0
Tern sp.	19	4	0
Wader sp.	3	0	0

ORNITHOLOGICAL SURVEYS OF THE BURBO BANK EXTENSION OFFSHORE WIND FARM AREA

November 2010 to April 2011

Report commissioned by DONG Energy

2011

AARHUS UNIVERSITY
DCE – DANISH CENTRE FOR ENVIRONMENT AND ENERGY

Ornithological Surveys of the Burbo Bank Extension Offshore Wind Farm area

November 2010 to April 2011

Ib Krag Petersen, Geoff Groom, Michael Stjernholm & Rasmus Due Nielsen

Aarhus University, Institut for Bioscience

Datablad

Title:	Ornithological Surveys of the Burbo Bank Extension Offshore Wind Farm area
Subtitle:	November 2010 to April 2011
Report request:	Report commissioned by DONG Engergy A/S
Authors:	Ib Krag Petersen, Geoff Groom, Michael Stjernholm & Rasmus Due Nielsen
Department:	Aarhus University, Department of Bioscience
Publisher:	Aarhus University, DCE - Danish Centre for Environment and Energy ©
Year of publication:	October 2011
Editing completed:	September 2011
Editor:	Tommy Asferg
Referee:	Antony David Fox
Financial support:	DONG Energy A/S
Please cite as:	Petersen, I.K, Groom, G., Stjernholm, M. & Nielsen, R.D. 2011. Ornithological Surveys of the Burbo Bank Extension Offshore Wind Farm area. November 2010 to April 2011. Report commissioned by DONG Energy A/S. Aarhus University, DCE - Danish Centre for Environment and Energy. 28 pp.
	Reproduction permitted provided the source is explicitly acknowledged
Layout:	Graphics Group, AU Silkeborg
Cover photo:	BLOM Aerofilms
Number of pages:	28

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1 Introduction

1.1.1 In 2010 Department of Bioscience, Aarhus University entered a contract with DONG Wind UK Ltd. concerning surveys of marine birds in and around the Burbo Bank Extension and the Walney Extension offshore wind farms in the Irish Sea. In this report we report ornithological data for the Burbo Bank Extension study site.

1.1.2 In the period from November 2010 until April 2011 a total of six surveys were performed.

1.1.3 The surveys were conducted along 10 pre-defined transect lines, using a VexcelUltracam camera, delivering images with a ground resolution of 3 or 4 cm. The 10 transects had an approximate total length of 109 km. The Vexcel camera was owned and operated by Blom Aerofilms Ltd. through a subcontract with Aarhus University.

1.1.4 The objective of the study is to map bird distributions in the study area by monthly aerial image surveys. The data will provide input for an assessment of potential conflicts between birds and wind turbines in the Burbo Bank Offshore Wind Farm area.

1.1.5 The most abundant bird species groups were gulls and Razorbill/Guillemot. With densities of up to 11.11 birds/km2 we estimated a total abundance of more than 2,300 Razorbills/Guillemots in the study area. Likewise, we calculated densities of up to 7.99 gulls/km2, leading to a total abundance estimate of more than 1,600 birds in the study area.

1.1.6 Densities and total numbers were calculated and estimated for relevant species and presented in this report.

1.1.7 Birds were identified manually (visibly) by experienced ornithologists from 20% of the images. An automated pattern recognition algorithm was also used on all images, and performed satisfactorily for this survey. The results presented in this report are based on the data output from the automated bird search as described below.

1.1.8 The current data represents all ornithological data collected by use of digital images in the Burbo Bank Extension area. No surveys were scheduled for the summer. One more survey is scheduled for October 2011.

2 Method

2.1 Aerial surveys using the high resolution image method

2.1.1 The six surveys presented in this report were performed using aerial digital imagery. The image survey area covered the proposed footprint of the Burbo Bank Extension Offshore Wind Farm site and a buffer zone of 4 km around this, comprised a total area of 210.5 km^2.

2.1.2 Five of the six surveys were carried out with a VexcelUltracam XP camera. The resulting XP images cover a width of 520 m and a ground resolution of 3 cm. The survey performed on 8th December 2010 was carried out using a VexcelUltracam D camera. This camera had an image width of 430 m and a ground resolution of 4 cm.

2.1.3 The camera was operated from a twin engine aircraft, either a Cessna 402B or a Cessna 404. Images were obtained from an altitude of 475 m and a speed of 140 knots.

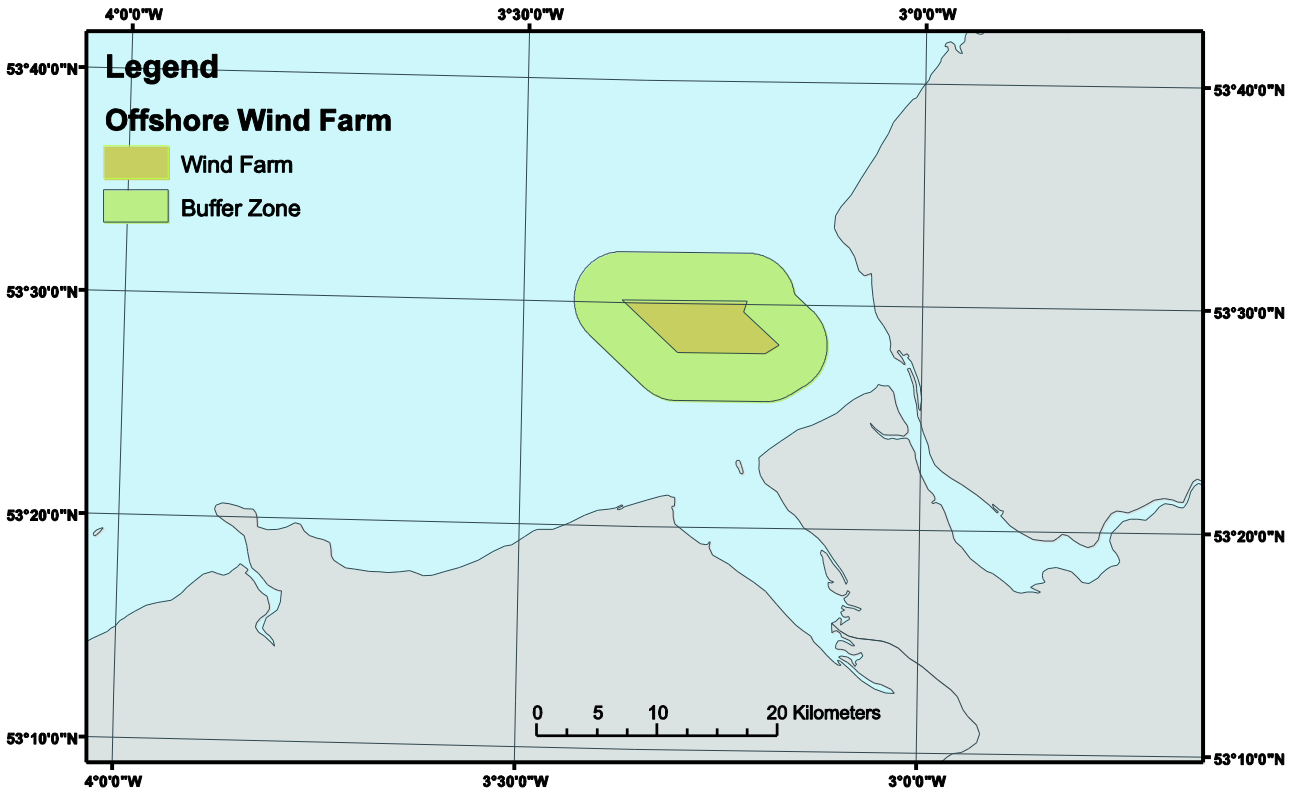

Figure 1. The Burbo Bank Extension bird study area for the six surveys conducted from November 2010 until April 2011.

GIS Processing

2.1.4 The GIS processing in relation to the image analysis falls in two separate phases, the pre-processing of images and analysis masking followed by the post-processing of results coming out of the image analysis. As the data volume to be handled is quite large (several TB per survey) and the team will need to be able to return

to the data at a later stage two different subsets of the images are created – a long term storage set and a short term analysis set.

2.1.5 The long term stored data include the half of each panchromatic and
colour image which is faced away from the sun in order to reduce sun glare disturbance and a reduced resolution panchromatic overview image. The reduced resolution image is calculated as the median value in a 3 by 3 pixels window.

2.1.6 The analysis set is a subpart of the long term stored dataset extracted by a mask. The analysis set focuses on areas not affected by vignetting, or better covered by images south of the current. The primary image acquisition has an overlap of 60 % between images.

2.1.7 The data flow in the image processing steps is illustrated in Figure 2 and 3.

Pre-Processing

2.1.8 The pre-processing phase includes:

- A reception control of images to ensure that data is readable and of acceptable quality
- Determination of exact footprint of each image (Figure 3A)
- Calculation of the storage mask covering the part of the image facing away from the sun, this is calculated on the basis of the time of image acquisition (Figure 3B)
- Calculation of the analysis mask based on the storage mask, a circle describing the part of the image not eligible to vignetting effects and cut-out of areas covered by neighboring images in the direction of the sun (Figure 3C)
- Extraction of sub-images based on storage and analysis mask respectively (Figure 3D)
- Generation of reduced resolution panchromatic overview image. The reduced resolution is calculated as the median value in a 3 by 3 pixels window (Figure 3E).

Post-Processing

2.1.9 The post-processing phase includes:

- Generation of "contact sheets" in a 2 metre by 2 metre window around centre of potential birds that are detected in the eCognition image analysis process
- The contacts sheets are evaluated by trained ornithologists and the final classification is linked back to the detected bird positions.

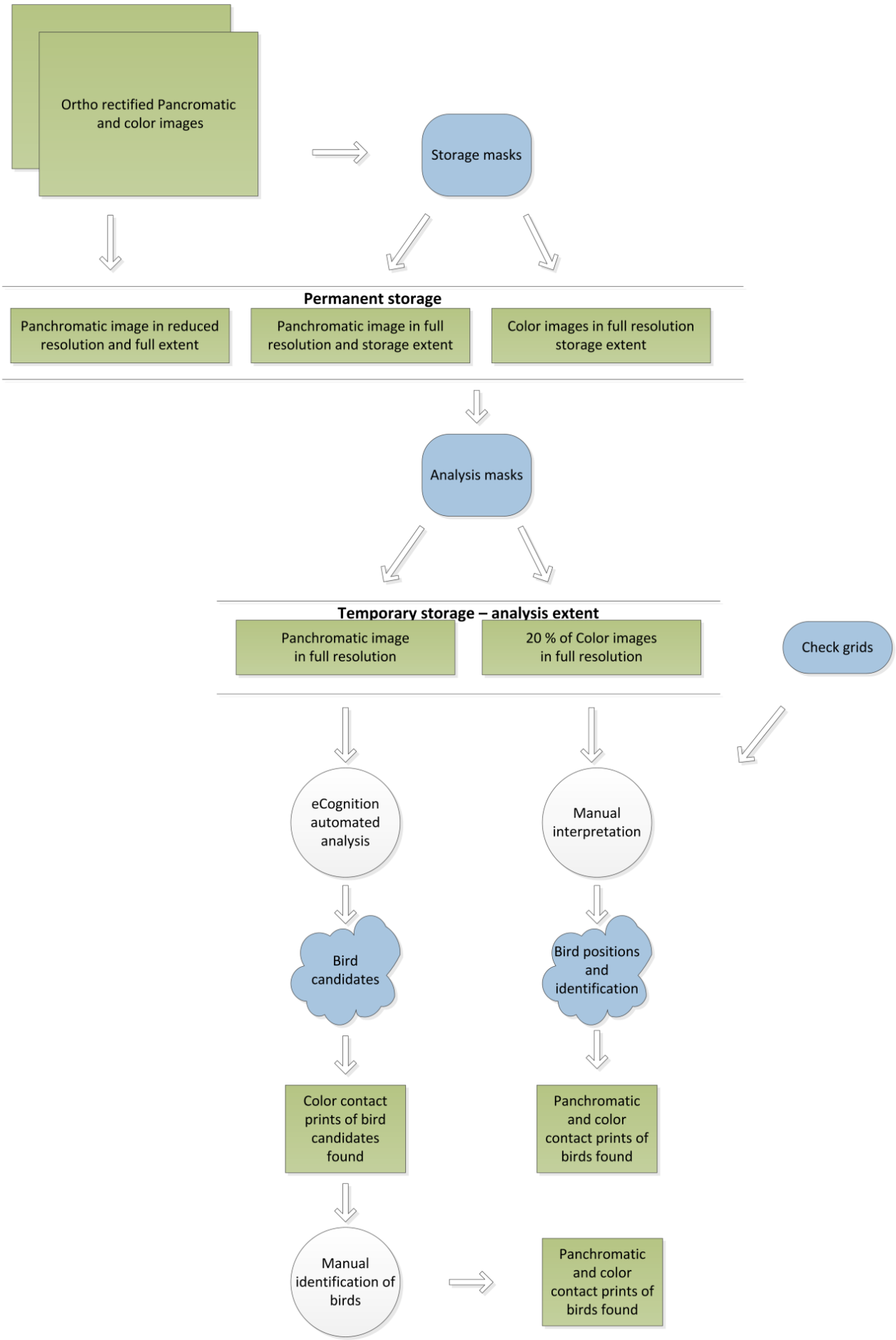

Figure 2. A sketch of the data flow analysing the image data from aerial image surveys of birds in the Burbo Bank Extension study area.

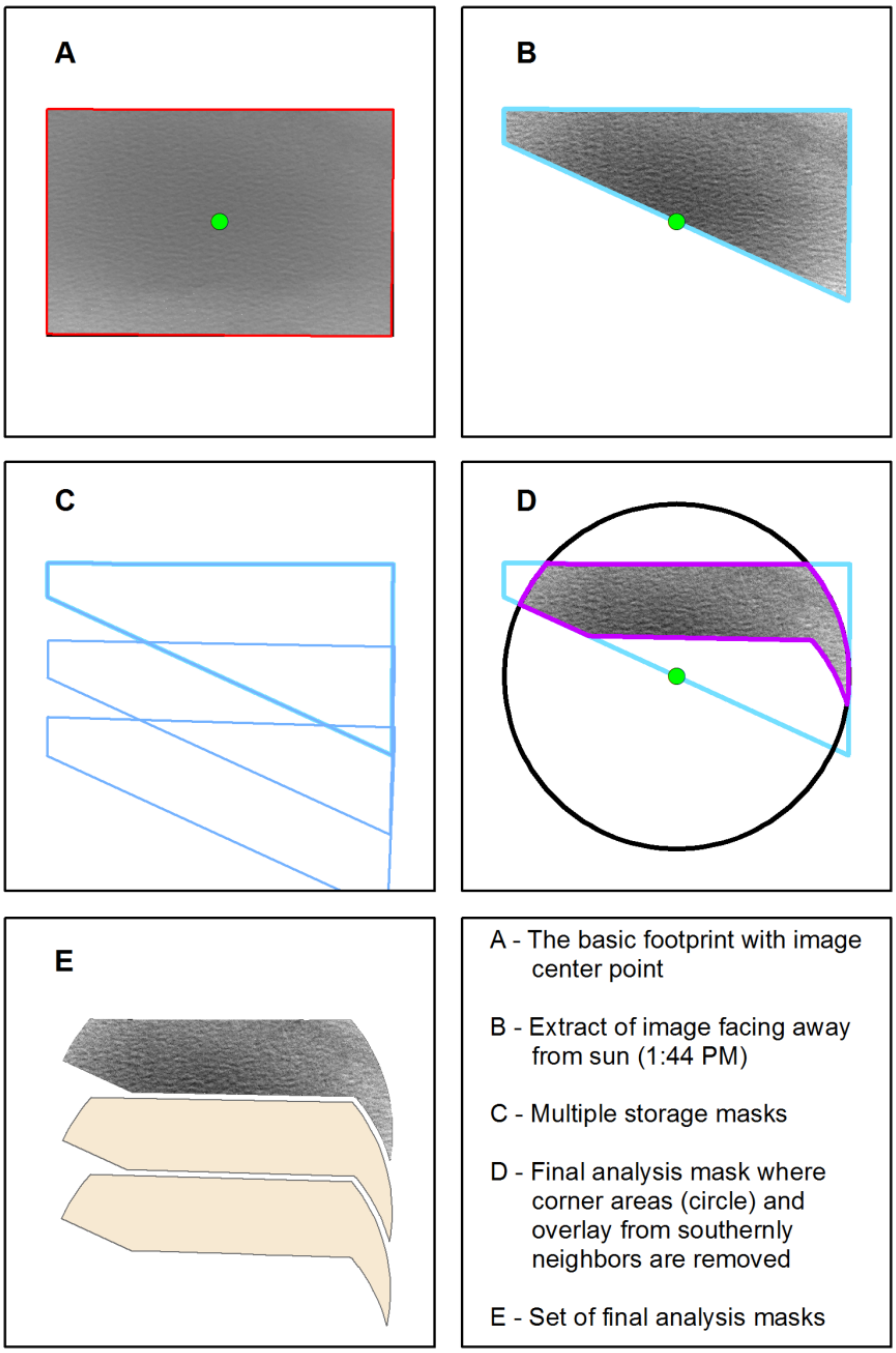

Figure 3. The GIS pre-processing steps of the image analysis, indicating the initial definition of the image area as a polygon and its centre point (A), the reduction of the image area, excluding parts highly exposed to sun glare (B), a set of overlapping long-term storage masks (C), identifying parts of the remaining image which is not affected by vignetting effects (circle) and not better covered by images south of the current image (D) and an illustration of the extension of an individual image part actually used for analysis and neighboring footprints of other images (E).

General overview of the Object Based Image Analysis (OBIA)

2.1.10 OBIA operates by a combination of (i) image data segmentation operations that define the shape of objects and (ii) image object filtering operations that enable labels to be given to object subsets (so called "classification"). An OBIA mapping process ("Rule Set") must begin with a segmentation operation to give an initial set of objects primitives to work with but then typically proceeds as a sequence of filtering and further segmentation operations in order to provide the required mapping result (Figure 4).

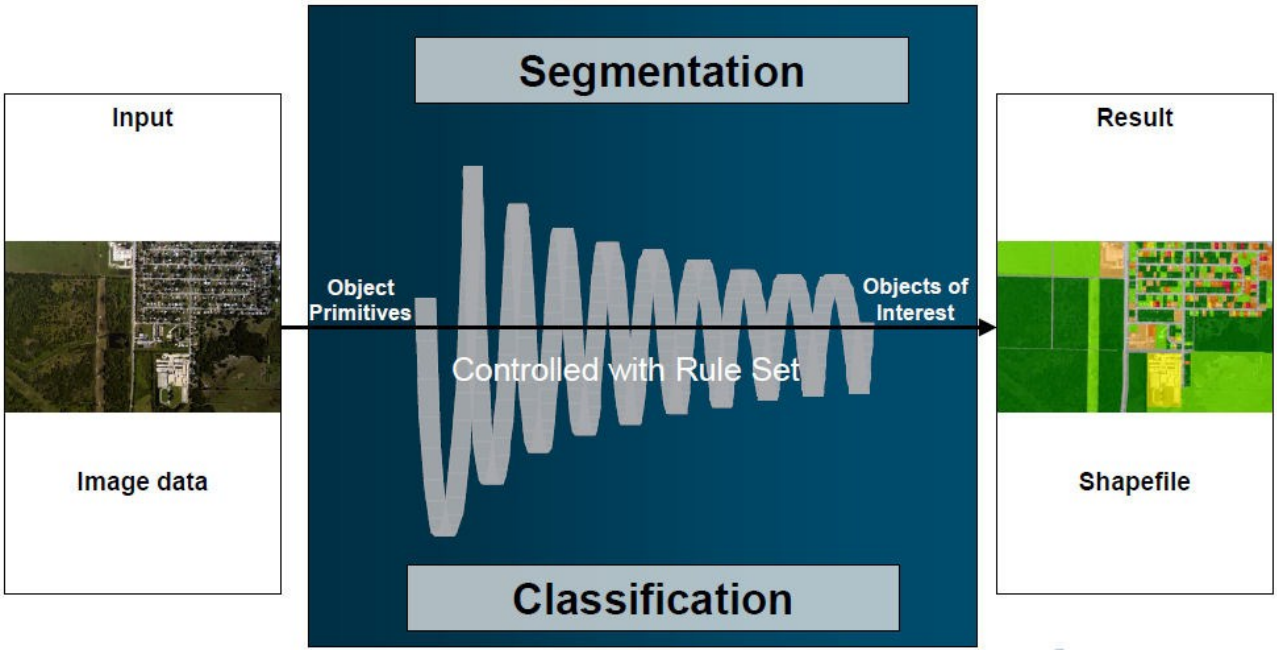

Figure 4. The essence of Object-based image analysis. (source: Trimble).

Development of Burbo Bank Extension OBIA bird survey algorithm

2.1.11 In the Burbo Bank Extension image scenes certain localised scene elements, other than the birds present, are also represented by relatively bright image data. These comprise collapsing wave crests ("white-caps"), disturbed water such as where larger waves have collapsed, residual sun glare (the major sun glare extent having been removed by the clipping) and artificial elements such as turbine towers, turbine blades and passing vessels. The OBIA processing has been configured to detect and delineate in its initial stages large artificial elements and larger areas of disturbed water. The other non-bird relatively bright elements present in these image data are characterised in many cases by particular patterns related to their brightness and size or shape, e.g. the residual sun glare typically occurs as bright spots far smaller than the light parts of the birds present. Thus, whilst it is possible to apply filters in the OBIA for some of the residual sun glare, it is accepted, in keeping with the design criterion, that the set of bird candidates mapped by the OBIA also includes cases of white-caps, sub-glint and similar non-bird elements. Such "false" objects are factored out at later stages of the process.

2.1.12 An additional image data pattern that is present in certain scenes is more contrasted areas of relatively lighter or darker image brightness over larger sections of a scene. These patterns, where present, are typically associated with cumulus type cloud conditions that result in some parts of the sea surface within a scene being sun illuminated and other parts being cloud shadowed. As the applied OBIA bird detection algorithm exploits properties of the image data brightness cumulative frequency histogram and it is important that the histograms are each based on relatively uniform parts of each scene. Therefore an initial stage of the OBIA processing detects and delineates regional variations in the image data brightness (Figure 5.A). Subsequent OBIA processing operates within each of these regions independently. Large bright ob-

jects, such as turbines and larger areas of disturbed water, are also mapped at this stage and where present are excluded from the subsequent processing stages (Figure 5.B, 5.C). If the scene is relatively homogeneous, the entire scene is passed to the next processing stage.

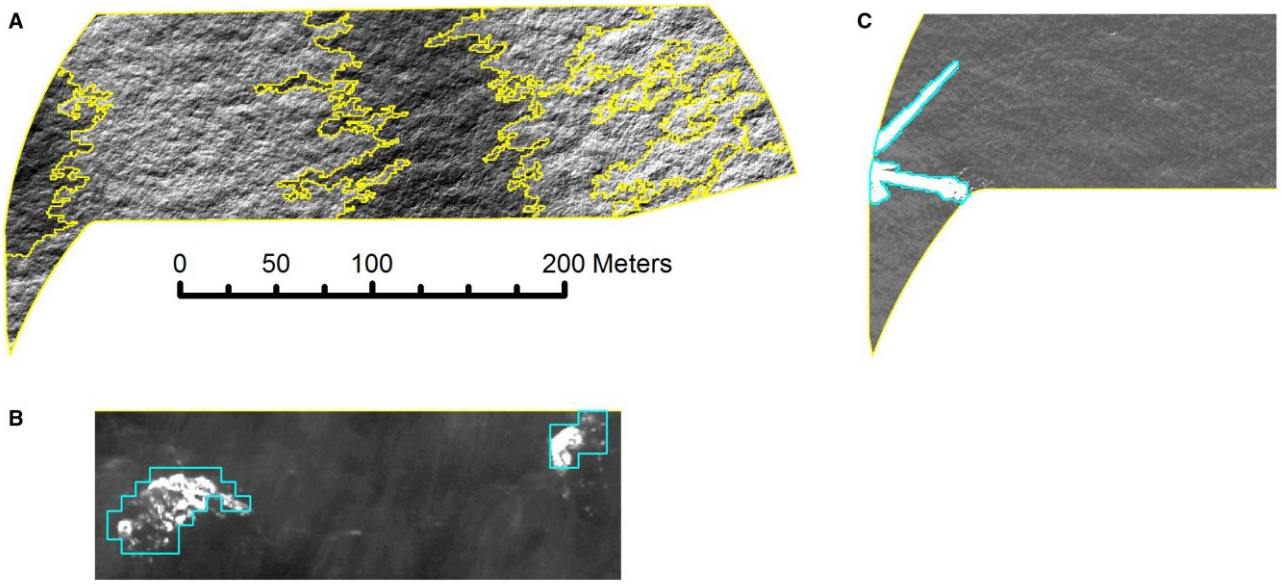

Figure 5. Pre-processing of each image data frame using OBIA methods to separate (A) parts of the frame with major illumination differences, (B) larger areas of disturbed water (the steps in the blue polygon borders represent 0.75 m) and (C) major large brighter items within the frame.

The core bird detection OBIA processing

2.1.13 The core OBIA processing stage for bird candidate detection is initialised by a per-pixel cumulative frequency histogram analysis of the image data. As it is more time-efficient to undertake this analysis on spatial units smaller than an entire frame or even any light/dark sub-sections within a frame, each frame is split into a set of no-overlapping sections or "tiles" with a nominal size of 50 x 50 m (Figure 6). In cases where the scene has been divided into relatively lighter or darker parts (as described above) these divisions are preserved within the tiling. Any fragments with an area less than 100 m^2 are joined to adjacent tiles with a similar relative brightness.

2.1.14 In each tile the core bird candidate detection algorithm initially locates image data that is relatively bright relative to the tile. These "hotspots" are then grown pixel-by-pixel, limited by the local pixel brightness gradient (Figure 7). This growing is not restricted by the extent of the tiles. Filters are then applied to each member of the set of grown hotspots to remove items that are relatively small (e.g. sun glare), and/or have relatively low contrast to their local context. The items that pass these filters comprise the set of bird candidates that are output as shape polygon GIS data for subsequent manual inspection via "contact print" representations of each item and its local ("stamp") 8 bit panchromatic and 24 bit RGB (red/green/blue) image data.

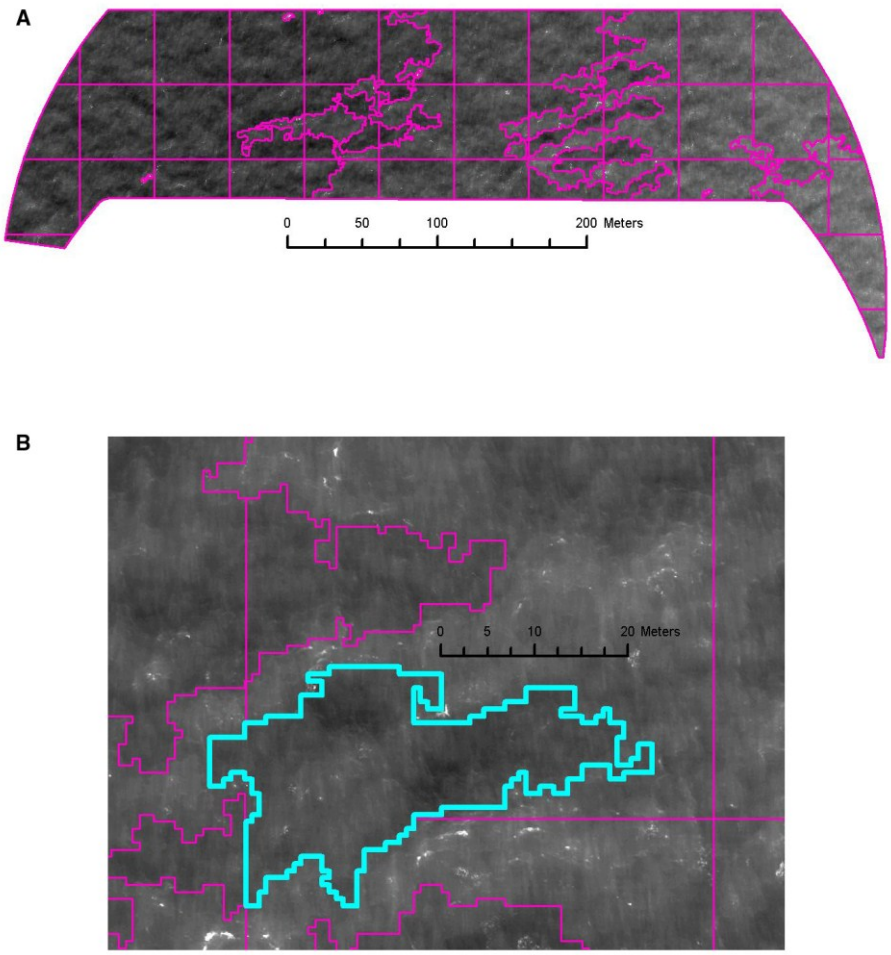

Figure 6. The frame tiling process. (A) tiling of an image frame superimposed on a separation of frame parts with illumination differences; (B) illustration of the result of integration of tiling units with illumination polygons avoiding production of small fragment tiles.

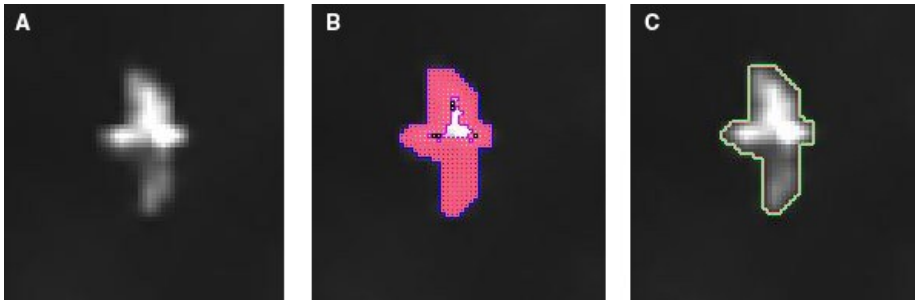

Figure 7. Demonstration of the bird candidate detection process for one individual bird. (A) representation of one flying gull in the image data; (B) identification of relatively bright pixels in the image data (pink) and one object of very bright pixels (white area within the pink); (C) filter based growth of the very bright part into the set of relatively bright pixels to delineate extent of bird candidate object – in this case all the relatively bright pixels pass the growth filter.

Result evaluations by trained Ornithologists

2.1.15 The automated eCognition procedure identified a number of potential bird candidates in the images. In all cases far more bird candidates were detected than the actual number of birds present in the images. In images with many white horses more than 10,000 bird candidates could be found. Each potential bird found by eCognition was represented by a geo-referenced polygon.

2.1.16 In order for the trained ornithologist to evaluate these bird candidates, a 2x2 metre image with the bird candidates in the centre was isolated in a new and re-placed image mosaic. The re-placed polygons representing the bird candidates followed the re-placed image bits. The trained ornithologist evaluated all bird candidates in this "Contact sheet". Species identification, age information, behaviour and flight direction was entered into the attribute table. With a link ID field the records confirmed to be birds and their associated information could be associated with the original bird candidate polygons. Isolating all records with a species or species group identification enabled the presentation of bird species distribution across the study area.

2.1.17 For all surveys 20% of the images were selected for a full human evaluation by a trained ornithologist. Every fifth image was selected, securing an even distribution of evaluated images across the study area. A RGB version of the images (colour images) was selected for this evaluation. In order to guide the ornithologist through the images a "Data Driven Pages" facility under ArcGIS was used. This utility creates view frames of a predefined size that the observer can click through the images at a fixed zoom of 1:220 in a systematic way. All birds detected in the images were digitized, and species name, age, behaviour and flight direction was recorded.

2.1.18 A comparison between the final results of the evaluation of the eCognition analyses and the results of the 20% of the images that was manually evaluated by a trained ornithologist could be performed. Only automatically detected birds from the 20% of the images that were also used for the manual evaluation by a trained

ornithologist were selected for this purpose. Initial evaluations showed a high degree of correspondence between the two sets of results. The output from the automated eCognition procedure was used to present bird numbers and distributions in the study area. The final results of a comparison will be thoroughly presented in a later publication.

3 Results

3.1.1 The six surveys conducted in the Burbo Bank Extension study area were carried out on 10th November 2010, 8th December 2010, 24th February 2011, 3rd March 2011, 18th March 2011 and 8th April 2011. All surveys, apart from the December 2010 survey, revealed a total of 788 images. In December 2010 a slightly different camera, the VescelUltracam D, was used, delivering images with a slightly smaller footprint, but a total of 904 images (Table 1).

Table 1. Dates, number of images and the area covered under each of six surveys of birds in the Burbo Bank Extension study area.

Date	No of images	Area covered (Km^2)
10-11-2010	788	48.91
08-12-2010	904	45.7
24-02-2011	788	45.28
03-03-2011	788	40.73
18-03-2011	788	46.08
08-04-2011	788	32.69

3.1.2 The survey weather and light conditions were generally good during the surveys. The surveys on 10th November 2010, 16th February 2011 and 24th February 2011 had varying degree of cloud cover, while the conditions was windy on 8th December 2010. The surveys flown 24th February and 3rd March had almost calm conditions, with no or very few whitecaps on the sea surface (Appendix 1).

3.1.3 The images were obtained along ten predefined survey transect lines. The length of the image track lines and for each survey had a total length of around 109 km per survey (Table 2).

Table 2. The length (in Km) of the individual transects and for each survey in the Burbo Bank Extension study area.

Transect No.	10th Nov 2010	8th Dec 2010	24th Feb 2011	3rd Mar 2011	18th Mar 2011	8th Apr 2011
1	6.1	6.4	6.2	6.4	6.0	6.0
2	8.9	9.3	9.2	9.2	9.1	9.1
3	11.3	11.1	11.4	11.5	11.4	11.4
4	12.6	12.6	12.8	12.7	12.7	12.7
5	12.8	12.8	12.9	12.8	12.8	12.8
6	12.8	12.9	12.9	12.8	12.9	12.9
7	12.8	12.9	12.8	12.9	12.8	12.8
8	12.6	12.5	12.5	12.6	12.6	12.6
9	11.2	11.0	11.3	11.3	11.3	11.3
10	6.9	7.0	7.0	6.8	6.8	6.8
Total	108.0	108.5	109.0	109.0	108.3	108.3

3.1.4 The image footprints for each of the six surveys covered from 33 to 48 km^2 of sea surface (Figure 8). The variation in coverage is primarily caused by the process of selecting parts of the images with least sun glare. This process causes images taken either early

in the day or late in the afternoon to cover a smaller sea surface area than images taken around noon (see Figure 3).

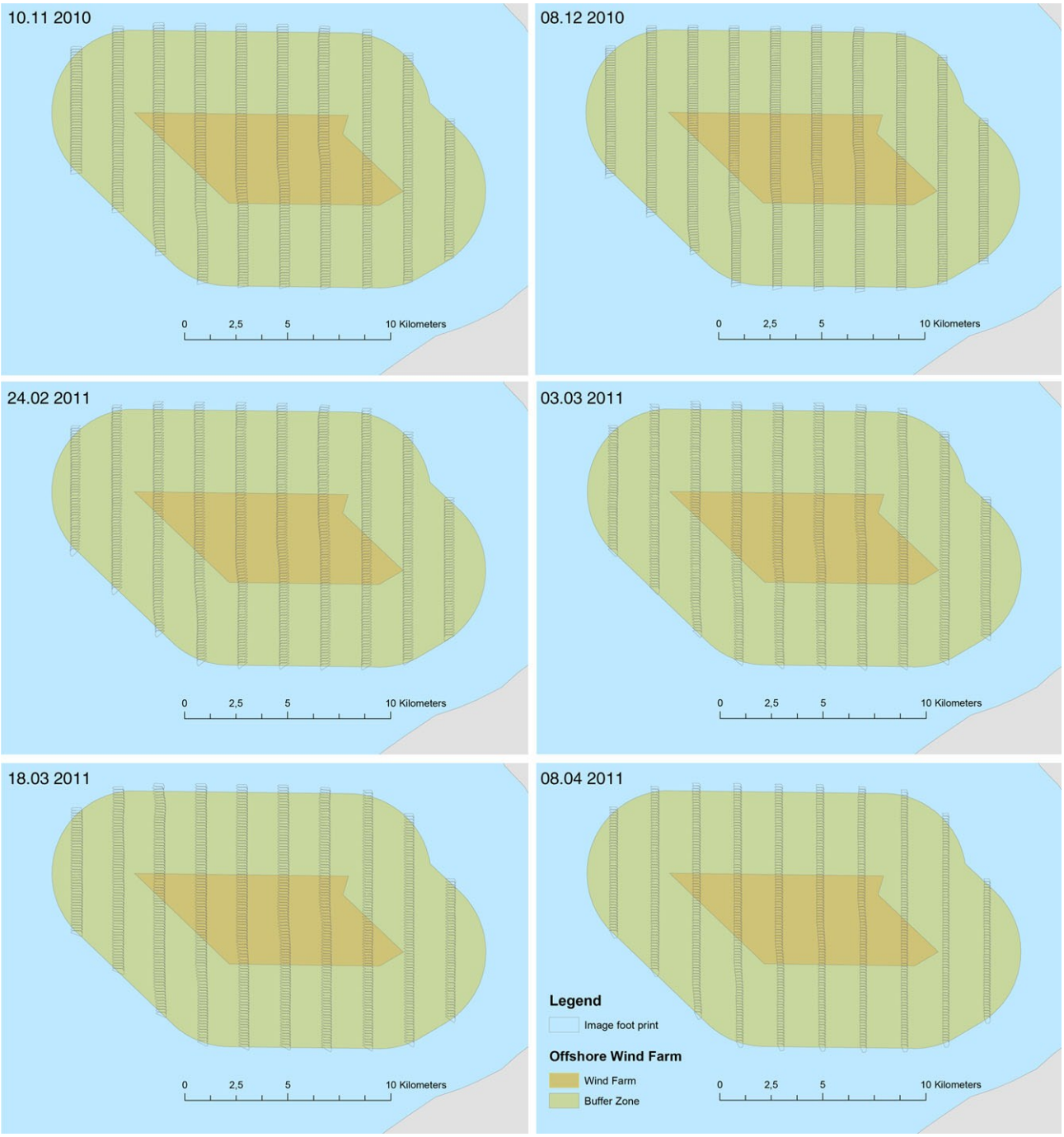

Figure 8. The aerial image footprints for each of six surveys performed in the Burbo Bank Extension study area from November 2010 until April 2011.

3.1.5 A total of 14 bird species and 6 bird species groups were identified in the images. Moreover three species of marine mammals were identified (Table 3). Gulls and Razorbills/Guillemots were the two species groups with the highest numbers of individuals in the survey area. This was true for all six surveys. Other species of birds frequently detected in the images were Red-throated Diver/Black-throated Diver, Cormorant, Shag and Puffin. Three spe-

cies of diving ducks were detected in the images, namely Scaup, Common Scoter and Red-breasted Merganser.

Table 3. The number of birds, marine mammals and sharks per species or species group, detected in the images for each of the surveys in the Burbo Bank Extension survey area from November 2010 until April 2011.

	Total	10th Nov 2010	8th Dec 2010	24th Feb 2011	3rd Mar 2011	18th Mar 2011	8th Apr 2011
Diver sp.	66	10	3	13	25	10	5
Gannet	8	4		3		1	
Cormorant	8		1		2	5	
Shag	1		1				
Cormorant/Shag	58	8	3	20	18	8	1
Scaup	33			33			
Common Scoter	43	6		32	5		
Red-breasted Merganser	2			2			
Common Gull	172	59	9	41	38	20	5
Herring Gull	219	78	1	41	69	16	14
Lesser Black-backed Gull	16	1		3	8	1	3
Great Black-backed Gull	45	21	2	17	4		1
Black-headed Gull	13	3		1	5	1	3
Little Gull	12	1				4	7
Kittiwake	44	5	1	20	3	6	9
Grey Gull sp.	437	78	51	196	44		68
Gull sp.	377		142	43	45	129	18
Tern sp.	23				5		18
Razorbill/Guillemot	1193	163	114	503	106	152	155
Puffin	145	34		106	2		3
Harbour Seal	3	1		1			1
Harbour Porpoise	18	3	4	3		3	5
Grey Seal	3	1				2	
Shark sp.	1					1	

3.1.6 Because the analyzed image parts were selected in such a way that impacts from sun glare and vignetting were reduced we can measure bird densities as the number of detected birds divided by the area of sea surface surveyed. For each of the bird species and bird species groups the overall density was calculated. With a study area of 210.5 km^2 we also estimated the total abundance of each species and species group (Table 4).

Table 4. The calculated densities (D, given as N/km^2) and the estimated abundance within the entire Burbo Bank Extension study area (N) of birds, marine mammals and sharks per species or species group and for each of the six surveys from November 2010 until April 2011.

	10th Nov 2010		8th Dec 2010		24th Feb 2011		3rd Mar 2011		18th Mar 2011		8th Apr 2011	
	D	N	D	N	D	N	D	N	D	N	D	N
Diversp.	0.20	43	0.07	14	0.29	60	0.61	129	0.22	46	0.15	32
Gannet	0.08	17	0.00	0	0.07	14	0.00	0	0.02	5	0.00	0
Cormorant	0.00	0	0.02	5	0.00	0	0.05	10	0.11	23	0.00	0
Shag	0.00	0	0.02	5	0.00	0	0.00	0	0.00	0	0.00	0
Cormorant/Shag	0.16	34	0.07	14	0.44	93	0.44	93	0.17	37	0.03	6
Scaup	0.00	0	0.00	0	0.73	153	0.00	0	0.00	0	0.00	0
Common Scoter	0.12	26	0.00	0	0.71	149	0.12	26	0.00	0	0.00	0
Red-breasted Merganser	0.00	0	0.00	0	0.04	9	0.00	0	0.00	0	0.00	0
Common Gull	1.21	254	0.20	41	0.91	191	0.93	196	0.43	91	0.15	32
Herring Gull	1.59	336	0.02	5	0.91	191	1.69	357	0.35	73	0.43	90
Lesser Black-backed Gull	0.02	4	0.00	0	0.07	14	0.20	41	0.02	5	0.09	19
Great Black-backed Gull	0.43	90	0.04	9	0.38	79	0.10	21	0.00	0	0.03	6
Black-headed Gull	0.06	13	0.00	0	0.02	5	0.12	26	0.02	5	0.09	19
Little Gull	0.02	4	0.00	0	0.00	0	0.00	0	0.09	18	0.21	45
Kittiwake	0.10	22	0.02	5	0.44	93	0.07	16	0.13	27	0.28	58
Grey Gull sp.	1.59	336	1.12	235	4.33	911	1.08	227	0.00	0	2.08	438
Gull sp.	0.00	0	3.11	654	0.95	200	1.10	233	2.63	589	0.55	116
Tern sp.	0.00	0	0.00	0	0.00	0	0.12	26	0.00	0	0.55	116
Razorbill/Guillemot	3.33	702	2.49	525	11.11	2338	2.60	548	1.91	694	4.74	998
Puffin	0.70	146	0.00	0	2.34	493	0.05	10	0.00	0	0.09	19
Harbour Seal	0.02	4	0.00	0	0.02	5	0.00	0	0.00	0	0.03	6
Harbour Porpoise	0.06	13	0.09	18	0.07	14	0.00	0	0.07	14	0.15	32
Grey Seal	0.02	4	0.00	0	0.00	0	0.00	0	0.04	9	0.00	0
Shark sp.	0.00	0	0.00	0	0.00	0	0.00	0	0.02	5	0.00	0

3.2 Red-throated Diver/Black-throated Diver *Gavia stellate/arctica*

3.2.1 A total of 66 divers were detected in the images from all of the combined surveys. The birds could not be securely identified to species, and are therefore pooled. The vast majority of the birds are expected to be Red-throated Diver. Divers were found in all surveys. The highest number of birds detected was on 3rd March when 26 divers were located (Table 3). On 8th April only five divers were detected, which was the lowest number found.

3.2.2 Divers were primarily found in the southern, southeastern and central parts of the study area, with few observations from the western and northern parts of the area (Figure 9). This pattern was consistent between surveys.

3.2.3 The calculated densities reached from 0.07 to 0.61 birds/km^2 on 8th December 2010 and 3rd March 2011 respectively, which led to estimated total numbers of 14 to 129 individuals within the study area (Table 4).

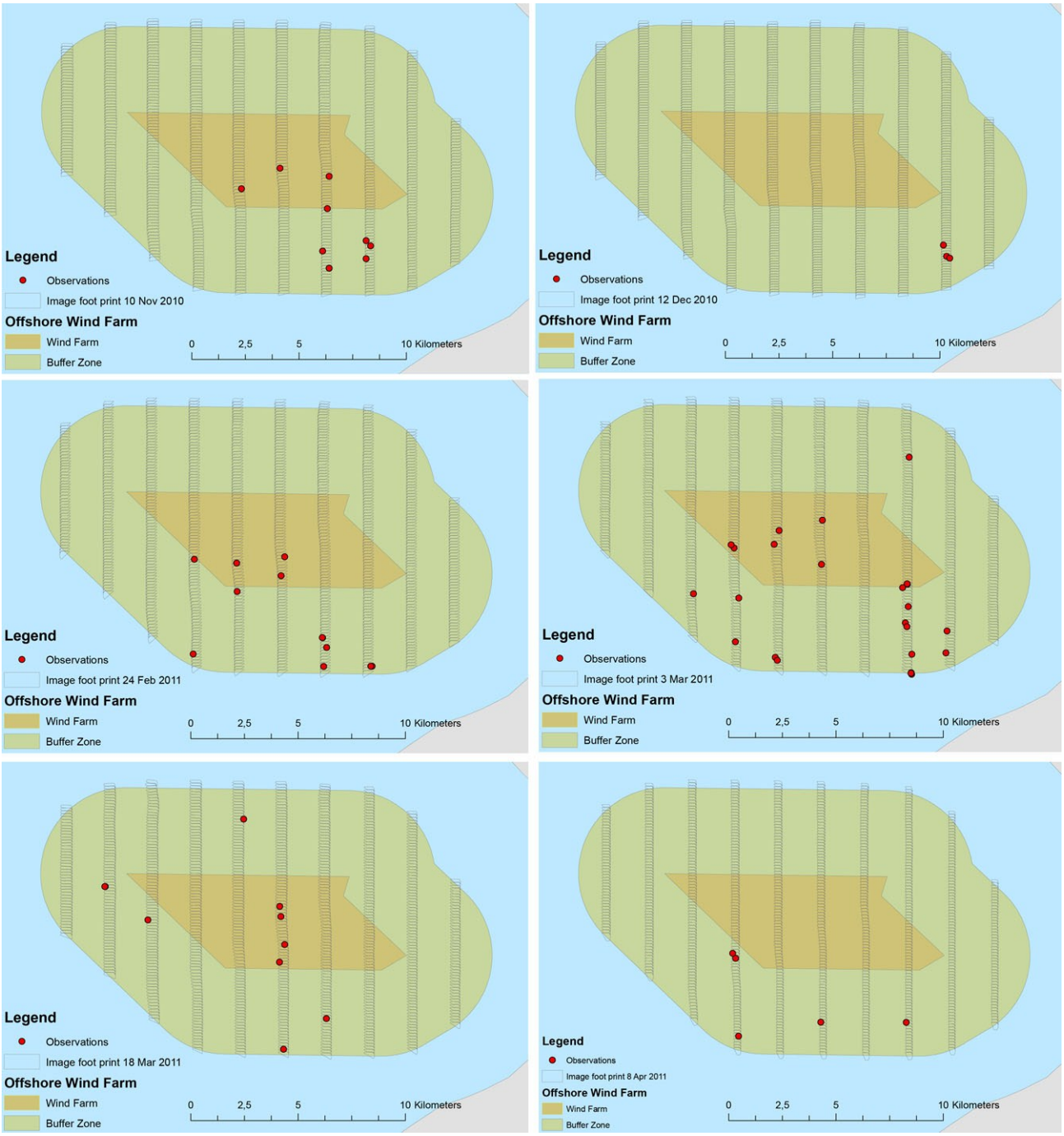

Figure 9. The distribution of Red-throated/Black-throated Diver in the Burbo Bank Extension study area during each of six surveys performed from November 2010 until April 2011.

3.3 Gannet *Morus bassanus*

3.3.1 A total of 8 Gannets were recorded during three of the six surveys, 4 on 10th November 2010, 3 on 24th February 2011 and 1 on 18th March 2011 (Table 3).

3.3.2 The few Gannets were recorded in the central and northern parts of the study area (Figure 10). Surveys in which Gannets were absent are not illustrated.

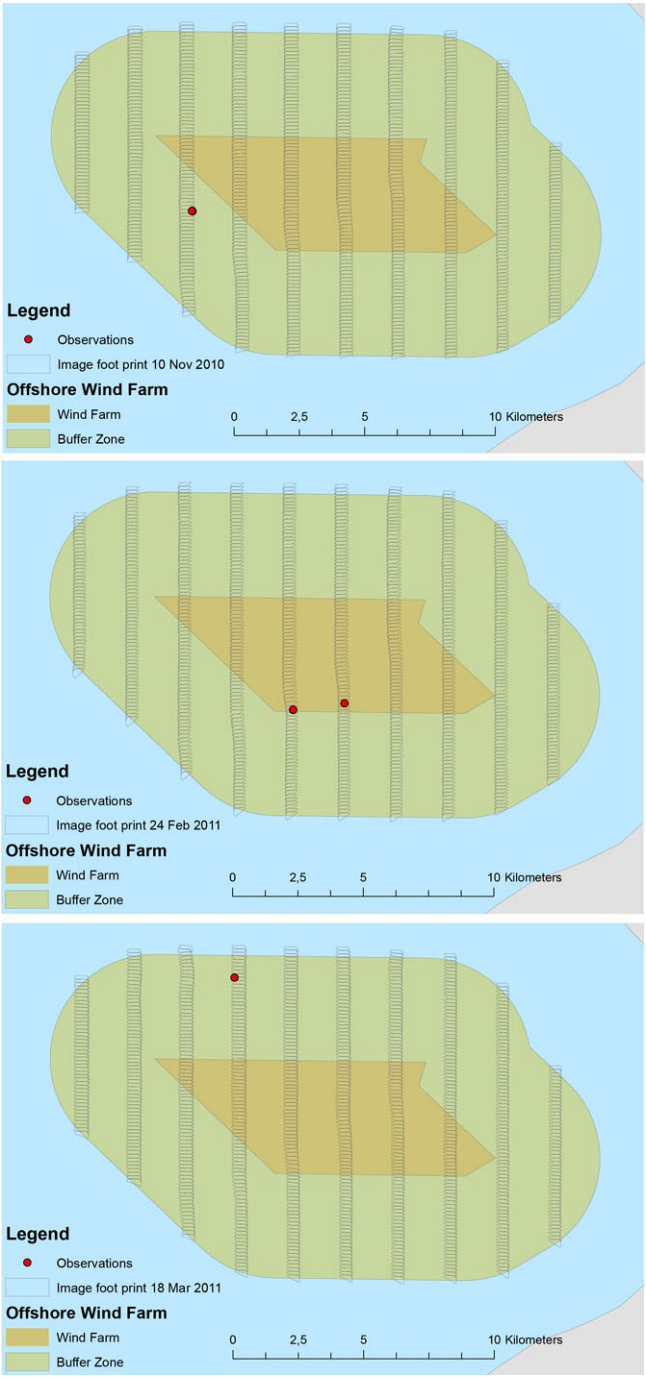

Figure 10. The distribution of Gannets in the Burbo Bank Extension study area on 10th November 2010, 24th February 2011 and 18th March 2011.

3.3.3 The calculated densities reached from 0.02 to 0.07 birds/km^2 on 18th March 2011 and 10th November 2010 respectively, which led to estimated total numbers of 5 to 17 individuals within the study area (Table 4).

3.4 Cormorant/Shag *Phalacrocoraxcarbo/aristotelis*

3.4.1 A total of 67 Cormorants/Shags were recorded during six surveys. Of these 8 were identified as Cormorants and 1 as Shag. The remaining birds were not identified to species level (Table 3).

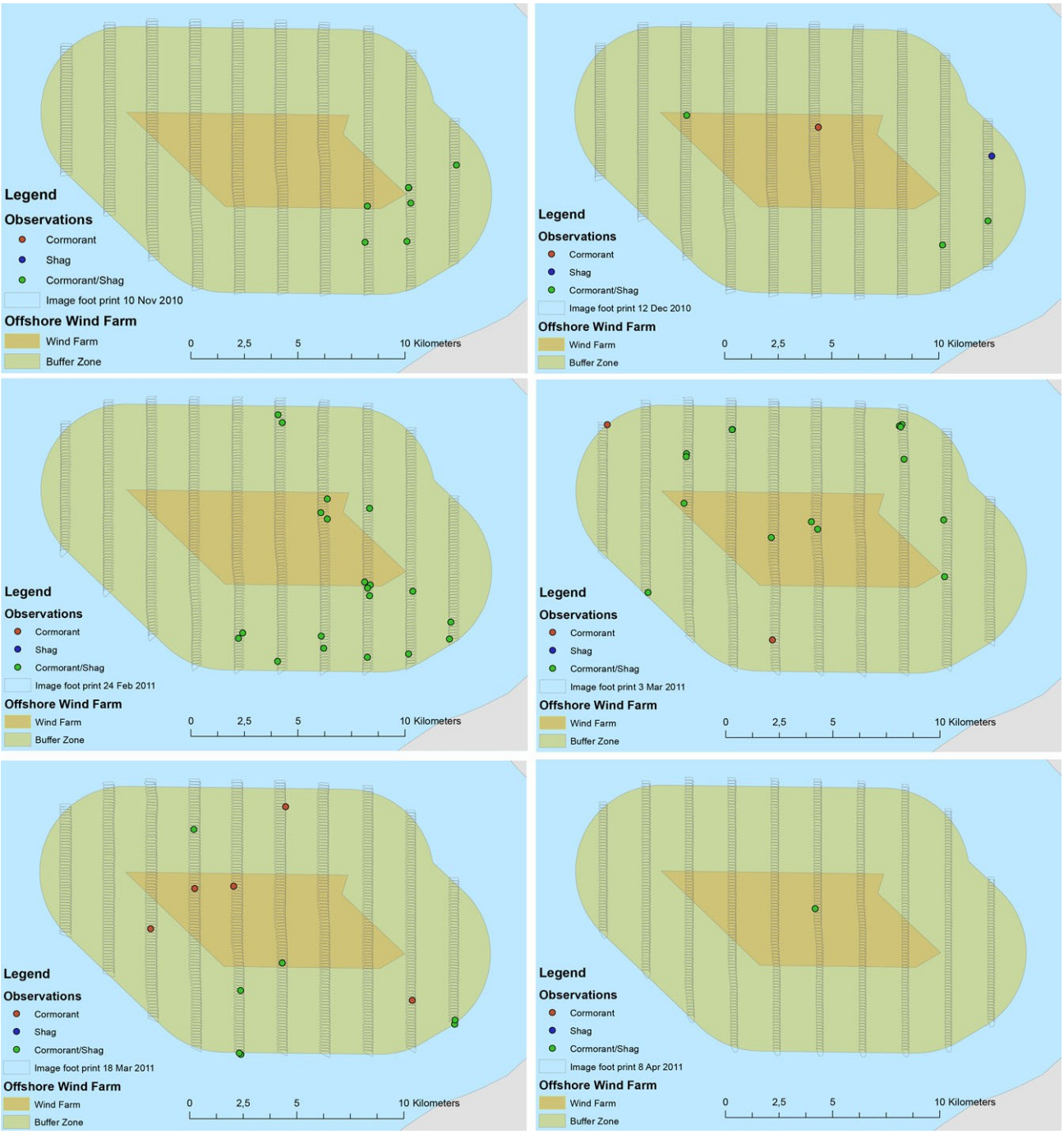

Figure 11. The distribution of Cormorants/Shags in the Burbo Bank Extension study area during each of the six surveys performed from November 2010 until April 2011.

3.4.2 The calculated densities reached from 0.03 to 0.44 birds/km² on 8thApril 2011 and 24thApril 2011 respectively, which led to estimated total numbers of 6 to 93 individuals within the study area (Table 4).

3.5 Scaup *Aythya marila*

3.5.1 Scaups were only recorded during the survey performed on 24th February 2011. A group of 33 individuals were detected in one flock in the southeastern part of the study area (Table 3, Figure 12).

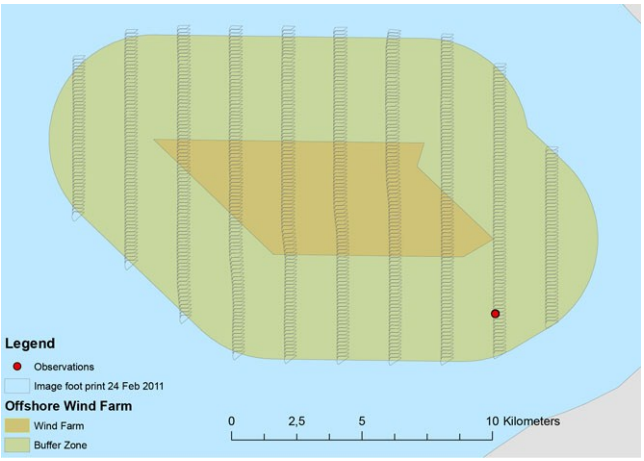

Figure 12. The distribution of 33 Scaup in the Burbo Bank Extension study area on 24th February 2011.

3.5.2 The recordings led to a calculated density of 0.73 birds/km², and a total abundance estimate of 153 for the entire study area (Table 4).

3.6 Common Scoter *Melanittanigra*

3.6.1 A total of 43 Common Scoters were recorded during three of six surveys in the study area, 6 on 10th November 2010, 32 on 24th February 2011 and 5 on 3rd March 2011 (Table 3).

3.6.2 The Common Scoters were primarily recorded in the southeastern parts of the study area, with few recordings also from the central parts of the area (Figure 13).

3.6.3 The calculated densities reached from 0.26 on 10th November 2010 and 3rd March 2011 to 0.71 birds/km² on 8th April 2011 and 24th April 2011, which led to estimated total numbers of 26 to 149 individuals within the study area (Table 4).

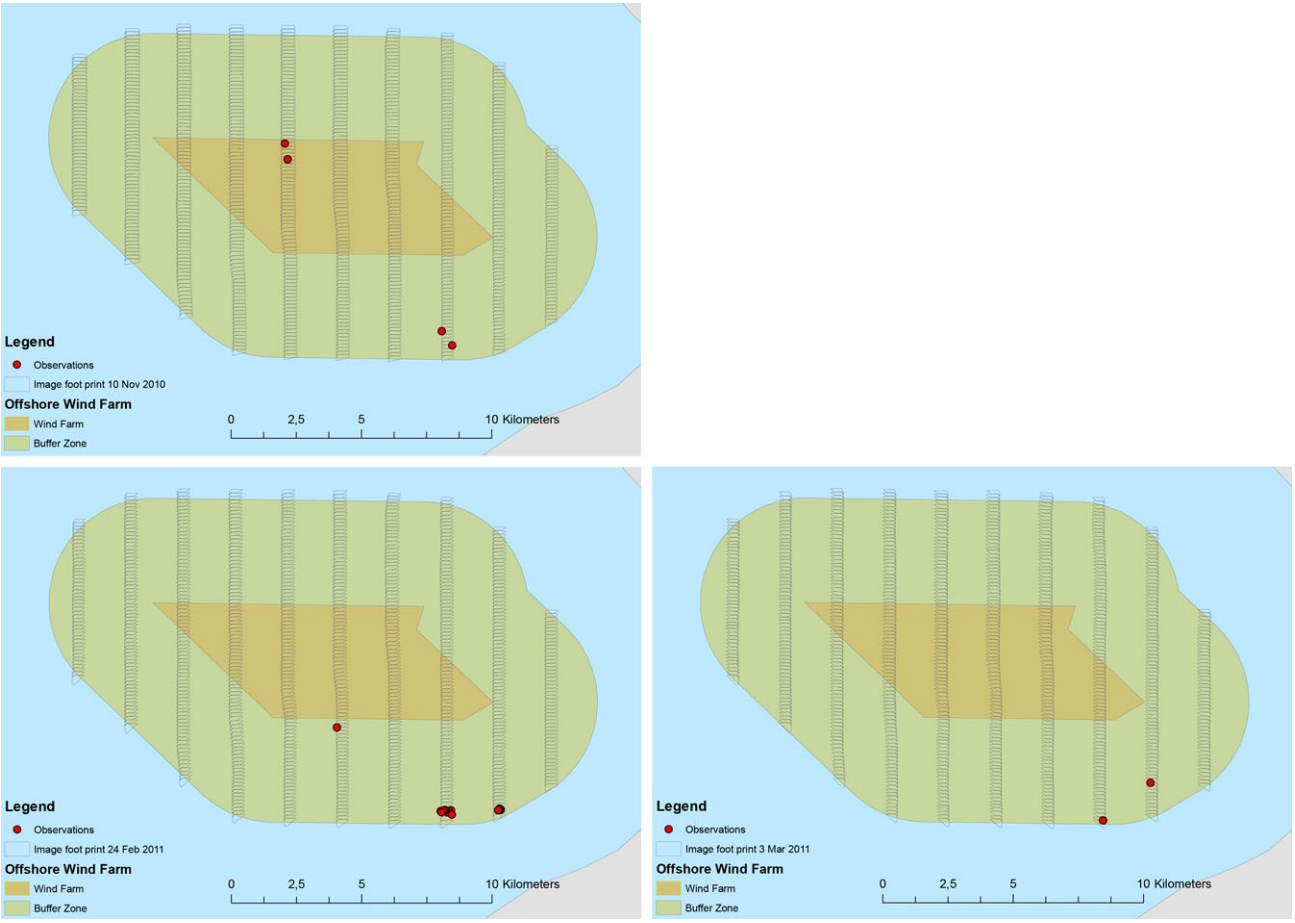

Figure 13. The distribution of 43 Common Scoters during three surveys in the Burbo Bank Extension study area on 10th November 2010, 24th February 2011 and 3rd March 2011.

3.7 Gulls *Laridae*

3.7.1 A total of 1,335 gulls was recorded during the six surveys in the study area between November 2010 and April 2011. The most abundant species were Common Gull (172) and Herring Gull (219), even though the group of unidentified gulls was bigger. Kittiwake (44) and Great Black-backed Gull (45) were also relatively numerous in the area, while few Lesser-Black-backed Gulls were recorded (Table 3).

3.7.2 The gulls were recorded across the study area, though higher concentrations were seen in the southeastern parts of the study area (Figure 14).

3.7.3 The calculated overall gull densities reached from 3.84 on 18th March 2011 to 7.99 birds/km^2 on 24th February 2011, which led to estimated total numbers of 809 to 1,683 individuals within the study area (Table 4).

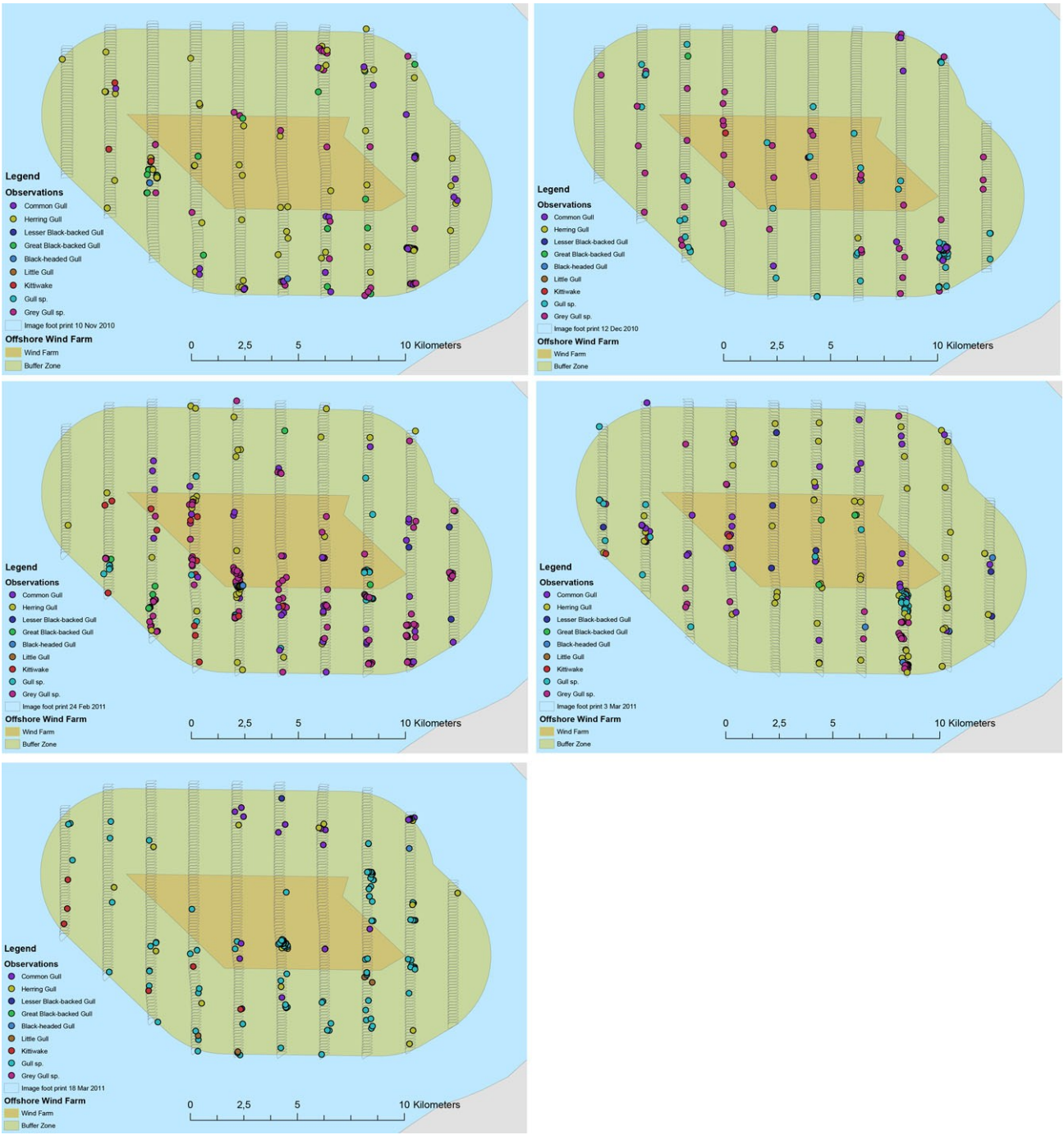

Figure 14. The distribution of gulls during five surveys in Burbo Bank Extension study area between November 2010 and April 2011.

3.8 Razorbill/Guillemot *Alcatorda/Uriaaalge*

3.8.1 A total of 1,193 Razorbills/Guillemots were recorded in the images from the six surveys (Table 3). None of these were identified to species, though parts of the detected birds had indications of being Razorbill or Guillemot. Because these identifications are not certain we have chosen to present all observations of Razorbills/Guillemots in common.

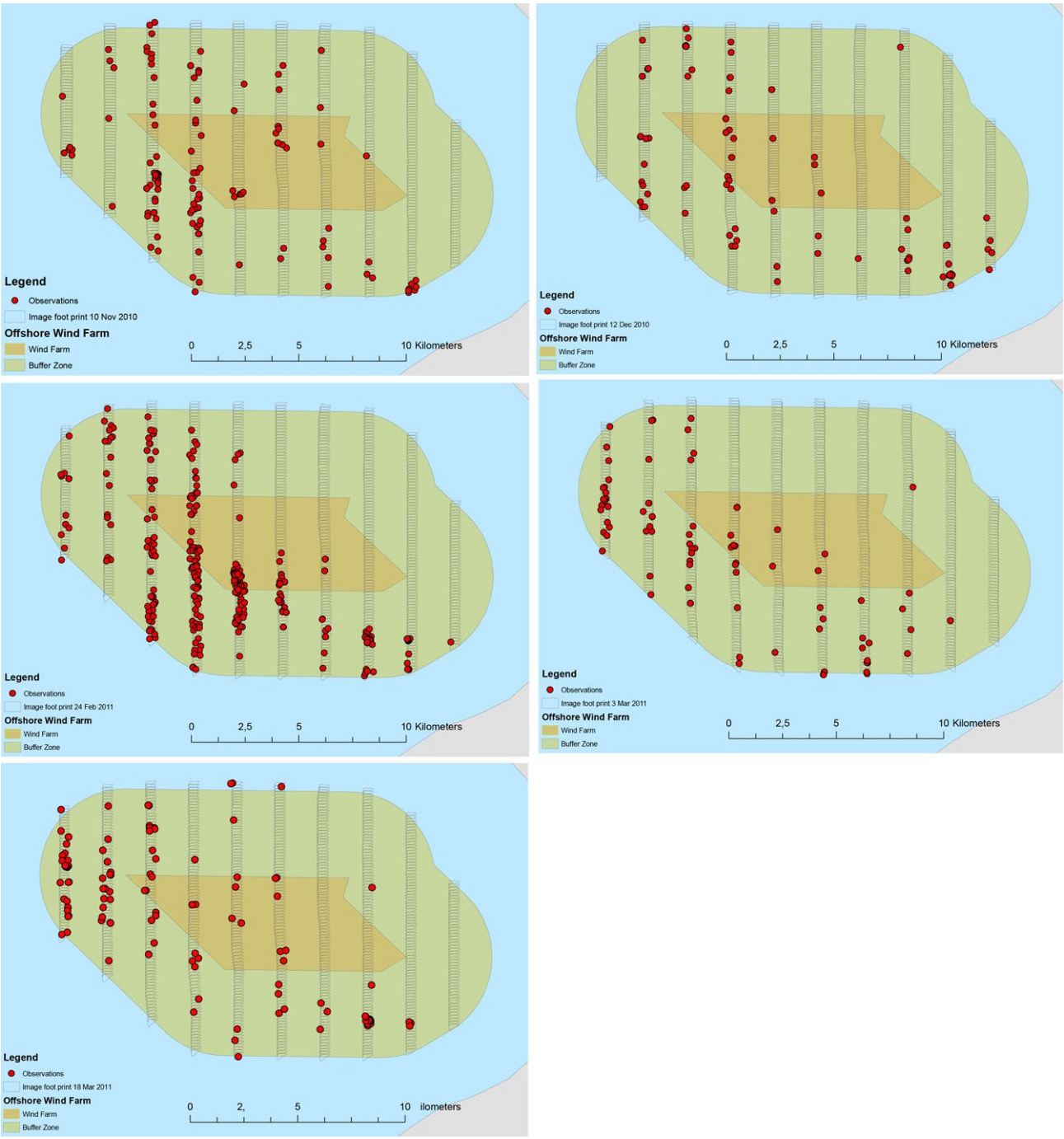

Figure 15. The distribution of 1,193 Razorbills/Guillemots recorded during six surveys in the Burbo Bank Extension study area between November 2010 and April 2011.

3.8.2 The distribution pattern for Razorbill/Guillemot was relatively consistent between surveys, with the vast majority of the birds being found in the western, southwestern and southern parts, while

in the northeast and in the east hardly any Razorbills/Guillemots were detected (Figure 15).

3.8.3 The calculated densities reached from 1.91 on 18th March 2011 to 11.11 birds/km² on 24th February 2011, which led to estimated total numbers of 694 to 2,338 individuals within the study area (Table 4).

3.9 Puffin *Fraterculaarctica*

3.9.1 A total of 145 Puffins were recorded in the images from four of the six surveys, 34 on 10th November 2010, 106 on 24th February 2011, 2 on 3rd March 2011 and 3 on 8th April 2011 (Table 3).

3.9.2 The distribution pattern of the Puffins was similar to that of Razorbill/Guillemot, with the vast majority of the birds being found in the western, southwestern and central parts of the study area, while in the northeast and in the east no Puffins were detected (Figure 16).

3.9.3 The calculated densities reached from 0.05 on 3rd March 2011 to 2.34 birds/km² on 24th February 2011, which led to estimated total numbers of 10 to 493 individuals within the study area (Table 4).

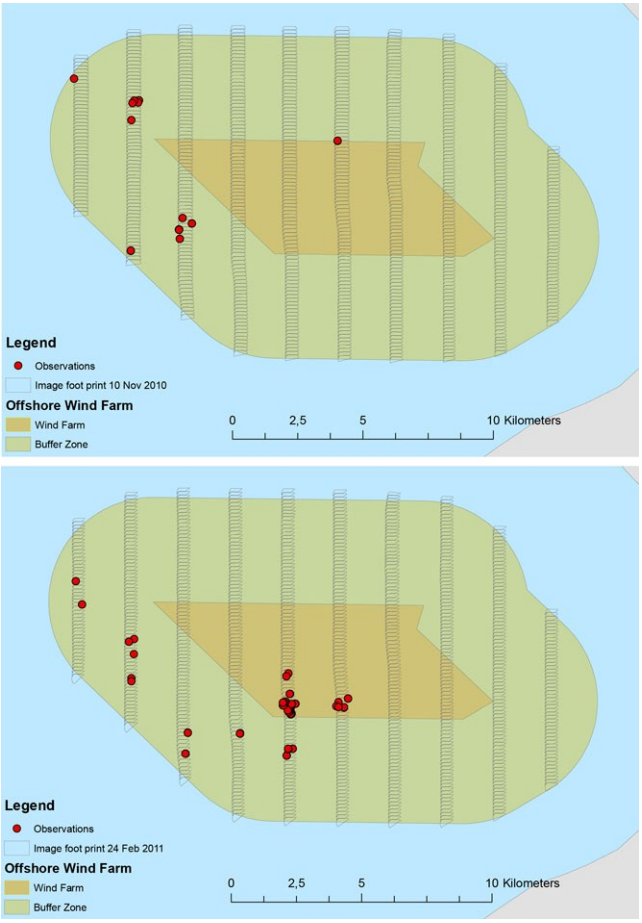

Figure 16. The distribution of 140Puffins recorded during two surveys in the Burbo Bank Extension study area on 10th November 2010 and 24th February 2011.

3.10 Marine Mammals

3.10.1 A total of 18 Harbour Porpoises, 3 Harbour Seals and 3 Grey Seals were detected in the images (Table 3).

3.10.2 Harbour Porpoises and seals were recorded across the entire study area, with no obvious distribution pattern (Figure 17).

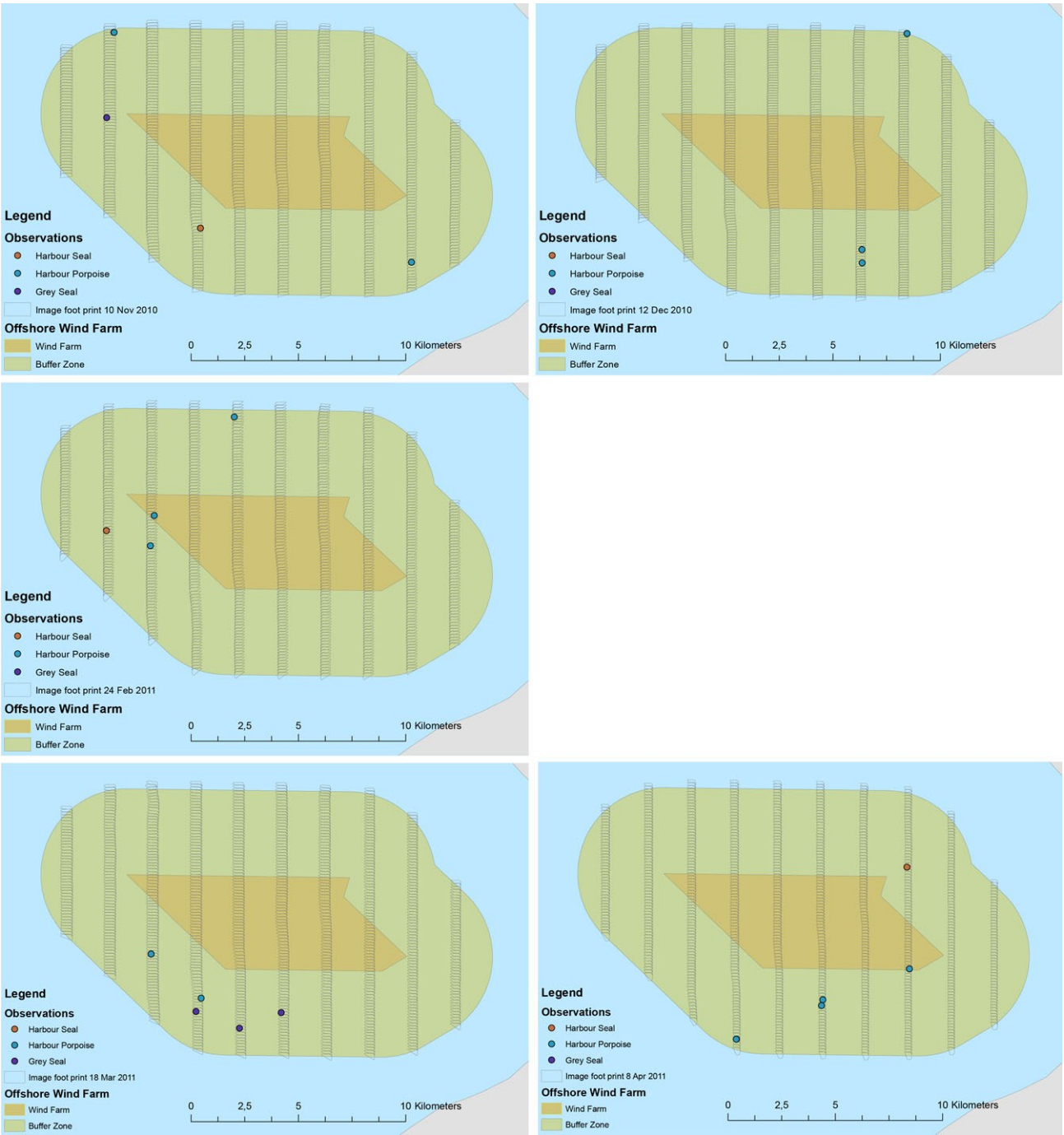

Figure 17. The distribution of 18 Harbour Porpoises, 3 Harbour Seals and 3 Grey Seals recorded during five surveys in the Burbo Bank Extension study area between November 2010 and April 2011.

3.10.3 Most Harbour Porpoises were detected in the data from 8th April 2011, where 5 animals were recorded. This led to an estimated density of 0.15 animals/km^2, and a total estimate of 32 animals across the entire study site (Table 4).

4 Discussion and conclusion

4.1.1 The data presented in this report is a compilation of birds and marine mammals recorded in digital orthophotos of the Burbo Bank Extension study area in Liverpool Bay, obtained in the period from November 2010 until April 2011.

4.2 The ability to detect and identify birds from the images

4.2.1 The six surveys presented here were analysed using the eCognition algorithms to automatically detect bird candidates in the images. This process led to a huge overmapping of birds because the eCognition algorithm catch many non-bird items, such as for instance white horses, sun glare or litter. All candidates are manually examined and birds are identified by an experienced ornithologist. Detected birds and marine mammals are selected and presented on the GIS platform. In the Appendices of this report each bird detected within these six surveys are presented in tiny 2x2 m image frames (contact sheets). Additionally an evenly distributed 20% of the images are searched by an experienced ornithologist in an attempt to reduce bias and to maintain quality control procedures. Comparisons of the results from the automated output and the manually evaluated 20% of the images showed excellent correspondence between the two results. A more formal QA result will be presented in a later publication.

4.2.2 A number of bird species are very similar in appearance, and thus very difficult to identify to species level in the images. This is true for Red-throated Diver and Black-throated Diver, for Razorbill and Guillemot, for most grey gulls sitting on the sea surface and for Cormorants and Shags. These species groups are similarly or even more difficult to separate to species level from aerial surveys using human observers in comparison to the high resolution method used in this study.

4.2.3 We found that most Puffins could be identified from Razorbills/Guillemots. From images obtained under good survey conditions we could tentatively separate Razorbills from Guillemots, though this was only the case in less than 10% of the cases. A combination of simultaneous ship-based surveys and image surveys could form a way to evaluate this field further.

4.2.4 Experience from surveys with combined simultaneous aerial surveys with human observers and image surveys showed that the proportion of flying gulls identified to species was higher from image data than from the human based surveys.

4.3 Eliminating areas of unfavorable light conditions by selecting from image overlaps

4.3.1 The images have an overlap of 60% along the axis of the flight direction. By selecting the optimal parts of overlapping images, and by cutting areas of sun glare and corners affected by vignetting

we extracted image parts in which we can safely assume that we find all birds present. Knowing the exact area covered by each of the image extractions we can calculate bird density directly. This has the advantage from aerial survey data from human observers that densities are derived from fitting a detection function. This estimate is associated with a varying confidence interval. With the data presented here densities can be calculated directly, and abundance estimates can be derived from the entire study area by simple multiplication. With access to bathymetric data and other environmental covariates a surface covering density estimation for the study area could be established at a fine geographical resolution. Since we at this stage have no access to such data we calculate average densities for the entire study area, but not at a high geographical resolution.

4.4 Bird densities, abundances and distributions

4.4.1 The most prominent groups of bird species were gulls and Razorbills/Guillemots.With densities of up to 11.11 birds/km^2 we estimated a total abundance of more than 2,300 Razorbills/Guillemots in the study area. Likewise, we calculated densities of up to 7.99 gulls/km^2, leading to a total abundance estimate of more than 1,600 birds in the study area.

DONG Energy

January 2013

Burbo Bank Extension Offshore Wind Farm

Technical Annex 4: Collision Risk Modelling

NIRAS Consulting Ltd
Sheraton House, Castle Hill
Cambridge CB3 0AX, UK

Reg. No.: 07470870
England & Wales
www.niras.com/uk

T: +44 (0)1223 370181
F: +44 (0)1223 370040
@: iel@niras.com

NIRAS Project Number	N0034
Document Title	Annex 4 - Collision risk modelling
Status	Final
Client	DONG Energy
Client Project No (if applicable)	
Client Contact Name	Jennnifer Brack

Document Control

The following personnel are designated contacts for queries relating to this document:

Name	**Job Title**	**Telephone**	**Email**
Rachel Barker	Environmental Consultant	01223 370181	reb@niras.com
Matthew Hazleton	Environmental Consultant	01223 370181	haz@niras.com

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1. Introduction

1.1.1 This technical annex provides a worked example of the Collision Risk Modelling (CRM) undertaken to inform the Environmental Impact Assessment (EIA) for the proposed Burbo Bank Extension Offshore Wind Farm (the 'Project'). Where appropriate, the example follows the format presented in Band (2012), produced for the Strategic Ornithological Support Services (SOSS). This is a demonstration of the CRM process followed, therefore, the method and input data discussed below is for a non-contentious species – gannet.

1.1.2 The annex also presents analysis of migratory waterfowl species by virtue of the SOSS Migration Assessment Tool with the resultant flyway estimates also subject to collision risk modelling.

2. Collision risk modeling worked example for gannet

2.1. Stage A - flight activity

Bird density

2.1.1 Due to the nature of the baseline data collection for the Project, a novel method of calculating densities was required. It was agreed with Statutory Nature Conservation Bodies (SNCBs) that one year of site-specific survey data were required, due to there being a large amount of ornithological data available for the region, which had been collected over a number of years. The methodology for the modelling was presented to and agreed with Natural England and Countryside Council for Wales in August 2012.

2.1.2 Mean monthly densities from this array of surveys were collated for each species. Mean counts were used to derive the densities, as a few one off peaks for some species (e.g. common scoter and Manx shearwater) skewed the data, making the collision risk modelling results higher than would be expected and therefore not realistic. The peak mean density from all the surveys undertaken for a particular month, was then ascertained and used as the 'seasonal density'. This seasonal density was then applied as a monthly density e.g. if peak mean density during the pre-breeding season (March to April) was 0.5, density for March was 0.5 and density for April 0.5. These monthly densities were then applied to the Band (2012) model. Table 1, provides details of the various surveys carried out in the region, which were reviewed to calculate seasonal densities for the purposed of CRM for the Project.

Table 1: Data sources for monthly density measures for CRM, shading indicates seasons

Month	Boat-based survey of the Project (including some surveys of the operational wind farm)			Aerial surveys of the Project	DBERR surveys			
	2005	2006	2011	2010-11	2004/5	2005/6	2007	2008
Mar				**	*	*	*	
Apr			*	*				
May	*		*		*			

Month	Boat-based survey of the Project (including some surveys of the operational wind farm)			Aerial surveys of the Project	DBERR surveys			
	2005	2006	2011	2010-11	2004/5	2005/6	2007	2008
Jun			*		**	*		
Jul	*		*					
Aug			*		*			
Sep			*					
Oct					*			
Nov				*	**	**		
Dec	*			*	*			
Jan		*			*		*	
Feb		*		*	*	*	*	*

2.1.3 Table 2 shows the mean densities of gannet (per km^2) for the Project site (plus 1km buffer) for each survey undertaken. Shaded cells indicate that no survey was undertaken during that month.

Table 2: Mean densities of gannet derived for each survey undertaken covering the Project site (plus 1km buffer).

Survey	Year	Method	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Project site	**2011**	**Boat**				0.04	1.44	0.04	0.92	0	0.28			
	2010/11	**Aerial**		0.07	0.01	0							0.08	0
Operational site	**2005**	**Boat**					0.52		0.07					0
	2006	**Boat**	0	0										
DBERR	**2004/05**	**Aerial**	0	0	0		0	0.01		0		0	0	0
	2005/06	**Aerial**		0	0			0					0	
	2007	**Aerial**	0	0	0									
	2008	**Aerial**		0										

2.1.4 As described above, the peak density from these surveys for each season was then ascribed to each month within that season. The values and seasons for gannet are shown in Table 3.

Table 3: Peak gannet densities for each season, based on all surveys covering the Project site (plus 1km buffer)

Season	Months	Mean-peak density
Pre-breeding	March – April	0.01
Breeding/post breeding	May – August	0.30
Autumn migration	September – October	0.09
Winter	November – February	0.01

Proportion flying at risk height

2.1.5 Site specific data on flight heights were unavailable for the Project. Cook *et al*. (2012) utilised data from a number of surveys for proposed, consented and operational offshore wind farms (including those located in the Irish Sea), to model proportion of birds flying at potential collision height, for a number of species. As this study presents the most contemporary data of flight heights in UK waters and provides confidence levels of the analyses, it was considered appropriate to incorporate into the Project CRM.

Nocturnal activity factor and daylight hours

2.1.6 Levels of nocturnal activity by gannet are believed to be low but significant, ascribed by Garthe and Hüppop (2004) a score of 2 on a range from 1 (hardly any flight by night) to 5 (much flight activity at night). Surveys are not undertaken during the night as standard for offshore wind farm developments, therefore, the activity factor presented in Garthe and Hüppop (2004) is considered as a reasonable estimate of nocturnal activity. In the case of gannet, a nocturnal activity factor of 2, equates to approximately 25% the level of activity during daylight hours.

2.1.7 The windfarm latitude is 53.5°. This is used, in combination with predicted nocturnal activity, to determine the total daylight and night-time hours for which the derived densities of gannet may be expected.

2.2. Stage B - estimating number of flights through wind farm

2.2.1 This stage provides the potential number of bird transits through rotors, per month and per annum.

Turbine data

2.2.2 A key parameter for the assessment of collision risk impacts on birds relates to the number and size of turbines. For the Project, as part of the defined worst case scenario, a number of scenarios are being considered, therefore all of these scenarios have been modelled in terms of collision risk.Turbine parameters used at this stage of the CRM, for each possible scenario, are provided in Table 4. Of these scenarios, the likely worst case scenario for collision risk is considered to be 69 x Siemens 3.6MW SWT-120 class turbines (Scenario 3). This scenario includes the greatest number of

the smallest turbines which, in CRM, results in the largest rotor swept area and greatest collision risk.

Table 4: Turbine parameters used for Stage B

	No of turbines	Rotor radius (m)
Scenario 1	64	60
Scenario 2	36	82
Scenario 3	69	60
Scenario 4	50	60
Scenario 5	43	77

Bird behavioural data

2.2.3 For this stage, the only data required for gannet is the flight speed, which is 14.9m/s (Pennycuick, 1987).

2.3. Stage C - probability of collision for a single rotor transit

2.3.1 This stage provides the probability of collision for a single transit through a turbine rotor.

Turbine data

2.3.2 The relevant turbine parameters required for this stage of the model are presented in Table 5. These are derived from the manufacturers specifications.

Table 5: Turbine parameters for Stage C

	No of blades	Maximum blade width	Average pitch	Rotation speed
Scenario 1	3	4.2	6	13
Scenario 2	3	5.4	6	10.5
Scenario 3	3	4.2	6	13
Scenario 4	3	4.2	6	13
Scenario 5	3	5.4	6	11

Bird physiological and behavioral data

2.3.3 This stage of the CRM requires various details on bird size and flight behaviour. The relevant data for gannet are provided in Table 6. Typical dimensions have been taken from BTO BirdFacts (2012). Orientation of the wind turbines is not known at this time, therefore, it is assumed that flights are equally split between those that are upwind and downwind and the same flight speed is used for both.

2.3.4 Typical gannet flight is a mix of gliding and flapping : flapping flight has been used in this collision risk modelling, which will give a slightly more precautionary estimate (i.e. a higher collision estimate) than for gliding flight.

Table 6: Bird data required for Stage C of CRM

Bird data	
Bird length	0.94m
Wingspan	1.72m
Flight speed	14.9m/s
Flight style	Flapping
Proportion of flights upwind	50%

2.4. Stage D - predicted number of collisions per year

2.4.1 To calculate the predicted number of collisions per year, the output from Stage B is multiplied by the output of Stage C, multiplied by the percentage of time the turbines are predicted to be operational. If necessary, a large array correction factor is also applied at this stage.

Turbine operational time

2.4.2 There are certain occasions when turbines are not rotating and this results in a reduction in collision risk. For example, when there is a cut in wind speed or down-time for maintenance reasons. As this varies throughout the year, the monthly proportion of operational time is input into the CRM. This is based on wind frequency distribution and likely operations and maintenance requirements. Table 7 presents the predicted turbine operational time for the Project, relevant to all scenarios.

Table 7: Turbine operational time for the Project

Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
90%	85%	86%	80%	82%	77%	81%	81%	82%	87%	89%	86%

Large array correction

2.4.3 The large array correction factor takes into the account the fact that a declining numbers of birds survive passage through initial rows of turbines which reduces the probability of collision in later rows, when flying through the wind farm. This correction factor considers the width of the wind farm and likely number of turbine rows within the site. For gannet at the Project site, the large array correction factor does not result in any change to the overall collision risk.

Results

2.4.4 Table 8 shows the predicted collision rates for gannet per month and per annum. This assumes no avoidance behaviour.

Table 8: Monthly and annual collision rates of gannet at the Project site, assuming no avoidance behaviour

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Overall
Scenario 1	7	7	8	8	350	340	359	323	85	78	7	6	**1576**
Scenario 2	4	4	5	5	232	225	238	214	56	51	4	4	**1043**
Scenario 3	7	7	8	9	378	366	387	348	92	84	7	6	**1699**
Scenario 4	5	5	6	6	274	265	281	252	66	61	5	5	**1231**
Scenario 5	5	5	6	6	275	266	282	253	67	61	5	5	**1236**

2.5. Stage E – bird behaviour

Avoidance and attraction

2.5.1 Due to lack of empirical evidence regarding likely avoidance rates for gannet, a range of avoidance rates are presented, with 98% given as a precautionary estimate. There is no evidence to suggest gannets will be attracted to the Project site, if the wind farm is constructed. Therefore, there are no additional factors required for the CRM in relation to this behaviour.

Results

2.5.2 Table 9 presents the overall collision risk for gannet, at a range of avoidance rates.

Table 9: Annual collision rates for gannet, at a range of avoidance rates for each Project scenario

	No avoidance	95%	98%	99%	99.50%
Scenario 1	1576	79	32	16	8
Scenario 2	1043	52	21	10	5
Scenario 3	1699	85	34	17	8
Scenario 4	1231	62	25	12	6
Scenario 5	1236	62	25	12	6

2.6. Results for worst case scenario

2.6.1 Table 10 presents the results of each stage the CRM for gannet for the worst case scenario proposed for the Project.

Table 10: Outputs and overall results of CRM for gannet, based on Project worst case scenario

Outputs at each stage of CRM		
Stage B	Potential annual transits	20,708
Stage C	Risk for single rotor transit	10.2%
Stage D	Annual collisions– no avoidance	1699
Stage E	Annual collisions - precautionary avoidance rate of 98%	34

3. Migratory waders and waterfowl

3.1.1 Analysis of the potential interaction of the Project site with waders and waterfowl utilized the recently published guidance from the British Trust for Ornithology, relating to the SOSS Migration Assessment Tool (MAT) (Wright *et al.*, 2012), which details a method in which the flight passages of migratory species can be calculated.

3.1. Migration Assessment Tool (MAT)

3.1.2 The first stage in the assessment was to determine the number of movements of wading and waterfowl species across Burbo Bank Extension. The MAT utilizes 251,599 lines of connectivity which were constructed as line of sight sea crossings for migrants travelling across UK waters. These lines were then assigned on a species specific basis based on the migration routes presented in Wright *et al.* (2012).

3.1.3 Provided with the guidance is a GIS shapefile which was used to determine those lines of connectivity which interact with the Project site. A dataset which details those lines which interact with the wind farm site can then be extracted from GIS and imported into the MAT. In the case of Burbo Bank Extension this dataset contained 1,178 lines of connectivity.

3.1.4 The next stage in the process is to decide which sea crossings are pertinent to the wind farm being assessed. In the case of Burbo Bank Extension the following sea crossings were selected based on the descriptions given in Wright *et al.* (2012):

- England and Wales Bristol Channel to England and Wales Irish Sea;
- England and Wales Irish Sea to England and Wales Irish Sea;
- England and Wales Irish Sea to Northern Ireland Celtic Seas coast;
- England and Wales Irish Sea to Scottish mainland Celtic Seas coast;

- Republic of Ireland – Celtic Seas Eastern coast to England and Wales Irish Sea; and
- Spanish North coast to England and Wales Irish Sea.

3.1.5 The final stage of the MAT requires two pieces of information relating to the population estimated to interact with the wind farm site. The first piece of information is the UK population size of each considered species. The second piece of information is a population correction factor which estimates the percentage of the UK population that interacts with the wind farm footprint. The population of each species predicted to interact with the footprint of the wind farm was estimated using the population of each species cited for SPAs deemed to be connected with Burbo Bank Extension (Table 111) (Stroud *et al.,* 2001). The proportion was calculated by comparing the total population of a species cited for connected SPAs and the UK population size.

Table 111: Species, SPA populations and the proportion of the GB population interacting with Burbo Bank Extension used for migratory collision risk assessment

Species	**SPA populations**				**Proportion of UK population interacting with Burbo Bank Extension (%)**
	Mersey Estuary SPA	**Mersey Narrows and North Wirral Foreshore SPA**	**The Dee Estuary SPA**	**Total**	
Shelduck	5,039	-	6,827	**11,866**	19
Teal	11,667	-	5,918	**17,585**	8
Pintail	2,744	-	6,498	**9,242**	32
Oystercatcher	-	-	28,434	**28,434**	9
Ringed plover	1,453	-	-	**1,453**	4
Golden plover	3,070	-	-	**3,070**	1
Grey plover	-	-	2,193	**2,193**	5
Knot	-	10,655	21,553	**32,208**	10
Dunlin	44,300	-	22,479	**66,779**	19
Black-tailed godwit	-	-	1,739	**1,739**	4
Bar-tailed godwit	-	3,344	1,013	**4,357**	11
Curlew	-	-	4,028	**4,028**	3
Redshank	4,689	-	8,541	**13,230**	11

3.1.6 The number of movements across the wind farm footprint calculated by the MAT, were then used within the Band (2012) collision risk model. Two key months during each migration were arbitrarily chosen (March and October), which were populated with the number of movements across the wind farm footprint.

3.2. Width of migration corridor

3.2.1 The width of the migration corridor was calculated using ArcGIS. The migration corridor was taken as the longest width of Walney Extension Offshore Wind Farm running from east to west. This gave a value of 10.26 km.

3.3. Number of flights across Burbo Bank Extension

3.3.1 The number of birds predicted to interact with the footprint of Burbo Bank Extension is shown in table 12.

Table 12: Number of movements of wading and waterfowl species across Burbo Bank Extension offshore wind farm

Species	Number of movements across wind farm footprint
Shelduck	283
Teal	420
Pintail	221
Oystercatcher	680
Ringed plover	35
Golden plover	74
Grey plover	52
Knot	770
Dunlin	2318
Black-tailed godwit	41
Bar-tailed godwit	138
Curlew	96
Redshank	316

3.4. Collision risk modelling

3.4.1 The number of movements across the wind farm footprint calculated by the MAT, were then used within the Band (2012) collision risk model. Two key months during each migration were arbitrarily chosen (March and October), which were populated with the number of movements across the wind farm footprint.

3.4.2 As stated in Band (2012), the proportion of birds on migration at rotor height is likely to be different from the proportion of birds at collision height (PCH) when not on migration for a number of species. Wright *et al.* (2012) makes recommendations on the values to use for the proportion of birds at rotor height. For wading birds and waterfowl Wright *et al.* (2012) recommends a PCH of 25 % and 15 %, respectively.

3.4.3 The flight movements shown in Table 12 were then used within the Band (2012) collision risk model to calculate the collision risk values shown in Table .

Table 13: Collision risk estimates (collision per annum) for wading and waterfowl species for Burbo Bank Extension.

Species	No avoidance	98% avoidance
Shelduck	2	0
Teal	2	0
Pintail	1	0

Species	No avoidance	98% avoidance
Oystercatcher	6	0
Ringed plover	0	0
Golden plover	1	0
Grey plover	0	0
Knot	5	0
Dunlin	16	0
Black-tailed godwit	0	0
Bar-tailed godwit	1	0
Curlew	1	0
Redshank	2	0

4. Migratory seabirds

4.1.1 The MAT methodology is not suitable for use with migratory seabirds and as such a different approach was implemented to estimate the collision risk to migratory seabirds with Burbo Bank Extension. Collision risk modeling was undertaken to calculate the collision risk to Arctic skua and great skua with Burbo Bank Extension.

4.1.2 Due to the nature of site-specific surveys, it is predicted that the population estimates of gannet, Arctic skua and great skua are under-estimated for the Burbo Bank Extension offshore wind farm project site. Site-specific surveys were carried out on a single day for each month (with the exception of October), as such data collected during these surveys was extrapolated to estimate the passage rate of gannet, Arctic and great skua through Burbo Bank Extension. Extrapolation was carried out by taking the number of each species recorded during surveys and multiplying this by the number of days in a given month. This provided a monthly passage rate to be used in collision risk modelling (Table 14Table). In some cases a species was unrecorded during site-specific surveys during periods when these species are potentially relatively abundant, and, in these cases, the highest passage rate calculated for a month either side of the month in which the species was unrecorded was used.

Table 14: Potential Monthly passage rates of migratory seabird species through Burbo Bank Extension

	Apr	May	Jun	Jul	Aug	Sept	Oct
Gannet	240	7626	9150	0	0	1950	1950
Arctic skua	0	248	0	62	248	1020	1054
Great skua	0	180	180	0	180	180	186

4.1.3 The figures in Table 14 were used to populate the *'Migration passages'* tool within the Band (2012) collision risk model. Collision risk estimates for gannet, Arctic skua and great skua are shown in Table 112.

Table 112: Collision risk for three migratory seabird species with Burbo Bank Extension

Species	No avoidance	98% avoidance
Gannet	247	5
Arctic skua	10	0
Great skua	4	0

5. References

Band, B. (2012). *Using a collision risk model to assess bird collision risks for offshore wind farms – with extended method*. Report to Strategic Ornithological Support Services, March 2012.

BTO BirdFacts (2012). http://www.bto.org/about-birds/birdfacts Accessed 01/03/2012

Cook, A.S.C.P, Johnston, A., Wright, L.J. and Burton, N.H.K. (2012). *SOSS-02 A review of flight heights and avoidance rates of birds in relation to offshore wind farms*. Report to Strategic Ornithological Support Services.

Garthe, S. and Hüppop, O. (2004). Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index. *Journal of Applied Ecology*, 41(4), 724-734.

Pennycuick, C.J. (1987). Flight of auks (Alcidae) and other northern seabirds compared with southern Procellariiformes: ornitholodite observations. *Journal of Experimental Biology* 128: 335-347.

Stroud, DA, Chambers, D, Cook, S, Buxton, N, Fraser, B, Clement, P, Lewis, P, McLean, I, Baker, H & Whitehead, S (eds).(2001). *The UK SPA network: its scope and content.* JNCC, Peterborough

Wright, L.J., Ross-Smith, V.H., Austin, G.E., Massimino, D., Dadam, D., Cook, A.S.C.P., Calbrade, N.A. and Burton, N.H.K. (2012) *SOSS-05 Assessing the risk of offshore wind farm development to migratory birds designated as features of UK Special Protection Areas (and other Annex 1 species).* Report to Strategic Ornithological Support Services

DONG Energy

Burbo Bank Extension Offshore Wind Farm
Apportioning collision risk to SPAs and determination of Potential Biological removal (PBR) for key species.

15 February 2013

Prepared by Robin Ward, Ian Ellis
and Matthew Hazleton

Document Control and Revision Status

Project	Burbo Bank Extension Offshore Wind Farm
Project Number	N0034
Document Title	PBR for common tern, herring gull and lesser black-backed gull and it's apportioning between Special Protection Areas
Level	Advice Note
Status	Final

Revision History		Date	Original	Check	Approval	Client
01	Internal draft	07/11/2012	HAZ	IEL	IEL	DONG Energy
02	Draft	09/11/2012	RWA	IEL	TNO	DONG Energy
03	Draft	23/11/2012	RWA	IEL	TNO	DONG Energy
04	Draft	04/02/2013	RWA	IEL	TNO	DONG Energy
05	Draft	11/02/2013	RWA	IEL	TNO	DONG Energy
06	Final	15/02/2013	RWA	IEL	TNO	DONG Energy
Signatories		IEL – Ian Ellis; RWA – Robin Ward; HAZ – Matthew Hazleton; TNO – Tim Norman				

Document Distribution		
Copy Number	Distributed to	Date
Master	DONG	26/12/2012

The following personnel are designated contacts for queries relating to this document			
Name	Job Title	Telephone	Email
Ian Ellis	Principal Ecologist	01223 370181	iel@niras.com

1. Introduction

1.1 Background

1.1.1 Further to consultation with Natural England, the assessment of the significance of predicted collision rates was made in light of the Potential Biological Removal (PBR) approach proposed by Watts (2010). Clarification was sought on the ornithological impact assessment, particularly with respect to information used to determine whether impacts arising from predicted collision mortality were significant for affected populations.

1.1.2 This note summarises PBR calculations alongside collision risk outputs for common tern, herring gull and lesser black-backed gull populations in the study area of the Burbo Bank Extension offshore wind farm ("the Project"). Taking these outputs, a novel approach is used that in part overcomes the limitations of past models (i.e. a uniform density of birds at sea around a colony) to estimate the contribution from each seabird breeding colony to the birds present at the Project site and the predicted annual collision mortality. This note briefly describes the model, its application and output with respect to this study.

1.1.3 This Annex (Annex 5 to the Environmental Statement Chapter 15, Ornithology) corresponds with Annex 2 of the Habitats Regulations Assessment Report (HRA Report).

2. Methods: Allocating collision risk to individual SPAs

2.1 Introduction

2.1.1 In the breeding season, it is a reasonable assumption (when ignoring the issue of the spatial heterogeneity of available food) that for a seabird colony of a given size, the further it is away from the Project site, the lower its likely contribution to the birds present at that site. This relationship has been acknowledged in offshore wind farm EIAs elsewhere through the use of the term $1/\text{distance}^2$ as a weighting factor to estimate the contribution from a SPA to the birds present at the site of the proposed development. Therefore for a colony of a given size, the further it is away from the site of the proposed development, the lower its overall weighting factor will be and so too will its estimated contribution to the birds present at the site. However the underlying assumption of using this weighting is that the density of birds is uniform across the sea area around a colony. This is not the case, as breeding gulls and terns are ‘central place foragers’, with the need to optimise their time spent away from the nest and energy expended in foraging. Density can therefore be expected to be greater closer to the colony and decline with distance away from it.

2.1.2 Limited data exists for known breeding seabirds with which to construct a model that predicts the proportion of birds found foraging at different distances from a colony. An example of those data that does exist is summarised in the BirdLife’s Seabird Foraging Range Database accessed via Seabird wikispace (http://seabird.wikispaces.com/). This latter resource has been taken to

construct a model whose output has enabled the calculated collision risk and PBR outputs for the Project to be apportioned to individual SPAs. The model and its application are summarised below.

2.2 Method

2.2.1 BirdLife's Seabird Foraging Range Database provides cumulative frequency and proportion of birds found foraging at different distances from a colony for several species, including common tern. However the suite of species do not include herring gull or lesser black-backed gull, so for the purpose of this analysis, data are used for the two species most representative of herring gull and lesser black-backed gull on the basis of foraging range (Thaxter *et al*. 2012), kittiwake and gannet. For lesser black-backed gull the mean foraging range is 72 km and the mean maximum foraging range 141km. This lies between the values for kittiwake (25km and 60km respectively) and gannet (93km and 229km). For herring gull the mean foraging range and mean maximum foraging range are 11km and 61km respectively, similar to the values for kittiwake. The data available for kittiwake and gannet were used to construct separate models whose application would result in two scenarios the range between which it can be expected encompasses comparative values for herring gull or lesser black-backed gull.

2.2.2 The distance between each breeding colony (*i*) of the species (i.e. common tern, lesser black-backed gull or herring gull) predicted to interact with the Project site, and the latter locality was determined giving the value d_i.

2.2.3 Individual equations were derived for the curves that best describes the cumulative bird distribution plots (on http://seabird.wikispaces.com/) for foraging common tern, kittiwake and gannet from a colony. These were initially derived using Microsoft Excel to apply a logarithmic trend line through the data points. The R^2 square values of these logarithmic trend lines were 0.70, 0.82 and 0.87 for common tern, gannet and kittiwake respectively. To ensure the curves were as close to zero birds foraging when at the colony, a constant was added to the distance parameter prior to the application of natural logarithm within the equation. This was derived using within What-if Analysis the Goal Seek tool of Microsoft Excel. The resultant logarithmic equation provided the cumulative proportion of birds (CPB) found foraging out to distance d from the colony when divided by 100.

2.2.4 The cumulative proportion of birds (CPB) found foraging out to distance *d* and *d-1* from each colony for a target species was calculated using the appropriate derived logarithmic equation(s).

2.2.5 The average density of birds (of the target species i.e. common tern, lesser black-backed gull or herring gull) from each colony of a species (as tabulated in Section 9) was then calculated for that expected to occur at the 1km distance band[1] away from colony that coincides with the Project site boundary using the formula:

$$\boldsymbol{D}_i = ((\boldsymbol{CPB}_d - \boldsymbol{CPB}_{d-1}) \times \boldsymbol{C}_i) \div \boldsymbol{s}_d$$

Where:
$\boldsymbol{D}_i$ is the density of birds from colony ***i*** that would be expected to occur at the 1km distance band away from colony that coincides with the Project site boundary.

[1] i.e. of the concentric 1km bands extending out from a colony, the 1km band in which the Project site coincides.

$\boldsymbol{C}_i$ is the size of colony $\boldsymbol{i}$ of a species (for the colonies listed in Section 9).
$\boldsymbol{s_d}$ is the sea area within the concentric 1km band around a colony between d and $d-1$ km calculated using the equation:

$$\boldsymbol{s}_d = (2\pi\boldsymbol{d} - 2\pi(\boldsymbol{d}-1))$$

2.2.6 The value $\boldsymbol{D}_i$from each colony was then expressed as a proportion of the sum of densities ($\boldsymbol{D}$) using the formula:

$$\boldsymbol{P}_i = \boldsymbol{D}_i \div \sum \boldsymbol{D}$$

Where:
P_i is the proportion of the sum of densities ($\boldsymbol{D}$) at the Burbo Bank Extension's central location originating from all the colonies considered which was associated with birds from colony *i*.

2.2.7 Assuming there is no difference in the individual's susceptibility to mortality between colonies, it can be assumed that P_i represents the proportion of collisions that can be apportioned to colony *i*. It also therefore follows that P_i represents the proportion of background mortality and PBR that can be apportion to colony *i.*

3. Methods: Collision risk at the Project site

3.1.1 The predicted collision risk estimates for common tern, herring gull and lesser black-backed gull at the Project site were modelled using a worst-case scenario with the maximum number of turbines (69). Collision risk modelling was carried out for a range of avoidance rates (Table 4).

3.1.2 Further information on the approach to collision risk modelling is provided in Annex 4 to the Environmental Statement Chapter 15, Ornithology and Annex 1 to the HRA Report.

4. Methods: Potential Biological Removal

4.1.1 Following apportioning of collisions to respective SPAs for each species, Potential Biological Removal can be used to determine a sustainable level of mortality for each population.

4.1.2 PBR provides a means of estimating the number of additional mortalities that a given population can sustain. Wade (1998) and others have defined a simple formula for PBR:

$$PBR = \frac{1}{2} r_{max} N_{min} f$$

Where:
r_{max} is the maximum annual recruitment rate
N_{min} is a conservative estimate of the population size
f is a "recovery factor" applied to depleted populations where the management goal may be to facilitate growth back to a target population size

4.1.3 Wade (1998) showed that PBR can be used to identify sustainable harvest rates that would maintain populations at, or above, maximum net productivity level (MNPL or maximum sustained yield). Based on a generalised logistic model of population growth and assuming that the density

dependency in the population growth is linear (θ = 1.0) then MNPL is equivalent to 0.5K (where K is the notional carrying capacity) and the net recruitment rate at MNPL (RMNPL) is 0.5 r_{max}.

4.1.4 Wade (1998) also showed that PBR is conservative for populations with θ > 1.0 (i.e. a convex density-dependent growth curve) where RMNPL will be > 0.5 r_{max} (see Figure 1 in Wade 1998).

4.2 Estimating r_{max}

4.2.1 The maximum annual recruitment rate (r_{max}) is equivalent to λ_{max} – 1, therefore:

$$r_{max} = \lambda_{max} - 1$$

Where:
λ_{max} is the maximum discrete rate of population growth.

4.2.2 Niel & Lebreton (2005) show two methods for calculating λ_{max}:

A quadratic solution (equation 15 of Niel & Lebreton 2005) also used by Watts (2010):

$$\lambda\max \approx \frac{(s\alpha - s + \alpha + 1) + \sqrt{(s - s\alpha - \alpha - 1)^2 - 4s\alpha^2}}{2a}$$

And a relationship based on mean optimal generation length (equation 17 of Niel & Lebreton 2005):

$$\lambda\max = exp\left[\left(\alpha + \frac{s}{\lambda\max - s}\right)^{-1}\right]$$

Where:
s is annual adult survival
α is age of first breeding

4.2.3 Niel & Lebreton (2005) suggest that the second method is most suitable for short-lived species. A comparison of the results of both methods indicated that the first generated slightly more precautionary PBRs for the relatively long-lived species considered in this note. Consequently λmax has been estimated using the first method for all species below.

4.3 Estimating N_{min}

4.3.1 N_{min} is a conservative estimate of the population size. Where the population is not known or there are different estimates of its size Wade (1998) suggests using the lower bound of a 60% confidence interval. Dillingham & Fletcher (2008) provide further methods for approximating N_{min} in circumstances where there is uncertainty about the population size.

4.4 Selecting f

4.4.1 The recovery factor *f* is an arbitrary value set between 0.1 and 1.0 and its purpose is to increase conservatism in the calculation of PBR or to identify a value for PBR that is intended to achieve a specific outcome for nature conservation (eg population recovery).

4.4.2 Dillingham & Fletcher (2008) link the value of *f* to conservation status and (following IUCN status criteria) suggest that *f* = 0.1 is adopted for 'threatened' species; *f* = 0.3 for 'near threatened' species and *f* = 0.5 for species of 'least concern'. They further argue that a value of *f* = 1.0 may be suitable for species of 'least concern' that are known to be increasing or stable.

4.4.3 A similar scheme could be used for individual populations and their status in relation to specific conservation objectives.

5. Population data

5.1 Common tern population

5.1.1 Population estimates for common tern were taken from Stroud et al. (2001), with additional information on the Mersey Narrows and North Wirral Foreshore pSPA taken from the departmental brief prepared for the potential site (Natural England, 2011). Data from the JNCC SMP database[2] was considered incomplete and inappropriate to use for this species.

5.1.2 The Mersey Narrows and North Wirral Foreshore pSPA includes common terns as a qualifying species as both breeding and passage features. As such, the breeding and passage periods are considered separately in this analysis. Table 1 summarises the relevant populations within foraging range of the Project (using the range values in Thaxter et al., 2012). Table 1 presents the populations as number of individuals contra Stroud et al. (2001) which presents the information as number of pairs.

Table 1 Populations of common tern within foraging range of the Project (foraging range is calculated based on the distance between the site boundary and project boundary)

	No. of individuals	
SPA / Ramsar	Passage	Breeding
Dee Estuary	-	554
Mersey Narrows and North Wirral Foreshore	1475	354
Ribble and Alt Estuaries	-	364
Total	1475	1272

5.2 Herring gull population

5.2.1 The population of herring gull predicted to be within foraging range of the Project site was calculated using three data sources (Table 2). As with common tern populations, information from the SPA review was used (Stroud et al., 2001). An alternative and more contemporary estimation of the Morecambe Bay SPA population was taken from the JNCC SMP Database[2]. Thirdly, an estimation of the regional population, including birds outside of designated sites (local breeding colonies and SSSIs not associated with SPAs), was calculated from JNCC SMP data using guidance from Mitchell et al., (2004) and the most recently available counts on the SMP database.

[2] http://jncc.defra.gov.uk/smp/

Table 2 Populations of herring gull within foraging range of the Project (foraging range is calculated based on the distance between the site boundary and project boundary)

	No. of individuals		
SPA	SMP[3] (year of count)	SPA Review	Regional population
Morecambe Bay	4188 (2011)	22000	4188
Other sites[4]	-	-	2705
Total	4188 (2011)	22000	6893

5.3 Lesser black-backed gull population

5.3.1 Analysis of lesser black-backed gull population figures was undertaken in line with that for herring gull. SPA review data (for Bowland Fells, Morecambe Bay and Ribble & Alt Estuaries SPAs) is presented in Table 3, alongside more contemporary data from the JNCC SMP database. A regional population derived from the database is also presented using the most recently available count data including local breeding colonies that are not associated with SPAs.

Table 3 Populations of lesser black-backed gulls within foraging range of the Project (foraging range is calculated based on the distance between the site boundary and project boundary)

	No. of individuals		
SPA	SMP[1] (year of count)	SPA Review	Regional population
Bowland Fells	10937 (2011)	27800	10937
Morecambe Bay	16274 (2011)	44000	16274
Ribble and Alt Estuaries	8234 (2008)	3600	8234
Other sites[5]	-	-	7159
Total	35445	75400	42604

6. Results

6.1 Collision risk at the Project site

6.1.1 The predicted annual collision rates for the Project site are shown in Table 4. The predicted rate for the common tern, using an avoidance rate of 98%, was calculated as 17 collisions/annum. The predicted collision rate amongst the breeding population, using an avoidance rate of 98%, is 12 collisions/annum. The collision risk for the autumn passage population of common terns accounts for 5 collisions/annum. The Mersey Narrows and North Wirral Foreshore pSPA includes common terns as a qualifying species as both breeding and passage features. As such, the breeding and passage periods are considered separately in this analysis.

6.1.2 The predicted annual collision rate for herring gull at the Project site, at an avoidance rate of 98%, was calculated as 95 collisions/annum. However, 40% of predicted collisions occurred outside of

[3] http://jncc.defra.gov.uk/smp/

[4] List of sites is presented in Table 16

[5] See Table 17 for list of sites

the breeding period and as such are not considered relevant to the Morecambe Bay SPA designation for breeding herring gull. Therefore Table 4 presents breeding period collisions separately, with this figure considered most appropriate to inform the assessment.

6.1.3 The predicted annual collision rate for lesser black-backed gull at the Project site, at an avoidance rate of 98%, was calculated as 176 collisions/annum, 0.6% of predicted collisions occurred outside of the breeding period and as such is considered not relevant to the three SPAs under consideration in the Offshore Ornithology Chapter (Chapter 15) and the HRA Report. Table 4 presents breeding period collisions separately, with this figure considered most appropriate to inform the assessment.

Table 4 Predicted annual collision mortality at the Project site across a range of avoidance rates

Species	Time period of collisions	No. of collisions at a range of avoidance rates (%)				
		No avoidance	95	98	99	99.5
Common tern	Breeding period only (April - July)	587	29	12	6	3
	Autumn passage period only (August - October)	286	14	5	3	1
Herring gull	All year	4732	236	95	47	24
	Breeding period only (March - September)	2836	142	57	28	14
Lesser black-backed gull	All year	8818	440	176	88	44
	Breeding period only (March - September)	8738	437	175	87	44

6.2 Allocating collision risk to individual SPAs

6.2.1 Table 5 and Table 6 present the predicted annual collision mortality (individuals per annum) and changes in background mortality for the proportion of the populations of common tern, herring gull and lesser black-backed gull attributed to SPAs. The results are presented to show collisions for the entire year and the breeding period only. As previously stated 40% and 0.6% of predicted collisions for herring gull and lesser black-backed gull respectively occurred outside of the breeding period and as such are considered not relevant to the SPAs under considerations. Therefore the results presented for breeding period collisions are considered most appropriate to inform the assessment and are the only findings discussed in this section.

6.2.2 The cumulative bird distribution plots for foraging herring gull from a colony is more likely to be similar to that for kittiwake than gannet on consideration of their respective mean foraging range and mean maximum foraging range. For the purposes of this assessment, only minor differences exist between the predicted number of collisions that would be apportioned to Morecambe Bay SPA

when comparing the outcomes from using the model derived from kittiwake and gannet data (during the breeding season 3 collisions using the kittiwake function and 4 using the gannet function).

6.2.3 The predicted annual collision rate for herring gull during the breeding season and for birds within foraging range of the Project site (based on the populations in the SMP database), using an avoidance rate of 98%, was calculated as 57 collisions/annum. When the predicted collisions are apportioned to individual colonies, Morecambe Bay SPA is estimated to contribute no more than 4 collisions/annum to the predicted collision rate for the Project. The remaining collisions are attributed to other breeding colonies that make up the total regional population.

6.2.4 The collision risk for the regional population of lesser black-backed gulls, as presented in the SMP database at an avoidance rate of 98%, was calculated as 175 collisions/annum. Upon apportioning all but one collision was predicted to involve birds originating from the three SPAs cited for breeding lesser black-backed gulls within foraging range of the Project site (Morecambe Bay SPA, Ribble and Alt Estuaries SPA and Bowland Fells SPA).

6.2.5 When the SPAs are considered individually, Ribble and Alt Estuaries SPA contributed 94% of the predicted collisions (164 collisions/annum). No more than 2% and 4% of the predicted collisions were apportioned to Bowland Fells SPA and Morecambe Bay SPA respectively.

6.2.6 The predicted collisions for common tern at the Project site were close to being equally apportioned amongst the three SPAs cited for breeding common tern within foraging range of the Project site.

Table 5: Predicted annual collision mortality (individuals per annum) and changes in background mortality for the proportion of the populations of herring gull and lesser black-backed gull attributed to SPAs predicted to interact with the Project.

Species (Time period of collisions)	Component population[6]	Proportion of sum of densities at Burbo Bank Extension originating from all regional colonies considered[7]		No. of collisions at 98% avoidance rate apportioned to population affected		Increase in background mortality (population affected)	
		Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function
Herring gull (all year)	Morecambe Bay SPA	0.060	0.061	6	6	1.13%	1.15%
Herring gull (breeding period collisions only)	Morecambe Bay SPA	0.060	0.061	3	4	0.68%	0.69%
Lesser black-backed gull (all year)	Bowland Fells SPA Morecambe Bay SPA Ribble and Alt Estuaries SPA	0.992	0.991	175	174	5.66%	5.66%
	Bowland Fells SPA	0.020	0.023	4	4	0.38%	0.43%
	Morecambe Bay SPA	0.034	0.039	6	7	0.42%	0.48%
	Ribble and Alt Estuaries SPA	0.938	0.929	165	164	23.04%	22.83%
Lesser black-backed gull (breeding period collisions only)	Bowland Fells SPA Morecambe Bay SPA Ribble and Alt Estuaries SPA	0.992	0.991	174	173	5.63%	5.63%
	Bowland Fells SPA	0.020	0.023	4	4	0.38%	0.43%
	Morecambe Bay SPA	0.034	0.039	6	7	0.42%	0.48%
	Ribble and Alt Estuaries SPA	0.938	0.929	164	163	22.91%	22.70%

[6] Data source: JNCC SMP database

[7] See section 2.2 for explanation of kittiwake and gannet functions

Table 6: Predicted annual collision mortality (individuals per annum) and changes in background mortality for the proportion of the populations of common tern attributed to SPAs predicted to interact with Burbo Bank Extension.

Species (Time period of collisions)	Component population	Proportion of sum of densities at Burbo Bank Extension originating from all regional colonies considered	No. of collisions at 98% avoidance rate apportioned to population affected	Increase in background mortality (population affected)	Data source
Common tern (breeding period)	Ribble and Alt Estuaries SPA	0.356	4	11.75%	Stroud *et al.*, 2001
	Mersey Narrows and North Wirral Foreshore SPA	0.347	4	11.75%	Stroud *et al.*, 2001
	Dee Estuary SPA	0.297	4	6.43%	Stroud *et al.*, 2001
Common tern (autumn passage)	Mersey Narrows and North Wirral Foreshore SPA	1.0	5	3.39%	Stroud *et al.*, 2001

6.3 Potential Biological Removal

6.3.1 Table 7 presents the PBR results for common tern, herring gull and lesser black-backed gull for a range of recovery factors for both the regional population and SPA populations for each species.

6.3.2 With regards to common tern, it is assumed that the populations are stable within the region and that a recovery factor of 1.0 is appropriate (Brown & Grice, 2005). The population sizes stated in Table 1 have been used for the N_{min} values as a conservative estimate of population size (Wade 1998). With this assumption, for the SPA populations the PBR value for common tern is 97 birds for the breeding population and 112 for the passage population.

6.3.3 For herring gull using the data for the Morecambe Bay SPA from the SMP database (N_{min} of 4188) at a recovery rate of 0.5, PBR was calculated as 140 birds (compared to 737 birds for the population detailed in Stroud et al., 2001). For the regional population, the calculated PBR value was 231 birds.

6.3.4 For lesser black-backed gull populations, using the data for SPAs from the SMP database at a recovery factor of 0.5, PBR was calculated as 1049 birds. For the SPA populations, taken from Stroud et al. (2001), PBR was calculated as 2232 birds. The regional population derived from the SMP database has a PBR calculated at 1261 birds. An *f* value of 0.5 was used for all populations, due to the inter-connectivity between the breeding sites.

Table 7: PBR values for populations of common tern, herring gull and lesser black-backed gull predicted to interact with the Project.

Species	Reference population	Age of first breeding (α)[8]	Annual adult survival (s)[9]	Growth rate (λ_{max})	N_{min}	f_r	PBR	PBR rounded to nearest decimal place	Reference for population size
Common tern - Breeding	Dee Estuary SPA Mersey Narrows and North Wirral Foreshore pSPA Ribble and Alt Estuaries SPA	3	0.9	1.15	1272	0.1	9.7	10	Stroud *et al.* (2001)
						0.2	19.4	19	
						0.3	29.1	29	
						0.4	38.7	39	
						0.5	48.4	48	
						1.0	96.8	97	
Common tern - Breeding	Dee Estuary SPA	3	0.9	1.15	554	0.1	4.21	4	Stroud *et al.* (2001)
						0.2	8.44	8	
						0.3	12.65	13	
						0.4	16.87	17	
						0.5	21.09	21	
						1.0	42.18	42	
Common tern - Breeding	Mersey Narrows and North Wirral Foreshore pSPA	3	0.9	1.15	354	0.1	2.70	3	Stroud *et al.* (2001)
						0.2	5.39	5	
						0.3	8.09	8	
						0.4	10.8	11	
						0.5	13.5	14	
						1.0	27.0	27	
Common tern - Breeding	Ribble and Alt Estuaries SPA	3	0.9	1.15	364	0.1	2.77	3	Stroud *et al.* (2001)
						0.2	5.54	6	

[8] Taken from Robinson (2005)

[9] Taken from Robinson (2005)

Species	Reference population	Age of first breeding (α)[8]	Annual adult survival (s)[9]	Growth rate (λ_{max})	N_{min}	f_r	PBR	PBR rounded to nearest decimal place	Reference for population size
						0.3	8.31	8	
						0.4	11.1	11	
						0.5	13.9	14	
						1.0	27.7	28	
Common tern - Passage	Mersey Narrows and North Wirral Foreshore pSPA	3	0.9	1.15	1475	0.1	11.2	11	Natural England, 2011
						0.2	22.5	23	
						0.3	33.7	34	
						0.4	44.9	45	
						0.5	56.1	56	
						1.0	112.3	112	
Herring gull (SPA-SMP)	Morecambe Bay SPA[10]	4	0.88	1.13	4188	0.1	28.1	28	JNCC SMP database
						0.2	56.1	56	
						0.3	84.2	84	
						0.4	112.2	112	
						0.5	140.3	140	
						1.0	280.5	281	
Herring gull (SPA-2001 Review)	Morecambe Bay SPA	4	0.88	1.13	22000	0.1	147.4	147	Stroud *et al.* (2001)
						0.2	294.7	295	
						0.3	442.1	442	
						0.4	589.4	589	
						0.5	736.8	737	
						1.0	1473.5	1474	
Herring gull (Regional pop.)	Multiple sites from SMP database[11]	4	0.88	1.13	6893	0.1	46.2	46	JNCC SMP database
						0.2	92.3	92	

[10] Morecambe Bay SPA herring gull population data SMP, 2011

Species	Reference population	Age of first breeding (α)[8]	Annual adult survival (s)[9]	Growth rate (λ_{max})	N_{min}	f_r	PBR	PBR rounded to nearest decimal place	Reference for population size
	(Regional population)					0.3	138.5	139	
						0.4	184.7	185	
						0.5	230.8	231	
						1.0	461.7	462	
Lesser black-backed gull (SPA-SMP)	Bowland Fells SPA[12] Morecambe Bay SPA[13] Ribble and Alt Estuaries SPA[14]	4	0.913	1.12	35445	0.1	209.9	210	JNCC SMP database
						0.2	419.7	420	
						0.3	629.6	630	
						0.4	839.5	840	
						0.5	1049.3	1049	
						1.0	2098.7	2099	
Lesser black-backed gull (SPA – 2001 Review)	Bowland Fells SPA Morecambe Bay SPA Ribble and Alt Estuaries SPA	4	0.913	1.12	75400	0.1	446.4	446	Stroud *et al.* (2001)
						0.2	892.9	893	
						0.3	1339.3	1339	
						0.4	1785.8	1786	
						0.5	2232.2	2232	
						1.0	4464.4	4464	
Lesser black-backed gull	Multiple sites from SMP database[15]	4	0.913	1.12	42604	0.1	252.3	252	JNCC SMP database
						0.2	504.5	505	

[11] Morecambe Bay SPA herring gull population data SMP, 2011

[12] Bowland Fells SPA lesser black-backed gull population – 10,937 birds, SMP 2011

[13] Morecambe Bay SPA lesser black-backed gull population – SMP South Walney 2011 (16,274 birds)

[14] Ribble and Alt Estuaries SPA lesser black-backed gull population – 8,234 birds, SMP 2008

[15] See Table 17 for list of sites

Species	Reference population	Age of first breeding (α)[8]	Annual adult survival (s)[9]	Growth rate (λ_{max})	N_{min}	f_r	PBR	PBR rounded to nearest decimal place	Reference for population size
(Regional pop.)	(Regional population)					0.3	756.7	757	
						0.4	1009.0	1009	
						0.5	1261.3	1261	
						1.0	2522.6	2523	
Lesser black-backed gull	Bowland Fells SPA	4	0.913	1.12	10937	0.1	64.8	65	JNCC SMP database
						0.2	129.5	130	
						0.3	194. 3	194	
						0.4	259.1	259	
						0.5	323.8	324	
						1.0	647.6	648	
Lesser black-backed gull	Morecambe Bay SPA	4	0.913	1.12	16274	0.1	96.4	96	JNCC SMP database
						0.2	192.7	193	
						0.3	289.1	289	
						0.4	385.4	385	
						0.5	481.8	482	
						1.0	963.6	964	
Lesser black-backed gull	Ribble and Alt Estuaries SPA	4	0.913	1.12	8234	0.1	48.8	49	JNCC SMP database
						0.2	97.5	98	
						0.3	146.3	146	
						0.4	195.1	195	
						0.5	243.7	244	
						1.0	487.5	488	

7. Cumulative assessment

7.1 Introduction

7.1.1 A cumulative assessment of lesser black-backed gull collisions was undertaken using data available from other wind farm sites in the Irish Sea. This further informs the assessment of the Project particular with reference to impacts on the Ribble and Alt Estuaries SPA.

7.2 Methodology

7.2.1 Using the method described in section 2.2, collision risk estimates at five offshore wind farms being considered within the cumulative impact assessment were apportioned to individual SPAs for lesser black-backed gull. For reasons discussed in section 6.1.3, only the breeding period collisions were considered in this section. It should also be noted that with the exception of the Project site and Walney Extension, the collisions are apportioned between the individual SPAs only and do not include the local breeding colonies that are not associated with SPAs. The number of collisions apportioned to each SPA are therefore likely to be over-estimates.

7.2.2 The five sites included in the analysis in addition to the Project site are:

- West of Duddon Sands;
- Walney I and II;
- Walney Extension;
- Ormonde; and
- Rhiannon (Celtic Array).

7.2.3 Walney I and II and Ormonde are currently operational, while West of Duddon Sands is under construction. Walney Extension and Rhiannon are proposed projects in the pre-application phase. The predicted number of collisions at 98% avoidance for each wind farm and the data source are found in Table 8.

7.2.4 For the purposes of this analysis, only three breeding colonies from which birds are predicted to interact with the Project site and the other wind farms were considered when allocating birds to breeding colonies. These sites are Bowland Fells SPA, Ribble & Alt Estuaries SPA and Morecambe Bay SPA. In taking this approach, the contribution of each SPA to the collision risk may be over-estimated given other local breeding colonies lie within the species mean maximum foraging range (141 km), these sites are listed in Table 17 Section 9 of this Annex.

7.3 Results

7.3.1 Tables 9-14 presents the predicted annual collision mortality (individuals per annum) and changes in background mortality for the proportion of the populations of lesser black-backed gull attributed to SPAs predicted to interact with the Project site and five neighbouring wind farms in the Irish Sea for which data are available. Table 15 summarises these figures.

7.3.2 A total of 225 lesser black-backed gulls were considered to potentially be lost to the Ribble and Alt Estuaries population per annum. This represents 2.7% of the current colony size (JNCC SMP figures).

8. References

Brown, A. and Grice, P. (2005). Birds in England, A & C Black Publishers Ltd, London.

Centrica Energy (2012). Irish Sea Zone Zonal Appraisal and Planning Report: Chapter 13 Ornithology. Centric Energy Limited

Dillingham, P.W. and Fletcher, D. (2008). 'Estimating the ability of birds to sustain additional human-caused mortalities using a simple decision rule and allometric relation-ships', Biological Conservation, 141, pp. 1783-1792.

DONG Energy (2006). Walney Offshore Windfarm: Environmental Statement

Ecology Consulting (2006). Ormonde Proposed Offshore Wind Farm: Ornithological Impact Assessment. Report to Ormonde Energy Ltd.

Mitchell, P I, Newton, S, Ratcliffe, N. and Dunn, T E. (2004). Seabird populations of Britain and Ireland (Results of the Seabird 2000 Census 1998-2000). T&D Poyser, London, UK: 511pp.

Natural England (2011). Departmental Brief: Mersey Narrows and North Wirral Fore-shore. Potential Special Protection Area and Proposed Ramsar site. [Online]. Available at: http://www.naturalengland.org.uk/ourwork/consultations/merseynarrows.aspx

Niel, C. and Lebreton, J-D. (2005). 'Using Demographic Invariants to Detect Overharvest-ed Bird Populations from Incomplete Data', Conservation Biology, 19 (3), pp. 826-835.

Robinson, R.A. (2005). BirdFacts: profiles of birds occurring in Britain & Ireland (BTO Research Report 407). BTO, Thetford (http://www.bto.org/birdfacts, accessed on 04/02/2013)

RPS (2006). Walney Offshore Windfarm: Ornithological Impact Assessment. RPS, St Ives.

RSKENSR Ltd (2006). West of Duddon Sands Offshore Wind Farm: Environmental Statement. Report to Morecambe Wind Ltd.

Stroud, D.A., Chambers, D., Cook, S., Buxton, N., Fraser, B., Clement, P., Lewis, P., McLean, P., Baker, H. and Whitehead, S. (2001). The UK SPA network: its scope and content – Volume 2: Species accounts, Joint Nature Conservation Committee, Peterborough.

Thaxter, C.B., Lascelles, B., Sugar, K., Cook, A.S.C.P., Roos, S., Bolton, M., Langston, R.H.W. and Burton, N.H.K. (2012). 'Seabird foraging ranges as a preliminary tool for identifying candidate Marine Protected Areas', Biological Conservation.

Wade, P.R. (1998). 'Calculating Limits to the Allowable Human-Caused Mortality of Ceta-ceans and Pinnipeds', Marine Mammal Science, 14 (1), pp. 1-37.

Watts, B. D. (2010). Wind and waterbirds: establishing sustainable mortality limits within the Atlantic Flyway. Center for Conservation Biology Technical Report Series, CCBTR-10-05. College of William and Mary / Virginia Commonwealth University, Williamsburg, VA. 43ppBrown, A. and Grice, P. (2005). *Birds in England.* A & C Black Publishers Ltd, London.

Table 8 Predicted collision risks of lesser black-backed gull for Burbo Bank Extension and five other wind farms in the Irish Sea during the breeding period.

Site	Collisions at 98%	Source / notes
Burbo Bank Extension	175	Burbo Bank Extension ES
Walney I & II	87	RPS (2006); DONG Energy (2006). Based on proportion of birds recorded in breeding period which is then applied to total collision risk
West of Duddon Sands	128	RSKENSR (2006)
Ormonde	48	Ecology Consulting (2006); based on precautionary proportion of birds recorded in breeding season which is applied to annual collision rate
Rhiannon	132	Centrica Energy (2012)
Walney Extension	20	
Total	590	

Table 9 Predicted annual collision mortality (individuals per annum) for the proportion of the populations of lesser black-backed gull attributed to SPAs predicted to interact with the Rhiannon offshore wind farm during the breeding period

Species	Component population*	Proportion of sum of densities at Rhiannon originating from 3 SPA colonies considered		No. of collisions at 98% avoidance rate apportioned to population affected		Change in background mortality (population affected)		% of PBR	
		Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function
Lesser black-backed gull	Bowland Fells SPA	0.187	0.188	24.6	24.8	2.58%	2.60%	7.60%	7.65%
	Morecambe Bay SPA	0.535	0.534	70.6	70.5	4.98%	4.98%	14.64%	14.63%
	Ribble and Alt Estuaries SPA	0.279	0.279	36.8	36.8	5.14%	5.13%	15.11%	15.09%

* Data source: JNCC SMP database

Table 10 Predicted annual collision mortality (individuals per annum) for the proportion of the populations of lesser black-backed gull attributed to SPAs predicted to interact with the Walney Extension offshore wind farm during the breeding period

Species	Component population*	Proportion of sum of densities at Walney Extension originating from all regional colonies considered		No. of collisions at 98% avoidance rate apportioned to population affected		Change in background mortality (population affected)		% of PBR	
		Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function
Lesser black-backed gull	Bowland Fells SPA	0.066	0.068	1.3	1.4	0.14%	0.14%	0.41%	0.42%
	Morecambe Bay SPA	0.718	0.712	14.4	14.2	1.01%	1.01%	2.98%	2.96%
	Ribble and Alt Estuaries SPA	0.072	0.074	1.5	1.5	0.20%	0.21%	0.59%	0.61%

* Data source: JNCC SMP database

Table 11 Predicted annual collision mortality (individuals per annum) for the proportion of the populations of lesser black-backed gull attributed to SPAs predicted to interact with the West of Duddon Sands offshore wind farm during the breeding period

Species	Component population*	Proportion of sum of densities at West of Duddon Sands originating from 3 SPA colonies considered		No. of collisions at 98% avoidance rate apportioned to population affected		Change in background mortality (population affected)		% of PBR	
		Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function
Lesser black-backed gull	Bowland Fells SPA	0.064	0.067	8.2	8.6	0.86%	0.91%	2.53%	2.67%
	Morecambe Bay SPA	0.835	0.828	106.9	106.0	7.55%	7.49%	22.2%	22.0%
	Ribble and Alt Estuaries SPA	0.101	0.105	12.9	13.4	1.80%	1.87%	5.30%	5.50%

* Data source: JNCC SMP database

Table 12 Predicted annual collision mortality (individuals per annum) for the proportion of the populations of lesser black-backed gull attributed to SPAs predicted to interact with the Ormonde offshore wind farm during the breeding period

Species	Component population*	Proportion of sum of densities at Ormonde originating from 3 SPA colonies considered		No. of collisions at 98% avoidance rate apportioned to population affected		Change in background mortality (population affected)		% of PBR	
		Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function
Lesser black-backed gull	Bowland Fells SPA	0.037	0.040	1.8	1.9	0.19%	0.20%	0.55%	0.60%
	Morecambe Bay SPA	0.930	0.924	44.6	44.3	3.15%	3.13%	9.26%	9.20%
	Ribble and Alt Estuaries SPA	0.033	0.036	1.6	1.7	0.22%	0.24%	0.66%	0.71%

* Data source: JNCC SMP database

Table 13 Predicted annual collision mortality (individuals per annum) for the proportion of the populations of lesser black-backed gull attributed to SPAs predicted to interact with the Walney I & II offshore wind farms during the breeding period

Species	Component population*	Proportion of sum of densities at Walney I & II originating from 3 SPA colonies considered		No. of collisions at 98% avoidance rate apportioned to population affected		Change in background mortality (population affected)		% of PBR	
		Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function
Lesser black-backed gull	Bowland Fells SPA	0.070	0.074	6.1	6.4	0.64%	0.67%	1.89%	1.98%
	Morecambe Bay SPA	0.852	0.846	74.2	73.6	5.24%	5.20%	15.4%	15.3%
	Ribble and Alt Estuaries SPA	0.077	0.080	6.7	7.0	0.93%	0.97%	2.76%	2.86%

* Data source: JNCC SMP database

Table 14 Predicted annual collision mortality (individuals per annum) for the proportion of the populations of lesser black-backed gull attributed to SPAs predicted to interact with the Project site during the breeding period

Species	Component population*	Proportion of sum of densities at the Project site originating from all regional colonies considered		No. of collisions at 98% avoidance rate apportioned to population affected		Change in background mortality (population affected)		% of PBR	
		Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function
Lesser black-backed gull	Bowland Fells SPA	0.020	0.023	3.6	4.1	0.38%	0.43%	1.10%	1.26%
	Morecambe Bay SPA	0.034	0.039	6.0	6.8	0.42%	0.48%	1.23%	1.40%
	Ribble and Alt Estuaries SPA	0.938	0.929	164.1	162.6	22.9%	22.7%	67.3%	66.7%

* Data source: JNCC SMP database

Table 15 Predicted annual collision mortality (individuals per annum) for the proportion of the populations of lesser black-backed gull attributed to SPAs predicted to interact with six Irish Sea wind farms during the breeding period and PBR values for each SPA.

Sites	Collision numbers*							
	Burbo Bank Extension	Walney I & II	West of Duddon Sands	Ormonde	Walney Extension	Rhiannon	Total	PBR
Ribble and Alt Estuaries SPA	164	7	13	2	2	37	225	244
Morecambe Bay SPA	6	74	107	45	14	71	317	482
Bowland Fells SPA	4	6	8	2	1	25	46	324

* The values presented here are rounded values from Tables 9 to 14.

9. JNCC SMP Database – sites included in regional figures

Table 16 Sites from the JNCC SMP database within foraging range of the Project site and included in regional population estimate for herring gull.

County	SMP site
Clwyd	Colwyn Bay Town
	Kinmel Bay
	Llandulas Quarries
	Llawndy
	Rhyl
Cumbria	Barrow-in-Furness
Gwynedd	Bangor Buildings
	Beaumaris
	Conwy Mountain
	Conwy Town
	Deganwy Town
	Llandudno Town
	Puffin Island
	RSPB Conwy
Lancashire	Belmont Reservoir
	Bowland Fells SPA
	Fleetwood Town
	Heysham Power Station
	Layton Industrial Estate
	Morecambe Bay SPA
	Morecambe Gas Platform
	RSPB Leighton Moss
	Victoria Hospital
Merseyside	Liverpool Buildings
	Netherton
	Seaforth Nature Reserve

Table 17 Sites from the JNCC SMP Database within foraging range of the Project site and included in regional population estimate for lesser black-backed gull.

County	SMP site
Clwyd	Llandulas Quarries
	Prestatyn
	Rhyl
Cumbria	Arnaby Marsh
	Askam-in-Furness
	Barrow-in-Furness
	Cleator Moor
	Costrells Rocks

County	SMP site
	Crummock Water
	Derwent Water
	Greenside Quarry/Kendall Fell Quarry
	Hardendale Quarry
	Haverigg Prison
	Hen Holme and Lady Holme
	Hensingham
	Hodbarrow RSPB
	Lillyhall
	Marchon Chemical Works
	Millom
	Morecambe Bay SPA
	Moresby Parks
	Mossbay
	Ribble & Alt Estuaries SPA
	Ridding Bay
	Rowrah Quarry
	RSPB Haweswater
	Salterbeck
	Salterhall Quarry
	Sellafield
	Silver Holme
	Stickle Tarn
	Thirlmere
	Ulverston
	Walney Urban gulls
	Wet Sleddale Reservoir
	Whitehaven
	Workington Town
Dyfed	Aberystwyth
Gwynedd	Aberdovey Quarry
	Bangor Buildings
	Bardsey Island
	Beaumaris
	Bodorgan Head
	Caernarfon
	Carreg Chwislen
	Conwy Town
	Deganwy Town
	East Mouse
	Ebolion
	Freshwater Bay
	Llandudno Town

County	SMP site
	Llyn Conwy
	Llyn Elsi
	Middle Mouse
	Pen y Cil
	Penllyn to Gogarth
	Puffin Island SPA
	Rhoscolyn Beacon
	RSPB Conwy
	South Stack
	The Skerries
	Trwyn Penrhyn
	Valley Wetlands
	West Mouse
	Ynys Dulas
	Ynys Moelfre
	Ynysoedd Gwylan
	Ynys Piod
	Ynys Traws
Isle of Man	Calf of Man
	Clay Head
	Da Leura Strands
	Dhoon
	Doughlas
	Eairnyerey
	Fleshwick
	Glen Maye
	Peel
	Phurt
	Port - St Mary
	Port Grenaugh
	Port Mooar
	Port Soderick
	Ramsey
	Stroin Vuigh
	The Ayres
Lancashire	Belmont Reservoir
	Bowland Fell SPA
	Fleetwood Town
	Heysham Power Station
	Layton Industrial Estate
	Morecambe Town
	Thornton - Cleveleys
Merseyside	Liverpool Buildings
	Netherton

County	SMP site
	Seaforth Nature Reserve

DONG Energy

Burbo Bank Extension Offshore Wind Farm
Apportioning collision risk to SPAs and determination of Potential Biological removal (PBR) for key species.

15 February 2013

Prepared by Robin Ward, Ian Ellis
and Matthew Hazleton

Document Control and Revision Status

Project	Burbo Bank Extension Offshore Wind Farm
Project Number	N0034
Document Title	PBR for common tern, herring gull and lesser black-backed gull and it's apportioning between Special Protection Areas
Level	Advice Note
Status	Final

Revision History		Date	Original	Check	Approval	Client
01	Internal draft	07/11/2012	HAZ	IEL	IEL	DONG Energy
02	Draft	09/11/2012	RWA	IEL	TNO	DONG Energy
03	Draft	23/11/2012	RWA	IEL	TNO	DONG Energy
04	Draft	04/02/2013	RWA	IEL	TNO	DONG Energy
05	Draft	11/02/2013	RWA	IEL	TNO	DONG Energy
06	Final	15/02/2013	RWA	IEL	TNO	DONG Energy
Signatories		IEL – Ian Ellis; RWA – Robin Ward; HAZ – Matthew Hazleton; TNO – Tim Norman				

Document Distribution		
Copy Number	Distributed to	Date
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The following personnel are designated contacts for queries relating to this document			
Name	Job Title	Telephone	Email
Ian Ellis	Principal Ecologist	01223 370181	iel@niras.com

1. Introduction

1.1 Background

1.1.1 Further to consultation with Natural England, the assessment of the significance of predicted collision rates was made in light of the Potential Biological Removal (PBR) approach proposed by Watts (2010). Clarification was sought on the ornithological impact assessment, particularly with respect to information used to determine whether impacts arising from predicted collision mortality were significant for affected populations.

1.1.2 This note summarises PBR calculations alongside collision risk outputs for common tern, herring gull and lesser black-backed gull populations in the study area of the Burbo Bank Extension offshore wind farm ("the Project"). Taking these outputs, a novel approach is used that in part overcomes the limitations of past models (i.e. a uniform density of birds at sea around a colony) to estimate the contribution from each seabird breeding colony to the birds present at the Project site and the predicted annual collision mortality. This note briefly describes the model, its application and output with respect to this study.

1.1.3 This Annex (Annex 5 to the Environmental Statement Chapter 15, Ornithology) corresponds with Annex 2 of the Habitats Regulations Assessment Report (HRA Report).

2. Methods: Allocating collision risk to individual SPAs

2.1 Introduction

2.1.1 In the breeding season, it is a reasonable assumption (when ignoring the issue of the spatial heterogeneity of available food) that for a seabird colony of a given size, the further it is away from the Project site, the lower its likely contribution to the birds present at that site. This relationship has been acknowledged in offshore wind farm EIAs elsewhere through the use of the term $1/\text{distance}^2$ as a weighting factor to estimate the contribution from a SPA to the birds present at the site of the proposed development. Therefore for a colony of a given size, the further it is away from the site of the proposed development, the lower its overall weighting factor will be and so too will its estimated contribution to the birds present at the site. However the underlying assumption of using this weighting is that the density of birds is uniform across the sea area around a colony. This is not the case, as breeding gulls and terns are ‘central place foragers’, with the need to optimise their time spent away from the nest and energy expended in foraging. Density can therefore be expected to be greater closer to the colony and decline with distance away from it.

2.1.2 Limited data exists for known breeding seabirds with which to construct a model that predicts the proportion of birds found foraging at different distances from a colony. An example of those data that does exist is summarised in the BirdLife’s Seabird Foraging Range Database accessed via Seabird wikispace (http://seabird.wikispaces.com/). This latter resource has been taken to

construct a model whose output has enabled the calculated collision risk and PBR outputs for the Project to be apportioned to individual SPAs. The model and its application are summarised below.

2.2 Method

2.2.1 BirdLife's Seabird Foraging Range Database provides cumulative frequency and proportion of birds found foraging at different distances from a colony for several species, including common tern. However the suite of species do not include herring gull or lesser black-backed gull, so for the purpose of this analysis, data are used for the two species most representative of herring gull and lesser black-backed gull on the basis of foraging range (Thaxter *et al*. 2012), kittiwake and gannet. For lesser black-backed gull the mean foraging range is 72 km and the mean maximum foraging range 141km. This lies between the values for kittiwake (25km and 60km respectively) and gannet (93km and 229km). For herring gull the mean foraging range and mean maximum foraging range are 11km and 61km respectively, similar to the values for kittiwake. The data available for kittiwake and gannet were used to construct separate models whose application would result in two scenarios the range between which it can be expected encompasses comparative values for herring gull or lesser black-backed gull.

2.2.2 The distance between each breeding colony (*i*) of the species (i.e. common tern, lesser black-backed gull or herring gull) predicted to interact with the Project site, and the latter locality was determined giving the value d_i.

2.2.3 Individual equations were derived for the curves that best describes the cumulative bird distribution plots (on http://seabird.wikispaces.com/) for foraging common tern, kittiwake and gannet from a colony. These were initially derived using Microsoft Excel to apply a logarithmic trend line through the data points. The R^2 square values of these logarithmic trend lines were 0.70, 0.82 and 0.87 for common tern, gannet and kittiwake respectively. To ensure the curves were as close to zero birds foraging when at the colony, a constant was added to the distance parameter prior to the application of natural logarithm within the equation. This was derived using within What-if Analysis the Goal Seek tool of Microsoft Excel. The resultant logarithmic equation provided the cumulative proportion of birds (CPB) found foraging out to distance d from the colony when divided by 100.

2.2.4 The cumulative proportion of birds (CPB) found foraging out to distance *d* and *d-1* from each colony for a target species was calculated using the appropriate derived logarithmic equation(s).

2.2.5 The average density of birds (of the target species i.e. common tern, lesser black-backed gull or herring gull) from each colony of a species (as tabulated in Section 9) was then calculated for that expected to occur at the 1km distance band[1] away from colony that coincides with the Project site boundary using the formula:

$$\boldsymbol{D}_i = ((\boldsymbol{CPB}_d - \boldsymbol{CPB}_{d-1}) \times \boldsymbol{C}_i) \div \boldsymbol{s}_d$$

Where:
$\boldsymbol{D}_i$ is the density of birds from colony ***i*** that would be expected to occur at the 1km distance band away from colony that coincides with the Project site boundary.

[1] i.e. of the concentric 1km bands extending out from a colony, the 1km band in which the Project site coincides.

$\boldsymbol{C}_i$ is the size of colony $\boldsymbol{i}$ of a species (for the colonies listed in Section 9).
$\boldsymbol{s_d}$ is the sea area within the concentric 1km band around a colony between d and $d-1$ km calculated using the equation:

$$\boldsymbol{s}_d = (2\pi\boldsymbol{d} - 2\pi(\boldsymbol{d}-1))$$

2.2.6 The value $\boldsymbol{D}_i$from each colony was then expressed as a proportion of the sum of densities ($\boldsymbol{D}$) using the formula:

$$\boldsymbol{P}_i = \boldsymbol{D}_i \div \sum \boldsymbol{D}$$

Where:
P_i is the proportion of the sum of densities ($\boldsymbol{D}$) at the Burbo Bank Extension's central location originating from all the colonies considered which was associated with birds from colony *i*.

2.2.7 Assuming there is no difference in the individual's susceptibility to mortality between colonies, it can be assumed that P_i represents the proportion of collisions that can be apportioned to colony *i*. It also therefore follows that P_i represents the proportion of background mortality and PBR that can be apportion to colony *i.*

3. Methods: Collision risk at the Project site

3.1.1 The predicted collision risk estimates for common tern, herring gull and lesser black-backed gull at the Project site were modelled using a worst-case scenario with the maximum number of turbines (69). Collision risk modelling was carried out for a range of avoidance rates (Table 4).

3.1.2 Further information on the approach to collision risk modelling is provided in Annex 4 to the Environmental Statement Chapter 15, Ornithology and Annex 1 to the HRA Report.

4. Methods: Potential Biological Removal

4.1.1 Following apportioning of collisions to respective SPAs for each species, Potential Biological Removal can be used to determine a sustainable level of mortality for each population.

4.1.2 PBR provides a means of estimating the number of additional mortalities that a given population can sustain. Wade (1998) and others have defined a simple formula for PBR:

$$PBR = \frac{1}{2} r_{max} N_{min} f$$

Where:
r_{max} is the maximum annual recruitment rate
N_{min} is a conservative estimate of the population size
f is a "recovery factor" applied to depleted populations where the management goal may be to facilitate growth back to a target population size

4.1.3 Wade (1998) showed that PBR can be used to identify sustainable harvest rates that would maintain populations at, or above, maximum net productivity level (MNPL or maximum sustained yield). Based on a generalised logistic model of population growth and assuming that the density

dependency in the population growth is linear (θ = 1.0) then MNPL is equivalent to 0.5K (where K is the notional carrying capacity) and the net recruitment rate at MNPL (RMNPL) is 0.5 r_{max}.

4.1.4 Wade (1998) also showed that PBR is conservative for populations with θ > 1.0 (i.e. a convex density-dependent growth curve) where RMNPL will be > 0.5 r_{max} (see Figure 1 in Wade 1998).

4.2 Estimating r_{max}

4.2.1 The maximum annual recruitment rate (r_{max}) is equivalent to λ_{max} – 1, therefore:

$$r_{max} = \lambda_{max} - 1$$

Where:
λ_{max} is the maximum discrete rate of population growth.

4.2.2 Niel & Lebreton (2005) show two methods for calculating λ_{max}:

A quadratic solution (equation 15 of Niel & Lebreton 2005) also used by Watts (2010):

$$\lambda\max \approx \frac{(s\alpha - s + \alpha + 1) + \sqrt{(s - s\alpha - \alpha - 1)^2 - 4s\alpha^2}}{2a}$$

And a relationship based on mean optimal generation length (equation 17 of Niel & Lebreton 2005):

$$\lambda\max = exp\left[\left(\alpha + \frac{s}{\lambda\max - s}\right)^{-1}\right]$$

Where:
s is annual adult survival
α is age of first breeding

4.2.3 Niel & Lebreton (2005) suggest that the second method is most suitable for short-lived species. A comparison of the results of both methods indicated that the first generated slightly more precautionary PBRs for the relatively long-lived species considered in this note. Consequently λmax has been estimated using the first method for all species below.

4.3 Estimating N_{min}

4.3.1 N_{min} is a conservative estimate of the population size. Where the population is not known or there are different estimates of its size Wade (1998) suggests using the lower bound of a 60% confidence interval. Dillingham & Fletcher (2008) provide further methods for approximating N_{min} in circumstances where there is uncertainty about the population size.

4.4 Selecting f

4.4.1 The recovery factor *f* is an arbitrary value set between 0.1 and 1.0 and its purpose is to increase conservatism in the calculation of PBR or to identify a value for PBR that is intended to achieve a specific outcome for nature conservation (eg population recovery).

4.4.2 Dillingham & Fletcher (2008) link the value of *f* to conservation status and (following IUCN status criteria) suggest that *f* = 0.1 is adopted for 'threatened' species; *f* = 0.3 for 'near threatened' species and *f* = 0.5 for species of 'least concern'. They further argue that a value of *f* = 1.0 may be suitable for species of 'least concern' that are known to be increasing or stable.

4.4.3 A similar scheme could be used for individual populations and their status in relation to specific conservation objectives.

5. Population data

5.1 Common tern population

5.1.1 Population estimates for common tern were taken from Stroud et al. (2001), with additional information on the Mersey Narrows and North Wirral Foreshore pSPA taken from the departmental brief prepared for the potential site (Natural England, 2011). Data from the JNCC SMP database[2] was considered incomplete and inappropriate to use for this species.

5.1.2 The Mersey Narrows and North Wirral Foreshore pSPA includes common terns as a qualifying species as both breeding and passage features. As such, the breeding and passage periods are considered separately in this analysis. Table 1 summarises the relevant populations within foraging range of the Project (using the range values in Thaxter et al., 2012). Table 1 presents the populations as number of individuals contra Stroud et al. (2001) which presents the information as number of pairs.

Table 1 Populations of common tern within foraging range of the Project (foraging range is calculated based on the distance between the site boundary and project boundary)

	No. of individuals	
SPA / Ramsar	Passage	Breeding
Dee Estuary	-	554
Mersey Narrows and North Wirral Foreshore	1475	354
Ribble and Alt Estuaries	-	364
Total	1475	1272

5.2 Herring gull population

5.2.1 The population of herring gull predicted to be within foraging range of the Project site was calculated using three data sources (Table 2). As with common tern populations, information from the SPA review was used (Stroud et al., 2001). An alternative and more contemporary estimation of the Morecambe Bay SPA population was taken from the JNCC SMP Database[2]. Thirdly, an estimation of the regional population, including birds outside of designated sites (local breeding colonies and SSSIs not associated with SPAs), was calculated from JNCC SMP data using guidance from Mitchell et al., (2004) and the most recently available counts on the SMP database.

[2] http://jncc.defra.gov.uk/smp/

Table 2 Populations of herring gull within foraging range of the Project (foraging range is calculated based on the distance between the site boundary and project boundary)

	No. of individuals		
SPA	SMP[3] (year of count)	SPA Review	Regional population
Morecambe Bay	4188 (2011)	22000	4188
Other sites[4]	-	-	2705
Total	4188 (2011)	22000	6893

5.3 Lesser black-backed gull population

5.3.1 Analysis of lesser black-backed gull population figures was undertaken in line with that for herring gull. SPA review data (for Bowland Fells, Morecambe Bay and Ribble & Alt Estuaries SPAs) is presented in Table 3, alongside more contemporary data from the JNCC SMP database. A regional population derived from the database is also presented using the most recently available count data including local breeding colonies that are not associated with SPAs.

Table 3 Populations of lesser black-backed gulls within foraging range of the Project (foraging range is calculated based on the distance between the site boundary and project boundary)

	No. of individuals		
SPA	SMP[1] (year of count)	SPA Review	Regional population
Bowland Fells	10937 (2011)	27800	10937
Morecambe Bay	16274 (2011)	44000	16274
Ribble and Alt Estuaries	8234 (2008)	3600	8234
Other sites[5]	-	-	7159
Total	35445	75400	42604

6. Results

6.1 Collision risk at the Project site

6.1.1 The predicted annual collision rates for the Project site are shown in Table 4. The predicted rate for the common tern, using an avoidance rate of 98%, was calculated as 17 collisions/annum. The predicted collision rate amongst the breeding population, using an avoidance rate of 98%, is 12 collisions/annum. The collision risk for the autumn passage population of common terns accounts for 5 collisions/annum. The Mersey Narrows and North Wirral Foreshore pSPA includes common terns as a qualifying species as both breeding and passage features. As such, the breeding and passage periods are considered separately in this analysis.

6.1.2 The predicted annual collision rate for herring gull at the Project site, at an avoidance rate of 98%, was calculated as 95 collisions/annum. However, 40% of predicted collisions occurred outside of

[3] http://jncc.defra.gov.uk/smp/

[4] List of sites is presented in Table 16

[5] See Table 17 for list of sites

the breeding period and as such are not considered relevant to the Morecambe Bay SPA designation for breeding herring gull. Therefore Table 4 presents breeding period collisions separately, with this figure considered most appropriate to inform the assessment.

6.1.3 The predicted annual collision rate for lesser black-backed gull at the Project site, at an avoidance rate of 98%, was calculated as 176 collisions/annum, 0.6% of predicted collisions occurred outside of the breeding period and as such is considered not relevant to the three SPAs under consideration in the Offshore Ornithology Chapter (Chapter 15) and the HRA Report. Table 4 presents breeding period collisions separately, with this figure considered most appropriate to inform the assessment.

Table 4 Predicted annual collision mortality at the Project site across a range of avoidance rates

Species	Time period of collisions	No. of collisions at a range of avoidance rates (%)				
		No avoidance	95	98	99	99.5
Common tern	Breeding period only (April - July)	587	29	12	6	3
	Autumn passage period only (August - October)	286	14	5	3	1
Herring gull	All year	4732	236	95	47	24
	Breeding period only (March - September)	2836	142	57	28	14
Lesser black-backed gull	All year	8818	440	176	88	44
	Breeding period only (March - September)	8738	437	175	87	44

6.2 Allocating collision risk to individual SPAs

6.2.1 Table 5 and Table 6 present the predicted annual collision mortality (individuals per annum) and changes in background mortality for the proportion of the populations of common tern, herring gull and lesser black-backed gull attributed to SPAs. The results are presented to show collisions for the entire year and the breeding period only. As previously stated 40% and 0.6% of predicted collisions for herring gull and lesser black-backed gull respectively occurred outside of the breeding period and as such are considered not relevant to the SPAs under considerations. Therefore the results presented for breeding period collisions are considered most appropriate to inform the assessment and are the only findings discussed in this section.

6.2.2 The cumulative bird distribution plots for foraging herring gull from a colony is more likely to be similar to that for kittiwake than gannet on consideration of their respective mean foraging range and mean maximum foraging range. For the purposes of this assessment, only minor differences exist between the predicted number of collisions that would be apportioned to Morecambe Bay SPA

when comparing the outcomes from using the model derived from kittiwake and gannet data (during the breeding season 3 collisions using the kittiwake function and 4 using the gannet function).

6.2.3 The predicted annual collision rate for herring gull during the breeding season and for birds within foraging range of the Project site (based on the populations in the SMP database), using an avoidance rate of 98%, was calculated as 57 collisions/annum. When the predicted collisions are apportioned to individual colonies, Morecambe Bay SPA is estimated to contribute no more than 4 collisions/annum to the predicted collision rate for the Project. The remaining collisions are attributed to other breeding colonies that make up the total regional population.

6.2.4 The collision risk for the regional population of lesser black-backed gulls, as presented in the SMP database at an avoidance rate of 98%, was calculated as 175 collisions/annum. Upon apportioning all but one collision was predicted to involve birds originating from the three SPAs cited for breeding lesser black-backed gulls within foraging range of the Project site (Morecambe Bay SPA, Ribble and Alt Estuaries SPA and Bowland Fells SPA).

6.2.5 When the SPAs are considered individually, Ribble and Alt Estuaries SPA contributed 94% of the predicted collisions (164 collisions/annum). No more than 2% and 4% of the predicted collisions were apportioned to Bowland Fells SPA and Morecambe Bay SPA respectively.

6.2.6 The predicted collisions for common tern at the Project site were close to being equally apportioned amongst the three SPAs cited for breeding common tern within foraging range of the Project site.

Table 5: Predicted annual collision mortality (individuals per annum) and changes in background mortality for the proportion of the populations of herring gull and lesser black-backed gull attributed to SPAs predicted to interact with the Project.

Species (Time period of collisions)	Component population[6]	Proportion of sum of densities at Burbo Bank Extension originating from all regional colonies considered[7]		No. of collisions at 98% avoidance rate apportioned to population affected		Increase in background mortality (population affected)	
		Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function
Herring gull (all year)	Morecambe Bay SPA	0.060	0.061	6	6	1.13%	1.15%
Herring gull (breeding period collisions only)	Morecambe Bay SPA	0.060	0.061	3	4	0.68%	0.69%
Lesser black-backed gull (all year)	Bowland Fells SPA Morecambe Bay SPA Ribble and Alt Estuaries SPA	0.992	0.991	175	174	5.66%	5.66%
	Bowland Fells SPA	0.020	0.023	4	4	0.38%	0.43%
	Morecambe Bay SPA	0.034	0.039	6	7	0.42%	0.48%
	Ribble and Alt Estuaries SPA	0.938	0.929	165	164	23.04%	22.83%
Lesser black-backed gull (breeding period collisions only)	Bowland Fells SPA Morecambe Bay SPA Ribble and Alt Estuaries SPA	0.992	0.991	174	173	5.63%	5.63%
	Bowland Fells SPA	0.020	0.023	4	4	0.38%	0.43%
	Morecambe Bay SPA	0.034	0.039	6	7	0.42%	0.48%
	Ribble and Alt Estuaries SPA	0.938	0.929	164	163	22.91%	22.70%

[6] Data source: JNCC SMP database

[7] See section 2.2 for explanation of kittiwake and gannet functions

Table 6: Predicted annual collision mortality (individuals per annum) and changes in background mortality for the proportion of the populations of common tern attributed to SPAs predicted to interact with Burbo Bank Extension.

Species (Time period of collisions)	Component population	Proportion of sum of densities at Burbo Bank Extension originating from all regional colonies considered	No. of collisions at 98% avoidance rate apportioned to population affected	Increase in background mortality (population affected)	Data source
Common tern (breeding period)	Ribble and Alt Estuaries SPA	0.356	4	11.75%	Stroud *et al.*, 2001
	Mersey Narrows and North Wirral Foreshore pSPA	0.347	4	11.75%	Stroud *et al.*, 2001
	Dee Estuary SPA	0.297	4	6.43%	Stroud *et al.*, 2001
Common tern (autumn passage)	Mersey Narrows and North Wirral Foreshore pSPA	1.0	5	3.39%	Stroud *et al.*, 2001

6.3 Potential Biological Removal

6.3.1 Table 7 presents the PBR results for common tern, herring gull and lesser black-backed gull for a range of recovery factors for both the regional population and SPA populations for each species.

6.3.2 With regards to common tern, it is assumed that the populations are stable within the region and that a recovery factor of 1.0 is appropriate (Brown & Grice, 2005). The population sizes stated in Table 1 have been used for the N_{min} values as a conservative estimate of population size (Wade 1998). With this assumption, for the SPA populations the PBR value for common tern is 97 birds for the breeding population and 112 for the passage population.

6.3.3 For herring gull using the data for the Morecambe Bay SPA from the SMP database (N_{min} of 4188) at a recovery rate of 0.5, PBR was calculated as 140 birds (compared to 737 birds for the population detailed in Stroud et al., 2001). For the regional population, the calculated PBR value was 231 birds.

6.3.4 For lesser black-backed gull populations, using the data for SPAs from the SMP database at a recovery factor of 0.5, PBR was calculated as 1049 birds. For the SPA populations, taken from Stroud et al. (2001), PBR was calculated as 2232 birds. The regional population derived from the SMP database has a PBR calculated at 1261 birds. An *f* value of 0.5 was used for all populations, due to the inter-connectivity between the breeding sites.

Table 7: PBR values for populations of common tern, herring gull and lesser black-backed gull predicted to interact with the Project.

Species	Reference population	Age of first breeding (α)[8]	Annual adult survival (s)[9]	Growth rate (λ_{max})	N_{min}	f_r	PBR	PBR rounded to nearest decimal place	Reference for population size
Common tern - Breeding	Dee Estuary SPA Mersey Narrows and North Wirral Foreshore pSPA Ribble and Alt Estuaries SPA	3	0.9	1.15	1272	0.1	9.7	10	Stroud *et al.* (2001)
						0.2	19.4	19	
						0.3	29.1	29	
						0.4	38.7	39	
						0.5	48.4	48	
						1.0	96.8	97	
Common tern - Breeding	Dee Estuary SPA	3	0.9	1.15	554	0.1	4.21	4	Stroud *et al.* (2001)
						0.2	8.44	8	
						0.3	12.65	13	
						0.4	16.87	17	
						0.5	21.09	21	
						1.0	42.18	42	
Common tern - Breeding	Mersey Narrows and North Wirral Foreshore pSPA	3	0.9	1.15	354	0.1	2.70	3	Stroud *et al.* (2001)
						0.2	5.39	5	
						0.3	8.09	8	
						0.4	10.8	11	
						0.5	13.5	14	
						1.0	27.0	27	
Common tern - Breeding	Ribble and Alt Estuaries SPA	3	0.9	1.15	364	0.1	2.77	3	Stroud *et al.* (2001)
						0.2	5.54	6	

[8] Taken from Robinson (2005)

[9] Taken from Robinson (2005)

Species	Reference population	Age of first breeding (α)[8]	Annual adult survival (s)[9]	Growth rate (λ_{max})	N_{min}	f_r	PBR	PBR rounded to nearest decimal place	Reference for population size
						0.3	8.31	8	
						0.4	11.1	11	
						0.5	13.9	14	
						1.0	27.7	28	
Common tern - Passage	Mersey Narrows and North Wirral Foreshore pSPA	3	0.9	1.15	1475	0.1	11.2	11	Natural England, 2011
						0.2	22.5	23	
						0.3	33.7	34	
						0.4	44.9	45	
						0.5	56.1	56	
						1.0	112.3	112	
Herring gull (SPA-SMP)	Morecambe Bay SPA[10]	4	0.88	1.13	4188	0.1	28.1	28	JNCC SMP database
						0.2	56.1	56	
						0.3	84.2	84	
						0.4	112.2	112	
						0.5	140.3	140	
						1.0	280.5	281	
Herring gull (SPA-2001 Review)	Morecambe Bay SPA	4	0.88	1.13	22000	0.1	147.4	147	Stroud *et al.* (2001)
						0.2	294.7	295	
						0.3	442.1	442	
						0.4	589.4	589	
						0.5	736.8	737	
						1.0	1473.5	1474	
Herring gull (Regional pop.)	Multiple sites from SMP database[11]	4	0.88	1.13	6893	0.1	46.2	46	JNCC SMP database
						0.2	92.3	92	

[10] Morecambe Bay SPA herring gull population data SMP, 2011

Species	Reference population	Age of first breeding (α)[8]	Annual adult survival (s)[9]	Growth rate (λ_{max})	N_{min}	f_r	PBR	PBR rounded to nearest decimal place	Reference for population size
	(Regional population)					0.3	138.5	139	
						0.4	184.7	185	
						0.5	230.8	231	
						1.0	461.7	462	
Lesser black-backed gull (SPA-SMP)	Bowland Fells SPA[12] Morecambe Bay SPA[13] Ribble and Alt Estuaries SPA[14]	4	0.913	1.12	35445	0.1	209.9	210	JNCC SMP database
						0.2	419.7	420	
						0.3	629.6	630	
						0.4	839.5	840	
						0.5	1049.3	1049	
						1.0	2098.7	2099	
Lesser black-backed gull (SPA – 2001 Review)	Bowland Fells SPA Morecambe Bay SPA Ribble and Alt Estuaries SPA	4	0.913	1.12	75400	0.1	446.4	446	Stroud *et al.* (2001)
						0.2	892.9	893	
						0.3	1339.3	1339	
						0.4	1785.8	1786	
						0.5	2232.2	2232	
						1.0	4464.4	4464	
Lesser black-backed gull	Multiple sites from SMP database[15]	4	0.913	1.12	42604	0.1	252.3	252	JNCC SMP database
						0.2	504.5	505	

[11] Morecambe Bay SPA herring gull population data SMP, 2011

[12] Bowland Fells SPA lesser black-backed gull population – 10,937 birds, SMP 2011

[13] Morecambe Bay SPA lesser black-backed gull population – SMP South Walney 2011 (16,274 birds)

[14] Ribble and Alt Estuaries SPA lesser black-backed gull population – 8,234 birds, SMP 2008

[15] See Table 17 for list of sites

Species	Reference population	Age of first breeding (α)[8]	Annual adult survival (s)[9]	Growth rate (λ_{max})	N_{min}	f_r	PBR	PBR rounded to nearest decimal place	Reference for population size
(Regional pop.)	(Regional population)					0.3	756.7	757	
						0.4	1009.0	1009	
						0.5	1261.3	1261	
						1.0	2522.6	2523	
Lesser black-backed gull	Bowland Fells SPA	4	0.913	1.12	10937	0.1	64.8	65	JNCC SMP database
						0.2	129.5	130	
						0.3	194. 3	194	
						0.4	259.1	259	
						0.5	323.8	324	
						1.0	647.6	648	
Lesser black-backed gull	Morecambe Bay SPA	4	0.913	1.12	16274	0.1	96.4	96	JNCC SMP database
						0.2	192.7	193	
						0.3	289.1	289	
						0.4	385.4	385	
						0.5	481.8	482	
						1.0	963.6	964	
Lesser black-backed gull	Ribble and Alt Estuaries SPA	4	0.913	1.12	8234	0.1	48.8	49	JNCC SMP database
						0.2	97.5	98	
						0.3	146.3	146	
						0.4	195.1	195	
						0.5	243.7	244	
						1.0	487.5	488	

7. Cumulative assessment

7.1 Introduction

7.1.1 A cumulative assessment of lesser black-backed gull collisions was undertaken using data available from other wind farm sites in the Irish Sea. This further informs the assessment of the Project particular with reference to impacts on the Ribble and Alt Estuaries SPA.

7.2 Methodology

7.2.1 Using the method described in section 2.2, collision risk estimates at five offshore wind farms being considered within the cumulative impact assessment were apportioned to individual SPAs for lesser black-backed gull. For reasons discussed in section 6.1.3, only the breeding period collisions were considered in this section. It should also be noted that with the exception of the Project site and Walney Extension, the collisions are apportioned between the individual SPAs only and do not include the local breeding colonies that are not associated with SPAs. The number of collisions apportioned to each SPA are therefore likely to be over-estimates.

7.2.2 The five sites included in the analysis in addition to the Project site are:

- West of Duddon Sands;
- Walney I and II;
- Walney Extension;
- Ormonde; and
- Rhiannon (Celtic Array).

7.2.3 Walney I and II and Ormonde are currently operational, while West of Duddon Sands is under construction. Walney Extension and Rhiannon are proposed projects in the pre-application phase. The predicted number of collisions at 98% avoidance for each wind farm and the data source are found in Table 8.

7.2.4 For the purposes of this analysis, only three breeding colonies from which birds are predicted to interact with the Project site and the other wind farms were considered when allocating birds to breeding colonies. These sites are Bowland Fells SPA, Ribble & Alt Estuaries SPA and Morecambe Bay SPA. In taking this approach, the contribution of each SPA to the collision risk may be over-estimated given other local breeding colonies lie within the species mean maximum foraging range (141 km), these sites are listed in Table 17 Section 9 of this Annex.

7.3 Results

7.3.1 Tables 9-14 presents the predicted annual collision mortality (individuals per annum) and changes in background mortality for the proportion of the populations of lesser black-backed gull attributed to SPAs predicted to interact with the Project site and five neighbouring wind farms in the Irish Sea for which data are available. Table 15 summarises these figures.

7.3.2 A total of 225 lesser black-backed gulls were considered to potentially be lost to the Ribble and Alt Estuaries population per annum. This represents 2.7% of the current colony size (JNCC SMP figures).

8. References

Brown, A. and Grice, P. (2005). Birds in England, A & C Black Publishers Ltd, London.

Centrica Energy (2012). Irish Sea Zone Zonal Appraisal and Planning Report: Chapter 13 Ornithology. Centric Energy Limited

Dillingham, P.W. and Fletcher, D. (2008). 'Estimating the ability of birds to sustain additional human-caused mortalities using a simple decision rule and allometric relation-ships', Biological Conservation, 141, pp. 1783-1792.

DONG Energy (2006). Walney Offshore Windfarm: Environmental Statement

Ecology Consulting (2006). Ormonde Proposed Offshore Wind Farm: Ornithological Impact Assessment. Report to Ormonde Energy Ltd.

Mitchell, P I, Newton, S, Ratcliffe, N. and Dunn, T E. (2004). Seabird populations of Britain and Ireland (Results of the Seabird 2000 Census 1998-2000). T&D Poyser, London, UK: 511pp.

Natural England (2011). Departmental Brief: Mersey Narrows and North Wirral Fore-shore. Potential Special Protection Area and Proposed Ramsar site. [Online]. Available at: http://www.naturalengland.org.uk/ourwork/consultations/merseynarrows.aspx

Niel, C. and Lebreton, J-D. (2005). 'Using Demographic Invariants to Detect Overharvest-ed Bird Populations from Incomplete Data', Conservation Biology, 19 (3), pp. 826-835.

Robinson, R.A. (2005). BirdFacts: profiles of birds occurring in Britain & Ireland (BTO Research Report 407). BTO, Thetford (http://www.bto.org/birdfacts, accessed on 04/02/2013)

RPS (2006). Walney Offshore Windfarm: Ornithological Impact Assessment. RPS, St Ives.

RSKENSR Ltd (2006). West of Duddon Sands Offshore Wind Farm: Environmental Statement. Report to Morecambe Wind Ltd.

Stroud, D.A., Chambers, D., Cook, S., Buxton, N., Fraser, B., Clement, P., Lewis, P., McLean, P., Baker, H. and Whitehead, S. (2001). The UK SPA network: its scope and content – Volume 2: Species accounts, Joint Nature Conservation Committee, Peterborough.

Thaxter, C.B., Lascelles, B., Sugar, K., Cook, A.S.C.P., Roos, S., Bolton, M., Langston, R.H.W. and Burton, N.H.K. (2012). 'Seabird foraging ranges as a preliminary tool for identifying candidate Marine Protected Areas', Biological Conservation.

Wade, P.R. (1998). 'Calculating Limits to the Allowable Human-Caused Mortality of Ceta-ceans and Pinnipeds', Marine Mammal Science, 14 (1), pp. 1-37.

Watts, B. D. (2010). Wind and waterbirds: establishing sustainable mortality limits within the Atlantic Flyway. Center for Conservation Biology Technical Report Series, CCBTR-10-05. College of William and Mary / Virginia Commonwealth University, Williamsburg, VA. 43ppBrown, A. and Grice, P. (2005). *Birds in England.* A & C Black Publishers Ltd, London.

Table 8 Predicted collision risks of lesser black-backed gull for Burbo Bank Extension and five other wind farms in the Irish Sea during the breeding period.

Site	Collisions at 98%	Source / notes
Burbo Bank Extension	175	Burbo Bank Extension ES
Walney I & II	87	RPS (2006); DONG Energy (2006). Based on proportion of birds recorded in breeding period which is then applied to total collision risk
West of Duddon Sands	128	RSKENSR (2006)
Ormonde	48	Ecology Consulting (2006); based on precautionary proportion of birds recorded in breeding season which is applied to annual collision rate
Rhiannon	132	Centrica Energy (2012)
Walney Extension	20	
Total	590	

Table 9 Predicted annual collision mortality (individuals per annum) for the proportion of the populations of lesser black-backed gull attributed to SPAs predicted to interact with the Rhiannon offshore wind farm during the breeding period

Species	Component population*	Proportion of sum of densities at Rhiannon originating from 3 SPA colonies considered		No. of collisions at 98% avoidance rate apportioned to population affected		Change in background mortality (population affected)		% of PBR	
		Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function
Lesser black-backed gull	Bowland Fells SPA	0.187	0.188	24.6	24.8	2.58%	2.60%	7.60%	7.65%
	Morecambe Bay SPA	0.535	0.534	70.6	70.5	4.98%	4.98%	14.64%	14.63%
	Ribble and Alt Estuaries SPA	0.279	0.279	36.8	36.8	5.14%	5.13%	15.11%	15.09%

* Data source: JNCC SMP database

Table 10 Predicted annual collision mortality (individuals per annum) for the proportion of the populations of lesser black-backed gull attributed to SPAs predicted to interact with the Walney Extension offshore wind farm during the breeding period

Species	Component population*	Proportion of sum of densities at Walney Extension originating from all regional colonies considered		No. of collisions at 98% avoidance rate apportioned to population affected		Change in background mortality (population affected)		% of PBR	
		Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function
Lesser black-backed gull	Bowland Fells SPA	0.066	0.068	1.3	1.4	0.14%	0.14%	0.41%	0.42%
	Morecambe Bay SPA	0.718	0.712	14.4	14.2	1.01%	1.01%	2.98%	2.96%
	Ribble and Alt Estuaries SPA	0.072	0.074	1.5	1.5	0.20%	0.21%	0.59%	0.61%

* Data source: JNCC SMP database

Table 11 Predicted annual collision mortality (individuals per annum) for the proportion of the populations of lesser black-backed gull attributed to SPAs predicted to interact with the West of Duddon Sands offshore wind farm during the breeding period

Species	Component population*	Proportion of sum of densities at West of Duddon Sands originating from 3 SPA colonies considered		No. of collisions at 98% avoidance rate apportioned to population affected		Change in background mortality (population affected)		% of PBR	
		Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function
Lesser black-backed gull	Bowland Fells SPA	0.064	0.067	8.2	8.6	0.86%	0.91%	2.53%	2.67%
	Morecambe Bay SPA	0.835	0.828	106.9	106.0	7.55%	7.49%	22.2%	22.0%
	Ribble and Alt Estuaries SPA	0.101	0.105	12.9	13.4	1.80%	1.87%	5.30%	5.50%

* Data source: JNCC SMP database

Table 12 Predicted annual collision mortality (individuals per annum) for the proportion of the populations of lesser black-backed gull attributed to SPAs predicted to interact with the Ormonde offshore wind farm during the breeding period

Species	Component population*	Proportion of sum of densities at Ormonde originating from 3 SPA colonies considered		No. of collisions at 98% avoidance rate apportioned to population affected		Change in background mortality (population affected)		% of PBR	
		Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function
Lesser black-backed gull	Bowland Fells SPA	0.037	0.040	1.8	1.9	0.19%	0.20%	0.55%	0.60%
	Morecambe Bay SPA	0.930	0.924	44.6	44.3	3.15%	3.13%	9.26%	9.20%
	Ribble and Alt Estuaries SPA	0.033	0.036	1.6	1.7	0.22%	0.24%	0.66%	0.71%

* Data source: JNCC SMP database

Table 13 Predicted annual collision mortality (individuals per annum) for the proportion of the populations of lesser black-backed gull attributed to SPAs predicted to interact with the Walney I & II offshore wind farms during the breeding period

Species	Component population*	Proportion of sum of densities at Walney I & II originating from 3 SPA colonies considered		No. of collisions at 98% avoidance rate apportioned to population affected		Change in background mortality (population affected)		% of PBR	
		Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function
Lesser black-backed gull	Bowland Fells SPA	0.070	0.074	6.1	6.4	0.64%	0.67%	1.89%	1.98%
	Morecambe Bay SPA	0.852	0.846	74.2	73.6	5.24%	5.20%	15.4%	15.3%
	Ribble and Alt Estuaries SPA	0.077	0.080	6.7	7.0	0.93%	0.97%	2.76%	2.86%

* Data source: JNCC SMP database

Table 14 Predicted annual collision mortality (individuals per annum) for the proportion of the populations of lesser black-backed gull attributed to SPAs predicted to interact with the Project site during the breeding period

Species	Component population*	Proportion of sum of densities at the Project site originating from all regional colonies considered		No. of collisions at 98% avoidance rate apportioned to population affected		Change in background mortality (population affected)		% of PBR	
		Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function	Kittiwake function	Gannet function
Lesser black-backed gull	Bowland Fells SPA	0.020	0.023	3.6	4.1	0.38%	0.43%	1.10%	1.26%
	Morecambe Bay SPA	0.034	0.039	6.0	6.8	0.42%	0.48%	1.23%	1.40%
	Ribble and Alt Estuaries SPA	0.938	0.929	164.1	162.6	22.9%	22.7%	67.3%	66.7%

* Data source: JNCC SMP database

Table 15 Predicted annual collision mortality (individuals per annum) for the proportion of the populations of lesser black-backed gull attributed to SPAs predicted to interact with six Irish Sea wind farms during the breeding period and PBR values for each SPA.

Sites	Collision numbers*							
	Burbo Bank Extension	Walney I & II	West of Duddon Sands	Ormonde	Walney Extension	Rhiannon	Total	PBR
Ribble and Alt Estuaries SPA	164	7	13	2	2	37	225	244
Morecambe Bay SPA	6	74	107	45	14	71	317	482
Bowland Fells SPA	4	6	8	2	1	25	46	324

* The values presented here are rounded values from Tables 9 to 14.

9. JNCC SMP Database – sites included in regional figures

Table 16 Sites from the JNCC SMP database within foraging range of the Project site and included in regional population estimate for herring gull.

County	SMP site
Clwyd	Colwyn Bay Town
	Kinmel Bay
	Llandulas Quarries
	Llawndy
	Rhyl
Cumbria	Barrow-in-Furness
Gwynedd	Bangor Buildings
	Beaumaris
	Conwy Mountain
	Conwy Town
	Deganwy Town
	Llandudno Town
	Puffin Island
	RSPB Conwy
Lancashire	Belmont Reservoir
	Bowland Fells SPA
	Fleetwood Town
	Heysham Power Station
	Layton Industrial Estate
	Morecambe Bay SPA
	Morecambe Gas Platform
	RSPB Leighton Moss
	Victoria Hospital
Merseyside	Liverpool Buildings
	Netherton
	Seaforth Nature Reserve

Table 17 Sites from the JNCC SMP Database within foraging range of the Project site and included in regional population estimate for lesser black-backed gull.

County	SMP site
Clwyd	Llandulas Quarries
	Prestatyn
	Rhyl
Cumbria	Arnaby Marsh
	Askam-in-Furness
	Barrow-in-Furness
	Cleator Moor
	Costrells Rocks

County	SMP site
	Crummock Water
	Derwent Water
	Greenside Quarry/Kendall Fell Quarry
	Hardendale Quarry
	Haverigg Prison
	Hen Holme and Lady Holme
	Hensingham
	Hodbarrow RSPB
	Lillyhall
	Marchon Chemical Works
	Millom
	Morecambe Bay SPA
	Moresby Parks
	Mossbay
	Ribble & Alt Estuaries SPA
	Ridding Bay
	Rowrah Quarry
	RSPB Haweswater
	Salterbeck
	Salterhall Quarry
	Sellafield
	Silver Holme
	Stickle Tarn
	Thirlmere
	Ulverston
	Walney Urban gulls
	Wet Sleddale Reservoir
	Whitehaven
	Workington Town
Dyfed	Aberystwyth
Gwynedd	Aberdovey Quarry
	Bangor Buildings
	Bardsey Island
	Beaumaris
	Bodorgan Head
	Caernarfon
	Carreg Chwislen
	Conwy Town
	Deganwy Town
	East Mouse
	Ebolion
	Freshwater Bay
	Llandudno Town

County	SMP site
	Llyn Conwy
	Llyn Elsi
	Middle Mouse
	Pen y Cil
	Penllyn to Gogarth
	Puffin Island SPA
	Rhoscolyn Beacon
	RSPB Conwy
	South Stack
	The Skerries
	Trwyn Penrhyn
	Valley Wetlands
	West Mouse
	Ynys Dulas
	Ynys Moelfre
	Ynysoedd Gwylan
	Ynys Piod
	Ynys Traws
Isle of Man	Calf of Man
	Clay Head
	Da Leura Strands
	Dhoon
	Doughlas
	Eairnyerey
	Fleshwick
	Glen Maye
	Peel
	Phurt
	Port - St Mary
	Port Grenaugh
	Port Mooar
	Port Soderick
	Ramsey
	Stroin Vuigh
	The Ayres
Lancashire	Belmont Reservoir
	Bowland Fell SPA
	Fleetwood Town
	Heysham Power Station
	Layton Industrial Estate
	Morecambe Town
	Thornton - Cleveleys
Merseyside	Liverpool Buildings
	Netherton

County	SMP site
	Seaforth Nature Reserve

DONG Energy

January 2013

Burbo Bank Extension Offshore Wind Farm

Red-throated diver displacement

NIRAS Consulting Ltd
Sheraton House, Castle Hill
Cambridge CB3 0AX, UK

Reg. No.: 07470870
England & Wales
www.niras.com/uk

T: +44 (0)1223 370181
F: +44 (0)1223 370040
@: rwa@niras.com

Document Control

NIRAS Project Number	N0034
Document Title	Burbo Bank Extension Offshore Wind Farm: Red-throated diver displacement
Status	Final
Client	DONG Energy
Client Project No (if applicable)	
Client Contact Name	Jennifer Brack

The following personnel are designated contacts for queries relating to this document:

Name	Job Title	Telephone	Email
Robin Ward	Senior Ornithologist	01223 370181	rwa@niras.com

Revision Status for Issue

	Name	Date
Checked by	Tim Norman	07/01/2013
Accepted by	Ian Ellis	08/01/2013

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1. Introduction

The proposed Burbo Bank Extension offshore wind farm is located in the Liverpool Bay SPA (Chart 1) and the displacement of red-throated diver, an interest feature of this SPA, has been identified as a potential impact.

Liverpool Bay SPA was formally designated in August 2010 due to its importance for wintering populations of seabirds, particularly common scoter and red-throated diver. The site supports over 1% of the Great Britain population of the Annex 1 listed (on the EC directive on the Conservation of Wild Birds 79/409/EEC) red-throated diver, with a mean peak count of 922 individuals recorded over the period 2001/02 – 2005/06. This accounts for 5.4% of the total estimated British wintering population. The species occurs throughout Liverpool Bay SPA with highest densities occurring off the Ribble Estuary, North Wales and the North Wirral Foreshore (Webb *et al.*, 2006).

In a review of the sensitivity of seabird species to offshore wind farms, Furness and Wade (2012) found that red-throated divers had the second highest sensitivity score. Potential effects on the species include displacement due to disturbance from the turbines or from maintenance activities.

Further to consultation with Natural England, it was agreed that the magnitude of potential red-throated diver displacement from Burbo Bank Extension would be analysed in detail. This report quantifies this potential displacement effect, using different displacement scenarios, and considers the implication for the red-throated diver populations of the Liverpool Bay SPA and the wider Irish Sea area. The report also details cumulative impact assessment methodology and results using historical JNCC aerial data as the basis for a SPA wide study.

2. Methodology

2.1. Potential displacement

The magnitude of potential displacement effects on red-throated divers at Burbo Bank Extension has been quantified using a similar methodology to that used to assess the impact of London Array Offshore Wind Farm on the Outer Thames Estuary SPA red-throated diver population. In addition, a variation of this approach has also been employed which uses information about displacement effects obtained from Kentish Flats Offshore Wind Farm (Pizzola, 2011).

Table 1 summarises the assumptions about the proportions of birds displaced in the approach used at London Array and Kentish Flats Extension.

To calculate the numbers of birds displaced, the density of red-throated divers expected to be present in each of the regions within and around the wind farm was calculated using site specific aerial survey data. The data used were calculated densities from six site specific surveys using aerial digital imagery of the Burbo Bank Extension Offshore Wind Farm site during the period November 2010 to April 2011, undertaken by Aarhus University (Petersen *et al.*, 2011). The number of birds displaced from each of the regions was calculated (using the assumptions in Table 1) and summed to estimate the total number of birds expected to be displaced by the wind farm.

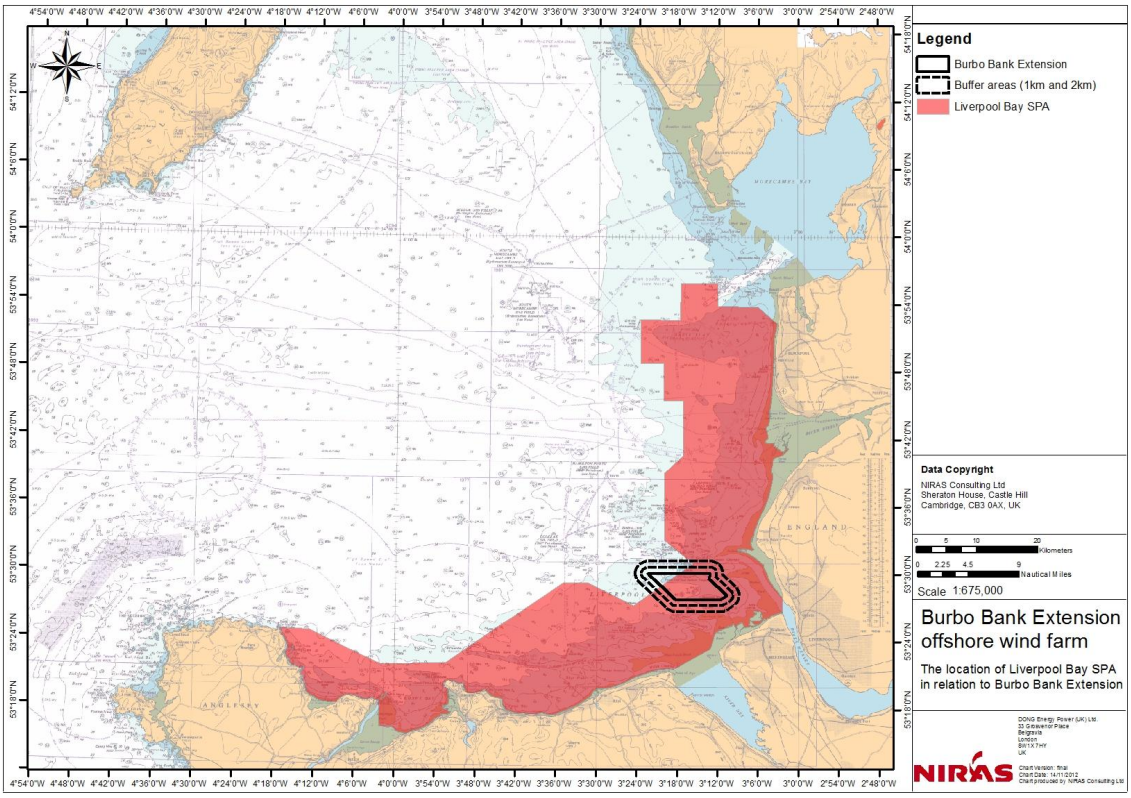

Chart 1: The location of Burbo Bank Extension Offshore Wind Farm in relation to Liverpool Bay SPA

Table 1: Approaches to estimating the magnitude of displacement effects.

Region	Proportion of birds displaced	
	'London Array' approach	'Kentish Flats' approach
Project area	100%	94%
0-500m	50%	83%
500 – 1000m	50%	77%
1000 – 2000m	0%	59%

2.2. Displacement scenarios

It is expected that displaced birds will relocate to habitat adjacent to the wind farm and elsewhere within the SPA and its surrounding waters. The capacity of these habitats to accommodate additional birds will depend on the existing density of divers within receptor areas.

The consequences of displacement have been explored through different assumptions about the way in which birds relocate to receptor habitats. The initial scenario explored was that all birds displaced could relocate to all remaining parts of the Liverpool Bay SPA. Assuming that divers only relate to the SPA is precautionary as it takes no account of the availability habitats elsewhere that may be suitable for this species. It was assumed that displaced divers would redistribute to any part of the SPA, although only to those areas already known to support divers (as indicated by aerial survey data). A more restrictive series of scenarios is that relocation within the SPA is restricted by flight distance. Four different scenarios have been used for this purpose which with the original scenario are:

Scenario 1 – displaced birds could relocate to all remaining parts of Liverpool Bay SPA

Scenario 2 – displaced birds could relocate to all remaining parts of Liverpool Bay SPA within 10km

Scenario 3 – displaced birds could relocate to all remaining parts of Liverpool Bay SPA within 20km

Scenario 4 – displaced birds could relocate to all remaining parts of Liverpool Bay SPA within 40km

Scenario 5 – displaced birds could relocate to all remaining parts of Liverpool Bay SPA within 60km

The five proposed receptor buffer areas (SPA, 10, 20, 40 and 60 km) are shown in Chart 2. The extent of each of the proposed receptor buffer areas is measured from the boundary of the Burbo Bank Extension wind farm.

2.3. Density of divers within receptor habitats

Data from 22 aerial surveys conducted between December 2001 and February 2007 (Table 2), provided by Joint Nature Conservation Committee (JNCC), was analysed to provide overall mean red-throated diver densities for 4 km^2 grid squares within the Liverpool Bay and adjacent sea areas. These densities were not corrected for distance related detection errors i.e. they are 'observed' densities. Each grid square in Liverpool Bay SPA was assigned to one of four density categories (**None**, **Low**, **Medium** and **High**) with the category boundaries for occupied squares calculated so as to provide an arbitrarily even three way split in the number of birds counted within each occupied category as is possible (Chart 6). The category boundaries were defined by initially calculating the mean number of birds of each 4 km^2 grid square (density multiplied by 4) and summating these to provide a total number of birds for Liverpool Bay SPA. The 4 km^2 grid squares in Liverpool Bay SPA were sorted by density in descending order and a corresponding cumulative running total calculated of the mean number of birds counted. All 4 km^2 grid squares contributing to the first third of the cumulative running total were assigned to and defined the range of the High density category, as was the next third for the Medium density category, and final third for the Low density category (Table 3). Although some of the densities presented in this analysis are described as High, in relation to red-throated diver densities elsewhere around the UK coast they are considerably lower (see later).

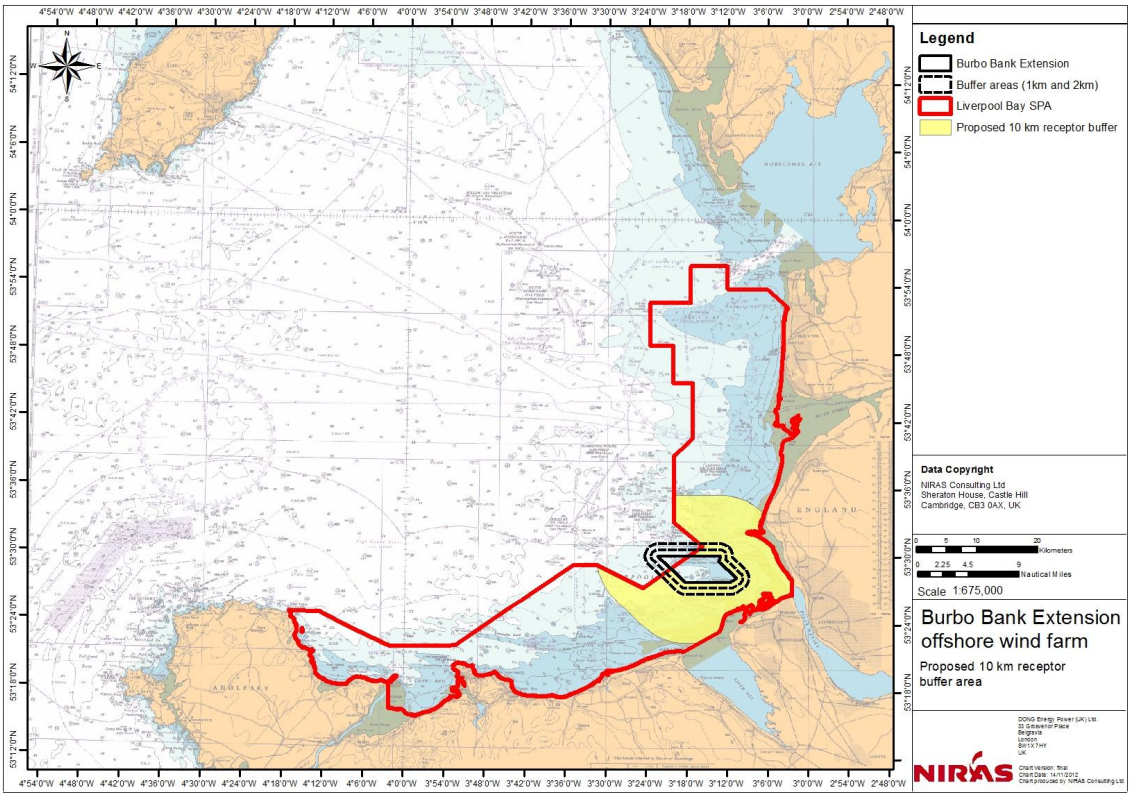

Chart 2: Burbo Bank Extension and the proposed 10km receptor buffer area used for displacement analysis of red-throated diver

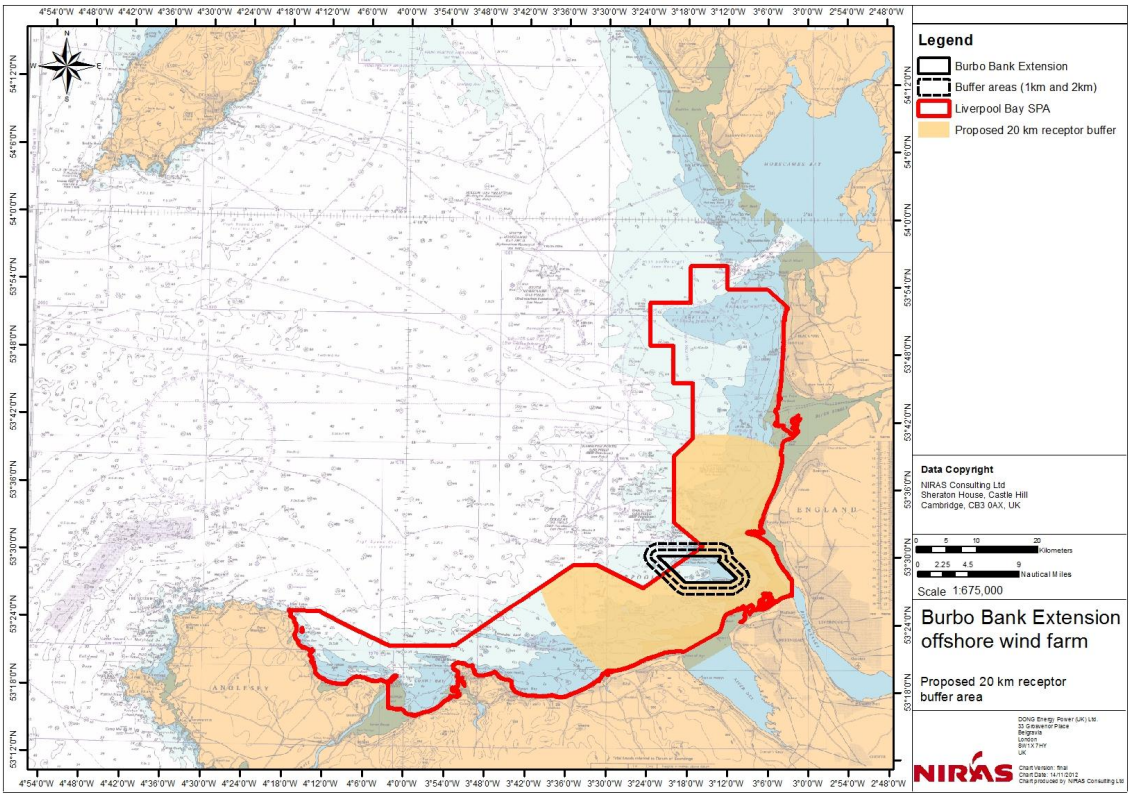

Chart 3: Burbo Bank Extension and the proposed 20km receptor buffer areas used for displacement analysis of red-throated diver

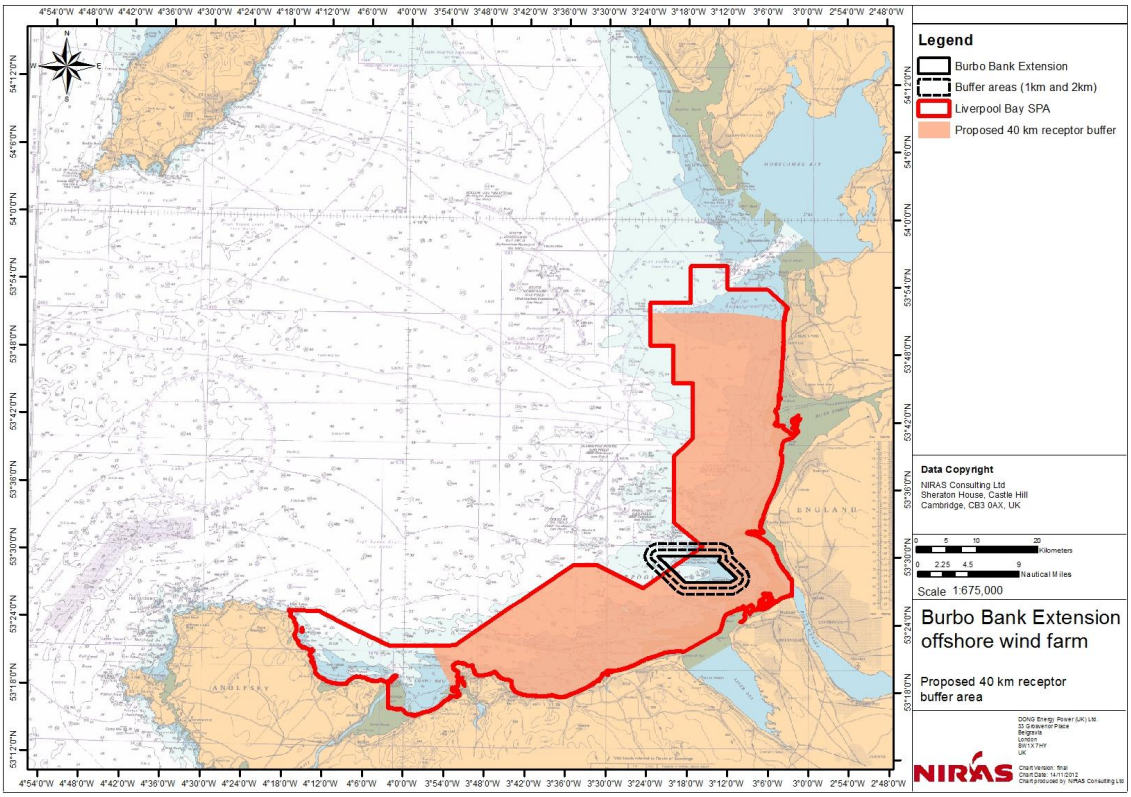

Chart 4: Burbo Bank Extension and the proposed 40km receptor areas used for displacement analysis of red-throated diver

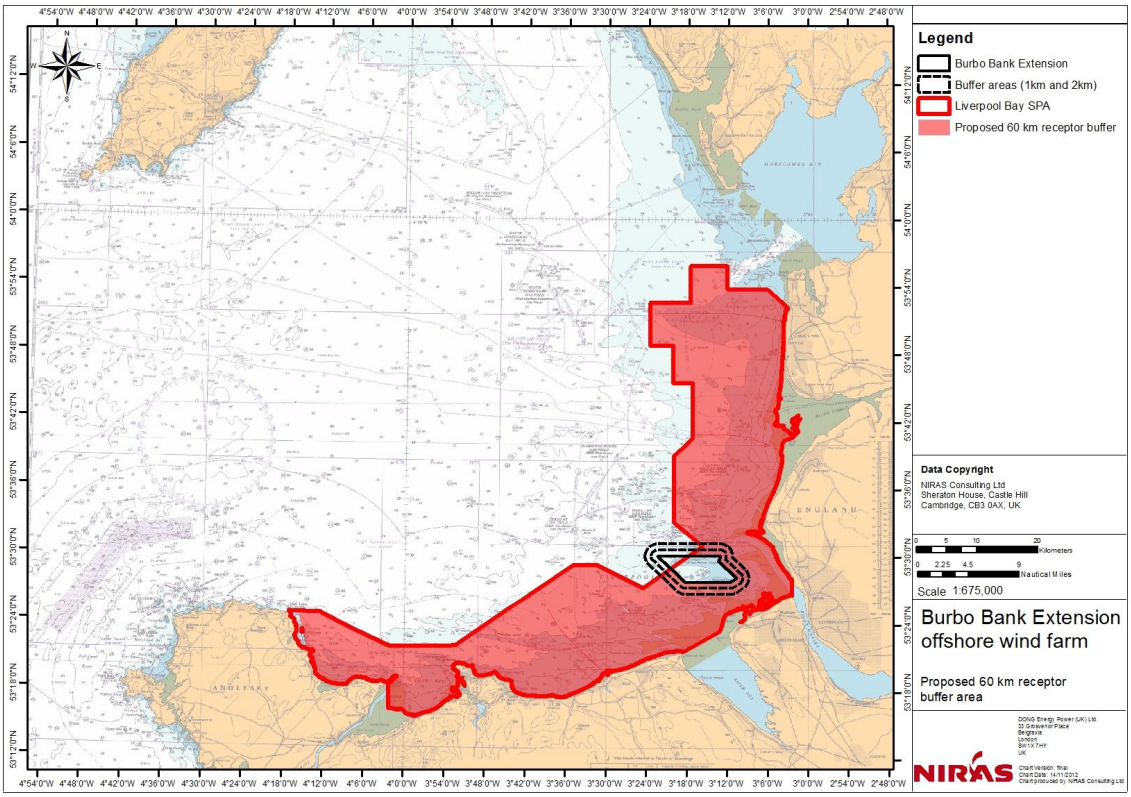

Chart 5: Burbo Bank Extension and the proposed 60km receptor buffer area used for displacement analysis of red-throated diver

Table 2. The number of JNCC Aerial Surveys of Liverpool Bay SPA by month and year.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2001												1
2002	1	1	1	1							1	
2003	1	1										
2004										1	1	1
2005	1	1	1							1	1	1
2006	1	1	1									
2007	1	1										

Table 3. The ranges for density categories used as an indicator of habitat quality.

Density categories	Observed density range (no. of birds/km^2)
None	0
Low	0.0001 – 0.1049
Medium	0.105 – 0.189
High	0.190 – 1.0

The grid squares within Liverpool Bay SPA and four proposed receptor buffers around Burbo Bank Extension (10, 20, 40 and 60 km) were identified. The densities of divers in those squares were collated into one dataset for each proposed receptor buffer to provide an area into which divers from Burbo Bank Extension could be displaced. Grid squares were included in a proposed receptor buffer area only if the centroid of the square fell within the boundary.

2.4. Displacement scenarios modified by receptor habitats

It can be expected that quality of habitat will modify the relocation of displaced birds across a proposed receptor buffer so as to depart from equality i.e. bird density will not uniformly increase across those areas receiving displaced birds. It is also a reasonable assumption that numbers of birds in an area is a surrogate for quality of habitat. Higher quality habitat attracts higher densities of birds until no more can be supported i.e. it is at carrying capacity. Furthermore, those birds in higher density areas are more likely to be at a greater competitive advantage (or higher dominance) to those individuals residing in areas of lower bird densities. For the purposes of this analysis, it is assumed that habitat within the proposed receptor buffers is not at or will not reach during displacement, carrying capacity for divers[1].

Based upon the above stated expectations, the final step of the analysis was to restrict the relocation of birds so that displaced birds from each density category (Table 3) were only relocated to identical habitat within the proposed receptor buffer. This was applied to each of the five above listed scenarios (see section

[1] The carrying capacity of the receptor buffers are unknown with such quantification a challenge when attempted for much simpler habitats in which to measure the required parameters.

2.2), thus imposing an additional restrictive and further realistic level of conditions to the relocation of birds already restricted by flight distance. The total number of displaced birds by the wind farm from each region (using the assumptions in Table 1) was apportioned to density categories in the same ratio as for those grid squares whose centroids lie within the respective region. No 4 km^2 grid square centroid is located within the 0-500m region. The total displaced birds from the 0-500m region was therefore apportioned to density categories in a ratio equating to that of grid squares whose centroids lie in the 500-1km region.

2.5. Comparison of scenarios

In a synthesis of the results, the two approaches and five scenarios are compared on the basis of change in the density of divers in each habitat. The relocation of displaced birds is assumed to be constrained by the quality of available habitat. It is expected that such a comparative analysis will highlight how the interaction between size of area into which divers are displaced and the availability of habitat differentially influences the extent of change in density of red-throated divers in each habitat from the existing baseline.

3. Results

3.1. Numbers of birds potentially displaced

The results from the two approaches used for displacement analysis are shown in Table 4 and Table 5. Using the London Array displacement approach a total of 47.18 divers would be displaced from Burbo Bank Extension and a 1 km buffer around the site. Using the Kentish Flats displacement approach a total of 75.72 divers would be displaced from Burbo Bank Extension and a 2 km buffer.

Table 4: London Array displacement approach for red-throated diver at Burbo Bank Extension

Area	Peak density (no. of birds/km^2)	Total abundance	% displaced	Total displaced	% SPA population displaced
Project site	1.06	41.83	100	41.83	4.54
1 km buffer	0.32	10.70	50	5.35	0.58
Total	**1.38**	**52.53**	**N/A**	**47.18**	**5.12**

Table 5: Kentish Flats displacement approach for red-throated diver at Burbo Bank Extension

Area	Peak density (no. of birds/km^2)	Total abundance	% displaced	Total displaced	% SPA population displaced
Project site	1.06	41.84	94	39.33	4.27
500 m buffer	0.39	6.18	83	5.13	0.56
500 m – 1 km buffer	0.27	9.09	77	7.00	0.76
1 km – 2 km buffer	0.56	41.12	59	24.26	2.63
Total	**2.28**	**98.23**	**N/A**	**75.72**	**8.22**

3.2. Density assignment

The survey area, Liverpool Bay SPA, was divided into 431 grid squares each of 4 $km^2$and of which 430 were surveyed. The observed density of red-throated divers in each these grid squares as indicated by aerial survey data, was categorised as indicated in Table 6. The number of grid squares in each category has also been calculated. Chart 6 shows the distribution of divers in Liverpool Bay SPA, colour coded by the categories of mean observed densities (Table 3), including Burbo Bank Extension and the associated buffers.

The average observed density of red-throated diver within Burbo Bank Extension and a 1 km buffer was 0.056 birds / km^2 (**i.e. Low** density) with the average observed density for Burbo Bank Extension and a 2 km buffer being 0.053 birds / km^2 (**Low** density).

Table 6: The density categories used for displacement analysis of red-throated diver at Burbo Bank Extension with the number of grid squares in each density category for the whole survey area and Burbo Bank Extension and the associated buffers

Category	Observed density range (no. of birds/km^2)	No. of 4 km^2 grid squares		
		Survey area (Liverpool Bay SPA)	Burbo Bank Extension + 1 km buffer (London Array approach)	Burbo Bank Extension + 2 km buffer (Kentish Flats approach)
None	0	80	6	6
Low	0.0001 – 0.1049	234	11	15
Medium	0.105 – 0.189	77	5	5
High	0.190 – 1.0	40	1	1

3.1. Displacement analysis of red-throated diver from Burbo Bank Extension using the London Array approach

Approximately 48 divers were predicted to be displaced from Burbo Bank Extension and a 1 km buffer. As described in Section 2.2 these divers were redistributed according to five different scenarios: to all of the Liverpool Bay SPA and to four different receptor areas (based on 10, 20, 40 and 60 km buffers around the wind farm) within Liverpool Bay SPA.

The displacement of divers into Liverpool Bay SPA and to four different receptor areas resulted in an increase in the number of squares classified as having a High density of divers (Table 7). Further to this, there was also an increase in the number of squares classified as having a Medium density of divers in all scenarios but the 10km, when displacement of birds was not constrained by receptor habitats. It was the converse when displacement of birds was constrained by receptor habitats. All options considered for the displacement of divers resulted in some grid cells originally classified as having Low density of divers being re-classified as of Medium or High density. The exception was when the displacement of birds was not constrained by receptor habitats for the 10 km buffer scenario.

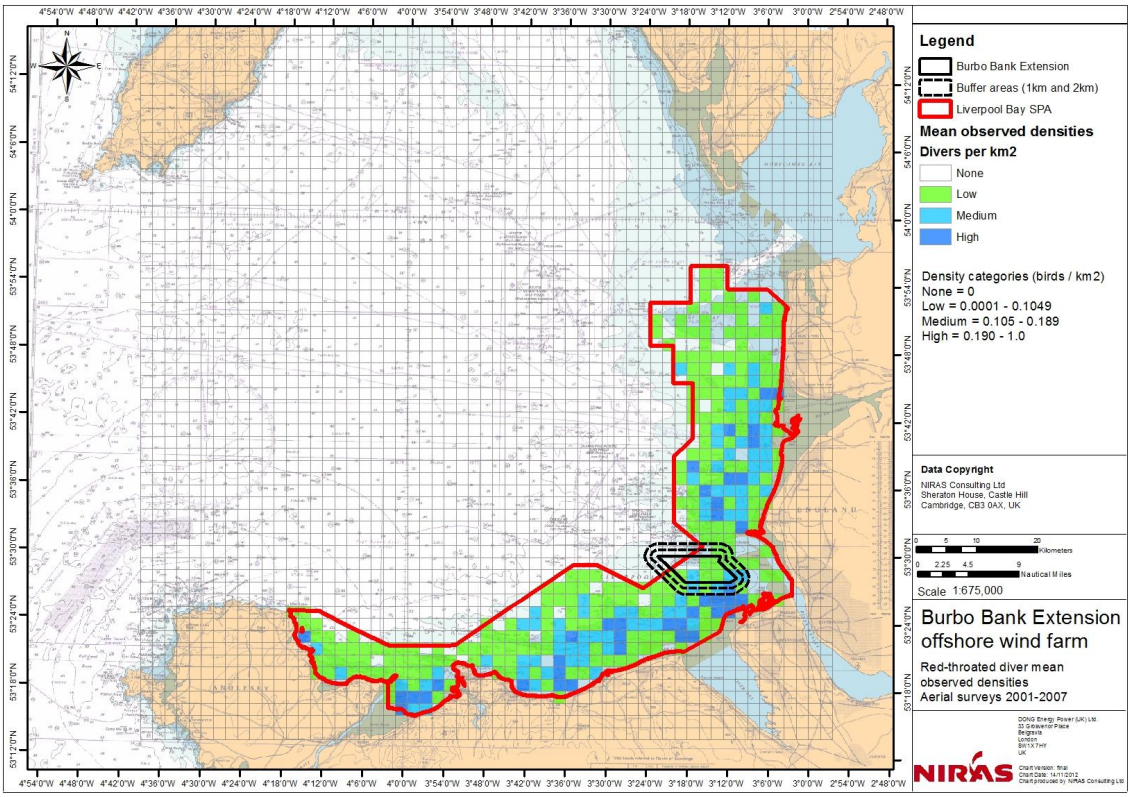

Chart 6: The mean observed densities of red-throated diver in Liverpool Bay SPA as recorded by aerial surveys 2001-2007

A lower proportion of the squares classified as having a Low density of divers changed category as displacement occurred over a larger area. Furthermore, this proportion was always less when the displacement of birds was constrained by the receptor habitats. The trend in the proportional increase of squares classified as having a High density of divers as displacement occurred over a larger area differed between whether habitat modified relocation or not. When the displacement of birds was constrained by the receptor habitats, the proportional increase of squares classified as having a High density of divers increased as displacement occurred over a larger area, up to a peak at the 40 km scenario.

Table 7: Displacement analysis of red-throated diver from Burbo Bank Extension using the London Array approach

Displacement scenario	Before or following displacement	Displacement scenario modified by receptor habitats	Peak observed density (no. of birds/km^2)	Number of grid cells in each density category			
				Zero	Low	Medium	High
SPA	Existing baseline	n/a	0.48	76	226	72	39
	Displacement	No	0.51	76	188	88	61
		Yes	0.49	76	204	22	111
10km	Existing baseline	n/a	0.48	14	42	12	14
	Displacement	No	0.65	14	0	2	66
		Yes	0.50	14	12	30	26
20km	Existing baseline	n/a	0.48	23	91	36	24
	Displacement	No	0.56	23	22	77	52
		Yes	0.49	23	68	23	60
40km	Existing baseline	n/a	0.48	57	175	64	33
	Displacement	No	0.52	57	125	92	55
		Yes	0.49	57	156	19	97
60km	Existing baseline	n/a	0.48	76	225	72	39
	Displacement	No	0.52	76	187	88	61
		Yes	0.49	76	203	22	111

3.2. Displacement analysis of red-throated diver from Burbo Bank Extension using the Kentish Flats approach

Approximately 76 divers were predicted to be displaced from Burbo Bank Extension and a 2 km buffer. As described in Section 2.2 these divers were redistributed according to five different scenarios: to all of the Liverpool Bay SPA and to four different receptor areas (based on 10, 20, 40 and 60 km buffers around the wind farm).

The displacement of divers into Liverpool Bay SPA and to four different receptor areas resulted in an increase in the number of squares classified as having a High density of divers. Conversely, the displacement resulted in some if not all grid cells originally classified as having Low density of divers, being re-classified as of Medium or High density.

A lower proportion of the squares classified as having a Low density of divers changed category as displacement occurred over a larger area. This proportion was always less when the displacement of birds was constrained by the receptor habitats. Similarly, re-classified squares generally comprised of a lower proportion of those classified as having a High density of divers as displacement occurred over a larger area.

Table 8: Displacement analysis of red-throated diver from Burbo Bank Extension using the Kentish Flats approach

Displacement scenario	Before or following displacement	Displacement scenario modified by receptor habitats	Peak observed density (no. of birds/km^2)	Number of grid cells in each density category			
				Zero	Low	Medium	High
SPA	Existing baseline	n/a	0.48	76	222	72	39
	Displacement	No	0.54	76	140	113	80
		Yes	0.50	76	158	64	111
10km	Existing baseline	n/a	0.48	14	38	12	14
	Displacement	No	0.78	14	0	0	64
		Yes	0.84	14	0	0	64
20km	Existing baseline	n/a	0.48	23	87	36	24
	Displacement	No	0.61	23	0	61	86
		Yes	0.51	23	0	66	81
40km	Existing baseline	n/a	0.48	57	171	64	33
	Displacement	No	0.55	57	60	131	60
		Yes	0.50	57	71	100	97
60km	Existing baseline	n/a	0.48	76	221	72	39
	Displacement	No	0.54	76	140	112	80
		Yes	0.50	76	158	63	111

4. Synthesis

As expected, the density of divers increases in receptor habitats. The overall density of red-throated divers within Liverpool Bay SPA and the four buffer areas used in this assessment, increases in every displacement scenario for both the London Array and Kentish Flats approaches. In all cases this increase results in an increase in 4 km^2 grid squares classified as having a High density of divers. As would be expected this effect reduces when displacement occurs over larger areas with densities showing the largest increase in the 10 km buffer and the smallest increase in the 60 km buffer. The exception to this expectation was for the London Array Approach scenarios when the receptors habitat constrained relocation of the displaced birds.

Caution should be applied when interpreting Thames Estuary scenarios in relation to Liverpool Bay SPA. Red-throated divers are much less abundant in Liverpool Bay SPA than in the Outer Thames Estuary, with

the latter site supporting restricted areas of shallow sand bank habitat at which divers congregate (NIRAS 2012). Divers within Liverpool Bay SPA appear to be considerably more widespread and exhibit a more homogenous distribution (Webb et al. 2004; 2006). Further to this, although some of the densities presented in this report are described as High, in relation to red-throated diver densities elsewhere around the UK coast they are considerably lower. Peak and mean red-throated diver density estimates from distance analysis for London Array wind farm ranged respectively between 2.68 – 19.92 diver/km^2 and 1.27 – 8.73 diver/km^2 (APEM 2011), the variation due to whether visual survey (the lower limit) or calibrated visual survey (the upper limit). In the current analysis, peak densities have not exceeded 0.84 diver/km^2 following application of the displacement scenarios to the Liverpool Bay SPA cited population of 922 red-throated divers.

Table 9 summarizes the change in diver density for each of the five scenarios when relocation of displaced birds is constrained by quality of available habitat; the colour coding categories are for presentation purposes only, arbitrarily determined from the range of density increases. As would be expected, when displacement occurs over larger areas the change in density diminishes. The percentage difference in density will however remain identical as the same numbers of birds are displaced to each of the habitats. Of the two approaches considered, the change in densities is for any given scenario greater with the Kentish Flats Approach as to be expected given more divers are displaced. It should be noted that the density increase of up to 15% for a habitat following displacement of less than 9% of the SPA diver population, is a reflection of the comparatively low baseline densities in Liverpool Bay SPA. As highlighted previously, the resultant densities are themselves considerably lower than red-throated diver densities elsewhere around the UK coast.

The implication of these results is that the majority of displaced birds might be expected to successfully relocate to parts of the Liverpool Bay SPA. The changes in density are low, considerably less than 1 birds/km^2, and the relative change, even under the most extreme scenarios seemingly low (a maximum of 15%). So even if it were assumed that less than 100% of birds relocated the proportion that die or emigrate would be relatively small. Table 10 shows the proportion of displaced divers that could be lost to the SPA through mortality or emigration, as a percentage of the total SPA population when using the London Array and Kentish Flats approaches. It is reasonable to assume that a reduction in the red-throated diver SPA population of approximately 5% is considered acceptable. This would therefore classify all displacements under the London Array approach as acceptable whilst making the extremely precautionary assumption that all displaced birds may emigrate or die. To assume that 100% of displaced birds would emigrate from or die was agreed as overly precautionary by an independent panel of ornithological experts when considering development the London Array Offshore Wind Farm in the Outer Thames Estuary SPA (NIRAS Consulting Ltd. 2012). When using the Kentish Flats approach, it is assumed that 60% or less of displaced birds die or emigrate for there to be no more than a 5% reduction in the red-throated diver population of Liverpool Bay SPA. It is reasonable to conclude that most divers can be expected to relocate within the SPA given the displacement analysis results were of low changes in density and low relative change.

Table 9: Increases in red-throated diver density for each of five scenarios when relocation of displaced birds is constrained by the quality of available habitat

Displacement scenarios	London Array approach: Density increase in each habitat (density category) (no. of birds/km^2)			Kentish Flats approach: Density increase in each habitat (density category) (no. of birds/km^2)		
	Low	Medium	High	Low	Medium	High
SPA	0.01	0.11	0.02	0.02	0.11	0.05
10km	0.02	0.66	0.09	0.05	0.65	0.27
20km	0.01	0.22	0.04	0.03	0.21	0.12
40km	0.01	0.12	0.02	0.02	0.12	0.06
60km	0.01	0.11	0.02	0.02	0.11	0.05
% difference in density	0.4%	10.9%	4.9%	1.0%	11.4%	15.1%

Colour key to Table 9

Category	Low	Medium	High
Density increase (no. of birds/km^2)	<0.1	0.1 – 0.5	>0.5

Table 10: The proportion of displaced divers that could be lost to the SPA through mortality or emigration, as a percentage of the total SPA population when using the London Array and Kentish Flats Approaches

			Proportion of displaced birds lost to the SPA (mortality or emigration)										
Approach	Birds Displaced	% of SPA pop^n	100%	90%	80%	70%	60%	50%	40%	30%	20%	10%	0%
London Array	48	5.2%	5.2%	4.7%	4.2%	3.6%	3.1%	2.6%	2.1%	1.6%	1.0%	0.5%	0.0%
Kentish Flats	76	8.2%	8.2%	7.4%	6.6%	5.8%	4.9%	4.1%	3.3%	2.5%	1.6%	0.8%	0.0%

Colour key to Table 10

Category	Low	Medium	High
Percentage of the red-throated diver SPA population	<5.0	5.0% – 9.9%	>10%

5. Cumulative impact assessment

5.1. Overview

Appropriate estimates of population and/or density are not available within Environmental Statements of the four sites. Therefore, to inform a cumulative impact assessment counts of red-throated diver from the twenty-two surveys within Table 2 from each of the five sites were extracted from visual aerial survey data supplied by JNCC.

The use of a single data set circumvents any potential comparability between survey techniques used to inform the assessment. Although a study by Rexstad and Buckland (2009) of common scoter in Camarthen Bay indicated that population estimates by digital aerial methods (as used at Burbo Bank Extension in 2011) were typically higher than from visual aerial techniques (as used to inform the designation of Liverpool Bay SPA), the review by Thaxter and Burton (2009) detail other studies that give inconclusive results.

The analysis presented below uses the historical JNCC data only and provides further insight not only into potential cumulative impacts but further supporting information on the effects of Burbo Bank Extension alone.

5.2. Methodology

Five wind farm sites were assessed for cumulative displacement impacts on red-throated diver. These were:

- Burbo Bank Extension;
- Burbo Bank (operational October 2007);
- Gwynt-y-Môr (constructed 2012);
- North Hoyle (operational 2003); and
- Rhyl Flats (operational July 2007).

Only the area of each wind farm that fell within Liverpool Bay SPA was assessed for displacement effects. Burbo Bank, North Hoyle and Rhyl Flats Offshore Wind Farms are located wholly within the SPA, while a substantial proportion of Gwynt-y-Môr lies to the north of the SPA boundary.

The total counts of red-throated diver and unidentified divers were combined, as it is assumed all records are of red-throated diver due to this species being the overwhelmingly the most abundant diver species in the Irish Sea (Brown and Grice, 2005).

In order to calculate population sizes of red-throated diver, the count data was extracted using ArcGIS for each site and then corrected for survey coverage. The length of transect within each wind farm, and three buffer areas around each wind farm (0 – 500 m, 500 - 1000 m and 1000 - 2000 m) was calculated using ArcGIS and from this a transect area was calculated. The total area of the wind farm site or relevant buffer was then divided by the transect area to produce a correction factor which was applied to the total raw count of red-throated diver. In some cases the buffers of two wind farms overlapped with birds within these overlap zones applied to the sites who's boundary lay in closest proximity. Chart shows the five wind farm sites, and associated buffer areas, used in cumulative displacement assessment together with the transect lengths within each of the study areas.

A limited amount of data provided by JNCC relating to transect routes could not be successfully plotted in ArcGIS and as such the transect lengths surveyed during these surveys could not be calculated. Therefore, in order to correct for survey coverage in these cases, the average transect length, calculated from surveys for which data was available, was used.

The Kentish Flats displacement scenario, outlined in Table 1, was used to the assess the potential displacement of divers from the project area and each of the three buffer areas. These figures were totalled to provide a displacement figure for each wind farm and a 2 km buffer. These totals were compared to the red-throated diver population cited for Liverpool Bay SPA (922 individuals) (Stroud *et al.,* 2001).

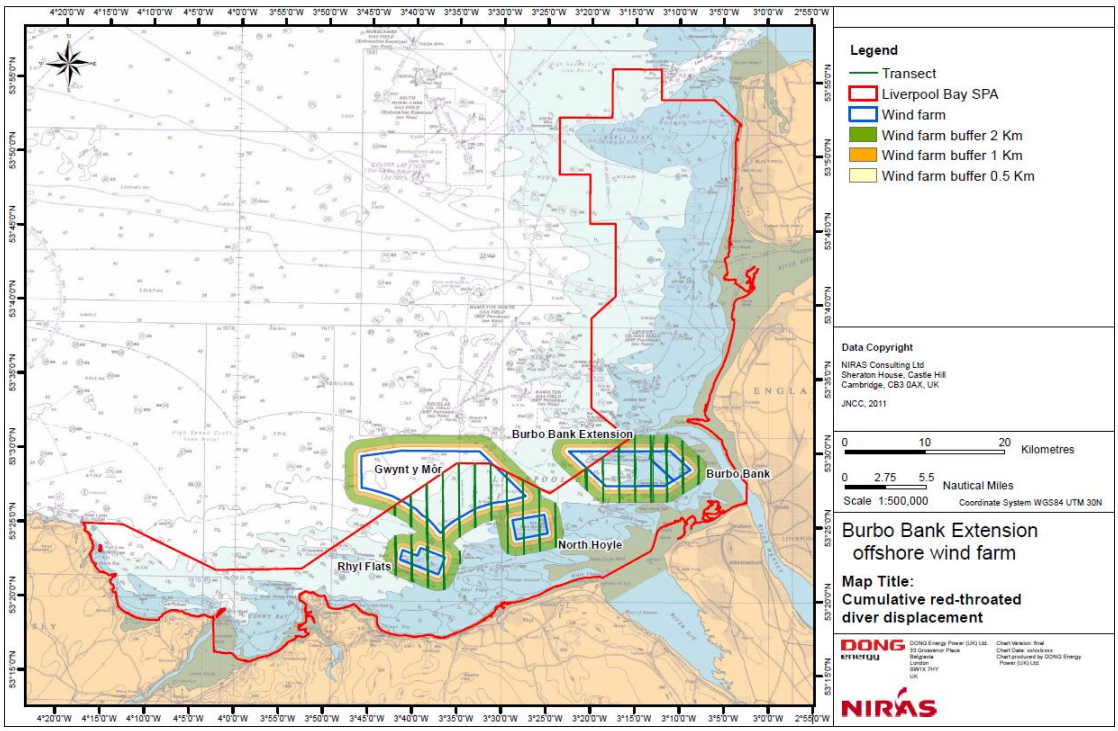

Chart 7: Wind farm areas and transect lengths used for cumulative displacement analysis of red-throated diver within Liverpool Bay SPA.

5.3. Results

The number of divers potentially displaced from all five wind farm sites assessed for cumulative impact assessment totalled 86 individuals (Table 11). The highest displacement occurred at Gwynt-y-Môr Offshore Wind Farm (26 individuals), with Burbo Bank Extension predicted to displace 16 individuals using this method of analysis.

Table 11: Cumulative displacement analysis for red-throated diver at five offshore wind farm sites.

Wind farm	Kentish Flats displacement[1]				Total	% of SPA population
	Wind farm	0 – 500 m	500 – 1000 m	1000 – 2000 m		
Burbo Bank	6	5	0	1	12	1.32
Burbo Bank Extension	8	2	2	4	16	1.73
Gwynt-y-Môr	13	4	6	4	26	2.85
North Hoyle	4	3	3	6	16	1.76
Rhyl Flats	3	3	3	6	16	1.69
Total					**86**	**9.36**

Using the JNCC data set the predicted displacement of red-throated divers from Burbo Bank Extension is lower than that estimated using the 2011 baseline data and further supporting the view that displacement effects from Burbo Bank Extension are not likely to be significant.

The Kentish Flats scenario involves displacement up to a 2 km buffer. It is acknowledged that smaller levels of displacement may occur beyond this buffer such as in Percival (2010). However these figures were updated in Vattenfall (2011) and Pizzola (2011) to provide the scenario presented in Table 1 and were also critical reviewed in Skov (2011). In any case, expanding the buffer zones to 3 km will mostly cause overlap with other sites and it is considered would not support a significant displacement effect on red-throated divers in Liverpool Bay SPA.

5.4. Effects of wind farm commissioning

As detailed in section 5.2, the commissioning of North Hoyle Offshore wind farm occurred during the JNCC aerial survey program and as such analysis was undertaken to investigate whether diver densities significant altered after the wind farm became operational. Table 12 presents the numbers of divers potentially displaced from North Hoyle taken from surveys carried out before 2003.

Table 12: Red-throated diver displacement from North Hoyle offshore wind farm pre-construction.

North Hoyle	Kentish Flats displacement				Total	% of SPA population
	Wind Farm	0 – 500 m	500 – 1000 m	1000 – 2000 m		
North Hoyle	4	3	3	6	16	1.76

Peak densities at North Hoyle all occurred before the operational period so that the results in Tables 1 and 2 are identical.

[1] Figures rounded to the nearest individual

6. References

APEM (2011). *Red-throated divers & offshore wind farms in the Outer Thames: historic data review.* APEM Scientific Report 411134. London Array Ltd., June 2011 v2 Final, 154 pp.

Brown, A. and Grice, P. (2005). Birds in England. T & AD Poyser, London, UK: 694pp. ISBN 07136 6530 0.

Furness, B. and Wade, H. (2012). *Vulnerability of Scottish seabirds to offshore wind turbines*. MacArthur Green Ltd. Glasgow, Scotland.

Garthe, S. and Hüppop, O. (2004). Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index. *Journal of Applied Ecology*, 41(4), 724-734.

Skov, H. (2011). *Review of Kentish Flats Monitoring Reports*. DHI Group.

NIRAS Consulting Ltd. (2012). *London Array Offshore Wind Farm Phase 2 – Report to Inform Appropriate Assessment.* NIRAS Consulting Ltd, Cambridge.

Petersen, I.K., Grrom, G., Stjenholm, M. & Nielsen, R.D. (2011). *Ornithological Surveys of the Burbo Bank Extension Offshore Wind Farm area November 2010 to April 2011*. Report commissioned by DONG Energy A/S. Aarhus University, DCE – Danish Centre for Environment and Energy. 29pp.

Pecival, S.M. (2010). *Kentish Flats Offshore Wind Farm: Diver Surveys 2009-10*. Ecology Consulting Report to DONG Energy.

Pizzola, P. (2011). Kentish Flats Offshore Wind Farm Extension – Habitat Regulations Assessment Report. Vattenfall Wind Power Ltd.

Stroud, DA, Chambers, D, Cook, S, Buxton, N, Fraser, B, Clement, P, Lewis, P, McLean, I, Baker, H & Whitehead, S (eds).(2001). The UK SPA network: its scope and content. JNCC, Peterborough

Rexstad, E. & Buckland, S. (2009). Comparison of aerial survey methods for estimating the abundance of common scoters. CREEM Technical Report 2009-01.

Thaxter, C.B. & Burton, N.H.K. (2009). High Definition Imagery for Surveying Seabirds and Marine Mammals: A Review of Recent Trials and Development Protocols. British Trust for Ornithology Report commissioned by COWRIE Ltd.

Vattenfall. (2011). *Kentish Flats Offshore Wind Farm Extension Environmental Statement: Offshore Ornithology.*

Webb, A., McSorely, C.A., Dean, B.J., Reid, J.B, Cranswick, P.A., Smith, L. & Hall, C. (2004). *An assessment of the numbers and distributions of inshore aggregations of waterbirds using Liverpool Bay during the non-breeding season in support of possible SPA identification.* Joint Nature Conservation Committee Report No. 373.

Webb, A., McSorely, C.A., Dean, B.J. & Reid, J.B. (2006). *Recommendations for the selection of, and boundary options for, an SPA in Liverpool Bay.* Joint Nature Conservation Committee Report No. 388.

DONG Energy

January 2013

Burbo Bank Extension Offshore Wind Farm

Displacement Analysis

NIRAS Consulting Ltd
Sheraton House, Castle Hill
Cambridge CB3 0AX, UK

Reg. No.: 07470870
England & Wales
www.niras.com/uk

T: +44 (0)1223 370181
F: +44 (0)1223 370040
@: tno@niras.com

Document Control

NIRAS Project Number	N0034
Document Title	Burbo Bank Extension: Displacement Analysis
Status	Final
Client	DONG Energy
Client Project No (if applicable)	
Client Contact Name	Jennifer Brack

The following personnel are designated contacts for queries relating to this document:

Name	Job Title	Telephone	Email
Matthew Hazleton	Environmental Consultant	01223 370181	HAZ@NIRAS.com

Revision Status for Issue

	Name	Date
Checked by	Ian Ellis	23/01/2013
Accepted by	Tim Norman	23/01/2013

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1. Introduction

Operational offshore wind farms illicit species specific behavioural responses in seabirds. These behavioural responses may take the form of avoidance behaviour which can influence the movement of seabird species, disrupting functional links between feeding and breeding areas. This annex presents results of displacement analysis for a number of species in relation to Burbo Bank Extension offshore wind farm.

2. Methodology

Displacement analysis followed recently published interim guidance from JNCC and Natural England (Natural England and JNCC, 2012).

Site specific data for Burbo Bank Extension Offshore Wind Farm was collected in twelve surveys: six digital aerial surveys carried out between November 2010 to April 2011 and six boat-based surveys carried out between April 2011 and September 2011. Data collection by aerial and boat-based surveys encompassed the wind farm footprint plus a 4 km buffer; the interim guidance suggests a range of generic displacement buffers from 2 to 4 km depending on the species considered. Within this analysis data from 4 km is used in all cases on a precautionary basis. The species detailed are:

- Manx shearwater;
- Red-throated diver;
- Common scoter;
- Cormorant;
- Guillemot; and
- Razorbill.

The basis for the assessment were monthly population estimates (corrected for survey coverage and distance related errors) and included birds both on the water and in flight within the study area. The mean-peak population estimates for each species were extracted from boat-based and aerial data. Certain species are more sensitive to disturbance at different times during their life cycle. For example, after the breeding season guillemot undertake a post-breeding moult during which time they are flightless and more sensitive to displacement. As such, different population estimates for each species were assessed relating to breeding, non-breeding, post-breeding and moulting periods where relevant.. The periods from which these data were taken are shown in Table 1.

Table 1: Periods used to assess displacement on sensitive receptors

Species	Breeding	Post-breeding	Non-breeding	Moulting
Common scoter	N/A	Aug-Sept	Oct-Mar	N/A
Red-throated diver	N/A	N/A	Oct-Mar	N/A
Manx shearwater	May-Aug	Sept-Oct	Nov-Apr	N/A
Cormorant	N/A	N/A	Oct-Mar	N/A
Guillemot	May-Jul	N/A	Oct-Apr	Jul-Sept
Razorbill	May-Jul	Aug-Sept	Oct-Apr	N/A

In order to assess the results of the displacement analysis, different reference populations were required. These were taken from Stroud *et al.* (2001) for SPA reference populations, while the BTO Birdfacts online species database[1] and Baker *et al.* (2006) for national breeding populations. A variety of references were used to provide national wintering population estimates including Holt *et al.* (2012), Musgrove *et al.* (2011) and Banks *et al.* (2007) for national wintering reference populations. Finally, Mitchell *et al.* (2004) was used as a basis to estimate regional reference populations.

2.1. Potential displacement and mortality

The displacement and mortality rate for each species were both assessed via a matrix approach from 0 to 100 % of the population affected, in line with interim guidance (JNCC and Natural England, 2012).

The potential level of displacement for each species is highlighted in the matrices. These are based on currently available evidence (where it exists) or from standard guidance on species sensitivity to displacement (.g. Furness & Wade, 2012; Garthe and Hüppop, 2004).

3. Results

3.1. Common scoter

The displacement matrix for common scoter during the wintering period is shown in Table 2. The number of common scoter potentially at risk of displacement do not pass a 1 % threshold level of the national population size at any levels of displacement or mortality. Similarly the figures provided does not surpass 1 % of the population cited for Liverpool Bay SPA. As guidance a level of 80% of displacement is predicted as the likely impact of Burbo Bank Extension based on the species sensitivity to disturbance (Furness and Wade, 2012; Kaiser *et al.,* 2006; Schwemmer *et al.,* 2011).

Table 2: Common scoter displacement from Burbo Bank Extension during the wintering period (Oct-Mar)

Common scoter (Wintering)	**Mortality (%)**											
Displacement level (%)		**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	0	1	1	2	2	2	3	3	4	4
	20	0	1	2	2	3	4	5	6	6	7	8
	30	0	1	2	4	5	6	7	8	10	11	12
	40	0	2	3	5	6	8	10	11	13	14	16
	50	0	2	4	6	8	10	12	14	16	18	20
	60	0	2	5	7	10	12	14	17	19	22	24
	70	0	3	6	8	11	14	17	20	23	25	28
	80	0	3	6	10	13	16	19	23	26	29	32
	90	0	4	7	11	14	18	22	25	29	33	36

[1] http://www.bto.org/about-birds/birdfacts

	100	0	4	8	12	16	20	24	28	32	36	40
Input data – Mean peak population estimates for Burbo Bank Extension + 4 km buffer, aerial surveys Oct – Mar												
Reference population 1: Liverpool Bay SPA - 54,675 individuals												
Reference population 2: National population - 100,000 individuals												

3.2. Red-throated diver

The displacement matrix for red-throated diver during the wintering period is shown in Table 3. The number of divers at risk of displacement presented below do not surpass 1 % of the national population. As guidance a level of 50% of displacement is predicted as the likely impact of Burbo Bank Extension based on the species sensitivity to disturbance (Topping and Petersen, 2011) and the estimates of displacement from wind farms in the English North Sea (e.g. Percival, 2010; Pizzola, 2011). Within these studies it has been concluded that the majority of red-throated divers are displaced from within the wind farm footprint and lesser numbers thereafter in various buffer zones. Studies at Kentish Flats Offshore Wind Farm describe displacement of 59% up to a 2 km buffer (Pizzola, 2011).

At the predicted displacement level of 50 % it would require a mortality rate of 40 % and higher to surpass a 1% threshold of the Liverpool Bay SPA population.

Table 3: Red-throated diver displacement from Burbo Bank Extension during the wintering period (Oct-Mar)

Red throated diver (Wintering)	**Mortality (%)**											
Displacement level (%)		**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	1	1	2	2	3	4	4	5	5	6
	20	0	1	2	4	5	6	7	8	9	11	12
	30	0	2	4	5	7	9	11	12	14	16	18
	40	0	2	5	7	9	12	14	16	19	21	23
	50	0	3	6	9	12	15	18	20	23	26	29
	60	0	4	7	11	14	18	21	25	28	32	35
	70	0	4	8	12	16	20	25	29	33	37	41
	80	0	5	9	14	19	23	28	33	37	42	47
	90	0	5	11	16	21	26	32	37	42	47	53
	100	0	6	12	18	23	29	35	41	47	53	58
Input data – Mean peak population estimates for Burbo Bank Extension + 4 km buffer, aerial surveys Oct – Mar												
Reference population 1: Liverpool Bay SPA - 922 individuals												
Reference population 2: National wintering population - 17,000 individuals												

3.3. Manx shearwater

The displacement matrix for Manx shearwater during the breeding season is shown in Table 4. As guidance a level of 30% of displacement is predicted as the likely impact of Burbo Bank Extension based on the

species lack of sensitivity to disturbance (Furness & Wade, 2012) and preliminary results of monitoring work at Walney I and II (NIRAS, 2012).

The number of Manx shearwater at risk of displacement do not surpass a 1 % threshold of the regional population or 1 % of the population cited for Skokholm and Skomer SPA. At the predicted displacement level of 30 %, it requires a mortality rate of 60 % to result in numbers of this species potentially at risk which surpass 1 % of the population cited for the Aberdaron Coast and Bardsey Island SPA.

Table 4: Manx shearwater displacement from Burbo Bank Extension during the breeding season (May-Aug)

Manx shearwater (Breeding)	**Mortality (%)**											
Displacement level (%)		**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	8	17	25	33	41	50	58	66	74	83
	20	0	17	33	50	66	83	99	116	132	149	166
	30	0	25	50	74	99	124	149	174	199	223	248
	40	0	33	66	99	132	166	199	232	265	298	331
	50	0	41	83	124	166	207	248	290	331	372	414
	60	0	50	99	149	199	248	298	348	397	447	497
	70	0	58	116	174	232	290	348	405	463	521	579
	80	0	66	132	199	265	331	397	463	530	596	662
	90	0	74	149	223	298	372	447	521	596	670	745
	100	0	83	166	248	331	414	497	579	662	745	828
Input data: Mean-peak monthly population estimates for Burbo Bank Extension + 4 km buffer, boat-based surveys May-Aug												
Reference population 1: SPA populations - Aberdaron Coast and Bardsey Island / Glannau Aberdaron and Ynys Enlli SPA – 13,860 individuals; Skokholm and Skomer SPA – 301,936 individuals; Copeland Islands SPA – 9,600 individuals)												
Reference population 2: Regional population - 448,502 individuals												
Reference population 3: National breeding population - 590,000 individuals												

3.4. Cormorant

The displacement matrix for cormorant during the wintering period is shown in Table 5. The number of cormorants potentially at risk of displacement presented below do not surpass a 1 % of the regional population. As guidance a level of 50% of displacement is predicted as the likely impact of Burbo Bank Extension based on the species moderate sensitivity to disturbance (Garthe and Hüppop, 2004). At this level of displacement it requires a mortality rate of 60% for the number of cormorant potentially at risk to surpass a cumulative population estimate for the adjacent SPAs for which cormorant is listed as an assemblage feature.

Table 5: Cormorant displacement from Burbo Bank Extension during the wintering period (Oct-Mar)

Cormorant (Wintering)	Mortality (%)											
Displacement level (%)		**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	1	1	2	2	3	4	4	5	6	6
	20	0	1	2	4	5	6	7	9	10	11	12
	30	0	2	4	6	7	9	11	13	15	17	19
	40	0	2	5	7	10	12	15	17	20	22	25
	50	0	3	6	9	12	15	19	22	25	28	31
	60	0	4	7	11	15	19	22	26	30	33	37
	70	0	4	9	13	17	22	26	30	35	39	43
	80	0	5	10	15	20	25	30	35	40	44	49
	90	0	6	11	17	22	28	33	39	44	50	56
	100	0	6	12	19	25	31	37	43	49	56	62
Input data – Mean peak population estimates for Burbo Bank Extension + 4 km buffer, aerial surveys Oct – Mar												
Reference population 1: Cumulative SPA population 1,702. Cumulative population from the assemblages of Mersey Narrows and North Wirral Foreshore SPA, Morecambe Bay SPA, Ribble and Alt Estuaries SPA and The Dee Estuary SPA												
Reference population 2: National wintering population – 35,000 individuals												

3.5. Guillemot

The displacement matrices for guillemot during the breeding, non-breeding and moulting periods are shown in TablesTable 6, Table 7 and Table 8. The number of guillemot potentially at risk of displacement do not surpass 1 % thresholds of the national or regional population for guillemot during any season or at any displacement/mortality rates. As guidance a level of 70% of displacement is predicted as the likely impact of Burbo Bank Extension based on the species moderate-high sensitivity to disturbance (Thayer *et al.*, 1999; Garthe and Hüppop, 2004).

Table 6: Guillemot displacement from Burbo Bank Extension during the breeding season (May-Jul)

Guillemot (Breeding)	Mortality (%)											
Displacement level (%)		**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	19	37	56	75	93	112	131	150	168	187
	20	0	37	75	112	150	187	224	262	299	336	374
	30	0	56	112	168	224	280	336	393	449	505	561
	40	0	75	150	224	299	374	449	523	598	673	748
	50	0	93	187	280	374	467	561	654	748	841	935
	60	0	112	224	336	449	561	673	785	897	1009	1122
	70	0	131	262	393	523	654	785	916	1047	1178	1308
	80	0	150	299	449	598	748	897	1047	1196	1346	1495
	90	0	168	336	505	673	841	1009	1178	1346	1514	1682

	100	0	187	374	561	748	935	1122	1308	1495	1682	1869
Input data: Mean-peak monthly population estimates for Burbo Bank Extension + 4 km buffer, boat-based surveys May-Jul												
Reference population 1: Regional population - 664,836												
Reference population 2: National population - 1,300,000												

Table 7: Guillemot displacement from Burbo Bank Extension during the non-breeding season (Oct-Apr)

Guillemot (Non-breeding)	**Mortality (%)**											
Displacement level (%)		**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	9	18	27	37	46	55	64	73	82	91
	20	0	18	37	55	73	91	110	128	146	164	183
	30	0	27	55	82	110	137	164	192	219	247	274
	40	0	37	73	110	146	183	219	256	292	329	366
	50	0	46	91	137	183	228	274	320	366	411	457
	60	0	55	110	164	219	274	329	384	439	493	548
	70	0	64	128	192	256	320	384	448	512	576	640
	80	0	73	146	219	292	366	439	512	585	658	731
	90	0	82	164	247	329	411	493	576	658	740	822
	100	0	91	183	274	366	457	548	640	731	822	914
Input data – Mean peak population estimates for Burbo Bank Extension + 4 km buffer, aerial surveys Oct - Apr												
Reference population 1 – Regional population – 664,836												
Reference population 2 – National population – 1,300,000												

Table 8: Guillemot displacement from Burbo Bank Extension during the moulting period (Jul-Sep)

Guillemot (Moulting)	**Mortality (%)**											
Displacement level (%)		**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	29	58	88	117	146	175	204	233	263	292
	20	0	58	117	175	233	292	350	408	467	525	583
	30	0	88	175	263	350	438	525	613	700	788	875
	40	0	117	233	350	467	583	700	817	934	1050	1167
	50	0	146	292	438	583	729	875	1021	1167	1313	1459
	60	0	175	350	525	700	875	1050	1225	1400	1575	1750
	70	0	204	408	613	817	1021	1225	1429	1634	1838	2042
	80	0	233	467	700	934	1167	1400	1634	1867	2100	2334
	90	0	263	525	788	1050	1313	1575	1838	2100	2363	2626
	100	0	292	583	875	1167	1459	1750	2042	2334	2626	2917
Input data – Mean peak population estimates for Burbo Bank Extension + 4 km buffer, boat-based surveys Jul-Sept												

Reference population 1: Regional population - 664,836
Reference population 2: National population - 1,300,000

3.6. Razorbill

The displacement matrices for razorbill during the breeding and non-breeding periods are shown in Tables 9 and 10. The number of razorbill potentially a risk of displacement do not surpass 1 % thresholds of the national or regional population for guillemot during any season or at any displacement/mortality rates. As guidance a level of 70% of displacement is predicted as the likely impact of Burbo Bank Extension based on the species moderate-high sensitivity to disturbance (Garthe and Hüppop, 2004).

Table 9: Razorbill displacement from Burbo Bank Extension during the breeding season (May-Jul)

Razorbill (Breeding)	**Mortality (%)**											
Displacement level (%)		**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	1	2	4	5	6	7	8	10	11	12
	20	0	2	5	7	10	12	14	17	19	22	24
	30	0	4	7	11	14	18	22	25	29	32	36
	40	0	5	10	14	19	24	29	34	38	43	48
	50	0	6	12	18	24	30	36	42	48	54	60
	60	0	7	14	22	29	36	43	50	58	65	72
	70	0	8	17	25	34	42	50	59	67	76	84
	80	0	10	19	29	38	48	58	67	77	86	96
	90	0	11	22	32	43	54	65	76	86	97	108
	100	0	12	24	36	48	60	72	84	96	108	120
Input data – Mean peak population estimates for Burbo Bank Extension + 4 km buffer, boat-based surveys May – Jul												
Reference population 1 – Regional population –139,772 individuals												
Reference population 2 – National population – 164,000 individuals												

Table 10: Razorbill displacement from Burbo Bank Extension during the non-breeding season (Oct-Apr)

Razorbill (Non-breeding)	**Mortality (%)**											
Displacement level (%)		**0**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
	0	0	0	0	0	0	0	0	0	0	0	0
	10	0	1	1	2	2	3	3	4	4	5	5
	20	0	1	2	3	4	5	6	8	9	10	11
	30	0	2	3	5	6	8	10	11	13	15	16
	40	0	2	4	6	9	11	13	15	17	19	21
	50	0	3	5	8	11	13	16	19	21	24	27
	60	0	3	6	10	13	16	19	23	26	29	32
	70	0	4	8	11	15	19	23	26	30	34	38
	80	0	4	9	13	17	21	26	30	34	39	43

	90	0	5	10	15	19	24	29	34	39	44	48
	100	0	5	11	16	21	27	32	38	43	48	54
Input data – Mean peak population estimates for Burbo Bank Extension + 4 km buffer, aerial surveys Oct – Apr												
Reference population 1 – Regional population – 139,772 individuals												
Reference population 2 - National population – 164,000 individuals												

4. References

Baker, H., Stroud, D. A., Aebischer, N. J., Cranswick, P. A., Gregory, R. D., McSorley, C. A. , Noble, D. G. and Rehfisch, M. M. (2006). Population estimates of birds in Great Britain and the United Kingdom. *British Birds*, 99, 25-44.

Garthe, S. and Hüppop, O. (2004). Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index. *Journal of Applied Ecology*, 41(4), 724-734.

Holt, C.A., Austin, G.E., Calbrade, N.A., Mellan, H.J., Mitchell, C., Stroud, D.A., Wotton, S.R., Musgrove, A.J. 2011. *Waterbirds in the UK 2009/10: The Wetland Bird Survey*. BTO/RSPB/JNCC, Thetford.

Kaiser, M.J., M. Galanidi, D. A. Showler, A. J. Elliott, R. W. G. Caldow, E. I. S. Rees, R. A. Stillman and W. J. Sutherland. 2006. Distribution and behaviour of common scoter *Melanitta nigra* relative to prey resources and environmental parameters. Ibis 148: 110-128.

Mitchell, P. I., Newton, S., Ratcliffe, N. and Dunn, T. E. (2004). *Seabird populations of Britain and Ireland (Results of the Seabird 2000 Census 1998-2000)*. T&AD Poyser, London, UK: 511pp.

Musgrove, A.J., Austin, G.E., Hearn, R.D., Holt, C.A., Stroud, D.A. & Wotton, S.R. (2011). Overwinter population estimates of British waterbirds. *British Birds* 104: 364-397

Natural England and JNCC (2012) *Joint Natural England and JNCC Interim Advice Note – Presenting information to inform assessment of the potential magnitude and consequences of displacement of seabirds in relation of Offshore Windfarm Developments.*

Schwemmer, P., Mendel, B., Sonntag, N., Dierschke, V. and Garthe, S. 2011. Effects of ship traffic on seabirds in offshore waters: implications for marine conservation and spatial planning. Ecological Applications 21: 1851-1860.

Stroud, DA, Chambers, D, Cook, S, Buxton, N, Fraser, B, Clement, P, Lewis, P, McLean, I, Baker, H & Whitehead, S (eds).(2001). *The UK SPA network: its scope and content.* JNCC, Peterborough

Thayer, J.A., Sydeman, W.J., Fairman, N.P. and Allen, S.G. 1999. Attendance and effects of disturbance on coastal common murre colonies at Point Reyes, California. Waterbirds 22: 130-139.

Topping, C. and Petersen, I.K. 2011. Report on a red-throated diver agent-based model to assess the cumulative impact from offshore wind farms. Report commissioned by Vattenfall A/S. Aarhus University, DCE - Danish Centre for Environment and Energy.

BURBO BANK EXTENSION OFFSHORE WIND FARM

DONG Energy Burbo Extension (UK) Ltd.

Environmental Statement
Annex 18 – Commercial Fisheries

Document reference: 5.1.5.18
APFP 5(2)(a)

March 2013

DONG energy

Burbo Bank Extension offshore wind farm
DONG Energy Burbo Extension (UK) Ltd.

Environmental Statement
Annex 18 – Commercial Fisheries

Document reference: 5.1.5.18

Pursuant to: APFP 5(2)(a)

Prepared by: Brown & May Marine Ltd.

Checked by: Andy Revill (Environmental Lead, DONG Energy)

Accepted by: Stuart Livesey (Consents Project Manager, DONG Energy)

Approved by: Ferdinando Giammichele (Project Development Manager, DONG Energy)

Date: March 2013

Status: Final

Burbo Bank Extension offshore wind farm
c/o DONG Energy Burbo Extension (UK) Ltd.
33 Grosvenor Place
Belgravia
London
SW1X 7HY
United Kingdom

Tel: (+44) 020 7811 5235

Website: www.burbobankextension.co.uk
Email: burbobankextension@dongenergy.co.uk

Burbo Bank Extension Offshore Wind Farm Development

Commercial Fisheries Technical Report

Brown & May Marine Ltd
Progress Way
Mid Suffolk Business Park
Eye
Suffolk
IP23 7HU
Tel: 01379 870181
Fax: 01379 870673
Email: marine@brownmay.com

Ref	Issue	Checked	Approved	Issue Date
BBECFTR01	Final	RP/RR	SJA	15/06/2012

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Glossary of Terms

BMM – Brown and May Marine Limited
BWEA – British Wind Energy Association
CEFAS – Centre for Environment, Fisheries and Aquaculture Science
CFP – Common Fisheries Policy
CPA – Coast Protection Act 1949
CRZ – Cod Recovery Zone
Defra – Department for Environment, Food and Rural Affairs
EC – European Commission
EU – European Union
FEPA – Food and Environment Protection Act 1985
hp – horsepower
ICES – International Council for the Exploration of the Sea
ILVO – Institute of Agriculture and Fisheries Research (Belgium)
IFCA – Inshore Fisheries and Conservation Authorities
MCZ – Marine Conservation Zones
MLS – Minimum Landing Size
MMO – Marine Management Organisation
MSY – Maximum Sustainable Yield
nm – nautical mile
SFPA –Sea Fisheries Protection Agency
TAC – Total Allowable Catch
UN – United Nations
VCU – Vessel Capacity Units
VMS – Vessel Monitoring System

6nm limit – exclusive access to UK vessels only within 6nm
6nm-12nm limit – some access to certain EU Member States in identified areas around the UK coast, based upon historic access
12nm limit – Territorial waters of EU Member States extend to 12nm. Member States manage these waters exclusively within these limits

Under-10 metre (Under-10m) –Category of fishing vessels that are less than 10 metres in length
10 to 15 metre (10m-15m) – Category of fishing vessels that are between 10 and 15 metres in length
Over-15 metre (Over-15m) – Category of fishing vessels that are greater than 15 metres in length

Demersal – Activities or species located near or on the seabed
Pelagic – Activities or species located in the water column

Quota – A measure of the quantity of a species that can legally be landed within a set period

ICES Rectangle – A division of the sea covering approximately 900nm^2

1.0 Summary

1.1.1 The evidence currently available indicates that there is only limited fishing activity within the Project site. The majority of the Project is situated in ICES rectangle 35E6 and, to a lesser extent, 36E6. Both export cable route options are located in rectangle 35E6, with two landfall site options between Prestatyn and Rhyl. The Project is situated within the 6nm limit and as such is under the jurisdiction of the North West Inshore Fisheries and Conservation Authority (NW-IFCA). Additionally, only UK registered vessels are permitted to fish within the vicinity of the Project. As such vessels registered to other nationalities cannot legally fish within the Project.

1.1.2 It should be noted that the areas of ICES rectangles used by the Marine Management Organisation (MMO) for the spatial recording of fishing data are large (approximately 900nm² in open sea areas) relative to the area of the Project. The MMO data by ICES rectangle records only moderate landings values in rectangles 35E6 and 36E6 compared to other rectangles in the regional study area. It is however considered that the majority of the activity recorded within these rectangles is outwith of the Project boundary.

1.1.3 Within ICES rectangle 35E6, within which the majority of the Project is located, the MMO data identifies cockles, queen scallops, king scallops and sole as the principal target species. Consultation with fishermen suggests that dredging for king and queen scallops occurs to the west of the local study area, some distance from the Project. The main method for harvesting cockles is handpicking and charts provided by the NW-IFCA indicated that this only occurred in intertidal and near shore areas well to the south of the Project and not in areas which would be transacted by the export cable route.

1.1.4 Within the Project boundary, there is a small, discrete, seasonal fishery for sole, plaice and cod, generally targeted by vessels operating beam trawls during the spring. Consultation with fishermen has also identified a small thornback ray gillnet fishery in the north-west of the Project site and occasional otter trawling for plaice, sole and thornback ray throughout the site. The cable route transects seasonal gillnet fisheries for bass, tope, smoothound and flatfish.

1.1.5 All vessels targeting these fisheries are under-15m in length. The VMS data also identified that there is no over-15m activity occurring within the vicinity of the Project. Although there is non-UK activity (generally Belgian and Irish, although France has historic rights to fish in the 6nm to 12nm limit) occurring within the regional study area, there are no records of foreign activity within the boundary of the Project as non-UK vessels are prohibited from fishing within the 6nm limit.

1.1.6 The majority of the vessels operating within the Project are based at small, local ports along the Welsh, Cheshire and Lancashire coasts. The majority of landings values from rectangle 35E6 are recoded as being into Rhyl and these landings represent a significant proportion of the ports total annual income.

1.1.7 From consultation it is understood that a limited number of charter boats, from both the Rhyl and Liverpool/Wirral area undertake angling and occasional scuba diving activities throughout the local study area, including within the Project site. The skippers of the vessels concerned stated that they target a number of species throughout the year.

2.0 Introduction

2.1.1 Given below is the description of the commercial fishing baseline for the proposed DONG Energy offshore wind farm development, Burbo Bank Extension offshore wind farm, referred to as "the Project", situated in Liverpool Bay.

2.1.2 The preparation of the baseline takes into account the following guidelines:

- Marine and Coastal Access Act (2009)
- Department for Environment, Food and Rural Affairs (Defra)
- Centre for Environment, Fisheries and Aquaculture Science (CEFAS) as specified in the 2004 Guidelines (CEFAS 2004)
- British Wind Energy Association (BWEA) 2004 Recommendations (BWEA 2004)
- Scoping responses to the Scoping Report and Scoping Report addendum issued in July and October 2010 respectively.

2.1.3 At present, there is no single data source or recognised model for establishing commercial fisheries baselines within small, discrete sea areas such as offshore wind farm sites. As a result the following description of the baseline has been derived using data and information from a number of sources.

2.1.4 Establishing a commercial fisheries baseline is complicated by the fact that fishing activities rarely remain constant year on year. Fluctuations in landings, changes in legislation, economic constraints such as fuel costs and availability of crew, and environmental factors such as weather all contribute to variations in annual patterns of activity.

3.0 Study Area

3.1.1 The study area for the assessment of commercial fishing intensity and values is shown in Figure 3.1 below. The Project is located in Liverpool Bay, between the Mersey and Dee Estuaries, and is situated approximately 7.5km off the North Wirral and Sefton coasts and approximately 12.2km off the Welsh coast, covering an area of approximately 40km2. The Project export cable options are situated in ICES rectangle 35E6 and are approximately 20km in length, with the two landfall site options situated between Prestatyn and Rhyl. The Project falls almost exclusively within rectangle 35E6 (94.9%), with a very small proportion of the site located in rectangle 36E6 (5.1%). The zone encompasses 2.9% of the sea area in ICES rectangle 35E6 and 0.06% of 36E6.

3.1.2 The approach has been to briefly describe fishing activity within the regional area on a national context. The regional study area has been defined to ensure sufficient coverage of those areas surrounding the site, and the local study area is the smallest available spatial unit for the collation of fisheries statistics. Where possible, fishing activities in the specific area of the site have been further described.

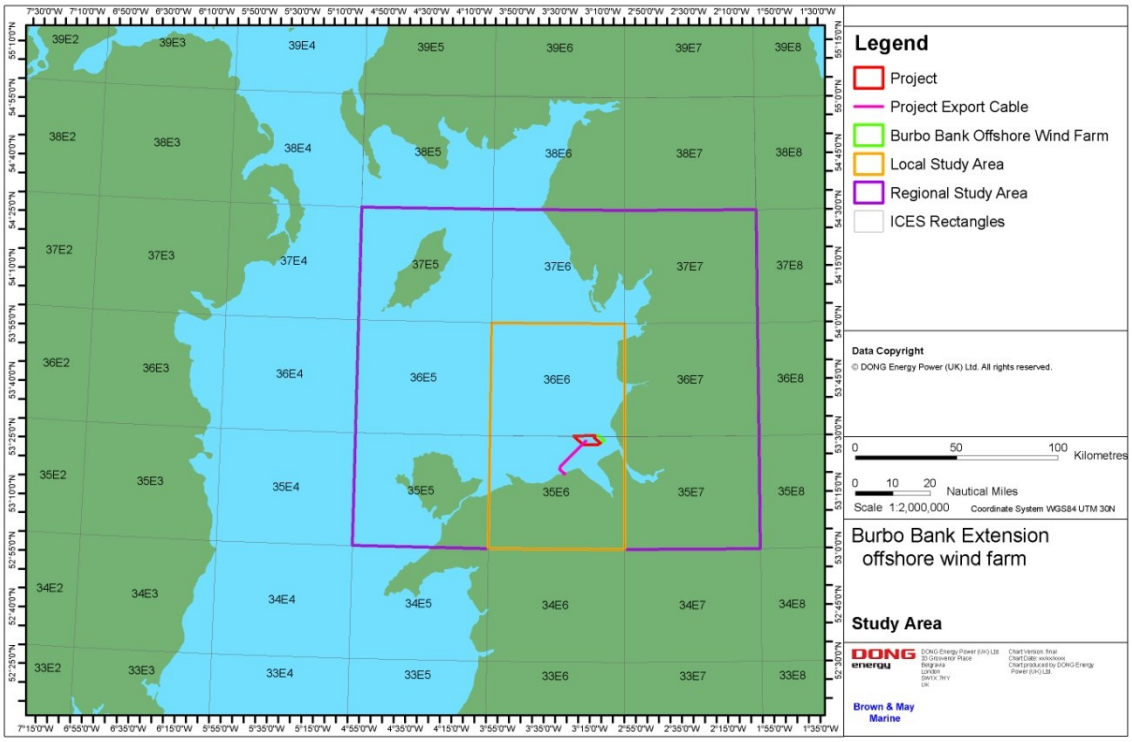


Figure 3.1 Burbo Bank Extension Offshore Wind Farm Study Area

4.0 Methodology

4.1.1 As previously stated there is no model or single source of data for establishing a commercial fisheries baseline; data and information have therefore been collated from a number of different sources. The data and information used are subject to varying sensitivities and limitations, described in Section 5.0, and as a result separate analysis is required in each instance. The aim has been to describe in progressive detail commercial fishing activities by building upon the sources and analysis outlined below:

4.1 MMO Fisheries Statistics (Landings Values and Effort Data Sets)

4.1.2 Fisheries statistical data for the ten year period between 2001 and 2010 has been collected by the Marine Management Organisation (MMO). The data includes landings (weight and value) and effort data (days fished). This data set has been analysed to identify:

- Species targeted
- Fishing methods used
- Vessel categories (under-10m, 10m-15m, over-15m and non-UK)
- Annual variations
- Seasonal variations
- Landings values and effort by port

4.2 MMO Satellite Tracking (VMS) Data

4.1.3 Satellite tracking data (VMS) for all fishing vessels over-15m in length (2007-2010) has been provided by the MMO. Due to the Data Protection Act (1998) the data has only been broken down by passive (i.e. static) and active (i.e. towed) methods and specific fishing methods have not been identified. The data has been cross-referenced with landings and effort data to give values in a 0.05° by 0.05° grid.

4.3 MMO Fisheries Surveillance Sightings Data

4.1.4 Sightings of all fishing vessels in UK waters by nationality and method have been provided by the MMO (2001-2010). The data records the location of all fishing vessels and is useful in assessing the spatial distribution of fishing activity, although the limitations are discussed in Section 0.

4.4 International Data

4.1.5 Data from Irish, French and Belgian fisheries has been obtained and is described in the assessment as a result of the proximity of the Project to international fishing grounds to the west. Data on foreign vessel activity has been separately analysed due to the data sets being in different formats to those of UK data.

4.5 Fishery Specific Information

4.1.6 Information provided by fishermen and their representatives also contributes to the establishment of a commercial fisheries baseline. Such information assists in the identification of the fisheries that occur in the regional and local areas relative to the Project, and the vessels that target those fisheries. The information has been collated through consultation and liaison with fishing organisations, fishermen and their representatives.

4.1.7 Consultation and liaison was undertaken and will continue with organisations and individuals whose valuable contribution in providing information and data for this assessment is recognised and appreciated.

5.0 Data and Information, Sensitivities and Qualifications

5.1.1 As stated previously, there is no single data source or model for establishing a commercial fisheries baseline within such a localised area as a wind farm site. Therefore, data and information from a range of sources have been used:

- International Council for the Exploration of the Sea (ICES)
- Marine Management Organisation (MMO)
    - Fisheries landings values and effort data (2001-2010)
    - Satellite tracking data (VMS) (2007-2010)
    - Surveillance Sightings (2001-2010)
- Belgium - Institute for Agriculture and Fisheries Research (ILVO)
    - Satellite tracking data (VMS) (2009 only)
- Republic of Ireland - Sea Fisheries Protection Agency (SFPA)
    - Satellite tracking data (VMS) (2005-2007)
- France - French Research Institute for Exploration of the Sea (IFREMER)
    - Satellite tracking data (VMS) (2008 only)
- Fishermen and Fishermen's Representatives

5.1 International Council for the Exploration of the Sea (ICES)

5.1.2 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 covering a sea area of approximately 900nm2 (Figure 3.1). The area of an ICES rectangle is relatively larger than the Project, which is predominantly situated in ICES rectangle 35E6, with a small percentage in 36E6. Furthermore, it is presumed that the distribution of activity within a rectangle is not evenly distributed. Analysis of fisheries statistics by ICES rectangle should therefore take into account the small proportion of a statistical area that the site covers and the uneven distribution of activity throughout the rectangle.

5.2 MMO Data Sets

MMO Fisheries Statistics

5.2.1 Fisheries data is collected by the MMO by ICES rectangle for all UK and non-UK vessels landing into UK ports. The main source of fisheries data comes from the EC daily log sheets that the over-10m fleet must complete and submit.

5.2.2 Fishing log sheets from vessels under-10m are not required to be submitted, although skippers can choose to make submissions. Checks on the under-10m fleet are made by local fisheries officers on the dockside. To further assist in the collection of information on the under-10m fleet, the Shellfish Entitlement Scheme (introduced during 2004) and the 'Registration of Buyers and Sellers of First Sale Fish and Designation Auction Site Scheme' (2005) have been introduced. It should be noted that data prior to the introduction of these schemes may underestimate the true levels of activity from the under-10m fleet.

MMO UK Satellite Tracking (VMS) Data

5.2.3 Satellite tracking applies to all EU registered vessels over-15m in length. The vessel monitoring system (VMS) is a satellite-based monitoring system which provides data to the fisheries authorities at regular intervals on the location, course and speed of fishing vessels. The vessels' positions are transmitted via satellite approximately every two hours to the MMO and other EU fisheries control centres.

5.2.4 EU legislation will require all Member State vessels over-12 metres in length to install VMS during 2012; this will not however be reflected in this assessment. As a result, the activity of

the under-15m fleet will not be represented in the analysis of this data set, which can be considerable, particularly in inshore areas.

5.2.5 The MMO receives information from all UK vessels, regardless of location, and all non-UK vessels within UK waters. The MMO cannot disclose information regarding non-UK vessels without prior permission from the vessels national regulating body.

5.2.6 It should be noted that satellite data does not differentiate between vessels steaming and vessels fishing and all vessels that are stationary in port have not been included in the data set. The VMS has been filtered by speed; with vessels travelling at speeds of between 1 and 6 knots included to include vessels which are potentially fishing (Lee et al., 2010). The disclosure of independent UK vessels' identities is restricted under the Data Protection Act (1998).

5.2.7 UK satellite tracking data is released in grid format and the coordinates of individual vessels is currently unavailable. At present the MMO will only provide the aggregated number of position plots by general vessel type (mobile or static gear) in a grid of rectangles of approximately 0.05° by 0.05°. Any rectangles that record less than five transmissions are not included in the data set to protect the identities of those vessels.

MMO Surveillance Sightings

5.2.8 Surveillance sightings in UK waters are recorded by aircraft and surface vessels as a means of fisheries protection, ensuring the fishing industry complies to UK and EU law. This data has been used to give an indication of the relative distribution of fishing activity by method and nationality in a given area. It should be noted however that sightings should not be used for quantitative assessments of activity due to the low frequency of flights in an area, which are generally weekly and only occur in daylight hours.

5.3 Belgian Data

5.3.1 Brown and May Marine (BMM) have been provided with images depicting VMS activity of Belgian vessels in UK waters by the Institute for Agriculture and Fisheries Research (ILVO). The data supplied is for vessels beam trawling and operating demersal gear in 2009 and applies to over-15m vessels only. It is however considered, largely due to the distance of the grounds from home ports, that there is negligible activity by the smaller category of Belgian vessels.

5.4 Republic of Ireland Data

5.4.1 The Republic of Ireland's Sea Fisheries Protection Agency (SFPA) has provided BMM with VMS data for Irish vessels over-15m in length for 2005 to 2007. The data set can only be categorised by fishing activity and therefore cannot be analysed by gear type.

5.5 French Data

5.5.1 French satellite tracking (VMS) data has been obtained from the Research Institute for Exploration of the Sea (IFREMER). The VMS data only accounts for French vessels over-15m in length and travelling at less than 4.5 knots. Vessels travelling at speeds greater than 4.5 knots are not considered to be fishing (Comite National des Peches, 2009) and have therefore been excluded from the data set.

5.6 Fishermen and Fishermen's Representatives

5.6.1 Consultation has been undertaken with individual skippers and their representatives, with information collected and collated from these sources. It is possible that certain individuals and some unaffiliated stakeholders may not have been identified during the course of this assessment, although every attempt has been made to contact all interested parties.

6.0 Fisheries Controls and Legislation

6.1.1 Whilst the international aspect of European fisheries negotiation, such as the settings of quotas, remains a reserved power, the implementation of fisheries regulations is undertaken by the MMO in English waters, the Welsh Assembly Government in Welsh waters and the Scottish Parliament in Scottish waters.

6.1.2 The Common Fisheries Policy (CFP) is the main method through which the EU manages fishing activity in European waters. The seas around Europe are a large resource that is shared amongst all EU Member States. As a result of this the CFP is required to provide management strategies for fishing activities in order to prevent overfishing and provide economic and social stability to fishing communities.

6.1.3 As of 2009 the CFP has been under review and changes to the Policy will come into legislation in 2013, the reform will aim to:

- Make fisheries sustainable
  - Limit the size of the fleet
  - Limit effort (time at sea)
  - Restrict the quantity of fish caught through quotas
  - Regulate how and where fish are caught
- Improve enforcement
  - To ensure that only permitted quantities of fish are caught
- Regulate the size of the European fleet
  - Under the "entry/exit scheme", capacity in the form of tonnage is not allowed to rise above the level of 1st January 2003

6.1.4 In addition to fisheries management at a European and national levels, regional organisations such as the Inshore Fisheries and Conservation Authorities (IFCAs) in England, the Inshore Fisheries Group in Scotland and the Welsh Government, have jurisdiction on a regional and local scale (out to 6nm).

6.1 Fishing Vessel Licenses

6.1.5 For a vessel to commercially fish (i.e. to catch and sell fish for profit) it must hold a valid licence. The current vessel licensing scheme was introduced to stabilise fleet numbers and reduce its catching capacity through the use of vessel capacity units (VCUs). Successive decommissioning schemes have also reduced the size of UK and several other Member States' fleets over the past 20 years.

6.2 Territorial Limits

6.1.6 Under the UN Convention on the Law of the Sea (UNCLOS, 1982), the UK's territorial sea extends out to 12nm from the mean low water mark. With few exceptions, access within 6nm of the coast is restricted to the vessels of that country. Access to fishing grounds between the 6nm and 12nm limit is only granted to vessels from non-UK countries if they have historic fishing rights.

6.1.7 Vessels from Ireland and France have a right to fish between 6nm and 12nm in the Irish Sea, and are permitted to target nephrops and demersal species (Figure 6.1). Outside the 12nm limit, Belgian beam trawl vessels target sole, plaice and skate (Natural England 2010).

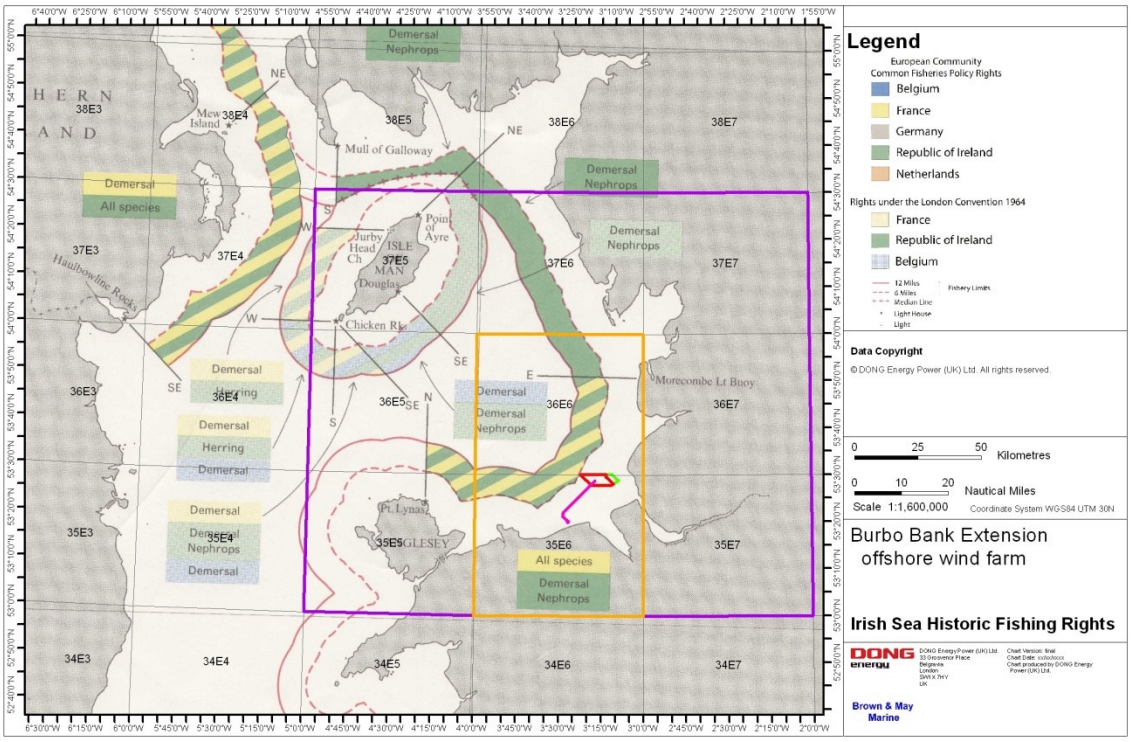


Figure 6.1 Historic Fishing Rights of Non-UK Vessels in the Irish Sea

6.3 Quota Restrictions

6.1.8 In European waters, quota in the form of Total Allowable Catches (TACs) is allocated to EU Member States by ICES sub-area based on historic fishing rights. A quota is a permission to catch quota stocks that are allocated between the non-sector vessels (those who own quota), Producer Organisations who manage quota for their members and the inshore fleet. The UK quota management system aims to ensure that the quota is shared fairly amongst the UK fishing industry and that fishing activity is managed to ensure that these quotas are not exceeded.

6.1.9 In recent years the quota system has been heavily criticised due to the volume of fish that are discarded at sea either because they are undersized or over-quota. The problems associated with quota allocation are likely to be addressed in the reform of the CFP, although they are currently the main species management tool.

6.1.10 The Project is located within ICES sub-division VIIa (Irish Sea). The TACs allocated for the majority of commercial species are set for ICES division VII with the exception of sole, cod, whiting, plaice, haddock, herring and horse mackerel which have a TAC allocation for ICES sub-division VIIa. The allocated TAC for VIIa for all EU nations is illustrated in Figure 6.2. It should be noted that horse mackerel has been excluded within this figure due to its high quota allocation. The TAC for horse mackerel is given in Table 6.1.

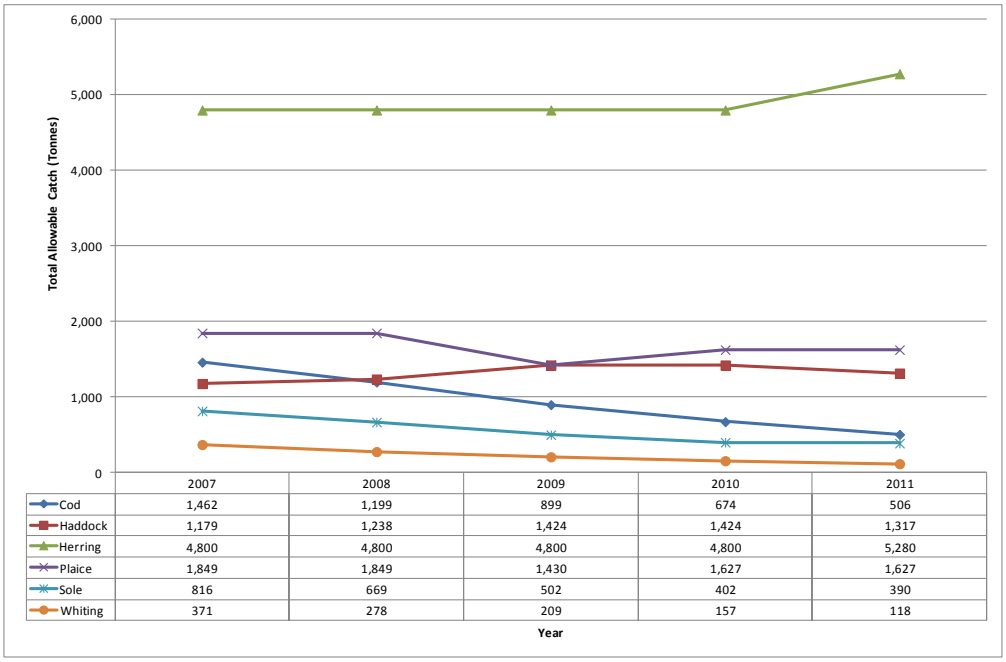


Figure 6.2 EU TACs in ICES Division VIIa (Irish Sea) 2007-2011 (Source: MMO)

Table 6.1 EU Horse Mackerel TAC for ICES Division VIIa (Irish Sea) 2007-2012 (Source: MMO)

Species	Area	TAC (Tonnes)					
		2007	2008	2009	2010	2011	2012 (Proposed)
Horse Mackerel	VIIa	135,518	167,920	165,939	98,986	156,587	157,989

UK Quota

6.1.11 The UK TACs for ICES division VIIa are shown in Figure 6.3. As with the EU TAC, horse mackerel has been excluded from the figure due to its high quota allocation, this is provided in Table 6.2. It can be seen that the highest TAC allocation is for horse mackerel, although this has fluctuated slightly. The quota for herring has remained constant with an increase in 2011. Cod, sole and whiting have recorded the largest declines in quota allocation in recent years.

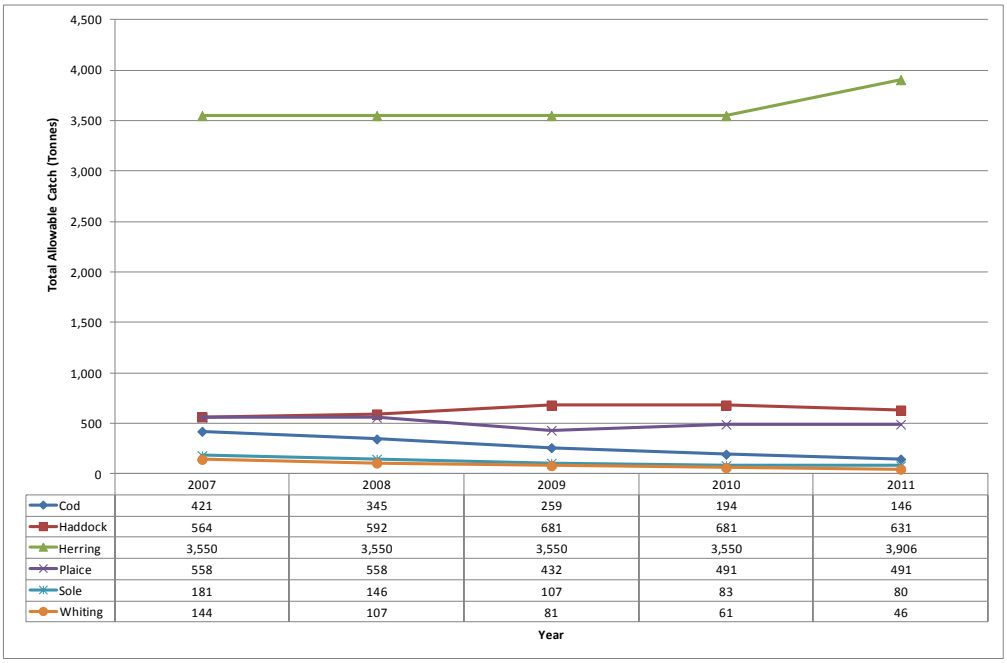


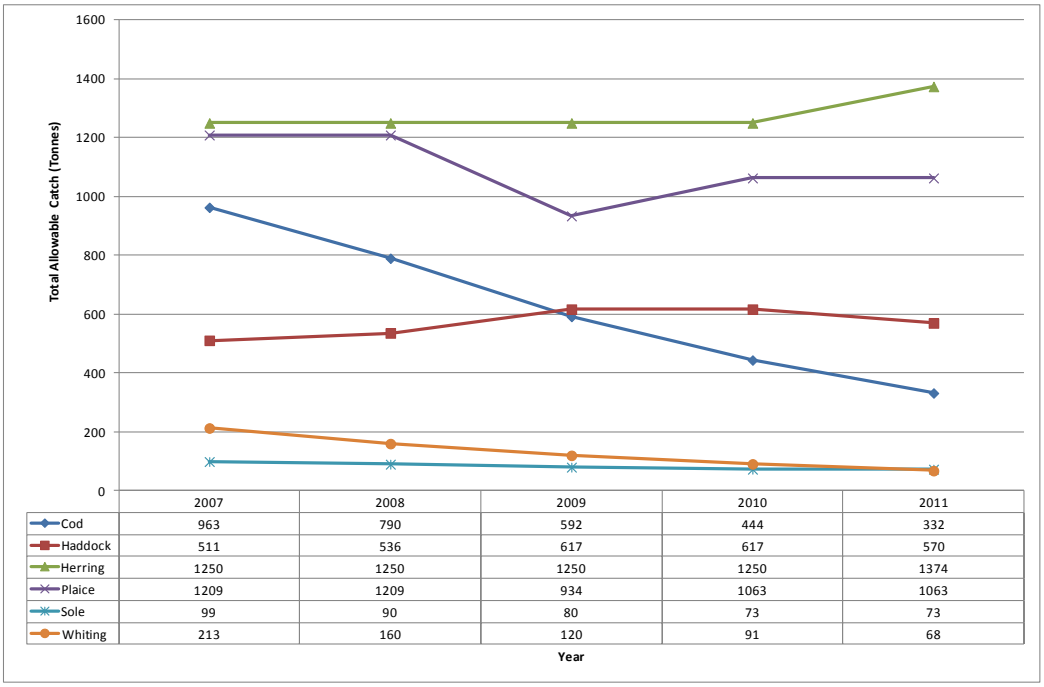
Figure 6.3 UK TACs in ICES Division VIIa (Irish Sea) 2007-2011

Table 6.2 UK Horse Mackerel TAC for ICES Division VIIa (Irish Sea) 2007-2011 (Source: MMO)

Species	Area	TAC (Tonnes)				
		2007	2008	2009	2010	2011
Horse Mackerel	VIIa	13,292	16,470	16,276	9,256	14,643

Irish Quota

6.1.12 The Irish TAC for ICES division VIIa is shown in Figure 6.4. Overall, the Irish TAC allocation is of similar levels to the UK TAC allocation. Horse mackerel represents the largest quota allocation for Ireland in VIIa (Table 6.3) and the allocation is much larger than the UK allocation for this species. The TAC for plaice and haddock show a similar pattern to the EU and UK TACs. The TACs of cod, sole and whiting has shown the largest declines.



	2007	2008	2009	2010	2011
Cod	963	790	592	444	332
Haddock	511	536	617	617	570
Herring	1250	1250	1250	1250	1374
Plaice	1209	1209	934	1063	1063
Sole	99	90	80	73	73
Whiting	213	160	120	91	68

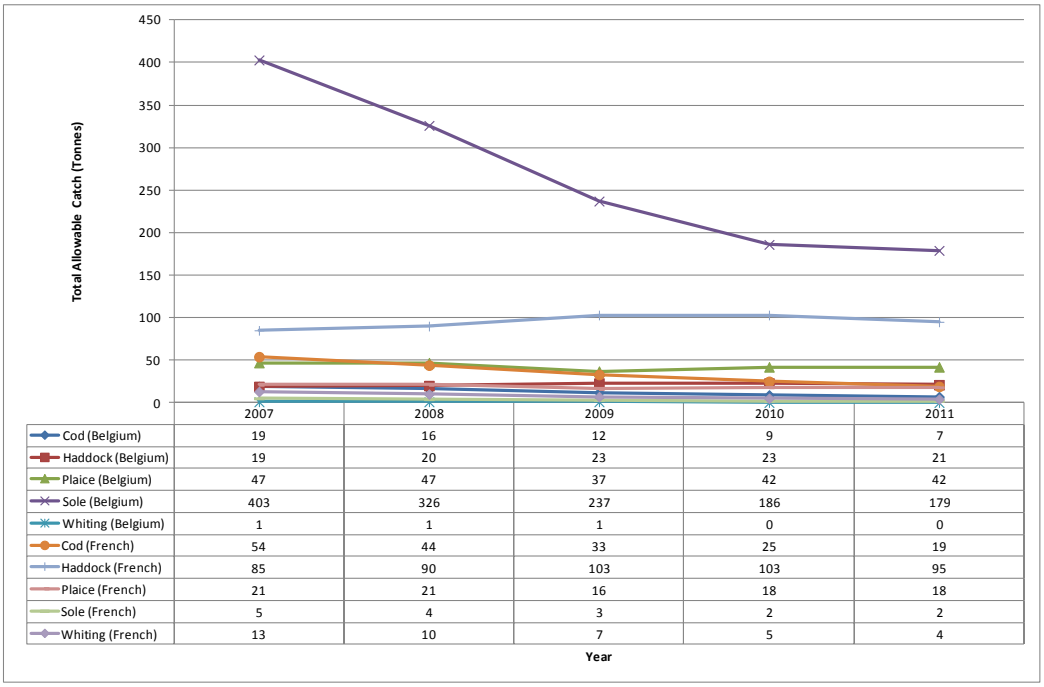
Figure 6.4 Irish TAC in ICES Division VIIa (Irish Sea) 2007-2011

Table 6.3 Irish Horse Mackerel TAC for ICES Division VIIa (Irish Sea) 2007-2011

Species	Area	TAC				
		2007	2008	2009	2010	2011
Horse Mackerel	VIIa	31,996	39,646	39,179	25,560	40,439

French and Belgian Quota

6.1.13 The French and Belgian TACs for ICES division VIIa are shown in Figure 6.5 and the French horse mackerel quota allocation shown in Table 6.4. Belgium does not have quota for horse mackerel. The TACs allocated to these nations for demersal species is comparatively lower than that allocated to the UK and Ireland, with the exception of sole for Belgian vessels. The Belgian quota for sole has seen a reduction of 44% in the five year period and the quota allocation looks likely to fall further in 2012 with the EU proposed TAC for sole in VIIa provisionally set at 300 tonnes (Council of the European Union, 2011).



	2007	2008	2009	2010	2011
Cod (Belgium)	19	16	12	9	7
Haddock (Belgium)	19	20	23	23	21
Plaice (Belgium)	47	47	37	42	42
Sole (Belgium)	403	326	237	186	179
Whiting (Belgium)	1	1	1	0	0
Cod (French)	54	44	33	25	19
Haddock (French)	85	90	103	103	95
Plaice (French)	21	21	16	18	18
Sole (French)	5	4	3	2	2
Whiting (French)	13	10	7	5	4

Figure 6.5 French and Belgian TACs in ICES Division VIIa (Irish Sea) 2007-2011

Table 6.4 French Horse Mackerel TAC for ICES Division VIIa (Irish Sea) 2007-2011

Species	Area	TAC				
		2007	2008	2009	2010	2011
Horse Mackerel	VIIa	6,494	8,047	7,952	3,950	6,250

Over-10 Metre Fleet

6.1.14 National, regional and individual quotas for the over-10m fleet are assigned on the basis of historic rights. Vessel quotas are tangible assets which are eligible to be sold or leased, and national quotas may be exchanged between Member States.

Under-10 Metre Fleet

6.1.15 Vessels under-10m in length represent 65% of the UK's fishing fleet but are allocated 4% of the UK's fishing quota. Half of the under-10m fleet have uncapped licences allowing them to catch more than 300kg of quota species per year (NUFTA, 2012).

6.4 Effort (Days at Sea) Restrictions

6.1.16 The over-10m fleet is subject to days at sea restrictions in addition to quotas. Regulations controlling days at sea (Annex V, EU Regulations 2287/2003) take into account a number of criteria such as target species, gear type, mesh size and management periods. The process in regulating days at sea is complex but generally equates to 14 to 15 fishing days per month for vessels targeting whitefish.

6.5 Shellfish Entitlements

6.1.17 National shellfish entitlement licences were introduced in 2004 for vessels targeting crabs and lobsters. The licences allow an unrestricted quantity of crab and lobster to be caught by vessels which have a historic record in the fishery. Vessels that are under-10m and have a valid shellfish licence must submit monthly shellfish return sheets that have daily entries for crab and lobster to the local Fishery Officer.

6.1.18 The minimum landing size and condition of crabs and lobsters landed is governed under EU regulations outside 6nm and by local byelaws within the 6nm limit by the local IFCA.

6.6 Scallop Dredge Restrictions

6.1.19 Vessels within the UK scallop fleet generally fall into two categories: the smaller and predominantly inshore fleet which operates a limited number of dredges in grounds within operational range of their home port; and the large category 'nomadic' fleet operating a high number of dredges and seasonally targeting grounds around the UK.

6.1.20 At present there is no quota restriction on scallops; landings are limited only by minimum landing size (110mm for king scallops and 40mm for queen scallops in the Irish Sea). Gear restrictions and area closures are in place to manage the fishery in certain areas. Restrictions on the number of dredges that can be used depend upon the distance the vessel is operating from the coast. In the Irish Sea, vessels are allowed up to eight dredges per side inside 6nm and there is no restriction outside of the 6nm limit. In recent years the number of UK vessels targeting the scallop fishery has increased, partly due to the increasing pressure on quota stocks. Scientific evidence suggests that current scallop stocks are at sustainable levels.

6.1.21 The proposed English Scallop Order 2012 will replace the English Scallop Order 2004. The new order will introduce measures to:

- Provide protection for the small scale fleet
- Reduce catching capacity in certain areas to safeguard stocks
- Improve enforcement

6.1.22 The present English Scallop Order 2004 introduced the following measures to regulate the fishery:

- The specification of dredges
- A limit of eight dredges per side within 6nm
- A ban on attachments

6.1.23 Within UK waters each devolved administration (England, Scotland, Northern Ireland, Wales and the Isle of Man) implement their own management strategies within their waters. Restrictions on dredging and number of dredges by fishing administration are provided in Table 6.5 and Table 6.6, respectively.

Table 6.5 National Scallop Dredging Restrictions by Fisheries Administration (Source: Defra 2011a)

Scallop Dredging Restrictions	England	Scotland	Wales	Northern Ireland	Isle of Man
Engine Power Limit within 12nm	Nil	Nil	221kw	Nil	221kw
Closed Season	Irish Sea Closures	Irish Sea Closures	May to October	Irish Sea Closures	June to October
Curfew	Nil	Nil	Nil	0600 to 2000, no Weekends	0600 to 2000 only
Closed Areas	Lyme Bay	Nil	Yes	Nil	Yes

Table 6.6 Restrictions on Numbers of Scallop Dredges Permitted by Fisheries Administrations (Source: Defra 2011a)

Scallop Dredging Number Restrictions	England	Scotland	Wales	Northern Ireland
0-1nm	8 per side	8 per side	Scalloping not permitted	6 per side
1-3nm	8 per side	8 per side	3 per side	6 per side
3-6nm	8 per side	8 per side	4 per side	6 per side
6-12nm	Nil	10 per side	7 per side	6 per side
12nm+	Nil	14 per side	Nil	Nil

6.7 Regional and Local Fishing Restrictions

6.1.24 As mentioned previously, the Project falls within the jurisdiction of the North West IFCA (NW-IFCA), which enforces the local byelaws within 6nm of the coast. Byelaws include:

- Minimum Landing Sizes (MLS) for fish and shellfish species
- Restrictions on gear and vessels
    - No drift or seine netting
    - Minimum cod-end mesh size of 110mm
    - No twin or multi-rig trawls
    - No vessels with engines greater than 221kW
- No vessels greater than 13.2m within 3nm of the coast
    - This is to ease fishing efforts on local whitefish and shellfish by large, high powered vessels
- Seasonal and temporary closures
- Fishing permits for shellfish species e.g. cockles, mussels, lobsters, crabs and whelks
- Catch restrictions
    - One tonne of cockles and mussels per person per day

6.1.25 MLS for certain fish and shellfish species are set by the EC Council Regulation 850/98 (Annex XII) and by local sea fisheries committees in waters within their jurisdictions.

Closed Areas

6.1.26 Within the regional study area there are a number of closed areas for the protection of cod and herring. In 2000, the Irish Sea Cod Recovery Zone (CRZ) Scheme was implemented within the Irish Sea to protect spawning cod stocks. The closed area was chosen to encompass the bulk of egg production. As part of the measures for cod recovery, restrictions on effort of the over-10m fleet and vessels using specific gear within the Irish Sea were implemented (European Commission, 2000). The current closed area only applies to the western Irish Sea.

6.1.27 Closed areas for herring in the Irish Sea were introduced in the 1980s when herring stocks were under high fishing pressure. The aim of the closed areas was to limit the risk of overfishing during periods when herring are aggregated in large shoals (Rogers, 1997). The Project falls within the area closed for herring spawning under EC Council Regulations 850/98. No fishing for herring can occur within the Project site throughout the year.

6.8 Marine Conservation Zones

6.1.28 At present the UK is in the process of establishing Marine Conservation Zones (MCZs) in both inshore and offshore waters. MCZs are designed to protect habitats and species of national importance. It is possible that some, if not all, fishing activity will be restricted within selected MCZ sites.

6.1.29 The Project falls within the Irish Sea Conservation Zone project area. The Irish Sea Conservation Zone Regional Stakeholder Group (RSG) recently finalised their recommendations for MCZs, which are shown in Figure 6.6. Currently, these MCZs and their recommendations for protection have yet to be approved by the government, and it is possible that areas will be modified. Within the local study area (rectangles 35E6 and 36E6) three recommended MCZs have been identified, these are listed below along with the reason for protection and possible impact on fisheries (Irish Sea Conservation Zone, 2011):

- Recommended Marine Conservation Zone 8: Fylde Offshore – Classified to protect red throated divers and common scoter. Commercial fishing activity is known to take place in this area, but at current levels no additional management would be required.
- Recommended Marine Conservation Zone 13: Sefton Coast – Identified to protect peat and clay exposure. At existing levels benthic fisheries that occur on the peat and clay exposure would require additional management. Fishing and bait digging on the beach would not require additional management at present.
- Recommended Marine Conservation Zone 14: Hilbre Island Group – Identified to protect blue mussel beds and exposed peat and clay beds. Hand collecting of shellfish is known to occur within the area, this may require additional management but only in areas where the peat and clay is exposed or on the blue mussel beds. Other fishing activity within the area would not require management as long as they avoid the clay and peat exposure and blue mussel beds.

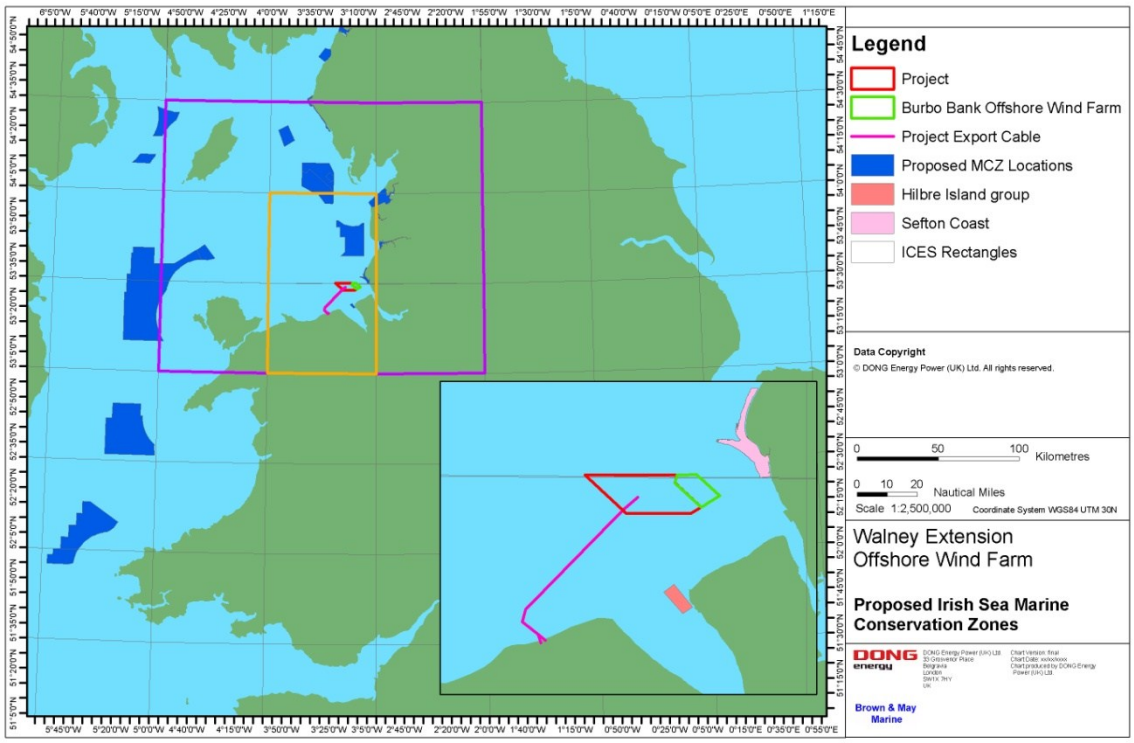


Figure 6.6 Proposed Marine Conservation Zones in the Local Study Area in Relation to the Project (Red) and existing Burbo Bank Wind Farm (Green) (modified from: Irish Sea Conservation Zone, 2011)

7.0 Fishing Methods, Gear and Practices

7.1.1 The main fishing activities undertaken in the vicinity of the Project are:

- Hand fishing for cockles
- Dredging for king and queen scallops
- Potting for whelks and lobsters
- Beam trawling for flatfish
- Otter trawling for mixed demersal species
- Gillnetting for mixed demersal species

7.1.2 Historically, beam trawling for brown shrimp has occurred in the area and the MMO landings data record significant values in rectangle 36E6; consultation has however highlighted that this activity occurs away from the Project and beam trawling for brown shrimp has never occurred in or around the Project (pers. comm. Fleetwood fisherman, 2012).

7.1 Hand Fishing for Cockles

7.1.3 In areas around the Lancashire coast, there are a number of cockle beds including beds at Morecambe Bay, in the Ribble Estuary and in the Wirral. Under the jurisdiction of the NW-IFCA, a closed cockle season is in operation between 1st May and 31st August, to protect the settling spat.

7.1.4 The cockle beds are a public fishery and anyone can take up to 5kg of cockles per day. A commercial fishing licence allows up to 1 tonne of cockles to be harvested per day. Cockles are collected at low tide with a rake; the sand is raked backwards to create a pile of cockles. Live cockles are separated from the empty broken shells and the collected cockles are placed in fresh sea water.

7.2 Dredging for Scallops

7.1.5 The gear used to target scallops is dependent upon the species targeted. King scallops are typically fished by vessels operating a “Newhaven” type dredge. These dredges have eight or nine spring loaded teeth up to 11cm in length which are designed to rake the scallops from the seabed into the following reinforced net.

7.1.6 Queen scallops which are more active than king scallops are targeted using either a simple towed dredge in which the teeth are replaced with tickler chains. A scallop dredger towing eight dredges per side is shown in Figure 7.1

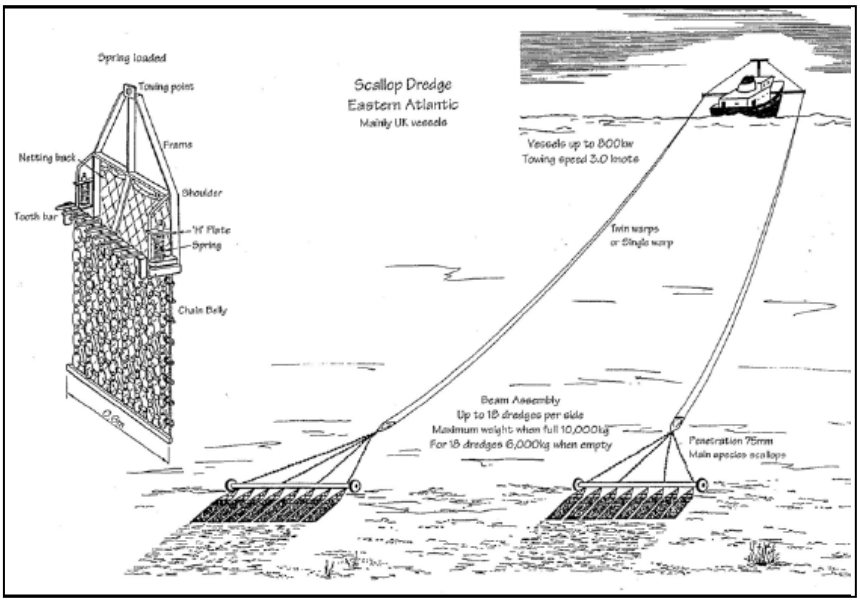


Figure 7.1 Scallop Dredging (Source: Drew & Hopper 2009)

7.3 Potting for Whelks and Lobsters

7.1.7 Throughout the UK the design of pots varies depending on region and target species. All pots have one or more "funnel" shaped entrances for the shellfish to enter. Pots are baited, usually with fish, and shot in fleets of typically between 20 to 50 pots. Surface marker buoys (dhans) are attached to each end of the fleets. Within the vicinity of the Project the main target species for potters are whelks and lobsters (Figure 7.2).

Figure 7.2 Whelk Pots (left) and "Parlour" Pots (right) used to target Whelks and Lobsters (Source: BMM)

7.4 Beam Trawling for Flatfish

7.1.8 Beam trawls comprise of steel beams held off the seabed by shoes or rollers at each end, onto which a net is attached. The larger categories of trawlers usually tow two beams from outrigger booms either side of the vessel. Beam trawls can range in length from 4 to 12 metres (Figure 7.3). Some smaller vessels deploy one beam from the stern. Due to the size and weight of beam trawl gear this method of fishing has high running costs, particularly due to fuel consumption. Beam trawlers predominantly target high value flatfish such as sole, plaice, turbot and brill.

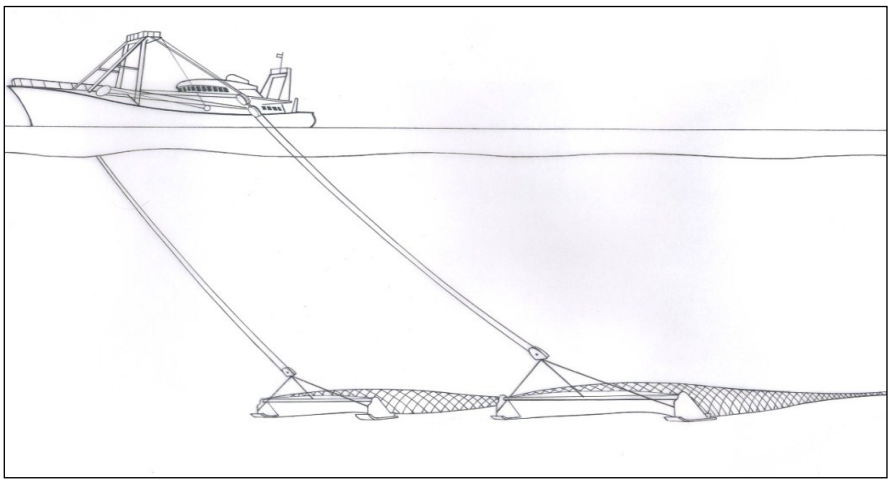


Figure 7.3 A Beam Trawl (Source: BMM)

7.5 Otter Trawling for Mixed Demersal Species

7.1.9 Otter trawls (Figure 7.4) are comprised of a funnel shaped net tapering towards the cod-end. The lateral opening of the net is maintained by the trawl doors and the vertical opening by a series of floats attached to the headline of the net. The ground lines of nets are weighted to maintain contact with the seabed and can vary in design depending on the type of ground fished.

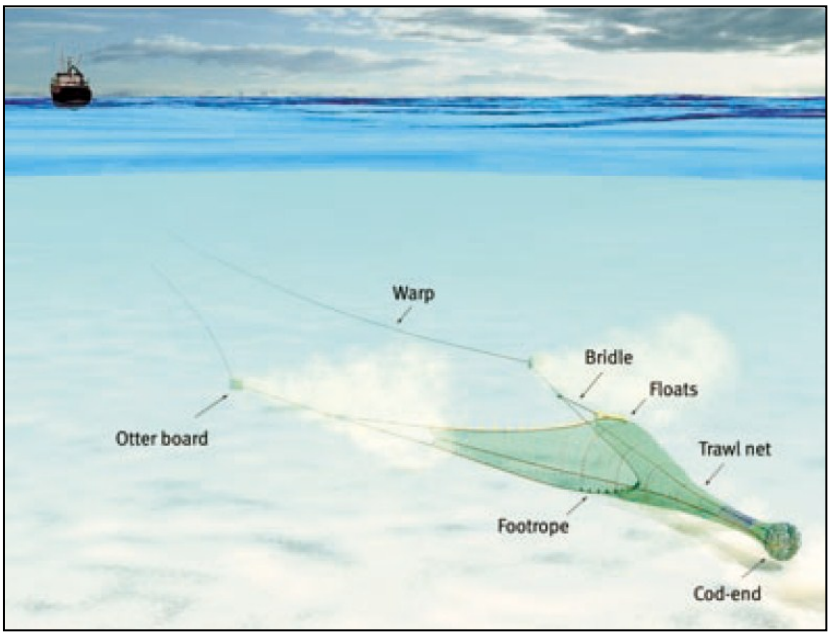


Figure 7.4 A Typical Otter Trawl (Source: Galbraith & Rice, 2004)

7.6 Gillnetting for Mixed Demersal Species

7.1.10 Gillnets (Figure 7.5), which can be either fixed or drifting, area series of monofilament nets joined together to form fleets which can be up to 1200m in length. As with fleets of pots, at each end of the fleets of nets are surface marker buoys. Gillnets can either be single panels of monofilament nets which are also called tangle nets, or trammel nets which comprise of a smaller mesh inner net with larger mesh net panels either side of it. Fixed nets are set either in line with the tidal flow or across it and are normally only deployed on neap tides. Drift nets are deployed across the tide and left for a period of normally three to six hours to drift over the seabed with the tidal current.

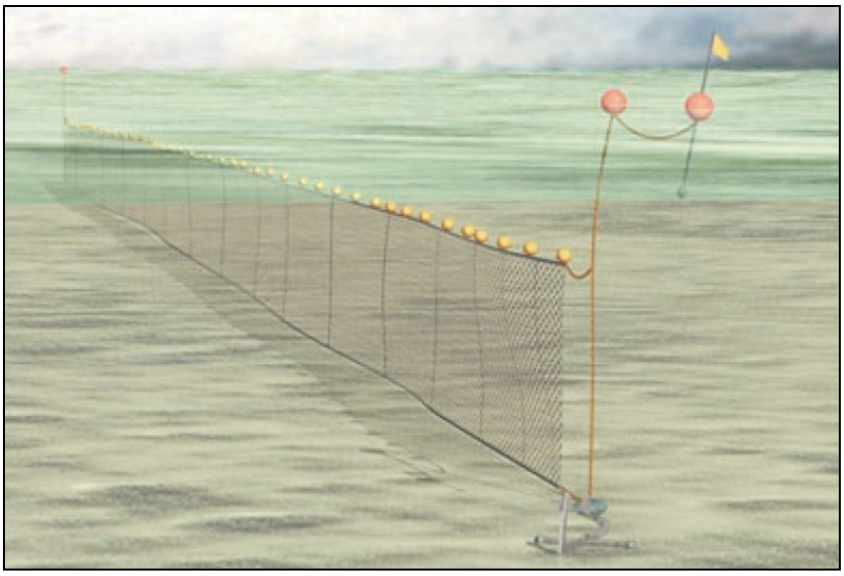


Figure 7.5 A Bottom Set Gillnet (Source: Galbraith & Rice, 2004)

8.0 MMO Fisheries Statistics (Landings Values and Effort Data Sets)

8.1.1 The fisheries statistics analysed below are collated by ICES rectangle and, as previously mentioned, an individual rectangle encompasses a relatively large sea area relative to the area of the Project. For the purpose of statistical analysis the regional study area is taken as that being encompassed by ICES rectangles 35E5, 35E6, 35E7, 36E5, 36E6, 36E7, 37E5, 37E6 and 37E7. The local study area is taken as being that covered by ICES rectangles 35E6 and 36E6.

8.1 Landings Values

National Overview

8.1.2 The landings values (average 2001-2010) of the top species in the local study area on a national scale are given in Figure 8.1. Overall the local study area records average landings values of £3.5 million per year (2001-2010). The ICES rectangles in which the Project is situated are of moderate (36E6) and low (35E6) importance on a national scale.

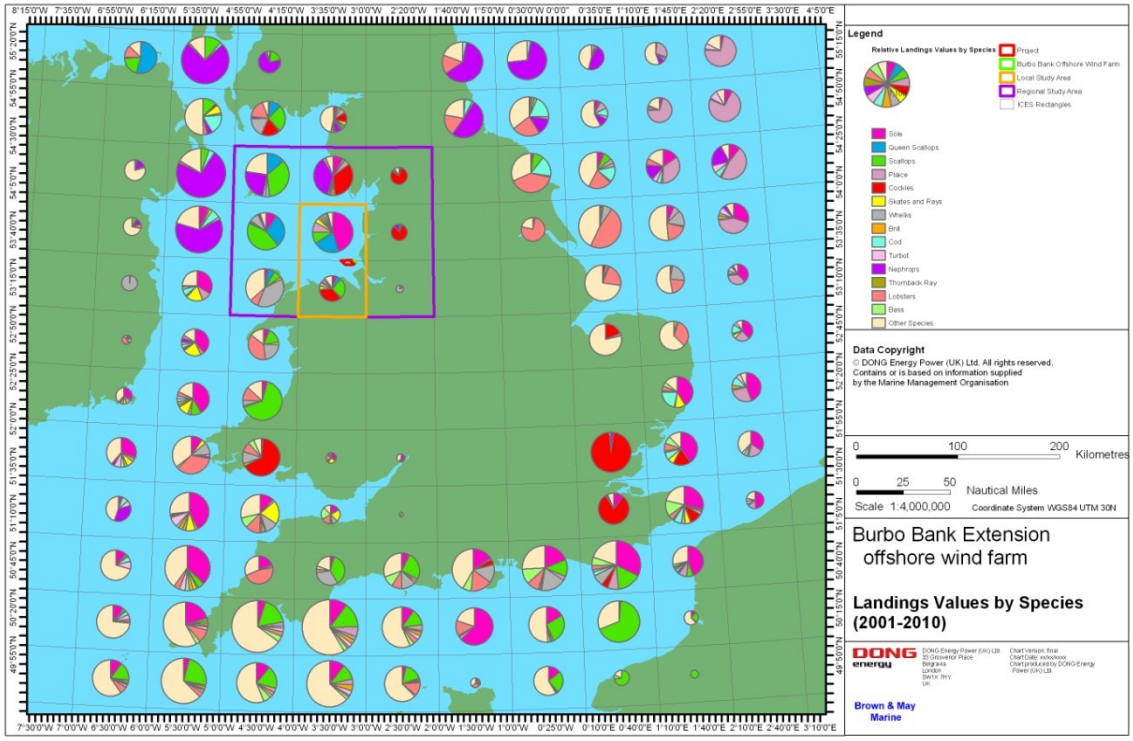


Figure 8.1 Landings Values by Species (average 2001-2010) in the National Study Area (Source: MMO)

8.1.3 Figure 8.2 to Figure 8.6 shows the average landings values (2001-2010) of the top five species within the local study area on a national scale. ICES rectangles with values less than £5,000 (average 2001-2010) have been removed from the data set to provide the relative values of each species. The top five species by value identified in the local study area are sole, queen scallops, scallops, plaice and cockles.

8.1.4 Figure 8.2 shows that beam trawling for sole within the regional study area represents moderate to high landings values on a national scale. The Irish Sea has in the past contained an important sole fishery for both UK and non-UK vessels. Other important sole grounds are located in the Bristol Channel, English Channel and southern North Sea.

8.1.5 As can be seen in Figure 8.3 queen scallops landings values recorded in rectangle 36E6 are among the highest in the UK as the majority of landings values are recorded within the Irish Sea.

8.1.6 The landings values of king scallops vary throughout the regional study area (Figure 8.4). Relatively high king scallop landings values are recorded in central areas of the Irish Sea, including in the waters around the Isle of Man. King scallop fisheries are also heavily targeted in the English Channel and off the east and west coasts of Scotland. Both king and queen scallops are principally targeted using dredges.

8.1.7 Within the regional study area, plaice constitutes low to moderate landings values on a national scale (Figure 8.5); however landings values in 36E6 are the highest recorded on the west coast of the UK. Plaice are generally targeted by vessels using beam trawl gear.

8.1.8 The UK cockle fishery is a localised, inshore fishery (Figure 8.6), with a significant proportion of UK activity occurring within the local study area (35E6). Other important cockle fishing grounds are located in the Thames Estuary and off the south coast of Wales. Cockles are mainly collected by hand or by suction dredge.

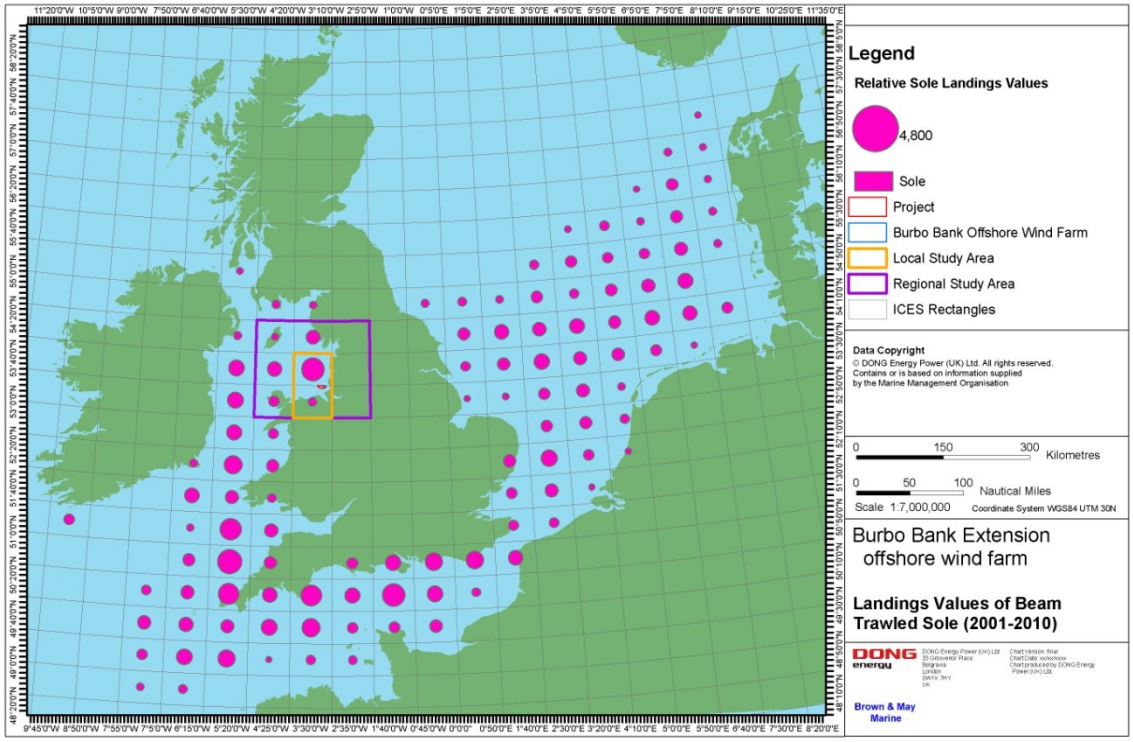


Figure 8.2 Landings Values (average 2001-2010) of Beam Trawled Sole only (Source: MMO)

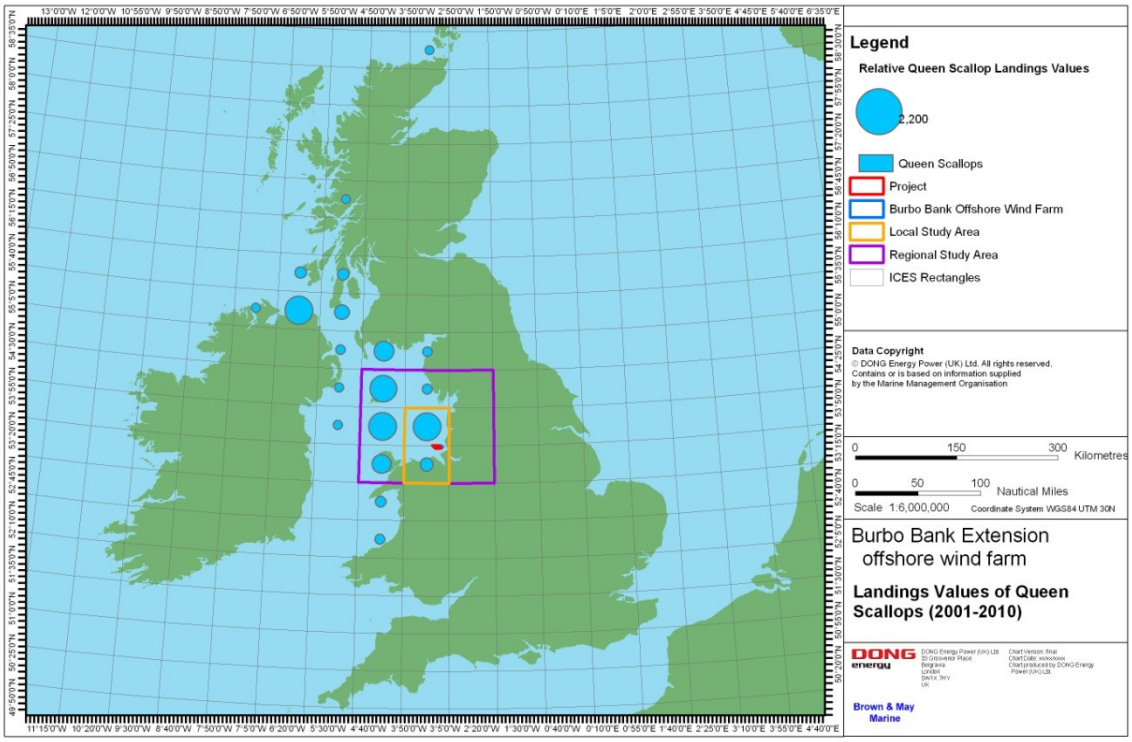


Figure 8.3 Landings Values (average 2001-2010) of Queen Scallops only (Source: MMO)

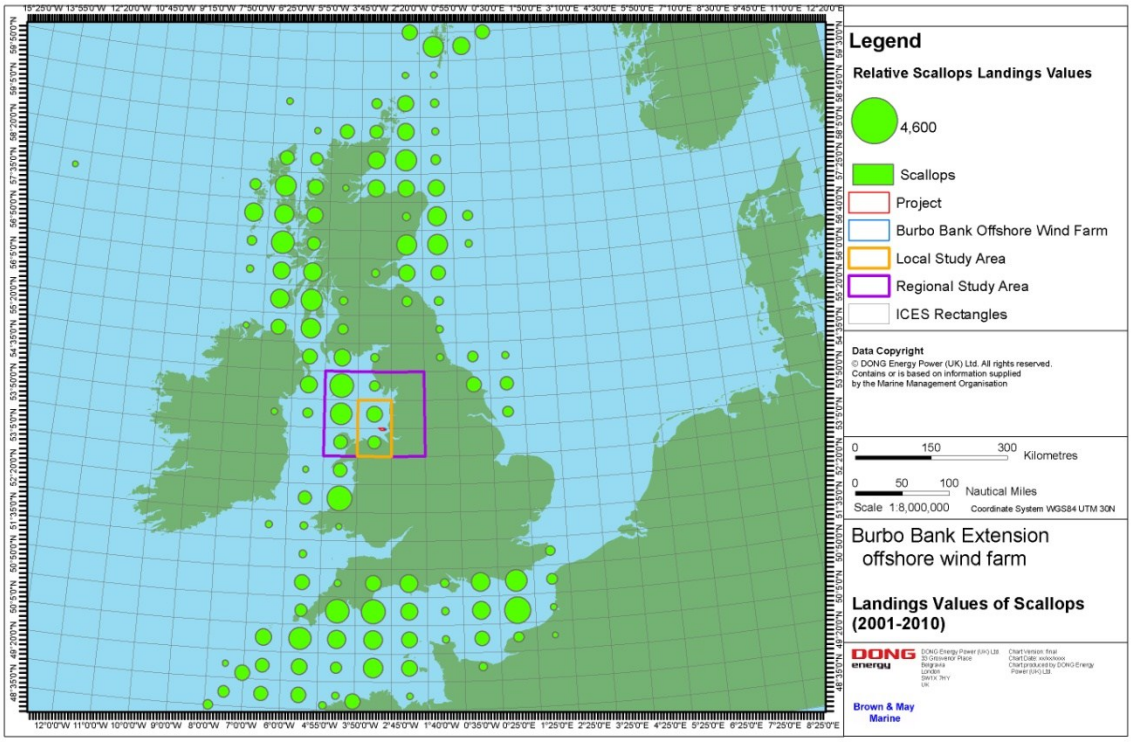


Figure 8.4 Landings Values (average 2001-2010) of King Scallops only (Source: MMO)

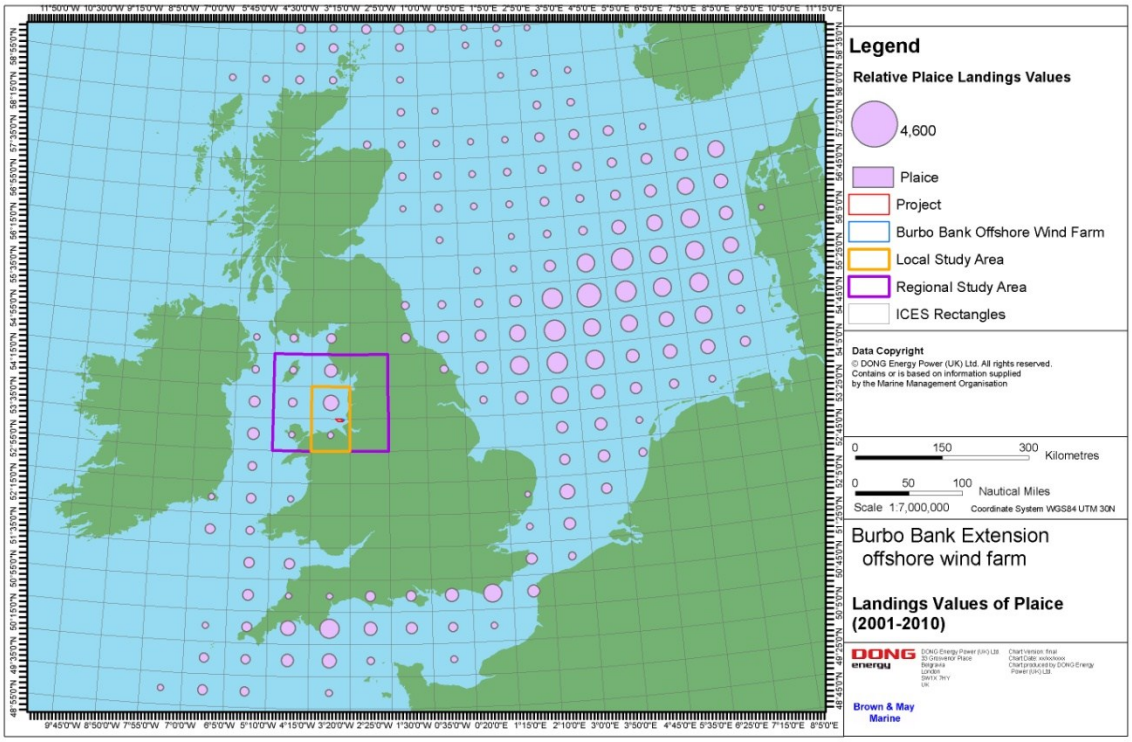


Figure 8.5 Landings Values (average 2001-2010) of Plaice only (Source: MMO)

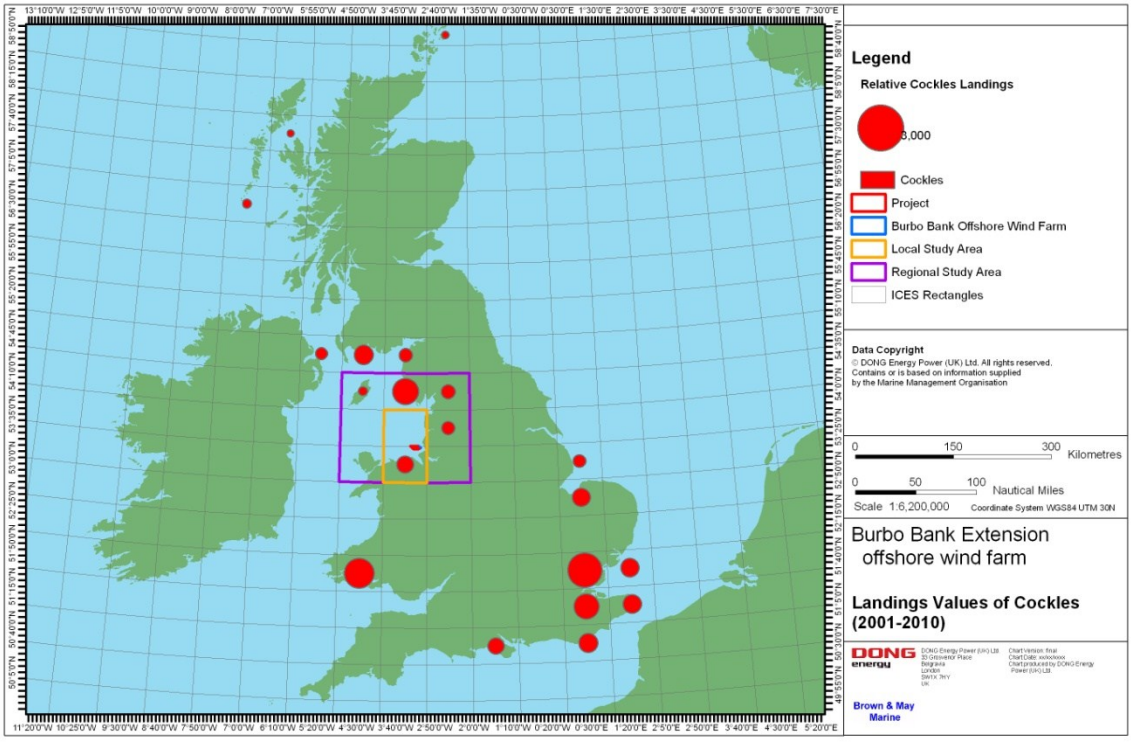


Figure 8.6 Landings Values (average 2001-2010) of Cockles only (Source: MMO)

Regional Overview

8.1.9 The average landings values (2001 to 2010) in the regional study area by species and method are shown in Figure 8.7 and Figure 8.8, respectively. Within the local study area, rectangle 35E6 records relatively low landings values whereas rectangle 36E6 records comparatively moderate landings values.

8.1.10 Higher landings values are recorded in the north-west (rectangle 37E5) of the regional study area, with king and queen scallops representing the highest landings values. Nephrops trawling within the area also contributes a relatively high proportion of the landings values. Fishing activity in 36E5 in the west of the regional study area follows a similar pattern to 37E5, recording moderate landings values of king and queen scallops, although there is also some beam trawling for sole.

8.1.11 In the south-west of the regional study area (35E5) the highest landings values are recorded by potters targeting whelks and mechanized dredgers targeting mussels.

8.1.12 In coastal waters within the regional study area, such as along the coasts of Cumbria, Lancashire and North Wales, including rectangle 35E6, one of the main fishing activities is hand fishing for cockles. The cockle fishing grounds are situated in areas above the mean low water mark so they can be accessed at low tide. There is also some dredging activity for scallops recorded in 35E6 and trawling for nephrops in 37E6.

8.1.13 The majority of activity within rectangle 36E6 is recorded by beam trawlers targeting sole and plaice. Mechanized and boat dredges targeting scallops and queen scallops also represent a proportion of the fishing activity recorded within this area.

8.1.14 The average landings values (2001-2010) by vessel category in the regional study area are shown in Figure 8.9. In coastal areas the higher landings values are recorded by the under-10m fleet. There are generally low levels of activity recorded by the 10m-15m fleet in the study area, with the majority of activity recorded in rectangle 35E5. Over-15m vessels record the highest landings values in the west of the regional study area.

8.1.15 It should be noted that a significant proportion of the activity in rectangle 36E6 is recorded by non-UK vessels as discussed further in Section 9.2.

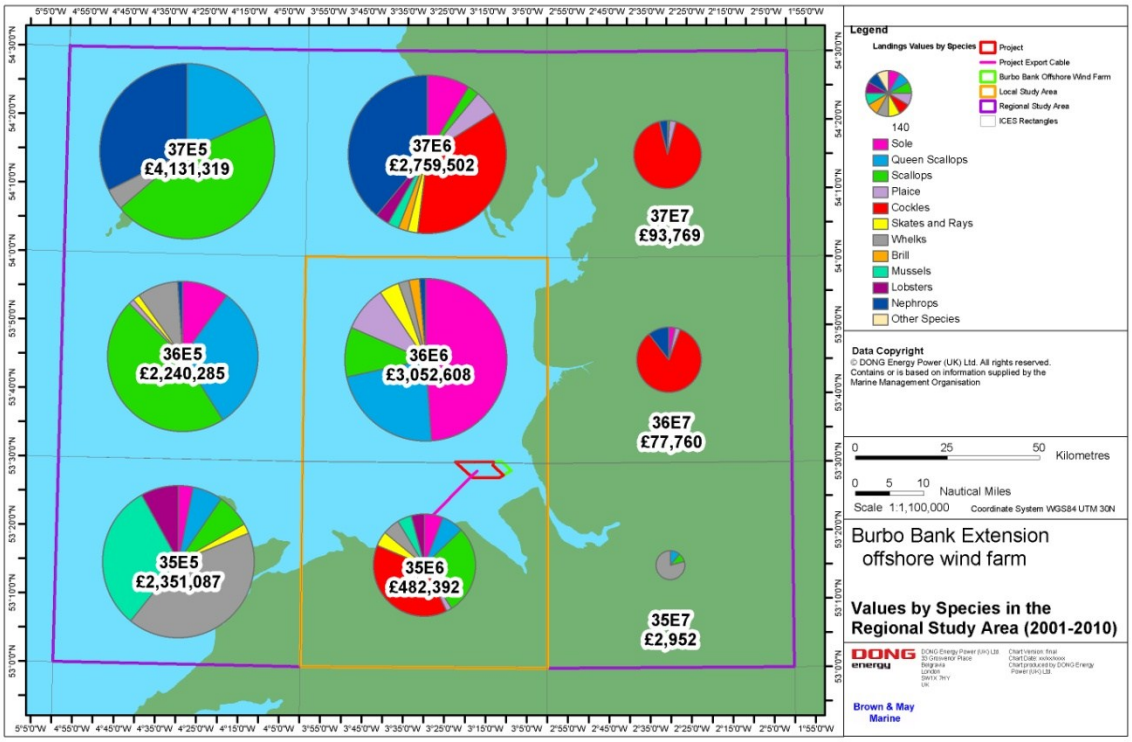


Figure 8.7 Landings Values by Species (average 2001-2010) in the Regional Study Area (Source: MMO)

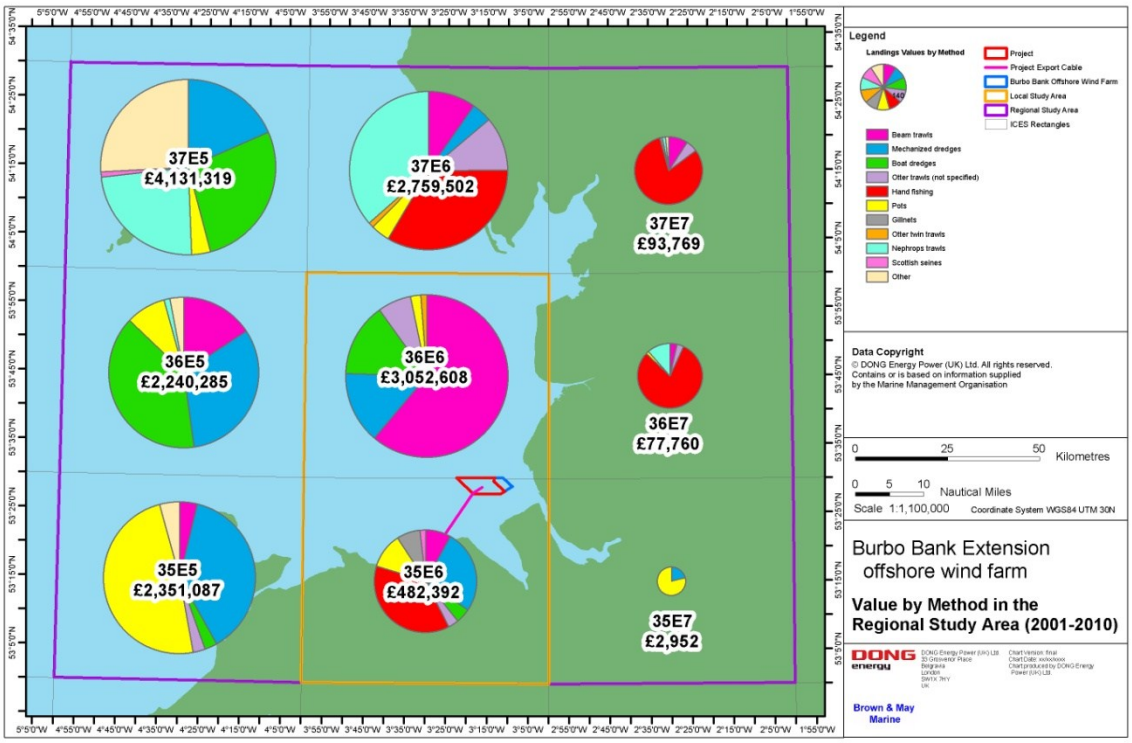


Figure 8.8 Landings Values by Method (average 2001-2010) in the Regional Study Area (Source: MMO)

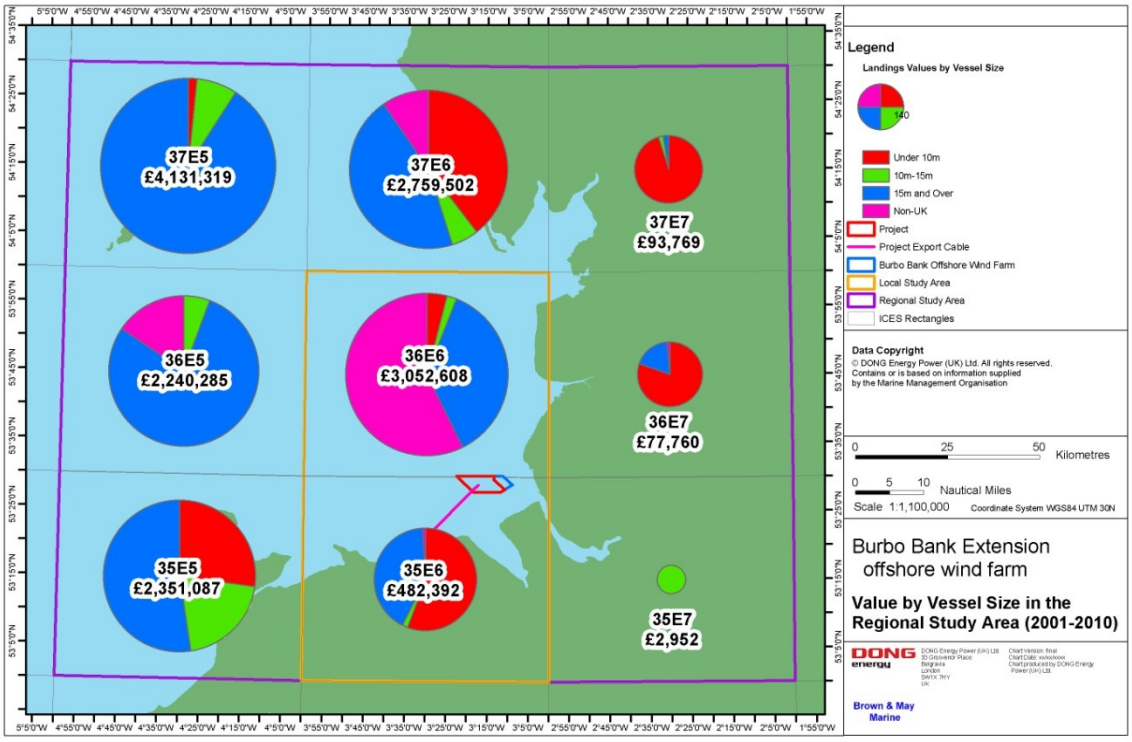


Figure 8.9 Landings Values by Vessel Category (average 2001-2010) in the Regional Study Area (Source: MMO)

Local Study Area

8.1.16 As mentioned previously the majority of the Project site is situated within 35E6, with only a small proportion located in 36E6. Due to this analysis of fishery statistics for the local study area has been undertaken on an individual ICES rectangle basis.

ICES Rectangle 35E6

8.1.17 Figure 8.10 shows the average annual landings values (2001-2010) by species in rectangle 35E6. Cockles record the highest landings values (£167,156, 34.7%), followed by king scallops (£121,960, 25.3%). The remainder of the landings values are principally comprised of queen scallops (£30,470, 6.3%), sole (£25,546, 5.3%) and whelks (£23,533, 4.9%).

8.1.18 Figure 8.11 shows that cockles and mussels are predominantly hand fished and as such occur in the intertidal zones and not in the Project area. The majority of king and queen scallops are targeted by mechanized dredgers, with a proportion target by boat dredgers. Vessels operating beam trawls primarily target sole. Whelks and lobsters are targeted by potters, and skates and rays are targeted by vessels operating gillnets.

8.1.19 Figure 8.12 shows that the majority of vessels operating pots and gillnets and a proportion of beam trawlers are under-10m in length. The majority of vessels operating mechanized dredges are over-15m in length. A small proportion of the beam trawling fleet are non-UK registered vessels.

Annual and Seasonal Landings Values

8.1.20 Figure 8.13 shows the annual variations in landings values by species in rectangle 35E6. It can be seen that landings values for the majority of species decreased over the ten year period although an increase was recorded during 2009 as a result of an increase in king scallop landings. Despite the overall decline, the landings values of certain species such as

whelks, skates and rays and bass have increased in recent years. The highest total landings values for the period were recorded in 2002 as a result of the high landings values recorded from the cockle fishery during this period (£1,273,200). These landings values were recorded as a result of the Wirral cockle beds opening in October and November.

8.1.21 Figure 8.14 shows the average annual landings values (2001-2010) by seasonality in rectangle 35E6. The highest landings values are recorded between October and February, inclusive, with moderate landings values recorded in August. The lowest landings values are recorded in July and September.

8.1.22 Figure 8.15 shows the seasonal variations in landings values for the top four species recorded in ICES rectangle 35E6: cockles, king scallops, queen scallops and sole. Cockles and king scallop landings values generally conform to the broad seasonality pattern of highest landings values recorded between October and February and lowest recorded during the summer months (although moderate cockle landings values are recorded in August). The high cockle landings values recorded in 2002 were principally caught during October and November, potentially misrepresenting the landings values recorded during these months for the remainder of the ten year period.

8.1.23 Queen scallops are targeted year round; the highest landings values are recorded between August and February and low landings values for the remainder of the year. Sole are targeted throughout the year although comparably lower landings values are recorded, with a peak in landings in April and May.

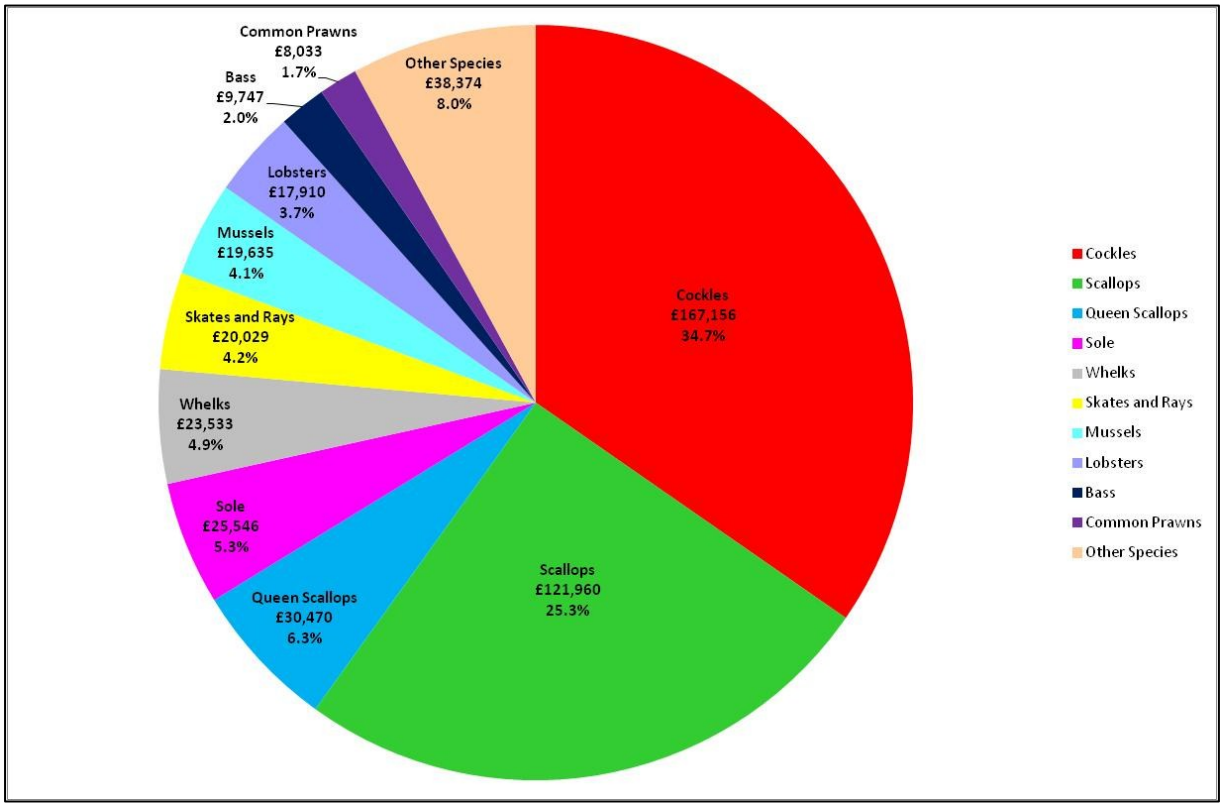
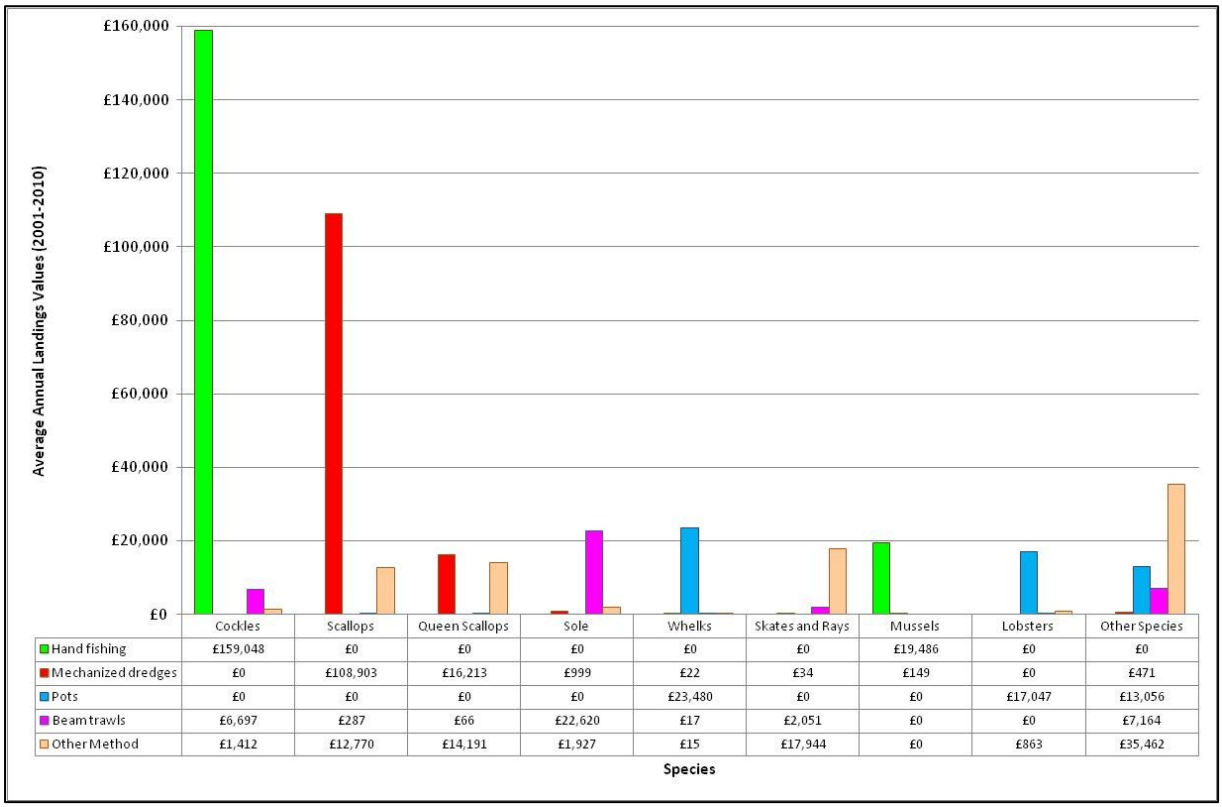
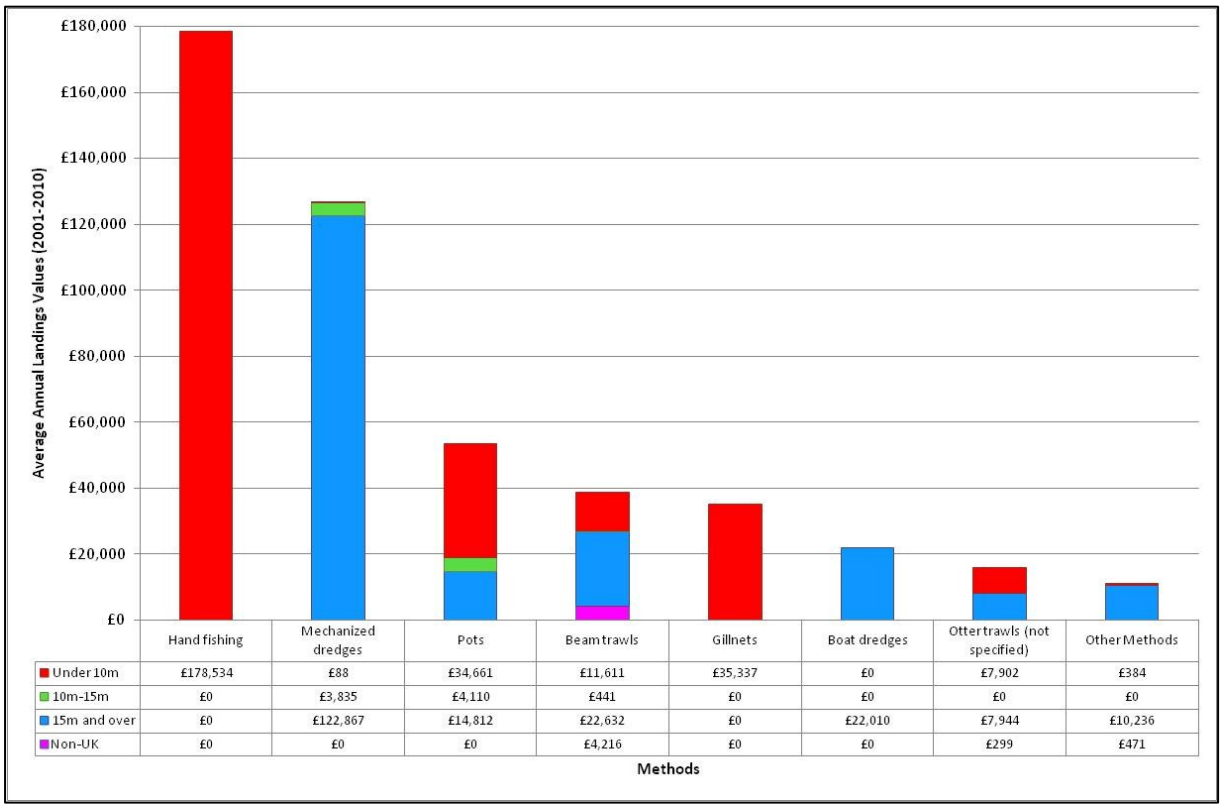


Figure 8.10 Percentage Distribution of Landings Values by Species in ICES Rectangle 35E6 (Source: MMO)



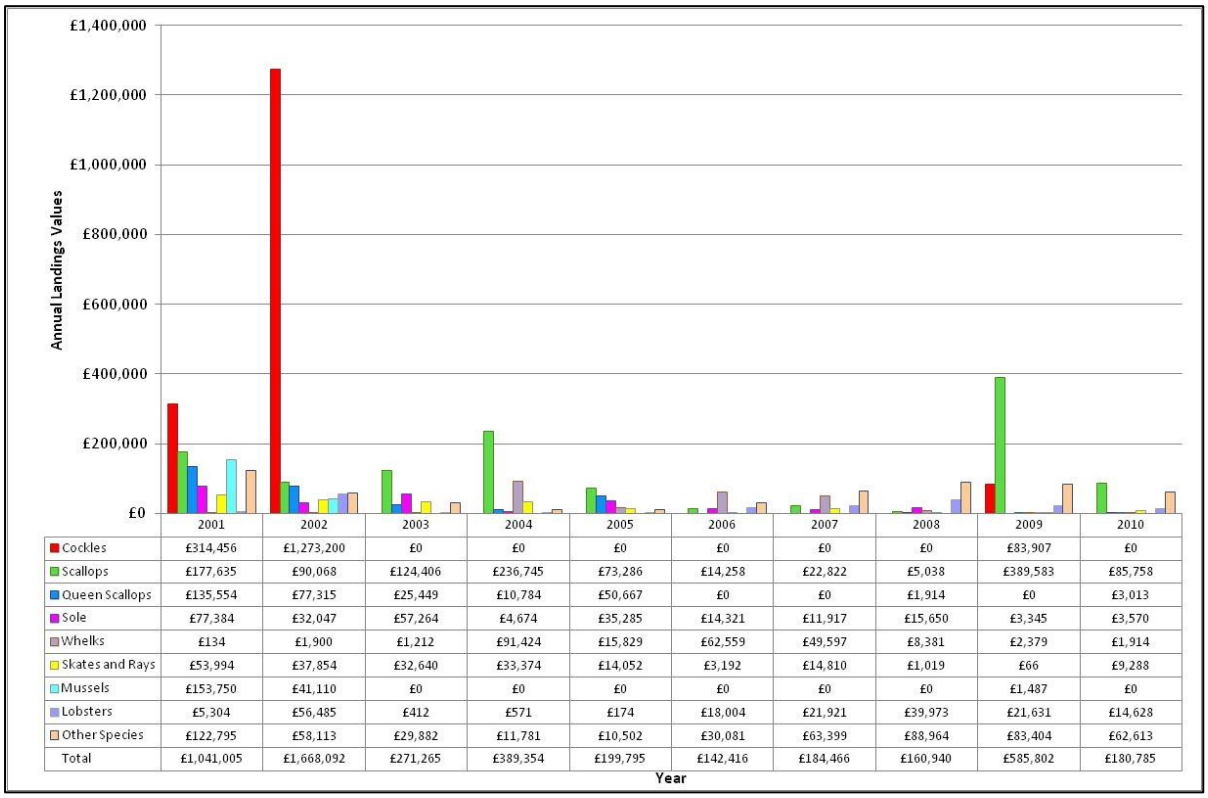
	Cockles	Scallops	Queen Scallops	Sole	Whelks	Skates and Rays	Mussels	Lobsters	Other Species
Hand fishing	£159,048	£0	£0	£0	£0	£0	£19,486	£0	£0
Mechanized dredges	£0	£108,903	£16,213	£999	£22	£34	£149	£0	£471
Pots	£0	£0	£0	£0	£23,480	£0	£0	£17,047	£13,056
Beam trawls	£6,697	£287	£66	£22,620	£17	£2,051	£0	£0	£7,164
Other Method	£1,412	£12,770	£14,191	£1,927	£15	£17,944	£0	£863	£35,462

Figure 8.11 Average Annual Landings Values (average 2001-2010) by Species and Methods in ICES Rectangle 35E6 (Source: MMO)



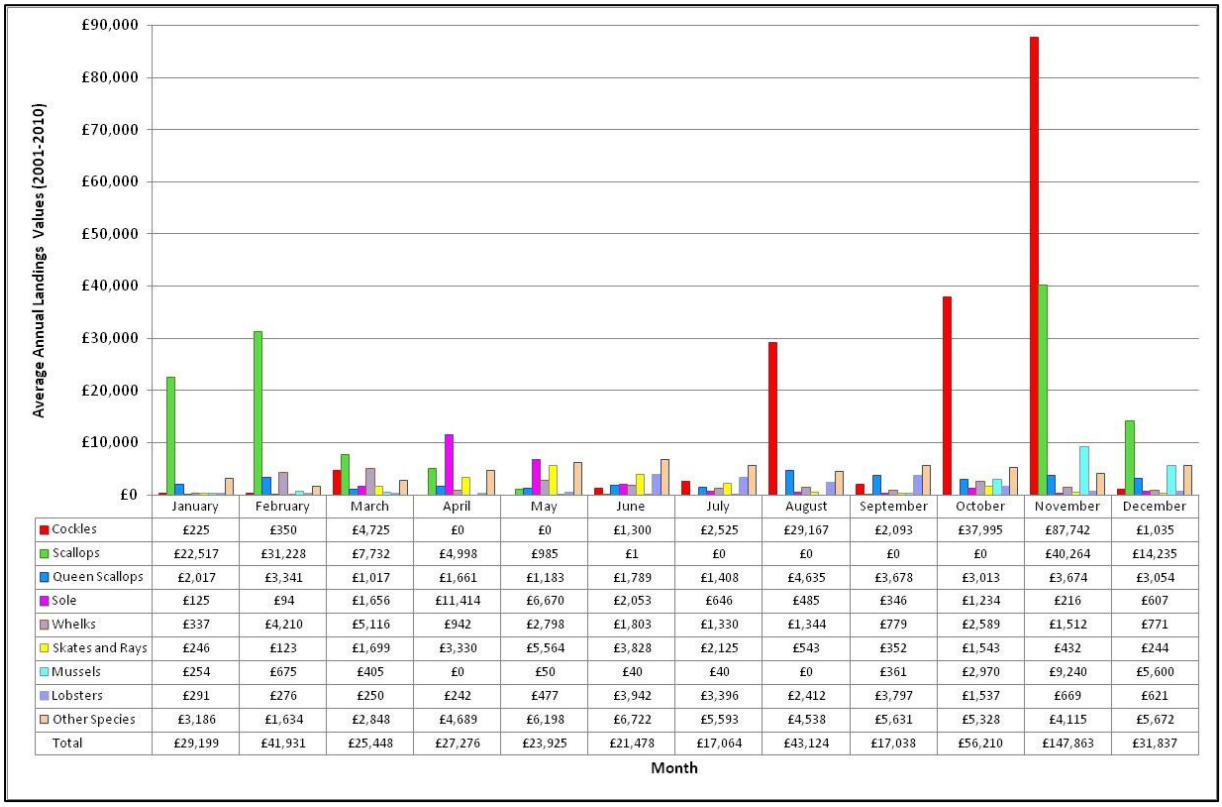
	Hand fishing	Mechanized dredges	Pots	Beam trawls	Gillnets	Boat dredges	Otter trawls (not specified)	Other Methods
Under 10m	£178,534	£88	£34,661	£11,611	£35,337	£0	£7,902	£384
10m-15m	£0	£3,835	£4,110	£441	£0	£0	£0	£0
15m and over	£0	£122,867	£14,812	£22,632	£0	£22,010	£7,944	£10,236
Non-UK	£0	£0	£0	£4,216	£0	£0	£299	£471

Figure 8.12 Average Annual Landings Values (average 2001-2010) by Methods and Vessel Length in ICES Rectangle 35E6 (Source: MMO)



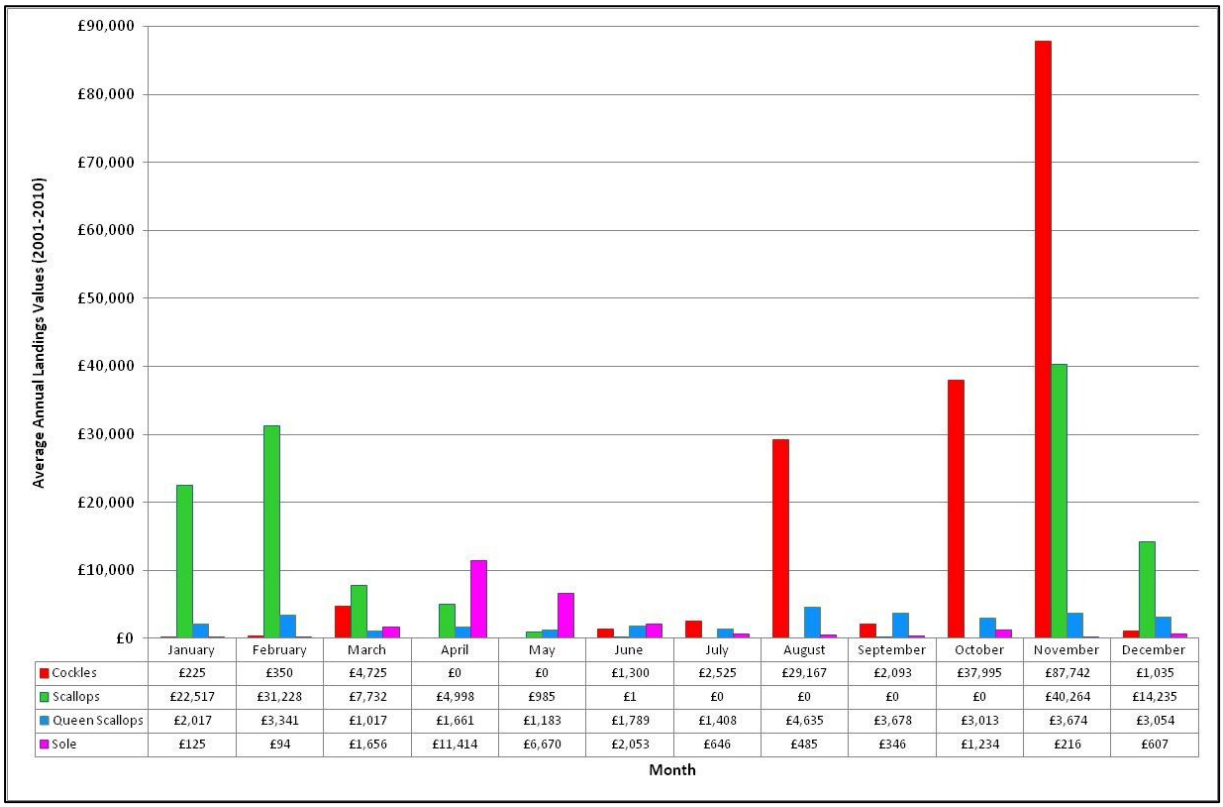
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Cockles	£314,456	£1,273,200	£0	£0	£0	£0	£0	£0	£83,907	£0
Scallops	£177,635	£90,068	£124,406	£236,745	£73,286	£14,258	£22,822	£5,038	£389,583	£85,758
Queen Scallops	£135,554	£77,315	£25,449	£10,784	£50,667	£0	£0	£1,914	£0	£3,013
Sole	£77,384	£32,047	£57,264	£4,674	£35,285	£14,321	£11,917	£15,650	£3,345	£3,570
Whelks	£134	£1,900	£1,212	£91,424	£15,829	£62,559	£49,597	£8,381	£2,379	£1,914
Skates and Rays	£53,994	£37,854	£32,640	£33,374	£14,052	£3,192	£14,810	£1,019	£66	£9,288
Mussels	£153,750	£41,110	£0	£0	£0	£0	£0	£0	£1,487	£0
Lobsters	£5,304	£56,485	£412	£571	£174	£18,004	£21,921	£39,973	£21,631	£14,628
Other Species	£122,795	£58,113	£29,882	£11,781	£10,502	£30,081	£63,399	£88,964	£83,404	£62,613
Total	£1,041,005	£1,668,092	£271,265	£389,354	£199,795	£142,416	£184,466	£160,940	£585,802	£180,785

Figure 8.13 Annual Variations in Landings Values of Species in ICES Rectangle 35E6 (Source: MMO)



	January	February	March	April	May	June	July	August	September	October	November	December
Cockles	£225	£350	£4,725	£0	£0	£1,300	£2,525	£29,167	£2,093	£37,995	£87,742	£1,035
Scallops	£22,517	£31,228	£7,732	£4,998	£985	£1	£0	£0	£0	£0	£40,264	£14,235
Queen Scallops	£2,017	£3,341	£1,017	£1,661	£1,183	£1,789	£1,408	£4,635	£3,678	£3,013	£3,674	£3,054
Sole	£125	£94	£1,656	£11,414	£6,670	£2,053	£646	£485	£346	£1,234	£216	£607
Whelks	£337	£4,210	£5,116	£942	£2,798	£1,803	£1,330	£1,344	£779	£2,589	£1,512	£771
Skates and Rays	£246	£123	£1,699	£3,330	£5,564	£3,828	£2,125	£543	£352	£1,543	£432	£244
Mussels	£254	£675	£405	£0	£50	£40	£40	£0	£361	£2,970	£9,240	£5,600
Lobsters	£291	£276	£250	£242	£477	£3,942	£3,396	£2,412	£3,797	£1,537	£669	£621
Other Species	£3,186	£1,634	£2,848	£4,689	£6,198	£6,722	£5,593	£4,538	£5,631	£5,328	£4,115	£5,672
Total	£29,199	£41,931	£25,448	£27,276	£23,925	£21,478	£17,064	£43,124	£17,038	£56,210	£147,863	£31,837

Figure 8.14 Average Annual (2001-2010) Seasonality of Species in ICES Rectangle 35E6 (Source: MMO)



	January	February	March	April	May	June	July	August	September	October	November	December
Cockles	£225	£350	£4,725	£0	£0	£1,300	£2,525	£29,167	£2,093	£37,995	£87,742	£1,035
Scallops	£22,517	£31,228	£7,732	£4,998	£985	£1	£0	£0	£0	£0	£40,264	£14,235
Queen Scallops	£2,017	£3,341	£1,017	£1,661	£1,183	£1,789	£1,408	£4,635	£3,678	£3,013	£3,674	£3,054
Sole	£125	£94	£1,656	£11,414	£6,670	£2,053	£646	£485	£346	£1,234	£216	£607

Figure 8.15 Average Annual (2001-2010) Seasonality of the Top Four Commercial Species in ICES Rectangle 35E6 (Source: MMO)

ICES Rectangle 36E6

8.1.24 Figure 8.16 shows the average annual landings values (2001-2010) by species in rectangle 36E6. Sole represents the highest landings values (£1,353,580, 44.3%), followed by queen scallops (£627,684, 20.6%). The remainder of the landings values are principally comprised of king scallops (£275,239, 9.0%), plaice (£247,835, 8.1%) and skates and rays (£112,652, 3.7%).

8.1.25 Figure 8.17 shows that the majority of species within 36E6 are targeted by vessels operating beam trawls, with sole recording the highest landings. Queen scallops are mainly targeted by vessels operating boat and mechanized dredges. Mechanized dredges are the main method recorded by vessels targeting king scallops. There is a relatively low level of activity recorded by vessels operating otter trawls, targeting flatfish and, to a lesser extent, skates and rays.

8.1.26 Figure 8.18 shows that the majority of beam trawlers operating in 36E6 are non-UK registered vessels. A small proportion of the landings values are recorded by the under-10m and over-15m UK fleets. The majority of the vessels operating boat and mechanized dredges are over-15m in length, with limited activity recorded by other vessel classes. The otter trawl fleet is mainly comprised of over-15m vessels, although a proportion of the activity is recorded by under-15m vessels.

Annual and Seasonal Landings Values

8.1.27 Figure 8.19 shows the annual variations in landings values by species in rectangle 36E6. It can be seen that landings values for the majority of species have declined over the ten year period. The highest total landings values for the period were recorded in 2001 due to the high landings values recorded by vessels targeting sole and queen scallops (£1,978,863 and £1,379,801, respectively).

8.1.28 Figure 8.20 shows the average annual seasonality of all species in rectangle 36E6. Landings values are highest between February and April, inclusive, with moderate landings values recorded in January, May, October and November.

8.1.29 Figure 8.21 shows the average annual seasonal variations in landings values for the top four species recorded in rectangle 36E6: sole, queen scallops, king scallops and plaice. Sole landings generally conform to the broad seasonality pattern of highest landings values recorded between February and May. The lowest landings values for sole are recorded during the summer months (June to September). Queen scallops are targeted throughout the year with the highest landings values recorded in October and November and lower landings values in June and July. King scallops are predominately targeted during the winter and spring with very low activity recorded during the summer months. Plaice are targeted throughout the year with little fluctuation in landings values.

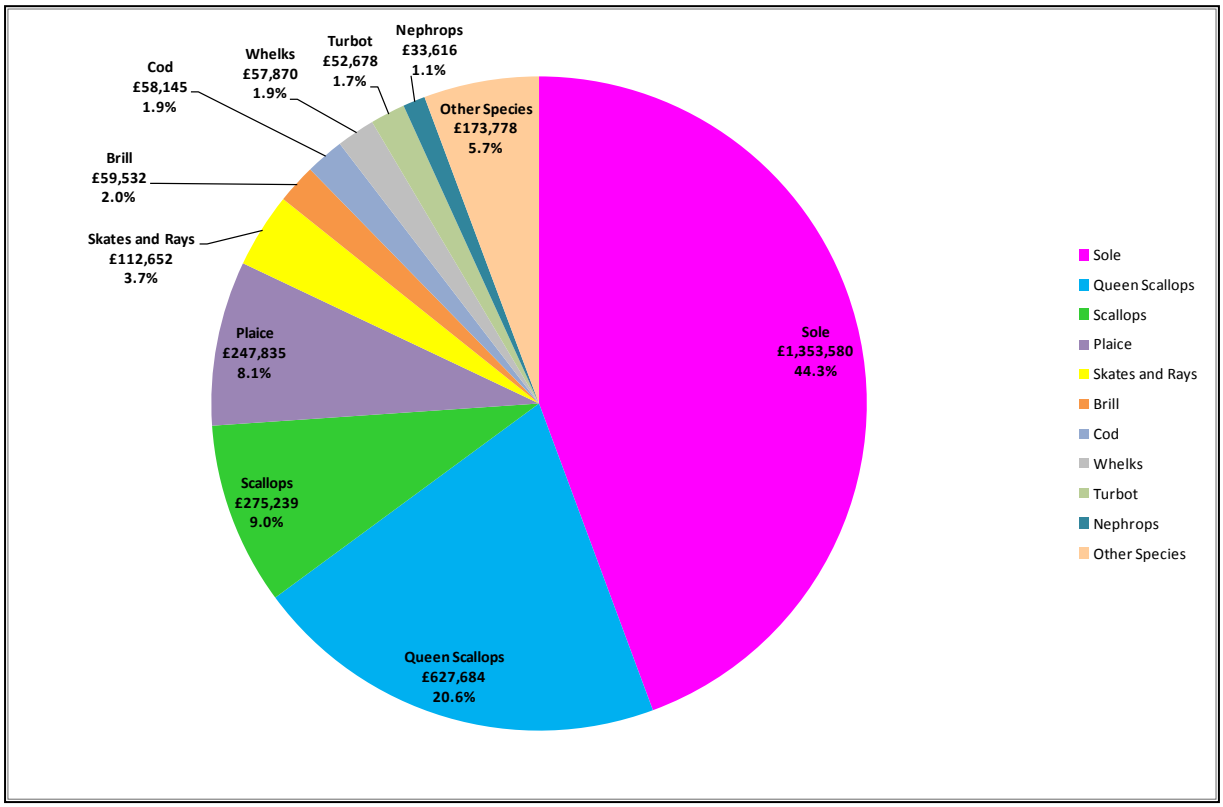
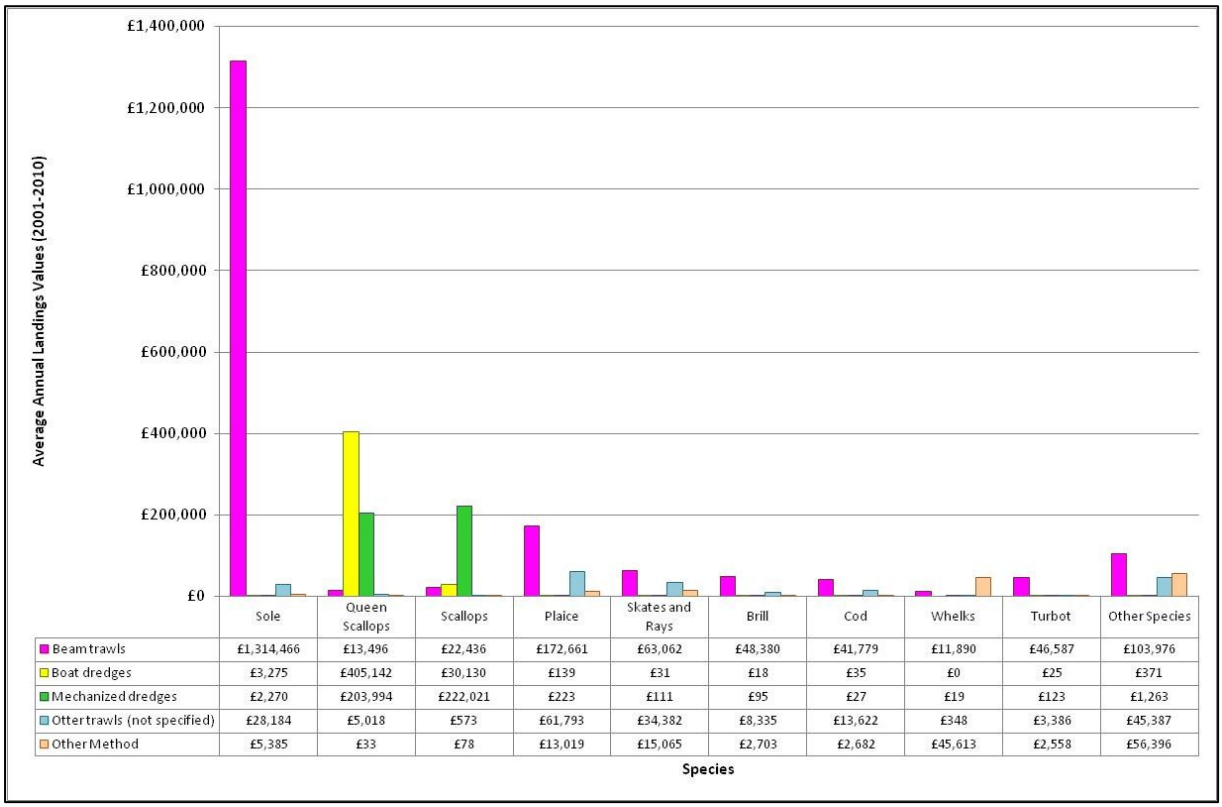
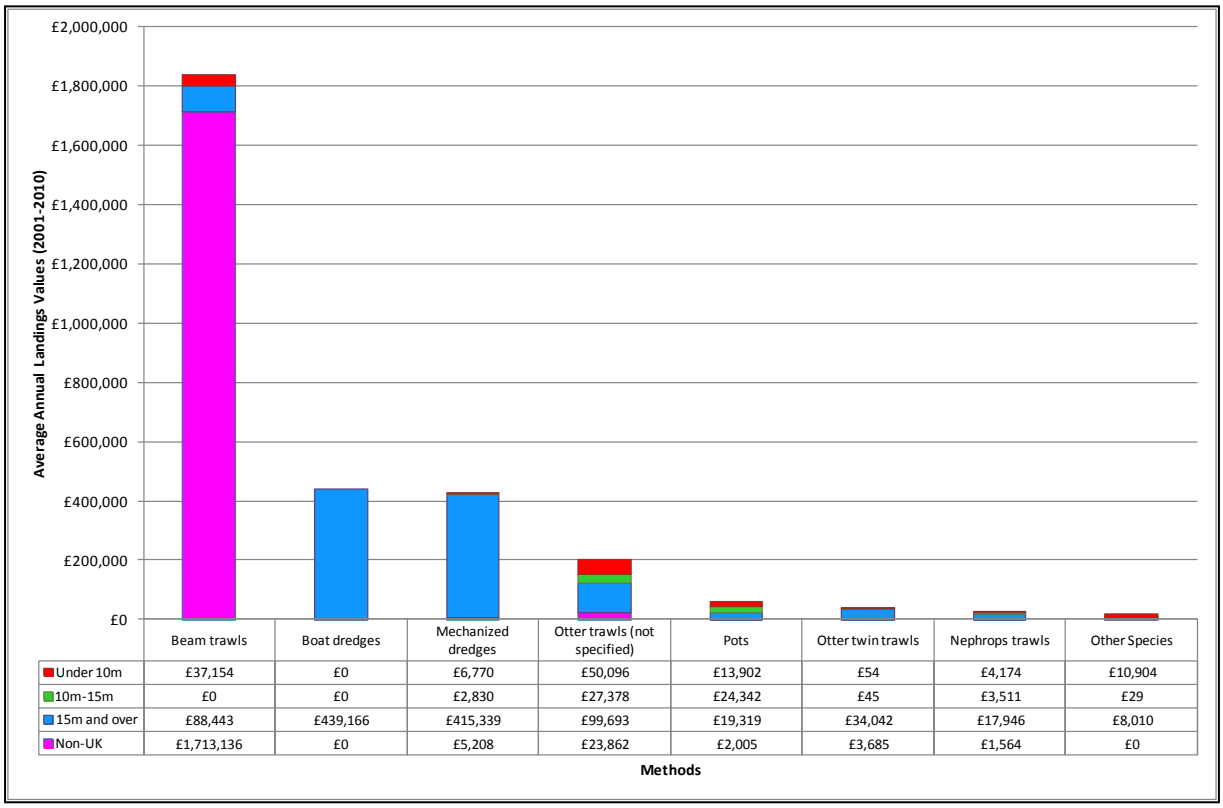


Figure 8.16 Percentage Distribution of Landings Values by Species in ICES Rectangle 36E6 (Source: MMO)



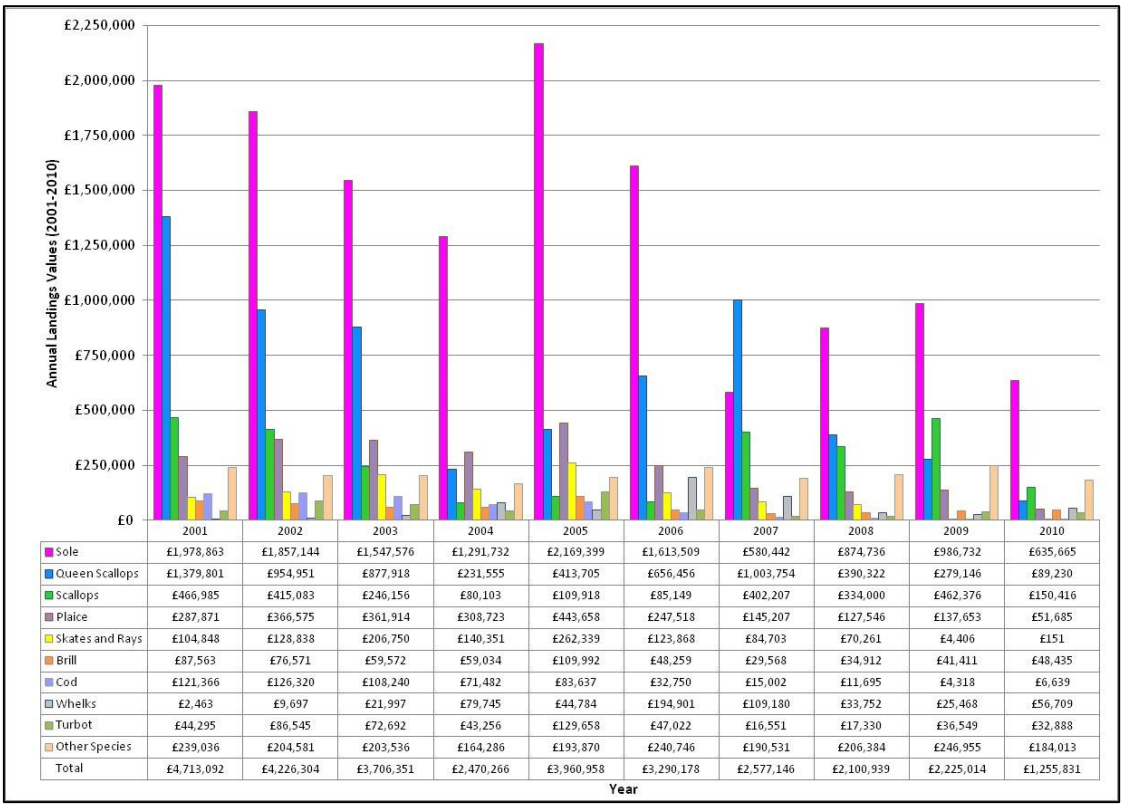
	Sole	Queen Scallops	Scallops	Plaice	Skates and Rays	Brill	Cod	Whelks	Turbot	Other Species
Beam trawls	£1,314,466	£13,496	£22,436	£172,661	£63,062	£48,380	£41,779	£11,890	£46,587	£103,976
Boat dredges	£3,275	£405,142	£30,130	£139	£31	£18	£35	£0	£25	£371
Mechanized dredges	£2,270	£203,994	£222,021	£223	£111	£95	£27	£19	£123	£1,263
Otter trawls (not specified)	£28,184	£5,018	£573	£61,793	£34,382	£8,335	£13,622	£348	£3,386	£45,387
Other Method	£5,385	£33	£78	£13,019	£15,065	£2,703	£2,682	£45,613	£2,558	£56,396

Figure 8.17 Average Annual Landings Values (2001-2010) by Species and Methods in ICES Rectangle 36E6 (Source: MMO)



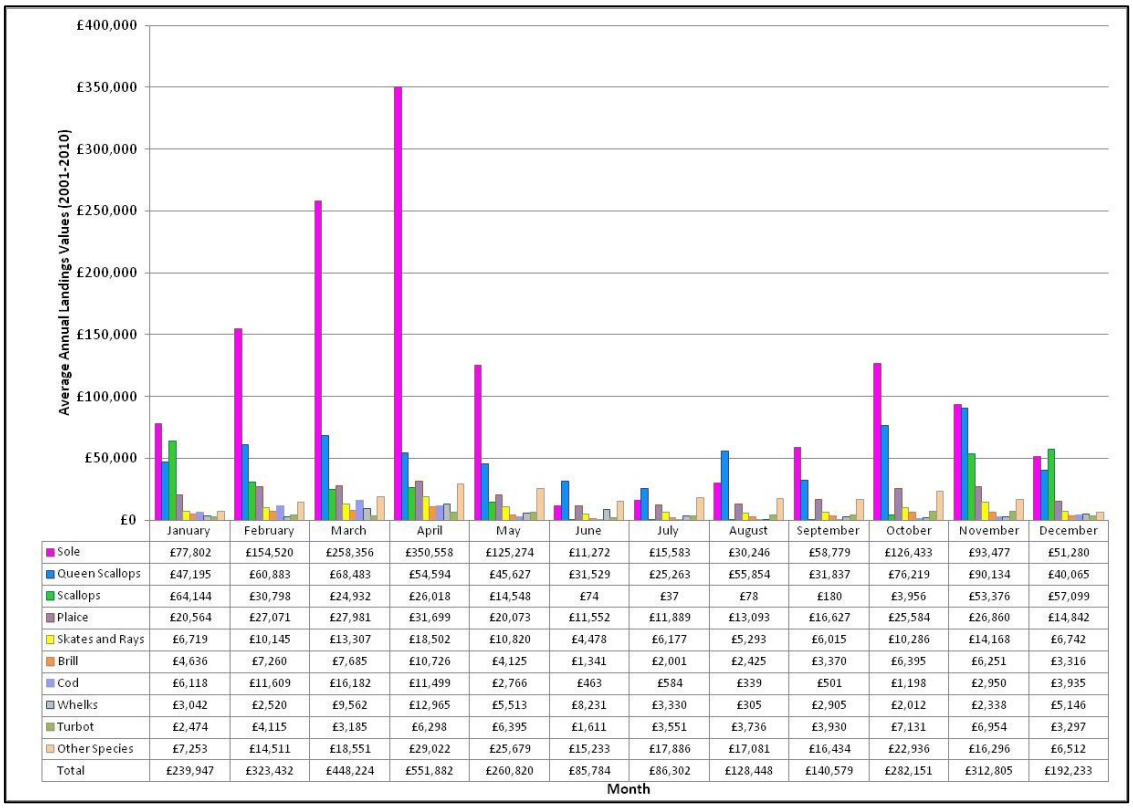
	Beam trawls	Boat dredges	Mechanized dredges	Otter trawls (not specified)	Pots	Otter twin trawls	Nephrops trawls	Other Species
Under 10m	£37,154	£0	£6,770	£50,096	£13,902	£54	£4,174	£10,904
10m-15m	£0	£0	£2,830	£27,378	£24,342	£45	£3,511	£29
15m and over	£88,443	£439,166	£415,339	£99,693	£19,319	£34,042	£17,946	£8,010
Non-UK	£1,713,136	£0	£5,208	£23,862	£2,005	£3,685	£1,564	£0

Figure 8.18 Average Annual Landings Values (2001-2010) by Methods and Vessel Length in ICES Rectangle 36E6 (Source: MMO)



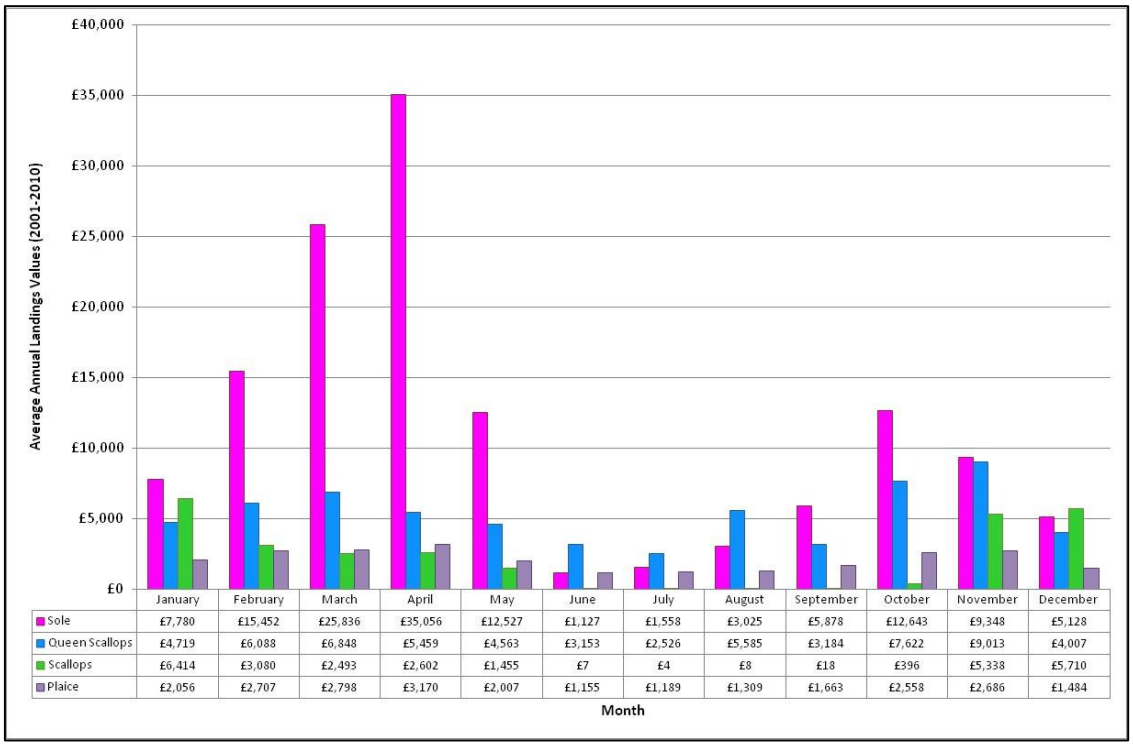
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Sole	£1,978,863	£1,857,144	£1,547,576	£1,291,732	£2,169,399	£1,613,509	£580,442	£874,736	£986,732	£635,665
Queen Scallops	£1,379,801	£954,951	£877,918	£231,555	£413,705	£656,456	£1,003,754	£390,322	£279,146	£89,230
Scallops	£466,985	£415,083	£246,156	£80,103	£109,918	£85,149	£402,207	£334,000	£462,376	£150,416
Plaice	£287,871	£366,575	£361,914	£308,723	£443,658	£247,518	£145,207	£127,546	£137,653	£51,685
Skates and Rays	£104,848	£128,838	£206,750	£140,351	£262,339	£123,868	£84,703	£70,261	£4,406	£151
Brill	£87,563	£76,571	£59,572	£59,034	£109,992	£48,259	£29,568	£34,912	£41,411	£48,435
Cod	£121,366	£126,320	£108,240	£71,482	£83,637	£32,750	£15,002	£11,695	£4,318	£6,639
Whelks	£2,463	£9,697	£21,997	£79,745	£44,784	£194,901	£109,180	£33,752	£25,468	£56,709
Turbot	£44,295	£86,545	£72,692	£43,256	£129,658	£47,022	£16,551	£17,330	£36,549	£32,888
Other Species	£239,036	£204,581	£203,536	£164,286	£193,870	£240,746	£190,531	£206,384	£246,955	£184,013
Total	£4,713,092	£4,226,304	£3,706,351	£2,470,266	£3,960,958	£3,290,178	£2,577,146	£2,100,939	£2,225,014	£1,255,831

Figure 8.19 Annual Variations in Landings Values of Species in ICES Rectangle 36E6 (Source: MMO)



	January	February	March	April	May	June	July	August	September	October	November	December
Sole	£77,802	£154,520	£258,356	£350,558	£125,274	£11,272	£15,583	£30,246	£58,779	£126,433	£93,477	£51,280
Queen Scallops	£47,195	£60,883	£68,483	£54,594	£45,627	£31,529	£25,263	£55,854	£31,837	£76,219	£90,134	£40,065
Scallops	£64,144	£30,798	£24,932	£26,018	£14,548	£74	£37	£78	£180	£3,956	£53,376	£57,099
Plaice	£20,564	£27,071	£27,981	£31,699	£20,073	£11,552	£11,889	£13,093	£16,627	£25,584	£26,860	£14,842
Skates and Rays	£6,719	£10,145	£13,307	£18,502	£10,820	£4,478	£6,177	£5,293	£6,015	£10,286	£14,168	£6,742
Brill	£4,636	£7,260	£7,685	£10,726	£4,125	£1,341	£2,001	£2,425	£3,370	£6,395	£6,251	£3,316
Cod	£6,118	£11,609	£16,182	£11,499	£2,766	£463	£584	£339	£501	£1,198	£2,950	£3,935
Whelks	£3,042	£2,520	£9,562	£12,965	£5,513	£8,231	£3,330	£305	£2,905	£2,012	£2,338	£5,146
Turbot	£2,474	£4,115	£3,185	£6,298	£6,395	£1,611	£3,551	£3,736	£3,930	£7,131	£6,954	£3,297
Other Species	£7,253	£14,511	£18,551	£29,022	£25,679	£15,233	£17,886	£17,081	£16,434	£22,936	£16,296	£6,512
Total	£239,947	£323,432	£448,224	£551,882	£260,820	£85,784	£86,302	£128,448	£140,579	£282,151	£312,805	£192,233

Figure 8.20 Average Annual (2001-2010) Seasonality of Species in ICES Rectangle 36E6 (Source: MMO)



	January	February	March	April	May	June	July	August	September	October	November	December
Sole	£7,780	£15,452	£25,836	£35,056	£12,527	£1,127	£1,558	£3,025	£5,878	£12,643	£9,348	£5,128
Queen Scallops	£4,719	£6,088	£6,848	£5,459	£4,563	£3,153	£2,526	£5,585	£3,184	£7,622	£9,013	£4,007
Scallops	£6,414	£3,080	£2,493	£2,602	£1,455	£7	£4	£8	£18	£396	£5,338	£5,710
Plaice	£2,056	£2,707	£2,798	£3,170	£2,007	£1,155	£1,189	£1,309	£1,663	£2,558	£2,686	£1,484

Figure 8.21 Average Annual (2001-2010) Seasonality of the Top Four Commercial Species in ICES Rectangle 36E6 (Source: MMO)

Landings Values by Port

8.1.30 The top 20 ports by landings values for rectangles 35E6 and 36E6, respectively, and the percentage of the ports' total income that this represents are listed in Table 8.1 and Table 8.2.

8.1.31 In rectangle 35E6, the highest percentage of landings values are recorded into the port at Rhyl (39.4%) which represents 94.6% of the ports' total annual average income. The ports of Conwy, Hoylake and Bagillt record lower proportions of the total landings values from 35E6 (7.2%, 3.8% and 0.9%, respectively), however this represents 81.1%, 92.7% and 95.7% of each ports total average annual landings values, respectively.

8.1.32 In rectangle 36E6, the highest percentage of landings values are recorded into the port at Liverpool (46.9%), which represents 40.5% of the ports' total annual average income. Smaller ports, such as Mersey Estuary and Lytham St Annes, record a lower proportion of the average annual landings from 35E6 (4.1% and 0.8%, respectively) however this represents 85.0% and 95.8%, respectively, of each ports total average annual income.

8.1.33 It is of note that the Belgian beam trawl fleet in the Irish Sea predominantly land into west coast ports of England and Wales such as Liverpool and Milford Haven, corresponding to the data in Table 8.2. The catch is subsequently transported by road to the continent.

Table 8.1 Top 20 Ports by Landings Value from ICES Rectangle 35E6 (Source: MMO)

Port	Average Annual Landings Values (£) in the 35E6 (2001-2010)	% of Annual Average Value in 35E6	Total Average Annual Port Value (2001-2010)	% of Total Annual Average Port Value that 35E6 Represents
Rhyl	£189,979	39.4%	£200,757	94.6%
Holyhead	£62,047	12.9%	£2,603,002	2.4%
Liverpool	£55,295	11.5%	£3,538,719	1.6%
Workington	£35,743	7.4%	£417,239	8.6%
Conwy	£34,971	7.2%	£43,101	81.1%
Whitehaven	£22,014	4.6%	£2,757,055	0.8%
Hoylake	£18,303	3.8%	£19,746	92.7%
Fleetwood	£16,719	3.5%	£889,599	1.9%
Kirkcudbright	£10,940	2.3%	£2,724,769	0.4%
Campbeltown	£9,082	1.9%	£2,956,673	0.3%
Bagillt	£4,438	0.9%	£4,635	95.7%
Kilkeel	£2,921	0.6%	£6,616,923	0.0%
Brixham	£2,289	0.5%	£18,785,729	0.0%
Plymouth	£2,187	0.5%	£10,489,276	0.0%
Mersey Estuary	£1,746	0.4%	£146,814	1.2%
Cemaes Bay	£1,576	0.3%	£115,529	1.4%
Padstow	£1,568	0.3%	£1,659,031	0.1%
Newlyn	£1,395	0.3%	£18,749,519	0.0%
Milford Haven	£1,191	0.2%	£13,601,861	0.0%
Amlwch	£970	0.2%	£206,364	0.5%

Table 8.2 Top 20 Ports by Landings Value from ICES Rectangle 36E6 (Source: MMO)

Port	Average Annual Landings Values (£) in the 36E6 (2001-2010)	% of Annual Average Value in 35E6	Total Average Annual Port Value (2001-2010)	% of Total Annual Average Port Value that 35E6 Represents
Liverpool	£1,432,839	46.9%	£3,538,719	40.5%
Fleetwood	£448,161	14.7%	£889,599	50.4%
Kirkcudbright	£431,826	14.1%	£2,724,769	15.8%
Holyhead	£190,852	6.3%	£2,603,002	7.3%
Milford Haven	£160,608	5.3%	£13,601,861	1.2%
Whitehaven	£130,027	4.3%	£2,757,055	4.7%
Mersey Estuary	£124,766	4.1%	£146,814	85.0%
Workington	£48,777	1.6%	£417,239	11.7%
Lytham St Annes	£24,371	0.8%	£25,444	95.8%
Barrow	£15,836	0.5%	£110,862	14.3%
Kilkeel	£6,814	0.2%	£6,616,923	0.1%
Brixham	£6,658	0.2%	£18,785,729	0.0%
Swansea	£5,711	0.2%	£2,261,159	0.3%
Plymouth	£4,052	0.1%	£10,489,276	0.0%
Newlyn	£2,673	0.1%	£18,749,519	0.0%
Campbeltown	£2,549	0.1%	£2,956,673	0.1%
Howth	£1,947	0.1%	£30,122	6.5%
Padstow	£1,927	0.1%	£1,659,031	0.1%
Isle Of Whithorn	£1,926	0.1%	£734,782	0.3%
Maryport	£1,578	0.1%	£298,016	0.5%

8.2 Effort (Days at Sea)

Regional Overview

8.1.34 The average annual effort by fishing method and vessel category in the regional study area is shown in Figure 8.22 and Figure 8.23, respectively.

8.1.35 It can be seen that effort data broadly corroborates with the landings values data with the lowest effort within the regional study area is recorded to the east, in coastal areas. The majority of the effort in rectangle 37E7 is recorded by under-10m vessels that are otter and beam trawling. In rectangle 36E7 effort is recorded by both the under-10m and over-15m fleets, the majority of which are nephrops and otter trawlers (the same category of vessel). Low effort is recorded in rectangle 35E7, the majority of which is attributed to 10m-15m potting vessels.

8.1.36 The highest effort is recorded in rectangles 37E5 and 37E6 in the north west of the regional study area. The majority of this effort is attributed to over-15m vessels operating otter trawls and dredges. Rectangles 36E5 and 35E5 in the west and south west of the study area record moderate effort. The majority of the effort in 36E5 is recorded by over-15m vessels operating dredges. In 35E5, the majority of the effort is recorded by under-10m potting vessels.

8.1.37 In the local study area, moderate levels of effort are recorded. In rectangle 36E6, the majority of the effort is recorded by over-15m, under-10m and non-UK vessels operating beam and otter trawls and, to a lesser extent, dredges. In rectangle 35E6, the majority of the effort is recorded by under-10m vessels operating gillnets and pots, in addition to hand fishing.

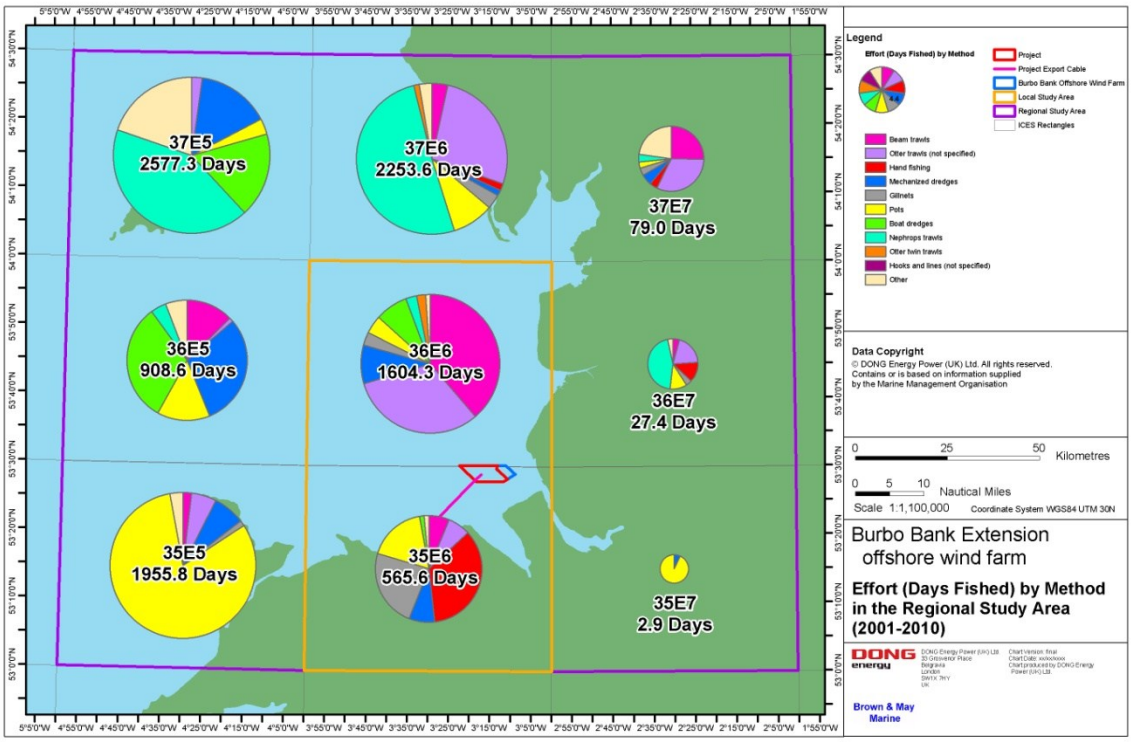


Figure 8.22 Effort (Days at Sea) by Fishing Method in the Regional Study Area (average 2001-2010) (Source: MMO)

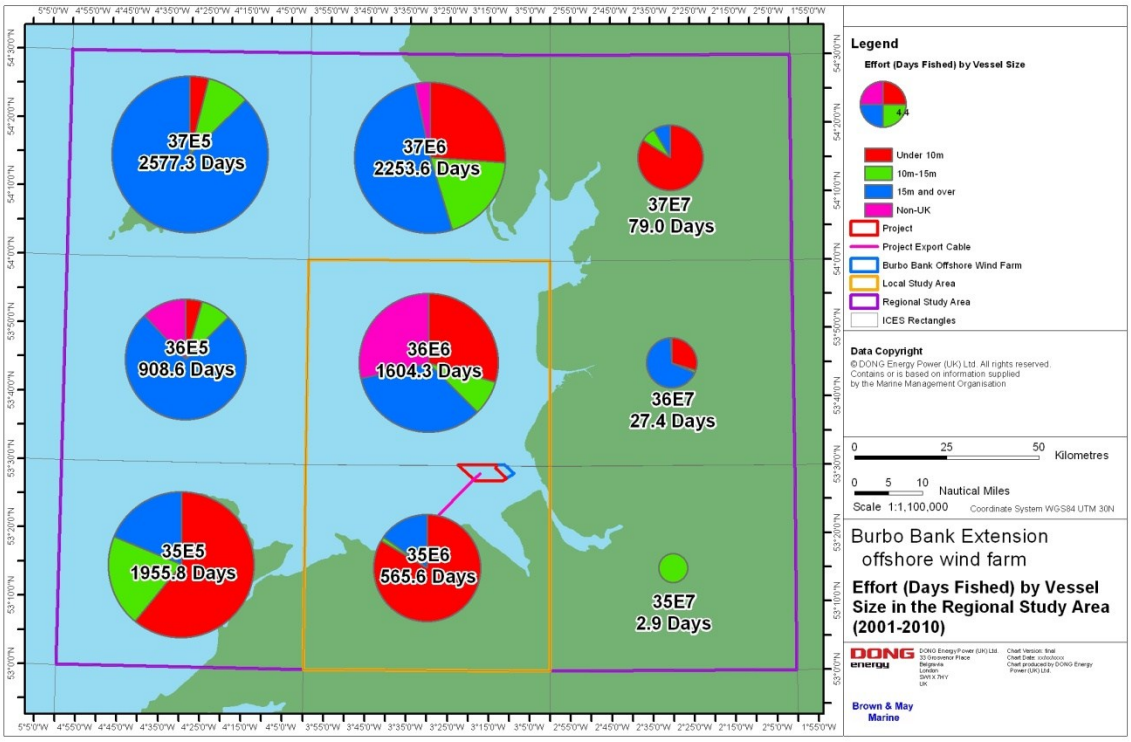


Figure 8.23 Effort (Days at Sea) by Vessel Category in the Regional Study Area (average 2001-2010) (Source: MMO)

8.2.1 Local Study Area

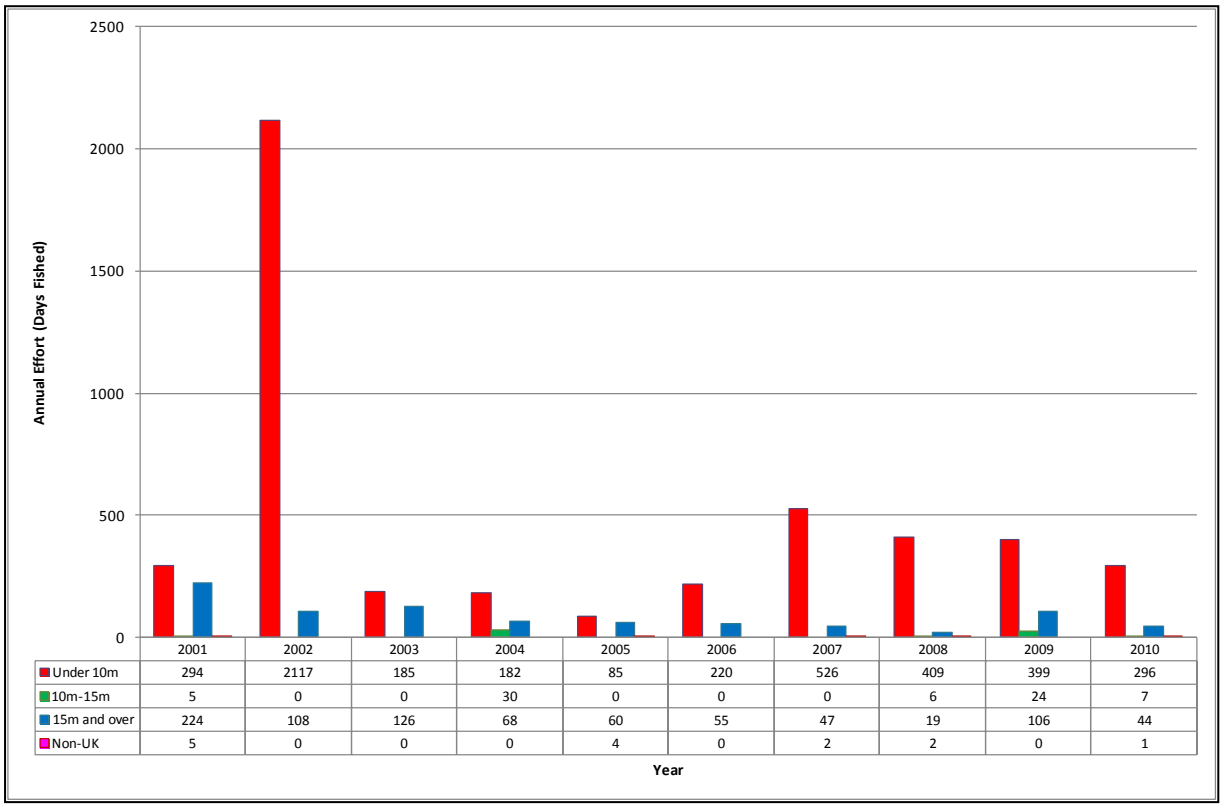
Annual Variation

8.1.38 Figure 8.24 and Figure 8.25 show the average annual effort in rectangles 35E6 and 36E6, respectively. The effort data broadly corroborates the landings values: in rectangle 35E6 the highest effort is attributed to the under-10m fleet, the majority of which was recorded in 2002. Effort recorded in rectangle 36E6 has generally declined over the ten year period, although an increase in under-10m activity was recorded in 2006 (likely due to the change in fisheries management of the under-10m fleet).

Seasonality

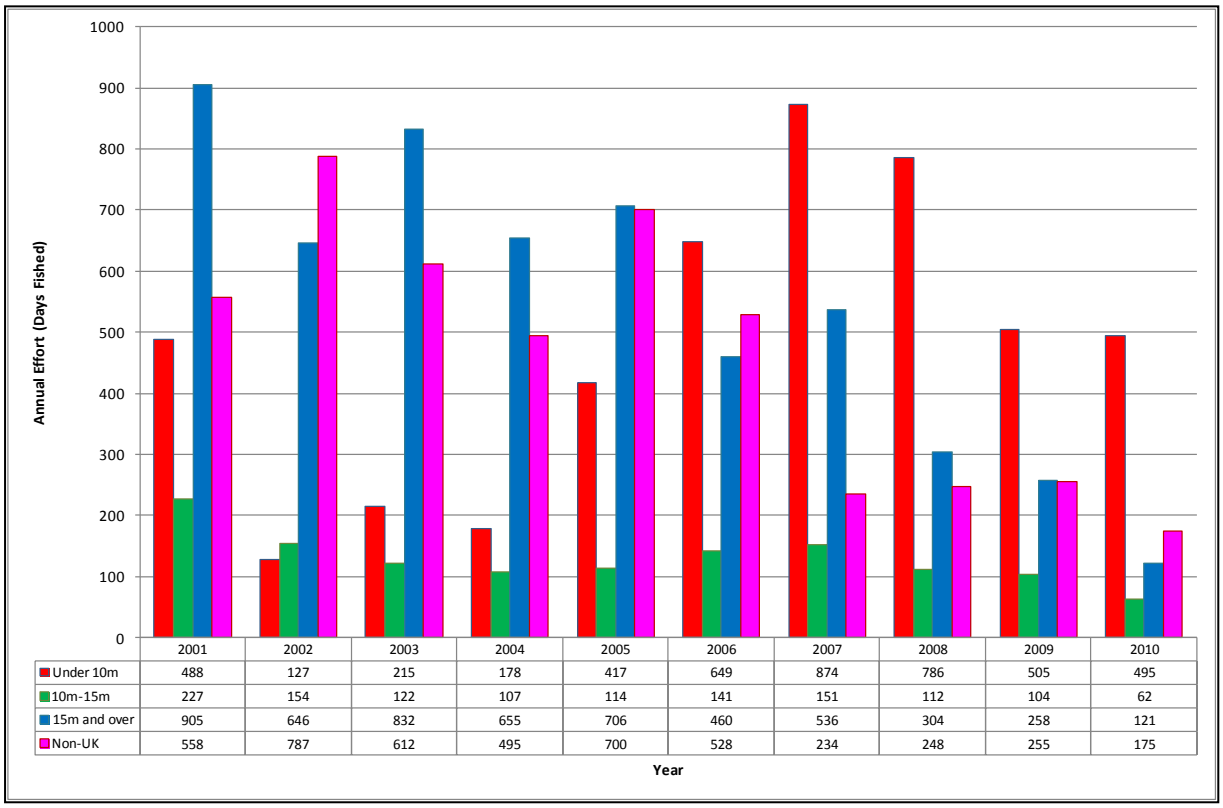
8.1.39 Figure 8.26 and Figure 8.27 show the average annual seasonality by effort in rectangles 35E6 and 36E6, respectively. The effort data broadly corroborates the landings values: the highest effort in rectangle 35E6 is recorded by under-10m vessels in October and November. Moderate effort is also recorded by the under-10m fleet during the summer months. Low effort is recorded by the over-15m fleet between November and May, inclusive.

8.1.40 In rectangle 36E6, the highest effort is recorded by the non-UK fleet in March and April. Moderate effort is recorded by the over-15m fleet between November and May and by the under-10m fleet between April and September. Low effort is recorded throughout the year by the 10m-15m fleet.



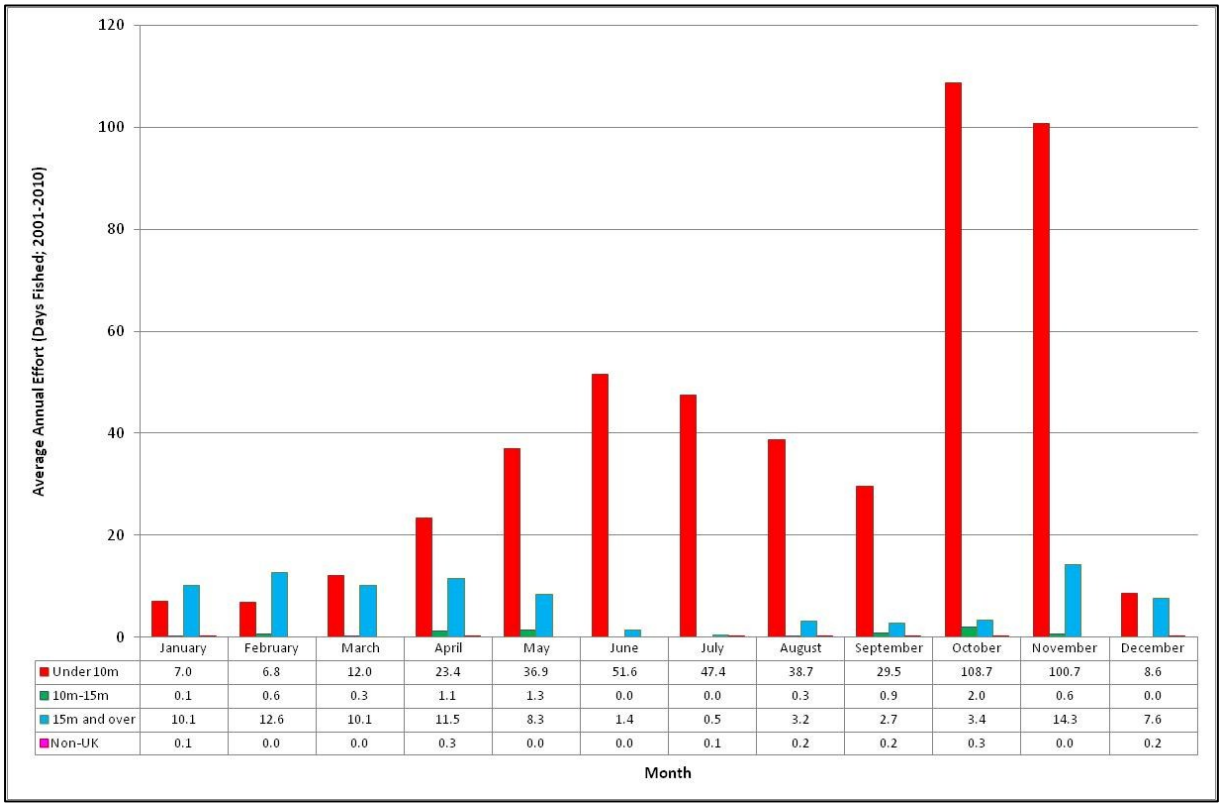
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Under 10m	294	2117	185	182	85	220	526	409	399	296
10m-15m	5	0	0	30	0	0	0	6	24	7
15m and over	224	108	126	68	60	55	47	19	106	44
Non-UK	5	0	0	0	4	0	2	2	0	1

Figure 8.24 Annual Variations in Effort (Days Fished) by Vessel Category in ICES Rectangle 35E6 (Source: MMO)



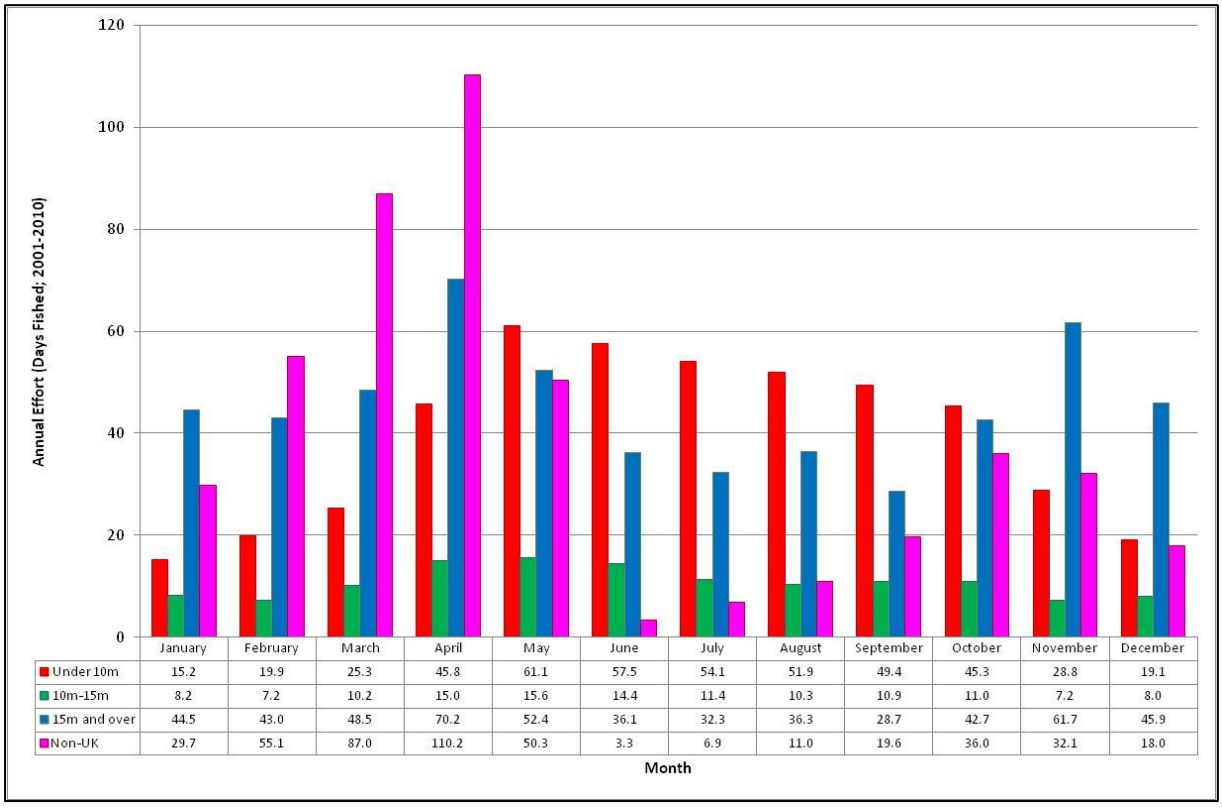
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Under 10m	488	127	215	178	417	649	874	786	505	495
10m-15m	227	154	122	107	114	141	151	112	104	62
15m and over	905	646	832	655	706	460	536	304	258	121
Non-UK	558	787	612	495	700	528	234	248	255	175

Figure 8.25 Annual Variations in Effort (Days Fished) by Vessel Category in ICES Rectangle 36E6 (Source: MMO)



	January	February	March	April	May	June	July	August	September	October	November	December
Under 10m	7.0	6.8	12.0	23.4	36.9	51.6	47.4	38.7	29.5	108.7	100.7	8.6
10m-15m	0.1	0.6	0.3	1.1	1.3	0.0	0.0	0.3	0.9	2.0	0.6	0.0
15m and over	10.1	12.6	10.1	11.5	8.3	1.4	0.5	3.2	2.7	3.4	14.3	7.6
Non-UK	0.1	0.0	0.0	0.3	0.0	0.0	0.1	0.2	0.2	0.3	0.0	0.2

Figure 8.26 Average Annual (2001-2010) Seasonality by Effort (Days Fished) and Vessel Category in ICES Rectangle 35E6 (Source: MMO)



	January	February	March	April	May	June	July	August	September	October	November	December
Under 10m	15.2	19.9	25.3	45.8	61.1	57.5	54.1	51.9	49.4	45.3	28.8	19.1
10m-15m	8.2	7.2	10.2	15.0	15.6	14.4	11.4	10.3	10.9	11.0	7.2	8.0
15m and over	44.5	43.0	48.5	70.2	52.4	36.1	32.3	36.3	28.7	42.7	61.7	45.9
Non-UK	29.7	55.1	87.0	110.2	50.3	3.3	6.9	11.0	19.6	36.0	32.1	18.0

Figure 8.27 Average Annual (2001-2010) Seasonality by Effort (Days Fished) and Vessel Category in ICES Rectangle 36E6 (Source: MMO)

Effort by Port

8.1.41 The top 20 ports by effort recorded in rectangles 35E6 and 36E6 and the percentage of the ports' total effort that it represents is listed in Table 8.3 and Table 8.4, respectively.

8.1.42 As would be expected, the effort data in rectangle 35E6 broadly corroborates the landings values as the highest percentage of effort is recorded by vessels landing into Rhyl (50.0%), which represents 93.9% of the port's total average effort. Vessels landing into the ports of Conwy, Bagillt and Glasson Dock record relatively low percentages of the effort in 35E6 (18.8%, 3.3% and 0.3%, respectively) however this represents 83.3%, 97.4% and 81.8% of each ports' total average effort, respectively.

8.1.43 The effort data in rectangle 36E6 also supports the landings values as the highest proportion of effort is recorded by vessels landing into Fleetwood (41.3%) and Liverpool (23.2%), which represents 60.6% and 36.4% of the ports' total average effort, respectively. Vessels landing into the ports of Lytham St Annes, Mersey Estuary and Knott End contribute relatively low percentages of effort in 36E6 (7.9%, 1.8% and 0.1%, respectively) however this represents 98.8%, 62.9% and 100.0% of the ports' total average effort, respectively.

8.1.44 Table 8.5 and Table 8.6 list the effort recorded in 35E6 and 36E6, respectively, by vessel category from each port over a ten year period (2001-2010). In rectangle 35E6, on average, the under-10m fleet contributes the most effort (471.3 days fished), followed by the over-15m fleet (85.7 days fished). The majority of these vessels land into Rhyl and Holyhead, respectively. The 10m-15m fleet records low effort and non-UK vessels record negligible effort.

8.1.45 The over-15m fleet records the highest effort from 36E6 (542.3 days fished), followed by the under-10m fleet (473.4 days fished). The majority of these vessels land into Fleetwood. The 10m-15m fleet records considerably less effort (129.4 days fished) also landing into Fleetwood. A high proportion of the effort is recorded by non-UK vessels (459.2 days fished) landing into Liverpool.

Table 8.3 Top 20 Ports by Effort (Days Fished) in ICES Rectangle 35E6 (Source: MMO)

Port	Annual Effort (Days Fished) in 35E6 (2001-2010)	% of Annual Effort in 35E6	Total Annual Port Effort (Days Fished) (2001-2010)	% of Total Annual Port Effort that 35E6 represents
Rhyl	282.6	50.0%	300.9	93.9%
Conwy	106.4	18.8%	127.7	83.3%
Liverpool	34.2	6.0%	1022.1	3.3%
Holyhead	32.2	5.7%	1647.9	2.0%
Bagillt	18.8	3.3%	19.3	97.4%
Fleetwood	15.7	2.8%	1095	1.4%
Whitehaven	11.9	2.1%	2644	0.5%
Hoylake	10.5	1.9%	16.8	62.5%
Mersey Estuary	10.5	1.9%	45.3	23.2%
Workington	7.6	1.3%	204.7	3.7%
Trefor	5.6	1.0%	351.7	1.6%
Kirkcudbright	4.5	0.8%	1073.8	0.4%
Kilkeel	3.5	0.6%	8938.9	0.0%
Cemaes Bay	2.4	0.4%	140.6	1.7%
Greenfield	2.3	0.4%	5.2	44.2%
Campbeltown	1.8	0.3%	3348.8	0.1%
Glasson Dock	1.8	0.3%	2.2	81.8%
Brixham	1.4	0.2%	12992.8	0.0%
Amlwch	1.3	0.2%	274.6	0.5%
Plymouth	1.3	0.2%	6084.7	0.0%

Table 8.4 Top 20 Ports by Effort (Days Fished) in ICES Rectangle 36E6 (Source: MMO)

Port	Annual Effort (Days Fished) in 36E6 (2001-2010)	% of Annual Effort in 36E6	Total Annual Port Effort (Days Fished) (2001-2010)	% of Total Annual Port Effort that 36E6 represents
Fleetwood	663.2	41.3%	1095	60.6%
Liverpool	371.7	23.2%	1022.1	36.4%
Lytham St Annes	126.9	7.9%	128.5	98.8%
Kirkcudbright	117.5	7.3%	1073.8	10.9%
Whitehaven	97.5	6.1%	2644	3.7%
Holyhead	67.8	4.2%	1647.9	4.1%
Milford Haven	39.1	2.4%	5725.9	0.7%
Mersey Estuary	28.5	1.8%	45.3	62.9%
Barrow	26.7	1.7%	255.9	10.4%
Workington	21.6	1.3%	204.7	10.6%
Kilkeel	9.2	0.6%	8938.9	0.1%
Hoylake	6	0.4%	16.8	35.7%
Brixham	4.3	0.3%	12992.8	0.0%
Plymouth	3.1	0.2%	6084.7	0.1%
Maryport	2.8	0.2%	478.4	0.6%
Knott End	2.2	0.1%	2.2	100.0%
Swansea	2.1	0.1%	1231.4	0.2%
Howth	1.4	0.1%	22.3	6.3%
Padstow	1.3	0.1%	1414.7	0.1%
Cemaes Bay	1.2	0.1%	140.6	0.9%

Table 8.5 Annual Effort (Days Fished) by Port and Vessel Length in ICES Rectangle 35E6 (Source: MMO)

Port and Vessel Length	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	10 Yr Average
Under-10m											
Rhyl	207	2081	129	121	30	2	187	9	26	34	**282.6**
Conwy	26	18	39	16	17	128	226	240	200	152	**106.2**
Bagillt	0	0	0	0	0	0	0	48	64	76	**18.8**
Liverpool	0	2	0	0	0	14	26	44	82	0	**16.8**
Hoylake	31	2	0	7	23	21	8	8	5	0	**10.5**
Mersey Estuary	21	14	13	12	1	20	20	4	0	0	**10.5**
Trefor	0	0	0	0	0	0	10	40	6	0	**5.6**
Holyhead	0	0	0	26	0	9	16	0	3	0	**5.4**
Fleetwood	0	0	0	0	0	7	19	5	3	16	**5.0**
Greenfield	0	0	0	0	0	0	1	7	7	8	**2.3**
Other Ports	9	0	4	0	14	19	13	4	3	10	**7.6**
Total	**294**	**2117**	**185**	**182**	**85**	**220**	**526**	**409**	**399**	**296**	**471.3**
10m-15m											
Fleetwood	0	0	0	28	0	0	0	0	0	2	**3.0**
Whitehaven	0	0	0	0	0	0	0	0	23	0	**2.3**
Annan	0	0	0	0	0	0	0	4	0	0	**0.4**
Holyhead	0	0	0	0	0	0	0	2	0	2	**0.4**
Liverpool	4	0	0	0	0	0	0	0	0	0	**0.4**
Amlwch	0	0	0	0	0	0	0	0	0	3	**0.3**
Conwy	0	0	0	2	0	0	0	0	0	0	**0.2**
Maryport	0	0	0	0	0	0	0	0	1	0	**0.1**
Padstow	1	0	0	0	0	0	0	0	0	0	**0.1**
Total	**5**	**0**	**0**	**30**	**0**	**0**	**0**	**6**	**24**	**7**	**7.2**
15m and Over											
Holyhead	81	27	17	3	17	24	39	6	28	22	**26.4**
Liverpool	47	36	26	14	17	4	4	0	8	1	**15.7**
Whitehaven	13	9	8	5	5	2	3	7	36	8	**9.6**
Fleetwood	11	3	17	28	1	8	0	3	6	0	**7.7**
Workington	18	7	28	7	8	2	0	0	6	0	**7.6**
Kirkcudbright	15	9	4	0	9	0	0	0	1	7	**4.5**
Kilkeel	18	5	11	0	0	0	0	0	0	1	**3.5**

Port and Vessel Length	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	10 Yr Average
Campbeltown	1	1	0	0	0	0	0	0	15	1	**1.8**
Brixham	5	0	5	1	1	0	0	0	2	0	**1.4**
Plymouth	0	0	10	0	1	0	1	0	1	0	**1.3**
Other Ports	15	11	0	10	1	15	0	3	3	4	**6.2**
Total	**224**	**108**	**126**	**68**	**60**	**55**	**47**	**19**	**106**	**44**	**85.7**
Non-UK											
Liverpool	5	0	0	0	4	0	2	2	0	0	**1.3**
Swansea	0	0	0	0	0	0	0	0	0	1	**0.1**
Total	**5**	**0**	**0**	**0**	**4**	**0**	**2**	**2**	**0**	**1**	**1.4**
Grand Total	**528**	**2225**	**311**	**280**	**149**	**275**	**575**	**436**	**529**	**348**	**565.6**

Table 8.6 Annual Effort (Days Fished) by Port and Vessel Length in ICES Rectangle 36E6 (Source: MMO)

Port and Vessel Length	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	10 Yr Average
Under-10m											
Fleetwood	392	108	209	170	398	322	430	448	296	57	**283.0**
Lytham St Annes	0	0	0	0	0	230	274	303	94	368	**126.9**
Barrow	21	7	0	0	19	82	111	22	0	3	**26.5**
Whitehaven	1	0	0	0	0	0	6	4	100	52	**16.3**
Hoylake	33	12	6	8	0	0	1	0	0	0	**6.0**
Liverpool	0	0	0	0	0	1	18	8	0	0	**2.7**
Knott End	20	0	0	0	0	0	2	0	0	0	**2.2**
Holyhead	15	0	0	0	0	0	0	0	0	0	**1.5**
Brixham	0	0	0	0	0	12	0	0	0	0	**1.2**
Kilkeel	0	0	0	0	0	0	12	0	0	0	**1.2**
Other Ports	6	0	0	0	0	2	20	1	15	15	**5.9**
Total	**488**	**127**	**215**	**178**	**417**	**649**	**874**	**786**	**505**	**495**	**473.4**
10m-15m											
Fleetwood	134	123	119	95	114	130	139	63	85	54	**105.6**
Whitehaven	93	30	3	10	0	1	0	31	1	2	**17.1**
Liverpool	0	0	0	0	0	9	10	0	0	0	**1.9**
Holyhead	0	0	0	0	0	0	0	7	3	4	**1.4**
Howth	0	0	0	0	0	0	0	11	3	0	**1.4**
Maryport	0	1	0	0	0	0	0	0	7	2	**1.0**
Other Ports	0	0	0	2	0	1	2	0	5	0	**1.0**
Total	**227**	**154**	**122**	**107**	**114**	**141**	**151**	**112**	**104**	**62**	**129.4**
15m and Over											
Fleetwood	220	184	297	401	363	237	242	139	50	26	**215.9**
Kirkcudbright	295	189	208	69	111	42	125	74	45	17	**117.5**
Whitehaven	67	55	139	66	81	61	43	19	46	57	**63.4**
Liverpool	118	62	50	31	60	79	116	54	47	1	**61.8**
Holyhead	120	95	76	24	31	20	4	1	8	6	**38.5**
Workington	26	38	33	30	27	5	4	10	43	0	**21.6**
Kilkeel	23	7	10	15	10	1	2	0	6	2	**7.6**
Brixham	13	2	0	5	2	5	0	2	0	2	**3.1**
Plymouth	0	3	3	0	11	0	0	0	1	2	**2.0**
Maryport	3	0	6	6	0	0	0	0	0	0	**1.5**
Other Ports	20	11	10	8	10	10	0	5	12	8	**9.4**
Total	**905**	**646**	**832**	**655**	**706**	**460**	**536**	**304**	**258**	**121**	**542.3**
Non-UK											
Liverpool	341	533	366	248	473	385	135	211	224	137	**305.3**
Fleetwood	74	75	75	91	57	101	86	28	0	0	**58.7**
Milford Haven	41	57	69	49	74	32	10	2	7	36	**37.7**
Mersey Estuary	30	80	76	63	31	0	0	0	0	0	**28.0**
Holyhead	72	40	26	42	62	8	1	0	13	0	**26.4**
Swansea	0	0	0	2	2	2	2	0	11	2	**2.1**
Whitehaven	0	0	0	0	0	0	0	7	0	0	**0.7**
Plymouth	0	2	0	0	0	0	0	0	0	0	**0.2**

Port and Vessel Length	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	10 Yr Average
Newlyn	0	0	0	0	1	0	0	0	0	0	**0.1**
Total	**558**	**787**	**612**	**495**	**700**	**528**	**234**	**248**	**255**	**175**	**459.2**
Grand Total	**2178**	**1714**	**1781**	**1435**	**1937**	**1778**	**1795**	**1450**	**1122**	**853**	**1604.3**

9.0 Satellite Tracking (VMS) Data

9.1.1 As previously mentioned satellite (VMS) density does not take into account fishing activity undertaken by vessels under-15m in length, therefore fishing activity in some areas, particularly inshore areas, is not represented by this data set.

9.1 MMO Data (UK Activity)

National Overview

9.1.2 The satellite (VMS) density data of all UK over-15m vessels by average landings values (2007-2010) and effort (average days fished; 2007-2010) is shown in Figure 9.1 and Figure 9.2, respectively. Areas of higher density generally occur in more offshore areas in the northern North Sea, offshore of the north-west coast of Scotland and west coast of Ireland. High concentrations are also recorded in the English Channel, northern Irish Sea and in inshore areas along the west coast of Scotland.

Regional Study Area

9.1.3 The satellite (VMS) density of all UK over-15m vessels by average landings values (2007-2010) and effort (average days fished; 2007-2010) in the regional study area is shown in Figure 9.3 and Figure 9.4, respectively.

9.1.4 The highest satellite (VMS) density is recorded off the east coast of Northern Ireland, in the waters around the Isle of Man and off the Cumbrian coast. Within the local study area there is a patch of low to moderate density recorded to the west and north-west of the Project, with only very low density levels recorded within the Project site.

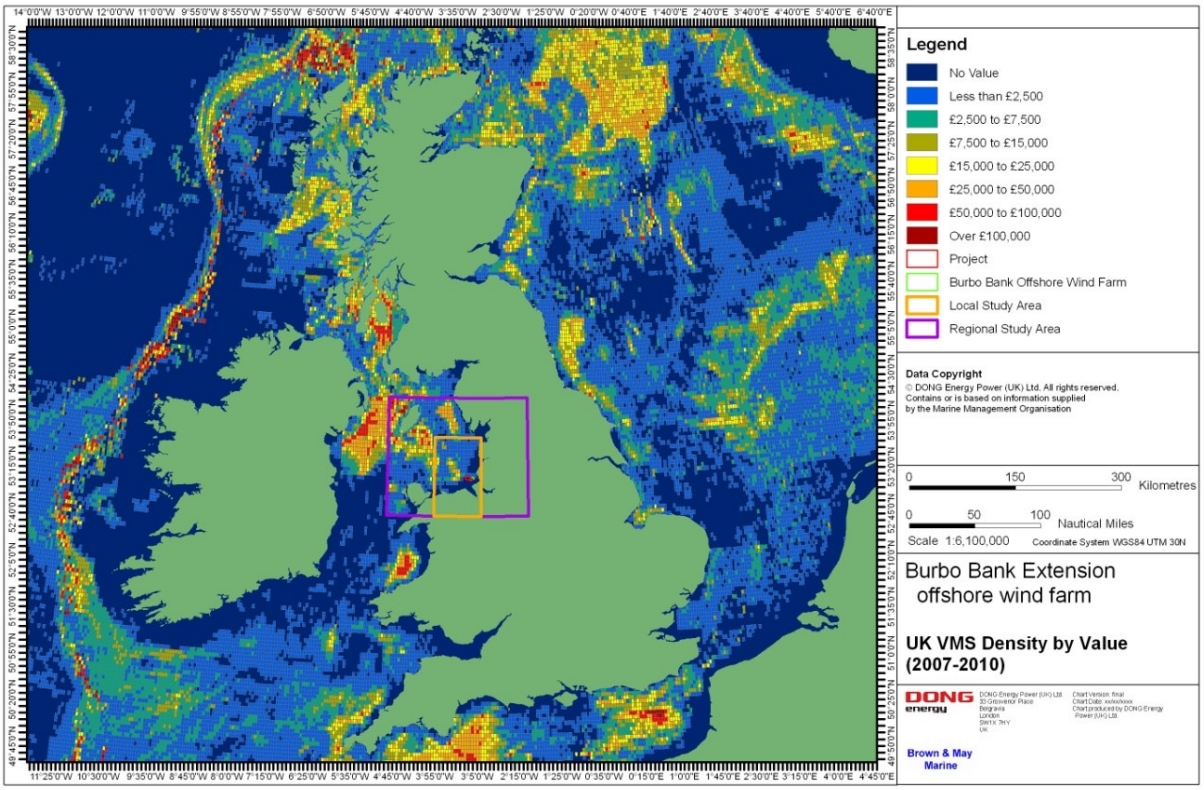


Figure 9.1 Satellite (VMS) Density of all UK Over-15m Vessels by Landings Values (Average Values 2007-2010) (Source: MMO)

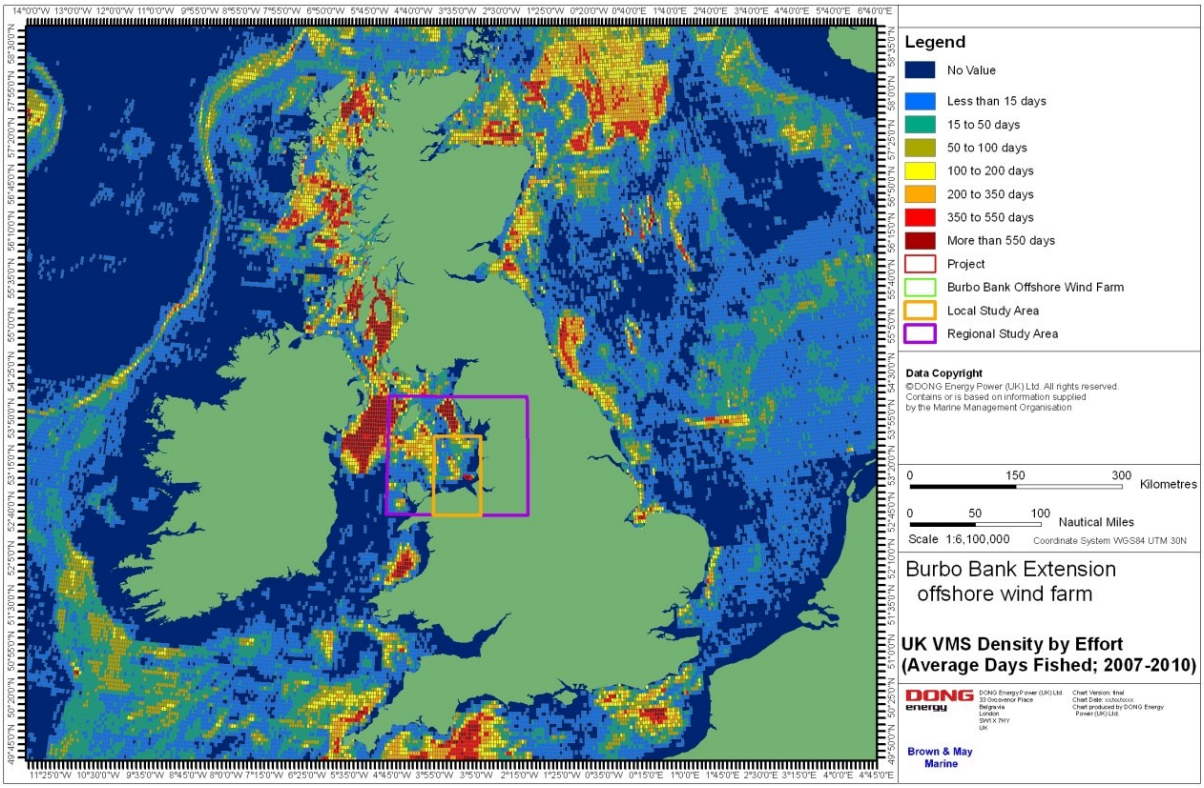


Figure 9.2 Satellite (VMS) Density of all UK Over-15m Vessels by Effort (Average Days Fished; 2007-2010) (Source: MMO)

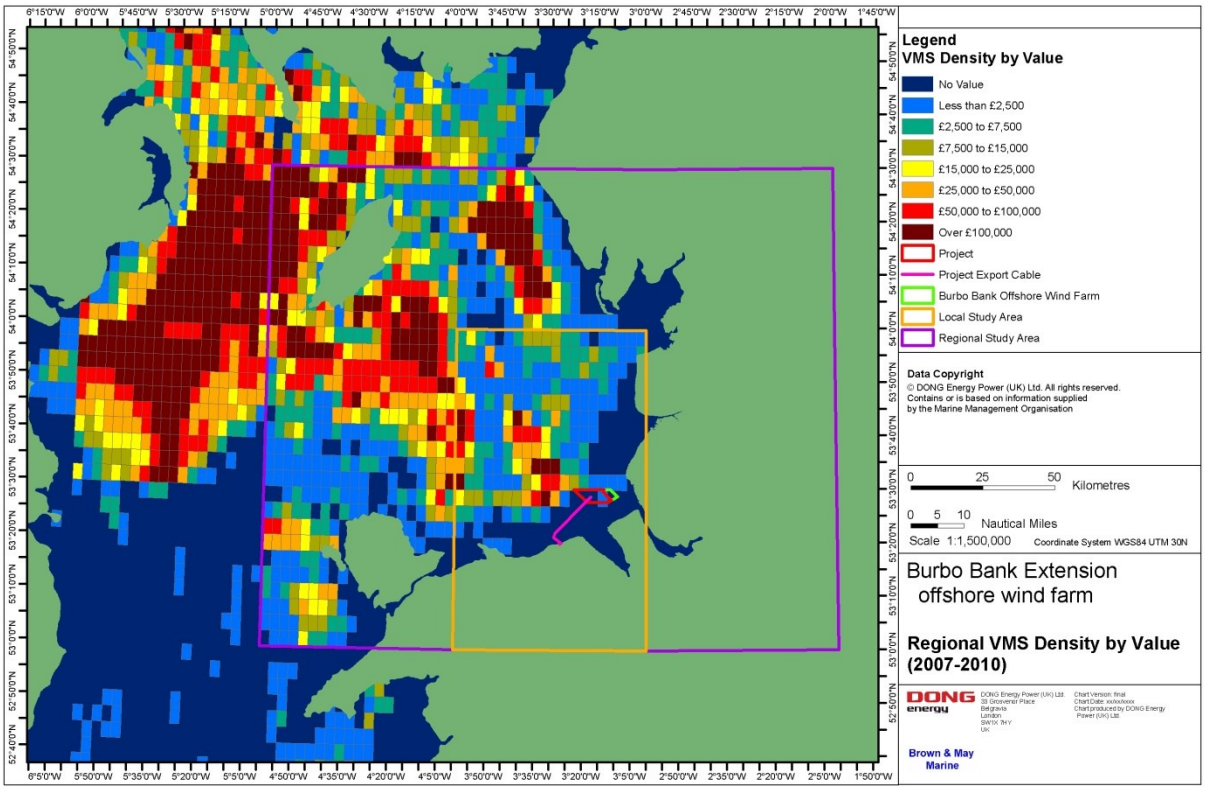


Figure 9.3 Satellite (VMS) Density of all UK Over-15m Vessels by Landings Values in the Regional Study Area (Average Values 2007-2010) (Source: MMO)

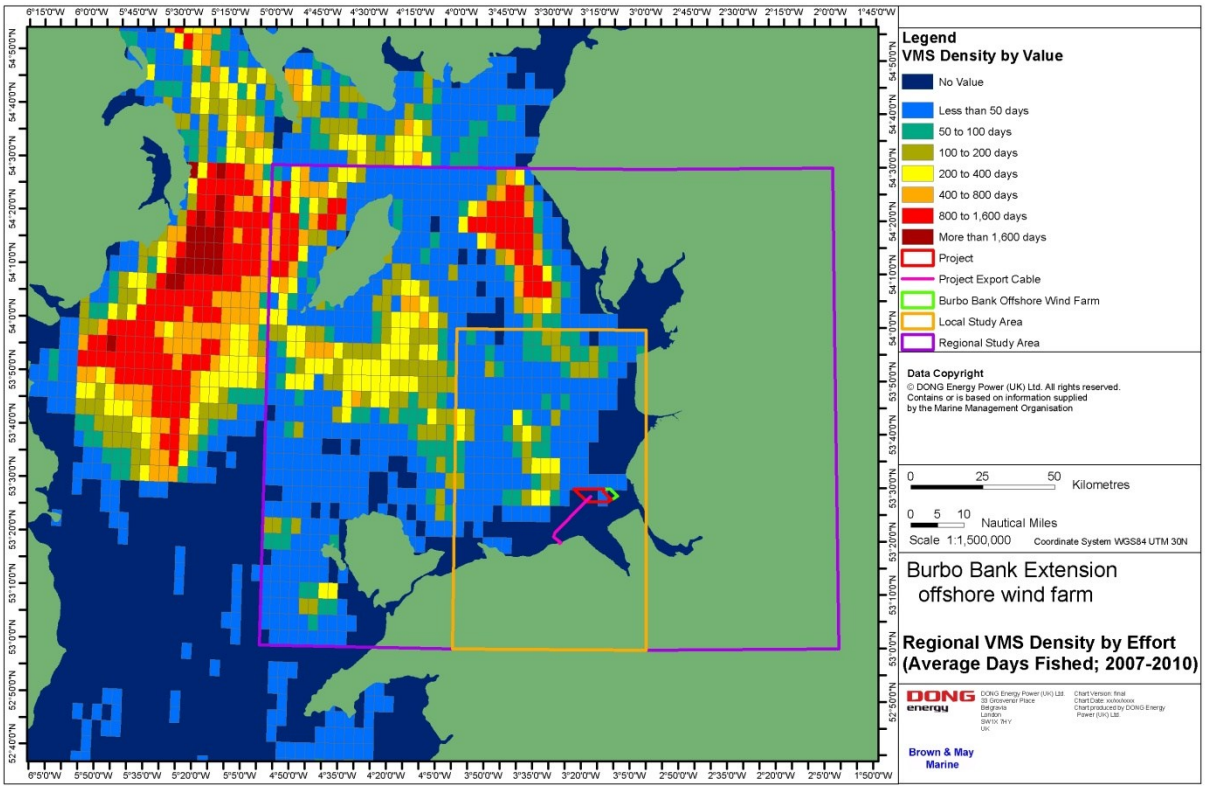


Figure 9.4 Satellite (VMS) Density of all UK Over-15m Vessels by Effort (Average Days Fished; 2007-2010) in the Regional Study Area (Source: MMO)

9.2 Non-UK Activity

9.1.5 As mentioned previously, both France and Ireland have historic access to fishing grounds within the UKs 6nm-12nm limits. It may be that these vessels do not currently target grounds within this area, although their potential to do so in the future should be recognised. Outside of 12nm all EU vessels have access subject to quota.

Irish VMS Data

9.1.6 Satellite (VMS) density of Irish vessels in the Irish Sea (average 2005 to 2007) is given in Figure 9.5. High levels of activity are recorded in the west of the Irish Sea with low to moderate activity recorded within the regional study area. Within the local study area moderate activity is recorded to the north of Project.

French VMS Data

9.1.7 The satellite (VMS) density of French bottom otter trawlers over-15m in length in the Irish Sea is given in Figure 9.6 (2008 only). The highest levels of French activity are recorded in the Celtic Sea, with activity decreasing to the north and very low activity recorded in the Irish Sea. Despite French vessels having historic rights to fish close to the Project area (Section 6.2), no activity was recorded in the vicinity of the Project in 2008.

Belgian VMS Data

9.1.8 Satellite (VMS) density of Belgian beam trawlers operating within the regional study area is shown in Figure 9.7 (2009 only).

9.1.9 ICES rectangle 36E6 (within which a small proportion of the Project is located) records the highest levels of Belgian beam trawling activity within the regional study area. This activity is recorded to the north-west of the rectangle, away from the Project site. The Belgian beam trawl fleet represents 50.2% of the total average landings values recorded per year from rectangle 36E6, 70.9% of which is Belgian beam trawlers targeting sole. Elsewhere within the regional study area low levels of Belgian beam trawl activity are recorded in 36E5 and 37E6.

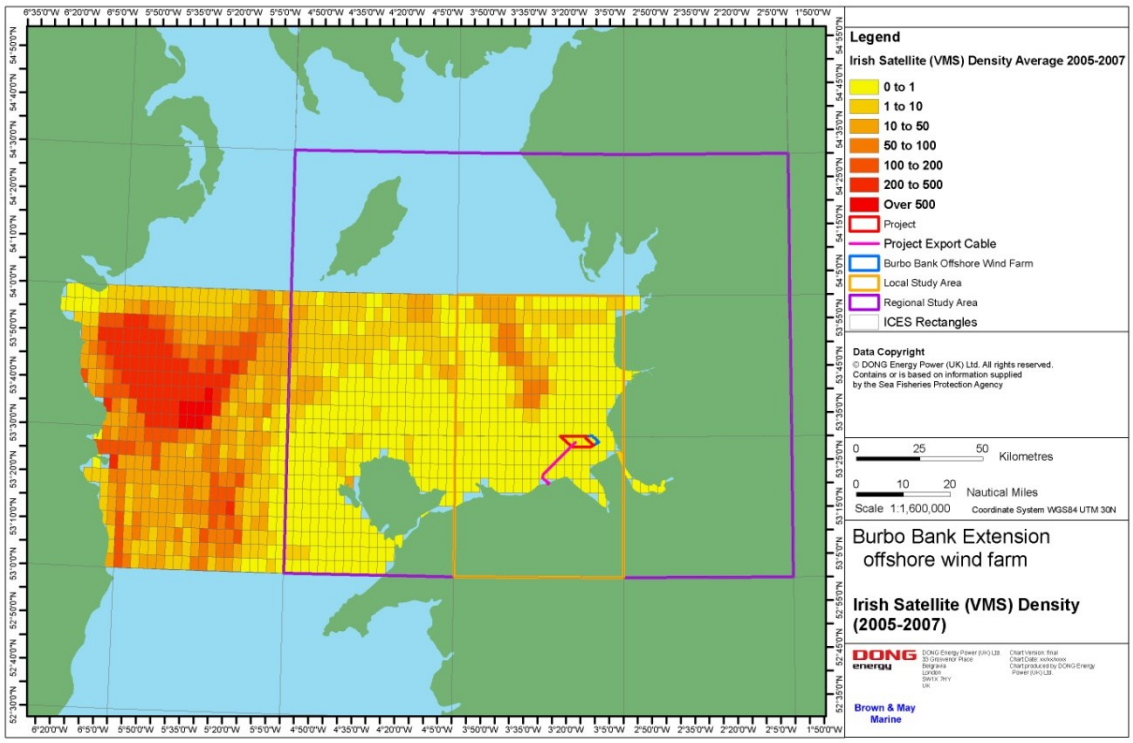


Figure 9.5 Satellite (VMS) Density of all Over-15m Irish Vessels Operating in the Irish Sea (average 2005-2007) (Source: SFPA)

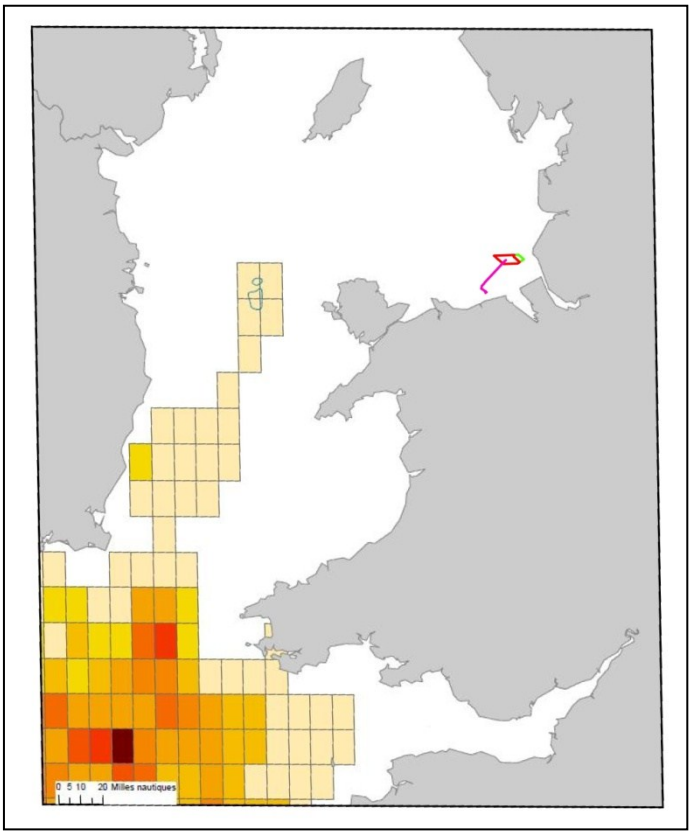


Figure 9.6 Satellite Density (VMS) of Over-15m French Bottom Trawlers in the Irish Sea (2008) (Source: IFREMER)

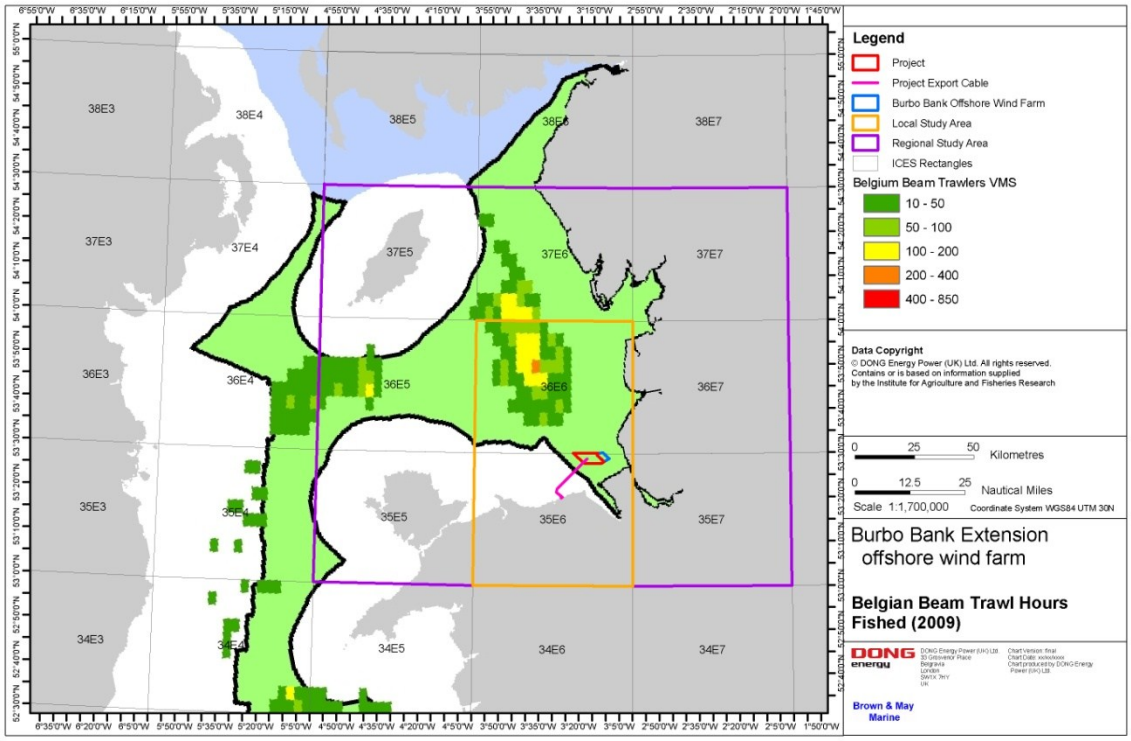


Figure 9.7 Satellite (VMS) Density of all Over-15m Belgian Beam Trawlers (Hours Fished; 2009 only) Source: ILVO)

10.0 MMO Fisheries Surveillance Sightings Data

10.1.1 The positions of vessels by nationality in the regional study area, identified by fisheries surveillance vessels and aircraft, are given in Figure 10.1. Surveillance sightings by fishing method of UK, Irish, Belgian and French vessels in the regional study area are given in Figure 10.2 to Figure 10.5, respectively.

10.1.2 It can be seen that high levels of activity are recorded in the north and north-west of the regional study area. The sightings data corroborates the UK VMS data which shows high concentrations of activity to the west of the Isle of Man and off the Cumbrian coast. In the south west of the regional study area there are low levels of activity. Moderate levels of activity are recorded within the local study area, the majority of which are vessels beam trawling or scallop dredging with some activity recorded by trawlers. Activity is low in the vicinity of the Project site; with three UK registered beam trawlers recorded fishing within the site over the ten year period.

10.1.3 The majority of the activity recorded in the regional study is by UK registered vessels operating a variety of fishing gears. Irish activity within the regional study area occurs to the north of the Project in rectangle 36E6, with vessels operating beam trawls and scallop dredges. Sightings of Belgian vessels correspond to the Belgian VMS data with high concentrations of vessels beam trawling recorded in rectangle 36E6 to the north west of the Project. The French surveillance sightings reflect the patterns shown in the VMS previously, with high concentrations of vessels sighted in the Celtic Sea and less activity recorded further north in the Irish Sea. No French vessels have been sighted within the regional study area over the ten year period. Overall the surveillance data infers negligible activity within the Project.

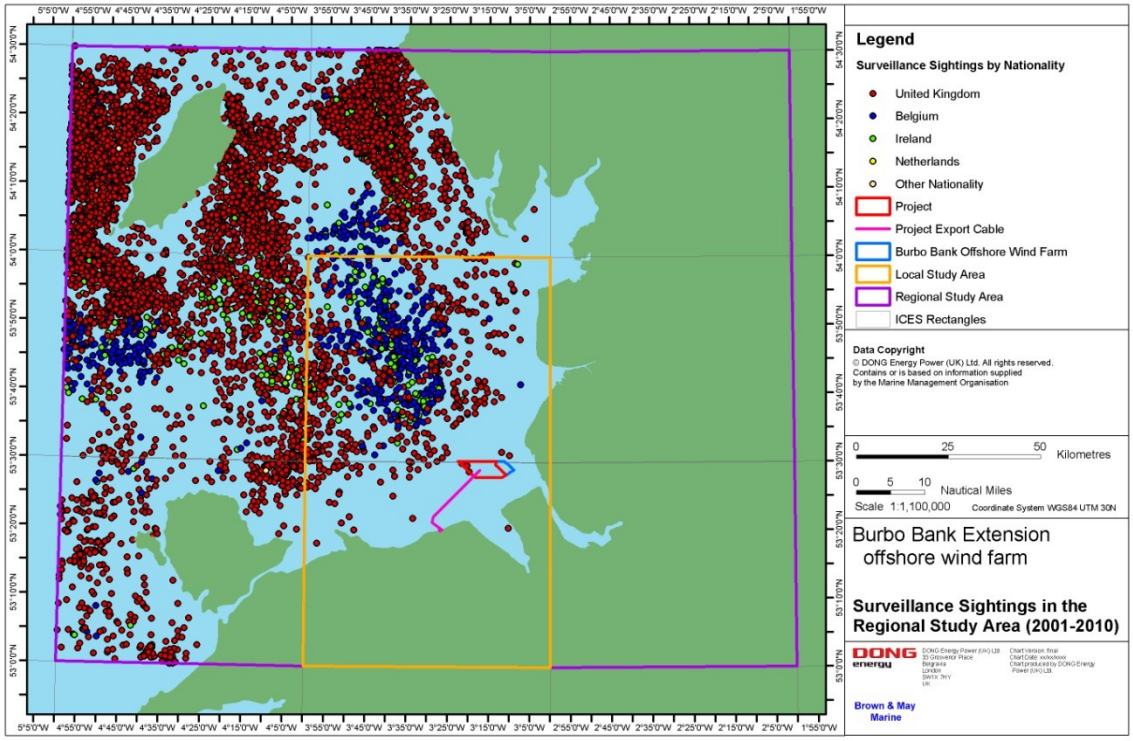


Figure 10.1 Surveillance Sightings by Nationality in the Regional Study Area (Source: MMO)

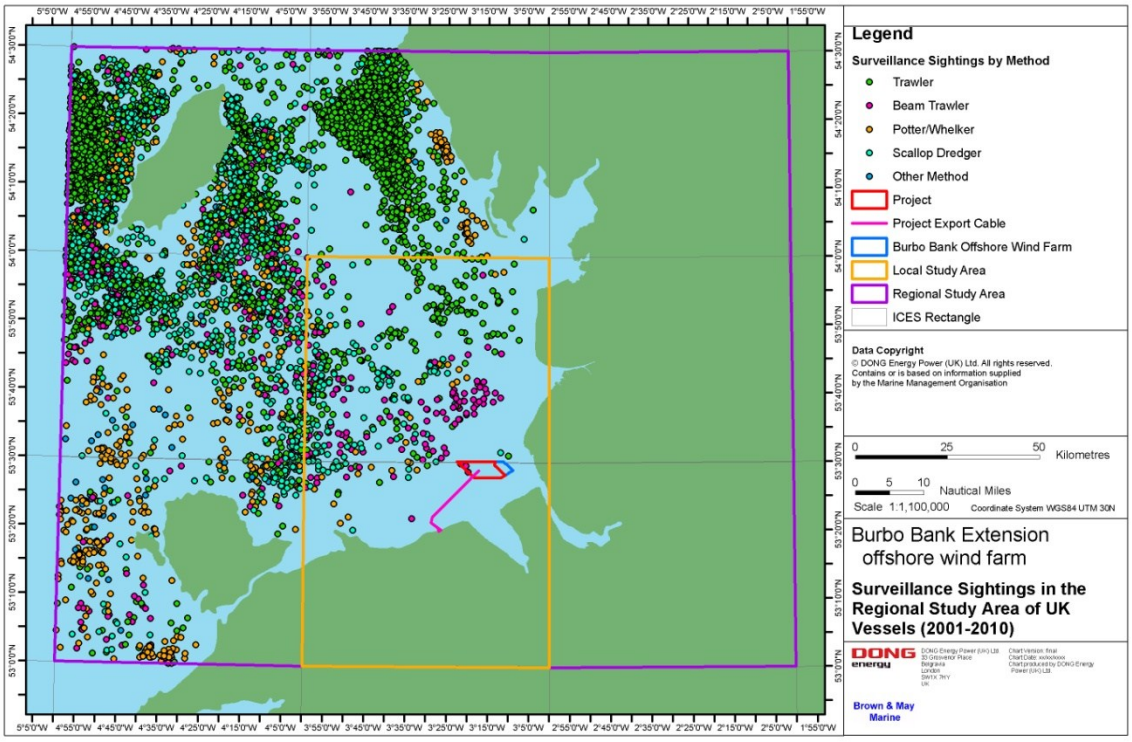


Figure 10.2 Surveillance Sightings of UK Vessels by Method in the Regional Study Area (Source: MMO)

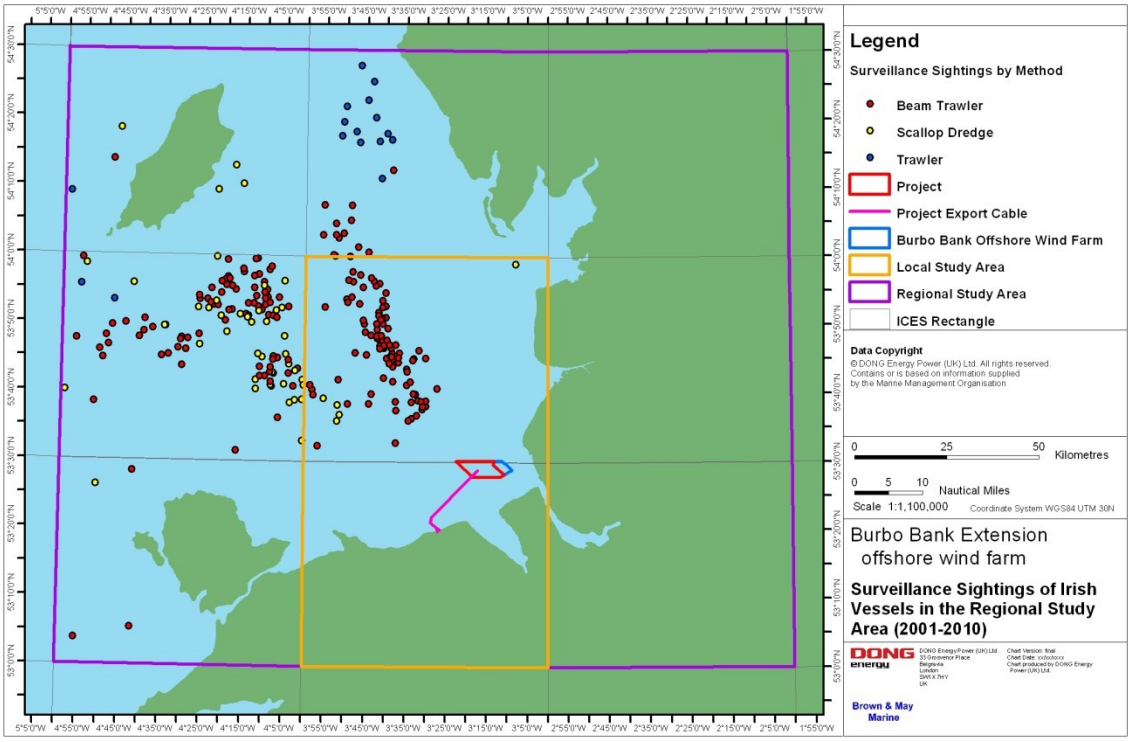


Figure 10.3 Surveillance Sightings of Irish Vessels by Method in the Regional Study Area (Source: MMO)

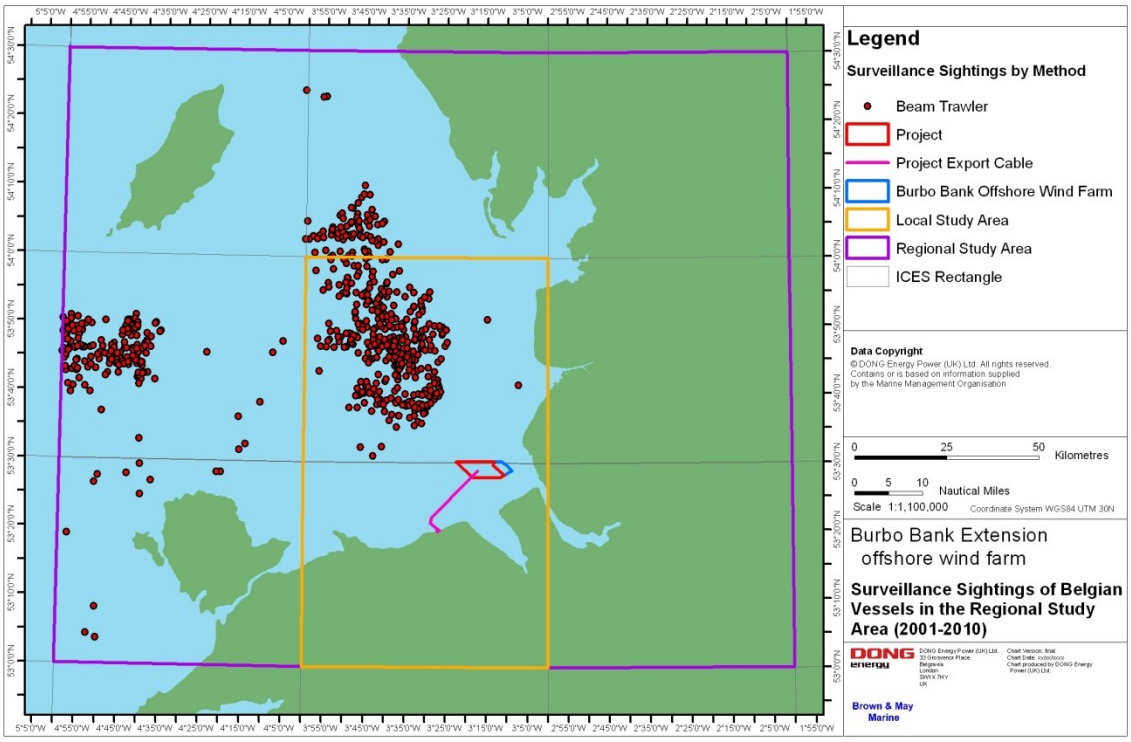


Figure 10.4 Surveillance Sightings of Belgian Vessels by Method in the Regional Study Area (Source: MMO)

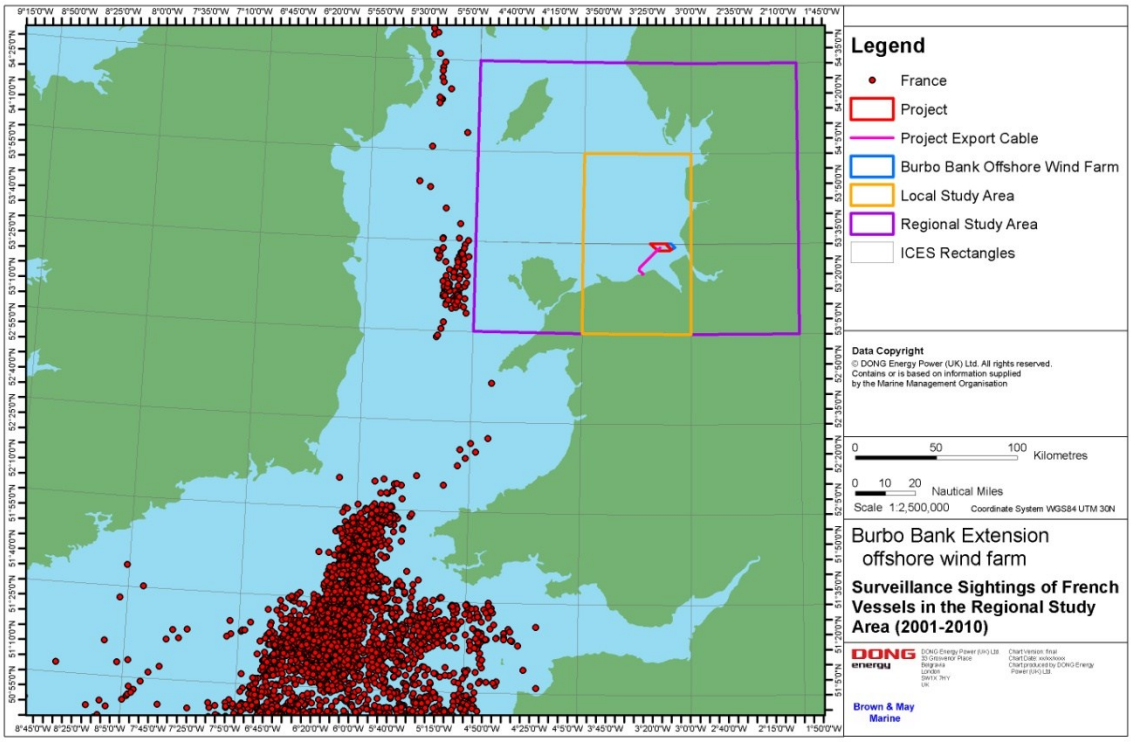


Figure 10.5 Surveillance Sightings of French Vessels in the Regional Study Area (Source: MMO)

11.0 Fishing Vessels

11.1.1 The majority of fishing vessels that operate within the vicinity of the Project are generally based at home ports in North Wales or Lancashire. Fleetwood is the only commercial fishing port within the regional study area; a number of vessels will register Fleetwood as their home port and base themselves elsewhere such as Hoylake, Chester, Mersey Estuary, Mostyn, Rhyl, Connah's Quay and Conwy. These vessels are generally small and fish within 6nm of the coast. The main fishing activities undertaken by these vessels are potting for lobsters, whelks and crabs, gillnetting and trawling (otter and beam) for sole, plaice, flounder, turbot, brill and skate. Under the NW-IFCA byelaws no vessel over-13.7m may fish within the 3nm limit.

11.1.2 The following sections details vessels that fish to varying degrees within the regional area and in theory in the area of the Project.

11.1 Scallop Fishery

11.1.3 Within the regional study area, one scallop dredger was identified as targeting grounds in the vicinity of the Project. The "Reiver" (Figure 11.1) is a scallop dredger operating out of Fleetwood. The basic specifications of the "Reiver" are listed in Table 11.1.

Figure 11.1 Scallop Dredger "Reiver" Operating out of Fleetwood (Source: Trawlerphotos.co.uk)

Table 11.1 Basic Specifications of the "Reiver", a Scallop Dredger

Vessel	Reiver
Vessel Reg.	E50
Home Port	Fleetwood
Main Fishing Method	Scallop Dredger
Length (m)	12.55
Beam (m)	4.29
Engine Power (hp)	220

11.1.4 Within the local study area the scallop fishery (kings and queen scallops) represents a high proportion of the average annual landings values (2001-2010) accounting for approximately 30% of the landings of each ICES rectangle. Vessels dredging for scallops within the vicinity of the Project are generally Scottish registered, over-15m vessels. The majority of the scallop dredging fleet is nomadic and fish around the UK coast; the areas fished depend on the productivity of each scallop ground and the changes in stock levels and regulations. Smaller vessels are based locally, landing their catch on a daily basis and employing fewer dredges allowing them to operate gear closer to the shore.

11.1.5 Due to the location of the Project within the 6nm limit the area is not targeted by the nomadic scallop fleet. Local scallop dredge vessels such as the "Reiver", which operate fewer than 8 dredges per side, can target grounds within 12nm. From the consultation undertaken to date it would however appear that scallop dredging does not occur within the Project.

11.2 Potting vessels

11.1.6 Ports of potting vessels that fish in the regional study area are given in Table 11.2. Figure 11.2 shows the "Welsh Maid" a 9.7m potter registered in Conwy. The basic specifications of this vessel are listed in Table 11.3. Potting vessels operating in the regional study area range in length up to 11.1m.

11.1.7 There are between 20 and 30 under-10m vessels that are actively potting between Holyhead and Bangor, with five under-10m potting vessels operating between Bangor and Conwy. These potters alternate between fishing for lobsters, crabs (edible and velvet), prawns and whelks (Natural England, 2010).

Whelks

11.1.8 The majority of whelk potting activity occurs in rectangle 35E6 and the highest values are landed into Holyhead. Potting for whelks takes place year round within the 6nm limit; vessels can set between 100 and 1500 pots per day. Whelk pots are baited and set in strings and left to soak for one to two days. The majority of the catch is exported to South Korea (Natural England, 2010).

Lobsters

11.1.9 The majority of potting for lobsters occurs in rectangle 35E6 and the highest values are landed into Conwy. Potting for lobsters generally occurs during the summer months and these vessels will target prawns during the winter. Vessels setting pots for lobster will generally operate in inshore waters, although will occasionally fish as far out as 12nm. Vessels can set between 50 and 500 pots per day (Natural England, 2010).

Table 11.2 List of Potters Registered to Ports within Liverpool Bay (Source: MMO)

Vessel Length	Number of Vessels	MMO Registered Home Port	
Under-10m	18	10	Fleetwood
		5	Conwy
		2	Rhyl
		1	Mostyn
10m-15m	1	1	Conwy

Figure 11.2 The "Welsh Maid", CO332, a Potter based at Conwy (Source: Intrafish 2009)

Table 11.3 Basic Specifications of the "Welsh Maid", a Potter

Vessel	Welsh Maid
Vessel Reg.	CO332
Home Port	Conwy
Main Fishing Method	Potter
Length (m)	9.75
Beam (m)	2.89
Engine Power (hp)	42

11.3 Beam Trawl Fishery

11.1.10 At the time of construction of the existing Burbo Bank Offshore Wind Farm, one beam trawler was known to regularly operate within the vicinity of the site. The vessel spent half of its time within the site fishing for sole, skate, plaice and brill; the landings of which represented half of the vessels annual earnings (Poseidon, 2002).

11.1.11 Table 11.4 below lists the home ports of 13 beam trawl vessels which by virtue of their distance from the Project area could potentially fish within it. The list should not however be considered to be a totally accurate record of the vessels based in the regional study area for the following reasons: individual vessels may have changed their home port; gear category may be in appropriate, and decommissioned/inactive vessels may still be included. In addition, the list does not distinguish between trawlers targeting different fisheries (e.g. Nephrops and whitefish trawlers).

Table 11.4 List of Beam Trawlers Registered to Ports within Liverpool Bay (Source: MMO)

Vessel Length	Number of Vessels	MMO Registered Home Port
Under-10m	12	3 Lytham St Annes 3 Mostyn 2 Mersey Estuary 2 Chester 1 Fleetwood 1 Hoylake
10m-15m	1	1 Liverpool

11.1.12 An example of this category of vessel is the "Corina II" (Figure 11.3) is a Liverpool based beam trawler, the vessel is 13.9m in length and therefore cannot fish within the 3nm limit. The basic specifications of this vessel are listed in Table 11.5. The majority of the beam

trawling fleet is under-10m, ranging in length from 5.6m to 13.9m with engine sizes of between 90 and 220kW.

Figure 11.3 The "Corina II", NN57, a Beam Trawler (Source: Intrafish 2009)

Table 11.5 Basic Specifications of the "Corina II", a Beam Trawler

Vessel	Corina II
Vessel Reg.	NN57
Home Port	Liverpool
Main Fishing Method	Beam Trawler
Length (m)	13.94
Beam (m)	4.86
Engine Power (hp)	249

11.4 Otter Trawling

11.1.13 Otter trawlers based at home ports in the regional study area are given in Table 11.6 below. These range in length from 5.0m to 12.2m and the majority of vessels have engines which are less than 100kW.

11.1.14 The basic specifications of the "Venture" and the "Firefly", two otter trawlers operating in the regional study area, are given in Table 11.7. The "Venture" can be seen in Figure 11.4.

11.1.15 Within the local study area otter trawling records the highest landings values in rectangle 36E6. The main target species are plaice, sole, skate and rays. Plaice are also targeted in rectangle 35E6.

Table 11.6 List of Otter Trawlers Registered to Ports within the Regional Study Area (Source: MMO)

Vessel Length	Number of Vessels	MMO Registered Home Port	
Under-10m	13	5	Fleetwood
		2	Rhy
		2	Connahs Quay
		1	Conwy
		1	Mostyn
		1	Hoylake
		1	Chester
10m-15m	1	1	Fleetwood

Table 11.7 Basic Specifications of the "Venture" and the "Firefly", two Otter Trawlers based in the Regional Study Area

Vessel Name	Venture	Firefly
Reg. No.	CH45	HL20
Home Port	Hoylake	Mostyn
Length (m)	8.2	7.18

Beam (m)	3.0	1.94
Draft (m)	1.1	0.63
Main Engine (HP)	22	15
Gear box reduction	2:1	N/A
Displacement (t)	5	1.24
Average No. of Days Fishing per Year	April to November, weather permitting	300
Typical Fishing Trip Duration (Hours)	12	10
Typical Distance Steamed per Trip (n. miles)	20	30
Average Speed (knots)	7	22
Principal Target Species	Plaice, Sole, Thornback Ray	Sole, shrimps, bass, mullet, plaice, cockles
Seasonality	April to November	Shrimps - autumn Bass, mullet, plaice – summer Sole - spring

Figure 11.4 The "Venture", CH45, an Otter Trawler based at Hoylake (Source: TrawlerPictures.co.uk)

11.5 Gillnets

11.1.16 The home ports of the gillnet vessels and number of vessels operating in the regional study area is given in Table 11.8. All of the gillnet vessels are under-10m in length. The basic specifications of three gillnetters known to be operating in the vicinity of the Project are given in Table 11.9.

11.1.17 Gillnetters with mesh sizes of between 100mm and 120mm target flatfish such as sole, plaice and flounder and larger mesh sizes of between 200mm and 300mm are used to target rays, turbot and brill. Round fish, such as cod and pollock are targeted using a mesh of between 120mm and 160mm (Walmsley and Pawson, 2007).

11.1.18 The majority of gillnetting activity occurs in rectangle 35E6 and most vessels target bass, skates and rays. In rectangle 36E6, the majority of landings by gillnetters are of bass. In both rectangles activity generally occurs between April and October.

Table 11.8 List of Gillnetters Registered to Ports within Liverpool Bay (Source: MMO)

Vessel Length	Number of Vessels	MMO Registered Home Port
Under-10m	25	7 Fleetwood 4 Conwy 4 Mostyn 4 Rhyl 2 Connahs Quay 2 Chester 1 Rhos on Sea 1 Lytham St Annes

Table 11.9 Basic Specifications of the "Lisa Gem", "Lizann" and "Snow Goose", Gillnetters

Vessel Name	Lisa Gem	Lizann	Snow Goose
Reg. No.	BS517	LL500	CH3
Home Port	Heswall	Wirral	Mostyn
Length (m)	4.86	5.0	5.08
Beam (m)	1.57	2.0	2.05
Draft (m)	0.3	0.3	0.5
Main Engine (HP)	6	40	50
Displacement (t)	0.86	1.3	0.85
Average No. of Days Fishing per Year	100	90	300
Typical Fishing Trip Duration (Hours)	24	24	10
Typical Distance Steamed per Trip (n. miles)	30	30	30
Average Speed (knots)	10	22	22
Principal Fishing Method	Gillnet/Trammel Nets	Gillnets	Gillnets
Principal Target Species	Sole, Bass, Rays, Cod, Plaice	Sole, Bass, Rays, Plaice, Cod	Sole, Bass, Mullet, Plaice
Seasonality	Sole, Bass, Rays, Plaice - March to November Cod - November to March	Sole, Bass, Rays, Plaice - March to November Cod - November to March	Bass, Mullet, Plaice – summer Sole - spring

12.0 Fishing Grounds

12.1.1 The charts below have been produced using information provided by individual fishermen.

12.1 Beam Trawl Fishing Grounds

12.1.2 Figure 12.1 shows the location of beam trawl grounds in the vicinity of the Project. It was stated that beam trawling for cod and sole occurs in the south-east of the site and to the east of the Project.

12.2 Otter Trawl Fishing Grounds

12.1.3 Figure 12.2 shows the otter trawling grounds of the only vessel identified through consultation that appears to otter trawl within the Project and shows grounds located throughout the Project site. It was stated by the skipper that the principal target species are sole, plaice and thornback ray.

12.3 Gillnet Fishing Grounds

12.1.4 From the consultation undertaken to date it is understood that two under-10m gillnetters fish within the Project area and their fishing grounds as described by the skippers are given in Figure 12.3. The main target species of these vessels are bass, plaice, sole, cod, rays, mullet and flounder.

12.1.5 Figure 12.4 shows the gillnetting grounds by species as described by fishermen attending consultation meetings held at New Brighton and Rhyl (10th and 11th November 2011). As is apparent only one small fishing area of the skippers attending these consultation meetings is located within the Project area. As is also apparent the export cable route only transects two small fishing areas.

12.1.6 Consultation with fishermen identified the Burbo Bank Offshore Wind Farm as a good fishing ground for sole. The Project site was also identified as bass and sole fishing grounds; both species are targeted using fixed gillnets and trammel nets. The main sole fishery operates in March/April during the sole spawning season, cod and bass are also caught during this time (BMM Consultation 2011).

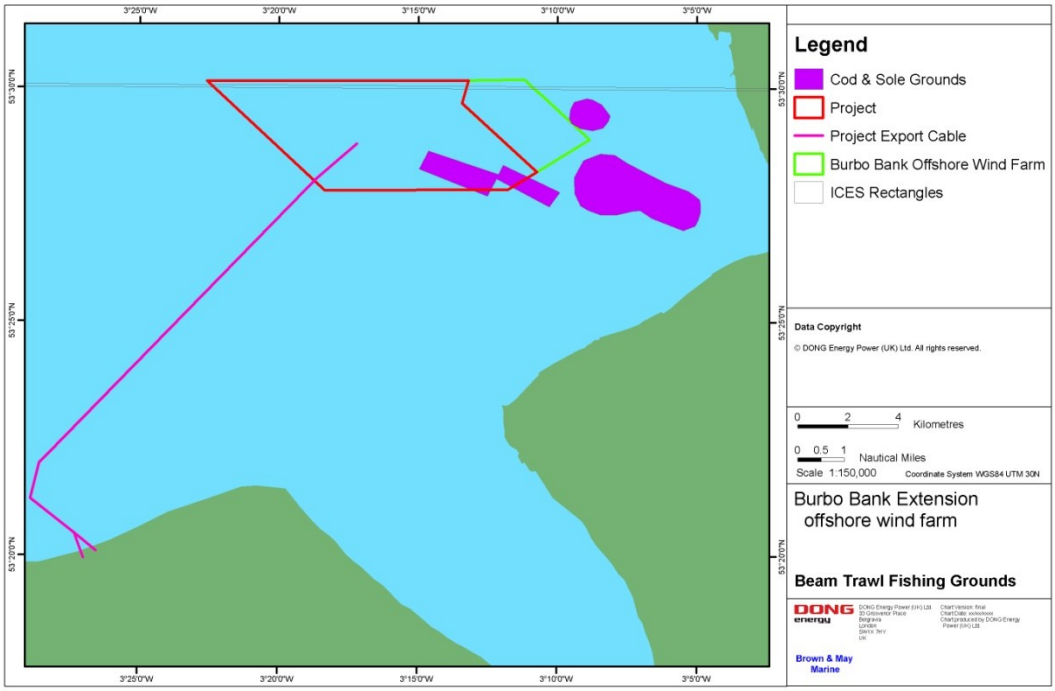


Figure 12.1 Beam Trawling Grounds by Species (Consultation with fishermen, 2011)

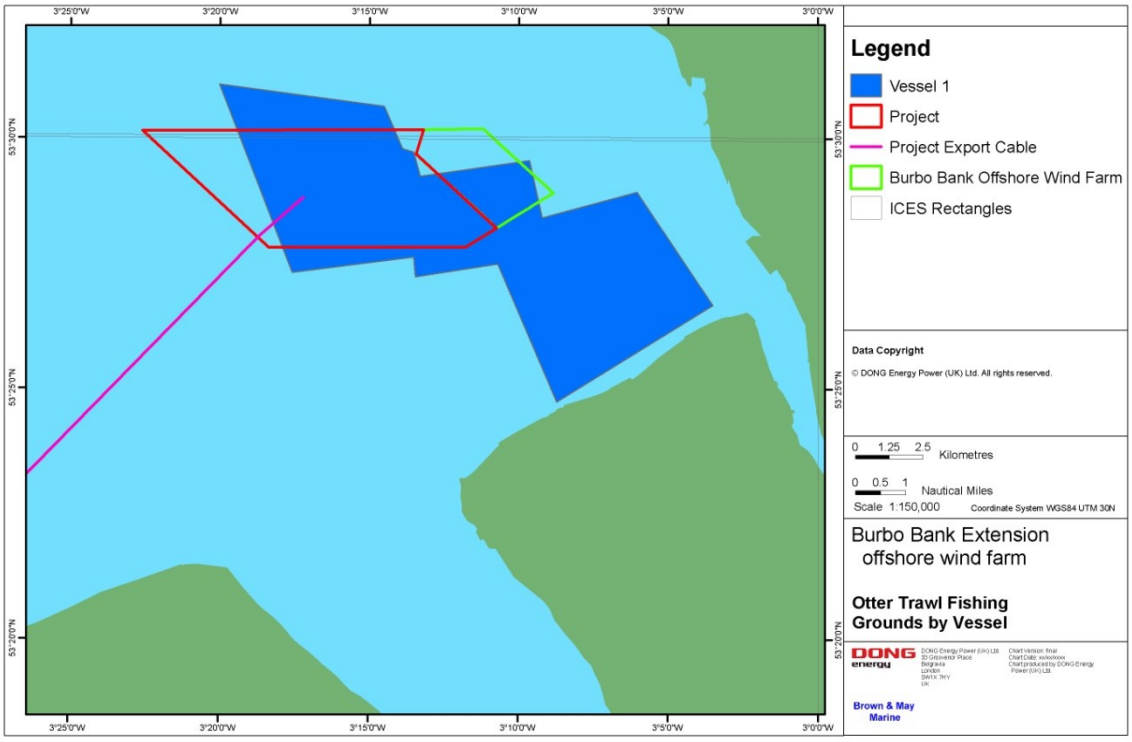


Figure 12.2 Otter Trawl Grounds by Vessel (Consultation with fishermen, 2011)

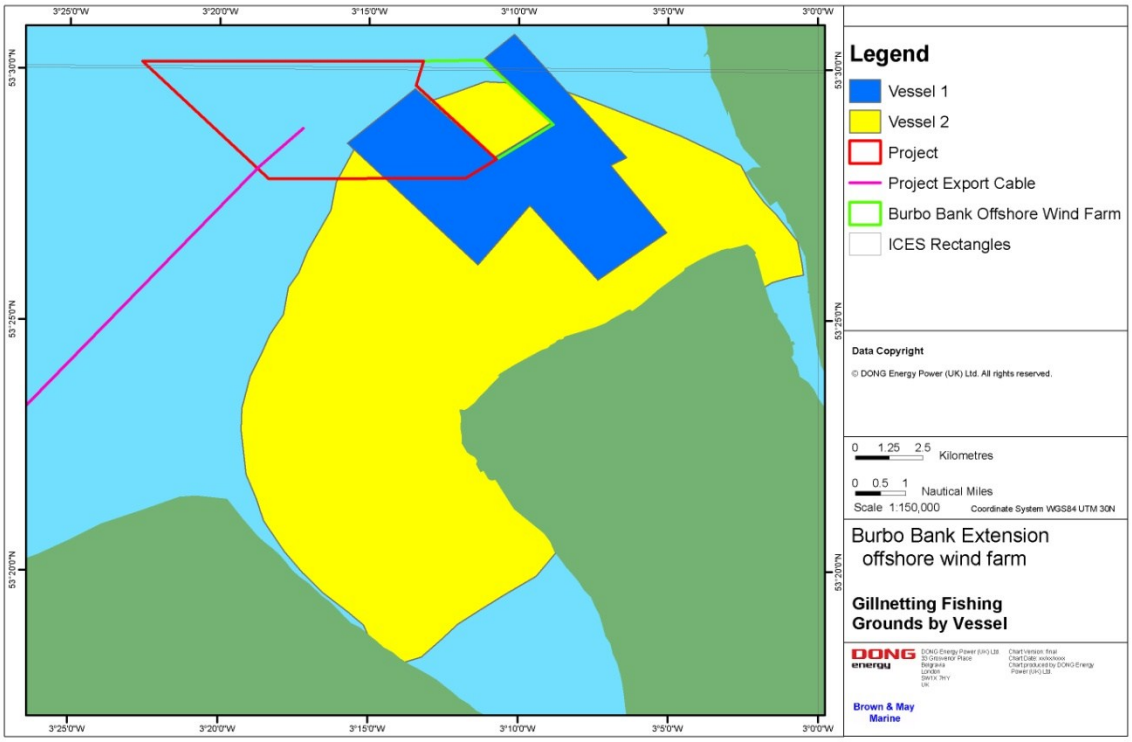


Figure 12.3 Gillnetting Grounds by Vessel (Consultation with fishermen, 2011)

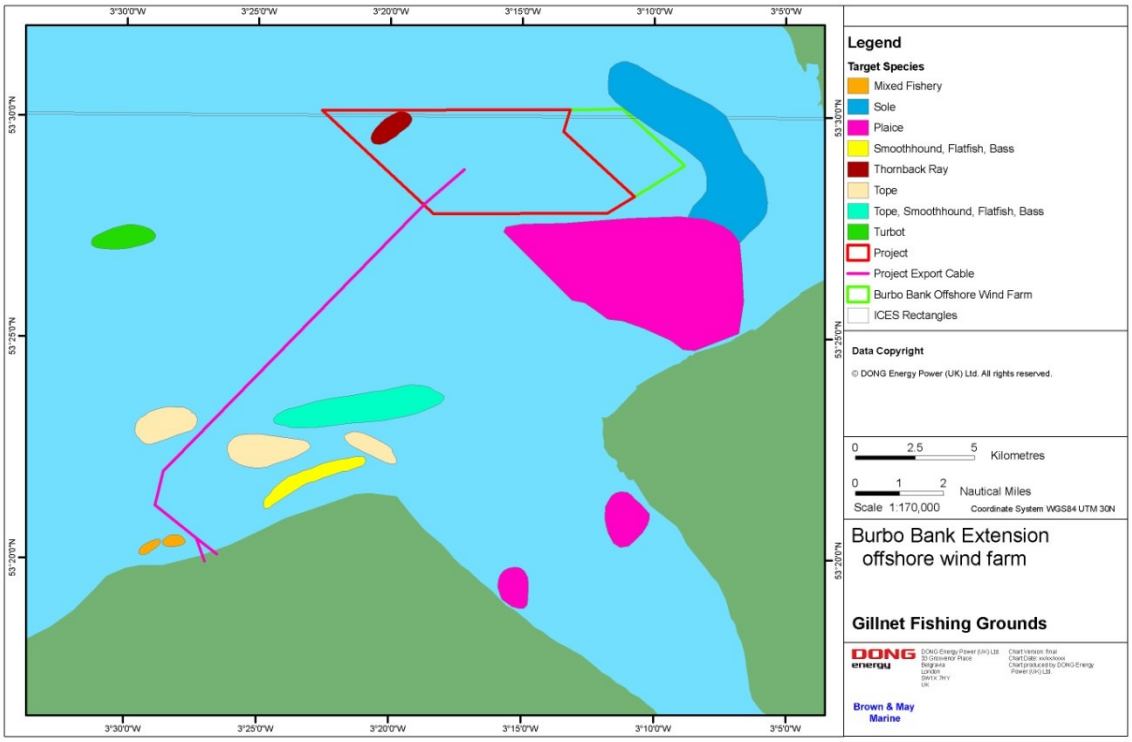


Figure 12.4 Gillnet Fishing Grounds by Species (Consultation with fishermen, 2011)

12.1.7 A larger scale depiction of fishing grounds relative to the Project is given in a schematic overview as prepared by Mackinson *et. al.* (2006). Whilst the grounds shown differ from those obtained from consultation with fishermen, Figure 12.5 illustrates that the majority of the fishing grounds within the general vicinity of the Project are located some distance from it, with only a small proportion of the sole, plaice and cod grounds actually occurring within the Project site boundary.

12.1.8 The location of shellfish beds in relation to the Project are shown in Figure 12.6. Shellfish beds are located on intertidal areas to the south-east of the project on the Wirral peninsula (Cefas, 2011); cockle beds are also located in the Dee estuary (Environment Agency, 2005 & Environment Agency, 2012). It is therefore apparent that there are no identified shellfish beds within the Project area or along the export cable route.

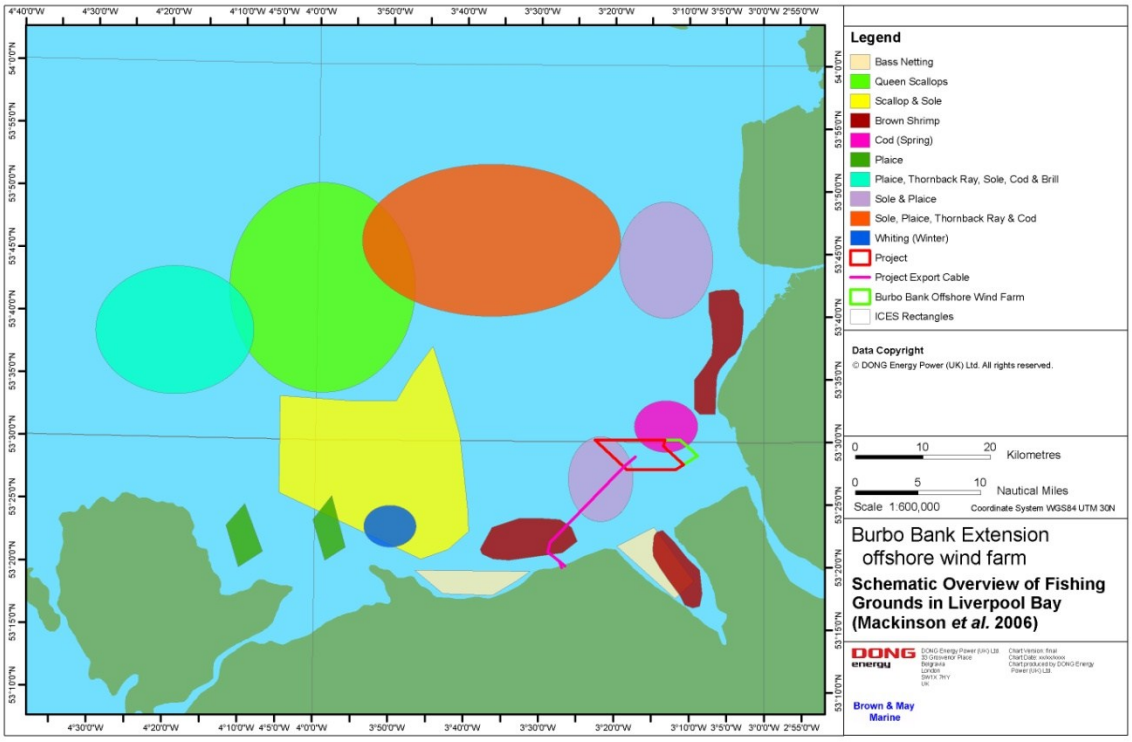


Figure 12.5 Schematic Overview of Fishing Ground in the North West in Relation to the Project area (adapted from Mackinson *et. al.,* 2006)

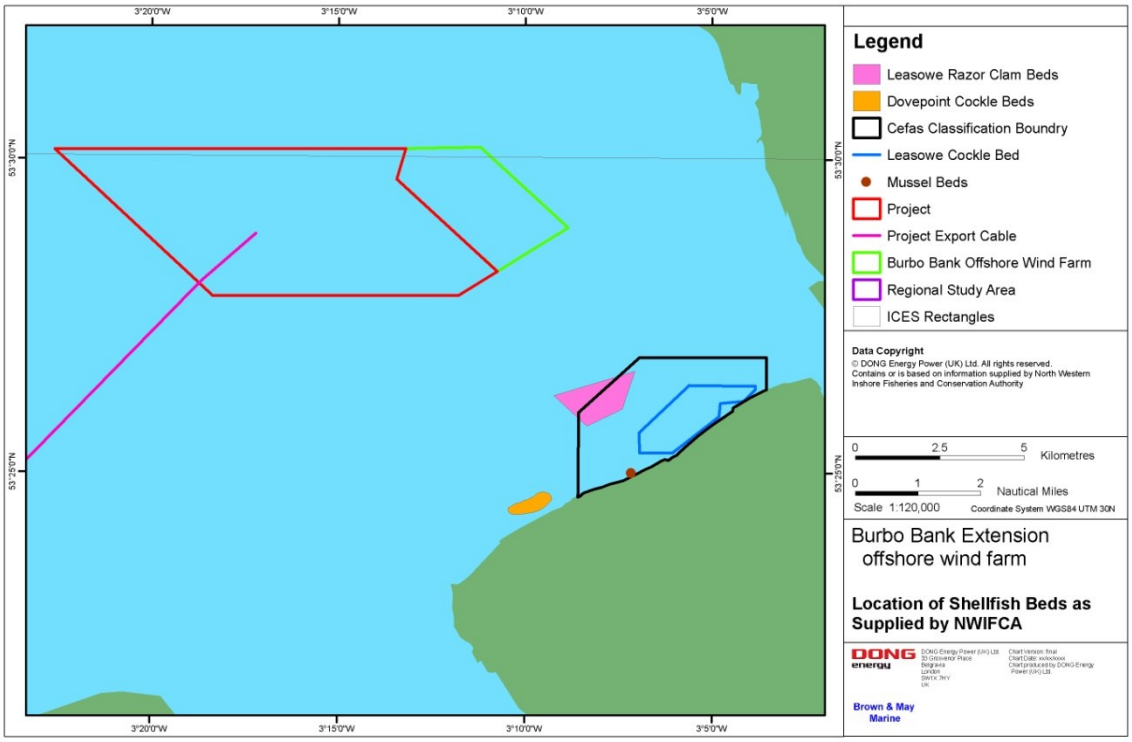


Figure 12.6 North Wirral Foreshore Known Shellfish Beds (Source: NW-IFCA, 2011a)

13.0 Angling

13.1.1 In the course of local consultation, a number of angling charter boats skippers stated that on occasions, they operate within the vicinity and within the Project (Table 13.1). Typical examples of the specifications of the charter vessels operating in the general Project area are given in Table 13.2.

Table 13.1 Charter Vessels Operating in the Regional Study Area

Vessel	Home Port	Length (m)
Sea Gem II	Rhyl	11.0
Suveran II	Rhyl	8.0
Supreme	Rhyl	11.5
Jensen II	Rhyl	10.5
Merlin	Rhyl	10.0
Goldilocks	Rhyl	9.5
Discovery	Liverpool	10.0
Tuskar	Liverpool	10.5
George Griffith MBE	Runcorn	9.0

Table 13.2 Charter Boat Vessel Specifications and Operating Practices

Vessel Name	Discovery	Sea Gem II	Jensen II
Home Port	Liverpool	Rhyl	Rhyl
Length (m)	10.0	11.0	10.5
Beam (m)	5.0	4.0	3.6
Draft (m)	1.5	1.1	0.9
Engine Power (HP)	215 x 2	250	420
Average No. of Passengers	10	10	10
Average No. of Trips per Year	118	250	250
Typical Fishing Trip Duration (Hours)	10	10	5 to 12
Typical Distance Steamed per Trip (n. miles)	80 - Summer 15 to 20 - Winter	60 to100	1 to 100
Average Speed (knots)	18	13	14
Principal Target Species	Summer - All species Winter - Cod and Flatfish	Tope, Skate, Bass, Smoothhound, Gurnard, Dab, Whiting, Dogfish, Herring, John dory, Cod, Weever, Mackerel	Summer - Up to 40 Species Winter - Cod, Dab, Rays, Whiting

13.1.2 It was stated that angling within the vicinity of the Project occurs all year and vessels will alter their operating practices depending on the seasonality of the target species. During the summer months it is understood that up to 40 different species are caught, whereas during the winter months catches are generally limited to cod, dab, rays and whiting. The durations of fishing trips are for the most part of between 5 to 12 hours.

13.1.3 Figure 13.1 and Figure 13.2 show the main fishing grounds of charter boats operating from Liverool and Kimmel Bay, respectively. Vessels from Liverpool fish grounds within the Project site and the Burbo Bank Offshore Wind Farm whereas vessels from Kimmel Bay fish grounds to the south and west of the Project site. All of the charter skippers consulted stated that they mainly fish wreck sites throughout the region (pers. comm. BMM, 2012).

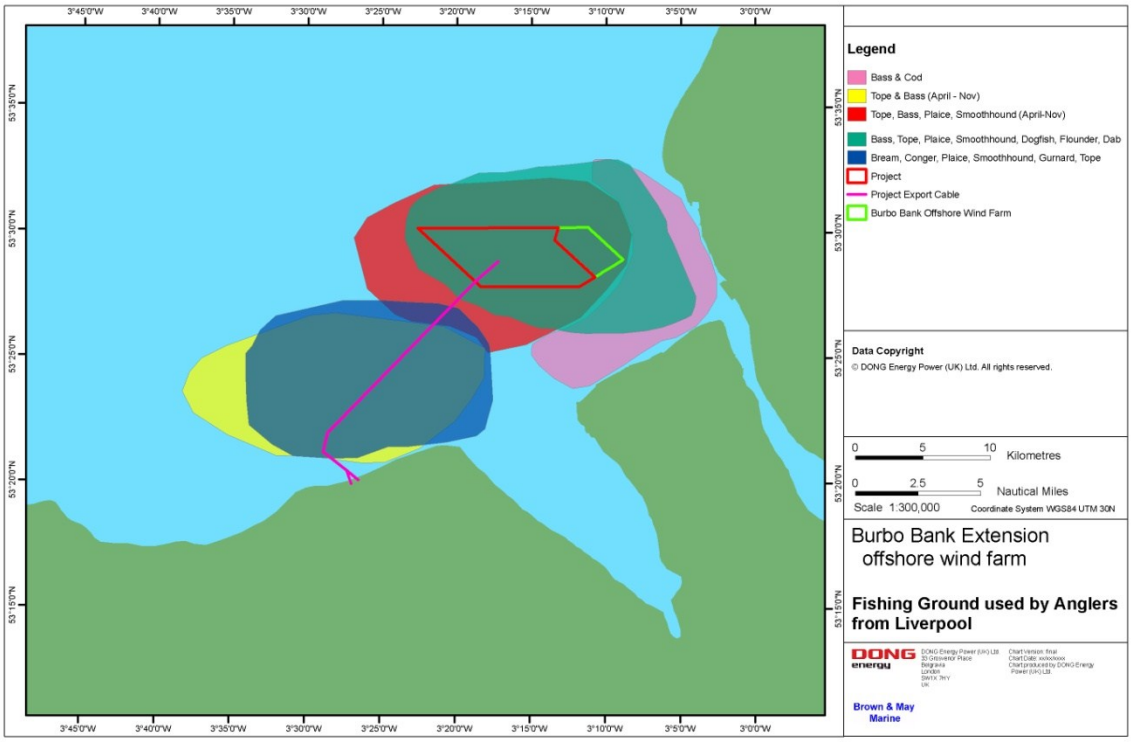


Figure 13.1 Grounds Identified by Anglers from Liverpool

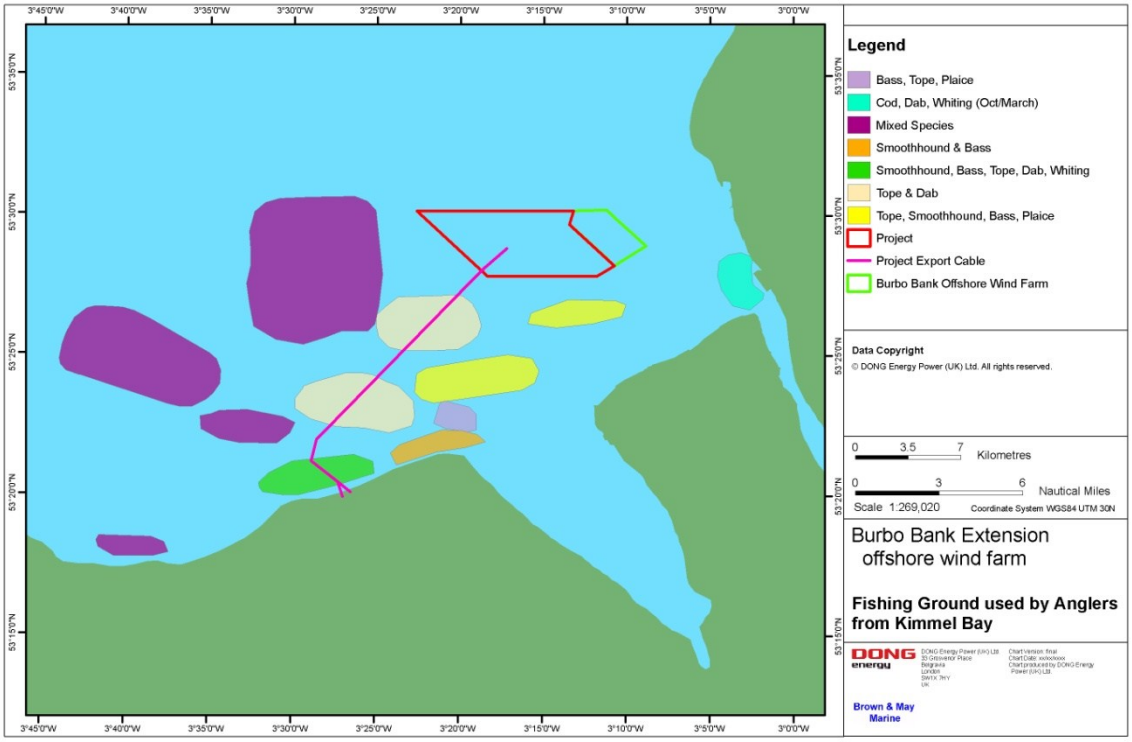


Figure 13.2 Grounds Identified by Anglers from Kimmel Bay

14.0 Future Fisheries

14.1.1 As stated previously, fishing activity does not remain constant year on year due to fluctuations in fish stocks, changes in legislation and alterations in the economy. These factors make the future of fishing activity within the area difficult to predict. The following section outlines possible changes to current fishing activity and practices.

14.1 Fisheries Legislation

Common Fisheries Policy (CFP)

14.1.2 Management of the EU fishing industry is under the CFP. Reforms of the CFP are in progress and are expected to come into effect in 2013 which may result in changes to the management of the fishing industry particularly with regard to quota and days at sea allocations.

Quotas

14.1.3 Over the past ten years, the quotas for a number of species have shown a progressive decline due to concern over the condition of a number of fish stocks within the Irish Sea which can increase effort on non-quota species such as scallops. For example, a number of beam trawl vessels previously targeting flatfish species with quota allocations have converted to targeting non-quota species such as scallops.

14.1.4 The proposed 2012 Total Allowable Catches (TAC) for ICES division VIIa in which the Project is located are provided in Table 14.1 which shows a further reduction from those of 2011. It is possible that in subsequent years TACs for pressure stock species may be further reduced due to continuing concern about the condition of stocks.

Table 14.1 Proposed 2012 TAC for ICES Division VIIa for all Countries

Species	TAC		Comparison 2012/2011
	2012	2011	
Cod	380	560	-25%
Haddock	1,251	1,317	-5%
Herring	4,752	5,280	-10%
Horse Mackerel	157,989	158,789	-1%
Plaice	1,627	1,627	0%
Sole	300	390	-23%
Whiting	89	118	-25%

Community Quota

14.1.5 A number of fishing communities around the UK have signed up to community quota schemes. The community quota scheme has been established to find a long term solution for the under-10m fleet. The scheme will enable fishermen and other local businesses and organisations to manage their quotas flexibly and allow them to swap and purchase additional quota. The scheme may also introduce a rights based management scheme for shellfish, beginning with edible crab and lobsters (Defra, 2011b).

Days at Sea

14.1.6 Over-10m vessels are restricted by the number of days per month they can spend fishing depending on species targeted, gear type and mesh size. Currently, vessels targeting whitefish are restricted to 14 to 15 days per month. The present days at sea system is under review in the CFP reform which may result in changes to the current restrictions.

14.1.1 Marine Conservation Zones (MCZs)

14.1.7 The implementation of MCZs may cause a change in fishing practices in specific areas. There are currently three proposed MCZs within the vicinity of the Project although, as discussed previously, it is unlikely that they will have an impact on local fisheries.

15.0 References

Cefas (2009) Sole in the Irish Sea (ICES Division VIIa)

Cefas (2011). Classification of bivalve mollusc production areas in England and Wales. Sanitary Survey Report. Liverpool Bay.

Comite National des Peches (2009) French answer to the consultation on round 3 UK wind farms proposal – 2009. *CNPMEM*

Council of the European Union (2011) Press Release, 3137th Council meeting, Agriculture and Fisheries, *European Union, Brussels*

Defra (2011a) Consultation on the evidenced base for a proposed new English scallop order. *Defra*

Defra (2011b), New plan to secure future of fishing communities and fleets, available online: http://www.defra.gov.uk/news/2011/04/05/fisheries-future/ (Accessed 26/01/12)

Drew, S. C. and Hopper, A. G. (2009) Fishing and submarine cables – Working Together, *International Cable Protection Committe*

Environment Agency (2005) Dee cockle fishery regulating order: appropriate assessment

Environment Agency (2012). Keeping cockles and mussels alive oh. Available online: http://www.environment-agency.gov.uk/news/132685.aspx?page=2&month=8&year=2011. (Accessed 02/02/12).

European Commission (2000) Commission Regulations (EC) No. 304/2000 of 9 February 2000 establishing measures for the recovery of the cod stocks in the Irish Sea (ICES Division VIIA). *Official Journal of the European Communities*

Galbraith, R. D. and Rice, A. (2004) An introduction to commercial fishing gear and methods used in Scotland. *Scottish Information Pamphlet No. 25*

ICES (2010) Report of the ICES Advisory Committee 2010. ICES Advice, 2011. Book 5, 77-83

ICES (2011) Report of the Benchmark Workshop on Flatfish (WKFLAT). *ICES Advisory Committee ACOM: 39*

Irish Sea Conservation Zone (2011) Final Recommendations Summary, *Irish Sea Conservation Zone*

Lee, J., South, A.B. and Jennings, S. (2010) Developing reliable, repeatable, and accessible methods to provide high-resolution estimates of fishing-effort distributions from vessel monitoring system (VMS) data. 2010 *International Council for the Exploration of the Sea*.

Mackinson, S., Curtis, H., Brown, R., McTaggart, K., Taylor, N., Neville, S. and Rogers, S. (2006) A report on the perceptions of the fishing industry into the potential socio-economic impacts of offshore wind energy developments on their work patterns and income. *Cefas Technical Report no. 133*

Natural England (2010) Evidence base for Impact Assessment of designation of Liverpool Bay / Bae Lerpwl Special Protection Area, *Natural England*

North West Inshore Fishery and Conservation Authority (2011a) North Wirral Foreshore Known Shellfish Beds December 2011, *North Western IFCA*

North West Inshore Fishery and Conservation Authority (2011b) The Ribble Estuary and Wirral Cockle Bed Closure

North West Inshore Fishery and Conservation Authority (2011c) Update on the Leasowe cockle fishery

NUFTA – The New Under Ten Fishermans Association (2012), The fishing industry, available online: http://www.nutfa.org/#/the-fishing-industry/4543398810 (Accessed 26/01/12)

Poseidon Aquatic Resource Management Ltd (2002) The Burbo Bank Offshore Wind Farm – Impact on the human environment (main report on commercial fisheries).

Rogers, S.I. (1997), A review of closed areas in the United Kingdom Exclusive Economic Zone, *Cefas Technical Report,* Number 106

Walmsley S.A. and Pawson, M.G., 2007. The coastal fisheries of England and Wales, Part V: a review of their status 2005–6. Sci. Ser. Tech Rep., Cefas Lowestoft, 140: 83pp.