BURBO BANK EXTENSION OFFSHORE WIND FARM

DONG Energy Burbo Extension (UK) Ltd.

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

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

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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).

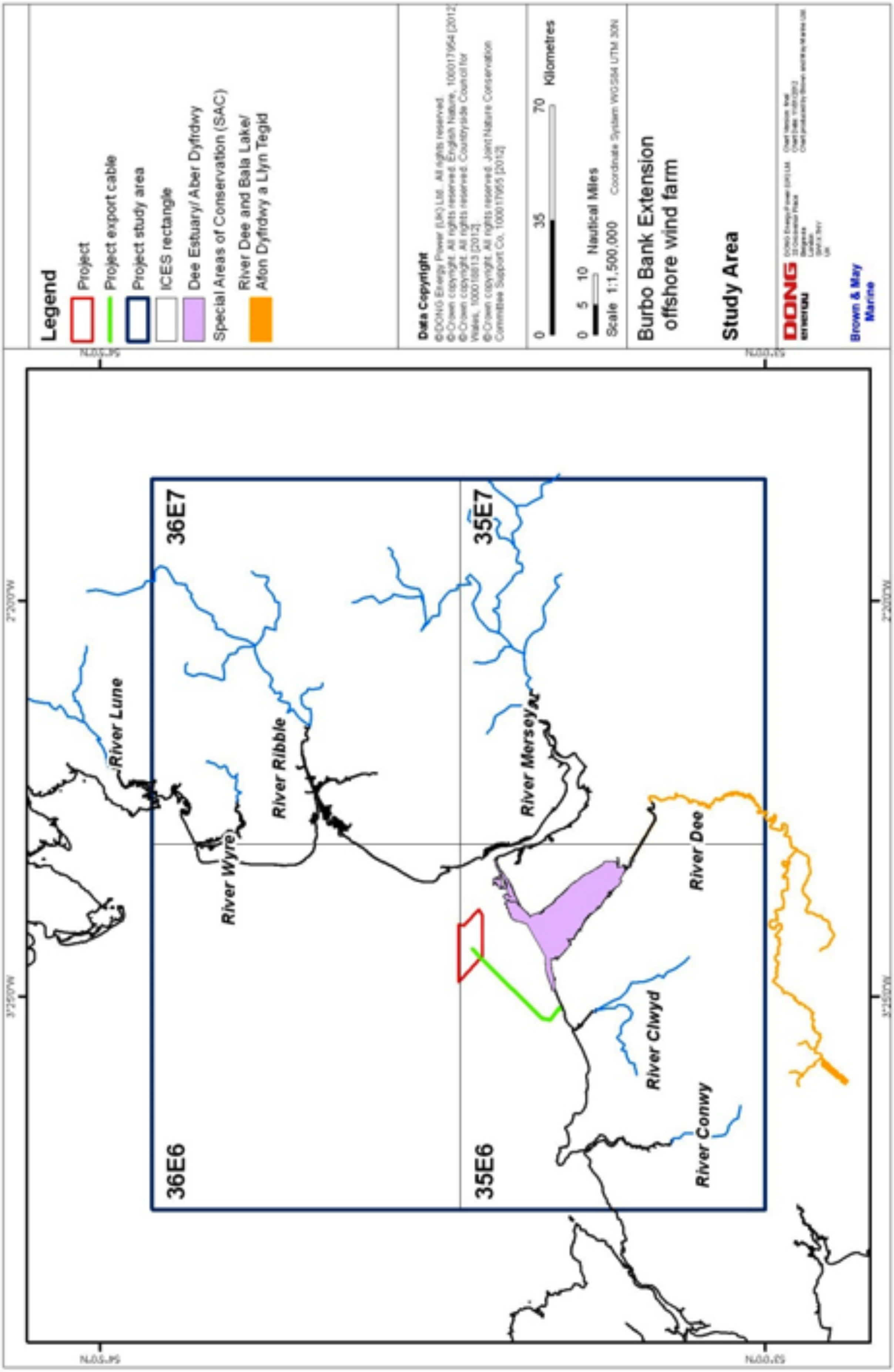

Figure 13.1: Project assessment study area

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).

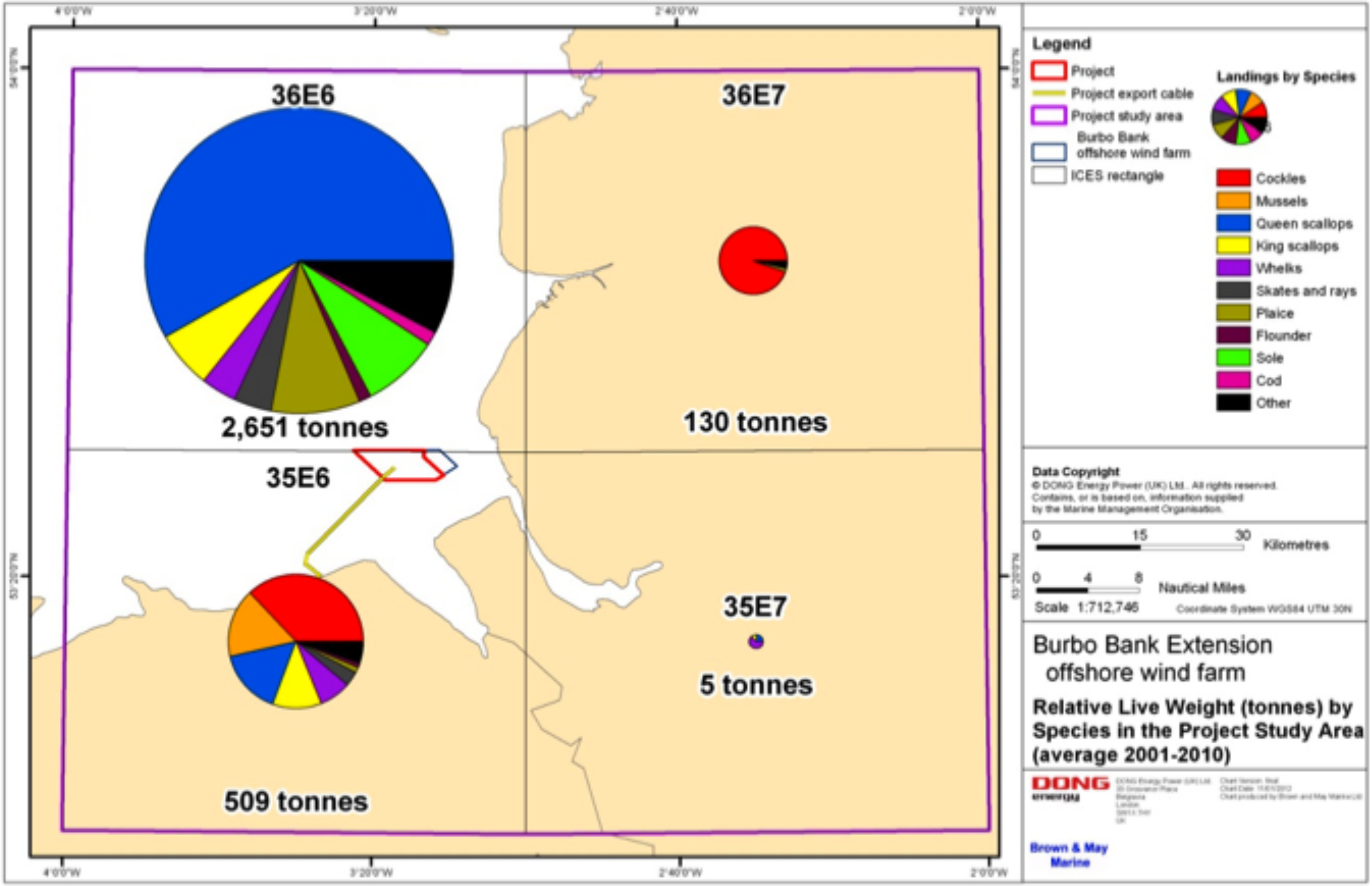

Figure 13.2: Average (2001-2010) live weight (tonnes) by species in the study area (MMO, 2011)

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.

<u>Shellfish</u>

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.

<u>Early life stages of limited mobility</u>

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

<u>Fish and Shellfish</u>

Lethal and Traumatic Hearing Effects

<u>Juvenile and adult fish</u>

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.

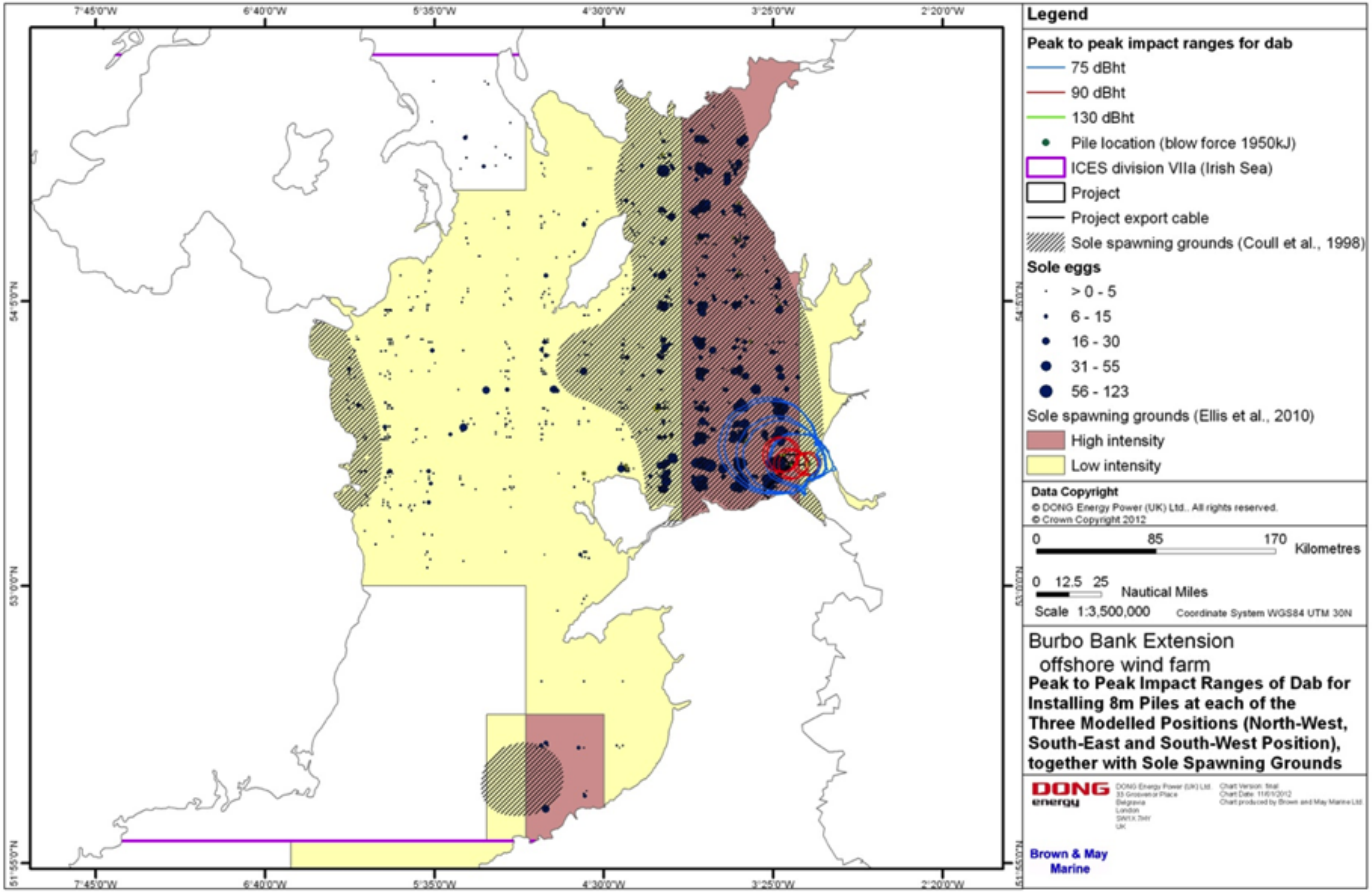

Figure 13.3: Estimated 75, 90 and 130 dB_{ht} (Limanda limanda) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at each of the three piling modelled locations together with sole spawning grounds as provided in Ellis et al., (2012)

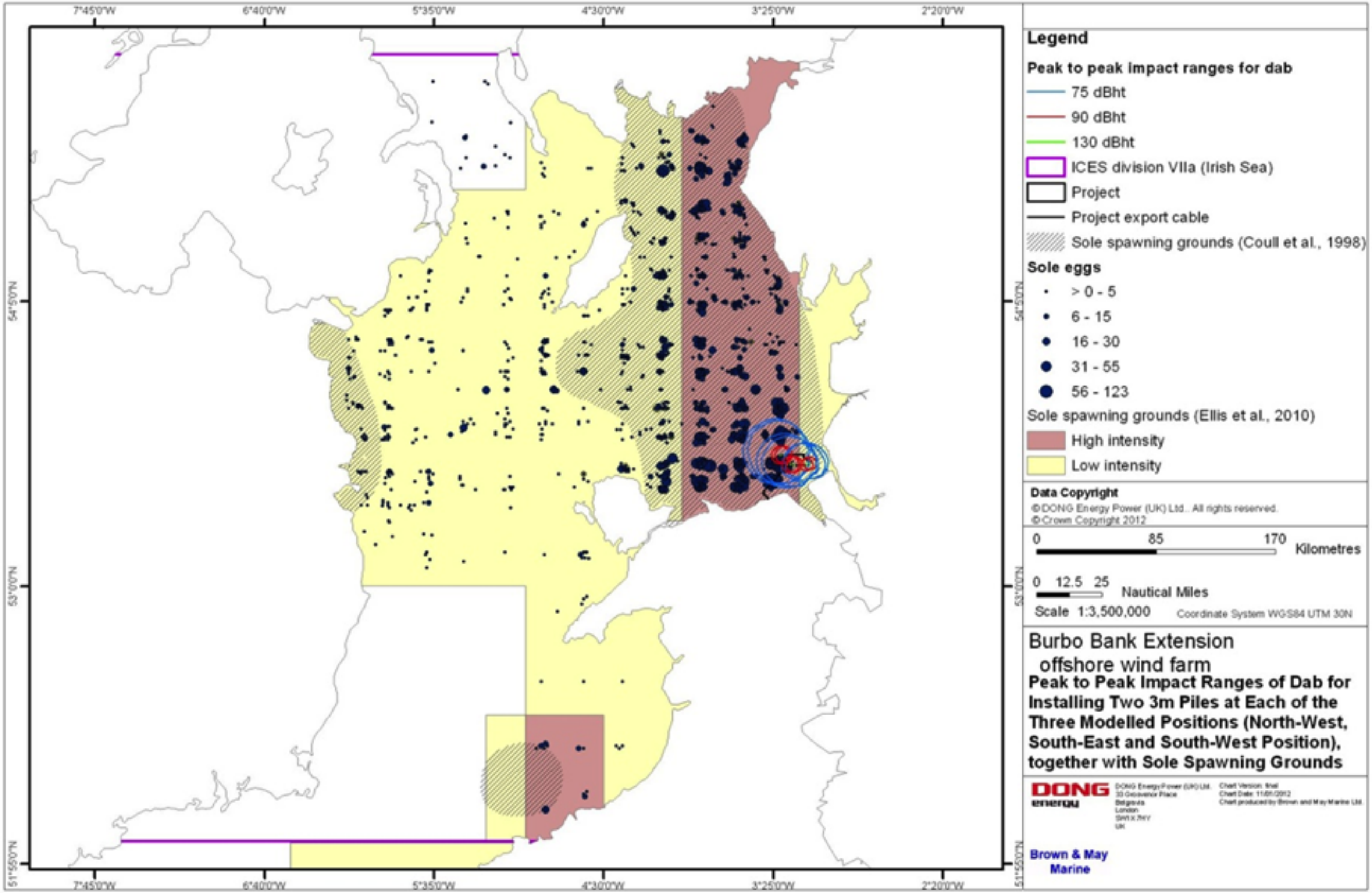

Figure 13.4: Estimated 75, 90 and 130 dB$_{ht}$ (Limanda limanda) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at each of the three piling modelled locations together with sole spawning grounds as provided in Ellis et al., (2012)

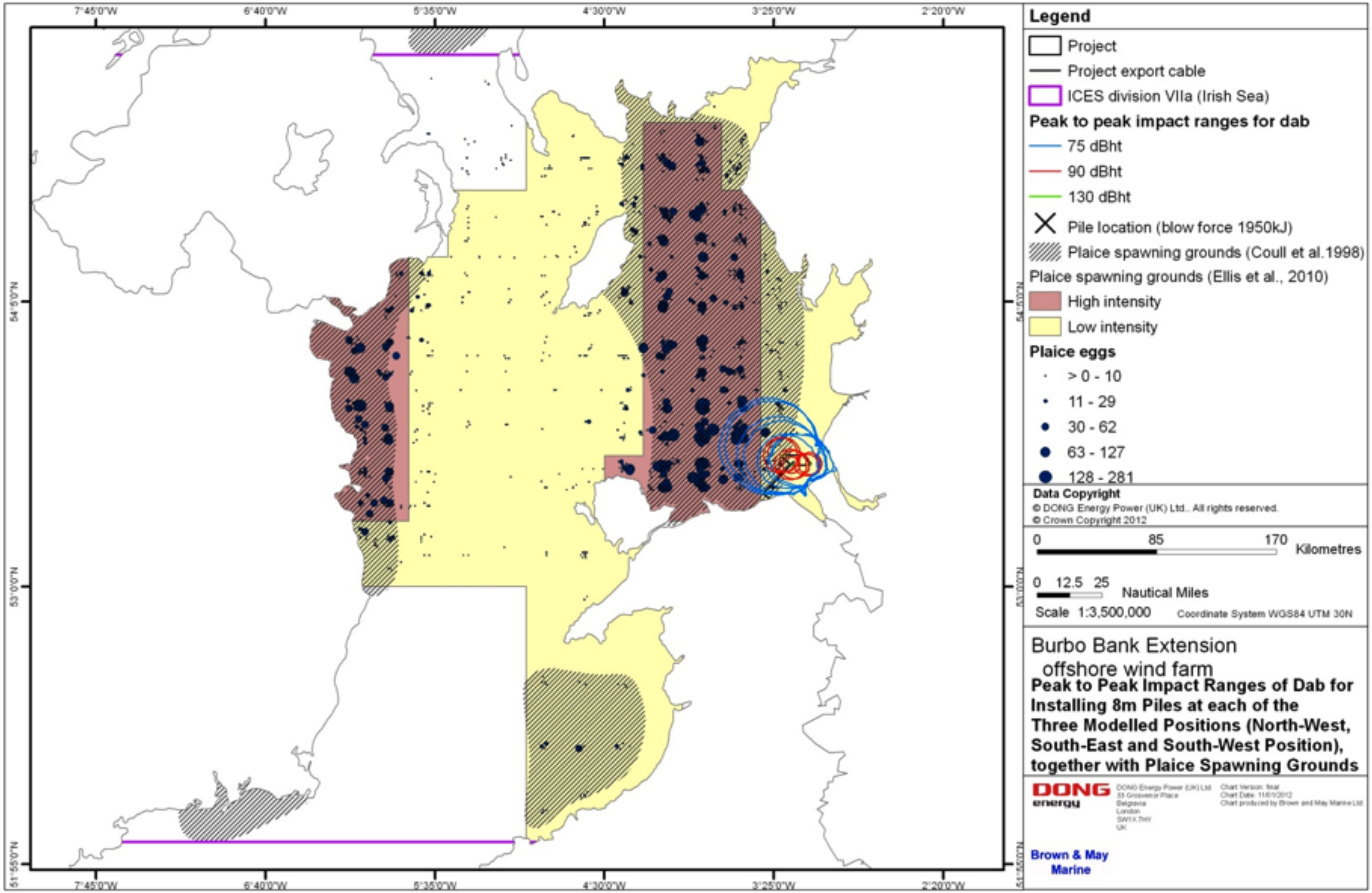

Figure 13.5: Estimated 75, 90 and 130 dB$_{ht}$ (Limanda limanda) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at each of the three modelled locations together with plaice spawning grounds as provided in Ellis et al., (2012)

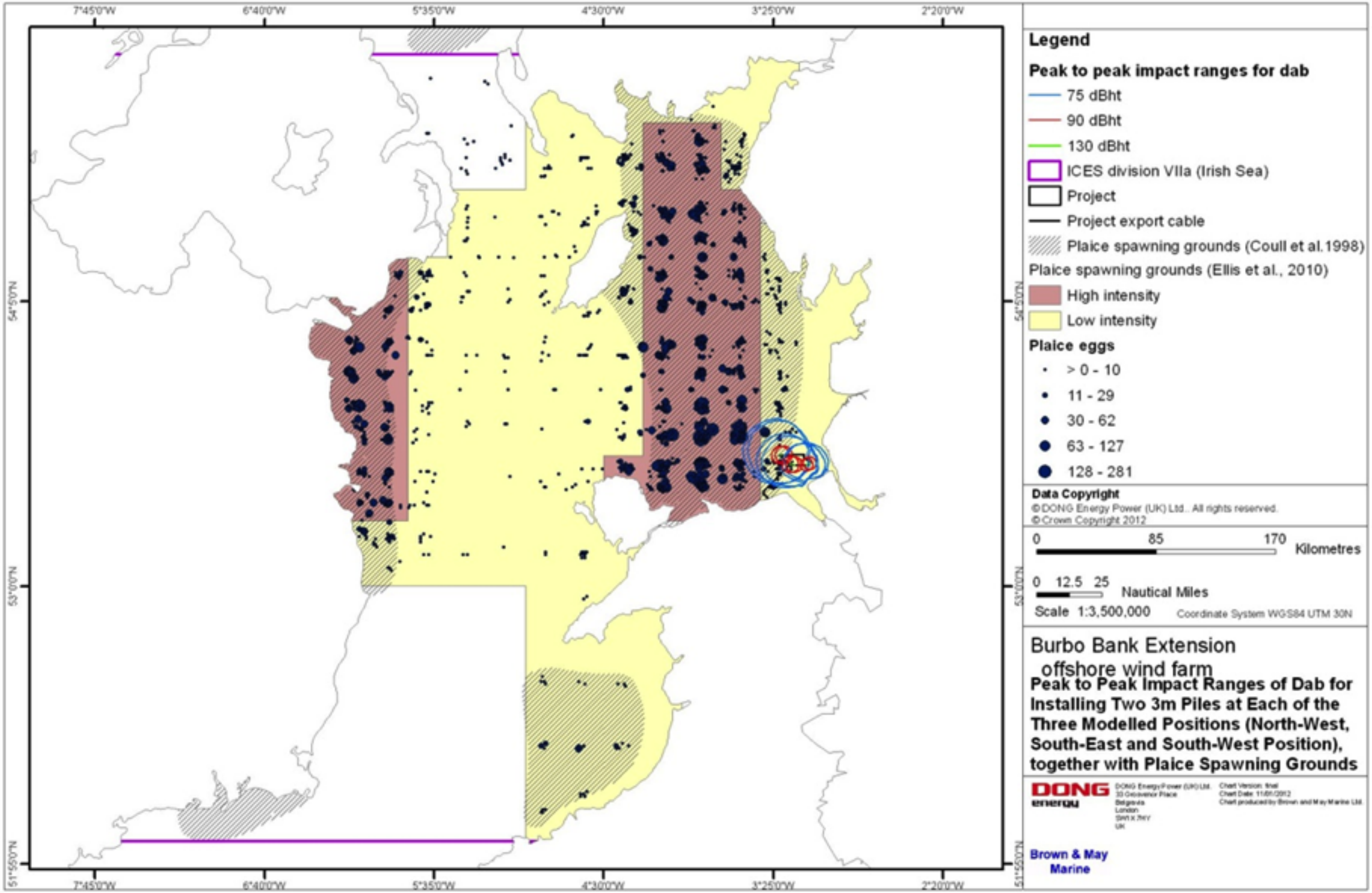

Figure 13.6: Estimated 75, 90 and 130 dB$_{ht}$ (Limanda limanda) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at each of the three modelled locations together with plaice spawning grounds as provided in Ellis et al., (2012)

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.

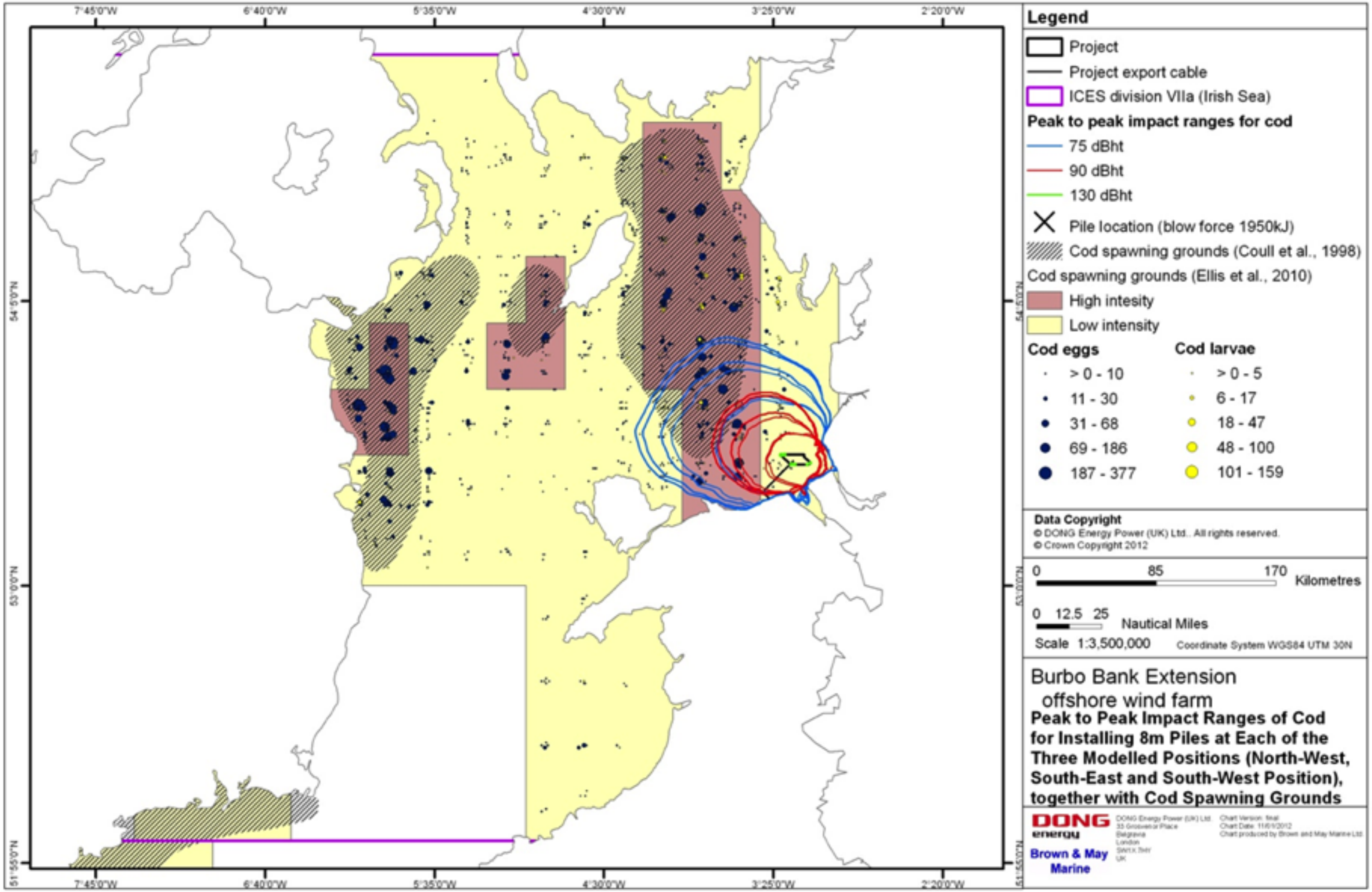

Figure 13.7: Estimated 75, 90 and 130 dB_{ht} (Gadus morhua) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at each of the three modelled locations, together with cod spawning grounds as provided in Ellis et al. (2012)

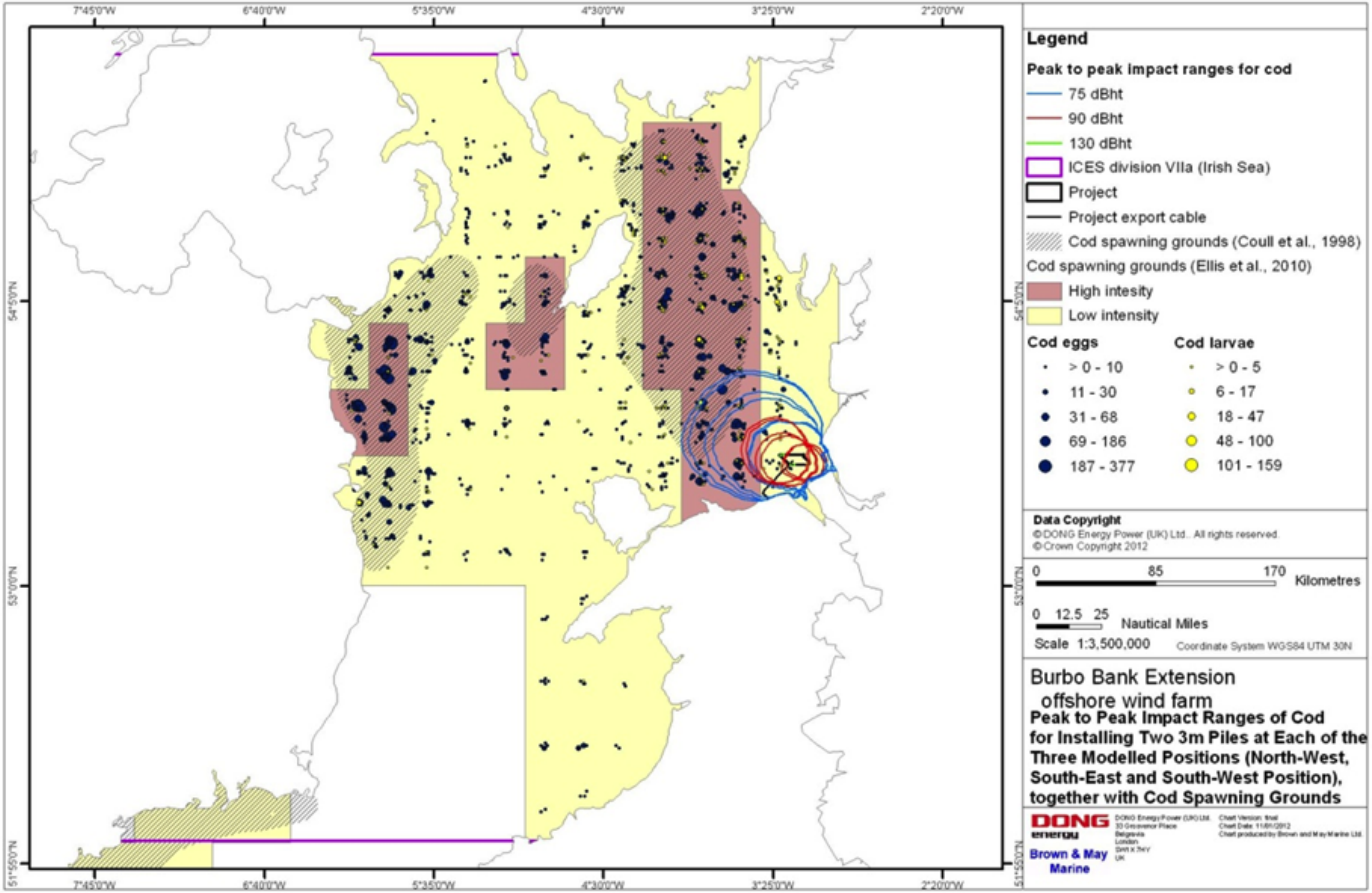

Figure 13.8: Estimated 75, 90 and 130 dB$_{ht}$ (Gadus morhua) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at each of the three modelled locations, together with cod spawning grounds as provided in Ellis et al. (2012)

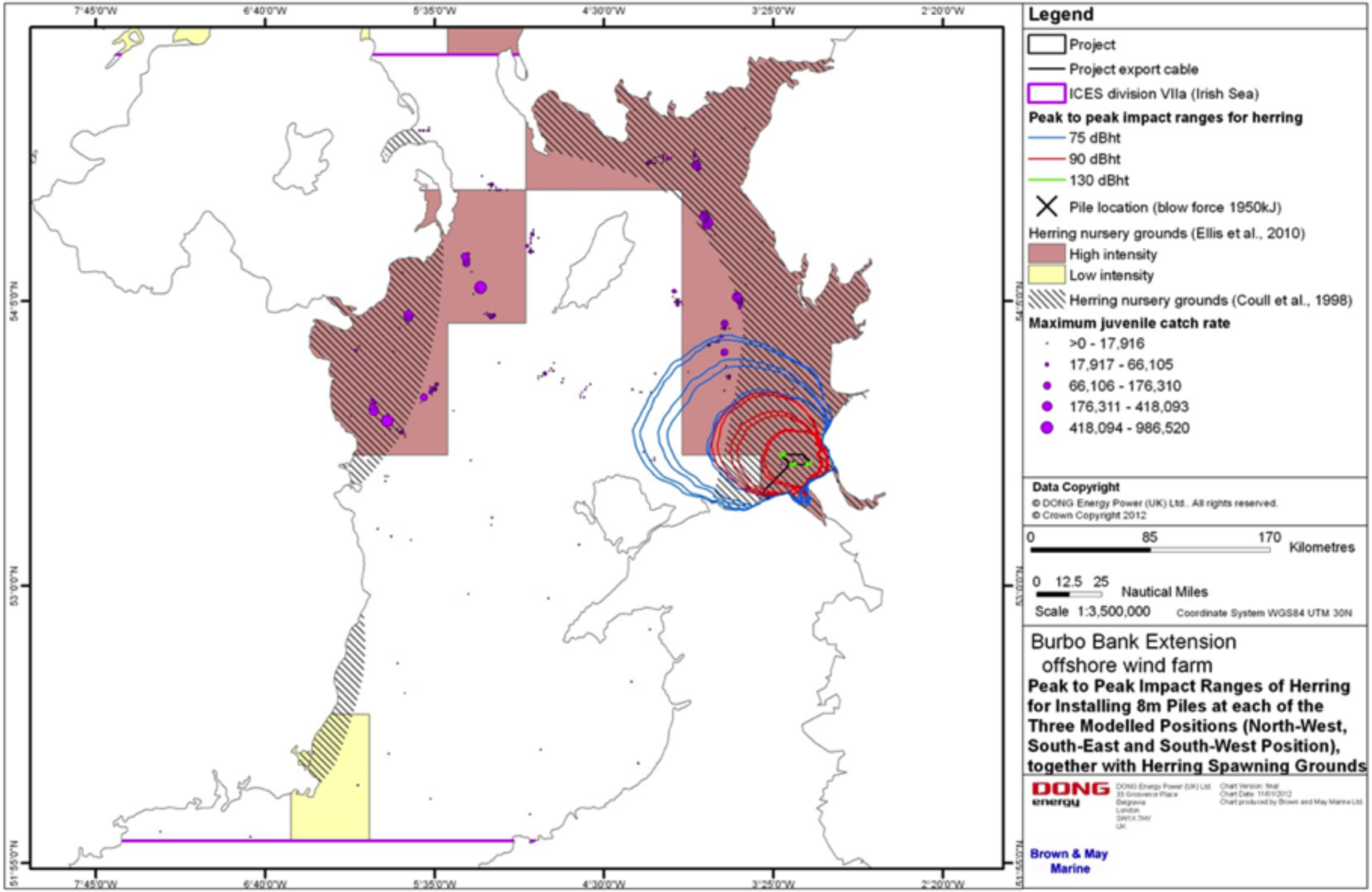

Figure 13.9: Estimated 75, 90 and 130 dB_{ht} (Clupea harengus) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at each of the three modelled locations, together with herring nursery grounds as provided in Ellis et al. (2012)

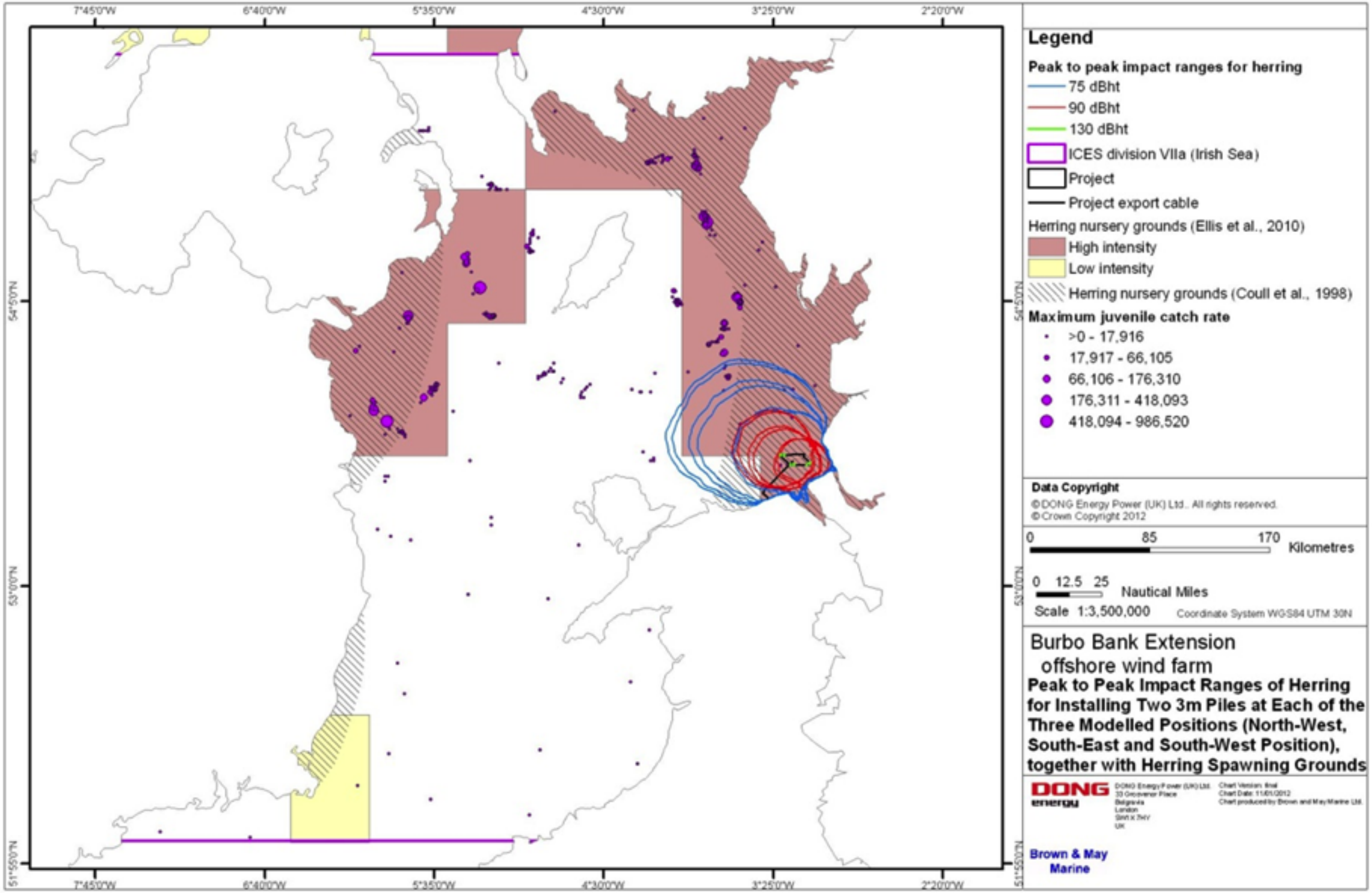

Figure 13.10: Estimated 75, 90 and 130 dB$_{ht}$ (Clupea harengus) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at each of the three modelled locations, together with herring nursery grounds as provided in Ellis et al. (2012)

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.

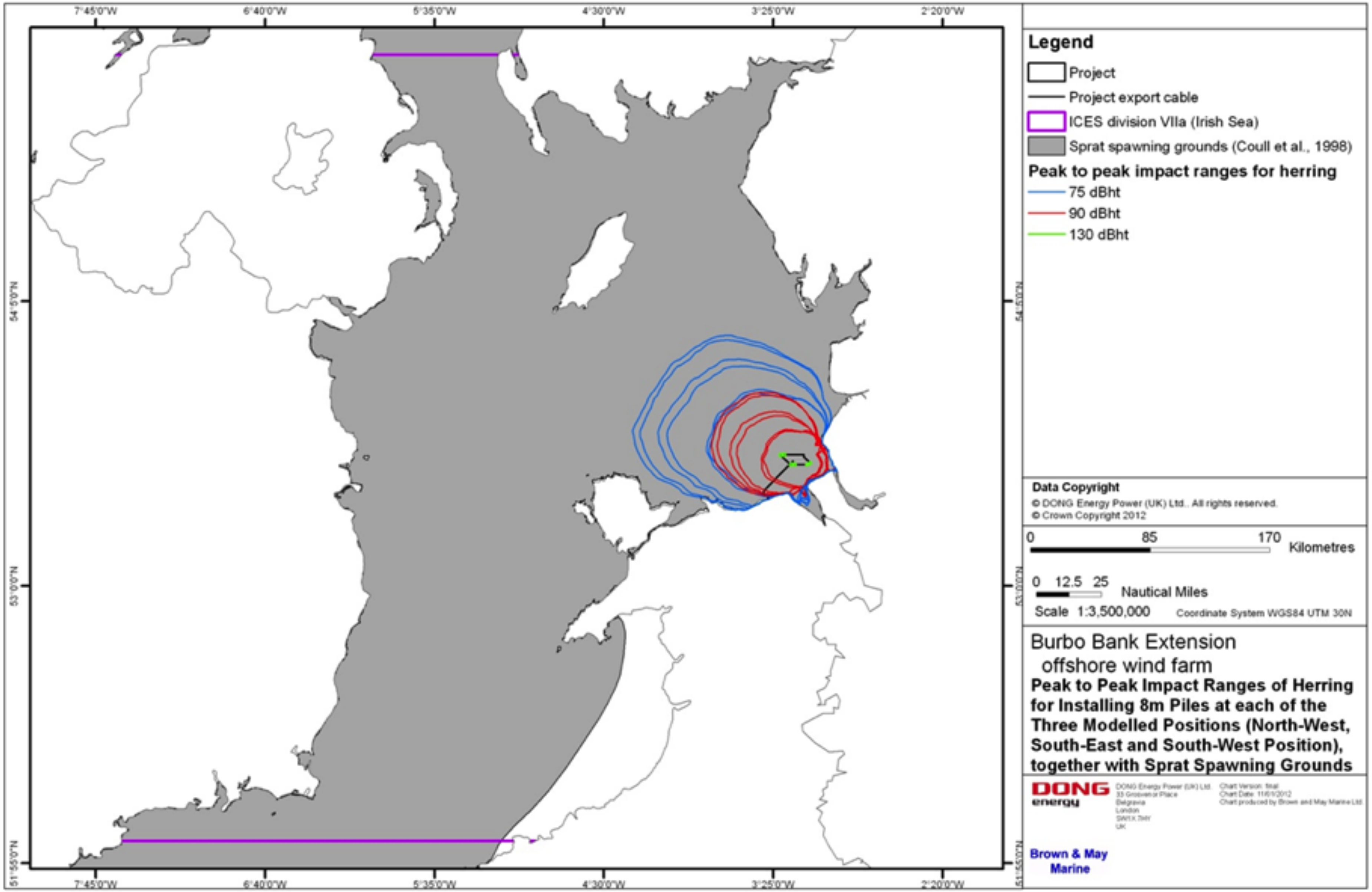

Figure 13.11: Estimated 75, 90 and 130 dB_{ht} (Clupea harengus) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at each of the three modelled locations together with sprat spawning grounds as provided in Coull et al. (1998)

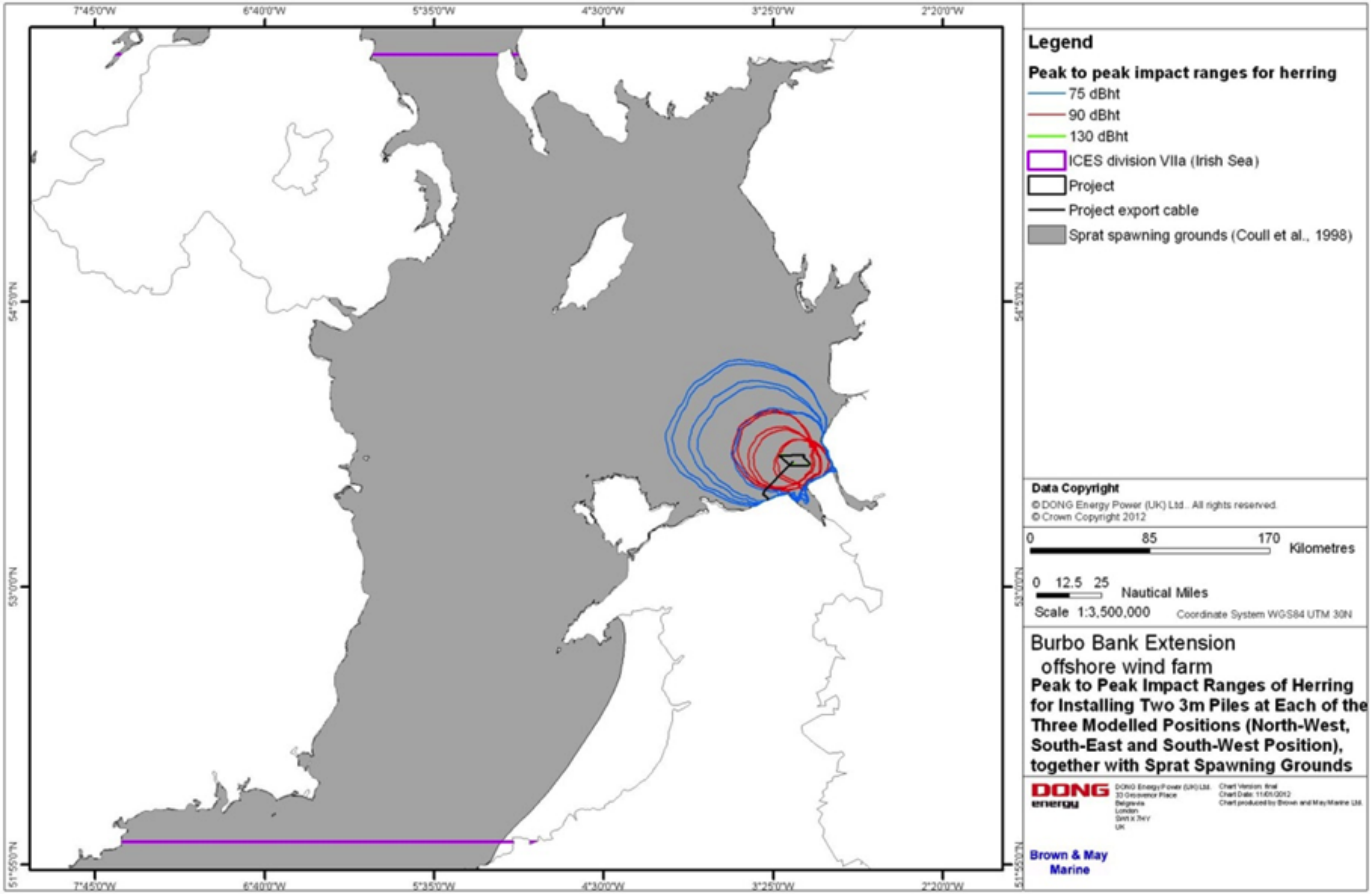

Figure 13.12: Estimated 75, 90 and 130 dB_{ht} (Clupea harengus) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at each of the three modelled locations together with sprat spawning grounds as provided in Coull et al. (1998)

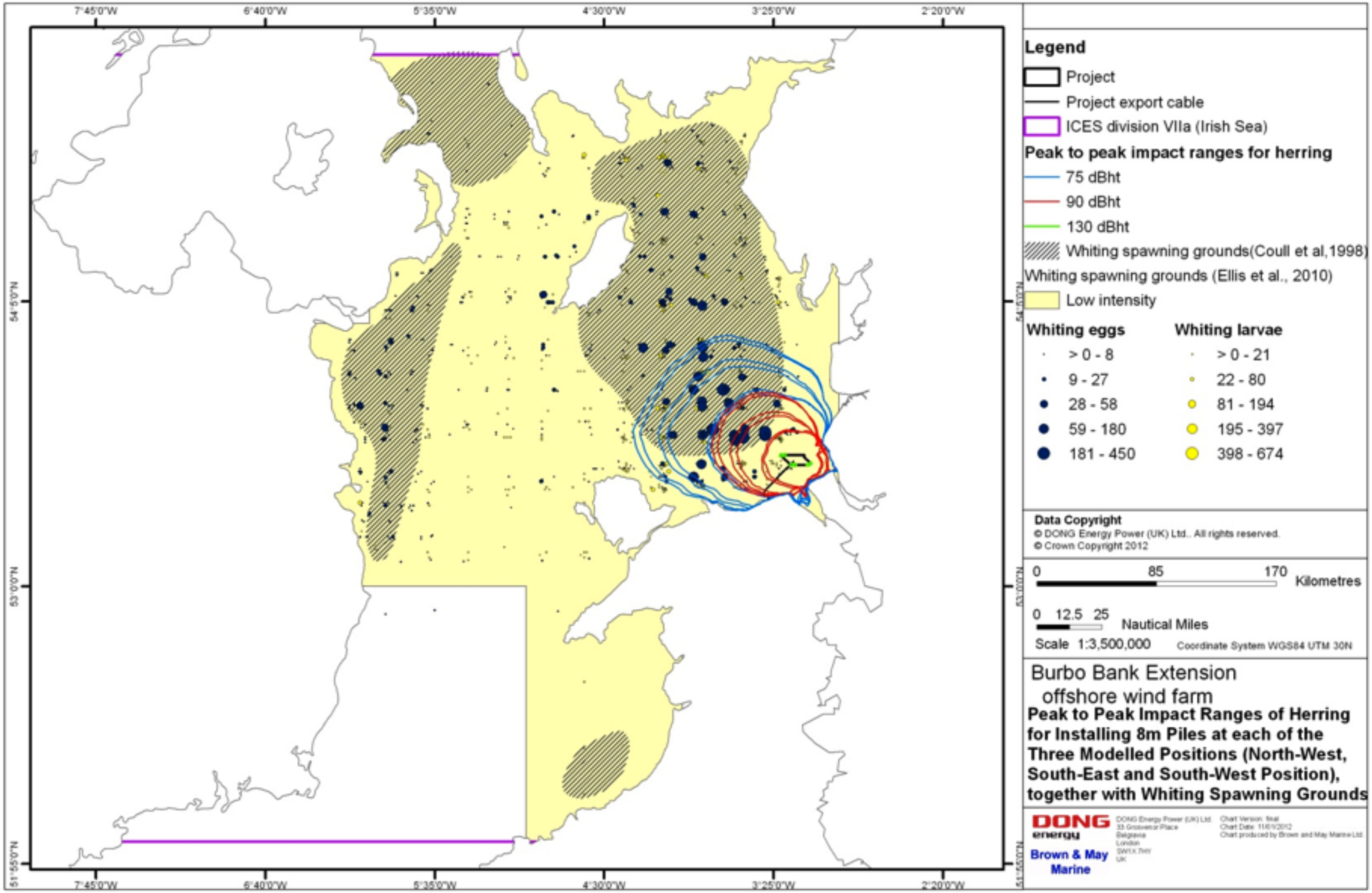

Figure 13.13: Estimated 75, 90 and 130 dB$_{ht}$ (Clupea harengus) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at each of the three modelled locations (together with whiting spawning grounds as provided in Ellis et al. (2012)

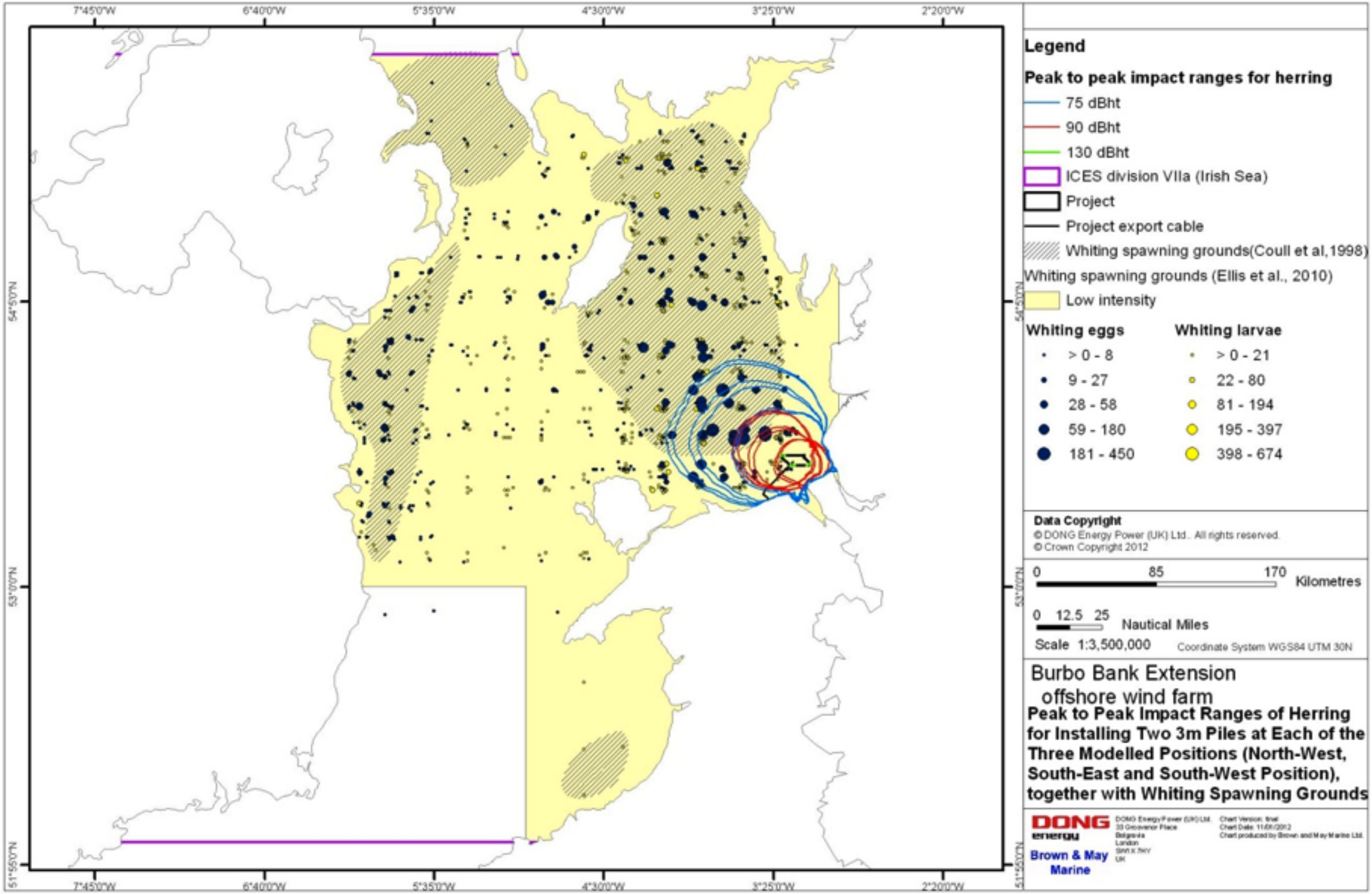

Figure 13.14: Estimated 75, 90 and 130 dB$_{ht}$ (Clupea harengus) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at each of the three modelled locations (together with whiting spawning grounds as provided in Ellis et al. (2012)

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.

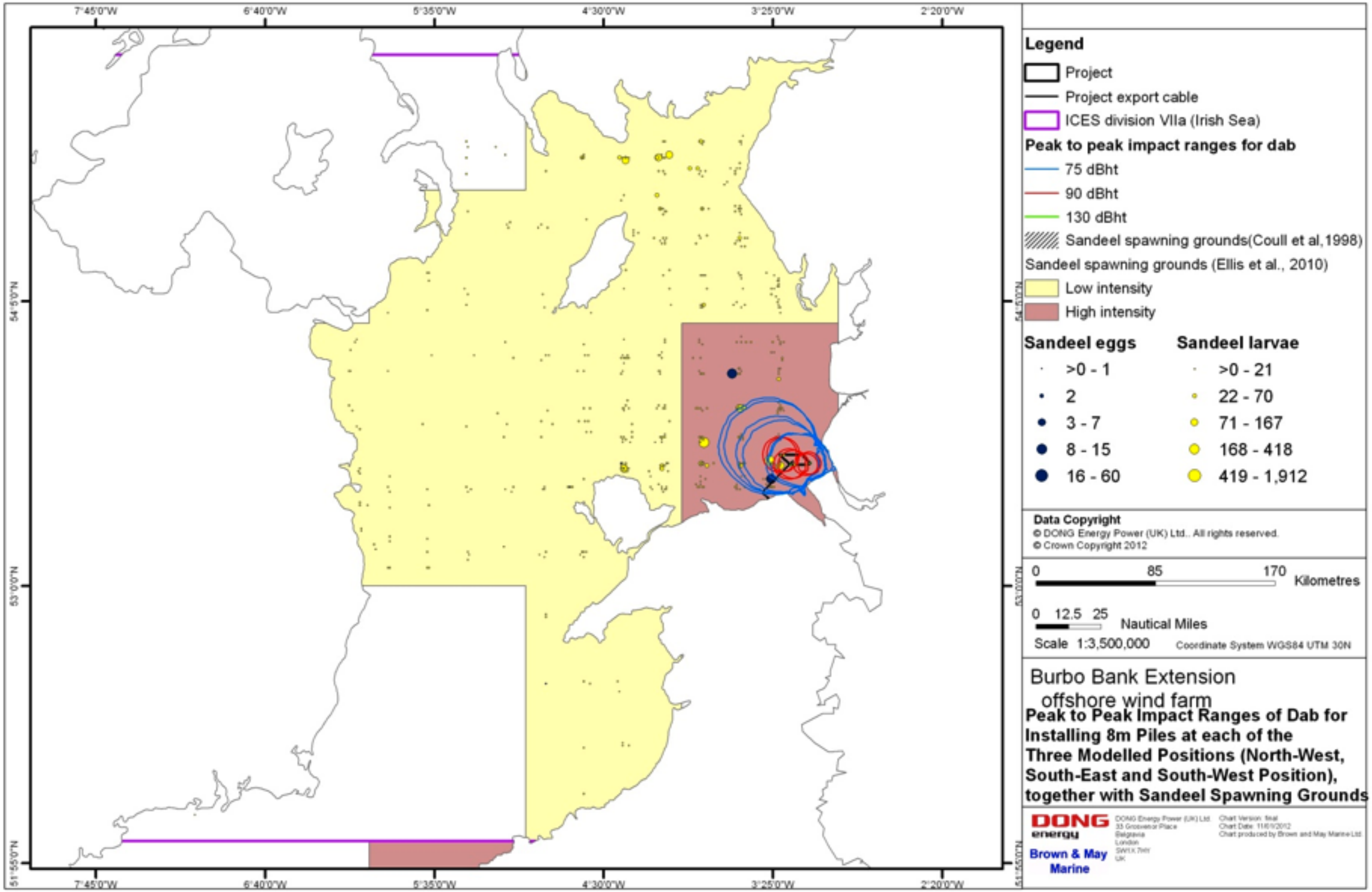

Figure 13.15: Estimated 75, 90 and 130 dB$_{ht}$ (Limanda limanda) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at each of the three modelled locations together with sandeel spawning grounds as provided in Ellis et al. (2012)

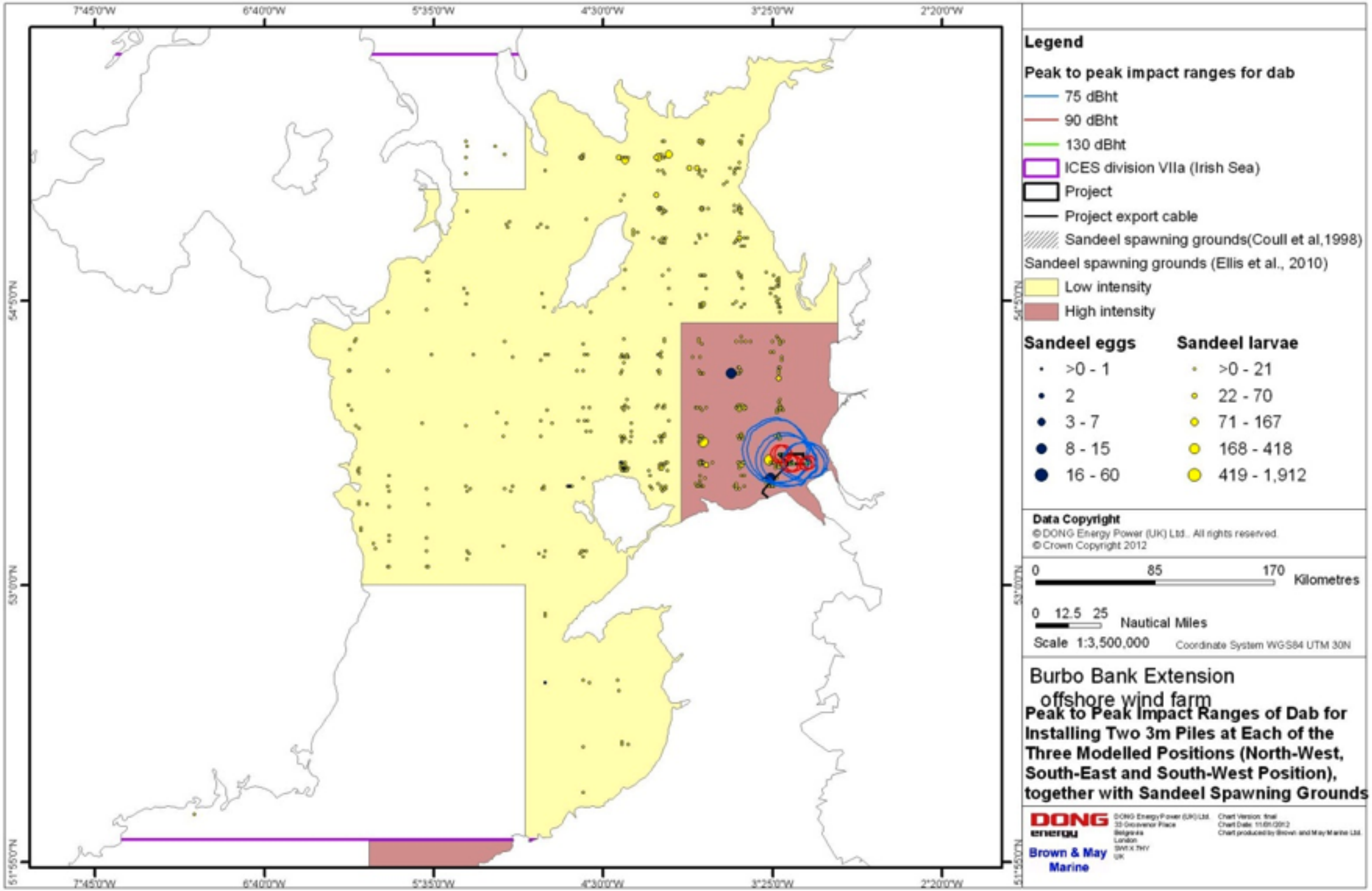

Figure 13.16: Estimated 75, 90 and 130 dB_{ht} (Limanda limanda) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at each of the three modelled locations together with sandeel spawning grounds as provided in Ellis et al. (2012)

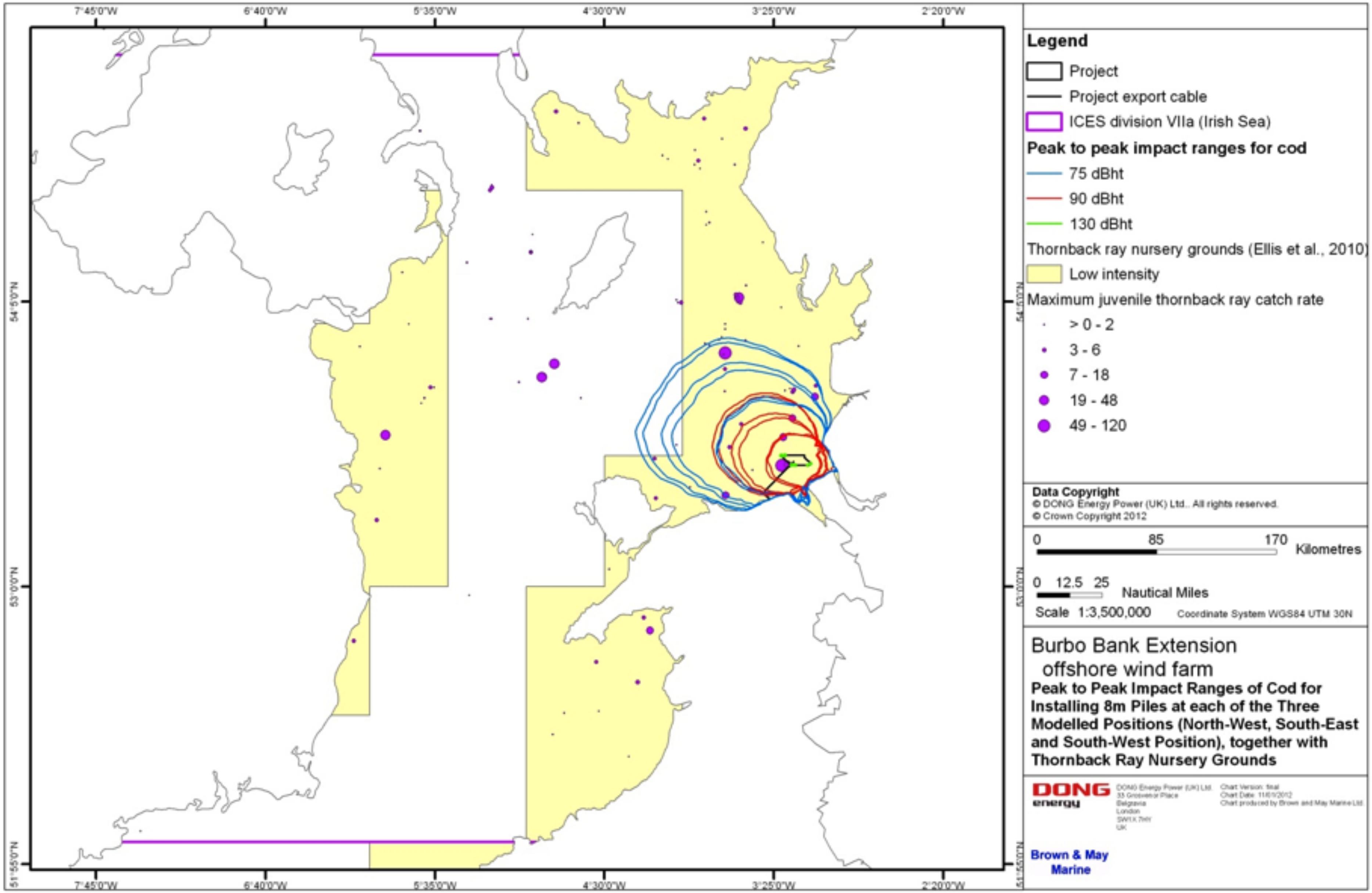

Figure 13.17: Estimated 75, 90 and 130 dB$_{ht}$ (Gadus morhua) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at each of the three modelled locations together with thornback ray nursery grounds as provided in Ellis et al., (2012)

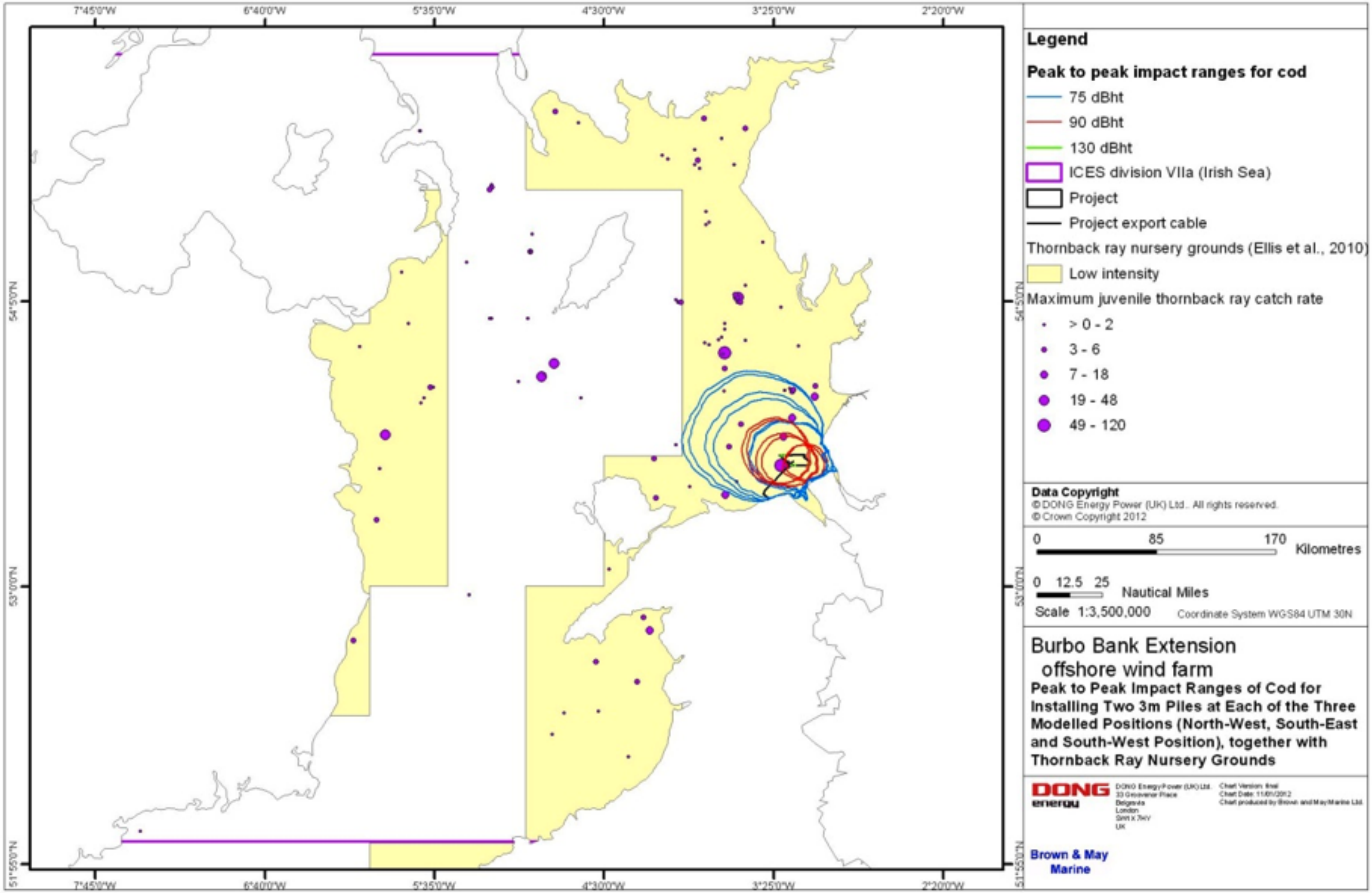

Figure 13.18: Estimated 75, 90 and 130 dB$_{ht}$ (Gadus morhua) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at each of the three modelled locations together with thornback ray nursery grounds as provided in Ellis et al., (2012)

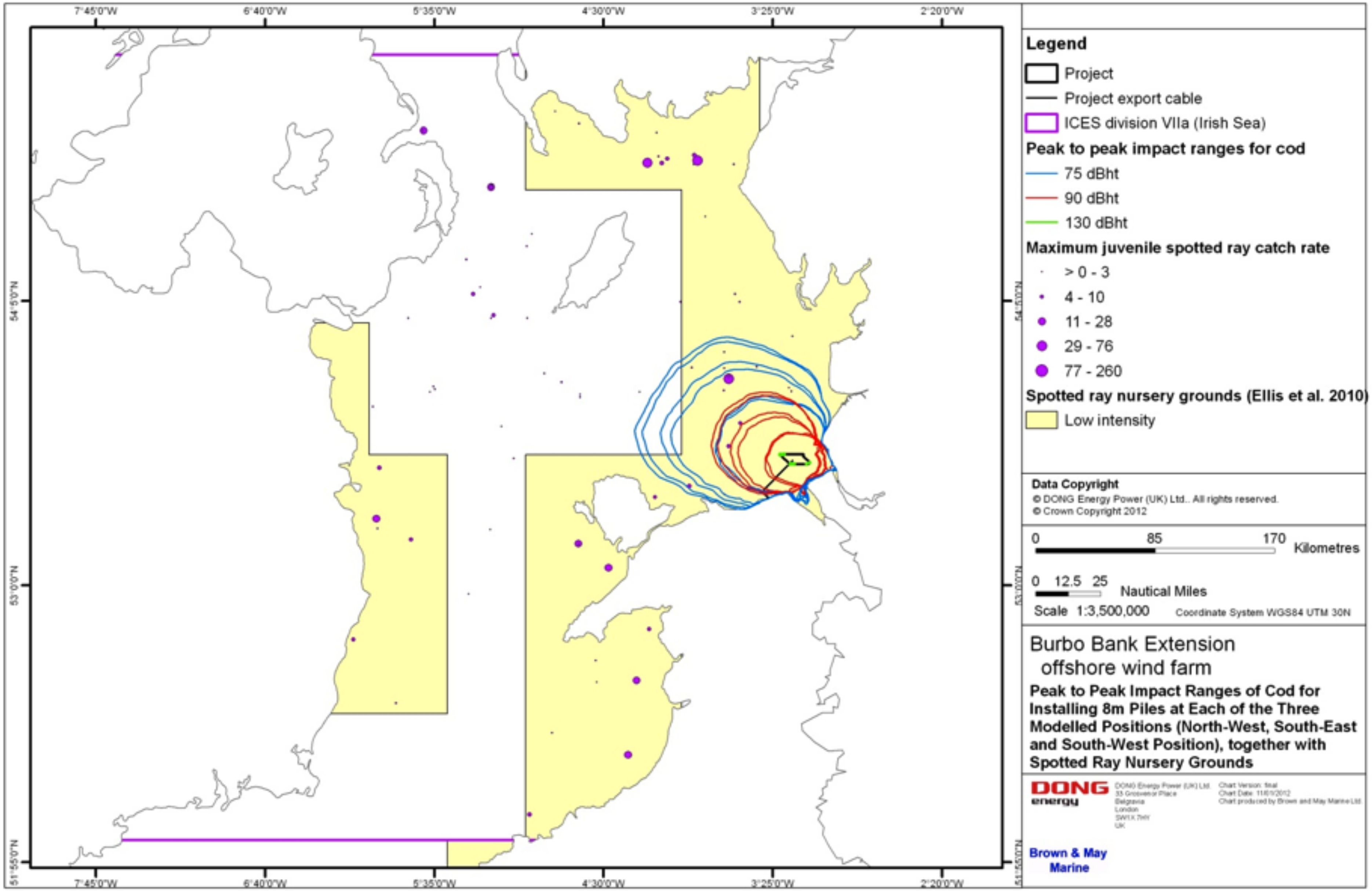

Figure 13.19: Estimated 75, 90 and 130 dB_{ht} (Gadus morhua) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at each of the three modelled locations together with spotted ray nursery grounds as provided in Ellis et al., (2012)

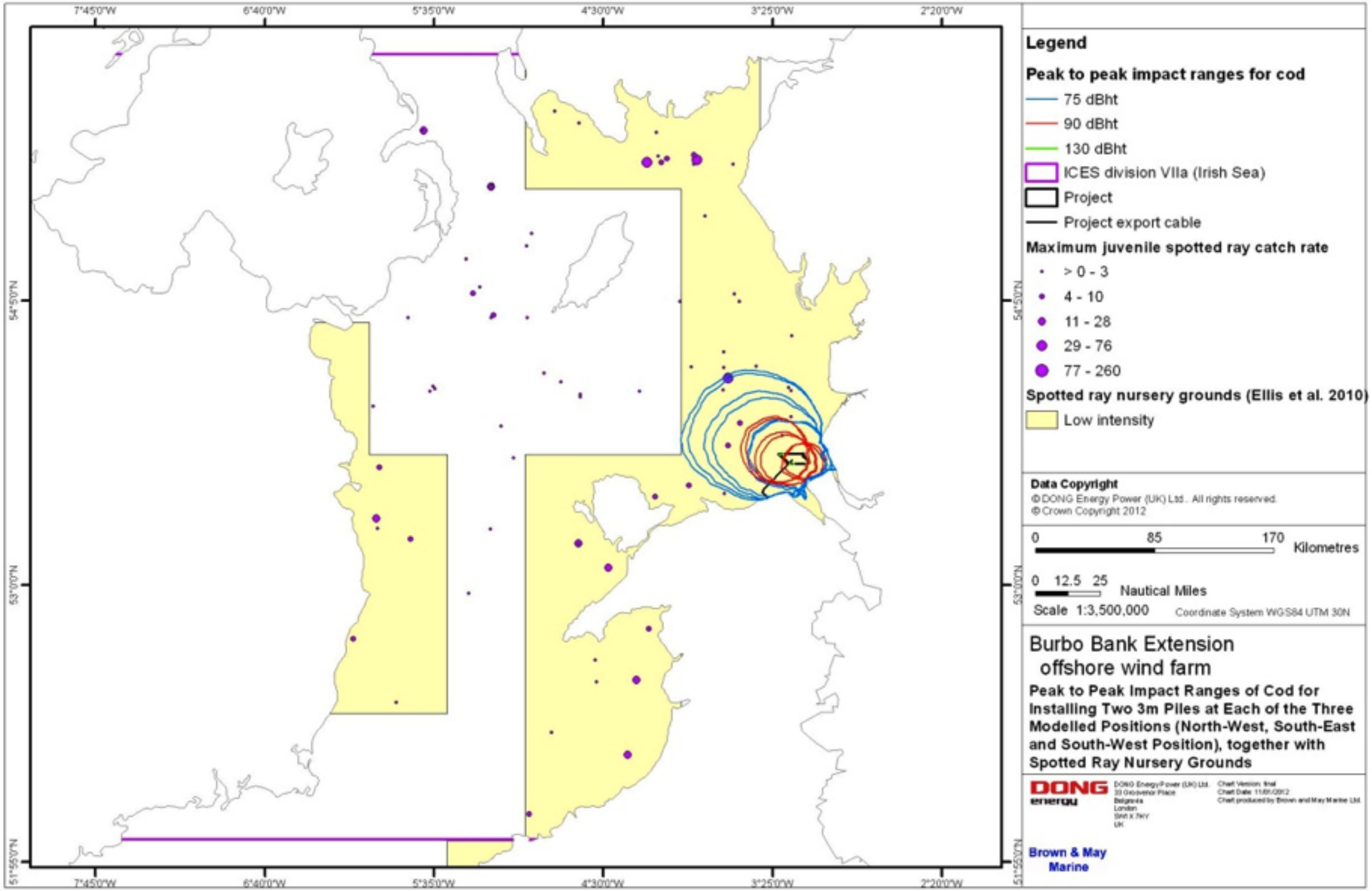

Figure 13.20: Estimated 75, 90 and 130 dB_{ht} (Gadus morhua) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at each of the three modelled locations together with spotted ray nursery grounds as provided in Ellis et al., (2012)

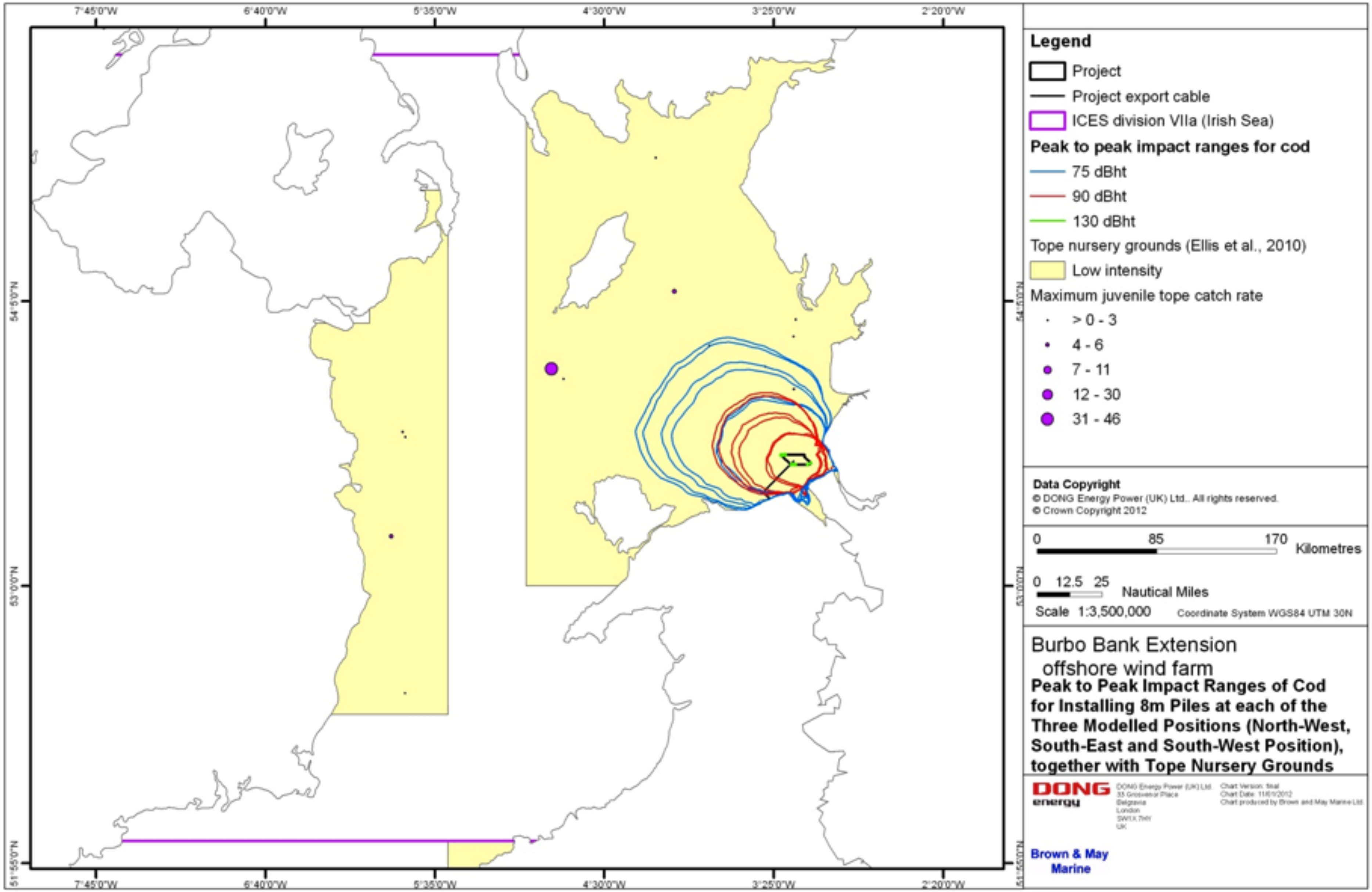

Figure 13.21: Estimated 75, 90 and 130 dB$_{ht}$ (Gadus morhua) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at the three modelled locations together with tope shark nursery grounds as provided in Ellis et al., (2012)

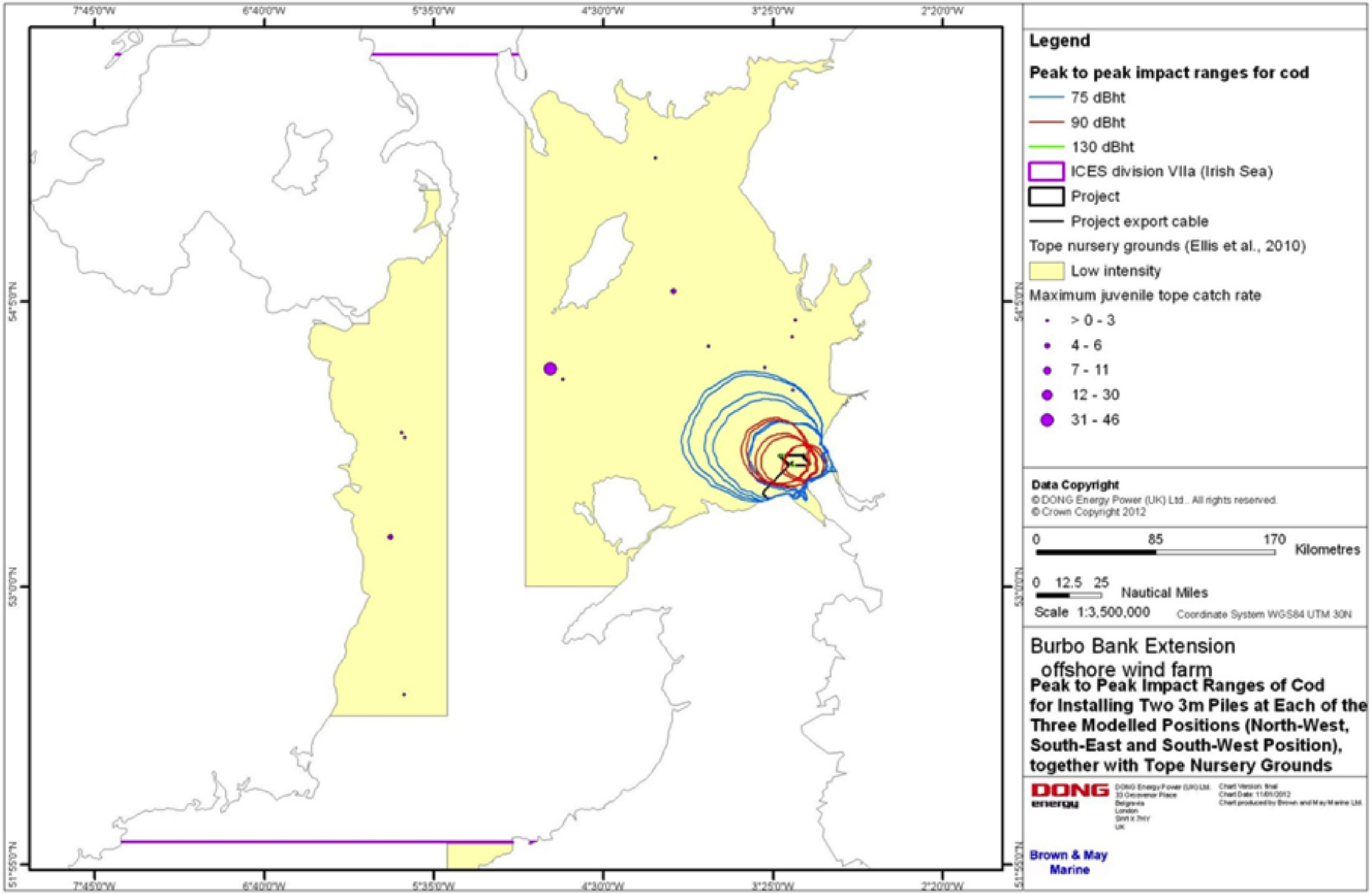

Figure 13.22: Estimated 75, 90 and 130 dB_{ht} (Gadus morhua) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at the three modelled locations together with tope shark nursery grounds as provided in Ellis et al., (2012)

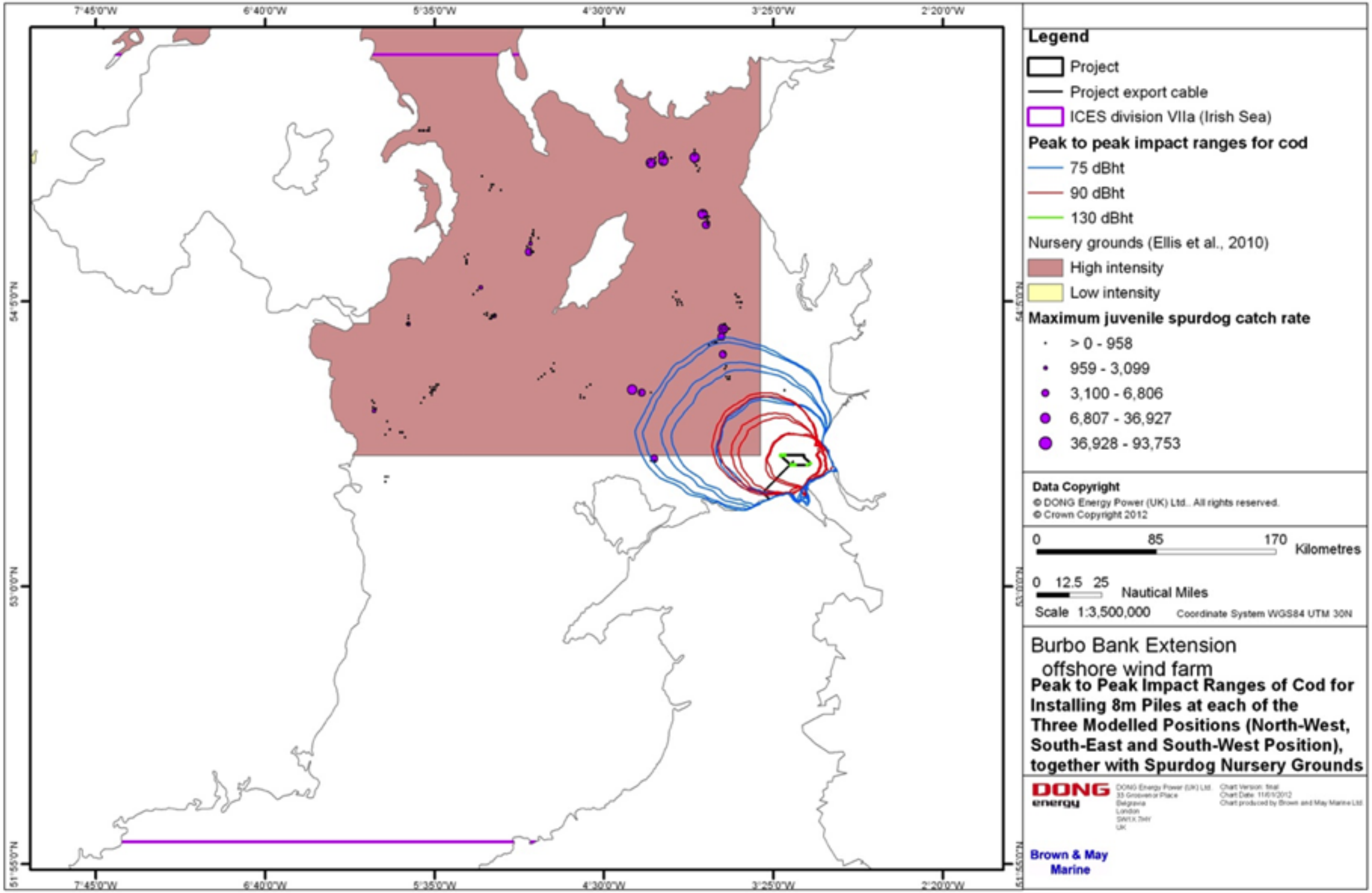

Figure 13.23: Estimated 75, 90 and 130 dB$_{ht}$ (Gadus morhua) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, the three modelled locations together with spurdog nursery grounds as provided in Ellis et al., (2012)

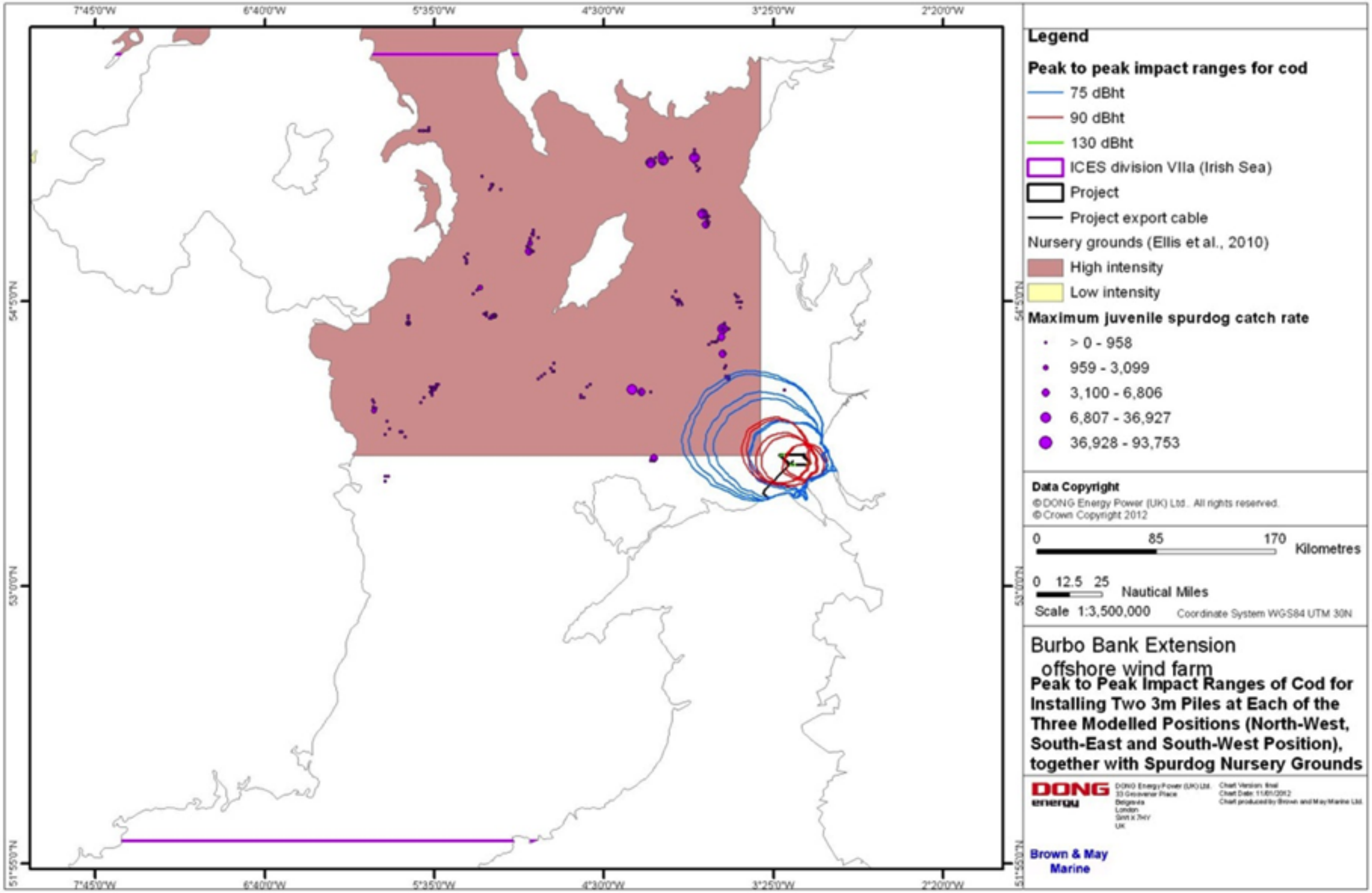

Figure 13.24: Estimated 75, 90 and 130 dB$_{ht}$ (Gadus morhua) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, the three modelled locations together with spurdog nursery grounds as provided in Ellis et al., (2012)

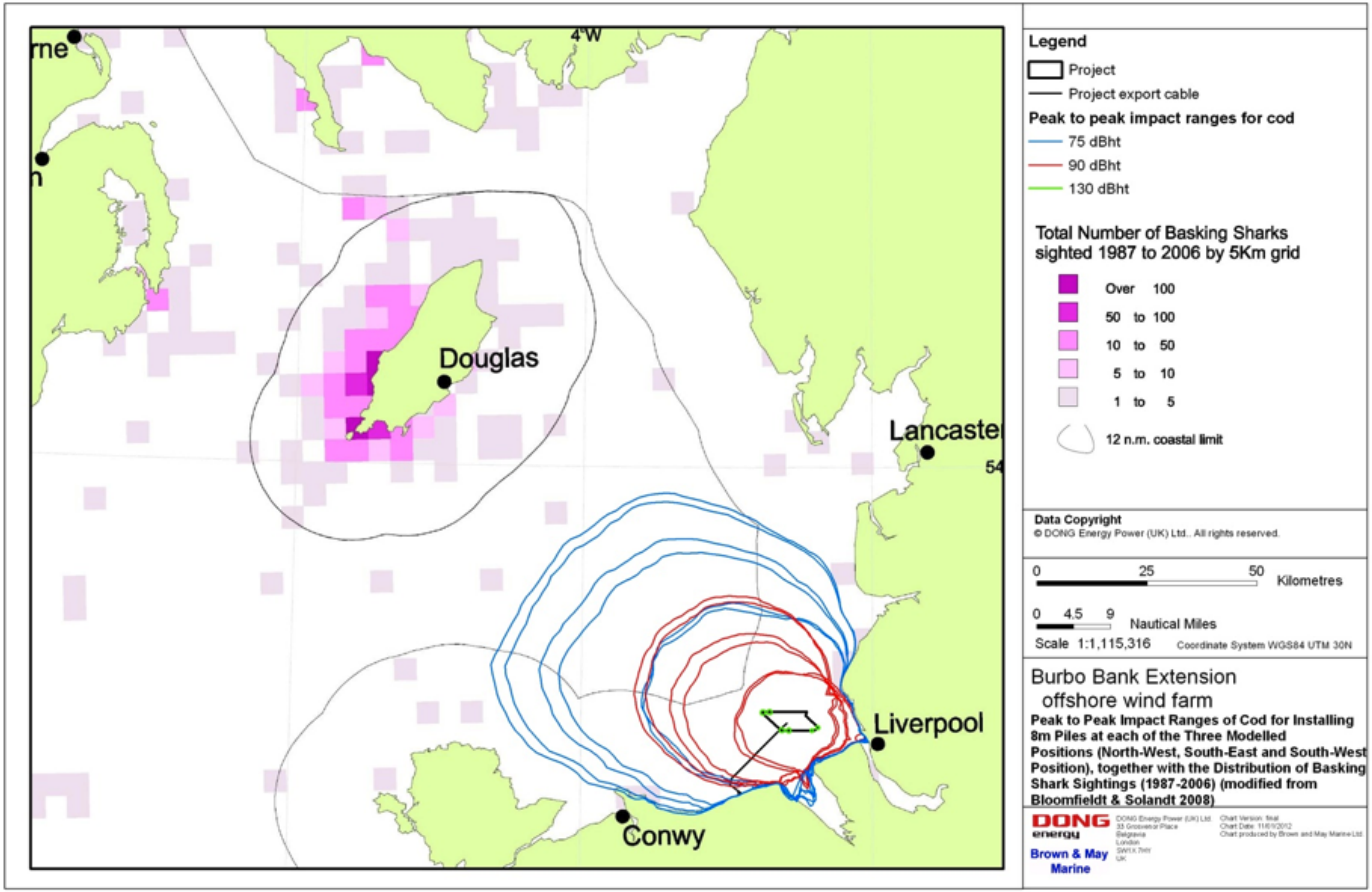

Figure 13.25: Estimated 75, 90 and 130 dB_{ht} (Gadus morhua) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, the three modelled locations together with the number of basking shark sightings (by 5 km² cell) from Irish Sea/ Isle of Man waters (modified from Bloomfield & Solandt, 2008)

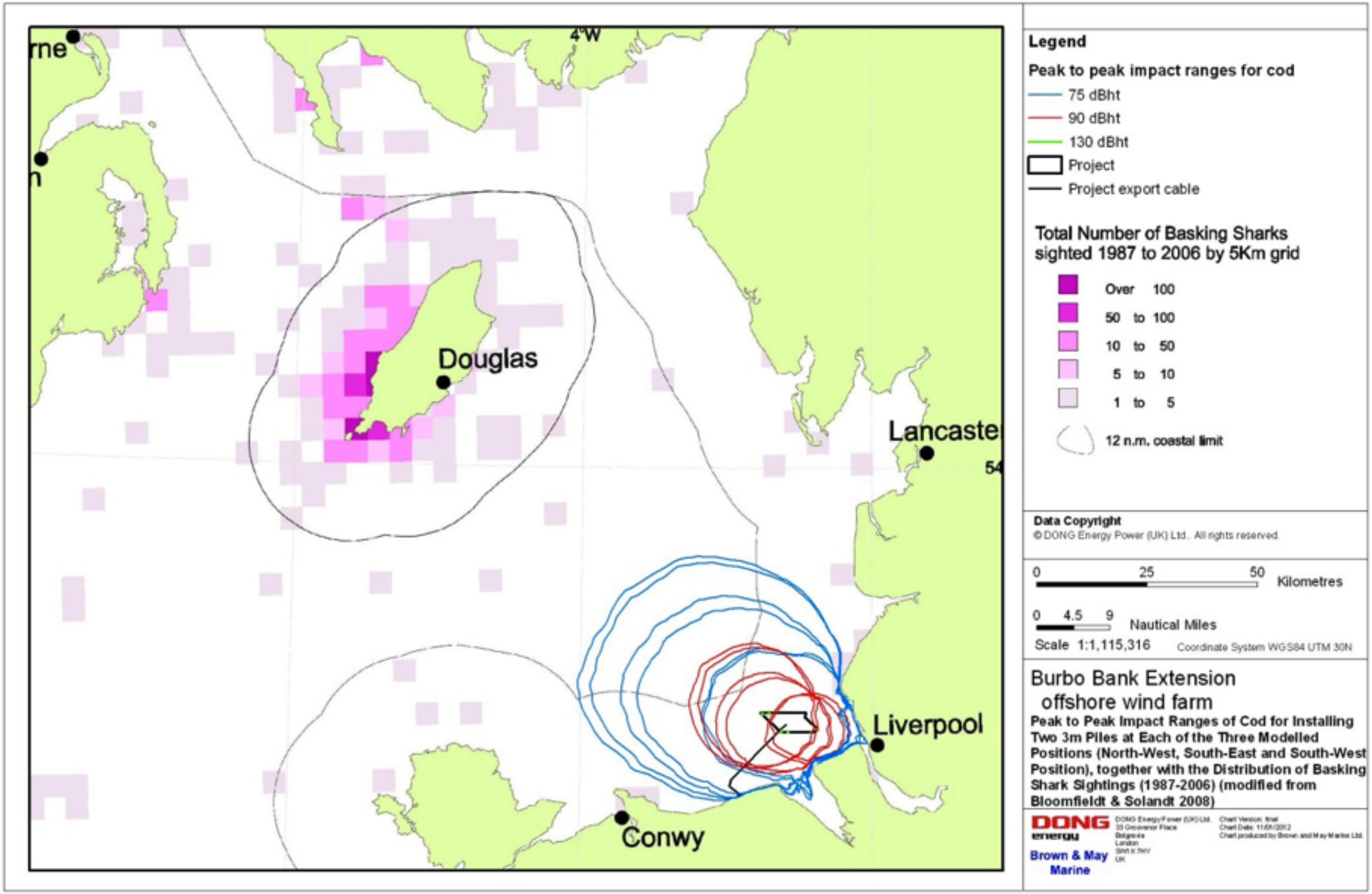

Figure 13.26: Estimated 75, 90 and 130 dB$_{ht}$ (Gadus morhua) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, the three modelled locations together with the number of basking shark sightings (by 5 km^2 cell) from Irish Sea/ Isle of Man waters (modified from Bloomfield &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

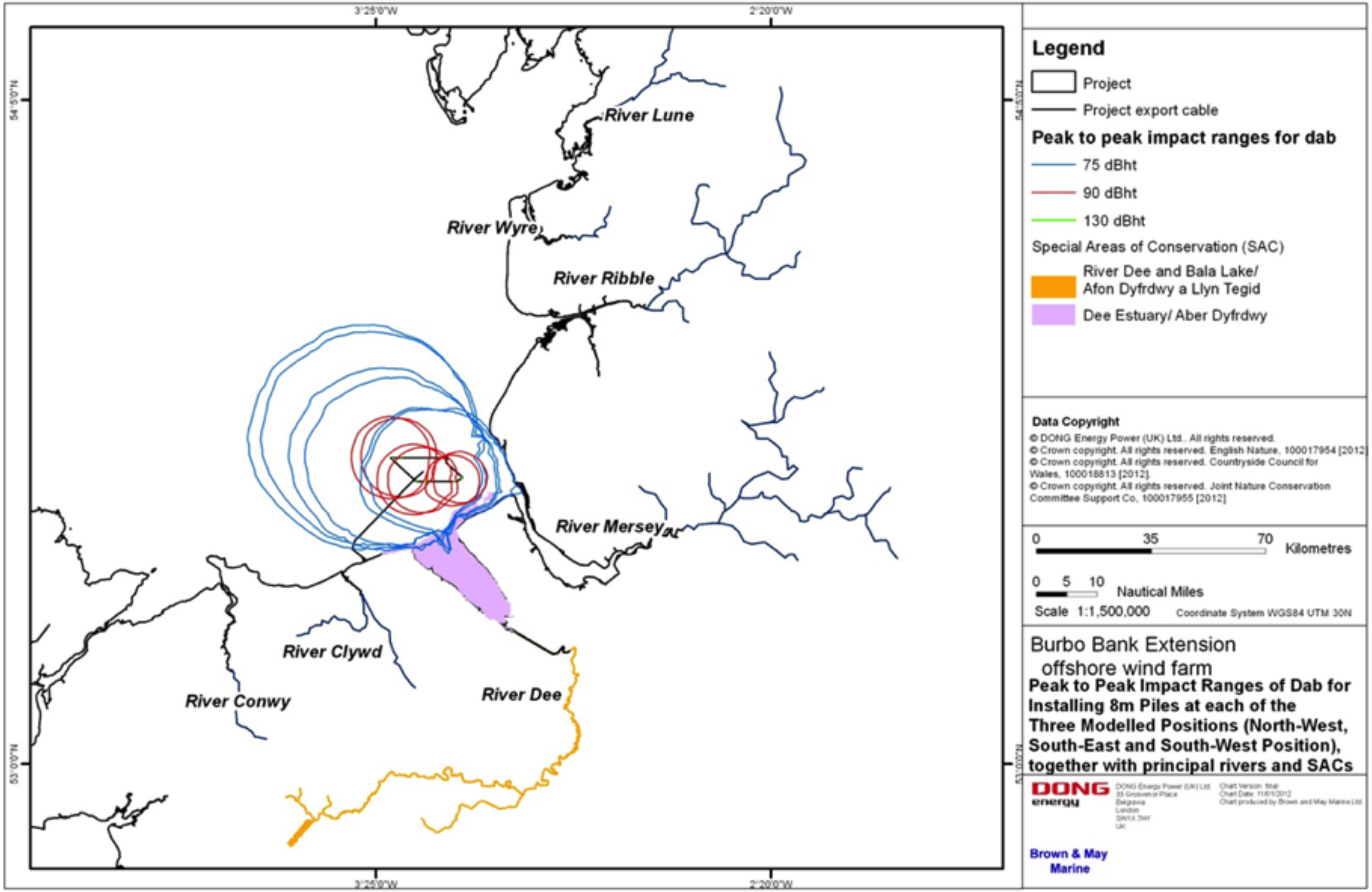

Figure 13.27: Estimated 75, 90 and 130 dB$_{ht}$ (Limanda limanda) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at the three modelled locations ,together with principal rivers and Special Areas of Conservation (SACs), where river and sea lamprey are qualifying features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

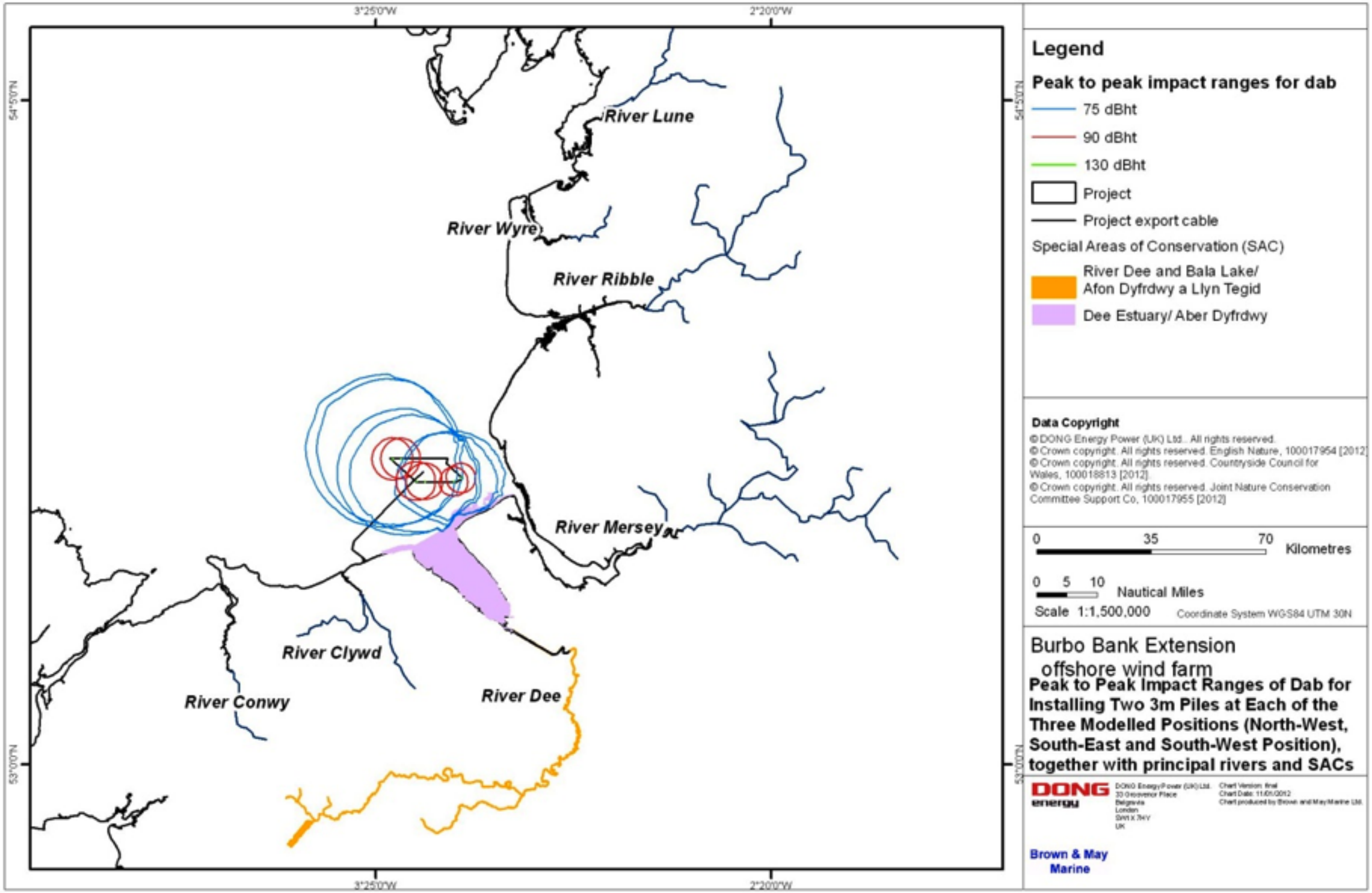

Figure 13.28: Estimated 75, 90 and 130 dB$_{ht}$ (Limanda limanda) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at the three modelled locations ,together with principal rivers and Special Areas of Conservation (SACs), where river and sea lamprey are qualifying features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

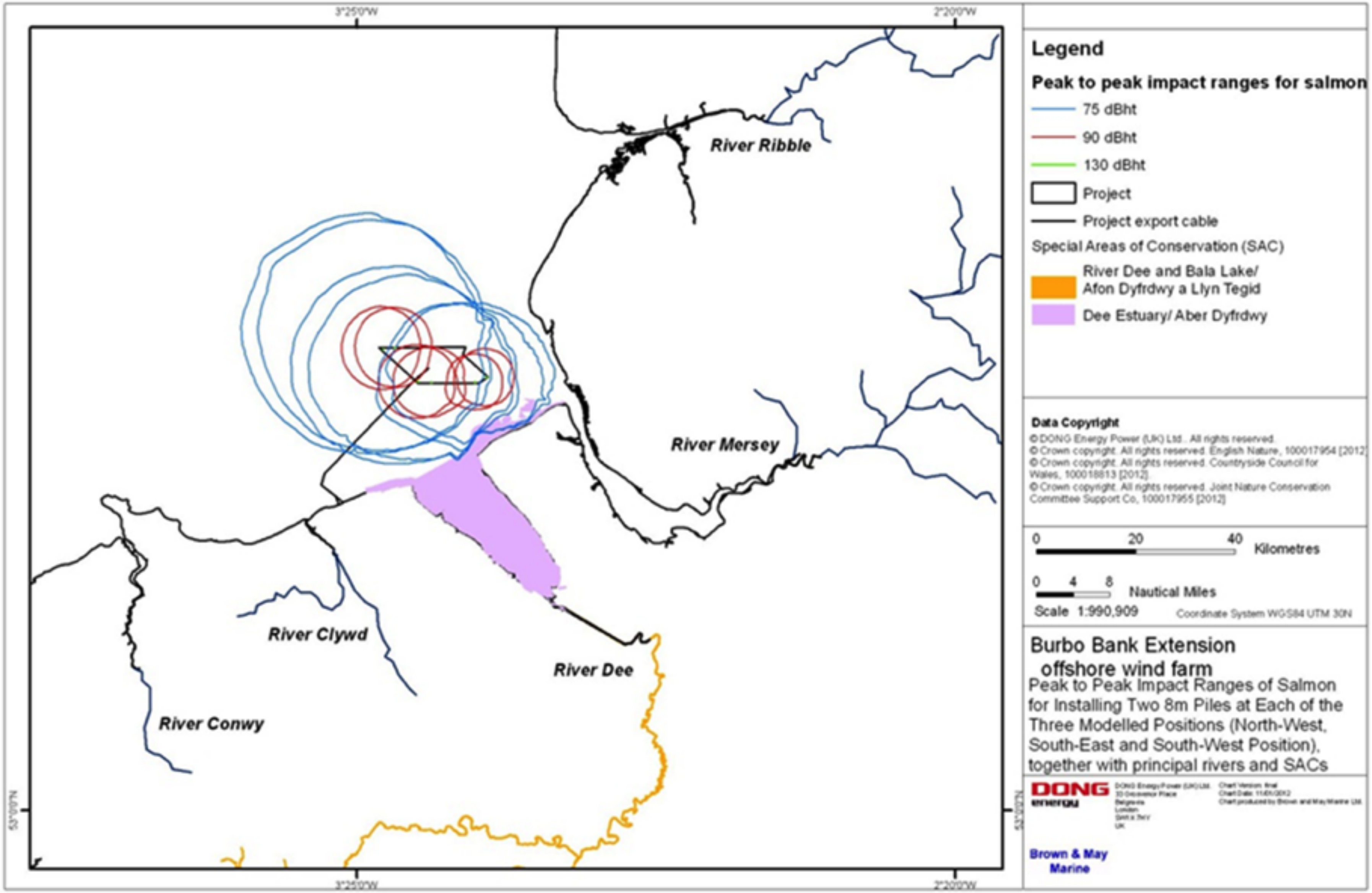

Figure 13.29: Estimated 75, 90 and 130 dB_{ht} (Salmo salar) peak to peak impact ranges modelled for installing 8 m piles, 1.5 km apart, at the three modelled locations together with principal rivers and Special Areas of Conservation (SACs), where salmon are qualifying features for the site selection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

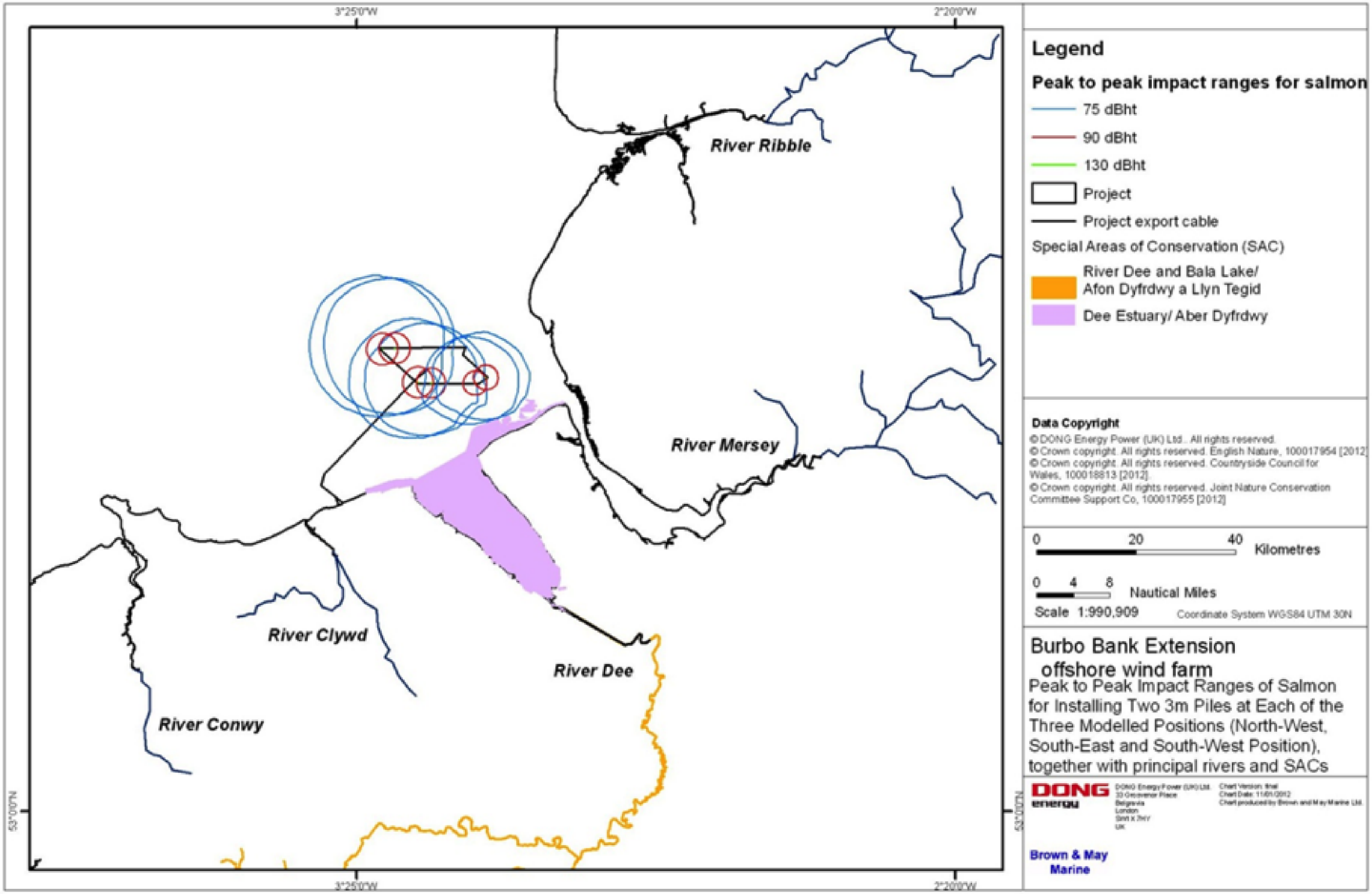

Figure 13.30: Estimated 75, 90 and 130 dB$_{ht}$ (Salmo salar) peak to peak impact ranges modelled for installing 3 m piles, 1.5 km apart, at the three modelled locations together with principal rivers and Special Areas of Conservation (SACs), where salmon are qualifying features for the site selection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

<u>Feeding</u>

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.

European Eel

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'

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