



Rampion Offshore Wind Farm



ES Section 8 – Fish and Shellfish Ecology

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8 FISH AND SHELLFISH ECOLOGY

8.1 Introduction

- 8.1.1 This section of the Environmental Statement (ES) presents an assessment of the potential impacts on fish and shellfish that might arise from construction, operation and decommissioning of the proposed Rampion Offshore Wind Farm (the Project). The assessment has been made using data gathered from desk-based assessment, consultations and site-specific surveys.
- 8.1.2 This section addresses the following topics:
- assessment methodology;
 - an overview of the baseline;
 - an account of potential impacts on fish and shellfish, together with discussion of appropriate mitigation, and
 - a summary of residual impacts in tabular form.
- 8.1.3 This assessment covers the ecological aspects of all fish and shellfish species in the development area. Aspects relating to commercial fisheries are covered in Section 18 - Commercial Fisheries.

8.2 Legislation and Policy Context

National Policy Statements

- 8.2.1 National Policy Statements (NPS) are the principal decision making documents for Nationally Significant Infrastructure Projects (NSIP). The following paragraphs provide detail from sections of the NPSs considered relevant to the assessment of impacts on fish and shellfish as a result of the Project.
- 8.2.2 Section 5.3 of EN-1 sets out policy for the Secretary of State in relation to generic biodiversity impacts. Paragraphs 2.6.58 to 2.6.71 of EN-3 set out offshore wind-specific biodiversity policy. In addition, there are specific considerations that apply to the effect of offshore wind energy infrastructure proposals on fish as set out below.
- 8.2.3 Paragraph 2.6.73 of EN-3 states that:
- 8.2.4 *“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.”*

8.2.5 Paragraph 2.6.74 states that:

8.2.6 “The applicant should identify fish species that are the most likely receptors of impacts with respect to:

- *feeding areas;*
- *spawning grounds;*
- *nursery grounds; and*
- *migration routes.”*

8.2.7 Paragraphs 2.6.75, 2.6.76 and 2.6.77 also discuss mitigation measures for reducing electromagnetic field (EMF) effects as well as for reducing the overall impacts of construction on fish communities.

Habitats Directive

8.2.8 The EC Directive 92/43/EEC on Conservation of Natural Habitats and of Wild Fauna and Flora, 1992 (the ‘Habitats Directive’) is discussed in Section 9 (Nature Conservation). It is an offence to deliberately kill, capture or disturb European protected species, and to damage or destroy their breeding sites or resting places. Marine fish species listed on Annex I of the Habitats Directive include sea lamprey (*Petromyzon marinus*), river lamprey (*Lampetra planeri*), allis shad (*Alosa alosa*), twaite shad (*A. fallax*), and Atlantic salmon (*Salmo salar*).

Wildlife and Countryside Act 1981

8.2.9 The Wildlife and Countryside Act 1981 protects several fish species found in the marine environment. Under the Variation of Schedule 5 (England) Order 2008, both short-snouted (*Hippocampus hippocampus*) and spiny/long-snouted (*H. guttulatus*) seahorses and their habitat are fully protected out to the 12 nautical mile limit. This protection means that it is an offence to intentionally or recklessly harm or disturb any seahorse. Protection includes a prohibition of killing, injuring or taking, damage or destruction of their places of shelter, or disturbance while such animals are occupying places of shelter. Additionally, shad are protected from intentional killing, injuring or taking (allis shad) or damage to, destruction of, obstruction of access to any structure or place used for shelter/protection (both allis shad and twaite shad). Basking shark (*Cetorhinus maximus*) and angel shark (*Squatina squatina*) are also protected.

Marine and Coastal Access Act 2009

8.2.10 The Marine and Coastal Act 2009 is discussed in Section 9 - Nature Conservation. A network of recommended Marine Conservation Zones (rMCZs) has been identified based on the principles outlined in the ecological network guidance (ENG) by a Regional Stakeholder Group (RSG). Features proposed to be designated for protection by MCZs are all listed in the ENG and comprise ‘broad-

scale habitats', which comprise groups of species together into types of marine habitat; and 'Features of Conservation Interest (FOCI)', which comprise specific species and habitats for which more detailed data are available. Features not listed in the ENG may also be recommended for designation if there is reasonable scientific evidence available to support this. Fish FOCI include the undulate ray *Raja undulata* and shellfish species include the native oyster *Ostrea edulis*, while non-ENG fish that have been proposed for rMCZs include the black bream *Spondyliosoma cantharus*.

Biodiversity Action Plans

- 8.2.11 Biodiversity Action Plans (BAPs) are discussed in Section 9 - Nature Conservation. Marine fish species on the Sussex BAP comprise the undulate ray, herring (*Clupea harengus*), plaice (*Pleuronectes platessa*), horse mackerel (*Trachurus trachurus*), mackerel (*Scomber scombrus*), Dover sole (*Solea solea*) and both species of seahorse. Anadromous fish species listed comprise twaite and allis shad, European eel (*Anguilla anguilla*), smelt (*Osmerus eperlanus*), Atlantic salmon and sea trout (*Salmo trutta*). The native oyster is also on the Sussex BAP.

Eel recovery

- 8.2.12 Due to major declines of eels in recent years European Council (EC) Regulation No. 1100/2007 now requires Member States to establish management plans at a river basin scale, with the objective of restoring populations through various measures including habitat improvement. Possible impacts to freshwater fish, including eels, are discussed in Section 24 (Ecology and Nature Conservation), and are not discussed further here.

Scoping and consultation

- 8.2.13 Initial consultation on the Project was carried out via the Rampion Offshore Wind Farm Scoping Document (E.ON/RSK, September 2010), as well as further consultation exercises in 2011. Responses received are presented in the Infrastructure Planning Commission (IPC) Scoping Opinion report (IPC, October 2010).
- 8.2.14 The information, advice and comments received during the scoping process with regard to fish and shellfish issues is summarised in Table 8.1 together with a list of the locations in the ES where the comments are addressed.

Table 8-1: Scoping and consultation responses

Date	Consultee	Summary of issues	Sections where addressed
8/10/10	Environment Agency	Recommended that potential impacts on migratory fish (e.g. sea trout, salmon and eels) from electromagnetic fields are considered. Potential impacts from construction operations such as piling noise and loss of habitat and disturbance to prey should also be considered. Suitable mitigation should be demonstrated.	Salmonids and eels are considered in the electromagnetic field (EMF) impact assessment.
11/10/10	Natural England	Sussex Sea Fisheries District Committee (SSFC) (and partners) should be consulted for information.	E.ON & RSK met with SSFC in February 2011.
		Biodiversity Action Plan fish species should be considered.	BAP species are considered in the baseline section.
		Species of local importance, such as native oyster, bass and mackerel should be mentioned.	These species are considered in the baseline section.
		The most accurate and up to-date data on the range of black bream, should be obtained from the Sussex Inshore Fisheries and Conservation Association (IFCA).	Sussex IFCA were consulted. A desk-top review of black bream nesting in the area was commissioned by E.ON (see Appendix 8.1).
12/10/10	Marine Management Organisation (MMO)	Few details of literature sources for fish data are presented; e.g. Cefas (Centre for Environment, Fisheries and Aquaculture Science) 2006 report by Parker-Humphreys may be useful.	These and other key literature sources have been considered (Section 8.3.1.1).
		Black bream spawning areas should be investigated further.	E.ON consulted with MMO, Cefas and Sussex IFCA to agree a scope for black bream surveys. These will commence in April 2012.
		Some species may not be adequately sampled by standard survey methodologies.	A program of fisheries surveys using three different methodologies to sample a wide range of species was developed and agreed with MMO (Section 8.3.1.2).

- 8.2.15 The scope of the assessment was modified accordingly to take account of the above consultee responses and the opinions of the IPC, the findings of which were reported in the Draft ES and subject to stakeholder consultation.

Formal Pre-application Consultation

- 8.2.16 As detailed in Section 5 – EIA Methodology, an extensive programme of engagement has been undertaken with regard to the Project, details of which are provided in the Consultation Report for the Project (Document 5.1). This included publication of the Draft ES as part of the Section 42 and Section 48 consultation in June 2012.

- 8.2.17 Key consultees (i.e. Natural England; Marine Management Organisation; Sussex IFCA; Sussex Wildlife Trust) provided responses to the draft ES on fish and shellfish ecology. These responses, and the modifications subsequently made to the final ES, were as follows:

- The potential impacts of piling noise on the following specific fish and shellfish receptors was raised as a concern:
 - Generally, further information on the rationale for usage of biologically similar ‘surrogate’ species (which is necessary where no data on the hearing abilities of a specific species is available) in the noise modelling was requested. Requests were also made that the ES consider a much broader range of species. Specialist consultants Subacoustech, were commissioned to group a list of common local fish (and fishery) species into their most biologically similar surrogates, to broadly estimate noise impacts (e.g. dab was confirmed as a suitable surrogate for several other flatfish species). The rationale for allocating to local species to the appropriate surrogate is explained in Appendix 8.6.
 - Black bream, particularly in relation to nationally important populations present locally, and this species contributing to the Kingmere rMCZ and the proposed ‘recover’ status of this species at this site. Noise modelling by Subacoustech was commissioned to predict the responses of black bream to underwater noise, based on data from a similar, surrogate species (red bream *Pagrus major*), as data on the hearing abilities of black bream are not currently available. Detailed methodology and results are presented in Appendix 8.6.
 - Herring, particularly in relation to 1) the location of spawning areas of the important Downs stock in the eastern English Channel, and 2) their role as a prey species to breeding terns from Special Protection Areas (SPAs) in the region. In response, a range of additional data on herring spawning intensity in the eastern English Channel were collated and mapped against modelled noise impact scenarios.

- Seahorse: impacts to short-snouted seahorse (W&CA, MCZ FOCI and BAP species). The draft ES used bass as a surrogate species for seahorses, as the two have similar audiograms. However, in response to comments on the draft ES, further noise modelling was commissioned, using recent audiogram data from a closely related seahorse species (lined seahorse *Hippocampus erectus*), to better understand potential impacts. In addition, potential impacts to seahorses from direct physical injury (e.g. turbine or jack-up vessel footprint) was considered.
- Life history stages: Sussex IFCA requested further information on potential damage to e.g. larvae and juvenile fish from piling noise. In response, Subacoustech were commissioned to critically examine the literature for potential impacts to this group from piling noise.
- Cuttlefish: potential damage to or disturbance of cuttlefish was raised by Sussex Wildlife Trust. As for juvenile/larval fish, Subacoustech were commissioned to critically examine the literature for potential impacts to this group from piling noise.
- The results of these additional noise studies were then used to inform detailed consultation with the relevant stakeholders (Cefas, Natural England, Sussex IFCA and Sussex Wildlife Trust) and the possible need for mitigation such as seasonal piling restrictions.
- Sussex IFCA requested a more holistic approach to the baseline and impacts, with consideration of the numerous species present through their life cycles, and the distribution of these in the area throughout the year. In response, considerable further information was added on temporal and spatial distribution of different species and their sensitive life history stages.
- Stakeholders expressed concern regarding the current lack of scientific knowledge on the potential impacts of electromagnetic fields, particularly on elasmobranchs. In response, data from additional studies have been included as well as acknowledgement of uncertainty of potential impacts.
- Other changes, such as expansion or clarification of draft ES text; acknowledgement of survey limitations; or consideration of additional or new data, have also been noted and incorporated.

8.3 Assessment Methodology

Establishment of Baseline Environment

- 8.3.1 The baseline has been compiled from both desk-based studies and field surveys.

Desk-based review

8.3.2 The study area, part of the eastern English Channel, extends approximately from the eastern Isle of Wight to Eastbourne, and from the coast to the middle of the English Channel.

8.3.3 Information on fish and shellfish in the study area was collated from a number of sources, including (but not limited to) the following:

- Sussex Sea Fisheries Committee/Sussex Inshore Fisheries and Conservation Association (IFCA), various documents and website information, including summaries of the biology of local fish and shellfish species (Sussex IFCA, 2012);
- South Coast Regional Environmental Characterisation (James *et al.*, 2010), and Marine Aggregate Levy Sustainability Fund (MALSF) synthesis study in the central and eastern English Channel (James *et al.*, 2011)
- Ellis *et al.* (2012): Maps of fish spawning and nursery areas;
- Martin *et al.* (2010) and Ellis *et al.* (2004): Distribution of sharks & rays around the UK;
- Rogers *et al.* (1998): Distribution of young and small fish around SE England.
- Data specifically on black bream were collated from:
 - A desk-based study of black bream in the English Channel off the Sussex coast, commissioned by E.ON (Emu 2012, see Appendix 8.1);
 - GIS layers of recent records of black bream nests were obtained from the MALSF synthesis study (James *et al.*, 2011);
 - Side-scan sonar mosaics of the inshore cable route from the 2010 geophysical survey (see Section 6 – Physical Environment) were examined by an RSK geophysical surveyor for black bream nests, based on known side scan sonar signatures for these structures (James *et al.* 2010). A number of potential nests were identified, which were then grouped into three main areas for further investigation during the 2011 benthic survey. During this survey, drop-down video transects were undertaken across these three areas in an attempt to confirm the presence of nests. However, this survey could not confirm the presence or absence of black bream nests at these locations; and
 - In addition, a field study of black bream spawning condition in the area was commissioned (see below).

- Data specifically on seahorses in the study area was sought via a direct request to the Seahorse Trust; published scientific literature (Pinnegar *et al.*, 2008); reports of 2m beam trawl surveys from 2005-2010 in the eastern English Channel (East Channel Association, 2010-2012); and unverified reports from the public (British Marine Life Study Society, 2012).
- Desk-based underwater noise assessment (Appendix 8.6), including a number of scientific publications on the effects of underwater noise on fish and shellfish.

Field surveys

- 8.3.4 In order to further refine the information from the desk studies, a number of site-specific surveys in and around the Project site were undertaken to better characterise the baseline fish and shellfish environment (Table 8.2). Location of stations for fish surveys were based on those developed for the benthic survey (see Section 7, including rationale for station locations), and were divided into two main areas: the Offshore Project site, and 'reference areas' outside of the Offshore Project site. Charts of fish survey locations are included in each of the survey reports (see Appendices 7.2, 8.2, 8.3, 8.4). The methodology of these surveys was agreed with Cefas and the MMO.
- 8.3.5 It is acknowledged that, as each of these surveys is designed to target a specific group (such as using a commercial beam trawl to catch flatfish close to the seabed), each survey type necessarily under-represents certain other groups. It should be noted that no surveys were proposed (nor requested by the MMO) for several groups, including shellfish, seahorses, and pelagic fish (i.e. species such as mackerel and herring that live in the water column, and are generally highly mobile).

Table 8-2: Summary details of fish surveys commissioned to characterise the Rampion offshore wind farm (the Project site).

Gear type (Target species)	July 2011 ¹	Autumn 2011 ²	February 2012 ³	April 2012 ⁴
2m scientific beam trawl (juvenile and small fish)	✓	✓	✓	X
Demersal otter trawl (Autumn: broad species composition; Feb/Mar: spawning plaice/cod)	X	✓	✓	X
Commercial beam trawl (4-6m) Target: spawning Dover sole	X	X	X	✓

¹ See Appendix 7.2; ² See Appendix 8.2; ³ See Appendix 8.3; ⁴ See Appendix 8.4

- 8.3.6 The July 2011 2m scientific beam trawl survey was undertaken on 10 and 11 July 2011 by Emu Ltd., primarily to obtain data on epibenthic invertebrates (see Appendix 7.2). However, this survey methodology also provides data on small fish (small species, and juveniles of larger species), of which a summary is provided here and full details presented in Appendix 7.2.

Black bream spawning condition

- 8.3.7 In addition to those surveys above, a further species-specific survey was undertaken to assess the spawning condition of black bream caught in local commercial fisheries in order to generate refined, site-specific data for one of the most sensitive times in the life cycle of this species. The survey collected black bream on 6 dates throughout the month of May 2012 (1st, 8th, 17th, 22nd, 28th, 29th), from vessels fishing between Littlehampton and Brighton in water depths of around 5-20m. Length, weight, sex, and spawning condition of black bream was analysed in a Cefas laboratory.
- 8.3.8 The potential requirement for identifying the usage of the area by other species which are present locally during key life history stages will be discussed with stakeholders. Further surveys may be undertaken in advance of construction.

Identification and Assessment of Impacts and Mitigation Measures

- 8.3.9 Impacts were identified and assessed based on expert judgement and taking into account the Institute of Ecology and Environmental Management's "Guidelines for ecological impact assessment in Britain & Ireland: Marine and Coastal" (IEEM, 2010), which were specifically developed for marine and coastal environments and species. When assessing potential impacts to fish and shellfish (such as impacts to essential habitat, or normal distribution and behaviour), the following factors were considered:
- Magnitude/extent: the size or amount of impact, such as the area of sea impacted by subsea noise or change in area of seabed habitat to shellfish;
 - Duration: the duration of time before recovery is complete. The duration of the activity causing the impact may be much less than the duration of the impact itself, for example the immediate avoidance reaction of certain fish in response to subsea noise, compared to the time taken to return to the area affected;
 - Reversibility: whether irreversible (permanent) or reversible (temporary);
 - Timing and frequency: for example whether the impact occurs once, or is repeated, or only occurs in a certain season.

Piling noise

- 8.3.10 To specifically address the potential effects of underwater noise from piling on fish Subacoustech Environmental Ltd. (Subacoustech) were commissioned to undertake a study, using preliminary engineering parameters and current project design. The study used Subacoustech's proprietary sub-sea acoustic modelling software package (INSPIRE), which calculates contours showing the approximate limits of the impact of underwater sound caused by an underwater noise. A

summary of the study is presented in this Section. Details of methodology and results can be found in Appendix 8.6.

- 8.3.11 The model for the assessment of noise impacts on fish and shellfish uses two criteria; the dB_{ht} metric and unweighted lethal and physical injury effect levels.

Unweighted Effect Levels (lethal or physical injury)

- 8.3.12 Parvin *et al.* (2007) presents a comprehensive review of information on physical impacts (potentially lethal in direct proximity to piling) on marine species from underwater noise and proposed the following criteria to assess the likelihood of these effects (NB these criteria have been used in the noise modelling assessment);

- Lethal effects may occur where peak-to-peak noise levels exceed 240dB re 1 μ Pa; and
- Physical injury (e.g. rupturing of swimbladders) may occur where peak-to-peak noise levels exceed 220dB re 1 μ Pa. Such physical injury may indirectly lead to death, for example through reduced ability to swim or control buoyancy.

dB_{ht} Metric (auditory damage and behavioural responses)

- 8.3.13 The dB_{ht} metric is based on the audiogram of a species. When measuring the audiogram of an animal, it is necessary to determine the response to the sound by a technique that does not require cognitive compliance. Two principal techniques have been used to determine the audiogram of fish species: these involve either a behavioural response technique or auditory evoked potential measurements (monitoring of the electrical activity of the animals hearing mechanism; Lovell *et al.*, 2005). The dB_{ht} Metric is used to measure a range of responses from a low likelihood of disturbance to traumatic auditory injury, as shown in Table 8-3.

- 8.3.14 The assessment criteria detailed in Table 8-3 have also been used throughout the noise assessment to assess the potential impacts of underwater noise on marine species from low levels of disturbance up to auditory damage. The following assessment criterion was published by the Department of Business, Enterprise and Regulatory Reform (BERR) (Nedwell *et al.*, 2007) using the dB_{ht} Metric.

Table 8-3: Assessment criteria used in this study to assess the potential impact of underwater noise on dB_{ht} marine species

Level in dB _{ht} (Species)	Effect
0 – 50	Low likelihood of disturbance
75 and above	Significant avoidance reaction by the majority of individuals but habituation or context may limit effect
90 and above	Strong avoidance reaction by virtually all individuals
Above 130	Possibility of traumatic hearing damage from single event (e.g. permanent damage to hearing structures)

8.3.15 The species upon which the dB_{ht} metric analysis has been conducted in this study were been selected based upon:

- The species (including species similar to it) being significant regionally because of their relevance to one or more of the following:
 - Commercial fisheries importance (e.g. cod, bass, flatfish);
 - Conservation importance (e.g. seahorses, black bream, shad);
 - Ecological importance (herring and sandeels, both key prey items to a range of predators such as fish and birds).
- Crucially, on the availability of a good quality peer-reviewed audiogram of hearing capabilities. This is essential in order to generate scientifically robust results of noise modelling. It should be noted that the analysis undertaken for black bream and shad was based on surrogates and therefore cannot be considered as completely accurate.

8.3.16 In this study, the following species of fish have been considered, or used as surrogates for other key species where no audiogram data are available:

- Herring (*Clupea harengus*), the most sensitive marine fish to underwater sound; reactions of sprat are likely to be similar;
- Shad (*Alosa* sp.), thought to be less sensitive to underwater sound although no reliable data exist;
- Cod (*Gadus morhua*), also likely to represent whiting, pollack, coalfish and pouting;
- Lined seahorse (*Hippocampus erectus*), used to represent UK species of seahorses; also likely to be similar to mackerel and horse mackerel;

- Bass (*Dicentrarchus labrax*), also likely to represent wrasse (although these are likely to be less sensitive);
- Red sea bream (*Pagrus major*), used as a surrogate to represent black bream.
- Sandeels or sand lances (Ammodytidae) lack a swim bladder and generally have poor sensitivity to sound; and
- Dab (*Limanda limanda*) one of the most sensitive flatfish to underwater sound; likely to represent other flatfish (sole, plaice, lemon sole, flounder) and be similar to both European eel and conger eel.

8.3.17 Species that are considered to be of 'low' sensitivity to subsea noise include thornback ray (Nedwell *et al.*, 2004); salmonids (e.g. salmon and trout, including sea trout) are thought to be relatively insensitive to sound (Nedwell *et al.*, 2003, 2006). These groups were therefore not specifically considered in the potential impacts of noise.

Noise modelling scenarios

8.3.18 The subsea noise modelling assessment was carried out for two locations within the Project Site (easternmost and westernmost) as indicated in Appendix 8.6. At each location three scenarios were modelled; for the use of large and small jackets, and monopiles; the details and assumptions for each are shown in Table 8-4.

Table 8-4: Scenarios modelled in the underwater noise assessment study

	Scenario A – pin pile foundations	Scenario B – pin pile foundations	Scenario C – monopile foundation
Number and diameter of piles	4 x 1.53m	4 x 2.6m*	1 x 6.5m
Maximum hammer blow energy	600 KJ	900 KJ	1500 KJ
Estimated number of piles installed in a 24 hour period	3	3	1

* Scenario B (2.6m diameter piles) relates to either a tripod foundation (3 piles) to support a 3-4MW turbine, or piles for a jacket foundation (4 piles) to support a 5-7MW turbine.

8.3.19 Further details of the methodologies are supplied in Appendix 8.6.

8.3.20 The sensitivity of different fish and shellfish to any impact was also considered as part of the impact assessment (Table 8-5).

Table 8-5: Sensitivity of fish and shellfish receptors

Receptor sensitivity	Example
High	Fish or shellfish species, and/or their habitat, that are legally protected (e.g. seahorse). An internationally or nationally designated site or candidate site designated for fish or shellfish features (SAC, MCZ). Fish or shellfish species that have critical life history constraints, such as restricted habitat requirements (e.g. black bream, herring), or restricted seasonal spawning. Nationally important populations of fish or shellfish species (e.g. black bream, cuttlefish, undulate ray).
Medium	Commercial species that are locally important to fisheries, but that are otherwise widely distributed and abundant in the broader region. Fish or shellfish species of conservation interest (BAP, MCZ FOCI) occurring in areas that are not designated conservation sites.
Low	Widespread and abundant non-commercial fish or shellfish species

8.3.21 The magnitude of impact was assessed according the criteria presented in Table 8-6.

Table 8-6: Magnitude of impact

Magnitude	Definitions
Large	The fish/shellfish interest feature of internationally or nationally designated sites (SAC, MCZs) are degraded, destroyed or changed to such an extent that the designation is compromised. Legally protected species and/or their habitats are damaged. Activities predicted to occur and affect receptors continuously over the long term, and during sensitive life stages (e.g. spawning). Recovery, if it occurs, would be expected to be long term i.e. up to 10 years following the cessation of activity. Impacts not limited to areas within and adjacent to the development.
Medium	The quality and availability of habitats and species are degraded or changed to the extent that the population or habitat experiences reduction or change in number or range. Activities predicted to occur and affect receptors regularly and intermittently, over the medium to short term and during sensitive life stages. Recovery expected to be medium term timescales i.e. up to 5 years following cessation of activity. Impacts largely limited to the areas within and adjacent to the development.
Small	The quality and availability of habitats and species experience some limited degradation. Disturbance to population size and occupied area is within the range of natural variability. Activities predicted to occur intermittently and irregularly over the medium to short term. Recovery expected to be short term i.e. up to one year following cessation of activity. Impacts limited to the area within the development.

Magnitude	Definitions
Negligible	Disturbance is within the range of natural variability. Activities predicted to occur occasionally and/or for a short period. Recovery expected to be relatively rapid i.e. less than ~ 6 months following cessation of activity. Impacts limited to the area within the development.

Significance of Residual Impacts

- 8.3.22 The overall significance of residual impacts was determined by combining sensitivity of the receptor (Table 8-5) and the magnitude of the impact (Table 8-6), as presented in Table 8-7.

Table 8-7: Significance of Impact

Magnitude	Sensitivity		
	High	Medium	Low
Large	Major	Major/Moderate	Moderate
Medium	Major or Moderate	Moderate	Minor
Small	Moderate or Minor	Minor	Minor or None
Negligible	Minor	Negligible	Negligible

- 8.3.23 An assessment has been made of the significance of residual effects, i.e. those remaining after mitigation.

Uncertainty and Technical Difficulties Encountered

- 8.3.24 No particular difficulties were encountered during the surveys, although some minor relocation of a limited number of trawl stations was required (see Appendices 7.2, 8.2, 8.3 etc for further details).
- 8.3.25 There is some uncertainty as to the possible impact of electromagnetic fields emitted from power cables. It is widely acknowledged that there are significant gaps in the existing scientific knowledge of the effect of subsea power cables on marine biota (Normandeau *et al.*, 2011), making assessment of potential impacts difficult at present. Furthermore, while some studies have demonstrated responses by marine fauna to subsea power cables (e.g. Gill *et al.*, 2009) the question of whether these responses have any negative impacts at the population or ecosystem level has not been addressed (Normandeau *et al.*, 2011) and is therefore not known.

8.4 Environmental Baseline

Fish diversity

Elasmobranchs

- 8.4.1 Elasmobranchs are cartilaginous fish including sharks, skates and rays that reproduce either by laying eggs on the seabed (catsharks ('dogfish') and rays) or giving birth to live young (e.g. spurdog, tope). Elasmobranchs are also notable in

that they have a highly developed ability to detect small electromagnetic fields, which they use in hunting prey. Species commonly found in the study area include smaller demersal sharks (e.g. small spotted catshark *Scyliorhinus canicula* and nursehound *S. stellaris*; smoothhound *Mustelus* sp.; spurdog *Squalus acanthias*), rays (thornback *Raja clavata*, blonde *R. brachyura*, spotted *R. montagui*) (Ellis *et al.*, 2004). In the eastern English Channel, the Project site is largely within one of two main centres identified as being important for combined ray abundance and diversity (Martin *et al.*, 2010).

- British populations of the undulate ray may be largely confined to the English Channel (Ellis *et al.*, 2004), and high surveyed densities of this species overlap with the western part of the Project site (Martin *et al.*, 2010). Undulate ray are thought to lay eggs on the seabed between March and June, the empty cases of which can be found all along the south coast (Moura *et al.*, 2008; Shark Trust, 2008). Survey data suggest that, unlike other ray species locally, undulate ray are found almost exclusively on hard substrata of gravel and pebble (Martin *et al.*, 2010). Although the status of undulate ray in the eastern English Channel has been suggested as being stable (Martin *et al.*, 2010), the species is currently assessed as 'Endangered' (Coelho *et al.*, 2009), and in 2009 received full EC protection (i.e. cannot be retained or landed if caught) in a number of ICES fishing areas including VIId, in which the Rampion development is located.

8.4.2 Larger, highly mobile shark species (e.g. porbeagle *Lamna nasus*; shortfin mako *Isurus oxyrinchus*, tope *Galeorhinus galeus*, blue *Prionace glauca*) may also occur in the study area. The huge (up to 12m in length) basking shark *Cetorhinus maximus* is found in summer months around the UK and can often be observed near the surface although the English Channel is not thought to be an important area for this species.

8.4.3 Since 2007, 15 elasmobranch species have been included as 'Priority Species' on the UK Biodiversity Action Plan (UK BAP), of which several (spurdog, porbeagle shark, shortfin mako, basking shark, tope, blue shark, undulate ray) are likely to occur to some degree in the study area.

8.4.4 In their review of rMCZs, Natural England and JNCC have advised Defra that undulate rays should be included as a FOCI for the Kingmere Reef rMCZ (see Section 9 Nature Conservation), although this species was not originally proposed by the RSG (JNCC and Natural England, 2012).

Marine teleosts

8.4.5 Teleosts are bony fish, which dominate the marine environment in terms of diversity. Around the UK, they include the majority of commercially important fish as well as a large number of other species.

8.4.6 **Flatfish** in the study area include species that are commercially valuable and locally abundant (Dover sole *Solea solea*, plaice *Pleuronectes platessa*),

commercially valuable and less abundant (turbot *Psetta maxima*, brill *Scophthalmus rhombus* and lemon sole *Microstomus kitt*), and those with little or no commercial value (e.g. dab *Limanda limanda*, topknot *Zeugopterus punctatus* and scaldfish *Arnoglossus laterna*). All flatfish in the study area spawn into the water column.

8.4.7 **Roundfish** is a broad term for non-flatfish teleosts, many of which are of commercial interest. In the study area, these include:

- Gadoids: cod *Gadus morhua*, whiting *Merlangius merlangus*, pollack *Pollachius pollachius*, coalfish (saithe/coley) *P. virens*, and ling (*Molva molva*). These species also spawn into the water column.
- Pelagics: these include oily fish (herring *Clupea harengus*, sprat *Sprattus sprattus*, mackerel *Scomber scombrus*, horse mackerel *Trachurus trachurus*), as well as garfish *Belone belone*.
 - While most species spawn into the water column, herring are notable in that they spawn directly on to the seabed. As well as being a UK BAP priority species, herring are important ecologically and form an important component of diets of larger predators such as other fish, birds and marine mammals. Although there are several spawning groups within the English Channel, the main population is known as the Downs stock (Sussex IFCA, 2012), and based on density of larvae recorded in surveys this stock is thought to be nationally important (Ellis *et al.*, 2010). Adults of the Downs stock spend summer in the central North Sea, before migrating south in autumn to spawn between November and January, after which they return to their summer grounds (Coull *et al.*, 1998; Sussex IFCA, 2012). Hatching of eggs takes 7 to 49 days, depending on water temperature (Sussex IFCA, 2012) and winter surveys have shown that larval fish drift south and east with the current, and by April post-larvae are found along the north-eastern French coast, and possibly east of this. Fish of around 1 year of age probably move into the central North Sea to join adults, becoming mature at 2-3 years (Sussex IFCA, 2012).
- Other species:
 - Black bream: as well as local populations of this species being nationally important, this species is unusual in that it spawns on the seabed. Black bream are discussed separately in section 8.4.1.3;
 - Bass *Dicentrarchus labrax* are of high value as a food fish, and as a highly valued target species to both commercial (see Section 18 - Commercial Fisheries) and recreational (angling and spearfishing) interests. Bass are found around the UK, and are often associated with seabed features such as reefs. Bass spawn directly into the water column and have nursery areas in estuaries and natural

harbours, which can be designated and protected from fishing activity under The Bass (Specified Areas) (Prohibition of Fishing) (Variation) Order 1999. The nearest designated bass nursery to the development area is in Chichester harbour, approximately 50km to the west of the landfall;

- Other species found locally of varying commercial value include grey mullet (Mugilidae), red mullet (Mullidae) and gurnards (Triglidae). Conger eels (*Conger conger*) are often associated with rocks or reefs, and of interest to recreational anglers.

8.4.8 **Small non-commercial species** from a variety of taxa include a wide diversity of species such as gobies (Gobiidae), dragonets (Callionymidae), pipefish (Syngnathidae), poggie (*Agonus cataphractus*), rockling, bib (Gadidae), wrasse (Labridae), and weever (Trachinidae) that are generally associated with the seabed. Sandeels (Ammodytidae) include several species that are highly abundant and a key prey species to larger fish, seabirds and marine mammals. Sandeels swim actively in the water column, and are often associated with sandy substrates, into which they deposit their eggs and burrow into when threatened.

Black bream

8.4.9 Black bream are a demersal fish species that are near the northern limit of their distribution around the UK, and the eastern English Channel is a key breeding area for the species. Like bass, black bream are of significant interest to commercial and recreational fishers. The nearby Kingmere Reef rMCZ (see Section 9 - Nature Conservation) has been proposed based partly on its interest as a black bream spawning and nesting area, a non-ENG feature. The conservation objective for the black bream feature at this rMCZ has been proposed as 'recover to favourable condition'.

8.4.10 Black bream are unusual in that their eggs are laid directly onto the seabed. The stock which occupies the English Channel overwinters in water depths of between 50-100m, prior to migrating inshore to breed between May and June in suitable habitats, including the Sussex Coast (Sussex IFCA, 2011). During their migrations eastward along the English Channel, it has been suggested that they follow the isotherm of 9°C (see Emu, 2012). When water temperature is between 8-10°C large males start making nests, which may be enlarged to around 1m diameter when the spawning season approaches. Egg laying in the area occurs from early May until June when the temperature range is between 13°C and 16°C. This species seeks specific grounds for laying eggs on with substrate types identified including open gravel areas, gravel areas adjacent to chalk reefs, sandstone reefs and ship's wreckage (see Emu, 2012). After fertilizing the eggs, males remain in close proximity to the nests protecting them from predators and keeping the nests clean from excessive siltation. After hatching, the first juvenile stage remains in the vicinity of the nests until they reach a length of 7-8 cm; they then move inshore to feed, remaining in the wider inshore area around the nests until maturity at an age of 2-3 years and a size of around 20cm. Black bream are

hermaphrodites, and change sex from female to male at about 30-40cm (see Sussex IFCA, 2012).

- 8.4.11 As noted in Section 8.3.3 above, three possible black bream nesting areas in the inshore proposed export cable route corridor were investigated by drop-down photography in the 2011 benthic survey. The presence of nests could not be confirmed. This area is likely to be surveyed pre-construction to identify possible nesting areas. It should be noted that black bream nests may vary in their exact location and density from year to year.

Seahorses

- 8.4.12 Both short-snouted and spiny seahorses are regularly recorded in UK waters, including the English Channel coast. Seahorses can be found in a range of habitats including sand and soft sediment, rock and algae, and artificial habitats including marinas; they are not (as is commonly perceived) necessarily restricted to seagrass. Research suggests that seahorses are present in shallower waters during summer months for breeding, and migrate to deeper water during winter months (December to April) to avoid storms. Ongoing research off the Dorset coast has shown that male seahorses can be found with fertilized eggs throughout spring-autumn, with these 'pregnancies' lasting around 1 month (Garrick-Maidment, 2011).

- 8.4.13 Literature review and data requests revealed the following:

- The entire study area is a potential overwintering area for both short-snouted and spiny seahorses (Neil Garrick-Maidment, pers. comm. to RSK 14 Sept 2012);
- Short-snouted seahorses have been recorded the Shoreham and Brighton marina areas (Sussex Biodiversity Partnership, 2010), as well as several unverified records submitted by the public from strandings and captures in the area (British Marine Life Society, 2012);
- 1 short-snouted seahorse caught by an annual 2m scientific beam trawling monitoring program in late summer 2006, approximately 35km south-east of the wind farm area in mid-Channel. Water depth was around 40m. No seahorses were apparently recorded in equivalent surveys in 2005 or 2007-2010, which included sites within around 15km of the wind farm site (East Channel Association 2010-2012); and
- 1 short-snouted seahorse caught in a trawl near Dungeness in 2007 (Pinnegar *et al.*, 2008).

- 8.4.14 Scientific studies of seahorses globally have indicated that they generally occur in low densities, and are patchy in distribution (Foster and Vincent, 2004). Reported seahorse densities vary widely by several orders of magnitude, with higher reported densities of (0.02-1.1 seahorses per m²) generally being from studies of

‘focal grids’ (i.e. focusing on known populations), and notably lower ranges (0.007-0.07 seahorses per m²) from linear transects, which is more likely to represent their true overall density in any broad area.

- 8.4.15 The home range of seahorses is thought to be small. The size of the area occupied by a pair of short-snouted seahorses tagged in Studland Bay, Dorset, was 7m by 29m (Garrick-Maidment *et al.*, 2011). Home ranges of the two species found in the UK have been reported from studies elsewhere as varying widely, but always small (0.7-18.1m², mean 7.8m² for short-snouted seahorse; 0.005-67m², mean 12.1m² for spiny/long-snouted seahorse) (Foster and Vincent, 2004). A further study on the spiny/long-snouted seahorse in Portugal found a broadly similar mean home range of 19.9m² during breeding seasons (Curtis and Vincent, 2006).

Anadromous and estuarine teleosts

- 8.4.16 European eels *Anguilla anguilla* are also likely to occur in both intertidal and subtidal environments of the study area; adult eels descend to the sea around September for spawning, while young (elvers) return to ascend rivers in April/May. Eels are known to be present in the rivers Adur and Ouse in the study area, although in low densities.
- 8.4.17 Smelt *Osmerus eperlanus* is a UK BAP priority species. It is found inshore and in estuaries, and spawns in rivers in spring. Although shoals have been seen off the Sussex coast, records in the Ouse and Adur are not known and their population status in the area requires further research (Rogers *et al.*, 1998; Maitland 2003).
- 8.4.18 Sea trout *Salmo trutta* spend much of their life at sea, but ascend rivers in summer to spawn on gravel beds in winter. Sea trout are known to spawn in rivers (e.g. Adur, Arun and Ouse) that discharge into the sea in the study area. The Ouse (discharging near Newhaven) is one of the most important rivers for angling catches of this species between Hampshire and Yorkshire (Sussex Ouse Conservation Society 2011), with between 29 and 51 caught annually from 2007-2009 (Environment Agency 2009). Sea trout are also reported from the River Adur (discharging near Shoreham) and River Arun (Littlehampton) (Environment Agency, 2009; River Adur Conservation Society, 2010).
- 8.4.19 Shad *Alosa* sp., which ascend rivers to spawn, are known to be present in the marine environment off the coast of Sussex; however, it is not known how these populations relate to rivers in the region (R. Clark, Sussex IFCA, pers. comm.). Landings data obtained from the MMO for fish caught in areas surrounding the Project site (i.e. the ICES statistical reporting areas 30E9 and 30F0) show that a number of local ports have landed this species, with Hastings, Newhaven and Rye particularly notable in sometimes reporting annual landings of several thousand pounds in value.

Shellfish

8.4.20 Shellfish in the study area can be broadly divided into the following groups, all of which contain species that are commercially important locally (see Section 18 - Commercial Fisheries):

Crustaceans

8.4.21 Key commercial species are brown/edible crab (*Cancer pagurus*), lobster (*Homarus gammarus*), spider crab (*Maja squinado*) and velvet swimmer crab (*Necora puber*), with minor fisheries for other species such as green crab (*Carcinus maenas*); other abundant non-commercial species include swimming (*Liocarcinus* sp.) and masked crabs (*Corystes cassivelanus*), hermit crabs (Paguridae), and squat lobsters (Galatheididae). In general, females carry fertilised eggs (termed 'in berry' or 'berried') until these larvae are released.

- Brown crab can inhabit a variety of habitats, from the rocky intertidal to deeper shelf waters as adults. While both sexes can be found under boulders, some research suggests males prefer rocky habitat with females more abundant on sand and gravel. Mating occurs inshore in spring. Females initially store sperm, before moving offshore in late summer where the eggs are fertilized. The females then remain largely stationary (often buried in sediment) through the winter, incubating their eggs. In late spring, the larvae are released, which settle onto the seabed after 2 months in the plankton. Juveniles remain in shallow intertidal waters for around 3 years, before moving in to deeper water (Sussex IFCA, 2012).
- Lobsters inhabit holes and crevices in or under rocks and artificial structures. Studies have shown lobsters are largely sedentary and do not undertake significant migrations. Lobster breed in the summer, and berried females release planktonic larvae in the following spring, which settle to the seabed after about 3 weeks (Sussex IFCA, 2012).

Molluscs

8.4.22 Cephalopods in the study area include the highly mobile cuttlefish and squid (both regularly commercially exploited off Sussex), as well as octopus. These species spawn directly onto the seabed with adhesive eggs. Cuttlefish spend winter in the western English Channel, and move into shallow Sussex waters to breed, laying eggs from February to May (peaking from mid-April to mid-May). Eggs are laid on objects such as seaweed, hydroids and artificial structures such as crab pots and ropes. After approximately 3 months the eggs hatch, and juveniles are thought to remain in shallow waters until around October, when they move offshore. After the first winter, juvenile cuttlefish again move inshore (spring-autumn), before another winter offshore, after which they are fully mature; in the following spring they return inshore, breed, and die (Dunn, 1999; Sussex IFCA, 2012).

- 8.4.23 Bivalves: commercial species include those that are attached to the seabed when adult (e.g. mussel *Mytilus edulis*; native oyster), or with limited mobility (using a predator-avoidance 'swimming'), i.e. king scallop *Pecten maximus* and queen scallop *Aequipecten opercularis*. All of these bivalve species spawn directly into the water column, with planktonic larvae. King scallop spawn in the spring (April/May), and possibly also in the autumn (late August). King scallop larvae settle to the seabed within about 1 month, and attach themselves to the seabed until they are around 4-13mm in length, after which they settle on the seabed (Sussex IFCA, 2012).
- 8.4.24 Gastropods include commercially harvested whelks *Buccinum undatum* and a number of smaller species. Whelks are the third most valuable fishery to Sussex (after scallops and Dover sole), and the second most valuable to the under-10m fleet (which comprises 80% of registered vessels). Whelks are found on hard and soft seabed substrates, and have very limited movement and dispersal. Whelks spawn their egg capsules on to the seabed from around November to April; the young do not have a planktonic phase, and emerge as fully formed whelks in February and March (Sussex IFCA, 2012).

Fish spawning and nursery areas

- 8.4.25 The most recent, robust data available for the spawning and nursery grounds of many species (e.g. Ellis *et al.*, 2012) were reviewed, with a view to identifying areas of high intensity spawning in or around the Offshore Project site, as well as highly localised, or regionally/nationally important, spawning in the study area. However, it should be noted that this study does not cover some locally important species such as black bream and cuttlefish, which are known to have high intensity spawning in the area.
- 8.4.26 Based on consultation with Cefas in August 2011, bass are considered to have widespread spawning areas in the region, with no proven centres of activity. Lemon sole are also considered to spawn widely and often, and centres of whiting spawning are not in the vicinity of the Offshore Project site.
- 8.4.27 Spawning areas in the study area, based on the data in Ellis *et al.* (2012), are presented in Figure 8.1. (8.1a for high intensity spawning, and 8.1b for low intensity (or intensity not stated) spawning). These show that:
- High intensity spawning (Figure 8.1a) is present for sole in inshore waters, covering the entirety of the Offshore Project area. High intensity plaice spawning does not overlap with the Offshore Project area, but occurs further offshore.
 - Low intensity (or intensity not stated) spawning (Figure 8.1b) for both sole and plaice is opposite to that for high intensity (i.e. plaice is more inshore, whereas sole is more offshore). Sandeel and cod spawning is widely distributed across the entire study area, and lemon sole spawning is broadly distributed across more inshore waters including the entire Offshore Project

area. Whiting spawning areas are more restricted, to a lobe at the easternmost end of the Offshore Array area.

8.4.28 Figure 8.2 presents a summary of herring spawning data based on the following sources:

- ‘Spawning area’ as identified by Coull *et al.*, (1998); and
- Larval density, based on more recent International Herring Larvae Survey (IHLS) data, as mapped by Ellis *et al.* (2012). It should be noted the linear distribution presented on the Figure is likely to be an artifact of the sampling strategy; it should be assumed that similar high densities occupy areas between the mapped areas.

8.4.29 In general, all three of these sources support the distribution of high intensity spawning in a similar area well to the south and particularly the south-east of the Rampion wind farm, largely on the French side of the mid-Channel line.

8.4.30 Nursery areas in the study area, based on the data in Ellis *et al.* (2012), are presented in Figure 8.3). These show that nursery areas for whiting, lemon sole and both thornback and undulate rays cover the entire area. Nursery areas for plaice, sole and sandeel are thought to be on the margins of the broad area.

Results of field surveys

2m scientific beam trawl surveys

July 2011

8.4.31 Results of the July 2011 survey are summarised in Table 8.8. A total of 21 fish species were recorded and the most abundant fish species were small, non-commercial taxa: gobies, dragonets, solenette and weever. The most common commercial fish species recorded was plaice, with Dover sole, lemon sole and rays (thornback and spotted) recorded in smaller numbers. No protected species were recorded. It should be noted that the 2m beam trawl methodology is not expected to record more mobile species, such as small sharks or adult roundfish.

October/November 2011

8.4.32 The fish community recorded in the October/November 2011 survey was broadly similar to that recorded in July 2011, and consisted almost entirely of small non-commercial teleosts. Sand goby *Pomatoschistus minutus* dominated, comprising over 70% of all fish individuals recorded, with solenette (12%) also important. No elasmobranchs were recorded, and the only commercial teleosts species were two lemon sole, and a single individual each of black bream, plaice and John Dory, all from within the Offshore Project site.

8.4.33 Notably, a single short-snouted seahorse was recorded from station BT05 on the 7th November, in approximately 29m water depth in the north-eastern part of

the Offshore Project site. Based on the 2010 geophysical survey and the 2011 benthic survey, the predominant substrate in this area is considered to be sandy gravel, and adjacent to areas of gravelly sand and rock, with scattered boulders. The seahorse did not survive trawling.

Table 8-8: Fish species recorded in the July 2011 2m scientific beam trawl survey

Area	Elasmo-branches	Commercial teleosts	Non-commercial species
Offshore Array	Spotted ray	Monkfish, lemon sole, Dover sole	Dragonets, gobies, solenette , poor cod; pogge, lumpfish; weever; scaldfish, dab
The Crown Estate Zone 6 (excl. above area)	-	Plaice , lemon sole, Dover sole	Weever , pogge, sandeel, dragonet, gobies, scaldfish, dab
Export cable corridor	Thornback ray	Plaice, Dover sole.	Gobies, solenette , dragonet, pogge, weever
Tidal envelope	Thornback ray, spotted ray	Lemon sole, plaice, Dover sole	Gobies, solenette, dragonet , pout, poor cod, pipefish, pogge, lumpfish, weever, scaldfish, dab
Reference area (see Appendix 7.2)	-	Red gurnard, lemon sole, Dover sole	Dragonets, gobies, weever , rockling, goldsinny wrasse

NB The most abundant taxa for each area are indicated in bold.

February 2012

- 8.4.34 As with previous surveys, small non-commercial species were the most frequently recorded, with sand gobies comprising nearly half of all individuals, and solenette, other goby species, dragonets and weever also occurring regularly. The only commercial fish species recorded were three plaice and a single specimen each of Dover sole and lemon sole, all of which were caught in the Offshore Project site. No elasmobranchs were caught within the Offshore Project site. Three short-snouted seahorses were recorded, all within the Offshore Project site: one at BT05 (20th February, 27-29m water depth; note this is the same location where a seahorse was recorded in the previous survey), and two at BT03 (21st February, 31-33m water depth), within the western part of the Offshore Project site. As with the previous survey, these seahorses were caught from an area of sandy gravel. None of the seahorse specimens survived.

Commercial otter trawl

October/November 2011

- 8.4.35 Full details of the October/November 2011 survey are presented in Appendix 8.2. Key aspects are summarised below. It should be noted that in some cases sample sizes for certain species were too small to provide comment on.

8.4.36 A total of 2,024 individuals were recorded, comprising 32 species. Just 6 species comprised over 80% of individuals, i.e. whiting, long-finned squid, small spotted catshark, horse mackerel, black bream and plaice.

- Elasmobranchs. The only elasmobranch fish recorded in abundance was the small spotted catshark, which comprised 16% of all trawled organisms (the third most frequently recorded species in the survey); averaged catch rate of this species for the Offshore Project site and reference area stations was broadly similar. Several other elasmobranch species (spotted, blonde, cuckoo and thornback ray; tope; smoothhound) were caught in far smaller numbers, as was the BAP-listed undulate ray, which was only recorded from stations within the Offshore Project site (Figure 8.4).
- Commercial teleosts. The most abundant species caught in the survey was whiting (ca. 25% of all individuals), with averaged catch rates significantly greater at reference stations. Around 75% of whiting in both areas were above the minimum landing size (MLS: 27cm), and around two thirds of whiting in both sampling areas were female. The greatest proportion of whiting caught at reference and Offshore Project site stations were represented by maturing (36%) and spent (29%) females.
 - Black bream comprised around 6% of all individuals, with most of these from Offshore Project site stations where averaged catch rates were greater than at reference stations. Around two thirds of fish in both areas were female. Immature males and females comprised around half of the black bream at Offshore Project site stations, although maturing and spent females were also important (around 30% of all black bream).
 - Plaice (6% of all individuals) averaged catch rates were lower in the Offshore Project site; around 90% of this in the Offshore Project site were above the MLS. Around two-thirds of plaice in the Offshore Project site were female, whereas sexes were in equal numbers at reference stations. Nearly all plaice (from both areas) were maturing.
 - Lemon sole, bass and cod each contributed around 1% to the total of individuals. All cod were above the MLS, and most in the Offshore Project site were spent (both females and females).
 - A handful of high-value brill, red mullet and John Dory were recorded, which had higher catch rates at reference area stations. Only a single Dover sole was recorded, which was a spent male (above the MLS) from within the Offshore Project site.
- Non-commercial/low value teleosts. Horse mackerel and dab were relatively common and comprised around 10% and 4% of all individuals. Other species recorded in lower numbers were bib, poor cod, red and tub gurnard and dragonet.

- Shellfish. Long-finned squid was the second most frequently recorded species (comprising over 20% of all individuals), with catch rates higher in the Offshore Project site compared to reference area stations. A small number of other shellfish species were also recorded: queen scallop (both within and outside the Offshore Project site), and a handful of king scallop, cuttlefish, whelk and edible crab from within the Offshore Project site.
- Protected species. A single allis shad was recorded from within the cable route corridor (Figure 8.4).

February 2012

8.4.37 Full details of the February 2012 survey are presented in Appendix 8.3. A total of 4,197 individuals were recorded, comprising 31 species. Whiting were by far the most abundant species (nearly 58% of individuals), which together with flounder and herring comprised over 75% of all individuals. Sprat (~6%), plaice (5.4%), dab (3.6%) and lemon sole (2.6%) also occurred regularly.

- Elasmobranchs. Small spotted catshark was the most commonly recorded species (1.1% of trawled individuals), although a further six species were recorded in lower numbers (spotted ray, smoothhound, blonde ray, cuckoo ray, thornback ray and undulate ray (Figure 8.4).
- Commercial teleosts. Again, whiting were the most abundant species overall, with averaged catch rates greater at reference stations. The majority (60.5%) caught at the reference stations were below the MLS, whereas within the Offshore Project site around half (46%) were below the MLS. Females dominated in both the Offshore Project site (~60%) and reference areas (69%). The greatest proportion of whiting caught both within the Offshore Project site and at the reference stations was represented by maturing males (34%), followed by hyaline and maturing females (29% and 27%, respectively).
 - In contrast to the autumn survey, no black bream were recorded.
 - A small number (6) of bass were recorded. Of the four from within the Offshore Project site, half were above the MLS.
 - Nearly all herring were caught in the Offshore Project site, 99% of which were above the MLS.
 - Plaice averaged catch rates were broadly similar across both the Offshore Project site and the reference areas. The majority of plaice (~73%) across the survey area were below the MLS. Around 65% of plaice in both Offshore Project site and reference areas were female. The most frequently recorded spawning conditions for plaice from both areas were spent females (33%) and immature females (31%).
 - Lemon sole averaged catch rates were broadly similar across both the Offshore Project site and reference areas. Females dominated in both the Offshore Project site (65%) and reference areas (70%). Spawning

conditions from both the Offshore Project site and at the reference stations were dominated by maturing females (41.7%) and maturing males (26%).

- Although cod were caught in relatively low numbers, all those in both Offshore Project site and reference areas were above the MLS, with around two thirds of fish being female. The most commonly encountered spawning stage in both areas was spent females (~36%).
- Only seven Dover sole were caught in total. Of the four individuals caught within the Offshore Project site, all were above the MLS and either spent females or maturing males.
- Two individuals each of high-value brill and John Dory were caught within the Offshore Project site.
- Non-commercial/low value teleosts. Flounder, dab and sprat were commonly recorded and together comprised around 20% of all individuals. Averaged catch rates for these species were similar between Offshore Project site and reference areas, excepting a notably higher catch rate of flounder in the Offshore Project site. Other species recorded in lower numbers were poor cod, bib, grey and tub gurnard, greater weever and dragonet.
- Shellfish In comparison to the autumn survey, only a handful (5) of long-finned squid were recorded. A few whelks a single edible crab were also recorded (all of which were above the MLS), mostly from within the Offshore Project site.
- Protected species: A single twaite shad was recorded from within the Offshore Project site (Figure 8.4).

Commercial beam trawl

8.4.38 This survey was designed specifically to sample flatfish, as commercial beam trawling catches relatively slow-moving fish that live on (or close to) the seabed. As such, more mobile and/or pelagic species are likely to be under-represented.

April 2012

8.4.39 Full details of the April 2012 survey are presented in Appendix 8.4. Key aspects are summarised below. It should be noted that in some cases sample sizes for certain species were too small to allow valid observations to be made.

8.4.40 A total of 2,638 fish individuals were recorded comprising 39 species, although around half of all species (19) were recorded on 10 or less occasions. Plaice dominated (~39% of individuals), and along with bib, small spotted catshark, Dover sole, dab, lesser weever, common dragonet and whiting, comprised around 80% of all fish.

- Elasmobranchs. Around 13% of trawled fish were elasmobranchs, the majority of which were small spotted catsharks (6.9%). Thornback ray, starry smoothhound, spotted ray and undulate ray were recorded frequently, and a few cuckoo and blonde ray were also caught.
- Commercial teleosts.
 - Black bream: Only a small total number of individuals (16) were caught (0.6% of all trawled fish), in approximately equal numbers between the Offshore Project site and reference areas. In the Offshore Project site the average length was 16.6cm with a maximum of 30cm; individuals of 9cm (probably representing 1 year old fish) were also caught. Most fish could not be sexed and were immature, but a single immature female (17cm) and two maturing females (28-30cm) were recorded from the Offshore Project site, and a single maturing male (16cm) from the reference area.
 - Plaice: averaged catch rates were slightly higher in reference areas compared to the Offshore Project site. The highest catch rates were recorded in less than ~20m depth around the cable corridor, notably at two stations outside it to the east (BT23 and BT24) but also at stations within it (e.g. BT14, BT12), including those that were shallow (BT18, ~8-9m). Plaice in the Project site spanned all 5cm size classes from >15cm to <59cm, with the most common being 25-29cm. In both sampling areas around half of all individuals were above the MLS, and most individuals of both sexes were spent. Around two-thirds of plaice in the Offshore Project site were female, whereas sexes were approximately equal in the reference area.
 - Lemon sole: a notably high catch rate was recorded at station BT08 in the eastern part of the Offshore Project site.
 - Dover sole: averaged catch rates in the Offshore Project site were around half that in reference areas. In both sampling areas, around three-quarters of individuals were above the MLS; the majority were females (most of which were maturing), most males were spent.
 - No cod, and only a single herring, was recorded. Only 3 bass were caught: two below the MLS (Offshore Project site) and one above the MLS (reference area). Single individuals or a few each of high-value commercial fish (brill, red mullet, turbot, John Dory, anglerfish) were also caught.
- Non-commercial/low value teleosts: bib, dab, lesser weever and common dragonet were the most abundant, and along with tub gurnard, solenette, poor cod, scaldfish, pogge and flounder made up around 32% of trawled fish. A number of other species were recorded on one or a few occasions, including blennies and three species of wrasse.
- Shellfish. The total of 736 individuals was composed of ten species, nearly all of which are commercially exploited locally. Whelks dominated (60% of

trawled shellfish), and with smaller numbers of king scallop, cuttlefish, and queen scallop comprised around 90% of individuals. Sizes were broadly similar between the two sampling areas with around 85% upwards of king and queen scallop, and whelk, above the MLS; conversely, most of the small number of edible crab were below the MLS.

- Protected species.
 - Of the 25 undulate ray caught, all but one of these was caught in the Offshore Project site; of these, the majority were juveniles of <20cm disk width.
 - Of the 13 native oysters caught, 12 were within the Offshore Project site; 8 of these were caught from a single station (BT16, part of which lies in the export cable route corridor) in around 10m of water (based on other survey data, probably over sand and gravel seabed type).

Black bream spawning condition

8.4.41 A total of 769 black bream were sampled during a brief survey carried out in spring 2012, ranging in length from 21 – 37cm (mean of 26.6cm, with most common size class 24cm), and weighing from 256 to 463g (mean 330g). Excepting two individuals that could not be sexed, 59.6% of the black bream were female. All males and females were classed as ‘maturing’, i.e. with developing milt and eggs, but had not yet spawned.

8.4.42 This survey, although limited to a single month, confirms that black bream present in the area in the month of May are almost entirely maturing, although it is recognised that this may be subject to annual variation due to water temperature fluctuations. To expand on this preliminary study, pre-construction surveys of the spawning condition of black bream in the area will be undertaken, over a greater range of months in the early summer. Data collected from these studies will refine the assessment of potential impact.

Summary of seasonal & spatial sensitivities

8.4.43 This section briefly summarises key sensitivities, based on the detailed information gathered from both field surveys and desk-based sources.

8.4.44 Figure 8.4 presents locations of where fish and shellfish of conservation interest were recorded from the 2011/2012 characterisation surveys. Notably, black bream nests appear to be concentrated within an area of sandy sediment either side of the 10m depth contour. As noted above, seahorse records were all from areas of sandy gravel/coarse sediment. The distribution of other species recorded does not appear to show any particular pattern.

8.4.45 **Table 8-9** summarises life cycles of the key fish and shellfish species in the study area, and includes reference to presence, absence or relative abundance for key species from the 2011 and 2012 surveys.

Table 8-9: Summary of the life cycles of key fish and shellfish species in the study area.

Receptor	Winter		Spring			Summer			Autumn				
Fish	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Undulate ray		Present		Present (mostly juveniles)						Present			
			Egg cases laid on seabed										
Herring Adult	Spawning <i>Abundant</i> (Feb.)		Migrate N to central North Sea			(in central North Sea)			Migrate S to eastern Channel		Spawning		
Juveniles	Probably offshore in North Sea												
Eggs/larvae	Hatch			Larvae drift & are found along NE French coast and eastward								Hatch	
Bass Adult	Overwinter in W Channel <i>Present</i> (Feb.)			Present	Spawning							Overwinter in W Channel	
Larvae/young	Larvae move into estuaries from June onwards; young remain in these nurseries for 2 years												
Black bream Adult	Offshore <i>Not recorded</i> (Feb.)			<i>Not abundant; mostly immature</i>	<i>Maturing individuals present</i>					<i>Present. Immature M/Fs (50%); maturing/ spent F (~30%)</i>		Offshore	
Juvenile	In nest area, and inshore of nest, all year; ~1 year old fish recorded at site in April												
Eggs					Eggs laid								
Seahorse		Present								Present			
	Overwintering offshore		Breeding inshore; males may be carrying fertilised eggs										
Plaice		Present (Feb); mostly spent & immature females		Abundant, especially in <20m. Most spent.			Juvs. common			Present; Nearly all maturing; ~66% F;			

Receptor	Winter		Spring			Summer			Autumn			
Fish	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Dover sole		Not abundant		Present, majority maturing F; most males spent.			Juvs. present			Not abundant		
Cod		Present (Feb), inc. spent females		Not recorded						Not abundant		
Shellfish												
Edible crab	Females incubating eggs; buried		Mating (inshore); Planktonic larvae released from incubated females & settle after ~2 months				Females moves offshore		Females incubating eggs; buried in sediment			
	Juveniles in shallow and intertidal waters											
Lobster			Planktonic larvae released from incubated females & settle after ~3 weeks			Mating						
Cuttlefish (adult)	In W English Channel	Move inshore to Sussex waters; Lay eggs (peaking mid-Apr to mid-May) Death				(Not present inshore)						In W English Channel
1 st year juvs.	Offshore			Hatch & remain inshore							Move offshore	
2 nd year juvs.				Move inshore								
Whelk	Eggs laid onto seabed	Young hatch									Eggs laid onto seabed	
King scallop				Spawn; planktonic larvae settle after ~1 month				Possible secondary spawning				

Key: Presence/absence/abundance in surveys is indicated in *italics*. Where species were recorded by surveys in the Offshore Project area, they are noted as 'Present'. Light shading = spawning, dark shading = peak spawning (where known)

8.5 Predicted Impacts

- 8.5.1 In line with the use of the “Rochdale Envelope” (see Section 5), the assessment in this chapter has been based on a development scenario that is considered to be the worst case in terms of impacts to fish and shellfish. Table 8-10 lists the components of the design of the marine part of the project that could influence the magnitude of impacts to fish and shellfish. The realistic worst-case scenarios in terms of number of turbines, seabed take, and source noise levels and duration are presented in Section 2 - Project Description.

Table 8-10: Wind farm design features and their influence on the Rochdale envelope for fish & shellfish

Design feature	Design options
Wind farm site layouts	Layouts which place turbines close to the eastern edge of the redline boundary could result in greatest noise effects on the herring spawning area
Wind turbines	Larger turbines result in larger pins/piles and higher underwater noise for fish etc. Selection of smaller turbines is likely to result in more foundations being constructed, which may mean that construction takes place over a longer timescale, extending the impacts period.
Foundations	The choice of turbine size in terms of number of units and max size of pile to be installed influence the worst case in subsea noise generation terms. A 6.5m diameter monopile would present the worst case in terms of peak noise. While installation of keystone jackets for 175 turbines would give the worst case in terms of duration.
Offshore substation	
Cables	More turbines may result in greater lengths of cable, with potentially increased EMF impacts. Routing of export cable will also be a key factor in potential impacts to black bream nests in shallow water.
Construction and installation	Scheduling of piling activities could influence the magnitude of noise impacts on sensitive life history stages (such as spawning).
Operation and Maintenance	Frequent maintenance works affecting the seabed would represent a worst case scenario for fish and shellfish populations.
Decommissioning	Decisions on the level of seabed disturbance will be heavily influenced during the array design and foundation selection. Decisions on the degree of material left in situ at the end of the project’s life will also influence the degree of impact on fish and shellfish, as will the decommissioning methods proposed.

Construction

Noise and vibration

- 8.5.2 The most important potential source of subsea noise during construction will be from piling the turbine foundations into the seabed, which produces high sound pressure levels. The underwater noise levels during construction have been measured at many of the wind farms that have been constructed to date. It is apparent that the noise levels are a function of the pile diameter, pile wall thickness, hammer energy, site geology and the noise propagation properties for the selected site. A modelling exercise has been undertaken to determine the

likely noise levels from installation of the piles at the Offshore Project site. A detailed report on the modelling is provided as Appendix 8.6.

- 8.5.3 The average expected time for driving a monopile is approximately two hours, typically ranging between one and four hours. In the worst case, installation of a single monopile could take up to 24 hours if geological conditions prove to be particularly difficult and drilling is also required. The maximum number of turbines will be 175; it has been estimated that the total construction period will be around 30 months. Of this period, installation of turbine foundations (encompassing all foundation types) is expected to last for around 12 months. This assumes that two installation vessels are used, although actual pile driving operations will not be carried out by both vessels at the same time. With two vessels working, one monopile could be installed per day (each vessel installs one monopile every other day). Most of the installation vessel's time will be spent in positioning and other preparation works for piling.
- 8.5.4 Based on the average expected piling routine duration of two hours, piling noise will only be generated for one-twelfth (~8.5%) of any given monthly period. This could increase to one-sixth (~17%) for installations of four hour duration. These percentages may be reduced if ground conditions allow for a shorter piling time, or in the event of weather or technical delays.
- 8.5.5 Modelled noise contour maps also assume the worst-case in terms of two other aspects:
- Maximum hammer blow energies for each pile size have been used. It is anticipated that the majority of piles will be installed without blow energies reaching these maxima.
 - The 'significant avoidance' contour does not take into account any habituation of fish to noise, and/or behavioural 'context' of fish. Fish pre-occupied with breeding or feeding, for example, may show reduced avoidance responses to noise in these circumstances.
- 8.5.6 Section 2a – Offshore Project Description – identifies worst-case scenarios for numbers of monopiles and other foundations which require larger pin piles. In summary, up to 95 monopiles could be installed for a development using 3-4MW turbines and up to 60 monopiles in a development using 5-7MW turbines.
- 8.5.7 The sensitivity of fish and shellfish species to subsea noise varies widely, as explained in the results of the noise modelling below and in Appendix 8.6;
- As noted above, species thought to have low sensitivity to underwater noise are thornback ray and salmonids (such as salmon and sea trout; Nedwell *et al.*, 2003, 2004, 2006).
 - The potential sensitivity of different life history stages of fish, such as larvae and juveniles, was raised as a concern by the Sussex IFCA in response to the

draft ES. In response, underwater noise specialists Subacoustech were commissioned to critically review available evidence for potential impacts to this group from piling noise, details of which are presented in Appendix 8.6. Bolle *et al.* (2012) studied the lethality of pile driving sound on common sole (*Solea solea*) larvae. The highest cumulative sound exposure level applied was 206dB re 1 $\mu\text{Pa}^2\text{s}$, corresponding to 100 strikes at a distance of 100m from a typical North Sea pile-driving site. There were no statistically significant differences in mortality between exposure and control groups at sound exposure levels which were well above the US interim criteria for non-auditory tissue damage in fish. Review of this and other scientific literature suggests that there appears to be a limited effect from noise on young fish in comparison to their mature counterparts. Generally, young fish were found to have a lower sensitivity to noise than adults, possibly indicating a greater degree of resistance to injury as a result of exposure to high noise levels. However, the limited information available for a small number of species means that results should not be extrapolated to other species without further research (Appendix 8.6).

- In addition to this study (and in response to Sussex IFCA concerns) RSK also briefly reviewed the specific scientific literature on the potential impact of piling noise on fish eggs. Very little is known about the potential impact of noise on fish eggs and further studies are needed (Wahlberg and Westerburg, 2005); based on the limited data available, these authors suggested that eggs might be less sensitive than adult fish. A major review (Popper and Hastings, 2009) found that the very limited studies on eggs are insufficient to reach any conclusions, particularly because the few studies had looked at noise/vibration sources likely to be very different to piling noise (seismic air guns; mechanical shock).
- Cephalopods and their potential sensitivity to noise was raised as a concern by the Sussex Wildlife Trust, in response to the draft ES, based on the results of a single study (Andre *et al.*, 2011) that suggested that species such as cuttlefish that have been demonstrated to sustain mortality and injury from high sound levels. In response to this underwater noise specialists Subacoustech were commissioned to critically review available evidence for potential impacts to this group from piling noise, details of which are presented in Appendix 8.6. Review of the scientific literature confirmed that cephalopods are able to detect vibration and have a measurable sensitivity to sound. While the Andre *et al.* (2011) study presented data on lesions in a range of cephalopod species resulting from relatively low noise levels, the results and methodology of this study have been subject to some scepticism by other researchers (Kessler, 2011). To date, there are no large scale studies that provide evidence of wild cephalopods being harmed by piling noise, and there are no criteria that could be used to provide an objective assessment (such as modelling) of its potential impact specifically on these species. There is evidence that their audiological sensitivity, and therefore the risk to their

audiological systems through exposure to noise, is likely to be somewhat lower than the least sensitive fish species assessed here.

8.5.8 Unmitigated piling noise has the potential to have the following impacts:

- Alteration of normal behaviour, for example through strong or significant avoidance (see Appendix 8.6) by fish of 'noisy' areas. The three potentially most significant aspects of this are:
 - Impacts to spawning adults: noise may restrict access of adult fish to spawning areas, resulting in them spawning in different and/or sub-optimal areas (e.g. in areas with more predators, or further away from the areas where larvae eventually settle). This may affect subsequent recruitment of young fish, which may in turn result in population declines. Based on circumstantial evidence, a study conducted off the coast of Norfolk suggested that piling noise from construction of Scroby Sands offshore wind farm was responsible for a significant reduction in herring abundance that could not be explained by environmental factors (Perrow *et al.*, 2011).
 - A change in the distribution of fish species, with resulting impacts on the commercial and/or recreational fisheries that target them; and
 - A change in the abundance and/or distribution of fish species in general, which may impact the abundance and/or distribution of predator and prey organisms. Perrow *et al.* (2011) suggested that reduced breeding success in tern colonies may have been as a result of piling noise from Scroby Sands impacting small herring on which the terns were known to depend,
- In extreme circumstances, physical injury or even death may result to fish if they are very close to a source of high-intensity piling noise. Depending on the species involved, this could potentially occur to a range of life history stages from larvae to adults.

8.5.9 Other sources of subsea noise may arise from construction activities such as construction vessel propeller noise, and burial of the export cable through any rocky substrates and/or placement of rock material onto the seabed (e.g. around foundations). Noise from construction vessel activity may increase noise levels locally, although this will be in the context of relatively high ambient levels in the English Channel, and only for a short duration in any one area. Impacts from propeller noise, cable lay and placement of protection (rock and mattresses) are considered to be minor and temporary.

Noise modelling results: unweighted effect levels (lethal effect or physical injury – all species)

- 8.5.10 The estimated worst-case range at which lethal injury may occur to marine species at maximum blow energy is 10m. Physical injury may occur between up to 25m or 65m, depending on the piling scenario.
- 8.5.11 It should be noted that these impact ranges are based on the extrapolation of data from measurements taken at considerably greater ranges since it is generally not possible to carry out measurements this close to impact piling operations. “Near field” acoustic effects are likely to occur at close range to the piling operations so the levels of underwater noise may be lower than those estimated through modelling. The ranges presented in Appendix 8.6 are therefore considered as worst case.
- 8.5.12 Ranges at which death or physical injury are likely to occur are relatively small, i.e. maximums of 10 - 65m for the 6.5m monopile. These impacts will therefore only affect receptors within the wind farm site, and will not affect fish and shellfish receptors in shallower, inshore waters (such as black bream in the Kingmere rMCZ, or preferred black bream nesting habitat in water depths of <10m).
- 8.5.13 For the vast majority of fish (including most fish of conservation importance, e.g. undulate ray, shad, sea trout) and shellfish present in the area at the time of piling, it is thought that death or physical injury will not occur, as a result of active avoidance by fish (and actively swimming shellfish that may be able to detect noise, such as cuttlefish or squid) once piling activities commence. As a ‘soft start’ procedure will be used, most fish will have time to swim away from the area before dangerous levels are reached and there will be, at worse, an impact of minor significance from temporary, localised displacement (based on low-medium sensitivity of the species involved, and negligible magnitude (i.e. confined to the development and temporary).
- 8.5.14 However, for some fish with very limited mobility there is the potential for physical injury to occur, as their swimming speed (or possibly other characteristics, such as highly territorial behaviour) may not allow them to leave the area before dangerous levels are reached. These may include very small species (such as gobies); larvae, and young of larger species, and seahorses.
- 8.5.15 Seahorses have low swimming speeds, with very inefficient fins for conventional swimming (Ashley-Ross, 2002). The size of the area occupied by a pair of short-snouted seahorses tagged in Studland Bay, Dorset, was 7m by 29m (Garrick-Maidment *et al.*, 2011), which suggests that swimming distances under 30m are within the capabilities of this species. Seahorses may therefore be able to escape areas of lethal effect (up to 10m, for all piling scenarios) and for physical injury for the 1.53m and 2.6m pin piles (25-40m). However, the larger (65m) impact area for physical injury for the 6.5m monopile may result in injury to seahorses before they are able to escape (although maximum blow energies will not be

used until some time after the commencement of piling, if at all). This impact is considered to be most applicable to the winter months when seahorses are in deeper water in the offshore wind farm, as seahorses are considered more likely to be in shallower inshore waters outside of the wind farm (and therefore not exposed to lethal/physical injury levels) for breeding in summer. In summary, seahorses may therefore be exposed to harmful levels of noise during piling of 6.5m monopiles in winter months. This impact is considered to be of moderate or minor significance (high sensitivity of seahorses, and small magnitude of impact limited to 65m from source within the development (with a maximum number of 95 monopiles of 6.5m diameter), taking into account the restricted range of seahorses). However, the significance of the impact could be considerably reduced (or even removed) if piling operations were limited to the use of smaller piles for some of the winter months (see Section 8.6.4). As noted above, seahorses are more likely to be able to flee over the smaller distances of potential injury associated with these smaller piles.

- 8.5.16 For other small fish unable to escape harmful noise levels even with a 'soft start', the overall significance of impact is considered to be negligible, based on low-medium sensitivity (i.e. common and abundant non-commercial species, and common commercial species) and negligible magnitude (short-term impact confined to the windfarm, impacting widespread/abundant species).

dBht species results (auditory injury, and strong and significant avoidance reaction)

Herring

- 8.5.17 Herring (along with cod) is the fish species modelled in this study with the greatest spatial extent of potential impact from noise.
- 8.5.18 For 130dBht (auditory injury), herring may suffer hearing injury up to 120m (1.53m pin pile) and 510m (6.5m monopile) away. As herring are active pelagic fish, and as soft start procedures will be used, a worst-case impact will be of minor significance.
- 8.5.19 Maximum predicted impact range for 90 dB_{ht} (strong avoidance) and 75 dB_{ht} (significant avoidance) is 38.5km and 81.2km respectively, for the installation of a 6.5m monopile in the east of the Offshore Array. Maximum distances for strong herring avoidance for 1.53m pin piles are approximately half that of 6.5m monopiles.
- 8.5.20 Figure 8.5 presents contour plots for herring showing estimated 130, 90 and 75dBht impact ranges.
- 8.5.21 As presented in Figure 8.5, it can be seen that:
- The 90 dB_{ht} (strong avoidance) impact zone for the 6.5m monopile extends into offshore waters of the Channel. The southernmost margins of this zone

extend into the northern edges of areas of 'high larval density' (Ellis *et al.*, 2012). The impact zone for this worst-case scenario does not extend into the bulk of high larval density areas, or those areas formerly identified as 'spawning grounds' (Coull *et al.*, 1998). For the 1.53m pin pile, impact areas are considerably less, and do not extend into either high larval density areas or 'herring spawning areas'.

- The 75dB_{ht} (significant avoidance) impact zone for the 6.5m monopile is large and extends beyond mid-Channel towards France. Both the east and west positions modelled encompass large areas of both high larval density; the impact zone for the eastern scenario extends into 'herring spawning grounds'. For the 1.53m pin pile, impact areas extend into the northern margins of high larval density.

8.5.22 Based on the known life history of the Downs stock of herring, piling noise will not directly impact adults and juveniles when they are resident in the North Sea for the majority of the year. However, unmitigated piling noise does have the potential to impact adults from when they enter the eastern English Channel in around November, during spawning here, and immediately after spawning (November-January).

8.5.23 Based on a worst-case scenario of 6.5m monopile, high sensitivity (critical life history constraints; NB this would be lowered to medium if piling was restricted during the peak spawning period) and large magnitude (impacts not limited to areas within the development, and impacting spawning; this could be lowered to medium if piling was restricted during the peak spawning period) unmitigated piling noise could therefore result in an impact of major significance.

Shad

8.5.24 For 130dB_{ht} (auditory injury), shad may suffer hearing injury in a relatively small zone up to 20m (1.53m pin pile) or 60m (6.5m monopile) away from the noise source. As shad are active pelagic fish, and as soft start procedures will be used, a worst-case impact will be of minor significance.

8.5.25 Figures showing modelled noise scenarios for shad are presented in Appendix 8.6. Results can be summarised as follows: the 90 dB_{ht} (strong avoidance) maximum impact zone is relatively small, and varies from 1km (1.53m pin pile) to 2km (6.5m monopile). For the 75 dB_{ht}, maximum impact zones are from ~6km (1.53m pin pile) to 11km (6.5m monopile).

8.5.26 Unmitigated impacts to shad (given high sensitivity, as Annex II species) from strong/significant avoidance are assessed as minor, given worst-case magnitude of small (i.e. short-term impact with rapid recovery, mostly limited to within the development).

Cod (including similar species whiting, pouting, coalfish and pollack)

8.5.27 Cod (and similar species) are sensitive to noise, with the areal extent of avoidance responses similar to those for herring.

8.5.28 For 130dB_{ht} (auditory injury), cod may suffer hearing injury up to 50m (1.53m pin pile) and 450m (6.5m monopile) away. As cod are active and relatively large demersal fish, and as soft start procedures will be used, a worst-case impact will be of negligible significance (based on medium sensitivity – i.e. a common and widespread commercial species; negligible magnitude).

8.5.29 As presented in Figure 8.6, it can be seen that:

- The 90dB_{ht} (strong avoidance) impact zone for the 6.5m monopile extends for a diameter up to ~80km, nearing mid-Channel. The eastern scenario extends all the way inshore, and along approximately 30km of coast. For the 1.53m pin pile, impact areas are considerably less and although still reasonably large (~10km from source) these do not extend to the shoreline.
- The 75dB_{ht} (significant avoidance) impact zone for the 6.5m monopile extends beyond mid-Channel towards France, and westwards nearly to the same longitude as the Isle of Wight; the zone also extends along the Sussex coastline for up to ~50km. For the 1.53m pin pile, impact areas extend offshore and span inshore, affecting up to ~30km of coast.

8.5.30 As noted in Figure 8.1b, cod spawning is thought to be of 'low intensity' both in the project area and for a very large area encompassing much of the eastern English Channel and North Sea. The nearest known high intensity spawning location for cod is in the outer Bristol Channel (Ellis *et al.*, 2012). Unmitigated impacts to cod (including similar species), given medium sensitivity (i.e. a widespread commercial species), from strong/significant avoidance are assessed as moderate-minor, given worst-case magnitude of small-medium (i.e. impacts occurring outside the development, but mitigated by no known areas of spawning importance nearby, temporary/intermittent nature of noise, and rapid recovery after cessation of piling).

Seahorse (and species with similar audiograms, i.e. mackerel, horse mackerel)

8.5.31 For 130dB_{ht} (auditory injury), seahorses may suffer hearing injury up to 20m (1.53m pin pile) and 60m (6.5m monopile) away from the noise source. Given these distances are similar to those for physical injury to this species noted above, impacts are considered to be moderate-minor overall. For highly mobile mackerel and horse mackerel with lower (medium) sensitivity, impacts will be negligible.

8.5.32 Figure 8.7 presents contour plots for seahorses showing estimated 130, 90 and 75dB_{ht} impact ranges. Figure 8.7a and 8.7b present results for 6.5m and 1.53m piles respectively. Figure 8.7 shows that:

- The 90 dBht (strong avoidance) impact zone between 2km (1.53m pin pile), and up to 10.4km (6.5m monopile) away from source. Modelling results suggest that a strong avoidance reaction zone for the worst-case scenario (6.5m monopile) would stretch across a large area of the wind farm site. This could result in seahorses being excluded from areas of up to 20km in diameter (extending up to ~10km from the wind farm boundary) for the duration of piling works (6.5m monopile scenario). This displacement could result in movement of seahorses to sub-optimal habitat. For the 1.53m pin pile, areas of impact are considerably less, with much smaller areas of strong avoidance of 2-2.6km.
- The worst-case significant avoidance (75 dB_{ht}) reaction zone (6.5m monopile) of up to 40km extends from the wind farm site across the entire inshore area to the coast, and out nearly to the central English Channel. For the 1.53m pin pile, significant avoidance distances would also be less (8.7-18.6km) and would not extend completely to the coast.

8.5.33 Unmitigated impacts to seahorses (given high sensitivity as a Wildlife & Countryside Act/BAP/MCZ FOCI species) from strong/significant avoidance are assessed as between major and minor, given worst-case magnitude of medium-small (i.e. impacts outside the development, but temporary/intermittent and over the short-medium term).

Bass (including wrasse)

8.5.34 For 130dBht (auditory injury), bass may suffer hearing injury up to 20m (1.53m pin pile) and 60m (6.5 m monopile) away from source. Bass are active demersal fish and given soft-start, worst-case impacts will be of negligible significance (medium sensitivity as common but commercially important fish, negligible magnitude).

8.5.35 Figure 8.8 presents contour plots for bass showing estimated 130, 90 and 75dBht impact ranges:

- The 90dBht (strong avoidance) impact zone is relatively small, between 1km (1.53m pin pile), and up to 4km (6.5m monopile) away from source. This impact would largely be contained within the boundaries of the wind farm.
- For significant avoidance (75dB_{ht}) the reaction distance is between 7.5km (1.53m pin pile), and 22.7km (6.5m monopile), the latter of which may extend to the coast.

8.5.36 For bass, worst-case unmitigated impacts from strong/significant avoidance of piling noise are predicted as moderate-minor, given medium sensitivity and small-medium magnitude (i.e. impacts largely limited to within/adjacent to the development, but temporary/intermittent).

Black bream

8.5.37 As noted above, no audiogram was available for this species. Noise modelling is based on an audiogram of a very similar species (red bream), and results should therefore be treated as tentative.

8.5.38 Auditory damage (130dB_{ht}) could occur in this species between up to 20m (1.53m pin pile) or 50m (6.5m monopile) away, and therefore not extend out of the wind farm zone (or into Kingmere rMCZ) or into shallow water <10m deep, which is preferred black bream nesting habitat. Given soft-start piling and the mobile nature of this species, it is unlikely that any individuals would be exposed to dangerous noise levels. Worst-case impact significance is therefore considered to be minor (high sensitivity as a nationally important population/having critical life history requirements/component of Kingmere rMCZ; negligible magnitude restricted to a very small area).

8.5.39 Figure 8.9 presents contour plots for black bream showing estimated 130, 90 and 75dB_{ht} impact ranges: Figure 8.9a and 8.9b present results for 6.5m and 1.53m piles respectively, summarised below:

- The 90dB_{ht} (strong avoidance) impact zone (6.5m monopile):
 - For the westernmost turbine location, this zone would extend into the south-eastern portion of the Kingmere rMCZ, but not significantly into water less than 10m deep (which is thought to be optimal black bream nesting depth).
 - For the easternmost turbine location, this zone (6.5m monopile) does not extend into either Kingmere rMCZ or water <10m;
- The significant avoidance (75 dB_{ht}) impact zone (6.5m monopile):
 - For the western location, this completely covers the inshore zone to the coast, including the entire rMCZ and a large area of the <10m contour;
 - For the eastern location, the zone only abuts the southeastern margin of the rMCZ, and covers a much smaller area of shallow water.

8.5.40 For the 1.53m pin pile, results are notably different. Even for the western location the strong avoidance (90dB_{ht}) impact zone does not extend into Kingmere rMCZ or water <10m. The significant avoidance (75dB_{ht}) zone for the western location does extend across around half of Kingmere rMCZ, and a relatively small area of water <10m.

8.5.41 These data suggest that unmitigated piling noise creates the potential for black bream individuals (particularly adults associated with spawning) to be displaced from nests/suitable nesting habitat, and out of the rMCZ with implications for both the species and its nature conservation aspects (Kingmere rMCZ).

- 8.5.42 Worst-case unmitigated impacts (i.e. with unrestricted piling during spawning; NB this would be lowered to medium if restrictions were applied during the peak spawning period) for black bream from strong/significant avoidance of piling noise could therefore be major, given high sensitivity and large magnitude (conservation designation, in this case Kingmere rMCZ, is compromised; NB this would also be lowered to medium if restrictions were applied during the peak spawning period, giving an overall moderate impact).

Sandeel

- 8.5.43 In general, sandeel are not sensitive to noise, with 130dB_{ht} (auditory injury) impact zones of <5m. Given low sensitivity (i.e. abundant and widespread non-commercial species) and negligible magnitude, overall impact from auditory injury is considered negligible.
- 8.5.44 Figures showing modelled noise scenarios for sandeel are presented in Appendix 8.6. In summary maximum impact zones for the worst-case (6.5m monopile) for 90dB_{ht} (strong avoidance) are small (maximum of 300m), with significant avoidance (75dB_{ht}) up to 2.6km.
- 8.5.45 For sandeel, overall unmitigated impacts from strong/significant avoidance of piling noise is assessed as negligible, given worst-case magnitude of negligible (i.e. short-term impact with rapid recovery, limited to within the development).

Dab (including other flatfish, and eels)

- 8.5.46 For 130dB_{ht} (auditory injury), dab may suffer hearing injury up to 20m (1.53m pin pile) and 90m (6.5m monopile) away from source. Dab are capable of strong swimming (at least for limited distances) and given soft-start, worst-case impacts will be of negligible significance, based on negligible magnitude. Sensitivity is considered to be medium, as although dab are not particularly valuable to commercial fisheries locally, several other flatfish species are of higher value (sole, plaice, lemon sole, brill, turbot).
- 8.5.47 Figure 8.10 presents contour plots for dab showing estimated 130, 90 and 75dB_{ht} impact ranges:
- The 90dB_{ht} (strong avoidance) impact zone is up to 9.4km for the 6.5m monopile, but considerably less for the 1.53m pin pile (0.9km).
 - For significant avoidance (75dB_{ht}) the reaction zone is 36.9km for the 6.5m monopile, which extends to and along a considerable portion of coastline (up to ~30km). Again, the impact area is considerably less for the 1.53m pin pile (6.1km maximum).
- 8.5.48 For dab, worst-case unmitigated impacts from strong/significant avoidance of piling noise are predicted as moderate-minor, given medium sensitivity and

small-medium magnitude (i.e. impacts largely limited to within/adjacent to the Offshore Project, but temporary/intermittent).

- 8.5.49 Plaice (which are thought to be likely to have a similar reaction to dab) are reported as having 'high-intensity' spawning in the broader offshore area at least 15km south of the Offshore Project boundary (see Figure 8.1a; based on Figure 30a in Ellis *et al.*, 2012). High intensity spawning areas for plaice are reported to cover much of the eastern English Channel and southern North Sea (Ellis *et al.*, 2012). The high intensity classification of rectangular grids south of the site appears to be based on relatively high egg concentrations that broadly follow the England-France median line in mid-Channel. For the worst-case 6.5m monopile scenarios for dab (=plaice), none of the 'strong avoidance' reaction areas (nor any of the significant avoidance areas for piling the westernmost turbine) approach this line. Additionally, none of the significant avoidance reaction zone for piling the easternmost 6.5m monopile extends to the median line, although some of the southern part of this does extend into the broader high intensity rectangle. Worst-case unmitigated impacts from strong/significant avoidance of piling noise to plaice are therefore also predicted as moderate-minor, given medium sensitivity (widespread commercial species) and medium-small magnitude (i.e. impacts occurring outside the development, but mitigated by minor extent of noise impacts to widespread spawning areas nearby, temporary/intermittent nature of noise, and rapid recovery after cessation of piling).
- 8.5.50 As presented in Figure 8.1a, Dover sole (which are also thought to be likely to have a similar reaction to dab) are reported as having 'high-intensity' spawning in inshore areas of the English Channel coast, encompassing the Offshore Project Site (see Figure 8.1a; based on Figure 32a in Ellis *et al.*, 2012). High intensity spawning areas for Dover sole are reported from much of the coast of southeastern England (Ellis *et al.*, 2012). Worst-case unmitigated impacts from strong/significant avoidance of piling noise to Dover sole are therefore also predicted as moderate, given medium sensitivity (widespread commercial species) and medium magnitude (i.e. impacts over the medium and short term occurring outside the development, but mitigated by the minor extent of noise impacts to widespread spawning areas nearby, temporary/intermittent nature of noise, and rapid recovery after cessation of piling).

Seabed disturbance

- 8.5.51 The majority of fish will be able to avoid these impacts due to their mobile nature. However, some construction activities (particularly on the seabed) may have the potential to affect some fish and shellfish receptors in the following ways:
- Direct mortality or injury as a result of the placement, burial or retrieval of infrastructure and equipment on the seabed (e.g. turbine foundations, rock armour, jack up vessel spud can footprint, cables, anchors). This has the potential to cause:

- Damage/destruction of active black bream nests from export cable installation (particularly as nesting activity has been recorded from much of the width of the corridor near the 10m depth contour): The worst-case significance of this unmitigated impact significance could be major/moderate, based on high sensitivity (nationally important populations with critical life history constraints) and a medium-small magnitude (i.e. may affect population and habitat, but impacts are limited to within the development);
- Mortality of seahorses (highly limited in their mobility): The worst-case significance of this unmitigated impact would be moderate, based on high sensitivity and a small magnitude (i.e. may reduce population or habitat, but limited to within the range of natural variability);
- Mortality of individuals (including their eggs or egg cases) of species that are limited in their ability to move. These could be commercially important (e.g. crab – especially buried females; lobster; scallops; whelk and their eggs; cuttlefish eggs; egg case of catsharks and rays) or BAP species (e.g. undulate ray egg cases; native oyster; mussels). The overall impact is predicted as minor, based on medium sensitivity receptors (i.e. commercially important species that are otherwise widely distributed; or species of conservation interest, but not legally protected or as part of a designated site) and small magnitude (disturbance within the range of natural variability);
- Mortality of widespread, abundant and non-commercial fish and shellfish species of limited mobility (e.g. gobies, squat lobsters); impact significance is considered negligible (low sensitivity; small magnitude of impact).
- Temporarily increased suspended sediment (e.g. from turbine foundation installation, cable burial) could potentially result in impacts to fish and shellfish. However, most species will be tolerant of naturally high background levels, and/or mobile enough to leave an affected area. The few available MarLIN assessments of fish sensitivity (i.e. a skate species, two goby species and seahorses) to suspended sediment report either a 'very low' sensitivity, or that this impact is 'not relevant' to the species in question (MarLIN, 2012, various). There was no evidence of black bream nests being impacted from suspended sediment from nearby aggregate extraction work (Emu, 2012). Similarly, a number of shellfish species (including brown crab, brown shrimp, a swimming crab, king scallop, and cuttlefish) are reported as ranging from 'not sensitive' to 'low' sensitivity (MarLIN, 2012, various). Overall impact significance is therefore considered negligible (low sensitivity; negligible temporary magnitude of impact).

Operation

8.5.52 Potential impacts to fish and shellfish from operation of the Offshore Project may originate from three main sources:

Presence of seabed infrastructure

8.5.53 The presence of turbine foundations, rock armour/scour protection, and cable mattressing (where appropriate) will result in a limited but permanent change in the character of the seabed and water column in the Offshore Project site. This has the potential to impact fish and shellfish species in the following ways:

- Permanent loss of seabed areas used for feeding, breeding or shelter by fish or shellfish. This impact would be more significant for any species that are particularly reliant on certain seabed features (e.g. black bream, seahorses). However, given that the total area impacted will be very small (see Section 2a – offshore Project Description for estimates of seabed habitat loss from placement of scour protection) and similar habitat will be available elsewhere locally, this impact is considered to be not significant for most species. Black bream nests are generally associated with a thin veneer of sediment over hard bedrock. This is a seabed type that, for engineering reasons, will be avoided by the cable route. However, if it is necessary to route the cable across this habitat type, concrete mattressing may be required, in which case it is possible that some areas of seabed suitable for black bream nests will be permanently lost. The spatial extent of this will however be limited, to i) only areas that require mattressing ii) the width of any cable mattressing iii) the water depth range where local black bream nests are known to occur in their highest concentrations (approximately 4.5m to around 10m; Emu, 2012). The significance of this impact is considered to be moderate, based on the sensitivity of the most sensitive receptor (seahorses: high) and small magnitude (some degradation, but limited to within the development).
- Permanent addition of features either to the seabed (e.g. turbine foundation; foundation armour/scour protection; cable protection) or to the water column (turbine shaft) (see Section 2a – Offshore Project Description for estimates of seabed habitat loss). Fish and shellfish are known to associate with man-made objects, especially in areas of otherwise uniform habitat, as this may offer benefits in terms of shelter from predation and currents, as well as feeding opportunities. Studies in Swedish waters on artificial structures in the water column showed that abundance and diversity of fish was greater than on the adjacent soft bottom around a year or less after installation (Andersson *et al.*, 2009). Seven years after the installation of wind turbine foundations in the Baltic Sea, high numbers of gobies were found to be associated with the structures (Andersson & Ohman, 2010). However, it is not entirely clear whether association of fish/shellfish with artificial features is due to an actual increase in fish locally or simply aggregation of existing organisms into a concentrated area. Species that are particularly known to associate with artificial features or outcrops/reefs include commercially

important bass, pollack, lobster and edible crab; non-commercial wrasse and pouting; and small fish, including gobies and the fry of larger species. Overall, this impact is considered to be of moderate impact (based on medium sensitivity of commercial species being affected) and medium magnitude (availability of habitats changed).

- It should be noted that the presence of seabed infrastructure may provide habitat for, and even enhance, seahorse populations. Seahorses are known to frequent artificial habitat, including man-made objects and marinas (Garrick-Maidment, 2011), gas platforms (Fabi *et al.*, 2002), and jetty piles and piers (Foster and Vincent, 2004). Artificial structures can harbour high densities of seahorses (Foster and Vincent, 2004); field experiments elsewhere have shown that by increasing the structural complexity of artificial habitats, higher abundances of seahorses were supported (Hellyer *et al.*, 2011)
- A possible 'barrier effect' was raised as a concern by commercial fisheries consultees. This concern noted that the presence of the Rampion development in the broad bay extending from Selsey Bill to Beachy Head might impede or alter seasonal migrations of commercially important species into the area. Additionally, there were concerns that the presence of raised objects on the seabed (e.g. mattresses of cables) might prevent natural movement of flatfish. While there have been no studies specifically to examine this, it is not an issue that has been identified from existing wind farms, or raised by statutory consultees.

Electromagnetic fields (EMF)

8.5.54 Electromagnetic fields emitted from inter-array and export cables during the operational phase may have the potential to affect some fish and shellfish species, particularly those that are known to be electrosensitive and/or magnetosensitive. In the Project site, these include:

- Bivalve molluscs (e.g. scallops, oysters, and mussels);
- Crustaceans (e.g. lobster, crabs and prawns);
- Lampreys (e.g. sea lamprey, river lamprey);
- Elasmobranchs (e.g. small spotted catshark, undulate ray);
- Eels (European eel);
- Salmon and sea trout;
- Cod family (e.g. cod, whiting, coalfish, pollack, ling); and
- Plaice family (e.g. plaice, dab, flounder).

8.5.55 However, it is widely acknowledged that there are significant gaps in the existing scientific knowledge of the effects of subsea power cables (either single or within a network) on marine biota (Normandeau *et al.*, 2011), making assessment of potential impacts difficult at present. Furthermore, while some studies have demonstrated direct responses by marine fauna to subsea power cables (e.g. Gill *et al.*, 2009) the question of whether these responses have any implications or negative impacts at the population or ecosystem level has not been addressed (Normandeau *et al.*, 2011) and is therefore not known.

8.5.56 Once installed, there will be the following lengths of operational cable that have the potential to emit EMF, all cables are likely to operate using AC:

- Export cable: total maximum length of 92km (comprising 4 cables of up to 23km in length) of between 132kV and up to 220kV; and
- Inter-array cable network: maximum length of 230km at a likely operating voltage of 33kV, but up to 66kV.

Shellfish

8.5.57 Several groups of benthic invertebrates including crustaceans (lobsters, crab, isopods, amphipods), gastropods and bivalve molluscs are known to be sensitive to electric and/or magnetic fields (Normandeau *et al.*, 2011; Wilson & Woodruff, 2011). However, any effect of anthropogenic EMF on them is poorly understood and no direct evidence of impacts to invertebrates from undersea cable EMF exists (Normandeau *et al.*, 2011). Electrosensitive invertebrate species that have had their sensitivity thresholds identified were predicted as not being impacted by fields from undersea cables, although it was acknowledged that magnetosensitive species could be affected in close proximity to certain cable systems (Normandeau *et al.*, 2011). Preliminary work has suggested that EMF may cause behavioural changes in a species of crab under experimental conditions (Wilson & Woodruff, 2011), and theoretical work has suggested that the magnetic field from an AC cable might be detectable to a species of marine crayfish (similar to a lobster), which could potentially affect their orientation and/or navigation (Normandeau *et al.*, 2011). However, a separate study reported that no significant change to benthic communities after installation and operation of a buried HVDC cable in the Baltic Sea, with the authors concluding that EMF was not a detectable source of impact (Andrulewicz *et al.*, 2003).

8.5.58 In summary, potential impacts to shellfish are assessed conservatively as being of minor impact. This is based on the theoretical sensitivity of the most sensitive receptor (i.e. lobster, a commercial species and therefore of 'medium' sensitivity), combined with a 'minor' magnitude (i.e. limited to within the development).

Fish

8.5.59 Elasmobranchs, especially demersal species, are well known to be highly sensitive to EMF. Other fish species that are thought to be sensitive to EMF include lampreys, eels, salmonids and plaice (Gill *et al.*, 2009; Normandeau *et al.*, 2011). Two studies of note in reporting responses (NB not impacts) in fish to subsea power cables:

- **Elasmobranchs:**

- Experimental studies were conducted as part of Collaborative Offshore Wind Research into the Environment (COWRIE) research to determine whether elasmobranchs respond to the type of EMF likely to be transmitted by offshore wind farm cables. Principally, the study examined the spatial distribution of two species of benthic elasmobranch in large pens, or mesocosms, in response to the activation of a buried cable. In summary, the study found that the distribution of elasmobranchs could be significantly altered, although responses were variable between both species and individuals and were not predictable and did not always occur. For instance, while significantly greater numbers of the small spotted catshark were recorded near the cable when it was activated, this was not the case for thornback ray, although it was suggested that thornback rays encountering an active cable increased their movement response. It should be noted that the mesocosms study was the first of its kind anywhere in the world that aimed to determine if EMF could be detected, hence it was not intended to provide any evidence for either positive or negative effects on elasmobranchs, as these require different approaches (Gill *et al.*, 2009). In addition to the experimental work, Gill *et al.*, (2009) measured EMF in the field above cable landfalls from two operational wind farms. Based on these measurements, and the results of the experimental work, it was predicted that the elasmobranchs studied could potentially detect the active cables at a distance of 295m.
- A preliminary experimental study has also found that embryos of thornback ray can detect EMF while still in the egg case and in an early stage of development (Ball, 2007). Other experimental research with a similar species has also demonstrated that tail movements by the embryo that ventilate the egg case 'freeze' when the embryo detects a weak electrical field, which is thought to be an anti-predator response (Sisneros *et al.*, 1998). While caution is required in interpreting these findings and their relevance to the marine environment, it is possible that EMF from buried cables could impact with eggcases of elasmobranchs on the seabed by modifying behaviour of embryos. However, as with the studies for free-

swimming individuals noted above, it is not possible to determine whether these effects may be negative.

- **Eels:** A study in the Baltic Sea using tagged migrating European eels reported that swimming speed was significantly lower around a buried subsea 130kV AC cable (Westerberg and Lagenfelt, 2008).

8.5.60 For salmonids (i.e. salmon and sea trout), modelling suggested that this group might be able to detect magnetic fields from an AC power cable within several metres of the seabed. However, the pelagic swimming mode of salmonids in the water column was considered to make exposure to EMF unlikely although this would be a function of water depth; in shallow coastal waters the chances of encounter would be increased (Gill *et al.*, in prep.). In addition, no disruption to individuals on migration due to local disruption of geomagnetic fields was expected, as salmonids rely on a range of senses to migrate (Normandeau *et al.*, 2011).

8.5.61 For fish, the significance of the potential unmitigated impact is considered to be moderate, based on the most receptor with the highest sensitivity (i.e. undulate ray; 'High' as a BAP species), and the anticipated 'small' magnitude of the direct impact (i.e. limited to within the development).

Temperature

8.5.62 There may be the potential for active export and inter-array cables to emit heat into the surrounding environment, which will support shellfish and benthic fish communities. However, the NPS notes that for offshore export cables that are armored and buried at a sufficient depth to minimise heat effects; the effects of heat on sensitive species from cable infrastructure during operation are unlikely to be a reason for the IPC to refuse to grant consent for a development. As such, these are not considered further here as a potential impact to fish and shellfish communities.

Noise and vibration

8.5.63 Preliminary studies at operational wind farms off the Swedish coast have found that noise emitted by working turbines is detectable by fish at several kilometres, and is audible above that of commercial shipping traffic. Noise consists of lower frequencies tones from the turbines, and a higher frequency noise transmitted from the gearbox down to the foundations. While some agitation was observed in some species (such as eels), further studies are needed to determine whether or not the increased level of noise in the area of the wind farm has an adverse effect on fish (Andersson *et al.*, 2011; FOI, 2011). Given the uncertain nature of these preliminary findings, this impact is not considered further here.

Decommissioning

8.5.64 After the operational life of the development it will be decommissioned. Activities carried out during this phase of the development, resulting in potential impacts to fish and shellfish may include the following:

- Removal of foundations (e.g. by cutting) prior to removal for onshore processing, which may result in limited mortality of some shellfish or small fish living on the foundations, and a permanent loss of artificial habitat;
- Possible partial excavation of the seabed to allow e.g. cable cutting. This may result in localised, temporary mortality/injury/displacement of benthic fish and shellfish;
- Scour protection materials would be left in place, providing permanent artificial habitat;
- Cables that are not buried will be removed, using a water jetter or similar technology. This would result in similar impacts to that for cable installation, i.e. localised, temporary mortality/injury/displacement of benthic fish and shellfish. However, the extent would be more limited as only exposed cable would be removed.

8.6 Mitigation Measures

8.6.1 Proposed mitigation measures, and residual impacts, are summarized in Table 8-8.

During Construction

Noise and vibration

8.6.2 To mitigate the effects of piling noise on fish, all piling will be subject to a 'soft start' procedure, where operations commence with impulses of a reduced intensity and/or frequency, and are then gradually increased to maximum capacity. This allows nearby mobile organisms (including fish) to leave the area where there is the greatest potential for injury or significant behavioural responses. The impact of piling noise will also be mitigated in that it will be temporary, taking place only in suitable weather, and limited to the construction period.

8.6.3 Noise modelling indicates that there may be a requirement for seasonal and/or spatial restrictions on piling to minimise impacts on fish species as follows:

- **Herring:** monopiles will create noise levels that could disturb herring in their spawning areas during their spawning period. However, installation of smaller piles in the west of the wind farm during this time only affects a small part of the wide spawning area. Applying a peak spawning period restriction

to allow only the installation of smaller piles towards the west of the project site would mitigate potential impacts on spawning herring.

- **Black bream:** During the spawning period for black bream, installation of monopiles in the western part of the project site will create levels of noise that are likely to disturb this species within the Kingmere rMCZ. However, the same is not the case for installation of monopiles to the east of the site where modelling shows a reduced impingement of the 75dBht contour into the Kingmere site. In addition, installation of smaller piles in the east of the site is predicted to have no impingement of the 75dBht contour into the Kingmere rMCZ, or shallow areas around the 10m depth contour.
- **Dover sole:** this species presents a similar situation to black bream with installation of monopiles anywhere in the project site likely to create noise levels that extend over their spawning area. However, installation of smaller piles creates a much smaller, highly localised area within which impacts could occur.

8.6.4 The restrictions to piling which may be imposed as a mitigation measure to protect spawning herring will also reduce the magnitude of impacts to seahorses that are likely to be present in and around the Project site during the winter months. Furthermore the restrictions in place for black bream and Dover sole will also serve to reduce impacts on seahorses either in, or moving back into, shallower coastal waters in spring/early summer.

8.6.5 The above restrictions may also result in reduced levels of impact to other fish species which are present in and around the project site, particularly during key life history stages.

8.6.6 The periods of geographical restrictions applicable to the installation of certain pile sizes will be subject to further study post-submission of the ES, after the foundation types to be used are finalised.

Seabed disturbance

8.6.7 All seabed disturbance for the Project will be designed to fit within as small a footprint as is feasible.

8.6.8 The route of the export cable will take into consideration the presence of black bream nesting areas. The location where nests are found will either be avoided by the routeing or installation will take place outside of the nesting season; this latter restriction may also reduce impacts to seahorses breeding in inshore shallow waters.

8.6.9 For mussel beds, a survey of the export cable route will be conducted within a few months before planned construction. Any mussel bed features conforming to 'reef' criteria will be avoided. See Sections 7 (Benthos and sediment quality) and 9 (Nature Conservation) for further details.

During Operation

Presence of seabed infrastructure

- 8.6.10 The requirement for materials (e.g. number of turbines, rock dump, concrete mattresses) that are to be introduced into the marine and intertidal environment will be minimised as far as practically possible. For example, all cabling (intra-array and export) will be buried where possible, to avoid the need for concrete mattresses/ armour.

EMF

- 8.6.11 Adverse impacts to populations or ecosystems in the marine environment from exposure to EMF from subsea cables have not yet been determined (Normandeau *et al.*, 2011). However, a number of cable design factors that minimise or avoid exposure to EMF of marine organisms by subsea power cables were identified by Normandeau *et al.* (2011). These, and their application to the design of the cable systems for the Project, are presented in Table 8-7.

Table 8-7: Cable design factors that reduce or avoid EMF emissions, and their application to the Project

Factor	Rationale	Application to Project
Use of AC rather than DC	Research suggests that marine species are more likely to detect and react to magnetic fields from DC, rather than AC, cables.	AC will be used for both inter-array and export cables.
Current flow	EMF emissions are proportional to current. Higher voltage cable systems allow the same amount of power to be transmitted at a lower current.	Where possible, the final design will select the highest voltage both inter-array and export cables to achieve the required transfer of power.
Cable configuration	Three-phase AC cables located close together produce a lower resultant magnetic field than multiple single-phase cables located further apart.	Three core cabling will be used.
Sheathing/ armouring	Electric fields from AC cables are shielded effectively by metallic sheathing and armouring.	Cables will have integral metallic sheathing and armouring.
Burial depth and additional cable protection	EMF field strength decreases with distance from cables. Magnetic field reduces greatly with burial depth of ≥ 1 m, compared to 0.5m. Cable protection such as concrete mattresses provides additional barrier to EMF by physically increasing receptor separation from cabling.	Target burial depth of inter-array and export cables is 1m. Additional cable protection will be used where required.

- 8.6.12 In addition, the design of the export cable will incorporate two factors that will minimise emission of EMF:

- Minimising the length of cabling used wherever possible, for both inter-array and export cabling used, and using the shortest practical route to shore for the export cables;
- Limiting the export cable corridor to as narrow a corridor as practical to minimise the potential area of influence of any EMF emitted.

8.6.13 These factors will minimise the exposure of marine biota to EMF as far as is practicable.

Noise and vibration

8.6.14 As no adverse impacts to fish populations have been recorded from this source, no mitigation measures are proposed for the operational phase.

During Decommissioning

8.6.15 In advance of decommissioning, impacts to fish and shellfish will be fully considered within an environmental options appraisal and appropriate mitigation measures will be proposed, based on the recognised best practice at the time and consultation with regulatory authorities

8.7 Significance of Residual Effects

8.7.1 Residual impacts, and proposed mitigation measures, are summarized in Table 8-8.

During Construction

Noise and vibration

8.7.2 The significance of impacts presented in the above sections takes account of the standard soft start mitigation measure. Geographic and/or spatial piling restrictions proposed for specific species (e.g. black bream, herring) will result in reduced magnitudes of impact to other species of fish and shellfish, with resultant lower significance of impact.

Seabed disturbance

8.7.3 Avoidance of black bream nests (either by timing outside the nesting season, or micro-routeing of the cable) will reduce impacts from major or moderate (pre-mitigation) to minor. For most other receptors, residual impacts will be minor-negligible, although a worst-case residual impact of moderate significance may occur to seahorses.

During Operation

Presence of seabed infrastructure

- 8.7.4 Magnitude of impact will be large, as the structures will affect receptors continuously over the long term. Sensitivity is medium, as it is likely that some commercial species (such as bass) will have their distribution affected by new structures. This gives a residual significance of impact of major/ moderate, which might either be interpreted as negative (change to the existing ecosystem), or positive (aggregations of recreationally important fish).

Electromagnetic fields (EMF)

- 8.7.5 Residual impacts to shellfish are considered to be of minor significance, while those for fish are considered to be moderate. However, this is a low confidence assessment owing to the paucity of information.

Noise and vibration

- 8.7.6 As no impacts to fish populations have been reported from operational wind farm noise, the residual impact is considered to be negligible.

During Decommissioning

- 8.7.7 Upon decommissioning, appropriate mitigation measures will be proposed as necessary, based on both an assessment of likely impacts and the recognised best practice at the time with the intention of reducing impacts as far as possible. It is likely that impacts during decommissioning will be lower than those experienced during the construction phase.

8.8 Cumulative Impacts

During construction

Seabed disturbance

- 8.8.1 Two aggregate extraction areas in the vicinity of the Project site are in the application process (see section 19 - Other Marine Users). If these are consented and extraction commences during the construction of the Project (e.g. installation of turbine foundations and cables), there is the potential for the resulting suspended sediment to interact and cause cumulative impacts to fish and shellfish, particularly those that use the seabed for spawning. However, as noted in Section 7 - Benthos and Sediment Quality, potential impacts from Project construction are considered to be temporary, localised and minor. In addition, Emu (2012) reported that there was no evidence of black bream nests being impacted by nearby aggregate extraction work. Overall, it is therefore considered that there will be limited scope for cumulative impacts to fish and shellfish from seabed disturbance.

Noise and vibration

- 8.8.2 The planned Navitus Bay offshore wind farm (see section 19 - Other Marine Users) is approximately 94km to the west of the Project site, and it is assumed that at least some of the Navitus Bay turbine foundations will be installed using piling.
- 8.8.3 It is considered unlikely that piling works for both Rampion and Navitus Bay will overlap, with piling for the former expected to be completed prior to commencement of that for the latter. However, the schedules for both projects may change before construction takes place and therefore potential cumulative impacts are considered briefly here. In the unlikely event that turbine installation was to proceed at both developments at the same time, E.ON and the developer of Navitus Bay will take a joint approach to mitigating any cumulative impacts.
- 8.8.4 If unrestricted, worst-case piling in both Rampion and Navitus Bay were to take place simultaneously, it is theoretically possible that fish, through their avoidance reactions, could be displaced from their natural distribution from two different directions. For the most sensitive species, it is also possible that these avoidance zones could join and even overlap. This could create relatively large areas which fish might be displaced from, with potential indirect impacts on seabirds, marine mammals, and commercial fisheries. However, it should be stressed that it is considered extremely unlikely that installation of the piles will be planned to take place at both developments, at the same time. Even if such a scheduling situation does arise, the developers will work together to mitigate cumulative impacts.
- 8.8.5 As noted above, the avoidance reaction zones for some fish species could overlap, while for others they may come close to doing so. Once more project details (such as foundation types and construction schedule) are available for both developments detailed cumulative noise modelling may need to take place. Any results – in the form of avoidance zones – will need to be considered not only in the context of simultaneous piling at both developments, but also in relation to consecutive piling. For example, fish could be displaced from one geographical area during piling at Rampion. If piling at Navitus Bay were to commence shortly after Rampion piling was completed, it is possible there could then be avoidance for prolonged periods. This type of cumulative impact would also be discussed by the developers with regulators in order to reduce cumulative impacts to an acceptable level.

During operation

- 8.8.6 No significant cumulative impacts from the operation of the Project, together with known planned developments, have been identified.

During decommissioning

- 8.8.7 As it is not possible to predict what developments might be taking place during the decommissioning of Rampion, potential cumulative impacts cannot be assessed. These will be considered as part of the decommissioning process.

Table 8-8: Summary of Residual Effects and Mitigation Measures

Aspect	Effect	Proposed Mitigation Measures	Sensitivity	Magnitude	Residual Effect
Construction Phase					
Piling noise: Lethal /physical injury (240/220dBht)	Majority of large/mobile fish & shellfish	Soft, slow start procedure	Low-high	Negligible	Minor-negligible
	Seahorses (winter)		High	Small	Moderate-minor
	Small fish		Low-medium	Negligible	Negligible
Auditory injury (130dBht)	Herring, shad		High	Negligible	Minor
	Cod (and other gadoids)		Medium	Negligible	Negligible
	Seahorse (and mackerel/horse mackerel)		High (mackerels: medium)	Small (mackerels: negligible)	Moderate-minor (lower impacts during piling restrictions) (mackerels: negligible)
	Bass (and wrasse)		Medium	Negligible	Negligible
	Black bream		High	Negligible	Minor
	Sandeel		Low	Negligible	Negligible
	Dab (other flatfish and eels)		Medium	Negligible	Negligible
Strong/significant avoidance (90/75dBht)	Herring	Restriction on piling during the peak spawning season, limiting work to the installation of smaller piles in the western part of the Project Array.	Medium (High with unrestricted piling during spawning)	Medium	Moderate

Aspect	Effect	Proposed Mitigation Measures	Sensitivity	Magnitude	Residual Effect
	Shad		High	Small	Minor
	Cod	Piling restrictions for both herring and black bream during their peak spawning periods will reduce overall impacts to cod in the wider area.	Medium	Medium-Small	Moderate-minor
	Seahorses	Piling restrictions for both herring and black bream during their peak spawning periods will reduce overall impacts to seahorses in the wider area.	High	Medium-small	Major-minor
	Bass	Piling restrictions for black bream during their peak spawning period will reduce overall impacts to bass in the wider area.	Medium	Medium-small	Moderate-minor
	Black bream	Restriction on piling during the peak spawning season, limiting installation of the largest piles to the eastern part of the wind farm site.	Medium (High with unrestricted piling during spawning)	Medium	Moderate
	Sandeel		Low	Negligible	Negligible
	Dab (and similar flatfish (exc. plaice and Dover sole), eels)	Piling restrictions for both herring and black bream during their peak spawning periods will reduce overall impacts to these species in the wider area.	Medium	Small-medium	Moderate-minor
	Plaice	Piling restrictions for herring during their peak spawning period will reduce overall impacts to plaice in the wider area.	Medium	Medium-small	Moderate-minor

Aspect	Effect	Proposed Mitigation Measures	Sensitivity	Magnitude	Residual Effect
	Dover sole	Piling restrictions for black bream during their peak spawning period will reduce overall impacts to this species in the wider area.	Medium	Medium	Moderate
Seabed disturbance from installation of cables, turbine foundations etc	Black bream – damage/destruction of active nests in export cable route corridor	Export cable routed to avoid potential black bream nesting sites, and not to be installed in the peak spawning period if such routing cannot be achieved. Minimise footprint of impacts, where possible.	Medium	Small – negligible (with restriction)	Minor-negligible (with restriction)
	Mortality/injury - seahorses	Minimise footprint of impacts, where possible.	High	Small	Moderate
	Mortality/injury-commercially important and BAP species		Medium	Small	Minor
	Mortality/injury-widespread/abundant non-commercial species		Low	Small	Negligible
	Increased suspended sediment	Minimise footprint of impacts, where possible.	Low	Negligible	Negligible
Operational Phase					
Presence of seabed infrastructure	Permanent loss of seabed habitat.	Minimise footprint of impacts, where possible. Burial of cables as far as possible.	High	Small	Moderate
Presence of seabed infrastructure	Permanent addition of artificial habitat.	Minimise infrastructure to be installed, where possible.	Medium	Medium	Moderate

Aspect	Effect	Proposed Mitigation Measures	Sensitivity	Magnitude	Residual Effect
Emission of electromagnetic fields from export and inter-array cables	Possible changes to behaviour of some fish (particularly elasmobranchs) and shellfish individuals. No known impacts at population level.	Cable design parameters to limit EMF emissions, ensure as far as possible that the cable is buried.	High	Small	Moderate
Decommissioning Phase					
Effects from the decommissioning of the various wind farm components will be subject to a detailed assessment during the decommissioning planning study					

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