23 OFFSHORE TRANSMISSION WORKS FISH AND SHELLFISH ECOLOGY

23.1 INTRODUCTION

1. This Section of the ES evaluates the likely significant effects of the OfTW on fish and shellfish ecology. The assessment has been undertaken by Brown and May Marine Ltd.

2. This section of the ES is supported by the following documents:

- Annex 7B - Assessment of underwater noise during the installation of export power cables at the Beatrice Offshore Wind Farm;
- Annex 11A - Fish and Shellfish Ecology Technical Report;
- Annex 16B - Salmon and Sea Trout Ecology and Fisheries Technical Report; and
- Annex 22A - Cable Route Benthic Technical Report.

3. This Section includes the following elements:

- Assessment Methodology and Significance Criteria;
- Baseline Conditions ;
- Assessment of Potential Effects;
- Mitigation Measures and Residual Effects;
- Summary of Effects;
- Assessment of cumulative effects;
- Habitat Regulations Appraisal;
- Statement of significance; and
- References.

4. The cumulative effects of the OfTW are assessed in Section 11: Fish and Shellfish Ecology which assesses the Fish and Shellfish Ecology effects of the Wind Farm.

23.1.1 POLICY AND PLANS

5. The fish ecology baseline takes into account the following guidelines:

- Strategic Environmental Assessment (SEA) of Draft Plan for Offshore Wind Energy in Scottish Territorial Waters: Volume 1. Environmental Report (Marine Scotland, 2010);
- Habitats Regulations Appraisal of Draft Plan for Offshore Wind Energy in Scottish Territorial Waters. Appropriate Assessment information Review (Marine Scotland, 2011);
- Guidance Note for Environmental Impact Assessment in Respect of the FEPA and CPA Requirements (CEFAS, 2004); and
- Institute of Ecology and Environmental Management (IEEM) Guidance for Ecological Impact Assessment in Britain and Ireland (IEEM, 2010).

23.2 *ASSESSMENT METHODOLOGY AND SIGNIFICANCE CRITERIA*

23.2.1 CONSULTATION

6. Consultation was undertaken with the organisations and individuals listed below. Consultation has been an ongoing process throughout the EIA, and inputs have been included in the baseline and considered in the assessment where appropriate:

- MSS;
- SNH;
- JNCC;
- MSS sandeel specialists: Dr. Simon Greenstreet and Dr. Peter Wright; and
- MSS herring specialist: Emma Hatfield.

7. In the case of salmon and sea trout, additional consultation was undertaken with District Salmon Fishery Boards (DSFBs), stakeholders and their representatives. The full consultation list is provided in Annex 16B: Salmon and Sea Trout Ecology and Fisheries Technical Report.

- Findhorn, Nairn and Lossie Fisheries Trust;
- Cromarty Firth DSFB, Brora DSFB and Cromarty Netsmen;
- Moray Firth Sea Trout Project (MFSTP);
- Ness and Beauly Fisheries Trust, Ness DSFB and Beauly DSFB;
- Kyle of Sutherland and Helmsdale DSFB;
- Spey DSFB;
- Deveron DSFB; and
- Moray and Pentland Firths Salmon Protection Group (MPFSPG).

8. Further to the consultation above, scoping responses were taken into account for the undertaking of the assessment. These are summarised in Table 23.1 below:

Table 23.1 Summary of Consultation Responses

Consultee	Summary of Consultation Response	Team Response
SNH	The following potential impacts on fish and shellfish of conservation concern need to be considered: Smothering effects, construction noise and electromagnetic fields.	Effects due to increased suspended sediment concentrations, sediment re-deposition, noise during construction and electromagnetic fields have been addressed in the assessment.
	The qualifying freshwater fish interests of the following Special Areas of Conservation (SAC) should be considered: Berriedale and Langdale Waters SAC River Evelix SAC River Moriston SAC River Oykel SAC River Spey SAC River Thurso SAC	The qualifying fish and shellfish interests of the specified SACs were considered for assessment. These include Atlantic salmon, sea lamprey and freshwater pearl mussel.
Inshore Fisheries	King scallop should be added to the list of important fish species which have nursery or spawning grounds in the	King scallop and squid have been included for

Consultee	Summary of Consultation Response	Team Response
Group	area of the export cable corridor. The inshore areas of the cable corridor are also important spawning and egg laying areas for squid.	assessment and the potential for areas of the export cable route to be used as a nursery/spawning area has been noted.
	During operation there is potential for EMFs to have some effect on sensitive fish populations both resident and transitory, a group being elasmobranch species which are sensitive to such fields. There is potential for lobster spawning migration to be impacted. In addition the impact on adult and juvenile squid migrations for both spawning when adults are found close to the seabed, and juvenile's recruitment to the fishery, which involves an offshore migration, should be investigated.	The effect of EMFs has been assessed for elasmobranch species, diadromous migratory species and shellfish (including crustaceans and molluscs).
Marine Scotland	Marine Scotland believes that that there is a key nursery ground for cod at the proposed site. The exact patch would need to be investigated as the Moray Firth cod are thought to be a distinct group. There have been high densities of 0-group cod found in the area. Due to the patchy nature of these nursery grounds a finer scale sampling programme is recommended to further advise on relevance of the proposed area for cod. Investigation into noise associated with the cable work should be mentioned with regard to cod. Cod leck use noise during their mating pattern and may be disturbed if this is in a similar range to the noise of the development, or disturbed during breeding (if spawning is thought to occur). Investigation of this would be useful when carrying out the noise survey. Marine Scotland advises that it would be preferable to avoid works during herring spawning periods (Aug-Sep). As the cable route comes south this may be less of an issue as the sediment will be unsuitable for herring spawning as it moves into the muddier sediments associated with the Nephrops grounds. Marine Scotland had identified patches of sandeels in and around the site and proposed routes. Providing a patch is not completely within the cable route then there should be the opportunity for decolonisation of the site. There are records of sandeels off Cullen, and these may be important for wintering seabirds from Shetland There may be some localised disturbance and suspended sedimentation but this should be limited due to the sediments involved.	The potential effects on cod, herring, sandeels and diadromous migratory species, have been addressed in the assessment.
	Diadromous migratory fish: in order that Marine Scotland is able to assess the potential impacts of marine renewable devices on diadromous fish and meet legislative requirements the developer should consider the site location (including proximity to sensitive areas), type of device, and the design of any array plus installation methodology.	The location of the OfTW in relation to sensitive areas (SACs) has been considered in the assessment of effects on diadromous migratory fish.

9. Consultation with the various stakeholders above will continue through the consenting stage and through the development of the OfTW if consented.

23.2.2 SCOPE OF ASSESSMENT

10. For the purposes of the baseline information collection, four main aspects have been taken into account.

- Commercial importance of fish and shellfish species;
- Presence of spawning and nursery grounds;
- Key prey species to sea birds, marine mammals and fish; and
- Presence of species of conservation importance, including migratory species.

11. It should be noted that certain species are relevant within more than one of the aspects given above and as a result, some overlap is to be expected.

12. In addition to providing an assessment of the potential effects on a species/species group basis, an assessment of effects on fish and shellfish species that are qualifying interests in the Special Areas of Conservation (SACs), identified by SNH in their scoping response as requiring consideration (Table 23.1), has been undertaken for each potential effect. The significance of the expected effects on these in terms of conservation objectives is described in the Report to Inform an Appropriate Assessment, and is summarised in Table 23.23.

23.2.2.1 Geographical Scope

13. The study area used for the assessment of fish and shellfish ecology is shown in Figure 23.1. The approach has been to describe an area comprised of the ICES rectangles within which OfTW corridor is located (45E6, 45E7 and 44E6) and adjacent rectangle 44E7. The geographical scope above has been defined taking into account fisheries statistics, which are collated by ICES rectangle. In some instances (i.e. species with spawning and nursery grounds) a wider area is considered for assessment.

14. In the case of diadromous migratory species, given the uncertainties in relation to migratory pathways, the geographical scope of the assessment has been based on the proximity of the OfTW corridor to the rivers, taking account of those which are designated Special Areas of Conservation (SACs) and also providing a national context. Rivers designated as SAC in the Moray Firth and the wider area are also shown in Figure 23.1.

23.2.3 BASELINE COLLECTION METHODOLOGY

15. The principal sources of information used for the collation of the fish and shellfish ecology baseline were as follows.

- MSS publications;
- International Council for the Exploration of the sea (ICES) publications;
- Marine Management Organisation (MMO) landings data;
- SNH publications;
- JNCC publications;
- Centre for Environment, Fisheries and Aquaculture (CEFAS) publications; and

- Other relevant research publications.

23.2.4 ASSESSMENT METHODOLOGY

16. The following section describes the assessment methodology used for evaluation of effects on Fish and Shellfish Ecology.

17. The potential effects considered for assessment are as follows:

23.2.4.1 Direct Effects

- Increased sediment concentrations and sediment re-deposition;
- Noise; and
- Electromagnetic effects.

18. It is recognised that in addition to the above, the installation of the OfTW will result in a loss of habitat and in a creation of new habitat as a result of the introduction of the OfTW infrastructure. This is however expected to be very small (up to 0.26 km^2 considering up to 45% of the cables are protected using mattressing or rock dumping). The potential direct effects associated to habitat loss and indirect effects resulting from introduction of new habitat on fish and shellfish ecology have therefore been scoped out of this assessment. These effects are assessed for benthic communities in Section 22: OfTW Benthic Ecology.

19. The above potential effects will be separately assessed for the construction/decommissioning phases and the operational phase in terms of site specific effects. For the purposes of this assessment and in the absence of detailed information on decommissioning schedules and methodologies, it is assumed that any effects derived from the decommissioning phase will, at worst, be of no greater significance than those derived from the construction phase.

20. A full decommissioning plan will be prepared prior to any decommissioning being undertaken at the site. Outline details of how decommissioning could be undertaken are provided in Section 7: Project Description.

23.2.5 WORST CASE SCENARIO

21. The worst case scenario for the effects of the OfTW upon fish and shellfish ecology has identified the engineering design parameters which may result in the most detrimental effect upon fish and shellfish species.

22. For the installation phase it is considered that the maximum number of cable bundles/trenches will constitute the worst case scenario, as this would result in the greatest footprint, duration and frequency of cable installation operations. The assessment therefore focuses on the AC scenario, where nine cables in three trenches may be installed.

23. For the operational phase, however, both the installation of AC cables and DC cables have been considered, given the uncertainties in relation to species specific sensitivities to electromagnetic fields (EMFs) generated by both cable types.

24. A summary of the worst case scenarios defined for the assessment of effects on fish and shellfish ecology is given in Table 23.2 below.

25. Worst case descriptions are discussed further within the assessment of each effect in the following sections.

Table 23.2 Worst Case Scenario Design Parameters for Assessment of Effects on Fish and Shellfish Ecology

Potential Effect	Scenario
Construction	
Increase in suspended sediment and seabed disturbance	AC cables in 3 trenches
	Cable laying takes approx. 40 days per trench (120 Days in total)
	55% Cable buried and 45% protected
Noise	AC cables in 3 trenches
	1.5 km of cable installed per day
	Operations take place constantly over a 24 hour period.
Operation	
EMFs	AC Cables in 3 Trenches
	Or
	DC cables in 3 trenches
	55 % of cable buried - 45% of cable protected

23.2.6 ASSESSMENT LIMITATIONS

26. Due to the limited current knowledge of the sensitivity of particular species to certain potential effects, in certain instances other species/species groups assumed to have similar sensitivities, and for whom more detailed information is available, have been considered.

27. In addition, as a result of uncertainties in relation to the distribution of some species and the use that they may make of the area of the OfTW corridor, particularly in the case of migratory species, several conservative assumptions have had to be made. Where applied, these are detailed in the following sections.

23.2.7 SIGNIFICANCE CRITERIA

28. The significance of an effect is determined taking account of the magnitude of the effect and the sensitivity of the receptor. The parameters used to define these take account of the IEEM (2010) impact assessment guidelines and are described below.

23.2.7.1 Magnitude of Effect

29. The magnitude of the effect refers to the size or amount of an effect. Magnitude values have been assigned based on the following considerations.

- Extent of effect, referring to the full area over which the effect occurs (e.g. noise effect range);
- Duration of effect, referring to the duration over which the effect is expected to last;
- Frequency of the effect; and

- Reversibility: Irreversible effects are those from which recovery is not possible within a reasonable timescale. Reversible (temporary) are effects from which spontaneous recovery is possible or, for which effective mitigation is both possible and an enforceable commitment has been made.

23.2.7.2 Sensitivity

30. The sensitivity of the receptor is assigned taking account of its degree of adaptability, tolerance and recoverability to the potential effect. In addition the following parameters have been considered.

- Timing of the effect, referring to whether effects are caused during critical life-stages or season (e.g. spawning season, migration); and
- Ecological value, referring to the conservation status of the receptor and importance in the area (e.g. key prey species, species commercially important).

23.2.7.3 Significance

31. The significance of an effect is determined following the matrix below (Table 23.3) as "negligible", "minor", "moderate" or "major". Whether the predicted effect is considered to be "positive" or "negative" is also described. As set out in Section 4: Environmental Impact Assessment Process and Methodology, effects which are of moderate and major significance are considered to be significant in relation to the EIA Regulations, and those of minor and negligible significance are considered to be not significant.

Table 23.3 Effect Assessment Significance Criteria Matrix

Sensitivity or Value of Resources or Receptor	Magnitude of Effect			
	Negligible	**Small**	**Medium**	**Large**
Low	Negligible	Negligible	Minor	Moderate
Medium	Negligible	Minor	Moderate	Major
High	Negligible	Moderate	Major	Major

32. Taking the limitations of the assessment described above and the uncertainties in relation to the relative importance of the area of the OfTW corridor to some species, the probability for each predicted effect to occur has been assessed as "certain", "probable", "unlikely" and "extremely unlikely". The definition of the probability categories used in this assessment is given below as provided in the IEEM (2010) guidelines:

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

23.3 BASELINE CONDITIONS

33. The following section presents a summary of the baseline conditions present within the study area. This is described in further detail in Annex 11A: Fish and Shellfish Ecology Technical Report and Annex 16B: Salmon and Sea Trout Ecology and Fisheries Technical Report.

23.3.1 COMMERCIAL SPECIES

34. The Moray Firth supports several commercial fish and shellfish species. An indication of the relative importance of these in the study area is given in Figure 23.2, based on annual average (2000 to 2009) landings weights (tonnes) by species and ICES rectangle (MMO, 2010).

35. The annual average landings weights (2000 to 2009) by species are shown in Table 23.4 and 23.5 for shellfish and fish species respectively.

Table 23.4 Annual Average Landings Weights (2000-2009) of Principal Commercial Shellfish Species in the Study Area (ICES rectangles 45E6, 45E7, 44E6 and 44E7 combined)

Common Name	Latin Name	Average (2000-2009) Landings Weight (t)	Total Shellfish Landings Weight (%)	Total Landings Weight (all fish and shellfish species combined) (%)
Nephrops (Norway Lobster)	*Nephrops norvegicus*	1,238	34.9%	25.2%
King scallops	*Pecten maximus*	1,235	34.8%	25.2%
Squid	*Loligo forbesi*	522	14.7%	10.6%
Edible Crab	*Cancer pagurus*	237	6.7%	4.8%
Velvet Crab	*Necora puber*	103	2.9%	2.1%
Whelks	*Buccinum undatum*	88	2.5%	1.8%
Mussels	-	71	2.0%	1.4%
Lobsters	*Homarus gammarus*	26	0.7%	0.5%
Razor Clam	-	6	0.2%	0.1%
Cockles	*Cerastoderme edule*	4	0.1%	0.1%
Queen Scallops	*Aequipecten opercularis*	3	0.1%	0.1%
Green Crab	*Carcinus maenas*	3	0.1%	0.1%
Surf Clams	*Spisula solida*	2	0.1%	<0.1%
Octopus	-	2	<0.1%	<0.1%

Common Name	Latin Name	Average (2000-2009) Landings Weight (t)	Total Shellfish Landings Weight (%)	Total Landings Weight (all fish and shellfish species combined) (%)
Other	-	7	0.2%	0.1%

Source: MMO (2010)

Table 23.5 Annual Average Landings Weights (2000-2009) of Principal Commercial Fish Species in the Study Area (ICES rectangles 45E6, 45E7, 44E6 and 44E7 combined)

Common Name	Latin Name	Average (2000-2009) Landings Weight (t)	Total Fish Landings Weight (%)	Total Landings Weight (all fish and shellfish species combined) (%)
Haddock	*Melanogrammus aeglefinus*	800	58.8%	16.3%
Herring	*Clupea harengus*	136	10.0%	2.8%
Monks or Anglers	*Lophius piscatorius/L. budegassa*	127	9.3%	2.6%
Cod	*Gadus morhua*	59	4.3%	1.2%
Whiting	*Merlangius merlangus*	54	4.0%	1.1%
Plaice	*Pleuronectes platessa*	46	3.4%	0.9%
Mackerel	*Scomber scombrus*	22	1.6%	0.5%
Witch	*Glyptocephalus cynoglossus*	14	1.0%	0.3%
Skates and Rays	-	13	0.9%	0.3%
Megrim	*Lepidorhombus whiffiagonis*	13	0.9%	0.3%
Lemon Sole	*Microstomus kitt*	10	0.8%	0.2%
Ling	*Molva molva*	9	0.7%	0.2%
Horse Mackerel	*Trachurus trachurus*	8	0.6%	0.2%
Saithe	*Pollachius virens*	5	0.4%	0.1%
Spurdog	*Squalus acanthias*	5	0.4%	0.1%
Hake	*Merluccius merluccius*	5	0.4%	0.1%
Other	-	32	2.3%	0.6%

Source: MMO 2010

36. The principal shellfish species landed are nephrops, scallops, squid and edible crab. Haddock, herring, monks, cod and whiting account for the majority of the fish landings. The relative importance of each of these species to the total landings weights varies depending on the ICES rectangle under consideration. Nephrops for

example, are of greatest importance in the southern rectangles (44E6 and 44E7). Haddock accounts for a relatively high percentage of the total landings in the majority of rectangles, although the highest values for this species are recorded in rectangles 45E7 and 44E7. Landings for scallops are particularly high in rectangle 45E7.

37. Elasmobranch species (sharks and rays) constitute a very small percentage of the landings weights in the study area being included under the category 'other' in Figure 23.2 and Table 23.5.

38. The distribution and ecology of the principal commercial species in the area is described in Annex 16B: Salmon and Sea Trout Ecology and Fisheries Technical Report.

23.3.2 SPECIES WITH SPAWNING AND NURSERY GROUNDS

39. Spawning and nursery grounds have been defined for several species within and in the vicinity of the OfTW corridor. These are shown in Table 23.6 together with spawning times and intensity of spawning/nursery areas. Spawning times are given as provided in Coull et al (1998) and spawning/nursery grounds intensity as described in Ellis et al (2010).

Table 23.6 Species with Spawning and Nursery Areas within/in the Vicinity to the OfTW Corridor and Spawning Times and Intensity

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

Species	Seasonality of Spawning (Intensity and Peak Spawning *)	Nursery (Intensity)
Thornback Ray	n/a	

Sources: Coull et al (1998), Ellis et al (2010)
Note: Colour Key: (red) = high Intensity Spawning/Nursery Ground, (yellow) = low Intensity Spawning/Nursery Ground, (green) = unknown Intensity, (*) = Peak Spawning

40. The distribution of spawning and nursery grounds of the above species in the Moray Firth and the wider area are illustrated in Figure 23.3 to Figure 23.11.

41. It should be noted that in addition to the species mentioned above, king scallop may also use areas relevant to the OfTW corridor as a spawning and nursery ground. Post-plankton stages of this species are generally associated with coarse sand gravel substrates and bryozoan/hydroid communities.

42. Similarly, squid, also a species supporting important fisheries in the Moray Firth, are known to spawn in inshore areas in autumn/winter, laying eggs which attach to biogenic or manmade structures and surfaces. Fishermen have reported finding squid eggs off Burghead and Buckie in May and June in water depths 5 to 6 m and eggs have also been found on lobster creels shot on hard ground in the Moray Firth (Young et al, 2006).

23.3.3 KEY PREY SPECIES

43. Sandeels, herring and sprat play a key role in the North Sea's food-web, being situated in a mid-trophic position. They are major predators of zooplankton and the principal prey of many top predators such as birds, marine mammals and piscivorous fish.

44. Sandeels are most commonly preyed upon when they are in transit to, or feeding in the water column. They are a key component of the diet of many birds (kittiwakes, razorbills, puffins, common terns, etc), piscean predators such as herring, salmon, sea trout, cod and haddock and marine mammals such as grey seals, harbour porpoises and minke whales.

45. Herring is predated by several fish species (e.g. salmon, sea trout, whiting, cod), seabirds and several marine mammals such as harbour porpoises, bottlenose dolphins, grey seals and common seals. Similarly, sprat is also predated by several fish species, sea birds and marine mammals.

23.3.4 SPECIES OF CONSERVATION IMPORTANCE

46. A number of species of conservation importance are found in the Moray Firth and may therefore transit the OfTW area and/or its vicinity. These include diadromous migratory species, elasmobranchs and commercial fish species.

47. Diadromous migratory species potentially using areas relevant to the OfTW corridor and their conservation status are given in Table 23.7. The distribution and ecology of these is described in detail in Annex 11A: Fish and Shellfish Ecology

Technical Report and Annex 16B: Salmon and Sea Trout Ecology and Fisheries Technical Report.

Table 23.7 Diadromous Migratory Species of Conservation Importance

Common Name	Scientific Name	Conservation Status								
		OSPAR[1]	IUCN[2] Red List	Bern Convention	Habitats Directive	The Wildlife & Countryside Act 1981	The Conservation (Natural Habitats, &c.) Regulations 1994	UK BAP[3] species	Draft Scottish Priority Marine Feature (PMF) (SNH, 2011)	The Nature Conservation (Scotland) Act 2004
European eel	*Anguilla anguilla*	✓	Critically endangered	-	-	-	-	✓	✓	-
Allis shad	*Alosa alosa*	✓	Least concern	✓	✓	✓	✓	✓	-	-
Twaite shad	*Alosa fallax*	-	Least concern	✓	✓	✓	✓	✓	-	-
Sea Lamprey	*Petromyzon marinus*	✓	Least concern	✓	✓	-	-	✓	✓	-
River Lamprey	*Lampetra fluviatilis*	-	Least concern	✓	✓	-	✓	✓	✓	-
Smelt	*Osmerus eperlanus*	-	Least concern	-	-	-	-	✓	✓*	-
Salmon	*Salmo salar*	✓	Lower Risk/least concern	✓	✓	-	✓	✓	✓	-
Sea Trout	*Salmo trutta*	-	Least concern	-	-	-	-	✓	✓	-

(*)= Smelt is due to be added to the SNH PMF list (MS communication, 20/10/2011)

1 OSPAR: Oslo and Paris Convention for the Protection of the Marine Environment of the North-East Atlantic.
2 IUCN: The International Union for Conservation of Nature.
3 BAP: Biodiversity Action Plan.

48. It should be noted that of the diadromous fish species listed above, salmon and sea lamprey, are of conservation interest in a number of SAC rivers in the Moray Firth area.

49. In addition to these, the freshwater pearl mussel is also of conservation interest in a number of river SACs. Given the location of the OfTW relative to the habitat of this species (restricted to freshwater), freshwater pearl mussel populations will not be directly affected by the construction/decommissioning and operation of the OfTW. They could, however, be indirectly affected if significant effects on their host species (e.g. salmon and sea trout) occur.

50. The qualifying status of the fish and shellfish species of conservation interest in the River SACs identified by SNH as requiring assessment is given in Table 23.8.

Table 23.8 Qualifying Status of Species of Conservation Importance in SAC Rivers

SAC Rivers	Primary reason for SAC site selection	Qualifying feature for SAC site selection
Berriedale and Langwell Waters	Atlantic salmon	n/a
River Evelix	Freshwater pearl mussel	n/a
River Moriston	Freshwater pearl mussel	Atlantic salmon
River Oykel	Freshwater pearl mussel	Atlantic salmon
River Spey	Freshwater pearl mussel, sea lamprey, Atlantic salmon	n/a
River Thurso	Atlantic salmon	n/a

Source: JNCC (2011)

51. A description of the ecology and distribution of diadromous species of conservation importance is provided in Annex 11A: Fish and Shellfish Ecology Technical Report, with the exception of salmon and sea trout. The ecology of the latter is described separately in Annex 16B: Salmon and Sea Trout Ecology and Fisheries Technical Report.

52. Elasmobranchs (sharks and rays) have slow growth rates and low reproductive output compared to other species groups. This results in slow rates of stock increase and low resilience to fishing mortality. Directed fisheries have caused stock collapse for many species, although at present, mortality in mixed-species and by-catch fisheries seems to be a more important threat. The distribution and ecology of elasmobranch species in the Moray Firth is described in Annex 11A: Fish and Shellfish Ecology Technical Report.

53. The principal elasmobranch species with conservation status and/or declining stocks, potentially using areas relevant to the OfTW corridor are given in Table 23.9. The distribution and ecology of these is described in Annex 11A: Fish and Shellfish Ecology Technical Report.

Table 23.9 Principal Elasmobranch Species of Conservation Importance

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

54. In addition to the diadromous migratory species and elasmobranchs mentioned above, there are a number of other fish species with conservation status. The majority of these are commercially exploited in the Moray Firth having been recorded in landings data (2000-2009) within the study area. These are given in Table 23.10.

Table 23.10 Other Fish Species of Conservation Importance

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

23.4 ASSESSMENT OF POTENTIAL EFFECTS

55. The following section details the predicted effects from the construction/ decommissioning and operational phases of the OfTW on fish and shellfish ecology. Effects are expected to vary, depending on species specific sensitivities, life stage under consideration (eggs, larvae, juveniles and adults) and the use that particular species make of the area and of seasonal variations (e.g. spawning or nursery grounds, feeding grounds, migration routes).

23.4.1 CONSTRUCTION/DECOMMISSIONING PHASES

56. The following potential effects are assessed for the construction/decommissioning phase of the OfTW:

- Increased suspended sediment concentrations and sediment re-deposition; and
- Noise.

23.4.1.1 Increased Suspended Sediment Concentrations and Sediment Re-deposition

57. Cable trenching activities will result in sediment being released into the water column leading to increased suspended sediment concentrations (SSC). Sediment will be advected with ambient tidal currents and will be subject to general processes of dispersion and deposition. Once deposited, it will effectively rejoin the local sedimentary environment. These processes are described in detail in Section 21: OfTW Physical Processes and Geomorphology.

58. Different sediment types are expected along the OfTW corridor, including gravelly, sandy and muddy sections. The extent of magnitude of the effect of cable trenching in areas characterised by different sediment types is given in Section: 21 OfTW Physical Processes and Geomorphology:

- Cable installation on gravels and coarser sediment will have only a very localised effect as material will be almost instantly deposited and any effect will be confined to within a very small distance of the cable route (order of meters);
- Expected levels of suspended sediment will be considerably above natural levels in areas of medium sand seabed, although they will be very localised (main effects within 10s metres) and short term (order seconds to minutes). Once re-deposited, re-suspended sediment will join the natural sedimentary environment; and
- On finer materials, cable installation has the potential for a greater magnitude of effect. The effect will persist for longer than for sands but will still be short term (order of minutes to few hours) and will be more disperse (main effect within 100s to 1000s of meters). The resulting local thickness of accumulation is estimated to be less than 0.001m.

59. An indication of the seabed sediment type along the OfTW corridor is given in Figure 23.12. The northern and southern sections of the route are located in areas characterised by sandy and gravelly substrate (gravelly sand, slightly gravelly sand, sand and gravel) whilst in the central section finer sediments (muddy sand) are prevalent.

60. Based on the above the magnitude of the effect of increased SSC and sediment re-deposition is considered to be small.

61. The principal shellfish species present in areas relevant to the OfTW are, with the exception of squid, of limited mobility (e.g. scallops, crabs, lobster, nephrops, whelks) compared to most fish species. It is therefore likely that these will remain in areas disturbed by increased SSC whilst cable installation works are taking place. In addition, some of them could be affected by smothering as a result of sediment re-deposition.

62. Examples of the sensitivity to smothering, increased SSC and displacement for several shellfish species found within the site and in the wider Moray Firth are given below as defined in Marine Life Information Network (MarLIN, 2011).

Table 23.11 Sensitivity of Shellfish Species to Smothering, Increased SSC and Displacement

Species	Smothering	Increased SSC	Displacement
Edible Crab	Very low	Low	Not sensitive
King Scallop	Low	Low	Not sensitive
Nephrops	Not sensitive	Not sensitive	Very low

Source: MarLIN (2011)

63. In light of the above, shellfish species are considered receptors of low sensitivity and the effect is assessed to be negligible and probable. This effect is considered to be not significant in terms of the EIA Regulations.

64. Mobile fish species will be able to avoid localised areas disturbed by increased SSC. If displaced, juveniles and adults would be able to move to adjacent undisturbed areas within their normal distribution range. Fish are therefore considered receptors of low sensitivity. Taking the small magnitude of the effect as described above, the effect of increased SSC and sediment re-deposition is assessed to be negligible and probable. This effect is considered to be not significant in terms of the EIA Regulations.

65. There are several species and life stages potentially present in the study area, however, which may be of higher sensitivity due to certain aspects of their ecology and life cycles. These are assessed separately below and include the following.

- Diadromous migratory species;
- Fish and shellfish species which lay their eggs on the seabed (herring, sandeels and squid); and
- Post-settled king scallop larval stages.

66. In the case of diadromous species, assuming fish are migrating through areas where cable installation activities are taking place, increased SSC will, in general terms, result in localised avoidance and limited disturbance to migration. They are therefore considered receptors of low sensitivity and the effect on these is considered to be negligible and probable. In the particular case of fish originating in the River Spey, given its proximity to the proposed cable landfall, however, there is

potential for fish to be disturbed prior to river entry and/or immediately after leaving the river if transiting the southern sections of the OfTW corridor. The River Spey is a SAC for salmon and sea lamprey. In addition other species of conservation importance such as European eel and sea trout are known to be of importance in the Spey. Furthermore, in the case of salmon and sea trout, they support important fisheries which are of relevance to the local, regional and national level in Scotland. As indicated in Figure 23.12 the seabed in inshore areas close to the proposed landfalls is characterised by the presence of coarse substrate. As previously mentioned in these areas the effect of increased SSCs will be very localised and short term. In addition, works in close proximity to shore will only be undertaken over a limited period of time for installation of the cables in each of the trenches (order of days). In this context the seasonality of river entry and, particularly in the case of salmon, the diversity of runs should be noted. In light of the above diadromous migratory species entering/exiting the River Spey are considered of medium sensitivity and the effect of increased SSC is assessed to be negative, minor and probable. This effect is considered to be not significant in terms of the EIA Regulations.

67. Based on the above, the effect SSCs and sediment re-deposition on the SAC populations of Atlantic salmon, and sea lamprey and freshwater pearl mussel requiring assessment, is considered to be negligible and probable, with the exception of the River Spey SAC, where the effect is considered to be negative and minor. This effect is considered to be not significant in terms of the EIA Regulations.

68. Herring and sandeels deposit their eggs on the seabed, and there is therefore potential for these to be affected by increased SSC and smothering as a result of sediment re-deposition. The significance of any effect will however depend on the degree of overlap between their spawning areas and the areas affected. In the case of herring, spawning is thought to primarily take place in the area between the Orkneys and the Shetlands and to a lesser extent off the Caithness coast during August and September (subject to annual variability) and not generally in the immediate area of the OfTW corridor.

69. In light of the wider area where spawning herring are distributed and the likely relative small importance of the area of the OfTW as a spawning ground for the Orkney/Shetland herring stock, spawning herring are considered receptors of low sensitivity and the effect of increased SSCs and sediment re-deposition to be negligible and probable. This effect is considered to be not significant in terms of the EIA Regulations.

70. In the case of sandeels, not only do they deposit their eggs on the sediment but also spend most of the time buried within it. Sandeels are known to occur across the Smith Bank and in sandy areas in the wider Moray Firth. They prefer areas with low silt content and are therefore unlikely to be present in the central section of the OfTW corridor, where seabed type is characterised by the presence of muddy substrate (coinciding with the nephrops fishing grounds). There is however records of sandeels off Cullen (MS scoping response) and defined spawning and nursery grounds (Coull et al, 1998) overlap with the southern section of the OfTW corridor.

Sandeels are considered of medium sensitivity and the effect is assessed to be negative, minor and unlikely. This effect is considered to be not significant in terms of the EIA Regulations.

71. In the case of squid, they are thought to inhabit shallow, coastal waters when they move inshore to spawn (Viana et al, 2009) and eggs have been reported off Burghead and Buckie in May and June in water depths 5-6 m by fishermen (Young et al, 2006). Spawning occurs over an extended period from December to June, with peak spawning having being reported from December to March (Lum-Kong et al, 1992; Collins et al, 1997; Boyle et al, 1995). It is considered that spawning may occur in areas relevant to the OfTW corridor, particularly in its southern section, and that there is potential for eggs to be subject to high SSC and smothering through sediment re-deposition. Egg masses are found on biogenic and manmade structures and surfaces and are often seen on creels and ropes in the area. Given the localised effects expected as a result of increased SSC and sediment re-deposition, the degree of overlap between areas effected and squid spawning grounds is likely to be comparatively small. Squid are therefore considered receptors of medium sensitivity. The effect is assessed to be negative, minor and unlikely. This effect is considered to be not significant in terms of the EIA Regulations.

72. King scallops are also known to occur in some areas relevant to the OfTW corridor, particularly in the southern and northern sections, where they are targeted by the scallop fishery. As suggested by fisheries data (see Section 27: OfTW Commercial Fisheries), the area of the OfTW corridor is small relative to the total extent of the scallop grounds in the Moray Firth. Scallop post-plankton early life stages, are generally associated with coarse sand gravel substrates and bryozoan/hydroid communities, and may be affected as a result of increased SSC and sediment re-deposition given their limited mobility. The results of the benthic survey undertaken along the OfTW corridor (Annex 22A: Cable Route Benthic Technical Report) found encrusted cobble, pebble and gravel habitats where hydroids and other encrusting bryozoans were present on coarse material in the southern section of the cable corridor. These areas may therefore be suitable for the settlement of scallop larvae. It should be noted, however, that this habitat was also found at a control location outside the OfTW corridor (Annex 22A: Cable Route Benthic Technical Report – Figure 19). Scallops are considered receptors of medium sensitivity and the effect of increased SSC and sediment re-deposition is assessed to be negative, minor and unlikely. This effect is considered to be not significant in terms of the EIA Regulations.

23.4.1.2 Noise and Vibration

73. In order to assess the potential effects of construction noise on marine species, the noise levels resulting from a range of cable installation related activities were modelled taking account of the sensitivity to noise of particular species using the dB_{ht} *(Species)* metric. The methodology used for modelling is detailed in Annex 7B: Assessment of underwater noise during the installation of export power cables at the Beatrice Offshore Wind Farm.

74. The activities considered for assessment are summarised in Table 23.12 below and further described in Annex 7B: Assessment of underwater noise during the installation of export power cables at the Beatrice Offshore Wind Farm.

Table 23.12 Summary of Installation related Activities that generate Noise

Noise Generating Activities during Cable Installation	
Cable laying	Jetting/trenching
	Dredging
Cable protection	Rock dumping
	Concrete mattressing
Vessel Noise	

75. In addition to the above cable installation activities, HDD will be used in nearshore locations to bring the export power cables from the sea and onto the land. As indicated in Annex 7B: Assessment of underwater noise during the installation of export power cables at the Beatrice Offshore Wind Farm measurements of a generic HDD have been taken by Subacoustech Environmental in shallow riverine conditions. The noise levels associated to HDD operations were found to be very low. HDD operations have therefore not been considered any further in the noise assessment.

76. Modelling was undertaken for four fish species representing a range of different hearing abilities (salmon, dab, cod and herring). The criteria used for assessment of behavioural effects are given in Table 23.13.

Table 23.13 Criteria used to assess Behavioural Effects

Level dB_{ht} (Species)	**Effect**
90 and above	Strong avoidance reaction by virtually all individuals
Above 110	Tolerance limit of sound; unbearably loud
Above 130	Possibility of traumatic hearing damage from single event

Source: Annex 7B : Assessment of underwater noise during the installation of export power cables at the Beatrice Offshore Wind Farm

77. In addition, a lower level of 75 dB_{ht} (*Species*) was used for analysis to provide a level of 'significant avoidance'. At this level, approximately 85% of individuals will react to the noise, although the effect will probably be limited by habituation.

78. For the purposes of modelling, it was considered that 1.5 km of cable would be installed per day and that operations would take place constantly over a 24 hour period. As indicated in Section 7: Project Description an approximate duration of 40 days per trench for cable installation has been estimated.

79. An indication of the ranges at which strong avoidance and milder behavioural reactions would be expected for different species is given in Table 23.14 to Table 23.17. This takes account of the modelling outputs at the 90 dB_{ht} and 75 dB_{ht} *(Species)* level for herring, cod, dab and salmon, respectively (Annex 7B: Assessment of

underwater noise during the installation of export power cables at the Beatrice Offshore Wind Farm).

Table 23.14 90dB$_{ht}$ and 75 dB$_{ht}$ (Clupea harengus) Effect Ranges predicted for Cable Installation Activities on Herring

Activity	**90 dB$_{ht}$ *(Clupea harengus)***		**75 dB$_{ht}$ *(Clupea harengus)***	
	Effect range (m)	**Area of sea affected (km^2-hours)**	**Effect Range (m)**	**Area of sea affected (km^2- hours)**
Cable laying	8	<1	66	<1
Trenching	<1	<1	27	<1
Backhoe Dredging	1	<1	4	<1
Cable Protection	6	<1	62	<1
Vessel Noise	2	<1	29	<1

Table 23.15 90dBht and 75dB$_{ht}$ (Gadus morhua) Effect ranges predicted for Cable Installation Activities on Cod

Activity	**90 dB$_{ht}$ *(Gadus morhua)***		**75 dB$_{ht}$ *(Gaudus morhua)***	
	Effect range (m)	**Area of sea affected (km^2-hours)**	**Effect Range (m)**	**Area of sea affected (km^2- hours)**
Cable laying	1	<1	20	2
Trenching	1	<1	16	1
Backhoe Dredging	<1	<1	3	<1
Cable Protection	2	<1	25	2
Vessel Noise	2	<1	36	3

Table 23.16 90dB$_{ht}$ and 75dB$_{ht}$ (Limanda limanda) Effect ranges predicted for Cable Installation Activities on Dab

Activity	**90 dB$_{ht}$ *(Limanda limanda)***		**75 dB$_{ht}$ *(Limanda limanda)***	
	Effect range (m)	**Area of sea affected (km^2-hours)**	**Effect Range (m)**	**Area of sea affected (km^2- hours)**
Cable laying	<1	<1	1	0
Trenching	<1	<1	<1	<1
Backhoe Dredging	<1	<1	1	<1
Cable Protection	<1	<1	4	<1
Vessel Noise	<1	<1	2	<1

Table 23.17 90dBht and 75dB$_{ht}$ (Salmo salar) Effect ranges predicted for Cable Installation Activities on Salmon

Activity	**90 dB$_{ht}$ *(Salmo salar)***		**75 dB$_{ht}$ *(Salmo salar)***	
	Effect range (m)	**Area of sea affected (km^2-hours)**	**Effect Range (m)**	**Area of sea affected (km^2- hours)**
Cable laying	<1	<1	1	0
Trenching	<1	<1	2	<1
Backhoe Dredging	<1	<1	<1	<1
Cable Protection	<1	<1	4	<1
Vessel Noise	<1	<1	1	<1

80. As shown above, the predicted effect ranges are very small. The magnitude of the effect of noise is therefore considered to be negligible.

81. Any effect on fish species due to installation related noise is expected to be limited to the immediate vicinity of the area where works are being carried out at a given time. These are very small in relation to the available nursery grounds, spawning grounds and the normal distribution range of fish in the Moray Firth. In the case of migratory species given the expected noise levels and effect ranges, noise would result in limited disturbance during migration.

82. There is little information currently available on the sensitivity of shellfish species to noise. They are generally considered to be less sensitive than fish due to the lack of a swim bladder, however recent studies have found that species such as the shrimp (*Palaemus serratus*) and the longfin squid (*Loligo pealeii*) are sensitive to acoustic

stimuli and it has been suggested that these species may be able to detect sound similarly to most fish, via their statocysts (Lovell et al, 2005; Mooney et al, 2010).

83. Based on the above, fish and shellfish species are considered receptors of low sensitivity and the effect is assessed to be negligible and probable. This effect is considered to be not significant in terms of the EIA Regulations.

84. Taking the assessment above, it is considered that construction noise will result in a negligible and probable effect on the Atlantic salmon, sea lamprey and freshwater pearl mussel SAC populations requiring assessment (Table 23.8). This effect is considered to be not significant in terms of the EIA Regulations.

23.4.2 EFFECTS ARISING FROM THE OPERATIONAL PHASE

23.4.2.1 EMFs

85. Both AC and DC cabling options are currently considered for the OfTW. In order to facilitate the assessment of the potential effects of EMFs on natural fish and shellfish resources an overview of the main characteristics of these two types of cables is given below.

86. AC cables generate an electric field (E) and a magnetic field (B). The total E field cancels itself out to a large extent and the remaining E field is shielded by the metallic sheath and the cable armour. The varying magnetic field (B), however, produces an associated induced electric field (Ei). Both B and Ei fields would therefore be generated if the AC option is selected.

87. Similarly, in the case of DC cables both E and B fields are produced and the main E field is contained within the cable core. Due to the static nature of the B field in DC cables, however, an Ei field will not be produced directly. It should be noted that in the marine environment organisms and tidal streams will pass through the static B field and this would also indirectly result in the production of an Ei field. In addition, the interaction between the DC magnetic field of the cables and the geomagnetic field complicates the evaluation of magnetic fields from DC cables as the intensity, shape, and spatial extent of the resulting magnetic field (cable + geomagnetic) is affected by the orientation of the cable system with respect to the earths' north-south magnetic dipole (Normandeau et al, 2011).

88. The strength of the magnetic field decreases rapidly horizontally and vertical with distance from source. An indication of this is given for AC and DC cables in Table 23.18 and Table 23.19, respectively. These show averaged predicted magnetic fields at intervals above and horizontally along the seabed for a number of AC and DC projects, as provided in Normandeau et al (2011).

Table 23.18 Averaged Magnetic Field Strength Values from AC Cables above and horizontally along the Seabed assuming 1 m Burial

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

Source: Normandeau et al (2011)

Table 23.19 Averaged Magnetic Field Strength Values from DC Cables above and horizontally along the Seabed assuming 1 m Burial

Distance (m) above seabed	**Magnetic Field Strength (μT)**		
	Horizontal Distance (m) from Cable		
	0	4	10
0	78.27	5.97	1.02
5	2.73	1.92	0.75
10	0.83	0.74	0.46

Source: Normandeau et al (2011)

89. For the purposes of this assessment, it has been assumed that 55% of the cable length is buried and 45% protected by the range of options outlined in Section 7: Project Description. Cable burial does not effectively mitigate B or Ei fields, although reduces exposure of electromagnetically sensitive species to the strongest EMFs that exist at the 'skin' of the cable owing to the physical barrier of the substratum (OSPAR, 2008). It should be noted, that since the strength of the magnetic field decreases with distance from the source, the potential effects of EMFs on fish and shellfish will be influenced by the position of particular species in the water column and on water depth.

90. Taking the relatively small area where effects due to EMFs emissions may occur, limited to the location of the cables and their immediate vicinity, the effect of EMFs is considered to be of small magnitude.

91. A summary of species for which there is evidence of a response to electric (E) and magnetic (B) fields is given below in Table 23.20 and Table 23.21 respectively, as provided in Gill et al (2005). The potential effects of EMFs on these species are assessed separately in the following sections.

Table 23.20 Fish Species found in UK Coastal Waters for which there is Evidence of a Response to E Fields

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

Source: Gill et al (2005)

Table 23.21 Fish Species found in UK Waters for which there is Evidence of Response to B Fields

Species	
Elasmobranchs	
All Elasmobranchs possess the ability to detect magnetic fields	
Agnatha	
River lamprey	*Lampetra fluviatilis*
Sea lamprey	*Petromyzon marinus*
Teleosts	
European eel	*Anguilla anguilla*
Plaice	*Pleuronectes platessa*
Atlantic salmon	*Salmo salar*
Sea trout	*Salmo trutta*
Yellowfin tuna	*Thunnus albacares*
Crustacea	
Lobster, crabs, shrimps and prawns	Specific cases non-UK Decapoda: *Crangon crangon* (ICES, 2003) Isopoda: *Idotea baltica* (Ugolini and Pezzani, 1995) Amphipoda: *Talorchestia martensii* (Ugolini. 1993), *Talitrus saltator* (Ugolini and Macchi, 1988)
Molluscs	
Snails, bivalves and squid	Specific case non-UK Nudibranch: *Tritonia diomedea* (Willows, 1999)

Source: Gill et al (2005)

Elasmobranchs

92. Elasmobranchs are the major group of organisms known to be electrosensitive. They possess specialised electroreceptors called Ampullae of Lorenzini. These species naturally detect bioelectric emissions from prey, conspecifics and potential predators/competitors (Gill et al, 2005).

93. In addition they are known to either detect magnetic fields using their electronsensory systems or through a yet-to-be described magnetite receptor system (Normendaeu et al, 2011). Magnetic field detection is thought to be used as a means of orientation in elasmobranches, however, evidence for magnetic orientation by sharks and rays is limited to date (Meyer et al, 2005) and there is currently debate on the actual mechanisms used (Johnsen and Lohmann, 2005).

94. Both attraction and repulsion reactions have been observed associated to E-fields in elasmobranch species. Gill and Taylor (2001) found limited laboratory based evidence that the lesser spotted dogfish (*Scyliorhinus canicula*) avoids DC E-fields at emission intensities similar to those predicted from offshore wind farm AC cables. The same fish were attracted to DC emissions at levels predicted to emanate from their prey. Marra (1989) found evidence of a communication cable being damaged by elasmobranchs (*Carcharhinid* species and *Pseudocarcharias Kamoharai*). Further research on EMFs and elasmobranchs (Gill et al, 2009) found that two benthic species, lesser spotted dogfish and thornback ray, were able to respond to the EMFs of the type and intensity associated with sub-sea cables. The responses found were however not predictable and did not always occur; when there was a response this was species dependant and individual specific, meaning that some species and their individuals are more likely to respond by moving more or less within the zone of EMF (Gill et al, 2009). Information gathered as part of the monitoring programme undertaken at Burbo Bank suggest that certain elasmobranch species (sharks, skates and rays) do feed inside the wind farm and demonstrated that they are not excluded during periods of low power generation (CEFAS, 2009). Monitoring at Kentish Flats found an increase in thornback rays, smooth hound and other elasmobranchs during post construction surveys in comparison to surveys before construction. It appeared, however, not to be any discernible difference between the data for the wind farm site and reference areas, including population structure changes, and it was concluded that the population increase observed was unlikely to be related to the operation of the wind farm (CEFAS, 2009).

95. As suggested by the information provided above, EMFs produced by the cables may result in behavioural effects on elasmobranchs, by either temporarily affecting seasonal movements in migratory species over short distances or behaviourally affecting species inhabiting areas in the vicinity of cables, which could be attracted, repelled, unaffected by the presence of the cables or affected by means of interfering with feeding activity.

96. As described in Annex 11A: Fish and Shellfish Ecology Technical Report, the majority of elasmobranch species potentially transiting areas relevant to the OfTW corridor, are in most cases more frequently found in the north and west coast of Scotland. The OfTW corridor, however, falls within the defined nursery grounds for several of these, namely spurdog, thornback ray and spotted ray (Table 23.6).

97. Given the conservation status of most elasmobranch species, the potential for the OfTW area to be used as a nursery ground by some of them, and the evidence of their ability to detect E fields, they are considered of medium sensitivity. The effect of EMFs on elasmobranchs is therefore assessed to be negative, minor and probable. This effect is considered to be not significant in terms of the EIA Regulations.

River and Sea Lamprey (Agnatha)

98. Lamprey possess specialised ampullary electroreceptors that are sensitive to weak, low-frequency electric fields (Bodznick and Northcutt, 1981, Bodznick and Preston, 1983). Whilst responses to E fields have been reported on these species, information on the use that they make of the electric sense is limited. It is likely however that

they use it in a similar way as elasmobranches to detect prey, predators or conspecifics and potentially for orientation or navigation (Normadeau et al, 2011). Chung-Davidson et al (2008) found, based on experiments carried out on sea lamprey, that weak electric fields may play a role in their reproduction and it was suggested that electrical stimuli mediate different behaviours in feeding-stage and spawning-stage sea lampreys.

99. Both river and sea lamprey are species of importance from a conservation point of view. In addition, sea lamprey is a primary reason for selection of the River Spey SAC, which is located in the vicinity of the proposed cable landfall. Whilst the behaviour and distribution of both river and sea lamprey in the marine environment is poorly understood, on the basis of the proximity of the cable landfall to the River Spey it is likely that sea lamprey will encounter the OfTW cables during migration. Similarly, river lamprey has been reported in the Spey and in other rivers in the Moray Firth and hence is likely to at certain times be present in areas close to the cables.

100. EMFs generated by the cables could result in behavioural effects on these species in areas adjacent to the cable route and potentially cause limited disturbance during migration, assuming they use the electric sense for navigation and that their migration brings them close enough to the cable route that they could be within an area likely to receive an effect. In light of the above, and taking their conservation importance, lampreys are considered of medium sensitivity and the effect of EMFs assessed to be negative, minor and unlikely. This effect is considered to be not significant in terms of the EIA Regulations.

European Eel

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

102. A number of studies have been carried out in relation to the migration of eels and the potential effect of EMFs derived from offshore wind farm cables. Experiments undertaken at the operational wind farm of Nysted detected barrier effects, however correlation analysis between catch data and data on power production showed no indication that the observed effects were attributable to EMFs. Furthermore, mark and recapture experiments showed that eels did cross the export cable (Hvidt et al, 2006). Similarly research by Westerberg (1999) on HVDC cables and eel migration found some effects associated to the magnetic disturbance were likely to occur on eel migration although the consequences appeared to be small. In addition, no indication was found that the cable constituted a permanent obstacle to migration, neither for adult eels nor for elvers.

103. Further research where 60 migrating silver eels were tagged with ultrasonic tags and released north of the 130 kV AC cable found swimming speeds were significantly lower around the cable than in areas to the north and south

(Westerberg and Lagenfelt, 2008). It was noted that no details on the behaviour during passage over the cable were recorded and possible physiological mechanisms explaining the phenomenon were unknown. Based on the results of Westerberg and Lagenfelt (2008) before publication, Öhman et al (2007) suggested that even if an effect on migration was demonstrated the effect was small and pointed out that on average the delay caused by the passage was about 30 minutes.

104. Based on the above, European eel are considered of medium sensitivity and the effect of EMFs generated by the OfTW cables is assessed to be negative, minor and probable. This effect is considered to be not significant in terms of the EIA Regulations.

Salmon and Sea Trout

105. Research carried out on salmon and sea trout indicates these species are able to respond to magnetic fields (Formicki et al, 2004; Formicki and Winnicki, 2009; Tanski et al, 2005, Sadowski et al, 2007). Furthermore, the presence of magnetic material of a size suitable for magnetoreception has been reported in Atlantic salmon (Moore et al, 1990) and the ability to respond to electric fields (Rommel and McLeave, 1973). Most of the limited research undertaken on the subject on these species, has however, been focused on physiology based laboratory studies. Research under these conditions has found that EMFs can elicit localised physiological responses on these species (McCleave and Richardson, 1976; Formicki et al, 1997, 2004). It is however recognised that laboratory based responses to a stimulus do not necessarily imply that the same behavioural response will be triggered at sea. Öhman et al (2007) point out that detection of stimuli may not necessarily lead to behavioural responses in fish and that senses that detect magnetic fields are not the only means of spatial orientation, as vision, hearing and olfaction as well as hydrographic and geoelectric information could all be used for spatial orientation.

106. The strength of EMFs decreases quickly with distance to source. The magnitude and intensity of the potential movement and behavioural effects on salmonids, likewise in other pelagic species, would be closely linked to the proximity of the fish to the source of EMF. Gill and Barlett (2010) suggest that if there is going to be any effect on the migration of salmon and sea trout, this will be most likely dependent on the depth of water and the proximity of the rivers to the development site. Given the central location of the OfTW corridor in the context of the Moray Firth area, the uncertainties in relation to migratory patterns not only for fish originating in the Moray Firth rivers but also in other areas of Scotland, and the proximity of the proposed cable landfalls to salmon and sea trout rivers (particularly the Spey), it is likely that salmon and sea trout will transit the OfTW area.

107. As suggested above, there is potential for EMFs generated by export cables to result in a behavioural response on migrating salmon and sea trout (both adult and juveniles). It should be noted, however, that for the most they will not be exposed to the strongest EMFs as they normally swim in the upper metres of the water column during migration (Annex 16B: Salmon and Sea Trout Ecology and Fisheries Technical Report). Furthermore, they are able to use other cues for navigation in

addition to the geomagnetic field and these would more likely be prevalent in shallow areas in the proximity of the rivers.

108. Based on the above, salmon and sea trout are considered receptors of medium sensitivity and the effect assessed to be negative, minor and probable. This effect is considered to be not significant in terms of the EIA Regulations.

Other Fish Species

109. As indicated in Table 23.20 and Table 23.21, further to the species described above, there is some evidence of a response to EMFs for other teleost species such as cod and plaice. The results of monitoring programmes carried out in operational wind farms do not, however, suggest that EMFs have resulted in a detrimental effect on these species. Lindeboom et al (2011) suggest that EMFs from cabling does not seem to have a major effect on fish and other mobile organisms attracted to the hard bottom substrates for foraging, shelter and protection (Leonhard and Pedersen, 2006) . In line with this, research carried out at the Nysted offshore wind farm (Denmark), focused on detecting and assessing possible effects of EMFs on fish during power transmission (Hvidt et al, 2006), found no differences in the fish community composition after the wind farm was operational. Whilst effects on the distribution and migration of four species were observed (European eel, flounder, cod and Baltic herring), it was recognised that the results were likely to be valid on a very local scale and only on the individual level and that an effect on a population or community level was likely to be very limited. In general terms it is considered that fish species/species groups other than those previously assessed are receptors of low sensitivity and the effect of EMFs is assessed to be negligible and probable. This effect is considered to be not significant in terms of the EIA Regulations.

Shellfish Species

110. Limited research has been carried out to date on the ability of marine invertebrates to detect electromagnetic fields. Whilst there is to date no direct evidence of effects to invertebrates from undersea cable EMFs (Normandeau et al, 2011) the ability to detect magnetic fields has been studied for some species and there is evidence of a response to magnetic fields in some species, including molluscs and crustaceans (Table 23.21). Research undertaken by Bochert and Zettler (2004) , where a number of species, including crustaceans such as the brown shrimp (*Crangon crangon)* and molluscs such as mussels *(Mytilus edulis)* both found in UK waters, were exposed to a static magnetic field of 3.7 millitesla (mT) for several weeks, found no differences in survival between experimental and control animals.

111. The functional role of the magnetic sense in invertebrates is hypothesised to be for orientation, navigation and homing using geomagnetic cues (Cain et al, 2005; Lohmann et al, 2007). Concern has therefore been raised on the potential for EMFs to affect some invertebrate species during migration in the Moray Firth, particularly edible crab *(Cancer pagurus)* and lobster *(Homarus gammarus)*, with both species being commercially important in the area. As suggested by fisheries data, these species are found along the Caithness coast, in coastal areas off Fraserburgh and, to a lesser extent, in the proximity of the southern section of the OfTW corridor.

Whilst there is no detailed information on the extent and preferred migration routes used by these species in the Moray Firth, given the central location of the OfTW corridor there is potential for these species to encounter the cables during migration. Research undertaken on the Caribbean spiny lobster (*Panulirus argus)* (Boles and Lohmann, 2003) suggest that this species derive positional information from the Earth's magnetic field. Limited research undertaken with the European lobster (*Homarus gammarus*), however, found no neurological response to magnetic field strengths considerably higher than those expected directly over an average buried power cable (Normandeau et al, 2011; Ueno et al, 1986).

112. As indicated in Section 10: Wind Farm Benthic Ecology, indirect evidence from monitoring programmes undertaken in operational wind farms do not suggest that the distribution of potentially magnetically sensitive species of crustaceans or molluscs have been affected by the presence of submarine power cables and associated magnetic fields. In this context, however, the lack of shellfish specific EMFs monitoring programmes should be recognised.

113. Based on the above shellfish species are considered receptors of low sensitivity and the effect is assessed to be negligible and probable. This effect is considered to be not significant in terms of the EIA Regulations.

SAC Fish and Shellfish Populations

114. Based on the assessment provided above for salmon and sea lamprey the effect of EMFs on the SAC populations requiring consideration (Table 23.8) is considered to be negative and minor. This has been assessed to be probable in the case of salmon and unlikely in the case of sea lamprey.

115. Indirect effects on freshwater pearl mussel SAC populations derived from EMFs related effects on their host species (salmon and sea trout) are expected to, at worst, be of the same significance, as those assessed for salmon and sea trout (negative, minor and probable). This effect is considered to be not significant in terms of the EIA Regulations.

23.5 MITIGATION MEASURES

23.5.1 CONSTRUCTION/DECOMMISSIONING PHASES

116. No mitigation measures are proposed to reduce effects associated to the construction/decommissioning phases of the OfTW on fish and shellfish ecology.

23.5.2 OPERATIONAL PHASE

117. No mitigation measures other than cable burial/protection are proposed to reduce effects associated to the operational phase of the OfTW on fish and shellfish ecology.

23.6 RESIDUAL EFFECTS

23.6.1 CONSTRUCTION/DECOMMISSIONING

118. Residual effects are as described in the predicted effects section above.

23.6.2 OPERATION

119. Residual effects are as described in the predicted effects section above.

23.7 MONITORING AND ENHANCEMENT

120. BOWL will work with key stakeholders and Marine Scotland to identify any future monitoring programmes considered necessary.

23.8 SUMMARY

121. The effects on fish and shellfish ecology expected as a result of the construction/decommissioning and operational phases of the OfTW are summarised in Table 23.22.

Table 23.22 Summary of Effects on Fish and Shellfish Ecology

Effect	Receptor	Sensitivity of Receptor	Magnitude of Effect	Nature	Assessment of Effect	Probability	Significant Effect Y/N
	Construction/Decommissioning						
Increased Sediment concentrations and sediment re-deposition	Shellfish	Low	Small	-	Negligible	Probable	N
	Fish	Low	Small	-	Negligible	Probable	N
	Diadromous migratory species (except River Spey)	Low	Small	-	Negligible	Probable	N
	River Spey diadromous migratory species	Medium	Small	Negative	Minor	Probable	N
	Herring	Low	Small	-	Negligible	Probable	N
	Sandeel	Medium	Small	Negative	Minor	Unlikely	N
	Squid	Medium	Small	Negative	Minor	Unlikely	N
	Post-settled king scallops	Medium	Small	Negative	Minor	Unlikely	N
Noise	Fish and Shellfish	Low	Negligible	-	Negligible	Probable	N
	Operation						
EMFs	Elasmobranchs	Medium	Small	Negative	Minor	Probable	N
	River and sea lamprey	Medium	Small	Negative	Minor	Unlikely	N
	European eel	Medium	Small	Negative	Minor	Probable	N
	Salmon and sea trout	Medium	Small	Negative	Minor	Probable	N
	Other fish species	Low	Small	-	Negligible	Probable	N
	Shellfish	Low	Small	-	Negligible	Probable	N

23.9 ASSESSMENT OF CUMULATIVE EFFECTS

122. The potential cumulative effects of the OfTW with other offshore developments and activities are considered in Section 11: Wind Farm Fish and Shellfish Ecology. There are no other potential sources of cumulative effect in the OfTW area and therefore no further assessment of cumulative effects is provided in this Section.

23.10 HABITAT REGULATIONS APPRAISAL

123. As outlined in section 23.2.2, in addition to the assessment of sensitive receptors to the proposed OfTW in relation to the requirements for EIA, a Habitats Regulations Appraisal (HRA) has also been conducted. A Report to Inform an Appropriate Assessment has been prepared in relation to the designated sites set out in Table 23.8.

124. The requirements of the HRA are focussed on the qualifying features of European designated sites of conservation importance (often referred to as Natura 2000 sites). Where a proposed development could affect an SAC, there is a requirement for the Competent Authority to determine whether the proposal will have a Likely Significant Effect (LSE) on the conservation objectives, and if so, to make an Appropriate Assessment of the implications of the proposal on these. It should be noted that this is distinct from the determination of significant effects under the EIA Regulations.

125. The Likely Significant Effects on features of the European designated sites are summarised in Table 23.23. This table highlights those effects that will be carried forward for further assessment under the Habitat Regulations (to be presented in a Report to Inform and Appropriate Assessment).

Table 23.23 Screening matrix for the SACs with the potential to be affected by the OfTW

Designated Site and Qualifying Feature	Conservation Objectives	Potential Impacts and Effects	Proposed Generic Mitigation Measures	Likely Significant Effects Alone
Berriedale and Langwell Waters SAC Atlantic salmon	To avoid deterioration of the habitats of the qualifying species or significant disturbance to the qualifying species, thus ensuring that the integrity of the site is maintained and the site makes an appropriate contribution to achieving favourable conservation status for each of the qualifying features; and To ensure for the qualifying species that the following are maintained in the long term: -Population of the species, including range of genetic types for salmon, as a viable component of the site - Distribution of the species within site - Distribution and extent of habitats supporting the species - Structure, function and supporting processes of habitats supporting the species - No significant disturbance of the species - Distribution and viability of freshwater pearl mussel host species -Structure, function and supporting processes of habitats supporting freshwater pearl mussel host species	Disturbance associated to increased SSC Disturbance associated to noise during construction Disturbance associated to EMFs	Cables will be buried/protected where feasible	No likely significant effect
River Evelix SAC Freshwater pearl mussel				
River Moriston SAC Freshwater pearl mussel Atlantic salmon				
River Oykel SAC Freshwater pearl mussel Atlantic salmon				
River Spey SAC Freshwater pearl mussel Atlantic salmon Sea lamprey				
River Thurso SAC Atlantic salmon				

23.11 STATEMENT OF SIGNIFICANCE

126. As summarised in Table 23.22, the potential effects of the construction/ decommissioning and operational phase of the OfTW have been assessed to be negligible or minor and are therefore considered to be not significant in relation to EIA Regulations.

127. Potential cumulative effects of the OfTW with other developments and activities are discussed in Section 11: Wind Farm Fish and Shellfish Ecology.

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