# 4 Biological Environment

## 4.2 Fish and Shellfish Ecology

### 4.2.1 Baseline Information

#### Introduction

4.2.1.1 This report summarises the ecology and distribution of fish and shellfish, including salmon and sea trout in the areas relevant to the modified Offshore Transmission Infrastructure (modified OfTI) for the three consented wind farms, Telford, Stevenson and MacColl, (further detail provided in Technical Appendix 4.2 A, Fish and Shellfish Ecology, and Technical Appendix 4.2 B, Salmon and Sea Trout).

4.2.1.2 An impact assessment evaluating the potential effects of the modified OfTI on fish and shellfish receptors during the construction, operation and decommissioning phases has taken account of guidance provided in the National Policy Statement (NPS) for Renewable Energy Infrastructure (EN-3): Offshore Wind Farm Impacts –Fish Cumulative impacts potentially arising from other offshore renewable developments and other marine activities are also considered.

#### Consultations

4.2.1.3 Consultation undertaken to date is listed in Table 4.2-1.

**Table 4.2-1 Consultation Responses**

| Organisation | Consultation Response | MORL Approach |
|---|---|---|
| **JNCC** | Scoping opinion response: River Spey SAC is the most relevant river SAC in the vicinity of the modified OfTI. The following impacts need to be assessed:<br>• Smothering effects/ suspended sediment (particularly less mobile fish and shellfish species);<br>• Habitat loss; and<br>• EMFs.<br>Full scoping consultations provided in Chapter 1.3. | River Spey baseline in Appendix 4.2 B: salmon & sea trout technical report.<br>Suspended sediment, habitat loss and EMFs assessed in Impact Assessment section. |
| **Marine Scotland Science (MSS)** | Scoping opinion response:<br>Sandeels- there may be localised disturbance and suspended sedimentation, but should be limited due to sediments involved.<br>Herring- avoid works during the herring spawning period if possible (August to September).<br>Cod- cod survey data should be used to inform this process.<br>Full scoping consultations provided in Chapter 1.3 | Effects of suspended sediment on Herring and cod in Impact Assessment section. |

| Organisation | Consultation Response | MORL Approach |
|---|---|---|
| **MSS Fish Lab** | Scoping opinion response: Landfall is now likely to be on Inverboyndie Bay (immediately to the west of the Deveron). Large numbers of salmon and sea trout may be present at times and suitable precautions need to be considered. Consultation is required with the Deveron and Spey District Salmon Fishery Boards.<br><br>Full scoping consultations provided in Chapter 1.3 | Deveron and Spey Salmon & Fishery boards have commented on the fishery summaries in the salmon & sea trout technical report (Technical Appendix 4.2 B). |
| **Spey District Salmon Fishery Board** | Provided comment on the Salmon and Sea Trout technical report and supplied updated catch and release figures for the Spey. | Information incorporated within section 4.3 of salmon & sea trout technical report (Technical Appendix 4.2 B). |
| **Deveron District Salmon fishery board** | Provided further information regarding increased coastal fixed engine catches in the river Deveron district. | Information incorporated within Section 4.3 of salmon & sea trout technical report (Technical Appendix 4.2 B). |
| **MSS** | Add chart to show value of commercial fisheries.<br><br>Include units for all parameters.<br><br>Consider inter-array cables for changes to fishing activity. | Landings weights are included in Section 1.6 of Fish & Shellfish ecology technical report (Technical Appendix 4.2 A). Value of commercial fisheries is described in detail within Commercial Fisheries technical appendix (Technical Appendix 4.2 A). |

## Baseline Characteristics

### *Fish and Shellfish Ecology*

4.2.1.4 The modified Offshore Transmission Infrastructure (modified OfTI) is located within the Moray Firth. The principle study area used for this assessment has been defined by the ICES rectangles within which the modified OfTI is located (45E7 and 44E7) and is shown in Figure 4.2-1. Rivers designated as Special Areas of Conservation (SACs) in the Moray Firth and the wider area are also shown.

4.2.1.5 In addition to site specific fish and shellfish characterisation surveys, characterisation of the existing environment (i.e. the fish and shellfish ecological baseline) has been undertaken using data sources listed below. These data sources are subject to certain sensitivities and limitations, which are described in more detail in Technical Appendix 4.2 A, Fish and Shellfish Ecology Technical Report.

4.2.1.6 A detailed overview of the fish and shellfish distribution in the vicinity of the modified OfTI is provided in Technical Appendix 4.2 A, Fish and Shellfish Ecology Technical Report and Technical Appendix 4.2 B: Salmon and Sea Trout Ecology and Fisheries.

4.2.1.7 The Moray Firth supports a number of commercially targeted fish and shellfish species. The principal shellfish and cephalopod species landed are *Nephrops* (*Nephrops norvegicus*), scallops (*Pecten maximus*) and squid (*Loligo spp.*). With respect to fish, haddock (*Melanogrammus aeglefinus*), herring (*Clupea harengus*), whiting (*Merlangius merlangus*), monkfish/ anglerfish (*Lophius spp.*), mackerel (*Scomber scombrus*) and cod (*Gadus morhua*) constitute the majority of landings. The relative importance of each of these species to the total landings weights varies depending on the ICES rectangle under consideration.

4.2.1.8 Scallops landings weights are particularly high in rectangle 45E7, representing almost 50% of the total. In ICES rectangle 44E7 *Nephrops* and squid account for higher proportions of total average value. In both rectangles constituting the modified OfTI study area, haddock represents a considerably higher proportion of total landings than all other fish species. Landings weights for anglerfish, cod and herring are comparatively low. A full description of landings weights of species relevant to the modified OfTI is provided in Technical Appendix 4.2 A: Fish and Shellfish Technical Report.

***Spawning and Nursery Grounds***

4.2.1.9 The modified OfTI falls within, or is in close proximity to, the spawning and nursery grounds of a number of species (Coull *et al*., 1998; *Ellis et al*., 2010). Sandeel (Ammodytidae), *Nephrops*, cod, plaice (*Pleuronectes platessa*), lemon sole (*Micrstomus kit*), sprat (*Sprattus sprattus*) and whiting spawning grounds have all been defined within the vicinity of the modified OfTI. The modified OfTI does not however cross the spawning grounds of either the Orkney/Shetland or the Buchan herring stocks (the two stocks known to have spawning grounds in the vicinity of the Moray Firth).

4.2.1.10 A review of the species identified as having spawning and nursery grounds in the general area of the modified OfTI is given in the following sections. Charts and more detailed information are provided in Technical Appendix 4.2 A: Fish and Shellfish Technical Report (Section 1.7).

*Sandeels*

4.2.1.11 The Moray Firth is part of the Central Western North Sea sandeel sub-stock (ICES, 2009). Sandeels have a prolonged dormant overwintering period (September to March) during which they are buried (Winslade, 1974b; Wright & Bailey, 1993). Spawning occurs during December and January (Gauld & Hutcheon, 1990; Bergstad *et al*., 2001). Females lay demersal eggs which hatch during February and March (Macer, 1965; Langham, 1971; Wright & Bailey, 1996). Following spawning, overwintering resumes until April which marks the start of an extended period of pelagic feeding through spring and summer (Winslade, 1974b; Van der Kooij *et al*., 2008). The modified OfTI is located in high intensity spawning grounds and a low intensity nursery ground for sandeels (Ellis *et al*., 2010a) (Figure 3.4 of Technical Appendix 4.2 A: Fish and Shellfish Ecology).

4.2.1.12 Sandeels are highly substrate specific preferring a high proportion of medium and coarse sands (particle size 0.25 to <2 mm) with low silt content (Holland *et al*., 2005) as they create temporary burrows and ventilate their gills with interstitial water. The presence of fine particles of silt rich sediments potentially clogs the gills and inhibits respiration.

4.2.1.13 In light of the highly specific habitat requirements of sandeels they are likely to occupy discrete 'patches' within the Moray Firth and the area occupied by the modified OfTI.

*Nephrops*

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

4.2.1.15 Nephrops distribution is dependent upon the availability of substrates composed of fine cohesive mud within which they can construct burrows. The proposed location of the modified OfTI falls within the Nephrops spawning and nursery grounds defined by Coull *et al*. (1998). Based on the presence of significant fisheries in those ICES rectangles occupied by the modified OfTI, (particularly 44E7) and the presence of suitable habitats (muddy sand and sandy mud) in central areas of its offshore route, it is likely that spawning and nursery grounds could occur in these locations (Figure 3.5 of Technical Appendix 4.2 A: Fish and Shellfish Ecology).

*Herring*

4.2.1.16 North Sea herring is divided into four sub-stocks on the basis of areas used for spawning. The sub-stocks most relevant to the modified OfTI are the Orkney-Shetland stock and the Buchan stock. The Orkney-Shetland stock spawns off the Scottish east coast and in Shetland/Orkney waters and the Buchan stock spawns outside the Moray Firth off Fraserburgh and south as far as the Firth of Forth. Spawning of both sub-stocks occurs between August and September (Coull *et al*., 1998; Barreto & Bailey, 2013) and shoals of herring arrive at traditional spawning grounds in a series of waves (Lambert, 1987).

4.2.1.17 Herring are demersal spawners prefering coarse grounds and high energy environments (Parrish *et al*., 1959; Maucorps, 1969; de Groot, 1980; Blaxter, 1985, Munro *et al*., 1998; Barreto & Bailey, 2013). Females deposit sticky eggs in single batches directly onto the seabed in areas of coarse sand, gravel, small stones or rocks (Hodgson, 1957; Munro *et al*., 1998; Barreto & Bailey, 2013). Areas of suitable spawning habitat constitute a small proportion of the area covered by the modified OfTI and are located within the northern and southern sections of the corridor.

4.2.1.18 Herring larvae hatch after approximately three weeks, depending on sea temperature (Maucorps, 1969; Hodgson, 1957; Munro *et al*., 1998; Barreto & Bailey, 2013). Hatched larvae measure between 7-10 mm and depend on their yolk-sac until first feeding (Hodgson, 1957; ICES, 2013).

4.2.1.19 The modified OfTI does not pass through spawning grounds of either the Orkney-Shetland or Buchan herring stocks (Coull *et al*., 1998) but is located within high intensity nursery grounds as defined by Ellis *et al*. (2010a). Maximum juvenile catch rates were highest west of the central section of the modified OfTI (Figure 3.6 of Technical Appendix 4.2 A: Fish and Shellfish Ecology).

*Cod*

4.2.1.20 The cod population of the Moray Firth is genetically distinct from other North Sea populations (Hutchinson *et al*., 2001) with spawning occurring between January and April, (Coull *et al*., 1998; ICES, 2005a). Eggs remain pelagic hatching over a period of two to three weeks, dependant on water temperature (Wright *et al*., 2003).

4.2.1.21 The proposed location of the modified OfTI falls within a low intensity cod spawning area (Figure 3.10 of fish and shellfish technical report). The Moray Firth has been defined as a high intensity nursery ground for cod with significant numbers of eggs found off the Moray Firth and to the east of the Shetland Islands (Fox *et al*., 2008) with cod eggs and larvae being passively transported from Shetland (Heath & Gallego, 1997).

4.2.1.22 Potentially significant impacts on spawning cod were identified as a result of piling noise associated with the installation of the Offshore Generating Stations in the EIA submitted as part of the Environmental Statement (ES) detailing the Telford, Stevenson and MacColl offshore wind farms in August 2012 (Chapter 7.2 – Fish and Shellfish Ecology, MORL (2012)). In consultation with MSS, MORL committed to undertake additional survey work and monitoring with the objective of increasing the confidence in the impact assessment and identifying whether further mitigation would be required.

*Plaice*

4.2.1.23 The modified OfTI crosses a small area to the northwest and an area to the south of the plaice spawning grounds defined by Coull *et al*. (1998). The area occupied by the modified OfTI has also been identified as a low intensity nursery ground (Figure 3.13 of Technical Appendix 4.2 A: Fish and Shellfish Ecology).

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

4.2.1.25 The results of the North Sea egg survey (2004) showed that plaice eggs displayed a patchy distribution with higher abundances in the areas of Flamborough Head, the Firth of Forth, and the Moray Firth and to the east of the Shetland Isles (ICES, 2005b).

*Lemon Sole*

4.2.1.26 Lemon sole is widely distributed throughout the North Sea including in the vicinity of the modified OfTI and is thought to spawn where it is found (Rogers & Stocks, 2001). Spawning occurs from April until September (Coull *et al*., 1998) (Figure 3.14 of Technical Appendix 4.2 A: Fish and Shellfish Ecology).

*Sprat*

4.2.1.27 The modified OfTI falls within sprat spawning and nursery grounds defined by Coull *et al*. (1998) (Figure 3.15 of fish and shellfish technical report). The spawning grounds of sprat are widely distributed around the British Isles with spawning taking place from May to August (Coull *et al*., 1998), peaking in May to early July (Kraus & Köster, 2001). Females spawn repeatedly in batches throughout the spawning season (Milligan, 1986). Eggs and larvae of sprat are pelagic and subject to larval drift, often moving into coastal nursery areas within which the modified OfTI is situated (Nissling *et al*., 2003; Hinrichsen *et al*., 2005).

*Haddock*

4.2.1.28 The modified OfTI does not overlap with haddock spawning grounds as defined by Coull *et al*. (1998) although a more recent publication (Barreto & Bailey, 2013) shows that spawning occurs in an additional location to the east of the Moray Firth some distance away from the location of the modified OfTI. The modified OfTI does however fall within the haddock nursery grounds as defined by Coull *et al*. (1998) (Figure 3.16 of Techincal Appendix 4.2 A: Fish and Shellfish Ecology).

4.2.1.29 Results of international ichthyoplankton surveys found high concentrations of haddock stage I eggs in and off the Moray Firth (ICES, 2005b). The highest densities of mature and spawning haddock are found in depths of around 100 m and in areas of mud or sand (Gibb *et al*., 2004).

4.2.1.30 Haddock spawn between February and May (Coull *et al*., 1998) peaking in March and April (Coull *et al*., 1998; Fillina *et al*., 2009). Haddock release their eggs in batches over the spawning season (Gibb *et al*., 2004; Fillina *et al*., 2009). Haddock eggs are laid demersally and rise into the water column following fertilisation and develop into pelagic larvae (Page & Frank, 1989). Haddock produce a wide range of sounds (Wahlberg & Westerberg, 2005) bringing male and female fish together. It could also play a role in synchronising the reproductive behaviour of males and females (Hawkins & Amorim, 2000)

*Whiting*

4.2.1.31 The modified OfTI occupies a small area of low intensity whiting spawning ground and high intensity nursery ground by (Ellis *et al*. 2010a; Figure 3.17 of Technical Appendix 4.2 A: Fish and Shellfish Ecology). Whiting spawn between February and

June with females releasing their eggs in numerous batches (Teal *et al*., 2009). Eggs are pelagic and take about ten days to hatch (Russel, 1976).

*Other Species*

4.2.1.32 Low intensity nursery grounds have been defined in the vicinity of the modified OfTI for anglerfish, blue whiting (Micromesistius poutassou), hake (Merluccius merluccius), saithe (Pollachius virens), mackerel (Scomber scombrus), thornback ray (Raja clavata), spurdog (Squalus acanthias), spotted ray (Raja montagui) and tope (Galeorhinus galeus) as defined by Coull *et al*. (1998) and Ellis *et al*. (2010a) (Figure 3.18 and Figure 3.19 of Technical Appendix 4.2 A: Fish and Shellfish Ecology).

***Key Species in the Food-web***

4.2.1.33 Abundant species with high biomass such as sandeels and clupeids (e.g. herring and sprat) play an important functional role in North Sea food web dynamics occupying intermediate trophic levels, operating as significant predators of zooplankton and represent a key dietary component for a variety of aquatic and terrestrial predators including seals (Phoca spp.), harbour porpoise (Phocoena phocoena), minke whales (Balaenoptera acutorostrata) and seabirds (Wright & Bailey, 1993; Wanless *et al*., 1998; Furness, 1999; Wanless *et al*., 1999; Olsen & Holst, 2001; Wood, 2001; Santos and Pierce, 2003; Pierce *et al*., 2004; Santos *et al*., 2004; Wanless *et al*., 2005).

***Species of Conservation Importance***

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

4.2.1.35 Diadromous migratory species potentially present in the vicinity of the modified OfTI include European eel (Anguilla Anguilla), allis and twaite shad (Alosa alosa, Alosa fallax), sea and river lamprey (Lampetra fluviatilis, Petromyzon marinus), smelt (Osmerus osperlangus), salmon (Salmo salar) and sea trout (Salmo trutta).

4.2.1.36 Elasmobranchs have a low stock resilience to fishing mortality due to slow growth rates (Smith *et al*., 1998).

4.2.1.37 A number of other fish species, which are commercially exploited, with conservation status may be present in the area of the modified OfTI. These include anglerfish, mackerel, cod, herring and sandeel.

**Salmon and Sea Trout**

4.2.1.38 Atlantic salmon and sea trout are anadromous migratory species of the family Salmonidae. Anadromous species spend a significant proportion of their life history in marine habitats and migrate to freshwater to spawn, which, in Scotland, occurs in the upper reaches of rivers during late autumn and winter.

4.2.1.39 Before entering the ocean, salmon spend one to five years in their natal river, going through different stages of development. At the end of this period, they undergo ‘smolting’, a process of physiological and morphological changes which prepare for ocean entry (McCormick *et al*., 1998), which happens through late March to June.

4.2.1.40 Time spent feeding at sea varies within and among salmon populations. A distinction is to be made between adults which spend only a year at sea prior to spawning (‘grilse’) and those spending multiple years at sea (known as ‘multi- sea- winter’ (MSW) salmon). In recent years a decrease in the proportion of MSW fish in the annual run has been observed (Aprahamian *et al*., 2008; Environment Agency & Cefas, 2011) associated with a change in run timing from spring-summer to summer –

autumn (Gough *et al*., 1992; Milner *et al*., 2000; Aprahamian *et al*., 2008). A full description of the life cycle of Atlantic salmon is provided in Technical Appendix 4.2 B: Salmon and Sea Trout Ecology and Fisheries (Section 3.2).

4.2.1.41 The life cycle of sea trout is generally similar to salmon. Their marine migration is shorter however and the post spawning survival rates are higher (Gargan *et al*., 2004). More detailed information on sea trout ecology is provided in Technical Appendix 4.2 B: Salmon and Sea Trout Ecology and Fisheries (Section 3.2)

*Fisheries*

4.2.1.42 Salmon and sea trout are an important part of Scotland's natural and cultural heritage and support commercial and recreational fisheries which are of significant importance to the Scottish economy.

4.2.1.43 Fisheries statistics show that salmon and grilse account for the majority of the catch in all salmon fishery districts within the vicinity of the modified OfTI, with the exception of the Lossie, where sea trout is the principal species caught. Catches from the Spey and Deveron districts contribute the two highest proportions to the total salmon and sea trout catch from all Moray Firth Districts (32.7% and 13.5%, respectively).

4.2.1.44 The principal fishing method in the vicinity of the modified OfTI is rod-and-line and is the only method used in a number of districts, including the Spey. Fisheries statistics show that the proportion of fish released exceeds that retained in most Moray Firth districts. Netting by both fixed engines (fixed nets set close to the coast) and net-and-coble (a method of encircling salmonids where the net is paid out from a small boat) occurs to a lesser extent and is now only practiced in six of the 15 districts for which data are provided.

4.2.1.45 Statistics showing annual variation in fishing effort illustrate that net and coble effort (max number of crew) has been variable between 2004 and 2013. Effort in the Ness has declined severely from 11 in 2004 to one in 2014, whereas effort in the Conon has remained relatively stable at between four and seven per year. Effort in the Kyle of Sutherland had declined to zero in 2012 but has increased again in 2013.

4.2.1.46 Fixed engine effort (maximum number of traps) in the Halladale and Kyle of Sutherland has remained stable from 2008 to 2013, whereas effort in the Deveron has changed dramatically, increasing from zero in 2004 - 2011 to an average of 33.5 in 2013. Effort in the Strathy has shown a general decline from 30 in 2004 to 20 in 2013.

4.2.1.47 More detailed information and charts on salmon and sea trout fisheries can be found in section 4.2 of Technical Appendix 4.2 B: Salmon and Sea Trout Ecology and Fisheries.

*The Spey*

4.2.1.48 Rod-and-line is now the only method currently used in the Spey district. There is a voluntary catch and release conservation policy in place which has delivered increasing release rates. In 2013, 88% of salmon and 76% of sea trout were released (Consultation, 2014a).

4.2.1.49 The salmon rod-and-line fishery runs from 11th February to the 30th September (Consultation Meeting, 2011). Overall, statistics on seasonal variations show that the highest total catches in the district (all species) are recorded from June to August followed by May and September.

4.2.1.50 Salmon are principally caught from May to September although March and April record relatively high salmon catches reflecting the diversity of salmon stock components in the river. Grilse catches are highest in July and August.

4.2.1.51 The highest sea trout catches are recorded in June and July with low numbers in the earlier months of the season.

*The Deveron*

4.2.1.52 The Deveron is primarily a salmon river although sea trout are important during the summer months (Consultation with Deveron DSFB, 2011). From 1991 to 2012 rod and line was the only method used in this district. Although the majority of the netting rights were bought out in 1991, two redundant netting stations have recently been purchased by USAN Fisheries Ltd and are now active (see Salmon and Sea Trout Technical Report, Technical Appendix 4.2 B).

4.2.1.53 Total combined catches (salmon, grilse, and sea trout) from the commercial stations for the past two years were 1,233 (in 2012) and 2,254 (in 2013). Catches of salmon in this fishery are considerably greater than sea trout.

4.2.1.54 The seasonality of the rod-and-line catch show that the period from August to October records the highest total catches (all species combined). Sea trout are caught in highest numbers in June and July. Grilse catches peak in August, although July, September and October also record relatively high numbers. Salmon are caught throughout the season with higher catches recorded in September and October.

4.2.1.55 The salmon and sea trout rod-and-line season is open from 11th February to 31st October (Consultation with Deveron DSFB, 2011). All salmon and grilse must be released up to the end of May whereas after the 1st June one male salmon or grilse under 10 lbs can be kept per day with a maximum of two fish per rod per week. In the case of sea trout all must be released throughout the season (pers. comm. Deveron Salmon Fisheries Board, 2014).

**Site Specific Surveys**

4.2.1.56 Potentially significant effects on spawning cod as a result of piling noise associated with the installation of the three consented wind farms were identified. This was submitted as part of the Environmental Statement (ES) detailing the Telford, Stevenson and MacColl Offshore Wind Farms in August 2012 (Chapter 7.2 – Fish and Shellfish Ecology, MORL (2012)).

4.2.1.57 The impact assessment in the MORL ES (MORL, 2012) took a precautionary approach, where conservative assumptions were applied due to the uncertainty regarding how cod may utilise the Moray Firth area. In consultation with MSS, MORL committed to undertake additional survey work and monitoring with the objective of increasing the confidence in the impact assessment and identifying whether further mitigation would be required. A cod spawning survey was therefore undertaken in 2013, sampling spawning cod numbers at 58 stations within and in the vicinity of the three consented wind farms (Appendix 1 of Technical Appendix 4.2 A: Salmon and Sea Trout Ecology and Fisheries).

4.2.1.58 Cod were recorded in low numbers at 35 out of 58 stations with a maximum of nine individuals caught at a single station (0T38, Trip B). A total of 23 spawning cod were caught throughout the survey, 12 in Trip A and 11 in Trip B. Further detail is provided in Appendix 1 (Cod Survey Report) of Technical Appendix 4.2 A: Fish and Shellfish Ecology.

**Legislative and Planning Framework**

4.2.1.59 As the modified OfTI is within Scottish waters, guidance is followed from Marine Scotland, responsible for consenting offshore generating stations in Scottish waters under section 36 of the Electricity Act 1989 and for issuing associated Marine Licences under the Marine (Scotland) Act 2010 and the Marine and Coastal Access Act 2009. In addition, the following documents have provided guidance:

- Strategic Environmental Assessment (SEA) of Draft Plan for Offshore Wind Energy in Scottish Territorial Waters: Volume I: Environmental Report (Marine Scotland, 2010);
- Habitats Regulations Appraisal of Draft Plan for Offshore Wind Energy in Scottish Territorial Waters: Appropriate Assessment Information Review (Marine Scotland, 2011);
- CEFAS Guidance Note for Environmental Impact Assessment in Respect of the FEPA and CPA Requirements (CEFAS 2004);
- OSPAR guidance on environmental considerations for offshore wind farm development (OSPAR, 2008);
- Institute for Ecology and Environmental Management (IEEM) Guidelines for Ecological Impact Assessment (IEEM, 2010); and
- Habitats Regulations: Conservation (Natural Habitats, &c.) Regulations 1994 (as amended) and Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007.

## 4.2.2 Impact Assessment

**Summary of Effects and Mitigation**

4.2.2.1 The likely effects considered for assessment on fish and shellfish resources are as follows:

- Temporary disturbance of the seabed (increased suspended sediment concentrations (SSCs) and sediment re-deposition);
- Habitat loss;
- Underwater noise;
- Electromagnetic fields (EMFs); and
- Changes to fishing activity.

4.2.2.2 In the absence of detailed methodologies and schedules, the worst case scenarios for decommissioning activities and associated implications for fish and shellfish are considered analogous with those assessed for the construction phase.

***Summary of Effects***

4.2.2.3 Assessed impacts for the modified OfTI remain consistent with those previously assessed for the original OfTI described in detail within Chapter 7.2: Fish and Shellfish Ecology of the MORL ES (MORL, 2012).

4.2.2.4 No significant effects (e.g. above minor) have been identified on fish and shellfish ecology as a result of the construction/decommissioning phase of the modified OfTI. However, as discussed in the MORL ES (MORL, 2012) in Chapter 3.6, Underwater Noise, soft start piling will be used when constructing the two OSPs to enable mobile species to move away from the area of highest noise impact.

4.2.2.5 Similarly, no significant effects (e.g. above minor) have been identified on fish and shellfish receptors for the operational phase of the modified OfTI. As described in the assessment of EMFs, cable burial will reduce exposure of electromagnetically sensitive species to the strongest EMFs (OSPAR, 2008). Similarly, where burial is not feasible, cable protection will ensure that fish and shellfish receptors are not in direct contact with the cable, thus preventing exposure to the strongest EMFs. It is assumed that where cables are buried at depths greater than 1.5 m below the sea bed, effects of EMF on fish and shellfish species are likely to be negligible (DECC, 2008).

***Proposed Mitigation Measures and Residual Effects***

4.2.2.6 Mitigation measures further to those described above are not deemed necessary.

4.2.2.7 A summary of the pre and post mitigation impact assessment on fish and shellfish ecology is given in Table 4.2-2.

**Table 4.2-2 Impact Assessment Summary**

| Effect | Receptor | Pre-mitigation Effect | Mitigation | Post-mitigation Effect |
|---|---|---|---|---|
| *Construction & Decommissioning* | | | | |
| **Underwater disturbance to the seabed (Increased SSCs and sediment re-deposition)** | Adult and Juvenile Fish and Shellfish | Negative<br>Minor<br>Unlikely | None | Negative<br>Minor<br>Unlikely |
| | Diadromous Species | Negative<br>Minor<br>Unlikely (general)<br>Probable (salmon and sea trout) | None | Negative<br>Minor<br>Unlikely (general)<br>Probable (salmon and sea trout) |
| | Fish and shellfish which lay eggs on the seabed (herring, sandeels and squid) | Negative<br>Minor<br>Unlikely | None | Negative<br>Minor<br>Unlikely |
| **Habitat Loss** | Species of limited mobility | Negative<br>Not significant<br>Unlikely | None | Negative<br>Not significant<br>Unlikely |
| **Noise** | Plaice | Negative<br>Not significant<br>Probable | Soft start piling | Negative<br>Not significant<br>Probable |
| | Salmon and sea trout | Negative<br>Minor<br>Probable | Soft start piling | Negative<br>Minor<br>Probable |
| | Cod | Negative<br>Minor<br>Probable | Soft start piling | Negative<br>Minor<br>Probable |

| **Effect** | **Receptor** | **Pre-mitigation Effect** | **Mitigation** | **Post-mitigation Effect** |
|---|---|---|---|---|
| | Whiting | Negative<br>Minor<br>Probable | Soft start piling | Negative<br>Minor<br>Probable |
| | Herring | Negative<br>Minor<br>Probable | Soft start piling | Negative<br>Minor<br>Probable |
| | Larvae and Glass Eels | Negative<br>Minor<br>Probable | None | Negative<br>Minor<br>Probable |
| | Shellfish | Negative<br>Minor<br>Probable | Soft start piling | Negative<br>Minor<br>Probabale |
| *Operation* | | | | |
| **EMFs** | Elasmobranchs | Negative<br>Minor<br>Probable | Cable burial/protection | Negative<br>Minor<br>Probable |
| | River and Sea Lamprey | Negative<br>Minor<br>Unlikely | Cable burial/protection | Negative<br>Minor<br>Unlikely |
| | European eel | Negative<br>Minor<br>Probable | Cable burial/protection | Negative<br>Minor<br>Probable |
| | Salmon and Sea trout | Negative<br>Minor<br>Probable | Cable burial/protection | Negative<br>Minor<br>Probable |
| | Other fish Species | Negative<br>Minor<br>Unlikely | Cable burial/protection | Negative<br>Minor<br>Unlikely |
| | Shellfish Species | Negative<br>Minor<br>Unlikely | Cable burial/protection | Negative<br>Minor<br>Unlikely |
| **Changes to Fishing Activity** | General (All) | Negative<br>Not significant<br>Unlikely | None | Negative<br>Not significant<br>Unlikely |

**Introduction to Impact Assessment**

4.2.2.8 The following sections describe the assessment of likely significant effects of the construction, operation and decommissioning phases of the modified OfTI on fish and shellfish species. For the purposes of this assessment, the following modified OfTI elements have been considered:

- Two Alternating Current (AC) Offshore Substation Platforms (OSPs);
- 70 km of 220 kV HVAC cable for inter-platform cables and cabling up to the boundary of the three consented wind farms; and
- Up to four export 220kv cables of 52 km in length from the southern boundary of the three consented wind farms.

4.2.2.9 The precise location of the OSPs has not yet been defined, but they will be located within the boundaries of the three consented wind farm sites. The following Chapters and Appendices support this Chapter:

- Fish and Shellfish Ecology Technical Report (Technical Appendix 4.2 A);
- Salmon and Sea Trout Ecology and Fisheries Technical Report (Technical Appendix 4.2 B);
- Cod Survey Results (Appendix 1 of Fish and Shellfish Technical Report, Technical Appendix 4.2 A);
- Electromagnetic Fields Modelling (Appendix 4.3 D, MORL ES (MORL, 2012) );
- Commercial Fisheries (Chapter 5.1);
- Hydrodynamics, Sedimentary and Coastal Processes (Chapter 3.1);
- Benthic Ecology (Chapter 4.1); and
- Underwater Noise (Chapter 3.6 MORL ES, 2012).

**Details of Impact Assessment**

4.2.2.10 Fish and shellfish species could be affected in different ways, depending on how they utilise the area of the modified OfTI, their ecology and the life stage under consideration (i.e. migratory species and degree of mobility).

4.2.2.11 As described in this chapter and in Technical Appendix 4.2 A: Fish and Shellfish Ecology Technical Report, a number of species are known to spawn and have nursery areas within the Moray Firth, including areas where the modified OfTI is located. Sandeels and herring lay their eggs on the seabed and may therefore be particularly sensitive to the effects of seabed disturbance. In addition, sandeels, herring and sprat are important prey species in the area for other fish species, marine mammals and seabirds.

4.2.2.12 Migratory diadromous species of conservation importance, particularly salmon and sea trout, European eel and river and sea lamprey, may transit the area of the modified OfTI during migration and in some cases (particularly sea trout) as part of their foraging activity (Technical Appendix 4.2 B: Salmon and Sea Trout Ecology Technical Report).

4.2.2.13 In addition, shellfish species of commercial importance (Nephrops, scallops, squid, edible crab, lobster and whelks) and elasmobranchs are also present at varying degrees in the area. The likely effects derived from the construction/decommissioning and operational phases of the modified OfTI considered for assessment on fish and shellfish ecology are as follows:

- Temporary disturbance to the seabed (increased SSCs and Sediment re-desposition);
- Habitat loss:
- Underwater noise;
- Electromagnetic fields (EMFs); and
- Changes to fishing activity.

4.2.2.14 Effects have been separately assessed for the construction/decommissioning phases and the operational phase in terms of modified OfTI site specific effects. For the purposes of this assessment and in the absence of detailed methodologies and schedules, the worst case scenarios for decommissioning activities and associated implications for fish and shellfish are considered to be no worse than that assessed for the construction phase. Cumulative effects arising from other marine developments are discussed within section 4.2.3 of this chapter.

**Rochdale Envelope Parameters Considered in the Assessment**

4.2.2.15 The worst realistic case scenario for the effects of the modified OfTI on fish and shellfish ecology has identified the engineering design parameters which may result in the greatest effect upon fish and shellfish species.

4.2.2.16 In general terms, it is considered that the installation of the maximum number of cables and OSPs constitutes the worst case scenario, as this would result in the greatest footprint, duration and frequency of modified OfTI installation operations.

4.2.2.17 A summary of the worst case scenarios defined for the assessment of effects on fish and shellfish ecology is given in Table 4.2-3.

**Table 4.2-3 Rochdale Envelope Parameters Relevant to the Fish and Shellfish Ecology Impact Assessment**

| **Potential Effect** | **Rochdale Envelope Scenario Assessed** |
|---|---|
| *Construction & Decommissioning* | |
| **Temporary disturbance to seabed (increased suspended sediment concentrations and sediment re-deposition)** | Up to 6-legged Jacket foundations (suction caissons):<br>Max. number of OSPs: 2 AC<br>Max. number of suction caissons per OSP: 4<br>Max. suction caisson diameter: 20 m<br>Drilling to facilitate pin pile installation:<br>Pile diameter: 3 m<br>Cable installation by energetic means (i.e. jetting):<br>Inter-platform cable installation: 220kV AC<br>Max. number of trenches: 1<br>Target trench depth: 1 m<br>Trench affected width per trench: 6 m<br>Max. interplatform cabling length: 70 km of 220 kV HVAC cable for inter-platform cables and cabling up to the boundary of the three consented wind farms<br>Offshore Export Cables installation:<br>Max. number of export cables: 4<br>Max. number of cable trenches: 4<br>Cable route length from wind farm to shore: 52 km from edge of three consented wind farms |
| **Habitat Loss (temporary physical disturbance)** | Maximum area of physical disturbance during construction for the modified OfTI:<br>Max. number of suction caissons per OSP: 4<br>Max. suction caisson diameter: 20m<br>Max. scour protection diameter per OSP: 40m |
| **Noise** | Impact Piling for installation of OSPs:<br>Max. number of OSPs: 2 AC<br>Max. pile diameter: 3 m<br>Max. Number of piles for foundations: 16 piles for 8-legged jacket<br>Noise related to cable installation activities:<br>Cable ploughing & jetting<br>Cable laying<br>Rock placing or concrete mattressing<br>Vessel noise |

| *Operation* | |
|---|---|
| **EMFs** | Inter-platform cabling:<br>Type: 220 kV AC<br>Max. number of OSPs: 2 AC<br>Max. number of trenches: 2<br>Max. number of cables in a trench: 2<br>Max. cabling length: 70 km of 220 kV HVAC cable for inter-platform cables and cabling up to the boundary of the three consented wind farms<br>Target trench depth: 1 m<br>Offshore Export Cables:<br>Type: 220 kV AC<br>Max. number of cable trenches: 4<br>Max. number of cables: 4<br>Total width of cable corridor: four times water depth (up to 1,200 m in Southern Trench area)<br>Cable route length from wind farm to shore: 52 km<br>Target trench depth: 1m |
| **Changes to Fishing Activity** | Max. number of OSPs: 2 AC<br>Max. inter-platform cable length: 70 km of 220 kV HVAC cable for inter-platform cables and cabling up to the boundary of the three consented wind farms<br>Max. offshore export cables length: 52 km |

## EIA Methodology

4.2.2.18 The impact assessment methodology used for the evaluation of effects on fish and shellfish species is described below. The significance criteria used are based on the magnitude of the effect and the sensitivity of the receptors. Both magnitude of effect and receptor sensitivity have been assigned using professional judgement. The parameters used to define these take account of the IEEM (2010) impact assessment guidelines.

### *Magnitude of Effect*

4.2.2.19 Magnitude of Effect values have been assigned based on the following criteria:

- **Extent of effect**: referring to the full area over which the effect occurs (e.g. noise impact range);
- **Duration of effect:** referring to the duration over which the effect is expected to last;
- **Frequency:** how often the effect occurs; and
- **Reversibility:** Irreversible effects are those from which recovery is not possible within a reasonable timescale. Reversible (temporary) effects are those from which spontaneous recovery is possible or, for which effective mitigation is possible.

***Sensitivity***

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

- **Timing of the effect:** referring to whether effects are caused during critical life-stages or seasons (e.g. spawning season and migration); and
- **Ecological value:** referring to conservation status of the receptor (i.e. protected to the European level and/or national level) and importance in the area (i.e. species of importance as prey to other marine organisms, species of commercial importance).

***Significance***

4.2.2.21 The significance of an effect is defined using the following categories:

- **Not significant:** An effect that is predicted to be indistinguishable from natural background variation using conventional monitoring techniques. The effect is not significant in the context of the nature conservation objectives or legislative requirements;
- **Minor significance:** The effect will be measurable in the short term and/or over very local scales using standard monitoring techniques. The effect does not affect nature conservation objectives and falls within legislative requirements. Effects are typically reversible;
- **Moderate significance:** The effect will be measurable in the long term and over a broad to very broad spatial scale and is likely to have a measurable effect. It may affect nature conservation objectives and may fall outside of acceptable limits or standards stipulated under relevant legislation. Effects may be reversible; and
- **Major significance:** A permanent effect which has a measurable effect on wider ecosystem functioning and nature conservation objectives and exceeds acceptable limits or standards.

4.2.2.22 The significance of an effect is determined taking account of the magnitude of the effect and the sensitivity of the receptor following the matrix below (Table 4.2-3). In addition to the significance ratings, whether the predicted effect is considered positive or negative has also been described. Those effects assessed to be above minor (i.e. moderate or major) are considered to be significant.

**Table 4.2-3 Impact Assessment Matrix**

| **Impact Assessment Significance Criteria** | | **Sensitivity of Receptor** | | |
|---|---|---|---|---|
| | | Low | Medium | High |
| **Magnitude of Effect** | Negligible | Not significant | Minor | Minor |
| | Small | Minor | Minor | Moderate |
| | Medium | Minor | Moderate | Major |
| | Large | Moderate | Major | Major |

4.2.2.23 The impact assessment uses the most up to date information on sensitivity for particular species/species groups, taking into account any limitations of the data. In addition, as a result of uncertainties in relation to the distribution of some species and how they utilise the area of the modified OfTI, (particularly in the case of migratory species) a number of conservative assumptions have been made.

4.2.2.24 For certain effects, the limited information available to date does not allow for the impact assessment to follow the standard methodology described above, making the assignment of magnitude and sensitivity difficult.

4.2.2.25 In light of the limitations of the impact assessment the probability for each effect to occur has been assessed as "certain/near certain", "probable", "unlikely" and "extremely unlikely". The definition of the probability categories used in the 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 %.

4.2.2.26 Probabilities have been assigned taking into account the available evidence for an effect to occur, the degree of available baseline information on the ecology of the receptors and the use that a species makes of the area in the vicinity of the modified OfTI.

**Impact Assessment**

***Construction***

4.2.2.27 A summary of effects on fish and shellfish receptors during the construction phase is provided in Table 4.2-2. The potential effects on fish and shellfish species are assessed for the construction phase of the modified OfTI below:

- Temporary disturbance to the seabed (increased SSCs and sediment re-deposition);
- Habitat loss; and
- Underwater noise.

*Temporary Disturbance to the Seabed (Increased SSCs and Sediment Re-deposition)*

4.2.2.28 Cable installation activities will result in sediment being released into the water column, leading to an increase in suspended SSCs. Sediment will be advected with ambient tidal currents and will be subject to general processes of dispersion and deposition. Once deposited, the sediment will effectively re-join the local sedimentary environment. These processes are described in detail in Chapter 3.1: Hydrodynamics, Sedimentary and Coastal Processes.

4.2.2.29 Physical disturbance resulting from offshore export cable installation could in theory affect fish and shellfish, particularly species of limited mobility. However, potential disturbance will be short-term (order of seconds to minutes, depending on the sediment grain size and degree of aggregation) and will be largely localised to the export cable installation (main effect within 10s of metres). The thickness of sediment accumulation will be limited by the volume of sediment being disturbed and should not exceed a few tens of centimetres other than immediately adjacent to the cable. Once re-deposited to the seabed, the displaced material will join the natural sedimentary environment and cease to present any further potential effect (see section 3.1.2 of Chapter 3.1: Hydrodynamics, Sedimentary and Coastal Processes).

4.2.2.30 Taking the localised and short term nature of increased SSCs and sediment re-deposition, the magnitude of the effect is considered to be small. The potential effects of increased SSCs and sediment re-deposition on fish and shellfish receptors are assessed below by species/species group.

Diadromous Migratory Species

4.2.2.31 In the case of diadromous species, assuming fish are migrating through areas where cable and OSP installation activities are taking place, increased SSCs may result in localised avoidance and limited disturbance during migration. Given the proximity of the modified OfTI landfall to salmon and sea trout rivers, particularly those relevant to the Deveron and Spey Salmon Fishery Districts (SFDs) it is considered that there is potential for salmon and sea trout to be disturbed prior to river entry and immediately after leaving the rivers (see Technical Appendix 4.2 B: Salmon and Sea Trout Ecology and Fisheries Technical Report). The river Deveron is in very close proximity to the modified OfTI and the river Spey SAC is approximately 32km away from the cable landfall.

4.2.2.32 Works in close proximity to shore will only be undertaken over a limited period of time for cable installation in each trench. In this context the seasonality of river entry and, particularly in the case of salmon, the diversity of runs should be noted. Diadromous migratory species are considered of medium sensitivity. In combination with the small magnitude of the effect, the impact of increased SSCs is assessed to be negative, of minor significance and probable (for salmon and sea trout) and unlikely (for other diadromous species potentially entering/exiting rivers in the vicinity of the offshore export cable landfall site).

Fish and Shellfish Which Lay Their Eggs on the Seabed (Herring, Sandeels and Squid)

4.2.2.33 As herring and sandeels deposit their eggs on the seabed there is potential for these species to be affected by increased SSCs 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.

4.2.2.34 The herring sub-stocks most relevant to the modified OfTI are the Orkney-Shetland stock and the Buchan stock. As shown in Figure 4.2-2, the modified OfTI does not pass through either of these spawning grounds. However, as suitable herring spawning substrate is present to the north east and southern areas of the offshore export cable route, the presence of herring eggs in these areas cannot be ruled out.

4.2.2.35 As sandeels spend a major proportion of their life cycle partially buried within the seabed, increased SSCs and sediment re-deposition have the potential to adversely affect this species group. Eggs are deposited on benthic substrates between December and January. Egg membranes are adhesive onto which grains of sand may become attached. Eggs covered by sediment experiencing reduced current flow and therefore lower oxygen tension, can have delayed hatching periods. This is considered a necessary adaptation to egg survival in a dynamic environment (Hassel et al., 2004). Based on Figure 4.2-3, the modified OfTI passes through a high intensity sandeel spawning ground (Ellis et al., 2010). These grounds are however extensive and the area covered by the modified OfTI is proportionally small.

4.2.2.36 Taking the wider area where both sandeels and spawning herring are distributed and the likely small degree of overlap with the areas affected by SSCs and sediment re-deposition, herring and sandeel are considered receptors of **medium sensitivity**. The effect is therefore assessed to be **negative** of **minor significance** and **unlikely**.

4.2.2.37 As described in Technical Appendix 4.2 A: Fish and Shellfish Ecology, squid spawning may occur in areas relevant to the modified OfTI, particularly in the southern section. Therefore, there is potential for eggs to be subject to high SSCs and smothering through sediment re-deposition. However, given the localised effects of increased SSC and sediment re-deposition, the degree of overlap between areas affected and squid spawning grounds is likely be comparatively small. Squid are therefore considered receptors of **medium sensitivity** and the effect is assessed to be **negative**, of **minor significance** and **unlikely**.

Adult and Juvenile Fish

4.2.2.38 Mobile adult and juvenile fish will be able to avoid localised areas disturbed by increased SSCs. If displaced, juveniles and adults would be able to move to adjacent undisturbed areas within their normal distribution range. Adult and juvenile fish are therefore considered receptors of **low sensitivity** and the effect of increased SSCs and sediment re-deposition is assessed to be **negative**, of **minor significance** and **unlikely**.

Shellfish Species

4.2.2.39 The principal shellfish species (i.e. scallops, crabs, lobster, Nephrops and whelks) present in the vicinity of the modified OfTI are of limited mobility. It is therefore likely that these will remain in areas disturbed by increased SSC during cable installation. In addition, some shellfish species could be affected by smothering as a result of sediment re-deposition.

4.2.2.40 The distribution of these species is comparatively large in the context of the areas where seabed disturbance related effects may occur. Examples of the degree of sensitivity to smothering, increased SSCs and displacement for several shellfish species found in the area of the modified OfTI and in the wider Moray Firth for which the Marine Life Information Network (MarLIN) provides species specific information are given in Table 4.2-4 (MarLIN, 2014).

**Table 4.2-4 Sensitivity of Shellfish Species to Smothering, Increased SSC and Displacement (Source: MarLIN, 2014)**

| 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 |

4.2.2.41 Utilising the above information, the distribution ranges of shellfish species in the mmodified OfTI corridor and MarLIN's examples of sensitivity, shellfish species are considered of **low sensitivity** and the effect is assessed to be **negative**, of **minor significance** and **unlikely.**

*Habitat Loss (Temporary Physical Disturbance)*

4.2.2.42 Physical disturbance resulting from offshore export cable installation could in theory affect fish and shellfish, particularly species of limited mobility. A maximum area of 1.99km$^2$ seabed habitat could be temporarily disturbed or lost during the construction phase of the modified OfTI.

4.2.2.43 In addition to indirect effects through increased SSCs and sediment re-deposition, the disturbance of the seabed associated to construction works may result in a direct effect on species and life stages of limited mobility, such as shellfish species and demersal eggs (i.e. if unable to avoid construction machinery).

4.2.2.44 Considering the relatively small area directly affected and the temporary, intermittent and reversible nature of the effect, the magnitude of temporary seabed disturbance during construction activities for the modified TI is considered to be **negligible**. In addition, the majority of fish and shellfish species present in the area are mobile and their distribution ranges are extensive in comparison to areas potentially being disturbed by the installation of the modified OfTI.

4.2.2.45 It is not anticipated that there will be an effect on pelagic fish, pelagic eggs or pelagic larvae from habitat loss/temporary physical disturbance. Since there is no apparent impact pathway for temporary physical disturbance/loss of seabed habitat to impact on pelagic eggs and larvae they are therefore scoped out of the assessment.

4.2.2.46 As such, the only relevant receptors with the potential to be affected are herring by virtue of their substrate specificity for spawning. The modified OfTI does not overlap with herring spawning grounds as defined by Coull *et al*., (1998), therefore sensitivity of herring eggs is to be considered **low**. The effects of temporary physical disturbance and habitat loss on herring are assessed as **negative, not significant** and **unlikely**.

4.2.2.47 Likely significant effects on the benthic community derived from this are assessed in Chapter 4.1: Benthic Ecology.

*Noise and Vibration*

4.2.2.48 The following assessment considers the potential for underwater noise generated by construction activities to affect fish and shellfish receptors. Noise levels generated by decommissioning activities are not anticipated to exceed those of the construction phase. A number of activities associated with the construction phase of the modified OfTI generate underwater noise and vibration. These are as follows:

- Piling noise derived from the installation of pin pile OSPs;
- Cable ploughing and jetting;
- Cable laying;
- Rock placement or concrete mattressing; and
- Vessel noise.

4.2.2.49 Potential sensitivity to noise may vary between species or species groups. Therefore, to assess the likely effect of construction noise on fish, modelling was undertaken using the $dB_{ht}$ (Species) metric which allows for species specific impact ranges to be defined. The noise modelling methodology is described in detail in Chapter 3.6: Underwater Noise in MORL ES (2012). The criteria for assessment of effects on fish is summarised in Table 4.2-5 below:

**Table 4.2-5 Noise Assessment Effect Criteria**

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

4.2.2.50 Noise modelling was undertaken for cod, dab, herring and salmon; species representing different degrees of hearing ability and sensitivity to noise. The outputs of the noise modelling at the 90 $dB_{ht}$ (Species) for different construction activities are given in Chapter 3.6: Underwater Noise of the MORL ES (MORL, 2012). Detailed information on the noise modelling methodology and hearing ability of fish species is provided in Chapters 3.6: Underwater Noise in MORL ES (MORL, 2012) and Chapter 10.2: Fish and Shellfish Ecology in MORL ES (MORL, 2012).

4.2.2.51 Piling noise in relation to the installation of pin piles of the OSPs would produce the highest levels of underwater noise and therefore has the worst case potential to result in adverse effects on fish and shellfish receptors with other construction activities having negligible impact ranges on fish. Installation of pin piles has therefore been studied in more detail. The assessment of noise on fish has been primarily focused on the outputs of the modelled 90 $dB_{ht}$ (Species) impact ranges, at which the greatest behavioural effects are to be expected.

4.2.2.52 Noises at 130 $dB_{ht}$ (Species) have the potential to of cause traumatic hearing damage and noise at 110 $dB_{ht}$ (Species) may cause unbearably loud sounds Chapter 3.6: Underwater Noise in MORL ES (MORL, 2012). This however would only occur in close proximity of where piling is taking place (10s to 100s of meters) (Table 4.2-6). A 'soft-start' (a period at the onset of piling when the hammer strike energy would be gradually increased) will be utilised at all piling locations. The aim of 'soft-start' piling is to allow mobile fish to leave the vicinity of the foundations before the highest noise levels are reached, in order to prevent exposure to the 110 and 130 $dB_{ht}$ (Species) levels.

**Table 4.2-6 130dB$_{ht}$ and 110dB$_{ht}$ (Species) Impact Ranges Associated to Piling of a 3 m pile by Species (Source: MORL ES, 2012)**

| Species | 130dB$_{ht}$ (Species) Range (m) | 110 dB$_{ht}$ (Species) Range (m) |
|---|---|---|
| **Cod** | 220 | 4,000 |
| **Dab** | 30 | 460 |
| **Herring** | 370 | 5,400 |
| **Salmon** | <10 | 160 |

4.2.2.53 For the purposes of this assessment one construction scenario (scenario1) was modelled (see Chapter 3.6: Underwater Noise in MORL ES (MORL, 2012). The construction programme of this scenario is summarised in Table 4.2-7.

**Table 4.2-7 Noise Modelled Scenarios**

| Scenario | Build programme (years) | Max. no. years with piling activities | Max.no. of vessels (piling activities) |
|---|---|---|---|
| 1 | 5 | 2 | 1 |

4.2.2.54 The following parameters have been considered to assess the worst case scenario for underwater noise effects, based on conservative assumptions:

- 8 pin piles per OSP;
- 2 OSPs; and
- 260 minutes per pile (assuming 3 m diameter piles).

4.2.2.55 Assuming piling over two years (one construction vessel), the average percentage of piling days (six) will constitute 1% of the total build programme.

Fish Species

4.2.2.56 Concerns were raised during consultation as part of the previous EIA process (for the three consented wind farms) with regard to the sensitivity of juvenile fish and in particular salmon and sea trout smolts. To address this issue a report on ontogenic development of auditory sensitivity in fish was commissioned. The report concluded that available experimental evidence suggests that the juveniles of marine fish are no more sensitive to sound than the adults of the species (Technical Appendix 3.6 A: Underwater Noise in MORL ES (MORL, 2012)). Furthermore, in some cases it appears that there maybe a degree of insensitivity to sound in juveniles when compared with adults, implying some protection from the adverse effects of noise. In light of this, juvenile fish have been assessed using the same criteria as that used for evaluation of the effect of impact piling on adults.

4.2.2.57 A comparative indication of the expected 90 dB$_{ht}$ (Species) noise effects for the four species modelled is given for a single piling operation (3 m pile) in Figure 4.2-4. Table 4.2-8 below shows the maximum, minimum and mean impact ranges modelled by species at the 90dB$_{ht}$ and 75 dB$_{ht}$ (Species) levels for a 3 m pile.

**Table 4.2-8 Maximum, Minimum and Mean Impact Ranges Modelled by Species at the 90 dBht and 75 dBht Levels for a 3 m Pin Pile (Source: MORL ES, 2012)**

| Modelled Location | Species | 90 dB$_{ht}$ Impact Range (km) | | | 75 dB$_{ht}$ Impact Range (km) | | |
|---|---|---|---|---|---|---|---|
| | | Max. | Min. | Mean | Max. | Min. | Mean |
| 1 | Cod | 34 | 25 | 30 | 82 | 41 | 64 |
| | Dab | 6.9 | 6.7 | 6.8 | 33 | 26 | 30 |
| | Herring | 39 | 29 | 34 | 94 | 41 | 69 |
| | Salmon | 2.5 | 2.5 | 2.5 | 14 | 13 | 14 |

4.2.2.58 As shown in both Figure 4.4-4 and Table 4.2-8 dab and salmon are expected to exhibit strong avoidance reactions (90dB$_{ht}$ level) only in close proximity to the piling works, whilst cod and herring are expected to avoid wider areas. This pattern is similar at the 75 dB$_{ht}$ level, where dab and salmon would be expected to exhibit behavioural responses over relatively short ranges when compared to cod and herring (Table 4.2-9).

4.2.2.59 The precise location of the OSPs within the boundary of the three consented wind farms has not yet been defined. Therefore a conservative approach has been taken where a 'worst case' piling location has been selected on the basis of closest proximity to the defined spawning grounds of plaice, cod and herring (Tables 4.2-5 to 4.2-7). Due to the substrate specificity of herring spawning, the distribution of gravel and sandy gravel (based on BGS data) is also shown. For salmon, the location of the two main rivers of the districts forming the local study area (Spey and Deveron) are shown in addition to the location of SAC rivers (Table 4.2-8).

4.2.2.60 The assessment of noise related effects is based primarily on the 90 dB$_{ht}$ effect contours as strong avoidance is expected by virtually all individuals. In the case of salmon, 75 dB$_{ht}$ levels, at which only mild avoidance reactions can be expected, have also been used to inform the assessment given its conservation status and the importance of associated fisheries at the local, regional and national levels in Scotland.

4.2.2.61 Due to the small number of OSPs (two), the frequency and duration of piling noise will be considerably less than that previously assessed for the installation of turbine foundations or for OSPs, which previously numbered up to eight (Chapter 3.6, Underwater Noise, in the MORL ES, 2012). Taking account of the species impact ranges and the short term nature and frequency of the effect, the magnitude of construction noise has been defined as follows:

- Based on the noise modelling outputs for **dab** (surrogate for plaice) the magnitude of the effect is assessed as **negligible**;
- Based on the noise modelling outputs for **cod** (surrogate for whiting) and herring, the magnitude of the effect is assessed as **small**; and
- Based on the noise modelling outputs for **salmon** (surrogate for sea trout), and taking into account the conservative 75 dBht levels, the magnitude of the effect is assessed as **negligible**.

4.2.2.62 The sensitivity of the receptors modelled based on their ecological importance, the use that they make of the modified OfTI corridor and the wider area and the significance of the predicted effects is given below:

- Plaice have defined spawning and nursery grounds in areas relevant to the modified OfTI. However the spawning and nursery grounds of plaice are spatially extensive and are considered of low intensity (Ellis *et al*., 2010). Plaice is therefore considered a receptor of **low** sensitivity. The effect of noise on plaice is assessed to be **negative, not significant** and **probable**.
- The cod population of the Moray Firth is genetically distinct from other North Sea populations and spawning activity has been low in recent years. In addition the Moray Firth is known to be a nursery ground for cod (Technical Appendix 4.2 A: Fish and Shellfish Ecology Technical Report). Noise contours at the 90 $dB_{ht}$ level could overlap a significant area of their spawning (Figure 4.2-6). The uncertainties in relation to the current extent and importance of these grounds should however be recognised. For example, low numbers of spawning cod were encountered during the cod spawning survey (Appendix 1 of Technical Appendix 4.2 A, Fish and Shellfish Technical Report). Based on these results MSS did not require any further mitigation than that described in the MORL ES (2012) in relation to spawning cod during the construction of the three consented wind farms. The sensitivity of cod is therefore considered to be **medium**. The effect of piling noise on cod is therefore assessed as **negative,** of **minor significance** and **probable**.
- Whiting (for which cod has been used as a surrogate) have defined spawning and nursery grounds in the area relevant to the modified OfTI. However the extent of these grounds is large in relation to the small proportion potentially intersected by the modified OfTI. Whiting are therefore considered receptors of **low** sensitivity. The effect on whiting is therefore assessed as **negative,** of **minor significance** and **probable**.
- Herring are known to spawn in the Moray Firth, use the area as a nursery ground and are an important prey species for a number of other marine organisms. In addition, herring are substrate specific spawners. As shown in Figure 4.2-7 the modified OfTI does not pass through herring spawning grounds. In most years, the highest intensity of herring spawning tends to occur between Orkney and the Shetlands. Gravelly substrate, on which herring prefer to spawn, is available to the stock in various areas unaffected at 90 $dB_{ht}$ levels (Figure 4.2-7)). As a result, herring are considered receptors of **medium** sensitivity and the effect is assessed to be **negative,** of **minor significance** and **probable.**
- In the absence of detailed information regarding the migratory routes of salmon and sea trout, it is assumed that they may transit the modified OfTI corridor as part of their normal migration and/or as part of their foraging activity. This is particularly pertinent to sea trout as marine migration and feeding occurs in more inshore/coastal habitats than salmon. It is considered that areas in the immediate vicinity of the rivers will not be affected by noise and hence fish will not be disturbed immediately prior to river entry or immediately after leaving the rivers at either the 90$dB_{ht}$ or 75$dB_{ht}$ levels, as demonstrated by the noise contours shown in Figure 4.2-8). No barrier effect is therefore expected to occur given the relatively small ranges expected for these species at both the 90$dB_{ht}$ or 75$dB_{ht}$ level (Figure 4.2-8). Taking the above into account and given the conservation status of salmon and sea trout and the importance of their fisheries to the local and national level in Scotland, they are considered to be of **medium** sensitivity. The effect on salmon and sea trout is assessed to be **negative,** of **minor significance** and **probable.**

Other Fish Species Present in the Vicinity of the Modified OfTI

4.2.2.63 The level of hearing specialisation in fish is assumed to be associated with possession of a swim bladder and whether the swim bladder is connected to the ear. Fish with specialist structures are considered to have the highest sensitivity, non-specialists with swim bladder of medium sensitivity and non-specialists without a swim bladder of lowest sensitivity (Nedwell *et al.*, 2004). Based on this classification, potential magnitudes of effect have been assigned to a number of species that are present in the Moray Firth area (i.e. species with conservation status, of commercial value, key prey species) for which noise modelling has not been undertaken and direct surrogates have not been defined:

- For non-flatfish species that lack a swim bladder, namely sandeels, elasmobranchs, anglerfish, river lamprey and sea lamprey, the magnitude of effect may be similar to that assigned to dab (negligible);
- For species with a swim bladder that is not connected to the ear, namely mackerel, haddock and European eel, the magnitude of effect may be between that assigned to cod (small) and that assigned for dab (negligible); and
- For species which possess a connection between the swim bladder and the ear such as sprat, the potential magnitude of effect may be similar to that assigned to herring (small).

4.2.2.64 It is acknowledged that data relating to hearing ability exists only for a limited number of species and extrapolation of hearing capabilities between different species (especially those that are taxonomically distant), should be undertaken with caution (Hastings & Popper, 2005).

4.2.2.65 The likely potential magnitude of effect and the sensitivity of the species above is summarised in Table 4.2-9. Given the limitations and qualitative nature of the assessment, significance ratings and probabilities have not been defined. The limitations and the qualitative nature of the noise assessment for the species which have not been modelled and for which direct surrogates have not been defined should be recognised and only be taken as an indication of potential effects.

**Table 4.2-9 Qualitative Assessment for Species Not Modelled and Without Defined Surrogates Based on Potential Magnitude of Effects and Receptor Sensitivities**

| Species | Potential Magnitude of Effect | Sensitivity of receptor | |
|---|---|---|---|
| **Sandeels** | Negligible | • Important prey species<br>• Export cable site specific distribution unknown. The results of the sandeel survey undertaken suggest that there are not extensive areas supporting important sandeel populations within the Moray Firth Round 3 Area<br>• Substrate specific | Medium |
| **Elasmobranchs** | Negligible | • Most species are of conservation Importance<br>• Generally more prevalent in the north and west of Scotland than in the Moray Firth<br>• Some with nursery grounds defined in the proposed sites (spurdog, spotted ray and thornback ray) | Low-Medium |
| **River and sea lamprey** | Negligible | • Conservation importance<br>• Potentially transiting the site during migration (lack of detailed information on migration) | Medium |
| **Anglerfish** | Negligible | • Commercially important<br>• High intensity nursery area in the wind farm sites | Medium |
| **Haddock** | Negligible-Small | • Commercially important<br>• Nursery grounds in the area and spawning grounds in the proximity of the proposed wind farm sites | Low |
| **European eel** | Negligible - Small | • Conservation importance<br>• Potentially transiting the site during migration (lack of detailed information on migration) | Medium |
| **Mackerel** | Negligible-Small | • Seasonal commercial fishery in inshore areas along the Moray coast and in the vicinity of the export cable landfall (Chapter 5.1: Commercial Fisheries)<br>• No spawning or nursery grounds in the vicinity of the modified OfTI | Low |
| **Sprat** | Small | • Important as prey species<br>• Spawning and nursery grounds in the area, however these are comparatively large | Low-Medium |

Life Stages of Limited Mobility

4.2.2.66 Larvae and early life stages of fish have limited flight ability and are probably at least as sensitive as adults to acoustic noise (Wahlberg & Westerberg, 2005). Life stages of limited mobility such as larvae, and in the case of European eel, their juvenile form (glass eels), could be vulnerable to effects from acoustic sources as they have a limited ability to move out of areas where mortality, physical injury and auditory injury could occur, assuming they drift through the vicinity of the modified OfTI corridor. Although there is limited information on the effect of piling noise to date on early life stages of fish, research recently carried out by the Institute for Marine Resources and Ecosystem Studies (IMARES) (Bolle *et al.*, 2011) suggests that the assumption of 100% of larvae mortality within a radius of 1,000 m around a piling site (used in the Appropriate Assessment of Dutch offshore wind farms) is too conservative. Bolle *et al.*, (2011) found no significant effects in the larval stages analysed at the highest exposure level (cumulative SEL = 206 dB re 1µPa2s) which represented 100 pulses at a distance of 100 m from piling. It is recognised that the results, based on sole larvae, cannot be directly extrapolated to fish larvae in general as inter-specific differences in vulnerability to sound exposure may exist. The findings, however, suggest that larval mortality would only occur within a few hundred metres from where piling is taking place. On this basis the magnitude of the effect is considered **negligible**. The sensitivity of larvae and glass eels is considered **medium** and the effect is assessed to be **negative, of minor significance and probable**.

<u>Shellfish Species</u>

4.2.2.67 The majority of shellfish species present in areas relevant to the modified OfTI, with the exception of squid, have limited mobility in comparison to most fish species. They therefore may not be able to avoid areas in close proximity to piling operations as quickly as mobile fish. The hearing mechanism of invertebrate species is currently not well understood although it is generally thought that invertebrate species are less sensitive to noise than fish due to the lack of a swim bladder.

4.2.2.68 Piling noise should not however interfere with normal behaviour as mobile shellfish species would be likely to return to the areas soon after cessation of the piling activity. Furthermore, other marine bivalves (e.g. mussels and periwinkles) exposed to a single airgun at a distance of 0.5 m also have shown no effects after exposure (Kosheleva, 1992). As such no effects on sedentary macro-invertebrates are to be expected.

4.2.2.69 Some species of squid and shrimp are thought to be 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). The limited studies which have examined the effect of anthropogenic noise on invertebrates almost exclusively consider the effects of geophysical survey, particularly the effects of 'airguns', used in seismic surveys. Generally, these are of a lower frequency and higher source pressure than piling associated with installation of OSPs (Vella *et al.*, 2001).

4.2.2.70 Levels recorded during piling at the Belwind offshore wind farm during construction showed that the maximum underwater noise level produced by piling was 196 dB re1µPa recorded at 520 m from the source, within the range of 100-1,000 Hz (Norro *et al.*, 2009). The fact that these frequencies are within the same bandwidth as those which crustaceans appear to be sensitive to (e.g. 100–3,000Hz; Popper *et al.*, 2001; Lovell *et al.*, 2005) suggests that species such as lobster, crab and *Nephrops* are likely to be able to detect noise generated by construction activity. However, this does not necessarily imply a response in these species and provides no indication of whether there are any associated negative impacts.

4.2.2.71 Experiments exposing adult American lobster, which belongs to the same genus as the European lobster, to seismic air gun noise at frequencies similar to those associated with piling for turbine foundations (peak–to-peak pressure measures approximately 202 dB re 1µPa in the low level exposure and 227 dB re 1µPa in the high level exposure) found no evidence of immediate or delayed mortality (up to nine months after noise exposure). Furthermore, based on measurements of serum enzymes (used as an indicator of internal tissue damage) even high level exposure had not resulted in internal organ damage. Results also suggested that noise exposure is unlikely to affect orientation and navigation in lobsters as no effect of exposure was recorded on either geo-orientation or equilibrium functions (Payne, 2007).

4.2.2.72 In laboratory experiments, *Nephrops* has been shown to display distinct postural responses to sound frequencies of 20-180 Hz. In the field *Nephrops* was found to respond to particle displacement and not pressure but no response was observed when the stimulus was further than 0.9 cm from the animal. This would suggest that sensitivity to noise in *Nephrops* is low (Goodall *et al*., 1990, Popper and Fay 1999, Popper *et al*., 2001).

4.2.2.73 Taking the above into account and the short term nature and frequency of piling associated with OSPs, the magnitude of the effect of noise on shellfish is considered **negligible** and the sensitivity of shellfish **low**. The effect on shellfish species is therefore assessed to be **negative**, of **minor significance** and **probable**.

***Operation***

*Electromagnetic Fields*

4.2.2.74 The export and inter-platform cables will generate EMFs during the operational phase of the modified OfTI. For both inter platform and export cables 220 kV AC will be used. AC cables will generate an electric field (E) and a magnetic field (B). The sheathing and armoured cores prevent the propagation of E fields into the environment, however, these materials are permeable to B fields, which therefore emanate into the surrounding environment.

4.2.2.75 The magnetic fields generated by AC cables are constantly changing. In turn, the motion of these B fields through the surrounding seawater induces varying electric (Ei) fields. Therefore both B and Ei fields will be generated by both export and inter platform cables during the operational phase of the modified OfTI.

4.2.2.76 The strength of the magnetic field generated by AC cables decreases exponentially, both horizontally and vertically with distance from source (Normandeau *et al*., 2011). Cables will be buried to a target depth of 1 m. Whilst cable burial does not completely mitigate B or Ei fields, it 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).

4.2.2.77 In instances where adequate burial cannot be achieved, alternative protection such as mattresses or rock placement will be used. Benthic and demersal fish and shellfish species will therefore not be directly exposed to the strongest EMFs as a result of the physical barrier that burial and cable protection constitute.

4.2.2.78 The NPS EN-3 document states that where cables are buried at depths greater than 1.5 m below the sea bed, effects upon sensitive fish species are likely to be negligible. Since the strength of the magnetic field decreases with distance from the source, the likely effects of EMFs on fish and shellfish will be influenced by the position of particular species in the water column and water depth.

4.2.2.79 An estimate of the B fields expected to be produced by the cables proposed for the modified OfTI is given in Plate 4.2 - 1. The methodology used and the full results of the EMF modelling are provided in Technical Appendix 4.3 D of MORL ES (MORL, 2012). B fields are expected to decrease very quickly horizontally with distance from the cable (within a few metres) and vertically (within 5 metres from the seabed). The E fields induced by these B fields, will as a result, also similarly decrease with distance from the source.

4.2.2.80 The expected B fields generated by offshore export cables and inter-platform AC cables are, taking cable burial to 1 m, well below the Earth's magnetic field (assumed to be 50 µT) (Plate 4.2-1)).

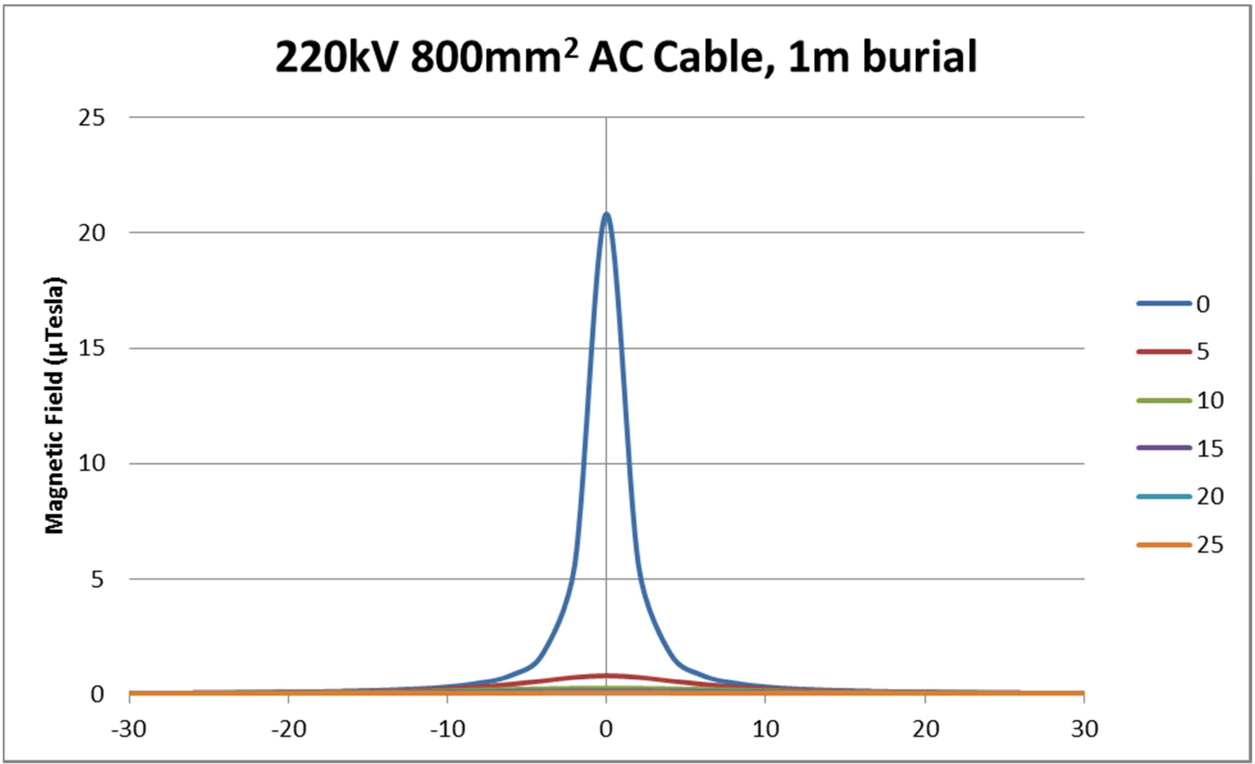


**Plate 4.2 - 1 Magnetic Field Expected from 220kV 800mm2 AC Inter-platform Cables Assuming 1 m Burial**

4.2.2.81 Taking the above into account it is considered that the area where EMF effects may occur will be limited to the modified OfTI and its immediate vicinity (e.g. within a few metres). The magnitude of the effect is therefore considered to be **small**.

4.2.2.82 A summary of the species for which there is evidence of a response to electric (E) and magnetic (B) fields is given below in Table 4.2-10 and Table 4.2-11 respectively, as provided in Gill *et al*., (2005). The potential effects of EMFs on these species are assessed separately in the following sections.

**Table 4.2-10 Species Found in UK 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* |

**Table 4.2-11 Species Found in UK Waters for Which There is Evidence of Response to B Fields**

| **Species/Species Group** | **Latin Name** |
|---|---|
| *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 albacores* |
| *Crustaceans* | |
| Lobster, crabs, shrimps and prawns | Specific cases non-UK<br>*Decapoda;* Crangon crangon (ICES, 2003)<br>*Isopoda: Idotea baltica* (Ugolini & Pezzani,1995)<br>*Amphipoda: Talorchestia martensii* (Ugolini, 1993) and *Talitrus saltator* (Ugolini and Macchi, 1988) |
| Molluscs | |
| snails, bivalves and squid | Specific case non-UK<br>Nudibranch: *Tritonia diomedea* (Willows, 1999) |

4.2.2.83 An assessment of the likely effect of EMFs on sensitive receptors expected to be present in the area of modified OfTI is given below. It is recognised that there is limited current information available on behavioural effects of EMFs. This is particularly evident in the case of diadromous migratory species for which very limited research is available. Research examining the response of EMFs on diadromous is being undertaken by MSS, but has not been published at the time of writing.

Elasmobranchs

4.2.2.84 Elasmobranch species are considered most susceptible to EMFs. Elasmobranchs naturally detect bioelectric emissions from prey, conspecifics and potential predators/competitors (Gill *et al.,* 2005). In addition, elasmobranchs are known to either detect magnetic fields using electrosensory systems or through an as yet undescribed magnetite receptor system (Normendaeu *et al*., 2011).

4.2.2.85 Both attraction and repulsion reactions associated with E fields in elasmobranch species have been observed. Gill & Taylor (2001) found limited laboratory based evidence that the lesser spotted dogfish avoids DC E fields at emission intensities similar to those predicted from the modified OfTI AC cables.

4.2.2.86 Threshold levels of EMF for elasmobranchs have not been defined, however the influence of EMF on fish appears to be limited to 2 m either side of the cable, indicating the scope of EMF propagation (Gill *et al*., 2005).

4.2.2.87 Information gathered as part of the monitoring programme at Burbo Bank wind farm suggests that certain elasmobranch species (sharks, skates and rays) do feed inside the wind farm and demonstrated that they are not excluded during periods of power generation (Cefas, 2009). Monitoring at Kentish Flats found an increase in thornback rays, smooth hounds and other elasmobranchs during post-construction surveys in comparison to pre-construction surveys.

4.2.2.88 A recent review by the UK Marine Management Organisation (MMO, 2014) concluded the following in relation to elasmobranchs and EMF generated by offshore wind cabling: "From the results of post-consent monitoring conducted to date, there is no evidence to suggest that EMFs pose a significant threat to elasmobranchs at the site or population level, and little uncertainty remains. Targeted research using high tech equipment and experimental precision has been unable to ascertain information beyond that of fish being able to detect EMFs and at what levels they become attracted or abhorrent to them. EMFs emitted from standard industry cables for offshore wind farms are unlikely to be repellent to elasmobranchs beyond a few metres from the cable if buried to sufficient depth. It is likely that the more subtle effects of EMF, including attraction of elasmobranchs, inquisitiveness and feeding response to low level EMFs, may occur. The Burbo Bank offshore wind farm post-consent monitoring undertook EMF specific surveys including stomach analysis of common elasmobranch species. Fish caught at the cable site (and hence subject to EMFs) were well fed. No deleterious effects were recorded to fish populations, at least when this effect occurs in association with the probable increased feeding opportunities reported as a result of increased habitat heterogeneity".

4.2.2.89 As such, EMFs produced by the cables may result in some behavioural effects on elasmobranchs, however, these are not likely to result in significant deviations from normal behaviour (e.g. feeding or migration).

4.2.2.90 The majority of elasmobranch species potentially transiting the area of the modified OfTI are in most cases more frequently found off the north and west coast of Scotland. The modified OfTI, however, falls within defined low intensity nursery grounds (Ellis *et al*., 2011) for several of these, namely spurdog, thornback ray and spotted ray.

4.2.2.91 Given the conservation status of most elasmobranch species, the potential for the modified OfTI to be used as a nursery ground by some of them, and the evidence of their ability to detect EMFs, they are considered to be a receptor group of **medium sensitivity**. The effect of EMFs on elasmobranchs is therefore assessed to be **negative** of **minor significance** and **probable.**

River and Sea Lamprey

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

4.2.2.93 Both river and sea lamprey are species of conservation importance. In addition, sea lamprey is a primary reason for selection of the River Spey as a SAC. Whilst the behaviour and distribution of both river and sea lamprey in the marine environment is poorly understood, given the central location of the modified OfTI in the Moray Firth, it is likely that sea lamprey may transit the area where the modified OfTI is located. Similarly, river lamprey have been reported in rivers in the Moray Firth and are hence also likely to be present in the vicinity of the modified OfTI.

4.2.2.94 EMFs generated by the cables could therefore result in behavioural effects on these species in areas adjacent to the OfTI and potentially cause limited disturbance during migration. Lampreys are considered of **medium sensitivity** and the effect of EMFs assessed to be of **negative minor significance** and **likely.**

European Eel

4.2.2.95 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 (Berge, 1979; Vriens & Bretschneider, 1979).

4.2.2.96 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. It has been shown that a B-Field from the cable connecting the wind farm at Nysted (Denmark), to the mainland at around 5 μT resulted in some deviation in the swimming direction of European eel (Eltra, 2000). However this result was found to be statistically insignificant Westerberg (1994). Research by Westerberg (1999) on High Voltage Direct Current (HVDC) cables and eel migration found some effects associated with magnetic disturbance were likely to occur on eel 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.

4.2.2.97 Further research where 60 migrating silver eels were tagged with ultrasonic tags and released north of the 130 kV AC export cable of the Nysted wind farm found swimming speeds were significantly lower around the cable than in areas to the north and south (Westerberg and Lagenfelt, 2008). 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 on average the delay caused by the passage was approximately 30 minutes.

4.2.2.98 Based on the above, European eel are considered of medium sensitivity and the effect of EMFs generated by the offshore transmission cables assessed to be **negative,** of **minor significance** and **probable.**

4.2.2.99 MSS is undertaking research into the behavioural effect of EMFs on diadromous species. It is anticipated that the results of MSS's study will contribute to increasing the knowledge in this field. This research is ongoing and results are expected to be released in 2015.

<u>Salmon and Sea Trout</u>

4.2.2.100 Research carried out on salmon and sea trout indicates that these species are able to respond to magnetic fields (Formicki *et al*., 2004; Tanski *et al*., 2005; Sadowski *et al*., 2007; Formicki and Winnicki, 2009). Furthermore, Atlantic salmon possess magnetic material in their lateral line, of a size suitable for magnetoreception (Moore *et al*., 1990). Most of the limited research undertaken on salmon and sea trout has however, been focused on physiology based laboratory studies.

4.2.2.101 Research under these conditions has found that EMFs can elicit localised physiological responses on salmon and sea trout (McCleave and Richardson, 1976; Vriens & Bretshneider, 1979; Hanson *et al*., 1984; Formicki *et al*., 1997, 2004). Swedpower (2003) however found no measurable impact when subjecting salmon and trout to magnetic fields twice the magnitude of the geomagnetic field. In line with this, Atlantic salmon migration in and out of the Baltic Sea appears to be unaffected despite crossing over a number of operational sub-sea HVDC cables (Walker, 2001). Öhman *et al*. (2007) state 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. Vision, hearing and olfaction as well as hydrographic and geoelectric information could all be used for spatial orientation. This is true of salmonids which are believed to use olfactory cues in the later stages of migration whilst searching for the natal river.

4.2.2.102 Since the strength of EMFs decreases exponentially with distance from the source, the magnitude and intensity of the potential behavioural effects on salmonids would be closely linked to the proximity of the fish to the source of EMF.

4.2.2.103 Gill and Barlett (2010) suggest that any effect on the migration of salmon and sea trout will be likely be dependent on the depth of water and the proximity of the rivers to a development site. Given the central location of the modified OfTI in the context of the Moray Firth area, the uncertainties in relation to migratory patterns and the proximity of the proposed offshore cable landfalls to salmon and sea trout rivers (particularly those relevant to the Deveron and Spey SFDs) it is likely that salmon and sea trout will transit the area of the modified OfTI.

4.2.2.104 There is potential for EMFs generated by offshore export cables to result in a behavioural response on migrating salmon and sea trout (both adult and juveniles). However, as they normally swim in the upper metres of the water column during migration, salmon will not be exposed to the strongest EMFs. It is acknowledged that there may be increased exposure to EMF in sea trout, as the species is known to also forage in benthic habitats. However, the potential EMF footprint originating from the cable is likely to be small (e.g. tens of meters) in comparison to the total foraging habitat available.

4.2.2.105 Furthermore, salmon and sea trout use other cues for navigation in addition to the geomagnetic fields and these would more likely be prevalent in shallow areas in the proximity of the rivers. As shown in Figure 4.2-9, the predicted B fields are expected to decrease significantly within 5 m from the seabed. Assuming 1 m burial the expected B fields produced by the proposed cables will in all cases be well below the Earth's magnetic field.

4.2.2.106 Based on the above, salmon and sea trout are considered receptors of **medium sensitivity** and the effect is assessed to be **negative,** of **minor significance** and **probable.**

4.2.2.107 It is anticipated that the findings of MSS's current research into the behavioural responses of migratory fish to EMFs will contribute to increase the current knowledge in this field.

Other Fish Species

4.2.2.108 As indicated in Table 4.2-10 and Table 4.2-11, 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 the presence of the foundations and scour protection and potential changes to the fisheries in the vicinity of offshore wind farm development, are expected to have the most effect upon fish species and that noise from the turbines and EMFs from cabling do 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 & Pedersen, 2006). In line with this, research carried out at the Nysted offshore wind farm, focused on detecting and assessing possible effects of EMFs on fish during power transmission and found no differences in the fish community composition after the wind farm was operational (Hvidt *et al*., 2005). 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 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 **negative,** of **minor significance** and **unlikely.**

Shellfish Species

4.2.2.109 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 in some of a response to magnetic fields, including molluscs and crustaceans. However, it is generally accepted that effects derived from EMFs on invertebrates are limited to behavioural reactions rather than direct effects (Normandeau *et al*., 2011).

4.2.2.110 The functional role of the magnetic sense in invertebrates has been hypothesised to be for orientation, navigation and homing using geomagnetic cues (Cain *et al*., 2005; Lohmann *et* al., 2007). Crustacea, including lobster and crabs, have been shown to demonstrate a response to B fields, with the spiny lobster (Panulirus argus) shown to use a magnetic map for navigation (Boles and Lohmann; 2003). 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), both species 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 offshore cable route.

4.2.2.111 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 modified OfTI there is potential for these species to encounter the offshore export cables during migration. Limited research undertaken with the European lobster, found no neurological response to magnetic field strengths considerably higher than those expected directly over an average buried power cable (Ueno *et al*., 1986; Normandeau *et al*., 2011).

4.2.2.112 It should be noted that 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. Based on the above shellfish species are considered receptors of **low sensitivity** and the effect is assessed to be **negative,** of **minor significance** and **unlikely**.

*Changes to Fishing Activity*

4.2.2.113 Changes to fishing activity during the operational phase of the modified OfTI could potentially have an effect on fish and shellfish receptors. Primarily this would relate to those species which are commercially targeted and/or caught as by-catch, although a wider range of organisms may also be affected due to changes in seabed communities associated with seabed disturbance.

4.2.2.114 As the export cables and inter-array cables within the modified OfTI are expected to be buried, it is expected that fishing activity will continue as previously during the operational phase and therefore it is considered that there will be no changes to fishing activity within the vicinity of the modified OfTI and hence it is considered that there will not be an impact (positive or negative) to fish and shellfish populations (Chapter 5.1: Commercial Fisheries).

4.2.2.115 In the commercial fisheries assessment, effects on commercial fisheries above minor were not identified during the operational phase of the modified OfTI (Chapter 5.1: Commercial Fisheries). The potential for changes in fishing activity to impact on fish and shellfish ecology have therefore been assessed as negative, unlikely and of minor significance.

***Decommissioning***

4.2.2.116 In the absence of detailed decommissioning schedules and methodologies it is assumed that the sensitivity of receptors during the decommissioning phase will be the same as given for the construction phase. Similarly, the magnitude of effect is considered to be no greater and in all probability less than that considered for the construction phase. Therefore it is anticipated that any decommissioning effects would be no greater and probably less than that assessed for the construction phase. As piling is not expected to be necessary during decommissioning, effects associated with noise during this phase will likely be considerably smaller than those assessed for the construction phase above.

**Proposed Monitoring and Mitigation**

***Construction and Decommissioning***

4.2.2.117 No significant effects (e.g. above minor) have been identified on fish and shellfish ecology as a result of the construction/decommissioning phase of the modified OfTI. In order that mobile species are not exposed to the highest noise levels during piling, 'soft start' methods will be employed for installation of the OSP foundations.

***Operation***

4.2.2.118 Similarly, no significant effects (e.g. above minor) have been identified on fish and shellfish receptors for the operational phase of the modified OfTI. As mentioned in the assessment of EMFs, cable burial will reduce 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). Similarly, where burial is not feasible, cable protection will ensure that fish and shellfish receptors are not in direct contact with the cable and will not be exposed to the strongest EMFs.

### 4.2.3 Cumulative Impact Assessment

**Summary**

4.2.3.1 This section presents the results of assessment of the potential cumulative effects upon fish and shellfish arising from the modified OfTI in conjunction with other existing or reasonably foreseeable marine coastal developments and activities. MORL's approach to the assessment of cumulative effects is described in Chapter 1.3: Environmental Impact Assessment.

4.2.3.2 A summary of the cumulative impact assessment is given below in Table 4.2-12. Likely significant cumulative effects (above minor) have been identified in relation to construction noise on a number of species, namely, cod, herring, salmon and sea trout. In addition, the potential for a significant cumulative effect associated to loss of habitat to occur on sandeels has been identified.

**Table 4.2-12 Cumulative Impact Summary**

| Effect/Receptor | MORL Modified OfTI | Whole Project Assessment: Telford, Stevenson and MacColl and Modified OfTI | Mitigation Method |
|---|---|---|---|
| **Temporary disturbance to the seabed (increased SSCs and sediment re-deposition)** | General: Minor<br>Salmon and sea trout: Minor | General: Minor<br>Salmon and sea trout: Minor | None proposed |
| **Overall CIA for Increased SSCs and Sediment Re-Deposition** | General: Minor<br>Salmon and sea trout: Minor | | |
| **Construction Noise** | General : Minor<br>Salmon and sea trout: Minor | General; Minor<br>Cod and Herring: Minor following mitigation | Soft start piling |
| **Overall CIA for Construction Noise** | General : Minor<br>Salmon and sea trout: Minor | | |
| **Habitat Loss** | General: Minor | General: Minor | None proposed |
| **Overall CIA for habitat loss** | General: Minor | | |
| **EMFs** | General: Minor | General: Minor | Cable burial/protection |

| Effect/Receptor | MORL Modified OfTI | Whole Project Assessment: Telford, Stevenson and MacColl and Modified OfTI | Mitigation Method |
|---|---|---|---|
| **Overall CIA for EMFs** | General: Minor | | |
| **Changes to fishing activity** | General: No impact | General: No impact | None proposed |
| **Overall CIA for changes to fishing activity** | General: No impact | | |

**Assessment of Cumulative Effects**

4.2.3.3 This section details the assessment of cumulative effects upon fish and shellfish ecology arising from the modified OfTI and the three consented wind farm sites (Telford, Stevenson and MacColl) and the Beatrice offshore wind farm (BOWL), WDA, European Offshore Wind Development Centre (EOWDC), Neart na Gaoithe, Inch Cape, and Firth of Forth wind farms (Figure 4.2-9) in conjunction with other existing and foreseeable planned marine project/ development activities.

4.2.3.4 The geographical scope of the cumulative assessment is principally focused in the Moray Firth area. It is, however, recognised that some species may spend varying periods of time outside the Moray Firth and, as a result, there is potential for these to be affected by other activities / developments further afield.

4.2.3.5 The developments and activities considered in detail within this assessment are listed below:

- Beatrice Offshore Wind Farm (BOWL) and associated infrastructure;
- MORL Western Development Area (WDA) generating stations;
- EOWDC.

4.2.3.6 Developments that are at an earlier stage and for which there are limited development details at this stage, are also considered. The worst case scenarios for these projects are limited in detail and are as follows:

- Firth of Forth phase 1; – 2 x 75 turbine wind farms;
- Inch Cape Offshore Wind Farm; - 213 turbines, three met masts, five offshore substations and 6 offshore export cables; and
- Neart na Gaoithe Offshore Wind Farm; – 125 turbines and two offshore substations

4.2.3.7 The developments listed above are likely to have particular relevance to potential cumulative impacts on salmon and sea trout due to their wide ranging and relatively poorly defined migration pathways. Therefore the potential impacts of these developments are considered separately.

4.2.3.8 In addition, the following developments have been identified which may have cumulative effects over the life of the modified Project but where there is insufficient information available for a detailed assessment of cumulative effects to be carried out :

- Hywind;
- Kincardine Offshore Wind Farm;
- The SHE-T cable;
- Relevant oil and gas activities (Beatrice and Jacky platforms and associated infrastructure and Suncor);
- Tidal and wave energy developments in the Pentland Firth and Orkney Waters Strategic Area;
- Port and harbour developments in the Moray Firth;
- Dredging and sea disposal in the Moray Firth; and
- Relevant military activities.

4.2.3.9 The cumulative effects arising from dredging, sea disposal and port and harbour development in the Moray Firth have not been taken forward for assessment, since these are sporadic and typically short-term activities and concentrated along the coastline of the Moray Firth.

**Methodology**

4.2.3.10 The assessment methodology has followed that outlined in the Moray Firth Offshore Wind Developers Group Discussion Document (ERM, 2011; see Appendix 1.3 D of the MORL ES (MORL, 2012)).

***Worst Case Scenario for Projects Where Detailed Assessment is Possible***

4.2.3.11 A summary of the realistic worst case parameters of wind farm design for the BOWL project, the WDA and the EOWDC, in terms of fish and shellfish ecology, is provided in Table 4.2-13 to Table 4.2-16. Worst case parameters for the modified OfTI are provided in Table 4.2-3.

**Table 4.2-13 Summary of the MORL Three Consented Wind Farms Worst Case Parameters**

| **Worst case parameters** | **Scenario assessed** |
|---|---|
| **Construction noise** | |
| Installation of 186 6 MW turbines and 2 met masts | Four 2.5m pin piles per foundation |
| Max. number of simultaneous piling events per wind farm | 2 |
| **Increased suspended sediment concentration and sediment re-deposition** | |
| Installation of 192 gravity bases (186 WTGs and 6 OSPs)<br>Installation of 572 km of inter –array cabling (target burial depth of 1m) | Drilling to facilitate pin pile installation and seabed preparation for installation of gravity bases. Inter array cable burial by energetic means 1 |
| **Loss of Habitat and Introduction of New Habitat** | |
| Installation of 192 gravity bases (186 WTGs and 6 OSPs)<br>Installation of 572 km of inter –array cabling (target burial depth of 1m) | Gravity Bases each with total foot print area of 65m diameter |
| **EMFs** | |
| Estimated total length of Inter –array cabling | 572 km |

**Table 4.2-14 Summary of BOWL Worst Case Parameters**

| **Worst case parameters** | **Scenario assessed** |
|---|---|
| **Construction noise** | |
| Installation of 140 turbines | Four pin piles (2.4m diameter) per foundation |
| Max. number of simultaneous piling events | 2 |
| **Increased suspended sediment concentration and sediment re-deposition** | |
| Installation of 143 gravity base foundations (turbines and OSPs)<br>Length of inter-array cables = 325 km and trench width = 3 m.<br>Length of export cable = 65 km | Drilling to facilitate pin pile installation and seabed preparation for installation of gravity bases. Inter array cable and export cable burial by energetic means |
| **Loss of Habitat and Introduction of New Habitat** | |
| Installation of 140 turbines if lowest rated (3.6 MW) turbines selected, plus 2 AC OSPs and 1 AC / DC substation.<br>Gravity base and scour protection with combined permanent zone of influence of 11,690 m2 per foundation. | Total area of loss of original habitat and area of new hard substrata = 3.52 km2 equating to 2.7 % of the BOWL development area |
| **EMFs** | |
| Inter array cabling total length | 325 km |
| Export cabling length | 65 km |

4.2.3.12 WDA Worst Case Parameters are provided in Table 4.2-16. The WDA comprises a part of the MORL Zone within which no wind farms have yet been applied for. MORL has been consented for 1,116MW within the Zone to date (within the three consented wind farms). The WDA could be developed for up to 500 MW, should the full consented capacity (1,116MW) for the three consented sites not be built out. Under any scenario, the maximum capacity of the entire Zone of 1.5GW, and will not be exceeded. The worst case parameters presented below are for 500 MW capacity within the WDA.

**Table 4.2-15 Summary of WDA Worst Case Parameters**

| Worst case parameters | Scenario assessed |
|---|---|
| **Construction noise** | |
| Installation of 100 turbines | Jackets on pin piles (2.4m diameter) per foundation |
| Max. number of simultaneous piling events | 2 |
| **Increased suspended sediment concentration and sediment re-deposition** | |
| Installation of 101 gravity base foundations (turbines and OSPs)<br>Length of inter-array cables = 130 km and trench width = 3 m.<br>Length of export cable = Approx. 60 km | Drilling to facilitate pin pile installation and seabed preparation for installation of gravity bases. Inter array cable and export cable burial by energetic means |
| **Loss of Habitat and Introduction of New Habitat** | |
| Installation of 100 turbines and 1 AC OSPs and with GBS foundations & scour material.<br>Cable protection associated with up to 4 J tubes per turbine assuming protection required up to 50 m distance from turbine and at 10 m width = 2,000 m2 per turbine; | Total area of loss of original habitat and area of new hard substrata = 1.20 km2 equating to 0.5 % of the WDA development area.<br>Note: development within the WDA will offset development within Telford, Stevenson and MacColl. |
| **EMFs** | |
| Inter array cabling total length | 130 km |
| Export cabling length | Approx. 60 km |

**Table 4.2-16 Summary of EOWDC Worst Case Parameters**

| Worst case parameters | Scenario assessed |
|---|---|
| **Construction noise** | |
| Installation of 11 turbines | Monopiles (8.5m diameter) per foundation |
| Max. number of simultaneous piling events | 1 |
| **Increased suspended sediment concentration and sediment re-deposition** | |
| Installation of 11turbines<br>Installation of inter-array cables<br>Installation of export cable | Gravity base foundations (40 m diameter)<br>Max length 13 km<br>Max length 26 km |

| Worst case parameters | Scenario assessed |
|---|---|
| **Loss of Habitat and Introduction of New Habitat** | |
| Installation of 11 turbines | Gravity base foundations (40 m diameter) |
| **EMFs** | |
| Inter array cabling total length | 13 km |
| Export cabling length | 26 km |

### *Other Developments*

4.2.3.13 Developments that are at an earlier stage and for which there are limited details at this stage, are also considered. Detailed cumulative impact assessment of these developments is not possible as insufficient information is available. Instead, a commentary on the potential for cumulative effects on the basis of the information available is presented but no quantitative conclusions on the likely significance of any impacts can be drawn. Projects for which a detailed cumulative impact assessment is not possible due to a lack of sufficient information include:

- Hywind;
- Kincardine Offshore Wind Farm;
- The SHE-T cable;
- Relevant oil and gas activities (Beatrice and Jacky platforms and associated infrastructure and Suncor);
- Tidal and wave energy developments in the Pentland Firth and Orkney Waters Strategic Area;
- Port and harbour developments in the Moray Firth;
- Dredging and sea disposal in the Moray Firth; and
- Relevant military activities.

### Cumulative Assessment

4.2.3.14 The types of effects considered in this assessment are:

- Temporary disturbance to the seabed (Increased SSCs and sediment re-deposition);
- Underwater Noise;
- Habitat Loss; and
- EMFs.

4.2.3.15 As the cables of the modified TI will be buried where possible, it is expected that normal fishing activity will resume within the vicinity of the modified OfTI, therefore, the contribution of the modified OfTI to the cumulative impact of changes to fishing activity will be of negligible significance. As a result, changes to fishing activity is scoped out of the assessment

***Temporary Disturbance to the Seabed (Increased SSCs and Sediment Re-deposition)***

4.2.3.16 The release of sediment into the water column as a result of construction works being carried out simultaneously in adjacent areas may result in an effect on fish and shellfish species. The likely cumulative impact of multiple and simultaneous sources of sediment release is detailed in Chapter 3.1 (Hydrodynamics, Sedimentary and Coastal Processes). This takes account of the following:

- The receptors identified for the three consented wind farms, modified OfTI and BOWL foundation installation (drilling for pin piles or bed preparation of GBS);
- The three consented wind farms, modified OfTI and BOWL inter array cable burial; and
- The three consented wind farms, modified OfTI and BOWL transmission cable burial.

4.2.3.17 The maximum cumulative result of interaction between sediment plumes is an additive increase in SSCs. As indicated in Chapter 3.1 (Hydrodynamics, Sedimentary and Coastal Processes) no significant cumulative effects are expected as a result of this. Similarly, **no significant cumulative effects** in terms of sediment re-deposition have been identified in Chapter 3.1 (Hydrodynamics, Sedimentary and Coastal Processes).

4.2.3.18 Taking the above into account the construction phase of the BOWL site is expected to result in effects of **minor significance** on fish and shellfish receptors. The cumulative effect of increased SSCs and sediment re-deposition is therefore considered to be of **minor significance** on fish and shellfish in general.

*Salmon and Sea Trout*

4.2.3.19 In the case of salmon and sea trout, in addition to the above, SSCs and sediment re-deposition associated with installation activities in the EOWDC project, may further contribute to the potential cumulative effects identified above for fish and shellfish in general, assuming salmon and sea trout also transit the Aberdeen Bay area during migration. Given the small number of foundations needing installation in the EOWDC (11) and the relatively small amount of cable installation disturbance through increased SSCs, it is expected to result in an effect of **minor significance** on salmon and sea trout.

4.2.3.20 Should the migratory pathways of salmon and sea trout take them into close proximity to the EOWDC, Neart na Gaoithe, Inch Cape and SeaGreen wind farms they may also be subject to increased SSCs related to construction activities from these developments. However, any increases in SSCs will be limited both temporally and spatially.

4.2.1.60 Taking the above into account, the cumulative effect associated with increased SSCs and sediment re-deposition on salmon and sea trout is assessed to be of minor significance.

***Underwater Noise***

4.2.3.21 For assessment of the cumulative impact of construction noise, it is possible that piling operations may take place simultaneously at the BOWL project, the three consented wind farm sites and the OSPs of the modified OfTI.

4.2.3.22 Worst case cumulative noise scenarios were modelled taking the potential maximum of eight simultaneous piling operations (six at Telford, Stevenson and MacColl / WDA and two at BOWL). The outputs of these are provided in Chapter 3.6

(Underwater Noise) of the MORL ES (MORL, 2012) and Technical Appendix 4.2 A for herring, cod, salmon and dab.

4.2.3.23 The expected impact ranges taking the cumulative scenario are similar to those expected from piling at six locations within Telford, Stevenson and MacColl. The noise effects associated to piling at BOWL, given the smaller number of piling operations needed (installation of a maximum of 140 turbines), the maximum of two piling operations proposed and the modelled impact ranges, are expected to be of minor significance on fish and shellfish species in general. An exception to this is the effect on cod and herring. Given the uncertainties in relation to the use that these species make of the Moray Firth area, particularly in relation to the extent and relative importance of the area in terms of spawning grounds, there may be potential for effects of minor to moderate associated with noise during construction of the BOWL site to occur.

4.2.3.24 Taking the above into account construction noise is considered to result in a cumulative effect of **minor** significance on fish and shellfish in general with the exception of cod and herring, for which a cumulative effect of **moderate** significance may occur.

*Salmon and Sea Trout*

4.2.3.25 In addition to the assessment for general species given above, due to the migratory behaviour of salmon and sea trout, additional projects have been included as part of the cumulative assessment. Given the relatively small ranges associated with two piling operations at BOWL, noise derived from construction work at BOWL is considered to result in an effect of **minor significance** on salmon and sea trout.

4.2.3.26 Assuming that the migratory pathways of salmon and sea trout take them into close proximity to the EOWDC, Neart ne Gaoithe, Inch Cape and Firth of Forth wind farms they may also be subject to noise generated during construction of these developments.

4.2.3.27 Taking the potential for salmon and sea trout to be exposed to construction noise not only in the Moray Firth area but also further afield, the cumulative effect of construction noise on these species is assessed to be of **minor to moderate** significance.

4.2.3.28 It should be noted that the potential for a cumulative effect to occur will be dependent on the construction schedules on the timing and migration route taken by salmon and sea trout populations from different rivers, and on the degree of overlap between these, and areas impacted by construction noise.

4.2.3.29 The impact assessment on these species has taken a precautionary approach, where conservative assumptions have had to be applied as a result of the uncertainty surrounding currently available information on the use that these species may make of the areas during the construction phase.

4.2.3.30 In order to mitigate this uncertainty, MORL is committed, in consultation with Marine Scotland and the relevant fisheries stakeholders, to strategic monitoring and research to help improve the knowledge base on salmon population ecology and migratory movements within the Moray Firth to help inform whether mitigation is required and, if so, to define feasible measures in order to reduce the significance of the likely effects.

***Loss of Habitat***

4.2.3.31 The installation of the BOWL project will result in an incremental loss of habitat as successive placement of foundations onto the seabed occurs. This will add to that resulting from the three consented windfarms and the modified OfTI. The loss of seabed area is however likely to be small in relation to the total extent of available habitat. The loss of habitat resulting from both the BOWL site, the three consented wind farms and the modified OfTI is therefore expected to result in an effect of negligible to minor significance on fish and shellfish species. The cumulative effect arising from this is therefore assessed to be of **minor** significance.

4.2.3.32 In the particular case of sandeels, the potential for a cumulative impact to occur will be dependent on the location of high density sandeel patches, the overall distribution of sandeel habitat in the Moray Firth and the degree of overlap between these and wind farm related infrastructure. The results of the sandeel survey undertaken, suggest that there are not extensive areas supporting important sandeel populations in the three consented wind farms sites. A specific sandeel survey has not been undertaken for the modified OfTI, however, utilising the benthic particle size distribution (PSD) data, station KPA2 contains substrates suitable for sandeels, and therefore it is possible that sandeels could be present.

4.2.3.33 Taking the relatively small area expected to be lost through the installation of the BOWL project, the three consented windfarms and the modified OfTI, the effect of loss of habitat on sandeels is expected to be of **minor** significance. The distribution and relative importance of the BOWL site and the wider Moray Firth in terms of sandeel distribution, are however currently unknown. In light of this and taking a precautionary approach, the cumulative effect of loss of habitat on sandeels is considered to be of **minor to moderate** significance.

*Salmon and Sea Trout*

4.2.3.34 The introduction of the EOWDC, Neart na Gaoithe, Inch Cape and Firth of Forth windfarms will further contribute the loss of seabed habitat for salmon and sea trout. The loss of seabed area is however likely to be small in relation to the total extent of available habitat therefore, the cumulative effect of loss of habitat on salmon and sea trout is considered to be, as assessed for fish and shellfish in general above, of **minor** significance.

***EMFs***

4.2.3.35 The adjacent location of BOWL will result in an increase in the spatial extent of EMF related effects associated with the operational phase of the modified OfTI.

4.2.3.36 Post-construction monitoring undertaken in operational wind farms to date, does not suggest that EMF related effects have had a significant detrimental effect on fish and shellfish species. EMF related effects resulting from the three consented wind farms, the BOWL project and the WDA are therefore considered to be of minor significance. Therefore the cumulative effect associated with the modified OfTI on fish and shellfish species in general is considered to be of **minor** significance.

*Salmon and Sea Trout*

4.2.3.37 There is potential for salmon and sea trout to be exposed to EMF related effects associated with the EOWDC, Neart na Gaoithe, Inch Cape and Firth of Forth windfarms. However, as they normally swim in the upper metres of the water column during migration, salmon and sea trout will not, for the most part, be exposed to the strongest EMFs. It is acknowledged that there is an increased potential for exposure to EMF in sea trout, as the species is known to also forage in benthic habitats.

However, the potential EMF footprint originating from the cable is likely to be small (e.g. tens of meters) in comparison to the total foraging habitat available. In light of these considerations and in addition to the results of the EMF modelling provided in Technical Appendix 4.3 D in the MORL ES (MORL, 2012) for AC cables, the effect of EMFs during the operational phase of the developments under consideration are considered to be of minor significance. The cumulative effect of EMF on salmon and sea trout, is therefore considered to be as assessed above for fish and shellfish in general, of **minor** significance.

***Other Developments***

*Construction*

4.2.3.38 There is potential for increased SSCs and sediment re-deposition and noise associated to construction works in other marine developments / activities to occur on fish and shellfish, including installation of the SHE-T cable, Oil and Gas and military activities in the Moray Firth. The potential for a cumulative impact to occur will depend on the location and nature of these activities.

4.2.3.39 In the particular case of herring, as spawning of the Orkney / Shetland stock primarily takes place in the area between the Orkney and the Shetlands, there might be also potential for suspended sediment concentrations, sediment re-deposition and construction noise associated with the Pentland Firth and Orkney waters marine energy developments to further contribute to cumulative impacts.

4.2.3.40 In addition to the above, there is potential for Salmon and Sea Trout to be subject to increased SSCs, sediment re-deposition and construction noise associated to construction works in the proposed offshore wind farm developments in the Firth of Forth.

4.2.3.41 It is appropriate to adopt a precautionary approach in light of uncertainties surrounding the developments considered here. However, it is important to consider that the potential for a cumulative effects to occur will be entirely dependent on the degree of overlap (if any) in construction schedules.

*Operation*

4.2.3.42 Other offshore developments, including the SHE-T cable, potential future oil and gas related infrastructure and the proposed Pentland Firth and Orkney waters marine renewable developments, may further contribute to any cumulative effects associated to loss of habitat and EMFs and changes to fishing activity during the operational phase. Given that for all three of these, potential effects were generally not assessed to be above minor. It is considered unlikely that the modified OfTI will further contribute to any significant cumulative effect.

**Habitats Regulations Appraisal**

***Modified OfTI***

4.2.3.43 As part of the Conservation (Natural Habitats, &c.) Regulations 1994 (as amended) and Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (the 'Habitats Regulations') it is required that the likely effect of the modified OfTI on Atlantic salmon and sea lamprey SAC populations be assessed. These species are qualifying features and primary reasons for selection of a number of SACs in the Moray Firth. In addition to these species, freshwater pearl mussel is also a primary reason for selection of a number of SACs. Given the central location of the modified OfTI relative to the habitat of the species (restricted to freshwater) it is not considered that freshwater pearl mussel SAC populations will be directly affected through construction/decommissioning or operation of the modified OfTI. It was agreed with SNH that freshwater pearl mussel would be scoped out of the terrestrial ecology assessment, and this is further discussed in the Terrestrial Ecology chapter (Chapter 4.6). It is however recognised that SAC populations of this species may be indirectly affected if significant effects on their host species (salmon and sea trout in particular) occur.

4.2.3.44 Through the implementation of the Habitats Directive and as a result of the European importance of Scotland's salmon populations, eleven Scottish rivers have been designated as Special Areas of Conservation (SACs), with salmon being a primary reason for the selection of the sites. Of these, the River Spey is the closest SAC located to the modified OfTI, is  and the salmon population is considered of high quality.

4.2.3.45 As specified in the JNCC and SNH scoping response (28/10/2010 and 29/05/2014), the SACs needing assessment in relation to fish and shellfish resources are as follows:

- River Spey SAC;
- Berriedale & Langwell Waters SAC;
- River Evelix SAC;
- River Moriston SAC ;
- River Oykel SAC; and
- River Thurso SAC.

4.2.3.46 The qualifying status of the SAC species and the conservation objectives of each relevant SAC are given in Table 4.2-18

**Table 4.2-17 Qualifying status of SAC species and SAC conservation objectives (SNH, 2012)**

| SAC | Qualifying Species | Conservation Objective |
|---|---|---|
| **River Spey** | **Freshwater pearl mussel;** Primary reason for SAC selection<br>**Atlantic salmon:** Primary reason for SAC selection<br>**Sea lamprey**: Primary reason for SAC selection<br>**Otter:** Primary reason for SAC selection | • To avoid deterioration 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 the qualifying features.<br>• To ensure for the qualifying features that the following are maintained in the long term:<br>1. Population of the species (including range of genetic types for Atlantic salmon only) as a viable component of the site;<br>2. Distribution of species within site;<br>3. Distribution of extent of habitats supporting the species;<br>4. Structure, function and supporting processes of habitats supporting the species;<br>5. No significant disturbance of the species;<br>6. Distribution and viability of the species' host species (for freshwater pearl mussel and sea lamprey); and<br>7. Structure, function and supporting processes of habitats supporting the species' host (for freshwater pearl and sea lamprey) |

| SAC | Qualifying Species | Conservation Objective |
|---|---|---|
| | | |
| **Berriedale & Langwell Waters** | **Atlantic salmon:** Primary reason for SAC selection | • To avoid deterioration of the habitats of Atlantic salmon or significant disturbance to Atlantic salmon, 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<br>• To ensure for the qualifying species that the following are maintained in the long term:<br>1. Population of the species, including range of genetic types for salmon, as a viable component of the site;<br>2. Distribution of the species within the site;<br>3. Distribution and extent of habitats supporting the species;<br>4. Structure, function and supporting processes of habitats supporting the species; and<br>5. No significant disturbance of the species. |
| **River Evelix** | **Freshwater pearl mussel:** Primary reason for SAC selection | • To avoid deterioration of the habitats of freshwater pearl mussels or significant disturbance to freshwater pearl mussels, 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<br>• To ensure for the qualifying species that the following are maintained in the long term:<br>1. Population of the species as a viable component of the site;<br>2. Distribution of the species within the site;<br>3. Distribution and extent of habitats supporting the species;<br>4. Structure, function and supporting processes of habitats supporting the species;<br>5. No significant disturbance of the species;<br>6. Distribution and viability of the species' host species; and<br>7. Structure, function and supporting processes of habitats supporting the species' host species. |
| **River Moriston** | **Freshwater pearl mussel:** Primary reason for SAC selection<br>**Atlantic salmon:** Qualifying feature for SAC selection | • 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<br>• To ensure for the qualifying species that the following are maintained in the long term:<br>1. Population of the species, including range of genetic types for salmon, as a viable component of the site;<br>2. Distribution of the species within the site;<br>3. Distribution and extent of habitats supporting |

| SAC | Qualifying Species | Conservation Objective |
|---|---|---|
| | | the species;<br>4. Structure, function and supporting processes of habitats supporting the species;<br>5. No significant disturbance of the species;<br>6. Distribution and viability of freshwater pearl mussel host species; and<br>7. Structure, function and supporting processes of habitats supporting fresh water pearl mussel host species. |
| **River Oykel** | **Freshwater pearl mussel:** Primary reason for SAC selection<br>**Atlantic salmon**: Qualifying feature for SAC selection | As above |
| **River Thurso** | **Atlantic salmon:** Primary reason for SAC selection | Idem as for the Berriedale & Langwell Waters SAC |

4.2.3.47 For the SACs detailed in section 1.3, the effects on the relevant fish and shellfish qualifying species have been assessed based on the Conservation Objectives outlined previously in 6.1-1 as follows:

1. Deterioration of the habitats of the qualifying species.
2. Significant disturbance to the qualifying species.
3. Changes in the distribution of the species within the site.
4. Changes in the distribution and extent of habitats supporting the species.

4.2.3.48 In addition, in the particular case of Atlantic salmon, sea lamprey and freshwater pearl mussel SAC populations, the following criteria have been also been taken into account for assessment:

5. Changes to the population of the species, (including range of genetic types of salmon) as a viable component of the site.
6. Structure, function and supporting processes of habitats supporting the species;
7. Changes to the distribution of freshwater pearl mussel and sea lamprey host species and to the structure, function and supporting processes of habitats supporting fresh water pearl mussel and sea lamprey host species.

4.2.3.49 It should be noted that, as indicated by JNCC/SNH in their scoping response, in the case of salmon, it is not possible to conclusively identify from/to which SAC watercourses any particular individuals (post smolts or adults) are coming or going. The assumption that all individuals are SAC salmon should therefore be made. As a result the effects identified for salmon are considered to be applicable to any of the relevant SACs. In the case of freshwater pearl mussel, as any effect on the SAC populations could only be a result of their host species being adversely affected (salmon and sea trout) the same limitation applies. In order to assess likely effects on freshwater pearl mussel SAC populations it has therefore been assumed that the effects identified for Atlantic salmon apply to the freshwater pearl mussel's host species in the relevant SACs.

4.2.3.50 A summary assessment of the potential effect of the modified TI on the relevant Atlantic salmon, freshwater pearl mussel and sea lamprey SAC populations is given in Table 4.2-18 below.

**Table 4.2-18 Assessment of Effects on Qualifying Species in the Relevant SACs per Criterion**

| Species | criterion | Assessment |
|---|---|---|
| **Atlantic salmon** | 1 | The habitat of the SACs will not be subject to any direct deterioration as a result of the construction/ decommissioning or operation of the modified OfTI as these are located in freshwater habitats. Deterioration of the marine habitats of Atlantic salmon could however theoretically occur. However,: Chapter 4.1 (Benthic Ecology) predicts not significant to minor effects on benthic habitats associated with the modified OfTI. Chapter 4.2 (Fish and Shellfish Ecology) predicts no potential for effects above minor associated to changes to fishing activity to occur. Deterioration of the marine habitats of Atlantic salmon are therefore not expected to occur. |
| | 2 | This chapter predicts that disturbance through increased SSC, sediment re-deposition, noise during construction and EMFs will result in minor effects which would likely only occur at the level of individuals as opposed to population. Significant disturbance to the qualifying species population are therefore not expected to occur. |
| | 3 | Changes to the distribution of the species are not expected in the site as no significant disturbance to the species or its habitat has been identified |
| | 4 | As assessed for criterion 1 |
| | 5 | As assessed in criteria 1, 2, 3 and 4 |
| | 6 | Based on assessment for criteria 1, structure, function and supporting processes of habitats supporting the species are expected to be maintained. |
| **Freshwater Pearl Mussel** | 1 | The freshwater pearl mussel SACs are located in-river, some distance from the modified OfTI. The habitat of the SACs will not be subject to direct deterioration as a result of the construction / decommissioning or operation of modified OfTI. |
| | 2 | Given the distribution of freshwater pearl mussel (restricted to the freshwater habitats) direct disturbance to the species has no potential to occur. In addition, as the established distribution and viability of the host species population (salmon) is not expected to be impacted, impacts on freshwater pearl mussel populations (driven indirectly) are not expected to occur |
| | 3 | Given the distribution of the species (restricted to the freshwater habitat) direct changes to the distribution of the species in any of the SACs associated with the to modified OfTI has no potential to occur. |
| | 4 | As assessed for criterion 1 |
| | 5 | As freshwater mussel populations are located in freshwater habitats they will not be subjected to any direct impacts relating to the modified OfTI which could potentially alter population structure. Furthermore, the established distribution and viability of the host species population (salmon) is not expected to be impacted. Therefore, indirectly driven impacts on freshwater pearl mussel populations are not expected to occur. |
| | 6 | Based on assessment for criteria 1, structure, function and supporting processes of habitats supporting the species are expected to be maintained. |
| | 7 | As assessed for criteria 1, 2, 3, 4 and 5 for Atlantic salmon. |

| | | |
|---|---|---|
| **Sea Lamprey** | 1 | The Spey SAC is located some distance from the modified TI. The habitat of the SAC will not be subject to any direct deterioration as a result of the construction/ decommissioning or operational phase of the modified OfTI. Deterioration of the marine habitats of sea lamprey could however theoretically occur: Chapter 4.1 (Benthic Ecology) predicts not significant to minor effects on benthic habitats. Chapter 4.2 (Fish and Shellfish Ecology) predicts no potential for effects above minor associated to changes to fishing activity to occur. Therefore no significant deterioration of the marine habitats of the qualifying species are expected to occur. |
| | 2 | There is no potential for disturbance to the qualifying species in Freshwater habitats. Chapter 4.2 (Fish and Shellfish Ecology) predicts that disturbance through increased SSC, sediment redeposition, noise during construction, and EMFs will result in minor effects. Significant disturbance to the qualifying species in the marine environment is therefore not expected occur. |
| | 3 | Changes to the distribution of the species are not expected in the site as no significant disturbance to the species or its habitats has been identified (See assessment against criteria 1 and 2 for sea lamprey). |
| | 4 | As assessed for criterion 1. |
| | 5 | As assessed for criteria 1, 2, 3 and 4. |
| | 6 | As assessed for criteria 1 Based on assessment for criteria 1, structure, function and supporting processes of habitats supporting the species are expected to be maintained. |
| | 7 | As assessed for 1,2,3,4 and 5 for Atlantic salmon. |

4.2.3.51 On the basis of the assessment summarised above, it is considered that the conservation objectives for the SACs under consideration will not be affected as a result of the construction, operation and decommissioning of the modified OfTI. Similalrly, it is anticipated that the favourable status of salmon, freshwater pearl mussel and sea lamprey will be upheld. Overall the conclusion of the assessment that the integrity of the SACs under consideration will not be impacted.

***In-Combination HRA***

4.2.3.52 The relevant SACs requiring in-combination assessment in relation to fish and shellfish resources are as specified in the preceding section. Similarly, the qualifying status of the SAC species and the conservation objectives of each relevant SAC are as provided in Table 4.2-17. A summary assessment of the potential in-combination effect of the modified TI in combination with the developments outlined in section 4.2.3 on the relevant Atlantic salmon, freshwater pearl mussel and sea lamprey SAC populations is given below in Table 4.2-19

**Table 4.2-19 In-Combination Assessment of Effects on Qualifying Species in the Relevant SACs per Criterion**

| Species | Criterion | Assessment |
|---|---|---|
| **Atlantic salmon** | 1 | The salmon SACs are located in freshwater habitats that are at a considerable distance from the Project, the BOWL site and associated TI, the EOWDC and other developments in the Firth of Forth and elsewhere. The habitat of the SACs will not be subject to any direct deterioration as a result of the in-combination effect of the construction/ decommissioning or operation of the modified OfTI. Deterioration of the marine habitats of Atlantic salmon could however theoretically occur: Chapter 4.1 (Benthic Ecology) predicts negligible to minor effects on benthic habitats. Chapter 4.2 (Fish and Shellfish Ecology) predicts minor effects associated to loss of habitat and introduction of new habitat and no potential for effects above minor associated to changes to fishing activity to occur. The habitat of the SACs will not be subject to any direct deterioration as a result of the in-combination effect of the construction/ decommissioning or operation of the modified OfTI. Therefore, in combination deterioration of the marine habitats of Atlantic salmon are not expected to occur. |
| | 2 | The in-combination assessment predicts disturbance through increased SSC, sediment re-deposition and EMFs will results in a minor in-combination effect. Noise during construction, has however been considered to have potential to result in minor to moderate effects on Atlantic salmon. Significant disturbance to the qualifying species may therefore occur in-combination. |
| | 3 | Significant disturbance to the species has been identified in relation to in-combination construction noise. Significant disturbance to the habitat of the species is however not expected to occur (See assessment against criteria 1 and 2 above).<br><br>Taking the above into account, there might be potential for changes to the distribution of the species in the site to occur. This will however depend on the degree of overlap between construction noise and migrating salmon. |
| | 4 | As assessed for criterion 1. |
| | 5 | As assessed in criteria 1, 2, 3 and 4 |
| | 6 | Based on assessment for criteria 1, structure, function and supporting processes of habitats supporting the species are expected to be maintained. |
| **Freshwater Pearl Mussel** | 1 | The freshwater pearl mussel SACs are located at a considerable distance from the Project, the BOWL site the EOWDC, and those developments located in the Firth of Forth and elsewhere. The habitat of the SACs will not be subject to any direct deterioration as a result of the construction / decommissioning or operation of these developments. |
| | 2 | Given the distribution of freshwater pearl mussel (restricted to the freshwater habitat) direct disturbance to the species has no potential to occur in combination. |
| | 3 | Given the distribution of the species (restricted to the freshwater habitat) direct changes to the distribution of the species in any of the SACs associated to modified OfTI has no potential to occur. |
| | 4 | As assessed for criterion 1. |
| | 6 | Based on assessment for criteria 1, structure, function and supporting processes of habitats supporting the species are expected to be maintained. |

| Species | Criterion | Assessment |
|---|---|---|
| | 7 | As assessed for criteria 1, 2, 3, 4 and 5 for Atlantic salmon. |
| **Sea Lamprey** | 1 | The Spey SAC is located some distance from the three consented MORL wind farms modified TI, the BOWL site and associated TI, the EOWDC and other developments in the Firth of Forth and elsewhere. The habitat of the SAC will not be subject to any direct deterioration as a result of the construction/ decommissioning or operational phase of the modified OfTI or other projects under consideration. Deterioration of the marine habitats of sea lamprey could however theoretically occur: Chapter 4.1 (Benthic Ecology) predicts not significant to minor effects on benthic habitats. This chapter predicts no potential for effects above minor associated with changes to fishing activity to occur. Therefore no in-combinadeterioration of the marine habitats of the qualifying species are expected to occur. |
| | 2 | The in-combination assessment predicts disturbance through increased SSC, sediment re-deposition, EMFs and noise will result in a minor effect on sea lamprey.Therefore significant in-combination disturbance to the qualifying species is not anticipated to occur. |
| | 3 | Changes to the distribution of the species are not expected to occur in-combinaion as no significant disturbance to the species or its habitats has been identified (See assessment against criteria 1 and 2 for sea lamprey). |
| | 4 | As assessed for criterion 1. |
| | 5 | As assessed for criteria 1, 2, 3 and 4. |
| | 6 | As assessed for criteria 1, 2, 3 and 4. |
| | 7 | As assessed for 1,2,3,4 and 5 for Atlantic salmon. |

4.2.3.53 The above HRA relating to the relevant SACs for the modified OfTI have determined that there is potential for combination effects on the SAC populations of Atlantic salmon to occur. As a result, there may also be potential for indirect in-combination effects on freshwater pearl mussel and sea lamprey SAC populations.

4.2.3.54 It is important to consider that the assessment of the effects on Atlantic salmon necessitated a precautionary approach due to the limited information currently available in relation to the use that Atlantic salmon make of the Moray Firth area and other coastal waters around Scotland. In addition, it is not possible to conclusively identify which SAC watercourses individuals from any population originate from (post smolts or adults), the conservative assumption being that the natal habitats of all individuals are SAC rivers.

4.2.3.55 The Appropriate Assessment undertaken by Marine Scotland Licensing Operations Team (MS-LOT) for the three consented MORL wind farms and associated transmission infrastructure as detailed in the MORL ES (MORL, 2012) concluded that the project would not adversely affect the site integrity of any of the Atlantic Salmon, Freshwater Pearl Mussel, or Sea Lamprey SACs assessed above, either alone, or in-combination with the BOWL development and other projects that have also been consented.

4.2.3.56 With respect to Atlantic Salmon SACs, MS-LOT considered that this was possible by agreement of working practice and mitigation that relate to the effects via conditions on any consents, as follows:

- Soft start for piling work could be expected to help mobile fish move out of the area and thereby assist in mitigating against noise disturbance to individuals during construction.

- Piling schedules and construction programmes should be further discussed, post-consent, between MS-LOT, MSS, the Association of Salmon Fishery Boards ("ASFB"), the SNCBs and developers, once turbine layouts, numbers and foundation choices and have been confirmed. It is noted that the zone of predicted noise impacts for Atlantic salmon is based on a 'worst case' scenario which may not occur.

- Strategic monitoring and research will help to improve the knowledge base on salmon population ecology and migratory movements in Scottish waters and may help inform mitigation proposals.

4.2.3.57 MS-LOT further concluded that:

> "The installation of the export cables close to shore could take a matter of days so that mitigation, or avoidance, of impacts to smolts could be possible by timing the work to avoid peak smolt runs (if the timing of these can be established). This mitigation should be progressed in post-consent discussions between MS-LOT, MSS, the ASFB, the SNCBs and developers. In relation to potential cumulative impacts arising from EMF around intra-array and export cables, proposed mitigation to shield / bury cables will help to reduce EMF. For Atlantic salmon, it is recommended that deeper burial depth or directional drilling removes the risk of any operational effect (the SNCBs advised up to 3m, where possible) i.e. for export cables in shallower water approaching landfall (water depths of up to ~20m). Where cable burial or directional drilling is not possible, rock armouring or a similar protective layer should be considered. It is considered that potential impacts from cable installation can be reduced or avoided and that while there may be some noise disturbance to individual salmon, the effects do not risk the integrity of SAC populations; but do merit further research and quantification. The SNCBs have advised that operational noise will not result in likely significant effects to salmon."

4.2.3.58 In consultation with Marine Scotland, DSFBs and other relevant stakeholders MORL has committed to undertake appropriate survey work and monitoring with the objective of increasing confidence in the impact assessment and identifying appropriate mitigation where required. Significance of likely effects will therefore be reduced to levels that are satisfactory to both regulators and stakeholders. It is the intention of MORL to continue this cooperative consultation with regard to the modified OfTI.

4.2.3.59 With this commitment in mind, and in light of the conclusions of the Appropriate Assessment previously undertaken by MS-LOT in respect of the three consented MORL wind farms and associated export cable, it is expected that no adverse in-combination effects on any Conservation Objectives will occur, and no changes are expected to the population viability of Atlantic salmon, freshwater pearl mussel or sea lamprey in any of the SACs assessed above.

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