BERWICK BANK WIND FARM
OFFSHORE ENVIRONMENTAL IMPACT ASSESSMENT

APPENDIX 9.1: FISH AND SHELLFISH ECOLOGY TECHNICAL REPORT

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1. INTRODUCTION

1. This Fish and Shellfish Ecology Technical Report provides a detailed baseline characterisation of the fish and shellfish ecology (e.g. species, communities and habitats) for the Berwick Bank Wind Farm (hereafter referred to as the 'Proposed Development'). Data were collated through a detailed desktop study of the existing resources available for fish and shellfish within the northern North Sea study area, incorporating site-specific survey data and data from third party organisations.

2. The aim of this technical report is to provide a robust baseline characterisation of the fish and shellfish resources within a defined study area (see section 2) against which the potential impacts of the Proposed Development can be assessed. To support the assessment of effects in the Environmental Impact Assessment (EIA), the ecological information presented in this technical report was used to identify a number of Important Ecological Features (IEFs). IEFs were determined based on the conservation, ecological and commercial importance of each identified feature within the Proposed Development fish and shellfish ecology study area relative to the northern North Sea fish and shellfish ecology study area.

3. This technical report is structured as follows:

- section 2: Study Area - Overview of the study areas relevant to the report;
- section 3: Methodology - Overview of desktop study and site-specific surveys used to inform the baseline;
- section 4: Baseline Characterisation – Details the results of desktop study and site specific surveys;
  - section 4.1: Broad descriptions of the fish and shellfish assemblages in the northern North Sea;
  - section 4.2: Broad descriptions of the fish and shellfish assemblages in the Forth and Tay Scottish Marine Region (SMR);
  - section 4.3: Fish Spawning and Nursery Grounds – Spawning and nursery grounds are described for key species;
  - section 4.4: Herring – A description of herring habitats and ecology (focussing on spawning);
  - section 4.5: Sandeel – A description of sandeel habitats and ecology;
  - section 4.6: Diadromous Fish: A description of diadromous fish ecology;
  - section 4.6.8: Shellfish: A description of shellfish habitats and ecology;
- section 5: Summary – A summary of the information provided in the report;
  - section 5.1: Baseline - A summary of the baseline of fish and shellfish ecology; and
  - section 5.2: Important Ecological Features - Describing the IEFs to be considered in the EIA.

2. STUDY AREA

4. Fish and shellfish are spatially and temporally variable, therefore for the purposes of the fish and shellfish ecology characterisation, two study areas are defined. These are shown in Figure 2.1 and described here:

- The Proposed Development fish and shellfish ecology study area has been defined with reference to the Proposed Development boundary that existed prior to the boundary refinement in June 2022. As the refinement resulted in a reduction of the Proposed Development array area, the fish and shellfish ecology study area is considered to remain representative and presents a conservative baseline against which the fish and shellfish assessment is undertaken. The Proposed Development fish and shellfish ecology study area has not therefore been realigned to the current Proposed Development boundary.
- The northern North Sea fish and shellfish ecology study area encompasses the Proposed Development fish and shellfish ecology study area and a surrounding area defined by the boundary of the northern North Sea as defined by the biogeographic region identified as part of the Review of Marine Nature Conservation (RMNC) (2004). This is the regional study area and also encompasses waters of the Forth and Tay SMR. The northern North Sea fish and shellfish ecology study area provides a wider context for the fish and shellfish species and populations identified within the Proposed Development fish and shellfish ecology study area and will inform assessments of those impacts affecting fish and shellfish receptors over a larger scale (e.g. underwater noise).

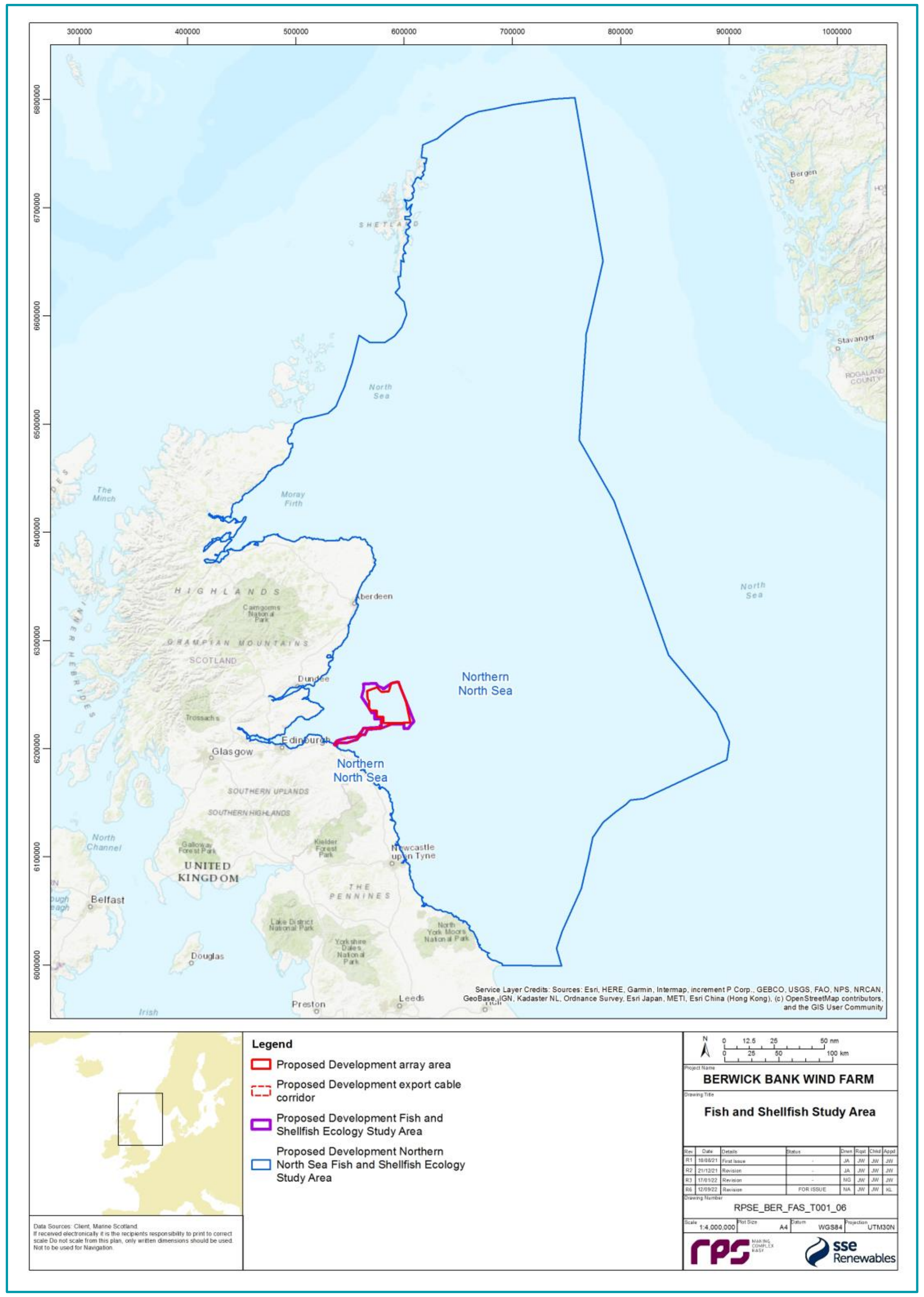

Figure 2.1: The Proposed Development Fish and Shellfish Ecology Study Area and the Northern North Sea Fish and Shellfish Ecology Study Area

3. METHODOLOGY

3.1. DESKTOP STUDY

5. Information on fish and shellfish within the Proposed Development fish and shellfish ecology study area was collected through a detailed desktop review of existing studies and datasets. These are summarised in Table 3.1.

Table 3.1: Summary of Key Desktop Reports

Title	Source	Year	Author
Seagreen Phase 1 (Seagreen Alpha and Seagreen Bravo): Natural Fish and Shellfish Resource Environmental Statement chapter for the original project	Chapter 12, Seagreen Environmental Statement Volume 1	2012	Seagreen Wind Energy Ltd
Sandeel Surveys in the east coast	Marine Scotland	2019	Marine Scotland
Seagreen Phase 1 (Seagreen Alpha and Seagreen Bravo): Natural Fish and Shellfish Resource Environmental Statement chapter for the optimised project	Chapter 9, Seagreen Environmental Statement Volume 1	2018	Seagreen Wind Energy Ltd
International Bottom Trawl Surveys	ICES	2021	ICES
Scallop Stock Assessment	Marine Scotland	2018b	Marine Scotland
Neart na Gaoithe Proposed Offshore Wind Farm Fish and Shellfish Ecology	Chapter 7, *Neart na Gaoithe* EIA Fish and Shellfish Ecology	2018	GoBe Consultants Ltd.
2018 landings data by the International Council for the Exploration of the Sea (ICES) rectangle	Marine Scotland	2018	Marine Scotland
International Herring Larvae Survey	Wageningen Marine Research, IJmuiden	2015	Wageningen Marine Research, IJmuiden
Mapping the spawning and nursery grounds of selected fish for spatial planning	Centre for Environment, Fisheries and Aquaculture Science (CEFAS)	2012	Ellis *et al*.
Review of migratory routes and behaviour of Atlantic salmon, sea trout and European eel in Scotland's coastal environment: implications for the development of marine renewables	Scottish Marine and Freshwater Science	2010	Malcolm *et al*.
Marine renewables Strategic Environmental Assessment (SEA) environmental report. Section C7 Fish and shellfish	Scottish Government	2007	Faber Maunsell
British sea fishes	Underwater World Publications Ltd	2001	Dipper
Fisheries sensitivity maps in British waters	United Kingdom Offshore Operators Association (UKOOA) Ltd	1998	Coull *et al*.
Fish and shellfish sensitivity reports	https://www.marlin.ac.uk/activity/pressures_report	n/a	Various
Salmon fishery statistics, including rod catch data	Marine Scotland	2021 (latest dataset)	Marine Scotland
Salmon smolt trawl surveys in Moray Firth and Firths of Forth and Tay	Marine Scotland	2018	Marine Scotland

3.2. SITE-SPECIFIC SURVEYS

6. A summary of the surveys undertaken to inform the fish and shellfish baseline characterisation is outlined in Table 3.2. The location of site-specific sampling is presented in Figure 3.1.

7. Given the wide ranging and comprehensive desktop information and data sources available to characterise the fish and shellfish baseline, site-specific fish ecology surveys to inform the EIA for the Proposed Development were not proposed. However, the results from site-specific surveys primarily designed to inform the benthic subtidal and intertidal ecology baseline characterisation, which include records of small demersal fish species and shellfish species present in the Proposed Development array area and export cable corridor, have been used to inform the baseline characterisation for fish and shellfish ecology.

8. Epibenthic beam trawl sampling was undertaken at 15 sampling locations distributed across representative sediment types to characterise epifaunal communities (Figure 3.1).

9. Epibenthic trawl sampling was undertaken using a standard 2 m scientific beam trawl (Lowestoft design) fitted with a knotless 5 mm cod end liner.

10. Combined grab and Drop Down Video (DDV) sampling were also completed across the Proposed Development array area and export cable corridor, with Particle Size Analysis (PSA) data obtained from grabs used to inform habitat characterisations for sandeel *Ammodytes sp.*, herring *Clupea harengus* and *Neprops norvegicus (*hereafter referred to as *Nephrops)*, and species presence/absence records taken from both grab samples and DDV sampling (Figure 3.1).

11. Herring spawning habitat characterisation was undertaken using results of the PSA to determine the composition of the sediment at grab locations. Samples were categorised into prime, subprime, suitable and unsuitable based on their suitability as herring spawning habitat, using classifications derived from Reach *et al*. (2013) based on the relative proportions of gravel and mud in the grab samples. Data from the International Herring Larvae Survey (IHLS) were also utilised to show herring spawning habitats in line with guidelines published by Boyle and New (2018). The abundances of larvae below 10 mm per m^2 were plotted on heat maps for the years 2007 to 2016 and also the average of those years combined. These maps, combined with the PSA data from site specific grab sampling, were used to determine where key spawning habitats were located within the vicinity of the Proposed Development fish and shellfish ecology study area (see section 4.4, Figure 4.10 to Figure 4.16).

12. Sandeel habitat characterisation was also completed, using a similar method as above where samples were categorised into prime, subprime, suitable and unsuitable, based on their suitability as sandeel habitat. Classifications were derived from Latto *et al*. (2013) based on the proportion of sand and mud in the grab samples. Incidental sandeel abundance data were collected from epibenthic beam trawls, alongside incidental presence/absence data of individual sandeels recorded within grab samples. The data was plotted into maps and reviewed alongside other desktop data sources to further characterise sandeel habitats within and around the Proposed Development fish and shellfish ecology study area (see section 4.5 for results).

13. *Nephrops* presence within the Proposed Development fish and shellfish ecology study area was assessed through abundance data collected from epibenthic trawls, as well presence/absence data derived from DDV sampling (taken at grab sample sites and specific DDV transects). These data were plotted alongside favourable *Nephrops* habitat as identified in a benthic biotope map as shown in volume 3, appendix 8.1 (only *Nephrops* habitat has been presented, see section 4.7.7 for results).

Table 3.2: Summary of Surveys Undertaken to Inform Fish and Shellfish Ecology Baseline Characterisation (See Also Volume 3, Appendix 8.1)

Title	Extent of Survey	Overview of Survey	Surveyor Contractor	Date	Reference to Further Information
Benthic subtidal survey	Across the Proposed Development fish and shellfish ecology study area	Grab samples, DDV sampling and epibenthic trawls	Ocean Ecology Ltd.	2020	Section 3.2

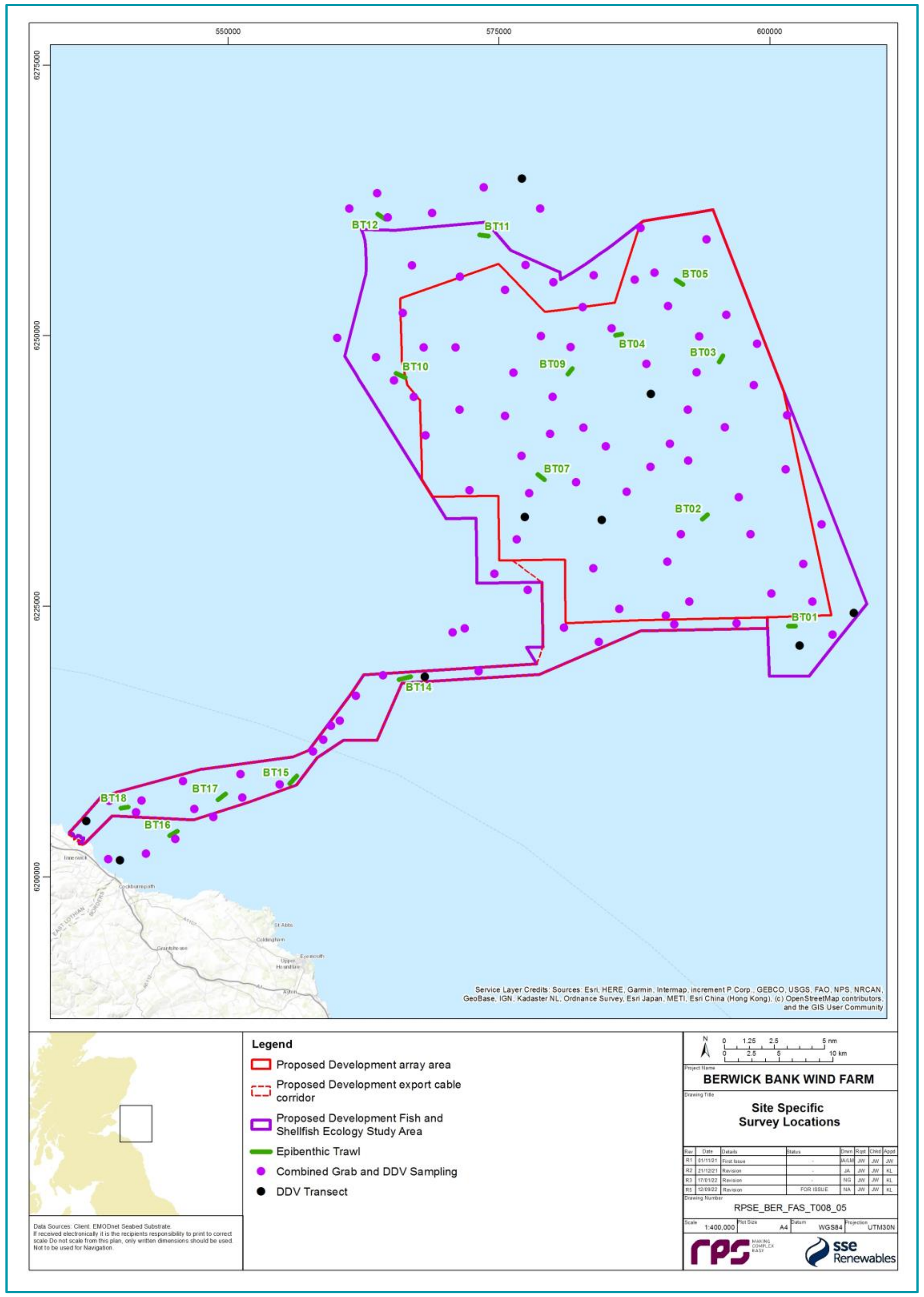

Figure 3.1: Site-specific Survey Locations

4. BASELINE CHARACTERISATION

4.1. NORTHERN NORTH SEA

4.1.1. DESKTOP STUDY

14. This section provides an overview of the fish and shellfish assemblages in the northern North Sea fish and shellfish ecology study area. The total British marine fish fauna is estimated to be 330 species, of which approximately 150 species are recorded from the North Sea (Maitland and Herdson, 2009). About 10% of the North Sea species are of significant commercial value and as such, the fish faunal abundance is affected by fishing pressure. The remaining species that occur in the North Sea are of little commercial value and so are not directly subject to fishing pressure. However, many of these species are of significant ecological importance as prey items for other marine species (e.g. birds and marine mammals).

15. The North Sea can be divided by depth contours and broad biogeographical patterns with three main fish assemblages associated with the shelf edge and northern North Sea, the central North Sea and southern and south-eastern North Sea (Callaway *et al*., 2002). The northern and central North Sea (which coincides with the northern North Sea fish and shellfish ecology study area) has a significant difference in fish assemblage to the southern and eastern North Sea, mainly attributed to the difference in depth profile and water temperature (Teal, 2011). The fish assemblage in this area is dominated by demersal, benthopelagic, pelagic, diadromous and elasmobranch fish species.

16. The spatial distribution of fish is determined by a range of factors including abiotic parameters such as water temperature, salinity, depth, local scale habitat features and substrate type, and biotic parameters such as predator-prey interactions and competition, alongside anthropogenic factors such as infrastructure and commercial fishing intensity. Demersal species include sandeel, whiting *Merlangius merlangus*, lemon sole *Microstomus kitt*, ling *Molva molva*, plaice *Pleuronectes platessa* and saithe *Pollachius virens*, with pelagic species including herring, and sprat *Sprattus sprattus* likely to be found in northern North Sea fish and shellfish ecology study area.

17. The International Bottom Trawl Survey (IBTS) is a historical time series of bottom and pelagic fish trawl surveys in the north-east Atlantic and Baltic Seas. The northern North Sea fish and shellfish ecology study area sits within IBTS zones 3 and 4 and these areas have hence been used to gain further understanding of the fish assemblage in the northern North Sea over 2020 – 2021 (IBTS, 2021).

18. Herring abundances within the IBTS are high with over thousands of individuals recorded per hour trawling. Herring abundance is also seasonal, with abundance being higher at the end of the year (Q3) than at the start of the year (Q1). The IBTS data showed a marked increase specifically in adult herring abundance during Q3, which supports existing literature on herring spawning seasons, as the influx of adult herring individuals in Q3 coincides with the spawning season (see Table 4.2).

19. Whiting are highly abundant within the northern North Sea. IBTS data for 2020 (Q1 and Q3) – 2021 (Q1) showed abundances as high as 5,000 individuals per hour trawled. Notably, juvenile whiting (less than one year old) were not recorded at all in Q1 trawls, however in Q3 trawls, juvenile whiting abundances were on average the highest age category recorded. IBTS data showed low abundances of cod, with only tens of individuals recorded per hour trawled.

20. Plaice are also widely abundant within the northern North Sea, with IBTS data indicating abundances of between 500 and 1,000 individuals regularly recorded per hour of trawling. No obvious differences in abundance associated with season or age distribution of individuals was observed in the 2020 (Q1 and 3) – 2021 (Q1) data.

21. Recorded abundance of mackerel *Scomber scombrus* was low during 2020 Q1, however higher abundances were recorded during Q3, and also in Q1 of 2021. This suggests that presence of mackerel in the northern North Sea can vary annually and can be sporadic, as shown by a particular haul capturing over 246,000 mackerel per hour trawled, with other hauls recording very few or no mackerel per hour trawled.

22. Sprat have relatively high abundance, where thousands of individuals were frequently recorded per hour trawled. However, similar to mackerel, the abundances recorded were found to be quite sporadic, with low numbers being recorded frequently. There are no obvious differences in seasonal or age distribution of individuals recorded.

4.2. FORTH AND TAY SCOTTISH MARINE REGION

4.2.1. DESKTOP STUDY

23. Several species of commercial and ecological importance are known to be present across and in the vicinity the Forth and Tay SMR including cod *Gadus morhua*, lemon sole, herring, mackerel, plaice, sandeel, saithe, sprat, spotted ray *Raja montagui*, spurdog *Squalus acanthias*, tope *Galeorhinus galeus* and whiting. The Forth and Tay SMR hosts important populations of shellfish species including *Nephrops,* European lobster *Homarus gammarus*, crab (edible (brown) crab *Cancer pagarus* and velvet swimming crab *Necora puber*) and squid *Loligo sp*. The distribution of lobster and crab species is highly dependent on habitat/substrate type due to the species preferences of habitat and low mobility. Many of these fish and shellfish species have high ecological value as prey species for marine mammals and seabirds (e.g. sandeel, herring, mackerel and sprat) as well as being of high importance for commercial fisheries (e.g. lobster, edible crab, king scallop *Pecten maximus* and squid) (see volume 3, appendix 12.1).

24. Other offshore wind farm developments, either in construction or in planning stages, exist within and in the vicinity the Forth and Tay SMR (Figure 4.1). Data collected through site-specific surveys for these other developments can be used to help characterise the fish and shellfish assemblage within the Forth and Tay SMR. Neart na Gaoithe Offshore Wind Project (NnG) is located within the Forth and Tay SMR and therefore data collected can be drawn upon to improve understanding of fish and shellfish assemblages in the Forth and Tay SMR. NnG also utilised beam trawl data from the benthic ecology characterisation which conducted 2 m beam trawl surveys (EMU, 2010). The NnG surveys were dominated by shrimp species *Crangon sp.* and *Pandalus sp.*, with the most abundant fish species being long rough dab/American plaice *Hippoglossoides platessoides*, gobies *Gobidae* and common dab *Limanda limanda.* When NnG survey data were analysed using multivariate statistics, they showed that the majority of trawls fit into a large distinct group, with one smaller distinct group, characterised by lower species diversity, which was associated with trawls in nearshore locations.

25. Epibenthic trawl data using 2 m beam trawls were also collected for what was known at the time as Seagreen Alpha/Bravo (IECS, 2012) (known since 2018 as Seagreen), located in vicinity of the Forth and Tay SMR and to the north of the Proposed Development fish and shellfish ecology study area. Only three trawls were conducted for this survey, so the characterisation of the assemblage is less comprehensive. However, these surveys also recorded relatively high abundances of *Crangon sp*. and *Pandalus sp.* as well as common dab. These trawls also recorded high numbers of starfish *Asterias rubens* and brittle stars *Ophiura ophiura.* Whilst the limitations of these surveys do not allow detailed conclusions to be drawn, it provides further evidence of the Forth and Tay SMR hosting a fish and shellfish assemblage consistent with that presented for NnG.

26. The Inch Cape Offshore Wind Development, located in the Forth and Tay SMR, conducted otter trawls on four occasions over 2012. A total of 30 fish species and 20 macro-invertebrates were recorded across all surveys. The Fish and Shellfish EIA Report chapter for the Inch Cape offshore wind farm only reported abundance of species deemed as sensitive receptors, so a full list of species assemblage from the trawls is unavailable. Of the species deemed as sensitive receptors (sprat, herring, cod, allis shad *Alosa alosa* and twaite shad *Alosa fallax*), only sprat, herring and cod were recorded, with sprat being noticeably highest in abundance (total catch of 1,194 individuals) compared to herring (161) and cod (15). The absence of allis and twaite shad is to be expected due to the low reported incidence from other sources. These data are harder to compare to beam trawl survey data, as different species are targeted by the different gear types, however they provide a useful indication of the types of demersal and pelagic species present within and in the vicinity of the Forth and Tay SMR.

27. Commercial fishing data can be utilised to gain further understanding of the fish and shellfish assemblage within the northern North Sea fish and shellfish ecology study area. As described in volume 3, appendix 12.1, the vast majority of landings are comprised of shellfish, with *Nephrops* contributing the highest proportion of total landings, with European lobster, edible crab and king scallop also being major contributors within the Forth and Tay SMR. Mackerel contribute a small proportion of the commercial fisheries landings, but only within the inshore coastal areas off Berwick upon Tweed (ICES Rectangle 40E7). See volume 3, appendix 12.1 for further breakdown of commercial fisheries landings data. Species such as cod, haddock, and flat fish species are not specifically targeted by commercial fisheries within and in the vicinity of the Forth and Tay SMR.

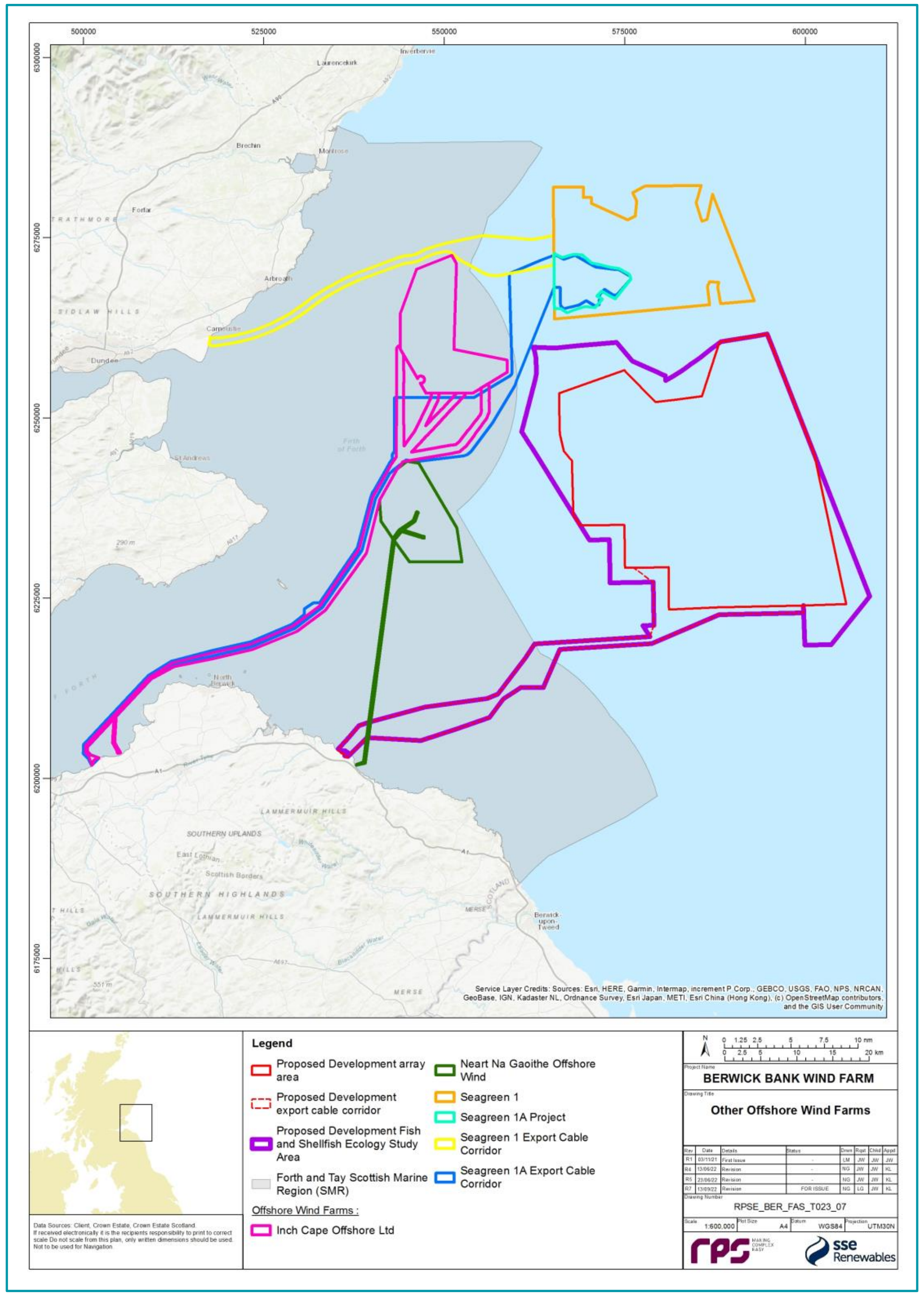

Figure 4.1: Location of Other Offshore Wind Developments Within and in the Vicinity of the Forth and Tay SMR

Elasmobranchs

28. Elasmobranchs are a cartilaginous fish group that comprises sharks, rays and skates, with species expected to be present in the Proposed Development fish and shellfish ecology study area including tope, spurdog, common skate *Dipturus batis*, spotted ray, and thornback ray *Raja clavata.* There are no specific fisheries for these species, however most of these species have commercial value, but not locally to the Proposed Development fish and shellfish ecology study area. Some of these species of elasmobranch have nursery grounds in or in close proximity to the Proposed Development fish and shellfish ecology study area (Ellis *et al*., 2012) (discussed further in section 4.3).

29. Basking sharks *Cetorhinus maximus* may pass through the vicinity of the Proposed Development fish and shellfish ecology study area. The basking shark is a large, filter feeding species that is predominately solitary but may also occur in aggregations where there is dense zooplankton abundance (Speedie, 1999). The basking shark's unique feeding strategy dominates all aspects of its ecology and life history; the basking shark is an obligate ram filter feeder whereby the flow of water across gill rakers within the mouth is controlled by swimming speed (Sims, 1999; Sims, 2008).

30. Basking shark migration routes cover large distances from north Africa up to Scotland, using both the continental shelf and oceanic habitats in the upper 50 m to 200 m of the water column (Doherty *et al.,* 2017). Distribution has been shown to be influenced by a range of environmental conditions (Austin *et al*., 2019); surface sightings of basking sharks are typically reported where sea surface temperatures range between 15°C and 17.5°C (Cotton *et al.,* 2005; Skomal *et al*., 2004) where thermal fronts are present (Sims and Quayle, 1998; Jeewoonarain *et al*., 2000) and where zooplankton is in its greatest abundance (Sims and Quayle, 1998; Sims, 1999). Twenty-eight basking sharks tagged off Scotland and the Isle of Man in the summer showed an average migration distance of 1,057 km with movements starting in October (Doherty *et al*., 2017), however, none of the tagged basking sharks migrated to the east coast of Scotland. Due the migratory behaviour of basking sharks and routes through Scottish waters, basking sharks have the potential to be present within the Forth and Tay SMR and in the vicinity of the Proposed Development fish and shellfish ecology study area, however, the majority of basking shark sightings are located on the west coast of Scotland. No basking shark were recorded during 25 months of aerial marine mammal and bird surveys of the Proposed Development.

4.2.2. SITE-SPECIFIC SURVEY

31. As outlined in section 3.2, 15 epibenthic beam trawls were undertaken across the Proposed Development fish and shellfish ecology study area (Figure 3.1).

32. Fish species prevalent in the epibenthic trawls included common dab, long rough dab, lesser sandeel *Ammodytes tobianus* and pogge *Agonus cataphractus.* As can be seen in Figure 4.2, long rough dab was by far the most abundant fish species in beam trawls with over 14 individuals per 1,000 m trawled. That compared with long rough dab and lesser sandeel which were recorded at much lower abundances. Other commercially important species including cod, lemon sole and plaice were only recorded at very low abundances (e.g. between one and three individuals per 1,000 m trawled). Shellfish recorded in site-specific surveys (including trawl surveys) are discussed in section 4.7.

33. Epibenthic trawl data were analysed using multivariate statistics using PRIMER v6 software statistical analysis package (Clarke and Gorley, 2006), to determine the similarity of fish assemblages between trawl sites. The data analysed were for fish species only. Analysis included hierarchical cluster analysis of the square root transformed fish dataset, together with a Similarity Profile (SIMPROF) test to test whether clusters were statistically distinct from one another. This identified three distinct assemblages within the fish trawl data, as can be seen in Figure 4.3. Group C comprised 12 of the total 15 trawls with group B containing just one trawl and group a containing two trawls. This demonstrates that the majority of the

trawls (group C) fit into a large distinct group showing a homogenous fish assemblage across the majority of trawl locations. The main species contributing to similarities within group C included common dab, lemon sole and pogge, with plaice, butterfish *Pholis gunnellus*, halibut, and sandeel also contributing but at lower abundances. Shellfish recorded in site-specific surveys (including trawl surveys) are discussed section 4.7.

34. The two smaller groups (groups A and B) are different to the main group primarily due to the number of species. These trawls were particularly impoverished, specifically group B with only low abundances of three species recorded. The main contributing species to group A being long rough dab and four bearded rockling *Enchelyopus cimbrius*. This dissimilarity can be explained by the sample location, with the three dissimilar trawls (BT15 - BT17) being nearshore trawl locations in the Proposed Development fish and shellfish ecology study area export cable corridor (Figure 3.1). The Proposed Development export cable corridor has a different benthic composition, with higher proportions of deep circalittoral mud sediment than in the Proposed Development array area which is characterised by deep coarse circalittoral and deep circalittoral sediments. Different habitat composition support different fish assemblages which can explain the significant differences between trawls in group C to groups A and B.

35. Results from data collected during site-specific benthic subtidal surveys are in agreement with reports of fish and shellfish communities in and around the Forth and Tay SMR, which validates baseline data presented in section 3.2 from NnG, Seagreen and Inch Cape developments fish and shellfish studies. This indicates a consistent benthic fish assemblage within and in the vicinity of the Forth and Tay SMR. Other common species known within the region may not have been identified through site-specific surveys due to the sampling method used for epibenthic trawls (e.g. epibenthic trawls do not target pelagic species), however these have been characterised by desktop data sources.

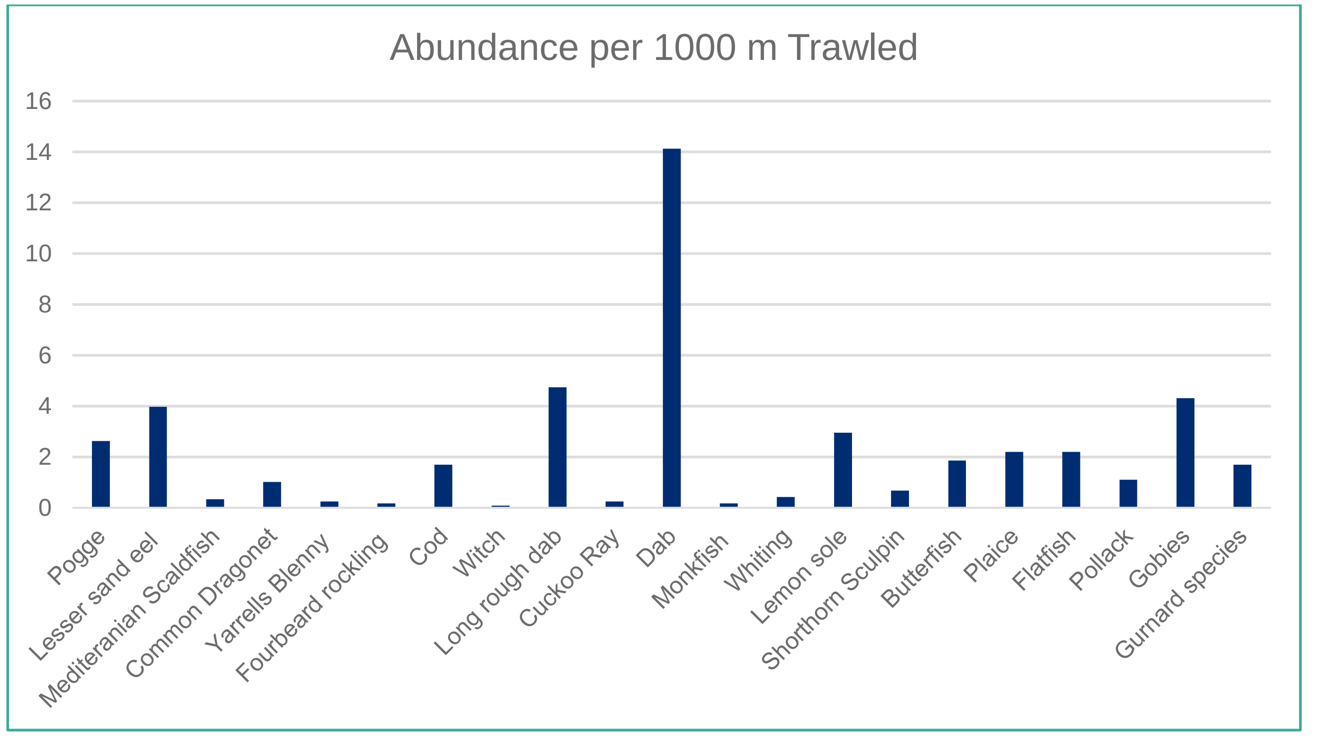

Figure 4.2: Fish Abundance per 1,000 m Trawled in Epibenthic Surveys

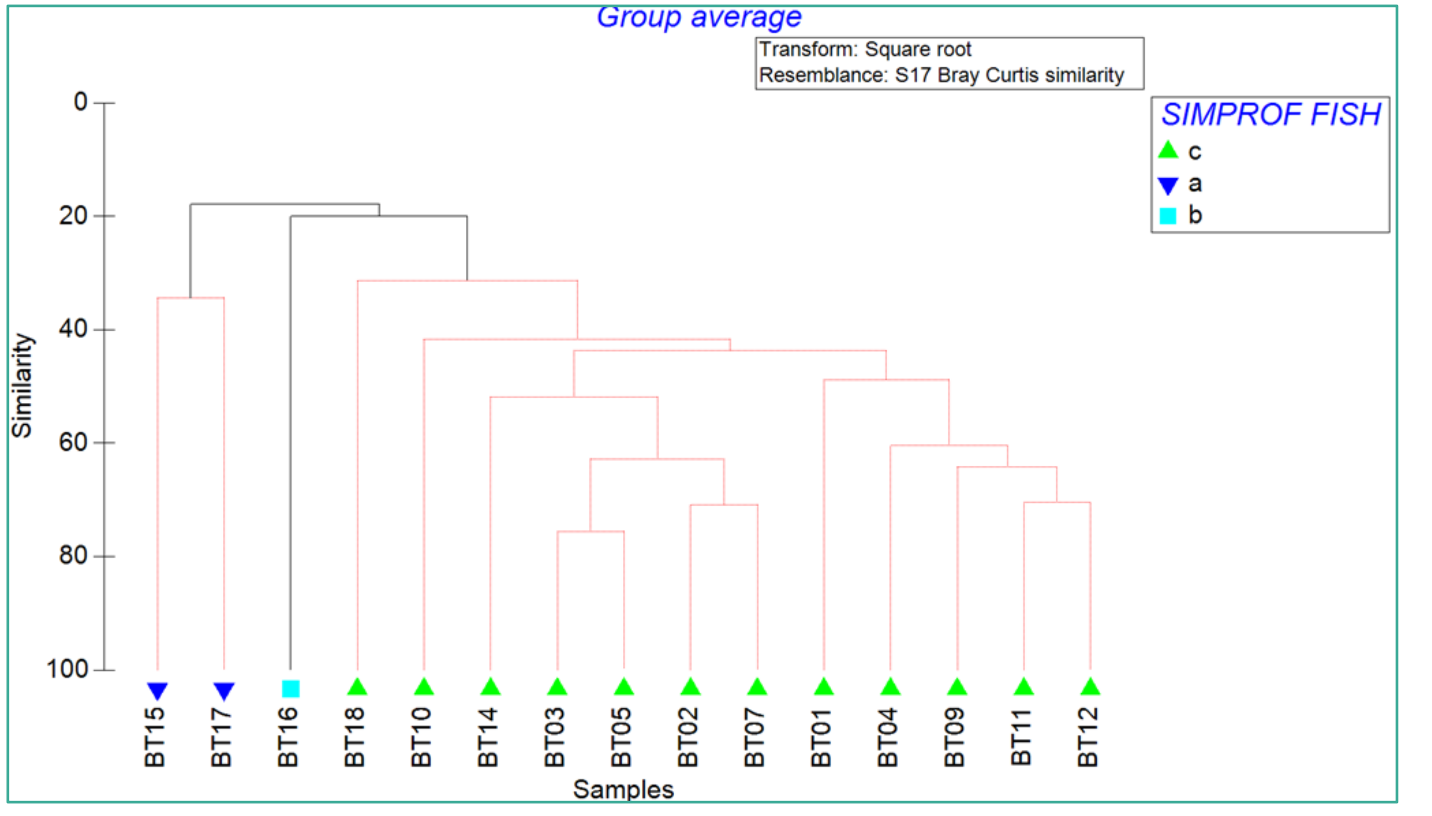

Figure 4.3: Dendrogram of Fish Assemblages from Epibenthic Trawls Surveys within the Proposed Development Fish and Shellfish Ecology Study Area

4.3. SPAWNING AND NURSERY GROUNDS

36. A number of fish species are known to have spawning and/or nursery grounds within the northern North Sea fish and shellfish ecology study area. Data from Cefas (Ellis *et al*., 2012; Coull *et al*., 1998) provides spatially explicit maps of the nursery/spawning areas for key species. It is worth noting that Coull *et al*. (1998) data may lack accuracy due to the age of the study and for this reason, it has only been used where no other data from Ellis *et al*. (2012) is available.

37. Potential nursery and spawning areas in the North Sea for a range of species were identified by Coull *et al.* (1998), based on larvae, egg and benthic habitat survey data. Ellis *et al.* (2012) reviewed this data for several fin fish species in the UK waters, including the North Sea, providing an updated understanding of areas of low and high intensity nursery and spawning grounds. Further information regarding nursery areas is provided in Aries *et al*. (2014). The study assessed evidence of aggregations of '0 group fish' (fish in the first year of their lives) around the UK coastline. These data were ascertained from species distribution modelling combining observations of species occurrence or abundance with environmental data (Aries *et al*., 2014). The outputs of this process have been suggested to be used as a guide for the most likely locations of aggregations of 0 group fish.

38. Based on the above data sources, spawning areas for several species overlap the Proposed Development fish and shellfish ecology study area, including low intensity spawning for cod and plaice, non-specified

spawning for *Nephrops*, sprat, whiting, lemon sole and herring, and high intensity for sandeel. Species with known spawning periods (Table 4.2) and nursery habitats identified within the Proposed Development fish and shellfish ecology study area have been summarised in Table 4.1 and Figure 4.4 to Figure 4.7

39. Cod are commonly found throughout the North Sea and have high intensity nursery grounds and low intensity spawning grounds overlapping the Proposed Development fish and shellfish ecology study area (Figure 4.4) (Ellis *et al.,* 2012), with spawning occurring between January and April with peak spawning occurring in April. The presence of cod nursery grounds is supported by outputs from Aries *et al*. (2014).

40. Whiting have high intensity nursery grounds and low intensity spawning grounds throughout the Proposed Development fish and shellfish ecology study area (Figure 4.4) with spawning occurring between May and July. Ideal conditions for whiting spawning include sandy substrate and fast movement of water. After the eggs hatch, the larvae drift in surface waters for a year, and then move closer to the seabed as juveniles. The presence of whiting nursery grounds is supported by outputs from Aries *et al*. (2014).

41. Haddock *Melanogrammus aeglefinus* have a pelagic larval phase feeding on plankton before juveniles move down towards the seabed to exploit demersal prey resources, including small crustaceans and small fish. There is an unspecified intensity nursery ground to the east of the Proposed Development fish and shellfish ecology study area, which overlaps the Proposed Development fish and shellfish ecology study area array area marginally (Figure 4.4). There are no haddock spawning grounds within the Proposed Development fish and shellfish ecology study area (Coull *et al*., 1998). The presence of haddock nursery grounds is supported by outputs from Aries *et al*. (2014) and may suggest higher intensity nursery grounds extending further into the Proposed Development array area than specified by Coull *et al*. (1998).

42. Sprat spawning and nursery grounds (unspecified intensity) coincide with the Proposed Development fish and shellfish ecology study area, with only nursery grounds coinciding with the offshore export cable route (Figure 4.5). The presence of sprat nursery grounds is not supported by outputs from Aries *et al*. (2014), with aggregations of 0 group fish seemingly limited to areas further inshore within the inner regions of the Firth of Forth.

43. Mackerel have low intensity nursery grounds which coincide with the majority of the Proposed Development fish and shellfish ecology study area (Ellis *et al.,* 2012), with no spawning grounds identified in the Proposed Development fish and shellfish ecology study area (Figure 4.5). Mackerel spawn over summer months from May to August. The presence of mackerel nursery grounds is not supported by outputs from Aries *et al*. (2014), with no modelled observations of 0 group fish on the east coast of Scotland.

44. Plaice mostly spawn between December and January, with peak spawning in January. Each female produces up to half a million eggs which drift passively in the plankton. Once the larvae reach a suitable size for settlement, they metamorphose into the asymmetric body shape and as young fish they inhabit mostly shallow water including tidal pools (Schreiber, 2013). In their second year they move into deeper water and are mostly found in a depth range of 10 m to 50 m. Low intensity nursery grounds coincide with the Proposed Development fish and shellfish ecology study area, with spawning grounds present in the Proposed Development export cable corridor (Figure 4.5). The presence of low intensity nursery grounds for plaice is supported by outputs from Aries *et al*. (2014).

45. Lemon sole key spawning activity is between April and September, with no defined peak periods. There are unspecified intensity nursery and spawning grounds for lemon sole which coincide with the Proposed Development fish and shellfish ecology study area (Figure 4.5).

46. Herring have high intensity nursery areas throughout the Proposed Development fish and shellfish ecology study area, with spawning grounds to the south which coincide with the Proposed Development export cable corridor marginally (Figure 4.6) and more extensive spawning grounds to the north along the Aberdeenshire coast. The presence of high intensity nursery grounds for herring is not supported by outputs from Aries *et al*. (2014), with predicted aggregations of zero group herring found further inshore. Spawning times for herring are dependent on sub populations, but generally for the Buchan stock, which falls within the northern North Sea fish and shellfish ecology study area, spawning is seen between July and September, with the peak months being August and September. Sticky eggs are deposited preferably on gravel substrate and the eggs adhere to the seabed forming extensive beds (Drapeau, 1973; Rogers and Stocks, 2001). After hatching the larvae enter the plankton and drift with the current until reaching inshore nursery grounds. A year later they migrate further offshore to join adults at feeding grounds. A further review of the herring spawning and has been included in section 4.4.

47. During the winter, sandeel remain in the sediment only emerging to spawn between January and February. The eggs are laid in clumps within sandy substrate until they hatch, after which they enter the water column. Sandeel will then metamorphose and settle in sandy sediments amongst adults (Van Deurs *et al*., 2009). Sandeel have high intensity spawning areas and low intensity nursery areas which coincide with the Proposed Development fish and shellfish ecology study area (Figure 4.6). Sandeel ecology is detailed further in section 4.5.

48. Spawning grounds in the North Sea have been further investigated by Marine Scotland Science (MSS) for cod, haddock and whiting (González-Irusta and Wright, 2016a; González-Irusta and Wright, 2016b; González-Irusta and Wright, 2017). These studies utilised generalised additive models applied to bottom trawl survey data (IBTS 2009 – 2015) to predict spawning habitat of North Sea cod, haddock and whiting. Cod spawning grounds were found to conform to the known widespread occurrence of spawning in the North Sea and was in agreement with previous studies of cod egg distribution, which suggests nearly all historical spawning areas are still in use (González-Irusta and Wright, 2016a). Haddock spawning grounds were found to have shifted southwards from predicted distribution, but generally conformed to historic reports (González-Irusta and Wright, 2016b). Whiting spawning areas were shown to have high inter annual variations in spawning, with two distinct areas of spawning in the south and in the west of the North Sea, however, it is suggested that spawning areas presented in Coull *et al*. (1998), may currently not be in use (González-Irusta and Wright, 2017).

49. There are several low intensity nursery grounds for elasmobranchs species within or in close proximity to the Proposed Development fish and shellfish ecology study area including, tope, spurdog, common skate, and spotted ray (Figure 4.7).

Table 4.1: **Species Known to Have Spawning and Nursery Grounds that Overlap with the Proposed Development Fish and Shellfish Ecology Study Area (Coull *et al*. (1998) and Ellis *et al*. (2012))**

Common Name	Species	Proposed Development Array Area		Proposed Development Export Cable Corridor	
		Spawning	Nursery	Spawning	Nursery
Anglerfish	*Lophius piscatorius*		✓		✓
Blue whiting	*Micromesistius poutassou*		✓		✓
Cod	*Gadus morhua*	✓	✓	✓ (partial)	✓
European hake	*Merluccius merluccius*		✓		✓ (partial)
Herring	*Clupea harengus*		✓	✓ (partial)	✓
Ling	*Molva molva*		✓		✓
Mackerel	*Trachurus trachurus*		✓		✓
Plaice	*Pleuronectes platessa*	✓	✓	✓	✓
Sandeel	*Ammodytidae*	✓	✓	✓ (partial)	✓
Spotted ray	*Raja montagui*		✓		✓
Spurdog	*Squalus sp.*		✓		✓ (partial)
Tope shark	*Galeorhinus galeus*		✓		✓ (partial)
Common skate	*Dipturus batis*		✓		✓
Whiting	*Merlangius merlangus*	✓	✓	✓	✓
Haddock	*Melanogrammus aeglefinus*		✓		
Sprat	*Sprattus sprattus*	✓	✓	✓ (partial)	✓
Lemon sole	*Microstomus kitt*	✓	✓	✓	✓

Table 4.2: **Main Periods of Spawning Activity for Key Fish Species in the Proposed Development Fish and Shellfish Ecology Study Area (Spawning Periods are Highlighted in Yellow, Peak Spawning Periods Marked Orange) (Adapted from Coull *et al*. (1998); *Buchan stock)**

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Herring*							Yellow	Orange	Orange			
Cod	Yellow	Yellow	Yellow	Orange								
Sandeel	Yellow	Yellow										
Sprat				Yellow	Orange	Orange	Yellow	Yellow	Yellow			
Whiting					Yellow	Yellow	Yellow					
Mackerel					Yellow	Yellow	Yellow	Yellow				
Plaice	Orange											Yellow
Saithe		Yellow	Yellow	Yellow	Yellow							
Lemon Sole				Yellow	Yellow	Yellow	Yellow	Yellow	Yellow			
Spurdog	Yellow	Yellow									Yellow	Yellow
Nephrops									Yellow			
Scallops			Yellow	Yellow	Yellow				Yellow	Yellow		
Edible Crab					Yellow	Yellow	Yellow	Yellow				
European Lobster						Yellow	Yellow					
Squid	Orange	Orange	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Orange	Orange

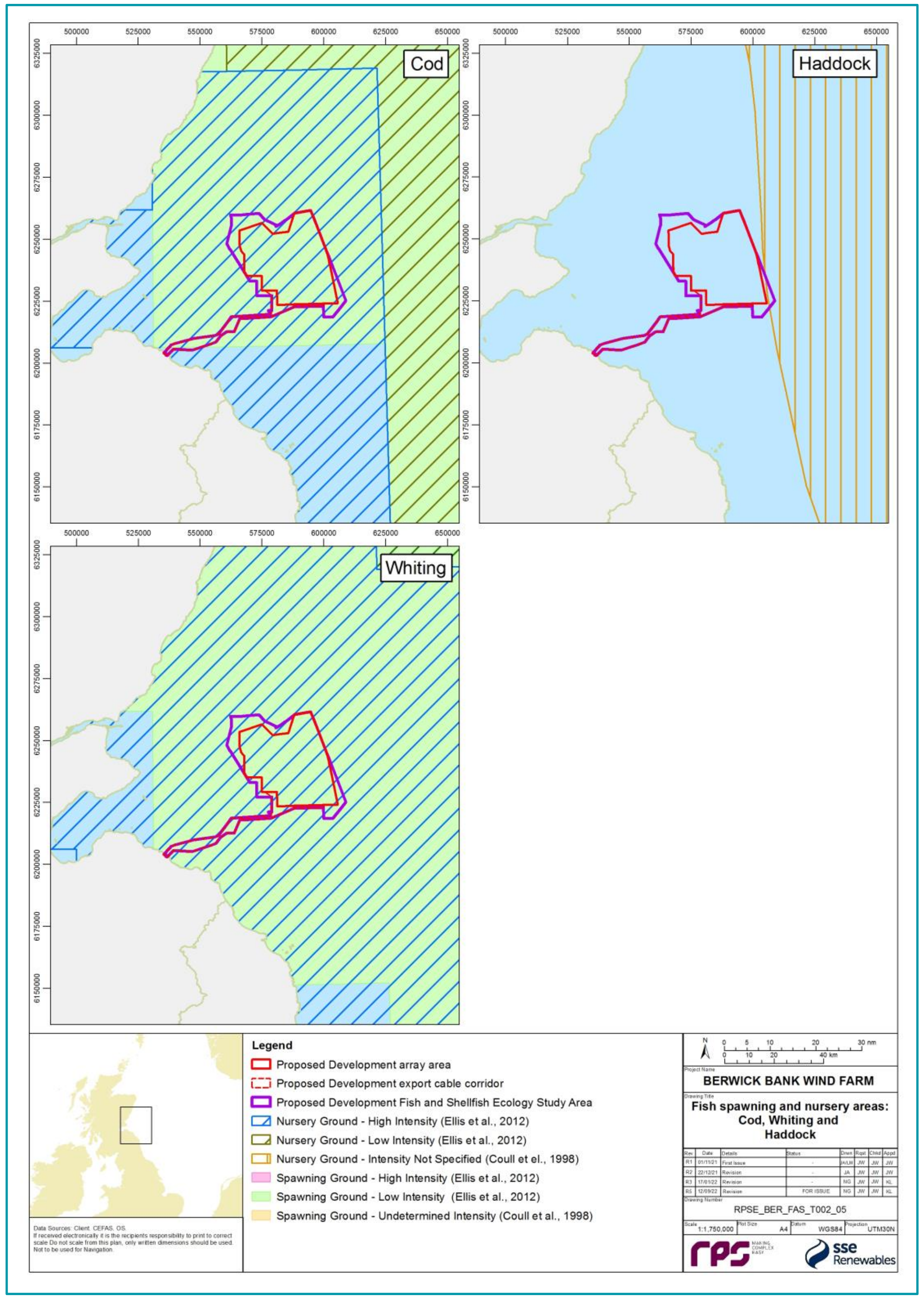

Figure 4.4: Cod, Whiting and Haddock Spawning and Nursery Grounds and Overlaps with the Proposed Development Fish and Shellfish Ecology Study Area

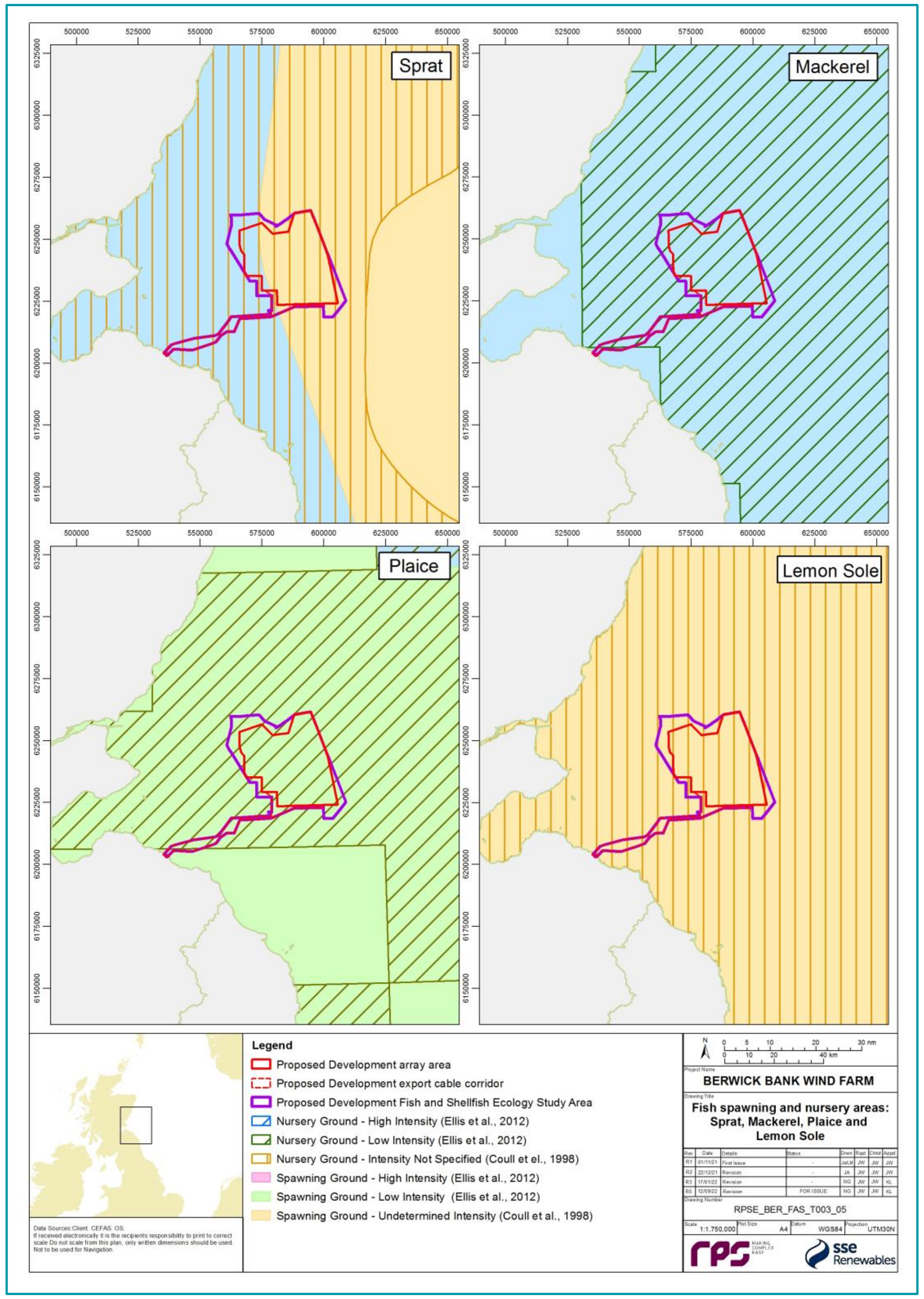

Figure 4.5: Sprat, Mackerel, Plaice and Lemon Sole Spawning and Nursery Grounds and Overlaps with the Proposed Development Fish and Shellfish Ecology Study Area

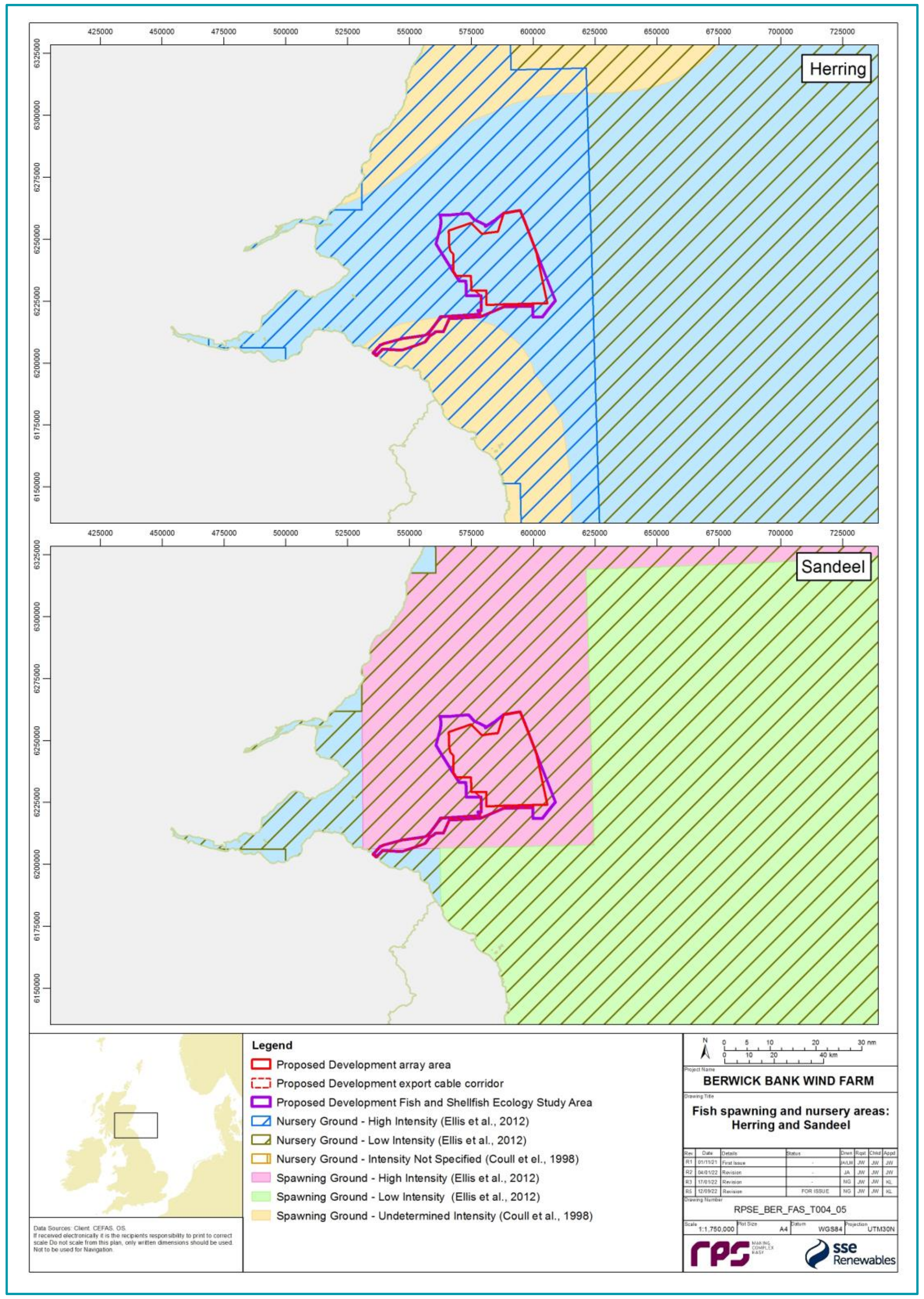

Figure 4.6: Herring and Sandeel Spawning and Nursery Grounds and Overlaps with the Proposed Development Fish and Shellfish Ecology Study Area

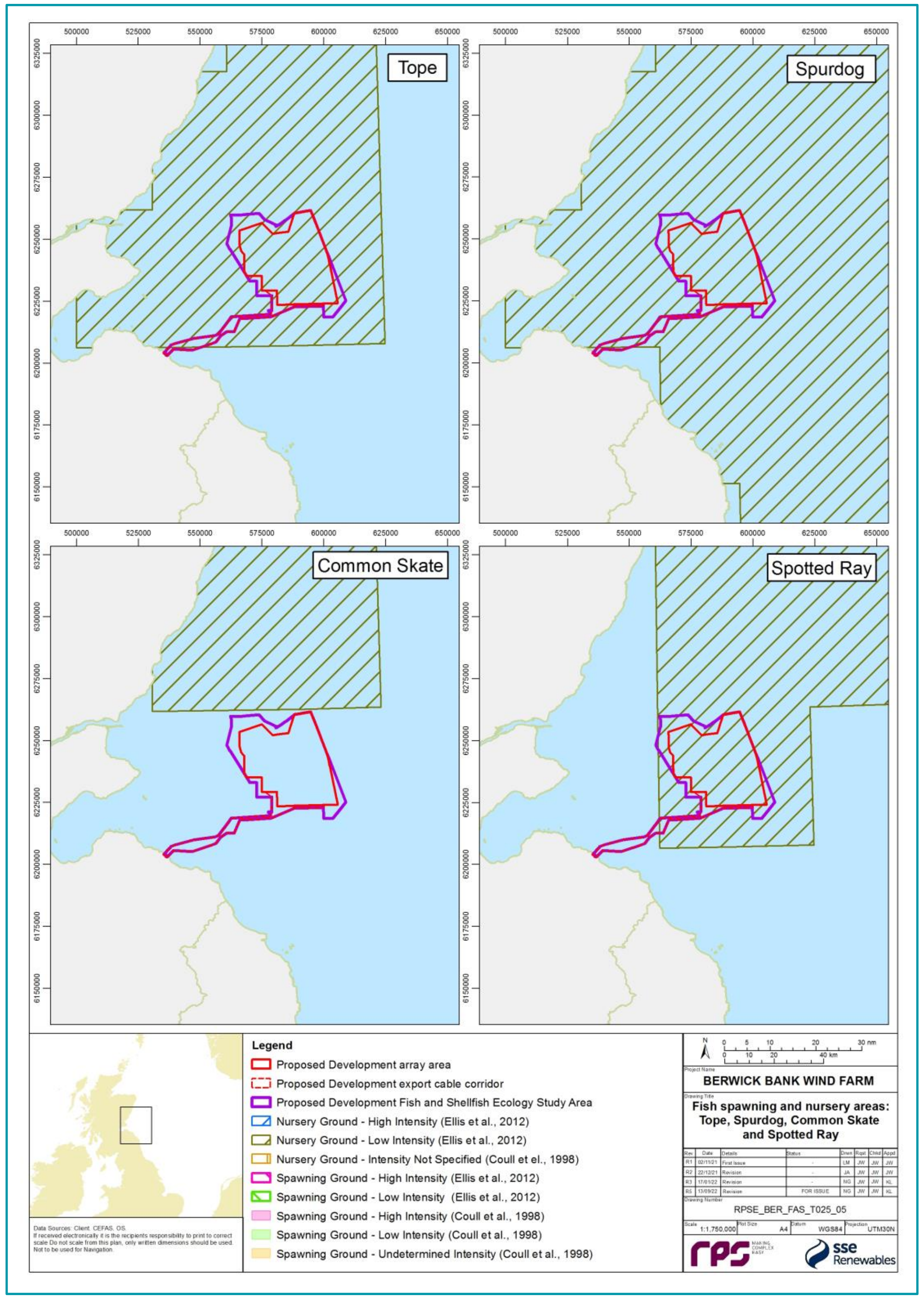

Figure 4.7: Tope, Spurdog, Common Skate and Spotted Ray Nursery Grounds and Overlaps with the Proposed Development Fish and Shellfish Ecology Study Area

4.4. HERRING

4.4.1. DESKTOP STUDY

50. Herring is a commercially important pelagic fish, common across much of the North Sea. Herring is a relatively large fishery; the most recently published figures (2020) for herring in the North Sea (ICES Area IVa to IVc) landed by Scottish vessels was 46,742 tonnes with a value of £26,078,000 (Scottish Government, 2020a).

51. Herring stocks in the North Sea crashed as a result of overfishing in the latter part of the 20th century. Although there has since been a recovery, active management is required to prevent a recurrence (Dickey-Collas *et al*., 2010). A herring recovery plan to reduce fishing mortality was implemented in 1996 for the North Sea and was revised in 2004. Although this was considered generally successful, it was not as successful for those herring stocks found in the northern North Sea. A ban on discards for pelagic fisheries such as herring started on 1 January 2015.

52. There are two herring fisheries certified as sustainable by the Marine Stewardship Council (MSC) in the North Sea (MSC, 2018). In addition to this, herring are listed as a Scottish Priority Marine Feature (PMF) (Fauchald *et al*., 2011 and Casini *et al*., 2004).

53. Herring nursery grounds, as described in section 4.3 and shown in Figure 4.6, are also widespread along the east Scottish and Northumberland coastlines (Ellis *et al*., 2012), with post larvae juveniles up to sub adults that are yet to reach sexual maturity feeding here until migrating to feeding grounds further offshore where they remain until reaching sexual maturity (ICES, 2006). Herring utilise specific benthic habitats during spawning, which increases their vulnerability to activities impacting the seabed. Further, as a hearing specialist, herring are vulnerable to impacts arising from underwater noise.

54. Herring deposit eggs on a variety of substrates from coarse sand and gravel to shell fragments and macrophytes, although gravel substrates have been suggested as their preferred spawning habitat. Once spawning has taken place (the peak spawning months being August and September for the Buchan stock), the eggs take approximately three weeks to hatch after which the larvae drift in the plankton (Dickey-Colas *et al*., 2010; Cefas 2011).

55. North Sea herring fall into a number of different ‘races’ or stocks, each with different spawning grounds, migration routes and nursery areas (Coull *et al*., 1998). North Sea autumn spawning herring have been divided into three, mainly self-contained stocks — the Buchan, Dogger and Downs herring groups, which show differences in spawning areas and spawning periods. The Buchan stock which spawn between around August and September off the Scottish east coast are most relevant to the Proposed Development fish and shellfish ecology study area as spawning grounds for this stock have been mapped to the north and south of the Proposed Development fish and shellfish ecology study area (Figure 4.6).

4.4.2. SITE-SPECIFIC SURVEYS

56. Herring spawning grounds are most accurately mapped using a combination of herring larval data and particle size data, as recommended by Boyle and New (2018). In order to characterise herring spawning habitats in the vicinity of the Proposed Development fish and shellfish ecology study area, these two factors have been considered to accurately determine where the key herring spawning ground for the Buchan stock are located, following the Boyle and New (2018) guidelines. That is, the area where herring are known to spawn most frequently, noting that there is some natural variability in spawning.

Particle size data

57. As outlined in section 3.2, site-specific survey data were collected alongside desktop studies to assess the extent of suitable spawning habitat within the Proposed Development fish and shellfish ecology study area. Grab sampling surveys were completed and PSA was undertaken on the sediment samples collected which allowed classification of the sediment types according to Reach *et al*. (2013), as described in Table 4.3. These classifications provided by Reach *et al*. (2013) were originally developed for the marine aggregates industry, drawing on work from Greenstreet *et al.* (2010b) investigating spatial interactions between the aggregate application areas and herring spawning habitat.

58. Habitat suitability classifications for herring spawning, based on site-specific data, showed that the majority of the Proposed Development fish and shellfish ecology study area has unsuitable sediment for herring spawning, with a small patch of suitable habitat in the north-west section of the Proposed Development array area (Figure 4.8).

59. Figure 4.8 shows site-specific survey data alongside EMODnet seabed substrate data. The EMODnet seabed substrate data can also be used to assign habitat suitability for herring spawning, showing sandy gravel and gravel as preferred spawning habitat and gravelly sand as marginal spawning. Where no shading is present, the habitat in that area is unsuitable for herring spawning. On the whole, there is good alignment between the results of site-specific surveys and EMODnet seabed substrate data, with the Proposed Development array area containing mostly unsuitable habitat with a few patches of marginal habitat. The Proposed Development export cable corridor contains predominantly unsuitable habitat with a few small patches of marginal habitat. It is worth noting, that the EMODnet seabed substrate data is of lower resolution and accuracy than the results of the site-specific survey data but provide an overall picture of the surrounding substrate. Figure 4.9 shows the same EMODNet data, but for the wider area comprising the Buchan Stock spawning habitat. This shows more extensive areas of marginal spawning habitat to the north of the Proposed Development fish and shellfish ecology study area, coinciding with the area mapped by Coull *et al*. (1998) and a smaller area of marginal and potential spawning habitat to the south. These patterns in sediment composition are considered in the context of herring larval abundances, as discussed in paragraph 60.

Table 4.3: Herring Potential Spawning Habitat Sediment Classifications Derived from Reach *et al*. (2013)

% Contribution (mud = <63 µm)	Habitat Sediment Preference (Adapted from Reach *et al*. (2013))	Habitat Sediment Classification (Adapted from Reach *et al*. (2013))
<5% mud, >50% gravel	Prime	Preferred
<5% mud, >25% gravel	Sub-prime	Preferred
<5% mud, >10% gravel	Suitable	Marginal
>5% mud, <10% gravel	Unsuitable	Unsuitable

International herring larvae study data

60. As outlined in paragraph 59, herring spawning grounds can be identified through monitoring of herring larvae, alongside data on sediment type. The IHLS conducts monitoring programmes where larvae numbers are recorded around the UK coastline and the North Sea. Herring larvae are identified as being recently hatched by their size, and therefore small herring larvae can be assumed to have been spawned recently and therefore in close proximity to the area where they are recorded. The IHLS present larval data by size per m^2, with larvae under 10 mm long used as a cut off point for recently spawned larvae. Recently

spawned larvae will not have drifted far from the location where eggs were spawned on the seabed and high abundances of these larvae are therefore a good indication of recent spawning activity local to where these were sampled. These data were plotted for each year from 2007 to 2016 in Figure 4.10 to Figure 4.14 showing the spatial distribution of herring spawning relative to areas of historical spawning grounds as identified by Coull *et al*. (1998), in line with guidance from Boyle and New (2018).

61. These data show that the spawning area north of the Proposed Development array area identified by Coull *et al*. (1998) has had persistently high levels of spawning with relatively little variation from 2007 to 2016. The spawning area identified to the south of the Proposed Development fish and shellfish ecology study area, which intersects the Proposed Development export cable corridor, has had variable spawning levels from 2007 to 2016. It is worth noting that spatial variability of larval densities may be as a result of the timing of data collection and/or variation in ocean and tidal current speeds and direction, which may account for some of the variability shown to the south of the Proposed Development fish and shellfish ecology study area. Both spawning areas identified through Coull *et al*. (1998) and the IHLS heat maps are supported by habitat suitability data from EMODnet, as shown in Figure 4.8 and Figure 4.9 by the large patches of favourable and marginal spawning habitat to the north and south of the Proposed Development fish and shellfish ecology study area, which corresponds with spawning areas identified through particle size data and IHLS larval data.

62. Each year of data were also presented cumulatively over the ten year period between 2007 and 2016 (Figure 4.15) to gain an understanding of where the most common spawning grounds were over the time period. However, the cumulative analysis of spawning density can be skewed by particularly high-density years, which may have been an anomalous result. To mitigate this Figure 4.16 provides a composite of the individual years of herring larval data for the years 2007 to 2016. This shows where high numbers of herring larvae were consistently recorded, using a cut off of 100 larvae <10 mm in length per m^2. Areas marked with darker blue patches indicate where spawning evidence was most regularly recorded and therefore indicates the core spawning habitat for the Buchan herring spawning stock. As shown in Figure 4.16, there is a large patch of darker blue to the north of the Proposed Development fish and shellfish ecology study area which corresponds with the annual herring larval data high density areas. The Proposed Development fish and shellfish ecology study area and the area to the south is marked as lighter blue which reflects the variability in the spawning areas shown in the previous figures in the same area. These data align with what was reported in the post consent fish monitoring strategy report for Seagreen (Seagreen, 2019).

63. Due to lack of ILHS survey data between 2017 and 2018, and a change in reporting strategy from IHLS, since 2019, more recent herring larvae data were not available for analysis. However, an ICES scientific report (ICES, 2021) noted that IHLS data for 2019 to 2020 in the Buchan area was in the same order of magnitude as previous years, therefore, it can be assumed that there are no significant changes from the results presented for 2007 to 2016 outside of normal annual variations.

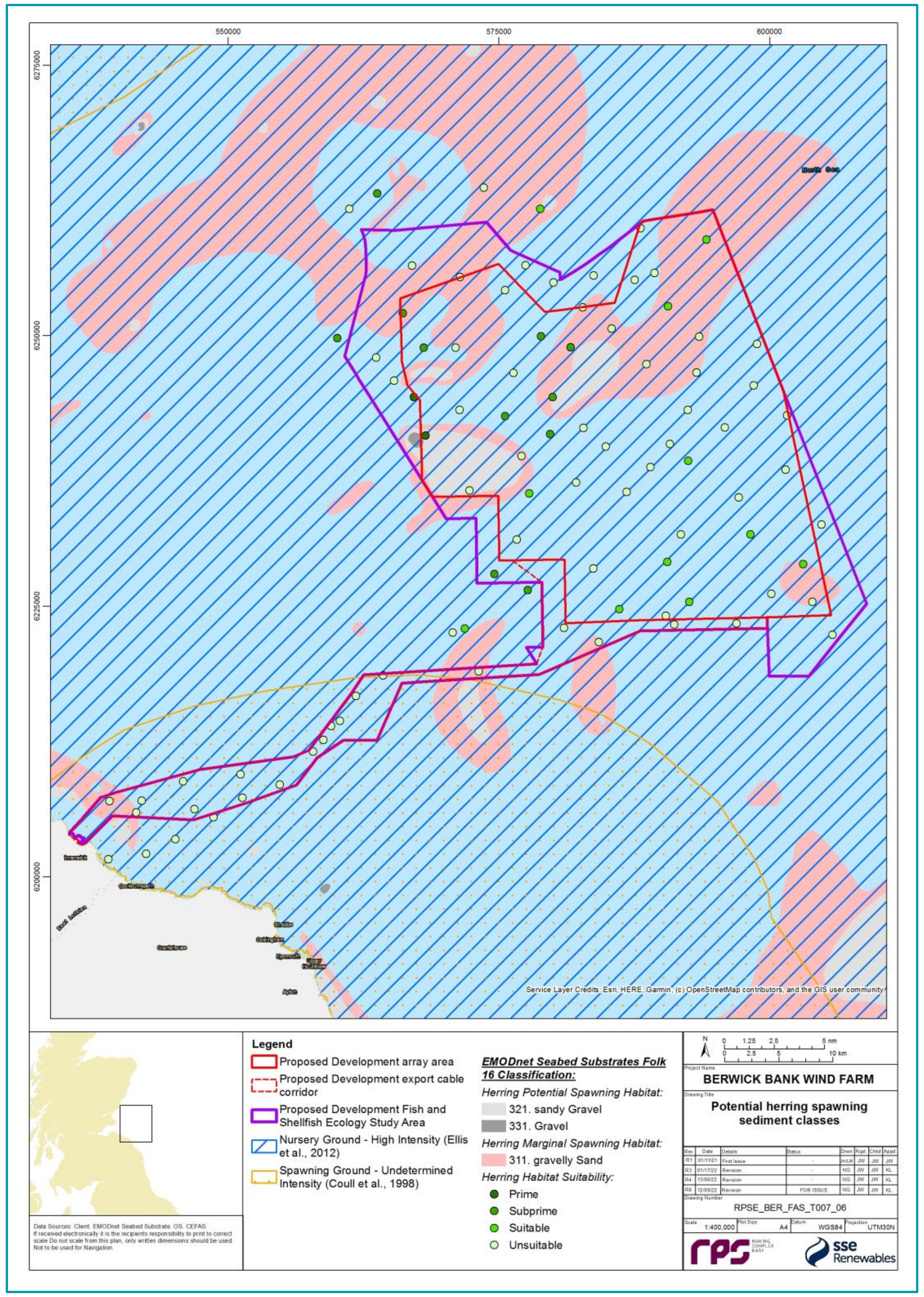

Figure 4.8: Herring Spawning Habitat Preference Classifications from EMODnet and Site-Specific Survey Data

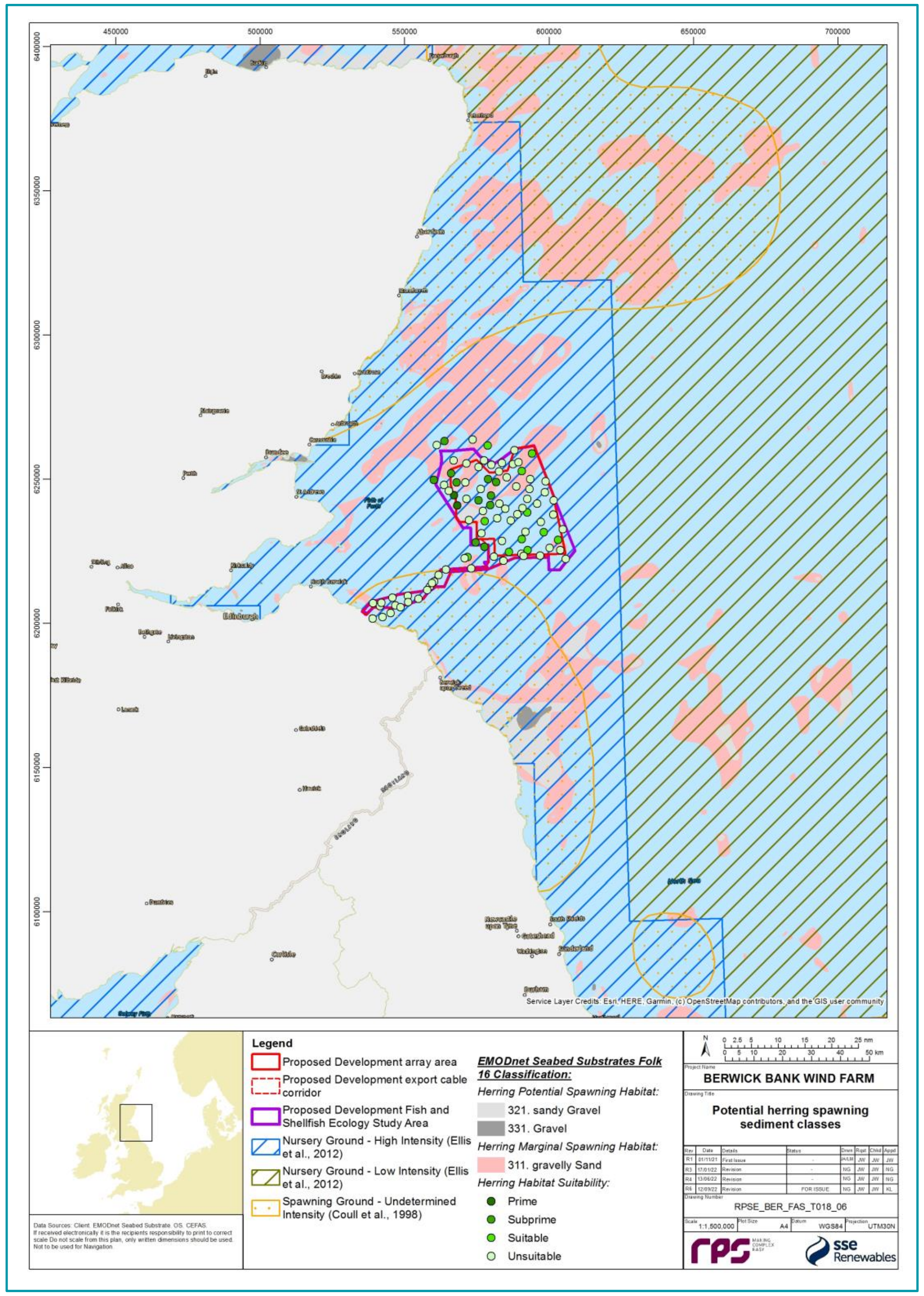

Figure 4.9: Herring Spawning Habitat Preference Classifications from EMODnet and Site-Specific Survey Data Covering the Buchan Stock Herring Spawning Habitats

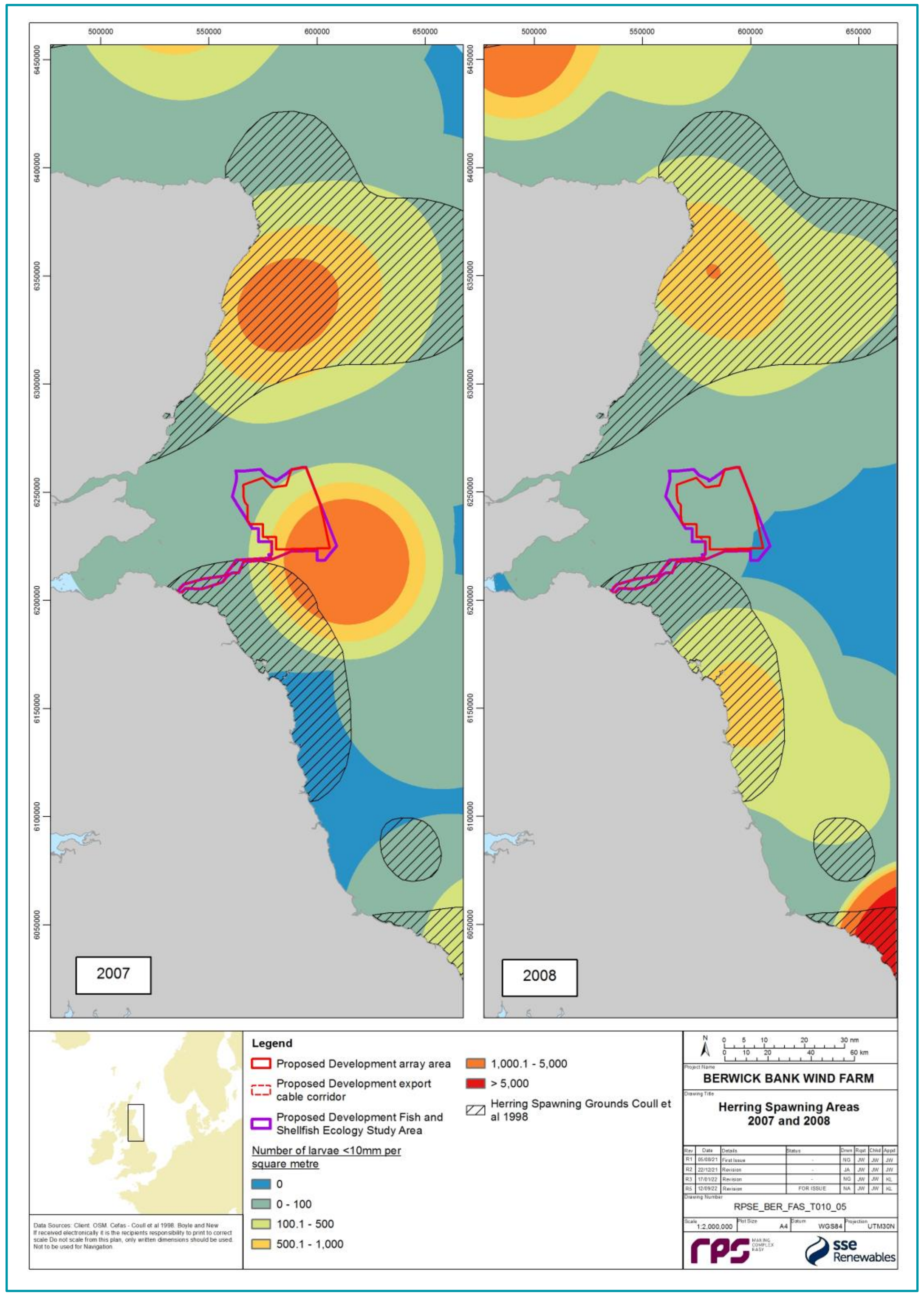

Figure 4.10: Herring Larval Density from IHLS Data Sets for 2007 to 2008

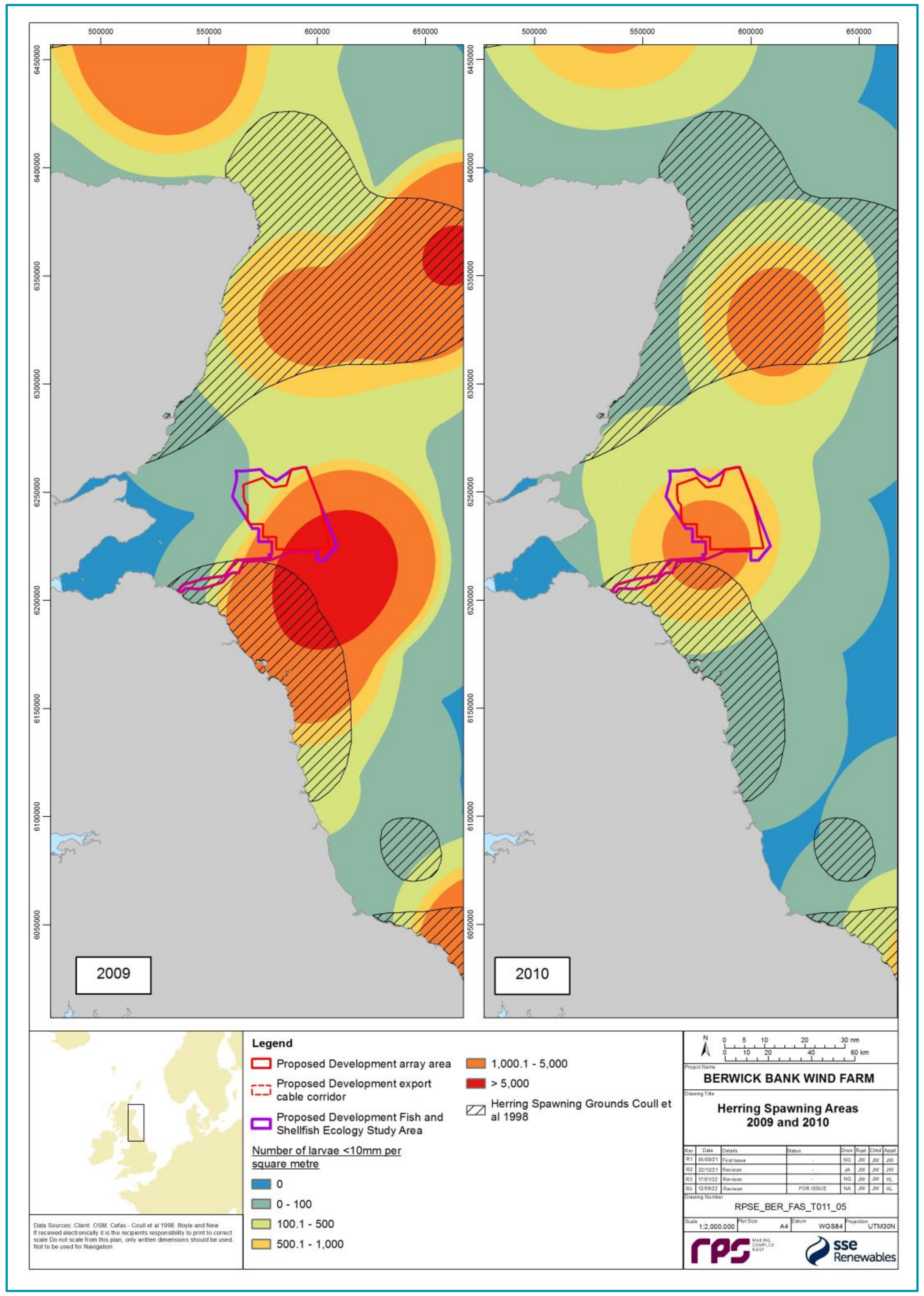

Figure 4.11: Herring Larval Density from IHLS Data Sets for 2009 to 2010

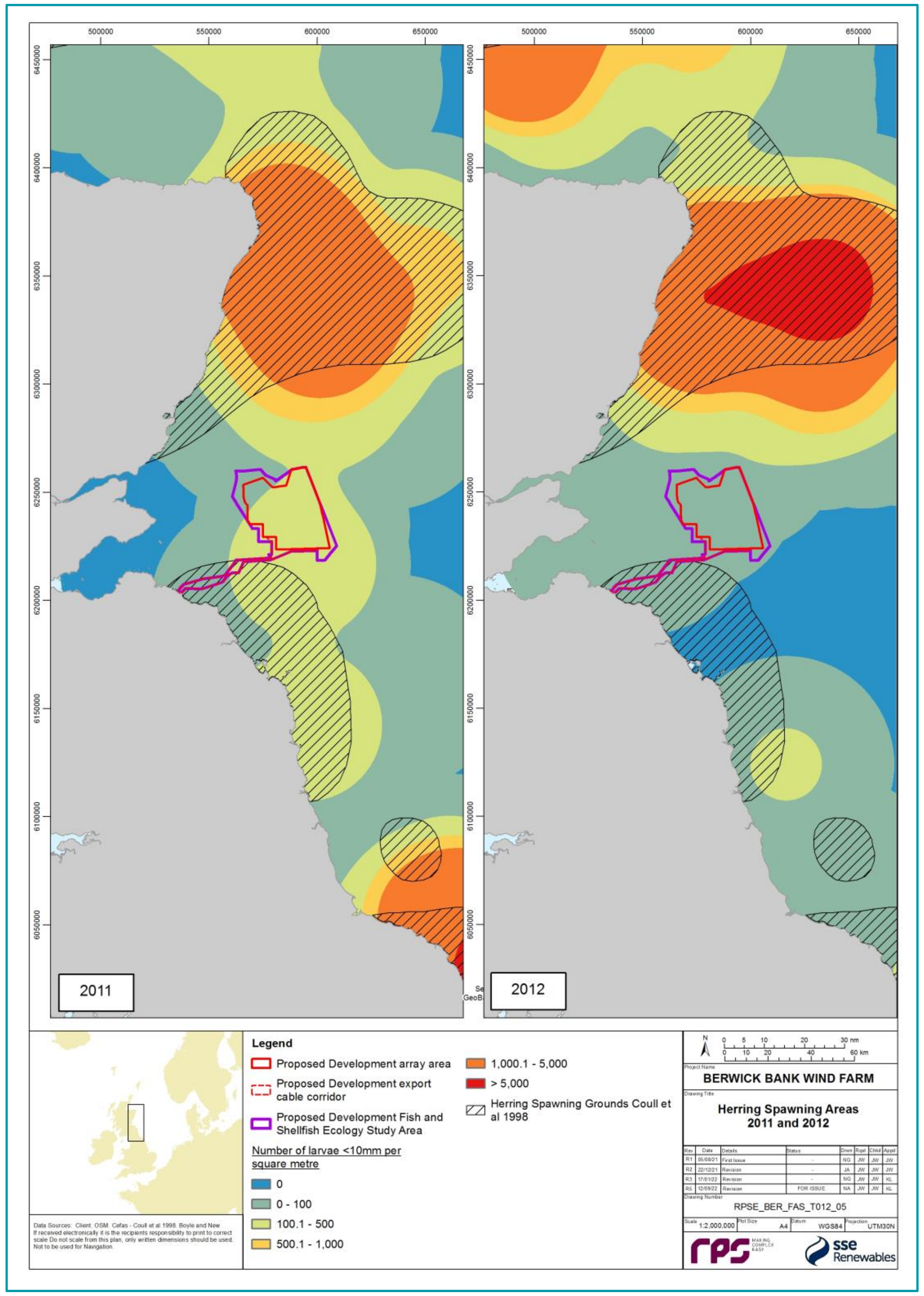

Figure 4.12: Herring Larval Density from IHLS Data Sets for 2011 to 2012

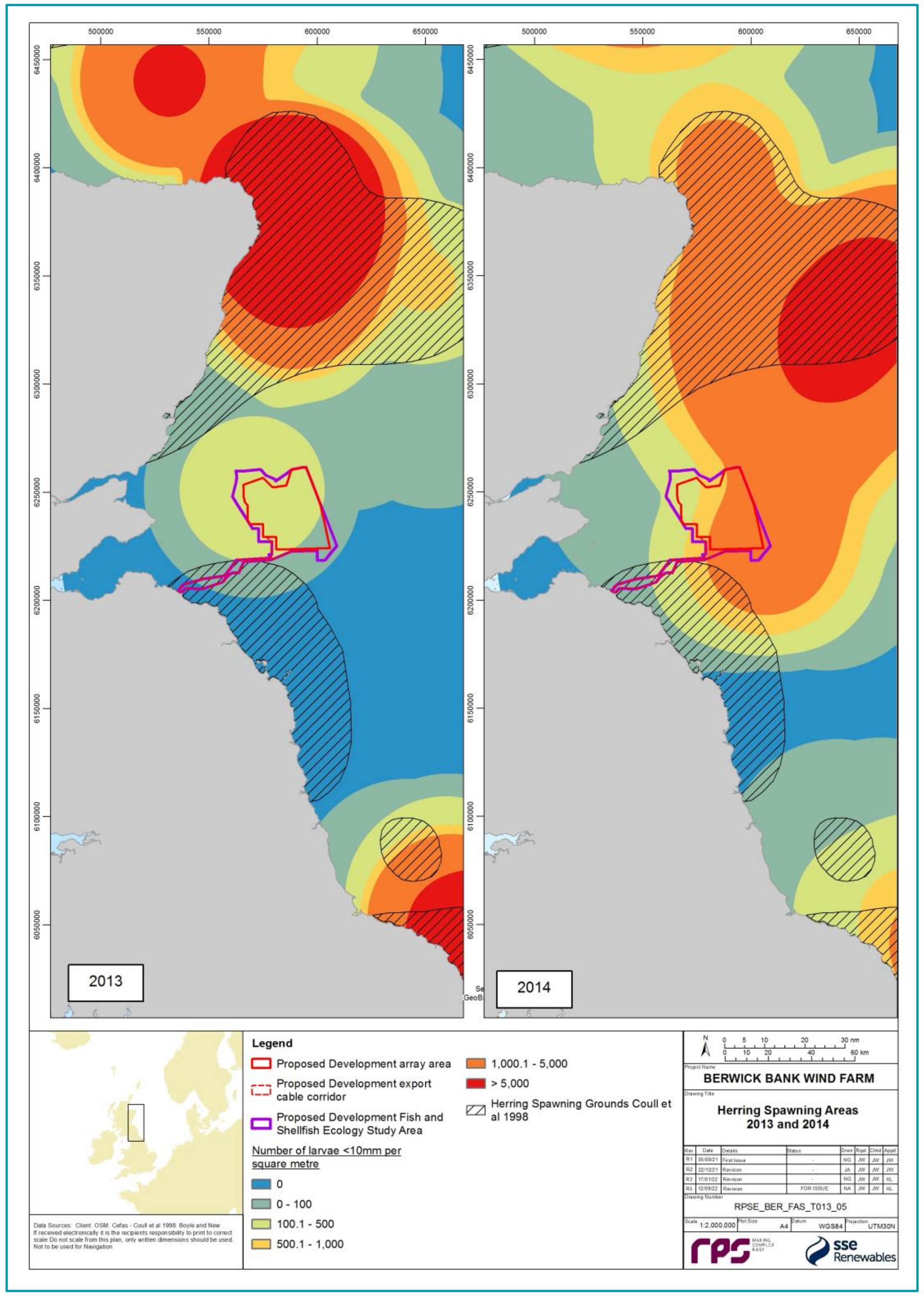

Figure 4.13: Herring Larval Density from IHLS Data Sets for 2013 to 2014

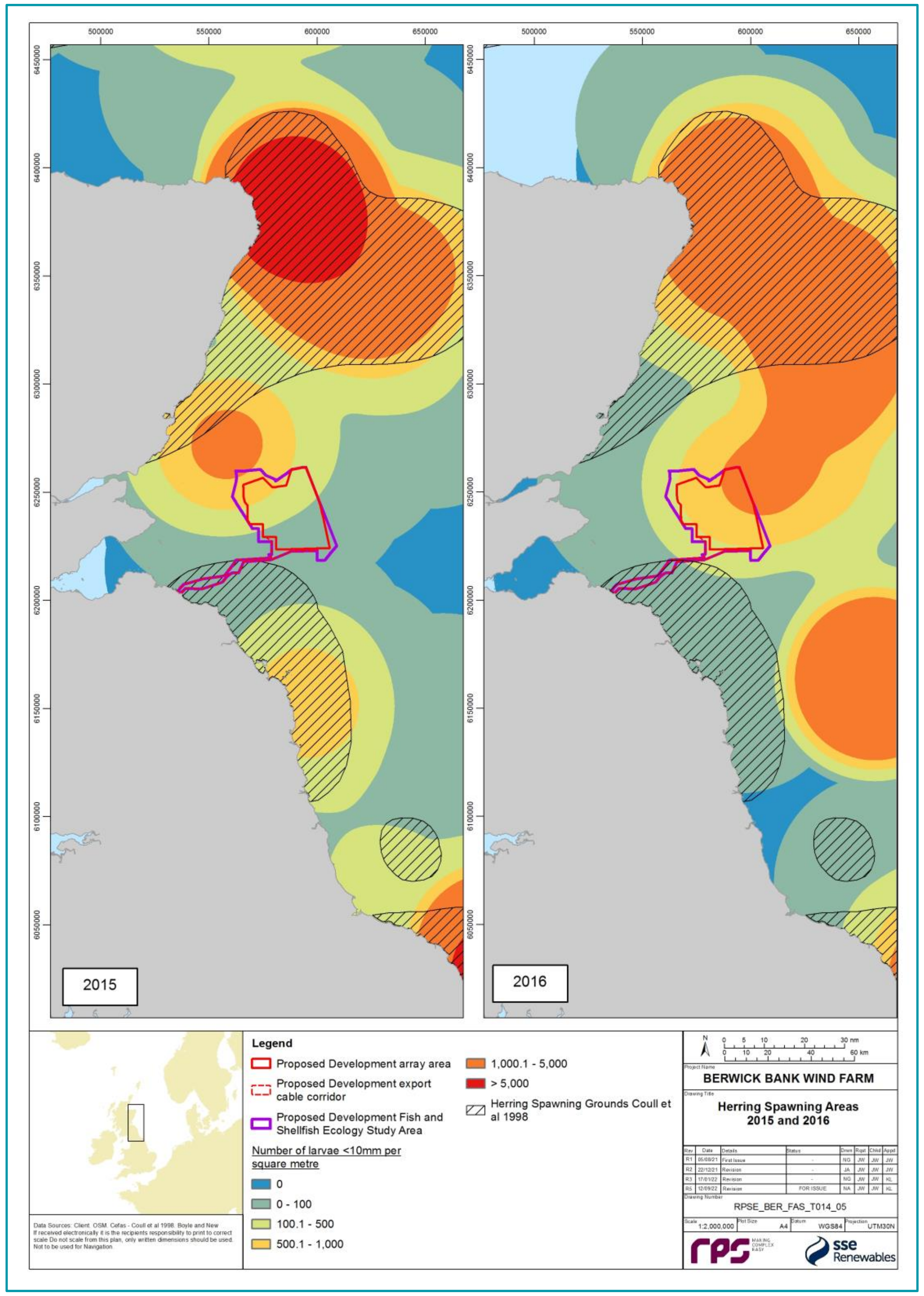

Figure 4.14: Herring Larval Density from IHLS Data Sets for 2015 to 2016

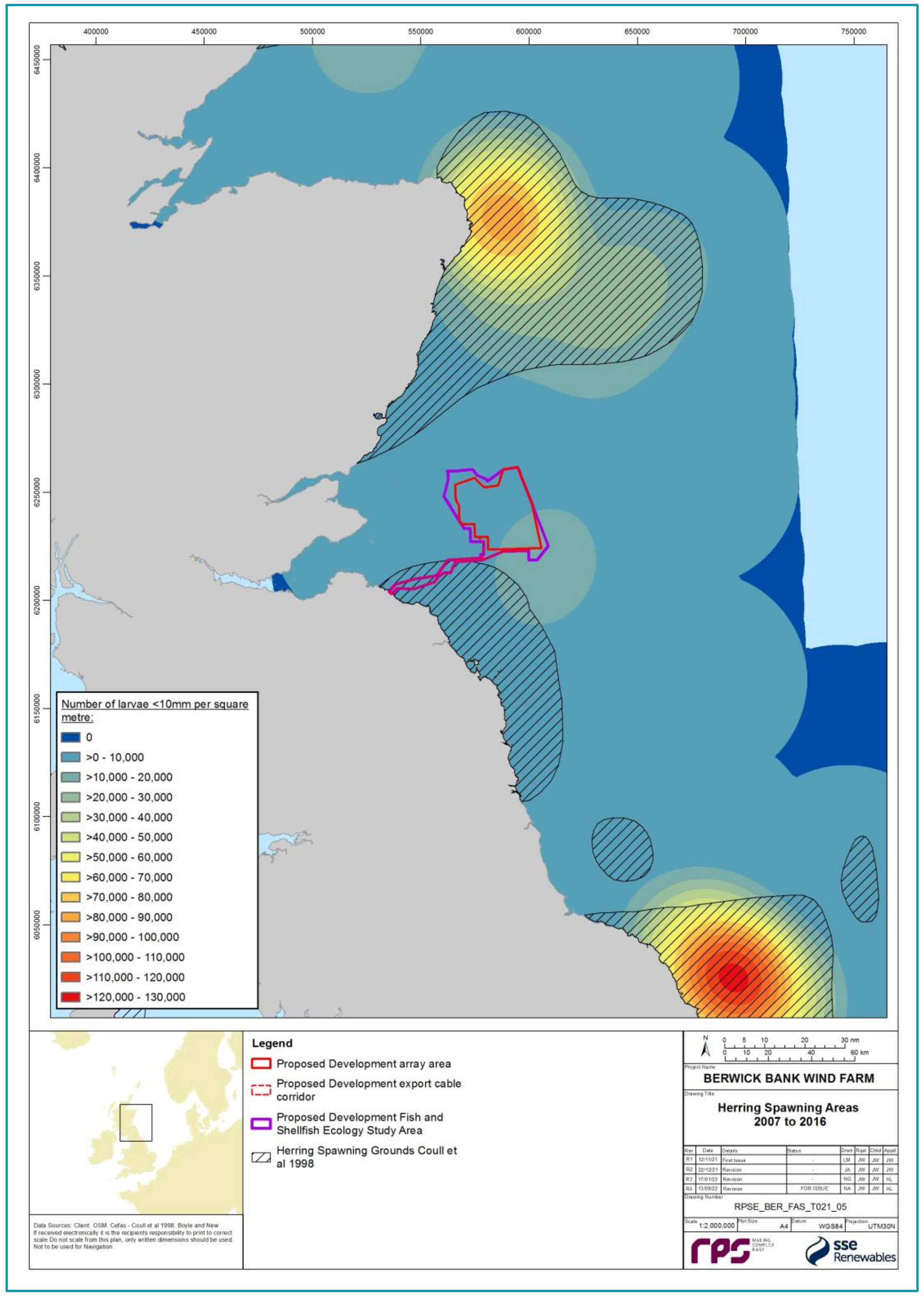

Figure 4.15: Herring Cumulative Larval Density from IHLS Data Sets for 2007 to 2016

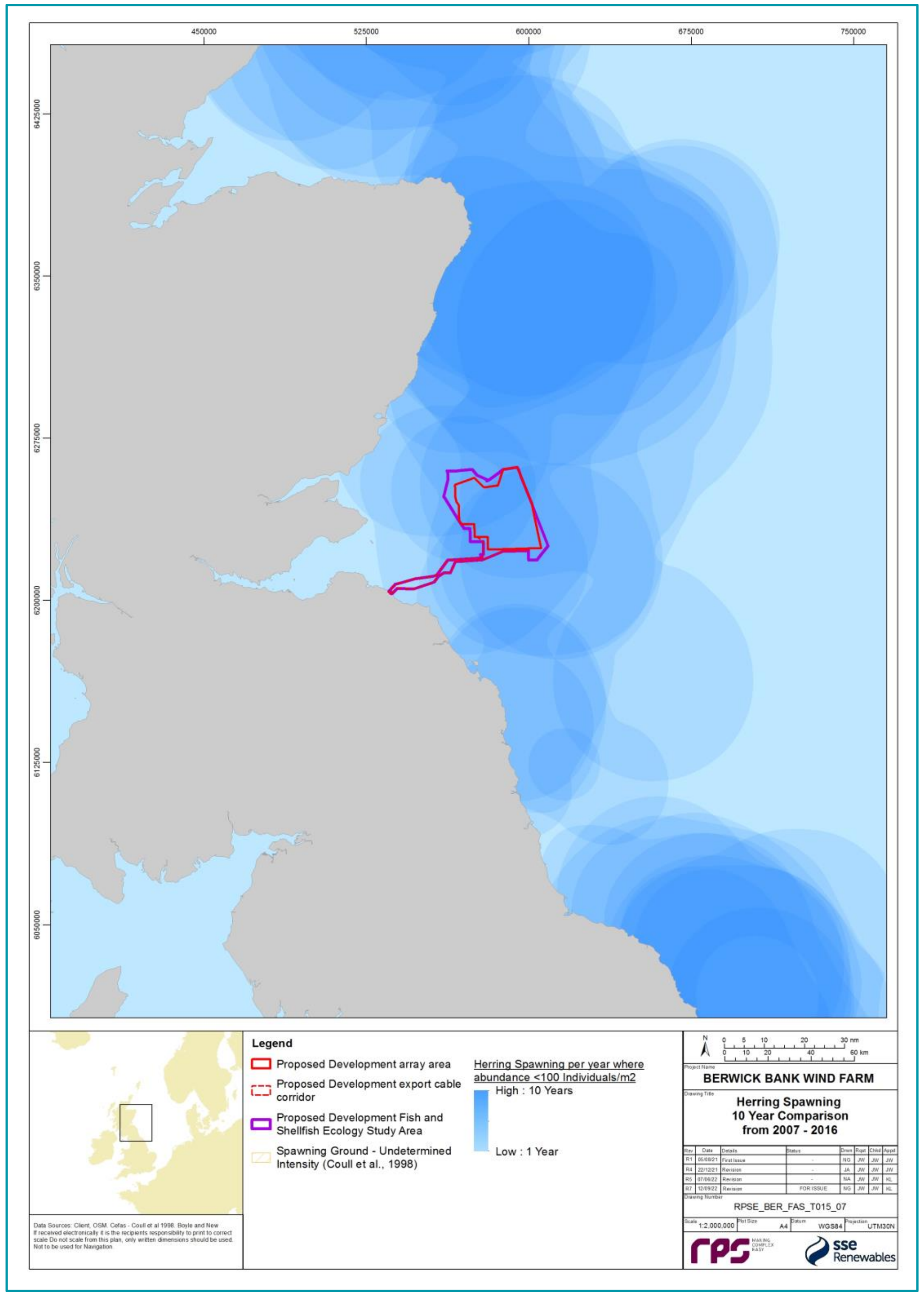

Figure 4.16: Herring Larval Density of over 100 per m^2 per Year from 2007 to 2016

4.5. SANDEELS

4.5.1. DESKTOP STUDY

64. There are a number of sandeel species present within the region. This section refers to sandeel species collectively, unless specified otherwise. The wider Forth and Tay SMR has been known historically to support important sandeel populations. The highest density of this population is focused on the Wee Bankie, however sandeels do range across much of the wider North Sea. In the early 1990s there was a substantial industrial sandeel fishery on the Wee Bankie, Marr Bank and Berwick Bank sandbanks. By 1993 landings from this area had peaked at over 100,000 t (Greenstreet *et al*., 2010a).

65. In 2000, this industrial sandeel fishery was closed in response to concerns that the fishery was having a deleterious effect on sandeel stocks within the Forth and Tay SMR. The sandeel closure within this region (precautionary closure — Article 29a from Council Regulation No 850/88) had the effect of limiting sandeel fishing on most of the Forth and Tay SMR sandeel grounds. The fishery remains closed and sandeel abundance is monitored by Marine Scotland and ICES (2022).

66. After the Forth and Tay SMR sandeel fishery closed, high levels of recruitment, combined with a lack of any significant fishing activity resulted in an immediate and substantial increase in the biomass of sandeel on the Wee Bankie sandbank. However, since 2001, sandeel biomass has steadily declined to levels that were similar to those observed when the sandeel fishery was active (Greenstreet *et al*., 2010). More recently sandeel stocks have recovered leading to an increase in sandeel fishing adjacent to the closed area. However, ICES recently stated "*The escapement strategy [*by which sandeel stocks are managed*] is not sustainable for short-lived species unless the strategy is combined with a ceiling (F_{cap}) on fishing mortality*" (ICES, 2022).

67. Two sandeel species, Raitt's sandeel *Ammodytes marinus* and lesser sandeel *Ammodytes tobianus*, are Scottish PMFs. Sandeel spend most of the year buried in the seabed, emerging in the winter to spawn (van der Kooij *et al*., 2008). Sandeel spawn a single batch of eggs in December to January, which are deposited on the seabed, several months after the active feeding season (April to September). The larvae hatch after several weeks, usually in February to March, and drift in the currents for one to three months, after which they settle on the sandy seabed. During the spring and summer, sandeel emerge during the day to feed in schools and at night return to bury in the sand. This is an adaptation to conserve energy and to avoid predation. There are indications that the survival of sandeel larvae is linked to the availability of copepod prey in the early spring, especially *Calanus finmarchicus* and that climate generated shifts in the *Calanus* species composition can lead to a mismatch in timing between food availability and the early life history of lesser sandeel (Wright and Bailey, 1993; van Deurs *et al*., 2009). Sandeel is an important prey species for many marine predators.

68. Sandeel have a close association with sandy substrates into which they burrow. They are largely stationary after settlement and show a strong preference to specific substrate types. Studies in the laboratory (Wright *et al*., 2000) and in the natural environment (Holland *et al*., 2005) has focused on identifying the sediment characteristics that define the seabed habitat preferred by sandeel. Both approaches produced similar results, indicating that sandeel preferred sediments with a high percentage of medium to coarse grained sand (particle size 0.25 mm to 2 mm), and avoided sediment containing >4% silt (particle size <0.063 mm) and >20% fine sand (particle size 0.063 mm to 0.25mm). As the percentage of fine sand, coarse silt, medium silt and fine silt (particles <0.25 mm in diameter) increased, sandeel increasingly avoided the habitat (this finding was also supported by Wright *et al*. (2000) as reported by Mazik *et al*. (2015)). Conversely, as the percentage of coarse sand and medium sand (particles ranging from 0.25 mm to 2.0 mm) increased, sandeel showed an increased preference for this substrate.

69. Work by Greenstreet *et al*. (2010b) draws on the research by Holland *et al*. (2005), to define four sandeel sediment preference categories, using hydro acoustic seabed surveys and nocturnal grab surveys. They merged fine sand, three silt grades and two coarser sand grades, to define two particle size classes, silt and fine sand and coarse sand, and then examined the combined effect of these two size grades of sediment particles on the percentage of grab samples with sandeel present. Latto *et al*. (2013) used this research to produce four sandeel sediment preference categories, which were defined as; Prime, Sub Prime, Suitable and Unsuitable (see Table 4.4).

70. Further work has been completed by Langton *et al*. (2021) where a predicted distribution model for sandeel was developed, producing predicted density and probability of occurrence for sandeel around the British coastline. This modelling was undertaken based on the dependence of sandeel on particular habitat types, with the four main explanatory variables within the model being silt, depth, sand and slope, and was supported by sandeel fisheries data (e.g. data from Jensen *et al*., 2011). The results were mapped, highlighting areas of importance for sandeel populations in the North Sea, including the Forth and Tay SMR and the Proposed Development fish and shellfish ecology study area. Figure 4.17 presents the outputs of the modelling within the Proposed Development fish and shellfish ecology study area and shows that a large proportion of the Proposed Development fish and shellfish ecology study area has high probability of sandeel presence, with more discrete areas where predicted density is high. These areas also correlate to previous studies where marine mammals and birds are known to congregate and feed on sandeels (Langton *et al.,* 2021).

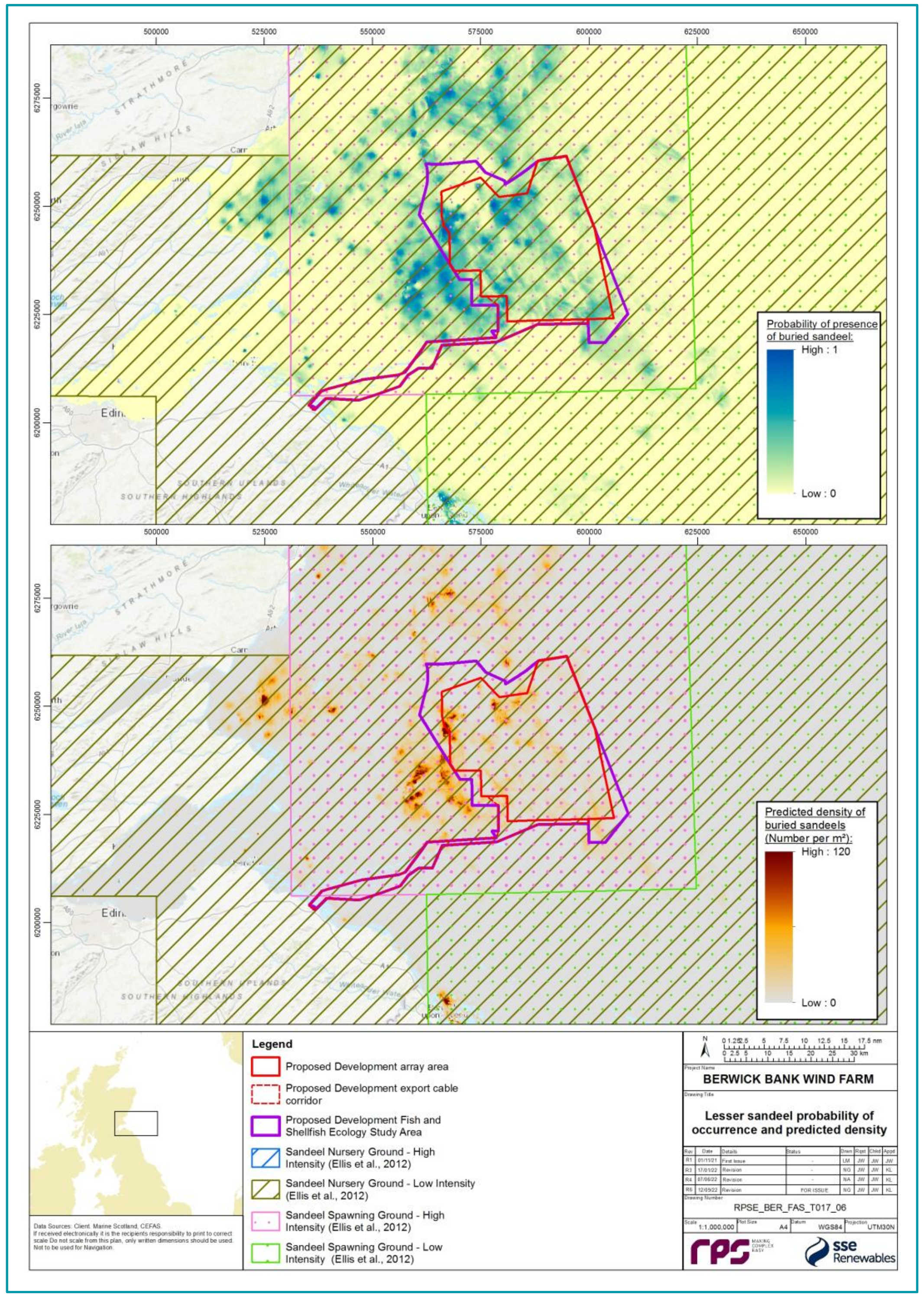

Figure 4.17: Model Derived Predictions of Density and Probability of Presence of Sandeel within the Proposed Development Fish and Shellfish Ecology Study Area (derived from Langton *et al*., 2021)

4.5.2. SITE-SPECIFIC SURVEYS

71. As outlined in section 3.2, site-specific survey data were collected and reviewed alongside desktop studies to assess the extent of suitable sandeel habitat within the Proposed Development fish and shellfish ecology study area. Grab sampling was undertaken (see section 3.2). PSA was undertaken on the sediment samples collected which allowed classification of the sediment types according to Latto *et al*. (2013), as described in section 3.2. These classifications provided by Latto *et al*. (2013) were originally developed for the marine aggregates industry, drawing on work from Greenstreet *et al.* (2010b) and Holland *et al.* (2005), investigating spatial interactions between the aggregate application areas and sandeel habitat.

72. Figure 4.18 shows the results of this analysis with sandeel habitat sediment preference classifications of prime, subprime, suitable and unsuitable habitat denoted. The distribution of the habitat suitability shows that the majority of the Proposed Development array area is prime to suitable habitat, with a small area to the north-west of the Proposed Development array area with unsuitable habitat. Within the Proposed Development export cable corridor, the majority of the grabs indicate that habitat is unsuitable.

73. Figure 4.18 shows the site-specific survey data alongside EMODnet seabed substrate data which can also be used to assign habitat suitability for sandeel. For the purposes of considering sandeel habitats suitability across the Proposed Development fish and shellfish ecology study area and surrounding areas, gravelly sand, (gravelly) sand, and sand in the EMODnet data were classified as preferred habitat and sandy gravel as marginal habitat. Where no shading is present, the habitat in that area is unsuitable for sandeel. On the whole, there is good alignment between the results of site-specific surveys and EMODnet seabed substrate data with the Proposed Development array area demonstrating mostly preferable habitat with a few patches of marginal habitat. The Proposed Development export cable corridor has a significant patch of unsuitable habitat, which matches PSA points of unsuitable habitat. There is some disagreement in the Proposed Development export cable corridor section where the habitat is indicated as preferred in the EMODnet data, but unsuitable by PSA. As described in section 4.2.2, the Proposed Development export cable corridor has been found to be dominated by muddy sediments, which further supports the site-specific survey results, which determine much of the Proposed Development export cable corridor as unsuitable. It is worth noting, that the EMODnet seabed substrate data is of lower resolution and accuracy than the results of the site-specific survey but provide an overall picture of the surrounding substrate.

74. Further site-specific survey results from grab samples and epibenthic trawls, as shown in Figure 4.19, has provided incidental data on abundance of sandeel within the Proposed Development fish and shellfish ecology study area. There were some instances where grab samples captured sandeel individuals. These are shown in Figure 4.19, with records in grab samples shown as presence/absence and trawl data shown as abundances per 500 m trawled. The abundance data collected indicates higher abundances of sandeel in the north-western section of the Proposed Development array area, due to the highest presence within grab samples and higher numbers of sandeel in epibenthic trawls within that area. However, it should be noted that both of these data collection methods do not target sandeel specifically, therefore these results should be regarded as opportunistic. Conversely, whilst these opportunistic data may indicate higher abundances in specific areas, it cannot be interpreted as low abundance or absence where sandeels were not recorded, due to the lack of specificity of sampling methods for sandeels. The site-specific survey data and desktop data indicate that sandeels are likely to be present across the Proposed Development array area and less likely in the Proposed Development export cable corridor.

Table 4.4: Sandeel Habitat Sediment Classifications Derived from Latto *et al*. (2013)

% Contribution (mud = <63 µm)	Habitat Sediment Preference (Latto *et al*., 2013)	Habitat Sediment Classification (Latto *et al*., 2013)
<1% mud, >85% sand	Prime	Preferred
<4% mud, >70% sand	Sub-prime	Preferred
<10% mud, >50% sand	Suitable	Marginal
>10% mud, <50% sand	Unsuitable	Unsuitable

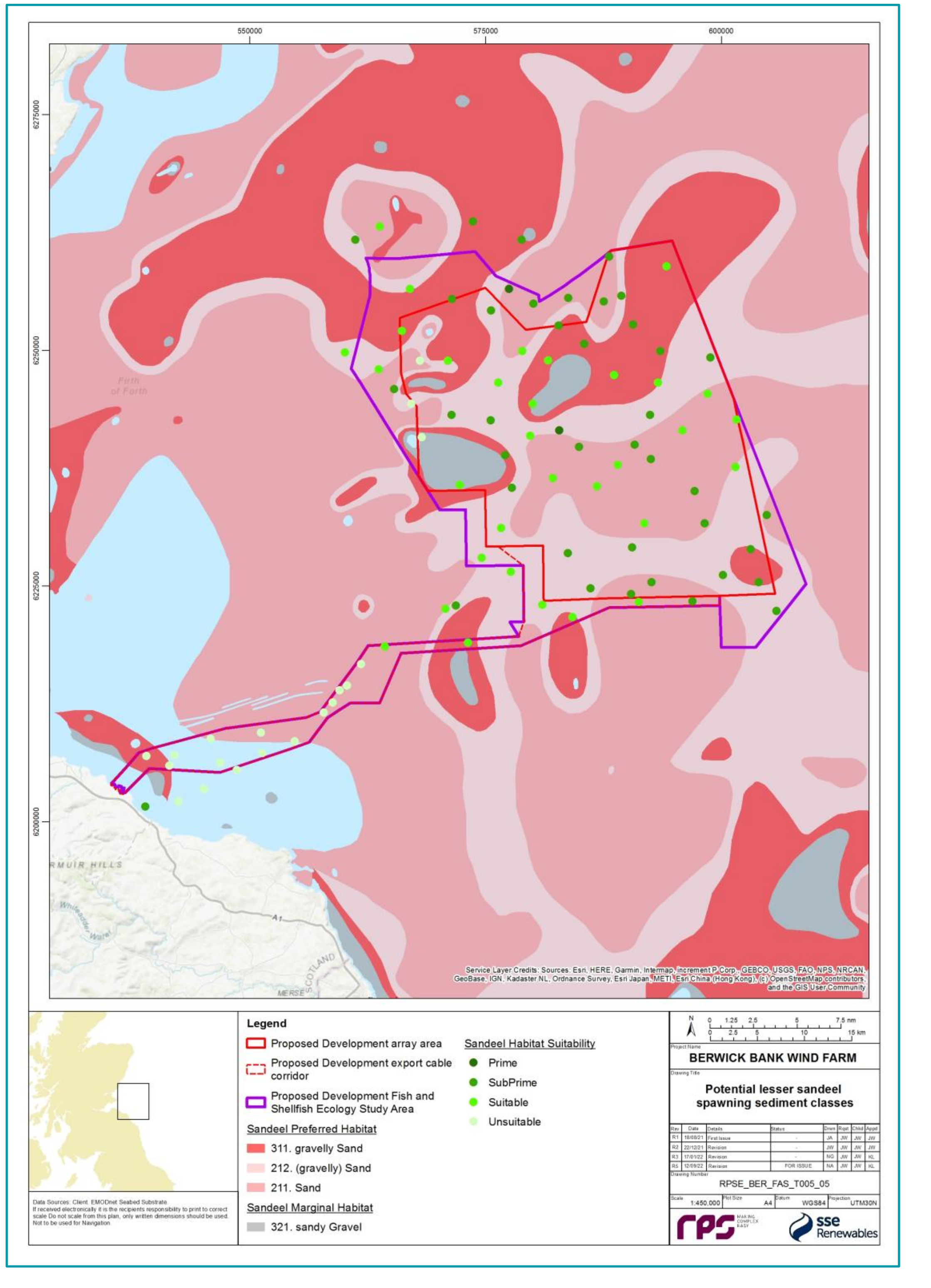

Figure 4.18: Sandeel Habitat Preference Classifications from EMODnet and Site-specific Survey Data

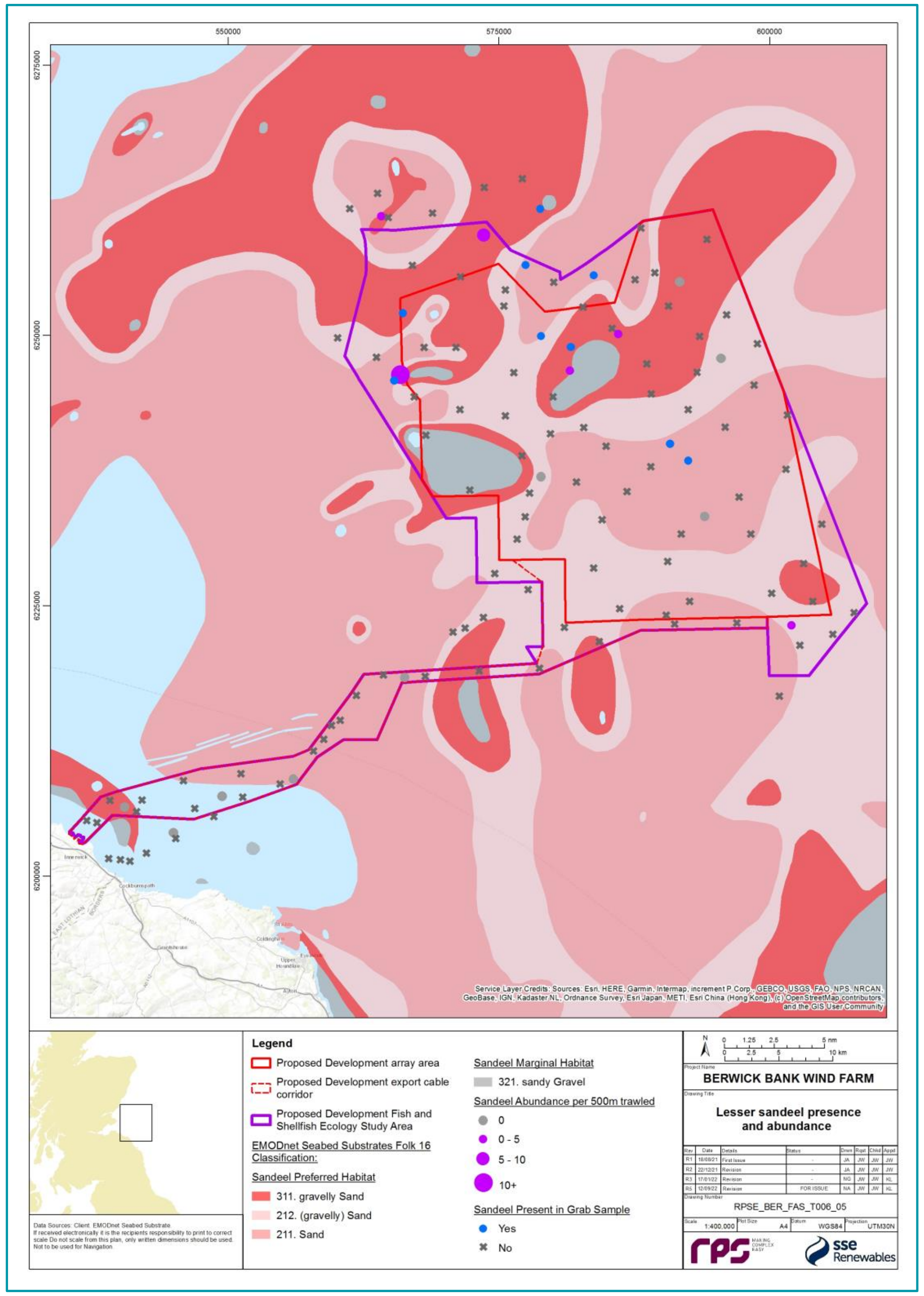

Figure 4.19: Sandeel Habitat Preference Classifications with Site-Specific Abundance Data

4.6. DIADROMOUS FISH

75. The term diadromous fish is used in this Technical Report to describe fish that migrate between fresh water and the marine environment. There is the potential for diadromous fish species to migrate to and from Scottish rivers in the vicinity of the Proposed Development fish and shellfish ecology study area and, therefore, they may migrate through the Proposed Development fish and shellfish ecology study area to rivers during certain periods of the year (National Biodiversity Network (NBN) Atlas, 2019).

76. The fish and shellfish ecology assessment for Seagreen (Seagreen, 2018) observed seven diadromous species of relevance: Atlantic salmon *Salmo salar*, sea trout *Salmo trutta*, sea lamprey *Petromyzon marinus*, river lamprey *Lampetra fluviatilis*, European eel *Anguilla anguilla*, allis and twaite shad *Alosa alosa* and *Alosa fallax* and sparling (European smelt) *Osmerus eperlanus*. The species which were considered as having the greatest potential to be present within the vicinity of Seagreen, and similarly the Berwick Bank Wind Farm, were Atlantic salmon, sea trout, European eel and the lamprey species.

77. No site-specific surveys were undertaken to inform the assessment of effects on diadromous fish species. For the purposes of the assessment of effects, it will be assumed that the aforementioned species are likely to be present within the Proposed Development array area and/or Proposed Development export cable corridor, during key migration periods (e.g. adult migration to spawning rivers and smolt migration from natal rivers in the vicinity of the Proposed Development fish and shellfish ecology study area). Depending on the key migration periods, there will be a greater/lesser likelihood of fish being present in the Proposed Development fish and shellfish ecology study area.

78. Timings of diadromous fish species migration are presented in Table 4.5, which displays the key migration times of diadromous fish species, and also the length of time each species spends in fresh water and at sea.

Table 4.5: Overview of Life Histories for Diadromous Fish Relevant to the Proposed Development Fish and Shellfish Ecology Study Area (Seagreen, 2018)

Species	Time Spent in Freshwater	Timing of Downstream Migration	Time Spent at Sea Before First Return	Timing of Upstream Migration
Salmon	2 to 3 years	April to May	1, 2 or 3 years	All year round with peak in late summer early autumn
Sea trout	2 to 3 years	Spring	2 or more	April to June
European Eel	Males 7 to 20 years Females 9 to 50 years	Late spring	Many do not return to fresh water	January to June
Sea lamprey	3 to 4 years	July to September to open sea	18 to 24 months	April to May spawning in May/June
River lamprey	5 years or more. Remain in burrow in river silt beds until adults	July to September to feed in estuaries	2 years spent in estuaries	Winter and spring when temps are <10°
Allis and Twaite Shad	Short period	N/A	Estuarine	April to May spawning in freshwater
Sparling (European smelt)	Short period	N/A	Estuarine	February to April spawning in freshwater

4.6.1. ATLANTIC SALMON

79. Salmon is of considerable cultural and conservation importance (Hindar *et al*., 2010) and in Scotland represents an important part of the rural economy (Radford *et al*., 2004). However, in recent decades, and especially the past thirty or so years, there have been declines in rod catch data across much of the species' range (Scottish Government, 2020b) There are many pressures on Atlantic salmon stocks in both marine and freshwater environments, including commercial and recreational exploitation of stocks, disease, impacts related to farmed salmon and climate change (ICES, 2017b). Atlantic salmon is an Annex II species under the Habitats Directive and is a feature of various Special Areas of Conservation (SAC). They are also a PMF in Scotland, and an Annex III species under the Bern Convention.

80. A Marine Scotland report on salmon fishery statistics (Marine Scotland, 2017) summarised rod and line, net and coble and fixed engine fisheries data for the period 1952 to 2016, based on completed fisheries returns. Rod caught spring salmon catches have declined since records began and are at a historically low level. The overall catch of salmon and, in later months, grilse, however, generally increased up to 2010, then fell sharply (second lowest on record in 2014) before recovering slightly in 2015 and 2016. By 2016 the reported catch and effort for the fixed engine and net and cobble fisheries were the lowest since records begin in 1952.

81. The Salmon Conservation Regulations which came into force in 2016 included measures to prohibit the killing of fish in coastal waters and in estuaries and rivers where the stocks were determined to be in poor conservation status. The great majority of rod and line caught salmon from the recreational fishery are returned to the water. In 2020, 93% of the annual rod catch, and 99% of the spring rod catch, were released (Scottish Government, 2020b).

82. Following spawning by adult salmon in Scottish east coast rivers, the ova mature into fry and then parr before migrating to sea as smolts. At sea, the smolts grow rapidly and after one to three years they return as adults to spawn, most commonly to their natal river. Many Atlantic salmon die after spawning, but some return to sea as kelts and may return again to rivers to spawn (Mills, 1989). Atlantic salmon are known to migrate in relation to diurnal cues. Evidence provided by Smith and Smith (1997) suggests that Atlantic salmon upstream migration into rivers is related to tidal phase and time of day. Up-estuary movements leading to river entry were found to be predominantly nocturnal and occur during ebb tides, with entry into nontidal reaches of rivers also being nocturnal, however significantly associated with tidal phase (Smith and Smith, 1997). Smolts migrating downstream/offshore have also been found to increase migratory activity nocturnally, with daytime utilised more for prey detection and predator avoidance (Hedger *et al*., 2008). Dempson *et al.* (2011) also found a small but significant increase in migratory movements nocturnally when compared to daytime, which suggests a slight preference for nocturnal migration.

83. Malcolm *et al*. (2015) used metadata to assess the timing of smolt emigration across Scotland. This suggests that most fish leave rivers between mid-April and the end of May. These results do not include the period spent by smolts in the coastal environment after leaving their native rivers. There was evidence that smolt emigration is becoming earlier (by around 1.5 days per decade over a period of around 50 years).

84. Migration of Atlantic salmon smolts through the Cromarty Firth and into the Moray Firth was tracked in a study undertaken for Beatrice Offshore Windfarm Ltd. by Glasgow University (BOWL, 2017). The study results indicated an eastwards migration of the tagged fish along the southern coast of the Moray Firth. Results also showed the majority of fish to remain predominantly within the upper 1 m of the water column during migration. Mortality of smolts was considered to be mainly attributable to predation and there was a strong relationship between group survival, early migration and group size.

85. Atlantic salmon smolts were tracked using acoustic telemetry in the River Deveron (south coast of the Moray Firth) and adjacent coastal areas (Lothian *et al*., 2017). Deveron fish had higher swim speeds in the early marine phase compared with the river. The majority of fish left the river in darkness on a flooding tide. Early marine migration speed decreased with increased environmental acoustic noise levels. Fish movements in the marine environment appeared more influenced by water currents than geographical features.

86. It has been suggested that once in the marine environment, the east coast Scotland 'post smolts', as they are known, are transported by North Sea currents firstly towards northern Norway and then into the Norwegian Sea (Holst *et al*., 2000; Jonsson *et al*., 1993). Smolt emigration at sea is poorly understood, however, and Malcolm *et al*. (2010) outlined a concept that fish from Scotland head west to feed and grow, utilising waters off west and east Greenland, as well as the Faroe Islands, as evidenced by recaptures of Scottish fish in all of these areas. This includes fish from the Aberdeenshire Dee, Tay and North Esk rivers.

87. Rod catch data from rivers on the east coast of Scotland can provide insight into the general trends of salmon populations within the vicinity of the Proposed Development fish and shellfish ecology study area. Data provided by Marine Scotland have been interrogated, with a focus on the following rivers relevant to the Proposed Development fish and shellfish ecology study area: Tweed, Forth, Tay, South Esk and Dee. At a simple level, Figure 4.20 evidences that salmon migrate to/from a number of rivers in the vicinity of the Proposed Development fish and shellfish ecology study area and therefore should be assumed very likely to pass through the Proposed Development fish and shellfish ecology study area, either as smolts or returning adults. This is consistent with the assumptions made within the Seagreen Alpha/Bravo Natural Fish and Shellfish Resource EIA Report (Seagreen, 2012).

88. This is further supported by recent evidence from the Moray Firth (Newton *et al*., 2017; Newton *et al*., 2019; Gardiner *et al*., 2018a) which suggests that smolts migrating from their rivers in the Moray Firth head directly across the North Sea relatively rapidly. It is thought that this route, rather than moving in a coastal direction upon leaving their natal rivers, allows them to take advantage of east flowing currents which cross the North Sea. This fast progress away from the coast limits exposure to predators close to the coast. It also reduces the potential for interaction with marine renewables developments (including offshore wind). Similar evidence of a rapid easterly migration out into the North Sea has also been shown for the River Dee in Aberdeenshire (Gardiner *et al*., 2018b). Therefore, it could be assumed that smolts from other east coast rivers (e.g. Tay, Forth and South Esk) would move in a similar fashion.

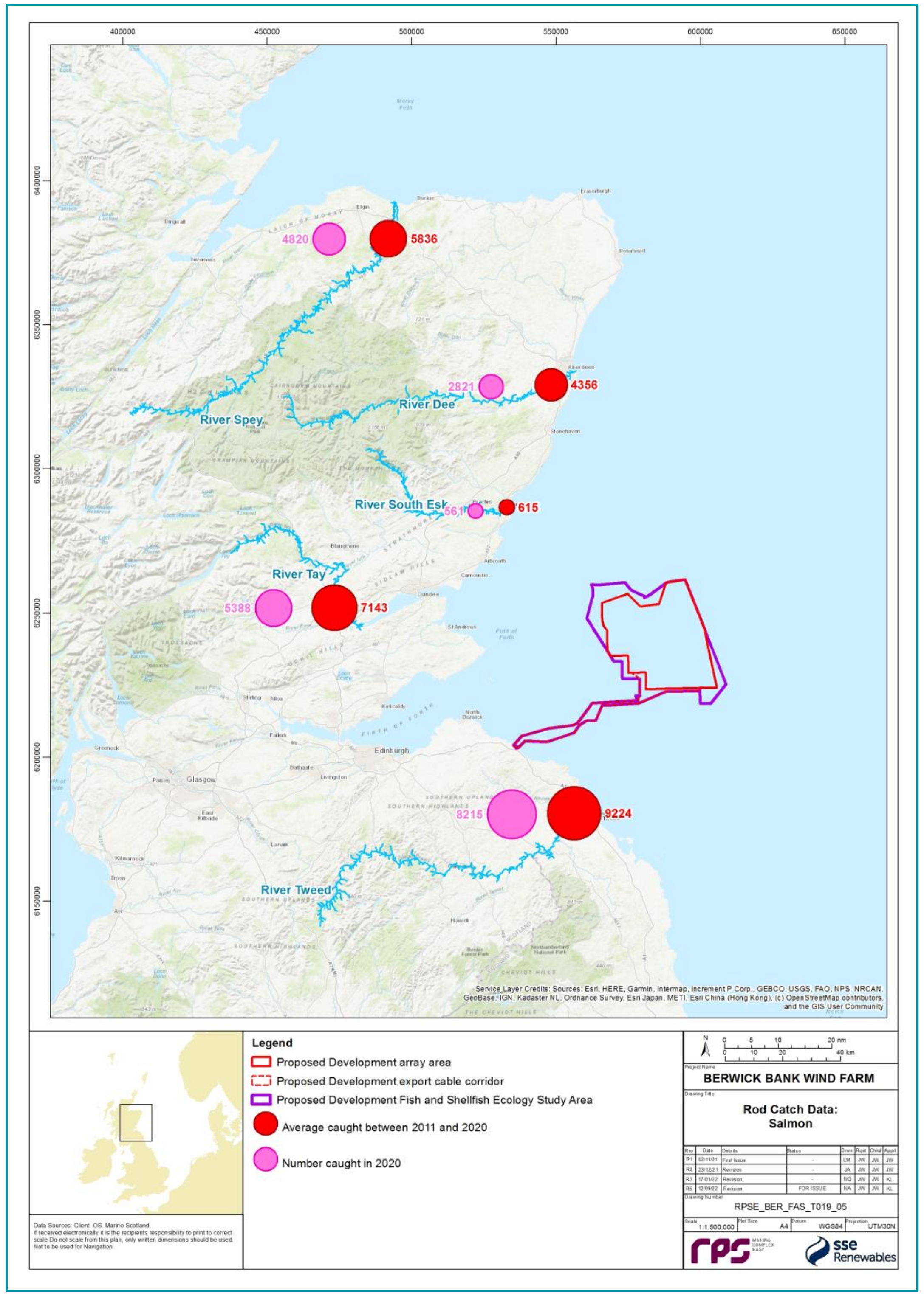

Figure 4.20: Catch Data for Rod Caught Atlantic Salmon using Marine Scotland Data (2011 to 2020)

4.6.2. SEA TROUT

89. Sea trout are found in rivers streams and lakes, preferring cold, well oxygenated upland waters. They spawn in rivers and streams with swift currents, usually characterized by downward movement of water into gravel, favouring large streams in the mountainous areas with adequate cover in the form of submerged rocks, undercut banks, and overhanging vegetation (Fishbase, 2021a). There is limited information regarding sea trout migration patterns, however available information suggests predominantly inshore and local (to the river) use of the marine environment (Malcolm *et al*., 2010). Figure 4.21 evidences that sea trout migrate to/from a number of rivers in the vicinity of the Proposed Development fish and shellfish ecology study area, however sea trout mainly stay close to the coastline and do not travel very far from the estuaries of their natal rivers. Sea trout are also known to be a host species for freshwater pearl mussel, see section 4.7.6 for further detail.

4.6.3. EUROPEAN EEL

90. European eels inhabit all types of benthic habitats from streams to shores of large rivers and lakes, migrating to the Sargasso Sea to spawn. Eel larvae are brought to European waters by the Gulf Stream and transform into glass eel and then elvers which migrate up estuaries around the Scottish coast, colonising, rivers and lakes. When sexual maturity is reached, they leave the river and migrate to the sea, covering great distances during their spawning migration (5,000 to 6,000 km) (Fishbase 2021b). It is a possibility that European eel will pass through the vicinity of the Proposed Development fish and shellfish ecology study area and therefore these will be considered as IEFs.

4.6.4. SEA LAMPREY

91. The sea lamprey is a primitive, jawless fish resembling an eel. It is the largest of the lampreys found in the UK. It occurs in estuaries and easily accessible rivers and is an anadromous species (i.e. spawning in freshwater but completing its life cycle in the sea) (JNCC, 2021a). Like the other species of lamprey, sea lampreys need clean gravel for spawning, and marginal silt or sand for the burrowing juveniles (*ammocoetes*). Sea lamprey spend most of their adult life at sea and are parasitic on a number of fish species and other marine fauna. Sea lampreys have a preference for warmer waters in which to spawn, which coincide with warmer spring temperatures in Scottish rivers (see Table 4.5) (JNCC, 2021a). It is a possibility that sea lamprey will be present in the vicinity of the Proposed Development fish and shellfish ecology study area and therefore these will be considered as IEFs.

4.6.5. RIVER LAMPREY

92. The river lamprey is found in coastal waters, estuaries and accessible rivers, but some populations are permanent freshwater residents, however the species is normally anadromous (i.e. spawning in freshwater but completing part of its life cycle in the sea) (JNCC, 2021b). They live on hard bottoms or attached to larger fish like cod and herring due to their parasitic feeding behaviour, with spawning taking place in pre-excavated pits in riverbeds. Due to their preference for estuarine waters, it is unlikely that river lamprey will be found within the Proposed Development fish and shellfish ecology study area and have therefore been scoped out with agreement of stakeholders (volume 2, chapter 9).

4.6.6. ALLIS AND TWAITE SHAD

93. The allis shad and twaite shad are members of the herring family and are difficult to distinguish between one another (JNCC, 2021c; JNCC 2021d). The habitat requirements of twaite shad are not fully understood. On the River Usk and the River Wye, twaite shad are known to spawn at night in a shallow

area near deeper pools, in which the fish congregate. The eggs are released into the water column, sinking into the interstices between coarse gravel/cobble substrates (JNCC, 2021c). The allis shad also has poorly understood habitat requirements. It grows in coastal waters and estuaries, spending most of its adult phase in the marine environment, but migrates into rivers to spawn, swimming up to 800 km upstream in continental Europe. Adults spawn at night with the eggs released into the current where they settle among gaps in gravelly substrates. Spawning sites tend to be shallow gravelly areas adjacent to deep pools are thought to represent optimal spawning habitat (JNCC, 2021d). These species are considered unlikely to be found in significant numbers within the vicinity of the Proposed Development fish and shellfish ecology study area, however they are considered to ensure a precautionary approach.

4.6.7. SPARLING (EUROPEAN SMELT)

94. Sparling or European smelt inhabit estuaries and large lakes, spending much of its life in the estuarine zone, with just short incursions in the littoral zone. Sparling enter rivers to spawn on sandy or gravelly bottoms, usually in fast flowing waters of lake tributaries or shallow shores of lakes and rivers (Fishbase, 2021c). Due to their preference of estuarine waters when they do enter the marine environment, it is unlikely that sparling will be found within the Proposed Development fish and shellfish ecology study area.

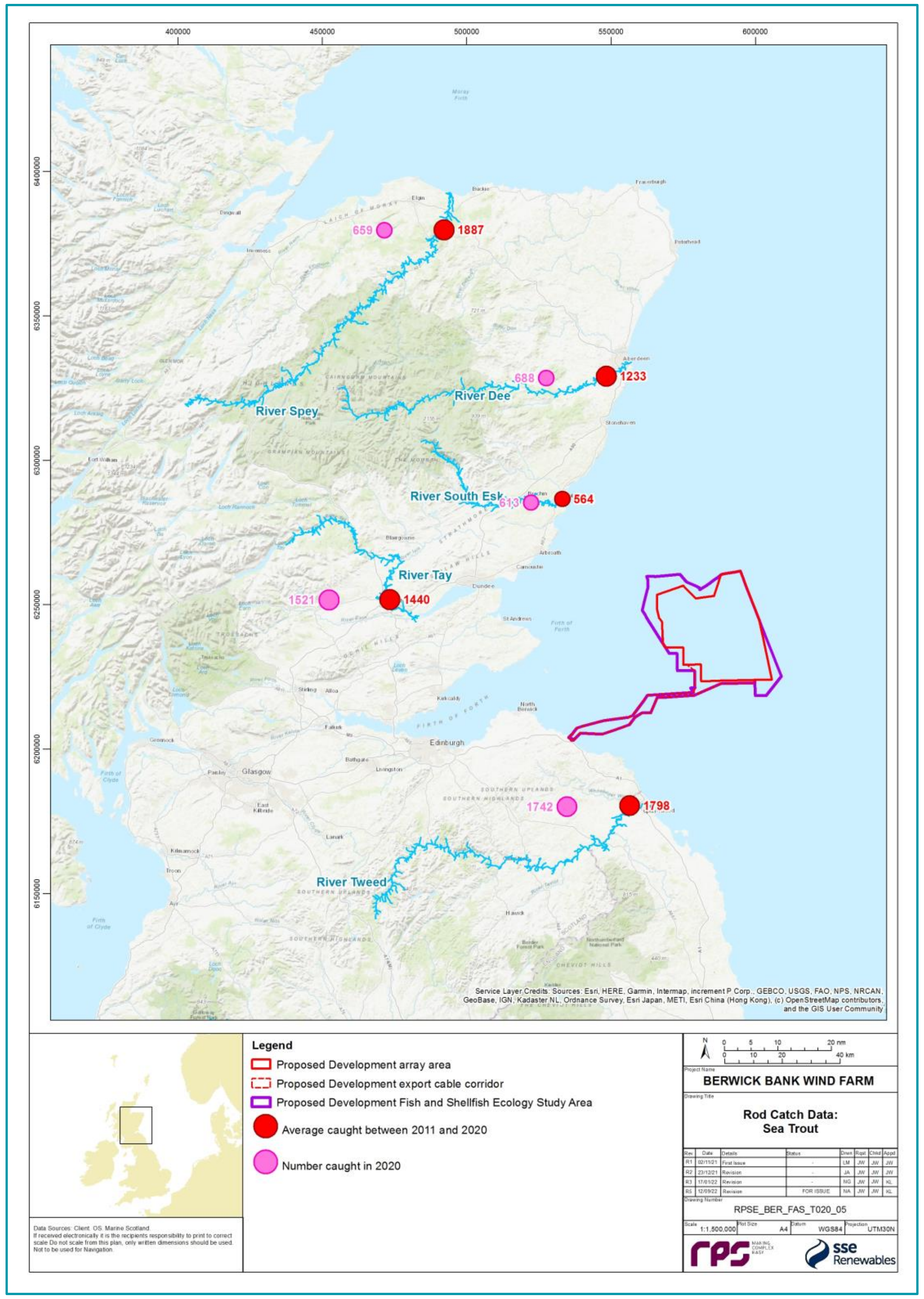

Figure 4.21: Catch Data for Rod Caught Sea Trout using Marine Scotland Data (2011 to 2020)

4.6.8. DESIGNATED SITES

95. Designated sites which have fish and shellfish qualifying features and which have been considered in the fish and shellfish assessment are described in Table 4.6, and the locations of the Special Areas of Conservation (SACs) and Nature Conservation Marine Protected Areas (MPAs) are displayed in Figure 4.22.

Table 4.6: Designated Sites Within the Northern North Sea Fish and Shellfish Ecology Study Area and Qualifying Interest Features

Designated Site	Closest Distance from the Proposed Development (km)	Relevant Features of Interest
River Tay SAC	61.3	• Atlantic salmon present as primary reason for site selection; and • sea lamprey and river lamprey present as a qualifying feature, but not a primary reason for site selection.
River Tweed SAC	48.0	• Atlantic salmon present as primary reason for site selection; and • sea lamprey and river lamprey present as a qualifying feature, but not a primary reason for site selection.
Tweed Estuary SAC	46.3	Sea lamprey and river lamprey present as a qualifying feature, but not a primary reason for site selection.
River Teith SAC	127.1	• sea lamprey and river lamprey present as primary reason for site selection; and • Atlantic salmon present as a qualifying feature, but not a primary reason for site selection.
River South Esk SAC	50.1	Designated for presence of Atlantic salmon and freshwater pearl mussel as primary reasons for site selection.
River Dee SAC	70.6	Designated for presence of Atlantic salmon and freshwater pearl mussel as primary reasons for site selection.
Turbot Bank Nature Conservation MPA	96.1	Lesser sandeel and Raitt's sandeel are listed as a protected feature

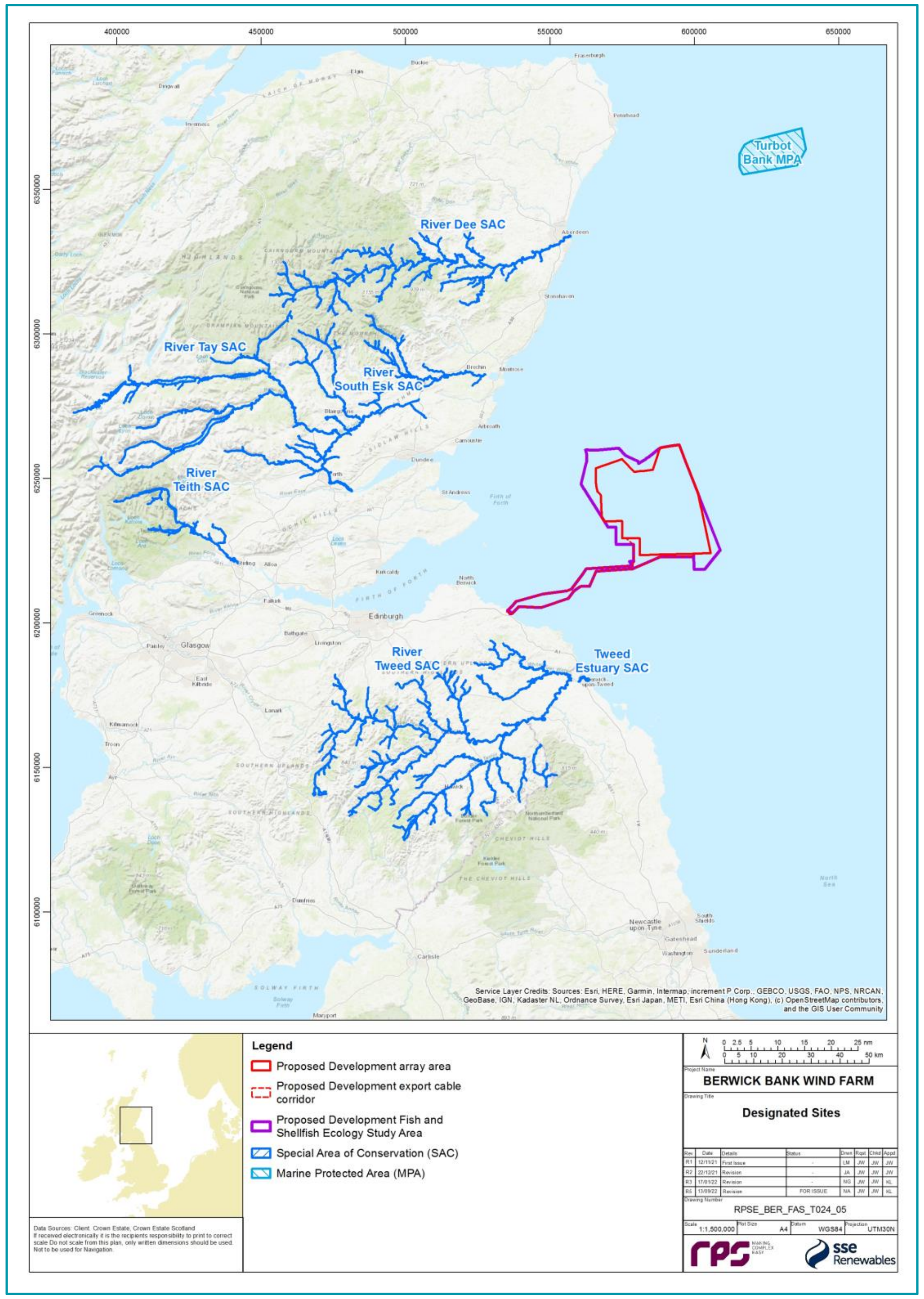

Figure 4.22: Designated Sites with Fish as Qualifying Features

4.7. SHELLFISH

96. Shellfish is a colloquial and fisheries term for exoskeleton bearing aquatic invertebrates used as food, including various species of molluscs, crustaceans, and echinoderms. Commercial landing data can be used as a proxy for identifying species present in the vicinity of the Proposed Development fish and shellfish ecology study area, which include *Nephrops,* edible crab, European lobster, velvet swimming crab, king scallop, and squid, as described in volume 3, appendix 12.1. Site-specific epibenthic trawl data (section 3.2) recorded *Nephrops*, edible crab and king scallop within the Proposed Development fish and shellfish ecology study area, albeit in low abundances. Shellfish found in high abundances in epibenthic trawls included brown shrimp *Crangon crangon* and other shrimp species (Pandalidae*)*; however, these are not a main target of commercial fisheries. Site-specific surveys for Seagreen Alpha/Bravo (Seagreen, 2012) also reported edible crab, velvet swimming crab and king scallop in the results of beam trawls. Habitats within the Firth of Forth Banks Complex MPA (which overlaps spatially with the FSF study area) support ocean quahog aggregations, which are a designated feature of the MPA in their own right. As impacts to ocean quahog are inherently tied to impacts on subtidal habitats and supporting habitats within the MPA, ocean quahog is assessed in volume 2, chapter 8 and the Berwick Bank Wind Farm Marine Protected Area Assessment (SSER, 2022b).

4.7.1. KING SCALLOP

97. Scallops show a preference for areas of clean firm sand, fine or sandy gravel and may occasionally be found on muddy sand. Distribution of this species is invariably patchy (Marshal and Wilson, 2009; Carter, 2009) but the areas with greatest abundance tend to be areas of little mud and with good current strength. In Scottish waters, scallops spawn for the first time in the autumn of their second year, and subsequently spawn each year in the spring or autumn. After settlement, scallops grow until their first winter, during which growth usually ceases. Thereafter, growth resumes each spring and ceases each winter, causing a distinct ring to be formed on the external surface of the shell.

98. King scallops are targeted commercially through dredge fisheries within the Proposed Development fish and shellfish ecology study area, with the majority of the activity, albeit at a moderate level, concentrated in the north-west section of the Proposed Development fish and shellfish ecology study area (see volume 3, appendix 12.1). Higher intensity scallop dredging is present immediately north of the Proposed Development fish and shellfish ecology study area.

4.7.2. EUROPEAN LOBSTER

99. The European lobster can be found throughout the British coasts on rocky substrata, down to depths of 60 m. European lobster are actively fished in areas in the vicinity of the Proposed Development fish and shellfish ecology study area and are likely to occur in the Proposed Development fish and shellfish ecology study area (see volume 3, appendix 12.1).

4.7.3. EDIBLE CRAB

100. Edible crab is a relatively long-lived species that are found on all coasts around Britain from the intertidal zone down to depths of 100 m. They live on rocky, gravelly substrate which they bury into. Following spawning there is a larval dispersal phase of around 30 to 50 days. Like European lobster, edible crab are actively fished in areas in the vicinity of the Proposed Development fish and shellfish ecology study area and are likely to occur in the Proposed Development fish and shellfish ecology study area (see volume 3, appendix 12.1).

4.7.4. VELVET SWIMMING CRAB

101. Velvet swimming crab can be found around the coast of Britain and are found on stony/rocky substrate intertidally and down to depths of 100 m (Howson and Picton, 1997). Velvet swimming crab are targeted by commercial fisheries with higher commercial values available in continental Europe and they are often caught alongside European lobster and edible crab (see volume 3, appendix 12.1). Velvet swimming crab were recorded in site-specific surveys within the Proposed Development fish and shellfish ecology study area and therefore can be assumed to be present within the Proposed Development fish and shellfish ecology study area.

4.7.5. SQUID

102. Squid species are reported to be found over sand and muddy bottoms (Wilson, 2006) and mostly demersal in nature and therefore often bycatch in demersal fisheries (Bellido *et al*., 2001) with research on squid determining that they are probably batch spawners. However, this can vary dependant on species, with other species utilising hard substrate for spawning purposes (Guerra and Rocha, 1994). In Scottish waters, squid exhibit a distinct seasonal migration pattern, travelling up to 500 km from the west coast of Scotland to the east coast in the winter months (Hastie *et al*., 2009). Squid are targeted by commercial fisheries, although main areas of fishing activity is within coastal waters and only overlap the Proposed Development export cable corridor (see volume 3, appendix 12.1).

4.7.6. FRESHWATER PEARL MUSSEL

103. The freshwater pearl mussel *Margaritifera margaritifera* is an endangered species of freshwater mussel. Freshwater pearl mussels are similar in shape to common marine mussels but grow much larger and live far longer. They can grow as large as 20 cm and live for more than 100 years, making them one of the longest-lived invertebrates (Skinner *et al.,* 2003). These mussels live on the beds of clean, fast flowing rivers, where they can be buried partly of wholly in coarse sand or fine gravel. Mussels have a complex life cycle, living on the gills of young Atlantic salmon or sea trout, for their first year, without causing harm to the fish (Skinner *et al.,* 2003). Freshwater pearl mussel is fully protected under Schedule 5 of the Wildlife and Countryside Act 1981 (as amended) and is also listed on Annexes II and V of the Habitats Directive and Appendix III of the Bern Convention. The conservation status of the species is reflected in its listing as Endangered on the International Union for Conservation of Nature (IUCN) Invertebrate Red List. While there is no potential for direct impacts on this species from the Proposed Development fish and shellfish ecology study area (as this is an entirely freshwater species), indirect impacts may occur due to effects on their host species (i.e. Atlantic salmon and sea trout) during their marine phase.

4.7.7. NEPHROPS

Desktop study

104. *Nephrops*, known variously as the Norway lobster, Dublin Bay prawn, langoustine or scampi, is a slim, orange pink lobster which grows up to 25 cm long, and is considered to be the most commercially important crustacean in Europe (Bell *et al*., 2006). *Nephrops* are exploited throughout their geographic range, from Icelandic waters to the Mediterranean and the Moroccan coast.

105. *Nephrops* are opportunistic predators, primarily feeding on crustaceans, molluscs and polychaete worms. They inhabit muddy seabed sediments and show a strong preference for sediments with more than 40% silt and clay (Bell *et al*., 2006). They build and spend significant amounts of time in semi-permanent burrows which vary in structure and size but typically range from 20 cm to 30 cm in depth (Dybern and

Hoisaeter, 1965). Due to strong habitat preferences, distribution patterns of *Nephrops* are determined by the presence of suitable habitats, with higher abundances found on more favourable substrates.

106. Female *Nephrops* usually mature at three years of age and reproduce each year thereafter. After mating in early summer, *Nephrops* spawn in September, and carry eggs under their tails (described as being 'berried') until they hatch in April or May. The larvae develop in the plankton before settling to the seabed six to eight weeks later (Coull *et al*., 1998). Unspecified intensity nursery and spawning grounds for *Nephrops* are present within the western section of the Proposed Development fish and shellfish ecology study area (Figure 4.23).

Site-specific survey

107. As discussed in paragraph 105, *Nephrops* display a strong preference for muddy sediments (silt and clay), therefore the majority of the Proposed Development fish and shellfish ecology study area is unsuitable for *Nephrops* as sands and gravel dominate the Proposed Development array area. The exception is within the Proposed Development export cable corridor, where the substrate is characterised by muddy sediments (see volume 3, appendix 8.1).

108. Incidental observations were made of *Nephrops* from DDV and trawl surveys during the epibenthic trawl survey and combined grab and DDV sampling conducted within the Proposed Development fish and shellfish ecology study area. As shown in Figure 4.24, DDV data were displayed as presence/absence records and trawls recording abundances per 1,000 m trawled. Figure 4.24 also shows biotope mapping produced within volume 3, appendix 8.1, where a large proportion of the Proposed Development export cable corridor was assigned the biotope SS.SMu.CFiMu.SpnMeg – Seapens and burrowing megafauna. This biotope is often associated with high abundance of *Nephrops* (JNCC, 2021e).

109. The location of *Nephrops* identified through site-specific surveys, correlated strongly with results of the biotope mapping, with all recordings of *Nephrops*, through trawls and DDV surveys, occurring within the area identified as the Seapens and burrowing megafauna biotope. This showed that *Nephrops* were present in the suitable substrates in the Proposed Development export cable corridor.

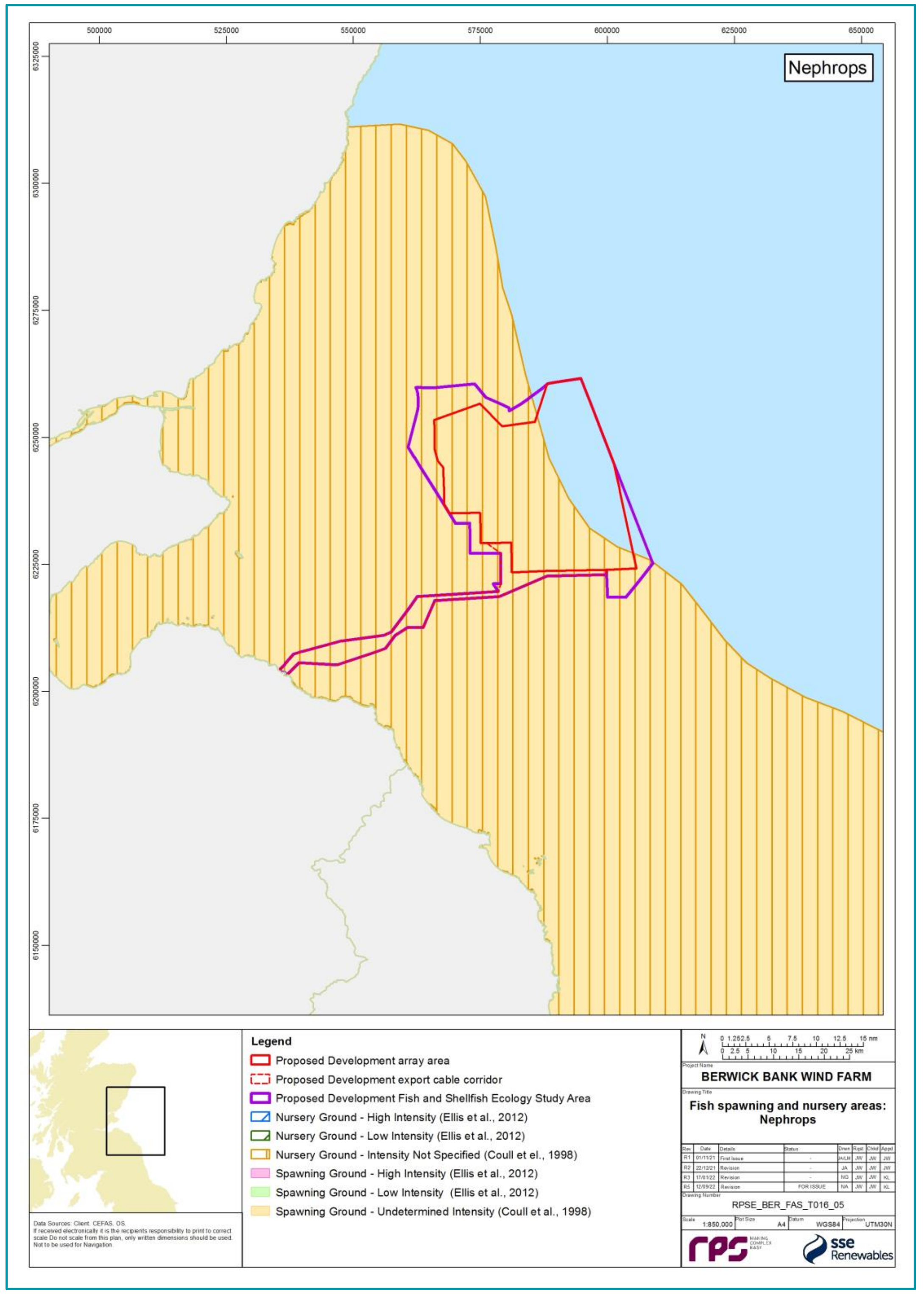

Figure 4.23: ***Nephrops* Spawning and Nursery Grounds and Overlaps with the Proposed Development Fish and Shellfish Ecology Study Area**

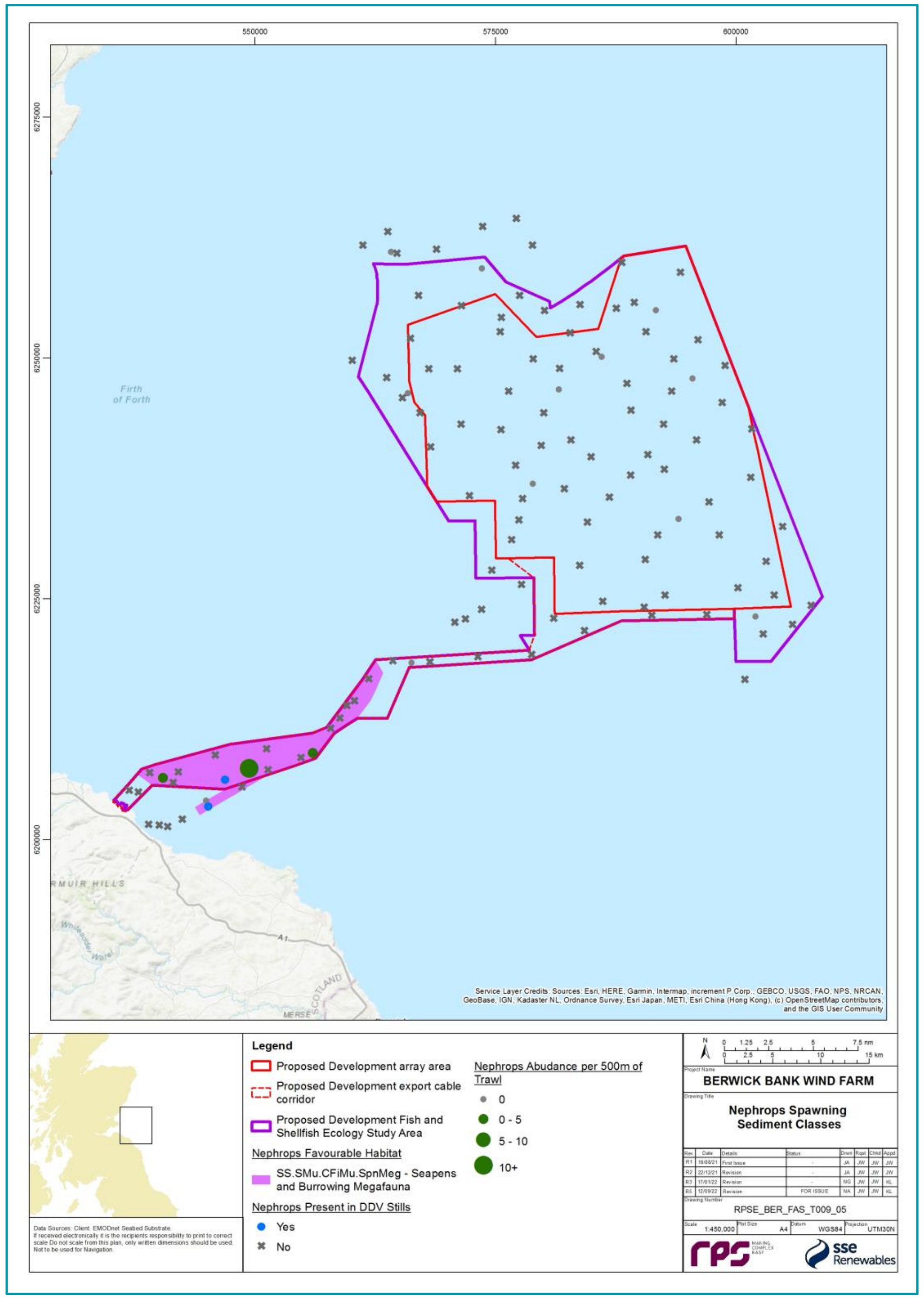

Figure 4.24: *Nephrops* Abundances Recorded During Site-Specific Surveys

5. SUMMARY

110. The following sections provide a summary of the fish and shellfish baseline characterisation and detail the IEFs to be considered in the EIA, as informed by the baseline.

5.1. BASELINE

111. The fish assemblage within the Proposed Development fish and shellfish ecology study area is typical of the northern North Sea and the Forth and Tay SMR. This is confirmed through site-specific survey and baseline data available from other developments in vicinity of the Proposed Development fish and shellfish ecology study area, with a mix of demersal and pelagic species. There are known spawning and nursery grounds for nine species, including spawning grounds for cod, herring and sandeel. Herring spawning grounds were further investigated, the results showing while there is some spawning activity which occurs in the vicinity of the Proposed Development fish and shellfish ecology study area, the majority of herring spawning occurs to the north and south of the Proposed Development fish and shellfish ecology study area. Habitat suitability for sandeel was assessed, with the majority of the Proposed Development fish and shellfish ecology study area having suitable and, in some areas, prime habitat for sandeel.

112. Eight species of diadromous fish were identified as having the potential to be present within and in proximity to the Forth and Tay SMR, of which Atlantic salmon, sea trout, sea lamprey, European eel and allis and twaite shad were deemed to have the potential to occur within the Proposed Development fish and shellfish ecology study area. Six SACs designated for diadromous fish species are present (or with the potential to be present, however remote), within the vicinity of the Proposed Development fish and shellfish ecology study area, and one Nature Conservation MPA, designated for sandeel is present in the northern North Sea fish and shellfish ecology study area to the north of the Proposed Development fish and shellfish ecology study area.

113. Shellfish in the Proposed Development fish and shellfish ecology study area and Forth and Tay SMR include *Nephrops*, European lobster, edible crab, velvet swimming crab and squid, which are targeted by commercial fisheries in the locality. *Nephrops* habitat was assessed, with favourable habitat identified, through biotope mapping and corroborated by incidental site-specific survey data, in the Proposed Development export cable corridor, but not within the Proposed Development array area.

5.2. IMPORTANT ECOLOGICAL FEATURES

114. IEFs are habitats, species, ecosystems and their functions/processes that are considered to be important and potentially impacted by the Proposed Development fish and shellfish ecology study area. As per stakeholder advice on the Proposed Development fish and shellfish ecology study area, guidance from the Chartered Institute of Ecology and Environmental Management (CIEEM) (2018) was used to assess IEFs. IEFs can be attributed to individual species (such as plaice) or species groups (for example other flat fish species). Each IEF is assigned a value or importance rating which are based on commercial, ecological and conservation importance, including PMFs and features of SACs etc. Table 5.1 details the criteria used for determining IEFs and Table 5.2 applies the defining criteria to specific species, providing justifications for importance rankings.

Table 5.1: Defining Criteria for IEFs

Value of IEF	Defining Criteria
International	Internationally designated sites. Species protected under international law (i.e. Annex II species listed as qualifying interests of SACs).
National	Nationally designated sites. Species protected under national law. Annex II species which are not listed as qualifying interests of SACs in the Proposed Development fish and shellfish ecology study area. OSPAR List of Threatened and/or Declining Species, and IUCN Red List species that have nationally important populations within the Proposed Development fish and shellfish ecology study area, particularly in the context of species/habitat that may be rare or threatened in Scottish waters. Species that are listed as PMFs as they have been deemed features characteristic of Scottish marine environment and are likely to be one of the characteristic species and or have spawning or nursery grounds within the Proposed Development northern North Sea fish and shellfish ecology study area. Species that have spawning or nursery areas within the Proposed Development fish and shellfish ecology study area that are important nationally (e.g. may be primary spawning/nursery area for that species).
Regional	OSPAR List of Threatened and/or Declining Species, and IUCN Red List species that have regionally important populations within the Proposed Development fish and shellfish ecology study area (i.e. are locally widespread and/or abundant). Species that are of commercial value to the fisheries which operate within the Proposed Development fish and shellfish ecology study area. Species that form an important prey item for other species of conservation or commercial value and that are key components of the fish assemblages within the Proposed Development fish and shellfish ecology study area. Species that are listed as PMFs but are not a key contributing species to the characterisation of the Proposed Development northern North Sea fish and shellfish ecology study area. Species that have spawning or nursery areas within the Proposed Development fish and shellfish ecology study area that are important regionally (i.e. species may spawn in other parts of Scottish waters but this is a key spawning/nursery area within the Proposed Development fish and shellfish ecology study area).
Local	Species that are of commercial importance but do not form a key component of the fish assemblages within the Proposed Development fish and shellfish ecology study area (e.g. they may be exploited in deeper waters outside the Proposed Development fish and shellfish ecology study area). The spawning/nursery area for the species are outside the Proposed Development fish and shellfish ecology study area. The species is common throughout Scottish waters but forms a component of the fish assemblages in the Proposed Development fish and shellfish ecology study area.

Table 5.2: IEF Species and Representative Groups within the Proposed Development Fish and Shellfish Ecology Study Area

IEF	Scientific Name / Representative species	Importance	Justification
Marine Fish IEF Species			
Plaice	*Pleuronectes platessa*	Regional	Low intensity nursery and spawning grounds identified throughout Proposed Development fish and shellfish ecology study area. It is an important commercial species, but not in the local area.
Lemon Sole	*Microstomus kitt*	Regional	Low intensity nursery and spawning grounds identified throughout Proposed Development fish and shellfish ecology study area. It is an important commercial species, but not in the local area.
Other flatfish species		Local	Other flatfish species including common dab, turbot and long rough dab are likely to occur within the Proposed Development fish and shellfish ecology study area. These species either have no known spawning or nursery grounds or low intensity/undetermined nursery and spawning grounds within the Proposed Development fish and shellfish ecology study area.
Cod	*Gadus morhua*	Regional	Listed as a PMF. Listed by OSPAR as threatened and/or declining and listed as vulnerable on the IUCN Red List. High intensity nursery grounds and low intensity spawning grounds are present throughout the Proposed Development fish and shellfish ecology study area. It is an important commercial species, but not in the local area.
Haddock	*Melanogrammus aeglefinus*	Regional	Spawning ground of unspecified intensity marginally overlaps the Proposed Development fish and shellfish ecology study area. Listed as vulnerable on the IUCN Red List.
Whiting	*Merlangius merlangus*	Regional	High intensity nursery grounds and low intensity spawning grounds identified throughout the Proposed Development fish and shellfish ecology study area. It is an important commercial species, but not in the local area.
Saithe	*Pollachius virens*	Regional	Partial overlap with the Proposed Development fish and shellfish ecology study area of unspecified nursery grounds. It is an important commercial species, but not in the local area.
Other PMF species		Regional	Species listed as PMFs including anglerfish *Lophius piscatorius* and ling *Molva molva* may be present within the Proposed Development fish and shellfish ecology study area however there are no spawning grounds present.
Other demersal species		Local	Species including pollack *Pollachius pollachius* and European hake are common throughout Scottish waters and are likely to be in the Proposed Development fish and shellfish ecology study area. They are important commercial species, but not in the local area.
Sandeel species		National	There are five species of sandeel found in Scottish waters with lesser sandeel *Ammodytes tobianus* and Raitt's sandeel *Ammodytes marinus* being the most commonly found species, particularly in the vicinity of the Proposed Development fish and shellfish ecology study area. Important prey species for fish, birds and marine mammals. High intensity spawning grounds and low intensity nursery grounds present throughout the Proposed Development fish and shellfish ecology study area. Identified as likely to be present in the Proposed Development fish and shellfish ecology study area based on historic data and habitat preference. Lesser sandeel and Raitt's sandeel are listed as PMFs and listed as protected features within the Turbot Bank Nature Conservation MPA, which occurs within the Proposed Development northern North Sea fish and shellfish ecology study area.
Herring	*Clupea harengus*	Regional	Important prey species for larger fish, birds and marine mammals. High intensity nursery grounds within the Proposed Development fish and shellfish ecology study area. Known to have spawning grounds in the vicinity of the Proposed Development fish and shellfish ecology study area, with core spawning habitats to the north and south of the Proposed Development fish and shellfish ecology study area. Listed as a PMF. It is an important commercial species, but not in the local area.

IEF	Scientific Name / Representative species	Importance	Justification
Mackerel	*Scomber scombrus*	Regional	Important prey species for larger fish, birds and marine mammals. Low intensity nursery grounds throughout Proposed Development fish and shellfish ecology study area. No spawning grounds in the vicinity. Listed as a PMF. It is an important commercial species, but not in the local area.
Sprat	*Sprattus sprattus*	Regional	Important prey species for larger fish, birds and marine mammals. Unspecified intensity spawning and nursery grounds within the Proposed Development fish and shellfish ecology study area. It is an important commercial species, but not in the local area.
Basking Shark	*Cetorhinus maximus*	National	The north-east Atlantic population are classed as Endangered on the IUCN Red List. They are listed under CITES Appendix II and classified as a Priority Species under the UK Post-2010 Biodiversity Framework. Protected in the UK under the Wildlife and Countryside Act. Listed as a PMF, however only likely to be present in low abundances if present at all.
Tope	*Galeorhinus galeus*	Regional	Listed as Vulnerable by the IUCN Red List and is a Priority Species under the UK Post-2010 Biodiversity Framework. Low intensity nursery grounds within the Proposed Development fish and shellfish ecology study area.
Spurdog	*Squalus acanthias*	Regional	Listed as Vulnerable by the IUCN Red List and is a Priority Species under the UK Post-2010 Biodiversity Framework. Low intensity nursery grounds within the Proposed Development fish and shellfish ecology study area.
Common skate	*Dipturus batis*	Regional	Listed as Critically Endangered on the IUCN Red List. It is a Priority Species under the UK Post-2010 Biodiversity Framework. Low intensity nursery grounds within the Proposed Development northern North Sea fish and shellfish ecology study area.
Rays		Regional	Ray species including spotted ray and thornback ray. These species either have low intensity nursery grounds or no known nursery grounds.
Shellfish IEF Species			
Edible crab	*Cancer pagurus*	Regional	Commercially important species. Identified as being likely to be present within the Proposed Development fish and shellfish ecology study area.
Norway lobster	*Nephrops norvegicus*	Regional	Commercially important species. Identified as being likely to be present within the Proposed Development export cable corridor. Spawning and nursery grounds present throughout the majority of Proposed Development fish and shellfish ecology study area.
European lobster	*Homarus gammarus*	Regional	Commercially important species. Identified as being likely to be present within the Proposed Development fish and shellfish ecology study area.
King Scallop	*Pecten Maximus*	Regional	Commercially important species. Identified as being likely to be present within the Proposed Development fish and shellfish ecology study area.
Velvet swimming crab	*Necora puber*	Regional	Commercially important species. Identified as being likely to be present within the Proposed Development fish and shellfish ecology study area.
Other crustaceans		Local	Other crustaceans including, swimming crabs, spider crabs and shrimp have been identified as being likely to occur within the Proposed Development fish and shellfish ecology study area. They are all important commercial species, but not in the local area.
Freshwater Pearl Mussel	*Margaritifera margaritifera*	International	Listed in Annexes II and V of the European Union (EU) Habitats and Species Directive and Appendix III of the Bern Convention. Listed as Endangered on the IUCN Red List. Annex II species and listed as qualifying features of a number of SACs in the vicinity of the Proposed Development fish and shellfish ecology study area. Freshwater pearl mussel are included due to their dependency on Atlantic salmon and sea trout.
Diadromous Fish IEF Species			
Sea trout	Salmo trutta	National	Likely to migrate through the Proposed Development fish and shellfish ecology study area. Listed as OSPAR threatened/declining species. Not a feature of any designated sites in the vicinity of the Proposed Development fish and shellfish ecology study area.
European eel	Anguilla anguilla	National	Likely to migrate through the Proposed Development fish and shellfish ecology study area. Listed as an OSPAR threatened/declining species and listed as critically endangered on the IUCN Red List. Not a feature of any designated sites in the vicinity of the Proposed Development fish and shellfish ecology study area.
Sea lamprey	Petromyzon marinus	International	Likely to migrate through the Proposed Development fish and shellfish ecology study area. Annex II species and listed as qualifying features of a number of SACs in the vicinity of the Proposed Development fish and shellfish ecology study area.

IEF	Scientific Name / Representative species	Importance	Justification
River lamprey	Lampetra fluviatilis	N/A	Scoped out: These are estuarine species and are therefore unlikely to have any interaction with the Proposed Development fish and shellfish ecology study area (see section 4.6.5). As such, these are not considered further.
Twaite shad	Alosa fallax	National	Likely to migrate through the Proposed Development fish and shellfish ecology study area. Annex II species although not listed as qualifying features of any SACs in the vicinity of the Proposed Development fish and shellfish ecology study area.
Allis Shad	Alosa	National	Likely to migrate through the Proposed Development fish and shellfish ecology study area. Annex II species although not listed as qualifying features of any SACs in the vicinity of the Proposed Development fish and shellfish ecology study area.
Atlantic salmon	Salmo salar	International	Likely to migrate through the Proposed Development fish and shellfish ecology study area. Annex II species and listed as qualifying features of a number of SACs in the vicinity of the Proposed Development fish and shellfish ecology study area.
Sparling / European smelt	Osmerus eperlanus	N/A	Scoped out: These are estuarine species and are therefore unlikely to have any interaction with the Proposed Development fish and shellfish ecology study area (see section 4.6.7). As such, these are not considered further.

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