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Glossary

Barrier effects	The effect seen when a disturbance restricts the free movement, breeding and mingling of populations of a species.
Baseline	Existing environmental conditions.
Benthic	On, relating to, or occurring on the bottom of the seabed. Benthos relates to the communities of organisms present on the seabed.
dBht	The dBht(Species) metric (Nedwell *et al.,* 2007) has been developed as a means for quantifying the potential for a behavioural impact of a sound on a species in the underwater environment. It uses a species' audiogram in its calculation. The dBht(Species) metric can be understood as the level above the minimum audible sound (threshold of hearing) which a species can hear. A level of 0 dBht(Species) represents the minimum audible sound.
Diadromous	The term used to describe migration of a species between fresh water and the sea.
Electromagnetic Field (EMF)	The coupled electric (iE) and magnetic (B) fields that are generated by time-varying currents and accelerated charges from, for example, subsea cables.
International Council for the Exploration of the Sea (ICES) rectangle	ICES rectangles create a grid dividing up the earth's surface. Each ICES rectangle is '30 min latitude by 1° longitude which is approximately 30 x 30 nautical miles. The average area of a rectangle in Scottish waters is 940 nautical miles^2.
Invertebrate	Animals lacking a backbone.
Local Study Area	The smallest special unit around the Development within which an impact is assessed.
Natal	The place of birth.
Nursery grounds	Any grounds where juvenile fish are found.
Otic bullae	Slim, protruding hollows, or diverticula, originating in the swim bladder of a fish, extending into the skull, and connected to the inner ear. Such structures aid transmission of acoustic vibrations and thus enhance the hearing capabilities of the fish. Singular otic bulla.
Otter trawl	A device which is pulled along the seabed with large rectangular boards called "otter boards" either side of the mouth that keep the net open.
Pelagic	Marine species inhabiting the mid and upper layers of the open sea.
Regional Study Area	The second largest boundary in which impacts from the Development are considered.
Salmonid	Fish belonging to the Salmonidae family such as salmon (*Salmo salar*), trout (*Salmo trutta*), grayling (*Thymallus thymallus*) and whitefish (Coregonus).

Smolt	A young salmon (or trout) after the parr stage, when it becomes silvery and migrates to the sea for the first time.
Spawning	Reproduction method utilised by some organisms, whereby eggs and sperm are released prior to fertilisation.
Spawning area	Area(s) used by species for spawning activities.
Study Areas	Boundaries used to encompass areas of sea around the Development in which impacts are considered.
Substrate	An underlying surface or layer, typically used to refer to the physical nature of the seafloor.
Swim bladder	An internal gas filled organ which enables a fish to regulate hydrostatic pressure and maintain buoyancy.

Abbreviations and Acronyms

CBD	Convention on Biological Diversity
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CIA	Cumulative Impact Assessment
CIEEM	Chartered Institute of Ecology and Environmental Management
CPUE	"Catch per unit effort"; individuals caught per hour
dB	Decibel
EIA	Environmental Impact Assessment
ES	Environmental Statement
EMF	Electromagnetic Field
EUBS	European Union Biodiversity Strategy
FCS	Favourable Conservation Status
HRA	Habitat Regulations Appraisal
IBTS	International Bottom Trawl Survey
ICES	International Council for the Exploration of the Sea
ICOL	Inch Cape Offshore Limited
IHLS	International Herring Larvae Survey
JNCC	Joint Nature Conservation Committee
kJ	Kilojoules, unit of energy
MMO	Marine Management Organisation
MS	Marine Scotland
MS-LOT	Marine Scotland Licensing Operations Team
MSS	Marine Scotland Science
NnG	Neart na Gaoithe
Nm	Nautical Miles
NMP	National Marine Plan
O&M	Operations and Maintenance

OfTW	Offshore Transmission Works
OSP	Offshore Substation Platform
OSPAR Convention	The Convention for the Protection of the Marine Environment of the North-East Atlantic
Pa	Pascal SI unit of pressure and stress
SAC	Special Area of Conservation
SEL	Sound Exposure Level
SFF	Scottish Fishermen's Federation
SNH	Scottish Natural Heritage
SSC	Suspended Sediment Concentration
TTS	Temporary Threshold Shift
UK	United Kingdom
µPa	Micropascals

9 Natural Fish and Shellfish

9.1 Introduction

1 This chapter presents the assessment of potential impacts on natural fish and shellfish predicted to arise from the construction, operation & maintenance and decommissioning of the Inch Cape Wind Farm and associated Offshore Transmission Works (OfTW) (the Development).

2 The following appendices and chapters, as well as the introductory chapters (1-8), should be read in conjunction with this chapter:

- *Appendix 9A: Herring Spawning Study*;
- *Appendix 9B: Underwater Noise Modelling*;
- *Appendix 9C: Discussion Paper on Salmon Migration Behaviour*;
- *Appendix 9D: Discussion Paper on Particle Motion*;
- *Appendix 9E: Discussion Paper on Impact of Suspended Sediment and Smothering on Scallops*;
- *Appendix 10B: Underwater Noise Modelling Using a 1% Conversion Factor;*
- *Chapter 11: Ornithology*; and
- *Chapter 14: Commercial Fisheries* (and *appendices 14A*, and *14B*).

9.2 Scoping and Consultation

3 The scoping process for the assessment of impacts of the Development on natural fish and shellfish resulted in the requirement for additional studies with regards to salmon and herring, in response to the availability of new information, as well as consideration of worse case impacts with regards to the potential for smothering of scallops and *Nephrops*. Following the production of the research papers, impacts on shellfish and salmon migration were scoped out on the basis that they would not likely result in significant effects.

4 This section summarises the Scoping Opinion and scoping responses as well as subsequent consultations with statutory and non-statutory consultees in relation to the assessment of effects of the Development on natural fish and shellfish.

5 A scoping report for the Development was issued by ICOL in April 2017. ICOL held a Scoping meeting on 26 May 2017 with Marine Scotland Licencing and Operations (MS-LOT), Marine Scotland Science (MSS) and Scottish Fishermen's Federation (SFF) with an additional meeting held with the SFF on 21 July 2017.

6 Following a statutory consultation period, MS-LOT acting as consenting authority to the Scottish Ministers responded with a Scoping Opinion on 21st July 2017. The scoping responses are summarised in *Table 9.1* with the outcomes of post-scoping correspondence in *Table 9.2.*

Table 9.1: Scoping responses and actions

Consultees	Scoping Response	ICOL Response
Scottish Ministers (and Marine Scotland Science (MSS))	MSS agreed, in the majority of cases, that the existing fish and shellfish baseline and proposed updates are appropriate to the potential level of impact from the proposed development. The exception is in relation to diadromous fish. MSS provided information on recently published work that provided more evidence on: Adult salmon routes to the coast during migration; Coastal migration of salmon smolts; The importance of geomagnetic navigation post-smolts in migrating to sea feeding grounds and by returning adult salmon in homing to their natal rivers; The timing of salmon smolt movement across Scotland. **The Scottish Ministers advise ICOL to consider whether the new information changes the outcome of the Original Development ES and if so, to carry out a further assessment. If ICOL consider no further assessment is required they must provide justification of their reasons.**	A discussion paper was produced which reviewed the papers identified by MSS as well as pertinent recently published papers. This was used to evaluate and validate the 2013 Inch Cape ES baseline regarding salmon. The salmon discussion paper concluded that the 2013 Inch Cape ES did not understate the likelihood that salmon will be present. **MSS and MS-LOT agreed with the discussion paper findings (Email from MS-LOT, dated 29/11/2017). On the basis that the Development is unlikely to result in a significant effect on diadromous fish, therefore no further assessment is necessary. The discussion paper is included as *Appendix 9C*.**
Scottish Ministers	The Scottish Ministers agree the Environmental Impact Assessment (EIA) Report should only concentrate on those receptors which may be subject to significant effects from the Development.	Therefore, those impacts that were likely to result in a non-significant effect are scoped out of assessment.
	The Scottish Ministers note two potential impacts that require further consideration within the impact assessment: Impact of suspended sediment and smothering on scallops and *Nephrops;* and Particle motion. Details are presented below on the scope of these assessments.	Discussion papers were produced on these topics and submitted to MS-LOT in order to establish if they should be considered in the Environmental Impact Assessment (EIA) Report. MSS and MS-LOT agreed with the discussion paper findings. On the basis that the Development is unlikely to result in a significant effect on diadromous fish, therefore no further assessment is necessary. (see below for details)

Consultees	Scoping Response	ICOL Response
Scottish Ministers (and Scottish Fishermen's Federation (SFF) and MSS)	The SFF raised the issue of the need for an assessment of the impact of suspended sediment in smothering species such as scallops and *Nephrops* in their consultation response and during discussions at the stakeholder meetings. Scottish Ministers advise that if gravity base foundations are to be used, further work to assess the impact of sediment on scallops and *Nephrops* is carried out. MSS suggested approaches for assessing the impact of sediment of scallops and *Nephrops* at different life phases, which included literature reviews, sediment plume modelling and comparison of affected areas to fisheries distribution. Scottish Ministers advised Inch Cape Offshore Limited (ICOL) to follow these proposed approaches.	Agreement reached with MS-LOT that as there is no connectivity between *Nephrops* and increased suspended sediments / deposition from gravity basis, no further assessment was required on this species. A discussion paper (which included sediment modelling) was produced following the approach recommended by MSS for scallops (*Appendix 9E*). Discussion paper found that the that baseline description and assessment for the of the Inch Cape 2013 ES remain valid. MSS and MS-LOT agreed (email from MS-LOT dated 05/04/2018) with the discussion paper findings. On the basis that the Development is unlikely to result in a significant effect, and therefore no further assessment is necessary.
Scottish Ministers (and MSS)	MSS note the need to consider potential impact of acoustic particle motion on sensitive receptors in addition to the effects of sound pressure on fish and invertebrates species. The Scottish Ministers agree that the potential impact of particle motion should be assessed and suggests that ICOL follows the approach outlined by MSS.	A discussion paper was produced following the approach recommended by MSS (*Appendix 9D*). Discussion paper found that the findings of the Inch Cape 2013 ES (and therefore the Scoping Report) remain valid. MSS and MS-LOT agreed with the discussion paper findings. On the basis that the Development is unlikely to result in a significant effect, and therefore no further assessment is necessary.
Scottish Ministers	The Scottish Ministers are satisfied with the proposed approach to the assessment of those effects scoped into the EIA Report and have provided the comments in relation to ensuring information on the impacts of a) diadromous fish, b) suspended sediment on scallops and *Nephrops*, and c) particle motion, is up to date and has been considered.	See above responses relating to each recommendation separately.

Consultees	Scoping Response	ICOL Response
Scottish Ministers	The Scottish Ministers were satisfied with the embedded mitigation but note that further mitigation may be required if any concerns were raised in relation to the noise associated with an increase in hammer energy. It was also noted that although mitigation against sound pressure will, in general, also apply to particle motion effects there may be a need for additional mitigation depending on the outcome of the assessment. Consideration of the new information in relation to diadromous fish will inform whether additional mitigation is required in this respect.	See above response relating to the particle motion recommendation. Following the outcome of the discussion paper (*Appendix 9D*), no additional mitigation measures were considered by ICOL to be required.
Scottish Ministers	The Scottish Ministers agreed that the cumulative impacts on natural fish and shellfish can be scoped out of the EIA Report for the Development, with the exception of piling noise effects. Depending on the outcome of the particle motion assessment there may be a need to include a Cumulative Impact Assessment (CIA) for this impact. The Scottish Ministers advise that the worst-case scenarios for natural fish and shellfish for each of the Forth and Tay developments should be identified and used in the following scenario for the CIA: Neart na Gaoithe (NnG) (whichever is the worst case scenario identified from NnG 2014 as consented or NnG 2017 Scoping Report); and Seagreen (whichever is the worst-case scenario identified from Seagreen Alpha and Bravo 2014 as consented or Seagreen 2017 Scoping Report).	Cumulative Impacts will be assessed in line with Scottish Ministers recommendations. MS-LOT agreed with discussion paper on particle motion findings. Therefore no cumulative assessment is required on the impacts of particle motion.

Consultees	Scoping Response	ICOL Response
Scottish Ministers (and Scottish Natural Heritage (SNH))	SNH advised that any impacts from marine renewables on diadromous fish should now be undertaken via EIA not Habitats Regulations Appraisal (HRA). This is because it is not possible to determine which Special Area of Conservation (SAC) rivers any individuals recorded at sea are coming from or returning to. The Scottish Ministers accept the advice provided by SNH and any effects on diadromous fish should be considered under EIA and not the Habitats Regulations. Embedded mitigation and consent conditions that will be used in any new consent, if granted, will reduce the potential for impacts relating to Electromagnetic Fields (EMF). The research outlined in the response to the first question in this section in relation to the importance of geomagnetic navigation for salmon should however be considered in terms of EIA. Indirect effects from sediment deposition do not require further assessment for river SAC qualifying features.	Whilst ICOL acknowledge this position the HRA for the Inch Cape 2013 Environmental Statement (ES) on diadromous fish has been reviewed. The design envelope for the HRA in 2013 remains valid for this Application as it was suitably conservative, and any new information reviewed as part of this assessment (see salmon Discussion Paper has shown that it would not alter the outcomes of the HRA. The HRA confirms that there is unlikely to be a significant impact on salmon or salmon populations in terms of the tests of the Habitats Regulations, and hence any impacts on diadromous fish are addressed in this EIA report. For reasons of completeness, the 2013 HRA has been submitted separately in the HRA report which accompanies this EIA Report. A discussion paper produced to validate the Inch Cape 2013 ES baseline regarding salmon, included in *Appendix 9C*, concluded that the Inch Cape 2013 ES did not understate the likelihood that salmon will be present. MS-LOT agreed with the discussion paper findings and that no further assessment is required on salmon.
SFF	The SFF would contend that the previous ES has again paid insufficient attention to the potential smothering of species on the export cable route.	Agreement was reached with MSS that there is no connectivity between species on the cable route (i.e. *Nephrops*) and increased suspended sediments from gravity based foundations, therefore no further assessment is required on the cable route. MS-LOT agreed that no potentially significant smothering impacts will arise from cable installation activities and as such it has been agreed that these impacts are scoped out of further assessment.

Consultees	Scoping Response	ICOL Response
SFF	The SFF believe there is insufficient proof that direct habitat loss or disturbance is negligible (as per the findings of the Inch Cape 2013 ES), only by installing a proper monitoring system can this be assessed fully.	MS-LOT agreed that there is no likelihood for habitat loss or disturbance to constitute a significant effect and as such it has been agreed that these impacts are scoped out of further assessment.
SFF	Noted that consent condition 24 (from the Inch Cape 2014 consent) must be expanded to provide baselines for *Nephrops*, scallops and squid and ongoing monitoring surveys for these 3 species which are of paramount importance to the area (should this application receive consent).	MS-LOT has agreed that there is no likelihood for significant impacts to arise in relation to these species.
MSS	The Scoping Report provided by ICOL to address a change in the design provides a useful description of the design envelope parameters and changes. The biggest change with regards impact pathways to marine fish species would seem to be in relation to the increase in hammer energy associated with the increased size of the turbines. MSS agree that this should be the main focus of the change in design envelope for the Project and is content that all other identified impacts remain within the worst-case scenario of the Inch Cape 2013 ES.	Impacts on hearing specialists due to underwater noise are assessed within this EIA Report.
MSS	The Scoping Report presents natural fish and shellfish receptor groups, as identified from site specific surveys. The marine fish receptor group identified as 'hearing specialists' is identified as the only group to be 'scoped in' against potential impacts from construction noise. MSS is content with this approach with when considering sound pressure effects from impact piling.	Impacts on hearing specialists due to underwater noise are assessed within this EIA Report.

Consultees	Scoping Response	ICOL Response
MSS	The Scoping Report provides an overview of the baseline data used to inform the original application in 2013 and highlights the work that was done post submission – both ICOL commissioned site specific surveys and studies and also external or pre-existing broader scale data and studies. MSS is content with these sources of data. MSS would also note that there is some new literature available (such as González-Irusta and Wright (2016a) relating to cod spawning grounds and González-Irusta and Wright (2016b) relating to haddock spawning grounds) that may be worth considering.	Data sources identified have been reviewed to inform updated baseline for hearing specialist fish (including new data on cod spawning grounds).

Table 9.2: Further consultations

Consultation	Consultees	Summary
Salmon and Sea District Salmon Fisheries Board Consultation Meeting Perth 7 November 2017	Don District salmon Fisheries Board Dee District salmon Fisheries Board Forth District salmon Fisheries Board Tweed Commission Tay District salmon Fisheries Board Esk District salmon Fisheries Board	Information on data used in the baseline and scope of the assessment for both the natural fish and commercial fisheries chapters was presented. There was general agreement that the data sources used were appropriate and accurate. Generally there was no concern over the fact that impacts to salmon would not be considered in the EIA. However, some concern was raised over the SNH advice regarding the requirement for an HRA (see HRA point addressed above in relation to SNH comment). Concerns relating to the ecological impact on salmon from the development were raised in relation to the impact of predation by seals and other predatory fish on salmon and smolts due to turbines acting as reefs. It was generally accepted that smolts have no known defined migratory routes on the East coast. Several reports were suggested that may be of relevance to the baseline: A study by Ministry of Agriculture, Fisheries and Food which shows salmon passing through the Development Area N. A., Hvidsten and R. A. Lund (1988) *Predation on hatchery-reared and wild smolts of Atlantic salmon, Salmo salar L., in the estuary of River Orkla, Norway.* Hedger, R. D., Uglem, I., Thorstad, E. B., Finstad, B., Chittenden, C. M., Arechavala-Lopez, P., Jensen. A. R., Nilson, R and Okland, F. (2011) *Behaviour of Atlantic cod, a*

Consultation	Consultees	Summary
		marine fish predator, during Atlantic salmon post-smolt migration. Russell, D. J.F., Brasseur, S. J.M., Thompson, D., Hastie, G. D., Janik, V. M., Aarts, G., McClintock, B. T., Mattiopoulos, J., Moss, S. E. W., and McConnell, B. (2014) *Marine mammals trace anthropogenic structures at sea.* These papers were reviewed and any pertinent information included in the Salmon and Sea Trout Baseline Report (*Appendix 14B of the Commercial Fisheries chapter*)
Commercial Fisheries and Natural Fisheries Pre – submission meeting 14/2/2018 Marine Scotland, Aberdeen	Attendees: MS LOT MSS SNH SFF Scottish White Fish Producers Association	Information on the data used in the baseline and scope of the assessment for both the natural fish and commercial fisheries chapters was presented. Other than EMF and Vibration impacts (which SFF still would like further information on) all other attendees were in agreement on the scope of the assessment and baseline used. ICOL noted that as EMF and Vibration were scoped out of the EIA it would not be assessed in the EIA. SFF's position is that operational phase can produce low frequency vibrations and that there is no evidence that this wouldn't lead to significant effects on shellfish. SNH noted that there had been a report reviewing EIA predictions as part of a review of Rounds 1 and 2 wind farms by the Marine Management Organisation (MMO)[1] and this work showed no significant effects. ICOL have subsequently provided recent publications on EMF to SFF demonstrating a lack impacts on key species. SFF responded in email (29/03/2017) noting: these [publications] do serve to prove the general hypothesis that EMF from windfarm cables has no discernible impact on the behaviour of fish. SFF also noted that it might be a good idea for a small, regular monitoring to provide the evidence of the innocent effects of EMF on fish species? ICOL remain of the position that as it was not included in the assessment, and thus not deemed significant that this is not necessary. MSS noted, for interest purposes only, that for particle motion that a new paper by Popper and Hawkins had been recently published (this has been reviewed by ICOL for pertinent information). MS also stated that they will be carrying out work in May which should give information on smolt distribution from the River Teith. The outcome of this work will not be available until after the date planned for this application.

[1] Marine Management Organisation, April 2014, *Review of Environmental Data associated with post consent monitoring of licence conditions for offshore wind*, MMO project 1031.

Consultation	Consultees	Summary
Gatecheck	SNH	SNH considered that the 0.5% conversion factor used in the noise modelling was too conservative and that 1% would be preferable. In response to this, revised modelling has been undertaken to illustrate the difference in outputs with the varying conversion factors. In addition, further justification has been provided on the appropriateness of the use of a 0.5% conversion factor and this justification is presented in *Appendix 10B*.

7 The information received through consultation, along with the formal Scoping Opinion and recognised best practice, has informed the methodology and scope for the assessment of the impacts on natural fish and shellfish presented in this chapter.

9.3 Scope of Assessment

8 As part of this application ICOL has drawn on the detail presented in the Scoping Report and subsequent Scoping Opinion from MS-LOT, requested research papers and consultation to agree on those impacts that may lead to a significant effect. Therefore, this chapter focusses on those impacts on natural fish and shellfish that have been agreed as having a potential for a significant effect, and therefore require assessment.

9 The resulting scope of assessment is set out in *Table 9.3*. For further information, reference should be made to the Scoping Report and the Scoping Opinion which can be found on Marine Scotland's (MS) website[2].

Table 9.3: Scope of assessment covered in the Natural Fish and Shellfish Chapter

Potential Impact	Scope of Assessment	Reason
Construction Phase – Wind Farm		
Barrier effects, disturbance, or physical injury associated with construction noise.	Impacts of barrier effects, disturbance or physical injury associated with construction noise from piling on hearing specialist fish species.	Potential for significant effects exists.

10 The following impacts have been scoped out of the EIA, in full agreement with MS-LOT through the formal Scoping Opinion and subsequent consultation as identified in *Table 9.1*:

- Construction Phase – Wind Farm & Offshore Export Cable Corridor
  - Direct temporary habitat disturbance;

[2] http://www.gov.scot/Topics/marine/Licensing/marine/scoping/ICOLRevised-2017[Accessed 26/04/18]

- Indirect disturbance as a result of sediment deposition and temporary increases in Suspended Sediment Concentration (SSC); and
- Barrier effects, disturbance, or physical injury associated with construction noise (for all species for the Offshore Export Cable Corridor, and all species except hearing specialists for the Development Area).

- Operation & Maintenance (O&M) Phase – Wind Farm & Offshore Export Cable Corridor
  - Long term loss of original habitat;
  - Disturbance or physical injury associated with operational noise;
  - Reduced fishing activity within the Development Area;
  - Creation of new habitat due to presence of infrastructure (including cable protection);
  - Behavioural responses to EMF associated with cabling; and
  - Direct temporary habitat disturbance via O&M activities.

11 Following the production of the Discussion Papers (provided in *Appendix 9C, D and E*) no further assessment is included on salmon migration behaviour, particle motion or the impact of suspended sediment and smothering on scallops.

9.4 Regulation and Guidance

12 Fish species in United Kingdom (UK) waters are protected by the following legislation:

- *Marine (Scotland) Act* (2010) provides the legal mechanism to help ensure clean, healthy, safe, productive and biologically diverse marine and coastal environments, managed to meet the long-term needs of both nature and people, by putting in place a new system for improved management and protection of the marine and coastal environment. The *Marine (Scotland) Act* introduced powers relating to functions and activities in the Scottish marine area, including provisions concerning marine plans, licensing of marine activities, the protection of the area and its wildlife including seals, and regulation of sea fisheries.
- *Council Directive 92/43/EEC* on the *Conservation of Natural Habitats and Wild Flora and Fauna 1992 (Habitats Directive)*. The *Habitats Directive* has been transposed into Scottish law in territorial waters (within 12 nautical miles (nm)) with the *Conservation (Natural Habitats, &c.) Regulations 1994* (as amended in Scotland) and in offshore waters via the *Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007*. The *Conservation of Habitats and Species Regulations 2017* also apply under *section 36* of the *Electricity Act 1989*. The aim is to maintain or restore natural habitats and species to a Favourable Conservation Status (FCS). The Directive introduced a range of measures including the development of a network of protected sites for listed habitats (Annex I) and species (Annex II). Shad is the only species assessed within this EIA Report which is protected under the *Habitats Directive*.

- The *Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention).* Since 1972, the *OSPAR Convention* has worked to identify threats to the marine environment through organised programs and measures to ensure national action. The *OSPAR Convention* assesses which species and habitats require protection due to being threatened and/or experiencing a decline in population. This list includes cod and allis shad. Also contained within the *Convention* are a series of annexes dealing with pollution from anthropogenic sources, including underwater noise pollution.
- The *UK Post-2010 Biodiversity Framework* was published on 17 July 2012. The *Framework* covers the period from 2011 to 2020, and was developed in response to two main drivers: the *Convention on Biological Diversity's (CBD's) Strategic Plan for Biodiversity 2011-2020* and its five strategic goals and 20 'Aichi Biodiversity Targets'; and the *European Union Biodiversity Strategy (EUBS).* The *Framework* shows how the work of the four UK countries joins up with work at a UK level to achieve the 'Aichi Biodiversity Targets' and the aims of the EUBS. It identifies the activities required to complement the country's biodiversity strategies, and where work in the country contributes to international obligations.

13 The following guidance has also been used within the EIA Report:

- Centre for Environment, Fisheries and Aquaculture Science (Cefas, 2012); Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects, Defra project code ME5403.
- The *Scottish Biodiversity List* was published in 2005 to satisfy the requirement under Section 2(4) of the *Nature Conservation (Scotland) Act 2004*. The purpose of the list is to help public bodies carry out their Biodiversity Duty by identifying the species and habitats which are the highest priority for biodiversity conservation in Scotland.
- The *Priority Marine Features list* was developed jointly by SNH and Joint Nature Conservation Committee (JNCC), prioritising marine habitats and species considered to be of conservation importance in Scotland's seas. The list was formally adopted by the Cabinet Secretary for Rural Affairs, Food and Environment in 2014, with some policy protection subsequently afforded through the *National Marine Plan (NMP).*

9.5 Design Envelope and Embedded Mitigation

9.5.1 Design Envelope

14 As the design of the Inch Cape Wind Farm is not fixed and flexibility in the design envelope is required, the following key parameters, detailed in *Tables 9.4* and *9.5*, represent the worst-case scenarios for impacts on natural fish and shellfish interests. For the fish and shellfish impact assessment, the impact from the largest blow energy from piling is considered the worst-case scenario. This is based on the fact that the noise associated with the largest blow energy will have the biggest impact on fish categorised as hearing specialists.

15 Key parameters for the worst-case scenario from piling impacts are detailed in *Tables 9.4* and *9.5* below, no other impacts are being assessed within this chapter. Most likely scenarios are

also presented, however it should be noted that only the worst case scenario has been modelled and assessed throughout the impact assessment for this EIA Report.

Table 9.4: Worst case scenario definition (piled jackets) - Development Area

Design Envelope Scenario Assessed				
Scenario	**Most Likely (i.e. 80% of locations)**		**Worst Case (i.e. 20% locations)**	
Pile Diameter (mm)	2438		2438	
Hammer Capacity Kilojoules (kJ)	2400		2400	
Max Blow Energy (kJ)	1080 (i.e. 45%)		2160 (i.e. 90%)	
Total Piling Duration (hours/pile)	2.5		2.6	
Ramp-Up Details	Time (minutes at % efficiency)	Efficiency (% of max blow energy)	Time (minutes at % efficiency)	Efficiency (% of max blow energy)
	20	10% (240 kJ)	20	10% (240 kJ)
	20	20% (480 kJ)	20	20% (480 kJ)
	10	30% (720 kJ)	10	30% (720 kJ)
	100	45% (1080 kJ)	106	90% (2160 kJ)
Average strike rate during soft start (blows/sec)	0.3			
Average strike rate after soft start (blows/sec)	2		2	
Total number of piles	244		60	

Table 9.5: Worst case scenario definition (monopiles) - Development Area

Scenario	**Most probable blow energies (80% of locations)**	**Worst Case - highest expected blow energy (20% of locations)**
Monopile diameter (mm)	12,000	12,000
Hammer capacity (kJ)	5,000	5,000
Max blow energy (kJ)	2,250 (45%)	4,500 (90%)

Scenario	Most probable blow energies (80% of locations)			Worst Case - highest expected blow energy (20% of locations)		
Total piling duration (hours/ monopile)	4			6		
Ramp-up details	Time (min)	Efficiency (% of max blow energy)	Average strike rate (blows/sec)	Time (min)	Efficiency (% of max blow energy)	Average strike rate (blows/sec)
	30[3]	10% (500 kJ)	0.29	30	10% (500 kJ)	0.29
	20	20% (1,000 kJ)	0.58	20	20% (1,000 kJ)	0.58
	10	30% (1,500 kJ)	0.58	10	30% (1,500 kJ)	0.58
	180	45% (2,250 kJ)	0.58	300	90% (4,500 kJ)	0.58
Total number of monopiles	59			15		

9.5.2 Embedded Mitigation Measures

16 The assessment of impacts on natural fish and shellfish has taken into account the following embedded mitigation measure:

- Piling operations will incorporate a soft start procedure (build-up of hammer energy over a set time-frame) which will reduce the potential for noise-related fatality for all species.

9.5.3 Consent Conditions

17 As well as the embedded mitigation measures, ICOL proposes to commit to the purpose of the relevant consent conditions granted for the Inch Cape 2014 Consent, as they are still relevant to this application. This will provide reassurance to stakeholders that the relevant issues will be addressed and secured by way of appropriate conditions.

18 ICOL recognises that the wording and detail of the consent conditions will be at the discretion of the Scottish Ministers. For Natural Fish interests, ICOL propose that the consent conditions address matters surrounding, but not limited to, the following;

[3] This row represents the 30 minute pile driving soft start period.

- Submit a piling strategy for approval (in the event that pile foundations are to be used);
- Submit a Construction Programme; and
- Submit a Project Environmental Management Plan.

9.6 Baseline Environment

19 The following section sets out the baseline for the relevant natural fish and shellfish receptors Study Areas (see *Section 9.6.1* below) used in this assessment. Following the scoping out of other species, as discussed above, information on hearing specialist fish only is presented.

20 The baseline description has been informed by a herring spawning study, which has been produced to provide information on the adult and larval distribution of herring (*Appendix 9A: Herring Spawning Study)*.

9.6.1 Study Area

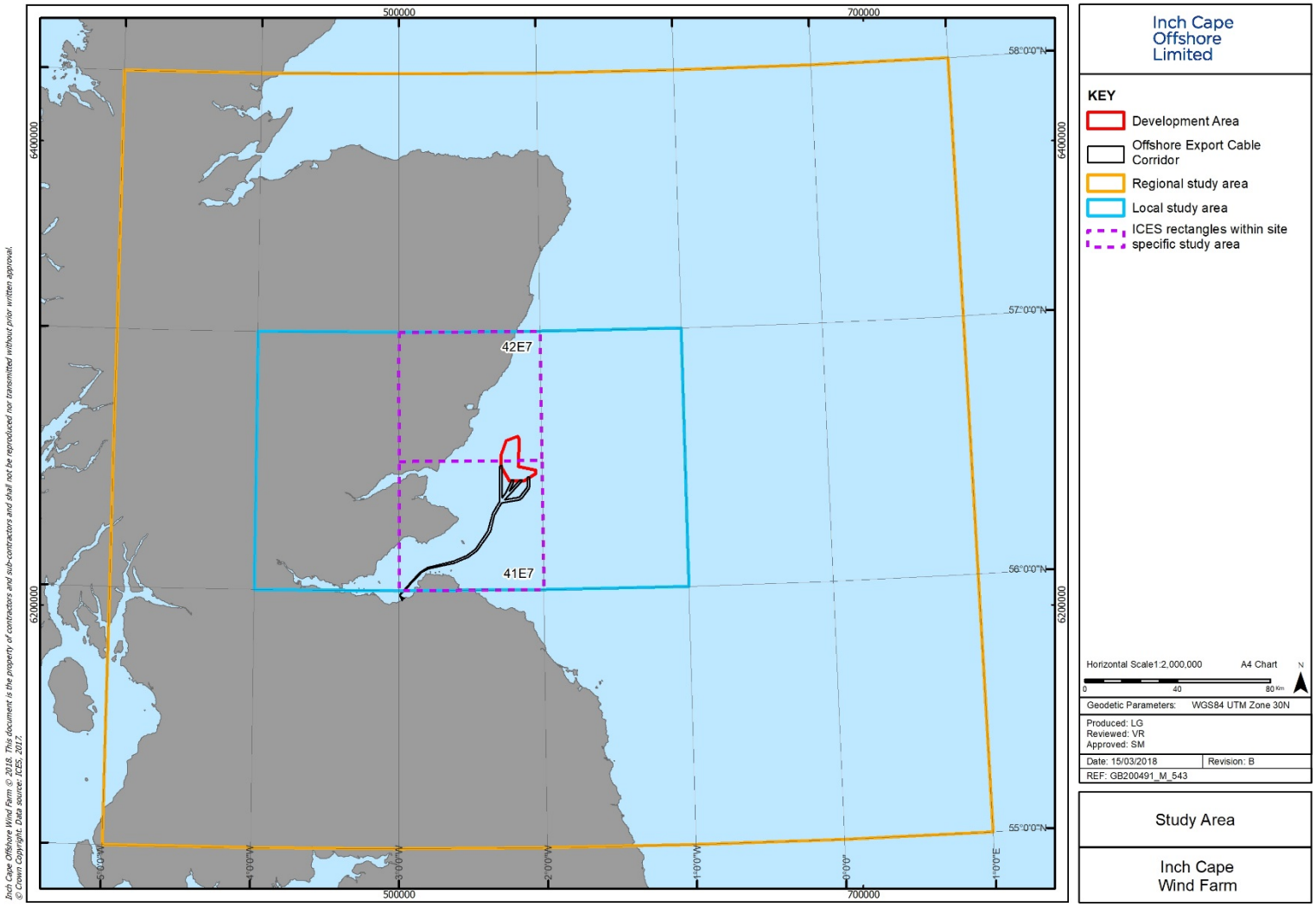
21 In line with the *Commercial Fisheries Assessment* (Chapter 14, Figure 14.1), the Study Area used for this assessment (and setting of the baseline) corresponds to relevant International Council for the Exploration of the Sea (ICES) Rectangles which overlap with the Development Area, i.e. ICES rectangles 42E7 and 41E7 (*Figure 9.1*), in addition to a Local and Regional Study Area[4].

22 The Local Study Area encompasses the ICES squares 42E8, 42E9 along with the salmon fishery districts in closest proximity to the Development; while the Regional Study Area has been defined to ensure sufficient coverage of fishing grounds and migration routes covering the Development Area.

23 Information relating to commercial fisheries data is also presented at Local and Regional Study Area level in order to give context to the distribution of species in relation to the Development.

[4] East coast areas only.

Figure 9.1: Study area



9.7 Data Sources

24 The data sources used to define the baseline environment for hearing sensitive fish included are as follows:

- Commercial landings data (MMO, 2012-2016);
- International Bottom Trawl Survey (IBTS) data (ICES);
- International Herring Larvae Surveys (IHLS) data (ICES);
- Site Specific Survey data (2011); and
- Spawning and nursery ground data (Ellis *et al*., 2012; Coull *et al*., 1998).

25 The use of commercial, IBTS, and site specific survey data in combination is deemed to provide a suitable picture of receptor distribution and abundances to allow a robust assessment to be undertaken, and considering that some bias may be inherent in each individual data set (depending on the method and purpose of collection) provides confidence in the overall conclusions.

9.8 Overview of Baseline

9.8.1 Species Assessed

26 The fish assessed within this chapter consist of cod (*Gadus morhua*), herring (*Clupea harengus*), allis shad (*Alosa alosa*), twaite shad (*Alosa fallax*) and sprat (*Sprattus sprattus*).

27 Popper *et al.* (2014) classified fishes into three categories in terms of their auditory acuity and detection mechanisms:

- Type 1: Fishes without a swim bladder or any other gas filled body cavities. These species are considered to only be sensitive to particle motion and include flatfish species and sandeels.
- Type 2: Fishes with swim bladders or other gas filled body cavities which are not involved in hearing. These species are also considered only to be sensitive to particle motion and include salmonids and some pelagic species, such as mackerel.
- Type 3: Fishes with swim bladders or other gas filled body cavities which are involved in hearing. These species are considered to be sensitive to both particle motion and sound pressure and include gadoids, such as cod, and some pelagic species, such as herring. Due to their ability to detect the pressure component of underwater noise, the frequency sensitivity ranges of these species and their acuity levels are greater, hence this group is frequently referred to as the 'hearing specialists'.

28 All species being assessed within this chapter are considered to be Type 3 Fishes. In herring, shad and sprat, diverticula (slim protruding hollows) originating in the swim bladder extend into the skull and are connected to the inner ear by specialised structures known as otic bullae. This aids transmission of acoustic vibrations from the swim bladder to the ear thus increasing the hearing capabilities of the species (Allen *et al.,* 1976). As a result, these species are

considered hearing specialists (Kastelein *et al.,* 2008; Nedwell and Howell, 2004; Enger *et al.,* 1993; Blaxter *et al.,* 1981). Gadoids such as cod do not have a direct connection between the swim bladder and the inner ear, however, are considered to be more sensitive to noise than other generalists (Chapman and Hawkins, 1973) and as such are considered as Type 3 species. For the avoidance of doubt, where the term hearing specialist is used throughout this chapter, it refers to those species under assessment only (i.e. Herring, Cod, Sprat and Shad species).

9.8.2 Commercial Landings Data

29 Commercial landings data has been examined as this data provides an indication of fish species present in the Local and Regional Study Areas. Data was examined in order to check the presence of the species assessed in this chapter. See also *Chapter 14 Commercial Fisheries* for more details.

30 Landings data from between 2012 and 2016 (as distributed by the MMO) has been evaluated to provide information on the abundances of hearing specialist fish within the Regional and Local Study Areas, as well as specifically within those ICES rectangles that overlap the Development Area (*Table 9.6*).

Table 9.6: Average annual UK fleet landings (tonnes) of hearing specialist fish within the study areas (MMO: 2012-2016)

Species	ICES Rectangle/ Study Area			
	41E7	42E7	Local Study Area	Regional Study Area
Cod	1.7	2.9	4.6	13.2
Herring	0.1	3.5	3.6	856.0
Sprat	0	0	0	0
Shad[5]	0	0	<0.0001	<0.001

31 Cod are widespread across the North Sea, and landings are recorded from both the Local and Regional Study Area, as well as those ICES rectangles that overlap the Development Area.

32 Herring were landed from the two ICES rectangles which cover the Development Area in 2012, 2013, 2015 and 2016, however no commercial landings of herring from these squares were reported in 2014. Herring are however landed from across the Local and Regional Study Area in relatively high abundances, with the greatest catches recorded to the north of the Development Area.

33 No landings of sprat were recorded within the Regional Study Area.

34 Catch records for shad are scarce, with very small volumes (or none) landed annually across the local and regional study areas. The greatest annual catch over the period was 0.0027

[5] Both allis and twaite shad species are recorded as 'shad' in the publication of the landings data.

tonnes which was landed from ICES rectangle 40E8 in 2013. No landings of Shad species were recorded in the ICES rectangles that intersect with the Project.

9.8.3 International Bottom Trawl Survey (IBTS)

35 Data from IBTS provides information on fish that are not commercially targeted, and which therefore can be missing from fisheries landings data.

36 Abundances recorded under the IBTS are reported as number of individuals captured per hour of trawling (i.e. Catch per Unit Effort (CPUE)) (*Table 9.7*) therefore are not directly comparable with the commercial landings data presented above.

Table 9.7: IBTS catch (CPUE) of hearing specialist fish within the study area (2012-2016)

Species	ICES Rectangle/ Study Area			
	41E7	42E7	Local Study Area	Regional Study Area
Cod	2.8	3.3	3.0	4.0
Herring	88.7	32.4	59.7	66.6
Sprat	473.3	437.5	454.9	265.4
Twaite shad	0.0	0.0	0.0	0.0
Allis shad	0.0	0.0	0.0	0.0

37 IBTS catch data indicates that cod have a relatively even distribution across the entire Regional and Local Study Areas, and although herring and sprat are also distributed across all study areas, their relative distributions vary.

38 Catches of shad are sporadic and of low density across the whole of the UK, with no allis or twaite shad caught within the study areas during the data period (2012 to 2016).

9.8.4 Spawning & Nursery Grounds

Herring

39 The Development Area does not coincide with potential herring spawning grounds as historically reported by Coull *et al.* (1998) (*Figure 9.2*). However, a review of spawning data by Ellis *et al.* (2012) suggested that herring could potentially spawn across a wider area although there was insufficient data to revise the historical spawning maps. This was further evidenced by a study conducted by Aires *et al*. (2014) which demonstrated that while nursery grounds may be present in the area they were not in high densities. In order to reduce uncertainties a Herring Spawning Study (*Appendix 9A*) was carried out to examine the possible extent of herring spawning and use of the area as nursery in and around the Development Area. This

included examination of International Herring Larvae Study (IHLS) data, IBTS data, site specific survey data and commercial fisheries data.

40 According to Coull *et al.* (1998) herring spawning grounds are located approximately 4.5 km to the north and 35.8 km to the south of the Development Area, although this report suggests that these may vary annually. To the north of the Development Area and off the north-east coasts of mainland Scotland and Shetland, herring of the Buchan/Shetland population spawn, while to the south of the Development Area and off the north-east England coast (and in the central North Sea) herring from the Banks or Dogger herring population spawn (*Figure 9.2*).

41 Adult herring migrate from offshore feeding grounds from mid-August peaking in September and lay eggs on gravel substrates at these spawning grounds. On hatching, the larvae move passively in a southerly direction on currents to coastal nursery areas along the east coast of the UK (*Figure 9.3*). The study by Ellis *et al*. (2012) indicates that the Development Area is located in high density herring nursery area.

42 A full review of the usage of the spawning and nursery areas in the north North Sea by herring is presented in *Appendix 9A*.

Figure 9.2: Herring spawning areas

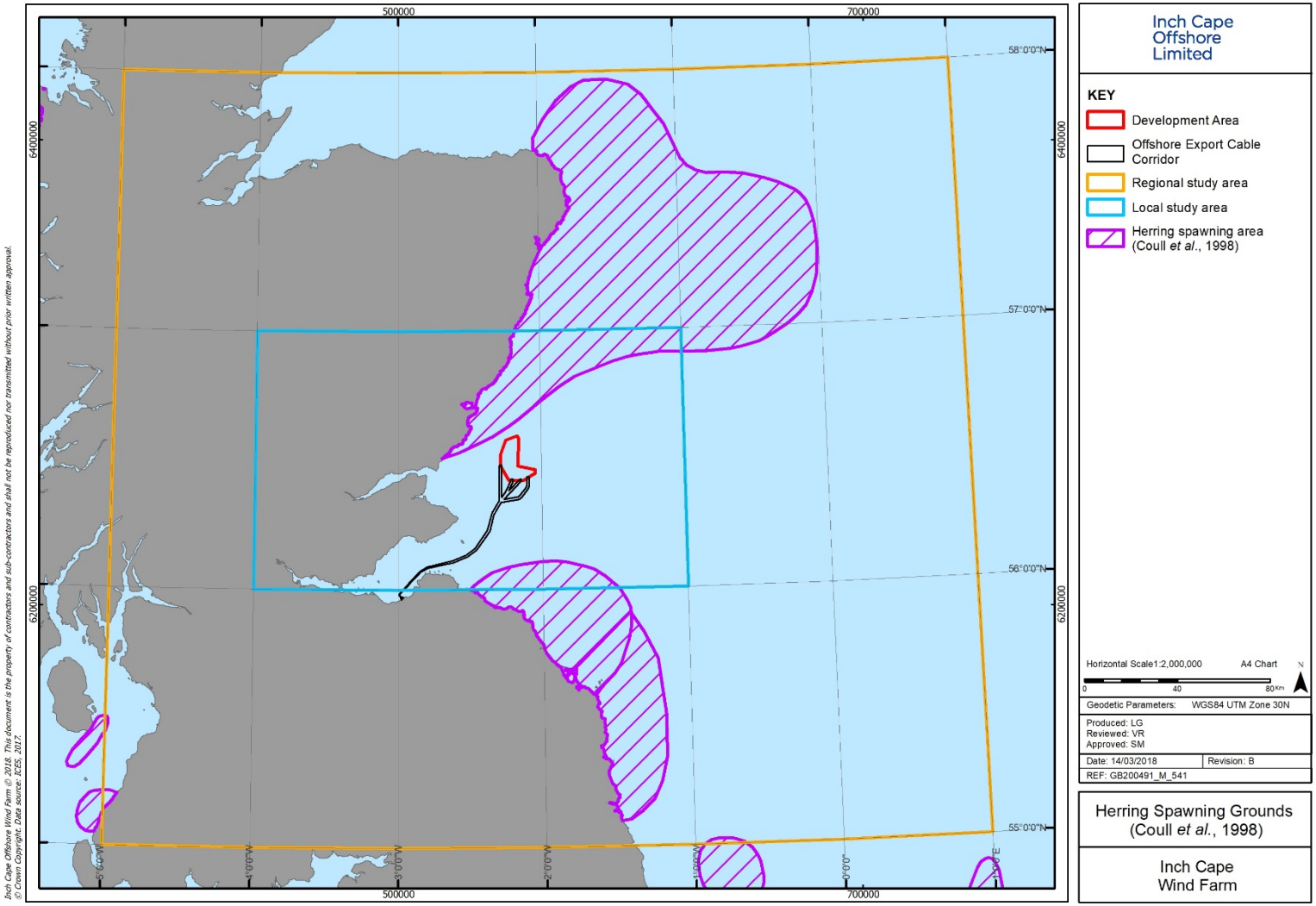
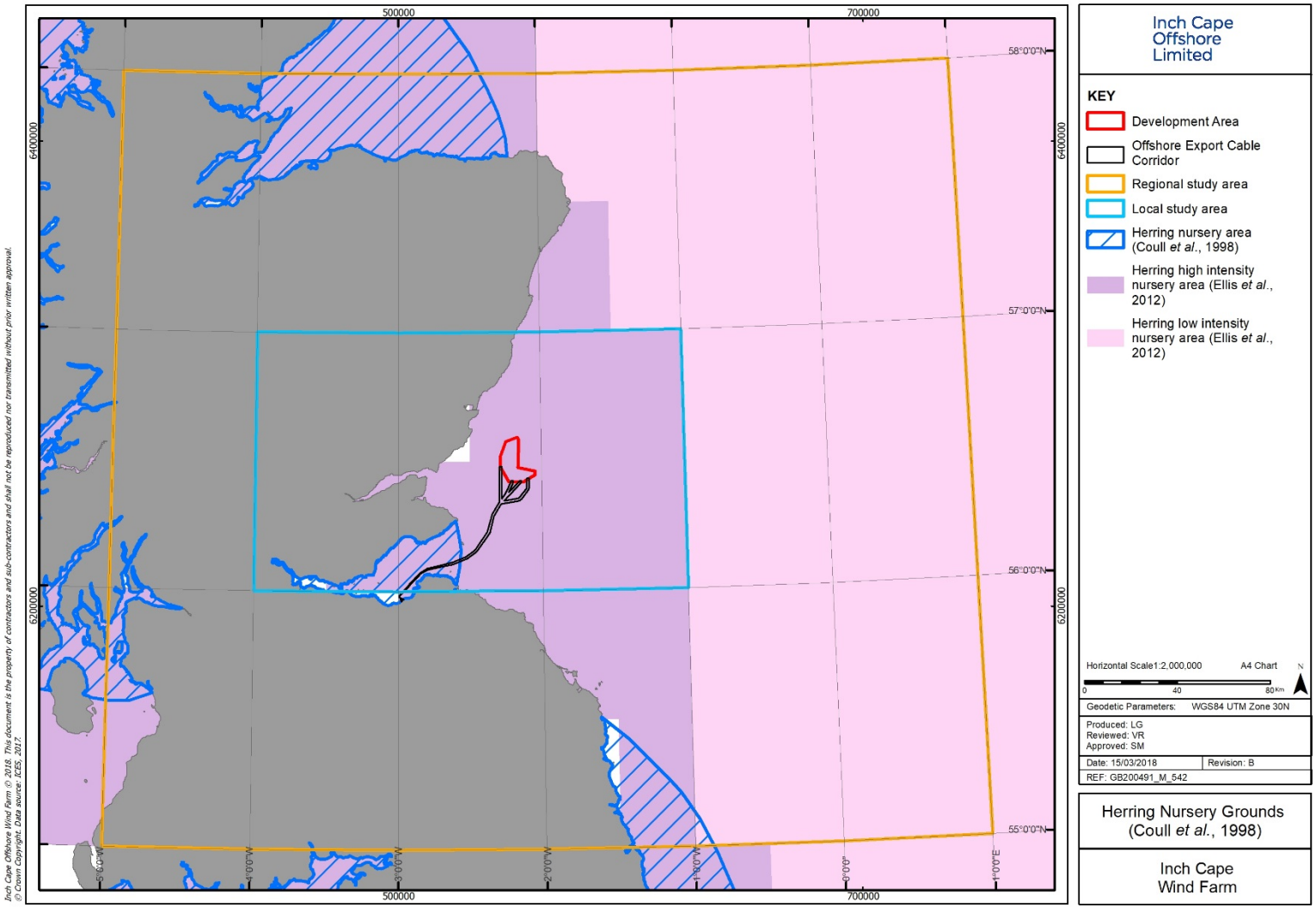


Figure 9.3: Herring nursery areas



Cod

43 The Development Area overlaps with nursery and spawning grounds for cod (*Figure 9.*4) (Coull *et al*., 1998; Ellis *et al*., 2012; Aires *et al*., 2014; and Gonza´lez-Irusta and Wright, 2016). Although it is a pelagic spawner, and found to be widespread throughout the North Sea, cod are considered to be restricted by specific parameters during the spawning season with the primary limiting factors found to be temperature (5-7 °C), salinity (28-36% ppt), depth (shallow to 260 m with an optimal max of 125 m) and sediment type (clean sandy gravel, and an aversion to mud) (Gonza´lez-Irusta and Wright, 2016). Although Cod are likely to spawn within the Development Area, this is considered unlikely to represent a substantial aggregation of the species.

Sprat

44 Sprat are broadcast spawners and spawn several times during the spawning season (Alheit, 1988). Sprat are known to spawn around the whole of the UK, however appear to avoid the inshore waters on the east coast. Sprat spawning is therefore identified within the Regional Study Area but not within the Local Study Area (*Figure 9.5*) (Ellis *et al*., 2012; Coull *et al*.,1998).

45 All inshore waters along the west coast of Scotland provide nursery areas for sprat.

Shad

46 Shad, as a migratory species, utilise fresh water habitats for spawning. Although historic spawning of allis shad has been recorded in some UK rivers (Severn, Thames, and Wye), there are now no known allis shad spawning sites in the UK, although records of sub-adults and sexually mature adults are still recorded around the British coast, including in the Solway Firth (Maitland & Hatton-Ellis, 2003). Twaite shad spawning populations are known to exist in the rivers Severn, Wye, Usk and Tywi (Maitland & Hatton-Ellis, 2003). It is thought that a population also exists in the river Cree in south west Scotland where individuals spawn within the estuary (Maitland & Lyle 1995). No known spawning populations of either shad species exist in Scottish east coast rivers. Based on the current information, it is considered unlikely that the migratory populations of shad occur within the Regional or Local Study Area.

Figure 9.4: Cod nursery and spawning Areas

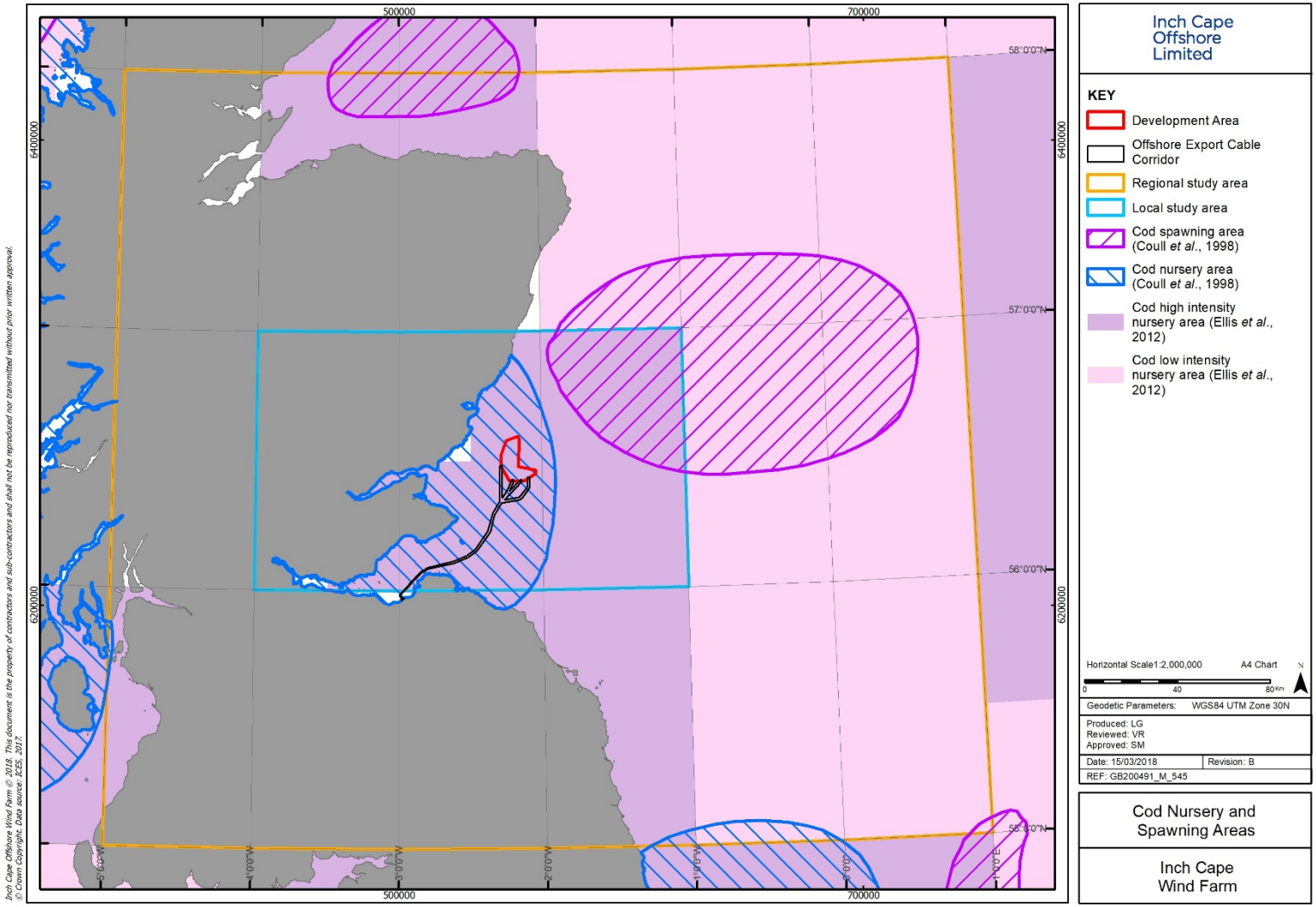
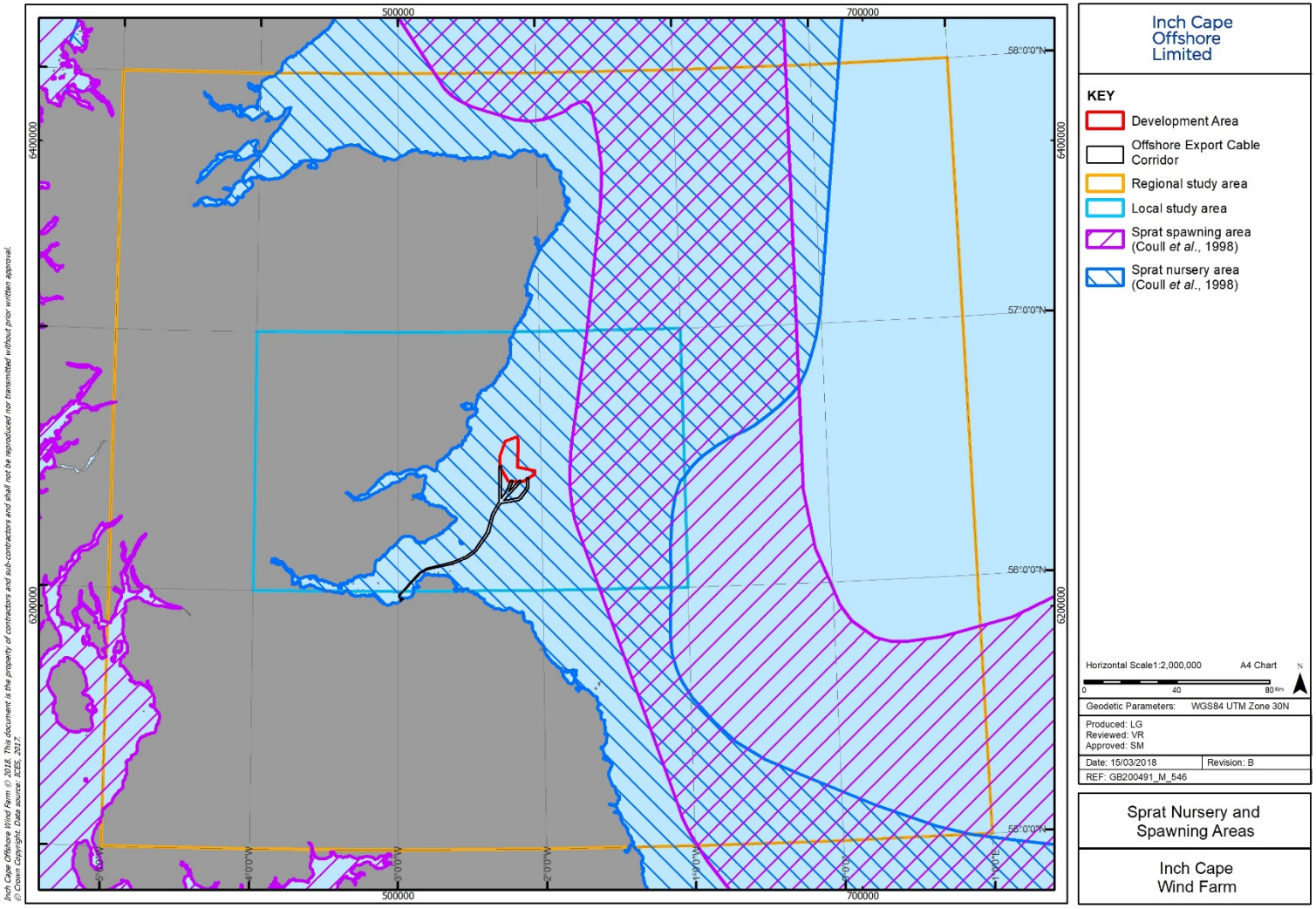


Figure 9.5: Sprat nursery and spawning areas



Site Specific Surveys

47 In order to assess fish presence and distribution in the Development Area, four separate targeted trawl surveys were undertaken in 2012 using a local fishing vessel deploying a commercial otter trawl. The survey methodology was agreed with MS and their advisors prior to the commencement of the January 2012 survey. Trawl surveys were conducted quarterly over a 12-month period in 2012 in order to try and identify any broad-scale variation in species distribution and abundance in the Development Area. It was agreed through Scoping that no further site specific surveys were required as the distribution of fish species is unlikely to differ greatly from that reported in 2012.

48 Overall, the site specific surveys captured a total of 30 fish species and 20 macro-invertebrate species, with 19,309 and 6,127 individuals recorded respectively. Of the receptors included within this chapter, only cod, herring and sprat were captured (*Table 9.8*). No allis or twaite shad were found in the site specific surveys, however this is as expected considering the low reported incidence of these species from other sources.

Table 9.8: Total catch of hearing specialist fish during site specific surveys (2012)

Species	Total Catch (all surveys)
Sprat	1194
Herring	161
Cod	15
Allis Shad	0
Twaite Shad	0

9.8.5 Baseline without Development

49 In the event of the Development not being developed, and no other developments occurring in the North Sea (including ICOL's consented Development) no change in the baseline conditions would be expected beyond those resulting from climatic factors (such as temperature change and subsequent impacts of species' ranges), or anthropogenic activities such as changes in fishing activities. Commercial fishing is subject to numerous factors which may cause fish and shellfish populations to differ in the future from the baseline provided. This could be as a result of, for example, changes in fisheries management policies and legislation, alterations in species distribution and abundance, or the introduction of marine conservation areas, increases in running costs such as fuel prices.

9.9 Assessment Methodology

50 The assessment has been carried out in accordance with Section 4 of this EIA Report, and in line with *Chartered Institute of Ecology and Environmental Management (CIEEM) Guidelines*

for Ecological Assessment in the UK and Ireland (CIEEM, 2016). The assessment will detail how the baseline conditions will change for each ecological feature scoped in to the assessment, and reference whether they are positive or negative, the extent of the impacts, as well as their magnitude, duration, timing, frequency and reversibility. Whether an impact is deemed significant is determined by evaluating the magnitude of the change arising from the Development with the sensitivity (value and vulnerability) of the particular receptor under consideration.

9.9.1 Sensitivity of Receptor

51 Features of the species' within the hearing specialist receptor group which contribute to their value or sensitivity under the assessment are provided in *Table 9.9*.

Table 9.9: Attributes of hearing specialist fish species

Cod *Gadus morhua*	• Species of principal importance for biodiversity conservation under the NERC* Act and Scottish biodiversity list, listed by OSPAR as threatened and/or declining and listed as vulnerable on the IUCN Red List; • Commercially important species; • Low intensity spawning areas in vicinity of study area; and • High intensity nursery areas in vicinity of study area.
Herring *Clupea harengus*	• Species of principal importance for biodiversity conservation under the NERC* Act and Scottish biodiversity list; • Listed as Least Concern on the IUCN Red List • Commercially important species; • Low/moderate abundance in the vicinity of the study area; • Historic spawning areas within the vicinity of the study area; • High intensity nursery habitat within the study area; and • Key prey species for birds and marine mammals.
Sprat *Sprattus sprattus*	• Commercially important species; • Low abundance recorded in the study area; • Important prey species for bird and marine mammal species; • Spawning areas (undefined intensity) do not overlap the local study area; and • Nursery areas (undefined intensity) present within the vicinity of the study area.
Shad Allis shad (*Alosa alosa*); twaite shad (*Alosa fallax*)	• Internationally Protected species (Annex II of the Habitats Directive); • Not a commercially important species; • Not recorded in the study area; • Not an important prey species; and • Spawning /nursery areas located in freshwater– no recognised spawning or nursery areas in the vicinity of the Development Area.

* Natural Environment and Rural Communities Act 2006

52 The receptors assessed (referred to within this chapter as the 'hearing specialist' receptor group), are collectively (for the purposes of the EIA Report) considered to be of moderate sensitivity. In this assignment, it is recognised that this group contains internationally designated species, however no key habitats exist for these species in the Regional Study Area and so it is not considered to be of high sensitivity in this instance. Other species in the group

are of moderate ecological or conservation (i.e. national) importance considering the wider status of stocks and as such this assignment is considered overall to be appropriate.

9.9.2 Magnitude of Impact

53 The magnitude of each impact will be determined by an evaluation of the following parameters on the receptor group:

- Spatial extent;
- Duration;
- Frequency of occurrence; and
- Reversibility.

54 The magnitude will be assigned a category based upon professional judgement and expert opinion and will be assessed at a spatial scale appropriate to the value of the receptor (*Table 9.10*).

Table 9.10: Overall classification of magnitude

Magnitude	Definition
High	Total loss or major alteration to key elements/features of the baseline conditions.
Moderate	Partial loss or large alteration to key elements/features of the baseline conditions.
Low	Minor shift away from the baseline conditions.
Negligible	Very slight change from baseline conditions.
No Impact	No change from the baseline conditions.

9.9.3 Method for Assigning Significance of Effect

55 The magnitude of any impact will be used to determine whether the predicted effect has the potential to be significant. An ecologically significant effect is defined as an impact which affects, in a positive or negative manner, the structure and function of a population or ecosystem, or the conservation objectives of that receptor (where such objectives exist). Effects shall be measured at an appropriate scale to the value of the receptor. Effects will be classified as either significant (i.e. effects are considered to be ecologically significant) or non-significant. It is anticipated that, combined with the moderate sensitivity of the hearing specialist group, effects with a magnitude of moderate or high would result in an ecologically significant effect.

56 Where uncertainty exists, the precautionary principle is adopted and appropriate conservative assumptions incorporated into assessment of magnitude. As a consequence, the assigned significance builds uncertainty into the assessment. This adoption of the

precautionary principle provides a high degree of confidence that the assessment conclusions are robust.

9.10 Impact Assessment

9.10.1 Effects of Construction

Barrier effects, disturbance, or physical injury associated with construction noise

57 The following impact assessment considers the potential for subsea noise generated by construction activities to impact hearing specialist fish receptors. Outputs of a project-specific noise modelling study have been used to inform this assessment (*Appendix 9B: Underwater Noise Modelling*). The outputs of this study have been used to evaluate the impact on hearing specialist fish.

58 As agreed during Scoping, it is only piling noise that is of concern to this assessment, as all other forms of construction noise are not considered to result in significant effects and have been scoped out of the assessment.

59 Thresholds (Sound Exposure Levels (SELs)) against which to assess impacts on fish from piling have been established in the literature and are summarised below (Popper *et al*., 2014):

- Mortality and mortal injury – immediate or delayed death (SEL – 207 re.1 μPa^2s);
- Recoverable injury – injuries, including hair cell damage, minor internal or external hematoma, etc. None of these injuries are likely to result in mortality (SEL – 203 re.1 micropascal (μPa^2s)); and
- Temporary Threshold Shift (TTS) – short or long-term changes in hearing sensitivity that may or may not reduce fitness (186 re.1 μPa^2s)

60 Up to two piling vessels would potentially be working at one time anywhere within the Development Area. Two pile locations were therefore modelled, one in the north and one at the south of the Development Area, considered to represent the worst-case locations for hearing specialists. Complete installation of all piles will occur within a seven month period during the construction phase, although piling will not be constant throughout this period.

61 The cumulative SELs for hearing specialist fish shows that there are no mortal effects until the third pin pile in any successive sequence. After all successive pin piles, the following areas of impact exist for hearing specialist fish based upon the predicted SELs:

- Mortality and mortal injury: 5 km^2
- Recoverable injury: 16.95 km^2
- TTS: 1,738.31 km^2

62 For monopiles, the impact areas are slightly reduced as the overall cumulative energy is lower for monopile installation compared with piled jackets:

- Mortality and mortal injury: 4.15 km^2
- Recoverable injury: 15.42 km^2
- TTS: 1,655.98 km^2

63 In terms of instantaneous impacts (at maximum hammer energy), mortality and injury effects (which have the same threshold under Popper *et al*. (2014) for peak sound pressure level (SPL) values) occur within 56 m or 115 m of piling for pin piles or monopiles respectively, for all species assessed. This equates to areas of 0.01 and 0.04 km^2 respectively.

64 In addition, although fleeing behaviours are not modelled specifically (due to uncertainties in specific fish behaviours) soft-start procedures may allow fish to leave the area before suffering lethal effects and physical damage, and consequently recoverable injury and behavioural impacts are considered more likely.

65 Due to the specificity of each species key habitats, the below text sets out whether there are any impacts on key habitats for each species, and summarises the magnitude of the impact at a species level.

Herring

66 Herring abundances in the area are highly variable, although individuals are likely to be present in the vicinity of the Development Area at all times. However, the area is not thought to be of high importance and as such large aggregations of individuals are not predicted at any time. Therefore, although it is likely some individuals will be affected at all effect levels, the areas of mortality and recoverable injury are relatively small (for both Cumulative SELs and instantaneous peaks), and as such the numbers of individuals predicted to be affected at such levels is likely to be very low (and may be reduced by soft start processes).

67 Herring spawning grounds are known to exist 4.5 km to the north (Buchan/Shetland population off the Aberdeen coast) and 35.8 km to the south of the Development Area (Banks population off the Berwickshire coast). No spawning grounds are noted to occur within the boundaries of the Development Area (Coull *et al.*, 1998).

68 Although Ellis *et al.* (2012) suggested that herring could spawn over a much larger area, the Herring Spawning Study (*Appendix 9A*) concluded, after thorough review of IHLS, IBTS, commercial fishing and site specific fish and benthic data, that there was little evidence of significant spawning outwith the spawning areas defined by Coull *et al.* (1998) in the Regional Study Area. Therefore, for the purpose of this assessment, the established herring spawning grounds as presented by Coull *et al.* (1998) are used as the basis of the discussion of impacts of the various noise contours.

69 Based upon the cumulative SELs, the noise from piling operations could potentially impact herring from the Buchan population off the Aberdeenshire coast when within (or migrating to) their spawning grounds at a behavioural level. There is no potential connectivity with the Banks population off the Berwickshire coast (*Figures 9.6* and *9.7*).

Figure 9.6: SEL interaction with herring spawning grounds – pin piles

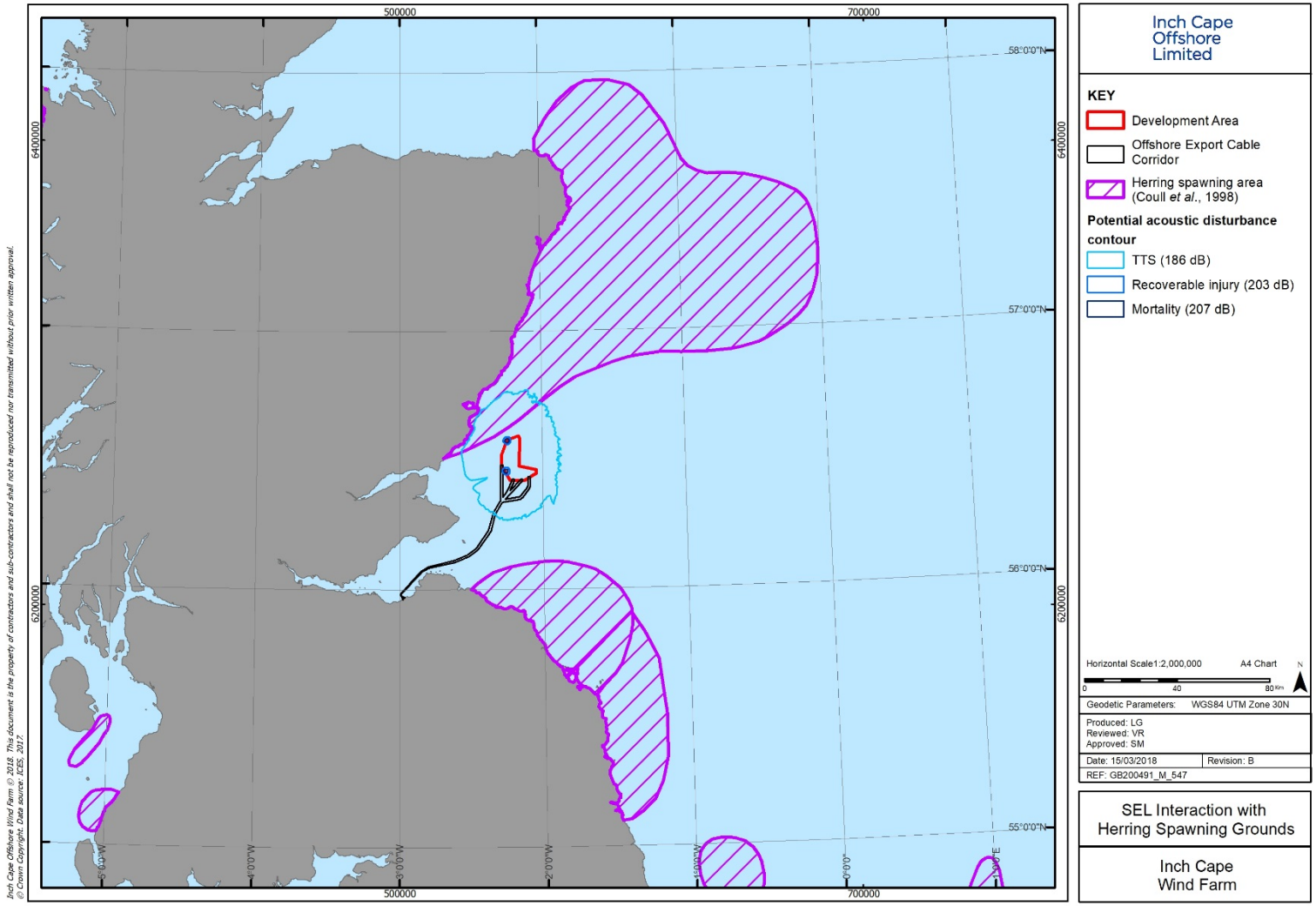
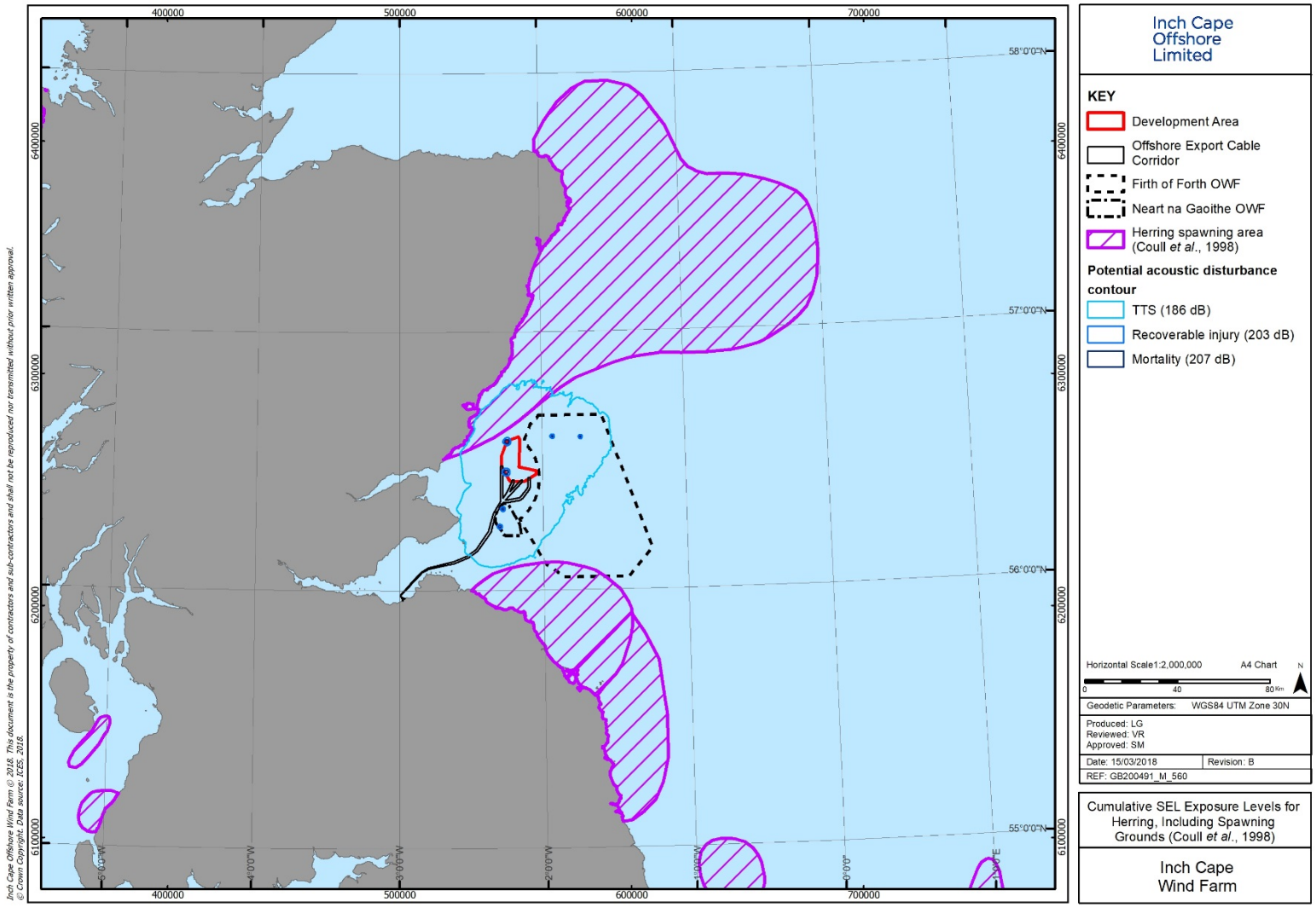


Figure 9.7: SEL interaction with herring spawning grounds – monopiles



70 The spawning study (*Appendix 9A*) illustrates that the southern limits of the Buchan population spawning ground (i.e. that affected by the piling noise) is rarely (if at all) utilised for spawning activity, with low adult numbers in this area and larvae <10 mm not recorded in this region in most years, and only at very low incidences when present. Rather, spawning activity is thought to be concentrated in the northern part of the spawning ground off the north Aberdeenshire coast, an area that would not be affected by piling noise from the Development.

71 As such, it can be concluded that there will be low impact on key spawning habitat for herring as a result of piling activity at the Inch Cape Wind Farm resulting in a negligible effect on species which is not significant.

72 In contrast to the well-defined spawning grounds (due to the substrate preferences), herring nursery grounds are less defined, and are thought to cover a large area of the North Sea (Ellis *et al.,* 2012). On hatching, the larvae which hatch on the Scottish east coast move passively in a southerly direction on currents to coastal nursery areas along the east coast of the UK. Larvae from the spawning grounds further north around Orkney and Shetland also support some of the Buchan sub-population however ocean currents are assumed to carry these larvae to nursery grounds in the Moray Firth and across the North Sea towards Denmark (Nichols, 1999), so no potential connectivity exists with these larvae. Larvae from the Banks spawning areas will move south away from the Development Area and so no potential connectivity exists with these larvae.

73 The potential for an interaction therefore exists between larvae moving south past the Development Area to nursery grounds along the east coast of the UK, and the emission of noise during piling. However, the development of sensory hearing organs occurs in late stage larvae and so impacts on the larval population from piling noise will be limited, and comparable to the (scoped-out) non-hearing specialist species. The area of sea affected by increased levels of noise represents a small proportion of the area utilised by the larvae, and as such no measurable effect on the herring spawning population is predicted as a result of impacts of piling noise on herring larvae. It is also noted that there is potential for non-auditory injury to occur to larvae, however it is noted that information quantifying thresholds is limited. Bolle *et al*. (2014), who exposed herring larvae to piling noise to determine whether any non-auditory injury may occur, found no statistical differences in mortality rates between control fish and those fish exposed to the piling noise. Bolle *et al*. (2014) also suggest that the Popper *et al.* (2014) thresholds for mortality and recoverable injury for larvae and eggs (210 and 207 dB re 1 μPa^2 respectively – i.e. greater than those assessed for adult fish in this assessment) could be considerably higher than this for larval stages. It is considered therefore that the model results for adult fish are conservative in terms of impacts to larval stages.

74 In summary, although limited injury or mortality effects are possible, these are only likely to affect a small number of individuals due to the lack of large aggregations predicted in the area. Furthermore, only a small area of the defined spawning grounds will be affected by piling noise from the Development, and the area predicted to be affected is not thought to represent key spawning habitat as larval and adult abundances in the area are consistently low to

absent. Therefore, no loss of key habitat (or barriers to migration to it) is predicted. Interaction with herring larvae is considered a possibility due to the southerly direction of travel of this life stage, however only limited effects of piling noise are predicted due to the early life stages present, and the area affected represents a negligible fraction of the total area of sea through which the larvae pass. As such, it is considered that the effect on herring will be of low magnitude and therefore this effect is not considered significant for the purposes of this assessment.

Sprat

75 Sprat abundances in the area are variable, and individuals are likely to be present in the vicinity of the Development Area at all times. However, large aggregations of individuals are not predicted at any time. Therefore, although it is likely some individuals will be affected at all effect levels, the areas of mortality and recoverable injury are relatively small (for both Cumulative SELs and instantaneous peaks), and as such the numbers of individuals predicted to be affected at such levels is likely to be very low (and may be reduced by soft start processes).

76 Sprat utilise coastal and offshore waters during spawning and release their eggs into the water column (Whitehead, 1986). As a result, spawning grounds are widespread around the North Sea and not limited to specific benthic habitats.

77 No spawning grounds are however thought to be present within or in proximity to the Development Area (Coull *et al.,* 1998), and therefore there will be no interaction between sprat spawning grounds and piling noise (*Section 9.7.1*; *Figure 9.5*).

78 Nursery areas for sprat extend almost the whole length of the UK east coast (Coull *et al.,* 1998), including the area around the Development Area and as such larvae may interact with piling noise from the Development Area, although as with other species, development of the sensory hearing organs occurs in late stage larvae and so effects on the larval population from piling noise will be limited.

79 In summary, although limited injury or mortality effects are possible, these are only likely to affect a small number of individuals due to the lack of large aggregations predicted in the area. Furthermore, interaction with sprat larvae and juveniles is considered a possibility due to the large nursery area present, however only limited effects of piling noise are predicted on early life stages present, and the area affected represents a negligible fraction of the total area of sea which acts as a nursery ground. As such, the effect on sprat is considered to be of negligible magnitude and therefore is not considered significant for the purposes of this assessment.

Cod

80 Cod are likely to be present in the vicinity of the Development Area at all times. However, large aggregations of individuals are not predicted at any time. Therefore, although it is likely some individuals will be affected at all effect levels, the areas of mortality and recoverable injury are relatively small (for both Cumulative SELs and instantaneous peaks), and as such the

numbers of individuals predicted to be affected at such levels is likely to be very low (and may be reduced by soft start processes).

81 Nursery areas cover almost the whole North Sea (a reflection of the lack of concentrated spawning grounds), including the area around the Development Area (Ellis *et al.,* 2012). As such, larvae may interact with piling noise from the Development Area *(Section 9.7.1*; Figure 9.4), although as with other species, development of the sensory hearing organs occurs in late stage larvae and so effects on the larval population from piling noise will be limited.

82 In summary, limited injury or mortality effects are possible, although these are only likely to affect a small number of individuals due to the lack of large aggregations predicted in the area. No cod spawning areas (as defined by Coull *et al.,* 1998) are predicted to be affected by piling noise, and although it is recognised that cod may also spawn across the development area and wider study area, this is considered unlikely to represent a substantial aggregation of the species. Defined cod nursery grounds will however be affected, although the area predicted to be affected is negligible in size compared to the extensive area over which this species' larvae will be distributed. Only limited effects of piling noise are predicted on larvae due to the early life stages present, and the proportion of the nursery area affected represents a negligible fraction of the total area of sea available. As such, it is considered that the effect on cod is of a negligible magnitude and is therefore not considered significant for the purposes of this assessment.

Shad

83 Both allis shad and twaite shad are known to use the coastal shelf for migrations, however records of shad species in the Study Areas are rare. Furthermore, the only known Scottish spawning river is found on the west coast, therefore interactions of shad species with the Development Area is considered highly unlikely. Given the rarity of shad in the Study Areas, no significant impact on these species are predicted.

Summary of Significance of Impact

84 Overall, the areas affected at a level deemed able to cause mortal or injurious effects to hearing specialist fish are very small, with mortal effects only becoming apparent after three successive piles (for pin piles only). This delay to the onset of mortality effects, and the planned soft start procedure, is likely to reduce mortality effects through fish leaving the affected area in this time period.

85 Some interaction with spawning and nursery habitats is expected, however such interactions are considered to not affect key areas of these habitats, or to affect such a small proportion that any effects are considered negligible.

86 Overall, the magnitude of the effect 'Barrier effects, disturbance, or physical injury associated with construction noise' on hearing specialists is considered to be of low magnitude due to the partial interaction with spawning and nursery habitats, and is not deemed to represent a significant effect for the purposes of this assessment.

Summary of Significance of Impact with a 1% Conversion Factor

87 In light of comments received by SNH during the Gatecheck process, although it is considered that a 0.5% conversion factor is the most suitable for the purposes of the assessment (*See Appendix 10B*), the underwater noise modelling has been re-run to illustrate the difference in extent of the impacts should a 1% conversion factor be used instead (*Figure 9.8*).

88 Although it can be seen the areas of effect do increase using the alternative modelling parameters, these increases are not considered to affect the significance of the impact as the areas of mortality and recoverable injury remain small across all scenarios (*Table 9.11*).

Table 9.11 variation in SEL impact extent with varying conversion factors

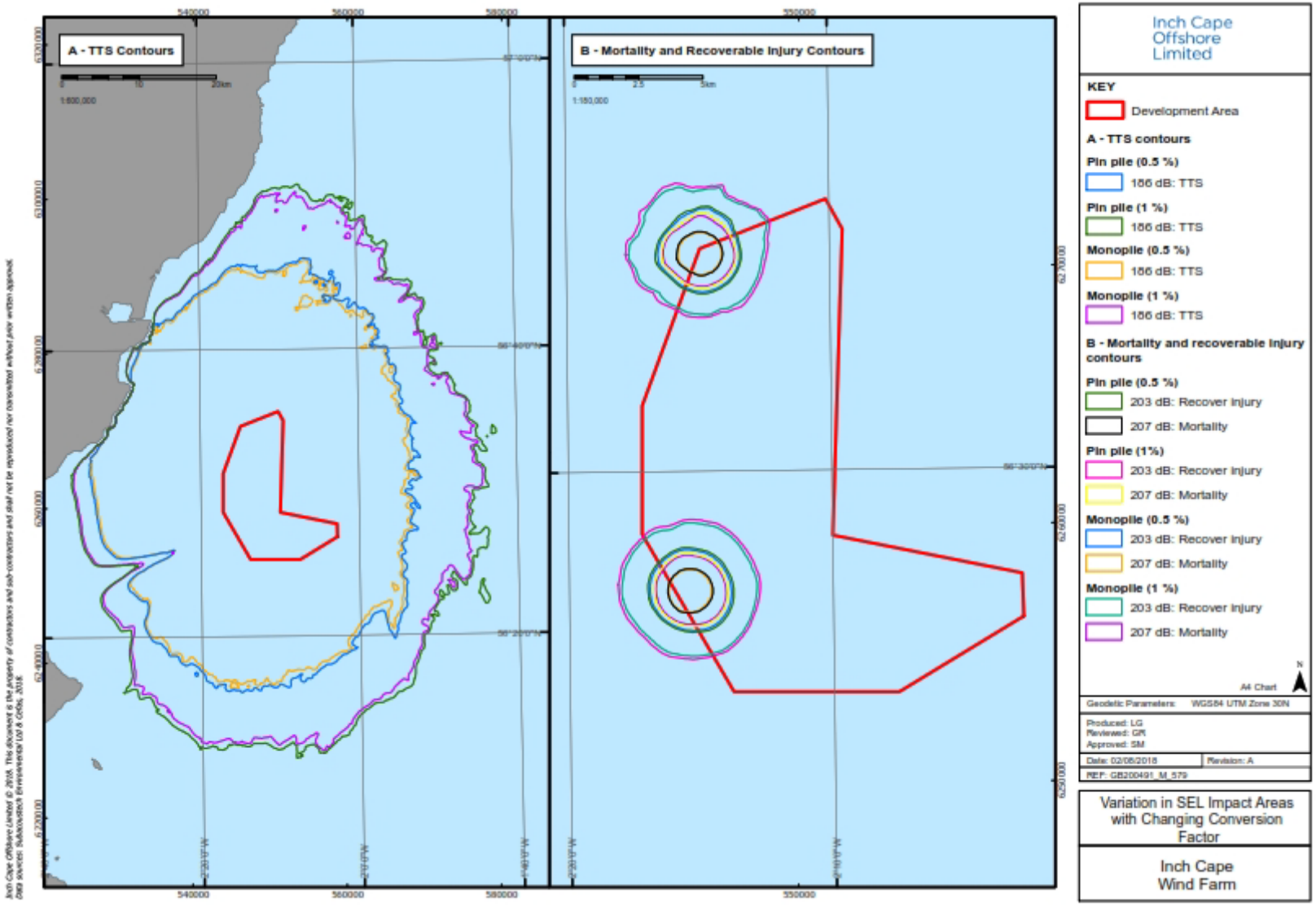
	Area (km^2)			
Model Parameter	**Pin Pile (0.5%)**	**Pin Pile (1%)**	**Monopile (0.5%)**	**Monopile (1%)**
Mortality	5	12	4	11
Recoverable Injury	17	45	15	41
TTS	1729	2686	1647	2573

89 With regard to the impacts to the herring spawning areas, although it is recognised that a greater extent of the defined spawning area is affected with the alternate modelling approach, it is considered that the significance of this assessment also does not change as the locations of highest use in the northerly areas of the defined spawning ground is still out with the predicted impact area.

90 For all other species included within the assessment, again it is recognised that a greater area of spawning and/or nursery grounds will be affected with the alternative modelling approach, however the extent of these impacted areas are still considered negligible in terms of the total area available to species.

91 In summary, if the alternate modelling with a 1% conversion factor were to be used in the consideration of impacts, it is considered that the assessment of significance would not change from that set out above.

Figure 9.8: Variation in SEL Impact Areas with Changing Conversion Factor



9.11 Cumulative Impact Assessment (CIA)

92 As agreed through the Scoping process, the projects considered within this cumulative assessment are only the other offshore wind farms located in the Firth of Forth and Tay area, namely:

- Neart na Gaoithe; and
- Seagreen (Alpha and Bravo).

93 For both projects, the worst case is considered to be the existing consented developments due to the larger number of turbines included which result in a greater duration of impact.

Neart na Gaoithe

94 The construction of Neart na Gaoithe is currently programmed to be between 2020 and 2022 (Mainstream, 2017). A maximum of 125 turbines with two Offshore Substation Platforms (OSPs) are proposed (with maximum of 4 piles per turbine with a hammer energy of 1635 kJ).

Seagreen

95 Construction work at the Seagreen projects is programmed to start in 2022 (Seagreen, 2017). A maximum of 75 turbines at each project (Alpha and Bravo) with up to five OSP's in total are proposed (with maximum of 4 piles per turbine and a total of 72 piles for all OSP's with a hammer energy of 1450 kJ).

9.11.1 Effects of Construction

Barrier effects, disturbance, or physical injury associated with construction noise

96 The following impact areas are considered as the worst case scenario for cumulative impacts of pin piling noise (defined as six piles at two locations per development in 24 hours) assessed against the Popper *et al.* (2014) criteria for hearing specialist fish:

- Mortality and mortal injury (207 decibel (dB)): 7.89 km^2
- Recoverable injury (203 dB): 29.22 km^2
- TTS (186 dB): 3,588.26 km^2

97 For monopiles, the cumulative impact areas are reduced slightly due to the reduction in total energy needed for monopile installation:

- Mortality and mortal injury: 7.38 km^2
- Recoverable injury: 27.64 km^2
- TTS: 3,535.37 km^2

98 The construction periods of the three developments have the potential for some overlap based on current construction timelines.

Herring

99 The areas affected at a level deemed able to cause mortal or injurious effects to herring are small across all developments (*Figures 9.9* and *9.10*), with mortal effects only becoming apparent after three successive piles (pin piles only). This delay to the onset of mortality effects, and the planned soft start procedure, is likely to reduce mortality effects through fish leaving the affected area in this time period.

100 The cumulative impacts of noise contours from the three developments for both pin pile and monopile options result in an increased area of disturbance (TTS) compared to the Development alone. Due to the project locations, this increased area of disturbance is predominantly focussed to the south and east of the Development Area.

101 The TTS contour for cumulative piling operations overlaps with the herring spawning grounds to a maximum area of 465.75 km^2. Spawning activity is not however uniformly distributed across the spawning ground with the data collected as part of the IHLS, along with commercial catch data indicating that the highest intensity of spawning activity falls outside the TTS noise contour in the northerly part of the spawning ground (*Figure 9A.8, Appendix 9A*). In addition, as herring are reported to be less sensitive to noise during the spawning season, this assessment can be considered to be conservative and actual disturbance effects may be reduced (Skaret *et al.*, 2005).

102 Therefore, although a proportion of the defined spawning area will be affected by the cumulative construction of all three developments, the area of affected habitat is not considered to represent an impact to key spawning areas.

103 In contrast to the well-defined spawning grounds (due to the substrate preferences), herring nursery grounds are less defined, and are thought to cover a large area of the North Sea (Ellis et al., 2012). As previously described, only those larvae moving south from the spawning grounds off the Aberdeenshire coast to nursery grounds along the east coast of the UK have the potential to be affected by the three developments.

104 However, the development of sensory hearing organs occurs in late stage larvae and so impacts on the larval population from piling noise will be limited, and comparable to the (scoped-out) non-hearing specialist species. The area of sea affected by increased levels of noise represents a small proportion of the area utilised by the larvae, and as such no measurable effect on the herring spawning population is predicted as a result of impacts of piling noise on herring larvae.

105 In summary, although a small area of the defined spawning grounds will be affected by piling noise cumulatively from the developments, the area predicted to be affected is not thought to represent key spawning habitat as larval and adult abundances in the area are consistently low to absent. Therefore, no loss of key habitat (or barrier to migration to it) is predicted. Interaction with herring larvae is considered a possibility due to the southerly direction of travel of this life stage, however only limited effects of piling noise are predicted due to the early life stages present, and the area affected represents a negligible fraction of the total

area of sea through which the larvae pass (also see above information on likelihood of non-auditory injury – section 9.10.1). As such, it is considered that the effect on herring will be of low magnitude and therefore is not considered significant for the purposes of this assessment.

Figure 9.9: Cumulative SEL interaction with herring spawning grounds – pin piles

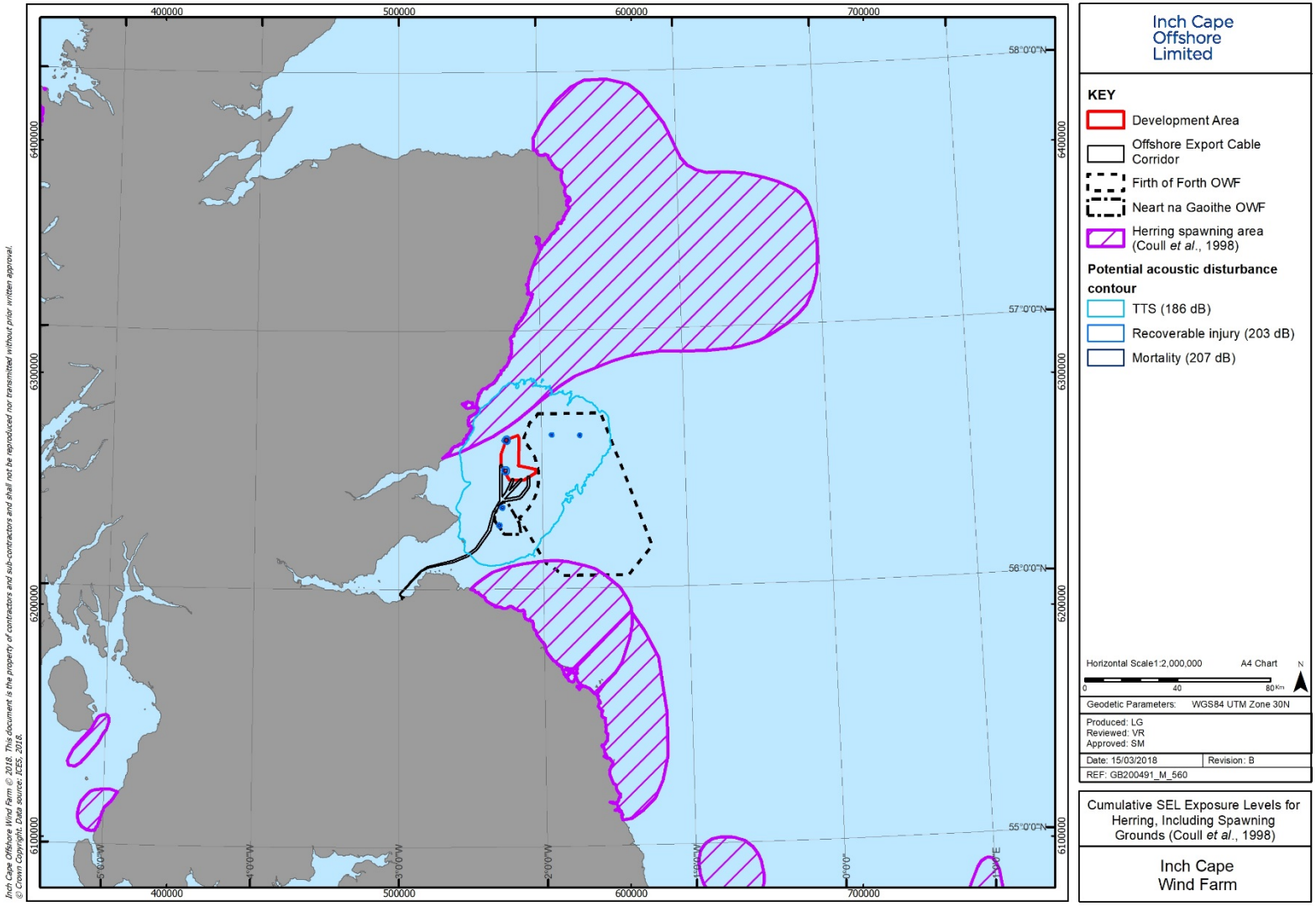
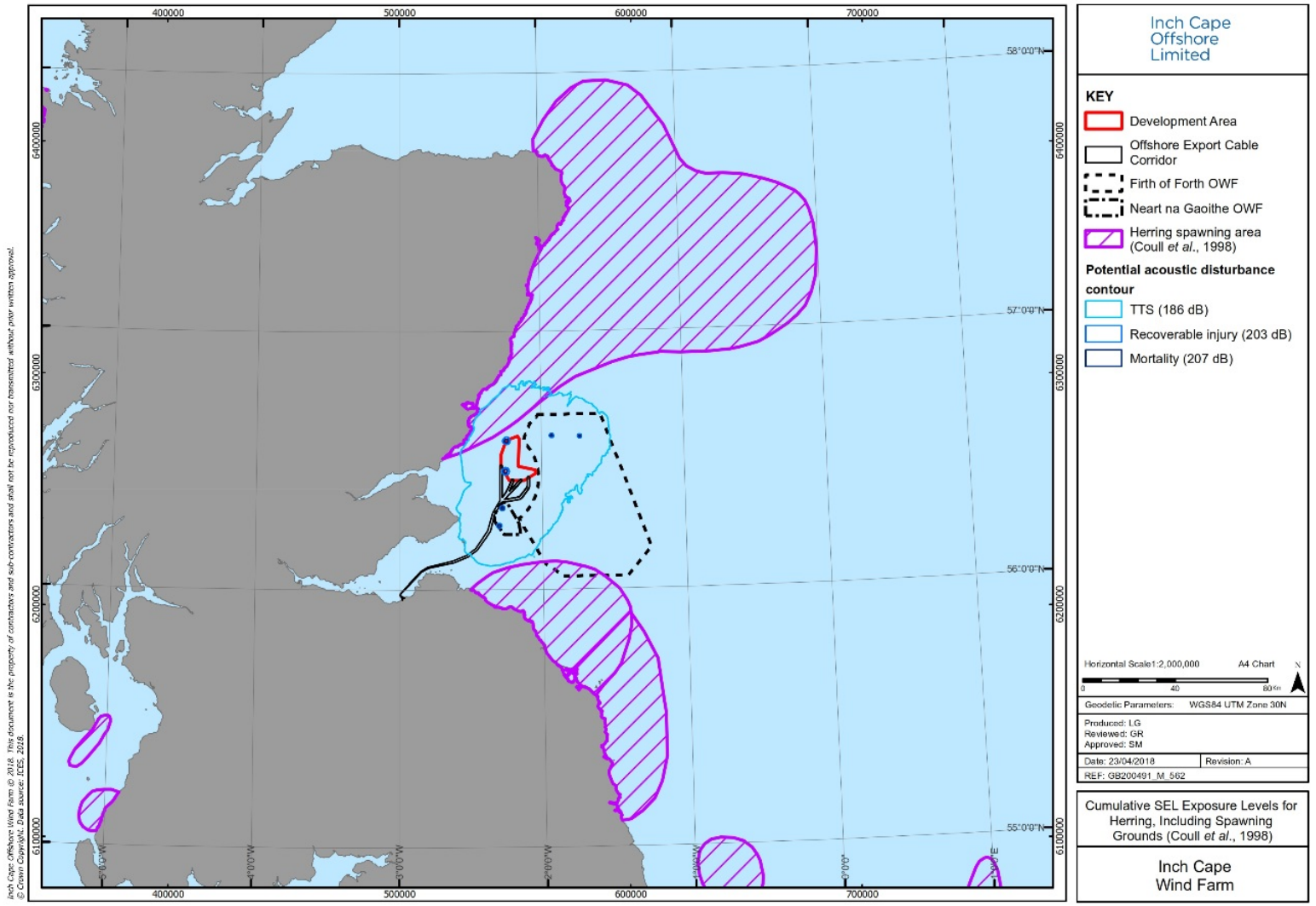


Figure 9.10: Cumulative SEL interaction with herring spawning grounds – monopiles



Sprat

106 The areas affected at a level deemed able to cause mortal or injurious effects are small across all developments, with mortal effects only becoming apparent after three successive piles (pin piles only). This delay to the onset of mortality effects, and the planned soft start procedure, is likely to reduce mortality effects through fish leaving the affected area in this time period.

107 The TTS cumulative noise contours interact with both spawning and nursery grounds for sprat. As both the spawning and nursery grounds are widespread within the North Sea (and around the UK) it is considered that the cumulative noise impacts will affect a negligible proportion of the overall area available. The magnitude is therefore considered to be negligible, and the cumulative effect of 'Barrier effects, disturbance, or physical injury associated with construction noise' on sprat is not deemed to be significant.

Cod

108 The areas affected at a level deemed able to cause mortal or injurious effects are small across all developments, with mortal effects only becoming apparent after three successive piles (pin piles only). This delay to the onset of mortality effects, and the planned soft start procedure, is likely to reduce mortality effects through fish leaving the affected area in this time period.

109 Although it is recognised that limited spawning could occur across the Development Area, the closest defined spawning area (Coull *et al.,* 1998) to the Forth and Tay projects is to the North East. Although there is some interaction with this spawning area with the influence of the TTS cumulative noise contours, the overlap is very small (Coull *et al.,* 1998). The TTS cumulative noise contours also interact with cod nursery grounds; Ellis *et al*. (2012) identified high intensity nursery areas extending from Aberdeen to the Humber with lower intensity nursery grounds throughout the North Sea. Due to the interaction of the cumulative noise contours with high intensity nursery areas and the small overlap with defined spawning areas, the magnitude is deemed to be low.

110 The cumulative impact of 'Barrier effects, disturbance, or physical injury associated with construction noise' on cod is therefore not deemed to be significant.

Shad

111 Shad (both twaite and allis) spawn in fresh water with no known spawning populations in Scottish east coast rivers. As a result, it can be concluded that there will be no impact on shad from the cumulative impact of 'Barrier effects, disturbance, or physical injury associated with construction noise'.

Summary of Significance of Cumulative Impact

112 Overall, the areas affected at a level deemed able to cause mortal or injurious effects to hearing specialist fish are very small. Although not included in the modelling due to uncertainty in fish behaviours, the planned soft start procedure is also likely to reduce mortality effects through fish leaving the affected area in this time period.

113 Some interaction with spawning and nursery habitats is expected, however such interactions are considered to not affect key areas of these habitats, or to affect such a small proportion that any effects are not considered significant.

114 Therefore, the cumulative effect of 'Barrier effects, disturbance, or physical injury associated with construction noise' on hearing specialists is not deemed to represent a significant effect for the purposes of this assessment due to the small areas over which individuals will be affected at mortal and recoverable injury levels, and the limited interaction with available or key spawning and nursery habitats.

115 Furthermore, considering the small increases in impacted areas observed in the site based assessment when altering the conversion factor in the noise model to 1%, it is considered that no changes to the assessment of significance would arise should a 1% conversion factor be applied cumulatively.

9.12 Impact Interactions

116 Potential impact interactions have been considered with both commercial fisheries, marine mammals and ornithological interests, whereby any impacts on natural fish could potentially influence availability of resource.

117 The impact assessment for natural fish solely focussed on hearing specialist (herring, sprat, cod and shad), as it was agreed that there would be no significant effect on any other species resulting from the Development. The impact assessment associated with hearing specialists has shown a non-significant effect for all of these species, and therefore any changes to fish ecology, or changes in spatial and temporal patterns, that may influence either commercial fishery, marine mammals ornithological interests is limited and therefore highly unlikely to lead to any significant interaction.

9.13 Additional Mitigation

118 No additional mitigation, over and above the embedded mitigation, is required as no significant impacts have been identified throughout this assessment.

9.14 Conclusion and Residual Effects

119 In line with the agreed scope of assessment, the impacts on hearing specialists from piling during the construction of the wind farms has been assessed. With the use of embedded mitigation the effect on all species is considered not significant, as shown in *Table 9.12* below.

Summary of Effects of Operation and Maintenance, Development Area

Table 9.12 Impacts on natural fish

Impact	Receptor	Sensitivity of the Receptor	Magnitude of Impact	Significance of Effect
Barrier effects, disturbance, or physical injury associated with construction noise.	Herring	Moderate	Low	Not significant
	Sprat	Moderate	Negligible	Not significant
	Cod	Moderate	Negligible	Not significant
	Shad	Moderate	No impact	Not significant

9.14.1 Cumulative Impacts

120 The cumulative impacts on hearing specialists from piling have been assessed with both NNG and Seagreen, as can be seen in *Table 9.13* no significant cumulative effects have been assessed.

Table 9.13 Impacts on natural fish

Impact	Receptor	Sensitivity of the Receptor	Magnitude of Impact	Significance of Effect
Barrier effects, disturbance, or physical injury associated with construction noise.	Herring	Moderate	Low	Not significant
	Sprat	Moderate	Negligible	Not significant
	Cod	Moderate	Low	Not significant
	Shad	Moderate	No impact	Not significant

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