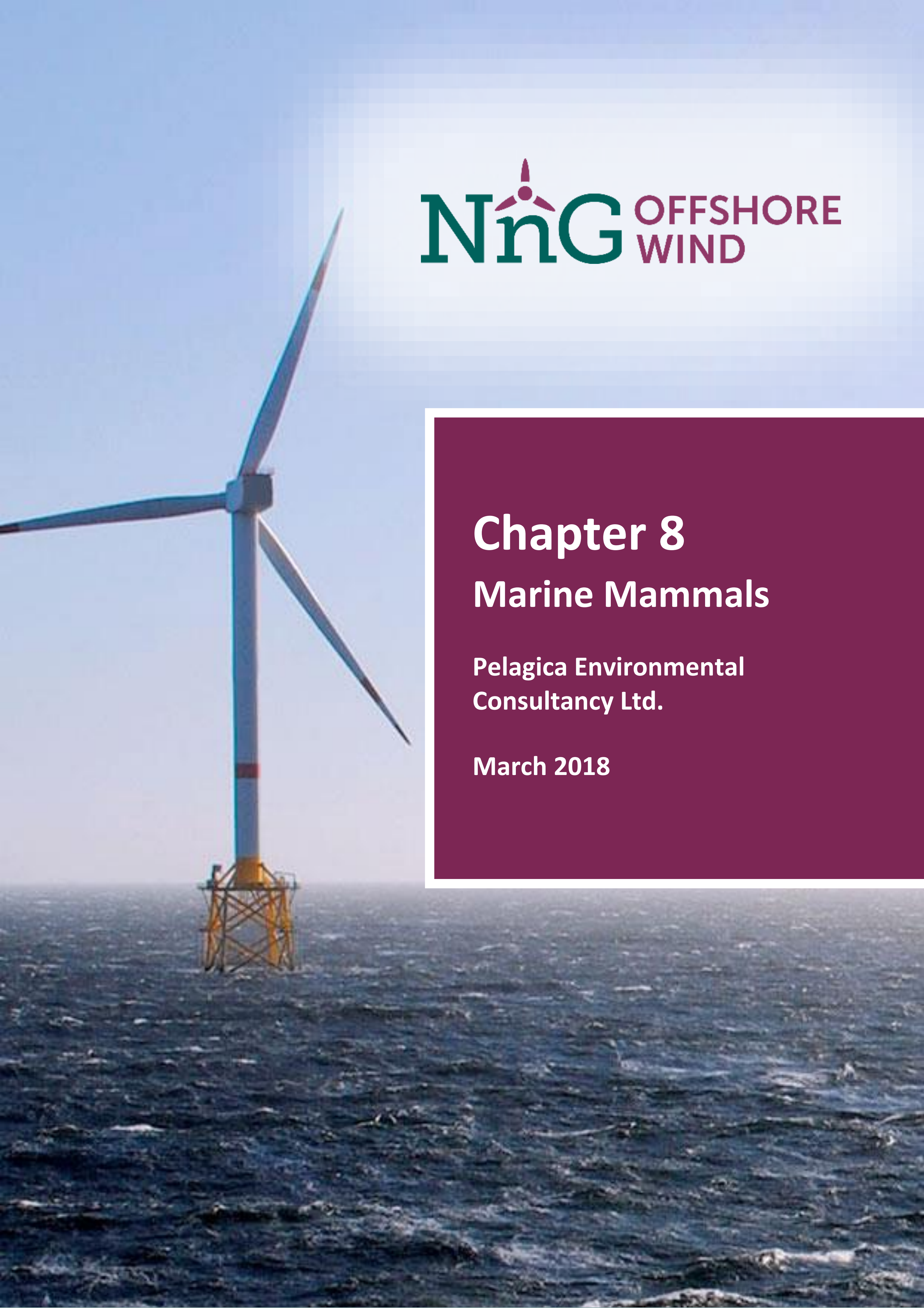

NnG OFFSHORE WIND

Chapter 8

Marine Mammals

Pelagica Environmental Consultancy Ltd.

March 2018

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8 Marine Mammals

8.1 Introduction

1. This chapter of the Environmental Impact Assessment Report (EIA Report) presents an assessment of the potential impacts upon marine mammals arising from the construction, operation and decommissioning of the Project, as detailed in Chapter 4: Project Description. This chapter has been drafted by Pelagica Environmental Consultancy Ltd. (Pelagica) with underwater noise (Genesis 2017a) and interim PCoD modelling undertaken by Genesis Oil and Gas Consultants Ltd. (Genesis 2017b).
2. The assessment is based upon a combination of the understanding of the Project in terms of the potential for impact and the resultant effects on receptors that were identified as present within the study area along with the results from project specific noise modelling as detailed within Appendix 8.1
3. This chapter is comprised of the following elements:
   - A summary of relevant guidance, policy and legislation;
   - Details of the data sources used to characterise the study area;
   - A summary of the relevant consultations with stakeholders;
   - A description of the methodology for assessing the impacts of the Project, including details of the study area and approach to the assessment of potential effects;
   - A review of the baseline conditions;
   - A description of the worst-case design scenario relevant to marine mammals;
   - An assessment of the likely effects for the construction, operation and decommissioning phases of the Project, including cumulative effects;
   - Identification of any further mitigation measures or monitoring requirements in respect of any likely significant effects;
   - A summary of the residual impact assessment determinations taking account of any additional mitigation measures identified.
4. It should be noted that there have been no significant changes to the marine mammal baseline since the original application was made, although new information has become available and has been used within this assessment. There have also not been any changes made to the Project that would likely affect the magnitude of impacts on marine mammals predicted in the original application. In particular, the maximum hammer energy of 1,635 kJ being used to install piles has remained the same and the overall number of piles to be installed has been reduced. Consequently, the level of impact from construction noise on marine mammals from the Project is predicted not to be no greater than has previously been assessed and consented. However, the potential cumulative impacts may have changed with increased hammer energies being considered by other wind farm developments in the Firths of Forth and Tay. Following advice received in the Scoping Opinion the approach to undertaking the assessment of impacts from noise on marine mammals has changed since the original application was made (Marine Scotland 2017a).

8.2 Guidance and Legislation

5. Marine mammals are protected under a range of national and international legislation, details of which are presented below and listed in Table 8.1.

European Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora.

6. Known as the Habitats Directive, the main objectives of the Directive are:

"...to contribute towards ensuring biodiversity through the conservation of natural habitats and of wild fauna and flora in the European territory of the Member States to which the Treaty applies" (Article 2.1); and

"...to maintain or restore, at favourable conservation status, natural habitats and species of wild fauna and flora of Community interest" (Article 2.2)

7. The Directive requires Member States to identify sites collectively known as Natura 2000 sites, which includes Special Areas of Conservation (SAC) that host particular habitats or species as listed in Annexes I and II of the Directive. Four species of marine mammal: harbour porpoise (*Phocoena phocoena*), bottlenose dolphin (*Tursiops truncatus*), grey seal (*Halichoerus grypus*) and harbour seal (*Phoca vitulina*) are listed in Annex II of the Directive.

8. The Directive also requires Member States to provide strict protection to all species listed in Annex IV of the Directive, this includes all species of cetacean.

***Conservation (Natural Habitats, &c.) Regulations 1994 (as amended), Conservation of Habitats and Species Regulations 2017* and Conservation of Offshore Marine Habitats and Species Regulations 2017 (together the "Habitats Regulations")**

9. In Scotland, the Habitats Directive has been transposed into domestic law by the Habitats Regulations. The Conservation (Natural Habitats, &c.) Regulations 1994 (as amended) apply in relation to the terrestrial environment and in territorial waters out to 12 nautical miles (nm), with the exception of certain matters, such as the consideration of Section 36 consent applications, in relation to which the Conservation of Habitats and Species Regulations 2017 apply. The Conservation of Offshore Marine Habitats and Species Regulations 2017 apply to UK territorial waters outside 12 nm.

10. The Habitats Regulations require:

(1) A competent authority, before deciding to undertake, or give any consent, permission or other authorisation for, a plan or project which–

(a) is likely to have a significant effect on a European site or a European offshore marine site (either alone or in combination with other plans or projects), and

(b) is not directly connected with or necessary to the management of the site,

must make an appropriate assessment of the implications of the plan or project for that site in view of that site's conservation objectives.

(2) A person applying for any such consent, permission or other authorisation must provide such information as the competent authority may reasonably require for the purposes of the assessment or to enable it to determine whether an appropriate assessment is required.

11. The information to inform an appropriate assessment is presented separately in the HRA Report, which accompanies the Application.

12. Animals and plants listed in Annex IV of the Habitats Directive, whose natural range includes any area in Great Britain, are referred to within the Habitats Regulations as European protected species (EPS) of animals and plants. They are species of European Community Interest in need of strict protection (SNH 2015).

13. Species listed in Annex IV of the Directive include porpoises and all species of dolphin and whale and are protected under the Habitats Regulations. In Scotland, it is an offence, with certain exceptions, to

- Deliberately or recklessly:
- Capture, injure or kill any wild animal of a European protected species;
- Harass such an animal or group of animals;
- Disturb such an animal while it is rearing or otherwise caring for its young;

- Obstruct access to a breeding site or resting place, or otherwise deny the animal use of the breeding site or resting place;
- Disturb such an animal while it is occupying a structure or place used for shelter or protection;
- Disturb such an animal in a manner that is, or in circumstances which are, likely to significantly affect the local distribution or abundance of the species to which it belongs;
- Disturb such an animal in a manner that is, or in circumstances which are, likely to impair its ability to survive, breed or reproduce, or rear or otherwise care for its young; or
- Disturb such an animal whilst migrating or hibernating.

14. These offences apply to all stages of the animal's life, and all stages of the biological cycle of the plants (SNH 2015).

Deliberate Injury Offence

15. The term "deliberate" has been interpreted as including indirect but foreseeable actions and the deliberate injury offence has been interpreted as occurring if a cetacean receives a sound exposure level, which may cause permanent threshold shift in hearing (JNCC 2010a).

Disturbance Offence

16. A disturbance offence may occur if the level of disturbance is likely to:

- Impair the ability to survive, to breed or reproduce, or to rear or nurture their young, or migrate,
- Affect significantly the local distribution or abundance.

17. The risk of a disturbance offence in respect of marine mammals will exist if there is sustained noise in an area and/or chronic noise exposure, as a result of an activity (JNCC 2010a).

18. The Habitats Regulations provide a licensing regime for certain activities that might otherwise constitute an offence in respect of EPS. The information to inform possible future EPS licence applications is presented in Appendix 8.3.

Marine Strategy Framework Directive

19. The main aim of the Marine Strategy Framework Directive is to achieve Good Environmental Status of EU marine waters by 2020. It requires EU Member States to develop marine strategies that apply an ecosystem approach to the management of human activities while enabling sustainable use of marine goods and services. It applies to all human activities that have an impact on the marine environment.

20. In order to determine Good Environmental Status a number of high level descriptors are specified within the Directive, one of which is the '*Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment*'. The initial purpose of this descriptor is to assess the overall pressure from manmade noise on the marine environment and the UK has produced a marine noise register, which requires noise, particularly impulsive noise, to be reported.

Marine (Scotland) Act 2010

21. The Marine (Scotland) Act 2010 re-enacts the Conservation of Seals Act 1970. Under Section 117 of the Marine (Scotland) Act specific seal haul out sites have been designated to provide additional protection for seals from intentional or reckless harassment. It is an offence under the Act to intentionally or recklessly harass seals at these sites. Within the Firths of Forth and Tay areas three haul out sites have been designated under the Act. Haul out sites within the Isle of May SAC and the Berwickshire and Northumberland Coast SAC are designated for grey seal and the haul out sites in the Firth of Tay and Eden Estuary SAC are protected for harbour seal.

Nature Conservation (Scotland) Act 2004.

22. The Nature Conservation (Scotland) Act 2004 sets out a series of measures, which are designed to conserve biodiversity and to protect and enhance the biological and geological natural heritage of Scotland. The Act makes amendments to the Wildlife and Countryside Act 1981 in Scottish waters, including the addition of 'reckless' acts to species protection, which make it an offence to intentionally or recklessly disturb a cetacean. The Act also implements the requirements of the Bern Convention 1979.

Wildlife and Countryside Act 1981

23. Section 9(4A) of the Act makes it an offence to intentionally or recklessly disturb or harass a wild animal listed in Schedule 5 and both whales and dolphins are listed in Schedule 5 of the Act.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) 1973.

24. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) has been implemented at a European level through a set of Regulations known as the EU Wildlife Trade Regulations, which includes Council Regulation 338/97 on the protection of species of wild fauna and flora by regulating trade therein, and in the UK (in respect of enforcement) through the Control of Trade in Endangered Species (Enforcement) Regulations 1997 (COTES. It aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival in the wild. Species covered under CITES are listed in three appendices according to the level of protection required. Appendix I includes species threatened with extinction, Appendix II includes species not necessarily threatened with extinction, but in which trade must be controlled and Appendix III contains species protected in at least one country. The minke whale appears on Appendix I with white-beaked dolphin and harbour porpoise appearing on Appendix II. All cetaceans are listed in Annex A of Council Regulation 338/97.

Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) 1979.

25. The Bern Convention is intended to promote cooperation between Contracting Parties in order to conserve wild flora and fauna and their natural habitats and to protect endangered and vulnerable species (including endangered and vulnerable migratory species). The Convention is largely implemented through the EU Habitats Directive (92/43/EEC). The obligations of the Convention are transposed into national law by means of the Wildlife and Countryside Act 1981 (as amended) and Nature Conservation (Scotland) Act 2004 (as amended). The Convention prohibits the deliberate killing and significant disturbance of species listed in Appendix II and requires that any exploitation of species listed in Appendix III is regulated. Most cetaceans (including harbour porpoise, minke whale, orca, white-beaked dolphin and bottlenose dolphin) are listed in Appendix II and seals (including grey seal and harbour seal) are listed in Appendix III.

Convention on the Conservation of Migratory Species of Wild Animals (CMS or Bonn Convention) 1979.

26. The Convention on the Conservation of Migratory Species of Wild Animals (CMS or Bonn Convention) aims to conserve migratory species throughout their range, with species that need, or would benefit from, international co-operation. Appendix II of the Convention covers migratory species that have an unfavourable conservation status and that require international agreements for their conservation and management. Species listed in Appendix II includes bottlenose dolphin, white-beaked dolphin (*Lagenorhynchus albirostris*) and harbour porpoise. Under the Bonn Convention, the UK ratified the Agreement on the Conservation of Small Cetaceans in the Baltic, North-East Atlantic, Irish and North Seas (ASCOBANS).

Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS) 1994 – amended in 2008 to the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas.

27. The Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) implements the requirements of the Bonn Convention and aims to promote close cooperation amongst Parties with a view to achieving and maintaining a favourable conservation status for small cetaceans, including the bottlenose dolphin, white-beaked dolphin and harbour porpoise.

Convention for the Protection of the Marine Environment of the North-East Atlantic 1998 (OSPAR Convention)

28. The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) aims to provide a comprehensive and simplified approach to addressing issues associated with maritime pollution. Additionally, OSPAR also provides for the '*protection and conservation of the ecosystem and biological diversity of the maritime area*', which includes criteria for identifying human activities and work on Marine Protected Areas (MPAs). There is an agreed list of threatened and declining species that includes harbour porpoise. Although not legally binding the purpose of the list is to strengthen the protection of the harbour porpoise at all life stages in order to recover its population, to improve its status and to ensure that the population is effectively conserved. Contracting Parties should consider establishing measures to reduce or avoid disturbing and/or harmful acoustic effects to harbour porpoises especially from seismic surveys, pile driving, shipping traffic, military activities and underwater explosions.

Table 8.1: Legislation and relevant species

Legislation / Conventions	Relevant Species
Habitats Directive	Cetaceans, grey and harbour seal
Habitats Regulations	Cetaceans, grey and harbour seal
Marine Strategy Framework Directive	Cetaceans and seals
Marine (Scotland) Act 2010	Seals
Wildlife and Countryside Act 1981 (as amended)	Cetaceans
Nature Conservation (Scotland) Act 2004	Cetaceans
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) 1973	Cetaceans
Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) 1979	Cetaceans, grey and harbour seal
Convention on the Conservation of Migratory Species of Wild Animals (CMS or Bonn Convention) 1979	Cetaceans
Agreement on the Conservation of Small Cetaceans in the Baltic and North Seas (ASCOBANS) 1994 – amended in 2008 to the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas.	Small cetaceans regularly occurring in the Baltic, North East Atlantic, Irish and North Seas
OSPAR Convention (Convention for the Protection of the Marine Environment of the North-East Atlantic) 1998	Harbour porpoise

29. There are also a number of published guidance documents providing information on impact assessments that have been used to inform the marine mammal chapter including:

- European Guidance on wind energy development in accordance with the European Union (EU) nature legislation (EC 2010),
- Oslo Paris Convention (OSPAR) Guidance on Environmental Considerations for Offshore Wind Farm Development (OSPAR 2008),
- Natura 2000 Conservation Guidelines on Offshore Wind Farm Development (Defra 2005).
- Scottish Natural Heritage (SNH) guidance on Habitats Regulation Appraisal (Tyldesley and Associates 2015,
- Chartered Institute for Ecology and Environmental Management (IEEM) Guidelines for Ecological Impact Assessment in Britain and Ireland (Marine and Coastal) (IEEM 2010).

8.3 Favourable Conservation Status

30. Favourable conservation status (FCS) is defined in Article 1 (i) of the Habitats Directive as follows:

- "Conservation status of a species means the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations within the territory referred to in Article 2. The conservation status will be taken as 'favourable' when:
  - Population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats;
  - The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future; and
  - There is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis."

31. The Favourable Conservation Status for the relevant marine mammals and the regional Management Unit populations are presented in Table 8.2.

Table 8.2: Favourable Conservation Status of marine mammals considered in this assessment

Species	FCS assessment	Regional Management Unit population
Harbour porpoise	Favourable	227,298 (95% CI 176,360 - 292,948) **333,808**
Bottlenose dolphin	Unfavourable	195 (95% HDPI 162 – 253)
White-beaked dolphin	Favourable	15,895 (95% CI 9,107 – 27,743) **35,908**
Orca	Unknown	Unknown 1,000's
Minke whale	Favourable	23,528 (95% CI=13,989-39,572) **11,819**
Grey seal	Favourable	9,607 (95% CI 8,028 – 11,958)
Harbour seal	Unfavourable	311 (95% CI 254 - 415)

Regional Management Unit population is based on IAMMWG (2015). Bottlenose dolphin population is based on the Coastal East Scotland population from Cheney *et al*. (2013).

Figures in bold are the latest management unit population estimates (JNCC 2017)

Grey and Harbour seal population estimates are the adjusted total for the East Coast Management Area.

Note: Seals are not listed under Annex IV of the Habitats Directive but are listed in Annex II and Annex V.

32. The status of a population becomes unfavourable should it decline by more than 1% per year or if there is an overall decrease in the population by more than 25% (European Commission, 2005).

8.4 Designated Sites

33. Four SACs along the east coast of Scotland and northern England have qualifying marine mammal species whose populations may make use of the Offshore Wind Farm Area (Figure 8-1). These SACs are:

- Isle of May (grey seal);
- Firth of Tay and Eden Estuary (harbour seal);
- Moray Firth (bottlenose dolphin); and
- Berwickshire and North Northumberland Coast (grey seal).

34. Given the potential connectivity of the proposed Project with these SACs, there is a requirement to consider the effects arising from the development of the Project in terms of the potential impacts on the integrity of these SACs. This is known as a Habitats Regulation Appraisal (HRA) and is required by the Habitats Directive (and transposing regulations). Further detailed information on HRA, including the legislative background and presentation of relevant information to inform an Appropriate Assessment, is provided separately in support of the consent applications (Habitats Regulations Appraisal Report, Document Ref. UK02-0504-0742-MRP-HRA_REPORT-RPT-A2).

35. The Southern North Sea cSAC, for which harbour porpoise is a qualifying species, is in excess of 100 km from the Project and therefore there is no potential for connectivity between impacts arising from planned activities relating to the proposed Project and the qualifying species within the site.

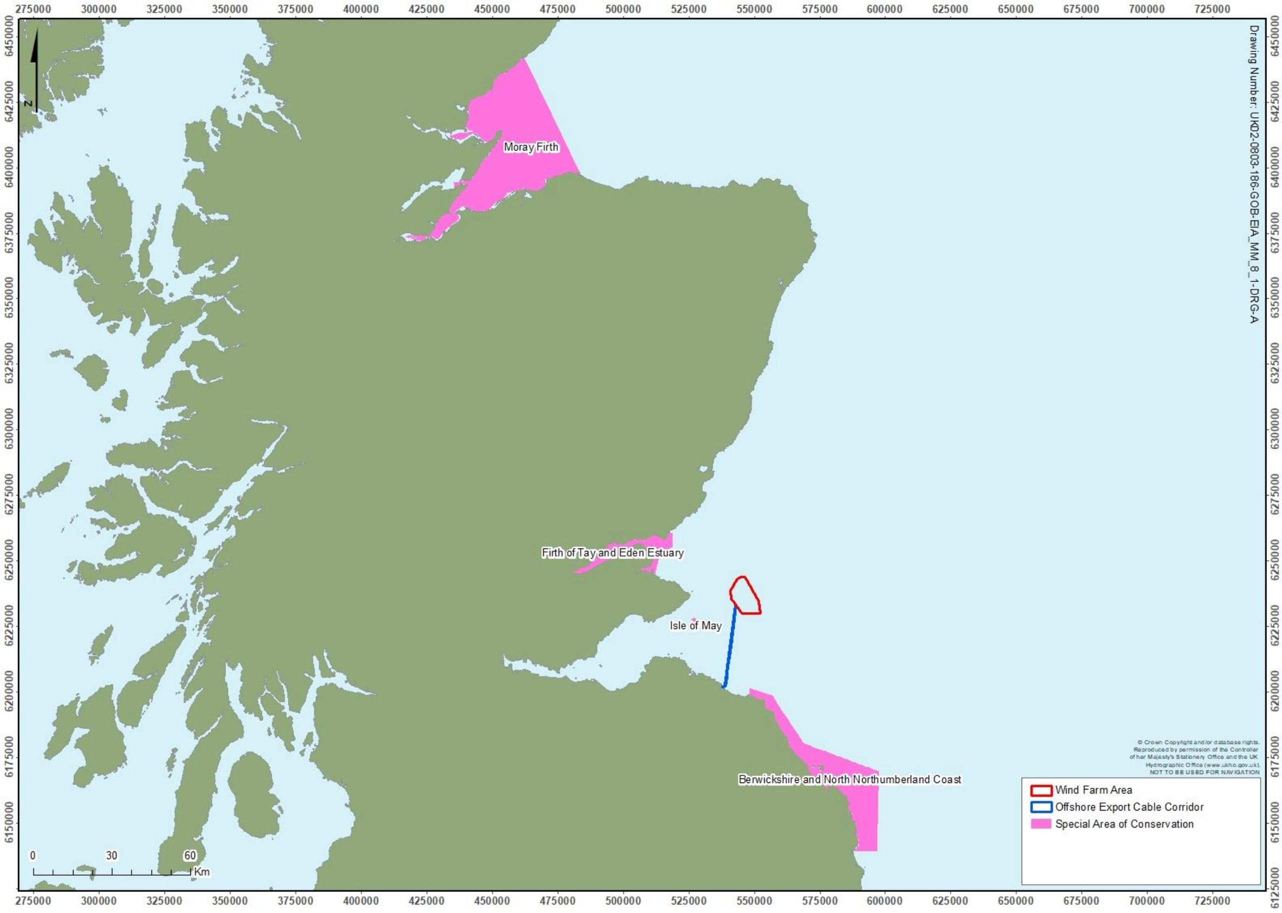


Figure 8-1: SACs identified as having qualifying species at risk of being impacted by the proposed Project

8.5 Data Sources

36. The assessment conducted considers the potential interaction between the Project, as described in Chapter 4: Project Description, and the marine mammal receptors, including their prey, that may be present within the study area.

37. Baseline characterisation data has been collated combining a thorough desk-based study of extant data supplemented with a series of site-specific surveys. Table 8.3 details the data sources used to inform the baseline characterisation within the study area.

Table 8.3: Data sources used to inform the baseline characterisation within the study area

Data Source	Study/Data Name	Overview
NnGOWL	Site specific marine mammal survey data 2009 – 2012. (NnGOWL, 2012; 2013).	Site specific marine mammal survey data collected monthly from between November 2009 and October 2012. The surveys covered the wind farm area and surrounding waters out to 8 km from the Wind Farm Area boundary.
SMRU	*Cetacean baseline characterisation for the Firth of Tay based on existing data: Bottlenose dolphins* (Quick and Cheney, 2011).	The report provides background information on bottlenose dolphins to inform site assessments. It presents the spatial and temporal extent of bottlenose dolphins in the region and their abundance. The report also assesses the connectivity of bottlenose dolphins between the Tay and the Moray Firth SAC.

Data Source	Study/Data Name	Overview
SMRU	*Assessment of The Crown Estate aerial survey marine mammal data for the Firth of Forth development areas* (Macleod and Sparling, 2011)	The report provides an overview of the marine mammal data collected from aerial surveys commissioned by The Crown Estate during 2009 and 2010.
SMRU	*Analysis of The Crown Estate aerial survey data for marine mammals for the FTOWDG*. (Grellier and Lacey, 2011)	The report presents the results of analysis undertaken on the marine mammals recorded from aerial surveys undertaken during 2009 and 2010. It presents estimates of abundance and densities for harbour porpoise, white-beaked dolphin and 'all seals'.
NnGOWL	*Marine Ecological Research, Marine Mammal Acoustic and Visual Surveys - Analysis of Neart Na Gaoithe data* (Gordon, 2012)	By using site specific acoustic and visual data collected over two years between November 2009 and October 2011, estimated densities of harbour porpoise and grey seal within the offshore wind farm area were calculated.
Forth and Tay Offshore Wind Developers Group (FTOWDG)	*Baseline seal information for the Forth and Tay area* (Sparling *et al.* 2012)	The report presents an analysis of existing satellite telemetry and aerial survey data to describe the abundance and distribution of harbour and grey seals in the Firths of Forth and Tay, specifically to inform site specific and cumulative assessments of the likely nature and extent of potential impacts from the development of offshore wind farms in the region.
DMP Statistical Solutions Ltd	*Forth and Tay Offshore Wind Developers Group: Cetacean surveys data analysis report* (Mackenzie *et al*. 2012).	The document presents the results of the statistical analyses of marine mammal survey data for the FTOWDG. The report presents spatial surfaces and associated estimates of abundance for harbour porpoise, white-beaked dolphin and minke whale.
University of Aberdeen	*Integrating multiple data sources to assess the distribution and abundance of bottlenose dolphins Tursiops truncatus in Scottish waters* (Cheney *et al*. 2013).	Using multiple sources of data, the report presents a comprehensive assessment of the abundance of bottlenose dolphins in the inshore waters of Scotland.
JNCC	*Management Units for cetaceans in UK waters* (January 2015) (IAMMWG 2015).	The report sets out the final agreed Management Units (MUs) for the seven most common cetacean species in UK waters. Details of each MU are provided, including boundaries and estimated abundance figures.
University of St Andrews	*Estimates of cetacean abundance in European Atlantic waters in summer 2016 from the SCANS-III aerial and shipboard surveys* (Hammond *et al*. 2017).	This report presents the initial results from the latest SCANS III surveys. It provides the latest cetacean population estimates.
University of St Andrews and Marine Scotland	*Categorizing click trains to increase taxonomic precision in echolocation click loggers* (Palmer *et al*. 2017).	Paper presents the findings from C-PODs deployed to detect dolphins in the Moray Firth and along the east coast of Scotland during 2013. Using newly developed statistical techniques to separate bottlenose and white-beaked dolphin vocalisations the relative encounter rates of both species within the region are presented.

Data Source	Study/Data Name	Overview
ECOMMAS	*The East Coast Marine Mammal Acoustic Study data. doi: 10.7489/1969-1* (Brookes, K. 2017).	Data from C-PODS deployed at ten locations in the Moray Firth and along the east coast of Scotland between 2013 and 2016.

8.6 Relevant Consultations

38. As part of the EIA process, NnGOWL has consulted with various statutory and non-statutory stakeholders. A formal scoping opinion was requested from MS-LOT following submission of the Scoping Report. Ongoing consultation with stakeholders continued post-scoping and responses have been used to develop an appropriate methodology and parameters for assessment.

39. In response to the scoping request, MS-LOT issued a Scoping Opinion identifying the impacts to be scoped into the assessment. A summary of the main issues raised during scoping and through other consultations are summarised in Table 8.4.

Table 8.4: Summary of consultation relating to marine mammals

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
3 April 2017. **NnGOWL Pre-Scoping Discussion, Seabirds and Marine Mammals with SNH**	SNH advised that it was not necessarily essential to update the noise modelling if it could be shown that the magnitude of any potential impacts had not increased since the application was made.	Due to the revised approach to modelling and changes in the thresholds at which noise may impact upon marine mammals, Revised noise modelling has been undertaken.
	It was agreed that the use of dBht, as previously used, was not now considered the most appropriate approach to use.	The use of dBht as a metric to assess impacts from noise on marine mammals has not been used in this assessment (See Appendix 8.1: Noise modelling).
	NnGOWL advised that the information required for an EPS licence application would be presented within the future application.	See Appendix 8.3: EPS Licence Assessment.
13 June 2017 **NnGOWL Scoping Meeting with MS-LOT, Marine Scotland Science (MSS) and SNH**	It was confirmed by MS and SNH that no new baseline survey data would be required for the application.	Information on the baseline data used can be found in Section 8.8.1 (Baseline surveys).
	As per the scoping document, the focus of the assessment is to be on construction noise, i.e. piling noise and potential impacts on marine mammals from other activities and noise sources could be scoped out of the EIA. No concerns were raised during the meeting about the approach taken in the scoping document.	Information on the scope of the EIA is presented in Table 8.23.
	Noise modelling presenting results based on both the Southall and NOAA thresholds should be presented within the application.	Both are presented, see Appendix 8.1: Noise modelling

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	SNH advised that an assessment of potential impacts from Acoustic Deterrent Devices (ADD) should be included in the EIA.	The use of ADDs are addressed in Section 8.11.
	Population Viability Analysis (PVA) modelling would be used to help determine possible population level effects from disturbance on bottlenose dolphins. MSS advised that the use of the interim PCoD model should be considered within the EIA.	The interim PCoD model has been used in this assessment (See Appendix 8.2: Interim PCoD modelling and Sections 8.10.6 and 8.10.12).
27 June 2017-10-11 **NnGOWL marine mammal meeting with Whale and Dolphin Conservation (WDC)**	WDC advised that impacts from helicopters should be addressed in the new application.	See Section 8.10.9.1.
	WDC advised that if ADDs were to be used then these would need to be assessed in the EIA.	See Section 8.11.
8 September 2017 Scoping Opinion – Scottish Ministers	The Scottish Ministers agree that the baseline detailed in the Original ES is still valid and note that the other data now available that can be used to ensure the information is the most up to date.	Section 8.8 includes an updated baseline description and uses latest published information.
	The Scottish Ministers agree that bottlenose dolphin, harbour seal, grey seal, harbour porpoise, minke whale and white-beaked dolphin should be included in the EIA.	Section 8.8 and 8.10 consider the potential impacts on these species.
	MSS agree with the developer and SNH that the assessment will need to cover the impact of increasing the energy of the hammer used to install the piled foundations. MSS also agree that since the other potential impacts to marine mammals are the same, or reduced, compared with the original ES, that this is the only area that requires consideration in the Project EIA.	Since the Scoping Opinion was issued, there was some discussion regarding a potential increase to hammer energy, compared with that presented in the Scoping Report. It was subsequently established this would not be required and that maximum hammer energy would remain the same as the Original Application. See Chapter 4: Project description.
	The Scottish Ministers agree that the IAMMWG 2015 figures for the cetacean reference populations and the additional references suggested by SNH should be used. The Scottish Ministers confirm that the approach agreed at the Inch Cape workshop on 27 July 2017, and described above, with regard to bottlenose dolphin distribution should be used.	IAMMWG reference populations have been used but also more up to date SCANS III survey abundances have been used. (See species accounts in Section 8.8)
	The Scottish Ministers agree that: • The management units based on the IAMMWG (2015) guidance should be used. • If available, the SCANS-III surveys should be used for abundance estimates as these are the most up to date, if not available	The Management Units as described in the IAMMWG (2015) are recognised with the exception of bottlenose dolphin, which is based on

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	then the IAMMWG (2015) guidance should be used. • The most up to date SCANS-III survey results for Block R should be used to provide a regional abundance estimate for use within the assessment. • Distribution data for these species can be taken from the Original ES, unless other more recently published data are available.	advice received in the Scoping Opinion. Management Units based on SCAN III data has been used for abundance estimates. SCANS III survey data from Block R have been used in the assessment for regional abundances. Distribution data has been updated to include a third year of survey results that were obtained following the submission of the Original Development ES. (See species accounts in Section 8.8)
	The Scottish Ministers agree that the Special Committee of Seals (SCOS) seal management units and population estimates are used and advise that the seal usage maps produced by [the] Sea Mammal Research Unit (SMRU) are used for distribution data on both species.	The SCOS seal management units are included and figures produced by SMRU are presented for both species of seal in in Section 8.8.
	Both instantaneous and cumulative permanent threshold shift (PTS) should be presented, modelled for each of the species. The total number of individuals from each species that may suffer PTS and the number that may be displaced through disturbance should be presented.	Detailed noise modelling has been undertaken in support of this assessment. The methods and results are presented in Appendix 8.1: Noise modelling
	Swim speeds as outlined by SNH in the guidance note should be used along with information provided by SMRU in relation to bottlenose dolphin swim speeds (which can be used as a proxy for white-beaked dolphin).	These have been used in the noise modelling (Appendix 8.1: Noise modelling).
	Fleeing should be considered to begin from the start of ADD use.	The use of ADD by the Project has not been confirmed yet and is discussed as possible mitigation (Section 8.11).
	PTS thresholds from both Southall *et al.* (2007) and the NOAA (2016) should be presented.	Outputs from noise modelling based on both Southall and NOAA thresholds are presented in Appendix 8.1: Noise Modelling. The assessment is based on the NOAA thresholds. These are the latest published information on marine mammal hearing thresholds and present the worst-case scenario.

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	A dose response curve should be used to determine the proportion of animals likely to be disturbed sufficiently to displace them by piling noise. NnGOWL should take into account the concerns noted above about the use of the Horns Rev II and make use of other relevant data as noted above, in particular the data from the Beatrice Offshore Wind Farm in relation to piling if available.	Presented in Appendix 8.1: Noise Modelling.
	The Scottish Ministers advise that, for bottlenose dolphin, an assessment of the impacts of the Revised Development alone on the East Scotland management unit population as well as cumulatively with other developments that may impact on the same population is required. NnGOWL should ensure that the information provided can be used for an Appropriate Assessment in relation to the Moray Firth SAC.	The relevant information can be found in Appendix 8.1: Noise Modelling, and the Habitats Regulations Assessment
	The Scottish Ministers advise for harbour porpoise, minke whale, white-beaked dolphin, harbour seal and grey seal that further assessment is only carried out if the effects of the Revised Development are found to be greater than those assessed for the Original Development.	Due to the revised noise modelling undertaken and the latest thresholds at which the onset of physical injury is predicted to occur, further assessment has been undertaken on all marine mammals identified as being at risk of a significant impact from noise during the construction phase. (Section 8.10)
	The Scottish Ministers request that, where necessary, the information is provided in a form that means it can be used for the EPS process or, where needed, to inform the Appropriate Assessment as part of an HRA.	Appendix 8.3 presents the information in a form that means it can used for the EPS application process should an EPS licence be required.
	The Scottish Ministers advise that the interim PCoD framework is used for species where population level impact assessments are undertaken. The Scottish Ministers request that a comprehensive list of the parameters input and other relevant information to allow MSS to be able to replicate the analysis is provided. As a minimum this must include: • The piling schedule, • The demographic parameters, • Starting population size, • Copy of the code used to run the model, • Any quality assurance/quality control outputs that the software produces, • The Scottish Ministers advise that the results of the assessment using interim PCoD should be presented using the	Appendix 8.2: Interim PCoD modelling presents the information relating to the interim PCoD.

Date and consultation phase / type	Consultation and key issues raised	Section where comment addressed
	metrics provided in the MSS guidance note.	
	The Scottish Ministers consider the following projects should be considered for inclusion in the cumulative impact assessment: • Worst case scenario of Neart na Gaoithe (2014 as consented) or Neart na Gaoithe (2017 scoping report) • Worst case scenario of Seagreen Alpha and Bravo (2014 as consented) or Seagreen (2017 scoping report) • Worst case scenario of Moray Offshore East Development or Moray East Offshore Wind Farm – Alternative Design • Beatrice Offshore Wind Farm • Moray West Offshore Wind Farm • Aberdeen Harbour Expansion project The Cumulative Impact Assessment is likely to benefit from discussion once the initial results of the noise modelling are available, therefore the list of projects to be included may be refined following this.	The projects advised to be considered for potential cumulative impacts have been included in the assessment (See Section 8.10.9). Including those for Inch Cape (2014 as consented and Inch Cape (2017 scoping report)
22/09/17 **NnGOWL Noise Modelling meeting with MS-LOT, MSS and SNH**	MS advised that the assessment can only use information that is available and it should be based on published information.	The assessment is based on the available information including those presented in Section 8.5.
	SNH confirmed that they were content with the algorithms being used for the noise modelling.	See Appendix 8.1: Noise modelling for details of noise modelling undertaken.
	SNH advised that outputs should be based on M-weighted cumulative SEL metric.	See Appendix 8.1: Noise Modelling for details of noise modelling undertaken.
	SNH confirmed that they were content with the use of interim PCoD as part of the assessment process.	The interim PCoD model has been used based on published available information. See Appendix 8.2: Interim PCoD modelling for details of the population modelling undertaken.
27/09/17 **Email MS to NnGOWL**	MS advise that the worst-case in-combination impact will arise if all projects undertake construction sequentially as opposed to concurrently, therefore this should be the basis for the cumulative assessment.	Cumulative impacts are based on sequential construction scenario (Appendix 8.1 Noise modelling and Section 8.10.10)

40. In summary, the results of the scoping exercise identified the impacts arising from the installation of the foundation piles as having potential to cause a significant impact on marine mammals. This was due to the noise produced by the hammer used for driving the foundation piles into the seabed.

41. All other sources of potential impacts on marine mammals arising during the construction, operation and decommissioning phases of the project were assessed as not causing a significant impact on marine mammals and were scoped out of requiring further assessment within the EIA Report (NnGOWL, 2017). This was agreed with Marine Scotland and their advisors in their response to the scoping document (Marine Scotland, 2017a).

8.7 Impact Assessment Methodology

42. This assessment considers the potential impacts associated with the construction, operation and decommissioning of the Project and the effects on marine mammals. The impact assessment process and methodology follows the principles and general approach outlined in Chapter 6: EIA Methodology. The methodology and parameters assessed have also taken into account issues identified through consultation with stakeholders as detailed in (Section 8.6) and the understanding of baseline conditions informed by the data sources referenced in (Section 8.5).

43. The Project Description (Chapter 4) and the project activities for all stages of the project life cycle (construction, operation and decommissioning) have been assessed against the environmental baseline to identify the potential interactions between the Project and the environment. These are known as the potential impacts and are then assessed to determine a level of significance of effect upon the receiving environment.

8.7.1 Assessment and Assignment of Significance

44. The sensitivities of marine mammals are defined by both their potential vulnerability to an impact from the Project, their recoverability and value or importance of the receptor. The definitions of terms relating to marine mammals are detailed in Table 8.5.

45. The magnitude of impact is defined by a series of factors including the spatial extent of any interaction, the likelihood, duration, frequency and reversibility of a potential impact. The definitions of the levels of magnitude used in this assessment in respect of marine mammals are described in Table 8.6.

Table 8.5: Sensitivity / importance of the environment

Receptor sensitivity / importance	Description / justification
High	High or very importance and rarity, international or national scale and limited potential for substitution. Receptor population has very limited tolerance of effect i.e. likely to have limited capacity to absorb change, so a population level effect is likely to occur. Likely to be limited to populations with poor existing conservation status.
Medium	High or medium importance and rarity, regional scale, limited potential for substitution. Receptor population has limited tolerance of effect, i.e. a very minor capacity to absorb change so a population level effect is possible. Likely to include but not be limited to populations with poor existing conservation status.
Low	Low or medium importance and rarity, local scale. Receptor population has some tolerance of effect i.e. likely to have minor capacity to absorb additional mortality or a reduction in productivity, or habitat loss, so a population level effect unlikely.

Receptor sensitivity / importance	Description / justification
Negligible	Very low importance and rarity, local scale. Receptor population generally tolerant of effect i.e. likely to have moderate capacity to absorb additional mortality or a reduction in productivity, or habitat loss, so a population level effect very unlikely.

Table 8.6: Magnitude of the impact

Magnitude of impact	Description (adverse)	Description (beneficial)
High	Loss of resource and/or quality and integrity of resource; severe damage to key characteristics, features or elements.	Large scale or major improvement or resource quality; extensive restoration or enhancement; major improvement of attribute quality.
Medium	Loss of resource, but not adversely affecting integrity of resource; partial loss of/damage to key characteristics, features or elements.	Benefit to, or addition of, key characteristics, features or elements; improvement of attribute quality.
Low	Some measurable change in attributes, quality or vulnerability, minor loss of, or alteration to, one (maybe more) key characteristics, features or elements.	Minor benefit to, or addition of, one (maybe more) key characteristics, features or elements; some beneficial impact on attribute or a reduced risk of negative impact occurring.
Negligible	Very minor loss or detrimental alteration to one or more characteristics, features or elements.	Very minor benefit to, or positive addition of one or more characteristics, features or elements.
No change	No loss or alteration or characteristics, features or elements; no observable impact in either direction.	

46. The magnitude of the impact is correlated against the sensitivity of the receptor to provide a level of significance. For the purposes of this assessment any effect that is considered to be of moderate or major significance in Table 8.7, is considered to be significant in EIA terms. Any effect that is considered to be minor or negligible is considered to be not significant.

Table 8.7: Significance of potential effects

		Magnitude of Impact			
		High	Medium	Low	Negligible
Sensitivity	High	Major	Major	Moderate	Minor
	Medium	Major	Moderate	Minor	Negligible
	Low	Moderate	Minor	Minor	Negligible
	Negligible	Minor	Negligible	Negligible	Negligible

8.7.2 Uncertainty and Technical Difficulties Encountered

8.7.2.1 Baseline Data

47. The assessment is based on the best information available at the time of undertaking the Project EIA. The assessment uses site-specific baseline survey data collected by trained and experienced observers each month for over a period of three years (See Chapter 9: Ornithology for details). These three years of marine mammal data along with supporting information on marine mammals over the wider area (See Table 8 3) provides a robust baseline on which to undertake an assessment.

8.7.2.2 Noise Modelling

48. The noise modelling used to help determine the extent and magnitude of any potential impact uses recognised published algorithms recommended for assessing impacts from sound arising from pile driving (Jensen et al. 2011; Porter and Liu, 1994). The model accounts for the effects of varying bathymetry, variations in sound speed through the water column and the differences that geo-acoustic properties of the seabed have on sound propagation. The noise model used for this assessment therefore reflects best practice as described by Farcas et al. (2016). There is an inherent degree of uncertainty associated with pile driving source levels, since the source frequency spectrum and source sound level are typically derived from back propagation of measurements made at distance from the sound source (Lepper et al. 2012a). To minimise such uncertainties, the noise model only utilises verifiable frequency spectra and source levels derived from peer reviewed published measurements.

49. There is however, uncertainty on the relationship between the levels of noise received and the impacts it may have upon a receptor. Published studies indicate that marine mammals with a relatively high frequency auditory range, e.g. harbour porpoise along with those with relatively low frequency auditory range, e.g. minke whale (Balaenoptera acutorostrata), may be more sensitive to sound than had previously been considered. The auditory weightings and the thresholds at which hearing damage are predicted to occur have therefore been revised. Currently there are two published thresholds at which hearing damage are predicted to occur: Southall et al. (2007) and NMFS (2016). The thresholds published in NMFS (2016), known as the NOAA thresholds, are based on more recent published research on marine mammal hearing than those published in Southall et al. (2007) and some of the authors of the NMFS (2016) paper were also authors of the Southall et al. (2007) paper. Noise modelling presented in Appendix 8.1: Noise Modelling, presents outputs based on both sets of thresholds. However, for the purposes of this assessment those based on the latest NOAA thresholds have been used.

50. It should be noted that the outputs from the noise modelling are based on there being no mitigation measures in place, specifically the use of Acoustic Deterrent Devices (ADDs). The use of ADDs significantly reduce the risk of any marine mammals occurring within the area in which the onset of PTS is predicted to occur and therefore effectively reduces the predicted number of marine mammals at risk of the onset of PTS to zero. Therefore, the noise and population modelling undertaken is considered worst-case if it is determined that ADDs are to be used (see Section 8.11.2: Acoustic Deterrent Devices).

51. Outputs from the noise model presented in Appendix 8.1 Noise modelling, include unweighted peak SPL and cumulative SEL metrics. Both metrics are considered suitable for assessing pulsed sound sources but it is recommended that the worst case should be used when undertaking assessments (e.g. Southall *et al*. 2007; NMFS, 2017). The differences in the estimated area of impact between the two metrics are often large, with cumulative SEL indicating a significantly larger area of impact compared with unweighted peak SPL and consequently producing potentially greater predicted impacts. This assessment has been based on the recommended approach of assessing based on the worst-case model outputs.

52. Different noise models are also available and these are also considered to be good industry practice. Results from these models may produce differing results that indicate less of an impact from pile driving. Given that NnG has applied a noise model that may produce results showing potentially larger areas of impact and consequently a greater number of marine mammals at risk of injury and disturbance the results from the noise modelling, which feed into NnG's iPCoD and marine mammal assessments, are very precautionary.

8.7.2.3 Interim Population Consequences of Disturbance Framework (iPCoD)

53. There is good evidence that marine mammals can be displaced or disturbed from an area while pile driving is being undertaken, e.g. Carstensen et al. 2006, Thompson et al. 2010 and Dähne et al. 2013.

However, there is uncertainty with regard to the effect the displacement from an area may have on a marine mammal. To address this uncertainty, the assessment is based on an assumption that displacement from an area will cause a negative effect on the ability of the individual to survive or breed; the consequences of which may be a population level effect. Version 3 of Interim Population Consequences of Disturbance Framework (iPCoD) population model has been used in this assessment to estimate the population level effects that displacement and disturbance may have (See Appendix 8.2: Interim PCoD modelling). The iPCoD was developed to evaluate the potential effects from the construction and operation of offshore renewable energy projects on marine mammal populations (King et al. 2015). Recognising the lack of empirical evidence for the effects disturbance may have on the survival and fecundity of marine mammals, the iPCoD framework relies on expert elicitation to estimate these effects. Although there is a level of uncertainty associated with this, the iPCoD framework has been previously used to assess potential population level effects from pile driving on harbour porpoises within SACs, e.g. Booth et al. (2017). However, the metrics used for these assessments have been based on the risk (or the additional risk) of an impact occurring. The outputs from the model and the metrics presented in this assessment are based on the recommendations from studies undertaken reviewing the robustness of population models and the metrics used (Cook and Robinson, 2017; Jitlal et al 2017) and the advice received in the Scoping Opinion (Marine Scotland 2017a).

54. It is recognised that the model is an interim model and is subject to ongoing development and refinement. It has had limited, if any use, in assessments on cetaceans other than harbour porpoise and it is understood that outputs have to date not been used to inform consent decisions in Scotland. The Marine Scotland website notes that 'We emphasise the interim nature of this approach, which was developed to deal with the current situation, where there is limited data on the way in which changes in behaviour and hearing sensitivity may affect the ability of individual marine mammals to survive and to reproduce.'

55. The SNCBs acknowledge that there are a number of gaps in understanding in respect of the influences disturbance can have on life-history parameters of marine mammals. Advances in the understanding of these effects will be used to replace parameters in the model as they become available and reduce uncertainty in the model outputs.

56. Key messages from SNCBs regarding iPCoD include the following:

57. 'Whilst SNCBs do not anticipate a need for the Interim PCoD to be used in the EIA/HRA processes for every single development, this tool may form a useful reference in standardising the type of data submitted in impact assessments which will help when assessing cumulative effects. For large-scale developments and clusters of developments the tool may also help standardise the process for population level assessments. Decisions on when PCoD might be a useful tool should be made on a case-by-case basis in discussion with the relevant SNCBs and Regulators.

58. One of the main strengths of the Interim PCoD may be at assessing the cumulative effect of several developments and SNCBs advise that this is better achieved at the strategic level (e.g. SEA, and/or as a result of a joint effort between regulators, their advisers and developers [e.g. regional monitoring groups]). We will be working to encourage this approach in the future.'

59. The results of iPCoD have been surprising, with predicted population increases due to piling in one instance, an error for another species and unexpectedly high long-term impacts for others. Given the interim nature of the model and the surprising results, outputs should be interpreted with caution.

8.7.2.4 Cumulative Construction Schedule

60. There is limited information available on other offshore wind farm developments considered within the cumulative assessment. Although information on the installation methods are presented in the applications for the consented Inch Cape Offshore Wind Farm and Seagreen Alpha and Bravo Offshore Wind Farms it is recognised that the revised projects, Inch Cape and Seagreen Phase I, will have

different design envelopes from those that were originally consented. Where available, information presented within the scoping document for each revised project has been used. However, where the relevant information is not available the assessment has been based on information published within the original applications.

61. There is considerable uncertainty over the potential construction schedule of other future offshore wind farms. Only offshore wind farms with a (Contract for Difference) CfD can progress to construction and at present, in Scotland only Beatrice, Moray East and NnG have CfDs. If all developments included in the cumulative impact assessment were to obtain CfDs, it is almost certain that there would be gaps between construction phases and potentially some overlap. This would therefore have a lower population level impact. However in the absence of certainty regarding certain projects (Moray West, Inch Cape and Seagreen) progressing or certainty regarding their construction programmes, a very much worst case scenario was adopted for the assessment.

62. This has potentially significant influence on the assessment when a population model is used to assess the population level effects arising from cumulative impacts. The worst-case scenario is predicted to arise when construction across the projects occurs sequentially over a period of years with no gaps in the construction activities between projects. For the purpose of this assessment this highly precautionary assumption has been made, with no breaks in pile driving noise between 2020 and 2028. This is extremely unlikely to occur. Cumulative impact results should therefore be viewed as highly precautionary.

8.7.2.5 Other Factors

63. The cumulative impacts from developments within the Moray Firth are based on published information presented within the applications. It is recognised that since these studies have been published that the noise models used and the output metrics have changed. Consequently, the number of individual marine mammals estimated to be impacted from the wind farms in the Moray Firth are based on different approaches than those used in the assessment of projects within the Firths of Forth and Tay.

64. The dose response curve used to assess the impacts from disturbance within this assessment is from published sources (Brandt et al. 2016). A dose response curve has been developed based on studies undertaken in the Moray Firth. However, it was not available at the time assessments for NnG were undertaken.

65. This assessment is based on the best available information and follows the assessment methods as required from the Scoping Opinion. Although there are areas of uncertainty these are recognised within the approaches used for this marine mammal impact assessment and a highly precautionary approach has been taken.

8.8 Baseline Description

66. The following section presents the baseline information on marine mammals that are known to occur regularly within the Firths of Forth and Tay and the wider area of eastern Scotland and north-east England. It draws upon existing information including studies undertaken to support the original application and the results from three years of site specific surveys.

67. A total of four species of cetacean: harbour porpoise, white-beaked dolphin, orca (*Orcinus orca*) and minke whale were recorded during site specific surveys undertaken between 2010 and 2012. In addition to the four species of cetacean recorded, existing information indicates that bottlenose dolphin occur regularly in nearshore waters of the Firths of Forth and Tay and along the east coast of Scotland. Although no bottlenose dolphins were recorded during site specific surveys, their potential proximity to the proposed Project suggests that there is potential for Project to impact on them. Therefore, bottlenose dolphin is also considered as part of this assessment.

68. Two species of seal: harbour seal and grey seal were recorded during the site specific surveys.

8.8.1 Site Specific Surveys

69. Much of the available site-specific information on marine mammals was obtained from three years of boat-based surveys undertaken each month between November 2009 and October 2012. In addition to boat-based surveys, monthly acoustic surveys were undertaken between December 2010 and August 2011. Data from aerial surveys undertaken across the Firth of Forth and Firth of Tay area during 2009 and 2010 are also available to inform the marine mammal baseline information. Based on advice received in the Scoping Opinion these data have been used to support this assessment (Marine Scotland 2017).

8.8.1.1 Survey Methods

Boat-Based Surveys

70. Three years of boat-based surveys were undertaken across the Wind Farm Area and an 8 km 'buffer' area surrounding the site. A series of transects running in a north-west to south-easterly direction across the study area and spaced 2 km apart was surveyed each month and an average of 52.4 km of line transect were collected each month, with the exception of November 2010 and December 2011 when no data were collected due to poor weather making it unsuitable for marine mammal surveys.

71. Marine mammals were counted ahead of the ship and out to one side of the survey vessel in a 90º arc, with a 300 m transect width and using two surveyors, as per Camphuysen *et al.* (2004). Three European Seabirds at Sea (ESAS) accredited surveyors were on board for the majority of surveys. At any one time, one surveyor was acting as the primary observer, with a second acting as scribe and secondary observer, while the third surveyor was on a break.

72. Marine mammals (seals and cetaceans) were recorded concurrently with seabirds. Sightings were recorded using the same methodology as for birds on the water. Species, number of animals, direction of travel and behaviour were recorded. Binoculars were used to confirm identifications as well as to scan ahead for species. Animals were assigned to distance bands (A = <50 m, B = 51-100 m, C = 101-200 m, D = 201-300 m, E = >300 m), according to their perpendicular distance from the ship's track. The count interval for surveys was 1 minute intervals, and synchronised GPS recorders were used to record the vessel position every minute.

73. In addition, the angle of the sighting was estimated using an angle board and the radial distance was estimated either using a range finder or a visual estimate in metres, if no horizon was visible. Any marine mammals seen on the 'non-survey' side of the vessel were also recorded. Other species that were visible from the vessel, such as basking sharks, were noted regardless of the distance from the vessel.

74. Environmental conditions such as wind direction and force, sea state, swell height and visibility were recorded every 15 minutes throughout survey days. Surveys were carried out in good weather where possible, to maximise detection rates of marine mammals on the water. Surveys were halted if conditions exceeded sea state 4, as recommended in Camphuysen *et al.* (2004).

Acoustic Survey

75. Monthly acoustic surveys using a stereo towed hydrophone system capable of detecting small odontocetes (porpoises and dolphins) were undertaken within the Wind Farm Area between 2010 and 2011. A total of 2,579 km of line transects were surveyed using a passive acoustic detection system covering a total area of 2,140 km^2. During this period, a total of 263 harbour porpoises were detected (Gordon, 2012).

76. The acoustic surveys provide additional means of collecting cetacean data which are less affected by weather conditions and sea state. For harbour porpoise acoustic surveys provide a higher detection

rate under most field conditions and provide an independent method for detecting odontocete cetaceans and therefore offered the possibility of determining the proportion of available animals missed by either visual or acoustic teams, allowing g(0) (the proportion of animals detected on the trackline) to be calculated. With a reliable estimate of g(0) absolute abundance estimates could be calculated.

Aerial Surveys

77. Aerial surveys, commissioned by The Crown Estate (TCE), were undertaken across the Firths of Forth and Tay area during 2009 and 2010. The surveys were undertaken using visual observers and standard survey techniques along a series of fixed transects. Data were collected monthly with the exception of April, September and October.

8.8.2 Harbour Porpoise Baseline Data

78. The following presents a summary of the existing information on harbour porpoise.

8.8.2.1 Existing baseline

79. The harbour porpoise (*Phocoena phocoena*) is the most abundant cetacean species in UK waters with an estimated total North Sea population of 345,373 (95% CL 246,526 – 495,752) individuals (Hammond *et al*. 2017). The North Sea Management Unit population (based largely on previous Small Cetaceans in the European Atlantic and North Sea (SCANS II) surveys) is estimated to be 227,298 (95% CI 176,360 - 292,948) (IAMMWG, 2015). However, more recent estimates based on the latest SCANS III survey results indicate a total of 333,808 harbour porpoise within the North Sea Management Unit (JNCC, 2017). Within the SCANS III Block R, the area in which the proposed development is located, the estimated population of harbour porpoise is 38,646 individuals (95% CL 20,584 – 66,524) (Table 8.8). The abundance of harbour porpoise across the North Sea has not changed significantly since the initial SCANS surveys were undertaken in 1994 (Hammond *et al*. 2017). However, it is recognised that population estimates derived from SCANS surveys are each based on data from a single survey collected during a single month and that densities of harbour porpoise across the North Sea vary both temporally and spatially.

80. Densities of harbour porpoise across the North Sea as a whole are estimated to be 0.52 ind./km^2 with a density of 0.599 ind./km^2 within SCANS III Block R (Hammond *et al*. 2017) (Table 8.9).

Table 8.8: Harbour porpoise abundance estimates

Abundance	SCANS III [1]	SCANS III Block R [1]	SCANS III North Sea MU [2]	North Sea MU [3]	Firths of Forth and Tay [4]
Harbour porpoise	345,373 (246,526 – 495,752)	38,646 (CL 20,584 – 66,524)	333,808	227,298	582 (CI 581 – 1,235)
Source: 1. Hammond *et al*. 2017; 2. JNCC, 2017; 3. IAMMWG, 2015; 4. Mackenzie *et al.* 2012.					

Table 8.9: Estimated harbour porpoise densities

Density Ind./Km²	SCANS III North Sea [1]	SCANS III Block R [1]	Firths of Forth and Tay [2]	Firths of Forth and Tay [3]	Firths of Forth and Tay [4]	NnG [4]	NnG [5]
Harbour porpoise	0.52	0.599	0 - 0.4	0.048 – 0.099	0.5	0 – 0.1	0.38
Source: 1. Hammond *et al*. 2017; 2. Mackenzie *et al.* 2012; 3 Grellier and Lacey, 2011; 4. King and Sparling 2012; 5. Gordon, 2012.							

81. Data from ESAS and other databases indicate harbour porpoise are widespread across the continental shelf with relatively higher densities occurring in the Southern North Sea, Moray Firth and the west coast of Scotland (Reid *et al*. 2003; Paxton, *et al.* 2016; NMPI, 2017) . Evidence from the SCANS surveys undertaken in 1994, 2005 and 2016 indicates that there may have been a southward shift in the distribution of harbour porpoise from occurring predominantly around eastern Scotland and the northern North Sea to the central and southern North Sea since the early 1990's (Hammond *et al*. 2013, 2017) (Figure 8-2).

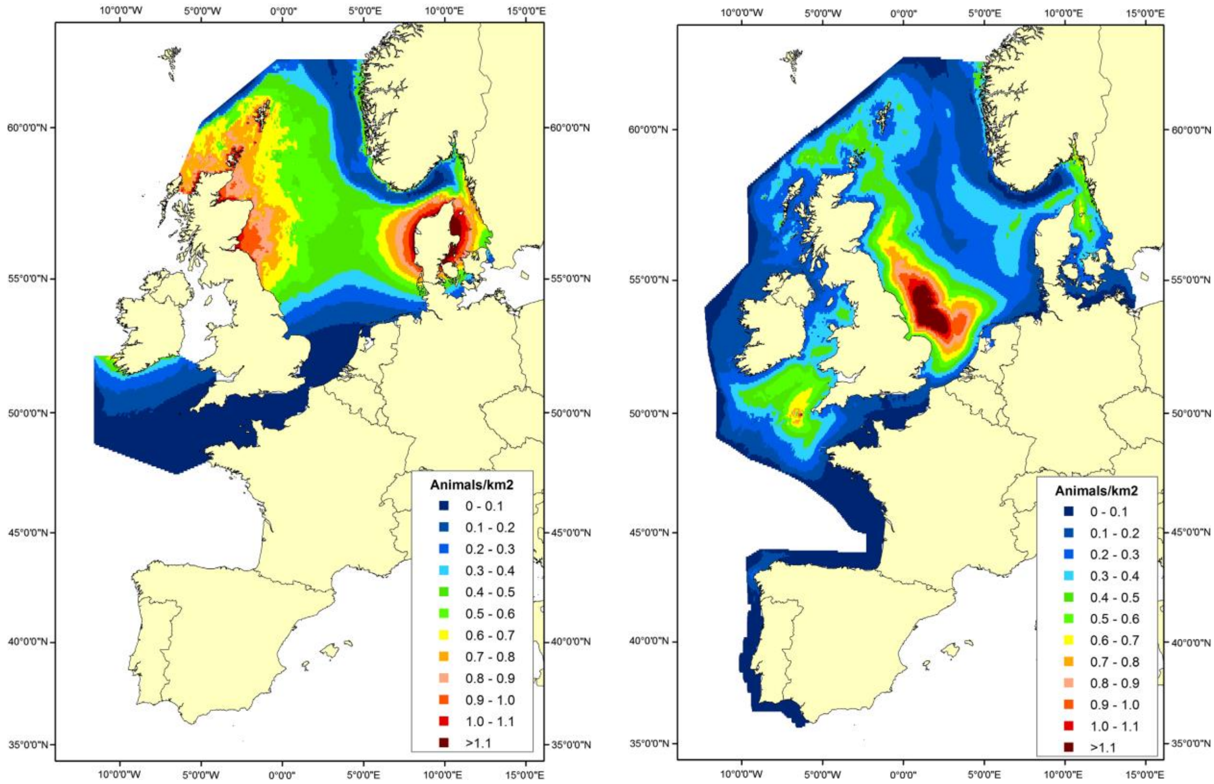


Figure a. **Figure b.**

Figure 8-2: a) Predicted surface density for harbour porpoise in 1994. b) Predicted surface density for harbour porpoise in 2005 (Source Hammond *et al.* 2013)

82. Harbour porpoise occur widely across shelf waters, predominantly either individually or in small groups but larger aggregations have been reported (Defra, 2015); with group sizes varying with season (Clark, 2005). Although harbour porpoise has a very broad distribution across the United Kingdom Continental Shelf (UKCS), higher densities occur in areas of up-wellings and strong tidal currents and in water depths of predominantly between 20 and 40 m (Clark, 2005; Whaley, 2004). Their distribution

may also be strongly correlated with seabed type, with areas of sandy gravel being preferred and this may be linked to prey availability (Clark, 2005).

83. Tagging studies undertaken in Denmark indicate that harbour porpoises are highly mobile and range widely in the North Sea, with individuals tagged in the Skagerrak travelling up to 100 km per day and occurring off the east coasts of England and Scotland (Sveegaard, 2011).

84. Swimming speeds vary with the highest recorded swimming speeds being 4.3 m/s (Otani *et al.* 2000). Mean recorded speeds are typically around 1 m/s, although the average descent and ascent speeds reported as being 1.4 m s^{-1} (Otani *et al.* 2000; SNH, 2016, Kastelein *et al.* 2018). When disturbed harbour porpoise can increase swimming speeds with increasing sound levels. Studies using playback experiments of pile-driving sounds have reported increases in swimming speed from an average of 1.2 m/s to 2.0 m/s at sound levels of 154 dB re 1 µPa that were sustained for at least 30 minutes (Kastelein *et al*. 2018).

85. Although harbour porpoises may dive to depths of up to 226 m and remain submerged for up to five minutes, they more frequently undertake relatively shallow dives of a short duration, with a mean depth of 14 m and duration of 44 seconds (Santos and Pierce 2003; Otani *et al*. 1998; 2000). Studies undertaken on tagged 14 harbour porpoise in Danish and adjacent waters reported that on average harbour porpoise spend 55% of the time in the upper 2 m of the surface waters. The most frequent dive depths were between 14 m and 32 m, with the maximum depth dived of 132 m. The number of dives per hour increased from an average of 29 dives hr^{-1} between April and August to 43 dives hr^{-1} in October and November when it was presumed that higher levels of foraging activity occurred to compensate for the higher energy requirements required during the cooler winter period (Teilmann *et al*. 2007).

86. Harbour porpoise live for a maximum of between 15 – 20 years. Females become sexually mature at around three to four years old (Lockyer, 2003). Breeding is thought to occur primarily during the summer months between May and September, particularly in August, with calving 10 months later. Calves are nursed for eight to ten months but may remain with the mother until a new calf is born (Defra, 2015; Lockyer, 2003; Weir *et al*. 2007).

87. Harbour porpoise use echolocation to detect and track individual prey and are opportunistic feeders, foraging close to the seabed or near the sea surface, preying on a wide range of fish species including, herring (*Clupea harengus*), cod (*Gadus morhua*), whiting (*Merlangius merlangus*) and sandeels (*Ammodytidae* Spp.). Their prey will vary during and between seasons (Santos and Pierce, 2003). Studies undertaken in Denmark indicate that their local distribution may be correlated with prey availability (Sveegaard, 2011). The prey of harbour porpoise may change over time with a reported long-term shift in prey from clupeid species to sandeels and gadoid species (IAMMWG *et al.* 2015).

88. Their prey preferences within the proposed development area are not well known. However, species known to occur within the region include herring, cod, whiting, sandeels and sprats (*Sprattus sprattus*), all of which may be prey for harbour porpoise.

89. There nearest Special Areas of Conservation (SAC) for which harbour porpoise is a qualifying species is the Southern North Sea candidate SAC (cSAC), which is located in excess of 100 km from the Wind Farm Area and the conservation status of the population is in a Favourable condition (Table 8.2).

8.8.2.2 Site Specific Data

90. During three years of boat-based surveys harbour porpoise were the most frequently recorded species of cetacean with between 86 and 107 individuals recorded each year and accounted for 88% of all cetacean sightings (Table 8.10). The distribution of harbour porpoise across the surveyed area was uneven with few sightings within the Wind Farm Area but widely scattered sightings across the 8 km buffer zone (Figure 8-3). The majority of sightings were recorded outwith the Wind Farm Area, with a total of 19 harbour porpoise recorded during all three years of surveys in the Wind Farm Area compared with 263 individuals recorded within the Buffer area.

91. Harbour porpoise occurred within the surveyed area throughout the year and showed both inter-annual and seasonal variations. However, peak number of sightings were typically between February and April and there were relatively few sightings between May and July (Figure 8-4).

Table 8.10: Number of harbour porpoise recorded within the Wind Farm Area and 8 km buffer during boat-based surveys undertaken between November 2010 and October 2013

Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Year 1 (Nov 2010 – Oct 2011)													
WFA	0	10	0	0	0	0	0	0	0	1	0	0	11
Buffer	15	27	2	1	7	7	0	0	0	7	1	11	78
Total	**15**	**37**	**2**	**1**	**7**	**7**	**0**	**0**	**0**	**8**	**1**	**11**	**89**
Year 2 (Nov 2011 – Oct 2012)													
WFA	n/c	0	0	0	2	0	0	0	0	2	0	0	4
Buffer	n/c	1	0	6	13	15	0	0	7	20	11	9	82
Total	**n/c**	**1**	**0**	**6**	**15**	**15**	**0**	**0**	**7**	**22**	**11**	**9**	**86**
Year 3 (Nov 2012 – Oct 2013)													
WFA	0	0	0	4	0	0	0	0	0	0	0	0	4
Buffer	7	0	4	47	14	16	2	0	0	4	2	7	103
Total	**7**	**0**	**4**	**51**	**14**	**16**	**2**	**0**	**0**	**4**	**2**	**7**	**107**

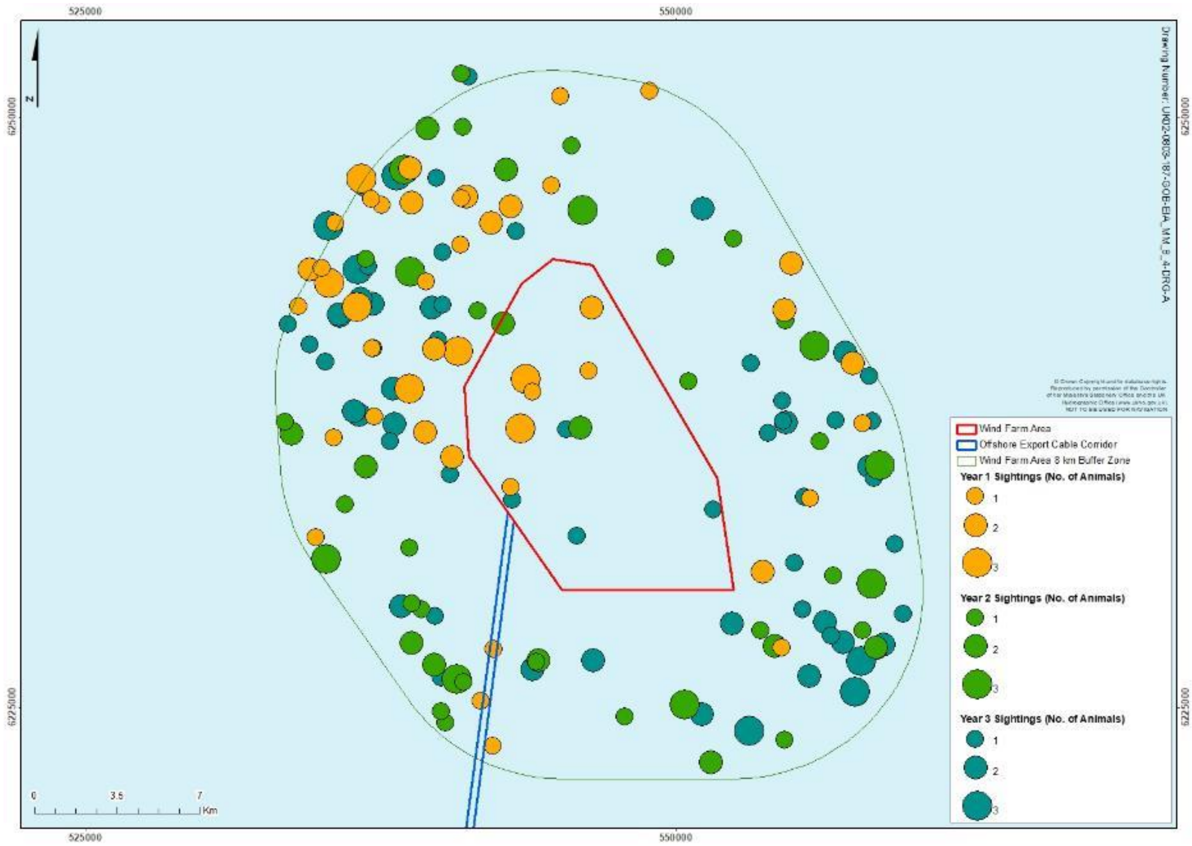


Figure 8-3: Distribution of harbour porpoise recorded within the study area during boat-based surveys undertaken between November 2010 and October 2013

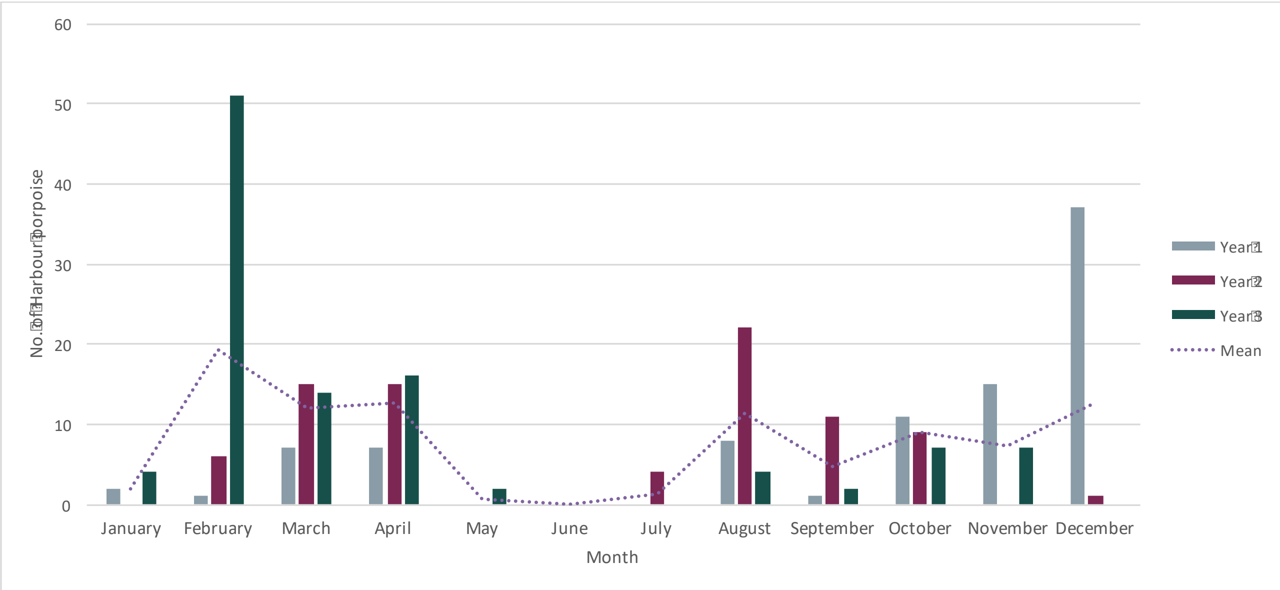


Figure 8-4: Monthly number of harbour porpoise recorded within the study area during boat-based surveys undertaken between November 2010 and October 2013

92. Within the local region harbour porpoise are recorded widely. Between 2013 and 2016 C-PODs have been deployed between Cromarty and St Abb's Head, including at five locations between Cruden Bay and St Abb's Head (Brookes, 2017). Porpoises were recorded most days with daily detection rates from all C-PODs of 97% or more. The exception being at a C-POD located within 5 km of St Andrews, where porpoises were only detected between 52% and 67% of the days that it was deployed over a period of four years (Figure 8-5 and Figure 8-6).

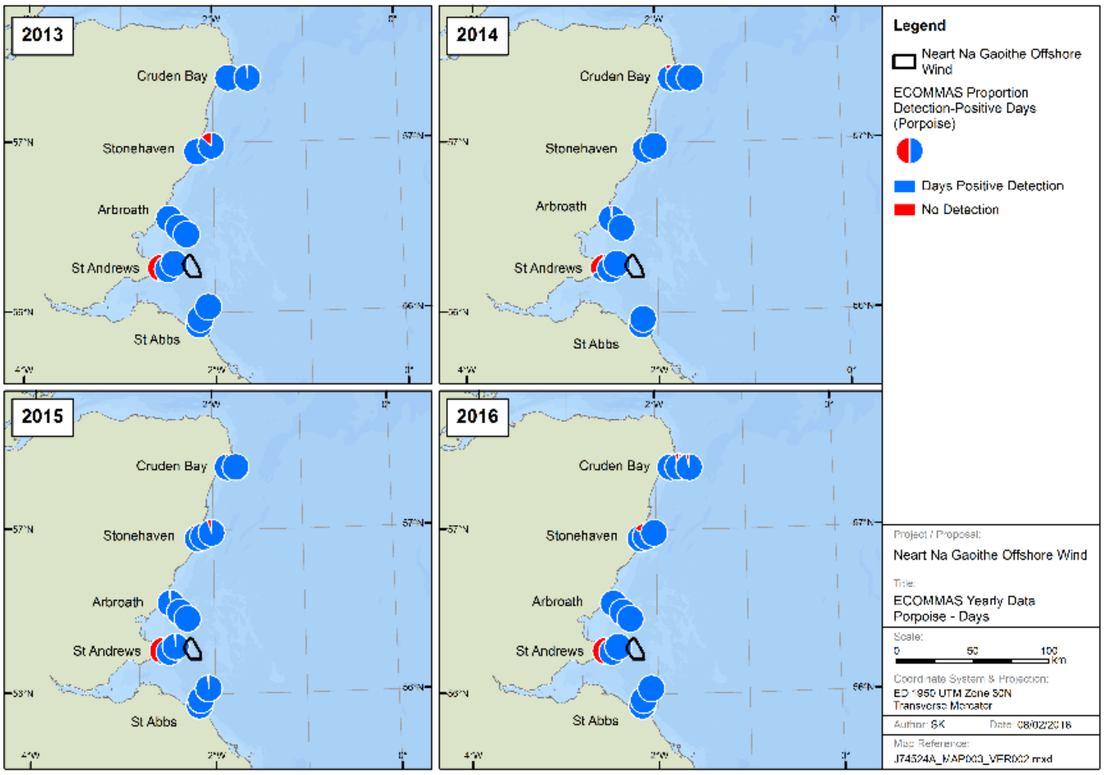


Figure 8-5: Harbour porpoise positive detection days at C-PODs located between Cruden Bay and St Abb's Head from 2013 to 2016 (Source Brookes, 2017)

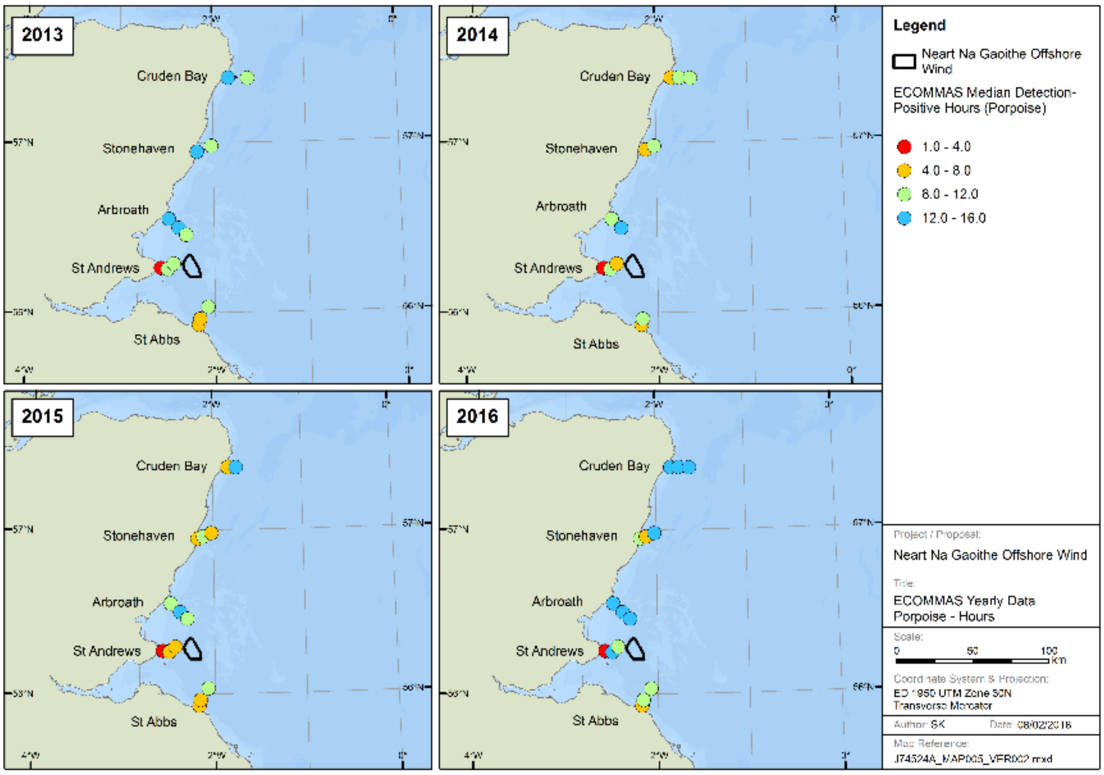


Figure 8-6: Harbour porpoise positive detection hours at C-PODs located between Cruden Bay and St Abb's Head from 2013 to 2016 (Source Brooks, 2017)

Harbour porpoise density estimates

93. Using acoustic data collected from 8,272 minutes of survey effort and covering an area of 2,140 km^2 during which 263 harbour porpoises were detected, a density of 0.27 porpoises per km^2 is estimated to occur across the Wind Farm Area (Gordon 2012).

94. Using visual data collected over the same period an estimated density of 0.28 harbour porpoise occur across the study area. However, based on all visual data covering a period of 22,754 minutes a density of 0.38 porpoises per km^2 has been calculated (Gordon, 2012).

95. Integrated analysis of all the Forth and Tay developer's marine mammal data and incorporating aerial survey data estimates, an average absolute abundance of 582 harbour porpoise across the Firths of Forth and Tay area, which is 0.25% of the North Sea management unit population (Mackenzie *et al*. 2012). This indicates that the Firth of Forth and Tay area is not an important area for harbour porpoise.

96. Densities of harbour porpoise vary across the Firths of Forth and Tay area with highest densities of 0.4 ind/km^2 occurring further offshore and to the north of Neart na Gaoithe (Mackenzie *et al*. 2012). Based on both visual and acoustic surveys undertaken across the Wind Farm Area the mean density of harbour porpoise across the year is 0.38 ind/km^2 (Table 8.10) (Gordon, 2012).

97. For the purposes of this assessment a SCANS III North Sea Management Unit population of 333,808 individuals and a regional density of 0.599 ind/km^2, based on SCANS III Block R, have been used. These are based on the most recent population estimates (JNCC, 2017; Hammond, *et al*. 2017).

8.8.3 Bottlenose Dolphin Baseline Data

98. The following presents a summary of the existing information on bottlenose dolphin.

8.8.3.1 Existing baseline

99. Bottlenose dolphin (*Tursiops truncatus*) occur widely in nearshore waters along the Moray Firth and the east coast Scotland. Elsewhere in the UK they occur regularly in Cardigan Bay with smaller numbers recorded elsewhere particularly around South-west England and North Uist (Reid *et al*. 2003; Paxton, *et al.* 2016; NMPI, 2017).

100. In Scotland, bottlenose dolphins occur widely along the east coast between the Moray Firth and the Firth of Forth with recognised areas of regular usage in the Moray Firth, Aberdeen Bay and the Firth of Tay (Figure 8-7 and Figure 8-8) (Anderwald and Evans, 2010; Quick *et al.* 2014). They are less frequently recorded between Montrose and Aberdeen or within the Firth of Forth (Quick *et al*. 2014).

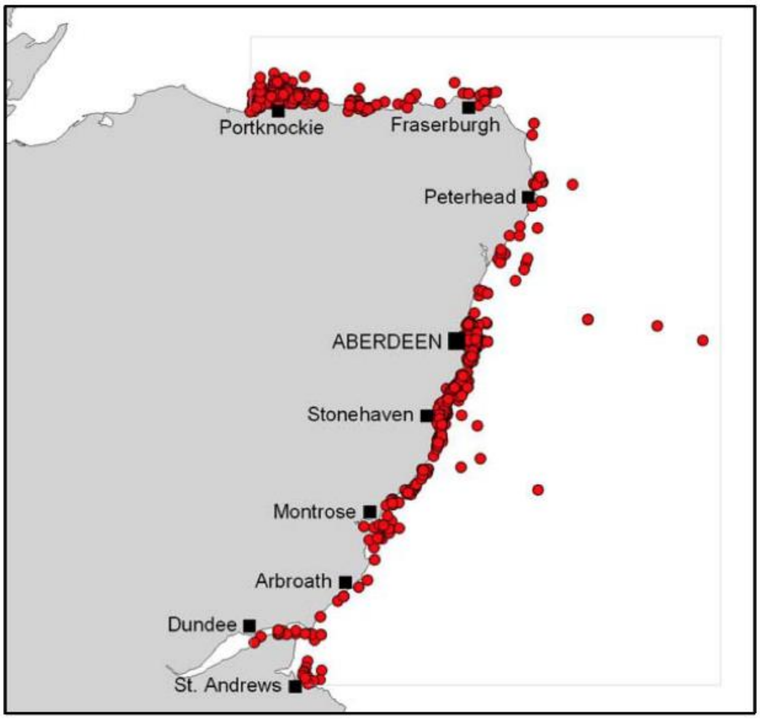


Figure 8-7: Bottlenose dolphin distribution in north-east Scotland (Anderwald and Evans 2010)

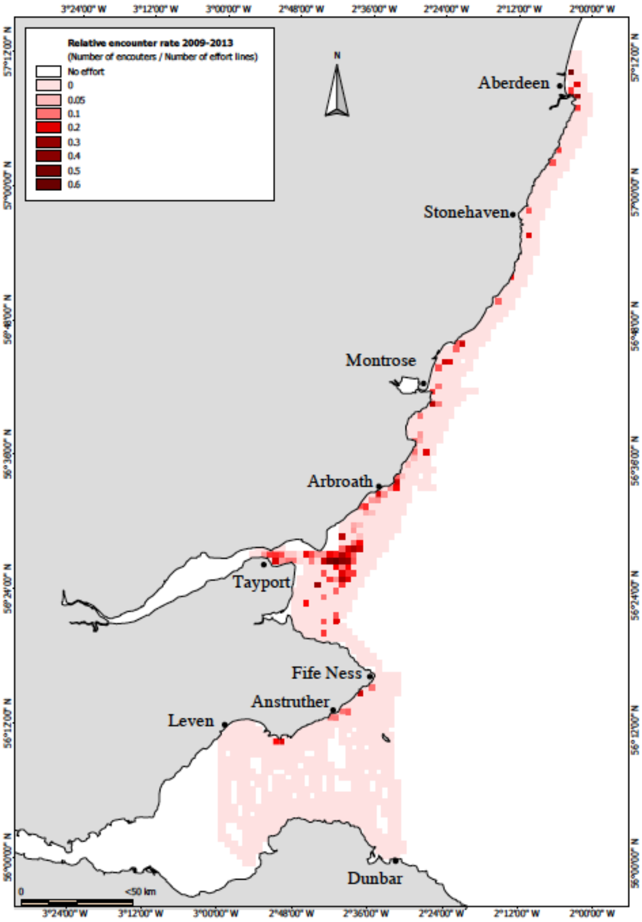


Figure 8-8: Bottlenose dolphin relative encounter rates between Aberdeen and the Firth of Forth between 2009 and 2013 (Quick *et al*. 2014).

101. Data from SCANS III, within Block R, estimated a population of 1,924 (95% CL 0 – 5,948) bottlenose dolphins (Hammond *et al*. 2017). The estimated population of bottlenose dolphins in the Moray Firth and the east coast of Scotland is 195 individuals (range 162 - 253) of which, based on surveys undertaken in 2003, between 81 and 142 bottlenose dolphins might occur in the Tay area (Cheney *et al*. 2013; Quick and Cheney, 2011; Thompson *et al.* 2011) (Table 8.11). The proportion of the east coast bottlenose dolphin population estimated to occur within the Firth of Forth and Firth of Tay area varies across years with between 71 (95% CI 63 - 81) and 91 (95% CI 82 - 100) individuals occurring within the area between 2009 and 2013 and between 35% and 55% of the east coast population (Arso Civil, 2014; Quick *et al*. 2014).

Table 8.11: Bottlenose dolphin abundance estimates

Abundance Ind./Km^2	SCANS III Block R [1]	Coastal East Scotland Management Unit [2]	Moray Firth and Firth of Tay [3]	East Coast Scotland [4]
Bottlenose dolphin	1,924 (0 – 5,048)	195 (95% HDPI 162 – 253)	195 (95% HDPI 162 – 253)	98
Source: 1. Hammond *et al.* 2017; 2. IAMMWG, 2015; 3. Cheney *et al.* 2013; 4. MS, 2017.				

Table 8.12: Estimated Bottlenose dolphin densities

Density Ind./Km^2	SCANS III Block R [1]	East Coast Scotland [2]	Firths of Forth and Tay [3]
Bottlenose dolphin	0.03	0.07 km^2	0.28 – 0.35
Source: 1. Hammond *et al.* 2017; 2. Derived from MS (2017); 3. Quick and Cheney, 2011.			

102. Bottlenose dolphins regularly move within the area between the Moray Firth and St Andrews Bay and the east coast population of bottlenose dolphin cannot be sub-divided on area alone and should be considered as a single management unit (Cheney *et al*. 2013; Thompson *et al.* 2011).

103. Sightings of bottlenose dolphin obtained from SCANS III data within Block R indicate a density across the wider region of 0.030 ind./km^2. Within the coastal waters of the Firths of Forth and Tay region densities of between 0.28 and 0.35 ind./km^2 have been estimated (Quick and Cheney 2011) (Table 8.12).

104. Based on advice received during Scoping the density of bottlenose dolphins has been estimated on an assumption that of the reference population of 195 bottlenose dolphins, 98 of them will be present along the east coast of Scotland at the time pile driving activities are undertaken (Marine Scotland 2017a). All bottlenose dolphins will be within the 20 m contour depth and that they are distributed evenly across their range (Figure 8-9). Areas within the Forth and Inner Tay were excluded, as per the advice received. Following this approach, a bottlenose dolphin density of 0.07 ind./km^2 is derived.

Figure 8-9: Distribution of coastal east Scotland bottlenose dolphins (Source: ICOL, 2017)

105. Along the east coast of Scotland, bottlenose dolphins occur predominantly within 2 km of the coast and in water depths of less than 20 m. There are relatively very few records of bottlenose dolphins in waters beyond 2 km and in water depths of greater than 20 m (Figure 8-8) (Quick *et al*. 2014).

106. Between 2013 and 2016 C-PODs that are able to detect bottlenose dolphins have been deployed between Cromarty and St Abb's Head, including at five locations between Cruden Bay and St Abb's Head (Brookes, 2017). Bottlenose dolphins were recorded most frequently within 5 km of Cromarty, in the Moray Firth, with detections recorded on more than 89% of the days that C-PODs were present. Daily detection rates at C-PODS located within 5 km of St Andrews were no greater than 18%. Further offshore daily detection rates were lower with detections on less than 10% of the days at distances of between 10 km and 15 km (Figure 8-10).

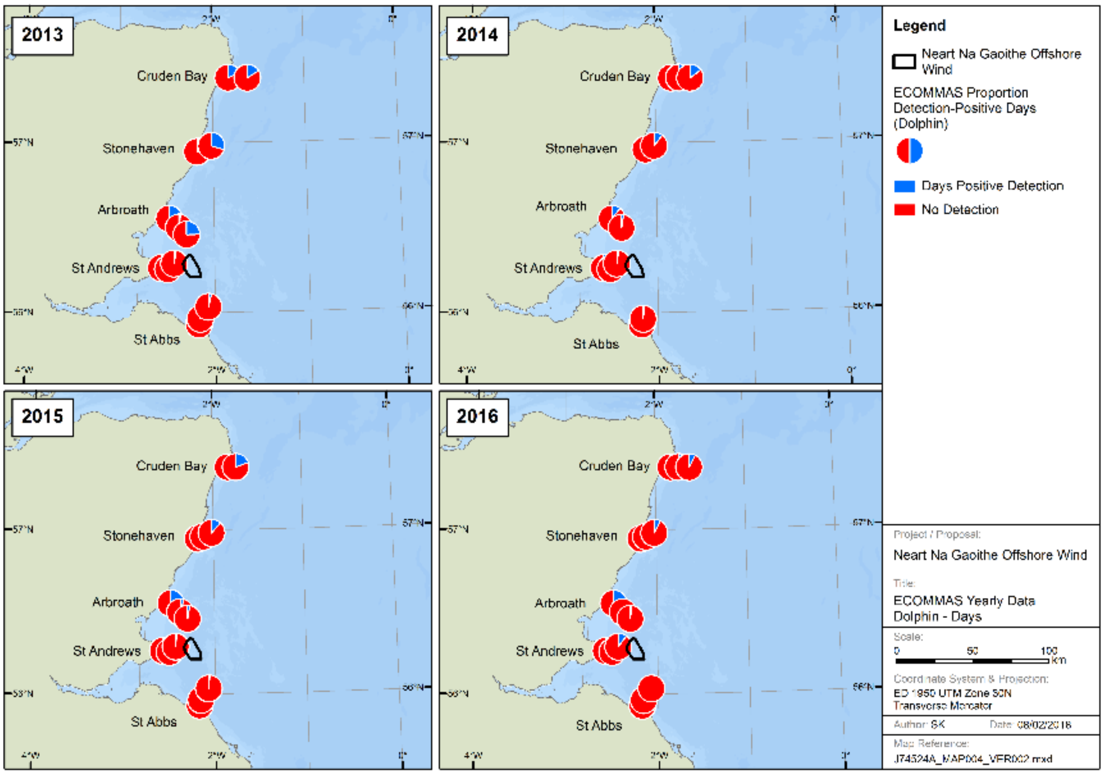


Figure 8-10: Bottlenose dolphin positive detection days at C-PODs located between Cruden Bay and St Abb's Head from 2013 to 2016 (Source Brookes, 2017)

107. The use of C-PODS to detect dolphins at five locations between Cruden Bay and St Abb's, including at Arbroath and St Andrews supports the evidence that the majority of dolphin activity along the east coast of Scotland occurs within 5 km of the coast (Brookes 2017, Palmer *et al.* 2017).

108. Acoustic surveys undertaken at two locations between Arbroath and Fife Ness using T-Pods between 2006 and 2009 indicated that dolphins occur in the coastal waters throughout the year, although there may be seasonal variation with an increase in the number of detections at Fife Ness between May and October compared with the rest of the year. However, a similar seasonal variation was not observed at Arbroath where the number of detections across the year are relatively similar (Figure 8-11) (Quick and Cheney; 2011).

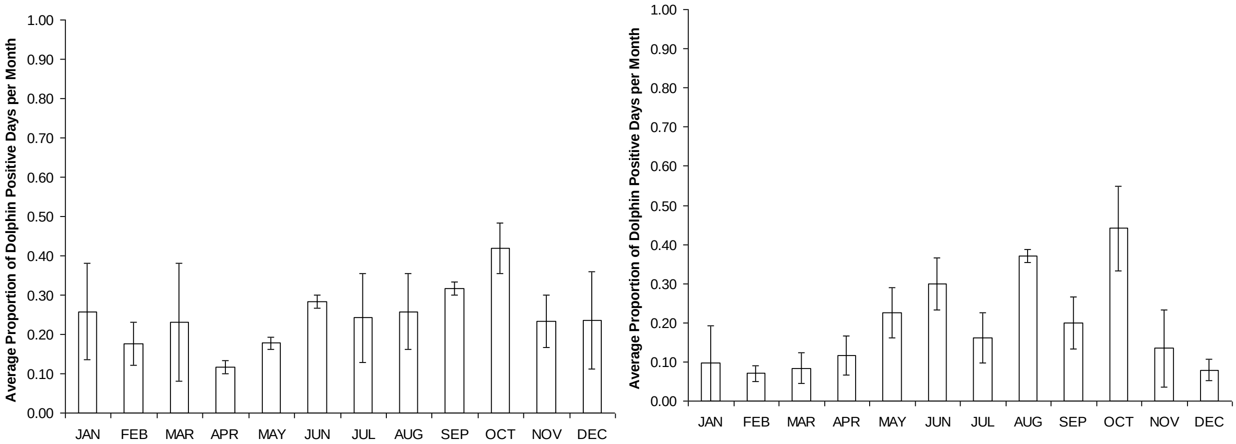


Figure 8-11: The average proportion of dolphin positive days in each month (+/- SE) for T-pod sites at a) Arbroath and b) Fife Ness, for the entire T-pod deployment period (Source: Quick and Cheney 2011)

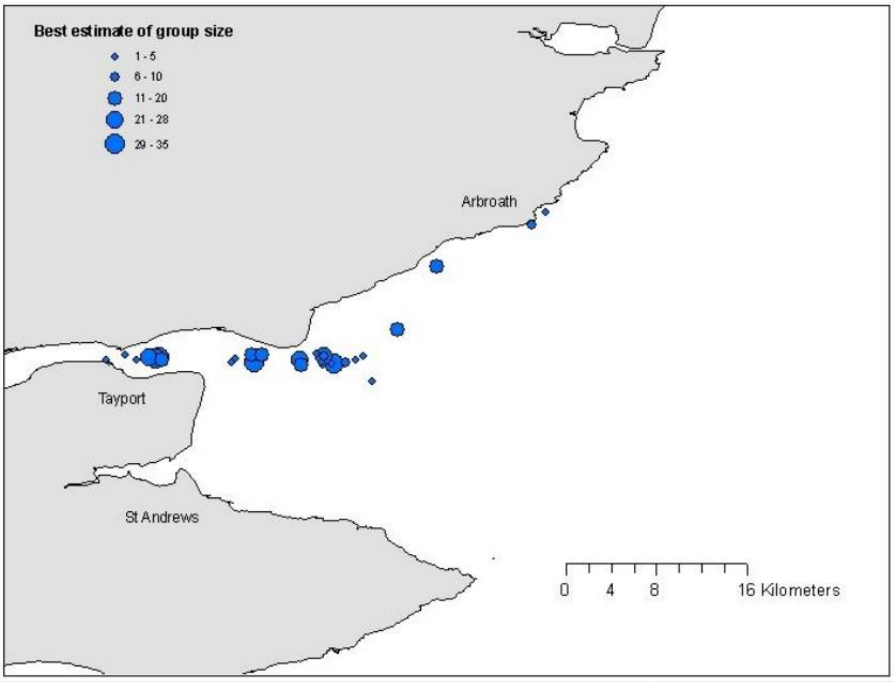
109. Within the Firths of Forth and Tay area bottlenose dolphin occur predominantly in nearshore waters within 10 km of the coast and in water depths of less than 20 m (Figure 8-12). Within the Firth of Tay bottlenose dolphin have been most frequently recorded along the north side of a sand bar to the south of a shipping lane (Quick and Cheney, 2011). However, complete survey coverage across the whole of the Firths of Forth and Tay has not been undertaken and therefore their distribution across the wider area is unclear.

110. Using photo identification techniques, it is recognised that many, if not all, the bottlenose dolphins occurring in the Firth of Tay area are associated with those that occur to the north, along the east coast of Scotland and the Moray Firth including within the Moray Firth SAC. There is a relatively high level of movement of bottlenose dolphins between those in the Firth of Tay and elsewhere along the east coast of Scotland and, to a lesser extent, along the coasts of North-east England (Quick and Cheney, 2011).

111. Bottlenose dolphins first breed from the age of between 5 and 13 years of age and produce a single offspring which will remain with its mother from between 3 and 8 years. Inter-birth years, the time between calves, range from between 2 and 9 years, although 3 years is most frequent. Mortality rates in the first year vary from between 19 and 29%. Adult survival within the east coast of Scotland population is 94.7% (Quick *et al*. 2014).

112. Bottlenose dolphins feed on a wide range of prey species with main prey items for bottlenose dolphins in the Moray Firth reported to be cod, saithe (*Pollachius virens*) and whiting with some salmon (*Salmo salar*), haddock (*Melanogrammus aeglefinus*) and cephalopods (Santos *et al*. 2001).

113. The bottlenose dolphin is a qualifying species for the Moray Firth SAC, which is located approximately 165 km from the Wind Farm Area.



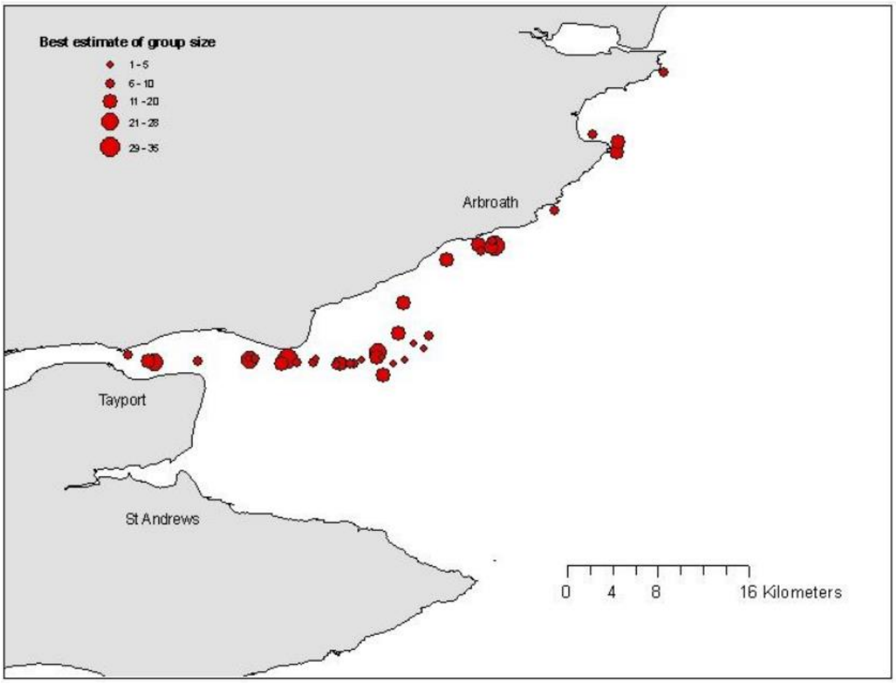


Figure 8-12: Bottlenose dolphin encounter locations in Firth of Tay during 2009 (top) and 2010 (bottom) (Source: Quick and Cheney 2011)

8.8.3.2 Site Specific Data

114. No bottlenose dolphins were recorded during three years of boat-based surveys within the Offshore Wind Farm Area and the 8 km buffer surrounding the site, i.e. no bottlenose dolphins have been recorded within 8 km of the Wind Farm Area.

115. The most recent estimate of the Moray Firth and east coast bottlenose dolphin population is 195 individuals. Published abundance estimates for the Firth of Tay area based on photo identification studies undertaken during the summers of 2003 and 2004 indicate a population of between 81 and 142 individuals (Quick and Cheney, 2011). Advice received during scoping is that half the bottlenose dolphin population, i.e. 98 individuals, may occur along the east coast of Scotland and are at risk of being impacted by the proposed Project (Marine Scotland 2017a).

116. The only estimated densities of bottlenose dolphin within the Firth of Forth and Tay area are between 0.28 and 0.35 ind/km^2 (Quick and Cheney, 2011). However, using the approach advised during scoping and assuming that bottlenose dolphins are evenly distributed along the east coast of Scotland out to the 20 m water depth, a density of 0.07 ind/km^2 has been estimated (Table 8.12).

117. For the purposes of this assessment a Coastal East Scotland Management Unit population of 195 individuals has been used and it is assumed that the population is split 50:50 between the Moray Firth and the east coast of Scotland. A regional density of 0.07 ind/km^2 has been calculated following the approach advised in the Scoping Opinion (Marine Scotland 2017a).

8.8.4 White-beaked Dolphin Baseline Data

118. The following presents a summary of the existing information on white-beaked dolphin.

8.8.4.1 Existing baseline

119. The white-beaked dolphin (*Lagenorhynchus albirostris*) occurs across the North Sea, although predominantly the central North Sea in waters of between 50 – 100 m deep and in waters at temperatures below 14°C. They are largely absent in waters greater than 200 m and where water temperatures exceed 18°C (Reid *et al*. 2003; MacLeod *et al*. 2008; Parsons *et al*. 2012; OSPAR, 2017).

120. Scottish waters are recognised to be a regionally important for white-beaked dolphin particularly in the Minch, to the north of the Outer Hebrides, in the outer Moray Firth and off the coast of Aberdeenshire (Lancaster *et al*. 2014a).

121. The species occurs throughout the year, with evidence of localised seasonal movements to nearshore waters during the summer months. In northeast Scotland, there is an increase in sightings of white-beaked dolphins in nearshore waters between June and August and off northeast England peak numbers occur in inshore waters during July and August (Weir *et al*. 2007; Brereton *et al*. 2013).

122. The estimated white-beaked dolphin population within Block R of the SCANS III survey area is 15,694 (95% CL 3,022– 33,340) individuals (Hammond *et al*. 2017). The Management Unit population comprising Celtic and Greater North Seas (CGNS) is estimated to be between 15,895 individuals and 36, 287 depending on the source of the data (Table 8.13) (IAMMWG, 2015; JNCC, 2017; Hammond *et al.* 2017). The CGNS Management Unit population of 15,895 individuals is largely based on the results from the SCANS II surveys which have subsequently been revised from a previous population estimate of 16,536 individuals to 37,689 individuals for the whole SCANS II surveyed area (Hammond *et al.* 2017). Consequently, white-beaked dolphin population within the CGNS Management Unit area may be higher than previously thought. For the purposes of this assessment the SCANS III CGNS Management Unit population of 35,908 has been used (JNCC, 2017).

123. Within the Firth of Forth and Firth of Tay area the white-beaked dolphin population is estimated to be 293 individuals (95% CI 266 – 1,055) (see Table 8.13) (Grellier and Lacey, 2011).

124. SCANS III survey data indicate densities within Block R of 0.24 ind/km^2 occur (Hammond *et al*. 2017). Densities of between 0.3 and 0.4 ind/km^2 are estimated to occur along the east coast of Scotland, with higher densities of up to 0.7 ind/km^2 occurring further offshore in the Central North Sea. Across the Forth and Tay estuaries peak white-beaked dolphin densities of 0.052 ind./km^2 have been estimated to occur during the summer and 0.024 ind./km^2 during winter period (Grellier and Lacey, 2011) (Table 8.14). This suggest that densities of white-beaked dolphin in the waters around the Firths of Forth and Tay are relatively low compared with adjacent areas.

Table 8.13: White-beaked dolphin abundance estimates

Abundance Ind./Km^2	SCANS III [1]	SCANS III CGNS Management Unit [2]	SCANS III Block R [1]	CGNS Management Unit [3]	Firths of Forth and Tay [4]
White-beaked dolphin	36,287 (CL 18,694 – 61,869)	35,908	15,694 (CL 3,022– 33,340)	15,895 (CI 9,107 – 27,743)	91 (CI 32 – 384)
Source: 1. Hammond *et al.* 2017; 2. JNCC, 2017; 3. IAMMWG, 2015; 4. King and Sparling, 2012.					

Table 8.14: Estimated white-beaked dolphin densities

Density Ind./km^2	SCANS III -1	SCANS III Block R [1]	Firths of Forth and Tay [2]	Firths of Forth and Tay [3]	NnG [3]
White-beaked dolphin	0.03	0.24	0.024 - 0.052	0.016	0 – 0.005
Source: 1. Hammond *et al*. 2017; 2. Grellier and Lacey 2011; 3. King and Sparling, 2012.					

125. Analysis of the sightings along the Aberdeenshire coast indicate that seabed depth and slope influence the distribution of white-beaked dolphins in this area and this is thought to be related to prey distribution. Sea temperature has been found to influence white-beaked dolphin group size, with smaller groups being recorded in waters at higher temperatures (Canning, 2008).

126. White-beaked dolphin breed mainly between July and August, with gestation lasting approximately 11 months (Culik, 2010). The high number of calves observed during the boat surveys off Aberdeenshire and in the stranding data during the summer suggests the inshore movement of this species at this time of year may be related to calving (Canning, 2008).

127. White-beaked dolphins have a broad range of prey, feeding on mackerel (*Scomber scombrus*), herring, cod, poor-cod (*Trisopterus minutus*), sandeels, whiting, haddock, and hake (*Merluccius merluccius*), as well as squid (*Loligo vulgaris*), octopus Sp. and benthic crustaceans (Anderwald and Evans, 2010).

128. There are no European designated sites for white-beaked dolphin in the UK. However, their range is thought to be contracting, possibly due to increasing sea temperatures (Lancaster *et al*. 2014a).

8.8.4.2 Site Specific Data

129. During three years of boat-based surveys white-beaked dolphins were recorded infrequently within the wind farm and buffer area. A total of 18 white-beaked dolphins were recorded during all surveys with no sightings during Year 1. Peak numbers occurred during May and June, with all but one sighting being recorded during this period. The only other sighting was of an individual observed in January 2012 (Table 8.15 and Figure 8-13). Possibly due to there being relatively few sightings from surveys, no clear pattern in the distribution of white-beaked dolphins has been identified with recorded sightings scattered across the surveyed area (Figure 8-14).

Table 8.15: Number of white-beaked dolphin recorded within the Wind Farm area and 8 km buffer during boat-based surveys undertaken between November 2010 and October 2013

Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Year 1 (Nov 2010 – Oct 2011)													
WFA	0	0	0	0	0	0	0	0	0	0	0	0	0
Buffer	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Year 2 (Nov 2011 – Oct 2012)													
WFA	n/c	0	0	0	0	0	3	3	0	0	0	0	6
Buffer	n/c	0	1	0	0	0	9	0	0	0	0	0	10
Total	**n/c**	**0**	**1**	**0**	**0**	**0**	**12**	**3**	**0**	**0**	**0**	**0**	**16**
Year 3 (Nov 2012 – Oct 2013)													
WFA	0	0	0	0	0	0	0	0	0	0	0	0	0
Buffer	0	0	0	0	0	0	0	2	0	0	0	0	2
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**2**

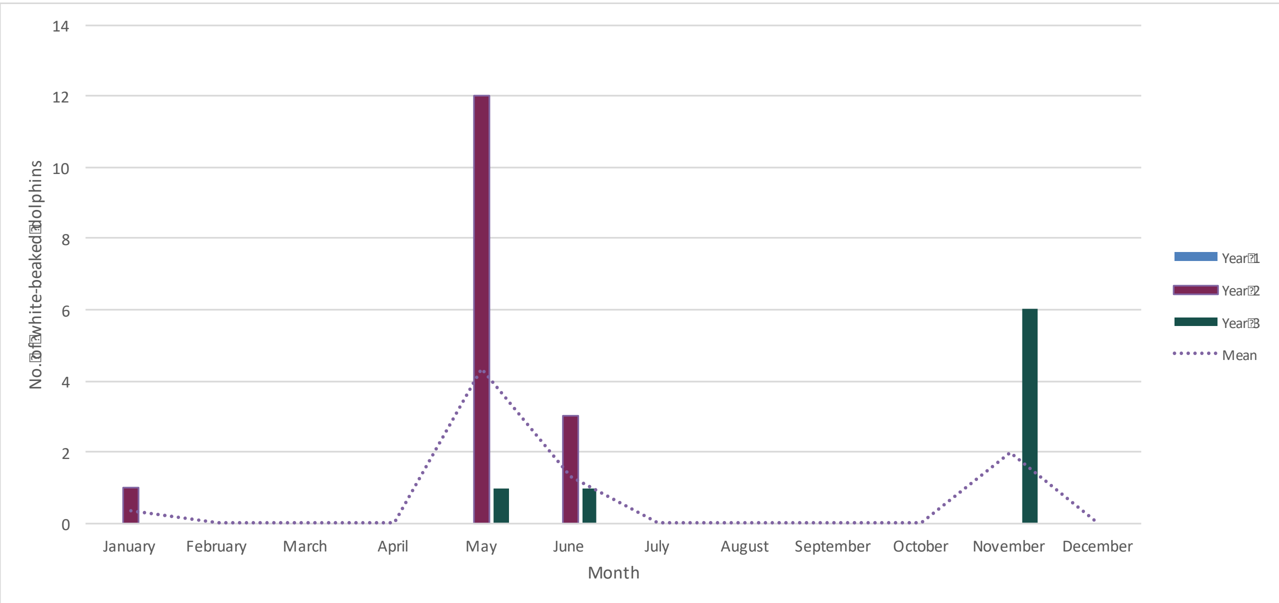


Figure 8-13: Monthly number of white-beaked dolphins recorded within the study area during boat-based surveys undertaken between November 2010 and October 2013

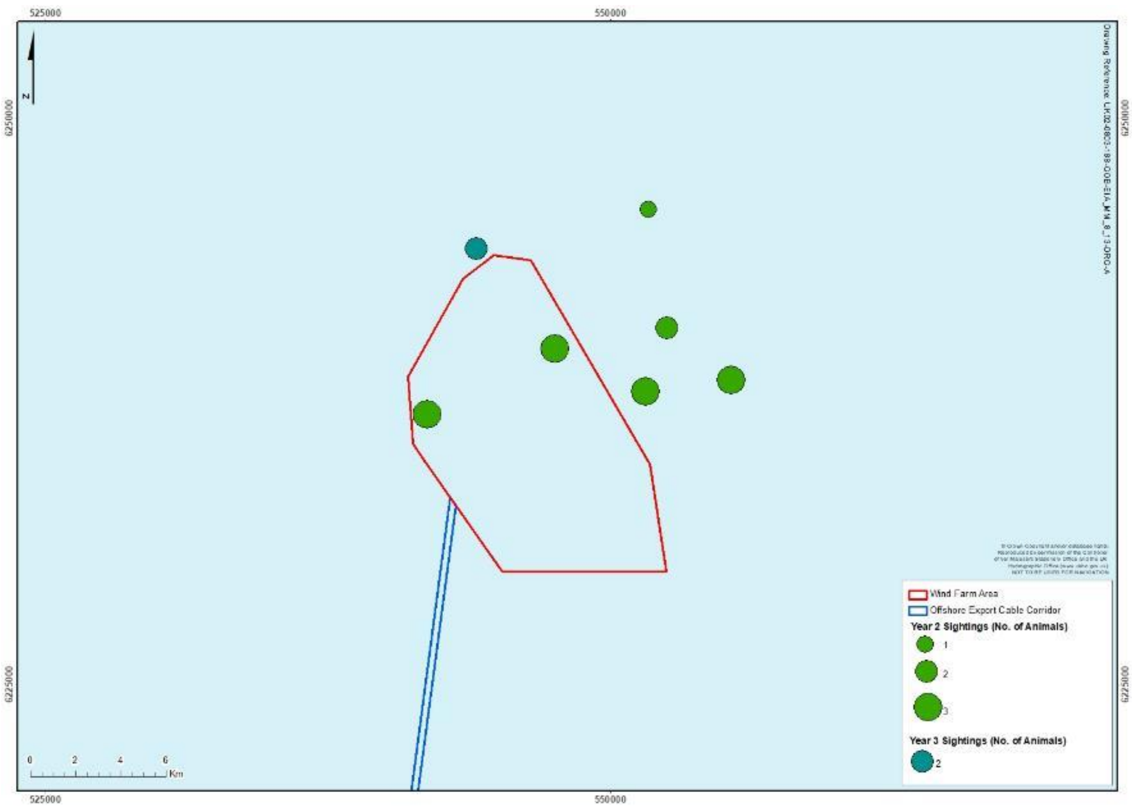


Figure 8-14: Distribution of white-beaked dolphin recorded within the study area during boat-based surveys undertaken between November 2010 and October 2013

130. Within the Wind Farm Area densities of between zero and 0.005 ind/km^2 have been estimated (Table 8.14) (King and Sparling, 2012). These densities are lower than reported over the wider area, therefore indicating that the Wind Farm Area is relatively less important to white-beaked dolphins than elsewhere.

131. For the purposes of this assessment a SCANS III based CGNS Management Unit population of 35,908 individuals and a regional density of 0.24 ind/km^2 have been used. These are based on the most recent population estimates and regional specific densities.

8.8.5 Orca Baseline Data

132. The following presents a summary of the existing information on orca.

8.8.5.1 Existing baseline

133. Orcas occur predominantly in waters to the north and west of the UK and are very scarce in the North Sea with few records south of the Moray Firth (Reid *et al*., 2003).

8.8.5.2 Study Area

134. A single orca was recorded in October 2011 within the buffer area. Due to the scarcity of this species in the area no further assessment has been made.

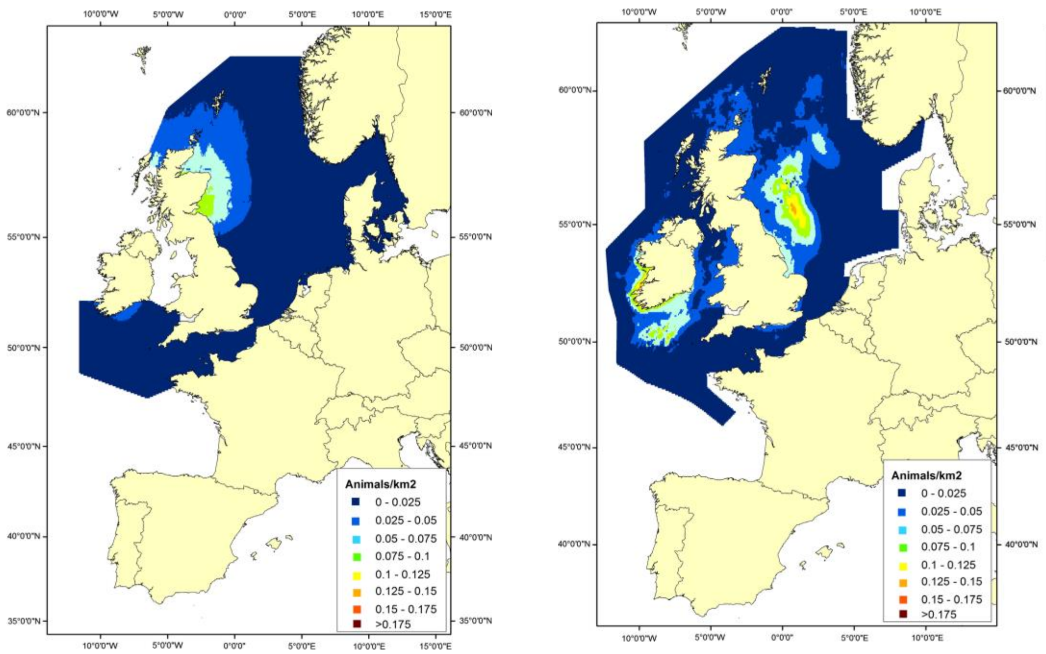
8.8.6 Minke Whale Baseline Data

135. The following presents a summary of the existing information on minke whale.

8.8.6.1 Existing baseline

136. The Minke whale (*Balaenoptera acutorostrata*) is the most abundant baleen whale in the region, occurring widely across the North Sea during the summer months (**Error! Reference source not found.**). They are predominantly a summer visitor to the waters off the east coast of Scotland, with animals distributed in both coastal waters and offshore throughout the central and northern North Sea during the summer months, particularly during July and August. There are few sightings of minke whale in the region between October and April (Anderwald and Evans, 2010; Reid *et al.* 2003). Off the east coast of Scotland minke whales appear to be more frequent in offshore waters between the Moray Firth and the borders of England (Lancaster *et al*. 2014b; NMPI, 2017) to the north of the Firth of Forth and Firth of Tay area, with highest numbers occurring off the coasts of Aberdeenshire (Anderwald and Evans, 2010).

137. The distribution of minke whales appears to have shifted southward over the last 20 years from a core area off North-east Scotland to the Central North Sea (Figure 8-15) (Hammond *et al.* 2013).



a) b)

Figure 8-15: a) Predicted density surface for minke whale in 1994. b) Predicted density surface for minke whale in 2005 (Source Hammond *et al.* 2013)

138. The estimated minke whale population within the SCANS III CGNS Management Unit is 11,819 individuals. Within Block R of the SCANS III survey area the estimated minke whale population is 2,498 (95% CL 604 – 6,791) individuals (Hammond *et al*. 2017). SCANS III survey data indicate densities of minke whale within Block R of 0.039 ind/km^2 occur (Table 8.17) (Hammond *et al*. 2017); these were the highest densities for any area recorded during the SCANS III surveys.

139. The estimated number of minke whales within the North Sea varies across years and this may be due to the presence of seasonal or inter-annual variations in water temperature, with higher numbers being recorded in areas of warm water where there may be increased productivity (Tetley *et al*. 2008).

Table 8.16: Minke whale abundance estimates

Abundance	SCANS III CGNS Management Unit [1]	SCANS III Block R [1]	CGNS Management Unit [2]	Firths of Forth and Tay [3]	Firths of Forth and Tay [4]
Minke whale	11,819	2,498 (604 – 6,791)	23,528 (95% CI=13,989-39,572)	594 (CI 483 – 2,695)	269 (CI 86 – 1,711)
Source: 1. JNCC 2017; 2. IAMMWG ,2015; 3. Mackenzie *et al.* 2012; 4. King and Sparling, 2012.					

Table 8.17: Estimated minke whale densities

Density Ind./km^2	SCANS III Block R [1]	Firths of Forth and Tay [2]	Firths of Forth and Tay [3]	NnG [3]
Minke whale	0.039	0 – 0.25	0.047	0.02 – 0.10
Source: 1. Hammond *et al*. 2017; 2. Mackenzie *et al.* 2012; 3. King and Sparling.				

140. Minke whales feed on both invertebrates and a variety of fish species, particularly herring, sandeel, cod, haddock and saithe (Anderwald and Evans, 2010).

141. Studies undertaken in the Moray Firth have identified strong correlations in the distribution of minke whales and water depth and sediment type, with minke whales occurring most frequently in water depths of between 20 m and 50 m and over areas with sandy gravel sediments. These habitats are known to be areas used by sandeels and it is thought that the distribution of minke whales during the summer months is associated with the distribution and availability of sandeels that make up between 62% and 87% of their diet by weight. From July onwards, they disperse to pre-spawning area for herring (Lancaster *et al*. 2014b). Another strong influencing factor in their distribution is the seabed bathymetry with more frequent occurrence in areas of relatively steep slopes and, in the Moray Firth, north facing slopes were preferred (Robinson *et al*. 2009). The presence of relatively steep seabed is thought to provide up-wellings where increased concentrations of prey may occur.

142. There are no European Protected Sites for minke whale in UK waters.

8.8.6.2 Site Specific Data

143. Minke whale were recorded in relatively low numbers during three years of boat-based surveys with a total of 18 individuals recorded, of which, one was in the proposed Wind Farm Area (Table 8.18 and Figure 8-16). All sightings were made between May and November, with peak numbers observed during November followed by June and August. However, the numbers were low across the year (Figure 8-17).

Table 8.18: Number of minke whales recorded within the Wind Farm and Buffer areas during boat-based surveys undertaken between November 2010 and October 2013

Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Year 1 (Nov 2010 – Oct 2011)													
WFA	0	0	0	0	0	0	0	0	0	0	0	1	1
Buffer	0	0	0	0	0	0	0	0	0	0	0	1	1

Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**
Year 2 (Nov 2011 – Oct 2012)													
WFA	n/c	0	0	0	0	0	0	0	0	0	0	0	0
Buffer	n/c	0	0	0	0	0	0	3	0	4	1	0	8
Total	**n/c**	**0**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**4**	**1**	**0**	**8**
Year 3 (Nov 2012 – Oct 2013)													
WFA	0	0	0	0	0	0	0	0	0	0	0	0	0
Buffer	6	0	0	0	0	0	0	2	0	0	0	0	8
Total	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**8**

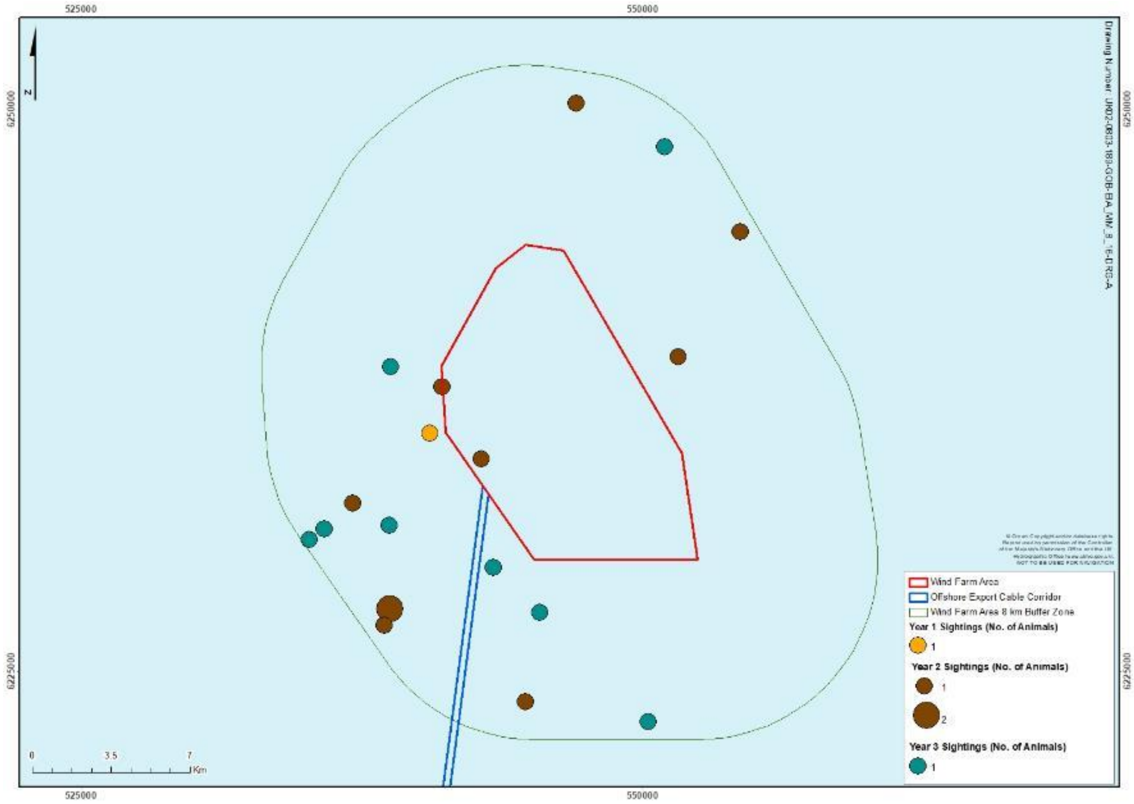


Figure 8-16: Distribution of minke whale recorded within the study area during boat-based surveys undertaken between November 2010 and October 2013

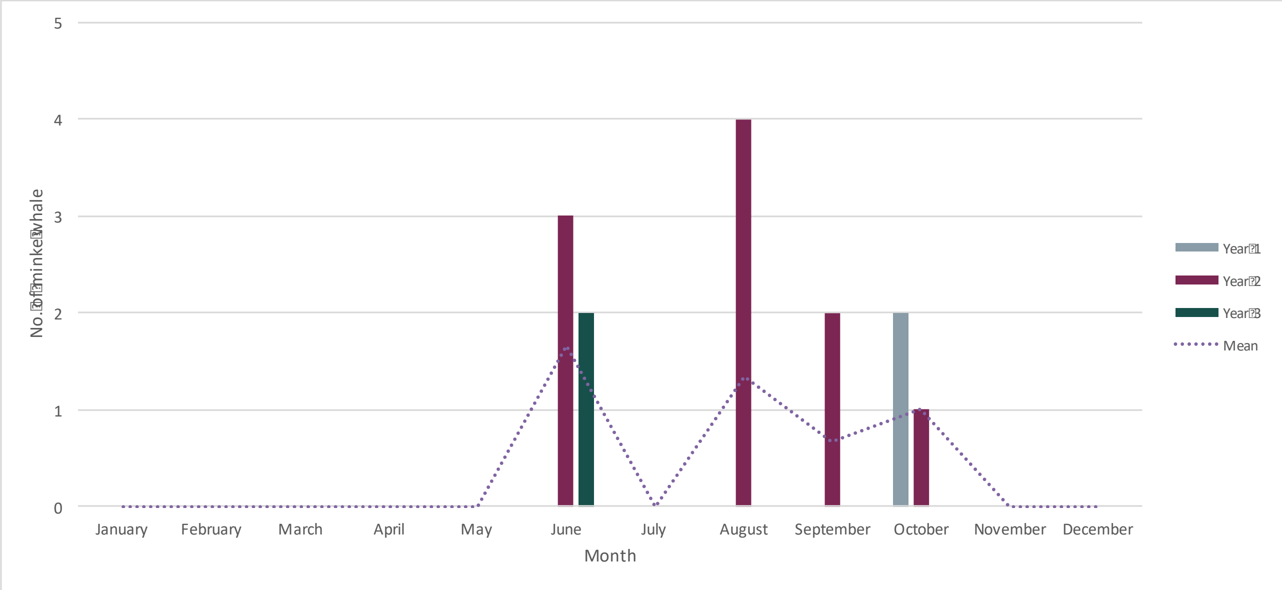


Figure 8-17: Monthly number of minke whales recorded within the study area during boat-based surveys undertaken between November 2010 and October 2013

144. Due to the low numbers of minke whales recorded in the area it is not possible to calculate population estimates or densities within the Wind Farm Area. However, within the Firths of Forth and Tay population estimates of between 269 (95% CI 86 – 1,711) and 594 (95% CI 483 – 2,695) minke whales has been estimated at densities of between zero and 0.25 ind./km^2 (Table 8.16 and Table 8.17) (King and Sparling, 2012; Mackenzie *et al*. 2012).

145. For the purposes of this assessment a SCANS III CGNS Management Unit population of 11,819 individuals and a regional density of 0.039 ind/km^2 have been used. These are based on the most recent population estimates and SCANS III Block R regional specific density.

8.8.7 Grey Seal Baseline Data

146. The following presents a summary of the existing information on grey seal.

8.8.7.1 Existing baseline

147. The grey seal (*Halichoerus grypus*) is the more abundant of the two species of seal that breed around the coast of the British Isles with a UK population of 139,800 (95% CI 116,500 - 167,100) individuals (SCOS, 2016). Approximately 88% of British grey seals breed in Scotland, mostly in the Outer Hebrides and Orkney. Elsewhere, they occur in Shetland and along the north and east coasts of the UK and in the southwest (SCOS, 2016).

148. Total counts of grey seals hauled out within the East Scotland and North-east England Management Areas are presented in Figure 8-18 (Duck *et al.* 2016). However, as not all grey seals are at haul-out sites at the same time the actual population will be greater than this. To account for this, the number of grey seals recorded at haul out sites is adjusted using a scalar multiplier of 2.39 (Russell *et al*. 2016a). By doing so this provides a population estimate based on the most recent available survey counts of grey seals in the East Coast Management Area (ECMA) of 9,607 (95% CI 8,028 – 11,958) individuals and a North-East England population of 29,046 (95% CI 24,272 – 36,156) individuals (Figure 8-18).

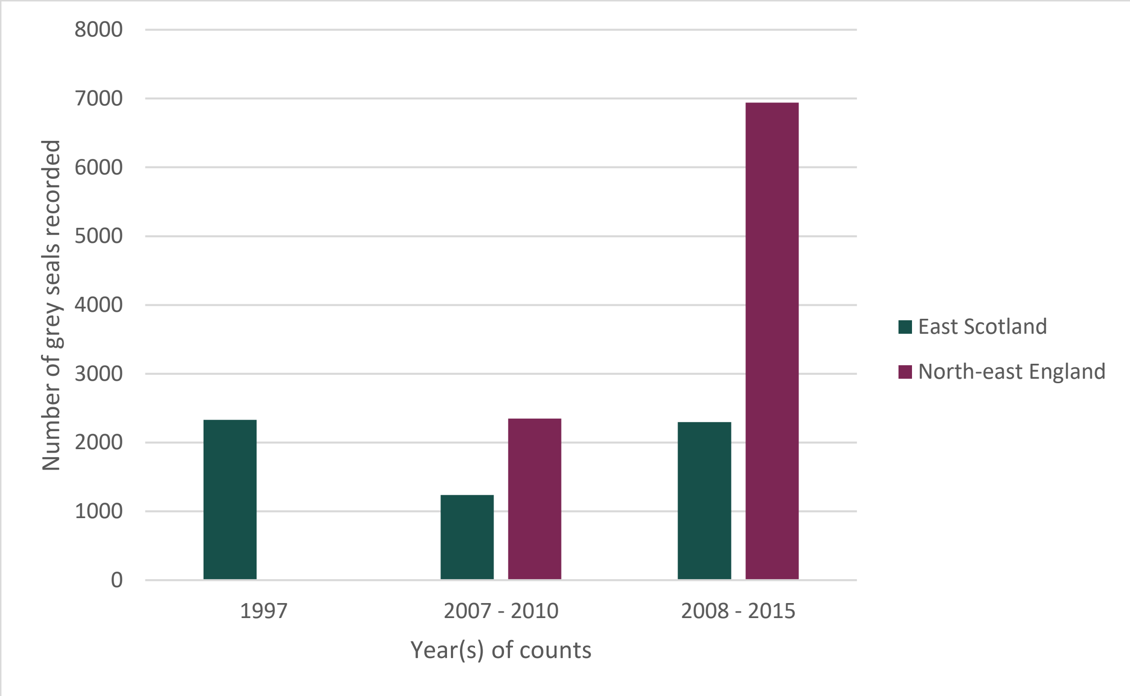


Figure 8-18: Estimated unadjusted number of grey seals hauled out within East Scotland and North-east England Seal Management Areas (Source: Duck *et al.* 2016)

149. Major grey seal colonies on the east coast of Scotland and northeast England include the Isle of May, Fast Castle and the Farne Islands. Fast Castle is the largest colony in the North Sea and between the three sites they hold 12% of the UK grey seal population (Figure 8-19) (Duck and Morris, 2012). Based on the numbers hauled out and the number of pups, the grey seal population in the region from Northeast Scotland to the Farne Islands is between 9,000 and 20,000 grey seals depending on time of year (Sparling *et al.* 2012).

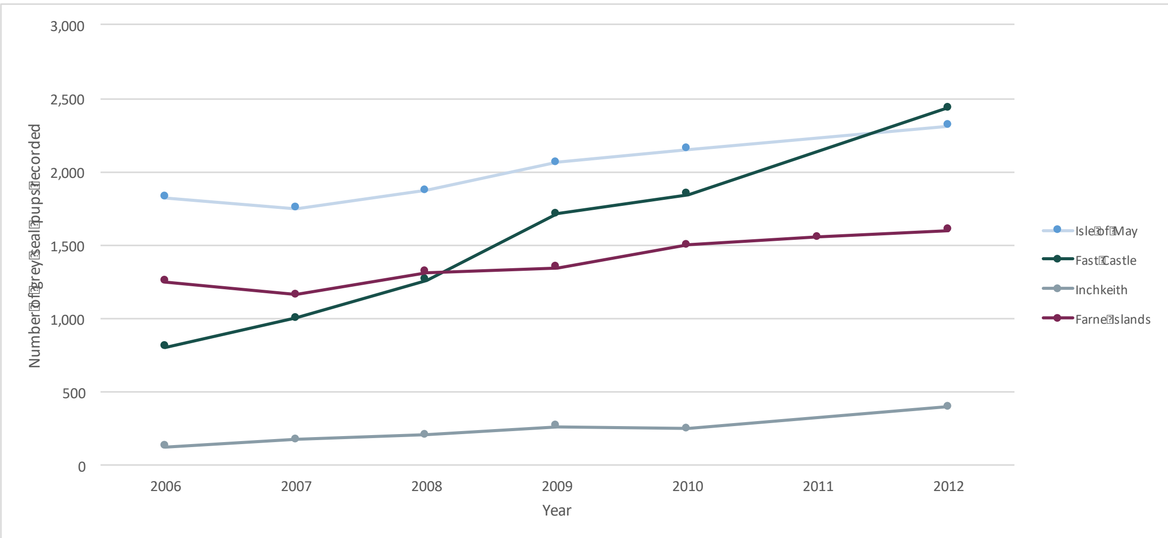


Figure 8-19: Grey seal pup production estimates for breeding colonies on the northeast coast of England and southeast coast of Scotland between 1999 and 2009

150. Tagging studies undertaken in the East Scotland Management Area indicate that grey seals occur throughout the Firths of Forth and Tay area with relatively higher occurrence in St Andrews Bay and around the Farne Islands and off North-east Scotland (Figure 8-20) (Marine Scotland 2017d).

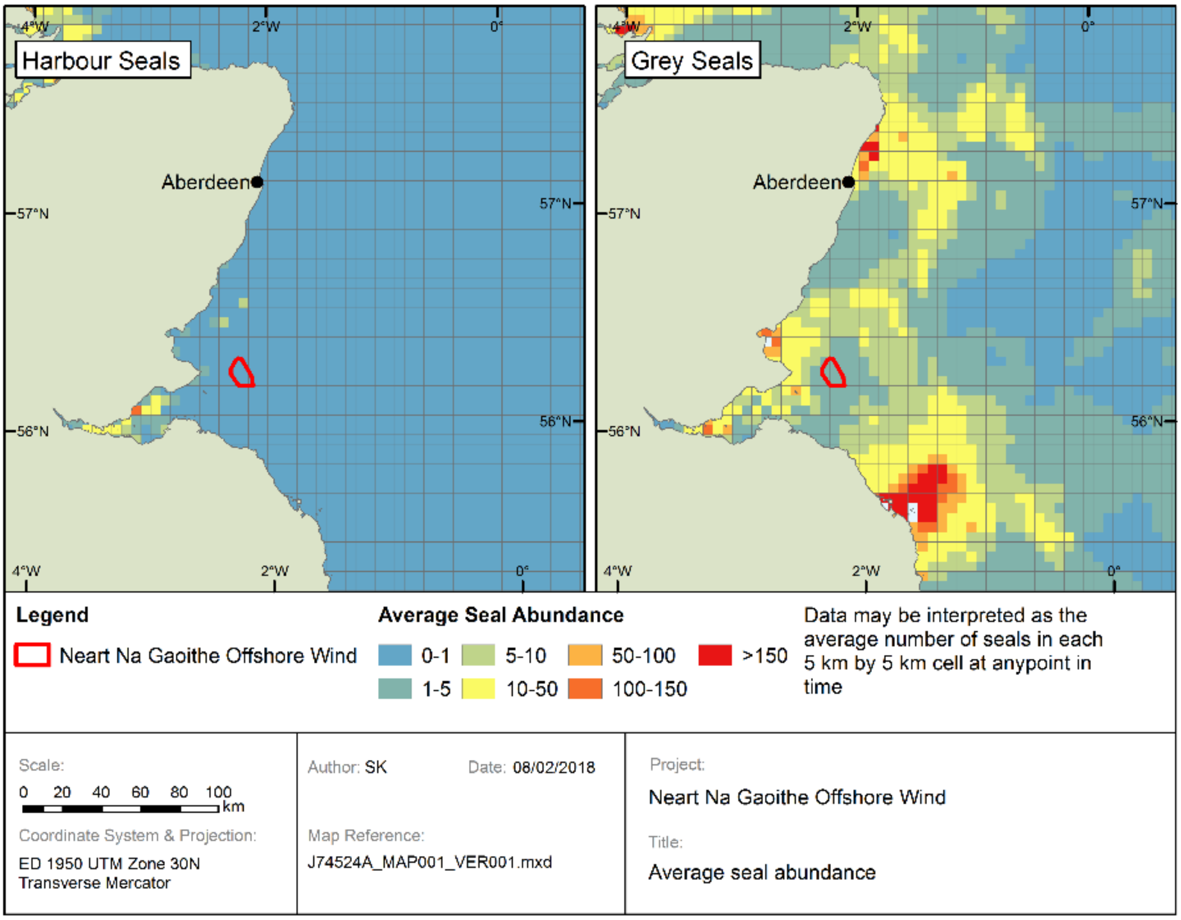


Figure 8-20: Estimated at sea distribution of grey and harbour seals off eastern Scotland (Source Marine Scotland 2017d)

151. Prior to pupping there is a gradual increase in the numbers of grey seals occurring in nearshore waters adjacent to the haul-out beaches (SNH, 2006). Pupping occurs late October and late November and the pup is weaned after approximately 2 weeks, after which mating takes place (Duck, 2010). During this period grey seals remain largely onshore or in nearshore waters; outwith this period grey seals are more widespread occurring more frequently in offshore foraging areas. Following breeding, grey seals undergo a moult in January and February (SNH, 2006).

152. Grey seals forage in areas that are up to at least 100 m deep and that tend to have gravel/sand seabed sediments, which are the preferred burrowing habitat of their primary prey, sandeels. Grey seal foraging movements are on two geographical scales: long and distant trips from one haul-out site to another; and local repeated trips to specific offshore areas. Long-term telemetry studies show that grey seals occur regularly in the waters around the Wind Farm Area (Hammond *et al* 2004).

153. Grey seals are qualifying species for the Isle of May SAC and the Berwickshire and North Northumberland Coast SAC. Their haul out sites within these SACs are protected under the Marine Scotland Act (2010).

8.8.7.2 Site Specific Data

154. During three years of boat-based surveys grey seals were occasionally recorded within the Offshore Wind Farm and buffer area. The majority of sightings were outwith the wind farm area with 125 of the 140 sightings occurring in the buffer area (Figure 8-21). Across years the total number of grey seals recorded was relatively constant with 43 in year 1, 58 in year 2 and 39 in Year 3 (Table 8.19).

155. Peak numbers occurred during March and October with a maximum of 16 grey seals recorded across the whole survey area in October 2011 (Figure 8-22). Outwith these periods, grey seals were recorded infrequently.

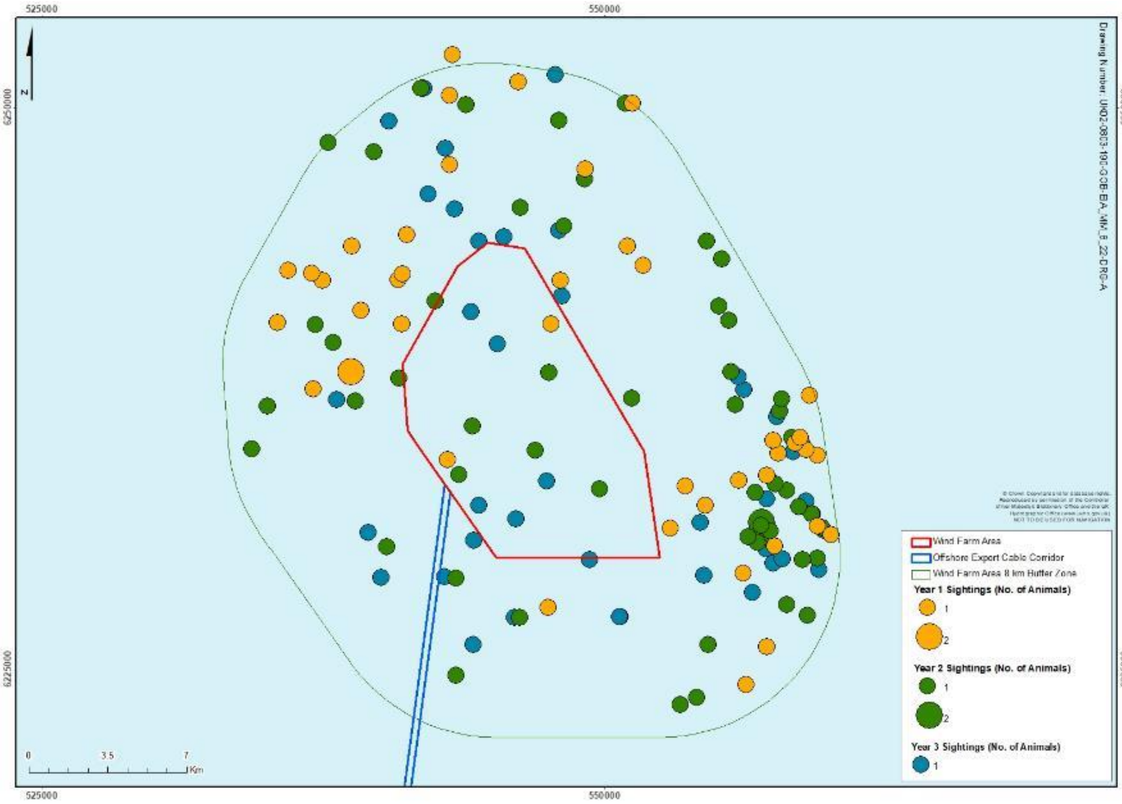


Figure 8-21: Distribution of grey seals recorded within the study area during boat-based surveys undertaken between November 2010 and October 2013

Table 8.19: Number of grey seals recorded within the Wind Farm and Buffer areas during boat-based surveys undertaken between November 2010 and October 2013

Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Year 1 (Nov 2010 – Oct 2011)													
WFA	0	0	0	0	1	0	0	0	0	1	0	0	2
Buffer	3	2	0	0	13	4	1	1	0	1	0	16	41
Total	**3**	**3**	**0**	**0**	**14**	**4**	**1**	**1**	**0**	**2**	**0**	**16**	**43**
Year 2 (Nov 2011 – Oct 2012)													
WFA	n/c	0	0	1	0	0	0	0	3	1	0	1	6
Buffer	n/c	3	1	6	6	0	7	1	4	9	7	8	52
Total	**n/c**	**4**	**1**	**7**	**6**	**0**	**7**	**1**	**7**	**10**	**7**	**9**	**58**
Year 3 (Nov 2012 – Oct 2013)													
WFA	0	0	2	1	3	0	0	0	0	0	1	0	7
Buffer	4	0	4	3	8	9	0	0	2	0	1	1	32
Total	**4**	**0**	**6**	**4**	**11**	**9**	**0**	**0**	**2**	**0**	**2**	**1**	**39**

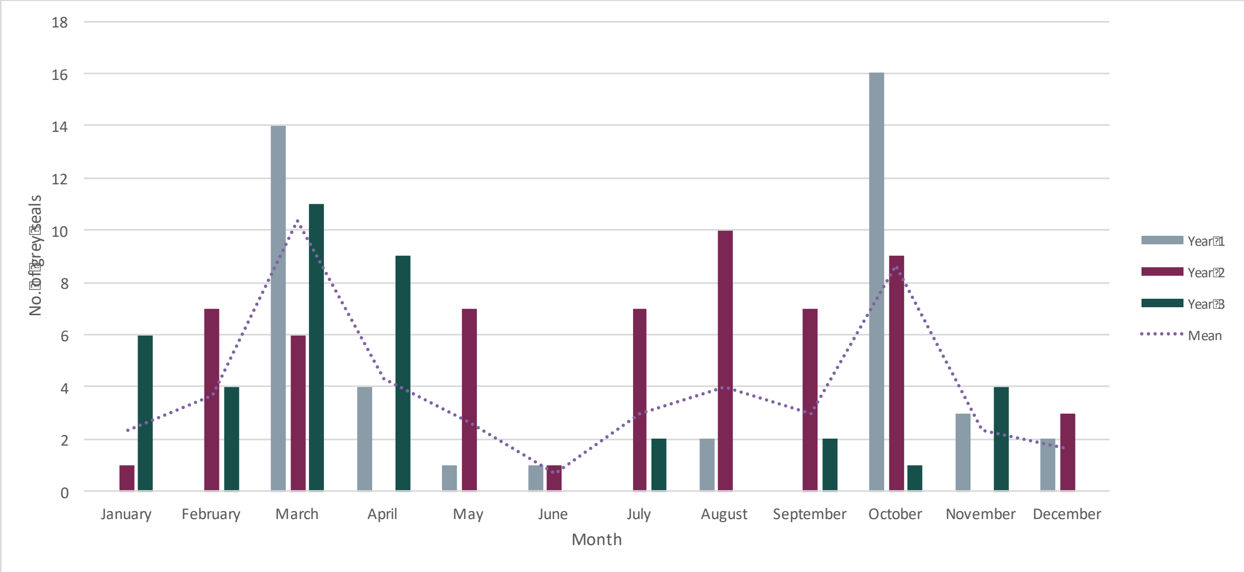


Figure 8-22: Monthly number of grey seals observed during three years of boat-based surveys

156. The abundance of grey seals within the study area varies with higher numbers occurring in nearshore waters, particularly adjacent to haul-out sites (Figure 8-18). Within the Offshore Wind Farm Area between one and five grey seals occurs within each 5 km^2. Site specific grey seal densities have been estimated based on two years of site specific studies on grey seal usage of the site. The results of the studies estimated a density of grey seals within the study area of 0.14 ind./km^2 with highest densities occurring to the south-east of the Offshore Wind Farm Area (Figure 8-23) (Gordon, 2012).

157. For the purposes of this assessment the adjusted East Coast Management Area of 9,607 individuals has been used. A regional specific density is not required as the number of individuals predicted to be impacted is estimated from the at sea distributions (See Appendix 8.2: interim PCoD Population Modelling for further details).

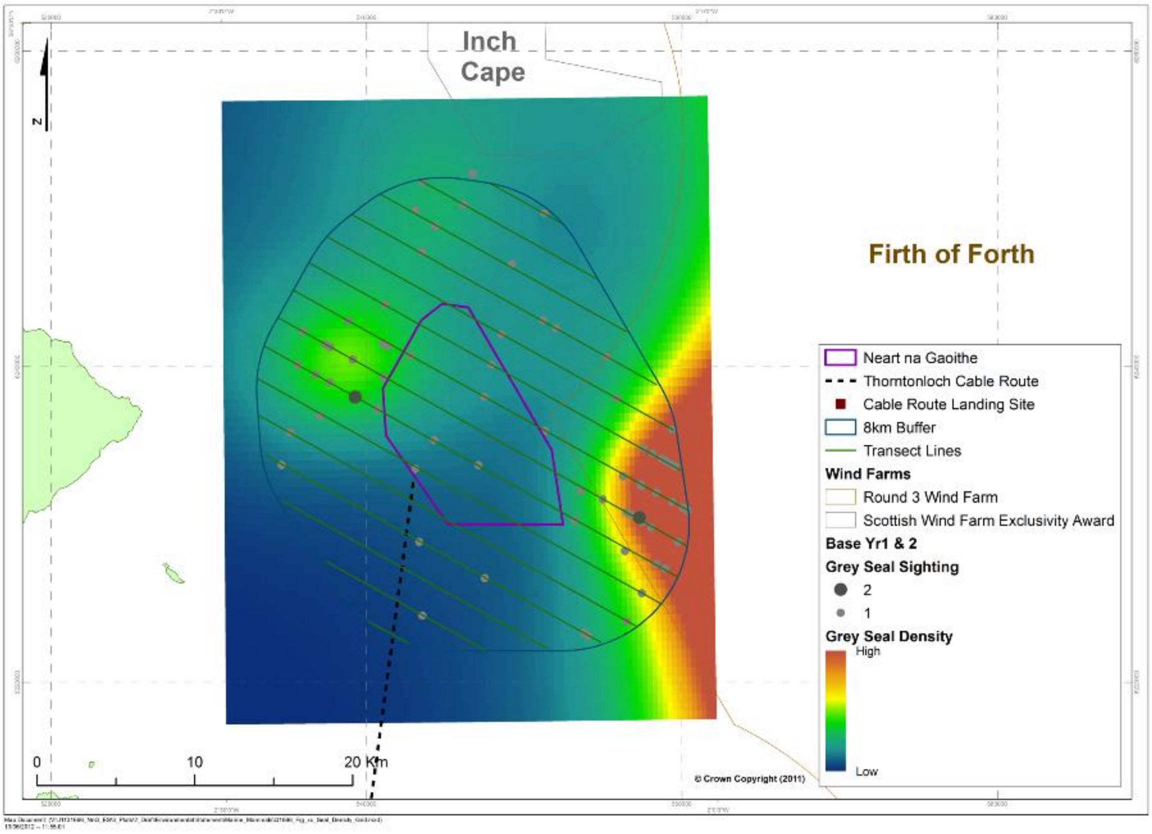


Figure 8-23: Estimated densities of grey seals in the Wind Farm Area and adjacent waters (Source: Gordon, 2012)

8.8.8 Harbour Seal Baseline Data

158. The following presents a summary of the existing information on harbour seal (*Phoca vitulina*).

8.8.8.1 Harbour Seal

159. The UK population of harbour seal is estimated to be 43,300 individuals (95% CI: 35,500 - 59,000) of which 224 individuals occur within the ECMA, which extends from Fraserburgh to the border with England (Duck *et al.* 2016).

160. Total counts of harbour seals hauled out within the East Coast and Moray Firth Management Areas are presented in Figure 8-24. However, as not all harbour seals are at haul-out sites at the same time, the actual population will be greater than the number of seals counted. To account for this, the number of harbours seals recorded at haul out sites is adjusted using a scalar of 1.39 (Sparling *et al.* 2012). By doing so this provides a population estimate of harbour seals in the ECMA of 311 (95% CI 254 - 415) individuals and a Moray Firth population of 1,034 (95% CI 846 – 1,379) individuals, based on the latest available survey data.

161. Since 1997 there has been a wide-scale decline in the number of harbour seals across much of the UK with significant reductions at most haul out sites along the east coast of Scotland. The Firth of Tay and Eden Estuary SAC lies approximately 30 km from the proposed development and like most other east coast harbour seal sites has recorded a decrease in the number of harbour seals present, with a 90% decline in the harbour seal population since 2002 (SCOS, 2016). The latest harbour seal population estimate based on counts undertaken in 2015 is 60 individuals (Duck *et al*. 2016).

162. The cause of the decline in harbour seals is unknown but if the trend continues, based on the current rate of decline, the population of harbour seals within the Firth of Tay and Eden Estuary SAC may become effectively extinct by approximately 2030 (Figure 8-25).

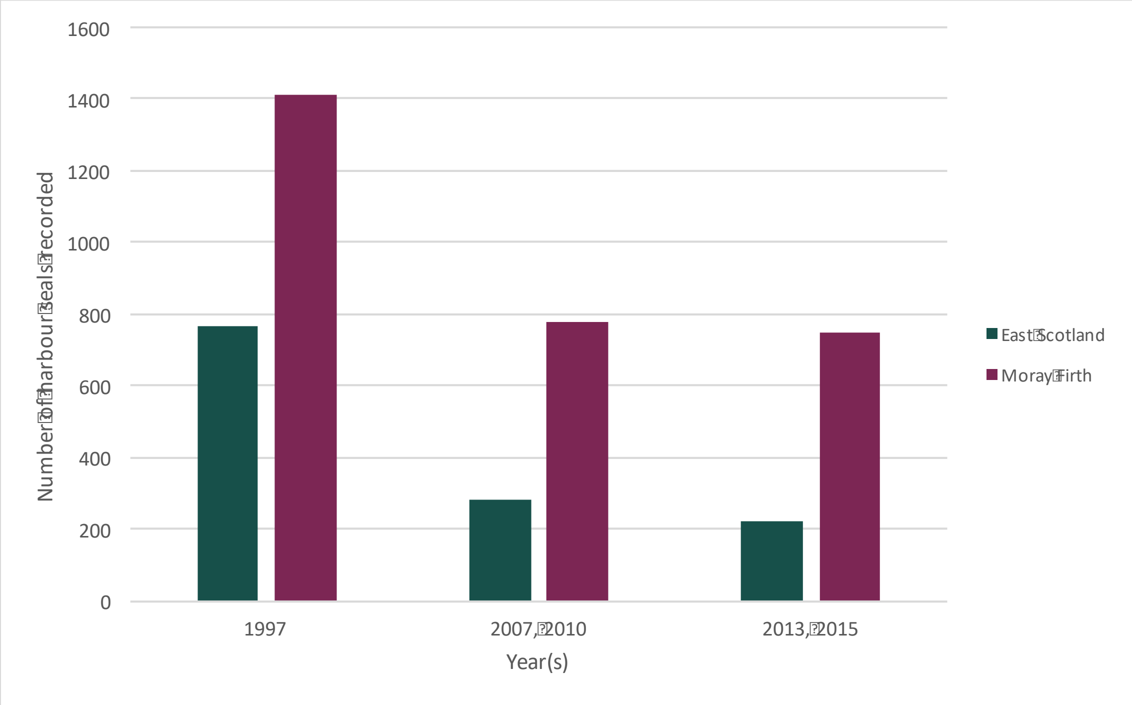


Figure 8-24: Estimated number of harbour seals hauled out within the East Coast and Moray Firth Seal Management Areas (Source: Duck *et al.* 2016)

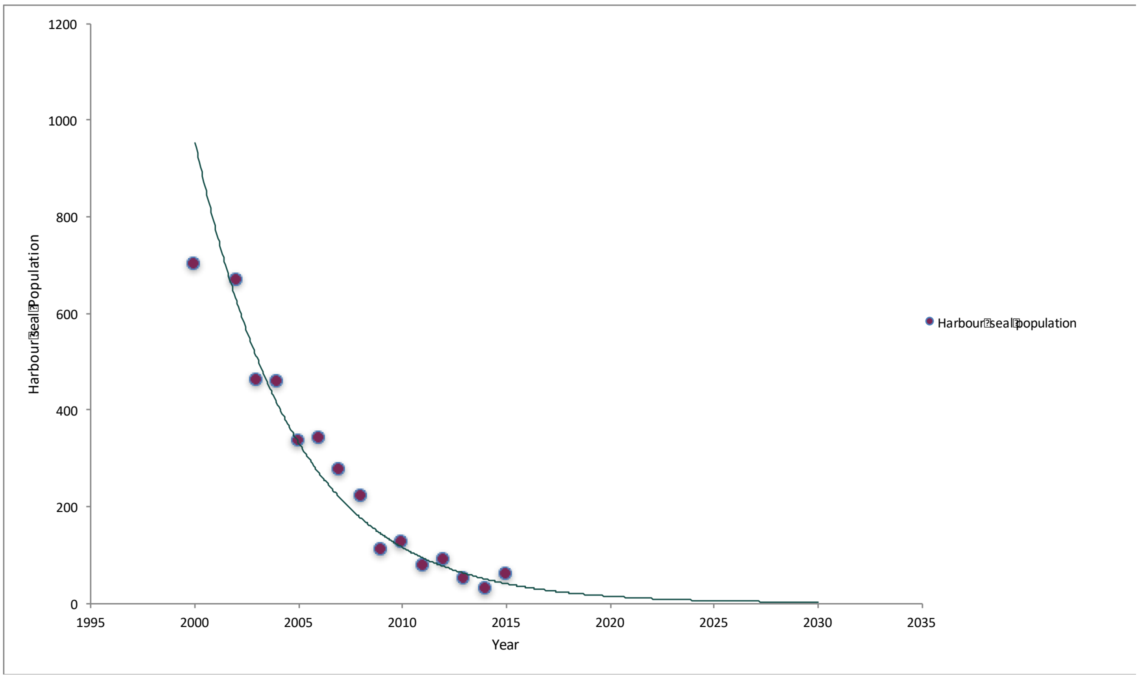


Figure 8-25: Harbour seal population in the Firth of Tay and Eden Estuary SAC from 2000 to 2015

163. Tagging studies of harbour seals indicate that they remain largely in nearshore waters with only infrequent occurrences further offshore (Marine Scotland, 2017d; Sparling *et al*. 2012). Tagging results indicate a very low abundance offshore with relatively higher numbers occurring the Firth of Forth and St Andrews bay area (Figure 8-20).

164. Pupping occurs during June and July followed by moulting during August. Mating also occurs during this period when males will hold underwater territories using vocalisation to help maintain their territories that are close to their haul-out sites. During this period harbour seals remain closer to their haul-out sites. Studies have shown that they spend on average 43% of their time within 10 km of haul out sites (McConnell *et al.* 1999).

165. Breeding in the region takes place between June and July and pups are nursed for a few weeks. Harbour seals undergo a moult during August during which time they spend a greater proportion of their time on shore (Brown and Pierce, 1997; SCOS, 2016).

166. Harbour seals are opportunistic feeders, preying on a wide range of fish species including sandeels, herring, whiting and gadoids, although there is seasonal and geographical variation with for example Gadoid fish being a dominant prey item for harbour seals on Mousa (Brown and Pierce, 1997; Hall and Kershaw, 2012).

167. Harbour seals normally feed within 40-50 km around their haul out sites, and take a wide variety of prey including sandeels, cod, haddock, whiting, ling (*Molva molva*), herring and sprat, flatfish species, octopus and squid, with some seasonal and regional variation with sandeels, octopus, whiting, flounder (*Platichthys flesus*) and cod being eaten by harbour seals in North-east Scotland and sandeels and salmonids being significant prey items for harbour seals in the Tay Estuary (Sparling *et al.* 2012; SCOS, 2005; Tollit and Thompson, 1996).

168. The harbour seal is a qualifying species for the Forth and Tay and Eden estuary SAC and their haul out site within the SAC is protected under the Marine Scotland Act (2010).

8.8.8.2 Site Specific Data

169. During three years of boat-based surveys harbour seals were infrequently recorded within the wind farm and buffer area. A total of 41 harbour seals were recorded over the three years of surveys, of which five were within the Wind Farm Area. Although the number of sightings was low across all three years, the number of harbour seals recorded in Year 1 was relatively lower than the number recorded in Years 2 and 3 (Table 8.20). The majority of sightings were outwith the Wind Farm Area with most observations to the south-east of the site (Figure 8-26).

170. The number of harbour seals recorded within the surveyed areas fluctuated each month with no distinct seasonal variation in the numbers recorded. However, the average number of harbour seal recorded tended to be lower between June and October. Although with relatively few sightings it is difficult to draw a firm conclusion on this (Figure 8-27).

Table 8.20: Number of harbour seals recorded within the Wind Farm and Buffer areas during boat-based surveys undertaken between November 2010 and October 2013

Year	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Total
Year 1 (Nov 2010 – Oct 2011)													
WFA	1	1	0	0	0	0	0	0	0	0	0	0	2
Buffer	1	2	0	1	0	0	0	0	0	0	0	0	4
Total	**2**	**3**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**6**
Year 2 (Nov 2011 – Oct 2012)													
WFA	n/c	0	0	0	0	0	0	0	0	0	0	0	0
Buffer	n/c	0	2	1	1	3	4	2	0	2	0	2	17
Total	**n/c**	**0**	**2**	**1**	**1**	**3**	**4**	**2**	**0**	**2**	**0**	**2**	**17**

Year 3 (Nov 2012 – Oct 2013)													
WFA	0	2	0	0	0	0	1	0	0	0	0	0	3
Buffer	2	0	1	4	0	3	2	0	1	1	1	0	15
Total	**2**	**2**	**1**	**4**	**0**	**3**	**3**	**0**	**1**	**1**	**1**	**0**	**18**

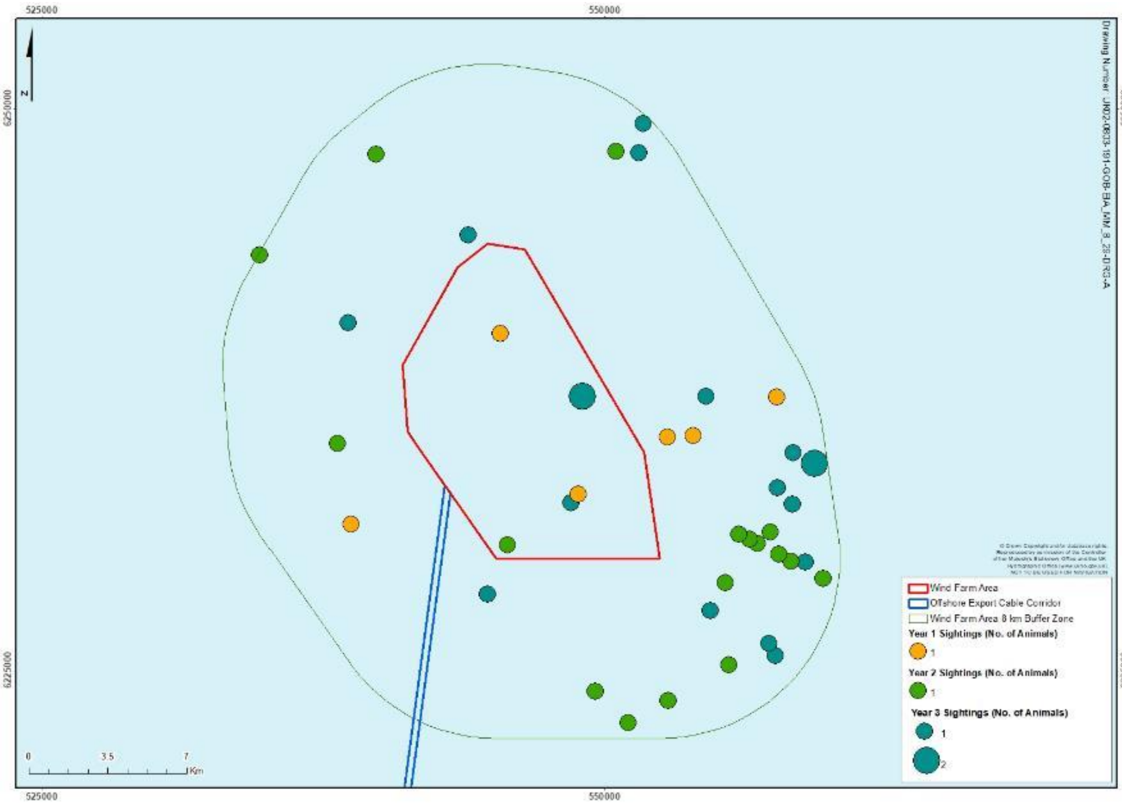


Figure 8-26: Distribution of harbour seals recorded within the study area during boat-based surveys undertaken between November 2010 and October 2013

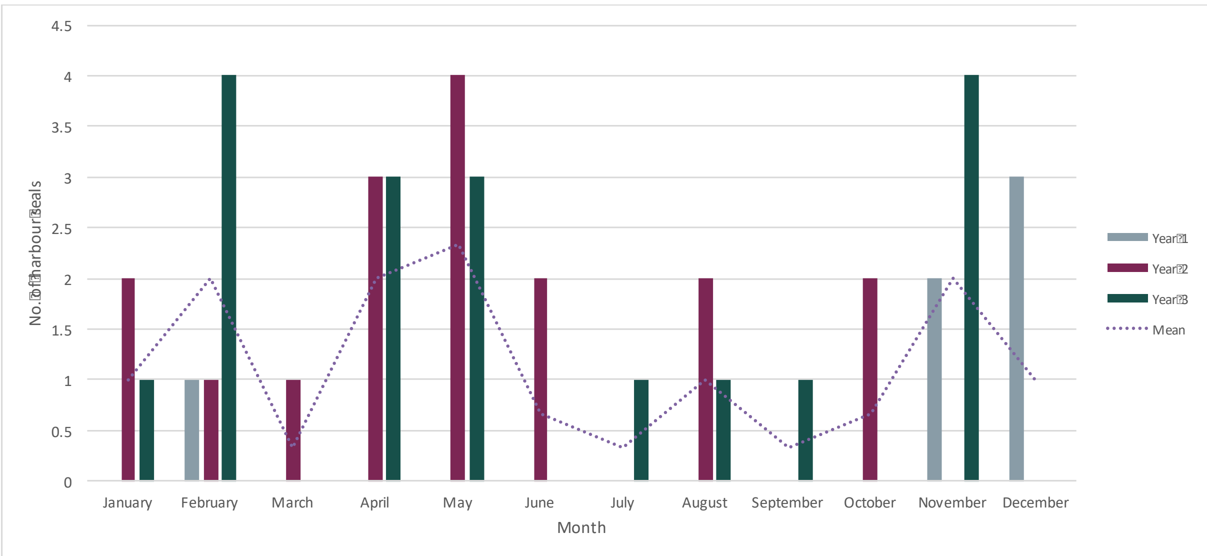


Figure 8-27: Monthly number of harbour seals observed during three years of boat-based surveys

171. Densities of harbour seals within the study area have been estimated based on the offshore usage presented in Figure 8-20. Based on the offshore usage within the Wind Farm Area a density of less than 0.04 ind/km^2 occur within the Wind Farm Area.

172. For the purposes of this assessment the adjusted ECMA population has been used; a total regional population of 311 individuals. A regional specific density is not required as the number of individuals predicted to be impacted is estimated from the at sea distributions (See Appendix 8.2: Interim PCoD modelling for further details).

8.8.9 Development of Baseline Conditions without the Project

173. In the event of the Project not being developed, there would be no change in the baseline conditions in the Offshore Wind Farm Area beyond those resulting from drivers such as climate change, natural variations in temporal and spatial distributions or impacts from other human activities.

174. Population modelling undertaken for this assessment indicate that, with the exception of harbour seal, populations of marine mammals are predicted to remain relatively stable with small fluctuations in populations over the next 24 years (see Appendix 8.2: Interim PCoD modelling).

8.9 Design Envelope – Worst Case Design Scenario

175. The Project application is for the construction, operation and decommissioning of an offshore wind farm with a maximum output of up to 450 MW, comprising of up to 54 turbines and with two OSPs. The assessment scenarios identified in respect of marine mammals have been selected as those having potential to represent the greatest effect based on the design envelope described in Chapter 4: Project Description. The worst-case design scenarios are set out in Table 8.21.

Table 8.21: Design envelope scenario assessed

Potential Impact	Worst Case Design Scenario	Justification
Construction		
Pile driving construction noise	'Drive-only' scenario. It is estimated that between 0% and 10% (max) of piles can be installed by driving without assistance from use of a drill (i.e. driven only piling). Pile driving will occur for up to 18 hrs in total at each wind turbine location with a maximum hammer energy of 1,635 kJ.	The 'Drive-only' scenario will require the highest hammer energy which causes the greatest extent of noise propagation. Noise modelling previously undertaken for both the 'Drive-only' and 'Drive-Drill-Drive' scenarios indicated that the worst-case scenario was 'Drive-only' (Nedwell and Mason, 2012).
Noise from pre-construction geophysical survey work	Sound arising from a range of geophysical survey equipment has potential to cause disturbance to marine mammals. The location and duration of surveys are not known at this stage. The assessment considers the use of multi-beam sonar, sidescan sonar and sub-bottom profilers.	NnGOWL have already completed a number of geophysical survey campaigns within the Development Area. Survey requirements will be determined following review of the already collected data, all potential geophysical survey equipment has therefore been considered within the EIA.
Disturbance from noise and particle motion	Sheet piling of interlocking steel sheets to create a dry area around the receiving pit at the HDD exit in shallow water close to the landfall	Installation of a dry area may be required to assist with export cable pull in and joining the OfTW and OnTW components of the export cable.

from the HDD site pipe works	location. The casing will be removed following export cable installation. The installation duration for the dry area is unknown but it is anticipated that it would be of short duration taking a number of days.	
Operation and Maintenance		
Disturbance from helicopter noise and physical presence	Up to 80 helicopter flights per year between a helicopter base likely situated on the east coast of Scotland and the Wind Farm Area.	Access to vessels and structures may utilise helicopter transfers during operation and maintenance for personnel transfer and transfer of equipment.

8.9.1 Embedded Mitigation

176. Embedded Mitigation measures to minimise the potential effects on marine mammals, are captured within the Project design envelope. The scoping of the assessment of effects on marine mammals has taken account of the following:

- Pile driving will be undertaken using the lowest possible hammer energy to allow satisfactory pile installation. This will reduce the area of potential impact from noise on marine mammals and their prey. Pile driving will commence by using a lower hammer energy and slowly, over a period of time, ramp-up to a maximum hammer energy. This reduces the duration at which marine mammals will be impacted by potentially significant levels of noise and provides time for them to leave the area in order to avoid possible risk of physical injury.

8.9.2 Anticipated Consent Condition Commitments

177. A number of conditions were attached to the Original Consents to manage the environmental risk associated with the Originally Consented Project. NnGOWL anticipates that any future consents issued to the Project may incorporate similar conditions to manage the risk to marine mammals commensurate with the Project design envelope where it remains necessary to do so. Table 8.22 sets out the conditions attached to the Consents which have relevance to the management of effects on marine mammals.

Table 8.22: Consent conditions for the Originally Consented Project relevant to marine mammals

Original Consent Requirement	Relevance to Marine Mammals
Piling Strategy	Setting out, for approval, the piling methods, in accordance with the Application and detailing associated mitigation incorporating data collected as part of pre-construction survey work to demonstrate how effects on bottlenose dolphin, harbour seal and grey seal will be adequately mitigated.
Noise registry	Prior to the commencement of piling activities the proposed date(s), location(s) and nature of the piling activities undertaken must be reported. In the event piling is to be carried out for more than 10 consecutive days, submit quarterly noise registry reports.
Construction Method Statement	Setting out, for approval, details of the finalised construction methods and set out the construction procedures and god working practices to be used. The CMS will be submitted for approval at least six months prior to the commencement of works.

Original Consent Requirement	Relevance to Marine Mammals
Vessel Management Plan	Requires details of the vessels to be used and working practices to reduce the use of ducted propellers.
Environmental Management Plan	Setting out, for approval, relevant environmental management and mitigation measures to be applied during the construction and operation of the Project.
Project Environmental Monitoring Plan	Setting out, for approval, the proposed environmental monitoring programme, to include the participation in surveys to be carried out in relation to marine mammals as set out in the Marine Mammal Monitoring Programme
Participation in the Scottish Strategic Marine Environmental Group (SSMEG)	Requires participation in the SSMEG with respect to research, monitoring and mitigation programmes for marine mammals.
Participation in the Forth and Tay Regional Advisory Group (FTRAG)	Participation in the FTRAG with respect to monitoring and mitigation for marine mammals.

8.10 Impact Assessment

178. The following section addresses the potential impacts on marine mammals from the construction, operation and decommissioning of an offshore wind farm. The assessment is based on:

- Knowledge of the marine mammals at risk of being impacted, as presented in Section 8.8;
- The potential magnitude of any impact, in particular impacts from sound arising during construction, based on the results of the noise modelling presented in Appendix 8.1: Noise modelling; and
- Our understanding of the effects any potential impacts may have on the marine mammals, in particular the population level effects, based on the results from population modelling (as presented in Appendix 8.2: Interim PCoD modellinginterim PCoD).

179. A summary of the potential impacts on marine mammals arising during the construction, operation and decommissioning phases of the Project is presented in Table 8.23. The potential impacts were identified during formal scoping and the subsequent formal and informal consultation (see Section 8.6 Impacts to be assessed).

180. The activities identified as having the potential to cause an impact on marine mammals and whether they were requiring assessment are summarised in Table 8.23 below.

Table 8.23: Activities recognised as having the potential to impact on marine mammals and the determination of whether they are assessed in the EIA

Activity	Scoped in/out of EIA
Disturbance resulting from vessel noise during construction, operation and decommissioning.	It is anticipated that the type and number of vessels operating during the construction period will be broadly similar to the Original Project design envelope; however, each vessel type will be present on site for a shorter duration. There is no change in the construction vessels required. However, duration on site of construction vessels associated with foundation and turbines installation and commissioning is likely to be reduced due to reduced scale of the Project.

Activity	Scoped in/out of EIA
	The potential impacts from vessel noise on marine mammals were assessed in the Original EIA as being not significant and were identified as not requiring further assessment in the NnGOWL Scoping document and agreed with MS in the Scoping Opinion (Marine Scotland 2017a).
Disturbance resulting from vessel presence during construction, operation and decommissioning.	The potential impacts from the presence of vessels on marine mammals were assessed in the Original EIA as being not significant and were identified as not requiring further assessment in the NnGOWL Scoping document and agreed with MS in the Scoping Opinion (Marine Scotland 2017a).
Hammer noise during construction.	The Project is for the installation of up to 54 turbines with a maximum of 6 piles per foundation. Up to 10% of piles can be installed by driving without assistance from use of a drill (i.e. driven only piling). Between 90 and 100% of piles can be installed using one or either of drive-drill-drive method or the drill only method. Where drill only is adopted, the sacrificial casing is expected to be driven to an average length of 30% of the pile length. The installation methods are similar to those assessed in the Original EIA and described in Chapter 4: Project description. The Original EIA concluded that the potential impacts were of minor significance. However, changes in the approach to assessing impacts from noise on marine mammals since the Original EIA indicate further assessment is required for the Revised Project. The potential impact from driving was identified in the Scoping Opinion (Marine Scotland 2017a) as requiring further assessment.
Drilling noise during construction	There is no significant change in the proportion of piles that will require drilling from the Originally Consented Project. The Original EIA concluded that impacts from drilling were not significant and were identified as not requiring further assessment in the Project Scoping document and agreed with MS in the Scoping Opinion (Marine Scotland 2017). However, as drilling will be an integral component of the installation of foundations, an assessment of the potential impacts from drilling noise on marine mammals has been undertaken.
Indirect effects resulting from impacts on prey species	Potential impacts on prey species considered in the Original EIA were identified as not requiring further assessment in the NnGOWL Scoping document and agreed with MS in the Scoping Opinion (Marine Scotland 2017). MS did request that consideration of the potential impacts of particle motion effects were considered on all fish and shellfish species. The impacts of particle motion arising from pile driving activity was considered to be of minor significance and not significant in EIA terms (See Chapter 7: Fish and Shellfish).
Suspended sediment concentrations during construction and decommissioning	Increased suspended sediment concentrations may arise during the installation (or possible removal) of inter-array and export cables. The design envelope relating to the inter-array cables remains unchanged compared to the Original Application although there has been an increase in Offshore Export Cable length. The Original EIA determined that the potential impacts were not significant and this is considered to remain valid. These impacts were identified as not requiring further assessment in the NnGOWL Scoping document and agreed with MS in the Scoping Opinion (Marine Scotland 2017).
Increased noise associated with cable installation (inter-	There is no change in the vessels required to install cables.

Activity	Scoped in/out of EIA
array and export cabling) during construction.	The Original EIA determined that the potential impacts were not significant and this is considered to remain valid. These impacts were identified as not requiring further assessment in the NnGOWL Scoping document and agreed with MS in the Scoping Opinion (Marine Scotland 2017).
Operational noise	No change in the level of noise from individual operating turbines but an overall reduction in the total number of turbines since the Original Project Application. The Original EIA determined that the potential impacts were not significant and this is considered to remain valid. These impacts were identified as not requiring further assessment in the NnGOWL Scoping document and agreed with MS in the Scoping Opinion (Marine Scotland 2017).
Electromagnetic fields from cables during operation	As per the Original Project Application the Offshore Export Cables will be high voltage alternating current (HVAC) and will be trenched and buried. The Original EIA determined that the potential impacts were not significant and this is considered to remain valid. These impacts were identified as not requiring further assessment in the NnGOWL Scoping document and agreed with MS in the Scoping Opinion (Marine Scotland 2017).
Geophysical and geotechnical surveys during construction, operation and decommissioning.	It is recognised that there is the potential for geophysical and geotechnical surveys to be undertaken within the NnG Development Area. Although they will be subject to their own applications as and when required, SNH have advised that they should be considered within the Project EIA.
Operation and Maintenance activities from helicopters	The potential impact on marine mammals from helicopters during operation and maintenance activities was raised during consultation. This had not previously been assessed in the Original Application and therefore potential impacts by helicopter on marine mammals are assessed in ES for the Project.

181. Based on the assessment undertaken during scoping and responses received during formal and informal consultation it has been determined that the activities arising from the construction, operation and decommissioning of the Neart na Gaoithe offshore wind farm that may cause a significant environmental impact on marine mammals are:

- The installation of foundation piles for the wind turbines, offshore substation platform and meteorological (met) mast.

182. In addition, two further activities have been identified as being appropriate for inclusion in the EIA. The activities are:

- Geophysical surveys required in order to determine seabed conditions. Sound arising from a range of geophysical survey equipment has potential to cause disturbance to marine mammals.
- The use of helicopters during the operational life-time of the project. The sound and physical presence could cause disturbance to marine mammals.

8.10.1 Marine Mammals and Noise

183. Sound arising from proposed construction activities has the potential to impact on marine mammals within or adjacent to the Offshore Wind Farm Area.

184. There is a substantial volume of literature describing the potential effects of sound on marine mammals, and summarised in e.g. Thomsen *et al.* (2006), Southall *et al.* (2007) and OSPAR (2009).

185. There are four main types of potential effect from noise that are recognised within the marine environment:

- *Fatal effects* caused by significant levels of noise in close proximity to the receptor.
- *Physical injury*, specifically hearing impairment, which can be permanent or temporary. These effects can impact on the ability of marine mammals to communicate, forage or avoid predators.
- *Behavioural effects* such as avoidance, resulting in displacement from suitable feeding or breeding areas, and changes in travelling routes.
- *Secondary impacts* caused by the direct effects of noise on potential prey causing a reduction in prey availability

186. The range at which marine mammals may be able to detect sound arising from offshore activities depends on the hearing ability of the species and the frequency of the sound. Pinnipeds (seals) are potentially more sensitive to low frequency sounds than bottlenose dolphin or harbour porpoise. Other factors potentially affecting the potential impact of sound on marine mammals includes ambient background noise, which can vary depending on water depth, seabed topography and sediment type. Natural conditions such as weather and sea state and other existing sources of human produced sound, e.g. shipping, can also reduce the auditory range.

Fatal effects

187. If source peak pressure levels from the proposed operations are high enough there is the potential for a lethal effect on marine mammals. Studies suggest that potentially lethal effects can occur to marine mammals when the peak pressure level is greater than 246 or 252 dB re. 1 µPa (Parvin, Nedwell and Harland, 2007). Damage to soft organs and tissues can occur when the peak pressure level is greater than 220 dB re. 1 µPa.

Physical injury

188. Underwater sound has the potential to cause hearing damage in marine mammals, either permanently or temporarily. The potential for either of these conditions to occur is dependent on the hearing bandwidth of the animal, the duty cycle of the sound source and duration of the exposure (Southall *et al*. 2007, OSPAR 2009).

189. Physical injury is described as either a permanent loss of hearing range (permanent threshold shift (PTS)) or temporary loss of hearing range (temporary threshold shift (TTS)). Sound exposure levels considered capable of causing the onset of either PTS or TTS do not mean that such physical impacts will always occur. The probability of developing PTS or TTS will follow a dose response curve, with increasing risk of physical injury as exposure increases. Studies undertaken on bottlenose dolphin indicate that only between 18% and 19% of bottlenose dolphins exposed to sound exposure levels of 195 dB re 1 μPa^2.s, actually resulted in the onset of TTS (Finneran *et al*. 2005).

190. Although PTS is a permanent physical injury impairing the marine mammal's ability to hear, TTS is not and impacts are relatively short-lived. Studies undertaken on harbour porpoise indicate that, depending on the exposure level and duration, hearing ability returns between 4 and 96 minutes after the sound causing the impact has ceased (Kastelein *et al*. 2012).

Behavioural Change

191. Potential changes in behaviour may occur depending on the sound source levels and the species' and individuals' sensitivities. Behavioural changes can vary from changes in swimming direction, diving duration, avoidance of an area and reduced communication from masking. The displacement of marine mammals could cause them to relocate to sub-optimal locations where there is lower prey availability or increased inter and intra-specific competition. If permanent or over a long period, this could cause lower fecundity or increased mortality.

192. Changes in behaviour arising from noise impacts may be easily detectable, e.g. a significant displacement from an area. Other effects caused by changes in behaviour, e.g. energetic stress, may be more difficult to detect and go unnoticed (OSPAR 2009).

193. Masking effects may also cause changes in the behaviour as the level of sound may impair the detection of echolocation clicks and other sounds that species use to communicate or detect prey thus causing them to alter their behaviour (David 2006).

Secondary Effects

194. There is potential for impacts on prey species to affect marine mammals and seabirds, in particular possible impacts of noise on fish species. The impacts from noise on fish are assessed in Chapter 7: Fish and Shellfish Ecology.

8.10.1.1 Harbour porpoise

195. Porpoises are generally considered to be 'high frequency' specialists with a relatively poor ability to detect lower frequency sounds (Southall *et al.* 2007). Studies undertaken on captive harbour porpoises indicate that porpoises have a functional hearing range of between 250 Hz and 180 kHz with their best hearing between 16 to 140 kHz and their maximum sensitivity between 100 and 140 kHz. This is within the frequency range of 130 to 140 kHz that harbour porpoise echolocate (Miller and Wahlberg 2013).

196. Their ability to detect sound below 16 kHz or above 140 kHz falls sharply (Kastelein *et al.* 2012, 2015, Southall *et al*. 2007). Harbour porpoise are therefore most sensitive to relatively high sound frequencies between 16 to 140 kHz and, although audible, they are unlikely to be sensitive to sound either above or below those frequencies.

197. Harbour porpoise use echolocation to communicate and detect prey. Reported sound levels produced range from between 166 to 194 dB re 1 µPa @ 1 m $_{(rms)}$ and 178 and 205 dB re. 1 µPa $_{(peak – peak)}$, with a mean level of 191 dB re. 1 µPa $_{(peak – peak)}$ and within the peak frequency range of 110 to 150 kHz (Villadsgaard, *et al*. 2007; Miller and Wahlberg, 2013; MMO, 2015).

8.10.1.2 Bottlenose dolphin and white-beaked dolphin

198. The frequencies at which bottlenose dolphins communicate through whistles and clicks is typically between 5 kHz and 10 kHz (Janik, 2000), However, lower frequency sounds of below 1 kHz have been reported (Simard *et al*. 2011). Bottlenose dolphins echolocate between 50 kHz and 115 kHz (Richardson *et al*. 1995, Jensen 2011). Sound levels produced by free-swimming bottlenose dolphins range from 196 to 228 dB re. 1 µPa $_{(peak – peak}$ and white-beaked dolphin of between 194 and 211 dB re. 1 µPa $_{(peak – peak)}$ (Rasmussen *et* al. 2004; Wahlberg *et al*. 2011).

8.10.1.3 Minke whale

199. Minke whales are generally considered to be 'low-frequency specialists' with a functional hearing range of between 7 Hz and 22 kHz (Southall *et al*. 2007). This suggests that they are more sensitive to low frequency sounds than other species of marine mammal. Low frequencies propagate further in the water column than higher frequencies and therefore the extent of impacts from low frequency sound are greater for baleen whales, including minke whales, than they are for other species of marine mammal.

200. Minke whales vocalise between 50 Hz and 9.4 kHz at broad band source levels of between 150 and 165 dB re. 1 µPa@1m (Gedamke *et al*. 2001).

8.10.1.4 Harbour and grey seal

201. Seals are thought to have a relatively broad hearing range of between 75 Hz and 70 kHz (Southall *et al*. 2007). Studies undertaken on captive harbour seals indicate their optimal hearing range is between 500 Hz and 40 kHz with relatively poor hearing ability of sound below or above these levels.

202. Measured underwater recordings indicate that grey seals vocalise at relatively low frequencies of between 100 Hz and 3.0 kHz (Asselin *et al.* 1993). During the mating season, male harbour seals hold territories underwater. They maintain their territories through vocalisation at relatively low frequencies of between 250 Hz and 1.4 kHz (van Parijs *et al* 2000). Anthropogenic sound produced at these frequencies during the mating season could impact on the ability of male harbour seals to hold territories.

8.10.2 Sound Modelling

203. In order to undertake an assessment of the potential impacts on marine mammals and their prey by proposed pile driving activities during the construction of the Project, modelling has been commissioned to assess the potential impacts from noise arising from pile driving activities. Details of the modelling undertaken are presented in Appendix 8.1: Noise modelling. A summary of the modelling undertaken is presented in this section.

204. Noise modelling has been undertaken at two locations within the Wind Farm Area and, to allow potential cumulative impacts to be assessed, modelling has also been undertaken at the Inch Cape Offshore Wind Farm and at a further four locations at Seagreen Phase 1 (Seagreen Alpha and Bravo) offshore wind farms. When considering potential cumulative impacts, the location within each of the wind farm areas that produced the worst-case scenario, i.e. greatest area of sound propagation, was selected.

205. Noise modelling results based on both peak Sound Pressure Level (SPL) and weighted Sound Exposure Level (SEL) are presented using both Southall *et al.* (2007) and NOAA (2016) thresholds and their auditory weightings for each species. The sound thresholds at which the onset of PTS and TTS are predicted to occur based on the Southall and NOAA thresholds are presented in Table 8.24 (Southall *et al.* 2007; NMFS, 2016).

Table 8.24: Sound thresholds at which the onset of PTS and TSS are predicted to occur

Sound Thresholds	PTS		TTS	
	Unweighted peak SPL (dB re 1 µPa)	Weighted SEL (dB re 1 µPa)	Unweighted peak SPL (dB re 1 µPa)	Weighted SEL (dB re 1 µPa)
SOUTHALL THRESHOLDS				
All Cetaceans (Harbour porpoise, Bottlenose dolphin, White-beaked dolphin, Minke whale)	230	198	224	183
Phocid Pinnipeds (Grey seal, Harbour seal)	218	186	212	171
NOAA THRESHOLDS				
High Frequency Hearing specialist, (Harbour porpoise)	202	155	196	140

Sound Thresholds	PTS		TTS	
	Unweighted peak SPL (dB re 1 µPa)	Weighted SEL (dB re 1 µPa)	Unweighted peak SPL (dB re 1 µPa)	Weighted SEL (dB re 1 µPa)
Mid Frequency Hearing Specialist (Bottlenose dolphin, White-beaked dolphin)	230	185	224	170
Low Frequency Hearing Specialist (Minke whale)	219	183	213	168
Phocid Pinnipeds (Grey seal, Harbour seal)	218	185	212	170

206. The potential magnitude of any impact on a marine mammal is dependent on whether the individual avoids the area by swimming away from the sound source. The speed and direction it swims has a significant effect on the extent of the potential impact. An increase in swimming speed from 1.5 m s-1 to 3.0 m s-1 decreases the area within which the onset of PTS is predicted to occur in harbour porpoise by approximately 60%. A similar reduction in the area of predicted effect occurs when a minke whale increases its swimming speed from 2.1 m s-1 to 3 m s-1 (See Section 6 in Appendix 8.1: Noise Modelling). For the purposes of this assessment the modelling assumes that marine mammals will swim away from the sound source at differing speeds, depending on the species. The swimming speeds for each of the marine mammals for which modelling has been undertaken are presented in Table 8.25 and are based on the advice received in the Scoping Opinion (Marine Scotland 2017a). However, evidence shows that animals will significantly increase swimming speeds when avoiding underwater noise, e.g. Otani *et al*. (2000), Sivle *et al*. (2015), McGarry *et al*. (2017), Kastelein *et al*. (2018). Consequently, the results from the noise modelling are considered to be precautionary.

Table 8.25: Swimming speeds of marine mammals used in the noise modelling (SNH 2016, Marine Scotland 2017a)

Species	Swimming speed (m s^{-1})
Harbour porpoise	1.4
Bottlenose dolphin	1.52
White-beaked dolphin	1.52
Minke whale	2.1
Grey seal	1.8
Harbour seal	1.8

207. The direction a marine mammal moves away from the sound will be variable and depends on a number of factors including the propagation of sound in the environment and the individual's tolerance to the noise. The noise modelling has been conducted for all possible directions that an individual may swim away from the sound source. Results are presented showing minimum, average and maximum impact distances. The minimum impact distance corresponds to the scenario where a marine mammal swims away from the sound source along the route where the lowest sound levels from the sound source exists, whilst the maximum impact distance corresponds to the scenario where a marine mammal swims away from the sound source along the direction of the sound source, where

sound levels are highest. It is considered unlikely that a marine mammal would swim away from the source along the route of maximum sound levels since it is conjectured that they would seek a route away from the sound source where they are not exposed to such high levels of sound. The average impact distance has been calculated by averaging the impact distances over all possible directions that a marine mammal may swim away from the sound source. For the purposes of this assessment the average impact distance has been used since it is based on all possible directions a marine mammal may move away from the sound source. This is considered suitably precautionary as an individual is likely to select a route along lower noise levels but also accounts for the variability in the behaviour of the individual. Furthermore, the modelling assumes that the marine mammal swims at a depth where there is greatest sound propagation within the water column. Evidence from studies indicate that marine mammals will rise to the surface and swim away from the area of disturbance at the sea surface (e.g. Sivle *et al*. 2015). Typically, this part of the water column has lower sound levels than other depths

208. There are three possible scenarios for the installation of piles: pile driving only (‘Drive-only’), pile driving followed by a period of drilling and completed with additional pile driving (‘Drive-Drill-Drive’) and Drilling only. Details of the installation methods are presented in Chapter 4: Project description. Previous modelling undertaken as part of the original application indicated that potential impacts on marine mammals were greatest from the Drive-only scenario (NnGOWL, 2012). Consequently, for the purposes of this assessment noise modelling has been based on the Drive-only scenario as this is predicted to be the worst-case scenario with respect to noise impacts on marine mammals or their prey, but noting that only a relatively small proportion of piles will be drive only installations (up to approximately 10% or up to approximately 41 piles out of a total of up to 344 piles for the wind turbines, OSPs and met mast).

8.10.2.1 Pile driving

209. The noise modelling is based on the pile driving of 4 x 50 m long piles sequentially over a period of approximately 20 hours. The Project design envelope also includes a 6 pile jacket option at each wind turbine foundation. However, noise modelling has considered the installation of 4 pile jackets as this is considered the worst case scenario. Installing 4 piles takes approximately the same length of time as it does to install six. However, when installing four piles a greater proportion of overall installation time is spent pile driving at the maximum hammer energy due to the longer pile length, than compared with installing six piles, i.e. there is, proportionally, less overall time at the lower hammer energies used during soft-start and ramp-up. Consequently, the predicted area of potential impact is greater when installing four piles.

210. The maximum SPL used in the model is 244 dB *re* 1 $\mu Pa^2 s_{\text{(0-peak)}}$. Modelled outputs are presented for the installation of a pile hammer operating at full energy and assuming a ramp-up scenario. The installation of a pile requires the hammer energy to be increased over a period of time until it reaches maximum energy and hammer blows maintained at this energy level until full pile penetration is achieved. This allows time for individuals to swim away from the sound source as the sound level increases. Ramp-up scenarios vary depending on the pile size and the seabed conditions and will therefore vary from site to site. However, there is limited information on the ramp-up scenarios to be used during pile driving by other projects. For the purposes of this assessment all the modelling is based on the most likely ramp-up scenario for the proposed Project (Table 8.26).

Table 8.26: Pile driving scenarios used for noise modelling at Neart na Gaoithe, Inch Cape and Seagreen A and B offshore wind farms

Abundance	Neart na Gaoithe	Inch Cape	Seagreen A and B
Hammer capacity (kJ)	1,800	2,400	2,400
No. of piles	4	4	4

Abundance	Neart na Gaoithe	Inch Cape	Seagreen A and B
Ramp-up duration	30 minutes at 360 kJ (approx. 20% capacity) 85 minutes at 1,026 kJ (approx. 57% capacity) 180 minutes at 1,635 kJ (approx. 91% capacity)	20 minutes at 264 kJ (approx. 11% capacity) 20 minutes at 480 kJ (approx. 20% capacity) 10 minutes at 720 kJ (approx. 30% capacity) 106 minutes at 2,160 kJ (approx. 90% capacity)	20 minutes at 264 kJ (approx. 11% capacity) 20 minutes at 480 kJ (approx. 20% capacity) 10 minutes at 720 kJ (approx. 30% capacity) 106 minutes at 2,160 kJ (approx. 90% capacity)

8.10.3 Sound Modelling Results for PTS and TTS on Marine Mammals

211. The following presents a summary of the results from the modelling that are used in the assessment of impacts from noise on marine mammals and their prey from the proposed Project on its own. The modelling results presented are based on the application of thresholds based on the latest studies on marine mammal hearing sensitivities published in NMFS (2016), i.e. they are based on the NOAA thresholds. The worst-case scenarios are presented, i.e. the modelling location where the greatest distance at which thresholds are exceeded based on the cumulative weighted results have been selected.

212. Further details of all the noise modelling undertaken in support of this assessment, including results based on the Southall thresholds, are presented in Appendix 8.1 Noise Modelling.

8.10.3.1 Harbour porpoise

213. The predicted extent that sound from pile driving could cause the onset of PTS and TTS on harbour porpoise, based on the cumulative weighted SEL, is presented in Figure 8-28.

214. The results from the noise modelling indicate that the average distances at which the onset of instantaneous PTS (un-weighted SPL) is predicted to occur on harbour porpoise from a 1,635 kJ hammer strike is 247 m from the pile driving and the onset of cumulative PTS occurs out to 6,357 m (Table 8.27).

215. The onset of TTS (un-weighted SPL) is predicted to occur on average within 823 m from the pile driving and the onset of cumulative TTS to occur within 25,112 m (Table 8.28).

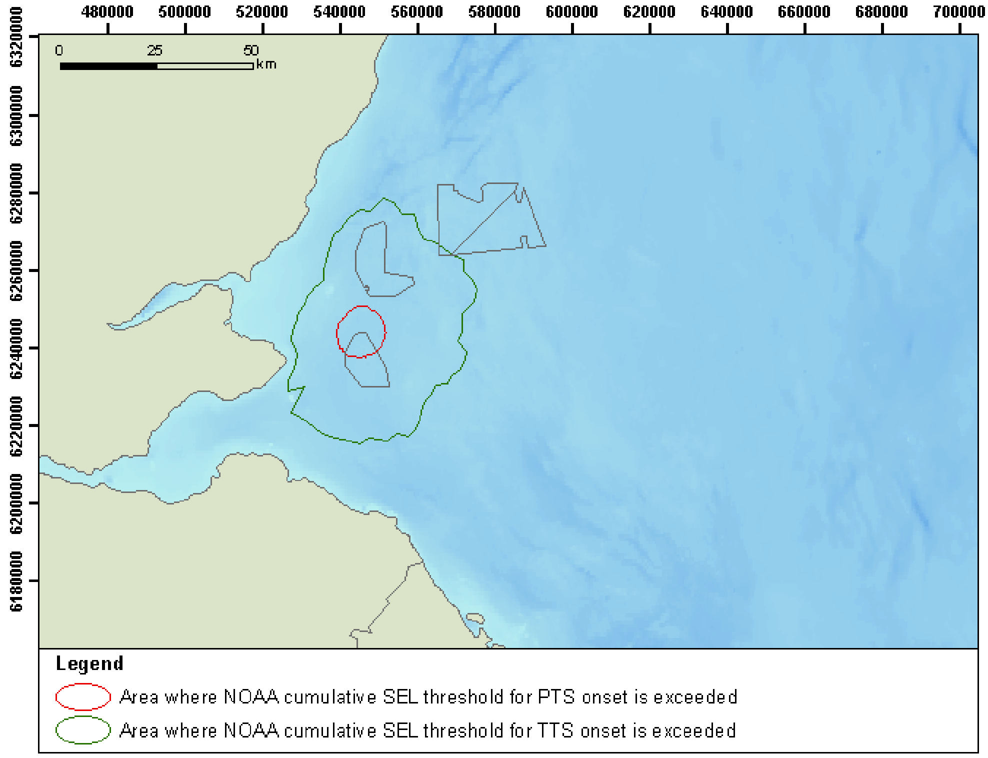


Figure 8-28: Predicted areas where NOAA cumulative SEL thresholds for high-frequency cetaceans are during pile driving at Neart na Gaoithe modelling location 1

Table 8.27: Predicted distances and areas where NOAA thresholds for PTS in high-frequency cetaceans are exceeded during pile driving at Neart na Gaoithe model location 1

Harbour Porpoise PTS	**Distance to threshold exceedance (m)**			**Area (km^2)**
	Minimum	Average	Maximum	
Unweighted single pulse peak SPL of 202 dB re 1 µPa	238	247	255	0.204
Weighted cumulative SEL of 155 dB re 1 µPa²s	5,424	6,357	6,876	127.3

Table 8.28: Predicted distances and areas where NOAA thresholds for TTS in high-frequency cetaceans are exceeded during pile driving at Neart na Gaoithe model location 1

Harbour Porpoise TTS	**Distance to threshold exceedance (m)**			**Area (km^2)**
	Minimum	Average	Maximum	
Unweighted single pulse peak SPL of 196 dB re 1 µPa	796	823	885	2.46
Weighted cumulative SEL of 140 dB re 1 µPa²s	15,897	25,112	35,141	2,074.9

8.10.3.2 Bottlenose dolphin and white-beaked dolphin

216. The results from the noise modelling indicate that the average distances at which the onset of instantaneous PTS (un-weighted SPL) is predicted to occur on dolphins from a single 1,635 kJ hammer

strike is within 3 m from the pile driving and the onset of cumulative PTS occurs within 1 m (Table 8.29).

217. The onset of TTS (un-weighted SPL) is predicted to occur on average within 8 m from the pile driving and the onset of cumulative TTS to occur within 493 m (Table 8.30).

Table 8.29: Predicted distances and areas where NOAA thresholds for PTS in mid-frequency cetaceans are exceeded during pile driving at Neart na Gaoithe model location 2

Bottlenose dolphin and White-beaked dolphin PTS	Distance to threshold exceedance (m)			Area (km^2)
	Minimum	Average	Maximum	
Unweighted single pulse peak SPL of 230 dB re 1 µPa	3	3	3	<0.001
Weighted cumulative SEL of 185 dB re 1 µPa²s	1	1	1	<0.001

Table 8.30: Predicted distances and areas where NOAA thresholds for TTS in mid-frequency cetaceans are exceeded during pile driving at Neart na Gaoithe model location 2

Bottlenose dolphin and White-beaked dolphin TTS	Distance to threshold exceedance (m)			Area (km^2)
	Minimum	Average	Maximum	
Unweighted single pulse peak SPL of 224 dB re 1 µPa	8	8	8	<0.001
Weighted cumulative SEL of 170 dB re 1 µPa²s	482	493	508	0.76

8.10.3.3 Minke whale

218. The predicted extent that sound from pile driving could cause the onset of PTS and TTS on minke whale, based on the cumulative weighted SEL, is presented in Figure 8-29.

219. The results from the noise modelling indicate that the average distances at which the onset of instantaneous PTS (un-weighted SPL) is predicted to occur from a 1,635 kJ hammer strike on minke whale is within 15 m from the pile driving and the onset of cumulative PTS occurs within 10,224 m (Table 8.31).

220. The onset of instantaneous TTS (un-weighted SPL) is predicted to occur on average within 37 m from the pile driving and the onset of cumulative TTS to occur within 44,889 m (Table 8.32).

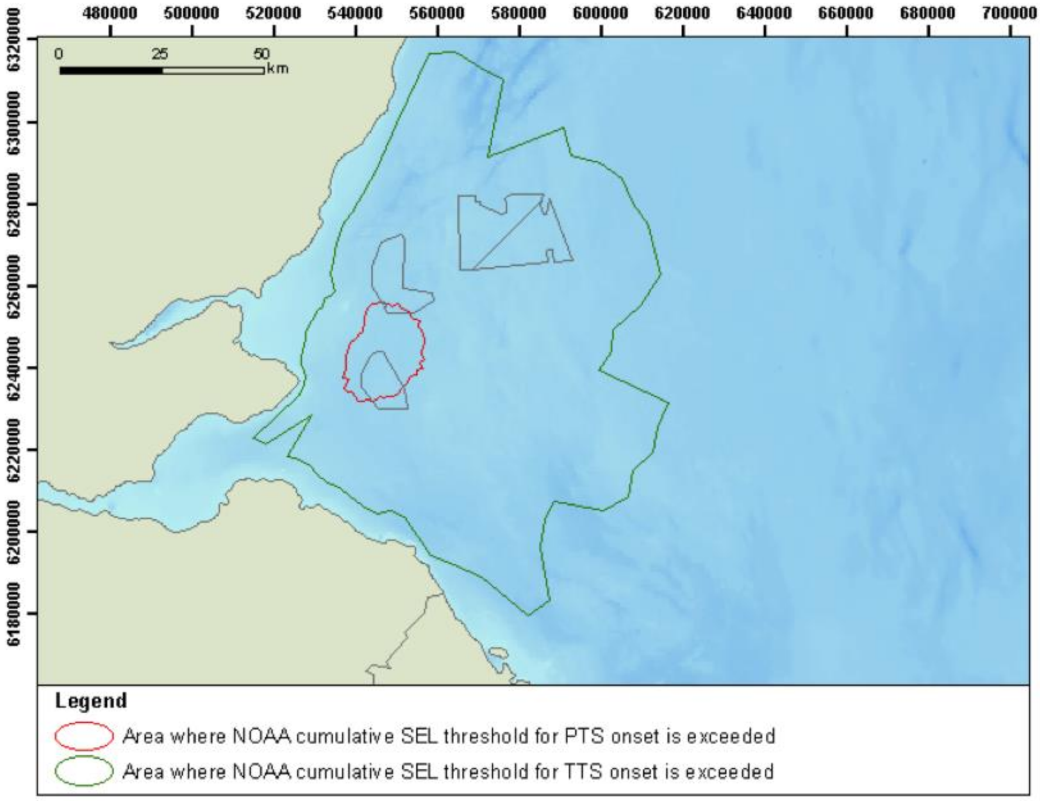


Figure 8-29: Predicted areas where NOAA cumulative SEL thresholds for low-frequency cetaceans are during pile driving at Neart na Gaoithe modelling location 1

Table 8.31: Predicted distances and areas where NOAA thresholds for PTS in low-frequency cetaceans are exceeded during pile driving at Neart na Gaoithe model location 1

Minke whale PTS	Distance to threshold exceedance (m)			Area (km²)
	Minimum	Average	Maximum	
Unweighted single pulse peak SPL of 219 dB re 1 µPa	15	15	15	<0.001
Weighted cumulative SEL of 183 dB re 1 µPa²s	5,693	10,224	13,115	344.4

Table 8.32: Predicted distances and areas where NOAA thresholds for TTS in low-frequency cetaceans are exceeded during pile driving at Neart na Gaoithe model location 1

Minke whale TTS	Distance to threshold exceedance (m)			Area (km²)
	Minimum	Average	Maximum	
Unweighted single pulse peak SPL of 213 dB re 1 µPa	37	37	37	<0.001
Weighted cumulative SEL of 168 dB re 1 µPa²s	17,035	44,889	75,421	7,724

8.10.3.4 Grey seal and harbour seal

221. The predicted extent that sound from pile driving could cause the onset of PTS and TTS on seals, based on the cumulative weighted SEL, is presented in Figure 8-30.

222. The results from the noise modelling indicate that the average distances at which the onset of instantaneous PTS is predicted (un-weighted SPL) to occur from a 1,635 kJ hammer on seals is within 18 m from the pile driving and the onset of cumulative PTS occurs within 472 m (Table 8.33).

223. The onset of TTS (un-weighted SPL) is predicted to occur on average within 47 m from the pile driving and the onset of cumulative TTS to occur within 20,312 m (Table 8.34).

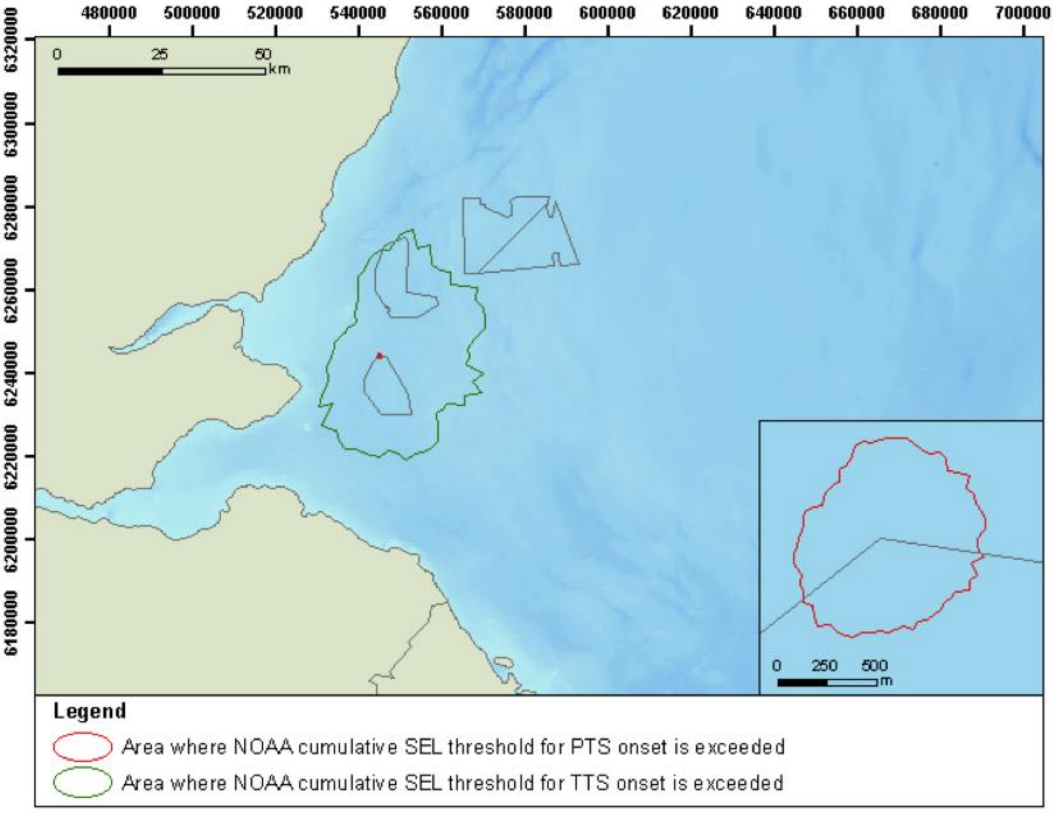


Figure 8-30: Predicted distances and areas where NOAA thresholds for TTS in phocid pinniped are exceeded during pile driving at Neart na Gaoithe model location 1

Table 8.33: Predicted distances and areas where NOAA thresholds for PTS in phocid pinnipeds are exceeded during pile driving at Neart na Gaoithe model location 1

Grey seal and Harbour seal PTS	Distance to threshold exceedance (m)			Area (km^2)
	Minimum	Average	Maximum	
Unweighted single pulse peak SPL of 218 dB re 1 µPa	18	18	18	0.001
Weighted cumulative SEL of 183 dB re 1 µPa^{2}s	337	472	553	0.706

Table 8.34: Predicted distances and areas where NOAA thresholds for TTS in phocid pinnipeds are exceeded during pile driving at Neart na Gaoithe model location 1

Grey seal and Harbour seal TTS	Distance to threshold exceedance (m)			Area (km^2)
	Minimum	Average	Maximum	
Unweighted single pulse peak SPL of 213 dB re 1 µPa	47	47	48	<0.007
Weighted cumulative SEL of 168 dB re 1 µPa²s	9,846	20,312	31,668	1,409

224. The estimated number of individuals at risk of the onset of PTS from single pile driving is presented in Section 8.10.8.1**Error! Reference source not found.**.

8.10.4Sound Modelling Results for Potential Disturbance to Marine Mammals

225. The area within which a marine mammal may be displaced or disturbed will vary depending on a number of factors including the level of sound received, the sensitivity of the species and individuals to noise and whether there are suitable areas to which they may move.

226. When considering the extent at which disturbance occurs, Southall *et al*. (2007) were not able to define thresholds for multiple-pulse and non-pulse sounds as empirical studies revealed no clear relationship between the received sound level and behavioural response. Similarly, NMFS (2016) did not present any thresholds at which disturbance to marine mammals may occur. Consequently, there are no defined published sound thresholds at which displacement or disturbance effects are predicted to occur.

227. Studies on marine mammals during pile driving activities have demonstrated that higher levels of displacement or disturbance occur at higher received sound levels. The received sound level decreases with increasing distance from the sound source and there is a corresponding reduction in displacement or disturbance.

228. Studies undertaken at eight offshore wind farms in German waters have estimated the proportion of harbour porpoise displaced within a range of SEL (Brandt *et al*. 2016). Based on these findings a dose-response curve has been developed from which it can be estimated the proportion of individuals displaced at any given received sound level (Figure 8-31). Details of the dose response curve are presented in Appendix 8.1: Noise Modelling.

229. It is recognised that further data have been obtained from pile-driving activities being undertaken within the Moray Firth, from which a dose response curve could be obtained (Marine Scotland 2017a). Requests were made for the data in order to produce a dose response curve. However, the data were not made available at the time of undertaking this assessment. In the absence of data from the Moray Firth the use of Brandt *et al*. (2016) data to produce a dose response curve is considered the most appropriate published data available.

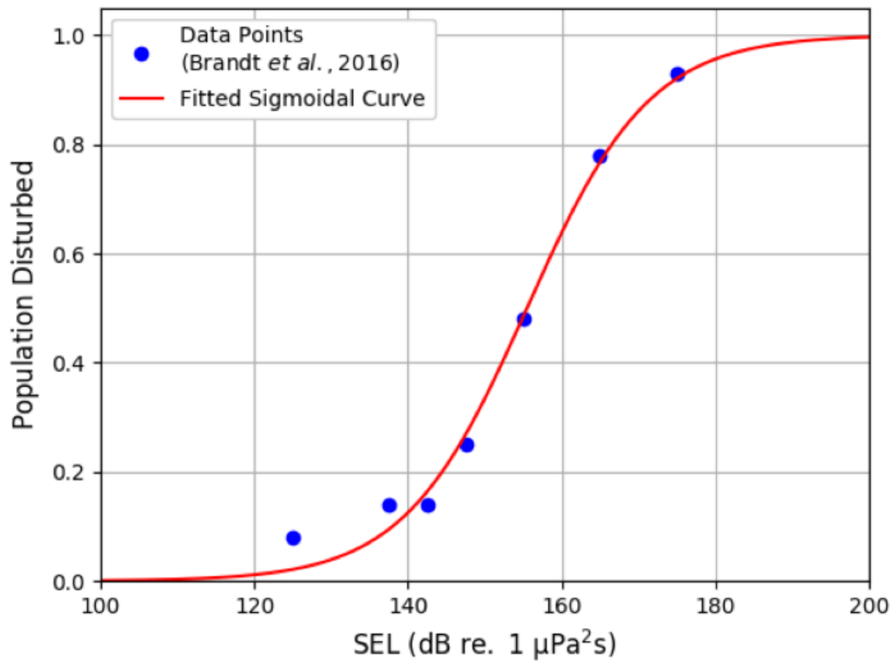


Figure 8-31: Behavioural response curve used for assessing potential behavioural disturbance to marine mammals

230. Noise modelling undertaken at two locations within the Offshore Wind Farm Area predicts the extent sound from pile driving will propagate (Figure 8-32 and Figure 8-33). From these figures, it is possible to estimate the area of impact at a range of SEL and the proportion of marine mammals that will be displaced (Table 8.35).

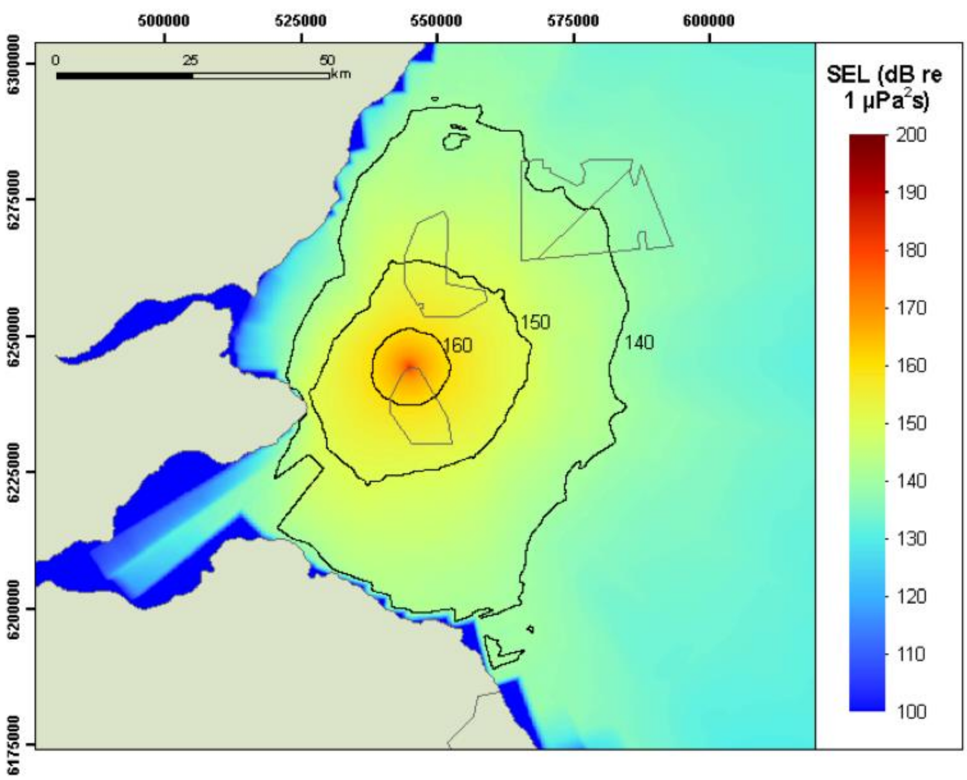


Figure 8-32: Predicted unweighted SEL during pile driving at Neart na Gaoithe modelling location 1 with hammer operating at maximum energy

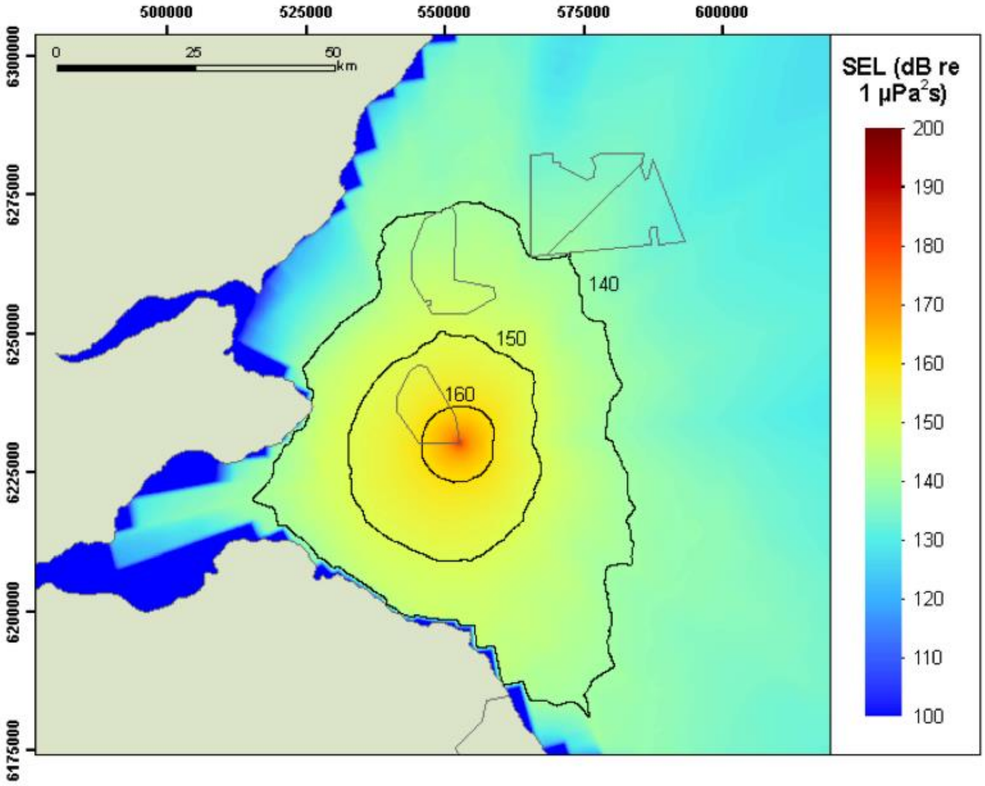


Figure 8-33: Predicted unweighted SEL during pile driving at Neart na Gaoithe modelling location 2 with hammer operating at maximum energy

Table 8.35: Predicted disturbance areas and probability of disturbance to marine mammals during pile driving at Neart na Gaoithe at modelled locations 1 and 2

SEL sound level (dB re 1 µPa²s)	Area encompassed by SEL band (km²)		Probability of disturbance (%)
	Location 1	Location 2	
>200	0.000	0.000	99.89
195 - 200	0.001	0.002	99.49
190 - 195	0.008	0.010	99.05
185 – 190	0.061	0.060	98.23
180 – 185	0.265	0.372	96.74
175 – 180	2.105	2.223	94.06
170 - 175	8.568	7.719	89.42
165 - 170	32.51	31.38	81.86
160 – 175	111.3	101.9	70.68
155 – 160	318.7	262.5	56.28
150 – 155	671.2	689.2	40.73

SEL sound level (dB re 1 µPa²s)	Area encompassed by SEL band (km²)		Probability of disturbance (%)
	Location 1	Location 2	
145 - 150	1,103	1,236	26.85
140 - 145	1,921	1,533	16.39
135 – 140	2,970	2,979	9.47
130 - 145	7,406	5,908	5.29

231. The results indicate that the areas encompassed by each SEL band are similar for Location 1 and Location 2, suggesting that there are no significant differences in the extent noise impacts will occur across the site.

232. The estimated number of marine mammals at risk of PTS and disturbance from single pile driving at Neart na Gaoithe based on the NOAA thresholds are presented in Table 8.36**Error! Reference source not found.** (See Appendix 8.2 Interim PCoD modelling).

Table 8.36: Estimated number of marine mammals at risk of the onset of PTS and disturbance from single pile driving activities at Neart Na Gaoithe

Species	Density (ind./km²)	PTS		Disturbed
		Area of PTS (km²)	Number of animals	Number of animals
Harbour Porpoise	0.599	127.276	77	1,177
Bottlenose Dolphin	0.070	0.00001	0	2
White-Beaked Dolphin	0.24	0.00003	<1	478
Minke Whale	0.039	344.357	14	77
Grey Seal	Variable	1.30591	1	821
Harbour Seal	Variable	1.30591	1	8

8.10.5Concurrent Pile driving

233. There is the potential for pile driving to occur simultaneously at two locations within the Offshore Wind Farm Area. The areas within which the onset of PTS and TTS are predicted to occur, should concurrent pile driving be undertaken, are presented in Table 8.37 and Table 8.38.

234. The results indicate that if concurrent pile driving is undertaken, the area within which PTS and TTS are predicted to occur, is greater than if only one pile driving activity takes place, although the area of impact is overall lower than if two temporally and spatially separate pile driving activities were undertaken (Table 8.39). The overall duration of any impacts are predicted to be shorter if concurrent pile driving occurs, as the installation of turbine foundations will be undertaken more quickly and therefore completed sooner. It is predicted that in the event concurrent pile driving is undertaken, all pile driving and drilling will be completed within nine months as opposed to potentially occurring over 15 months should pile driving occur at only one location at a time. The potential impacts this may have on marine mammals have been assessed and are discussed in Section 8.10.8: Construction Phase Impacts.

235. The areas of potential disturbance from concurrent pile driving and the probability of it occurring across a range of SELs are presented in Figure 8-34 and Table 8.40.

Table 8.37: Predicted area where NOAA thresholds for PTS in marine mammals are exceeded during concurrent pile driving at Neart na Gaoithe

Species	Area of PTS threshold exceedance (km^2) Concurrent Pile driving within NnG	
	Un-weighted SPL	Cumulative weighted SEL
Harbour porpoise	0.641	240.3
Bottlenose dolphin and white-beaked dolphin	<0.001	<0.001
Minke whale	<0.001	564.5
Grey seal and harbour seal	<0.002	1.306

Table 8.38: Predicted area where NOAA thresholds for TTS in marine mammals are exceeded during concurrent pile driving at Neart na Gaoithe

Species	Area of TTS threshold exceedance (km^2) Concurrent Pile driving within NnG	
	Un-weighted SPL	Cumulative weighted SEL
Harbour porpoise	5.509	2,582
Bottlenose dolphin and white-beaked dolphin	<0.001	1.035
Minke whale	0.01	9,039
Grey seal and harbour seal	0.015	1,785

Table 8.39: Areas within which the onset of PTS and TTS to marine mammals are predicted to occur from single and concurrent pile driving

Species	Area of PTS (km^2)			Area of TTS (km^2)		
	Single piling	Concurrent piling	% Difference	Single piling	Concurrent piling	% Difference
Harbour porpoise	127.3	240.3	89	2,075	2,582	24
Dolphin Sp.	<0.001	<0.001	0	0.760	1.035	36
Minke whale	344.4	564.5	64	7,724	9,039	17
Seal Sp.	0.706	1.306	85	1,409	1,785	27

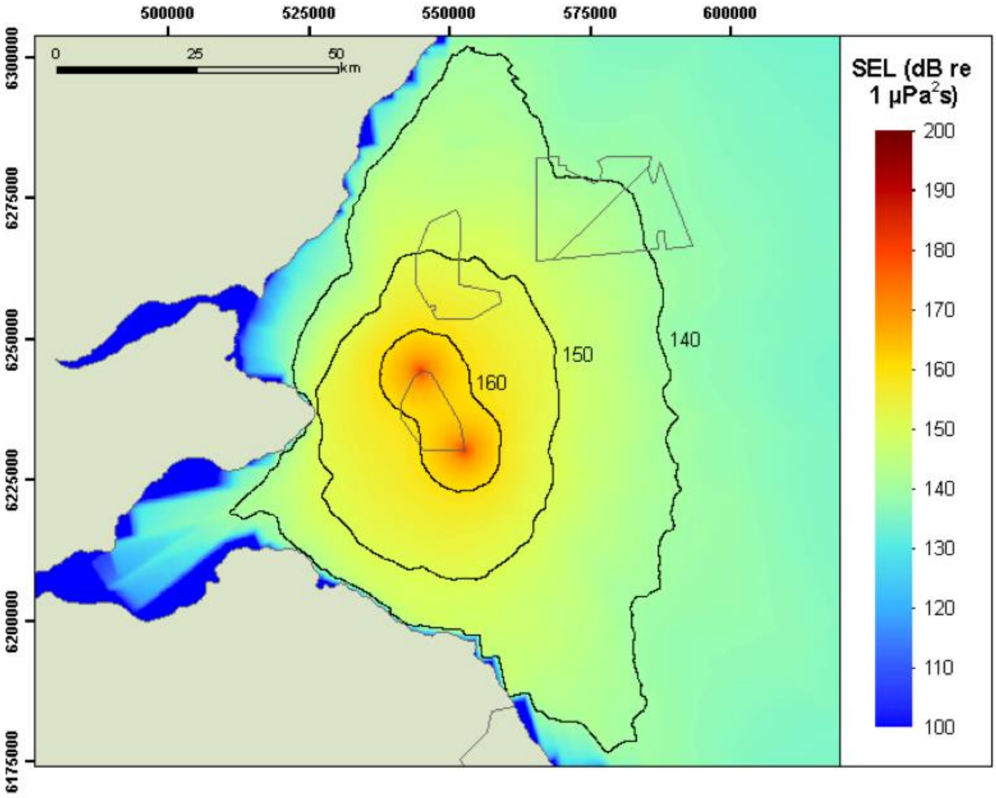


Figure 8-34: Predicted unweighted SEL during concurrent pile driving at Neart na Gaoithe with hammers operating at maximum energy

Table 8.40: Predicted disturbance areas and probability of disturbance to marine mammals during concurrent pile driving at Neart na Gaoithe

SEL sound level (dB re 1 µPa²s)	Area encompassed by SEL band (km²)	Probability of disturbance (%)
	Concurrent Piling	
>200	0.000	99.89%
195 – 200	0.001	99.49%
190 – 195	0.008	99.05%
185 – 190	0.148	98.23%
180 – 185	0.494	96.74%
175 – 180	4.069	94.06%
170 – 175	17.17	89.42%
165 – 170	70.21	81.86%
160 – 175	283.7	70.68%
155 – 160	566.3	56.28%
150 – 155	991.2	40.73%

SEL sound level (dB re 1 µPa²s)	Area encompassed by SEL band (km²)	Probability of disturbance (%)
	Concurrent Piling	
145 – 150	1,520	26.85%
140 – 145	2,280	16.39%
135 - 140	5,072	9.47%
130 - 135	16,551	5.29%

236. The estimated number of marine mammals at risk of PTS and disturbance from concurrent pile driving at Neart na Gaoithe based on the NOAA thresholds are presented in Tables 8-41**Error! Reference source not found.**.

Table 8.41: Estimated number of marine mammals at risk of the potential onset of PTS and disturbance from concurrent pile driving at Neart na Gaoithe

Species	Density (Ind./Km²)	PTS		Disturbed
		Area of PTS (km²)	Number of animals	Number of animals
Harbour Porpoise	0.599	240.251	144	1,880
Bottlenose Dolphin	0.070	0.00001	0	2
White-Beaked Dolphin	0.240	0.00001	<1	763
Minke Whale	0.039	564.483	23	123
Grey Seal	Variable	1.30591	1	1,357
Harbour Seal	Variable	1.30591	1	10

8.10.6Population Modelling

237. In order to determine the potential population level effects from noise on marine mammals, population modelling has been undertaken using the interim Population Consequences of Disturbance (interim PCoD) model. The interim PCoD model used for this assessment (version 3) was issued in October 2017. Details of the population modelling undertaken and the results are presented in Appendix 8.2: Interim PCoD Modelling.

238. In order to estimate the population level impact of PTS and disturbance, the model uses the outputs from the noise modelling undertaken and the timing of the planned activities, along with the proportion of the population predicted to be impacted. The model assumes that there is a level of mortality associated with the impacts from which the future growth of the impacted population is predicted (Sparling *et al*. 2017).

239. The number of individuals estimated to be impacted is based on the outputs from the noise modelling undertaken , presented above and in Appendix 8.1: Noise modelling. For harbour porpoise, white-beaked dolphin and minke whale the regional densities in SCANS III Block R have been used. For

bottlenose dolphin a density is estimated based on the approach described in Para. 104. For pinnipeds their abundances from the at sea distribution have been calculated across the impacted area based on the SEL contours (Figure 8-35).

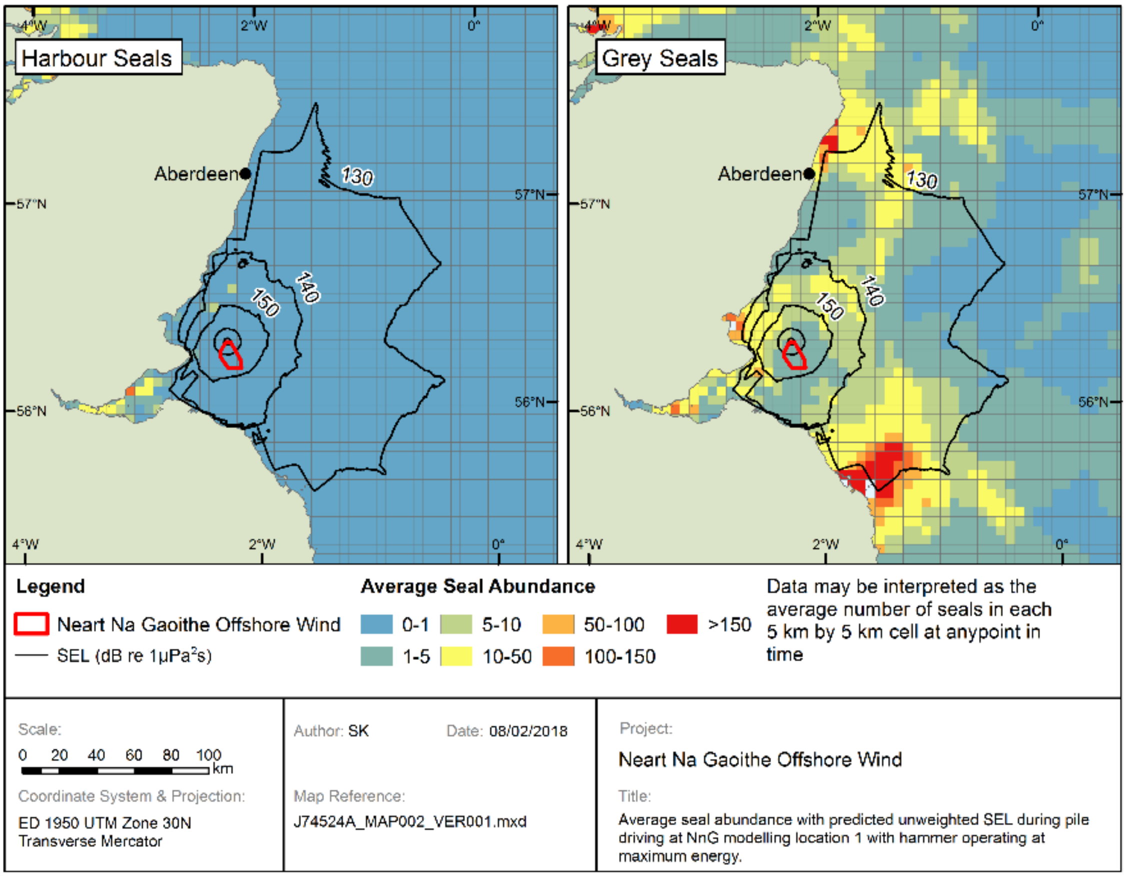


Figure 8-35: Harbour and grey seal offshore distributions in the Firths of Forth and Tay with overlapping SEL contours.

240. The relevant populations of marine mammal potentially affected are the Management Unit populations based on the results from the SCANS III surveys (JNCC, 2017) and for seals the adjusted East Coast Management Area populations from Duck *et al*. (2016) (See Para: 148 and 160).

241. The interim nature of the model is recognised and that the model relies on some assumptions and expert opinion. As further evidence on the behaviour of marine mammals to noise and its consequences become available the model will be revised. However, it is a tool that does allow the assessment of potential population level effects to be standardised, in particular when assessing cumulative impacts (Marine Scotland 2017b). Furthermore, the population model does not include any density dependence that would allow an impacted population to recover following cessation of activities (King *et al*, 2015, Booth *et al*. 2016). If there is density dependence in the marine mammal populations, a population may be predicted to recover more rapidly due a greater availability of resources. This is particularly important when considering what a population level might be after 24 years, many years after impacts from the proposed project alone or cumulatively with other know developments will have ceased. Therefore, the estimated population sizes after 24 years may be overly precautionary.

242. The model allows the population consequences of disturbance to be predicted for five species of marine mammal: Harbour porpoise, bottlenose dolphin, minke whale, grey seal and harbour seal. It does not have the biological parameters required to input into the model for white-beaked dolphin. Therefore, it is not possible to undertake population modelling for this species.

243. Recent reviews of population viability analysis (PVA) metrics have considered and tested the sensitivity of PVA models to a range of potential metrics (Cook and Robinson, 2017; Jitlal *et al*. 2017). The studies identify two metrics that are least sensitive to the quality of the input data, the ratio of the impacted to un-impacted annual growth rate and the ratio of impacted to un-impacted population size. With the first of these two ratio metrics being considerably better than the latter (Jitlal *et al*. 2017). These two counterfactual metrics estimate the difference in predicted numbers between impacted an unimpacted populations.

244. Metrics based on the probability of a change in the growth rate or population were identified as being sensitive to the data used to populate the model, e.g. survival rates and productivity. However, the report identified that the metric representing the centile from un-impacted population size equal to the 50th centile of the impacted population size after a set period of time was less sensitive than other metrics based on probability outputs. The recommendations of the Jitlal *et al* (2017) report and advice received in the Scoping Opinion have been used for this assessment (Marine Scotland 2017a).

245. The metrics used are:

- The median of the ratio of the impacted to un-impacted annual growth rate (the counterfactual of the annual growth rate),
- The median of the ratio of the impacted to un-impacted annual population size (the counterfactual of the population size),
- The difference in median impacted and median un-impacted annual growth rates after 24 years,
- The difference in median impacted and median un-impacted population size after 24 years,
- Centile for un-impacted population which matches the 50th centile for the impacted population after 24 years (i.e. the probability of an unimpacted population being below the median population size of the impacted population).

246. Results from the population model are summarised below for each species and further details of the model and the parameters used to undertake the modelling are presented in Appendix 8.2: Interim PCoD modelling.

8.10.6.1 Harbour porpoise

247. The results from the population modelling indicate that pile driving could cause a decrease in the annual growth rate and population size of harbour porpoise, with a potentially marginally greater effect occurring in the event concurrent pile-driving is undertaken (Table 8.42).

248. The median ratio of the impacted to unimpacted annual growth rate for both single and concurrent pile driving scenarios is 0.998 after 24 years (a counterfactual of growth rate of 99.8%). The difference between the median impacted and unimpacted growth rates after 24 years is -0.002.

249. The median ratio of the impacted to unimpacted population for a single pile driving scenario is 0.959 after 24 years and 0.954 for concurrent pile driving (a counterfactual of population size of 95.9% and 95.4%).

250. Based on the results from the interim PCoD model, the harbour porpoise population within the North Sea Management Unit is predicted to decrease over the next 24 years without any potential impacts from disturbance (Table 8.43 and Figure 8-36 and Table 8.45 and Figure 8-37). In the event that pile driving occurs over a period of 15 months or nine months it is estimated that after 24 years the harbour porpoise population may be between 4.20% and 4.68% lower compared with the unimpacted baseline population (Table 8.44 and Table 8.46). The difference between the median impacted and unimpacted growth rates after 24 years is -0.002.

251. Comparing the distributions of population sizes after 24 years for the unimpacted and impacted populations shows that at least 39% of the runs do not end lower than the median population size of the unimpacted population for single pile driving (Table 8.42).

Table 8.42: Harbour porpoise population model outputs for single and concurrent pile driving at NnG

Harbour Porpoise						
	Median of the ratio of impacted to unimpacted annual growth rate		Median of the ratio of impacted to unimpacted population size		Centile for impacted population that matches the 50th centile for unimpacted population	
Year	Single pile driving	Concurrent pile driving	Single pile driving	Concurrent pile driving	Single pile driving	Concurrent pile driving
1	1.000	1.000	1.000	1.000	0.50	0.51
6	0.997	0.996	0.987	0.982	0.42	0.39
12	0.997	0.996	0.969	0.964	0.37	0.34
18	0.998	0.997	0.962	0.958	0.36	0.36
24	0.998	0.998	0.959	0.954	0.39	0.39

Table 8.43: Estimated population size for harbour porpoise North Sea Management Unit with pile driving undertaken over 15 months

Harbour Porpoise						
NnG single pile driving over fifteen months						
	5th percentile		50th percentile		95th percentile	
Year	Undisturbed	Disturbed	Undisturbed	Disturbed	Undisturbed	Disturbed
1	309,250	309,244	333,535	333,532	351,491	351,491
6	285,561	282,201	324,113	318,648	367,716	361,308
12	263,940	252,630	314,675	303,414	369,895	355,153
18	250,609	240,727	305,878	293,048	372,304	356,897
24	234,112	223,548	296,184	283,733	373,476	359,889

Table 8.44: Estimated difference in median disturbed and median undisturbed harbour porpoise growth rates and population sizes with pile driving undertaken over 15 months

Harbour porpoise	Difference in median disturbed and median undisturbed annual growth rates over 24 years(%)	Difference in median disturbed and median undisturbed population size over 24 years	
Years		No. of individuals	% change in population size
1	±0.000	-3	±0.00
6	-0.003	-5,465	-1.69
12	-0.003	-11,261	-3.58
18	-0.002	-12,830	-4.19
24	-0.002	-12,451	-4.20

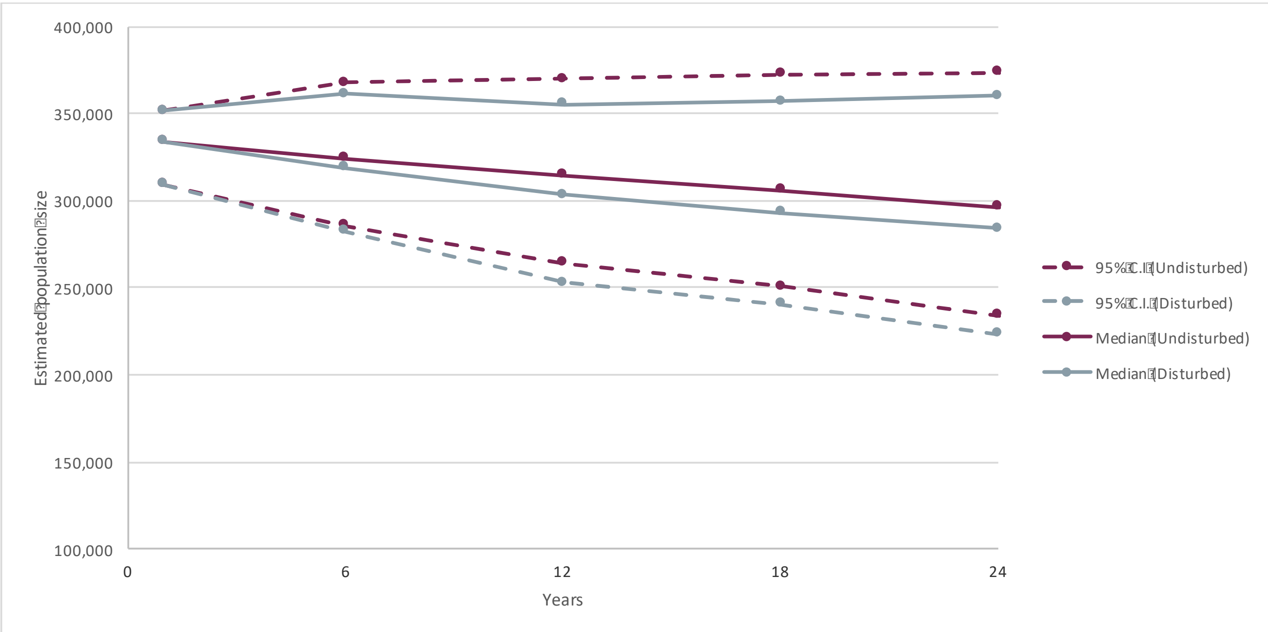


Figure 8-36: Estimated median (50th centile) and 95% C.I. for harbour porpoise North Sea Management Unit population with (disturbed) and without (undisturbed) single pile driving over a period of 15 months

Table 8.45: Estimated population size for harbour porpoise North Sea Management Unit with pile driving undertaken over 9 months

Harbour Porpoise						
NnG concurrent pile driving over nine months						
	5th percentile		50th percentile		95th percentile	
Year	Undisturbed	Disturbed	Undisturbed	Disturbed	Undisturbed	Disturbed
1	309,695	309,691	333,046	333,049	351,408	351,404
6	283,720	278,118	325,595	318,214	366,019	358,502
12	259,965	249,226	313,944	300,651	374,337	360,510
18	245,088	234,162	307,767	294,123	382,220	363,072
24	230,827	217,632	299,137	285,131	373,213	359,564

Table 8.46: Estimated difference in median disturbed and median undisturbed harbour porpoise growth rates and population sizes with concurrent pile driving undertaken over 9 months

Harbour porpoise	Difference in median disturbed and median undisturbed annual growth rates over 24 years(%)	Difference in median disturbed and median undisturbed population size over 24 years	
Years		No. of individuals	% change in population size
1	±0.000	+3	±0.00
6	-0.004	-7,381	-2.27
12	-0.004	-13,293	-4.23
18	-0.003	-13,644	-4.43
24	-0.002	-14,006	-4.68

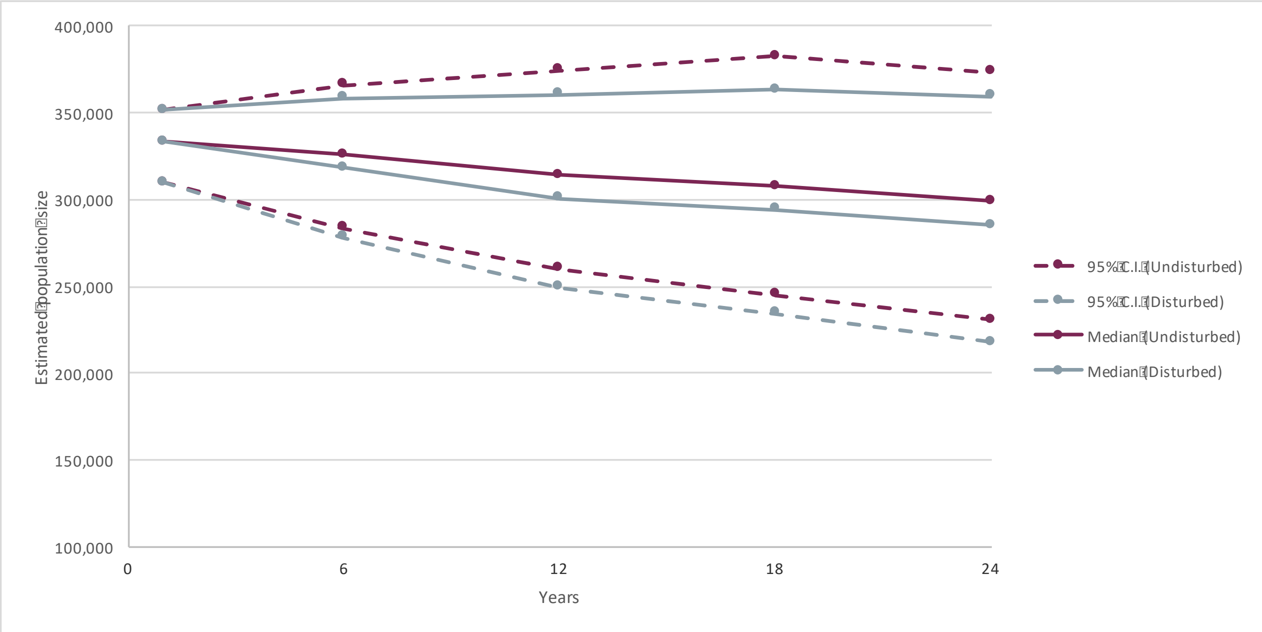


Figure 8-37: Estimated median (50th centile) and 95% C.I. for harbour porpoise North Sea Management Unit population with (disturbed) and without (undisturbed) concurrent pile driving over a period of 9 months

8.10.6.2 Bottlenose dolphin

252. The results from the population modelling indicate that disturbance to bottlenose dolphins from pile driving will not cause a decline in the bottlenose dolphin population with the median of the ratio of impacted to unimpacted growth rate and population size being greater than one (Table 8.47).

253. Based on the results from the interim PCoD model, the bottlenose dolphin population within the Coastal East Scotland Management Unit is predicted to increase over the next 24 years (Table 8.48 and Table 8.38) and Table 8.49 and Figure 8-39). The unimpacted bottlenose dolphin population in 24 years time is estimated to be 288 (204 – 388) individuals compared with 306 (216 - 420) in the event that pile driving occurs over a period of 15 months or 294 (202 - 408) individuals if concurrent pile driving occurs over a period of nine months (Table 8.48 and Table 8.50). Compared with the predicted baseline population the impacted population is predicted to increase by between 5.76% and 6.25% (Table 8.49 and Table 8.51). This counterintuitive result from the interim PCoD model was consistent over many modelling runs.

254. Comparing the distributions of population sizes after 24 years for the unimpacted and impacted populations shows that at least 62% of the runs do not end lower than the median population size of the unimpacted population for single pile driving and 60% of the runs for concurrent pile driving (Table 8.48).

Table 8.47: Bottlenose dolphin population model outputs for single and concurrent pile driving at NnG

Bottlenose dolphin						
	Median of the ratio of impacted to unimpacted annual growth rate		Median of the ratio of impacted to unimpacted population size		Centile for impacted population that matches the 50th centile for unimpacted population	
Year	Single pile driving	Concurrent pile driving	Single pile driving	Concurrent pile driving	Single pile driving	Concurrent pile driving
1	1.000	1.000	1.000	1.000	0.45	0.53
6	1.003	1.002	1.016	1.010	0.54	0.53
12	1.003	1.003	1.033	1.027	0.57	0.58
18	1.003	1.002	1.048	1.043	0.60	0.60
24	1.003	1.002	1.063	1.058	0.62	0.60

Table 8.48: Estimated population size for bottlenose dolphin East Scotland Management Unit with pile driving undertaken over 15 months

Bottlenose dolphin NnG single pile driving over fifteen months						
	5th percentile		50th percentile		95th percentile	
Year	Undisturbed	Disturbed	Undisturbed	Disturbed	Undisturbed	Disturbed
1	182	180	200	200	216	220
6	178	174	216	220	256	268
12	186	184	240	246	302	318
18	196	198	262	276	346	370
24	204	216	288	306	388	420

Table 8.49: Estimated difference in median disturbed and median undisturbed bottlenose dolphin growth rates and population sizes with pile driving undertaken over 15 months

Bottlenose dolphin	Difference in median disturbed and median undisturbed annual growth rates over 24 years	Difference in median disturbed and median undisturbed population size over 24 years	
Years		No. of individuals	% change in population size
1	±0.000	+0	±0.00
6	+0.003	+4	+1.85
12	+0.002	+6	+2.50
18	+0.003	+14	+5.34
24	+0.003	+18	+6.25

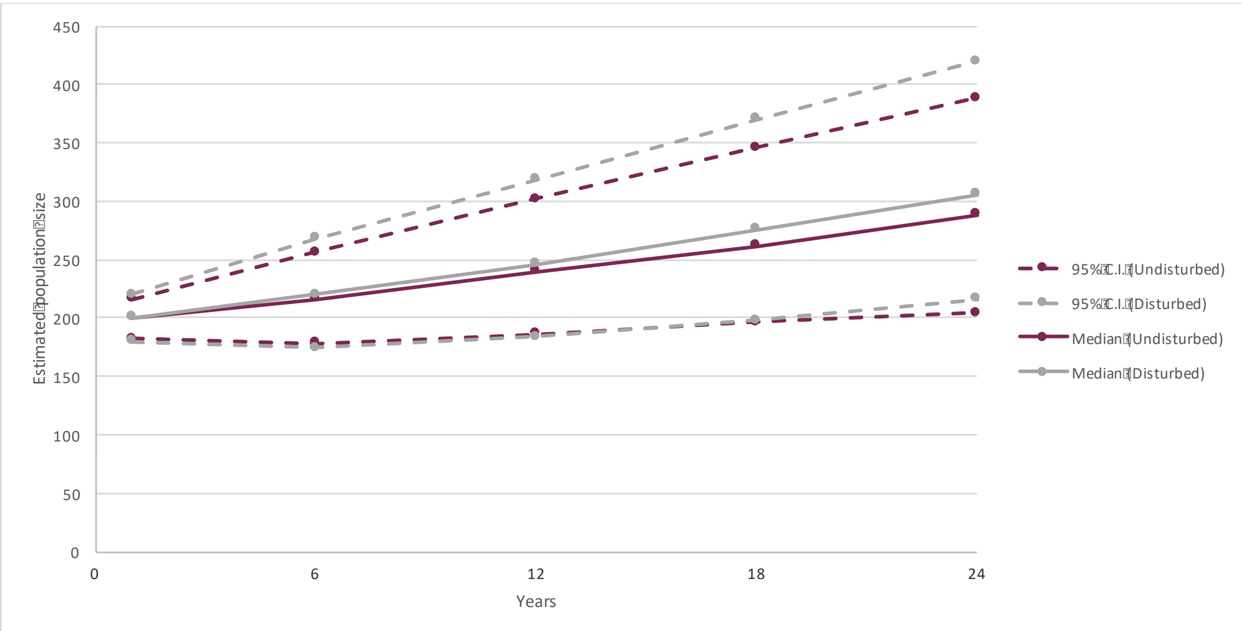


Figure 8-38: Estimated median (50th centile) and 95% C.I. for bottlenose dolphin Coastal East Scotland Management Unit population with (disturbed) and without (undisturbed) single pile driving over a period of 15 months

Table 8.50: Estimated population size for bottlenose dolphin East Scotland Management Unit with concurrent pile driving undertaken over 9 months

Bottlenose dolphin						
NnG concurrent pile driving over nine months						
	5th percentile		50th percentile		95th percentile	
Year	Undisturbed	Disturbed	Undisturbed	Disturbed	Undisturbed	Disturbed
1	182	180	198	200	216	220
6	172	166	213	216	250	260
12	184	182	232	240	294	308
18	184	188	256	268	332	358
24	192	202	278	294	374	408

Table 8.51: Estimated difference in median disturbed and median undisturbed bottlenose dolphin growth rates and population sizes with concurrent pile driving undertaken over 9 months

Bottlenose dolphin	Difference in median disturbed and median undisturbed annual growth rates over 24 years	Difference in median disturbed and median undisturbed population size over 24 years	
Years		No. of individuals	% change in population size
1	+0.010	+2	+1.01
6	+0.002	+3	+1.41
12	+0.003	+8	+3.45
18	+0.003	+12	+4.69
24	+0.002	+16	+5.76

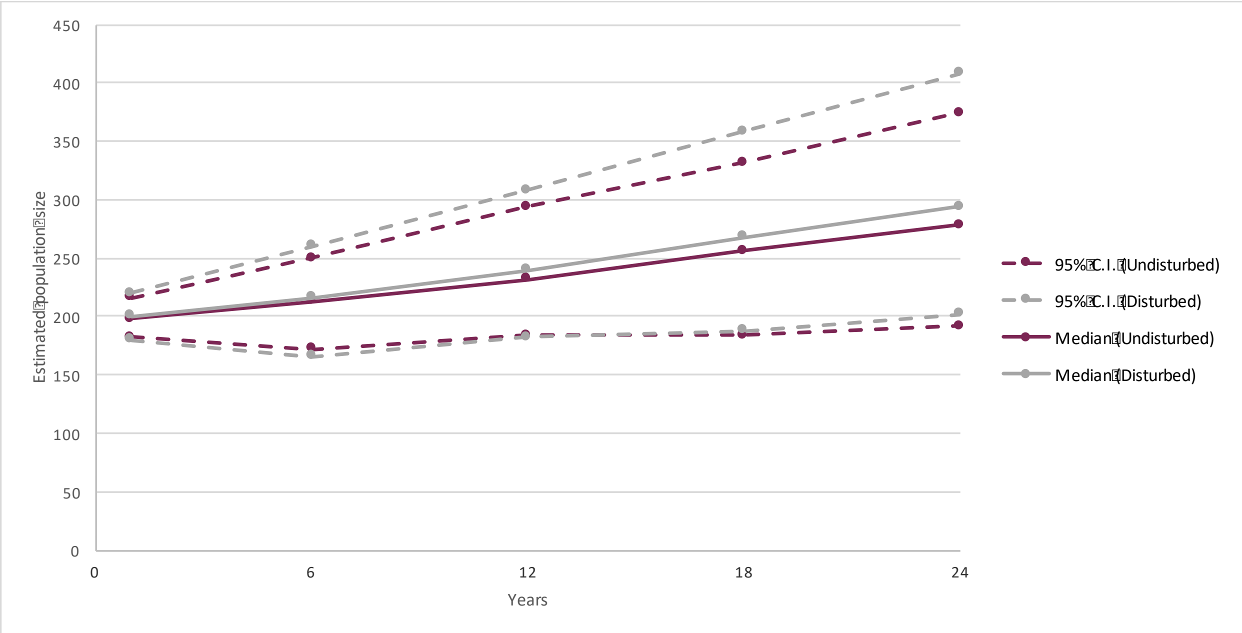


Figure 8-39: Estimated median (50th centile) and 95% C.I. for bottlenose dolphin Coastal East Scotland Management Unit population with (disturbed) and without (undisturbed) concurrent pile driving over a period of 9 months

8.10.6.3 Minke whale

255. The results from the population modelling indicate that pile driving could cause a decrease in the annual growth rate and population size of minke whale, with a potentially marginally greater effect occurring in the event concurrent pile driving is undertaken (Table 8.52).

256. The median ratio of the impacted to unimpacted annual growth rate for a single and concurrent pile driving scenarios is 0.993 after 24 years (a counterfactual of growth rate of 99.3%). The difference between the median impacted and unimpacted growth rates after 24 years is -0.007.

257. The median ratio of the impacted to unimpacted population for a single pile driving scenario is 0.839 after 24 years and 0.845 for concurrent pile driving (a counterfactual of population size of 83.9% and 84.5%).

258. Based on the results from the interim PCoD model, the minke whale population within the CGNS Management Unit is predicted to remain stable over the next 24 years without any potential impacts from disturbance (Table 8.53 and Figure 8-40 and Table 8.55 and Figure 8-41). In the event that pile driving occurs over a period of 15 months or nine months it is estimated that after 24 years the minke whale population may be between 14.8% and 14.6% lower compared with the unimpacted baseline population (Table 8.54 and Table 8.56).

259. Comparing the distributions of population sizes after 24 years for the unimpacted and impacted populations shows that at least 8% of the runs do not end lower than the median population size of the unimpacted population for single pile driving and 7% of the runs for concurrent pile driving (Table 8.52).

Table 8.52: Minke whale population model outputs for single and concurrent pile driving at NnG

Minke whale						
	Median of the ratio of impacted to unimpacted annual growth rate		**Median of the ratio of impacted to unimpacted population size**		**Centile for impacted population that matches the 50th centile for unimpacted population**	
Year	**Single pile driving**	**Concurrent pile driving**	**Single pile driving**	**Concurrent pile driving**	**Single pile driving**	**Concurrent pile driving**
1	1.000	1.000	1.000	1.000	0.51	0.50
6	0.992	0.991	0.957	0.954	0.25	0.23
12	0.989	0.990	0.878	0.883	0.06	0.05
18	0.991	0.992	0.850	0.856	0.05	0.05
24	0.993	0.993	0.839	0.845	0.08	0.07

Table 8.53: Estimated population size for Minke whale within the CGNS Management Unit with pile driving undertaken over 15 months

Minke whale						
NnG single pile driving over fifteen months						
	5th percentile		**50th percentile**		**95th percentile**	
Year	**Undisturbed**	**Disturbed**	**Undisturbed**	**Disturbed**	**Undisturbed**	**Disturbed**
1	11,076	11,076	11,842	11,843	12,443	12,448
6	10,530	9,956	11,765	11,218	13,028	12,546
12	10,254	8,658	11,718	10,258	13,446	12,183
18	9,932	8,254	11,547	9,898	13,724	12,050
24	9,564	8,014	11,523	9,814	13,721	11,940

Table 8.54: Estimated difference in median disturbed and median undisturbed minke whale growth rates and population sizes with pile driving undertaken over 15 months

Minke whale	Difference in median disturbed and median undisturbed annual growth rates over 24 years	Difference in median disturbed and median undisturbed population size over 24 years	
Years		No. of individuals	% change in population size
1	±0.000	+1	+0.01
6	-0.008	-547	-4.65
12	-0.011	-1,460	-12.46
18	-0.009	-1,649	-14.28
24	-0.007	-1,709	-14.83

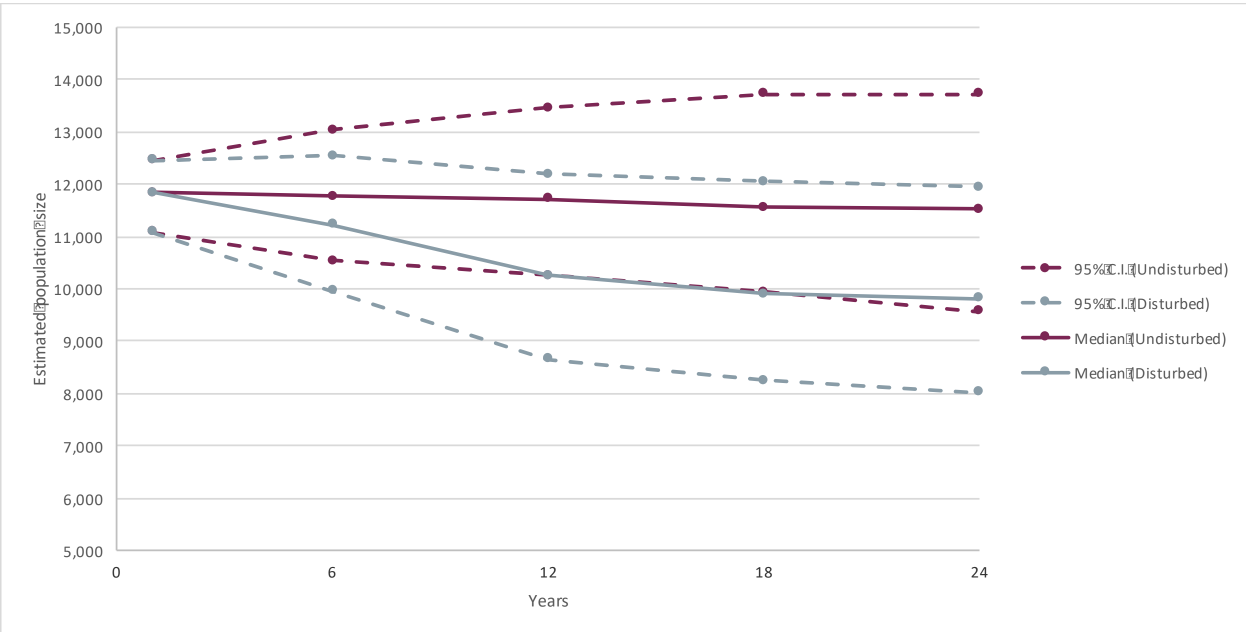


Figure 8-40: Estimated median (50th centile) and 95% C.I. for minke whale CGNS Management Unit population with (disturbed) and without (undisturbed) single pile driving over a period of 15 months

Table 8.55: Estimated population size for minke whale CGNS Management Unit with concurrent pile driving undertaken over 9 months

Minke whale						
NnG concurrent pile driving over nine months						
	5th percentile		50th percentile		95th percentile	
Year	Undisturbed	Disturbed	Undisturbed	Disturbed	Undisturbed	Disturbed
1	11,074	11,070	11,836	11,835	12,436	12,432
6	10,498	9,834	11,690	11,092	12,978	12,430
12	10,282	8,707	11,605	10,236	13,349	12,026
18	9,944	8,332	11,602	9,939	13,664	12,050
24	9,664	8,098	11,432	9,767	13,861	12,128

Table 8.56: Estimated difference in median disturbed and median undisturbed minke whale growth rates and population sizes with concurrent pile driving undertaken over 9 months

Minke whale	Difference in median disturbed and median undisturbed annual growth rates over 24 years	difference in median disturbed and median undisturbed population size over 24 years	
Years		No. of individuals	% change in population size
1	±0.000	-1	-0.01
6	-0.009	-598	-5.12
12	-0.010	-1,369	-11.80
18	-0.009	-1,663	-14.33
24	-0.007	-1,665	-14.56

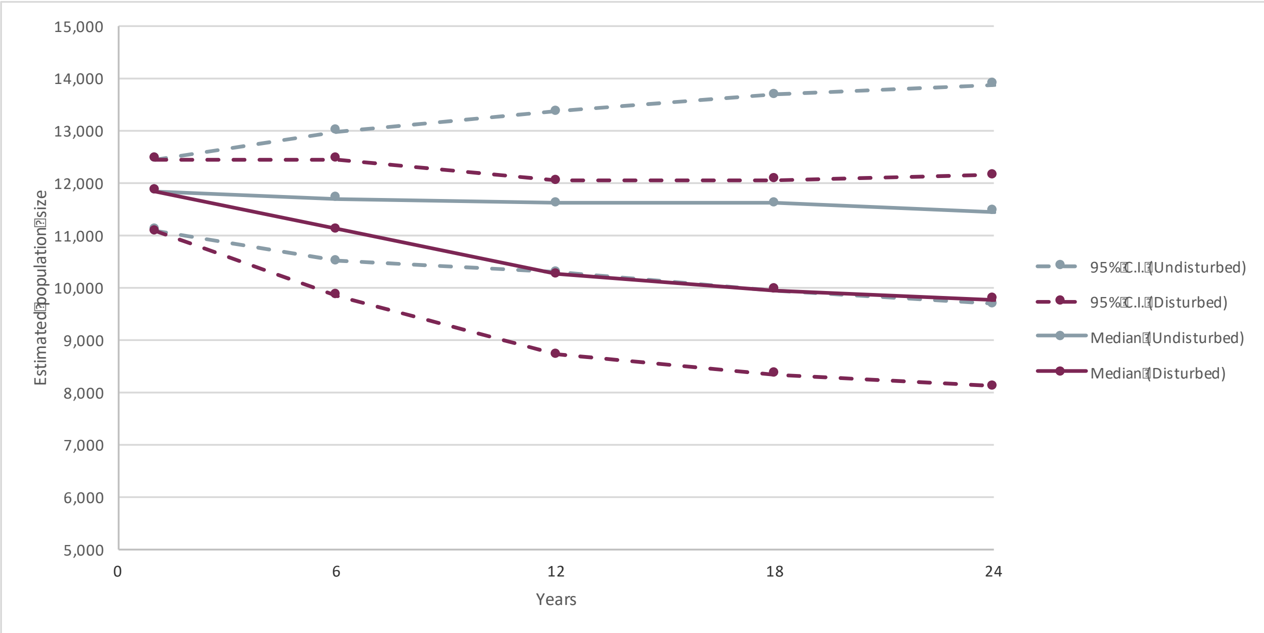


Figure 8-41: Estimated median (50th centile) and 95% C.I. for minke whale CGNS Management Unit population with (disturbed) and without (undisturbed) concurrent pile driving over a period of 9 months

Grey seal

260. The results from the population modelling indicate that impacts from pile driving could cause a decrease in the annual growth rate and population size of grey seals within the East Coast Management Area, with a potentially marginally greater effect occurring in the event single pile-driving is undertaken over a period of fifteen months (Table 8.57). However, the population is still predicted to increase from its current level.

261. The median ratio of the impacted to unimpacted annual growth rate for a single pile driving scenario is 0.997 after 24 years and 0.998 for concurrent pile driving (a counterfactual of growth rate of 99.7% and 99.8%). The difference between the median impacted and unimpacted growth rates after 24 years is -0.003 and 0.002 respectively.

262. The median ratio of the impacted to unimpacted population for a single pile driving scenario is 0.950 after 24 years and 0.973 for concurrent pile driving (a counterfactual of population size of 95.0% and 97.3%).

263. Based on the results from the interim PCoD model, the grey seal population within the East Coast Management Area is predicted to increase over the next 24 years without any potential impacts from disturbance (Table 8.58 and Figure 8-42 and Table 8.60 and Figure 8-43). In the event that pile driving occurs over a period of 15 months or nine months it is estimated that after 24 years the grey seal population will still have increased from its current level but may be between 7.72% and 5.67% lower compared with the unimpacted baseline population (Table 8.59 and Table 8.61).

264. Comparing the distributions of population sizes after 24 years for the unimpacted and impacted populations shows that at least 32% of the runs do not end lower than the median population size of the unimpacted population for single pile driving and 38% of the runs for concurrent pile driving (Table 8.57).

Table 8.57: Grey seal population model outputs for single and concurrent pile driving at NnG

Grey seal						
	Median of the ratio of impacted to unimpacted annual growth rate		Median of the ratio of impacted to unimpacted population size		Centile for impacted population that matches the 50th centile for unimpacted population	
Year	Single pile driving	Concurrent pile driving	Single pile driving	Concurrent pile driving	Single pile driving	Concurrent pile driving
1	1.000	1.000	1.000	1.000	0.50	0.50
6	0.987	0.992	0.945	0.976	0.16	0.28
12	0.994	0.996	0.953	0.975	0.28	0.35
18	0.996	0.997	0.951	0.974	0.31	0.36
24	0.997	0.998	0.950	0.973	0.32	0.38

Table 8.58: Estimated population size for grey seal within the ECMA with pile driving undertaken over 15 months

Grey seal						
NnG single pile driving over fifteen months						
	5th percentile		50th percentile		95th percentile	
Year	Undisturbed	Disturbed	Undisturbed	Disturbed	Undisturbed	Disturbed
1	9,040	9,040	9,667	9,667	10,220	10,220
6	8,706	7,399	9,992	9,237	11,338	10,773
12	8,442	7,662	10,393	9,713	12,589	11,885
18	8,524	7,731	10,751	9,978	13,555	12,630
24	8,602	7,768	11,224	10,357	14,676	13,692

Table 8.59: Estimated difference in median disturbed and median undisturbed grey seal growth rates and population sizes with pile driving undertaken over 15 months

Grey seal	Difference in median disturbed and median undisturbed annual growth rates over 24 years	Difference in median disturbed and median undisturbed population size over 24 years	
Years		**No. of individuals**	**% change in population size**
1	±0.000	±0.00	±0.00
6	-0.013	-755	-7.56
12	-0.006	-680	-6.54
18	-0.004	-773	-7.19
24	-0.003	-867	-7.72

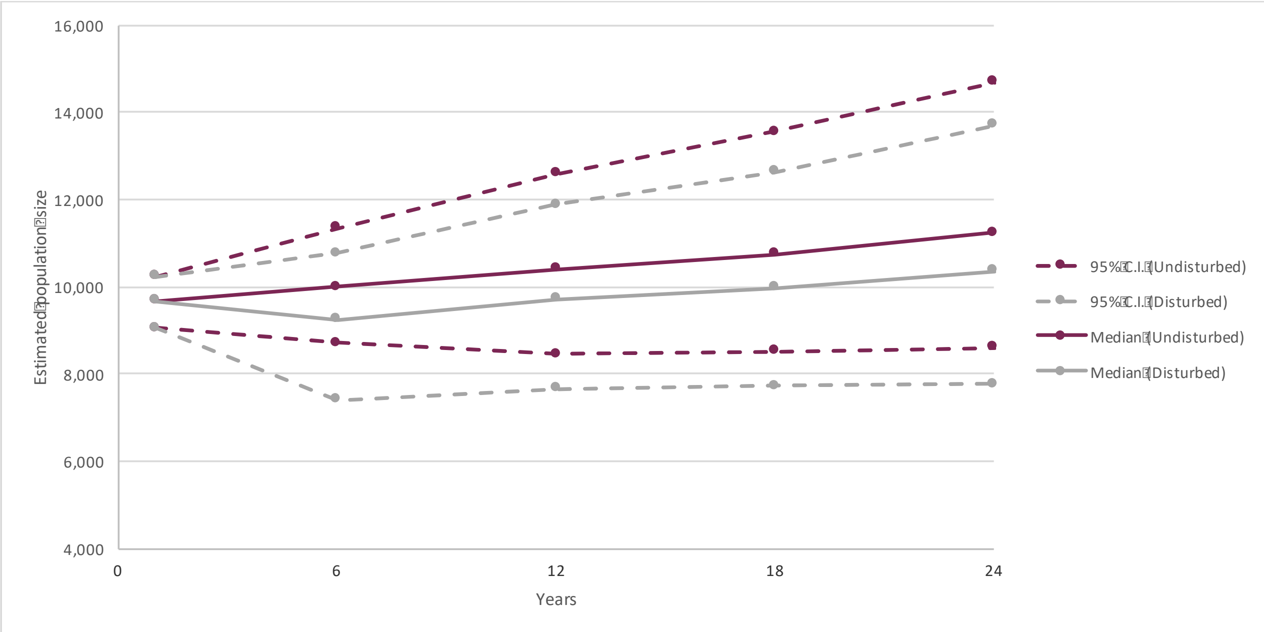


Figure 8-42: Estimated median (50th centile) and 95% C.I. for grey seal ECMA population with (disturbed) and without (undisturbed) single pile driving over a period of 15 months

Table 8.60: Estimated population size for grey seal ECMA with concurrent pile driving undertaken over 9 months

Grey seal						
NnG concurrent pile driving over nine months						
	5th percentile		50th percentile		95th percentile	
Year	Undisturbed	Disturbed	Undisturbed	Disturbed	Undisturbed	Disturbed
1	9,100	9,100	9,694	9,694	10,256	10,256
6	8,670	7,683	9,979	9,511	11,314	10,908
12	8,426	7,698	10,365	9,868	12,619	12,121
18	8,342	7,702	10,826	10,270	13,716	13,193
24	8,333	7,691	11,206	10,571	14,718	14,152

Table 8.61: Estimated difference in median disturbed and median undisturbed grey seal growth rates and population sizes with concurrent pile driving undertaken over 9 months

Grey seal	Difference in median disturbed and median undisturbed annual growth rates over 24 years	difference in median disturbed and median undisturbed population size over 24 years	
Years		No. of individuals	% change in population size
1	±0.000	±0	±0.00
6	-0.008	-468	-4.69
12	-0.004	-497	-4.79
18	-0.003	-556	-5.14
24	-0.002	-635	-5.67

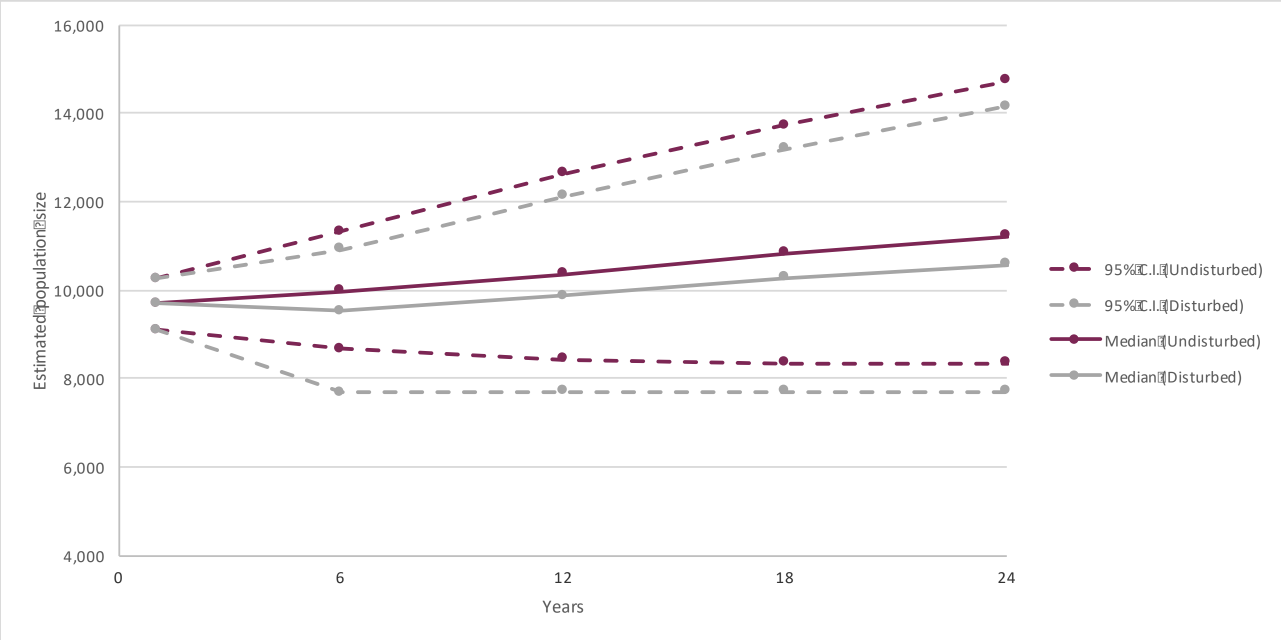


Figure 8-43: Estimated median (50th centile) and 95% C.I. for grey seal ECMA population with (disturbed) and without (undisturbed) concurrent pile driving over a period of 9 months

Harbour seal

265. The results from the population modelling indicate that the harbour seal population within the East Coast Management area will decrease and become effectively zero within 18 to 24 years. Impacts from pile driving could cause a decrease in the annual growth rate and population size of harbour seals (Table 8.62). However, it makes no effective difference as to when the population declines to zero irrespective if the pile driving is undertaken over 15 months or concurrently over nine months (Table 8.63, Table 8.64, Figure 8-44 and Table 8.65, Table 8.66 and Figure 8-45).

Table 8.62: Harbour seal population model outputs for single and concurrent pile driving at NnG

Harbour seal						
	Median of the ratio of impacted to unimpacted annual growth rate		Median of the ratio of impacted to unimpacted population size		Centile for impacted population that matches the 50th centile for unimpacted population	
Year	Single pile driving	Concurrent pile driving	Single pile driving	Concurrent pile driving	Single pile driving	Concurrent pile driving
1	1.085	0.660	1.083	1.083	0.82	0.83
6	1.004	N/A	1.038	1.037	0.54	0.52
12	0.982	N/A	0.778	0.923	0.27	0.40
18	N/A	N/A	1.000	1.000	0.37	0.33
24	N/A	N/A	1.000	1.000	0.01	0.01

Table 8.63: Estimated population size for harbour seal within the ECMA with pile driving undertaken over 15 months

Harbour seal						
NnG single pile driving over fifteen months						
	5th percentile		50th percentile		95th percentile	
Year	Undisturbed	Disturbed	Undisturbed	Disturbed	Undisturbed	Disturbed
1	218	238	250	270	284	302
6	56	52	82	84	116	126
12	6	4	20	16	40	40
18	0	0	4	4	16	16
24	0	0	0	0	8	8

Table 8.64: Estimated difference in median disturbed and median undisturbed harbour seal growth rates and population sizes with pile driving undertaken over 15 months

Harbour seal	Difference in median disturbed and median undisturbed annual growth rates over 24 years	Difference in median disturbed and median undisturbed population size over 24 years	
Years		No. of individuals	% change in population size
1	-0.065	+20	+8.00
6	-0.008	+2	+2.44
12	+0.004	-4	-20.00
18	-0.785	±0	±0.00
24	±0.000	±0	±0.00

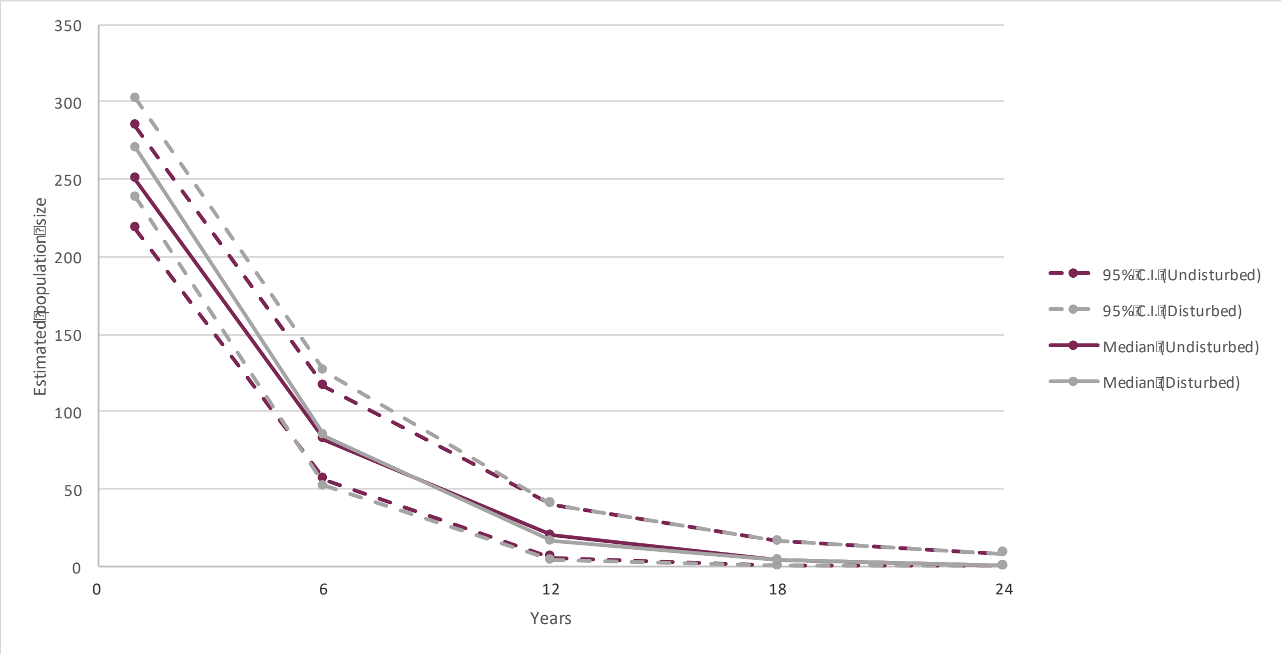


Figure 8-44: Estimated median (50th centile) and 95% C.I. for harbour seal ECMA population with (disturbed) and without (undisturbed) single pile driving over a period of 15 months

Table 8.65: Estimated population size for harbour seal ECMA with concurrent pile driving undertaken over 9 months

Harbour seal						
NnG concurrent pile driving over nine months						
	5th percentile		50th percentile		95th percentile	
Year	Undisturbed	Disturbed	Undisturbed	Disturbed	Undisturbed	Disturbed
1	214	236	250	270	282	302
6	56	52	82	84	114	124
12	6	6	22	20	40	42
18	0	0	6	4	18	18
24	0	0	0	0	8	8

Table 8.66: Estimated difference in median disturbed and median undisturbed harbour seal growth rates and population sizes with concurrent pile driving undertaken over 9 months

Harbour seal	Difference in median disturbed and median undisturbed annual growth rates over 24 years	Difference in median disturbed and median undisturbed population size over 24 years	
Years		No. of individuals	% change in population size
1	-0.064	+20	+8.00
6	-0.003	+2	+2.44
12	+0.006	-2	-9.09
18	+0.018	-2	-33.33
24	±0.000	±0	±0.00

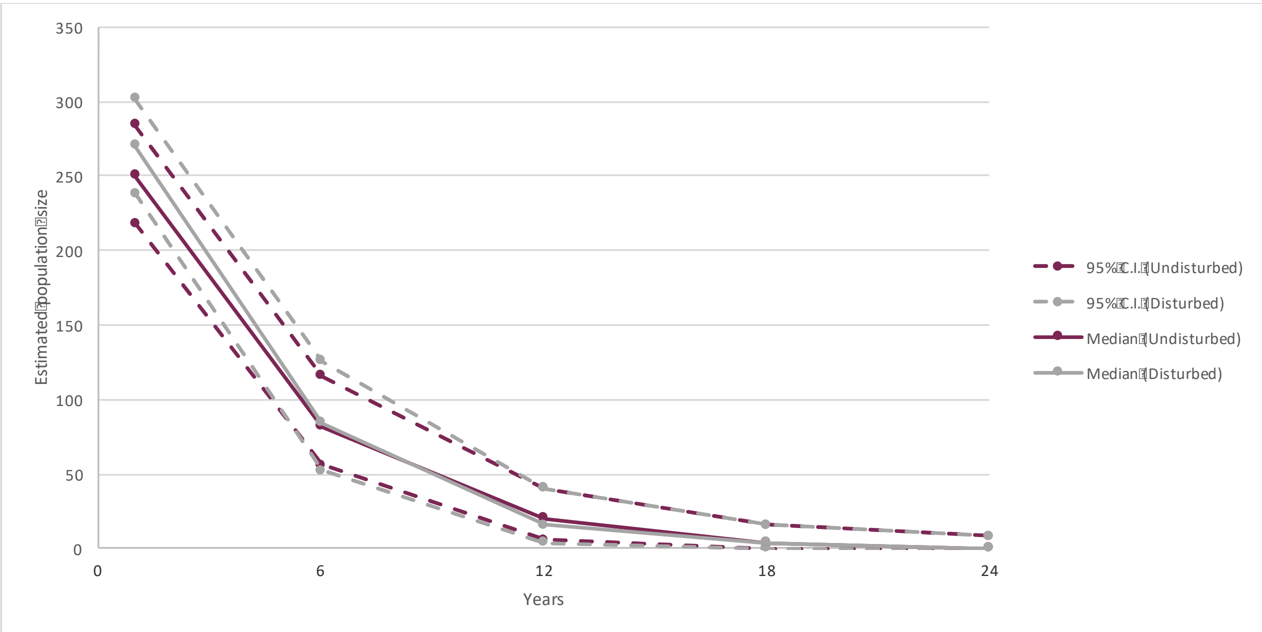


Figure 8-45: Estimated median (50th centile) and 95% C.I. for harbour seal ECMA population with (disturbed) and without (undisturbed) concurrent pile driving over a period of 9 months

8.10.7 Impacts on prey species

266. Based on the advice received in the Scoping Opinion the impacts from particle motion arising from pile driving on fish have been considered in Chapter 7: Fish and Shellfish. As significant effects on fish are not predicted it is reasonable to assume that secondary effects on marine mammal predators would also not occur. However, it is recognised that they are important prey items to marine mammals and for completeness a qualitative assessment has been undertaken.

267. The main prey items for the majority of the marine mammals recorded within the study area are fish, although some non-fish prey items such as cephalopods may also be taken. The main prey items recorded for marine mammals in the region are presented in Table 8.67. However, it is recognised that many marine mammals are opportunistic feeders and will prey on a wide variety of species if available.

Table 8.67: Main prey items for marine mammals recorded within the study area

Species	Main prey
Harbour porpoise	sandeel, whiting
White-beaked dolphin	haddock, whiting, cod
Bottlenose dolphin	cod, saithe, whiting, salmon and haddock
Minke whale	herring, sandeel, cod, haddock and saithe
Grey seal	sandeel, cod and haddock
Harbour seal	sandeel, whiting, flounder and cod

268. Sandeels are one of the main prey items for many of the marine mammals recorded in the area. They are also an important prey species for predatory fish such as whiting, cod and haddock, all of which are also prey to marine mammals (Greenstreet *et al*. 2006). Sandeels are not considered to have sensitive hearing (Popper *et al.* 2014). Studies undertaken using airguns indicate that sandeels have distinct but weak reactions to seismic airguns with initial startle responses reducing in frequency with on-going noise and no increased mortality detected (Hassel *et al.* 2004).

269. Results from studies on cod and sole indicate that pile driving may cause fish to increase swimming speed and move away from the pile driving noise (Mueller-Blenkle *et al.* 2010). Studies undertaken during 35 days of pile driving in a wharf on two species of fish which possess swim-bladders: grey snapper (*Lutjanus griseus*) and sheepshead (*Archosargus probatocephalus*), indicated little displacement effects at received SPL of between 152±157 dB re 1 µPa (peak) (Lafrate *et al*. 2016).

270. Similarly, studies undertaken during seismic surveys have reported localised and temporary changes in behaviour, with fish swimming away from the area or into deeper water but fish populations returning to pre-survey levels shortly after the seismic surveys has stopped (e.g. Wardle *et al*. 2001; Slotte *et al*. 2004; Løkkeborg *et al.,* 2010; Peña *et al*. 2013).

271. Construction surveys from existing wind farms have indicated that fish numbers present within operating wind farms are at least similar to those prior to construction and may be higher (e.g. Jensen *et al.* 2006; Leonhard and Pederson, 2006; Lindeboom *et al.* 2011, Leonhard *et al*., 2011). Consequently, no long-term impacts on fish on which marine mammals prey are predicted following cessation of construction activities.

272. Sound arising from pile driving may have an effect on some prey species for marine mammals. Although the level of impact is dependent on the level of the sound source and the species of fish, the results from the noise modelling indicate that there is a very low risk of injury to any fish species. Although there is potential for a wider area of displacement or disturbance published studies indicate that the impacts will be localised and temporary, with fish populations returning to background levels following cessation of the noise.

273. It is concluded that based on the low risk of injury and localised displacement / disturbance, the sensitivity of the fish population is low and the magnitude of any impacts will be low. The significance of any impacts is therefore assessed to be **minor** and the potential effect from pile driving noise on fish populations is not significant.

8.10.8 Construction Phase Impacts

274. The impact resulting from the construction of the Project alone are predicted to be no greater than those predicted by the assessment undertaken for the consented original application. However, the

methods used to assess the predicted impacts have changed and the results from these revised methods are discussed in this section.

8.10.8.1 Pile driving noise

275. The only impact identified from the scoping process that may have the potential to cause a likely significant impact on marine mammals during construction was noise arising from pile driving (NnGOWL 2017, Marine Scotland 2017a).

276. Pile driving and drilling within the Wind Farm Area is required to support jacket foundations for the wind turbines, the offshore substation(s) and the met mast. The overall piling duration is expected to lie within a period of nine or fifteen months depending on whether concurrent piling is undertaken.

277. Owing to the nature of the seabed sediments at the site and the presence of shallow bedrock, there are three main installation methods that could be used for the installation of the piles:

- Driven only pile - driving with a hydraulic hammer;
- Driven and drilled pile - the 'drive–drill-drive' method where successive driving and drilling phases are used; and
- Drill only pile - drilling out the entire hole for the pile and subsequently grouting the pile into the drilled socket in the bedrock. In this method, a sacrificial casing may be installed by driving to bedrock level ahead of the drilling operation. This is to prevent the sediment layer collapsing in to the drilled hole prior to pile installation.

278. Although the highest levels of noise will arise during pile driving, noise from drilling is predicted to occur over the longest period of time.

Harbour porpoise

279. The harbour porpoise North Sea Management Unit population based on the SCANS III data is estimated to be 333,808 individuals and the population is assessed as being in Favourable condition. The regional population based on SCANS III Block R is 38,646 (CL 20,584 – 66,254) individuals (Table 8.8) (Hammond *et al*. 2017; JNCC, 2017).

280. The results from the noise modelling indicate that during a single pile driving operation within the Wind Farm Area the average distance within which the onset of PTS in harbour porpoise will occur is 247 m from a single pulse (peak SPL) and 6,357 m from cumulative multiple pulses (Table 8.27). There is the potential for the onset of TTS to occur within 823 m from a single pulse and 25,112 m from cumulative multiple pulses (Table 8.28).

281. The number of individuals at risk of the onset of PTS is estimated to be 77 individuals and therefore an estimated 0.02% of the Management Unit population and 0.29% of the regional population may be impacted (Table 8.36). It is estimated that the number of harbour porpoise that may be disturbed during a single pile driving event is 1,177 individuals, equivalent to 0.35% of the Management Unit population and 3.0% of the regional population (Table 8.36). Consequently, the noise modelling undertaken indicates that a very small proportion of the harbour porpoise Management Unit population are predicted to be at risk of the onset of PTS irrespective of whether single pile driving or concurrent pile driving is undertaken.

282. The results from population modelling indicate that should pile driving be undertaken over a period of 15 months the median of the ratio of impacted to unimpacted annual growth rate will be 0.998. the difference in median growth rates is very small at -0.002. The median of the ratio of impacted to unimpacted population size may be 0.959 (Table 8.42). The potential difference in the population size between the impacted and unimpacted harbour porpoise populations in 24 years is estimated to be 4.2% (Table 8.44).

283. In the event that concurrent pile driving is undertaken, the pile installation across the Wind Farm Area could be completed within a single year. The number of harbour porpoise estimated to be at risk of PTS is 144 individuals, equivalent to 0.04% of the North Sea Management Unit population and 0.37% of the regional population. The estimated number of harbour porpoise predicted to be disturbed is 1,880 individuals; equivalent to 0.56% of the North Sea Management Unit population and 4.9% of the regional population (Table 8.41).

284. The population modelling undertaken indicates that should concurrent pile driving be undertaken within the Wind Farm Area this could result in a 4.6% difference in the harbour porpoise population in 24 years (Table 8.46).

285. Studies undertaken on harbour porpoise indicate that the impacts from TTS are temporary and, depending on the exposure level and duration, hearing ability returns between 4 and 96 minutes after the sound causing the impact has ceased (Kastelein *et al.* 2012; Kastelein *et al*. 2014). Consequently, the impacts from TTS are predicted to be of short duration and unlikely to have an effect on harbour porpoise.

286. Studies undertaken at existing offshore wind farms with regard to behavioural effects from pile driving, suggest that harbour porpoise return to areas from which they have been displaced relatively shortly after the cessation of pile driving activities. Results from Horns Rev offshore wind farm indicated that harbour porpoises were present in an area within 48 hrs of pile driving operations having stopped (Tougaard *et al.* 2006). Similarly, in the Moray Firth, harbour porpoise returned within 2 to 3 days following the installation of piles for two jacket based wind turbines (Thompson *et al*. 2010). At the Greater Gabbard offshore wind farm porpoises returned within four weeks following cessation of pile driving (GWFL, 2011). Studies undertaken during the construction of eight offshore wind farms in Germany indicate that there may be a level of displacement out to 20 km or more from the pile driving activities. However, the duration of any impacts were short with harbour porpoise returning, following the cessation of pile driving, within 20 to 31 hrs (Brandt *et al*. 2016).

287. Similar studies undertaken in the Moray Firth during 10 days of 2D seismic surveys using a 470 cu in airgun with peak-to-peak source levels estimated to be 242-253 dB re 1 µPa @ 1 m, reported a decrease in the relative densities of harbour porpoises within 10 km of the airgun and an increase in densities at greater distances. However, porpoises continued to occur at sites within the impacted area during the seismic survey and there was a decline in the level of displacement over the ten day period that surveys were undertaken; indicating an increasing level of acclimation during the surveys. Once the surveys had ceased the number of detections returned to baseline levels within a day (Thompson *et al.* 2013; Pirotta *et al.* 2014).

288. Displaced harbour porpoise will relocate elsewhere. The species occurs widely across the North Sea and is therefore not constrained by specific habitat preferences. Harbour porpoise are known to forage widely and prey on a wide selection of fish species (Sveegaard, 2011); they are therefore adaptable and capable of relocating to new areas. However, the impacts on their prey are predicted to be limited to when pile driving is being undertaken and fish populations are predicted to return to baseline level following the cessation of pile driving.

289. It is concluded that any displacement or disturbance impacts on harbour porpoise from pile driving will be temporary and not have a significant population level effect. The sensitivity of harbour porpoise population is assessed to be low and the magnitude of any effects are also low. The significance of any effect is therefore assessed to be **minor** and the potential impact from pile driving noise on harbour porpoise is not significant.

White-beaked dolphin

290. The white-beaked dolphin Management Unit population based on SCANS III survey results is estimated to be 35,908 individuals and the population is assessed as being in Favourable condition (IAMMWG,

2015; JNCC, 2017). The regional population based on SCANS III Block R is 15,694 (CL 3,022– 33,340) individuals (Table 8.13) (Hammond *et al*. 2017).

291. The results from the noise modelling indicate during a single pile driving operation undertaken over a period of fifteen months within the Offshore Wind Farm Area, the average distance within which the onset of PTS in white-beaked dolphin will occur is within 3 m from a single pulse (peak SPL) and 1 m from cumulative multiple pulses (Table 8.29). There is potential for the onset of TTS to occur within 8 m from a single pulse and 493 m from cumulative multiple pulses (Table 8.30). The number of individuals at risk of the onset of PTS is estimated to less than one individual and therefore less than 0.003% of the SCANS III based Management Unit population and 0.006% of the regional population may be impacted (Table 8.36).

292. The SCANS III surveys did not record any white-beaked dolphins in the in the Firths of Forth and Tay area and the regional densities for the SCANS III Block R are derived from sightings beyond the area potential impacted by pile driving activities (Hammond *et al*. 2017). Consequently, the estimated density of 0.24 ind. km^2 for SCANS III Block R may not reflect the densities of white-beaked dolphin within the area of potential impact. Three years of site specific surveys recorded a total of 18 white-beaked dolphins and for eight months of the year there were no sightings. Similarly, although data from aerial surveys did recorded white-beaked dolphins in the Firths of Forth and Tay area, the majority of sightings were further offshore with none within the Wind Farm Area (Grellier and Lacey, 2011). Densities based on data obtained from boat based and aerial surveys undertaken across Firths of Forth and Tay area indicate densities of white-beaked dolphin within the Wind Farm Area are between 0.00 and 0.005 ind/km^2 and the highest densities further offshore are between 0.1 and 0.2 ind/km^2. A density of 0.016 ind/km^2 has been calculated based on boat based and aerial survey data obtained across the Firths of Forth and Tay and the total number of white-beaked dolphins estimated to be in the area is 91 (95% CI 32 – 384) (King and Sparling 2012).

293. Based on the SCANS III regional density of 0.24 ind/km^2 it is estimated that the number of white-beaked dolphin that may be disturbed during a single pile driving event is 478 individuals and 763 individuals if concurrent pile driving occurs. The number of individuals estimated to be disturbed is therefore higher than the total population of white-beaked dolphins thought to occur in the Firths of Forth and Tay area. The use of the relatively high density of 0.24 ind/km^2 is therefore not considered appropriate for this assessment

294. Based on the densities of white-beaked dolphins within the Firths of Forth and Tay of 0.016 ind/km^2, it is estimated that up to 30 white-beaked dolphins could be affected from single pile driving, 0.08% of the Management Unit population and 0.19% of the regional population. In the event concurrent pile driving is undertaken an estimated 50 individuals may be affected, 0.13% of the Management Unit population and 0.32% of the regional population.

295. No studies on the potential impacts arising from the construction of offshore wind farms on white-beaked dolphins have been published. However, studies on other marine mammals have demonstrated that once activities causing the displacement cease, marine mammals will return to the area. It is predicted that white-beaked dolphins will also show similar behaviour as other marine mammals, with individuals returning shortly have activities have ceased.

296. White-beaked dolphin feed on a broad range of prey and therefore will be able to feed opportunistically in alternative areas should they be displaced. However, the impacts on their prey are predicted to be limited to when pile driving is being undertaken and fish populations are predicted to return to baseline levels following the cessation of pile driving.

297. The proportion of the white-beaked dolphin population predicted to be displaced or disturbed is relatively very low and any impacts from pile driving will be temporary. It is concluded that based on the relatively low numbers impacted and the temporary nature of any potential impacts that the sensitivity of white-beaked dolphins population is low and the magnitude of any impacts will be

negligible. The significance of any effect is therefore assessed to be **negligible** and the potential impact from pile driving noise on white-beaked dolphin is not significant.

Bottlenose dolphin

298. The bottlenose dolphin Management Unit population is estimated to be 195 individuals and the population is assessed as being in unfavourable condition.

299. Bottlenose dolphins do not occur within the Wind Farm Area and there were no sightings of bottlenose dolphin during the three years of surveys undertaken across the study area.

300. The results from the noise modelling indicate that during both single and concurrent pile driving operations within the Offshore Wind Farm Area the average distance within which the onset of PTS in bottlenose dolphin will occur is limited to within 3 m of the pile driving activities (Table 8.29). There is potential for the onset of TTS to occur within 8 m from a single pulse and 493 m from cumulative multiple pulses (Table 8.30). The number of individuals at risk of the onset of PTS and TTS is estimated to less than one individual.

301. It is estimated that the number of bottlenose dolphins that may be disturbed during a single pile driving event is two individuals, equivalent to 1.0% of the Management Unit population.

302. In the event that concurrent pile driving occurs within the Wind Farm Area, the area within which physical injury could occur remains at less than 0.001 km^2, although the onset of TSS could occur over a wider area of 1.035 km^2 (Table 8.37 and Table 8.38). The number of bottlenose dolphins estimated to be at risk of PTS and TTS is less than one individual and the number at risk of disturbance is two individuals; equivalent to 1.0% of the Management Unit population.

303. The very low numbers of bottlenose dolphin at risk of physical injury or disturbance indicates that there is a very low risk of any effect on the bottlenose dolphin population. This is supported by the results from the population modelling that indicates that the impacts from the pile driving will not cause a population level effect after 24 years (See Section 8.10.6.2)

304. Bottlenose dolphin feed on a broad range of prey and the few individuals that may be disturbed will, if dispalced, be able to feed opportunistically in alternative areas. The impacts on their prey are predicted to be limited to when pile driving is being undertaken and fish populations will return to baseline levels following the cessation of pile driving.

305. It is concluded that the impacts from pile driving at NnG will have no effect on the population of bottlenose dolphins. The sensitivity of the bottlenose dolphin population is assessed as high and the magnitude of any impacts will be negligible. The significance of any effect is therefore assessed to be **minor** and the potential effect from pile driving noise on bottlenose dolphin is not significant.

Minke whale

306. The Minke whale CGNS Management Unit population based on the SCANS III data is estimated to be 11,819 individuals and the population is assessed as being in Favourable condition. The regional population based on SCANS III Block R is 2,498 (CL 604 – 6,791) individuals(Table 8.16) (JNCC, 2017; Hammond *et al*. 2017).

307. The results from the noise modelling indicate that during a single pile driving operation within the Wind Farm Area the average distance within which the onset of PTS in Minke whale will occur is 15 m from a single pulse and 10,224 m from cumulative multiple pulses (Table 8.31). There is potential for the onset of TTS to occur within 37 m from a single pulse and 44,889 m from cumulative multiple pulses (Table 8.32).

308. The number of individuals at risk of the onset of PTS from cumulative multiple pulses is estimated to 14 individuals and therefore 0.11% of the Management Unit population and 0.56% of the regional population may be impacted.

309. It is estimated that the number of minke whales that may be disturbed during a single pile driving event is 77 individuals, equivalent to 0.65% of the Management Unit population and 3.1% of the regional population (Table 8.36). In the event that concurrent pile driving occurs within the Wind Farm Area, the duration of impacts from pile driving will be reduced to within nine months. The number of minke whales estimated to be at risk of PTS from concurrent pile driving increases to 23 individuals, equivalent to 0.19% of the Management Unit population and 0.92% of the regional population. The number at risk of disturbance increases to 123 individuals, equivalent to 1.0% of the management unit population and 4.9% of the regional population (Table 8.41).

310. The results from population modelling indicate that should pile driving be undertaken over a period of 15 months the median of the ratio of impacted to unimpacted annual growth rate will be 0.993 and the median of the ratio of impacted to unimpacted population size will be 0.839 (Table 8.52). The potential difference in the median impacted and unimpacted growth rates after 24 years is -0.007 and population size of 4.2% (Table 8.54).

311. The population modelling undertaken indicates that should concurrent pile driving be undertaken the median of the ratio of impacted to unimpacted annual growth rate will be 0.845 and the median of the ratio of impacted to unimpacted population size will be 0.950 (Table 8.52). Based on the modelling outputs this could result in a 14.8% difference in the minke whale population in 24 years (Table 8.54).

312. The low percentage of modelling runs where the estimated impacted population size is not lower than the estimated unimpacted population (Table 8.52) indicates that there is a relatively high probability that after 24 years impacted population will be lower than the unimpacted population due to the impacts from pile driving.

313. There are few studies on the potential effects of underwater noise on minke whales. Studies undertaken using naval sonar found that a minke whale started avoiding the source at a received SPL of 146 dB re 1 μPa and at a received cumulative SEL of 155 dB re 1 $\mu Pa^2 s$ it increased swimming speed and the whale moved away from the sound source. At a cumulative SEL of 171 dB re 1 $\mu Pa^2 s$ swimming speed increased up to more than 4 m s^{-1} and the animal remained near the sea surface. Within ten minutes of the noise stopping the swimming speed and diving behaviour returned to normal (Sivle *et al.* 2015; Kvadsheim *et al*. 2015). Studies undertaken on minke whales have shown that when ADD's are operating they increase swimming speeds to an average of 7.4 kmh^{-1} and swim away from the sound source (McGarry *et al.* 2017). It is predicted that minke whales impacted by pile driving noise will behave similarly and increase swimming speeds to move quickly away from the area.

314. There is a low risk of physical injury to minke whales with no more than 0.19% of the Management Unit population at risk of the onset of PTS. Displaced minke whales will swim rapidly away from the sound source and relocate to other areas. Within the study area only 18 minke whales were recorded during three years of monthly surveys and therefore the area is not considered to be important for minke whales (Table 8.18). The broad distribution of minke whales across the North Sea indicates that they are not restricted to specific habitats within their range and displaced individuals will be able to relocate elsewhere.

315. Minke whale feed on a broad range of fish species (Table 8.67) and will therefore will be able to feed opportunistically in alternative areas should they be displaced. The impacts on their prey are predicted to be limited to when pile driving is being undertaken and fish populations are predicted to return to baseline levels following the cessation of pile driving. Advice received in the Scoping Opinion is that the impacts on diadromous fish are not significant (Marine Scotland 2017a)

316. It is concluded that impacts on minke whale from pile driving will be temporary and not have a significant population level effect. The sensitivity of minke whale population is assessed to be low and the magnitude of any effects is Medium. The significance of any effect is therefore assessed to be **minor** and the potential effect from pile driving noise on minke whale is not significant.

Grey seal

317. The adjusted grey seal population in the ECMA is estimated to be 9,607 (CI 8,028 – 11,958) individuals and the NEEMA is 29,046 (95% CI 24,272 – 36,156) (See Para: 148). A combined regional population of 38,653 (CI 32,300 – 48,114) individuals. It is known from tagging studies that seals from the NEEMA occur with the Firths of Forth and Tay.

318. The results from the noise modelling indicate that during a single pile driving operation within the Wind Farm Area the average distance within which the onset of PTS in grey seals will occur is 18 m from a single pulse (peak SPL) and 472 m from cumulative multiple pulses (Table 8.33). There is potential for the onset of TTS to occur within 47 m from a single pulse and 20,312 m from cumulative multiple pulses (Table 8.34). The number of individuals at risk of the onset of PTS from cumulative multiple pulses is estimated to be one individual (Table 8.36) and therefore 0.01% of the ECMA population and <0.001% of the regional population (comprising East Coast and North-East England Management Areas) may be affected. It is estimated that during a single pile driving event 821 grey seals, 8.5% of the ECMA population and 2.1% of the regional population may be disturbed (Table 8.36).

319. In the event that concurrent pile driving occurs within the Wind Farm Area the number of grey seals estimated to be at risk of PTS is individual; 0.01% of the ECMA population. The number at risk of disturbance is 1,357 individuals; equivalent to 14.1% of the ECMA population and 3.5% of the regional population (Table 8.41).

320. The population modelling are based on the ECMA population only. The results indicate that the ECMA grey seal population will continue to increase over the next 24 years with or without impacts from proposed pile driving (Figure 8-42 and Figure 8-43).

321. Should pile driving be undertaken over a period of 15 months the median of the ratio of impacted to unimpacted annual growth rate will be 0.997 and the median of the ratio of impacted to unimpacted population size will be 0.950 (Table 8.57). The potential difference in the growth rate between the impacted and unimpacted grey seal population in 24 years is very small at -0.003 and the difference in population size may be 7.7% (Table 8.59).

322. Should concurrent pile driving be undertaken the median of the ratio of impacted to unimpacted annual growth rate will be 0.998 and the median of the ratio of impacted to unimpacted population size will be 0.973 (Table 8.57). Based on the modelling outputs this could result in a 5.7% difference in the grey seal population after 24 years (Table 8.61).

323. Studies undertaken at other offshore wind farms have not detected any declines in the population of grey seals following construction. At Scroby Sands Offshore wind farm the population of grey seals continued to increase following the construction of the wind farm (Skeate *et al* 2012). Similarly, following construction of the Nysted offshore wind farm in Denmark, no long term effects on the number grey seals hauled at Rødsand as close as 4 km away were recorded (Edrén, *et al*., 2010). Consequently, it is predicted that there will not be any decrease in the number of grey seals within the ECMA or wider regional population and the population may continue to increase.

324. Grey seals feed on a broad range of fish species and forage widely from their haul out sites (Figure 8-20) and will therefore will be able to feed opportunistically in alternative areas should they be displaced. The impacts on their prey are predicted to be limited to when pile driving is being undertaken and fish populations are predicted to return to baseline levels following the cessation of pile driving.

325. The potential impacts on individual grey seals will vary, depending on individuals' sensitivities and habituation to noise. Furthermore, studies suggest that the response to noise may depend on whether the sound is sudden and causes a startle response or is more gradual and allows habituation to occur and therefore avoids a startle response. Where sound levels are increased more gradually, i.e. by ramp-up, a reduced level of displacement may occur (Götz and Janik, 2011).

326. It is concluded that any displacement or disturbance impacts on grey seals from pile driving will be temporary. The sensitivity of grey seal population is assessed to be medium and the magnitude of any effects will be low. The significance of any effects is therefore assessed to be **minor** and the potential impact from pile driving noise on grey seal is not significant.

Harbour seal

327. The population of harbour seals within the ECMA has declined significantly over the last 20 years (Figure 8-24 and Figure 8-25) and the adjusted population is estimated to be 311 (95% CI 254 - 415) individuals (See Para: 160. The cause of the decline is unknown.

328. Results from noise modelling indicates that there is potential for the onset of PTS to occur within 472 m from the pile driving, and for the onset of TTS to occur within 20,312 m (Table 8.33).

329. Population modelling predicts that the ECMA harbour seal population will become extinct within 24 years with or without any impacts from pile driving. Although the decrease in the population may be marginally greater over the initial ten to fifteen years with pile driving (Figure 8-44 and Figure 8-45).

330. Tagging data obtained during the construction of the Lincs Offshore wind farm indicated that displacement effects could occur out to 25 km from the sound source with a predicted maximum SPL of 235 dB re 1 $\mu Pa_{(p\text{-}p)}$ @ 1 m and a maximum SEL of 211 dB re 1 $\mu Pa^2 s^{-1}$. However, following cessation of pile driving the distribution of harbour seals returned to the pre-pile driving scenarios (Russell *et al.* 2016b). Consequently, any potential displacement effects arising from pile driving are predicted to be temporary.

331. Studies undertaken at other offshore wind farms indicate that there is a low risk of any population level effect to harbour seals from construction activities. Following construction at Horns Rev offshore wind farm no changes in the abundance of harbour seals were recorded at haul-out sites (Teilmann *et al*. 2006) and at the Dutch Egmond aan Zee wind farm harbour seals avoided the wind farm area during construction but were recorded within the wind farm following the cessation of construction activities. However, due to the limited data it was not possible to conclusively conclude that there were no population effects (Brasseur *et al*. 2012).

332. Harbour seals prey on a wide variety of species including sandeels, whiting, flounder, cod and other fish species (SCOS, 2005; Tollit and Thompson, 1996). The main prey species for harbour seals in the Tay Estuary area are sandeels and salmonids (Sparling *et al*. 2012) neither of which are particularly sensitive to sound (Popper *et al*. 2014) and both have a relatively localised potential area of impact. Consequently, it is predicted that there will be potential prey available in the area during the period of construction.

333. Although there will be an impact on harbour seals arising from pile driving noise the results from the population modelling indicate that the additive effect on the harbour seal population from the pile driving is negligible.

334. It is concluded that any displacement or disturbance impacts on harbour seals from pile driving will be temporary and not have a significant population level effect. The sensitivity of harbour seal population is assessed to be high but the magnitude of any effects on the population will be negligible. The significance of any effects is therefore assessed to be **minor** and the potential impact from pile driving noise on harbour seal is not significant.

8.10.8.2 Drilling noise

335. It is anticipated that the majority of the foundations will require drilling to be undertaken in the 'drive-drill-drive' and 'drill only' scenarios and is predicted to be the most continuous sound source occurring during the installation of the foundations. Consequently, the potential impacts from drilling noise on marine mammals have been assessed.

336. Sound associated with drilling operations will propagate from rotating equipment such as generators, pumps and the drill string. In general, sound from drilling has been found to be predominantly low frequency (<1kHz) with relatively low source levels. Source levels have been found to be less than 195 dB (rms) re 1µPa-m for a drill ship (Nedwell and Edwards 2004). A study by Greene (1987) found that the sound generated by drilling activities from a semi-submersible did not exceed local ambient levels beyond 1 km, although weak tones were detectable up to 18 km away. Studies have shown that during drilling, other underwater sound levels increase when compared to periods of non-drilling, which has been related to the use of additional machinery and power demands (McCauley 1998). Drilling sounds, although of a relatively low level, will be continuously generated throughout the drilling activity.

337. Noise from drilling activities is largely dependent on the type of drilling platform being used. Jack-up rigs are the most frequently used drilling platform and produce the lowest levels of sound. Studies in Danish waters reported sound source levels of 148 re 1µ Pa-m $_{(rms)}$ from drilling activities undertaken from a fixed platform (Bach *et al.* 2010). The level of sound arising from drilling is relatively low and occurs predominantly at a low frequency and is a continuous sound source (Greene, 1986; McCauley, 1998; Nedwell and Edwards, 2004).

338. Sorensen *et al.* (1984) (cited in Hammond *et al.* 2003) reported that, although there were little data on the reactions of marine mammals to drilling noise, there was no clear evidence of avoidance behaviour by small odontocetes. Bottlenose dolphins, Risso's dolphins and common dolphins were all recorded close to platforms and sighting rates were similar in areas with and without drilling rigs.

339. Studies using Passive Acoustic Monitoring (PAM) at platforms located on the Dogger Bank did not record any decrease in harbour porpoise activity at the platforms when drilling was being undertaken, compared to when there was no drilling and indicated that porpoises appeared to use oil and gas platforms as feeding refuges (Todd *et al.* 2007; Todd *et al*. 2009). Similar results have been reported from studies undertaken at two platforms in Danish waters (Bach *et al.* 2010).

340. The levels of sound reported from drilling are below that which would be predicted to cause either PTS or TTS and although audible to marine mammals, studies indicate no adverse behavioural response to drilling noise.

341. The sensitivity of marine mammal populations to drilling noise is considered to be low and the magnitude of impacts is negligible. Consequently, effects arising from drilling are assessed to be **negligible** and not significant.

8.10.8.3 Geophysical surveys

342. Geophysical surveys are likely to be required, although precise details e.g. durations, are not currently known. If required, they will be subject to relevant applications and associated impact assessment. However, in line with the advice received during scoping, the following section provides an assessment of the potential impacts that may arise in the event that geophysical surveys are undertaken in the future.

343. The specific details of the geophysical equipment that may be used in any future geophysical survey are unknown and will depend on the survey requirements at the time. However, although there are many different types of equipment that could be used depending on the data required, the potential impacts on marine mammals are similar in nature for each type of equipment.

Sidescan Sonar

344. Sidescan sonar provides high resolution acoustic images of the seabed. It involves the use of an acoustic beam to obtain an accurate image over a narrow area of seabed to either side of the instrument. Maximum source levels can be up to 228 dB re 1 µPa-m $_{(0\text{-}p)}$ (SCAR 2002). However, the frequencies used by sidescan sonar are relatively very high (100-600 kHz), with higher frequency

systems providing higher resolution but shorter range measurements. The high frequencies emitted by sidescan sonar are predominantly outside of the hearing range of all marine mammals (JNCC 2010).

Multi-beam Echosounders

345. Multi-beam echosounders measure water depth and can determine the nature of the seabed. They use multiple (>100) transducers to send out a relatively broad swath of sound covering a large, fan-shaped area of the seabed beneath the vessel. The sound source level, firing rate and pulse duration can be varied depending on the depth of the area under investigation. In relatively shallow water depths multi-beam echosounders operate at a relatively lower sound source and at higher frequencies of between 200 to 500 kHz, that are outwith the hearing range of most marine species (SCAR 2002, Danson 2005, IHO 2005). Previous geophysical surveys undertaken within the Development Area operated band widths of between 200 and 400 kHz and 100 and 900 kHz.

Sub-bottom profilers

346. Sub-bottom profiling is used to determine the stratification of soils beneath the sea floor. Various types of instrument may be used, such as pingers, boomers, sparkers and chirpers, depending on the required resolution and seabed penetration. They produce sound source levels of between 196 and 225 dB re 1 µPa @ 1 m and at a broad range of frequencies ranging from between 0.5 and 300 kHz (King 2013, Danson 2005).

347. The majority of sound energy from sub-bottom profilers is directed vertically downwards and the pulse duration is short (tens to hundreds of milliseconds). The actual source levels generated by a sub-bottom profiler depends on the type of equipment used and its operating specification.

348. Pingers emit relatively high frequency sound between 2 and 12 kHz and Sound Exposure Levels (SEL) higher than those from sparkers with maximum source levels up to 214-225 dB re 1 µPa @ 1 m $_{(rms)}$. Sparkers operate at a lower frequency between 200 Hz and 800 Hz and also at source levels up to 222 dB re 1 µPa @ 1 m $_{(rms)}$. Maximum source SELs for pingers and chirpers are higher than those of the sparkers and boomers, primarily due to the much longer signals that they can produce. Chirpers are frequency modulated sub-bottom profilers capable of providing high penetration and high resolution data. They produce sound levels of between 189 and 214 dB re 1 µPa @ 1 m $_{(rms)}$ and at frequencies of between 2 and 24 kHz.

349. All types of sub-bottom profiling equipment may make sound that will be audible to cetaceans. However, sound from the higher frequency pingers will attenuate rapidly within the water column and the directionality of the sound source arising from pingers and chirpers reduces the amount of sound travelling horizontally (Danson 2005, Duncan & Salgado-Kent 2011, King 2013).

Magnetometers

350. Magnetometers are used to detect metallic objects on or near the surface of the seabed. They are frequently used during unexploded ordnance surveys. No noise is emitted from magnetometers.

8.10.8.3.1 Potential impacts on marine mammals from geophysical survey.

351. Figure 8-46 below presents a summary of the frequencies emitted from sidescan sonar, multi-beam echosounders and sub-bottom profilers that could potentially be used in any possible future geophysical surveys along with the hearing range of marine mammals that may be in the survey area. It is predicted that marine mammals will not be able to detect sound from multi-beam echo sounders or sidescan sonar but will be able to detect sound from sub-bottom profilers.

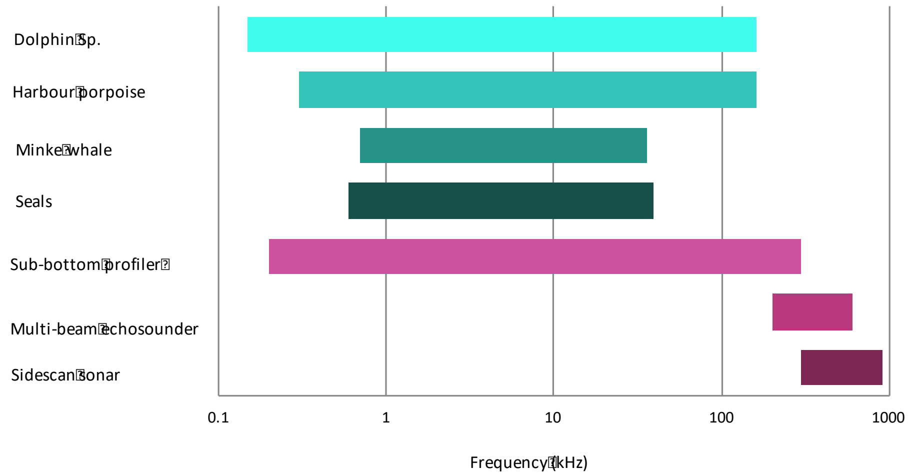


Figure 8-46: Frequency ranges of geophysical and the marine mammals

352. Sub-bottom profilers operate at frequencies of between 0.5 kHz and 300 kHz depending on the type of profiler and are audible to marine mammals (Figure 8-46).

353. No specific noise modelling for the use of a sub-bottom profiler has been undertaken for this assessment. However, studies from elsewhere indicate sound emitted from sparkers, with a source level of between 116 and 222 dB re 1 µPa @ 1 m $_{(0\text{-}p)}$, will be below levels at which the onset of TTS might occur within 5 m of the sound source and below 160 dB re 1 µPa^{2}s within 40 m from the sound source. This occurs in all water depths from between 3 m and 30 m (Duncan & Salgado-Kent, 2011). Based on maximum operating source levels King (2013) concluded that all types of sub-bottom profiler have the potential to exceed the marine mammal injury and disturbance thresholds. However, this was based on the maximum source levels from sub-bottom profilers and did not take into consideration the marine mammal hearing weightings nor that the sound from sub-bottom profilers is focussed downwards and therefore limits the horizontal propagation of sound and consequently the area of potential disturbance.

354. JNCC acknowledges that sound from sub-bottom profilers is within the hearing frequency range of marine mammals and could cause a localised behavioural response such as avoidance, but considers that it is unlikely to cause injury or disturbance due to the small area of ensonification (JNCC, 2010).

355. It is concluded that sidescan sonar and multi-beam echosounder emit sound at frequencies that are above the hearing thresholds of marine mammals predicted to occur within the Wind Farm Area (Figure 8-46). Consequently, sound from this equipment will not cause any impact on marine mammals that may be present in the area.

356. There is a very low risk of physical injury to any marine mammals from the potential use of sub-bottom profilers. There is potential for a relatively localised area of disturbance. The extent of disturbance will depend on the type of sub-bottom profiling equipment to be used. However, should it occur it is predicted that any displacement or disturbance impacts would be temporary with marine mammals returning to the area once the activity has ceased.

357. The sensitivity of marine mammal populations to noise from geophysical surveys is considered to be low and the magnitude of impacts is negligible. Consequently, the significance of any effects arising from geophysical surveys are **negligible** and not significant.

8.10.8.4 Disturbance from noise and particle motion arising from the HDD pipe site works

358. In addition to the main wind turbine and substation foundation pile driving works, installation of a temporary circular or rectangular steel casing is proposed in the shallow subtidal area to facilitate the excavation of a dry area within which a second receiving pit would be constructed for the emergence of the HDD drill (as described in Chapter 4: Project Description). This would involve interlocking steel sheets being lifted in to place by an excavator – with the potential for noise generated by this installation operation. Here, the cable will emerge and, if required, be joined with the Offshore Export Cable. The cable will then be buried, the disturbed area reinstated and the casing removed.

359. The installation of the steel casing, which may require sheet piling, has the potential to give rise to underwater noise which may lead to the disturbance of marine mammal species. The installation of the sheet piling will take place in relatively shallow water close to shore with installation taking a relatively short period (e.g. a number of days at most). Given this, the noise generated will attenuate over a relatively short distance (given the shallow water depths) so that effects on marine mammals will be limited spatially and temporally – given the short period for installation, and the effects are considered temporary and reversible. As such the effects on marine mammals arising from the sheet piling impacts are predicted to be **minor**, which is not considered significant in EIA terms.

8.10.9 Operational Phase Impacts

8.10.9.1 Aircraft and helicopter disturbance

360. It is envisaged that approximately 80 round trips by helicopter could occur each year. There is limited information on the impacts noise from helicopters may have on marine mammals although they have been reported to react to overflights by diving or changing in swimming direction (Richardson *et al*. 2005). The dominant sound from helicopters is below 500 Hz and therefore typically outwith the main hearing frequencies of marine mammals (Richardson *et al*. 2005). However, low-frequency hearing specialists such as minke whales may be impacted.

361. Studies on bowhead whale (*Balaena mysticetus*) and beluga whales (*Delphinapterus leucas*) in the Beaufort sea recorded most behavioural responses when the helicopter was less then 150 m above the sea surface and 250 m laterally from them (Patenaude *et al*. 2002). Studies on ringed seals (*Phoca hispida*) hauled out have shown that a helicopter flying at 150 m can cause behavioural disturbance at 1,250 m (Hoang 2013). Consequently, there is potential for low flying helicopters to cause localised disturbance. However, the duration of impacts are predicted to short, with behaviour returning to normal within a few minutes of the helicopter passing.

362. The effects of any helicopter noise are predicted to be localised and be of a long duration enduring for the operational lifecycle of the Project. However, it is considered that is it unlikely to cause a significant disturbance (JNCC 2008). The sensitivity of marine mammal populations to noise from helicopters is considered to be low and the magnitude of impacts is negligible. Consequently, the significance of any effects arising from helicopter flights are **negligible** and not significant.

8.10.10 Cumulative Impacts

363. Cumulative effects refer to effects upon receptors arising from the Project when considered alongside other proposed developments and activities and any other reasonably foreseeable project(s) proposals. In this context, the term ‘projects’ is considered to refer to any project, plan or programme with comparable effects and is not necessarily limited to offshore wind projects. Impacts from other projects identified as being most likely to have the potential to have a cumulative effect, in the context of the issues scoped into this EIA, are from other underwater sound sources.

364. Project and activities considered within the cumulative impact assessment are set out in Table 8.68 and are based on, and incorporate, the advice received during the formal consultation (Marine Scotland, 2017a) (see Section 8.6). It is recognised that there may be plans or projects for which there

is limited information and yet may be being undertaken at the same time as the planned construction period of NnG. It is also possible that activities arising from current projects that have been identified as having the potential to cause a cumulative impact may be completed prior to works commencing at NnG. There is, in some cases, also an element of uncertainty associated with the design envelope of certain of the other proposed projects. Therefore, a judgement is made on the confidence associated with the latest available design envelope.

Table 8.68: Projects for cumulative assessment

Development Type	Project	Status	Data Confidence Assessment / Phase
Offshore Wind Farm	Inch Cape Offshore Wind Farm	Consented	High – Consented project details available.
Offshore Wind Farm	Inch Cape Offshore Wind Farm	Proposed	High – Scoping report publicly available.
Offshore Wind Farm	Seagreen Alpha Offshore Wind Farm	Consented	High – Consented project details available.
Offshore Wind Farm	Seagreen Bravo Offshore Wind Farm	Consented	High – Consented project details available.
Offshore Wind Farm	Seagreen Phase 1 Wind Farm Project	Proposed	High – Scoping report publicly available.
Offshore Wind Farm	Beatrice Offshore Wind Farm	Consented	High – Consented project details available
Offshore Wind Farm	Moray East Offshore Wind Farm	Consented	High – Consented project details available
Offshore Wind Farm	Moray East Offshore Wind Farm – Alternative design	Proposed	High – Scoping report publicly available.
Offshore Wind Farm	Moray West Offshore Wind Farm	Proposed	High – Scoping report publicly available.
Harbour Expansion	Aberdeen Harbour Expansion Project	Consented	High – Consented project details available

365. Current timelines for other offshore wind farms are uncertain and likely to change. However, based on currently known schedules as available from publicly available information, there is potential for overlapping periods of construction activity with the Moray West Offshore Wind Farm.

366. It is anticipated that work arising from the Beatrice Offshore Wind Farm and the Aberdeen Harbour Expansion Project that could cause a potential cumulative impact on marine mammals will have been completed prior to any construction activities associated with the Project. However, it is recognised that impacts from these projects could cause population level effects that may continue beyond the end of the construction and therefore there is potential for an on-going cumulative impact.

367. The construction schedules for the other offshore wind farms located within the Firths of Forth and Tay, i.e. Inch Cape and Seagreen, are known, based on the publicly available information but must be considered subject to change at this stage. It is considered highly unlikely that there will be any construction being undertaken at other planned wind farms within the Firths of Forth and Tay area at the same time as NnG is being constructed. In addition, the worst-case scenario for marine mammals

would be unbroken sequential piling (as agreed with MS and SNH). Existing modelled outputs have been used to compare the potential for cumulative impacts with consented projects, the results of which are discussed in Section 8.10.11.

368. Table 8.69 sets out the potential cumulative impacts and the worst case cumulative design envelope scenario considered within the cumulative impact assessment.

Table 8.69: Cumulative worst-case design envelope scenarios

Impact	Project	Worst Case Design Scenario
Noise arising from hammering	Inch Cape Offshore Wind Farm (proposed)	Pile diameter - unknown Maximum hammer size 2400 kJ Total pile driving duration –unknown
	Inch Cape Offshore Wind Farm (consented)	Pile diameter - 2.43 m Maximum hammer size - 1200 kJ Total pile driving duration – 4.2 hrs
	Seagreen Alpha Offshore Wind Farm (consented)	Pile diameter – 3.0 m Maximum hammer size - 1800 kJ Total pile driving duration – 0.5 hrs
	Seagreen Bravo Offshore Wind Farm (consented)	Pile diameter – 3.0 m Maximum hammer size - 1800 kJ Total pile driving duration – 0.5 hrs
	Seagreen Phase 1 Wind Farm Project (proposed)	Monopiles now included as a potential foundation option. Maximum hammer size 2400 kJ Total pile driving duration – unknown
	Beatrice Offshore Wind Farm	Pile diameter – 2.4 m Maximum hammer size - 2300 kJ Total pile driving duration – 5 hrs
	Moray East Offshore Wind Farm (consented)	Pile diameter – 2.5 m Maximum hammer size - 1200 kJ Total pile driving duration – 1.2 hrs
	Moray East Offshore Wind Farm (proposed)	Potential use of suction bucket foundations eliminating the requirement to pile. Pile driving as previously consented still an option.
	Moray West Offshore Wind Farm	Pile diameter – 4 - 12 m (depending on foundation type) Maximum hammer size - Unknown Total pile driving duration – Unknown
Noise arising from blasting	Aberdeen Harbour Expansion Project	Blasting – maximum of two blasts per day.

369. No other projects or plans have been identified as having the potential to cause a cumulative impact on marine mammals with respect to noise arising from construction (Marine Scotland 2017a).

8.10.11 Cumulative Sound Modelling Results on Marine Mammals

370. The following section presents a summary of the results from the noise modelling undertaken for potential cumulative impacts. There is potential for cumulative impacts to arise from the proposed Project and a number of other planned offshore wind farms should construction occur either simultaneously as NnG or sequentially, i.e. each development is constructed in succession. There are three other consented offshore wind farms within the Firths of Forth and Tay: Inch Cape, Seagreen A and Seagreen B. Noise modelling has previously been undertaken to assess the potential impacts from these developments (Nedwell and Mason, 2012). The modelling undertaken used the Impulsive Noise Sound Propagation and Impact Range Estimator (INSPIRE) model, a proprietary software that produced outputs primarily based on the dBht metric developed by Subacoustech. This is a species specific weighting metric that takes into account the varying hearing abilities of marine species. Although the approach is similar to the weighted SEL metrics proposed by Southall *et al*. (2007) and NOAA (2016) and used in this assessment, the metrics are not comparable.

371. To ensure a consistent approach is taken across all projects when identifying potential cumulative impacts and to allow a direct comparison to be made, modelling has been undertaken for all consented and planned offshore wind farms within the Firths of Forth and Tay. The modelling is based on the design envelopes presented in Table 8.69.

372. Table 8.70 presents the predicted areas within which the onset of PTS is predicted to occur for all consented or planned offshore wind farms in the Firths of Forth and Tay area, based on the NOAA thresholds.

Table 8.70: Area within which the onset of PTS is estimated to occur from pile driving activities at consented wind farm developments in the Firths of Forth and Tay based on NOAA cumulative weighted thresholds

Scenario	Cumulative weighted SEL Area of auditory injury (PTS) km^2			
	Low-frequency cetacean	Mid-frequency cetacean	High-frequency cetacean	Pinnipeds
NnG (2017)	344.4	<0.001	127.3	0.706
NnG at 2 locations (2017)	564.5	<0.001	240.3	1.306
Inch Cape (consented)	192.5	<0.001	85.15	0.030
Seagreen Alpha (consented)	354.9	<0.001	152.6	2.459
Seagreen Bravo (consented)	252.6	<0.001	137.9	2.212
Inch Cape (new application)	376.1	<0.001	142.2	0.458
Seagreen Phase 1 Location 1 (formerly Seagreen Alpha) (new application)	586.7	<0.001	161.3	0.495
Seagreen Phase 1 Location 2 (formerly Seagreen Bravo) (new application)	333.1	<0.001	125.0	0.339

373. The modelling indicates that the revised Inch Cape and the two Seagreen Phase 1 developments will have greater impacts on marine mammals than the previously consented projects. This is likely due to the proposed increases in hammer energies used to install the piles. Hammer energy has an important effect on the level of sound produced, with pile driving using higher hammer energies typically creating higher noise levels (Lepper *et al*. 2012b). Other factors that could have an effect on the

propagation of noise include water depth and seabed type. However, these are the same for the consented developments and new applications. Consequently, it is predicted that as one of the main factors that affects the level of noise produced, i.e. hammer energy, has increased in the new applications the cumulative impacts will be greatest with the revised Inch Cape and Seagreen Phase 1 developments.

374. It is concluded that the worst-case cumulative effect with respect to the potential impacts from noise on marine mammals will arise from the proposed Inch Cape and Seagreen Phase 1 developments and the impacts from existing consented Inch Cape, Seagreen A and Seagreen B developments will be lower due to the assumed lower hammer energies.

The estimated number of marine mammals predicted to be at risk from the onset of PTS across all developments considered in the cumulative impact assessment is presented in Table 8.71 and for disturbance in

375. . The estimates for developments in the Firths of Forth and Tay are from noise modelling undertaken based on the revised design parameters available at the time modelling was undertaken. Data for other developments have been obtained from their applications.

Table 8.71: Estimated number of marine mammals at risk of the onset of PTS from developments considered in the cumulative impacts

Wind farm	Harbour porpoise	White-beaked dolphin	Bottlenose dolphin [1]	Minke whale	Grey seal [2,3]	Harbour seal [2,3]
Neart na Gaoithe	77	<1	<1	14	1	1
Inch Cape (revised project)	86	<1	<1	15	1	1
Seagreen Phase 1 (Location 1)	97	<1	<1	23	1	1
Seagreen Phase 1 (Location 2)	75	<1	<1	13	1	1
Beatrice	9	N/A	1	36	-	-
Aberdeen Harbour Expansion Project	1	<1	1	1	1	1
Moray East	7	N/A	1	13	-	-
Moray West [4]	7	N/A	1	13	-	

1 = The predicted area of PTS for wind farms in the Firths of Forth and Tay area did not overlap with the bottlenose dolphin management unit area.

2 = Number of seals that could potentially experience the onset of PTS has been estimated using seal distribution maps (SMRU and Marine Scotland, 2017). The number of seals that could experience PTS onset has been calculated by estimating the number of seals within the predicted PTS area using the latest seal distribution maps.

3 = It has been assumed that the Moray Firth projects will not impact the East Coast Scotland seal management unit area and therefore not applicable for this assessment.

4 = In the absence of any published information it is assumed that the number of individuals impacted by the Moray West development is the same as Moray East.

N/A = Not available.

Table 8.72: Estimated number of marine mammals at risk of disturbance from developments considered in the cumulative impacts

Wind farm	Harbour porpoise	White-beaked dolphin [2]	Bottlenose dolphin	Minke whale	Grey seal [2,3]	Harbour seal [2,3]
Neart na Gaoithe [1]	1,177	50	2	77	821	8
Inch Cape (revised project)	1,691	37	1	111	925	10
Seagreen Phase 1 (Location 1)	2,207	45	1	144	1,103	11
Seagreen Phase 1 (Location 2)	2,490	45	1	163	1,087	4
Beatrice	3,191	N/A	19	177	-	-
Aberdeen Harbour Expansion Project	30	N/A	15	2	N/A	N/A
Moray East	2,933	N/A	17	168	-	-
Moray West [4]	2,933	N/A	17	168	-	-

1 = For assessing potential cumulative impacts it is assumed that single pile driving will be undertaken at the time as this provides the greatest period of sequential pile driving.

2 = Number of seals that could potentially experience the onset of PTS has been estimated using seal distribution maps (SMRU and Marine Scotland, 2017). The number of seals that could experience PTS onset has been calculated by estimating the number of seals within the predicted PTS area using the seal distribution maps.

3 = It has been assumed that the Moray Firth projects will not impact the East Coast Scotland seal management unit area and is therefore zero.

4 = In the absence of any published information it is assumed that the number of individuals impacted by the Moray West development is the same as Moray East.

N/A = Not available.

8.10.12 Cumulative Population Modelling

376. Advice received during consultation is to use the interim PCoD population model to predict potential population level effects from cumulative pile driving activities. The worst case cumulative scenario is predicted to arise when construction across all proposed wind farms occur sequentially (Marine Scotland, 2017c).

377. The timing and duration of construction by the projects included within the cumulative impact assessment are known with a high degree of certainty for projects that have commenced construction. However, for projects that have not started construction or received consent there is a high degree of uncertainty as to when construction may occur. For those projects which have been awarded Contracts for Difference (CfDs), i.e. NnG and Moray East, broad timescales can be estimated. For those without CfDs there is no certainty regarding timescales and a highly precautionary worst-case scenario has been applied for the cumulative assessment. This assumes that all construction activities occur sequentially and that there are no breaks in the cumulative construction period between 2020

and 2028 (Figure 8-47). This scenario will almost certainly not occur, therefore cumulative assessment outputs are considered to be very conservative.

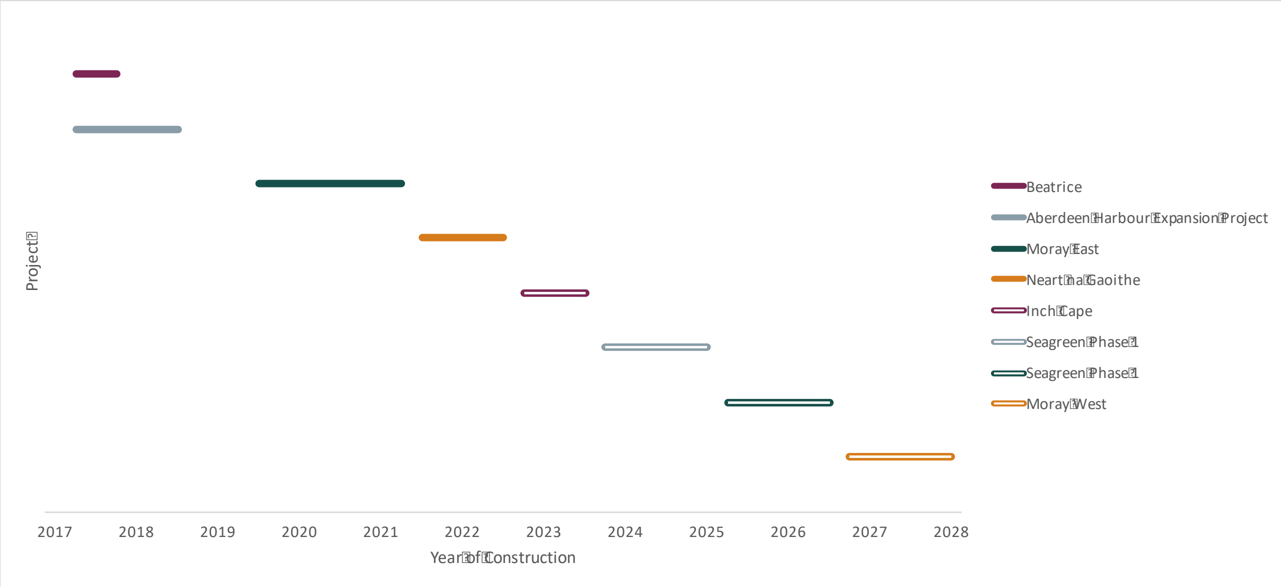


Figure 8-47: Estimated construction schedule used for cumulative population modelling

378. The following assesses the potential population level impacts on marine mammals from cumulative impacts arising from the construction of:

- Beatrice Offshore Wind Farm;
- Aberdeen Harbour Expansion Project;
- Moray East Offshore Wind Farm;
- Neart na Gaoithe Offshore Wind Farm;
- Inch Cape Offshore Wind Farm;
- Seagreen Phase 1 Alpha;
- Seagreen Phase 1 Bravo;
- Moray West Offshore Wind Farm.

8.10.12.1 Harbour porpoise

379. The results from the population modelling indicate that cumulative impacts from pile driving could cause a decrease in the annual growth rate and population size of harbour porpoise (Table 8.73).

380. The median ratio of the impacted to unimpacted annual growth rate for a cumulative sequential pile driving scenario is 0.996 after 24 years (a counterfactual of growth rate of 99.6%). The difference in the median growth rates between impacted and unimpacted populations is -0.004 (Table 8.75).

381. The median ratio of the impacted to unimpacted population for cumulative sequential pile driving is 0.904 after 24 years (a counterfactual of population size of 90.4%).

382. Based on the results from the interim PCoD model, the harbour porpoise population within the North Sea Management Unit is predicted to decrease over the next 24 years without any potential impacts from disturbance (Table 8.74, Table 8.75 and Figure 8-48). In the event that sequential pile driving occurs over a period of 11 years it is estimated that after 24 years the harbour porpoise population may be 9.7% lower compared with an unimpacted baseline population (Table 8.75).

383. Comparing the distributions of population sizes after 24 years for the unimpacted and impacted populations shows that at least 26% of the runs do not end lower than the median population size of the unimpacted population (Table 8.74).

Table 8.73: Harbour porpoise population model outputs for cumulative pile driving scenario

Harbour Porpoise			
Year	Median of the ratio of impacted to unimpacted annual growth rate	Median of the ratio of impacted to unimpacted population size	Centile for impacted population that matches the 50th centile for unimpacted population
1	0.998	0.999	0.48
6	0.995	0.975	0.37
12	0.993	0.921	0.22
18	0.994	0.910	0.25
24	0.996	0.904	0.26

Table 8.74: Estimated population size for harbour porpoise North Sea Management Unit with cumulative sequential pile driving undertaken over 11 years

Harbour Porpoise						
Cumulative sequential pile driving over 11 years						
	5th percentile		50th percentile		95th percentile	
Year	Undisturbed	Disturbed	Undisturbed	Disturbed	Undisturbed	Disturbed
1	310,263	309,821	332,722	332,082	352,841	352,381
6	285,452	275,933	324,423	315,211	364,692	358,063
12	260,864	238,263	314,854	288,611	371,177	343,225
18	242,521	217,219	305,720	276,636	374,931	343,793
24	229,815	206,772	294,888	266,251	372,956	341,717

Table 8.75: Estimated difference in median disturbed and median undisturbed harbour porpoise growth rates and population sizes with cumulative sequential pile driving undertaken over 11 years

Harbour porpoise	Difference in median disturbed and median undisturbed annual growth rates over 24 years	Difference in median disturbed and median undisturbed population size over 24 years	
Years		No. of individuals	% change in population size
1	-0.002	-640	-0.19
6	-0.005	-9,212	-2.84
12	-0.007	-26,243	-8.33
18	-0.006	-29,084	-9.51
24	-0.004	-28,637	-9.71

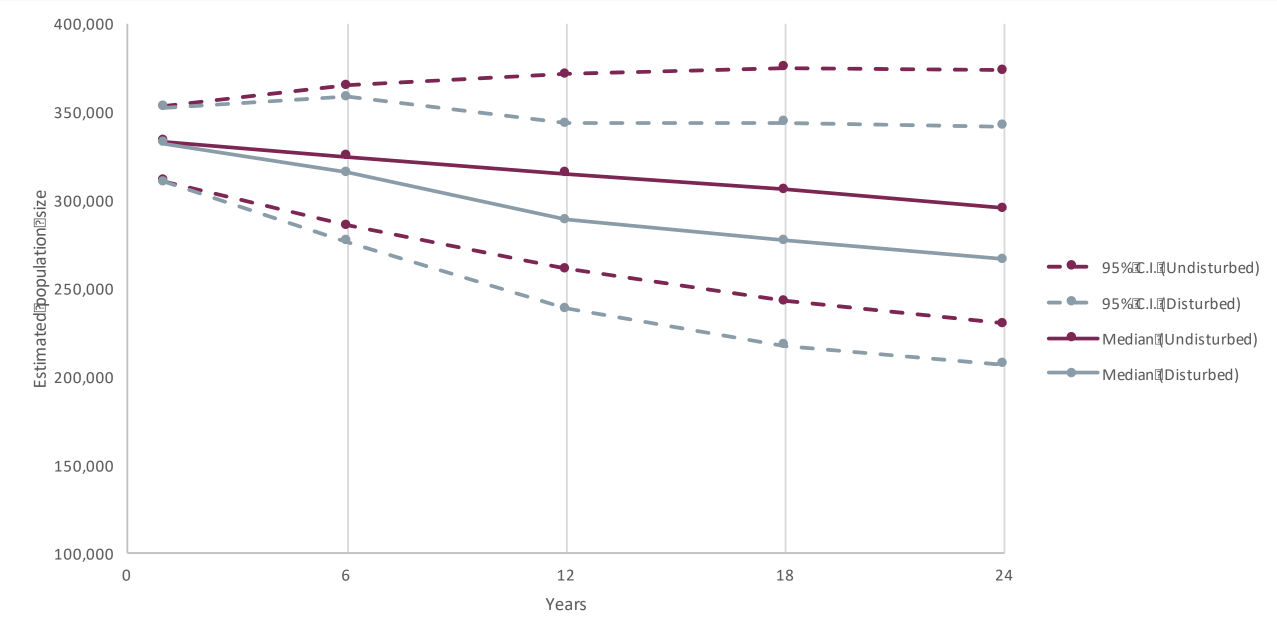


Figure 8-48: Estimated median (50th centile) and 95% C.I. for harbour porpoise North Sea Management Unit population with (disturbed) and without (undisturbed) sequential pile driving over a period of 11 years

8.10.12.2 Bottlenose dolphin

384. The results from the population modelling indicate that cumulative impacts from pile driving could cause a decrease in the annual growth rate and population size of bottlenose dolphin (Table 8.76).

385. The median ratio of the impacted to unimpacted annual growth rate for a cumulative sequential pile driving scenario is 0.973 after 24 years (a counterfactual of growth rate of 97.3%). The difference in the median growth rates between impacted and unimpacted populations is -0.027 (Table 8.78).

386. The median ratio of the impacted to unimpacted population for cumulative sequential pile driving is 0.535 after 24 years (a counterfactual of population size of 53.5%).

387. Based on the results from the interim PCoD model, the bottlenose dolphin population within the Coastal East Scotland Management Unit is predicted to increase over the next 24 years without any potential impacts from disturbance (Table 8.77 and Figure 8-49). In the event that sequential pile driving occurs over a period of 11 years it is estimated that after 24 years the bottlenose dolphin population may decrease and be 47.7% lower compared with an unimpacted baseline population (Table 8.78).

388. Comparing the distributions of population sizes after 24 years for the unimpacted and impacted populations shows that at least 1% of the runs do not end lower than the median population size of the unimpacted population (Table 8.76).

Table 8.76: Bottlenose dolphin population model outputs for cumulative pile driving scenario

Bottlenose dolphin			
Years	**Median of the ratio of impacted to unimpacted annual growth rate**	**Median of the ratio of impacted to unimpacted population size**	**Centile for impacted population that matches the 50th centile for unimpacted population**
1	0.960	0.970	0.18
6	0.966	0.828	0.04
12	0.965	0.679	0.01
18	0.968	0.588	0.01
24	0.973	0.535	0.01

Table 8.77: Estimated population size for bottlenose dolphin Coastal East Scotland Management Unit with cumulative sequential pile driving undertaken over 11 years

Bottlenose dolphin						
Cumulative sequential pile driving over 11 years						
	5th percentile		**50th percentile**		**95th percentile**	
Years	**Undisturbed**	**Disturbed**	**Undisturbed**	**Disturbed**	**Undisturbed**	**Disturbed**
1	182	156	200	192	216	224
6	176	84	212	172	252	270
12	178	46	228	149	284	278
18	180	38	244	136	320	296
24	180	36	256	134	354	304

Table 8.78: Estimated difference in median disturbed and median undisturbed bottlenose dolphin growth rates and population sizes with cumulative sequential pile driving undertaken over 11 years

Bottlenose dolphin	**Difference in median disturbed and median undisturbed annual growth rates over 24 years**	**Difference in median disturbed and median undisturbed population size over 24 years**	
Years		**No. of individuals**	**% change in population size**
1	-0.041	-8	-4.0%
6	-0.035	-40	-18.9
12	-0.035	-79	-34.6
18	-0.032	-108	-44.3
24	-0.027	-122	-47.7

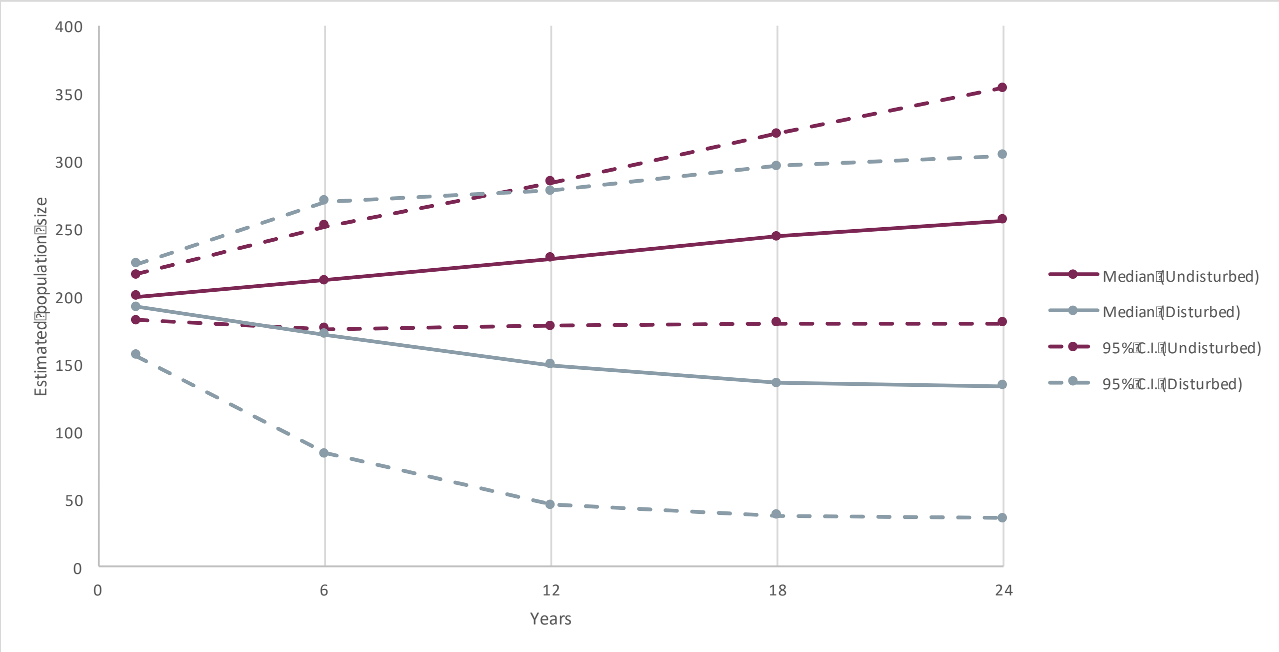


Figure 8-49: Estimated median (50th centile) and 95% C.I. for bottlenose dolphin Coastal East Scotland Management Unit population with (disturbed) and without (undisturbed) sequential pile driving over a period of 11 years

8.10.12.3 Minke whale

389. The results from the population modelling indicate that cumulative impacts from pile driving could cause a decrease in the annual growth rate and population size of minke whale (Table 8.79).

390. The median ratio of the impacted to unimpacted annual growth rate for a cumulative sequential pile driving scenario is 0.991 after 24 years (a counterfactual of growth rate of 99.1%). The difference in the median growth rates between impacted and unimpacted populations is -0.009 (Table 8.81).

391. The median ratio of the impacted to unimpacted population for cumulative sequential pile driving is 0.802 after 24 years (a counterfactual of population size of 80.2%).

392. Based on the results from the interim PCoD model, the minke whale population within the North Sea Management Unit is predicted to remain relatively stable over the next 24 years without any potential impacts from disturbance. However, disturbance impacts arising from potential cumulative sequential pile driving over a period of 11 years could cause a decrease in the minke whale CGNS Management Unit population (Table 8.80 and Figure 8-50). In the event that sequential pile driving occurs over a period of 11 years it is estimated that after 24 years the minke whale population may be 19% lower compared with the unimpacted baseline population (Table 8.81).

393. Comparing the distributions of population sizes after 24 years for the unimpacted and impacted populations shows that at least 2% of the runs do not end lower than the median population size of the unimpacted population (Table 8.79).

Table 8.79: Minke whale population model outputs for cumulative pile driving scenario

Minke whale			
	Median of the ratio of impacted to unimpacted annual growth rate	Median of the ratio of impacted to unimpacted population size	Centile for impacted population that matches the 50th centile for unimpacted population
Years	Single pile driving	Single pile driving	Single pile driving
1	0.993	0.994	0.43
6	0.987	0.929	0.12
12	0.986	0.845	0.02
18	0.989	0.819	0.02
24	0.991	0.802	0.02

Table 8.80: Estimated population size for minke whale CGNS Management Unit with cumulative sequential pile driving undertaken over 11 years

Minke whale						
Cumulative sequential pile driving over 11 years						
	5th percentile		50th percentile		95th percentile	
Years	Undisturbed	Disturbed	Undisturbed	Disturbed	Undisturbed	Disturbed
1	11,066	11,002	11,843	11,764	12,482	12,410
6	10,540	9,582	11,738	10,828	12,945	12,174
12	10,245	8,296	11,671	9,804	13,308	11,694
18	9,918	7,917	11,612	9,542	13,308	11,401
24	9,672	7,598	11,500	9,319	13,733	11,515

Table 8.81: Estimated difference in median disturbed and median undisturbed minke whale growth rates and population sizes with cumulative sequential pile driving undertaken over 11 years

Minke whale	Difference in median disturbed and median undisturbed annual growth rates over 24 years	Difference in median disturbed and median undisturbed population size over 24 years	
Years		**No. of individuals**	**% change in population size**
1	-0.007	-79	-0.7
6	-0.013	-910	-7.8
12	-0.014	-1,867	-16.0
18	-0.011	-2,070	-17.8
24	-0.009	-2,181	-19.0

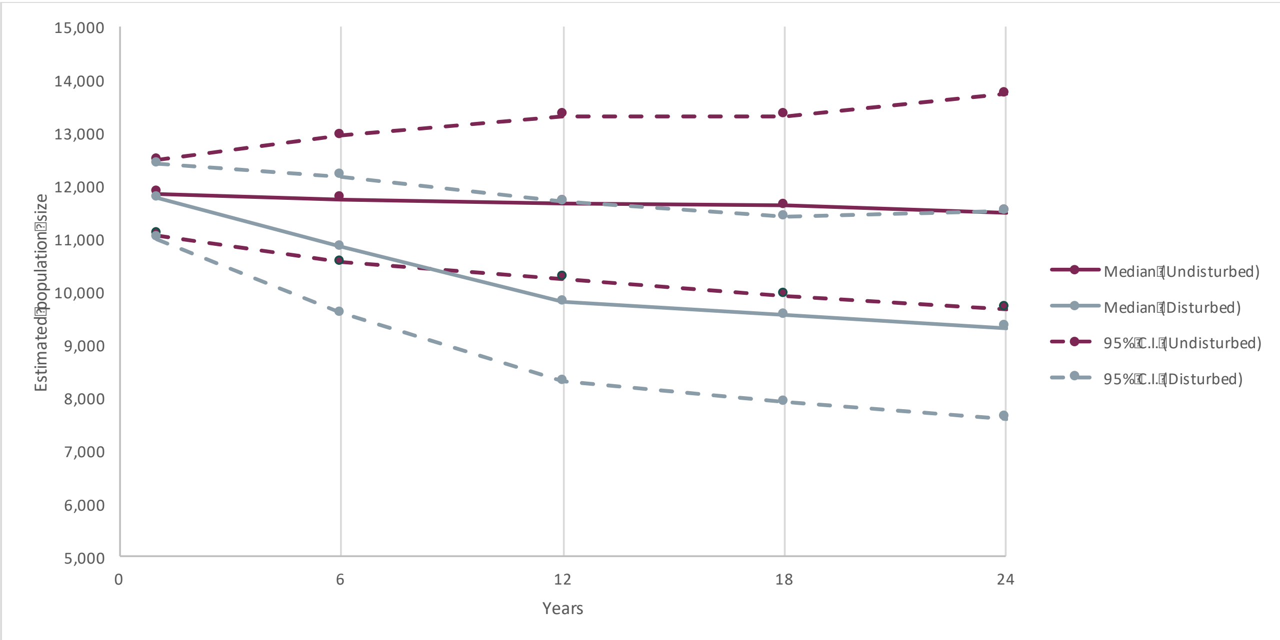


Figure 8-50: Probability of a decline in the population of minke whales within the CGNS Management unit over 24 years with and without cumulative pile driving events

8.10.12.4 Grey seal

394. The results from the population modelling indicate that cumulative impacts from pile driving could cause a decrease in the annual growth rate and population size of grey seal (Table 8.82).

395. The median ratio of the impacted to unimpacted annual growth rate for a cumulative sequential pile driving scenario is 0.985 after 24 years (a counterfactual of growth rate of 98.5%). The difference in the median growth rates between impacted and unimpacted populations is -0.015 (Table 8.84).

396. The median ratio of the impacted to unimpacted population for cumulative sequential pile driving is 0.707 after 24 years (a counterfactual of population size of 70.7%).

397. Based on the results from the interim PCoD model, the grey seal population within the East Coast Management Area is predicted to increase over the next 24 years without any potential impacts from disturbance. However, disturbance impacts arising from potential cumulative sequential pile driving over a period of 11 years could cause a decrease in the grey seal ECMA population (Table 8.83 and Figure 8-51). In the event that sequential pile driving occurs over a period of 11 years it is estimated

that after 24 years the grey seal population may be 30.8% lower compared with the unimpacted baseline population (Table 8.84).

398. Comparing the distributions of population sizes after 24 years for the unimpacted and impacted populations shows that at least 3% of the runs do not end lower than the median population size of the unimpacted population (Table 8.82).

Table 8.82: Grey seal population model outputs for cumulative pile driving scenario

Grey seal			
	Median of the ratio of impacted to unimpacted annual growth rate	Median of the ratio of impacted to unimpacted population size	Centile for impacted population that matches the 50th centile for unimpacted population
Years	Single pile driving	Single pile driving	Single pile driving
1	0.995	0.996	0.45
6	0.981	0.908	0.09
12	0.973	0.739	0.01
18	0.980	0.715	0.01
24	0.985	0.707	0.03

Table 8.83: Estimated population size for Grey seal ECMA with cumulative sequential pile driving undertaken over 11 years

Grey seal						
Cumulative sequential pile driving over 11 years						
	5th percentile		50th percentile		95th percentile	
Years	Undisturbed	Disturbed	Undisturbed	Disturbed	Undisturbed	Disturbed
1	9,118	9,068	9,692	9,635	10,284	10,222
6	8,772	7,300	10,042	8,953	11,360	10,532
12	8,624	5,215	10,427	7,519	12,557	9,963
18	8,524	5,135	10,876	7,577	13,652	10,329
24	8,567	5,059	11,260	7,793	14,902	11,100

Table 8.84: Estimated difference in median disturbed and median undisturbed grey seal growth rates and population sizes with cumulative sequential pile driving undertaken over 11 years

Grey seal	Difference in median disturbed and median undisturbed annual growth rates over 24 years	difference in median disturbed and median undisturbed population size over 24 years	
Years		**No. of individuals**	**% change in population size**
1	-0.006	-57	-0.6
6	-0.019	-1,089	-10.8
12	-0.027	-2,908	-27.9
18	-0.020	-3,299	-30.3
24	-0.015	-3,467	-30.8

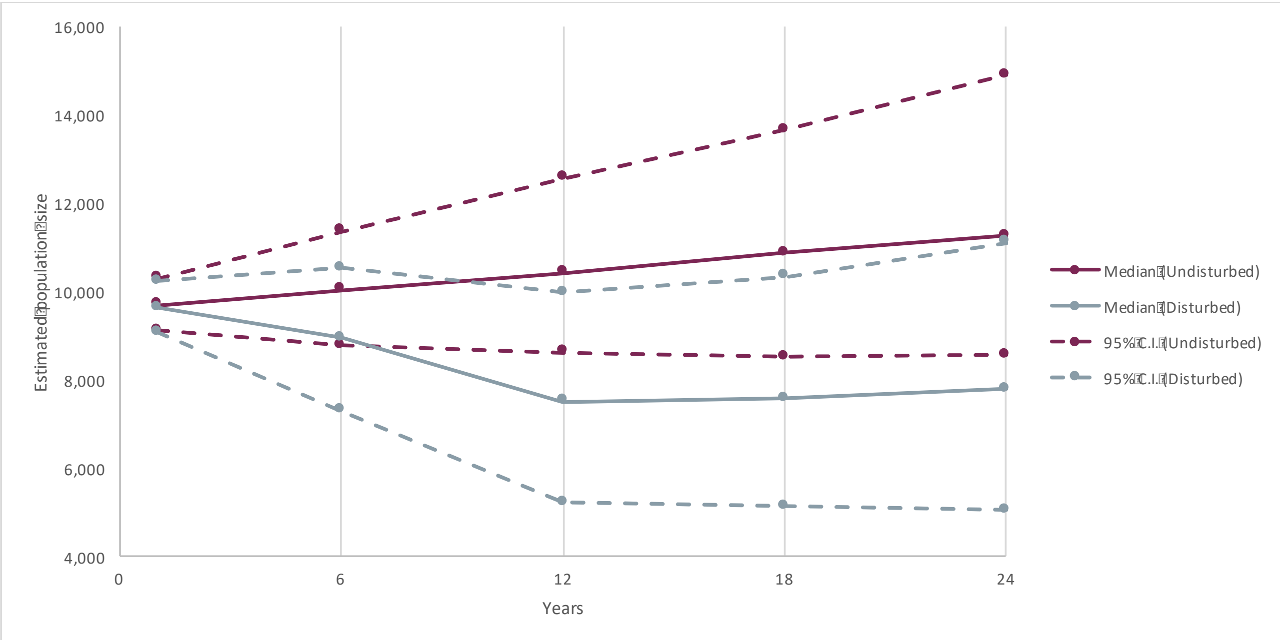


Figure 8-51: Probability of a decline in the population of grey seals within the East Coast and North-east England Management Areas over 24 years with and without cumulative pile driving events

8.10.12.5 Harbour seal

399. The interim PCoD model for harbour seals would not run successfully without reporting an error. The reasons for this error are unclear. It is possible that this is due to a combination of factors, including the number of animals predicted to experience PTS and behavioural disturbance, the small starting size of the management unit population, and the demographic parameters for the species which mean that the population goes to extinction within 24 years even without additional impact from piling at east coast wind farm and infrastructure projects. Consequently, population modelling was not able to be used to assess potential cumulative impacts on harbour seal. However, the population modelling undertaken for the Project alone predicted a significant decline in the harbour seal population without any possible impacts from pile driving (e.g. Table 8.62 and Figure 8-44). It is predicted that similar reductions in the harbour seal population will occur with potential cumulative impacts and that the impacts will not affect this decline to a significant extent.

8.10.13 Cumulative Construction Phase Impacts

400. The following section assesses the potential cumulative impacts on marine mammals from pile driving activities. The assessment is based on a number of precautionary assumptions including the noise modelling outputs based on cumulative sound exposure levels (which predicts the greatest area of impact) and population modelling assuming worst-case sequential pile driving schedules, with uninterrupted continuous pile driving over 11 years. The results are therefore considered to be precautionary.

8.10.13.1 Harbour porpoise

401. The results from the noise modelling indicate that the number of harbour porpoise at risk of the onset of PTS over a period of 11 years is 359 individuals and therefore an estimated 0.1% of the Management Unit population may be impacted (Table 8.71). It is estimated that the number of harbour porpoise that may be disturbed by any one wind farm project ranges from 1,177 and 3,191 individuals (Table 8.72). At most, at any one time, no more than 0.9% of the Management Unit population may be disturbed. Consequently, the noise modelling undertaken indicates that a relatively small proportion of the harbour porpoise Management Unit population may be at risk of the onset of PTS or disturbance.

402. The results from the population modelling indicate that cumulative impacts will have a relatively very small impact on the annual growth rate of harbour porpoise with difference of -0.004 after 24 years. However, the population modelling also indicates that should cumulative pile driving be undertaken sequentially over a period of 11 years that this could result in a 9.7% difference in the harbour porpoise population after 24 years (Table 8.75).

403. The population of harbour porpoises across the North Sea has remained largely stable since the first SCANS surveys, with 289,000 in 1994, 355,000 in 2005 and 345,000 in 2016 (Hammond *et al*. 2017). The predicted impacts on the population from cumulative pile driving indicate that the population, if undisturbed, will decline over the next 24 years to an estimated population size of 294,888 (229,815 – 372,956) individuals compared with 266,251 (206,772 – 341,717) individuals if there is cumulative pile driving; a potential difference of 28,637 (23,043 – 31,239) individuals (Table 8.74).

404. Although the effects on the annual growth rate are small, the potential cumulative impacts may be measurable and the results from the population modelling indicate a potential decline in the harbour porpoise population. The precautionary assumptions made and the uncertainties within model, particularly when predicting changes in populations over a 24 year period suggest that the future population may not be as impacted as indicated.

405. Based on the estimated differences in the harbour porpoise population after 24 years in the event sequential pile driving occurs, it is concluded that the sensitivity of harbour porpoise population is low, the magnitude of the impacts are medium and the significance of effect is **Minor**. Consequently, the impacts from cumulative pile driving are not significant.

8.10.13.2 White-beaked dolphin

406. It is not possible to undertake population modelling on white-beaked dolphin using interim PCoD as data on white-beaked dolphin required to run a population model are not available. Therefore, it is not possible to estimate population level effects on this species from sequential pile driving over a period of 11 years. However, the extent of any impacts that could cause the onset of PTS from pile driving at any of the proposed developments within the Firths of Forth and Tay are estimated to be very small and all less than 0.001 km^2 (Table 8.70) and the total number of individuals at risk of PTS across all developments is estimated to be less than eight individuals (Table 8.71) Similarly, the number of individuals predicted to be disturbed by each of the four developments within the Firths of Forth and Tay are broadly similar and relatively low, impacting on an estimated 177 individuals across a period of six years (Figure 8-47 and Table 8.72). Over any one year an estimated 0.2% of the CGNS Management Unit population and 0.3% of the regional population may be impacted.

407. The population is in favourable condition and it is predicted that the relatively low impact on the population will not affect its status.

408. It is concluded that the sensitivity of white-beaked dolphin population is low, the magnitude of the impacts are low and the significance of effect is **Minor**. Consequently, the impacts from cumulative pile driving are not significant.

8.10.13.3 Bottlenose dolphin

409. The results from the noise modelling indicate that the number of bottlenose dolphins at risk of the onset of PTS over a period of 11 years is no more than eight individuals and therefore an estimated 4% of the Management Unit population may be impacted (Table 8.71). It is estimated that the number of bottlenose dolphins that may be disturbed by any one wind farm development ranges from between 1 and 19 individuals (Table 8.72). At most, at any one time, no more than 1.0% of the Management Unit population may be disturbed by developments within the Firths of Forth and Tay. A higher proportion of the Management Unit population may be affected by developments within the Moray Firth with up to 9.7% of the population disturbed.

410. The results from the population modelling indicate that cumulative impacts will have a relatively small impact on the annual growth rate of bottlenose dolphin with a difference of -0.027after 24 years. However, the population modelling also indicates that should cumulative pile driving be undertaken sequentially over a period of 11 years that this could result in a 47.7% difference in the bottlenose dolphin population after 24 years (Table 8.78). The potential difference in the bottlenose dolphin population size of 47.7% after 24 years would be significant if it were to occur.

411. Based on the results from the population modelling, NnG on its own will not have a population level effect on bottlenose dolphin (See Table 8.48 and Table 8.50) and therefore the Project will not have a measurable, if any, cumulative impact on the bottlenose dolphin population. Although there is predicted to be a reduction in the population from cumulative impacts the Project does not significantly contribute to this predicted impact.

412. Based on the estimated decrease in the bottlenose dolphin population from potential cumulative impacts, it is concluded that the sensitivity of bottlenose dolphin population is high, and the magnitude of any cumulative impacts from construction noise impacts will be high. The significance of any effect is therefore assessed to be **major** and the potential effect from cumulative pile driving noise on bottlenose dolphin is significant. However, the Project does not have an impact on the population on its own and therefore does not have a cumulative impact on bottlenose dolphin Management Unit population.

8.10.13.4 Minke whale

413. The results from the noise modelling indicate that the number of minke whales at risk of the onset of PTS over a period of 11 years is 128 individuals and therefore an estimated 1.1% of the CGNS Management Unit population may be impacted (Table 8.71). It is estimated that the number of minke whales that may be disturbed by any one wind farm project ranges from between 77 and 177 individuals (Table 8.72). At most, at any one time, no more than 1.5% of the Management Unit population may be disturbed. Consequently, the noise modelling undertaken indicates that a relatively small proportion of the minke whale Management Unit population may be at risk of the onset of PTS or disturbance.

414. The results from the population modelling indicate that cumulative impacts will have a relatively very small impact on the annual growth rate of minke whale with a difference of -0.009 after 24 years. However, the population modelling also indicates that should cumulative pile driving be undertaken sequentially over a period of 11 years that this could result in a 19% difference in the minke whale population after 24 years (Table 8.81).

415. The predicted impacts on the minke whale population from cumulative pile driving indicate that CGNS Management Unit population may, if undisturbed, remain relatively stable over the next 24 years with

an estimated population size of 11,500 (9,672 – 13,733) individuals compared with 9,319 (7,598 – 11,513) individuals if there is cumulative pile driving; a potential difference of 2,181 (2,074 – 2,220) individuals (Table 8.80).

416. Although the effects on the annual growth rate are small, the potential cumulative impacts may be measurable and the results from the population modelling indicate a potential decline in the minke whale population.

417. Minke whales do not breed in UK waters and therefore potential impacts from pile driving are unlikely to affect survival. However, they are capital breeders and rely on stored energy reserves obtained during the summer to breed in their wintering grounds south of 30°N. Displacement or disturbance during the breeding season could affect the rate at which energy reserves are accumulated, with a subsequent impact on individual fertility (Harwood and King, 2014). The relatively low number of sightings recorded during baseline surveys, with only 18 sightings from three years of surveys, indicates that the Wind Farm Area is a relatively unimportant area for minke whales. Their broad distribution across the North Sea indicates that displaced minke whales will be able to relocate to other areas to feed and the impacts from displacement will be limited. In the event that an ADD is used this will reduce the risk of physical injury occurring to minke whales (See Section 8.11.2)

418. Based on the estimated differences in the minke whale population after 24 years in the event sequential pile driving occurs, it is concluded that the sensitivity of minke whale population is low, the magnitude of the impacts is high and the significance of the effect is **Moderate**. Consequently, the impacts from cumulative pile driving are significant.

8.10.13.5 Grey seal

419. The results from the noise modelling indicate that the number of grey seals at risk of the onset of PTS over a period of 11 years is five individuals and therefore an estimated 0.05% of the ECMA population may be impacted (Table 8.71). It is estimated that the number of grey seals that may be disturbed by any one wind farm project ranges from between 821 and 1,087 individuals (Table 8.72). At most, at any one time, no more than 11.3% of the Management Unit population may be disturbed.

420. The results from the population modelling indicate that cumulative impacts will have a relatively very small impact on the annual growth rate of grey seal with a difference of -0.015 after 24 years. However, the population modelling also indicates that should cumulative pile driving be undertaken sequentially over a period of 11 years that this could result in a 30.8% difference in the grey seal population after 24 years (Table 8.84).

421. The predicted impacts on the grey seal population from cumulative pile driving indicate that the ECMA grey seal population may, if undisturbed, increase over the next 24 years with an estimated population size of 11,260 (8,567 – 14,902) individuals compared with 7,793 (5,059 – 11,100) individuals if there is cumulative pile driving; a potential difference of 3,467 (3,508 – 3,802) individuals (Table 8.83).

422. Although the effects on the annual growth rate are small, the potential cumulative impacts may be measurable and the results from the population modelling indicate a potential decline in the grey seal population.

423. Based on the estimated differences in the grey seal population after 24 years in the event sequential pile driving occurs, it is concluded that the sensitivity of grey seal population is medium, the magnitude of the impacts is high and the significance of the effect is **Major**. Consequently, the impacts from cumulative pile driving are significant.

8.10.13.6 Harbour seal

424. The harbour seal population within the ECMA has declined significantly in recent years (see Figure 8-25) and at its current trajectory the population is predicted to become extinct within 24 years. The cumulative impacts from pile driving will not significantly alter the predicted on-going population decline. It is therefore concluded that the sensitivity of the harbour seal population is high, although

the magnitude of the impacts on the population are negligible and the significance of the effect is **Minor**. Consequently, the impacts from cumulative pile driving are not significant.

8.11 Mitigation and Monitoring

425. As outlined in Section 8.9.1, embedded mitigation has been incorporated in to the Project design. No later than six months prior to the start of construction a PEMP, CMS and Pile Driving Strategy will be submitted to the Scottish Ministers. The submissions will contain details of the pile driving locations, the maximum hammer energy to be used and details of any soft-start procedures to be implemented. They will also include agreed mitigation measures. Approval of these submissions is required prior to the commencement of any construction works.

426. No likely significant effects have been identified that require defined mitigation measures, however potential mitigation that could be included to reduce not significant, potential effects further and their likely effectiveness are described below:

8.11.1 Marine Mammal Observers and Passive Acoustic Monitoring

427. The use of a Marine Mammal Observer (MMOb) and Passive Acoustic Monitoring (PAM) are recognised to be effective means of minimising the risk of a marine mammal within 500 m of the pile at the commencement of pile driving and are therefore recognised to be suitable mitigation in ensuring marine mammals are not present in an area where they could be at risk of traumatic physical injury and, in the case of dolphins, PTS.

8.11.2 Acoustic Deterrent Devices (ADD)

428. The use of ADD has the potential to reduce the risk of marine mammals from being within the area within which physical injury could occur at the start of pile driving activities and may be an alternative approach to using MMOb and PAM. ADDs produce relatively high levels of sound in the water column with the aim of causing an avoidance behaviour in marine mammals and discouraging them from a particular area. The extent and duration of any displacement varies across devices and the behaviour of the individual species, with ADDs having less of an effect where marine mammals may be attracted to a site, e.g. seals and fish farms. However, in areas where there is less of an attraction, the use of ADDs have been found to be effective at temporarily displacing marine mammals from an area.

429. The Lofitech seal scarer ADD operates at a frequency of between 13.5 and 15 kHz with a signal duration of 0.5 seconds repeated randomly between <1 and 40 seconds. The sound source level is 189 dB re 1m Pa @ 1 m.

430. Two studies have been undertaken on the effectiveness of using the Lofitech ADD to displace harbour porpoise (Brandt *et al.* 2012 and 2013). Although the studies showed slightly differing results with one recording a harbour porpoise as close 798 m of an active ADD and the other showing that all harbour porpoise avoided the area within 1.9 km and for half the time between 2.1 and 2.4 km. They both reported a strong avoidance behaviour by harbour porpoise to the ADDs with an effective range of between 1.3 km and 1.9 km. The effects of avoidance lasted approximately six hours. It is recognised that the effects of ADD on harbour porpoise may be site specific but the results from these studies indicate that an ADD may effectively mitigate against the risk of harbour porpoise occurring in the area of risk of PTS at the onset of and during pile driving.

431. Studies undertaken on minke whales indicate that ADD's are effective at reducing the risk of minke whales being within an area at which the onset of PTS could occur. The studies showed that when an ADD was operating minke whales increased swimming speeds to of 7.4 kmh^{-1} and moved directly away from the sound source (McGarry *et al*. 2017).

432. The effectiveness of ADDs in causing avoidance behaviour in dolphins and minke whales is less well understood. However, recent studies on the effectiveness of ADD's on minke whale indicate that the

use of ADD on these species is predicted to have a similar deterrent effect. Furthermore, the physical impacts on dolphins are not predicted to occur beyond a few metres and therefore the use of a MMOb and PAM would be effective mitigation. Baseline surveys recorded relatively few minke whales and therefore there is less risk of an impact on minke whales.

433. Should an ADD be used it will be operated at the pile driving location for a period of time, typically approximately 20 minutes prior to the start of pile driving. It will be turned off once pile driving has started. In the event that the use of an ADD is planned, discussions with the Marine Scotland and SNH would be held.

8.11.3Soft-start procedures

434. Soft-start procedures for pile driving are considered to be embedded mitigation (See Section 8.9.1). The hammer energy used to install each pile will be increased slowly over a period of time. The initial hammer energy used at the start of each pile driving activity will be approximately 20% of the maximum possible hammer energy and will last for an estimated 53% of the total pile driving duration. Following this, the hammer will increase to 57% of the maximum hammer capacity for 40% of the total pile duration. This soft-start will allow marine mammals and their prey time to move away from the pile driving and reduce the risk of physical injury occurring.

8.11.4 Monitoring

435. A detailed monitoring programme will be developed through consultation with Marine Scotland and SNH. NnGOWL will also participate in regional and national fora such as the Forth and Tay Regional Advisory Groups (FTRAG) and the Scottish Strategic Marine Environment Group (SSMEG), through which a strategic monitoring plan will be developed.

436. At least six months prior to the start of the development a Project Environmental Management Plan (PEMP) will be submitted to the Scottish Ministers within which details of the planned monitoring to be undertaken will be presented. A Marine Mammal Monitoring Plan (MMMP) will be developed and agreed with Marine Scotland and SNH prior to the start of construction activities.

437. Details of the monitoring that could be undertaken are yet to be confirmed. However, potential monitoring could include:

- Measuring sound levels during pile driving activities. This would help improve our understanding of the sound levels produced from pile driving.
- Monitoring the responses of marine mammals to pile driving noise. The species that effective monitoring could be undertaken and the methods to be used will be agreed with Marine Scotland and SNH. However, it is envisaged that monitoring the responses to pile driving on bottlenose dolphins and harbour porpoise could be undertaken through the use of passive acoustic monitoring. This could improve our understanding of the potential impacts on marine mammals and confirm the predictions made within the Environmental Statement.

8.12 Summary of Residual Effects

438. This chapter has assessed the potential effects on marine mammals of the construction, operation and decommissioning of the Project, both in isolation and cumulatively. Where significant effects were identified, additional mitigation has been considered and incorporated into the assessment. Table 8.85 summarises the impact determinations discussed in this chapter and presents the post-mitigation residual significance.

Table 8.85: Summary of predicted impacts of the Project

Potential Impact	Significance of Effect	Mitigation Measures	Residual Significance of Effect
Construction			
Pile driving construction noise	Harbour Porpoise: Minor, adverse White-beaked dolphin: Negligible, adverse Bottlenose Dolphin: Minor, adverse Minke Whale: Minor, adverse Grey Seal: Negligible, adverse Harbour Seal: Minor, adverse	Use of MMOs, PAM systems, ADDs and soft-start procedures will be considered and agreed with MS-LOT, to further mitigate any risk of residual effect.	Harbour Porpoise: Minor, adverse White-beaked dolphin: Negligible, adverse Bottlenose Dolphin: Minor, adverse Minke Whale: Minor, adverse Grey Seal: Negligible, adverse Harbour Seal: Minor, adverse
Drilling construction noise	All species: negligible	n/a	All species: negligible
Noise from pre-construction geophysical survey work	All species: negligible, adverse	n/a	All species: negligible, adverse
Disturbance from noise and particle motion from the HDD site pipe works	All species: Minor, adverse	n/a	All species: Minor, adverse
Operation			
Aircraft and helicopter disturbance	All species: Negligible, adverse	n/a	All species: Negligible, adverse
Cumulative Effects			
Pile driving construction noise	Harbour Porpoise: Minor, adverse White-beaked dolphin: Minor, adverse Bottlenose Dolphin: Major, adverse Minke Whale: Moderate, adverse Grey Seal: Major, adverse Harbour Seal: Minor, adverse	Use of MMOs, PAM systems, ADDs and soft-start procedures will be considered and agreed with MS-LOT, to further mitigate any risk of residual effect.	Harbour Porpoise: Minor, adverse White-beaked dolphin: Minor, adverse Bottlenose Dolphin: Major, adverse Minke Whale: Moderate, adverse Grey Seal: Major, adverse Harbour Seal: Minor, adverse

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