FOREWIND

DOGGER BANK
TEESSIDE A & B

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Environmental Statement
Chapter 14
Marine Mammals

Application Reference: 6.14

Cover photograph: Installation of turbine foundations in the North Sea

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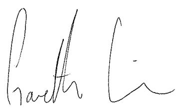
Forewind Approval			
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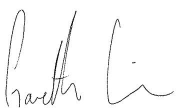
Approved by: Angela Lowe	Signature / Approval (Forewind)  Gareth Lewis		Approval Date: 24 January 2014

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1. Introduction

1.1.1. This chapter of the Environmental Statement (ES) describes the existing environment with regard to marine mammals; which includes pinnipeds (seals) and cetaceans (whales, dolphins and porpoise) and assesses the potential impacts of Dogger Bank Teesside A & B during the construction, operation and decommissioning phases. Where appropriate, mitigation measures and residual impacts are presented.

1.1.2. The assessment also considers information from, and refers to, the following:

- **Chapter 4 EIA Process**;
- **Chapter 5 Project Description**;
- **Chapter 7 Consultation**;
- **Chapter 8 Designated Sites**;
- **Chapter 13 Fish and Shellfish Ecology**;
- **Chapter 16 Shipping and Navigation**;
- **Chapter 33 Cumulative Impact Assessment**; and
- **Habitats Regulations Assessment (HRA) Report**.

2. Guidance and Consultation

2.1. Policy

2.1.1. The assessment of potential impacts upon marine mammals has been made with specific reference to the relevant National Policy Statements (NPS). These are the principal decision making documents for Nationally Significant Infrastructure Projects (NSIP). Those relevant to Dogger Bank Teesside A & B are:

- Overarching NPS for Energy (EN-1) (Department of Energy and Climate Change (DECC) 2011a); and
- NPS for Renewable Energy Infrastructure (EN-3) (DECC 2011b).

2.1.2. The specific assessment requirements for marine mammals, as detailed in the NPS, are summarised in **Table 2.1**, together with an indication of the paragraph numbers of the ES chapter where each is addressed.

2.1.3. With regard to the Infrastructure Planning Commission's (IPC) (now the Planning Inspectorate) decision making, NPS paragraphs 2.6.94 to 2.6.99 set out the issues and mitigation that may be considered. This refers to preferred methods of construction and suitable noise mitigation, the conservation status of marine European Protected Species (EPS) (and the need to take into account the views of the relevant statutory advisers) and notes that fixed structures are unlikely to pose a significant collision risk to marine mammals. With regard to mitigation, the potential for monitoring before and after piling is noted, a preference for 24 hour working to reduce the overall construction program and attendant effects is set out and the need for soft-start procedures for piling is also noted.

Table 2.1 NPS assessment requirements

NPS requirement	NPS reference	ES reference
"*Where necessary, assessment of the effects on marine mammals should include details of:* • Likely feeding areas; • Known birthing areas / haul out sites; • Nursery grounds; • Known migration or commuting routes; • Duration of the potentially disturbing activity including cumulative / in-combination effects with other plans or projects; • Baseline noise levels; • Predicted noise levels in relation to mortality, Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS); • Soft-start noise levels according to proposed hammer and pile design; and • Operational noise."	Paragraphs 2.6.90-2.6.99 of the NPS EN-3 (July 2011)	Sections 6, 7 and 8; assessment of impacts during construction, operation and decommissioning
"*The applicant should discuss any proposed piling activities with the relevant body. Where assessment shows that noise from offshore piling may reach noise levels likely to lead to an offence [as described above], the applicant should look at possible alternatives or appropriate mitigation before applying for a licence*."	Paragraph 2.6.93 of the NPS EN-3 (July 2011)	Section 6.1, assessment of pile driving noise

2.2. Legislation and guidance

2.2.1. Cetaceans and pinnipeds are protected under a wide range of national and international legislation as outlined in **Table 2.2**.

Table 2.2 National and international legislation in relation to marine mammals

Legislation	Protection	Details
Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS)	Odontocetes	Formulated in 1992, this agreement has been signed by eight European countries bordering the Baltic and North Seas (including the English Channel) and includes the United Kingdom (UK). Under the Agreement, provision is made for the protection of specific areas, monitoring, research, information exchange, pollution control and increasing public awareness of small cetaceans.
The Berne Convention 1979	All cetaceans, grey seal *Halichoerus grypus* and harbour seal *Phoca vitulina*	The Convention conveys special protection to those species that are vulnerable or endangered. Appendix II (strictly protected fauna): 19 species of cetacean. Appendix III (protected fauna): all remaining cetaceans, grey and harbour seal. Although an international convention, it is implemented within the UK through the Wildlife and Countryside Act 1981 (with any aspects not implemented via that route brought in by the Habitats Directive).
The Bonn Convention 1979	All cetaceans	Protects migratory wild animals across all, or part of their natural range, through international co-operation, and relates particularly to those species in danger of extinction. One of the measures identified is the adoption of legally binding agreements, including ASCOBANS.
The Wildlife and Countryside Act 1981 (as amended)	All cetaceans	Schedule five: all cetaceans are fully protected within UK territorial waters. This protects them from killing or injury, sale, destruction of a particular habitat (which they use for protection or shelter) and disturbance. Schedule six: Short-beaked common dolphin *Delphinus delphis*, bottlenose dolphin *Tursiops truncatus* and harbour porpoise *Phocoena phocoena*; prevents these species being used as a decoy to attract other animals. This schedule also prohibits the use of vehicles to take or drive them, prevents nets, traps or electrical devices from being set in such a way that would injure them and prevents the use of nets or sounds to trap or snare them.
The Countryside and Rights of Way Act 2000	All cetaceans	It is an offence to deliberately or recklessly damage, or disturb any cetacean in English and Welsh protected waters under this Act.
Oslo and Paris Convention for the Protection of the Marine Environment (OSPAR)	Bowhead whale *Balaena mysticetus*, northern right whale *Eubalaena glacialis*, blue whale *Balaenoptera musculus,* and harbour porpoise	OSPAR has established a list of threatened and/or declining species in the North east Atlantic. These species have been targeted as part of further work on the conservation and protection of marine biodiversity under Annex V of the OSPAR Convention. The list seeks to complement, but not duplicate, the work under the European Commission (EC) Habitats and Birds directives and measures under the Berne Convention and the Bonn Convention.

Legislation	Protection	Details
The Conservation of Habitats and Species Regulations 2010	All cetaceans, grey and harbour seal	In England and Wales, The Conservation of Habitats and Species Regulations 2007 (as amended) consolidate all the various amendments made to the Conservation (Natural Habitats, &c.) Regulations 1994, implementing the requirements of the Habitats Directive into UK law. All cetacean species are listed under Schedule 2 (EPS) and all seals are listed under Schedule 4 (animals which may not be captured or killed in certain ways). Provisions of The Habitats Regulations are described further below. It should be noted that the 2010 Habitats Regulations only apply within the territorial seas.
Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (as amended)	All cetaceans, grey and harbour seal	The Offshore Marine Conservation Regulations 2007 (as amended) apply the Habitats Directive to marine areas within UK jurisdiction, beyond 12 nautical miles, and provide further clarity on the interpretation of "disturbance" in relation to species protected under the Habitats Directive. Thus enabling energy developers to better qualify and, where possible, quantify, the impacts on marine mammals and determine whether the potential disturbance is permissible as part of a consented development. Provisions of The Offshore Marine Regulations are described further below.
Conservation of Seals Act 1970	Grey and harbour seal	Provides closed seasons, during which it is an offence to take or kill any seal, except under licence or in certain particular circumstances (grey seal: 1 September to 31 December; harbour seal: 1 June to 31 August). Following the halving of the harbour seal population as a result of the Phocine Distemper Virus (PDV) in 1988, an Order was issued under the Act which provided year round protection of both grey and harbour seal on the east coast of England. The Order was last renewed in 1999.
UK Biodiversity Action Plan (BAP)	Harbour porpoise	Harbour porpoise are a feature of the Norfolk, Suffolk and Essex Local Biodiversity Action Plans (LBAPs). These LBAPs are plans which seek to ensure that nationally and locally important species and habitats are conserved and enhanced in a given area through focused local action.

2.2.2. The principal guidance documents used to inform the assessment of potential impacts on marine mammals are as follows:

- Guidance on the Assessment of Effects on the Environment and Cultural Heritage from Marine Renewable Developments. Produced by: the Marine Management Organisation (MMO), the Joint Nature Conservation Committee(JNCC), Natural England, the Countryside Council for Wales (CCW) and the Centre for Environment, Fisheries and Aquaculture Science (Cefas) (MMO 2010);
- The Protection of Marine EPS From Injury and Disturbance: Guidance for the Marine Area in England and Wales and the UK Offshore Marine Area (JNCC 2010a);
- Guidelines for Ecological Impact Assessment in Britain and Ireland, Marine and Coastal (Institute for Ecology and Environmental Management (IEEM) 2010);
- Approaches to Marine Mammal Monitoring at Marine Renewable Energy Developments Final Report. Report by The Sea Mammal Research Unit on behalf of The Crown Estate, August 2010;
- Guidelines for Data Acquisition to Support Marine Environmental Assessments of Offshore Renewable Energy Projects. Cefas Report reference: ME5403 – Module 15. FINAL Issue date: 2nd May 2012; and
- Statutory Nature Conservation Agency Protocol for Minimising the Risk of Injury to Marine Mammals from Piling Noise (JNCC 2010b).

The Habitats Directive

2.2.3. Probably the most important wildlife legislation in relation to marine renewable energy and marine mammals is the European Union (EU) Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora ('the Habitats Directive').

2.2.4. All cetaceans are protected as EPS under Annex IV of the Habitats Directive because they are classified as being endangered, vulnerable or rare. Both grey seal and harbour seal are protected under Annex II of the Habitats Directive. Grey seal and harbour seal are also listed on Annex V of the Habitats Directive, which requires their exploitation or removal from the wild to be subject to management measures. Both these measures are provided for within national legislation, as for cetaceans.

2.2.5. Harbour porpoise and bottlenose dolphin are also listed under Annex II of the Habitats Directive, which requires Member States of the EU to designate areas essential to their life and reproduction as Special Areas of Conservation (SAC).

2.2.6. Under Article 12 of the Directive, Member States are required to take the requisite measures to establish a system of stricter protection for species in their natural range prohibiting:

- All forms of deliberate capture or killing of specimens of these species in the wild;

- Deliberate disturbance of these species, particularly during the period of breeding, rearing, hibernation and migration; and
- Deterioration or destruction of breeding sites or resting places.

Habitats Regulations and Offshore Marine Regulations Guidance

2.2.7. Under the Habitats Regulations 2010 (as amended) and Offshore Marine Regulations 2009 (as amended), a person is guilty of an offence if a person:

- Deliberately captures, injures or kills any wild animal of a EPS; and
- Deliberately disturbs wild animals of any such species.

2.2.8. The nature of 'disturbance' is further detailed, with an offence arising if the disturbance of any such species is likely:

- To impair their ability to survive, to breed or reproduce, or to rear or nurture their young; and
- In the case of animals of a hibernating or migratory species, to hibernate or migrate;
- To affect significantly the local distribution or abundance of the species to which they belong;
- Deliberately take or destroy the eggs of such an animal; and
- Damage or destroy, or does anything to cause the deterioration of, a breeding site or resting place of such an animal.

2.2.9. Following the amendments made to the Habitats Regulations and Offshore Marine Regulations in 2010, the Regulations now more clearly transpose the requirement contained in the Habitats Directive to prohibit deliberate disturbance, and better reflect the circumstances in which disturbance may be particularly damaging to the animals concerned (as envisaged by Article 12). In addition, the Habitats Regulations and Offshore Marine Regulations provide for the offence of deliberate injuries.

Favourable Conservation Status

2.2.10. In order to assess whether a disturbance could be considered non-trivial in relation to the objectives of the Habitats Directive, consideration should be given to the definition of the Favourable Conservation Status (FCS) of a species given in Article 1(i) of the Habitats Directive. There are three parameters that determine when the Conservation Status of a species can be taken as favourable:

- Population(s) of the species is maintained on a long-term basis;
- The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future; and
- The habitat on which the species depends (for feeding, breeding, rearing etc.) is maintained in sufficient size to maintain the population(s) over a period of years/decades.

2.2.11. Member states report back to the EU every six years on the Conservation Status of marine EPS. **Table 2.3** shows that in the UK, four out of 11 cetacean species have been assessed as having an ‘unknown’ Conservation Status during the 2007 to 2012 reporting period (JNCC, 2013). This is a result of a lack of recent population[1] estimates that encompassed their natural range in UK and adjacent waters and / or having no evidence to determine long-term trends in population abundance. Another 17 species were considered to be uncommon, rare or very rare in occurrence, so it was not possible to ascertain their Conservation Status. The seven species outlined in **Table 2.3** as having a ‘favourable’ Conservation Status, are underpinned by an assessment of moderate to low reliability. It can be interpreted that:

- A greater understanding of the species/population(s), or the factors affecting it, is required before a confident concluding judgment can be made by experts; and
- The current estimate of population and/or trend are based on recent, but incomplete or limited survey data, or based predominately on expert opinion.

2.2.12. At the time of writing, no conservation status criteria were available to inform a quantitative assessment of potential disturbance effects arising from Dogger Bank Teesside A & B on the Conservation Status of cetacean populations within the North Sea.

2.2.13. **Table 2.3** presents the Conservation Status of commonly occurring cetacean species within UK waters based on the 2007 to 2012 reporting and the associated UK EEZ population estimate and CV or minimum and maximum size the abundance estimates generated from the Small Cetaceans in the European Atlantic and North Sea (SCANS) surveys (SCANS-II 2008) and Cetacean Offshore Distribution and Abundance (CODA) surveys (Hammond *et al*. 2009).

[1] ‘Population’ is defined in the EC guidance on the strict protection of animal species as a group of individuals of the same species living in a geographic area at the same time that are (potentially) interbreeding (i.e. sharing a common gene pool)

Table 2.3 Common cetacean species in Annex IV of the Habitats Directive occurring in UK and adjacent waters.

Species	FCS assessment (JNCC 2013)	UK EEZ population estimate (JNCC, 2013)	Southern North Sea population	North Sea population	European population
Harbour porpoise	Favourable	177,567 (CV = 0.15)	SCANS II: 134,434	SCANS II: 232,450 (Northern North Sea (blocks J, M & T), Southern North Sea (blocks B, H, U & Y) and Central North Sea (blocks L & V) combined)	SCANS II: 375,358 (95% CI 256,304 - 549,713)
Minke whale *Balaenoptera acutorostrata*	Favourable	Minimum 6,819 Maximum 36,711	Unknown	SCANS II: 10,786 (Coefficient of variation (CV) 0.29)	SCANS II: 18,958 (CV 0.347) CODA: 6,765 (95% CI = 1,239-36,925)
Fin whale *Balaenoptera physalus*	Favourable	Minimum 512 Maximum 1,072	Unknown	Unknown	CODA: 7,523 (95% CI = 4,945-11,444)
Common dolphin *Delphinus delphis*	Favourable	Minimum 9,166 Maximum 23,178)	Unknown	Unknown	SCANS II: 56,221 (95% CI = 35,748 – 88,419) CODA: 162,266 (95% CI = 65,990-399,001)
Long-finned pilot whale *Globicephala melas*	Unknown	Minimum 20,091 maximum 76,158	Unknown	Unknown	CODA+: 83,441 (95% CI = 33,875-205,528)
Risso's dolphin *Grampus griseus*	Unknown	Minimum 175 Maximum 4,440	Unknown	Unknown	JNCC *et al.*, (2010a): Estimated at 100s, 1000s
Atlantic white-sided dolphin *Lagenorhynchus acutus*	Favourable	Minimum 34,535 Maximum 113,229	Unknown	Unknown	Unknown
Killer whale *Orcinus orca*	Unknown	Minimum 50 Maximum 100	Unknown	Unknown	JNCC *et al.*, (2010): Estimated at 1000s

Species	FCS assessment (JNCC 2013)	UK EEZ population estimate (JNCC, 2013)	Southern North Sea population	North Sea population	European population
White-beaked dolphin *Lagenorhynchus albirostris*	Favourable	Minimum 5,307 Maximum 18,379	Unknown	SCANS II: 10,666 (blocks J, T, U, V; no sightings in block B)	SCANS II: 16,536 (95% CI 9,245 – 29,586)
Sperm whale *Physeter macrocephalus*	Unknown	Minimum 340 Maximum 1,334	Unknown	Unknown	CODA: 2,424 (95% CI = 1,250 – 4,700)
Bottlenose dolphin	Favourable	12,758 (CV = 0.26)	Unknown (the only known resident populations within the UK are found within the Moray Firth (n = 129 individuals) and Cardigan Bay (n=213 individuals)	Unknown	SCANS II: 16,485 (95% CI = 7,463 – 36,421) CODA: 19,295 (95% CI = 11,842-31,440)

European Protected Species Guidance

2.2.14. The JNCC, Natural England and CCW (JNCC *et al*. 2010a) have produced draft guidance concerning the new Regulations on the deliberate disturbance of marine EPS (cetaceans, turtles and Atlantic sturgeon *Acipenser oxyrinchus*), which provides an interpretation of the regulations in greater detail, including pile driving operations (JNCC *et al*. 2010b), seismic surveys (JNCC *et al*. 2010c) and explosives (JNCC *et al*. 2010d).

2.2.15. The guidance details all activities at sea that could potentially cause a deliberate injury or disturbance offence and summarises information and sensitivities of species to which the regulations apply. The guidance refers to the Habitats Directive Article 12 Guidance (EC 2007) stating that, in their view, significant disturbance must have some ecological impact.

2.2.16. The guidance provides the following interpretations of deliberate injury and disturbance offences under Regulation 39(1) of the Habitats Regulations and Offshore Marine Regulations, as detailed in the paragraphs below:

- Deliberate actions are to be understood as actions by a person who knows, in light of the relevant legislation that applies to the species involved, and the general information delivered to the public, that his action will most likely lead to an offence against a species, but intends this offence or, if not, consciously accepts the foreseeable results of his action;
- Certain activities that produce loud sounds in areas where EPS could be present have the potential to result in an injury offence, unless appropriate mitigation measures are implemented to prevent the exposure of animals to sound levels capable of causing injury.

2.2.17. JNCC *et al*. (2010b) provides further details of best practice mitigation measures for pile driving.

2.2.18. The term “disturbance” is not defined in Article 1 or Article 12 of the Habitats Directive or in the Habitats Regulations or Offshore Marine Regulations. Although not legally binding, The Habitats Directive Article 12 Guidance (EC 2007) states that:

“In order to assess a disturbance, consideration must be given to its effect on the conservation status of the species at population level and biogeographic level in a Member State. For instance, any disturbing activity that affects the survival chances, the breeding success or the reproductive ability of a protected species or leads to a reduction in the occupied area should be regarded as a “disturbance” in terms of Article 12.”

2.2.19. Following amendments, the Habitats Regulations and the Offshore Marine Regulations better define the level of disturbance which constitutes an offence. Regulation 39(1)(b)(1A) makes it clear that any disturbance which is likely to have any of the negative effects which are potentially significant contributors, with regard to impact on the conservation status of EPS, will amount to disturbance under regulation 39(1)(b).

2.2.20. The EPS Guidance (JNCC 2010a) also highlights that sporadic “trivial disturbance” should not be considered as a disturbance offence under Article 12.

2.2.21. For the purposes of marine users, the draft EPS guidance (JNCC *et al*. 2010a) states that disturbance which can cause offence should be interpreted as:

“disturbance which is significant in that it is likely to be detrimental to the animals of an EPS or significantly affect their local abundance or distribution..”

2.2.22. JNCC *et al*. (2010a) also state that a disturbance offence is more likely where an activity causes persistent noise in an area for long periods of time, and a disturbance offence is more likely to occur when there is a risk of:

- Animals incurring sustained or chronic disruption of behaviour scoring 5 or more in the Southall *et al*. (2007) behavioural response severity scale; or
- Animals being displaced from the area, with redistribution significantly different from natural variation.

2.2.23. In order to assess whether a disturbance could be considered non-trivial in relation to the objectives of the Directive, JNCC *et al*. (2010a) suggest that consideration should be given to the definition of the FCS of a species given in Article 1(i) of the Habitats Directive. There are three parameters that determine when the CS of a species can be taken as favourable:

- Population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable element of its natural habitats.
- The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future.
- There is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis.

2.2.24. Therefore, any action that could increase the risk of a long-term decline of the population, increase the risk of a reduction of the range of the species, and/or increase the risk of a reduction of the size of the habitat of the species can be regarded as a disturbance under the Regulations. For a disturbance to be considered non-trivial, the disturbance to marine EPS would need to be likely to at least increase the risk of a certain negative impact on the species at FCS.

2.2.25. JNCC *et al*. (2010a) do not provide guidance as to what would constitute a ‘significant group’ or proportion of the population, but provide some discussion on how to assesses whether the numbers potentially affected could be of concern for a population’s FCS.

2.2.26. JNCC *et al*. (2010a) state that:

“*In any population with a positive rate of growth, or a population remaining stable at what is assumed to be the environmental carrying capacity, a certain number of animals can potentially be removed as a consequence of anthropogenic activities (e.g. through killing, injury or permanent loss of reproductive ability), in addition to natural mortality, without causing the population to decrease in numbers, or preventing recovery, if the population is* *depleted. Beyond a certain threshold however, there could be a detrimental effect on the population*".

2.2.27. Further discussion on the use of thresholds for significance and the permanent or temporary nature of any disturbance is considered in defining the magnitude of potential effect in this assessment (Section 3.3). Consideration of any potential essential habitat or geographical structuring is provided in the Existing Environment section (Section 4) of this chapter.

2.2.28. In order to assess the number of individuals from a species that could be removed from the regional population through injury or disturbance without compromising the FCS in its natural range, this ES considers:

- The numbers affected in relation to the best and most recent estimate of population size; and
- The threshold for potential impact on the FCS, which will depend on:
- The species' / populations' life-history;
- The species' FCS assessment in UK waters; and
- Other pressures encountered by the population (cumulative effects).

2.2.29. One of the key parameters for consideration within this assessment is the population size. The EPS Guidance advises that the best available abundance estimates could be used as a baseline population size, taking account of any evidence of regional population structuring (JNCC *et al.* 2010a). In the case of Dogger Bank Teesside A & B **Table 2.3** suggests that the European population estimates derived from the SCANS II and CODA surveys offer the best reference population for all commonly occurring cetacean species in the UK. In the case of harbour porpoise, the SCANS II data also offers the opportunity for assessing potential impacts of Dogger Bank Teesside A & B in the context of the North Sea population. Updated analysis of the SCANS II data by Hammond *et al.* (2013) has provided population estimates that have been used in this assessment along with the Inter-Agency Marine Mammal Working Group (IAMMWG) Management Units (MUs; IAMMWG (2013) , rather than those used in the FCS assessment (**Table 2.3**).

2.2.30. Consideration should be given to the fact that the estimates of population size for EPS are based on data collected in 2005, and numbers of individuals impacted is based on absolute abundance and density estimates from survey data collected between 2009 and 2012, and the population size of each species of cetacean may have changed over this time.

2.2.31. An EPS licence is required if the risk of injury or disturbance to cetacean species is assessed as likely under regulations 41(1) (a) and (b) in The Conservation of Habitats and Species Regulations and 39(1) (a) and (b) in The Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (amended in 2009 and 2010). Consultation with the JNCC for Dogger Bank Creyke Beck A & B highlighted that it is important to note that disturbance which impacts on species at a population level (i.e. is likely to affect FCS) cannot be licensed, whereas disturbance that does not have an impact on the species at population level but is sufficient to constitute an offence can potentially be licensed.

2.2.32. An EPS licence may be required for harbour porpoise, minke whale and white-beaked dolphin during the construction of Dogger Bank Teesside A & B, where the piling of foundations is proposed.

2.2.33. Given the potential implications of the EPS Guidance, this EIA has focused on cetaceans which have been recorded as either common, regular or uncommon, seasonal visitors to the Dogger Bank Teesside A & B study area. It follows that if an EPS licence is required, the risk assessment would also focus on these species.

2.2.34. As part of the risk assessment for potential injury and disturbance offences, an assessment has been undertaken to determine the likelihood of any injury and / or disturbance offences likely to occur from construction, operation and decommissioning activities relating to Dogger Bank Teesside A & B.

2.2.35. Additionally, it is noted that many activities at sea will not require a licence, since their potential for injury and / or disturbance can be effectively mitigated or because the characteristics of the disturbance will fall below the threshold of an offence.

2.2.36. If a licence is required, an application must be submitted, the assessment of which comprises three tests, namely:

- Whether the activity fits one of the purposes specified in Regulation 53(2)(e);
- Whether there are no satisfactory alternatives to the activity proposed (that would not incur the risk of offence); and
- That the licensing of the activity will not result in a negative impact on the species'/ population's FCS.

2.2.37. Under the revised definitions of 'deliberate disturbance' in the Habitats Regulations and Offshore Marine Regulations, chronic exposure and/or displacement of animals could be regarded as a disturbance offence. If these risks cannot be avoided, then Forewind is likely to be required to apply for a marine wildlife licence from the MMO in order to be exempt from the offence.

2.2.38. An EPS licence, if granted, will be valid for a limited time period, therefore an application will be submitted after the Development Consent Order (DCO) application is made prior to the onset of construction, and in consultation with the relevant Statutory Nature Conservation Agencies.

2.2.39. Forewind is proposing that any EPS licence application would draw on the information captured in this chapter, specifically definition of the realistic worst case scenario within the Rochdale Envelope (Section 5), the FCS of each species' / population (Section 4) and the potential impacts during construction, operation and decommissioning (Sections 6, 7 and 8).

2.2.40. The EPS licence application will be submitted post consent, and at least three to six months prior to the start of construction, such that the most up to date information can be used in the assessment of the potential impacts on the FCS of the species concerned. At this time the Rochdale Envelope will have been further refined through detailed design and procurement activities and hence further detail will be available on the construction techniques selected for the construction of the wind farm than are available at the time of writing this ES, as well as full consideration of the mitigation measures that will be in place following the development of the Environmental Management Plan (EMP) including a Marine Mammal Mitigation Protocol (MMMP).

2.3. Consultation

2.3.1. To inform the ES, Forewind has undertaken a thorough pre-application consultation process, including the following key stages:

- Scoping Report submitted to the IPC (May 2012);
- Scoping Opinion received from the IPC (June 2012);
- First stage of statutory consultation (in accordance with sections 42 and 47 of the Planning Act 2008) on Preliminary Environmental Information (PEI) 1 (report published May 2012); and
- Second stage of statutory consultation (in accordance with sections 42, 47 and 48 of the Planning Act 2008) on the draft ES designed to allow for comments before final application to the Planning Inspectorate.

2.3.2. In addition, consultation associated with the submission of the draft ES for Dogger Bank Creyke Beck is taken into account for Dogger Bank Teesside A & B where appropriate.

2.3.3. In between the statutory consultation periods, Forewind consulted specific groups of stakeholders on a non-statutory basis to ensure that they had an opportunity to inform and influence the development proposals. Consultation undertaken throughout the pre-application development phase has informed Forewind’s design decision making and the information presented in this document. Further information detailing the consultation process is presented in **Chapter 7**. A Consultation Report is also provided alongside this ES, as part of the overall planning submission.

2.3.4. A summary of the consultation carried out at key stages throughout the project, of particular relevance to marine mammals, is presented in **Table 2.4**. This table only includes the key items of consultation that have defined the assessment. A considerable number of comments, issues and concerns raised during consultation have been addressed in meetings with consultees and hence have not resulted in changes to the content of the ES. In these cases, the issue in question has not been captured in **Table 2.4**. A full explanation of how the consultation process has shaped the ES, as well as tables of all responses received during the statutory consultation periods, is provided in the Consultation Report.

Table 2.4 Summary of consultation and issues raised by consultees

Date	Consultee	Summary of issue	ES reference
29/01/14 (email, non-statutory)	JNCC and Natural England	With regard to the harbour porpoise PVA, "Natural England and JNCC have now reviewed the paper and we can confirm we have no objections to it being included in the application documents for the Dogger Bank Teesside project. We welcome the approach taken to the assessment and the clear outlining of the assumptions, levels of uncertainty and likelihood of over or underestimating and would like to highlight that Forewind should ensure that all of these assumptions are reflected within the final assessment. Whilst the assessment doesn't include the issue of cumulative impacts, we do not feel this is an issue for individual developers to tackle and work should be undertaken at a strategic level by regulators as to when cumulative effects could potentially become significant."	The PVA is referenced in the cumulative impact assessment in Section 10.2, and is included as **Appendix 14D Harbour Porpoise Population Viability Analysis**.
20/12/13 (Section 42 on the draft ES, statutory)	The Wildlife Trusts	"The Wildlife Trusts believe that comprehensive monitoring is required to test the assumptions of the assessment), so that mitigation measures can be adapted in response to any impacts that are greater than anticipated, and our collective understanding of the response of harbour porpoise to piling can be increased."	Forewind confirms that should site impact monitoring be deemed appropriate they will develop a monitoring plan in conjunction with Regulators and SNCBs.
		"The Wildlife Trust also suggests that the developers work collaboratively with other developers to devise and deliver monitoring strategies so that lessons can be learnt and comparisons made."	Forewind is committed to collaborative projects on monitoring and mitigation methods including the ORJIP initiative, and DEPONS project.
		"The Wildlife Trust request the opportunity to feed into the development of the cetacean monitoring programme to provide reassurance that significant impacts, if they occur can be identified at an early stage and appropriate mitigation applied."	Any impact monitoring programme will be developed in consultation with the Regulators and SNCBs responsible for sign off of the MMMP. It is expected that the Wildlife Trust will consult with the SNCBs as required.
19/12/13 (Section 42 on the draft ES, statutory)	The National Trust	"The issue of spiral injury does not appear to be mentioned within your Environmental Statement, and we consider this to be a significant omission, and would wish to see this considered".	This issue is considered in the assessment in Section 6.4, 7.4, 8.5 and in Section 10, under the heading 'collision risk- ducted propellers'.
21/11/13 (Section 42 on	Whale and Dolphin Conservation (WDC)	WDC suggest that:	Piled foundations are included in this assessment as the worst case

Date	Consultee	Summary of issue	ES reference
the draft ES, statutory)		Monopile, or pin pile, foundations should not be used,	scenario for marine mammals with regard to foundation installation within the Rochdale Envelope approach. Monopiles are currently the most economic and widely used foundation used in the offshore wind industry, Forewind therefore needs to retain flexibility of foundation types to ensure the most feasible and economic project can be built.
		Further assessments are made on alternative foundations to fully understand the potential impacts on marine mammals, and prey species;	It should be noted that the assessment considered other receptors where non-piled foundations may represent worst case. Using the Rochdale Envelope approach assessments are made of alternate worst case foundation for marine mammal prey species in **Chapter 13 Fish and Shellfish Ecology**. The results of this assessment are then used in Section 6.5, 7.7, 8.6 and Section 10.
		That a robust impact monitoring strategy (Marine Mammal Monitoring Plan) is developed for the range of species that can reasonably be impacted and a report provided within a reasonable timeframe;	Forewind is committed to producing a MMMP and confirm that should site impact monitoring be deemed appropriate they will develop a monitoring plan in conjunction with Regulators and SNCBs.
		Specific comments: EPS “Section 2.2, referring to the EPS Guidance, it is noted that SCANS II surveys have been used to estimate populations for commonly occurring cetaceans species in the UK. However, SCANS surveys are run 10 years apart and only	The EPS Guidance JNCC *et al.* (2010a) cites the SCANS II data as the best data to estimate population size of these species of cetacean. The limitations of these data are acknowledged in the ES (Section 2.2),

Date	Consultee	Summary of issue	ES reference
		give a snapshot of cetacean abundance and cannot be relied upon to give abundance and distribution numbers".	and their used has been agreed with JNCC and Natural England during consultation.
		Pile driving "Noise levels during construction remains a key concern with the other proposed foundations and, as a very minimum, should be monitored. All noise modelling should be ground-truthed".	It is expected that measurement of noise during construction will be a requirement of the DCO.
		"We note that the maximum construction period For Teesside A & B would be 11 years and 6 months (section 5.2.1). If this occurs after the construction of Dogger Bank Creyke Beck, which has a maximum construction period of 6 years (Dogger Bank Creyke Beck Draft Environmental Statement, section 5.2.1, Forewind 2013) this would result in a maximum 18 years of piling activity, and that marine mammals would be excluded from the site for the duration of the pile-driving".	Construction at Dogger Bank Teesside A & B could take up to 11 years and 6 months (Section 5.2). Construction at Dogger Bank Creyke Beck A & B could also take up to 11 years and 6 months (Forewind, 2013). However, all four projects are constrained to start construction no sooner than 18 months and within seven years of consent (Para 5.2.1). Therefore the latest construction finish on a project will be 13 years after consent award. In the CIA it has been assumed that Dogger Bank Teesside A & B consent is awarded six months after Creyke Beck A &B, and consent for Dogger Bank Teesside C & D will be awarded two years after Dogger Bank Creyke Beck A & B. Therefore, the maximum period over which construction can occur would be 13 years and six months. See Section 6.3 of **Chapter 5 Project Description.**
		"We recommend that the same consideration is given to marine mammals when the second pile-driving occurs as is given to the first and that it is not assumed that animals have moved out of the area as pile driving has already commenced elsewhere".	Multiple pile driving at Dogger Bank Teesside A & B is assessed in Section 6.1. Consideration of the potential impacts two concurrent piling vessels, and therefore multiple pile driving across each project, is given

Date	Consultee	Summary of issue	ES reference
			throughout the assessment using the 'footprint' approach. The assessment considers the worst case of the impacts across each project area prior to any movement out of the area as a result of other pile driving events.
		"We note that the methodology used by Southall have been used in underwater noise modelling. The limitations of the methodology used by Southall are acknowledged in the Southall paper itself, and they are extensive."	The methods used for underwater noise modelling following the approach agreed in consultation with the JNCC for Dogger Bank Creyke Beck A & B (Forewind, 2013).
		Monitoring "…. we note that in section 3.2.3 that the boat based surveys were conducted "between January 2010 and June 2012" the duration of this survey is not adequate to build up a picture of the use of the development area, and potential impact area, by cetaceans. We acknowledge that the data is collected and used in conjunction with other surveys (the limitations of some are noted above). We recommend a minimum of 2 years of boat based surveys, although preferably 5".	A total of 29 months of site specific boat based surveys were completed, along with 33 months of aerial surveys between May 2009 and July 2012 (Section 3.2). Other regional data sets were also used to characterise use of the area by cetaceans. The data were not limited to two years. Site specific aerial survey data were used in the impact assessment. This approach was agreed for Dogger Bank Creyke Beck A & B in consultation with JNCC (Forewind, 2013).
		"Section 3.2.3 also states that the methodology used to survey marine mammals "followed the methodology of Camphuysen et al. (2004)". However this methodology was designed for surveying seabirds in relation to offshore wind farms. We are concerned this methodology was used as it is not designed for marine mammal surveying".	The boat based surveys following the Camphuysen *et al*. (2004) methodology were not used in the impact assessment. The Hi-Def aerial survey data (**Appendix14B**) were used in the impact assessment following the approach agreed for Dogger Bank Creyke Beck A & B in consultation with JNCC (Forewind, 2013)
		Mitigation "Soft-start of pile driving has not been proven and so mitigation out to 700 metres must be in place for prevention of injury. Real-time mitigation measures should include acoustic barrier methods and other techniques that	As stated in Para 6.1.63 Forewind will, if deemed appropriate at the time of development of the MMMP, extend the mitigation zone to prevent the

Date	Consultee	Summary of issue	ES reference
		have been proved in recent studies - Wilke 2012 and Diederichs *et al*., 2013"	possibility of instantaneous PTS occurring in all species for the maximum hammer energy. The MMMP will be developed in consultation with JNCC and Natural England.
		Cumulative assessment "It is clear that the cumulative assessment has taken into account other offshore wind farms in UK waters alongside both Teesside applications; however we are concerned that the potential impacts have not been scaled up as it has been assumed that marine mammals will have already left the area. Of particular concern is the cumulative impacts of Dogger Bank Teesside A & B being constructed after Dogger Bank Creyke Beck as described above' we feel this should be given greater consideration".	The assessment does not assume that marine mammals have left the area; the assessment considers impacts following no redistribution of animals, as stated above and in Section 6.1.
		Operation "Section 7 – Whilst it is anticipated that operational noise levels will be much lower than construction noise, there is no data available on operational noise impacts on marine mammals so a long-term monitoring plan should incorporate operational noise impacts on cetaceans".	Observational data on operation noise from wind farms do exist, as cited in Section 7.1. However, Forewind confirms that should site impact monitoring be deemed appropriate they will develop a monitoring plan in conjunction with Regulators and SNCBs.
13/11/13 (Section 42 on the draft ES, statutory)	JNCC and Natural England	Key Issues Summary: "JNCC and Natural England advise that for there to be confidence in a cumulative impact assessment an agreed framework should be established under the responsibility of the regulator to investigate cumulative impacts on marine mammal populations as part of Strategic Environmental Assessments. This framework should be able to deal with any relevant past, present and planned projects, as well as other pressures (e.g. bycatch) that may influence cetacean populations and should also assess the relative influence of each of the projects/pressures".	Forewind would welcome a Strategic approach to the assessment of cumulative impacts that would help remove inconsistencies in approach and reduce uncertainty. In the absence of such a strategic approach Forewind believes that Section 10 provides the most robust approach to cumulative assessment possible.
		Specific comments: 117. Cumulative impacts "117.3 It is worth noting however that there is an updated version (available	Forewind has updated the ES, particularly in Section 2.2 and Section 3.3, to reflect the more recent guidance and how it has been applied in the

Date	Consultee	Summary of issue	ES reference
		in 2010) of the JNCC guidance referred to in the ES and in the current version there is no advice on „significant groups" as this term was removed from the amended regulations."	assessment.
		118. Mitigation and alternatives "118.1. It will therefore be beneficial if developers make a concerted attempt to reduce the acoustic output from pile driving (e.g. sleeving), to investigate alternative installation methods (e.g. suction bucket) and to plan activities within the scope of what is proposed to reduce the potential that they contribute to negative effects on populations".	Appendix C in **Appendix 5A Underwater Noise Modelling Technical Report** provides a review of the current status of noise reduction methods, including alternate foundations. Forewind consider alternatives to pile driving with the ES, and are committed to maintaining an up to date understanding and consideration of what measures may be used to reduce any negative effects on marine mammal populations.
		"119. JNCC and Natural England welcome the developers' commitment to implementing the JNCC piling guidelines as mitigation and will review the development of an effective marine mammal mitigation plan (MMMP) near construction time. This plan should include effective monitoring by MMOs and PAM of the predicted area over which auditory injury (the onset of PTS) could occur. JNCC and Natural England also recommend that the developers keep a watching brief on the work carried out under ORJIP on Acoustic Mitigation Devices and any further developments in relation to mitigation options".	As stated in Para 6.1.54 to 6.1.70 Forewind will develop a MMMP in consultation following JNCC Guidelines, and any new developments in relation to mitigation measure through ORJIP.
		"120. …Forewind should be prepared to work with other developers, alongside Regulators and SNCBs, in order to reduce cumulative effects as required. The Offshore Wind Developers Forum (OWDF) could be a potential host for these discussions."	Forewind is committed to working alongside other developers, Regulators and SNCBs to reduced cumulative effects as required.
		"122. JNCC and Natural England also recommend that site impact monitoring is considered and that if deemed appropriate a monitoring plan is developed by Forewind in conjunction with regulators and SNCBs."	Forewind confirms that should site impact monitoring be deemed appropriate they will develop a monitoring plan in conjunction with Regulators and SNCBs.
		"123. Section 6.1.54 (p.110) Mitigation and residual impacts: Auditory injury for some marine mammal species is predicted to occur beyond the standard	As stated in Para 6.1.63 Forewind will, if deemed appropriate at the time of

Date	Consultee	Summary of issue	ES reference
		500m mitigation zone (as specified in the JNCC piling guidelines). The mitigation zone proposed in the Marine Mammal Mitigation Plan should reflect those predictions in the ES and cover the maximum range out to which instantaneous Permanent Threshold Shift occurs."	development of the MMMP, extend the mitigation zone to prevent the possibility of instantaneous PTS occurring in all species for the maximum hammer energy. The MMMP will be developed in consultation with JNCC and Natural England.
		"125. Figure 10.1b Previously for the Creyke Beck Section 42 response Natural England commented that aggregate sites were missing from the figure. This was amended for the Creyke Beck application, but they appear to be missing from the figure within the Teesside report, so presumably this isn't the most recent version of the figure."	The Figure 10.1b does contain all of the aggregates areas considered in the CIA, as is the most up to date Figure. Please note as advised previously, and as detailed in Table 10.2 some of the application areas names were revised during the completion of the CIA.
		"126. Section 10.4.2 (p.192) Grey seal: Forewind states that there is a minor adverse impact on Grey seal. However in table 12.4 Forewind states that there is a moderate adverse impact. Natural England would like clarification on the conclusion made in regards to Grey seal."	Section 10.4.2 does not refer to grey seal. Para 10.4.14 (on page 192 of the draft ES) does refer to moderate adverse cumulative impact on grey seal of PTS. Para 10.4.38 assessed a minor adverse impact on grey seal behaviour. Full justification for the conclusion of the assessment is provided in Section 10.4. Table 12.4 summarised the impact from pile driving noise (PTS and behaviour combined) the heading on the column was mistakenly "underwater noise – behavioural disturbance", when it should be "all types of underwater noise impact combined". This has been amended in the ES.
		127. EPS Licensing "127.1. JNCC notes that the draft ES suggests that an EPS licence will not be	The ES states (Para 2.2.33) that a licence may be required for the key cetacean species found at the site i.e.

Date	Consultee	Summary of issue	ES reference
		required for minke whale and white-beaked dolphin but is likely to be needed in relation to harbour porpoise. On review of the information contained we conclude that an EPS license will be required to cover the risk of disturbance to all cetacean species….. For this, the consideration of less noisy alternatives to piling, the total area of impact, the duration of impact and the number of animals likely to be affected would need to be clearly presented. Clarification of how Forewind is considering its EPS application within this process would be welcomed".	harbour porpoise, minke whale and white-beaked dolphin. An EPS licence application will be completed once the foundation types have been confirmed and the selection justification will be clearly presented. In the ES Forewind states that the EPS licence will draw on the information within the ES, and any new information prior to submission of the licence application three to six months prior to construction (Para 2.2.40 and 2.2.41).
June 2012 (Scoping response statutory)	Natural England/ JNCC Scoping Response	Detailed timelines and potential construction scenarios should be provided in the ES, particularly with regard to more disturbing construction activities such as piling, to allow for sufficient assessment particularly with regard to sensitive species of bird and marine mammals.	The project description is outlined in **Chapter 5 Project Description.**
		The ES should set out the approach to noise assessment, including thresholds; units and presentation of data; and the full range of physical impacts including Temporary Threshold Shift and Permanent Threshold Shift, and the zone and duration of marine mammal avoidance / displacement.	The approach to underwater noise assessment is outlined in Section 3.3.
		EMF is not normally assessed against pinnipeds, however due to the lack of knowledge of effects and impacts of High Voltage Direct Current, pinnipeds should be scoped in to the EIA.	EMF is assessed in Section 7.5.
		Impacts during decommissioning should be considered separately to construction, especially in relation to cumulative impacts.	The impact assessment for impacts during decommissioning is outlined in Section 8.
		The secondary effects upon marine mammals prey resources during operation should be addressed by the EIA	The potential impact on marine mammals from changes to prey resource are discussed in Section 7.6.
June 2012 (Scoping response statutory)	Secretary of State	Due to the presence of the Dogger Bank cSAC within the offshore scoping area, and SAC's, cSAC's, pSAC's and SCI's within the wider area of the North Sea and European coastlines, a comprehensive assessment of the potential impacts on marine mammals and their habitats must be carried out.	**Chapter 8 Designated Sites** and the HRA assess the impacts on designated sites, drawing on information presented in this chapter.
		Offshore noise and vibration must be considered as part of the assessment. Appropriate cross-reference should be made to the fish and shellfish and the marine mammals topics in the ES.	**Appendix 5A Underwater Noise Modelling Technical Report** provides as assessment of the underwater noise

Date	Consultee	Summary of issue	ES reference
			which is then referred to in the impact assessment for marine mammals (Sections 6.1 and 7.1) and fish (**Chapter 13 Fish and Shellfish Ecology**)
07/06/12 (Dogger Bank Creyke Beck meeting, non-statutory)	JNCC	Joint Cetacean Protocol (JCP) population estimates will not be available in timeframe to feed into this Project. The use of average densities in the impact assessment for Creyke Beck was agreed for cetacean species due to the high degree of spatial and temporal variation in their occurrence across the zone.	Section 4 presents average densities for each species of cetacean calculated from Zone specific surveys.
		Reference populations for the assessment should be based on Marine Scotland and JNCC Statutory Advice (expected in summer 2013). The minke whale assessment should be made at a European as well as a central and north east Atlantic scale.	Reference population follows agreement with JNCC during the Dogger Bank Creyke Beck PEI3 process and draft guidance from Marine Scotland (Northridge *et al.*, 2012), Section 4.
		Agreement on species and reference populations for assessment. It is not necessary to take forward species with only incidental sightings. Harbour seal do not need to be taken forward in the assessment for underwater noise due to low occurrence in the zone.	Section 4 provides details of incidental sightings and species not taken forward in the assessment.
		Main concern for JNCC is cumulative impact of developments of all wind farms across the North Sea. Interim approach to assessment (using Population Consequences of Disturbance, PCoD) will be used to qualify cumulative assessment by JNCC.	Section 10 is the cumulative assessment conducted in the absence of the interim PCoD approach being available.
25/07/11 (email, non-statutory)	JNCC	Informing Forewind of a dedicated marine mammal survey to be carried out in 2011 co-funded by JNCC.	N/A

3. Methodology

3.1. Study area

3.1.1. Due to the mobile and transitory nature of marine mammals, it is necessary to examine species occurrence not only within the immediate study area, but also over the wider region. For each species of marine mammal this wider area has been defined based on current knowledge and understanding of the biology of each species, and taking account of feedback received during consultation.

3.1.2. The status and activity of cetaceans known to occur within or adjacent to Dogger Bank Teesside A & B is considered in the context of regional population dynamics at the scale of the southern North Sea, North Sea, or North western Atlantic, depending on the data available for each species.

3.2. Characterisation of existing environment – methodology

Marine mammals

3.2.1. In order to provide spatial and temporal information on marine mammals within the proposed development area and regional waters, several generic sources have been used to inform the site characterisation within this ES (**Table 3.1**).

3.2.2. Site specific aerial and boat based surveys have been carried out to supplement the data sets described in **Table 3.1**.

3.2.3. Monthly boat-based surveys of the Dogger Bank Zone were conducted (by Gardline, on behalf of Forewind), between January 2010 and June 2012 with all sightings of marine mammals being recorded on a JNCC marine mammal recording form. Surveys were conducted to provide information during the Zonal Characterisation of the Dogger Bank Zone (EMU 2010; EMU 2011), and to provide data for the characterisation of the baseline environment for the ES. Details of the survey methods can be found in **Appendix 11A Ornithology Technical Report (BTO 2013)**. **Figure 3.1** provides an example of the survey transects.

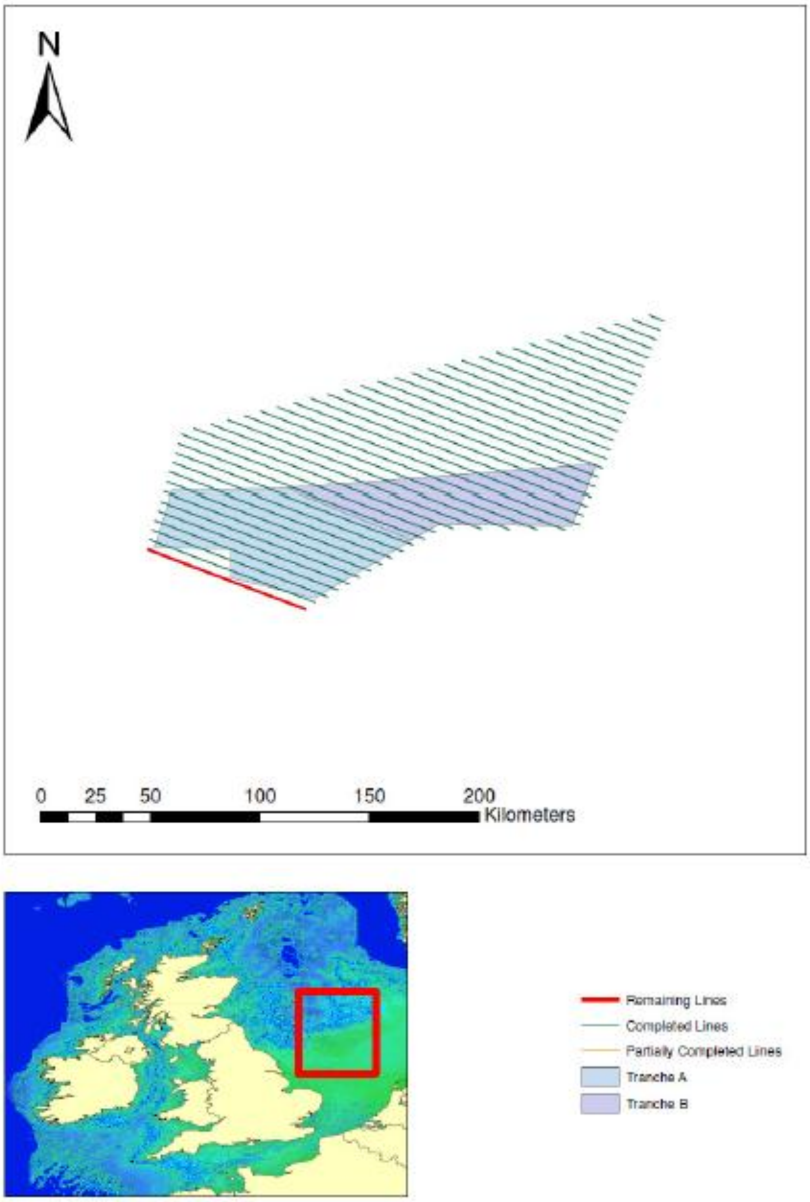


Figure 3.1 Example of survey line (primary and secondary) from September 2011 (Gardline 2011).

3.2.4. Aerial surveys encompassing the Dogger Bank Zone were conducted between May and August 2009 by the Wildfowl & Wetlands Trust (WWT) at the request of The Crown Estate (WWT 2009).

3.2.5. Subsequent aerial surveys (November 2009 to July 2012) were carried out using high definition video camera by HiDef Limited (on behalf of The Crown Estate from November 2009 to March 2010 and on behalf of Forewind from April 2010 to July 2012), again to supplement the Zone Appraisal and Planning (ZAP) process and to inform the characterisation of the existing environment for the ES. Further details of the survey methods can be found in **Appendix 11A**, and summaries of sightings rates are provided in EMU (2010) and EMU (2011). **Figure 3.2** provides an example of a typical flight track taken during the aerial surveys.

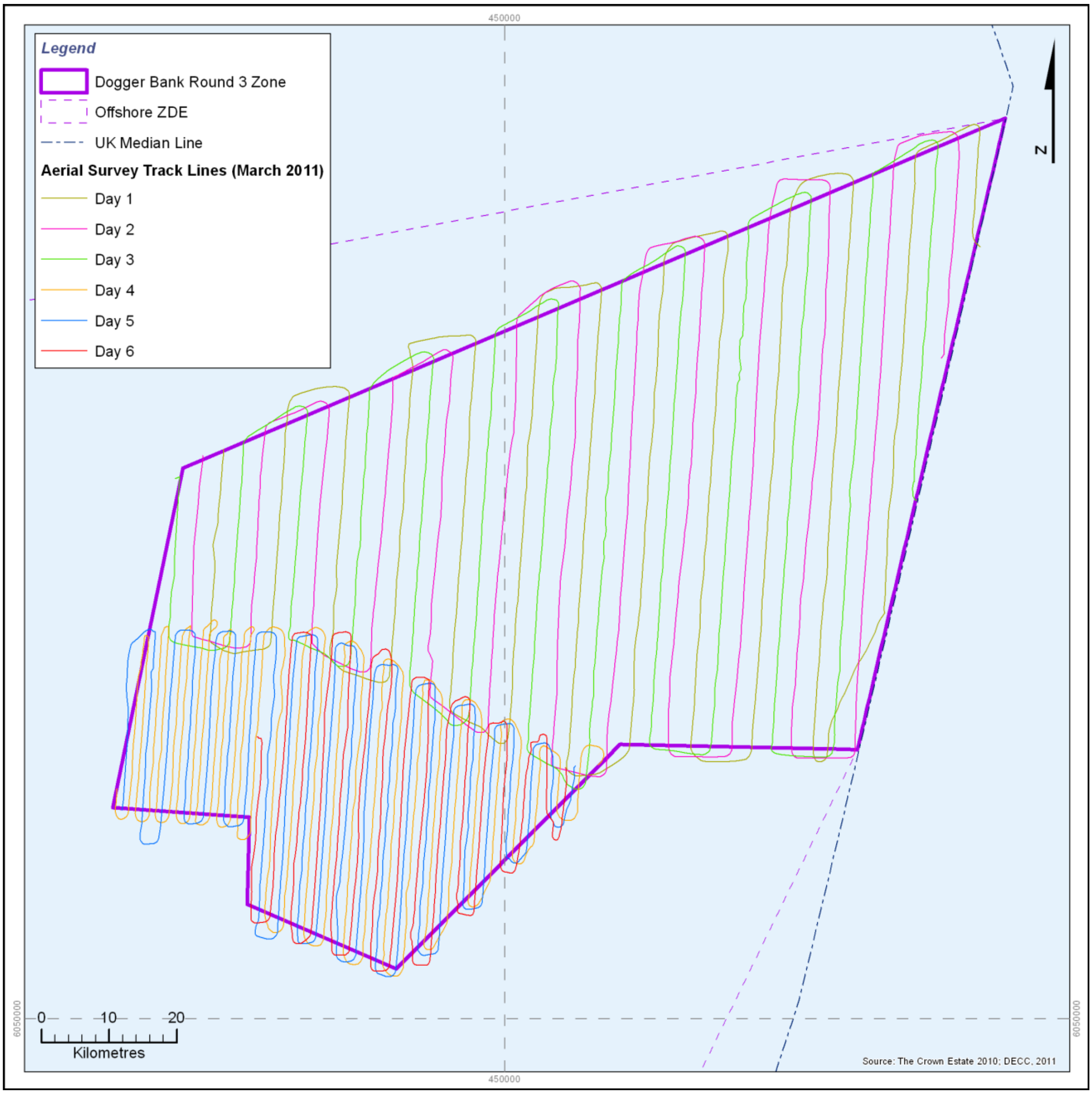


Figure 3.2 Typical flight tracks taken during the HiDef aerial surveys of Dogger Bank Zone (EMU 2011). N.B. Tranche A surveyed in greater detail from January 2011.

Baseline ambient noise

3.2.6. A review of the relevant subsea ambient noise studies has been undertaken by NPL Management Ltd. (**Appendix 5A**, Section 3), to assess the likely level of ambient noise in and around the Dogger Bank Zone.

Table 3.1 Broad-scale data sources to inform the marine mammal site characterisation at Dogger Bank Teesside.

Title	Nature of the data	Spatial coverage	Data holder	Publication
Atlas of Cetacean Distribution in North west European Waters “Joint Cetacean Database”	Provides an account of the distribution of all 28 cetacean species that are known to have occurred in the waters off north west Europe in the last 25 years, Data sources: SCANS data, European Seabirds at Sea and the Sea Watch Foundation.	North west European waters, including North Sea, Irish Sea and English Channel.	JNCC	Reid *et al.* 2003
Small Cetacean Abundance in the North Sea and Adjacent Waters (SCANS)	Shipboard (890,000km^2) and aerial line (150,000km^2) transect surveys conducted to provide accurate and precise estimates of abundance as a basis for conservation strategy in European waters.	North Sea, English Channel, Celtic Sea, western Baltic Sea, waters around north east Scotland and the west coast of Norway/Sweden.	The Sea Mammal Research Unit (SMRU)	Surveys conducted in summer 1994. Report by Hammond *et al*. 2002.
Small Cetacean Abundance in the Atlantic and North Sea (SCANS II)	SCANS-II provides the most precise broad-scale estimates of cetacean abundance in UK waters, covering over 1,350,000km^2 and over 35,000km of survey track line (boat and aerial surveys combined).	SCANS extended west and south into Irish, French and Spanish waters.	SMRU	Surveys carried out in 2005, report published 2008 and reissued with new analysis 2013 (Hammond *et al*. 2013).
The Coastal Directive Project – JNCC Coasts and Seas of the United Kingdom	The Coastal Directories Project, coordinated by the JNCC, was developed to produce a wide-ranging baseline of environmental information for each part of the UK coastal and near shore marine zone. Each section provides a summary of the regions environment, including protected sites, wildlife habitats and species, human uses, archaeology etc.	Region 6 Eastern England: Flamborough Head to Great Yarmouth and Region 5 North east England: Berwick-upon-Tweed to Filey Bay	JNCC	Evans 1995; Duck 1995
Distributions of Cetaceans, Seals, Turtles, Sharks and Ocean Sunfish recorded from Aerial Surveys 2001-2008. WWT	Data on the distributions and abundances of cetaceans, seals, turtles, sharks and ocean sunfish *Mola mola* were collected opportunistically during aerial surveys for waterbirds conducted by Wildfowl and Wetlands Trust Consulting. The report details the distributions of all records of these species collected in areas of waterbird surveys around the UK coast between 2001 and August 2008 using distance-sampling methodology developed in Denmark by National Environment	Majority of English and Welsh coastline, some areas of Scotland and Northern Ireland	WWT (Consulting) Ltd	WWT 2009

Title	Nature of the data	Spatial coverage	Data holder	Publication
	Research Institute (NERI).			
Harbour seal telemetry data	Pinniped tagging programmes are included as part of regular population monitoring programmes (e.g. Special Committee on Seals (SCOS 2010). The telemetry data allow usage of coastal and marine areas to be examined. Data from the DECC funded Wash 2012 tagging deployment will not be available until February 2014.	UK wide	SMRU	Sharples *et al.* 2008
SCOS	Scientific advice to government on matters related to the management of seal populations, the SCOS formulates this advice.	UK wide	SMRU	SCOS 2012, SCOS 2011, SCOS 2010
Strategic Environmental Assessment (SEA) 3	Information on the abundance and distribution of marine mammals within the SEA 3 Block. In particular, important seal breeding colonies in the Humber Estuary, The Wash and the Farne Islands.	Southern North Sea, from Dover to Berwick-Upon-Tweed	DECC	DECC 2002
Offshore Energy SEA (Appendix A3a.7)	Baseline description of distribution and abundance of marine mammals in UK waters.	UK wide	DECC	DECC 2009
Offshore Energy SEA (Various Technical Reports)	Boat based marine mammal surveys of the Dogger Bank Zone and North Sea between February 2008 and March 2009. Telemetry of grey seals in the North Sea (conducted by SMRU).	North Sea	DECC	DECC 2009
North Atlantic Marine Mammal Commission (NAMMCO) Scientific Publications (various titles)	NAMMCO Publications on population and biological data.	Harbour seals in the North Atlantic and Baltic, grey seals in the North Atlantic and Baltic, harbour porpoises in the North Atlantic.	Various	NAMMCO
Harbour seal telemetry data	Pinniped tagging programmes were undertaken as part of regular population monitoring programmes. The telemetry data allowed usage of coastal and marine areas to be examined.	UK wide surveys	SMRU	Sharples *et al.* 2008
Survey for small cetaceans over the	Report on aerial surveys of Dogger Bank and adjacent areas.	UK, Dutch, Danish and German waters	Institute of Terrestrial and	Gilles *et al*. 2012. 19^{th} ASCOBANS Advisory

Title	Nature of the data	Spatial coverage	Data holder	Publication
Dogger Bank and adjacent areas in summer 2011			Aquatic Wildlife Research (ITAW), The Institute for Marine Resources and Ecosystems Studies (IMARES)	Committee Meeting Document 5-08
Marine Scotland seal density estimates	Broad scale mapping of seal density estimates at 5x5km resolution	UK	Marine Scotland	Jones *et al.*2013

3.3. Assessment of impacts – methodology

3.3.1. The impact assessment follows the standard methodology as presented in **Chapter 4** and the description of Dogger Bank Teesside A & B given in **Chapter 5**. The existing environment for marine mammals has been described in Section 4 using the data sources summarised in **Table 3.1**.

3.3.2. Each impact was identified during scoping and consultation (**Table 2.4**), and through previous experience in offshore wind farm impact assessment. The impacts have been assessed through a consideration of receptor sensitivity and magnitude of effect, in order to derive an overall level of impact (see **Chapter 4** for further details).

Receptor sensitivity and value

3.3.3. In conducting an impact assessment, account is usually taken of both receptor sensitivity and value.

3.3.4. The value of ecological features is dependent on their biodiversity, social and economic value within a geographic framework of appropriate reference (IEEM 2010). The most straightforward context for assessing ecological value is to identify those habitats and species that have a specific biodiversity value recognised through international or national legislation or through local, regional or national conservation plans (e.g. Annex II species under the Habitats Directive, Biodiversity Action Plans (BAPs), existing and recommended Marine Conservation Zones (MCZ and rMCZ, respectively).

3.3.5. In the case of marine mammals a large number of species fall within legislative policy, and, in order to assess the value of each species, particular consideration should be given to the level of international designation of a species, given in Article 1(i) of the Habitats Directive, as well other designations listed in **Table 2.2**. The geographic frame of reference applied to determine the value of the marine mammal valued ecological receptors (VERs) in the Dogger Bank study area is presented in **Table 3.2**.

Table 3.2 Geographic frame of reference applied to valuing ecological receptors in the Dogger Bank study area

Value of VER	Geographic scale of legislation	Criteria to define VER
High	**International/European or International/Regional**	Species protected under international legislation (Habitats Directive): Species are cited as an Annex II feature of an SAC or SCI where medium or high connectivity occurs between that population and the Dogger Bank study area. Species are primary reason for designation. Species or population protected by international and/or regional designation: Species are considered under the ASCOBAS Conservation and Management Plan (or Bonn Convention); Species is protected under the Berne Convention; Species listed on the OSPAR Convention; and Annex IV species which in occurrence forms a significant proportion (>1%) of the regional population) i.e. occurs frequently.
Medium	**International/Regional or National**	Species or population protected by international and/or regional designation: Species are cited as an Annex II feature of an SAC or SCI where low connectivity occurs between that population and the Dogger Bank study area. Species are primary reason for designation; Species are cited as an Annex II feature of an SAC or SCI where high or medium connectivity occurs between that population and the Dogger Bank study area. Species are present but not primary reason for designation; and Annex IV species which is not a significant proportion (>1% of the regional population) i.e. occurs occasionally. Species protected under national legislation: Species listed on The Wildlife and Countryside Act (1981); Species listed on The Countryside and Rights of Way Act 2000; UK Biodiversity Action Plan (UK BAP) priority species and Nationally Important Marine Species that have nationally important populations within study area, particularly in the context of species/habitat that may be rare or threatened in the UK; and Species is protected by The Conservation of Seals Act 1970.
Low	**Local**	Species which are not protected under conservation legislation.

3.3.6. In summary, all cetaceans in UK waters are EPS and, therefore, internationally important (see Section 2.2). Harbour porpoise, white-beaked dolphin and minke whale currently have a favourable conservation status (JNCC 2007).

3.3.7. Grey and harbour seals are also afforded international protection through the designation of Natura 2000 sites, which have seals as a primary reason for site selection.

3.3.8. Given this international protection of all species of marine mammal, their value is considered high in the assessment where individuals are from an SAC population, they form a large proportion of the regional population of an Annex IV species, or are listed under other international designations.

3.3.9. The assessment of impacts here considers the sensitivity of the individual receptor to each impact. The value (high, medium or low) of the VER is presented in the characterisation of the existing environment (Section 4). **Chapter 8** and the HRA report (HRA Appendix B) together provide an assessment of marine mammals in the context of national and international nature conservation designations.

3.3.10. Definitions of the sensitivity of the marine mammal receptor are given in **Table 3.3**. The sensitivity of the receptor is a function of its capacity to accommodate change and reflects its ability to recover if affected.

Table 3.3 Definition of terms relating to the sensitivity of marine mammals.

Sensitivity	Definition
High	Individual receptor has very limited capacity to avoid, adapt to, accommodate or recover from the anticipated impact.
Medium	Individual receptor has limited capacity to avoid, adapt to, accommodate or recover from the anticipated impact.
Low	Individual receptor has some tolerance to avoid, adapt to, accommodate or recover from the anticipated impact.
Negligible	Individual receptor is generally tolerant to and can accommodate or recover from the anticipated impact.

Magnitude of effect

3.3.11. The significance of the potential impacts of Dogger Bank Teesside A & B is also based on the intensity or degree of disturbance to the baseline conditions and is categorised into four levels of magnitude: high; medium; low; or negligible, as defined in **Table 3.4**.

3.3.12. The thresholds for each category defining the potential magnitude of effect that can occur from a particular impact have been determined using expert judgement, current scientific understanding of marine mammal population biology, and JNCC *et al*. (2010a) draft guidance on disturbance to EPS species.

3.3.13. The JNCC *et al.* (2010a) EPS draft guidance (see Section 2.2) suggests when an impact on EPS species (which are high VER) may increase the risk of a long-term decline in the population. The Guidance also provides some discussion on how many animals may be removed from a population without causing detrimental effects to the population at FCS. As such this guidance has been considered in defining the thresholds for magnitude of effects. All species considered in this assessment (both cetaceans and pinnipeds) are high VER, so using the JNCC *et al.* (2010a) draft guidance is deemed appropriate in assigning the thresholds for magnitude of effect presented in **Table 3.4**.

3.3.14. As discussed in Section 2.2, the number of animals that can be 'removed' through injury or disturbance will vary between species, but is largely dependent on the growth rate of the population; populations with low growth rates can sustain the removal of a smaller proportion of the population.

3.3.15. The number of individuals that could be removed from a population will vary between species, with the size of the population and the potential growth rate of the population. For most species of cetacean there is a large amount of uncertainty as to the growth rate of the population, but JNCC *et al*. (2010a) consider that it is generally accepted that for cetaceans the population growth rates will be lower than 10% per year. The Guidance states that:

"*An IWC/ASCOBANS workshop in 2000 recommended that 4% a year should be used as a conservative estimate of the maximum potential growth rate for harbour porpoise. This value is generally accepted as the default for cetaceans and in the absence of better information is considered a reasonable measure that could be used*".

3.3.16. **Table 3.4** states the potential that different proportions of the population being impacted leads to different magnitudes of effects depending on whether the effect is permanent or temporary which have been used in this assessment.. The JNCC *et al*. (2010a) draft guidance provides limited consideration of temporary effects of disturbance, with guidance reflecting consideration of permanent displacement or removal.

3.3.17. In this assessment temporary effects are considered to be of medium magnitude at greater than 5% of the reference population. JNCC *et al*. (2010a) draft guidance considered 4% as the maximum potential growth rate in harbour porpoise, and the 'default' rate for cetaceans. Therefore, beyond natural mortality, up to 4% of the population could theoretically be permanently removed before population growth could be halted. In assigning 5% to a temporary impact in this assessment, consideration is given to uncertainty of the individual consequences of temporary disturbance.

3.3.18. For permanent effects, greater than 1% of the reference population is considered to be high magnitude in this assessment. The assignment of this level is informed by the JNCC *et al*. (2010a) draft guidance (suggesting 4% as the 4% as the 'default maximum growth rate for cetaceans) but also reflects the large amount of uncertainty in the potential individual and population level consequences of permanent effects, and what may be considered as the potential rate of increase in a population with regard to existing pressures (such as by-catch of harbour porpoise). For example, population modelling of harbour porpoise in the North Sea (Winship 2009) suggests relatively low rates of potential increase in this population. Even in the absence of by-catch, growth rates were estimated to be approximately 0% (95% probability interval of -6% to +5%) for a density-independent model, and around 2% (95% probability interval of 0 to 7%) for a density dependent model.

Table 3.4 Definition of terms relating to the magnitude of anticipated effect on marine mammals

Magnitude of effect	Definition
High	Permanent irreversible change to exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that >1% of the reference population are anticipated to be exposed to the effect. OR Temporary effect (limited to phase of development or Project timeframe) to the exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that >10% of the reference population are anticipated to be exposed to the effect.
Medium	Permanent irreversible change to exposed receptors or feature(s) of the habitat of particular importance to the receptor. Assessment indicates that >0.01% or <=1% of the reference population anticipated to be exposed to effect. OR Temporary effect (limited to phase of development or Project timeframe) to the exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that >5% or <=10% of the reference population anticipated to be exposed to effect.
Low	Permanent irreversible change to exposed receptors or feature(s) of the habitat of particular importance to the receptor. Assessment indicates that >0.001 and <=0.01% of the reference population anticipated to be exposed to effect. OR Intermittent and temporary effect (limited to phase of development or Project timeframe) to the exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that >1% or <=5% of the reference population anticipated to be exposed to effect.
Negligible	Permanent irreversible change to exposed receptors or feature(s) of the habitat of particular importance to the receptor. Assessment indicates that <=0.001% of the reference population anticipated to be exposed to effect. OR Intermittent and temporary effect (limited to phase of development or Project timeframe) to the exposed receptors or feature(s) of the habitat which are of particular importance to the receptor. Assessment indicates that <=1% of the reference population anticipated to be exposed to effect.

Overall impact

3.3.19. The level of overall impact, and its significance, is determined by a combination of the magnitude of effect as defined in **Table 3.4** and the sensitivity of the receptor (**Table 3.3**). The probability of the impact occurring is also considered in the assessment process. If doubt exists concerning the likelihood of occurrence or the prediction of an impact the precautionary approach is taken to assign a higher level of probability to adverse effects.

3.3.20. Following from the identification of a potential impact, the impact matrix (**Table 3.5**) is used to define the level of impact Impacts defined as major or moderate are considered significant for the purpose of EIA.

Table 3.5 Impact matrix

Magnitude of effect	Receptor sensitivity			
	High	Medium	Low	Negligible
High	Major	Major	Moderate	Minor
Medium	Major	Moderate	Minor	Negligible
Low	Moderate	Minor	Minor	Negligible
Negligible	Minor	Negligible	Negligible	Negligible

Assessment of underwater noise

3.3.21. The approach to investigating the potential impacts of underwater noise is outlined in **Appendix 5A** which details the noise propagation modelling work carried out by NPL.

3.3.22. It is widely accepted that the principal potential impact upon marine mammals from offshore wind farm development comes from underwater noise resulting from pile driving of foundations (Wursig *et al*.2000; Nedwell *et al*. 2003; Thomsen *et al*. 2006). Therefore, it is appropriate to assess this factor as robustly as possible through the use of methods such as noise propagation modelling, as recommended during consultation (**Table 2.4**).

3.3.23. Underwater noise is known to have potential to cause both physiological and behavioural impacts on marine mammals. The potential impacts of underwater noise are dependent on the noise source characteristics (frequency (Hz) and decibels (dB)), the receptor species, the distance from the sound source and noise attenuation within the environment. **Appendix 5A**, Section 2 provides a detailed description of the underwater acoustics. **Appendix 5A**, Section 4 provides information on the noise propagation modelling undertaken. A brief summary of both is provided below.

3.3.24. Sound measurements underwater are usually expressed using the dB scale relative to a reference pressure which is 1µPa. Sound may be expressed in many different ways depending upon the particular type of noise, and the parameters of the noise that allow it to be evaluated in terms of biological effect. In the UK, metrics most commonly used to describe underwater sound from impact piling include peak-to-peak pressure level and Sound Exposure Level (SEL).

3.3.25. Peak level is the maximum level of the acoustic pressure, and is usually used to characterise underwater blasts, where there is a clear positive peak following the detonation of explosives. Peak to peak level is usually used in calculating the maximum variation in pressure from a positive to a negative within the sound wave. It represents the maximum change in pressure, and is often used to characterise the sound transients from impulsive sources, such as percussive impact piling and seismic airguns. Sound pressure level (SPL) is normally used to characterise noise and vibration of a continuous nature such as drilling, boring or background noise levels. SEL provides a measurement of the total acoustic energy, by summing the acoustic energy over a given period. It takes account of both the SPL and the duration of the presence of the sound in the acoustic environment. SEL therefore, measures the cumulative broadband noise energy.

3.3.26. In order to assess the effects of noise on different marine mammals, frequency-weighted hearing curves have been developed. Southall *et al*. (2007) outline generalised frequency-weighting (called M-weighting) function for each of five groups of marine mammals based on known or estimated auditory sensitivity at different frequencies. There is, however, a paucity of data, and the auditory functions are precautionary (wide) and likely overestimate the functional bandwidth for most or all species (Southall *et al*. 2007). A modified threshold has been applied for harbour porpoise, based on Lucke *et al*. (2009).

3.3.27. NPL has modelled underwater noise using the energy flux model to propagate an SEL Source Level (SL) to establish the SEL received level as a function of range (**Appendix 5A**, Section 4). The SEL dose has been modelled for high-frequency, mid-frequency, low-frequency cetaceans, and pinnipeds in water functional hearing groups, as defined by Southall *et al*. (2007). By incorporation of the sensitivity of a species group to a particular sound, further consideration of the likelihood of a behavioural response in each species can be made. The effect of the SEL dose has been predicted by summing up the SEL received levels of the entire piling sequence, assuming a fleeing animal (swim speed of 1.5m/s).

3.3.28. The potential negative impacts of noise on marine mammals are: lethal doses (causing fatality) and physical non-auditory injury, auditory injury and behavioural responses. Very close to the source, high peak pressure sound levels have the potential to cause death or severe physical injury that leads to death.

3.3.29. Exposure to high levels of underwater sound can also cause hearing impairment. Sound exposure above certain levels and durations can result in recoverable hearing loss, Temporary Threshold Shift (TTS), or Permanent Threshold Shift (PTS) following greater exposures (at higher intensity or longer duration). Southall *et al*. (2007) define minimum exposure criterion for injury at the level at which single exposure is estimated to cause onset of PTS using TTS data. Southall *et al*. (2007) provide two measures of exposure, peak pressures which are unweighted, and SEL metric which are M-weighted for the relevant marine mammal group. The five groups and the associated designations are (1) mysticetes (baleen whales), designated as low frequency cetaceans (M_{lf}); (2) some odontocetes (toothed whales), designated as mid-frequency cetaceans (M_{mf}); (3) odontocetes specialised for using high frequencies (e.g. porpoises)(M_{hf}); (4) pinnipeds (seals, sea lions and walruses) listening in water (M_{pw}); (5) pinnipeds listening in air (M_{pa}).

3.3.30. For the purpose of this assessment, the 'M-weighted' sound exposure levels are used to quantify potential occurrence of PTS based on the Southall *et al*. (2007) criteria for low (M_{lf}) and mid (M_{mf}) frequency cetaceans, for pinnipeds in water (M_{pw}) and the modified threshold (single strike) for harbour porpoise, as shown in **Table 3.6**. More detail is provided in **Appendix 5A.**

3.3.31. The M-weighted PTS-onset threshold of 186dB for pinnipeds represents a conservative approach, and it is considered likely that the 198dB threshold represents the noise levels at which the effects of PTS and TTS start to occur (Thompson & Hastie 2011).

3.3.32. Behavioural responses or disturbance caused by underwater noise can occur due to exposure to noise at levels below those predicted to cause injury or hearing damage. Once again the thresholds used in the assessment are based on Southall *et al*. (2007) for all species, with the exception of harbour porpoise where a modified threshold based on Lucke *et al*. (2009) is used.

Table 3.6 Summary of noise criteria used in the assessment for the species of marine mammals most frequently sighted in the Dogger Bank Zone.

Species group/species	**Dual injury criteria (PTS)**	**Behavioural response criteria (TTS/fleeing response)**	**Behavioural response criteria Likely avoidance of area (Possible avoidance)**
Low frequency cetaceans (M_{lf}) (minke whale)	198dB re 1 µPa^2.s	183dB re 1 µPa^2.s	152dB re 1 µPa^2.s (142dB re 1 µPa^2.s)
Mid-frequency cetaceans (M_{mf}) (white-beaked dolphin)	198dB re 1 µPa^2.s	183dB re 1 µPa^2.s	170dB re 1 µPa^2.s (160dB re 1 µPa^2.s)
Harbour porpoise (modified threshold, single strike)	179dB re 1 µPa^2.s	164dB re 1 µPa^2.s	164dB re 1 µPa^2.s (145dB re 1 µPa^2.s)
Pinnipeds in water (M_{pw}) (grey seal)	186dB re 1 µPa^2.s	171dB re 1 µPa^2.s	171dB re 1 µPa^2.s

Calculating impacts

3.3.33. The approach used in calculating the potential number of individuals impacted by noise from pile driving is dependent on the species under consideration and the underlying data confidence. For each species, the potential impacts have been calculated by overlaying impact areas on average densities or over maximum mean densities (in the case of grey seal).

3.3.34. Site specific survey data have been used in the calculation of density surfaces. However, it has been assumed that densities of marine mammals in areas outwith the survey are the same as those generated within the survey area, to allow consideration of the magnitude of impacts beyond the extent of the survey boundary. This approach has been adopted as the most suitable method in the absence of the JCP database, which could have provided contextual data for the assessment but which was not available to Forewind at the time of writing the ES. Seal density estimates for 5km by 5km cells around the UK, made publically available by Marine Scotland (Jones *et al*. 2013), are used in the assessment.

3.3.35. The scale of the impacts across the regional populations is quantified in comparison to the reference populations, as defined in Section 4 Existing Environment.

4. Existing Environment

4.1. Study area

4.1.1. Cetacean populations occurring in UK waters are generally wide-ranging, their distribution and abundance vary considerably over time and space, influenced by both natural and anthropogenic factors (Reid *et al*. 2003). There may be some areas of regular high density for some species, but how important these areas are in comparison to others in their natural range, is still generally unknown (Reid *et al*. 2003).

4.1.2. When considering the foraging and haul-out patterns of harbour and grey seal, the potential effects of Dogger Bank Teesside A & B can be assessed in relation to a small number of breeding colonies scattered along the east coast of the UK and the west coast of mainland Europe.

4.1.3. The IAMMWG MUs for marine mammals in UK waters have been used as appropriate reference populations for cetacean species (IAMMWG 2013). Consideration has also been given to the relevant European populations for seal species, due to the limits of the MUs being UK territorial waters (12nm).

North Sea

4.1.4. The study area for marine mammal interest, with regard to Dogger Bank Teesside A & B, is relatively wide, covering a large portion of the North Sea for all species. For minke whale and white-beaked dolphin, the area of interest is even wider, extending to the North Atlantic.

4.1.5. The species diversity and abundance of marine mammals within the southern North Sea is relatively low and reduces progressively southwards (Sea Watch Foundation 2008). The most common and regularly occurring cetaceans are those species associated with relatively shallow continental seas, such as harbour porpoise and white-beaked dolphin.

4.1.6. The data presented by Reid *et al*. (2003), SCANS I and SCANS II reveal that eight marine mammal species occur regularly over large parts of the southern North Sea. These include:

- Pinnipeds; grey seal and harbour seal;
- Odontocetes; harbour porpoise, bottlenose dolphin, white-beaked dolphin, Atlantic white-sided dolphin, and killer whale; and
- Mysticetes; minke whale.

4.1.7. Other species, including sperm whale, long-finned pilot whale and short-beaked common dolphin are occasional visitors to the southern North Sea. The conservation status and best available population estimates for these species are presented in **Table 2.3**.

4.1.8. Based on the data sources presented in **Table 3.1**, species occurrence has been summarised in **Table 4.1**. Site specific surveys have been used to further refine occurrence later in this section of the chapter. Further information summarising distribution and breeding ecology of key species is shown in **Table 4.2**.

Table 4.1 Summary of potential occurrence of marine mammals in the Dogger Bank Zone and Offshore ZDE (Sources: Reid *et al*. 2003; Sharples *et al*. 2005; McConnell *et al*. 1999).

Species	Offshore ZDE	Dogger Bank Zone
Harbour porpoise	Common, occurs throughout the year, with peak numbers in the south eastern North Sea January – April.	Common, occurs throughout the year, with peak numbers in the south eastern North Sea January – April.
Minke whale	Regular, occurs throughout the year. Mainly in near-shore waters between May and September.	Regular, occurs throughout the year.
White-beaked dolphin	Common, occurs throughout the year, mainly between June and October in near-shore waters.	Common, occurs throughout the year.
Bottlenose dolphin	Occasional	Occasional
Common dolphin	Occasional	Occasional
Atlantic white-sided dolphin	Occasional	Occasional
Risso's dolphin	Occasional	Occasional
Killer whale	Occasional	Occasional
Grey seal	Regular, all year	Regular, all year
Harbour seal	Occasional	Occasional

Table 4.2 Summary of diet, distribution and breeding seasons of regular marine mammal species within the Dogger Bank Zone and Offshore Cable Area (Sources: Evans 1987; Perrin *et al*. 2002; Reid *et al*. 2003; SCOS 2010).

Species	Diet	Distribution	Breeding season
Harbour porpoise	Small fish including whiting *Merlangius merlangus*, poor cod *Trisopterus minutus*, Norway pout *Trisopterus esmarkii*, herring *Clupea harengus*, sandeels *Ammodytes spp*. and gobies *Gobiidae spp*.	Mainly over the continental shelf.	Birth – May to August. Gestation 10.5 months.
Minke whale	Wide variety of fish including herring, cod *Gadus morhua*, capelin *Mallotus villosus*, haddock *Melanogrammus aeglefinus*, saithe *Pollachius virens* and sandeel	Mainly over the continental shelf in water depths of 200m or less.	Birth – Diffusely seasonal. Gestation 10 months.
White-beaked dolphin	Fish including mackerel *Scomber scombrus*, herring, cod, capelin, whiting, haddock, hake *Merluccius merluccius*, sandeel, gobies and flatfish.	Usually over the continental shelf in waters of 50 – 100m depth.	Birth – Summer. Gestation 10 to11 months.
Grey seal	Fish including poor cod, whiting, cod, ling *Molva molva*, sandeels, flatfish, Atlantic salmon *Salmo salar*, mackerel and herring.	Mainly coastal waters and occasional further offshore.	Birth –October- January (mainland Europe). Gestation – 11 months (including delayed implantation).

Species	Diet	Distribution	Breeding season
Harbour seal	Fish including sandeels, herring, whiting, flatfish and saithe.	Mainly coastal waters and occasional further offshore.	Birth – June to July. Gestation – 11 months (including delayed implantation).

4.2. Cetaceans

Harbour porpoise

Desk-based data review

4.2.1. Harbour porpoise is the most commonly sighted cetacean in the North Sea (ASCOBANS 2012) and is the cetacean likely to be found in the greatest numbers in the Dogger Bank Teesside A & B study area.

4.2.2. Studies using skeletal material, along with studies of tooth structure, genetics and telemetry suggest that sub-populations of harbour porpoise exist in the North Sea and adjacent waters, with the North Atlantic population being divided into a total of 15 management units (Evans *et al*. 2009). The majority of the Dogger Bank Zone is encompassed by the South-western North Sea & Eastern Channel (SWNS) management unit, with the South-western fringes of North eastern North Sea & Skagerrak unit just to the north and east (**Figure 4.1**).

4.2.3. The gestation period for harbour porpoise is ten months, and peak mating activity is likely to occur in August. Evidence for social and sexual activity in late summer has been widely reported. Females are believed to nurse their calves for between eight and 12 months. Weaning is a gradual process, with young starting to take solid food after a month or two. Off the coast of the British Isles and in adjacent seas, calves have been observed between February and September, particularly during May to August, with a peak in June. This occurrence coincides with the findings of reproductive studies conducted on stranded or by-caught animals (Evans *et al*. 2009).

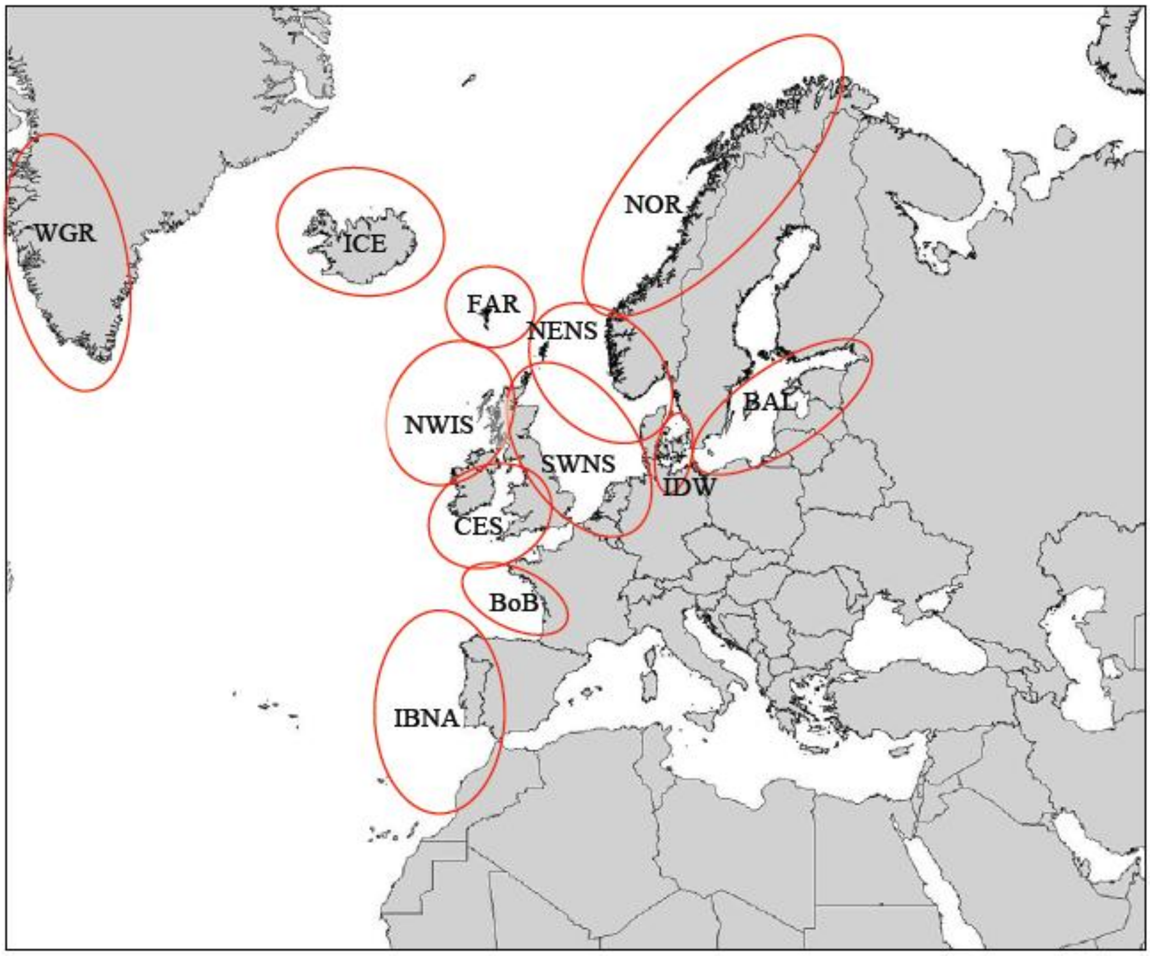


Figure 4.1 Recommended management units for harbour porpoise in the ASCOBANS agreement area and environs (Evans *et al*. 2009).

4.2.4. Genetic evidence from the UK and elsewhere also indicates that males disperse more widely than females (Reid *et al*. 2003).

4.2.5. Harbour porpoise in the North Sea feed mainly on demersal fish, notably small gadoids, clupeids and sandeels (Santos & Pierce 2003). It is believed that the balance of their diet has changed over the past 40 years from herring to whiting dominated, reflecting the change in composition of available food resources (Reid *et al*. 2003).

4.2.6. The SCANS surveys were a major international collaborative survey program carried out to provide baseline data on cetacean abundance in the North Sea, Baltic and Celtic Seas. Surveys were undertaken in 1994 and 2005, however the extent of the 2005 survey was larger than in 1994 (the extent of each survey can be seen in **Figure 4.2**).

4.2.7. Estimated abundance in 2005 in the equivalent area surveyed in 1994 was 323,968 (CV=0.22; 95% CI=256 300 - 549 700, Hammond *et al.* 2013), compared to 341,366 (CV=0·14; 95% CI=260 000 - 449 000) in 1994 (SCANS-II 2008) showing no change in the overall estimated abundance in the North Sea.

4.2.8. In 2005 the Southern North Sea population was estimated to be 140,229; the Northern North Sea 33,598; the Central North Sea 58,623; and a European wide population of 375,358 (95% CI 256,304 - 549,713).

4.2.9. The population used in the assessment is the IAMMWG North Sea (NS) MU, with an estimated abundance of 227,298 (CV 0.13, 95% CI 176,360 – 292,948) based on the Hammond et al. (2013) analysis. The NS MU comprises ICES area IV, VIId and Division IIIa (Skagerrak and north Kattegat). However, constraining the reference population to this MU could be a conservative approach as guidance from Marine Scotland (Northridge 2012) suggests that considering large stock areas for harbour porpoise is appropriate; with open borders existing between the North Sea and the Kattegat, the North Sea and Norwegian Sea and between western Channel and Celtic Shelf/Irish Sea.

4.2.10. Despite no overall change in population size, large scale changes in the distribution of porpoise were observed between the 1994 and 2005 SCANS II survey, with the main concentration shifting from North eastern UK and Denmark to the southern North Sea (**Figure 4.2a** and **b**). This trend is likely the result of changes to the availability of principal prey, notably within the northern North Sea (SCANS-II 2008).

4.2.11. As part of the SCANS II survey analysis, model-based estimates of harbour porpoise abundance were obtained by fitting a General Additive Modelling (GAM)-based density surface model to the survey data that included longitude, latitude, depth and distance to coast. The predictions from these models were used to obtain local density estimates (animals per km^2) on a two minute grid (i.e. ~$8.15km^2$). **Figure 4.3** shows the latest North Sea harbour porpoise surface densities derived from the SCANS II dataset (Hammond *et al*. 2013).

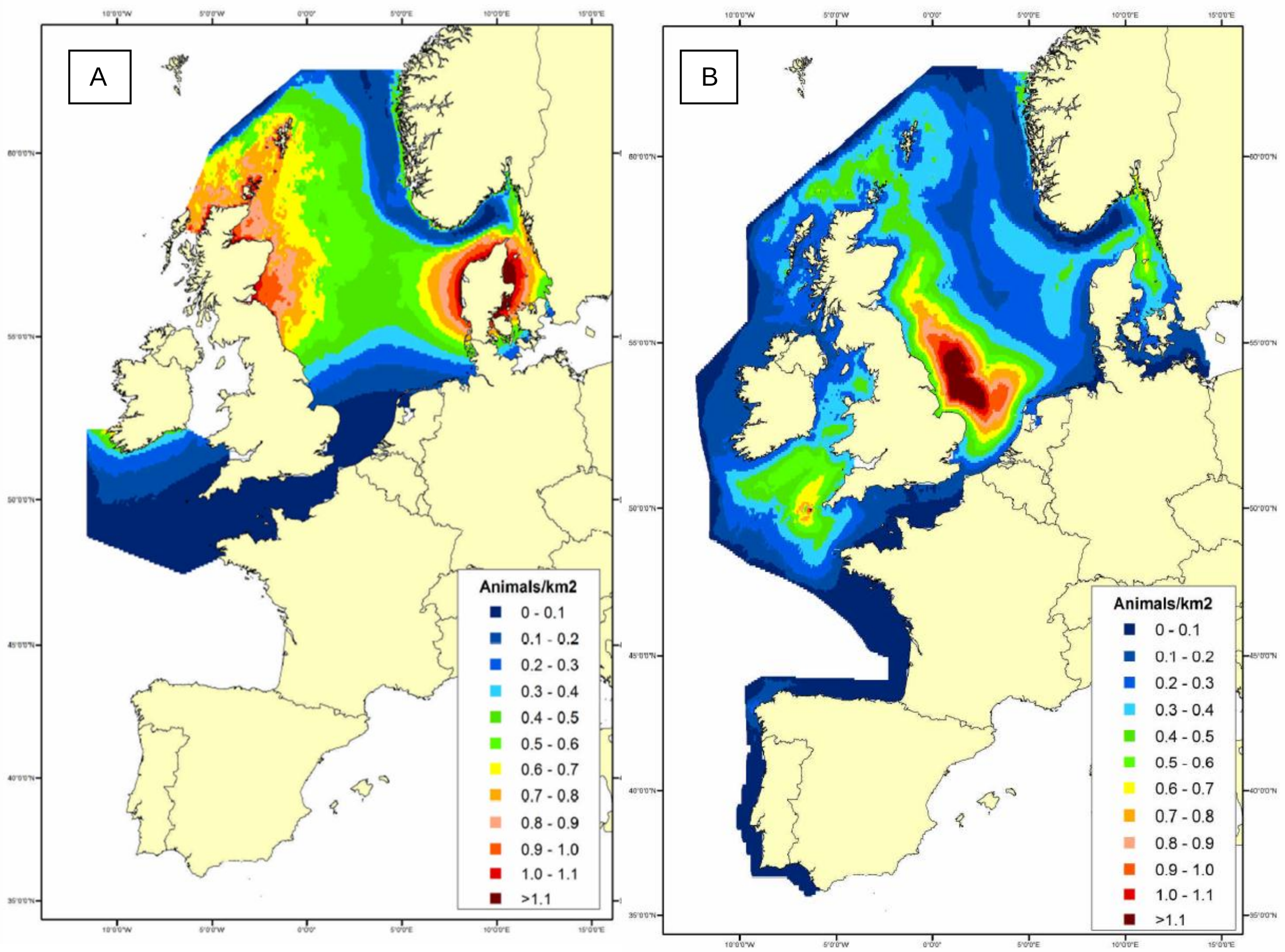


Figure 4.2 Harbour porpoise estimated density surface (animals per km^2) in (a) 1994 and (b) 2005 (Hammond *et al*. 2013).

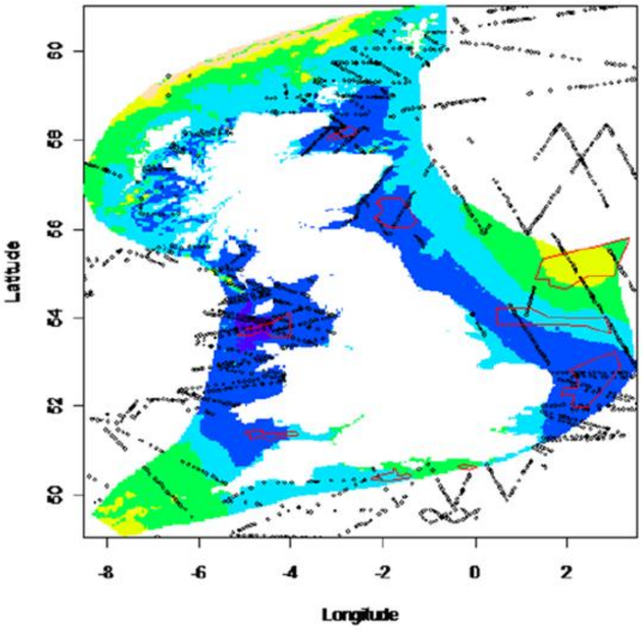


Figure 4.3 Estimates of local harbour porpoise density (animals per km^2) from SCANS-II at two- minute grid resolution. Key: Intervals 0 – 0.2 violet, 0.2 – 0.4 deep blue, 0.4 – 0.6 medium blue, 0.6 – 0.8 pale blue, 0.8 -1 blue-green, 1 – 1.2 green, 1.2 – 1.4 yellow. R3 zones are shown in red. Dots indicate survey effort. (SMRU Ltd 2010)

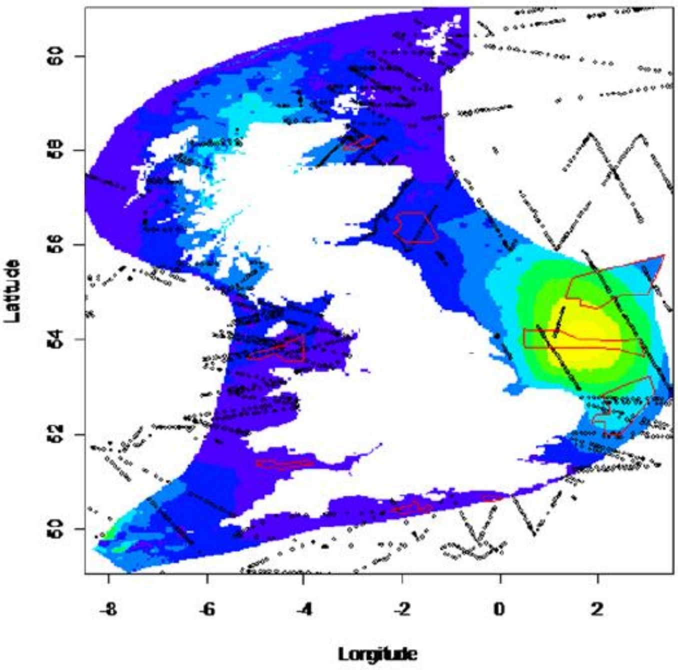


Figure 4.4 Estimates of coefficients of variation of SCANS-II harbour porpoise density at two- minute grid resolution. Key: Intervals 0 – 0.16 violet, 0.16 – 0.3 medium blue, 0.3 – 0.5 pale blue, 0.5 – 1 green, 1 – 2 green-yellow, 2 – 3 yellow, 3+ beige. R3 zones are shown in red. Dots indicate survey effort. (SMRU Ltd 2010)

4.2.12. These data confirm that, relative to the offshore areas of the southern North Sea, the waters within and adjacent to the Dogger Bank Teesside A & B study area have relatively high densities of harbour porpoise. In general, abundance estimates from surveys with a lot of effort and sightings tend to be more precise i.e. have a low CV. CVs for each grid cell were estimated from 200 bootstrap replicates made by re-sampling on transects (SMRU Ltd 2010). **Figure 4.4** shows the levels of uncertainty in relation to harbour porpoise density estimates over the UK continental shelf. Highest modelled harbour porpoise densities occurred off the east coast of the UK, particularly in the region of the Dogger Bank site. The uncertainty associated with the estimates for porpoise in the Dogger Bank region is high.

4.2.13. The SCANS II density surfaces presented in **Figure 4.3** suggest that the Dogger Bank Teesside A & B study area has a density of between 1.2-1.4 harbour porpoise per km^2.

4.2.14. **Figure 4.5** summarises the annual harbour porpoise distribution around the UK from the Atlas of Cetacean Distribution in North west European Waters (Reid *et al*. 2003). Harbour porpoise have been reported as being widely distributed across the north and central North Sea, with important concentrations off the west coast of Scotland in the southern Irish Sea, and off south-western Ireland. It was generally believed that the shallow, more silt laden, waters of the southern North Sea have fewer sightings, and authors have suggested that numbers of harbour porpoise in the southern North Sea and English Channel declined during the 20^{th} century (Reid *et al.* 2003). However, as highlighted by SCANS I and SCANS II, there is potential for changes in distribution to occur, the most likely cause being changes in availability and distribution of their prey species.

4.2.15. The JNCC Cetacean Atlas regularly recorded sightings of harbour porpoise throughout the Dogger Bank Zone. The highest sightings rates in the south eastern North Sea (**Figure 4.5**) occur in January to April; although overall sightings are low in this region. Most sightings around the Outer Hebrides, in contrast occurred between May and September; however survey effort was less in winter months (Reid *et al*. 2003).

4.2.16. A study of the distribution of cetaceans and pinnipeds (as well as sharks, turtles and ocean sunfish) has also been carried out by the WWT (2009). Data on distribution and abundance were collected opportunistically during aerial surveys for waterbirds conducted by WWT Consulting from 2001-2008. The survey method was comparable to that used for the collection of previous cetacean data including the SCANS project (Hammond *et al*. 2002).

4.2.17. A total of 4,588 sightings, comprising 5,439 individual animals, were made of harbour porpoise (WWT 2009). The results show a similar distribution to those presented in Reid *et al*. (2003), with higher frequencies close to shore around the west coast and off the Lincolnshire and Yorkshire coasts, but with much higher frequencies recorded off the coast between Norfolk and Kent.

4.2.18. Results are also similar to those recorded in the SCANS II project, in which much larger numbers of harbour porpoise were recorded in the southern North

Sea than in the 1994 SCANS surveys. Density estimates from WWT 2009 for harbour porpoise are illustrated in **Figure 4.6**.

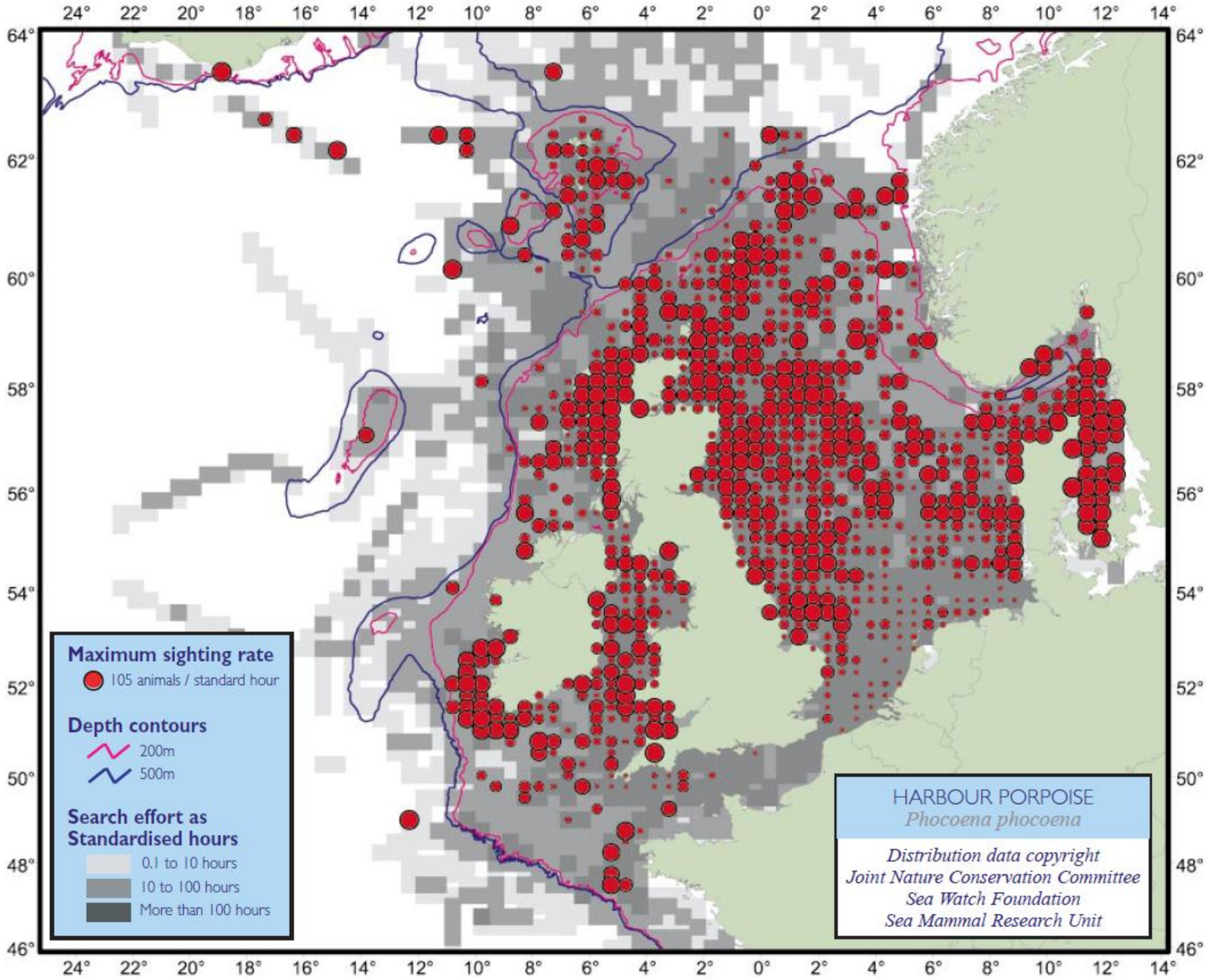


Figure 4.5 Annual harbour porpoise distribution around the UK (Reid *et al*. 2003).

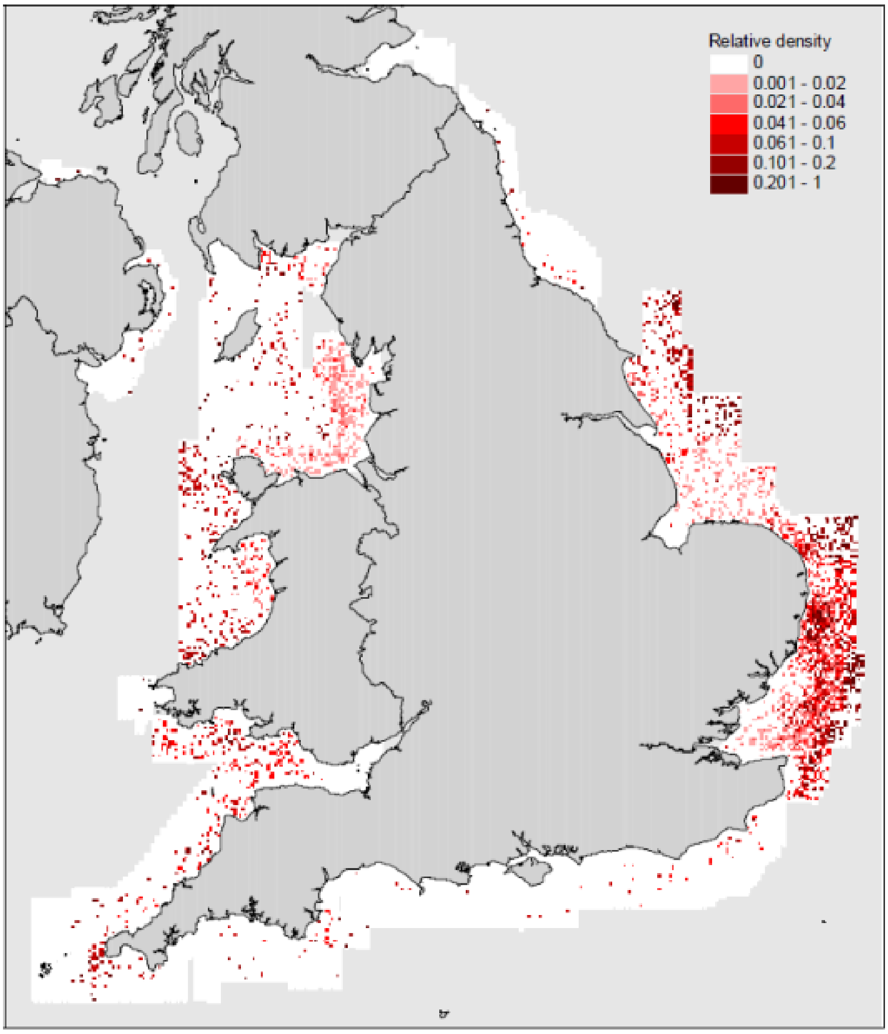


Figure 4.6 Harbour porpoise densities (WWT 2009).

4.2.19. In 2011, a dedicated aerial line transect survey was conducted over the Dogger Bank and adjacent area (including UK, Dutch, Danish and German waters) in order to investigate the importance of the marine habitat for marine mammals (Gilles *et al*. 2012, 2011a). The ITAW and IMARES conducted the surveys as part of a wider framework of the Natura 2000 monitoring programme, which also included acoustic surveys and aerial survey in 2010 and 2011 (Gilles *et al*. 2011b).

4.2.20. The 2011 late summer survey represented the first aerial survey covering the entire Dogger Bank area. It showed that harbour porpoise frequently occurred in the area at this time of year (10 survey days completed between 28 July and 1 September). The highest number of porpoise sightings was in UK and Danish waters (**Figure 4.7**). The abundance estimate for the whole area was 116,448 porpoise (CV=0.31), and the average density over the area was 1.82 animals per km^2. The highest densities were to the western and north eastern part of the survey area and lower on the sandbank itself (**Figure 4.8**).

4.2.21. Over the wider North Sea, harbour porpoise satellite telemetry has been conducted in Danish waters, and has shown that animals in the northern Kattegat, the Skagerrak and northern North Sea spend the majority of their time in the north western North Sea, with occasional trips to the south-western North

Sea, including the wider Dogger Bank Zone. Locations of the tagged porpoise are show in **Figure 4.9**.

4.2.22. Ship based surveys which included part of the Dogger Bank Zone in March 2008 recorded harbour porpoise in low abundance. The primary purpose of these surveys was seabird observations to update the European Seabirds At Sea (ESAS) data on seabird distribution, as part of the SEA process; surveys were funded by DECC. Surveys in August and September 2008, when coverage was complete, recorded harbour porpoise at low to moderate abundance, but with sporadic occurrence (less than 1 animal per km; Cork Ecology 2009).

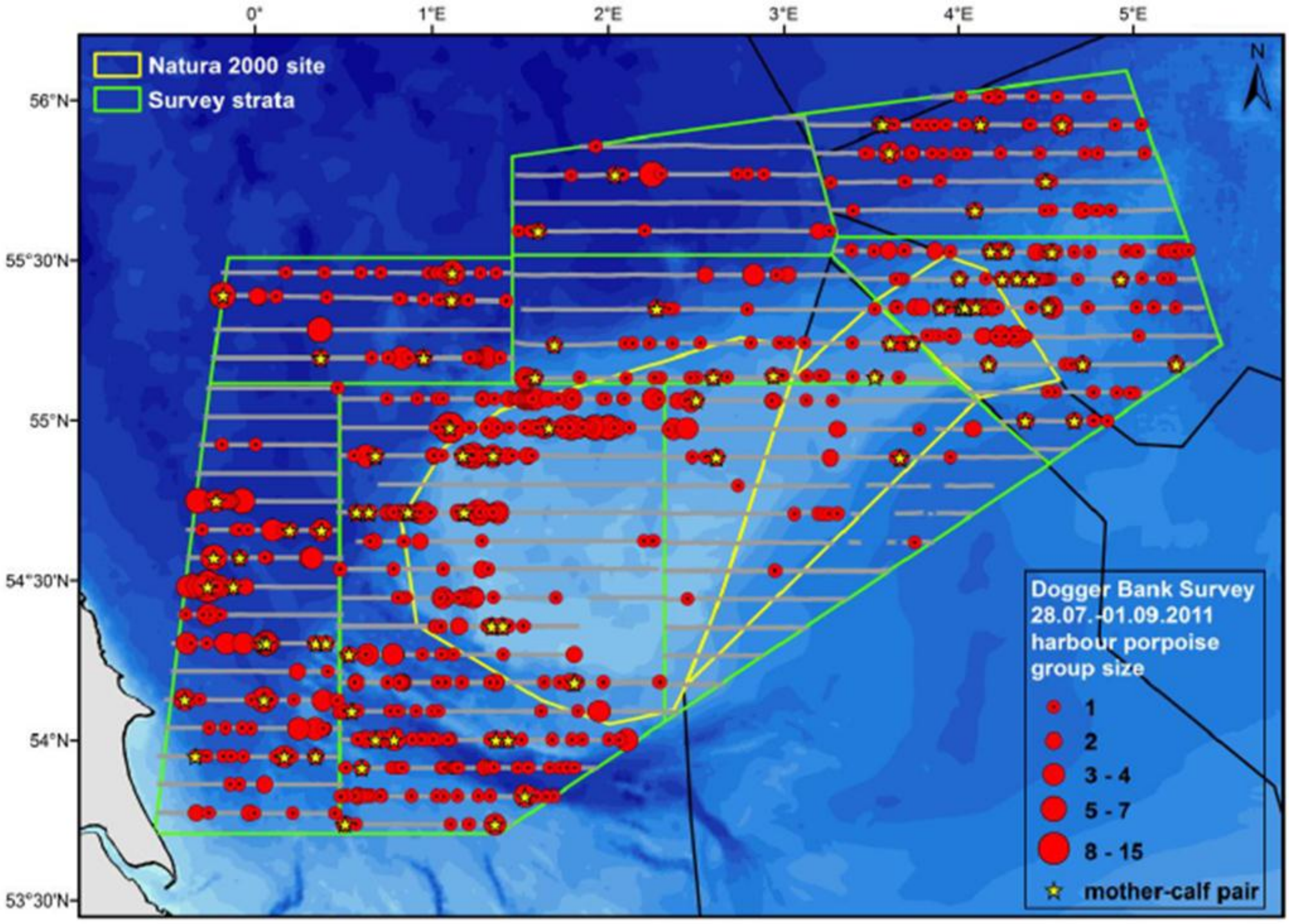


Figure 4.7 Realised survey effort (grey lines) and harbour porpoise group sightings. Only effort in good and moderate sighting conditions is shown (Gilles *et al*. 2012).

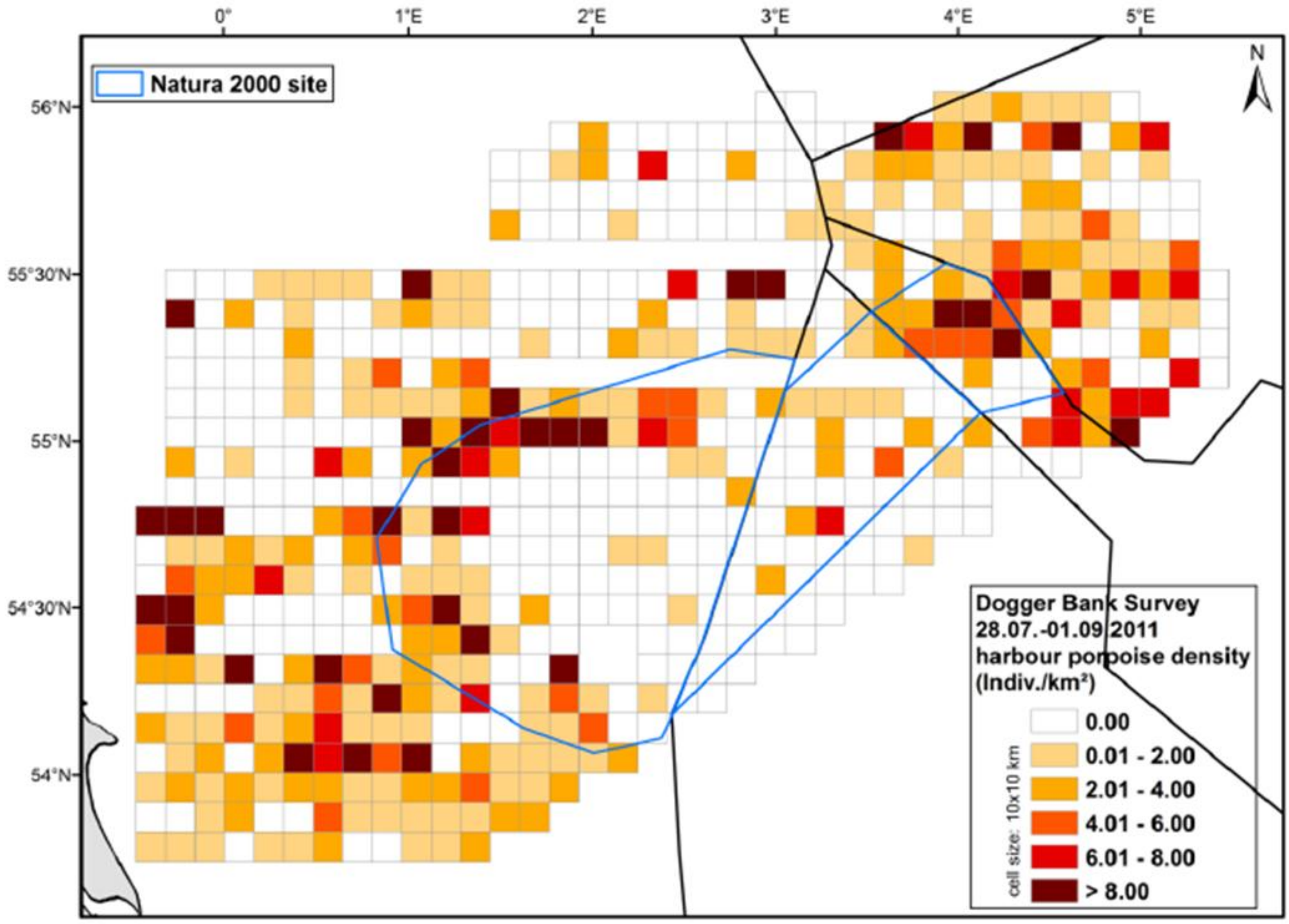


Figure 4.8 Spatial distribution of harbour porpoise density (individuals per km^2) during the survey at Dogger Bank in summer 2011. Grid size 10x10km (Gilles *et al*. 2012).

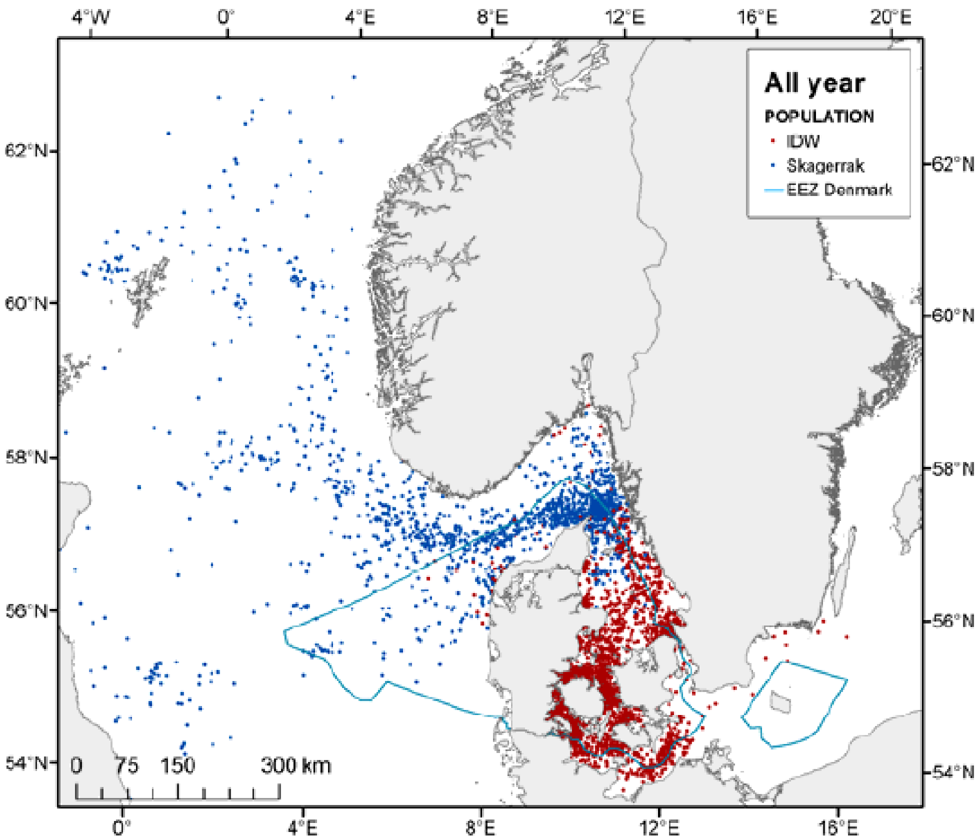


Figure 4.9 Locations (one per day) of 363 radio-tagged porpoises. Porpoise tagged in the Inner Danish Waters are red, and those tagged in the northern tip of Jutland (Skagen) are blue (N=63 porpoises, N = 4287 locations) (Evans *et al*. 2010).

Site Specific Surveys

4.2.23. Dogger Bank Zone-specific monthly boat-based surveys (between January 2010 and January 2012 recorded low numbers of harbour porpoise in the Dogger Bank survey area (**Figure 3.1**) between February and April 2010, with an increase in activity in May 2010. **Figure 4.10** summarises the number of sightings over the survey period. Sightings increased during spring 2011, peaking in April, but occurrence was highest in September 2011, when 81 individuals (in survey view) were identified. The hourly encounter rate in May 2010 was 0.5 animals per hour, or less than 0.1 animals per km, although this included data recorded in all sea states. Detection rate per km in May 2010 was lower than that recorded in the Dogger Bank Zone in August and September 2008 (Cork Ecology 2009).

4.2.24. As sea state increases, it becomes increasingly difficult to detect small cetaceans such as harbour porpoises. Camphuysen *et al*. (2004) recommended that only observations of marine mammals recorded in sea states of 0 to 3 should be used in subsequent analysis. Although a detailed analysis of weather conditions during the boat surveys was beyond the scope of this review, more than 90% of surveys between April and June 2010 were conducted in sea states of 0 to 3, though 44-84% of surveys outwith this period were in sea states 0 to 3. These results indicate that, generally, high numbers of harbour porpoises may be present in Dogger Bank Teesside A & B, especially during the periods of early summer and autumn.

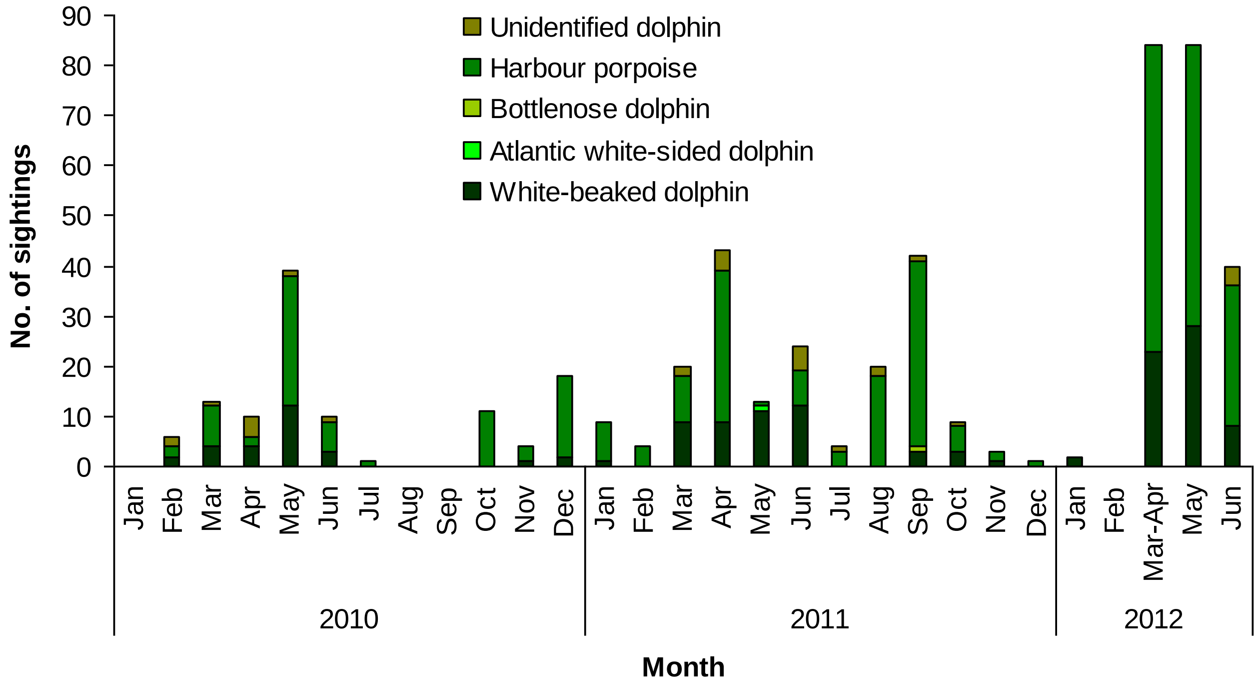


Figure 4.10 Odontocete sightings during boat based surveys January 2010 to June 2012 (Gardline Environmental 2012).

4.2.25. Aerial surveys of the Dogger Bank Zone using HiDef video cameras have been ongoing since November 2009. DMP Statistical Solutions UK Limited (DMP) has been contracted to undertake spatial and temporal adaptive modelling to calculate estimates of the abundance surfaces (by month, year and entire survey period), and annual estimates of abundance and associated inference from the high definition surveys up to July 2012.

4.2.26. The aerial surveys of Dogger Bank between November 2009 and July 2012 show harbour porpoise to be abundant, particularly in May and June each year. The highest number of individuals identified in a month was 930, in May 2011.

4.2.27. The large overall number of sightings of harbour porpoise meant that absolute abundance and absolute density could be investigated over temporal (yearly and monthly) and spatial scales. **Figure 4.11** shows the estimated absolute densities and associated uncertainty from analysis of the data between 2009 and 2012.

4.2.28. Spatial distribution of harbour porpoise was relatively consistent between the survey years. However, it should be noted that the models contain `year' fitted as a factor variable so the spatial patterns each year are informed by information collected throughout the survey period. The spatial patterns are not permitted to change in structure annually (e.g. the higher density areas cannot move across years), although the absolute number of individuals can change annually. This was deemed to be the best approach based on the data available, providing more confidence in the absolute density estimates shown in **Figure 4.11**. If the spatial patterns were permitted to change in structure annually the large number of parameters that need to be estimated can result in problems and in particular, high uncertainty about the estimated densities in every year.

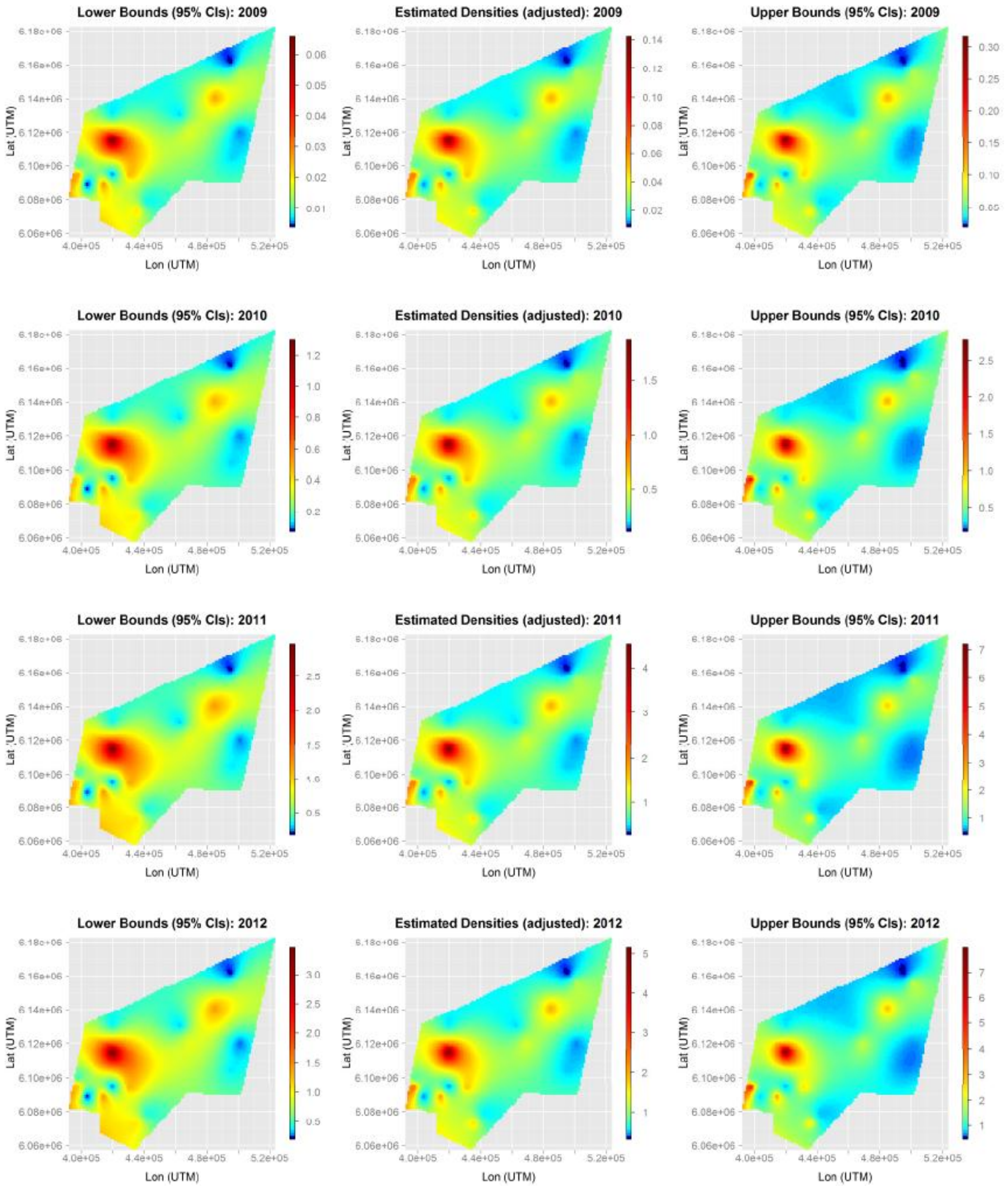


Figure 4.11 Estimated absolute densities, and upper and lower bounds of the associated 95% confidence intervals of harbour porpoise (on a fine grid) per km^2 in each year, averaged in each grid cell after adjusting for availability.

4.2.29. Modelled estimates of harbour porpoise absolute density, calculated from the raw and fitted data ranged from 0 to 1.5 (1.2-2.5) porpoise per km^2 in 2009, 0 to

2 (1.2-2.5) in 2010, 0 to 4 (2.5-7) porpoise per km^2 in 2011, and 0 to 5 (3-7) in 2012 (**Figure 4.11**). Upper and lower 95% CI for the maximum densities are provided in brackets showing the range, when incorporating the confidence intervals, is relatively wide. Density estimates appear to be increasing with the highest in 2012.

4.2.30. As previously discussed the results show a peak in harbour porpoise abundance annually in May-June. The absolute abundance estimates (after adjusting for availability) are relatively consistent outside these months (**Figure 4.12**). Estimated abundance in the zone peaks at a value approaching 40,000 in May 2011 and May 2012. The estimated absolute abundance for the zone averaged across years was 8,358 (95% CI 7536-9310) and the estimated absolute density across years was 0.64056 individuals per km^2 (95% CI 0.57756-0.71352) after adjusting for availability (**Appendix 14B**).

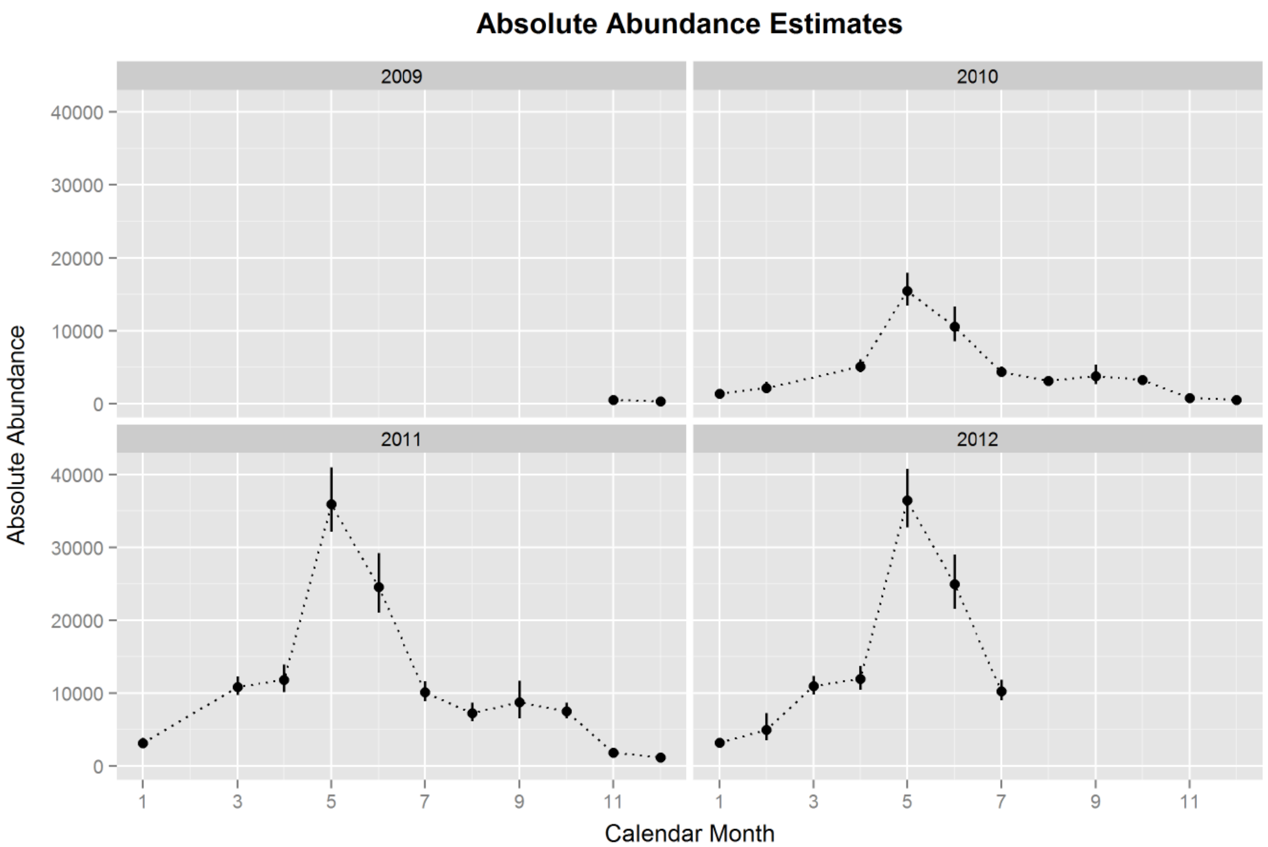


Figure 4.12 Estimates of absolute abundance of harbour porpoise (after adjusting for availability) and associated upper and lower 95% confidence intervals (see Appendix 14B for details of methods of calculation).

4.2.31. Given the high degree of spatial distribution of harbour porpoise, and the variation in monthly abundance it was agreed during consultation with JNCC for Dogger Bank Creyke Beck (**Table 2.4**) that the use of average densities would be appropriate in the impact assessment for this highly mobile species, therefore this has been applied to Dogger Bank Teesside A & B.

4.2.32. There is acknowledgement that the actual density of harbour porpoise will vary over space and time, and the use of average densities provides a simplistic, yet realistic representation of the distribution of animals, and thus the potential number of animals that could be exposed to an impact.

Potential harbour porpoise

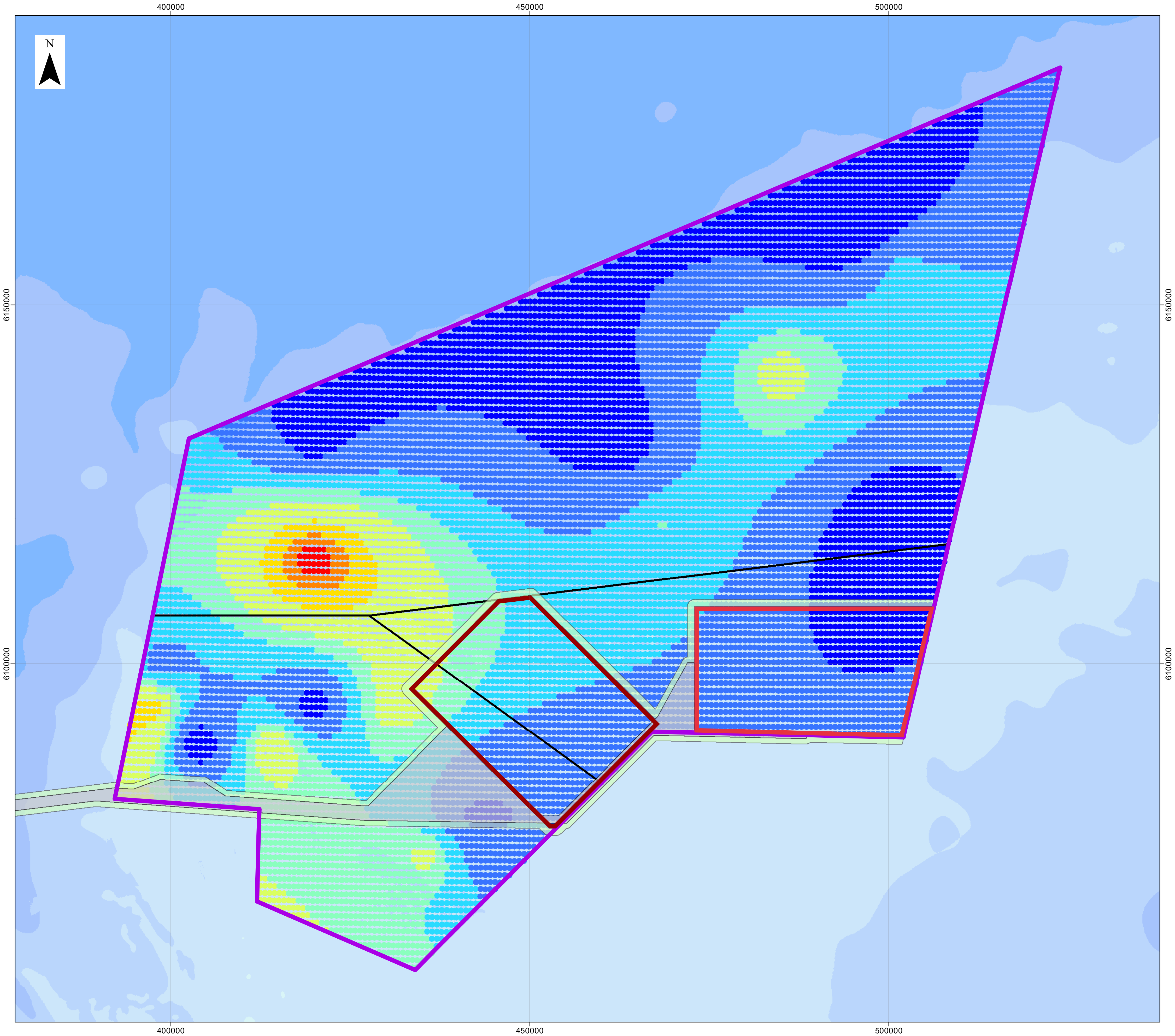
4.2.33. The estimates of density and absolute abundance presented above and generated from the HiDef surveys do not take account of sightings that are 'potentially' harbour porpoise. The sighting category of 'potential harbour porpoise' included all sightings that could not be definitely assigned to species level, e.g. sightings recorded as cetacean species, cetacean species/seal species/shark species, N/A, no ID, small cetacean species and small cetacean/seal species.

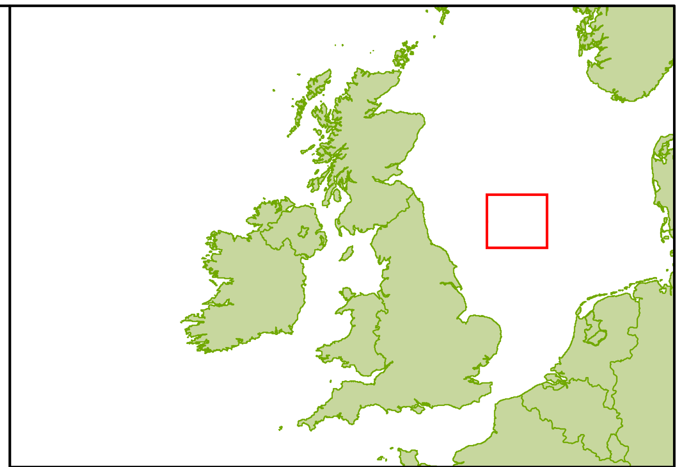
4.2.34. As observed for harbour porpoise, there was consistency in the spatial distribution of the sightings of 'potential harbour porpoise' and peaks in abundance were observed in May and June. Although it is likely that the majority, but not all, of these sightings are harbour porpoise, a precautionary approach of assuming all are harbour porpoise was adopted for the assessment. Following the same methods as applied for harbour porpoise, estimates of absolute density were then calculated for the harbour porpoise and potential harbour porpoise combined. Based on HiDef data up to July 2012, the revised absolute density estimates; when combining the data, produced approximate ranges from 0 to 2 (95% CI 1.4-3.5) in 2010, 0 to 4 (95% CI 3-7) in 2011 and 0 to 5 (95% CI 3-8) (**Appendix 14B** Figure 11).

4.2.35. Following from the logic for using average densities (over space and time) for harbour porpoise, average densities have also been generated for harbour porpoise and potential harbour porpoise combined for HiDef data collected until July 2012.

4.2.36. Based on data collected until the end of July 2012, estimates of absolute abundance for harbour porpoise and potential harbour porpoise combined were 9,344 (95% CI 6,822-12,700), and absolute density was 0.7161 (95% CI 0.52284 – 0.97333) individuals per km^2 across the survey area (**Appendix 14B**).

4.2.37. **Figure 4.13** shows the mean densities of harbour porpoise across the Dogger Bank Zone, based on the aerial survey data. **Figures 4.14** and **4.15** provide the lower and upper 95% confidence intervals, respectively. **Figure 4.16** shows the mean density estimates of harbour porpoise and potential harbour porpoise combined, with **Figures 4.17** and **4.18** providing the lower and upper 95% confidence intervals. Density estimates in the Dogger Bank Teesside A boundary is relatively low. Distribution is concentrated around an area to the north west of Dogger Bank Teesside B.





LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside A & B Export Cable Corridor
- Temporary works area

Absolute mean density (km²)

- ≤ 0.40
- 0.41 - 0.60
- 0.61 - 0.80
- 0.81 - 1.00
- 1.01 - 1.50
- 1.51 - 2.00
- 2.01 - 2.50
- ≥ 2.51

0 5 10 20
Kilometres

Data Source:
Density data © DMP Stats, 2013
Round 3 offshore wind farm boundary © Crown Copyright, 2013
Background bathymetry image derived in part from TCarta data © 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 4.13 Absolute mean densities (in km²) of harbour porpoise adjusted for availability

VER	DATE	REMARKS	Drawn	Checked
1	27/08/2013	Draft	LW	GK
2	03/10/2013	PEI3	JE	GK
3	11/02/2014	DCO Submission	JE	GK

DRAWING NUMBER: **F-OFL-MA-210**

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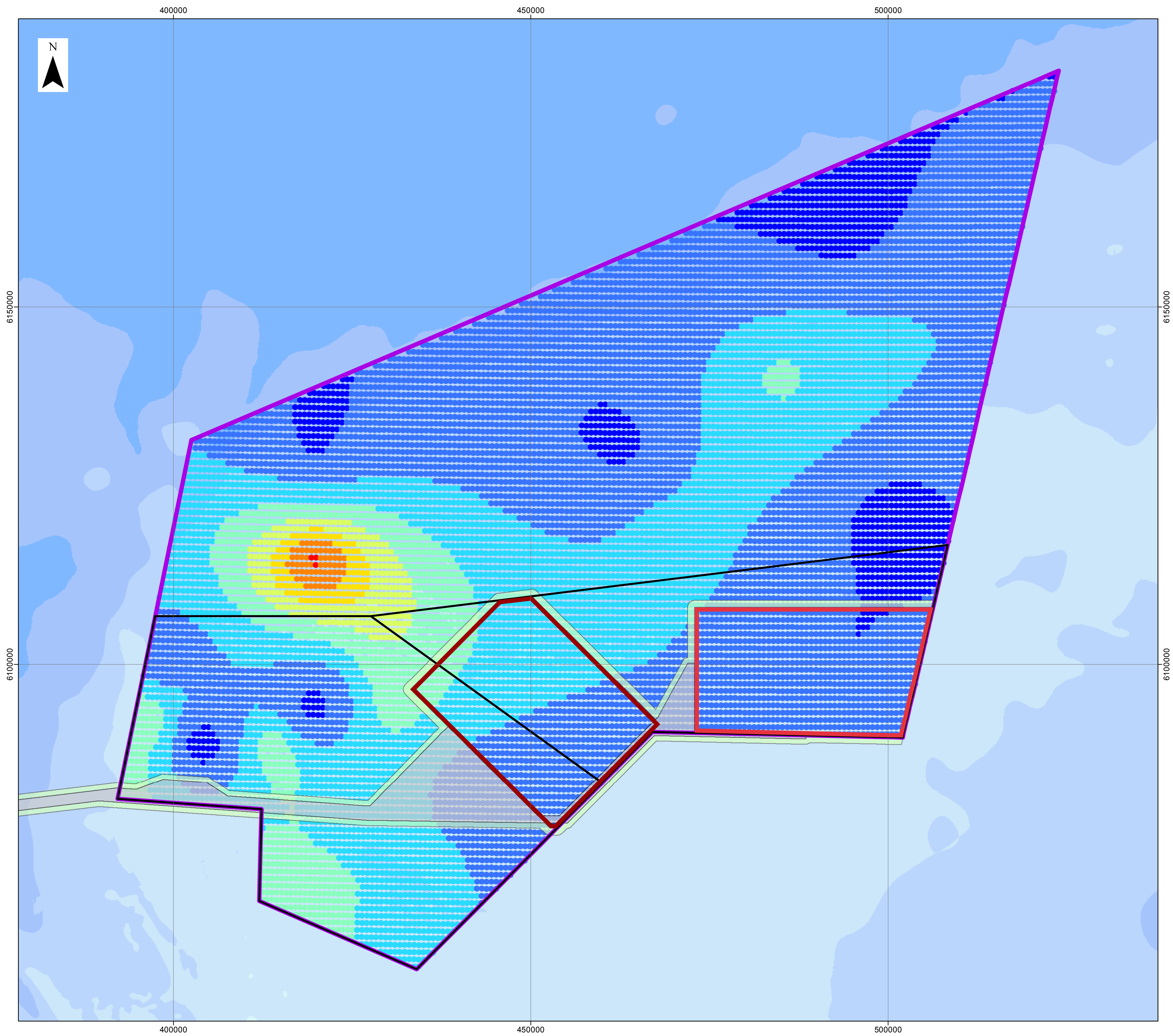

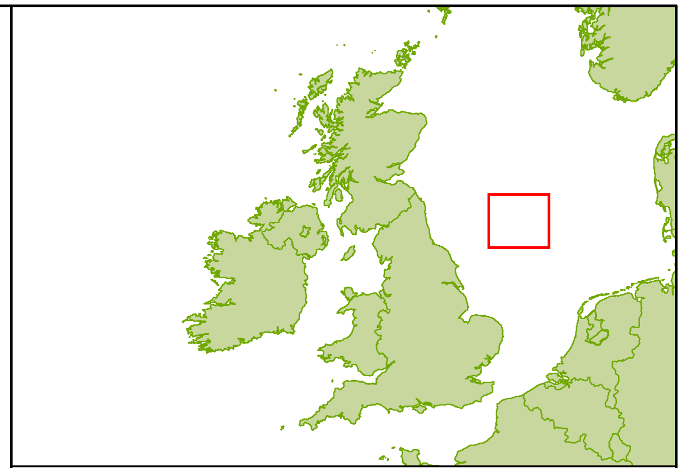

LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside A & B Export Cable Corridor
- Temporary works area

Absolute mean density (km²)

- ≤ 0.250
- 0.251 - 0.500
- 0.501 - 0.750
- 0.751 - 1.000
- 1.001 - 1.250
- 1.251 - 1.500
- 1.501 - 2.000
- ≥ 2.001

0 5 10 20
Kilometres

Data Source:
Density data © DMP Stats, 2013
Round 3 offshore wind farm boundary © Crown Copyright, 2013
Background bathymetry image derived in part from TCarta data © 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 4.14 The lower 95% confidence bound for the absolute mean densities (in km²) of harbour porpoise adjusted for availability

VER	DATE	REMARKS	Drawn	Checked
1	27/08/2013	Draft	LW	GK
2	03/10/2013	PEI3	JE	GK
3	11/02/2014	DCO Submission	JE	GK

DRAWING NUMBER: **F-OFL-MA-211**

SCALE	PLOT SIZE	DATUM	PROJECTION
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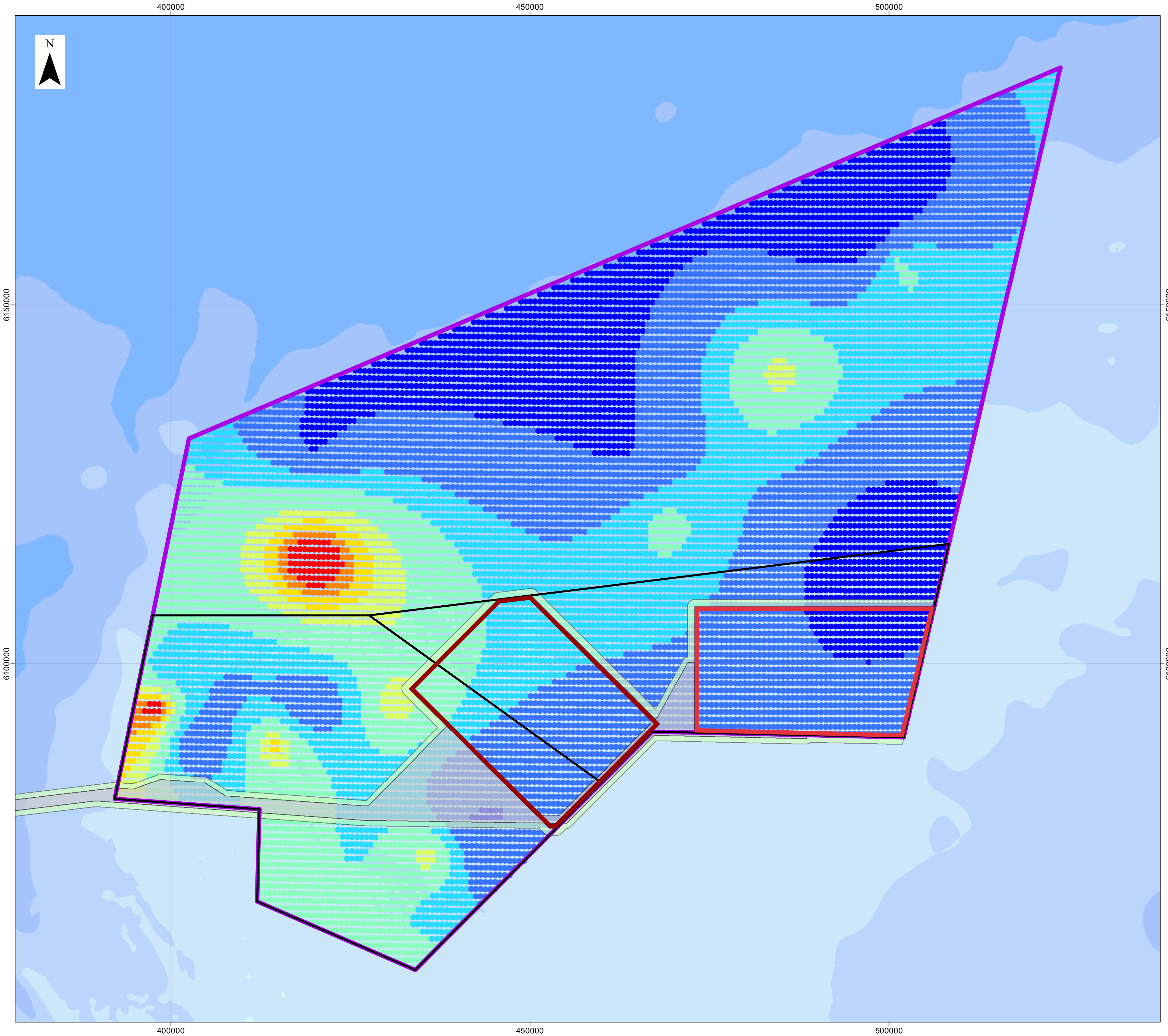

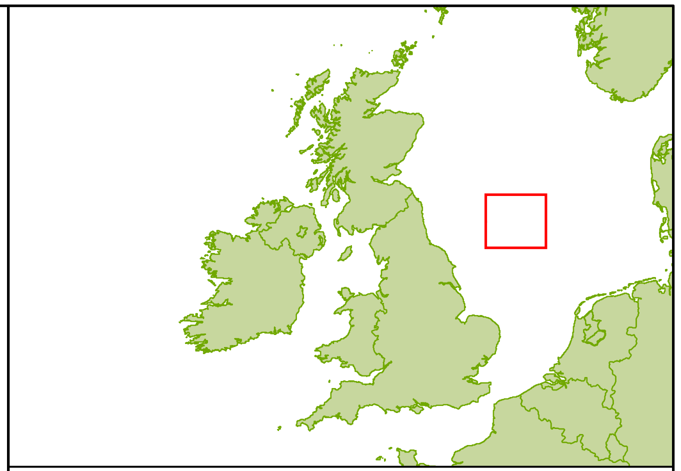

LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside A & B Export Cable Corridor
- Temporary works area

<u>Absolute mean density (km²)</u>

- ≤ 0.50
- 0.51 - 0.75
- 0.76 - 1.00
- 1.01 - 1.50
- 1.51 - 2.00
- 2.01 - 2.50
- 2.51 - 3.00
- ≥ 3.01

0 5 10 20
Kilometres

Data Source:
Density data © DMP Stats, 2013
Round 3 offshore wind farm boundary © Crown Copyright, 2013
Background bathymetry image derived in part from TCarta data © 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 4.15 The upper 95% confidence bound for the absolute mean densities (in km²) of harbour porpoise adjusted for availability

VER	DATE	REMARKS	Drawn	Checked
1	27/08/2013	Draft	LW	GK
2	03/10/2013	PEI3	JE	GK
3	11/02/2014	DCO Submission	JE	GK

DRAWING NUMBER:

F-OFL-MA-212

SCALE	1:550,000	PLOT SIZE	A3	DATUM	WGS84	PROJECTION	UTM31N

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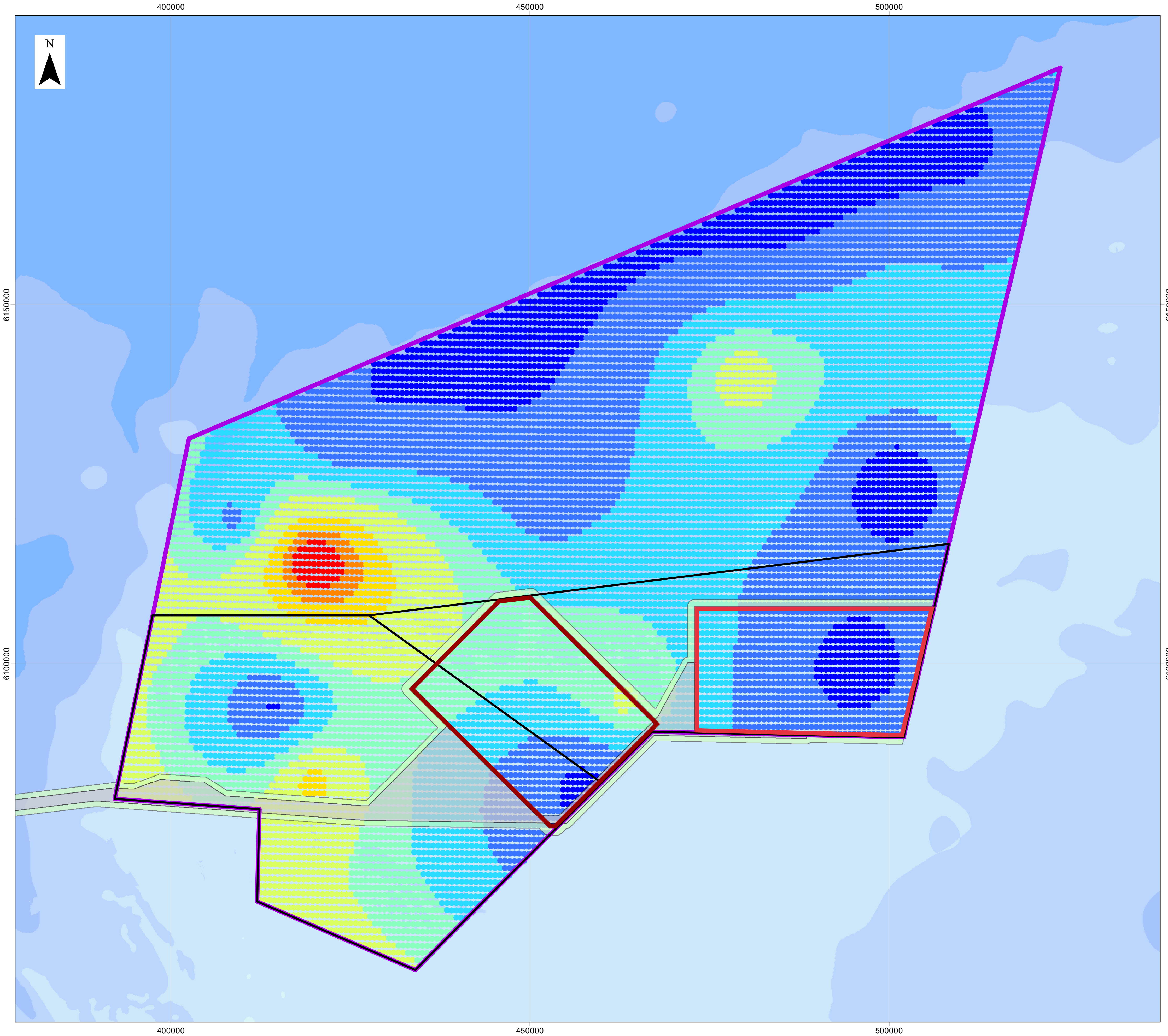

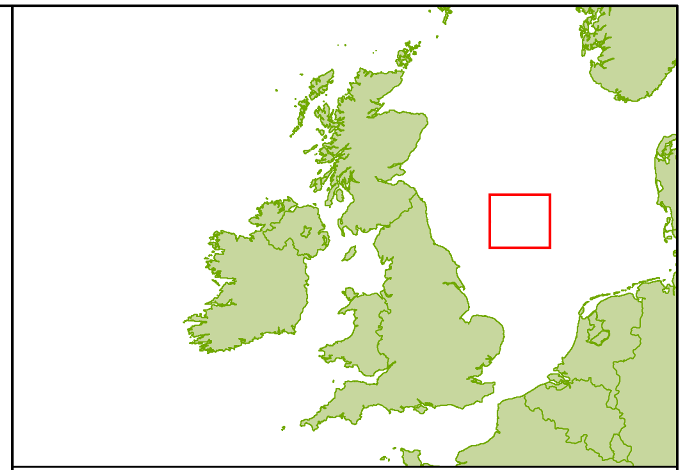

LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside A & B Export Cable Corridor
- Temporary works area

Absolute mean density (km²)

- ≤ 0.40
- 0.41 - 0.60
- 0.61 - 0.80
- 0.81 - 1.00
- 1.01 - 1.50
- 1.51 - 2.00
- 2.01 - 2.50
- ≥ 2.51

0 5 10 20
Kilometres

Data Source:
Density data © DMP Stats, 2013
Round 3 offshore wind farm boundary © Crown Copyright, 2013
Background bathymetry image derived in part from TCarta data © 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 4.16 Absolute mean densities (in km²) of harbour porpoise and potential harbour porpoise combined adjusted for availability

VER	DATE	REMARKS	Drawn	Checked
1	27/08/2013	Draft	LW	GK
2	03/10/2013	PEI3	JE	GK
3	11/02/2014	DCO Submission	JE	GK

DRAWING NUMBER:

F-OFL-MA-213

SCALE	1:550,000	PLOT SIZE	A3	DATUM	WGS84	PROJECTION	UTM31N

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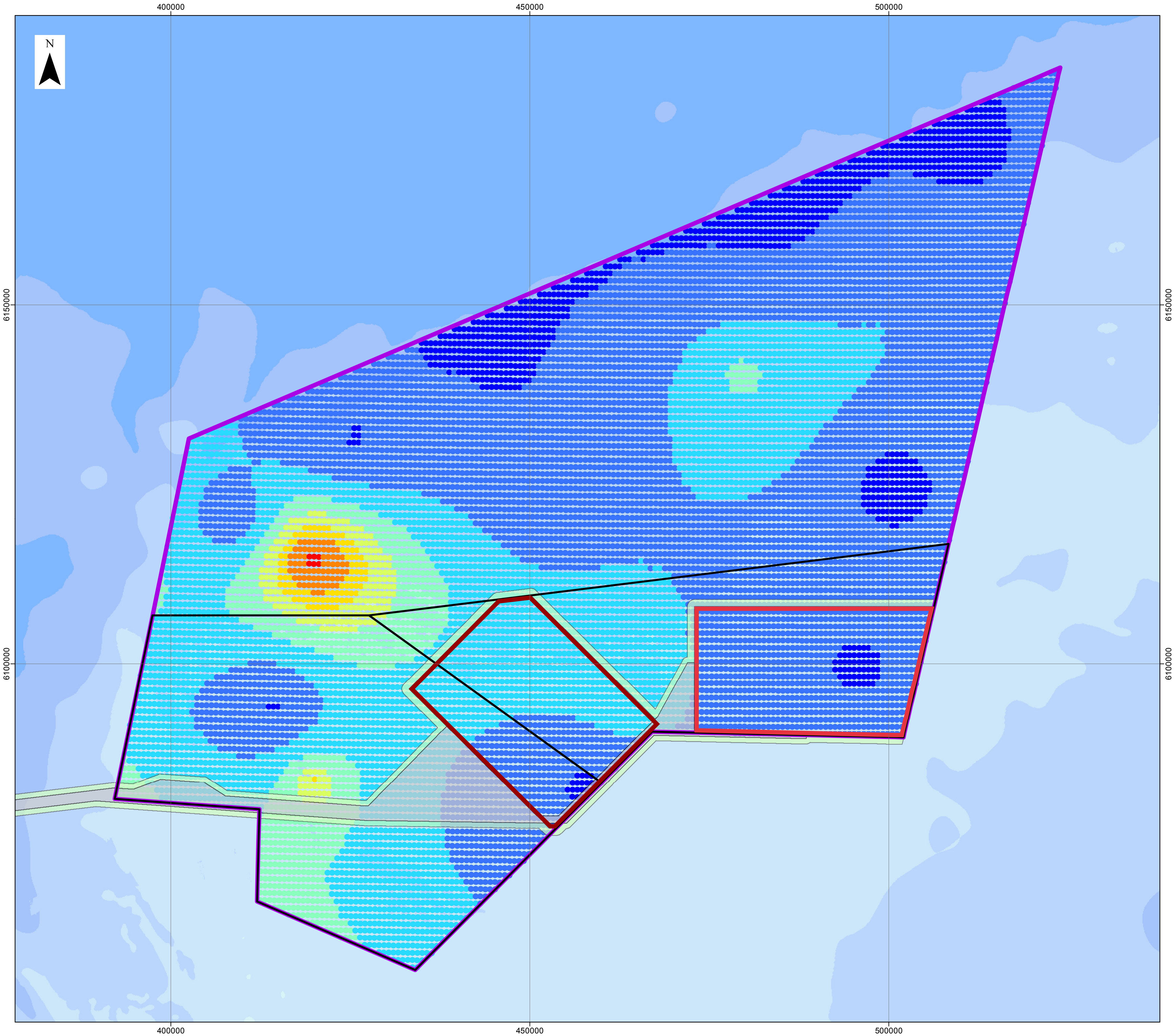
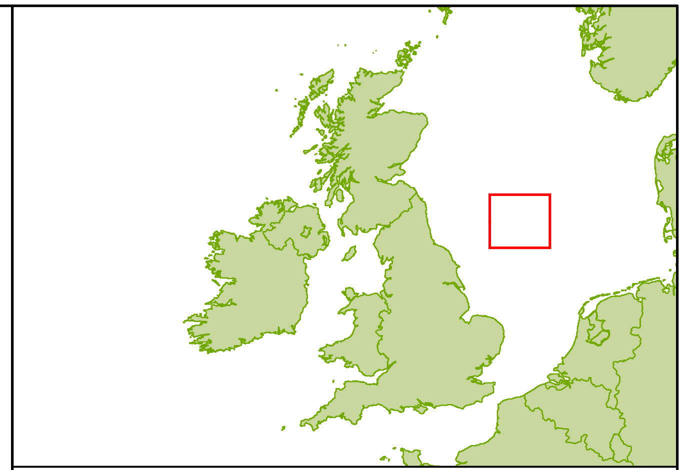




LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside A & B Export Cable Corridor
- Temporary works area

Absolute mean density (km²)

- ≤ 0.250
- 0.251 - 0.500
- 0.501 - 0.750
- 0.751 - 1.000
- 1.001 - 1.250
- 1.251 - 1.500
- 1.501 - 2.000
- ≥ 2.001

0 5 10 20
Kilometres

Data Source:
Density data © DMP Stats, 2013
Round 3 offshore wind farm boundary © Crown Copyright, 2013
Background bathymetry image derived in part from TCarta data © 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

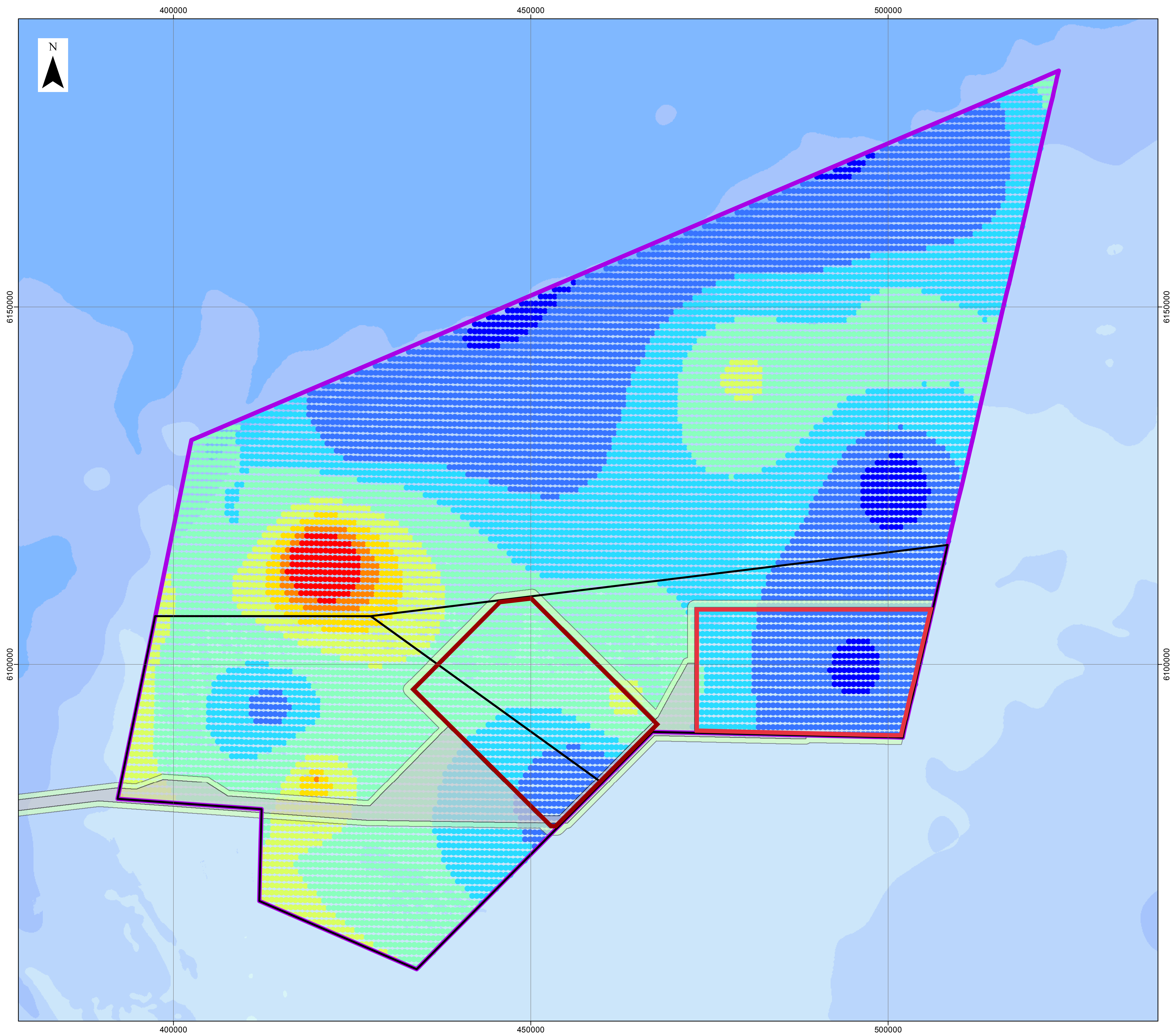
Figure 4.17 The lower 95% confidence bound for the absolute mean densities (in km²) of harbour porpoise and potential harbour porpoise combined adjusted for availability

VER	DATE	REMARKS	Drawn	Checked
1	27/08/2013	Draft	LW	GK
2	03/10/2013	PEI3	JE	GK
3	11/02/2014	DCO Submission	JE	GK

DRAWING NUMBER: **F-OFL-MA-214**

SCALE	1:550,000	PLOT SIZE	A3	DATUM	WGS84	PROJECTION	UTM31N

FOREWIND



LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside A & B Export Cable Corridor
- Temporary works area

Absolute mean density (km²)

- ≤ 0.50
- 0.51 - 0.75
- 0.76 - 1.00
- 1.01 - 1.50
- 1.51 - 2.00
- 2.01 - 2.50
- 2.51 - 3.00
- ≥ 3.01

0 5 10 20
Kilometres

Data Source:
Density data © DMP Stats, 2013
Round 3 offshore wind farm boundary © Crown Copyright, 2013
Background bathymetry image derived in part from TCarta data © 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 4.18 The upper 95% confidence bound for the absolute mean densities (in km²) of harbour porpoise and potential harbour porpoise combined adjusted for availability

VER	DATE	REMARKS	Drawn	Checked
1	27/08/2013	Draft	FK	PT
2	03/10/2013	PEI3	JE	PT
3	11/02/2014	DCO Submission	JE	GK

DRAWING NUMBER:

F-OFL-MA-215

SCALE	1:550,000	PLOT SIZE	A3	DATUM	WGS84	PROJECTION	UTM31N

FOREWIND

Harbour porpoise summary

4.2.38. The data presented show that harbour porpoise are likely to be found in relatively high densities across the Dogger Bank Zone. Individuals sighted within the zone are part of the South-western North Sea management unit (**Figure 4.1**), forming part of the wider North Sea population. Large scale (e.g. SCANS and SCANS II) surveys and Dogger Bank Zone surveys have shown both seasonal and inter-annual variation in distribution and, therefore, local abundance.

4.2.39. The assessment will use two site specific average densities generated from the HiDef surveys. These are based on harbour porpoise data (0.64056 (95% CI 0.57756-0.71352) individuals per km^2), and harbour porpoise and potential harbour porpoise combined (0.7161 (95% CI 0.52284 – 0.97333) individuals per km^2) which provides a precautionary approach. Impacts are assessed against the reference population based on the NS IAMMWG MU calculated from the sum of the survey blocks in the North Sea absolute abundance estimates from SCANS-II surveys; the population size is 227,298.

4.2.40. Harbour porpoise in the Dogger Bank Zone are considered high VERs due to their international designation under the Habitats Directive and other international conventions (**Table 3.2**).

Minke whale

Desk-based data review

4.2.41. Minke whale is widely distributed along the Atlantic seaboard of Britain and Ireland and throughout the North Sea. The JNCC Cetacean Atlas indicates that minke whale occur regularly in the North Sea to the north of Humberside, but are comparatively scarce in the southern North Sea. Animals are present throughout the year, but most sightings are between May and September. Most sightings were in the south and west of the Dogger Bank Zone, with fewer sightings elsewhere (Reid *et al.* 2003).

4.2.42. The only published population estimate for minke whale in UK waters is from the North Sea, English Channel and Celtic Sea undertaken for SCANS. The line transect survey conducted in July 1994 estimated 8,445 (95% CI 5,000-13,500) (Hammond *et al*. 2002). A more extensive line transect survey (SCANS II) over the north west European continental shelf in July 2005 gave an overall estimate of 18,958 (CV 0.347); 10,786 (CV 0.29) for the North Sea (blocks J,T, U and V); and 13,734 (CV 0.41; 95%CI 9,800 – 36,700) within an area comparable to the 1994 survey (Hammond *et al*. 2013). Although these estimates were not significantly different, there were noticeable changes in distribution between the two surveys (**Figure 4.19a** and **b**).

4.2.43. Genetic evidence suggests a limited spatial separation of populations within the North Atlantic (Anderwald & Evans 2010). The International Whaling Commission (IWC) treats this as a single stock (Central and North eastern North Atlantic), with a population estimate (in 1996-2001) of 174,000 (Northridge, 2012). However, from a precautionary perspective, in this assessment, the reference population is considered at both a IAMMWG MU level (based on the seaward boundary used by the European Commission for

Habitats Directive reporting area Marine Atlantic (MATL) British and Irish (BI) waters as well as using the Central and North eastern North Atlantic level (based on the IWC figures). Based on combined estimates from the SCANS II (Hammond *et al*. 2013)) and CODA (Hammond *et al*. 2009) surveys the BI MU reference population estimate is 23,168 (CV 0.27, 95% CI 13,772 – 38,958, IAMMWG, 2013),

4.2.44. The species is most commonly seen singly or, less commonly, in loose groups of up to three. In late summer, off the coast of northern and north west Britain, loose feeding aggregations of up to 15 animals may form (Anderwald & Evans 2010).

4.2.45. Minke whale feed upon a variety of fish species, including herring, sandeel, cod, haddock and saithe, as well as on invertebrates (Anderwald & Evans 2010). Feeding during the summer months is often observed in areas of upwelling or strong currents around headlands and small islands. In the northern hemisphere, mating is from October to March. Gestation is about 10 months, with calving occurring primarily between December and January (Seawatch Foundation 2008).

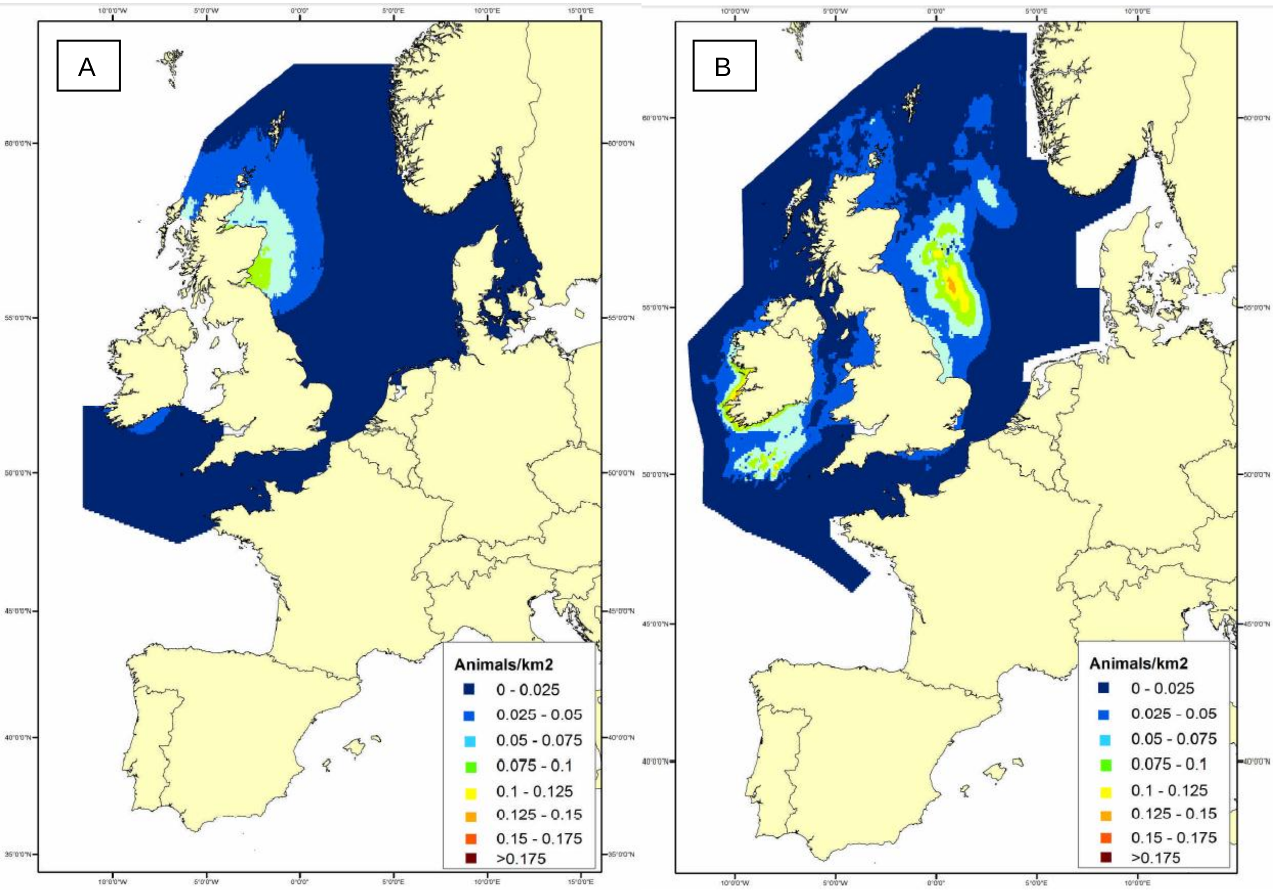


Figure 4.19 Minke whale density surface (animals per km^2) in (a) 1994 and (b) 2005 (Hammond *et al*. 2013).

Site specific surveys

4.2.46. Minke whale was not recorded in the Dogger Bank Zone on surveys undertaken during March, August and September 2008, although single animals were seen to the north and south of the area (Cork Ecology 2009).

4.2.47. No minke whale were recorded on boat-based surveys in Dogger Bank between January and April 2010; however, 20 animals were recorded in May 2010 and a minimum of 48 animals were recorded in June 2010 (**Figure 4.22**). Three of the May 2010 sightings involved adults and juvenile animals. Lower numbers were identified throughout the rest of 2010, increasing again in April 2011. Minke whale are present during the summer months in the development area, but sightings appear highest in the late spring, though sea state and weather will influence sighting rates.

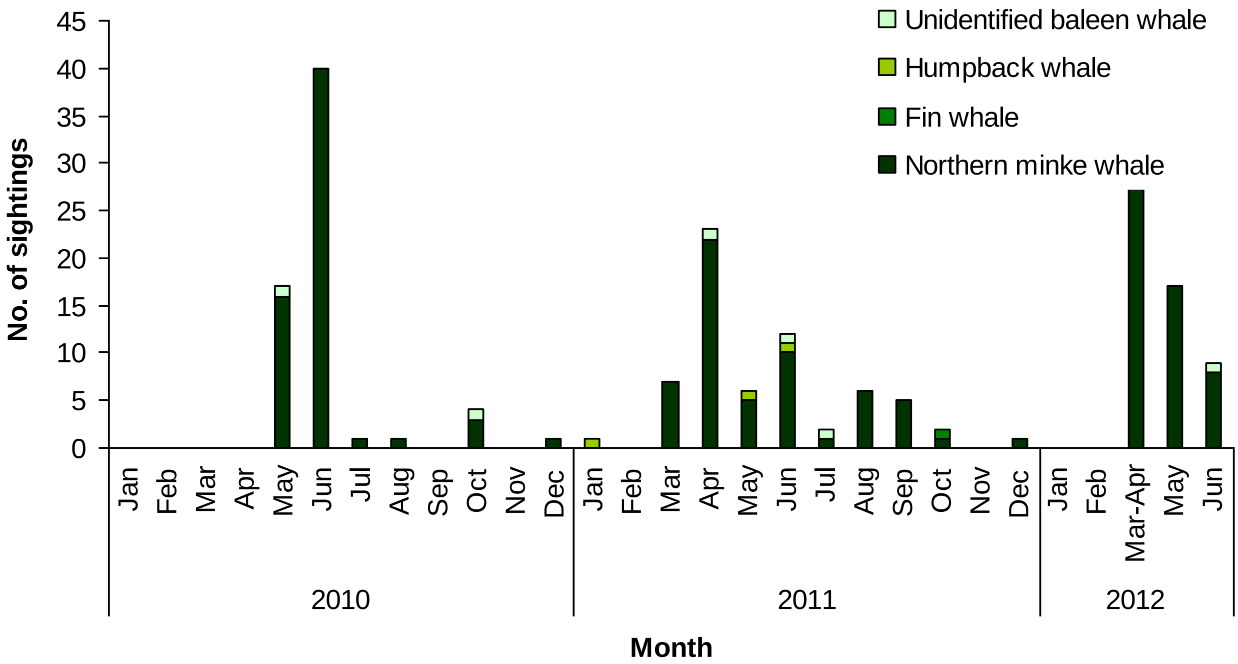


Figure 4.20 Mysticete sightings during boat based surveys January 2010 – June 2012 (Gardline Environmental 2012).

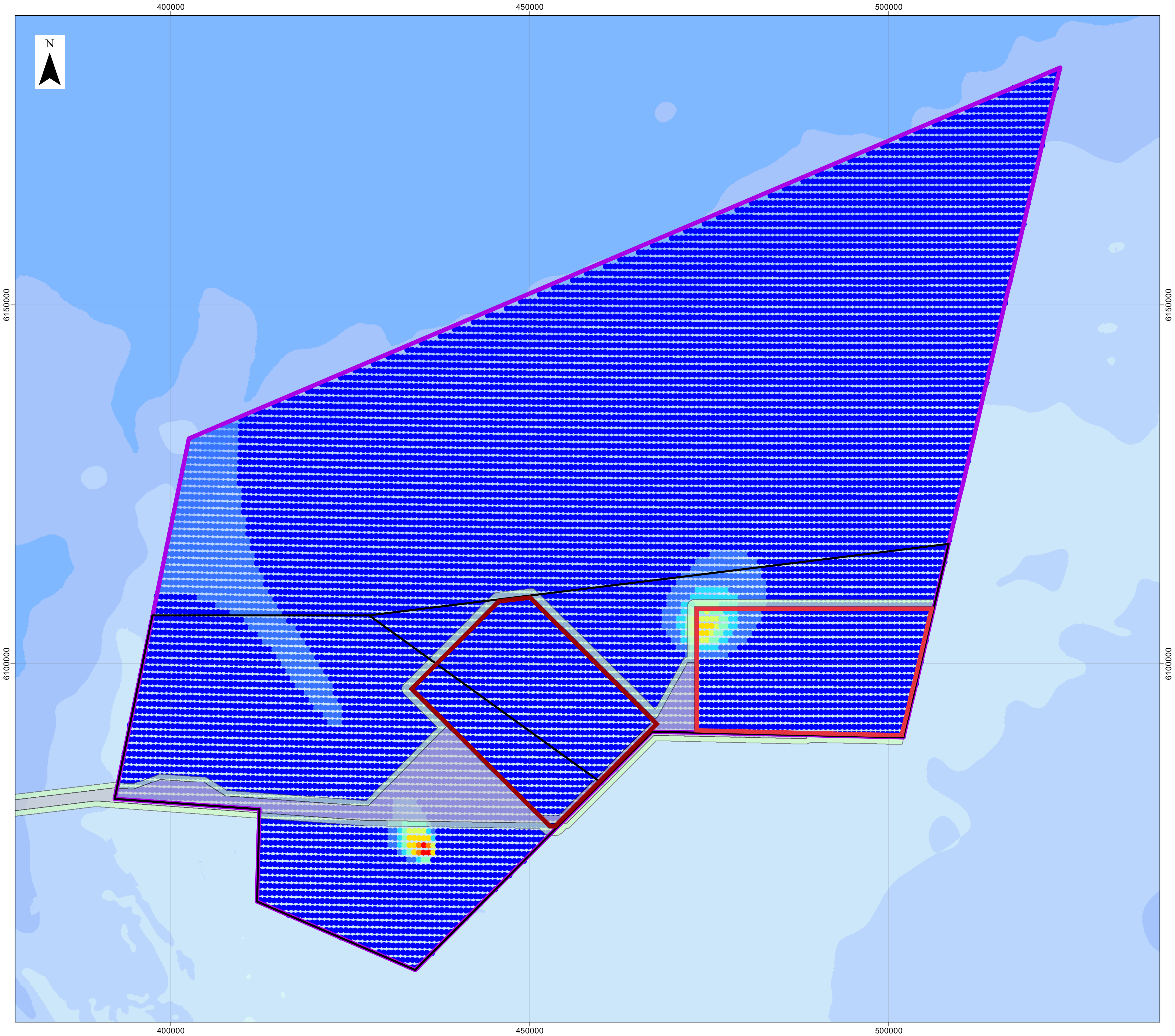
4.2.48. In contrast to harbour porpoise, the aerial surveys detected fewer minke whales than the boat based surveys; with most monthly surveys detecting no, or single, individuals except in both June 2010 and June 2011 where nine and five individuals were identified respectively.

4.2.49. The hourly encounter rate (number of animals divided by number of hours of survey effort) for the boat-based surveys peaked at 0.4 animals/hour (or 0.04 animals per km) in June 2010, although this included data recorded in all sea states.

4.2.50. The limited number of sightings of minke whale during the high definition aerial surveys means that absolute density could only be estimated for the three years of survey data combined (**Appendix 14B**). There were insufficient data to examine seasonal variation in occurrence of minke whale across the zone.

4.2.51. Two peaks in estimated density are shown in **Figure 4.21**, one within the Dogger Bank Teesside A boundary and the other to the south west of Dogger Bank Teesside B (**Figure 4.21**; along with associated uncertainty **Figure 4.22** and **4.23**). The results of spatial analysis using the data set over the entire survey period and survey area provides an estimate of absolute abundance for minke whale of 113 (95% CI 0 – 312), reflecting absolute densities of 0.00866 (95% CI 0 – 0.02391) individuals per km^2 (**Appendix 14B**).

4.2.52. Minke whale in the Dogger Bank Zone are considered high VERs due to their international designation under the Habitats Directive and other international conventions (**Table 3.2**).



LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside A & B Export Cable Corridor
- Temporary works area

Absolute mean density (km²)

- ≤ 0.020
- 0.021 - 0.040
- 0.041 - 0.060
- 0.061 - 0.080
- 0.081 - 0.100
- 0.101 - 0.200
- 0.201 - 0.300
- ≥ 0.301

0 5 10 20
Kilometres

Data Source:
Density data © DMP Stats, 2013
Round 3 offshore wind farm boundary © Crown Copyright, 2013
Background bathymetry image derived in part from TCarta data © 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

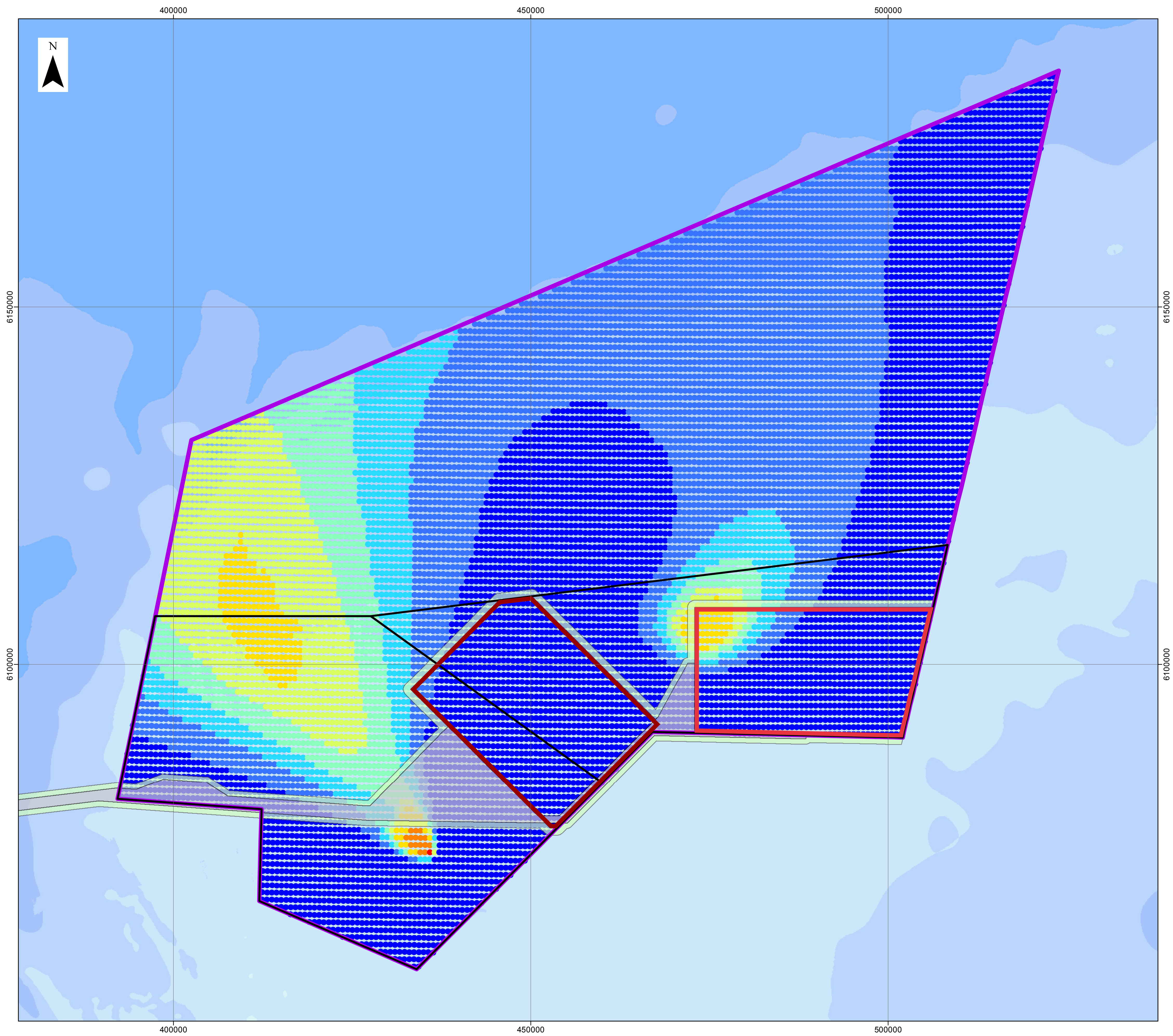
Figure 4.21 Absolute mean densities (in km²) of minke whale adjusted for availability

VER	DATE	REMARKS	Drawn	Checked
1	27/08/2013	Draft	LW	GK
2	03/10/2013	PEI3	JE	GK
3	11/02/2014	DCO Submission	JE	GK

DRAWING NUMBER: **F-OFL-MA-216**

SCALE	1:550,000	PLOT SIZE	A3	DATUM	WGS84	PROJECTION	UTM31N

FOREWIND



LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside A & B Export Cable Corridor
- Temporary works area

Absolute mean density (km²)

- ≤ 0.0020
- 0.0021 - 0.0040
- 0.0041 - 0.0060
- 0.0061 - 0.0080
- 0.0081 - 0.0100
- 0.0101 - 0.0250
- 0.0251 - 0.0500
- ≥ 0.0501

0 5 10 20
Kilometres

Data Source:
Density data © DMP Stats, 2013
Round 3 offshore wind farm boundary © Crown Copyright, 2013
Background bathymetry image derived in part from TCarta data © 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

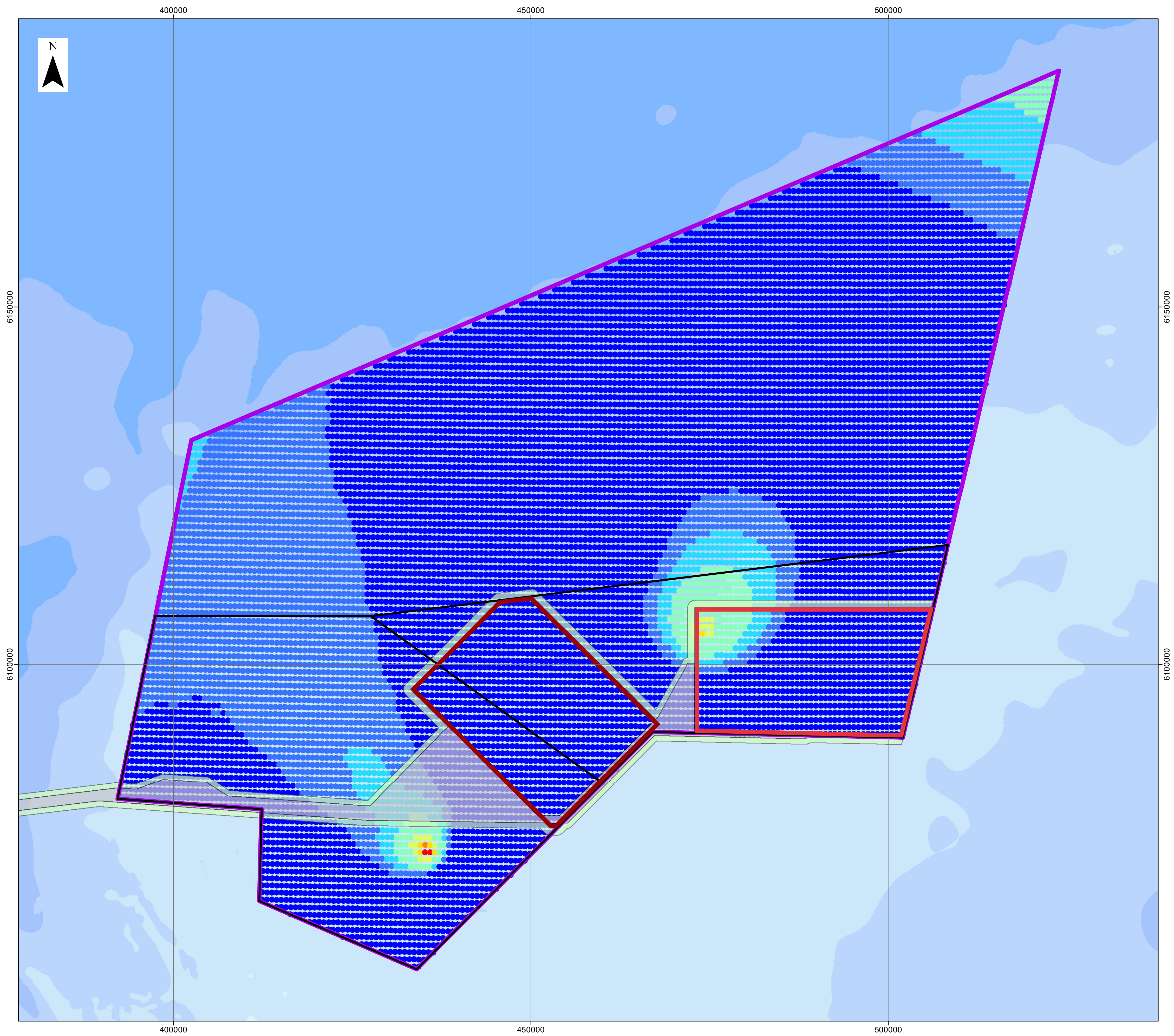
Figure 4.22 The lower 95% confidence bound for the absolute mean densities (in km²) of Minke whale adjusted for availability

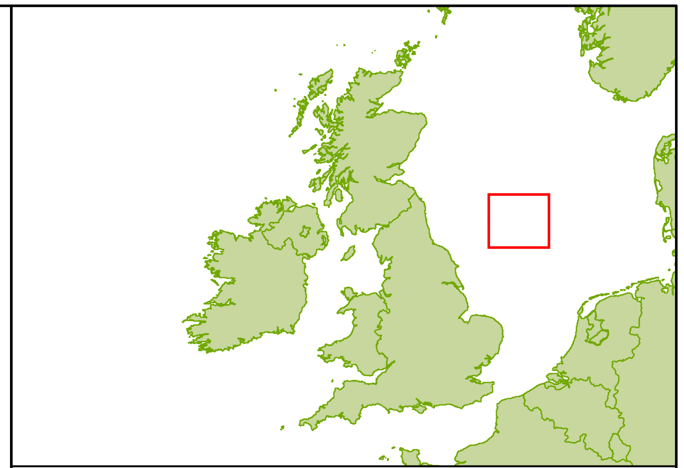
VER	DATE	REMARKS	Drawn	Checked
1	27/08/2013	Draft	LW	GK
2	03/10/2013	PEI3	JE	GK
3	11/02/2014	DCO Submission	JE	GK

DRAWING NUMBER: **F-OFL-MA-217**

SCALE	1:550,000	PLOT SIZE	A3	DATUM	WGS84	PROJECTION	UTM31N

FOREWIND





LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside A & B Export Cable Corridor
- Temporary works area

Absolute mean density (km²)

- ≤ 0.03
- 0.04 - 0.05
- 0.06 - 0.10
- 0.11 - 0.50
- 0.51 - 1.00
- 1.01 - 2.00
- 2.01 - 3.00
- ≥ 3.01

0 5 10 20
Kilometres

Data Source:
Density data © DMP Stats, 2013
Round 3 offshore wind farm boundary © Crown Copyright, 2013
Background bathymetry image derived in part from TCarta data © 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 4.23 The upper 95% confidence bound for the absolute mean densities (in km²) of Minke whale adjusted for availability

VER	DATE	REMARKS	Drawn	Checked
1	27/08/2013	Draft	LW	GK
2	03/10/2013	PEI3	JE	GK
3	11/02/2014	DCO Submission	JE	GK

DRAWING NUMBER:

F-OFL-MA-218

SCALE	1:550,000	PLOT SIZE	A3	DATUM	WGS84	PROJECTION	UTM31N

FOREWIND

White-beaked dolphin

Desk-based data review

4.2.53. White-beaked dolphin are widespread across the northern European continental shelf. The species is the most abundant cetacean after the harbour porpoise in the North Sea (Jansen *et al*. 2010). The waters off the coast of Scotland and north east England are one of the four global centres of peak abundance. The species occurs mainly in waters of 50-100m in depth (Reid *et al*. 2003). Scientific evidence supports the assumption that white-beaked dolphin from around the British Isles and North Sea represent one population, with movement between Scottish waters and the Danish North Sea and Skagerrak (Banhuera-Hinestroza *et al*. 2009). Sightings are common throughout the year, with peaks between June and October (Reid *et al*. 2003).

4.2.54. The latest SCANS II survey provides the most recent population estimate covering the North Sea of 10,666 (**Table 2.3**) and a wider European population estimate of 16,536 (95% CI 9,245 – 29,586, Hammond *et al*. 2013). The wider population estimate from SCANS II does not include a genetically distinct North Norwegian population (Northridge *et* al. 1997). The reference population for the assessment, based on the IAMMWG BI MU, is 15,895 (CV 0.29, 95% CI 9,107 – 27,743).

4.2.55. The numbers encountered in the southern North Sea are relatively low however, with density estimated at 0.003 animals per km^2 in the southern Central North Sea, which includes the Dogger Bank Zone (Hammond *et al.* 2013). Within the Dogger Bank Zone, the JNCC Cetacean Atlas indicates that the majority of white-beaked dolphin sightings were in the north western corner of the Dogger Bank Zone, with fewer sightings to the east and south (Reid *et al*. 2003; **Figure 4.27**).

4.2.56. White-beaked dolphin breed mainly between May and August, although some breeding occurs in September and October (Anderwald & Evans 2010). The gestation period is approximately 11 months (Culik 2010).

4.2.57. The diet of white-beaked dolphin within the North Sea is dominated by gadoids, notably whiting and cod (Jansen *et al*. 2010); however, in Scottish waters they also consume cephalopods (Santos *et al.* 1994). It is likely that the Dogger Bank Zone is used both for feeding and breeding.

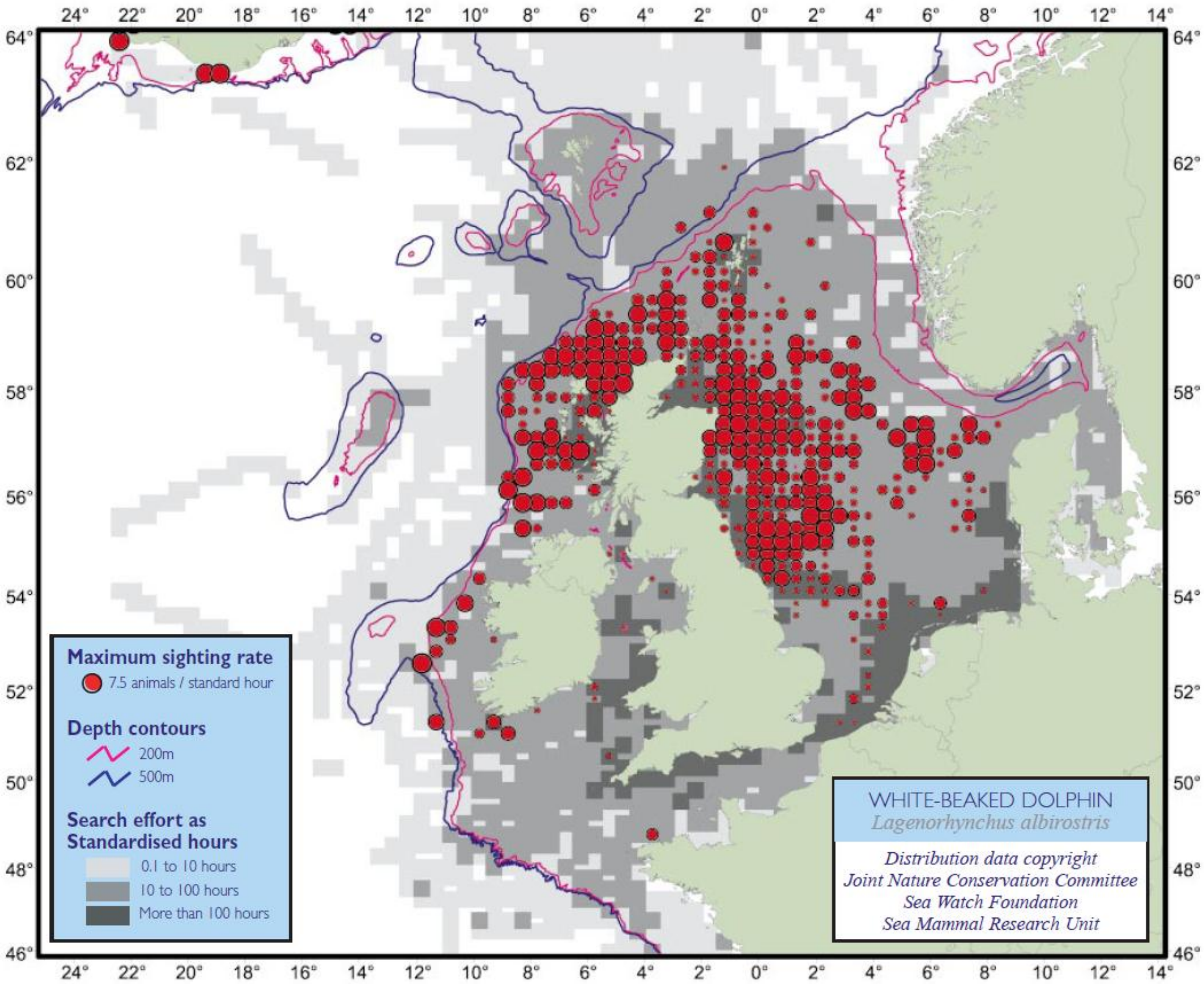


Figure 4.24 Sighting rates of white-beaked dolphin (Reid *et al*. 2003).

Site specific surveys

4.2.58. White-beaked dolphin were not recorded in the Dogger Bank Zone on surveys in March, August and September 2008 (Cork Ecology 2009).

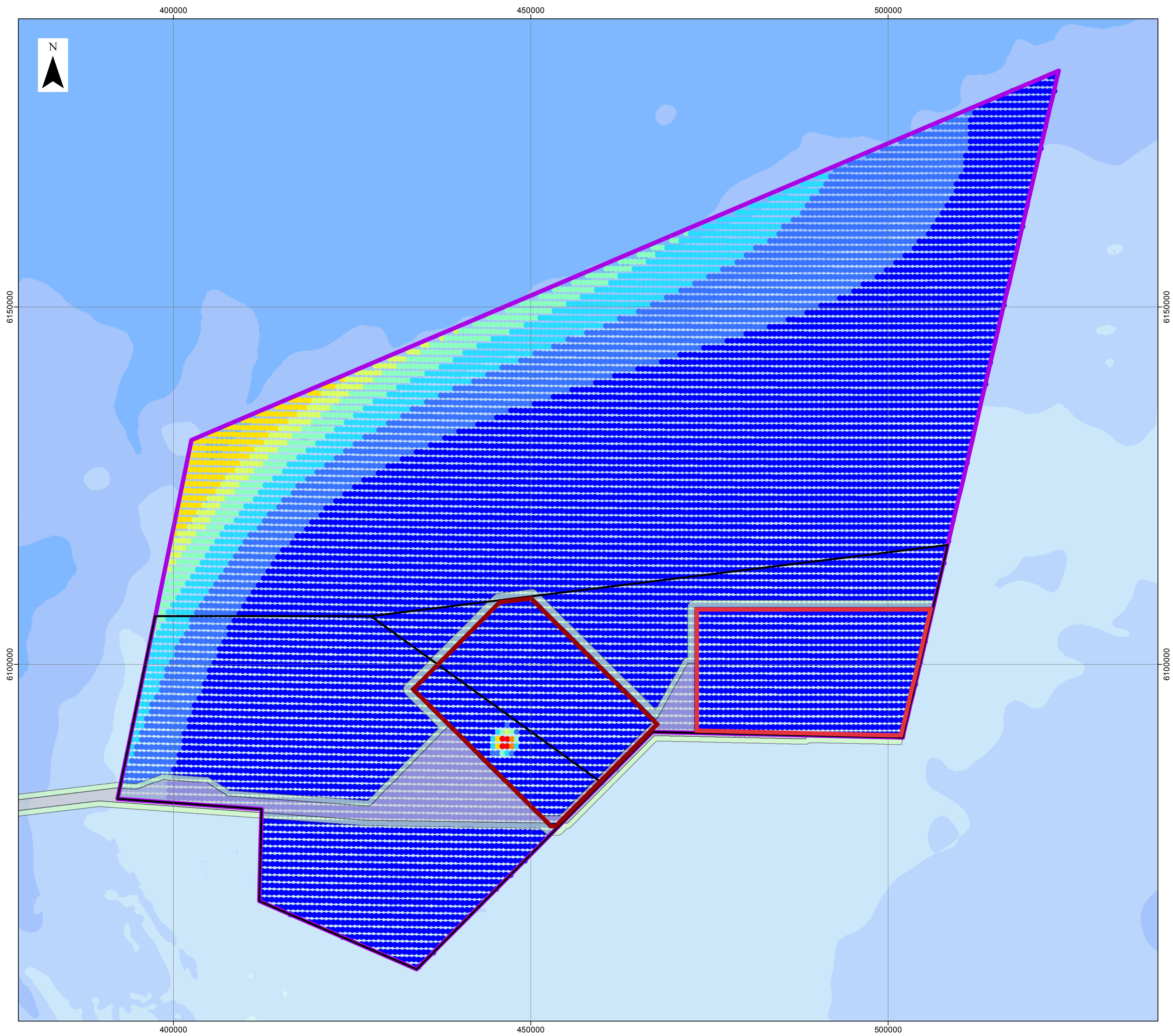
4.2.59. More recent boat-based surveys in the Dogger Bank Zone recorded low numbers between February and April 2010, with an increase in activity in May, when a minimum of 141 animals were recorded (**Figure 4.10**). Very few sightings were recorded for the months July 2010 to February 2011; totalling 12 individuals with no sightings for July to October 2010 or February 2011. The number of sightings again increased in spring and early summer 2011, peaked in June 2011, before returning to occasional sightings.

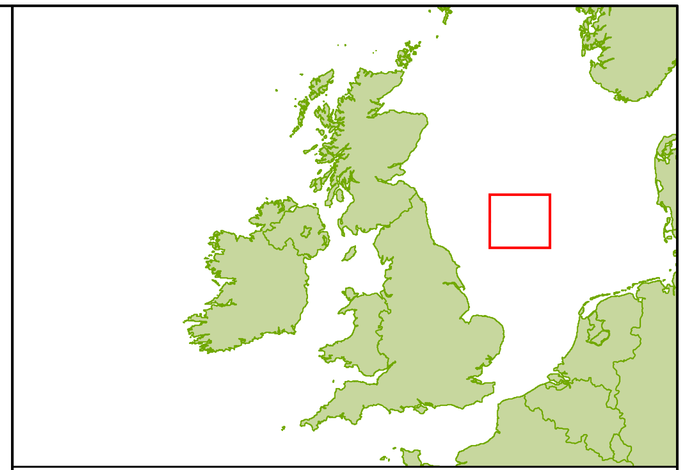
4.2.60. The HiDef aerial camera surveys detected fewer white-beaked dolphin than the boat based surveys. In both 2010 and 2011 the majority of sightings were between January and June, and no more than 16 individuals were recorded in a single month. In 2012 (up to July) sightings peaked in March and April, with 30 and 18 individuals recorded, respectively. There were no sightings in January, February and June 2012. Possible attraction of white-beaked dolphin to the boats may account for the differences in sightings between the boat-based and aerial surveys, though this may not always be the case. This potential behavioural response to vessels supports the use of the aerial survey data, where no observer effect will occur.

4.2.61. Due to the limited number of sightings, statistical analysis of the data was not possible on a monthly scale (**Appendix 14B**).

4.2.62. The results of spatial analysis using the wider data set, as completed for minke whale, provide spatial estimates of density as shown in **Figure 4.25** (along with associated uncertainty **Figure 4.26** and **4.27**). Estimates of average absolute abundance and density over the zone and survey period were calculated. Absolute abundance was 194 (95% CI 130-367), and absolute density was 0.01487 (95% CI 0.00663 – 0.02813) individuals per km^2.

4.2.63. White-beaked dolphin in the Dogger Bank Zone are considered high VERs due to their international designation under the Habitats Directive and other international conventions (**Table 3.2**).





LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside A & B Export Cable Corridor
- Temporary works area

Absolute Mean Density (km²)

- ≤ 0.020
- 0.021 - 0.040
- 0.041 - 0.060
- 0.061 - 0.080
- 0.081 - 0.100
- 0.101 - 0.200
- 0.201 - 0.300
- ≥ 0.301

0 5 10 20
Kilometres

Data Source:
Density data © DMP Stats, 2013
Round 3 offshore wind farm boundary © Crown Copyright, 2013
Background bathymetry image derived in part from TCarta data © 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

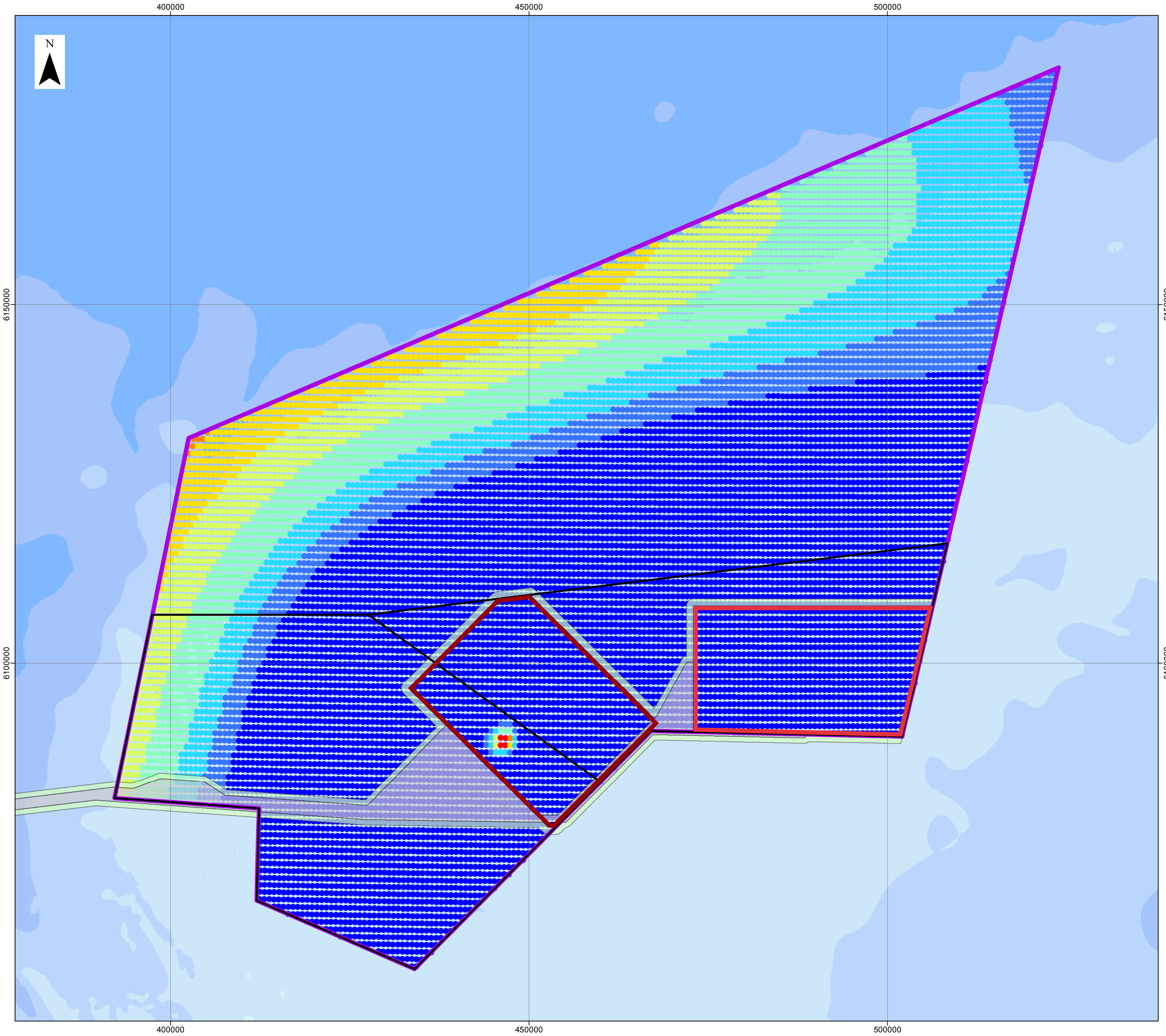
Figure 4.25 Absolute mean densities (in km²) of white-beaked dolphin adjusted for availability

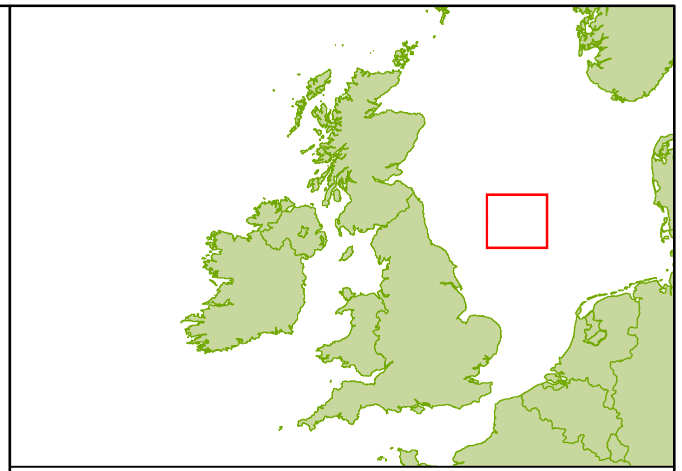
VER	DATE	REMARKS	Drawn	Checked
1	27/08/2013	Draft	LW	GK
2	03/10/2013	PEI3	JE	GK
3	11/02/2014	DCO Submission	JE	GK

DRAWING NUMBER: **F-OFL-MA-219**

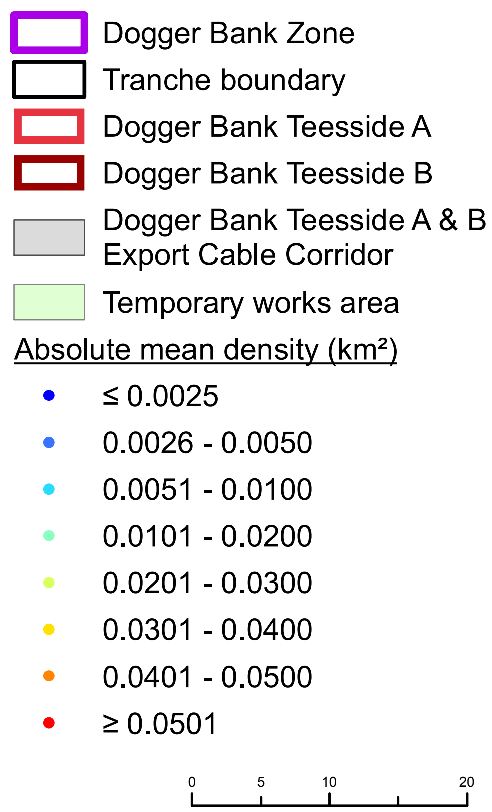
SCALE	PLOT SIZE	DATUM	PROJECTION
1:550,000	A3	WGS84	UTM31N

FOREWIND





LEGEND



Data Source:
Density data © DMP Stats, 2013
Round 3 offshore wind farm boundary © Crown Copyright, 2013
Background bathymetry image derived in part from TCarta data © 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

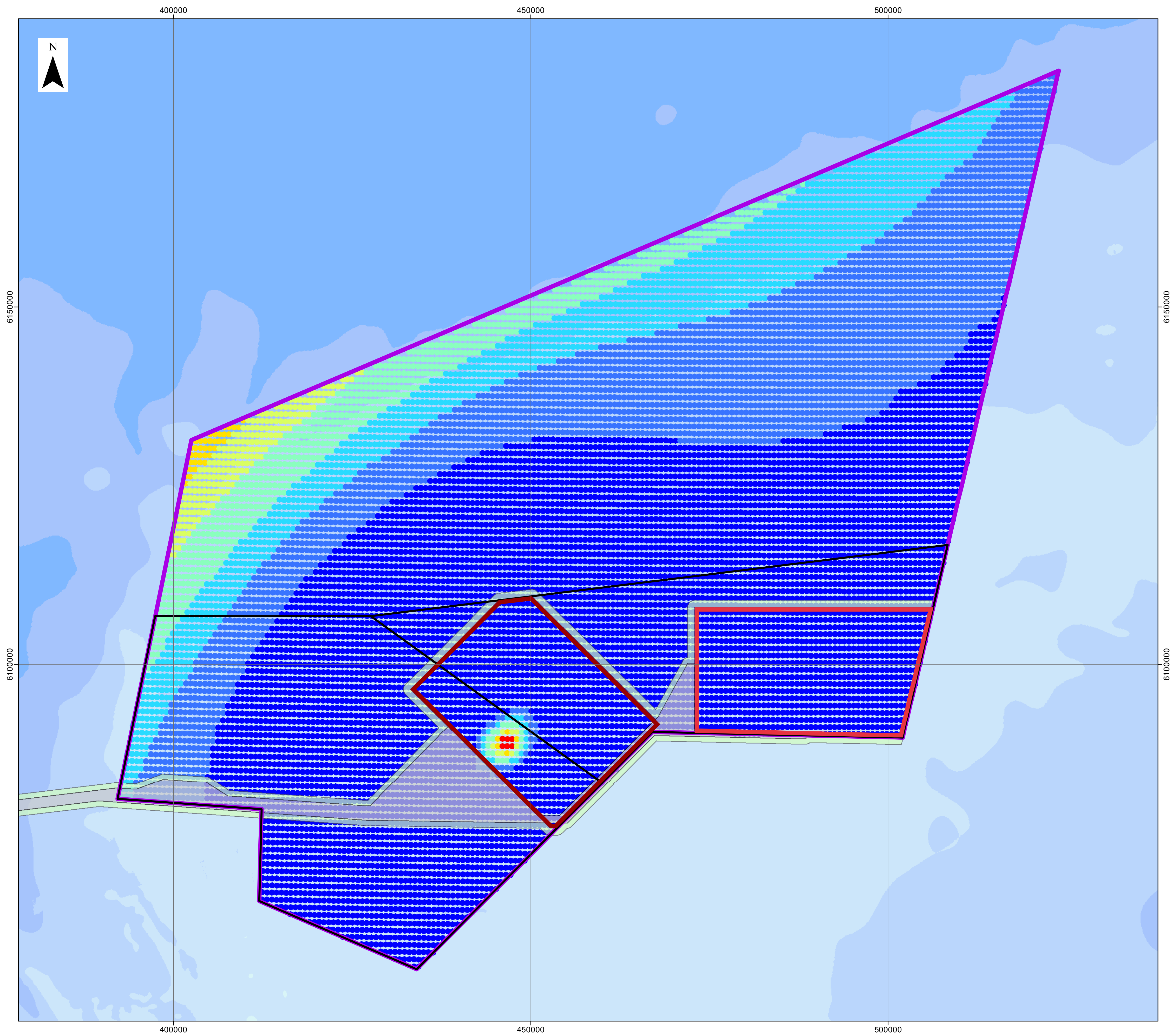
Figure 4.26 The lower 95% confidence bound for the absolute mean densities (in km²) of white-beaked dolphin adjusted for availability

VER	DATE	REMARKS	Drawn	Checked
1	27/08/2013	Draft	LW	GK
2	03/10/2013	PEI3	JE	GK
3	11/02/2014	DCO Submission	JE	GK

DRAWING NUMBER: **F-OFL-MA-220**

SCALE	1:550,000	PLOT SIZE	A3	DATUM	WGS84	PROJECTION	UTM31N

FOREWIND



LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside A & B Export Cable Corridor
- Temporary works area

Absolute mean density (km²)

- ≤ 0.025
- 0.026 - 0.050
- 0.051 - 0.100
- 0.101 - 0.250
- 0.251 - 0.500
- 0.501 - 1.000
- 1.001 - 1.500
- ≥ 1.501

0 5 10 20
Kilometres

Data Source:
Density data © DMP Stats, 2013
Round 3 offshore wind farm boundary © Crown Copyright, 2013
Background bathymetry image derived in part from TCarta data © 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 4.27 The upper 95% confidence bound for the absolute mean densities (in km²) of white-beaked dolphin adjusted for availability

VER	DATE	REMARKS	Drawn	Checked
1	27/08/2013	Draft	LW	GK
2	03/10/2013	PEI3	JE	GK
3	11/02/2014	DCO Submission	JE	GK

DRAWING NUMBER: **F-OFL-MA-221**

SCALE	1:550,000	PLOT SIZE	A3	DATUM	WGS84	PROJECTION	UTM31N

FOREWIND

Other species of cetacean

4.2.64. Other cetacean species that may occur occasionally within the Dogger Bank Zone include bottlenose dolphin, common dolphin, Atlantic white-sided dolphin, Risso's dolphin and killer whale (Reid *et al*. 2003).

4.2.65. During the zone specific aerial and boat based surveys there were numerous sightings of likely cetaceans which could not be classified to species. This included "unidentified dolphin", "whale", "small cetacean", "small cetacean or seal", and "unidentified cetacean or shark". All of these groups (excluding "unidentified dolphin") were grouped as "potentially harbour porpoise" in the spatial and temporal analysis (**Appendix 14B**). However, it is also possible that these sightings represent species that may only occur occasionally in the zone.

4.2.66. Unidentified dolphin occurrences were generally throughout the spring and summer months, with no more than 10 individuals recorded in each month. Larger cetaceans (or whales) that could not be further identified to species level were less common, with only five individuals throughout the high definition aerial surveys, and four individuals during the boat based surveys.

Bottlenose dolphin

4.2.67. The bottlenose dolphin has a worldwide distribution in temperate and tropical seas, both in nearshore and offshore waters, including the north west Atlantic seaboard of Europe (Reid *et al.* 2003). In terms of occurrence, the closest hotspot to the Dogger Bank Zone is centred on the Moray Firth SAC, north east Scotland which is a predominantly coastal resident population (Thompson *et al*. 2011). The current population estimate for the east coast of Scotland is 195 (95% highest posterior density interval 162-253; Cheney *et al*. 2012). Evidence suggests that the population is either stable or increasing (Cheney *et al*. 2012).

4.2.68. During the SCANS II surveys, no bottlenose dolphin were sighted in the southern/central area of the North Sea (SCANS Block U) which encompasses the Dogger Bank Zone, and there was only one sighting in Block V (Hammond *et al*. 2013). There is no estimate of abundance in Block U. In Block V (northern North Sea) abundance is estimated to be 157 (CV 1.14), with densities around 0.001 (CV 1.14).

4.2.69. There was only one confirmed sighting (of a pod of 25 individuals) of bottlenose dolphin within the Dogger Bank Zone during the site specific boat based surveys (**Figure 4.10**) and no confirmed sightings during the aerial surveys. Due to the low level of Zone specific sightings and the low likelihood of occurrence, bottlenose dolphin are not taken forward in the assessment.

Common dolphin

4.2.70. The common dolphin is the most numerous offshore cetacean species in the north east Atlantic, most commonly sighted off the western coast of the UK, in the Celtic Sea, and western approaches to the Channel, it is only occasionally sighted in the North Sea during the summer months (Reid *et al*. 2003). No confirmed sightings of common dolphin were made in the southern North Sea during the SCANS II surveys (SCANS II 2008) or during the site specific boat based or aerial surveys in the Dogger Bank Zone. Due to the absence of any zone specific sightings and the low likelihood of occurrence, common dolphin are not taken forward in the assessment.

Atlantic white-sided dolphin

4.2.71. Atlantic white-sided dolphin are less common than white-beaked dolphin in occurrence on the continental shelf, favouring the slope (at 100-300m depth). The southern and central North Sea is not part of their core habitat. Too few Atlantic white-sided dolphins were recorded on the SCANS II survey in 2005 to allow abundance estimates to be calculated (SCANS-II 2008). Identification to the species level between Atlantic white-sided dolphin and white-beaked dolphin, both *Lagenorhychus spp*. can be difficult in the field, as they are superficially similar and often form mixed herds (Reid *et al*. 2003). During the boat-based 2010-11 surveys, two Atlantic white-sided dolphins were encountered in a single sighting in the Dogger Bank Zone, this sighting occurred in May 2011 (**Figure 4.10**). Three animals, which were probably this species, were also seen at distance during the March 2010 survey. All other months had no positive identifications of this species. Only two Atlantic white-sided dolphin were recorded (in March 2012) during the aerial camera surveys undertaken by HiDef Limited. No other sightings were recorded from April 2010 to July 2012. Due to the low level of zone specific sightings and the low likelihood of occurrence Atlantic white-sided dolphin are not taken forward in the assessment.

Risso's dolphin

4.2.72. Risso's dolphin are generally associated with the deeper and warmer waters of the continental slope. As such, the majority of UK sightings of Risso's dolphin are made off the north west of Scotland, surrounding the Outer Hebrides (Reid *et al*. 2003). There have been occasional sightings in the North Sea, mainly in July and August. The status of Risso's dolphins in the UK is currently unknown, and there are no population estimates available (SCANS-II 2008). There were no confirmed sightings of Risso's dolphin during the boat based and aerial surveys of the Dogger Bank Zone. Due to the absence of any zone specific sightings and the low likelihood of occurrence, Risso's dolphin are not taken forward in the assessment.

Killer whale

4.2.73. In the UK, killer whale, or orca, are commonly sighted off northern and western Scotland, but sightings in the central and southern North Sea are rare (Reid *et al*. 2003). Their movements into UK waters are generally associated with changes in prey distribution, such as pelagic schooling fish (including herring) or breeding seals. A single orca was identified during the HiDef aerial surveys in June 2011. It was observed moving northwards through the Dogger Bank Zone. Orca are usually observed foraging cooperatively in pods, especially when chasing prey (Reid *et al*. 2003), making it unlikely that this animal was feeding in the area. Due to the single zone specific sighting and the low likelihood of occurrence, orca are not taken forward in the assessment.

Humpback whale

4.2.74. The JNCC Cetacean Atlas (Reid *et al.* 2003) does not identify humpback whale as present in the Dogger Bank Zone; most sightings are made off the continental shelf and north of Scotland between May and September. However, three of the boat-based surveys recorded humpback whale within the Dogger Bank Zone during 2011; these were the January, May and June surveys, totalling four individuals (**Figure 4.22**). The January sighting included two humpback whales associating with white-beaked dolphins, other sightings involved solitary animals, likely to be passing through the area. Due to the limited number of zone specific sightings and the low likelihood of occurrence humpback whale are not taken forward in the assessment.

Fin whale

4.2.75. The fin whale is rarely sighted in the North Sea, with only a few isolated records off Northern Scotland (Reid *et al*. 2003). During the October 2011 boat based survey there was one confirmed sighting of two individual fin whales. Due to the limited number of zone specific sightings and the low likelihood of occurrence fin whale are not taken forward in the assessment.

4.2.76. Due to the rare or occasional nature of sighting and likely occurrence of all of these species, it was agreed during consultation with JNCC (**Table 2.4**) that the only species to be taken forward in the assessment were harbour porpoise (with consideration of potential harbour porpoise) minke whale and white-beaked dolphin.

4.3. Pinnipeds

Grey seal

Desk-based data review

4.3.1. The geographical range of the grey seal is restricted to the Northern hemisphere. In the north east Atlantic, distribution is centred on breeding colonies in the UK (predominantly Scotland), Iceland, Norway, Ireland, and the Baltic.

4.3.2. Grey seal breed annually, when females come ashore to give birth on land or ice during which time the females fast. In the UK, the breeding season is between September and December. In the Wadden Sea, November to January and, in the Baltic, February to March. Conception occurs at the end of lactation, three to four weeks after giving birth.

4.3.3. Grey seal also spend a greater proportion of their time ashore during the annual moult (four months after conception) when delayed implantation of the fertilised egg occurs (Hall 2002). Densities at sea during the breeding season and moult are likely to be lower than at other times of the year (DECC 2009).

4.3.4. Grey seal were historically common around mainland Europe, prior to excessive hunting, mainly in the 11th century, which eradicated breeding in these areas (Harkonen *et al.* 2007). Since the 1970s, small breeding colonies have been re-established at sites in the Netherlands, Germany and France, with moulting sites also established in Denmark. Annual moult surveys are conducted in the

Wadden Sea, during the moult and breeding season, by the Trilateral Seal Expert Group (TSEG). The most recent count in 2012 was 4,039, the majority of which are counted in the Netherlands (TSEG 2012a). Since 2007, numbers have increased rapidly; it is likely that this high growth rate is sustained by some temporary immigration from the UK. The 2011/2012 count of pups born in this region was 288 (with an estimated pup production of 427).

4.3.5. The UK holds approximately 38% of the world's grey seal breeding population. In the UK, the major grey seal breeding colonies are monitored annually by SMRU to estimate pup production. The total number of pups born at annually monitored colonies in 2010 in the UK was estimated to be 50,174, of which 8,314 (16.5%) were estimated to be from North Sea colonies (including Isle of May, Fast Castle, Inchkeith, Firth of Forth Islands, Donna Nook, Blakeney Point, Horsey and the Farne Islands; SCOS 2012).

4.3.6. The closest major breeding colonies to the Dogger Bank Zone are Donna Nook, within the Humber Estuary SAC (approximately 150km from the zone), and the Farne Islands, within the Berwickshire and North Northumberland SAC (approximately 160km from the zone). Overall, pup production at UK colonies in the North Sea is increasing, which is primarily due to expansion of newer colonies on the coast in Berwickshire (Fast Castle) and East Anglia and southern North Sea (Donna Nook, Blakeney Point and Horsey; **Figure 4.32**).

4.3.7. In the UK, surveys of the adult population of grey seal are not routinely made, and the best estimates of population size are derived from estimates of pup production. In 2010 the estimated (based on best fitting model) size of the UK population associated with annual breeding colonies was 99,300 (95% CI 80,200-122,900; SCOS 2012), and the population associated with less regularly monitored colonies was 12,000 (approx. CI 9,900 to 14,800), thus giving a total population estimate for UK grey seals of 111,300 (95% CI 90,100 to 137,700).

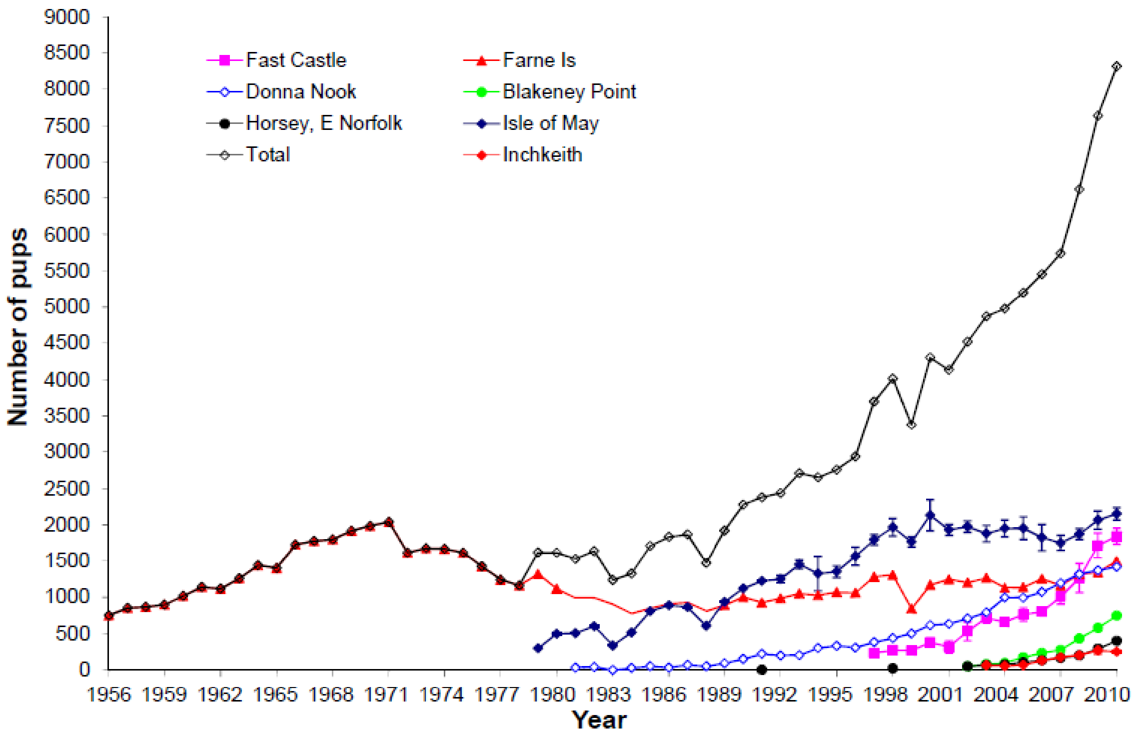


Figure 4.28 Grey seal pup production at North Sea colonies in the UK (SCOS 2011).

4.3.8. The most recent published estimate of the size of the UK North Sea grey seal population (at the start of the 2010 breeding season) is 19,100 (95% credibility interval 14,000-26,500; SCOS 2012).

4.3.9. Information on at sea distribution of grey seal is available from telemetry studies. Movements vary from short range trips between local haul out sites, to extended foraging trips, and journeys between distant haul out and breeding sites. Grey seal spend approximately 40% of their time at haul out sites, 12% of their time foraging, and the remainder of their time travelling between haul out and foraging areas (McConnell *et al*. 1992; McConnell *et al.* 1999).

4.3.10. Grey seal are known to forage up to 145km from their haul out sites (Thompson *et al.* 1996), over wide estimated ranges of 1,088 to 6,400 km² (Dietz *et al.* 2003). Individuals that use dispersed haul outs around the UK and European mainland coasts can forage over the proposed Dogger Bank Zone (see Figure 3a, 4a and 5a in **Appendix 14A Dogger Bank Seal Telemetry**; Brasseur *et al*. 2010). Brasseur *et al.* (2010) suggested that movements of this scale may be commonplace. Counts of grey seal in Dutch colonies are currently undergoing exponential rates of increase, reflecting likely immigration from and mixing with UK colonies. Argos telemetry data collected between April 2005 and April 2006 showed that three of eleven seals tagged at Dutch colonies crossed the North Sea to UK waters and haul out sites in the Moray Firth, Farne Islands and Orkney (**Figure 4.29**). In the April 2006 to May2007 tagging deployment (of GSM tags) only two of twelve tagged seals appeared to forage towards to the Dogger Bank Zone (**Figure 4.30**).

4.3.11. Usage maps can be generated to estimate at sea densities of grey seal by combining counts of hauled out animals with telemetry data, following the methods outlined in Matthiopoulos *et al.* (2004).

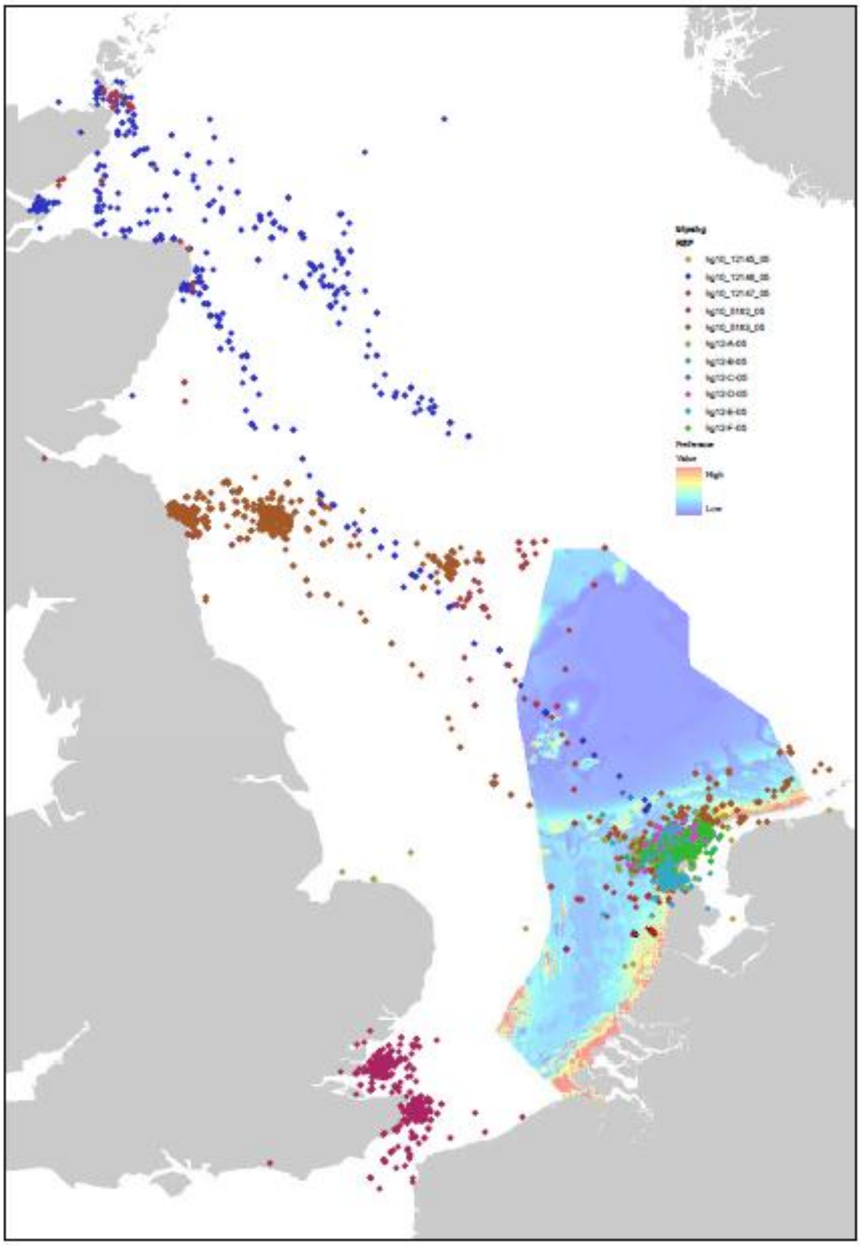


Figure 4.29 Tracking results of grey seals April 2005-April 2006 (Brassuer *et al*. 2010).

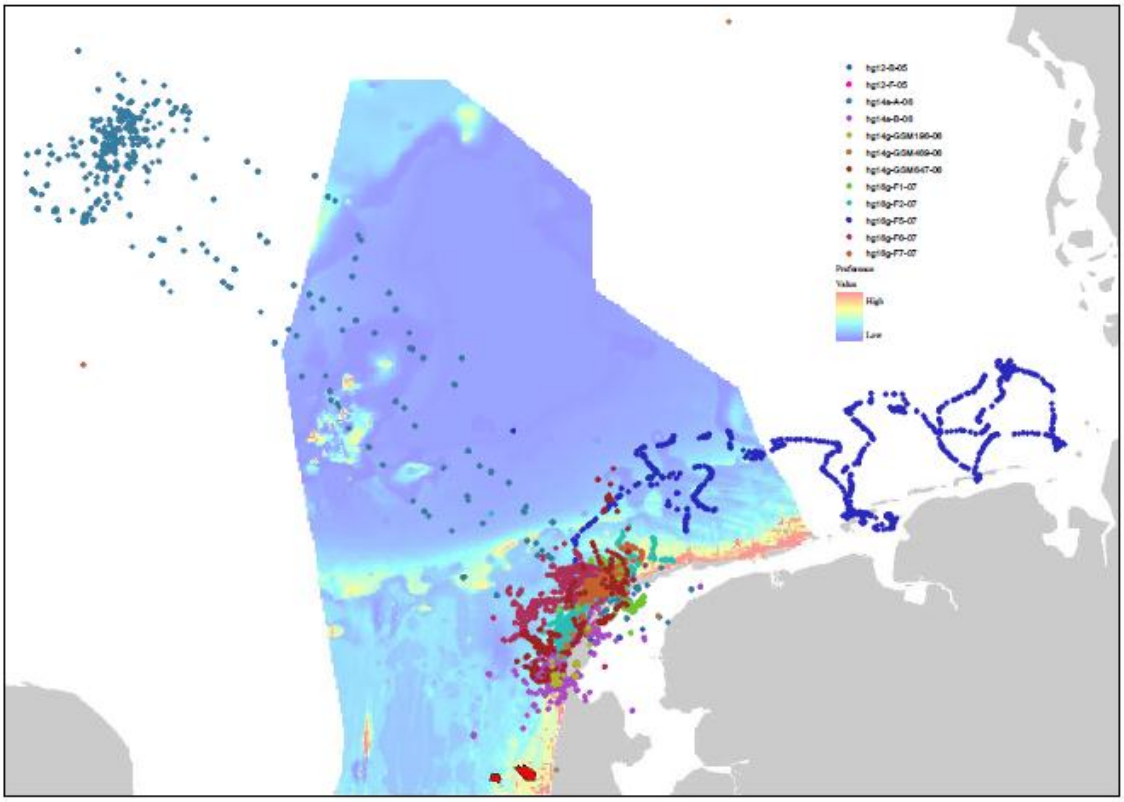
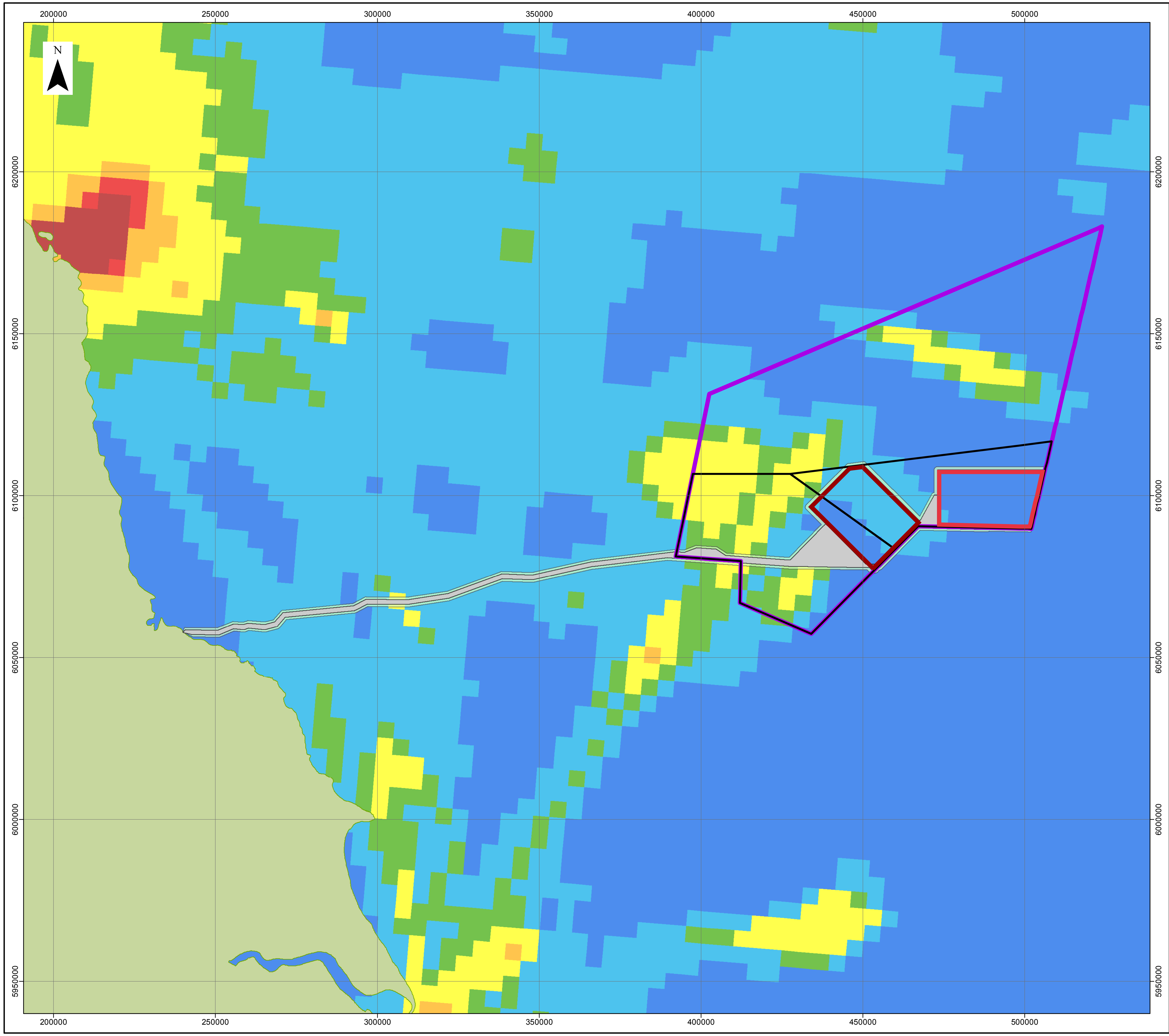
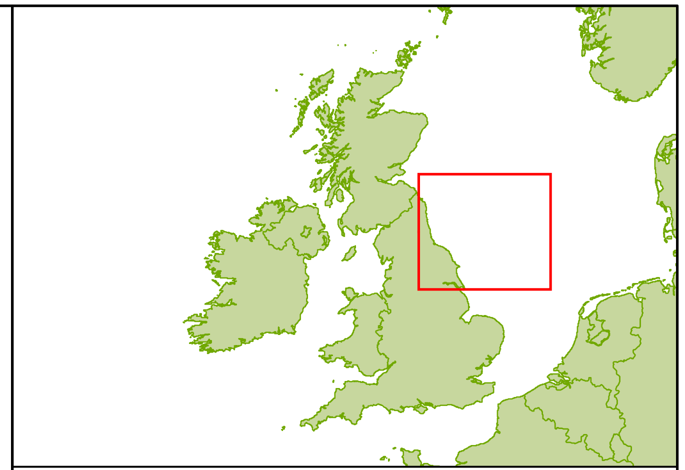


Figure 4.30 Tracking results of grey seals April 2006-May 2007 (Brasseur *et al*. 2010).

4.3.12. Data on haul out parameters and foraging trips relayed from SMRU Argos or GSM data logger telemetry tags have been analysed from deployments between 1991 and 2008 on animals caught at Abertay Sands (Firth of Tay) and the Farne Islands (McConnell *et al*. 2010). These data support the use of historical fishing grounds or large areas of sandbank as favoured foraging locations of grey seal (McConnell *et al*. 2010); this is most likely due to availability of key prey species.

4.3.13. Marine Scotland commissioned SMRU to map seal density estimates based on telemetry data around the UK, collected between 1991 and 2011 (grey seal) and 1991 to 2012 (harbour seal). The harbour seal estimates also use count data collected between 1988 and 2012. Mean density estimates with upper and lower 25% CI are provided at a resolution of 5 km by 5 km. Within the Dogger Bank Teesside A boundary the mean density estimate for 5km by 5km cells is 0.34 grey seals (0.014 per km^2). The density estimates range from 0 (minimum lower 25% CI from 45 cells) to 0.161 per km^2 (maximum upper 25% CI from 45 cells). Within the Dogger Bank Teesside B boundary the mean estimate for grey seal is 0.073 animals per km^2, ranging from 0 to 0.775 per km^2. There are 38 cells (5 km by 5 km) overlapping the Dogger Bank Teesside B boundary. **Figure 4.31** shows the mean at sea density estimates for grey seal around Dogger Bank Teesside A & B, as well as the Dogger Bank Teesside A & B Export Cable Corridor. For the purposes of providing a conservative impact assessment the maximum mean at sea density estimate of 0.085 per km^2 is used for Dogger Bank Teesside A and 0.23 per km^2 for Dogger Bank Teesside B.





LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside A & B Export Cable Corridor
- Temporary works area

Grey seal at-sea usage

- 0.000 - 1.000
- 1.001 - 5.000
- 5.001 - 10.000
- 10.001 - 50.000
- 50.001 - 100.000
- 100.001 - 150.000
- 150.001 - 913.000

0 10 20 40
Kilometres

Data Source:
Seal Density Data © Marine Scotland 2013
Round 3 offshore wind farm boundary © Crown Copyright, 2013

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 4.31 Grey seal at-sea usage within Dogger Bank

VER	DATE	REMARKS	Drawn	Checked
1	27/08/2013	Draft	LW	GK
2	03/10/2013	PEI3	JE	GK
3	11/02/2014	DCO Submission	JE	GK

DRAWING NUMBER: **F-OFL-MA-222**

SCALE	1:1,200,000	PLOT SIZE	A3	DATUM	WGS84	PROJECTION	UTM31N

FOREWIND

4.3.14. The grey seal is an opportunistic predator of fish and invertebrates. In the North Sea, principal prey items are sandeel, whitefish (cod, haddock, whiting and ling), and flatfish (plaice *Pleuronectes platessa*, sole *Solea solea*, flounder *Platichthys flesus*, dab *Limanda limanda*) (Hammond & Grellier 2006). Two major studies have been conducted on grey seal diet, one in 1985 and one in 2002. In 2002, the percentage of sandeel in the diet was much higher than in 1985; the percentage of haddock in the diet had also increased, with a five-fold decrease in the amount of cod in the diet (Hammond & Grellier 2006).

Site specific surveys

4.3.15. Although grey seal were not recorded in the Dogger Bank Zone on surveys in March, August and September 2008 (Cork Ecology 2009), more recent boat-based surveys have recorded low numbers (typically below 15) of grey seal in the Dogger Bank Zone throughout the year, whilst during December 2010 to March 2011, numbers were higher (**Figure 4.32**). No grey seal were recorded during boat-based surveys undertaken in August, September or October 2010.

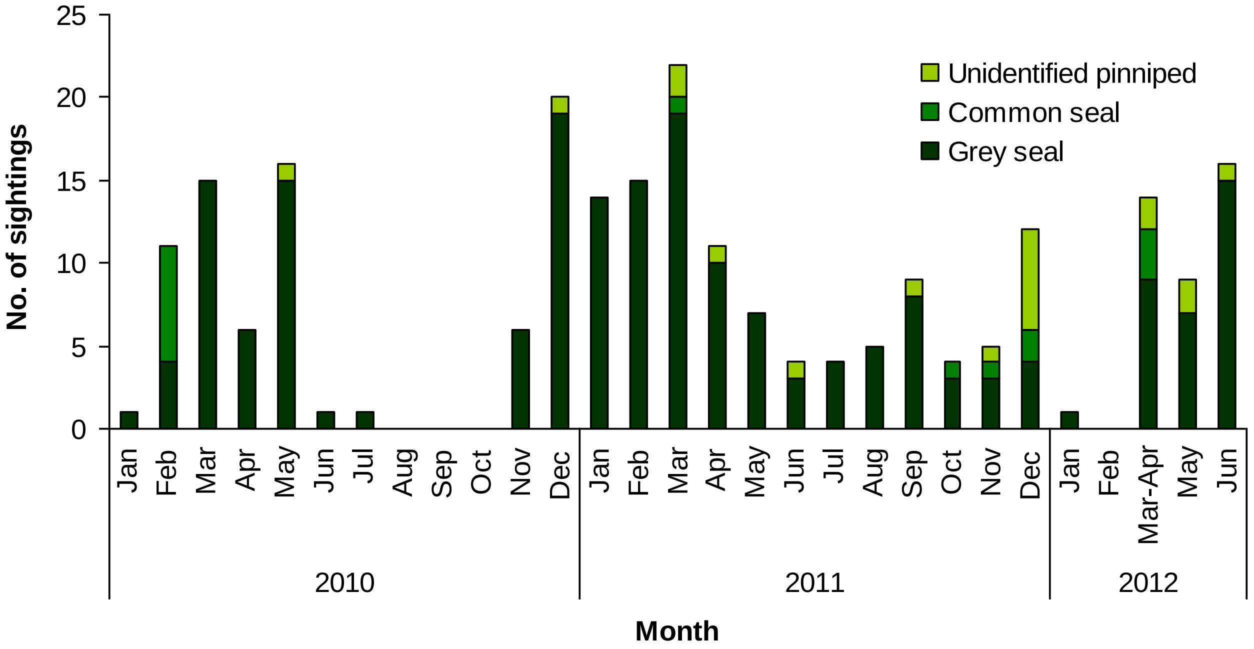


Figure 4.32 Pinniped sightings during boat based surveys of the Dogger Bank Zone (Jan 2011 – June 2012) (Gardline Environmental 2012). It should be noted that common seal is the same species (*Phoca vitulina*) as harbour seal.

4.3.16. Aerial surveys undertaken by HiDef detected even fewer grey seals, with a maximum of four seals for each month of January to April 2011 and January to May 2012. Most winter surveys encountered no grey seal, with other monthly surveys identifying one or two individuals.

4.3.17. The limited number of sightings means that monthly variation in numbers cannot be examined in detail. Although there was some variation in abundance between years, it was not statistically significant (**Appendix 14B**).

4.3.18. Estimates of absolute density for all years combined show higher density at the most inshore extent of the zone to the west of Dogger Bank Teesside B.

Another peak is shown to the north of Dogger Bank Teesside A. Densities peak in this area at approximately 0.5 seals per km^2 in 2011 and 2012. These estimates of peak density are comparable to estimates from telemetry data (**Figure 4.31**).

4.3.19. Estimates of average absolute abundance and density over the zone and survey period were calculated, spatial variation in absolute density is shown in **Figure 4.33** along with associated uncertainty (**Figure 4.34** and **Figure 4.35**). Estimated absolute abundance over the survey period was 278 (95% CI 205 - 425) individuals. Estimated average absolute density was 0.02131 (95% CI 0.01571 – 0.03257) seals per km^2.

4.3.20. Forewind commissioned SMRU Ltd to examine the degree of overlap between Dogger Bank Tranche B (plus a 10km buffer) and the 235 grey seal tagged by SMRU since 1988 (see **Appendix 14A**). The 10km buffer was based on the maximum potential range of behavioural disturbance from pile driving in this species (based on modelling presented in **Appendix 14A**).

4.3.21. The study allowed quantification of the interactions between grey seal populations that form part of UK SACs and Tranche B and consideration of the extent over which grey seal have the potential to interact with the development.

4.3.22. No grey seal with tagging records within Tranche B (or the 10km buffer zone) also had tagging locations within the Faray and Holm of Faray SAC. Therefore, it is concluded that there was very limited connectivity between this SAC and Tranche B. Grey seal tagged at the Humber Estuary SAC (Donna Nook), Berwickshire and North Northumberland SAC (Farne Islands) and the Isle of May SAC did show some connectivity with Tranche B. Grey seal hauling out at Abertay Sands outwith the breeding season were also considered.

4.3.23. Of a total of nine tagged grey seal pups from the Berwickshire and North Northumberland SAC (Farne Islands), none entered the buffer area, whilst of the 22 pups tagged on the Isle of May SAC four entered the buffer (**Appendix 14A**, Figure 2). Between approximately 0.3% and 1.2% of the locations of these pups respectively were in Tranche B, including the 10km buffer.

4.3.24. A total of 29 adult (seals aged 1+) grey seal were tagged at the Berwickshire and North Northumberland SAC (Farne Islands); two of these entered Tranche B and/or the buffer, with an average of between 1.4 and 2.2% of their at sea locations being in these areas (**Appendix 14A**, Figure 3). Twelve grey seal have been tagged at Donna Nook in the Humber Estuary SAC, one of which had at sea locations within Tranche B and/or the buffer area, and averages of between 33 and 34.2% of their locations were within Tranche B or the buffer (**Appendix 14A**, Figure 4).

4.3.25. Three of the 38 adult grey seal tagged at Abertay entered Tranche B and/or the buffer, (**Appendix 14A**, Figure 5). The average number of locations for each seal within this area was 11.4%, but ranged from 2.9% to 21.4%. Of the 11 adult grey seal tagged at the Isle of May, none entered Dogger Bank Tranche B or the buffer. However, one of the three seals tagged at Abertay Sands which entered Tranche B or the buffer had locations within 5km of the Isle of May

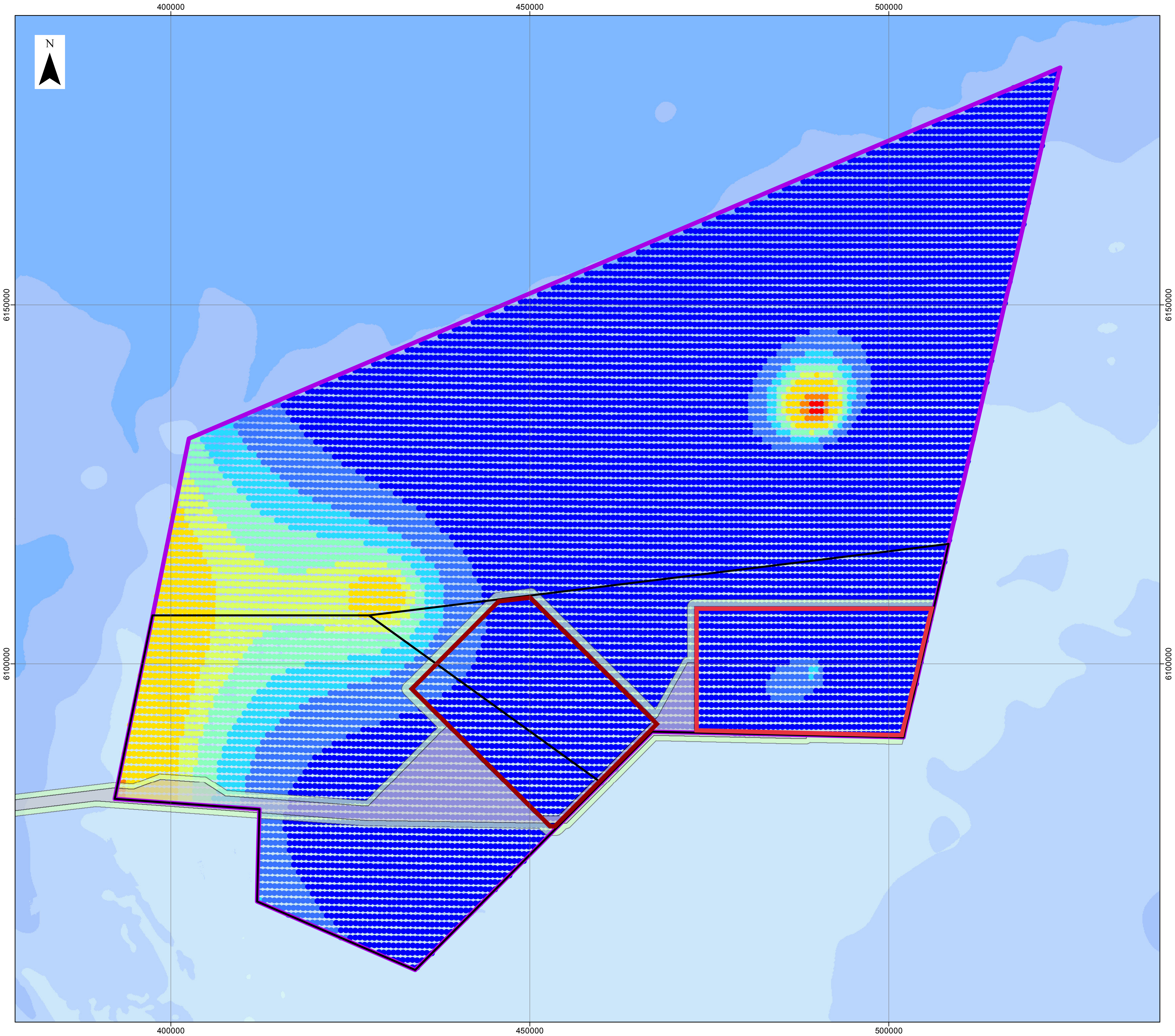
SAC. For context, 33 of the 188 tagged adult grey seal had locations within 5km of the Isle of May SAC.

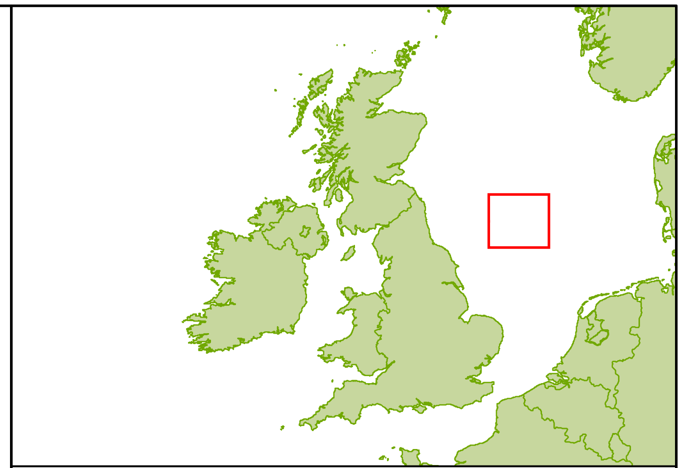
4.3.26. The Dogger Bank Teesside B boundary overlaps with Tranche A, as well as being predominantly in Tranche B. Analysis of the telemetry data overlapping with Tranche A for the Dogger Bank Creyke Beck EIA (**Appendix 14C**) showed nine tagged grey seal pups and 29 adults from Berwickshire and North Northumberland SAC had at sea locations within Tranche A. Two seals from Donna Nook in the Humber Estuary SAC and five grey seals from Abertay also entered Tranche A. However, as **Figure 4.31** shows the at sea densities within the Dogger Bank Teesside B boundary of Tranche A are relatively low in comparison to the rest of the Tranche A area, reflecting lower usage.

4.3.27. Grey seal in the Dogger Bank Zone are considered high VERs due to the medium connectivity with international designated SAC populations under the Habitats Directive (**Table 3.2**).

Reference population for assessment

4.3.28. The reference population is based on the IAMMWG (2013) MUs and evidence from **Appendix14A** (and **Appendix 14C**). **Appendix 14A** and **14C** show connectivity between seals in Dogger Bank Tranche A and Tranche B and a number of the MUs as well as evidence of European connectivity. Grey seal from the East Coast, North east England and Southeast England MUs have connectivity with Tranche A and Tranche B. The estimate population size for each of the MUs (based on data from 2007, 2008, 2010 and 2011) is 24,950 (IAMMWG, 2013). In addition, some connectivity has been shown with European colonies, so the most recent count of 4,039 is included in the estimated reference population size, giving a total of 28,989.





LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside A & B Export Cable Corridor
- Temporary works area

Absolute mean density (km²)

- ≤ 0.020
- 0.021 - 0.040
- 0.041 - 0.060
- 0.061 - 0.080
- 0.081 - 0.100
- 0.101 - 0.200
- 0.201 - 0.300
- ≥ 0.301

0 5 10 20
Kilometres

Data Source:
Density data © DMP Stats, 2013
Round 3 offshore wind farm boundary © Crown Copyright, 2013
Background bathymetry image derived in part from TCarta data © 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

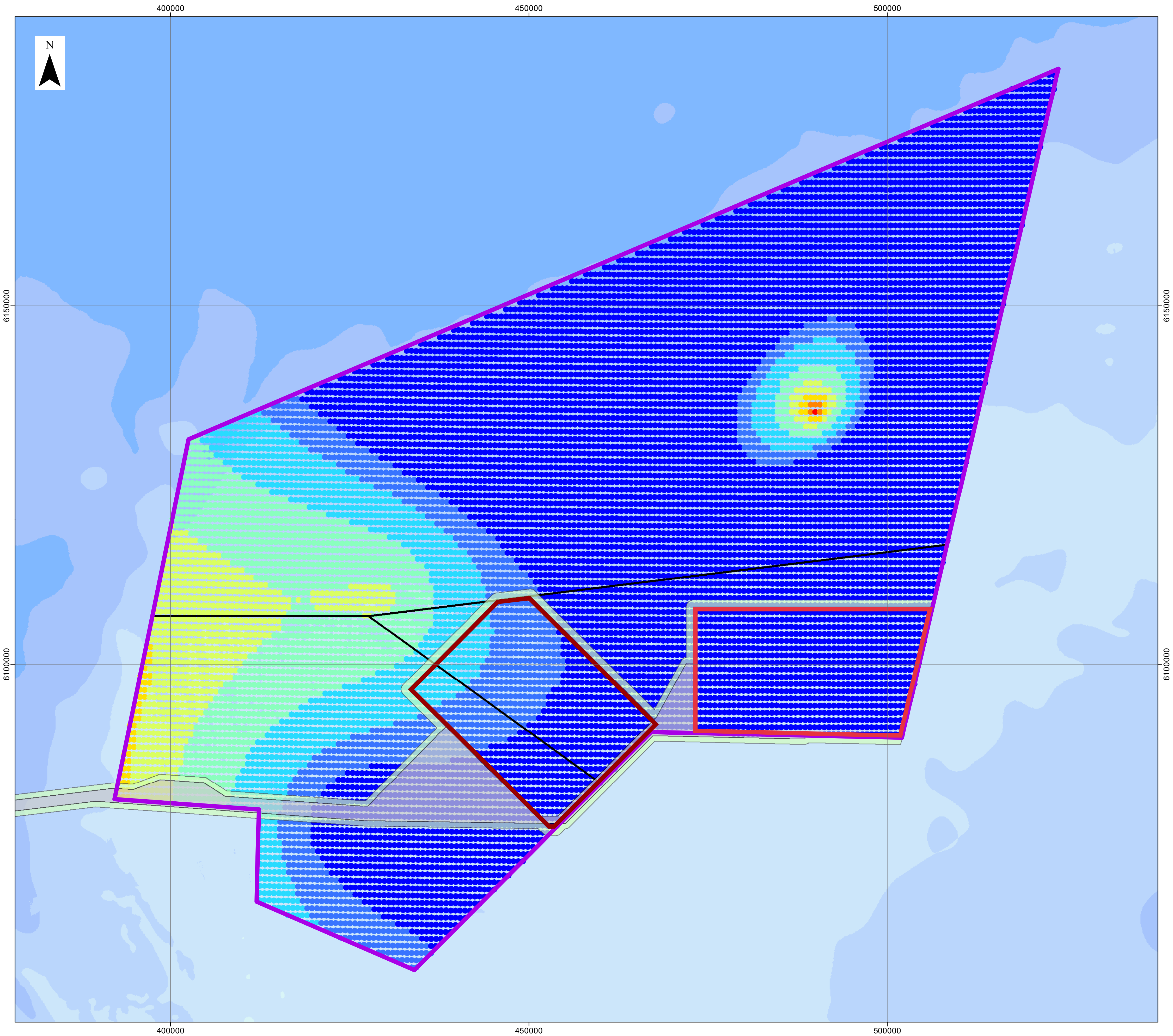
Figure 4.33 Absolute mean densities (in km²) of grey seal adjusted for availability

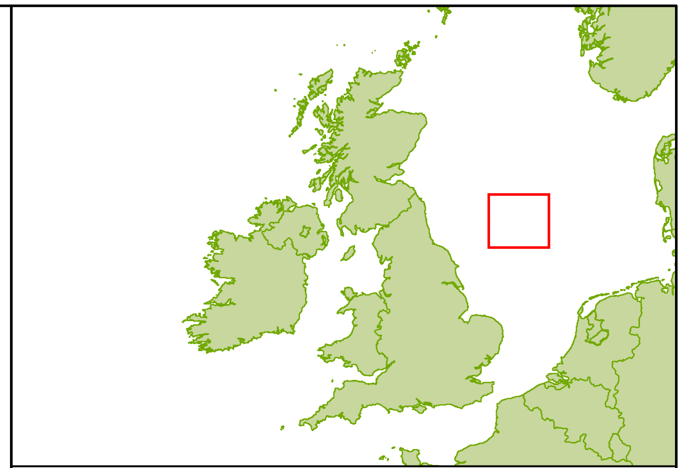
VER	DATE	REMARKS	Drawn	Checked
1	27/08/2013	Draft	LW	GK
2	03/10/2013	PEI3	JE	GK
3	11/02/2014	DCO Submission	JE	GK

DRAWING NUMBER: **F-OFL-MA-223**

SCALE	1:550,000	PLOT SIZE	A3	DATUM	WGS84	PROJECTION	UTM31N

FOREWIND





LEGEND

Dogger Bank Zone
Tranche boundary
Dogger Bank Teesside A
Dogger Bank Teesside B
Dogger Bank Teesside A & B Export Cable Corridor
Temporary works area

Absolute mean density (km²)

- ≤ 0.005
- 0.006 - 0.010
- 0.011 - 0.025
- 0.026 - 0.050
- 0.051 - 0.075
- 0.076 - 0.100
- 0.101 - 0.125
- ≥ 0.126

0 5 10 20
Kilometres

Data Source:
Density data © DMP Stats, 2013
Round 3 offshore wind farm boundary © Crown Copyright, 2012
Background bathymetry image derived in part from TCarta data © 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 4.34 The lower 95% confidence bound for the absolute mean densities (in km²) of grey seal adjusted for availability

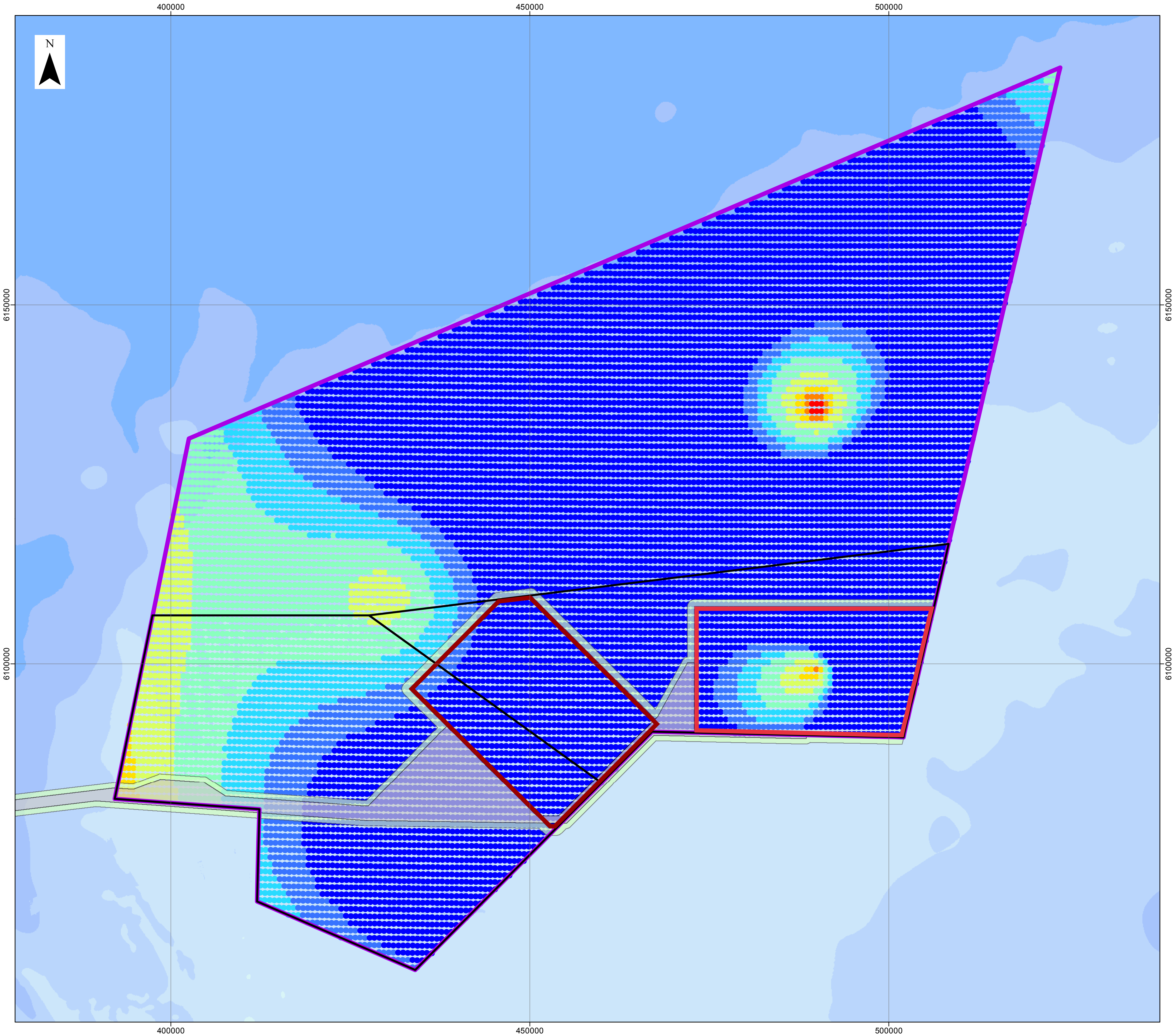
VER	DATE	REMARKS	Drawn	Checked
1	27/08/2013	Draft	LW	GK
2	03/10/2013	PEI3	LW	GK
3	11/02/2014	DCO Submission	JE	GK

DRAWING NUMBER:

F-OFL-MA-224

SCALE	1:550,000	PLOT SIZE	A3	DATUM	WGS84	PROJECTION	UTM31N

FOREWIND



LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside A & B Export Cable Corridor
- Temporary works area

Absolute mean density (km²)

- ≤ 0.040
- 0.041 - 0.060
- 0.061 - 0.100
- 0.101 - 0.200
- 0.201 - 0.400
- 0.401 - 0.600
- 0.601 - 0.800
- ≥ 0.801

0 5 10 20
Kilometres

Data Source:
Density data © DMP Stats, 2013
Round 3 offshore wind farm boundary © Crown Copyright, 2013
Background bathymetry image derived in part from TCarta data © 2009

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 4.35 The upper 95% confidence bound for the absolute mean densities (in km²) of grey seal adjusted for availability

VER	DATE	REMARKS	Drawn	Checked
1	27/08/2013	Draft	LW	GK
2	03/10/2013	PEI3	JE	GK
3	11/02/2014	DCO Submission	JE	GK

DRAWING NUMBER:

F-OFL-MA-225

SCALE	1:550,000	PLOT SIZE	A3	DATUM	WGS84	PROJECTION	UTM31N

FOREWIND

Harbour seal

Desk-based data review

4.3.29. Harbour seal have a circumpolar distribution and are widespread throughout the Northern Hemisphere. Harbour seals in the UK are surveyed by SMRU on a three to five yearly cycle during their annual moult. The most recent estimate of the minimum size of the harbour seal population in the UK is 26,260 (based on counts conducted between 2007 and 2010; SCOS 2012). When accounting for animals hauled out during the survey period, the total estimated size of the UK harbour seal population in 2011 was approximately 36,500 (approximate CI 29,900-48,650).

4.3.30. Approximately 4,023 harbour seal were counted around the coast of England during the most recent surveys. The majority are associated with colonies around The Wash (2,894) and Blakeney Point (349), which comprise The Wash and North Norfolk Coast SAC. The remaining east coast sites, Donna Nook and Scroby Sands, represent a small percentage of the UK population, with an approximate population of 205 and 119 respectively (SCOS 2012). In total these colonies are equivalent to the South-east England MU (IAMMWG, 2013), with a minimum estimate of population size of 3,567 (based on the 2011 surveys).

4.3.31. Numbers of harbour seal moulting and breeding at these English sites are undergoing a slow recovery since the 2002 phocine distemper outbreak. Elsewhere in the UK several populations are experiencing dramatic and largely unexplained declines (Lonergan *et al*. 2007).

4.3.32. There is a small haul out and breeding colony of harbour seal in the mouth of the River Tees (at Seal Sands) that has been routinely monitored since 1989. The most recent surveys in 2011, showed a peak count of 79 during the August moult, and a total of 16 pups were recorded at the site. The population has been increasing over recent years (since the 2002 phocine distemper outbreak; Woods, 2011). These counts are included in the reference population considered in the impact assessment however Seal Sands is approximately 10km (in a straight line) from the export cable landfall and so disturbance effects at the haul out site are not considered likely.

4.3.33. Mainland European harbour seal are also routinely surveyed in the Wadden Sea, where populations are showing a rapid and strong recovery since the two epizootic outbreaks (Reijnders *et al*. 2010). The most recent surveys (in 2012) across Denmark, Germany and the Netherlands counted 26,220 seals during the moult, and counted 7,267 pups during the breeding season surveys. The adult counts approximate to a population size of 35,500 seals. The population is continuing to grow, with an observed increase of 11% between 2011 and 2012 (TSEG 2012b).

4.3.34. In the UK, pupping occurs in the summer (June to July) and moulting occurs in August. Densities at sea are therefore likely to be lower during this period than at other times of the year (DECC 2011).

4.3.35. Harbour seal eat a wide range of prey, including sandeel, gadoids, herring, sprat, flatfish, octopus and squid (SCOS 2012). A detailed investigation in to harbour seal diet around the UK is currently being undertaken by SMRU.

4.3.36. Harbour seal generally range less widely than grey seal; foraging within 60km or so of their haul out sites (Thompson and Miller 1990). However, more recent evidence from Denmark suggests that harbour seal may range much more widely than this (Dietz *et al*. 2003; green locations **Figure 4.36**).

4.3.37. In the UK and the Wadden Sea, telemetry studies have been conducted to examine the at sea distribution of harbour seal (e.g. **Figure 4.36**, **Figure 4.37**). In the UK, marine usage maps have been generated (e.g. Sharples *et al*. 2008) which shows concentrations of usage in coastal waters around the haul out sites, with more occasional use of more offshore areas, such as the Dogger Bank Zone, which may represent the edge of their viable foraging range.

4.3.38. None of the 24 harbour seals tagged in the Wash by SMRU (excluding January 2012 DECC funded tagging deployment, where data are not yet available, anticipated February 2014) entered the Dogger Bank Teesside A boundary (**Figure 4.38**). One harbour seal track reaches the west boundary of Dogger Bank Teesside B. This low usage is confirmed by Jones *et al.* (2013) which shows harbour seal density at Dogger Bank Teesside A & B to be zero (**Figure 4.38**).

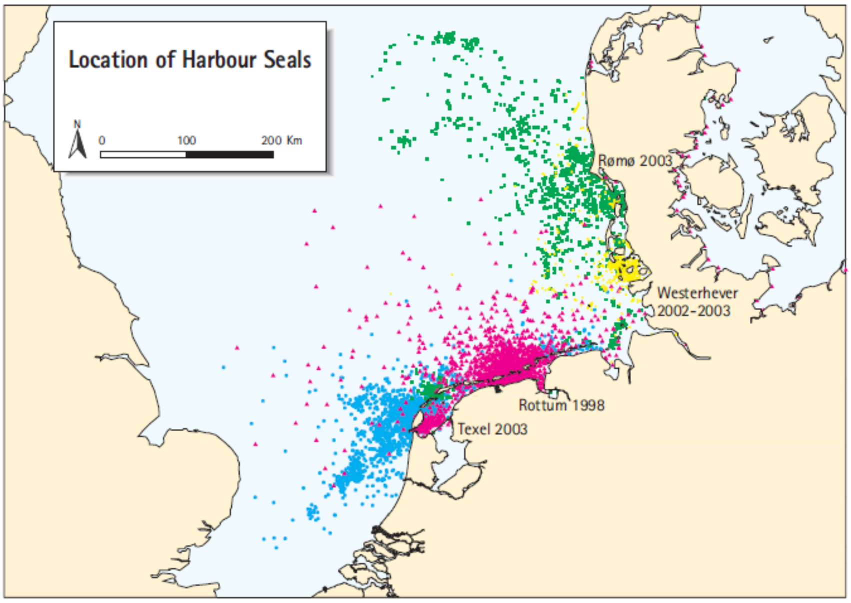


Figure 4.36 Locations of tagged harbour seals revealed through satellite telemetry. Blue seals tagged close to Texel in 2003, red seals tagged at Rottum in 1998, green seals tagged at Rømø in 2002, yellow seals tagged close to Westerhever in 2002/2003. Reijnders *et al*. (2005).

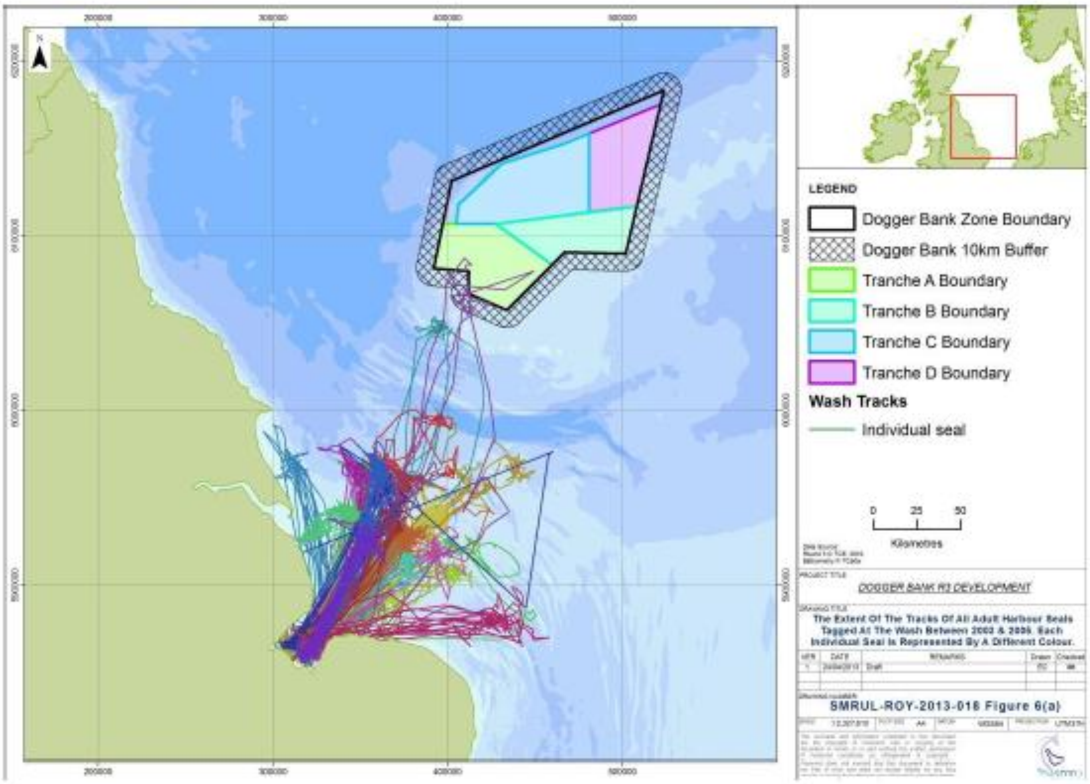
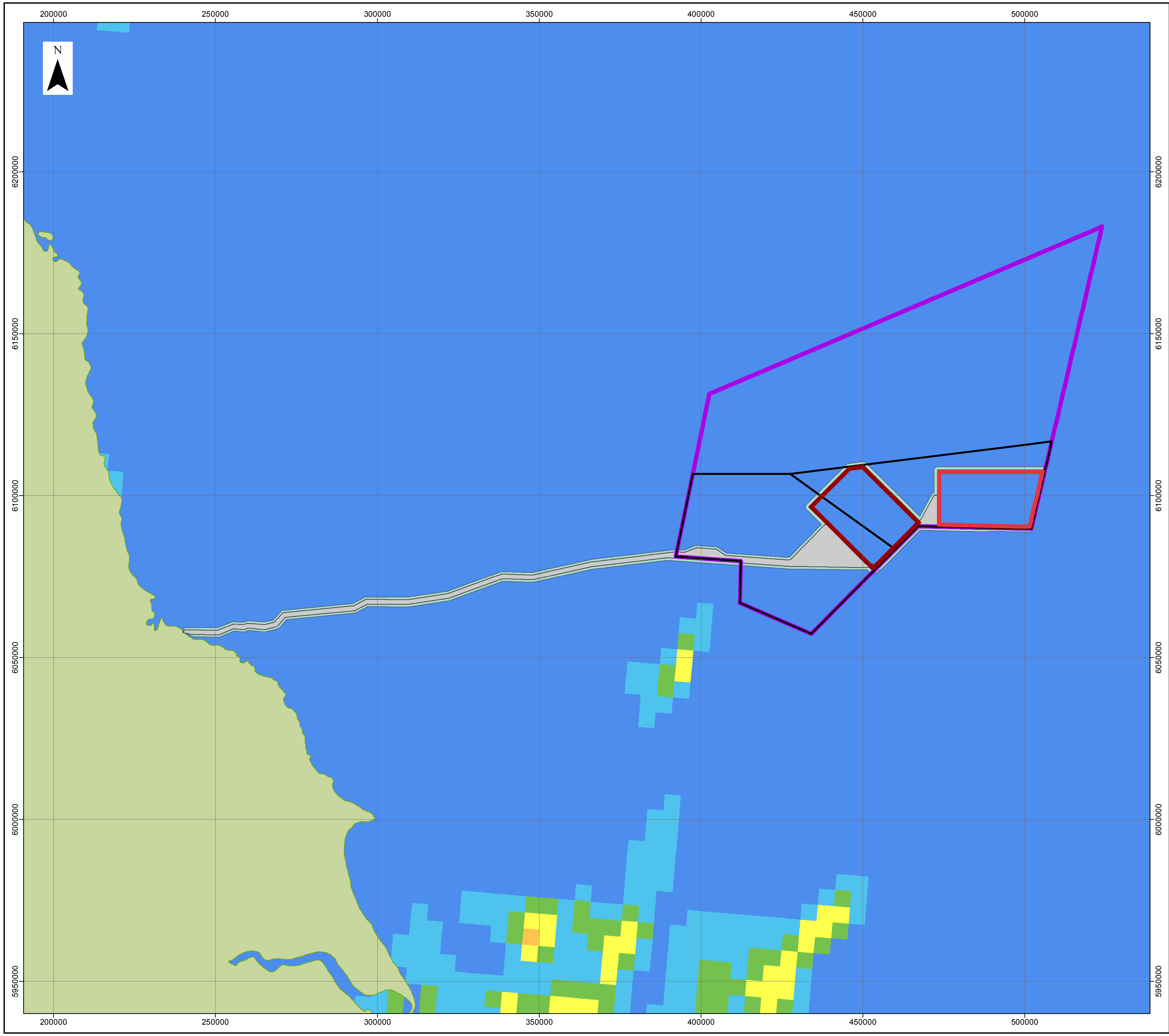
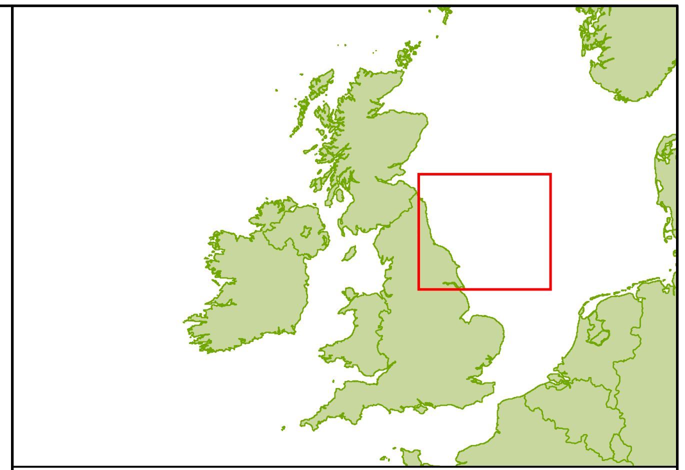


Figure 4.37 Tracks of all harbour seals tagged at The Wash (see Appendix 14A for further explanation).





LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside A & B Export Cable Corridor
- Temporary works area

Harbour seal at-sea usage

- 0.000 - 1.000
- 1.001 - 5.000
- 5.001 - 10.000
- 10.001 - 50.000
- 50.001 - 100.000
- 100.001 - 150.000
- 150.001 - 513.000

0 10 20 40
Kilometres

Data Source:
Seal Density Data © Marine Scotland 2013
Round 3 offshore wind farm boundary © Crown Copyright, 2013

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 4.38 Harbour seal at-sea usage within Dogger Bank

VER	DATE	REMARKS	Drawn	Checked
1	27/08/2013	Draft	LW	GK
2	03/10/2013	PEI3	JE	GK
3	11/02/2014	DCO Submission	JE	GK

DRAWING NUMBER: **F-OFL-MA-226**

SCALE	PLOT SIZE	DATUM	PROJECTION
1:1,200,000	A3	WGS84	UTM31N

FOREWIND

Site specific surveys

4.3.39. During the Gardline boat-based surveys seven harbour seals were recorded in the area in February 2011, one harbour seal in March 2011, October 2011, November 2011 and two in December 2011. There were no other sightings throughout the entire survey period.

4.3.40. The HiDef aerial surveys detected harbour seal in five of the 31 survey months. These amounted to nine individuals throughout the survey. As expected, due to the distance from shore of the development zone, the number of sightings of harbour seal is very low representing their low likelihood of occurrence.

4.3.41. Harbour seal in the Dogger Bank Zone are considered medium VERs due to the low connectivity with international designated SAC populations under the Habitats Directive, and national designations (**Table 3.2**).

4.4. Summary of species and reference populations considered in the assessment

4.4.1. **Table 4.3**, below, provides a summary of the species being taken forward for the impact assessment, and the reference populations for each species.

4.4.2. During the impact assessment, the magnitude of impacts will be put in context against these populations (see **Table 3.4** for definitions of magnitude).

Table 4.3 Summary of species and reference populations used in the impact assessment.

Species	**Reference population extent**	**Year of estimate and data source**	**Reference population size used in assessment (confidence intervals)**
Harbour porpoise	North Sea MU	2005 (IAMMWG, 2013 based on SCANS II Hammond *et al*. 2013)	227,298 (176,360 – 292,948)
Minke whale	(a) BI MU (b) Central and north east Atlantic	(a) 2005 & 2007 (IAMMWG, 2013 based on SCANS II (Hammond *et al*. 2013)CODA (Hammond *et al*. 2009) (b) 1996-2001 IWC	(a) 23,168 (13,772 – 38,958) (b)174,000 (125,000-245,000)
White-beaked dolphin	BI MU	2005 (IAMMWG, 2013 based on SCANS II Hammond *et al*. 2013)	15,895 (9,107 – 27,743)
Grey seal	North Sea (South-east England, North east England and East coast MU + Waddensea)	2007, 2008, 2010, 2011 and 2012 UK North Sea (IAMMWG, 2013) & Mainland Europe (Waddensea Secretariat)	24,950 + 4,039 = **28,989**
Harbour seal	South-east England MU	2011 (IAMMWG, 2013)	3,567 (minimum population size)

5. Assessment of Impacts – Worst Case Definition

5.1. General

5.1.1. This section establishes the realistic worst case scenario for each category of impact as a basis for the subsequent impact assessment. For this assessment this involves both a consideration of the relative timing of construction scenarios (i.e. the manner in which Dogger Bank Teesside A and Dogger Bank Teesside B will be built out; **Table 5.1**), as well as the particular design parameters of each project that define the Rochdale Envelope[2] for this assessment (**Table 5.2**).

5.1.2. Full details of the range of development options being considered by Forewind are provided within **Chapter 5**. Only those design parameters with the potential to influence the level of impact are identified.

5.1.3. The realistic worst case scenarios identified here are also applied to the Cumulative Impact Assessment (CIA). When the worst case scenarios for the project in isolation do not result in the worst case for cumulative impacts, this is addressed within the cumulative section of this chapter (see Section 10) and summarised in **Chapter 33**.

5.2. Construction scenarios

5.2.1. The specific timing of the construction of Dogger Bank Teesside A & B will be determined post consent and, therefore, a Rochdale Envelope approach has been taken for the EIA. There are a number of key principles relating to how the projects will be built, and that form the basis of the Rochdale Envelope (see **Chapter 5**). For the offshore assessment these are:

- The two projects may be constructed at the same time, or at different times;
- If built at different times, either project could be built first;
- Offshore construction will commence no sooner than 18 months post consent, but must start within seven years of consent (as an anticipated condition of the development consent order). Therefore if the construction period reaches the maximum six years, the projects will have to overlap by six months; and

[2] As described in Chapter 5 the term 'Rochdale Envelope' refers to case law (R.V. Rochdale MBC Ex Part C Tew 1999 "the Rochdale case"). The 'Rochdale Envelope' for a project outlines the realistic worst case scenario or option for each individual impact, so that it can be safely assumed that all lesser options will have less impact.

- Taking the above into account, the maximum construction period over which the construction of Dogger Bank Teesside A & B could take place is 11 years and six months.

5.2.2. To determine which offshore construction scenario is the worst realistic case for a given receptor, two types of effect exist with the potential to cause a maximum level of impact on a given receptor:

- Maximum duration effects; and
- Maximum peak effects.

5.2.3. To ensure that the Rochdale Envelope incorporates all of the possible offshore construction scenarios (as outlined in **Chapter 5**), both the maximum duration effects and the maximum peak effects have been considered for each receptor. Furthermore, the option to construct Teesside A or B in isolation is also considered ('Build A in isolation' and 'Build B in isolation'), enabling the assessment to identify any differences between the two scenarios. The three construction scenarios for Dogger Bank Teesside A & B considered within the assessment for marine mammals are, therefore:

- Single project (Build A or Build B) in isolation;
- Build A and B concurrently – provides the worst 'peak' impact and maximum working footprint; and
- Build A and Build B sequentially – provides the worst 'duration' of impact.

5.2.4. Any differences between the two projects, or differences that could result from the timing and manner in which the first and the second projects are built, are identified and discussed in the impact assessment discussion (Section 6). The justification for what constitutes the worst case is outlined in **Table 5.1**.

5.3. Operation scenarios

5.3.1. **Chapter 5** provides details of the operational scenarios for Dogger Bank Teesside A & B. Flexibility is required to allow for the following three scenarios:

- Dogger Bank Teesside A to operate on its own;
- Dogger Bank Teesside B to operate on its own; and
- For the two projects to operate concurrently.

5.3.2. For the marine mammal assessment there is not considered to be a material difference between either Dogger Bank Teesside A or Dogger Bank Teesside B operating on its own. As such, only one assessment for the single project scenario is presented and is considered to be representative of whichever project is operating in isolation (**Table 5.1**).

5.4. Decommissioning scenarios

5.4.1. **Chapter 5** provides details of the decommissioning scenarios for Dogger Bank Teesside A & B. Exact decommissioning arrangements will be detailed in a Decommissioning Plan (which will be drawn up and agreed with DECC prior to construction); however for the purpose of this assessment it is assumed that decommissioning of Dogger Bank Teesside A and Dogger Bank Teesside B could be conducted separately, or at the same time (**Table 5.1**).

Table 5.1 Realistic worst case construction, operation and decommissioning scenarios for marine mammal impact assessment

Impact	Realistic worst case construction scenario	Rationale
Construction		
Underwater noise Pile driving impact	Two projects built sequentially or concurrently	Should the two projects be constructed at the same time, an overlap in noise footprints could reduce the size of the noise footprint compared to the two projects being built sequentially. The maximum duration of the pile driving period will be greatest if the two projects are built sequentially, the total number of individuals impacted will be the sum of the two projects independently. The temporal aspect could be considered the worst case in a sequential build, but there is also the potential of a larger footprint over a shorter time during a concurrent build.
Underwater noise Vessel noise	All scenarios equal	The number of vessel movements is predicted to be the same for each scenario, whether the developments are concurrent or sequential as there is a large amount of uncertainty as to whether there could be a reduction in total vessel use that could occur during a concurrent build.
Collision risk	All scenarios equal	As above
Indirect impacts of changes in prey resource	The worst case scenario is represented using the impacts defined in **Chapter 13 Fish and Shellfish Ecology**.	The predicted changes to fish resource outlined in **Chapter 13 Fish and Shellfish Ecology** have the potential to impact on marine mammal foraging success.
Operation		
Underwater noise Wind turbines	All scenarios equal	There are no data to support that there is a lesser or greater overall impact when the total impact spatial footprint remains the same, yet the temporal footprint varies.
Underwater noise Vessels	All scenarios equal	As above
Collision Risk	All scenarios equal	The number of vessel movements is predicted to be the same for each scenario.
EMF	All scenarios equal	There is no data to support that there is a lesser or greater overall impact when the total impact spatial footprint remains the same, yet the temporal footprint varies.
Physical barrier	All scenarios equal	As above
Indirect impacts of changes in prey	The worst case scenario is represented using the impacts defined in **Chapter 13**	The predicted changes to fish resource outlined in **Chapter 13 Fish and**

Impact	Realistic worst case construction scenario	Rationale
resource	**Fish and Shellfish Ecology**.	**Shellfish Ecology** have the potential to impact on marine mammal foraging success.
Decommissioning		
Underwater noise Cutting	All scenarios equal	As above
Underwater noise Vessels	All scenarios equal	As above
Collision risk	All scenarios equal	As above

5.5. Realistic worst case scenarios

5.5.1. **Table 5.2** identifies the key design parameters for the impact assessment. The parameters identified have been derived from a desktop review and consultation with stakeholders.

Table 5.2 Key design parameters forming the realistic worst case scenarios for the marine mammal impact assessment

<table>
<tr><th>Impact</th><th>Realistic worst case scenario</th><th>Rationale</th></tr>
<tr><td colspan="3">Construction</td></tr>
<tr><td>Underwater noise
Pile driving - single pile</td><td>Maximum pile size:
(Method 100% pile driving monopoles (10MW)):
Pile diameter: 12m
Max Penetration: 55m
Hammer Capacity: 3000kJ
Max Blow Force: 3000kJ
Soft-start duration: 0.5h.
Soft-start hammer energy: 300 kJ
Total max pile driving duration: 5 hours 30 minutes (full force time per pile 5 hours, soft-start 30 minutes).</td><td>The worst case scenario for a single hammer blow represents the largest impact footprint and potential for injury to marine mammals.

Five hours is considered the worst case for the amount of time required to pile one foundation (plus 30 minutes soft-start).</td></tr>
<tr><td>Underwater noise
Pile driving - per project</td><td>Maximum number of piles:
(Method 100% pile driving multileg piles (6MW)):
<table>
<tr><th></th><th>No. structures</th><th>No. piles per device</th><th>Total no. piles</th><th>Pile diameter (m)</th><th>Penetration (m)</th><th>Blow force (kJ)</th><th>Time per pile excl. soft-start (hrs.)</th><th>soft-start blow force (kJ)</th><th>Soft-start duration (hrs.)</th><th>Total duration (hrs.)</th></tr>
<tr><td>WTG (6MW)</td><td>200</td><td>6</td><td>1200</td><td>3.5</td><td>55</td><td>2300</td><td>3</td><td>230</td><td>0.5</td><td>4200</td></tr>
<tr><td>met mast</td><td>5</td><td>4</td><td>20</td><td>3.5</td><td>52</td><td>1900</td><td>3</td><td>190</td><td>0.5</td><td>70</td></tr>
<tr><td>Offshore Collector Platform</td><td>4</td><td>24</td><td>96</td><td>2.75</td><td>60</td><td>1900</td><td>3</td><td>190</td><td>0.5</td><td>336</td></tr>
<tr><td>Offshore Converter Platform</td><td>1</td><td>24</td><td>24</td><td>2.75</td><td>70</td><td>1900</td><td>3</td><td>190</td><td>0.5</td><td>84</td></tr>
<tr><td>Accommodation platform</td><td>2</td><td>24</td><td>48</td><td>2.75</td><td>70</td><td>1900</td><td>3</td><td>190</td><td>0.5</td><td>168</td></tr>
</table>
Maximum construction period six years, minimum 3 years.
Maximum of 600 piling operations per year for wind turbine, plus up to 188 for other structures.</td><td>The worst case scenario for construction of the offshore wind farm represents the longest temporal duration of impact, which equates to the maximum number of pile driving events.

Five hours is considered the worst case for the amount of time required to pile one</td></tr>
</table>

Impact	Realistic worst case scenario	Rationale
	Maximum of two simultaneous piling operations. Both concurrent and sequential phasing are included in the worst case scenario Cumulative – a maximum of six projects in simultaneous construction (with two piling operations per project), a total of 12 rigs.	foundation (plus 30 minutes soft-start). However, this is only expected to be required for a very small number of foundations, if at all and hence a conservative worst case average is applied of three hours per pile across a whole project.
Underwater noise Vessel noise - per project	Large and medium crane vessels, floating and dynamic positioning and jack up type, logistics, transportation and feeder vessels, tugs and anchor handling vessels, hotel and accommodation vessels, personnel transfer craft, dredging, seabed preparation and aggregate handling craft, diving support vessels, guard ships, general offshore and subsea construction vessels, cable installation and maintenance vessels, survey vessels. • Indicative number of construction vessel movements for 6MW wind turbines: 5150 (for the full construction period). • Indicative number of materials transport (to construction site) vessel movements: 660 (for the full construction period). • Maximum of 66 vessels offshore during construction (peak in year 2) per project. • Cumulative: 396 vessels for six concurrent projects.	The worst case is based on the maximum number of wind turbines. This reflects the estimated maximum number of vessels that will be offshore during this phase.
Collision risk - per project	As above.	As above.
Indirect impacts of changes in prey resource - per project	The worst case scenario is represented using the impacts identified in **Chapter 13 Fish and Shellfish Ecology**.	The predicted changes to fish resource outlined in **Chapter 13 Fish and Shellfish Ecology** have the potential to impact on marine mammal foraging success.

Impact	Realistic worst case scenario	Rationale
Operation		
Underwater noise Wind turbines - per project	A maximum of 200 operating 6MW wind turbines.	The worst case is the maximum number of turbines.
Underwater noise Vessels - per project	Indicative number of vessels movements per year for 6MW wind turbines: 730 round trips to port. Including 3 large Operation and Maintenance (O&M) vessels (40 movements); 11 small O&M vessels (430 movements), 2 lift vessels (40 movements), 2 cable maintenance vessels (10 movements), 8 auxiliary vessels (210 movements). Maximum of 26 vessels on site at any one time during this phase of the development.	The worst case is based on the maximum number of wind turbines. This reflects the estimated maximum number of vessels movements required for O&M
Collision risk - per project	As above.	As above.
EMF- per project	950km of 33kV to 72.5kV inter-array cable (AC, minimum burial 0m). 320km of 132-400kV inter platform cable (minimum burial 0m). 573km of HVDC export cables (up to 550kV), cables will be buried or use industry standard shielding.	The worst case is the maximum cable lengths, and minimum burial depths. HVDC is also expected to be worse than HVAC.
Physical barrier - per project	Teesside A = Approximately 196km offshore. Teesside B = Approximately 165km offshore. Minimum turbine spacing 750m (6MW). Spacing of met masts and buoys – typically around 334m to 668m	The minimum turbine spacing and distance to shore of the array represents the worst case, which could present a physical barrier to movement.
Indirect impacts of	The worst case scenario is represented using the impacts defined in **Chapter 13 Fish and Shellfish Ecology**.	The predicted changes to fish

Impact	Realistic worst case scenario	Rationale
changes in prey resource - per project		resource outlined in **Chapter 13 Fish and Shellfish Ecology** have the potential to impact on marine mammal foraging success.
Decommissioning		
Underwater noise Cutting - per project	Cutting of foundations below sea level and removal of debris. 200 6MW devices 5 meteorological masts 4 Offshore Collector Platforms 1 Offshore Converter Platform 2 accommodation platforms	The worst case is the nosiest approach to removal or turbines and debris.
Underwater noise Vessels - per project	Level of vessel activity may be similar to construction. Indicative number of construction vessel movements for 6MW wind turbines: 5150 (for the full decommissioning period). Indicative number of materials transport vessel movements: 660 (for the full decommissioning period).	The worst case considers the same maximum number of vessels as construction.
Collision risk - per project	As above	As above.

6. Assessment of Impacts during Construction

6.1. Underwater noise: pile driving

6.1.1. The construction scenarios on which this assessment has been based are presented within **Chapter 5** and outlined in **Table 5.2**.

6.1.2. **Appendix 5A** provides details of the noise propagation modelling carried out by NPL for Dogger Bank Teesside A & B. The impact assessment below should be read in conjunction with **Appendix 5A**.

6.1.3. The dimensions of the piles are not expected to have a discernible effect on the noise energy output; for example, the noise resulting from a monopole using a given hammer energy would be expected to be the same as that from a smaller diameter pin-pile using the same hammer energy.

6.1.4. A range of hammer energies have been modelled from a soft-start up to the maximum expected for each turbine size and foundation type. The maximum hammer energy for each case has been summarised in **Table 6.1**.

6.1.5. The 300kJ hammer blow energy was taken to be representative of the maximum likely energy for the onset of soft-start. The 3,000kJ hammer energy represents the absolute maximum hammer blow energy that could be used for wind turbines on monopole foundations and is, therefore, the worst case scenario. Experience from previous wind farm construction shows that the maximum hammer energy is rarely achieved during a piling sequence and then only for a short duration (e.g. Bailey *et al.* 2010; Robinson *et al.* 2011).

6.1.6. To illustrate the total spatial extent of the potential impact ranges for species of cetacean resulting from the underwater noise during the construction phase, the sound propagation was modelled at various locations along the project boundaries of Dogger Bank Teesside A & B. The maximum noise level received at every location around each project was then calculated to show the construction noise footprint associated with each project.

6.1.7. Three piling sequence lengths have been considered (**Table 6.2**), all based on the use of a 3,000kJ hammer, the maximum hammer energy expected. The use of a 3,000kJ hammer represents the absolute worst case hammer used and not necessarily the actual hammer blow energy used to insert the pile.

Table 6.1 Summary of the maximum hammer energy proposed for construction across Dogger Bank Teesside, for each turbine size and foundation type.

Turbine size	Foundation type and required maximum hammer energy (Initial soft-start hammer energy)	
	Monopole	**Jacket/multipole**
6MW	3,000kJ (300kJ)	2,300kJ (230kJ)
10+MW	3,000kJ (300kJ)	2,300kJ (230kJ)

Table 6.2 Pile driving parameters assumed for calculating the worst case SEL dose resulting from prolonged exposure based on three sequences of different pile driving durations.

Parameter	Sequence 1	Sequence 2	Sequence 3
Hammer blow energy (soft-start)	300kJ	300kJ	300kJ
Inter-strike interval (soft-start)	3s	3s	3s
Number of strikes (soft-start)	600	600	600
Duration (soft-start)	**30mins**	**30mins**	**30mins**
Hammer blow energy (full piling)	3,000kJ	3,000kJ	3,000kJ
Inter-strike interval (full piling)	1.5s	1.5s	1.5s
Number of strikes (full piling)	1,400	4,400	12,000
Duration (full piling)	**35mins**	**110mins**	**300mins**
Duration (total piling time)	**65mins**	**140mins**	**330mins**[3]

6.1.8. The SEL dose has been modelled for high-frequency (M_{hf}), mid-frequency (M_{lf}) and low frequency (M_{lf}) cetaceans and pinnipeds in water (M_{pw}) functional hearing groups as defined by Southall *et al*. (2007). The auditory injury impact ranges predicted for mid-frequency and low-frequency cetaceans are based on the PTS onset levels proposed by National Marine Fisheries Service (NMFS) Marine Mammal Injury Criteria Group (Southall *et al*. 2007), which are based on data from a beluga whale *Delphinapterus leucas* (Finneran *et al*. 2002). These may not be applicable to harbour porpoise, and so harbour porpoise injury ranges are based on PTS threshold values obtained from data reported by Lucke *et al*. (2009). The auditory injury ranges for pinnipeds are based on the injury criteria by Southall *et al*. (2007) and are based on data for a harbour seal (Kastak *et al.* 2005).

6.1.9. The effect of an SEL dose was predicted by summing up the SEL received levels from the entire piling sequence, assuming a fleeing animal. The model predicts the SEL dose for an animal that moves away from the source, with a swim speed of 1.5m/s for all mammals (except for minke whale where 3.25m/s was adopted) once piling starts and continues to move away throughout the piling sequence. Swim speeds are based on a harbour porpoise mother-calf pair from Otani *et al*. (2000) and Blix and Folkow (1995) for minke whale.

6.1.10. The model is very precautionary in that it does not account for:

- Any time that a receptor may spend at the surface;
- Reduced sound exposure levels near the surface; and

[3] When considering the likely number of blows and hence duration of piling for a single foundation, Forewind drew upon industry experience to generate values for inclusion in the Rochdale envelope. This industry experience suggested that across a project there may be a very small number of foundations which require additional piling effort over and above the project norm, in order to satisfactorily install a foundation. It was estimated that for these foundations piling may take up to five hours in addition to any soft-start period. However, this was not felt to represent a realistic average across a project as it is highly unlikely to occur on a significant number of foundations. As a result, a conservative average of three hours per pile was considered more appropriate across a whole project. For this reason noise modelling was conducted for a range of piling durations, including for five hour duration, in order to provide an appropriate basis for the marine mammal impact assessment.

- Any temporal hearing recovery.

6.1.11. As such, the exposure predicted in the model is likely to be an overestimate of the exposure that a receptor might be subjected to. It is assumed that the animal swims away directly from the sound source which would be likely where the animal would be expected to show a strong avoidance reaction. However, this may not be an accurate description of the behaviour of an animal at greater distances, although harbour porpoise abundance has been shown to reduce out to ranges of up to about 20km from the pile (Tougaard *et al.* 2009a and Brandt *et al*. 2011), indicating that they do indeed move away from the sound source. Pinnipeds, however, are only expected to exhibit a strong avoidance response at ranges of less than 2km from the pile, although their ability to come to the surface would reduce the effects of prolonged noise exposure and allow some relaxation of TTS.

6.1.12. The simulated soft-start used in the model (all three scenarios in **Table 6.2**) will likely result in a higher cumulative SEL dose than a typical soft-start procedure which usually contains several short pauses in piling for alignment measurements, which would allow a fleeing animal to reduce its exposure to the sound and would further allow hearing sensitivity recovery to occur.

6.1.13. The modelled sequence is considered as the potential worst case piling scenario for a given pile in each of the wind farms. The precautionary maximum of 12,600 hammer strikes (including the soft-start) assumed for the worst case is much more than typically seen for previous wind farm developments in the UK.

6.1.14. The modelling considers the noise dose received from a single pile installation (or concurrent pile driving) due to the lack of information on the amount of hearing recovery between piling events. The gap between pile installations is expected to allow almost complete recovery of any TTS and the gap between successive pile installations for a multi pile foundation would be sufficient for measurable hearing recovery to occur.

6.1.15. The noise levels present in the water will also depend on the depth. Marine mammals near the surface will be exposed to lower noise levels with correspondingly smaller impact ranges. For example, a pinniped with its ears just below the water line would be exposed to substantially reduced noise levels, and even at one metre below the surface of the water, would be exposed to lower levels than those predicted in the propagation modelling.

Sensitivity of receptors

6.1.16. It is widely accepted that piling operations are likely to be the greatest source of noise which could have a potential impact on marine mammals. The potential impacts of noise on marine mammals include lethality, physical injury, auditory injury or hearing impairment, as well as behavioural disturbance or auditory masking. Appendix B within **Appendix 5A** provides a detailed description of the potential effects of sound on marine fauna.

6.1.17. In this assessment all species of marine mammal are considered to have high sensitivity to noise above thresholds that can cause death or physical non-auditory injury. By definition (**Table 3.3**) marine mammals have very limited (i.e. no) capacity to adapt to, or accommodate or recover from these impacts.

6.1.18. As cetaceans rely on sonar for navigation, finding prey and communication, they are also highly sensitive to permanent hearing damage (Southall *et al*. 2007). As such, sensitivity to PTS is considered high for all species of cetacean, as once again by definition (**Table 3.3**) they have very limited (i.e. no) capacity to adapt or accommodate or recover from these impacts.

6.1.19. It should be noted that as a precautionary approach in this assessment it is assumed that 100% of individuals exposed to the noise thresholds that can cause PTS actually develop PTS, yet the PTS criteria proposed by Southall *et al.* (2007) represents the thresholds at which PTS will start to occur. Finneran *et al.* (2005) produced a dose response curve by assessing the proportion of trials at different SELs that resulted in TTS. These data show that 50% of the population were predicted to experience TTS at 11dB above the TTS onset threshold. As Southall *et al.* (2007) set the thresholds for PTS onset at 15dB above TTS for single or multiple pulses, the onset of PTS in individuals should also follow a dose response curve. This type of dose response curve has been applied to PTS onset in the Moray Firth Framework using SAFESIMM (Statistical Algorithms For Estimating the Sonar Influence on Marine Megafauna; Thompson *et al.* 2012) where the probability of an individual developing PTS once exposed to the SEL equivalent to the Southall *et al*. (2007) criteria is 0.18.

6.1.20. Pinnipeds use sound both in air and water for social and reproductive interactions (Southall *et al*. 2007) but not for finding prey. Therefore, Thompson *et al*. (2012) suggest damage to hearing in pinnipeds may not be as important as it is in cetaceans. In addition, Thompson and Hastie (2011), suggest that the Southall *et al*. (2007) criteria for PTS in pinniped may be inappropriate, and should be revised to the same threshold as Southall *et al*. (2007) use of cetaceans as this is based on the best available data (i.e. 198 dB re 1 µPa2.s-1 rather than 186dB re 1 µPa2.s-1). Pinnipeds also have the ability to hold their heads out of the water during exposure to loud noise, and potentially avoid PTS. As such, sensitivity to PTS in grey seal is considered to be medium, with the individual showing limited capacity to avoid, adapt to or accommodate or recover from the anticipated impact (**Table 3.3**).

6.1.21. Southall *et al.* (2007) discuss a range of likely behavioural reactions that may occur as a result of exposure to noise. These include orientation or attraction to a noise source, increased alertness, modification of characteristics of their own sounds, cessation of feeding or social interaction, alteration of movement/diving behaviour, temporary or permanent habitat abandonment, and in severe cases panic, flight stampede or stranding, sometimes resulting in injury or death. These represent a range of likely responses, which in some cases will have no effect, and in other cases a large effect will occur on the number of individuals affected.

6.1.22. Southall *et al.* (2007) also present the fact that the nature of the individuals response will depend upon habituation and sensitisation. An animal's exposure history with regard to a particular sound affects whether it is subsequently less likely (habituation) or more likely (sensitisation) to respond to a stimulus such as sound exposure. The processes of habituation and sensitisation do not necessarily require an association with a particular adverse or benign outcome. Rather, individuals may be innately predisposed to respond to certain stimuli in certain ways. These responses may interact with the processes of habituation and sensitisation for subsequent exposure.

6.1.23. Examples of how behavioural responses differ have been shown in field and captive experiments. In a captive experiment with food presentation, seals habituated quickly to all sound types presented at normalised received levels of 146dB re 1 µPa2.s-1. However, the fast habituation of avoidance behaviour was also accompanied by a weak sensitisation process affecting dive times and place preference in the pool (Gotz & Janick 2010). In the same study, experiments in the field testing animals without food presentation revealed differential responses of seals to different sound types.

6.1.24. The implications of whether the behavioural response is initiated by a startle reflex are also an important consideration. For example grey seals that were repeatedly exposed to an acoustic stimulus that elicited a startle response would avoid a food source, whereas individuals exposed to a noise stimulus of the same maximum sound pressure but of a non-startling nature (i.e. with a long rise time) became habituated, and flight responses waned or were absent from the start (Gotz & Janik 2011). The application of soft-start procedures during pile driving should mean that startle responses that elicit a greater magnitude of behavioural response will be minimised.

6.1.25. Responses to noise stimulus also vary between species. Noise produced by acoustic deterrent devices was found to elicit behavioural avoidance responses that resulted in long-term habitat exclusion in some cetaceans (Odontocetes; Morton & Symonds 2002, Olesiuk *et al*. 2002), but seals that commonly forage on farmed salmon showed little or no response to the same sound (Jacobs & Terhune 2002). Observations of harbour seal and sea lion during pile driving in San Francisco Bay showed that harbour seal stayed in the vicinity of pile driving, and moved into the area during piling, while sea lions rapidly left the area (Caltrans 2001).

6.1.26. The likelihood of any biological impact from behavioural disturbance will be directly related to the magnitude and duration of the response to the noise. The impacts can be scaled in severity of response; some of these are unlikely to have individual effects on survival or reproductive rates which could in turn affect the long-term dynamics of a population.

6.1.27. The biological consequences of disturbance will vary between species, and within species dependant on size, body condition or age and time of year. Harbour porpoise for example, have relatively high daily energy demands and need to consume between 4% and 9.5% of their body weight in food per day (Kastelein *et al*. 1997). If a harbour porpoise does not capture enough prey to meet its daily energy requirements it can rely on stored energy (primarily blubber) for three to five days, depending on body condition (Kastelein *et al*. 1997).

6.1.28. Thermoregulation, especially in cold water, has high energy costs in marine mammals. Kastelein *et al.* (1997) estimate that a harbour porpoise may have a life expectancy of as little as three days in waters of 20°C under starvation conditions. Should harbour porpoise be excluded from an area of key prey resource, and be unable to find alternative food sources there could be serious impacts from behavioural disturbance.

6.1.29. In contrast to harbour porpoise, grey seal exhibit alternate periods of foraging and resting at haul out sites (during which limited or no feeding occurs). Prolonged fasting also occurs in these species during annual breeding and moult, when there are marked seasonal changes in body condition (Rosen & Renouf 1997; Bäcklin *et al*. 2011). Although adult seals may be relatively robust to short term (weeks rather than days compared to harbour porpoise) changes in prey availability, young and small individuals have a more sensitive energy balance. This is exhibited through effects of mass dependant survival (Harding *et al*. 2005).

6.1.30. Based on the available data and expert opinion, harbour porpoise are also considered to have medium sensitivity to behavioural disturbance (defined as TTS or fleeing response or likely avoidance in this assessment) from piling noise (Tougaard *et al*. 2005; Thomsen *et al*. 2006). In this assessment other species of cetacean are also considered to have medium sensitivity to behavioural disturbance. This assumption in this assessment implies that individual cetaceans have limited capacity to avoid, adapt to, accommodate or recover from the anticipated impact (**Table 3.3**). Although the effects of TTS and likely behavioural avoidance are temporary by definition, there is a large amount of uncertainty in the ability of individuals to recover from the consequences of fleeing from an area, and the timelines over which recovery might occur supports assigning medium sensitivity to this impact. There is also an expectation that across these thresholds all individuals will respond in the same way to the stimulus, and there is limited capacity to avoid the impact.

6.1.31. Grey seal are considered to have a low sensitivity similarly defined behavioural responses (defined as TTS, fleeing response or likely avoidance in this assessment). Sensitivity to possible disturbance is not a metric used in the assessment for grey seals.

6.1.32. For all species of cetacean, sensitivity to possible avoidance is defined as low. Of the individuals that are exposed to noise at the thresholds that may cause possible avoidance, it is likely that only proportion of the individuals will respond; with a reduced response with increased distance from the noise source (i.e. at lower received levels). This type of dose response has been observed in harbour porpoise (e.g. Brandt *et al*. 2011). In order to reflect a decreased behavioural response due to a decreased stimulus defining sensitivity as low reflects the fact that individuals have some tolerance to avoid, adapt, accommodate or recover from this impact. In order to account for the variation in responses, low sensitivity is combined with the assumption that 100% of the individuals respond at this threshold.

6.1.33. It should be noted that the impacts of a behavioural disturbance due to noise could become an issue for marine mammals where it leads to:

- Exclusion from key foraging habitat for prolonged periods, where it leads to increased individual fitness costs required to find food or an inability to find food;

- Isolation or fragmentation of parts of a single population; or
- Exclusion of animals from important breeding areas or haul out sites in the case of pinnipeds.

6.1.34. **Table 6.3** summarises the sensitivity to each noise impact assigned to each species for this assessment. Definitions of sensitivity are set out in **Table 3.3**.

Table 6.3 Summary of sensitivity of individuals in the reference population to the different impacts of noise from pile driving.

Species	Lethal effect or physical injury	Auditory injury (PTS)	Auditory injury (TTS)	Likely avoidance	Possible avoidance	Behavioural disturbance
Harbour porpoise	High	High	Medium[4]		Low	Medium
Minke whale	High	High	Medium	Medium	Low	Medium
White-beaked dolphin	High	High	Medium	Medium	Low	Medium
Grey seal	High	Medium	Low[4]		N/A	N/A

Uncertainty

6.1.35. Key areas for uncertainty to be introduced into the assessment process relate to biological and engineering factors. Biological uncertainty in the assessment is apparent in most species of marine mammal at several levels. Firstly, the thresholds for the onset of auditory injury, or PTS, are based largely on theoretical data (Southall *et al.* 2007). Furthermore, the individual fitness effects of the noise impacts, such as PTS and behavioural disturbance, are not well understood. No empirical evidence exists to link exposure to noise at these thresholds, to changes in rates of survival or reproduction, and therefore population level consequences.

6.1.36. Further uncertainty is introduced into the assessment from engineering uncertainties and potential weather constraints that will determine the timings between the installations of piles and the overall duration of the pile driving phase of the development. These factors further influence the likely worst case noise scenario that could occur for the assessment of project specific and cumulative impacts.

6.1.37. Where uncertainty is introduced into the assessment process further explanations of the uncertainty are provided and details of any precautionary approach adopted to negate the uncertainty are outlined. In many cases current knowledge and expert opinion is used to support the assumptions made in the assessment.

Dogger Bank Teesside A

6.1.38. Impact piling using the parameters outlined in **Table 6.1** was modelled at twelve locations within Dogger Bank Teesside A (Figure 4.1 in **Appendix 5A**). A range of locations were chosen to encompass a range of noise propagation

[4] The metrics used in the assessment of TTS and likely behavioural avoidance are the same in harbour porpoise and grey seal, the sensitivity is therefore the same, and the cells are therefore merged.

conditions; shallow and deep water, and up-sloping and down-sloping bathymetry. The locations are detailed in **Appendix 5A** Table 4.1.

6.1.39. It should be re-iterated that the model is very precautionary in that it does not account for any time that a receptor may spend at the surface, or the reduced sound exposure levels near the surface where the animal would not be exposed to such levels, and also does not account for any temporal hearing recovery. As such, the exposure predicted in the model is likely to be an overestimate of the exposure that a receptor might be subjected to.

Single piling event

6.1.40. The following provides an assessment of impacts on marine mammals from the modelled single piling event described above, against three categories: Lethal/physical injury; Auditory injury; and Behavioural response. **Table 3.6** provides a summary of the noise criteria used in the assessment. Following this section, an assessment of the impacts of multiple pile driving during the construction of Dogger Bank Teesside A is made.

Lethal and physical injury

Impact ranges

6.1.41. The predicted noise levels in close proximity to the piling activity are comparable to those estimated for auditory injury. Mortality would only be expected at noise levels substantially above those necessary to cause the onset of auditory injury. The pile driving installation is thus unlikely to result in radiated noise levels beyond a few metres which are sufficient to cause instantaneous mortality in marine mammals (Richardson *et al.* 1995, converted from Yelverton *et al.* (1975) for marine mammals).

Auditory Injury

Impact ranges

6.1.42. Ranges for potential instantaneous onset of auditory injury for marine mammals are expected to be up to a few hundred metres and are based on the onset of a PTS in hearing. Based on the injury criteria by Southall *et al*. (2007), these ranges at Dogger Bank Teesside A vary between less than 100m for mid-frequency cetaceans and low-frequency cetaceans and less than 200m for pinnipeds in water to less than 700m for harbour porpoise based on the 3,000kJ hammer energy. These are the ranges at which instantaneous auditory injury could occur if there was no soft-start, and the maximum hammer energy was used for a single pile strike. Such an event is highly unlikely to occur. The use of a soft-start, initiating with the hammer at 300 kJ will reduce the ranges for potential onset of auditory injury to less than 100m for all marine mammal groups, including harbour porpoise (**Table 6.4** to **Table 6.7**).

6.1.43. All marine mammals are expected to flee from the noise source once the soft-start is initiated. It is anticipated that mammals fleeing at 1.5m/s (all species except minke whale) will be outwith the zone of instanteous injury prior to noise levels reaching a theshold that could cause PTS. If it was assumed that animals did not flee the noise source during the soft-start then there would be the potential to cause PTS at the ranges presented in **Table 6.4** to **Table 6.7** for the higher hammer energies.

6.1.44. Assuming a hammer blow energy of 3,000kJ, the TTS range for Dogger Bank Teesside A is predicted to be less than 400m for low-frequency cetaceans, between 4.0km and 5.5km for harbour porpoise and 200m or less for mid-frequency cetaceans (**Tables 6.4** and **6.5**). The predicted TTS ranges for pinnipeds in water during construction at Dogger Bank Teesside A would be less than 1.7km for any assumed hammer blow energy (**Table 6.7**). For smaller hammer blow energies these ranges would be reduced.

6.1.45. The SEL dose has been predicted by summing up the pulse SEL over an entire piling sequence assuming the animal will swim away once piling commences. From the modelled location and transects, one was chosen to approximate the worst case (namely the most north westerly location where noise propagates more efficiently).

6.1.46. **Figure 6.1a**, **b** and **c** show the required starting range for marine mammal functional hearing groups from the pile when pile driving starts such that an animal is not over exposed and does not suffer noise threshold that can cause PTS onset (following a cumulative SEL dose) for the pile driving parameters outlined in **Table 6.2**. As stated in **Appendix 5A** Section 4.6, the 12,600 hammer blows is a worst case, with 2,000 to 5,000 hammer blows being typical for a pile installation in the UK, at a rate of 30 to 60 blows per minute, Based on the worst case maximum of 12,600 hammer blows (**Figure 6.1a**) starting ranges of cetaceans are less than 500m. In the case of pinnipeds, the potential for cumulative SEL dose causing PTS occurs at starting ranges which are much greater (approximately 14km). Therefore, based on the 186dB re 1 µPa2.s-1 threshold and assuming seals do not place their heads out of the water, there is the potential to cause PTS from the cumulative SEL.

Table 6.4 Summary of harbour porpoise impact ranges for construction at Dogger Bank Teesside A. Range of impacts primarily varies due to differences in bathymetry.

Estimated harbour porpoise impact ranges – Dogger Bank Teesside A				
Impact criterion	**Potential range of impact for harbour porpoise**			
	300kJ hammer energy	**1,900kJ hammer energy**	**2,300kJ hammer energy**	**3,000kJ hammer energy**
Auditory injury: Instantaneous injury/PTS (pulse SEL 179dB re 1 µPa^2·s)*	<100m	<500m	<600m	<700m
Auditory injury behavioural response: TTS/fleeing response (pulse SEL 164dB re 1 µPa^2·s)*	<1.5km	3.2 – 4.2km	3.5 – 4.6km	4.0 – 5.5km
Behavioural response: Possible avoidance of area (pulse SEL 145dB re 1 µPa^2·s)*	10.0 – 13.5km	20.0 – 28.0km	21.0 – 30.0km	22.0 – 33.0km

**Lucke et al. (2009)*

Table 6.5 Summary of mid-frequency cetacean functional hearing group impact ranges for construction at Dogger Bank Teesside A. Range of impacts primarily varies due to differences in bathymetry.

Estimated mid-frequency cetacean impact ranges - Dogger Bank Teesside A				
Impact criterion	**Potential range of impact for mid-frequency cetacean**			
	300kJ hammer energy	**1,900kJ hammer energy**	**2,300kJ hammer energy**	**3,000kJ hammer energy**
Auditory injury: Instantaneous injury/PTS (Mmf weighted 198dB re 1 μPa^2·s)*	<100m	<100m	<100m	<100m
Auditory injury: TTS/fleeing response (Mmf weighted 183dB re 1 μPa^2·s)*	<100m	<100m	<150m	<200m
Behavioural response: Likely avoidance of area (pulse SEL 170dB re 1 μPa^2·s)***	<600m	<2.0km	<2.0km	<2.5km
Behavioural response: Possible avoidance of area (pulse SEL 160dB re 1 μPa^2·s)***	<2.5km	5.0 – 7.0km	5.0 – 7.2km	6.0 – 8.5km

Southall et al. (2007) Injury Criteria, **Southall et al. (2007) Single pulse behavioural disturbance.*Southall et al. (2007) Multiple pulses severity scoring behavioural disturbance (RMS SPL converted to pulse SEL by subtraction of 10dB).*

Table 6.6 Summary of low-frequency cetacean functional hearing group impact ranges for construction at Dogger Bank Teesside A. Range of impacts primarily varies due to differences in bathymetry.

Estimated low-frequency cetacean impact ranges - Dogger Bank Teesside A				
Impact criterion	**Potential range of impact for low-frequency cetacean**			
	300kJ hammer energy	**1,900kJ hammer energy**	**2,300kJ hammer energy**	**3,000kJ hammer energy**
Auditory injury: Instantaneous injury/PTS (Mlf weighted 198dB re 1 μPa^2·s)*	<100m	<100m	<100m	<100m
Auditory injury: TTS/fleeing response (Mlf weighted 183dB re 1 μPa^2·s)*	<100m	<250m	<300m	<400m
Behavioural response: Likely avoidance of area (pulse SEL 152dB re 1 μPa^2·s)***	4.8 – 6.8km	11.0 – 15.5km	12.0 – 17.0km	13.5 – 18.0km
Behavioural response: Possible avoidance of area (pulse SEL 142dB re 1 μPa^2·s)***	13.5 – 18.0km	23.0 – 35.5km	24.0 – 37.5km	26.5 – 41.0km

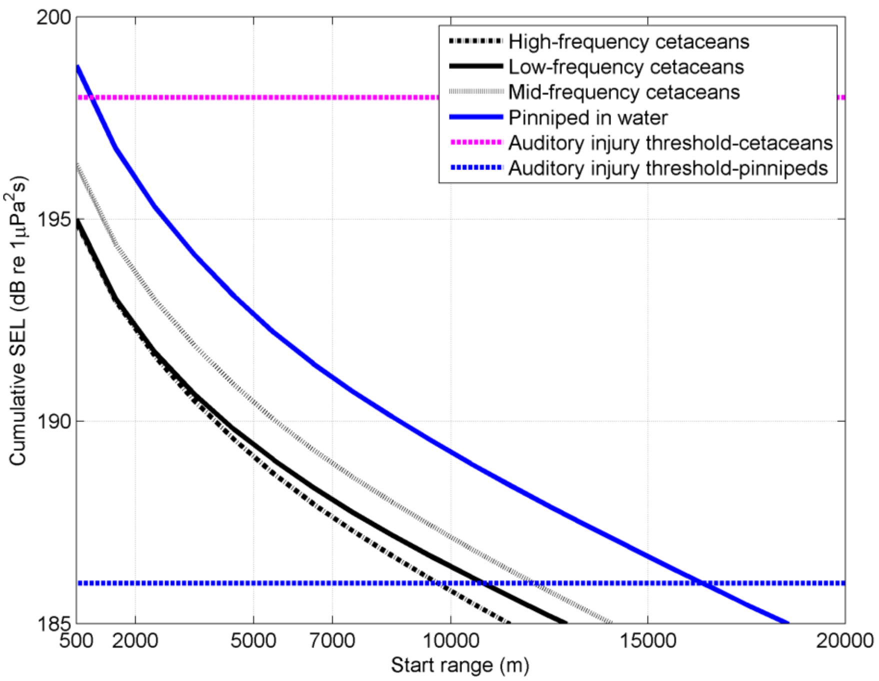
Southall et al. (2007) Injury Criteria, **Southall et al. (2007) Single pulse behavioural disturbance.*Southall et al. (2007) Multiple pulses severity scoring behavioural disturbance (RMS SPL converted to pulse SEL by subtraction of 8dB).*

Table 6.7 Summary of pinniped functional hearing group impact ranges for construction at Dogger Bank Teesside A. Range of impacts primarily varies due to differences in bathymetry.

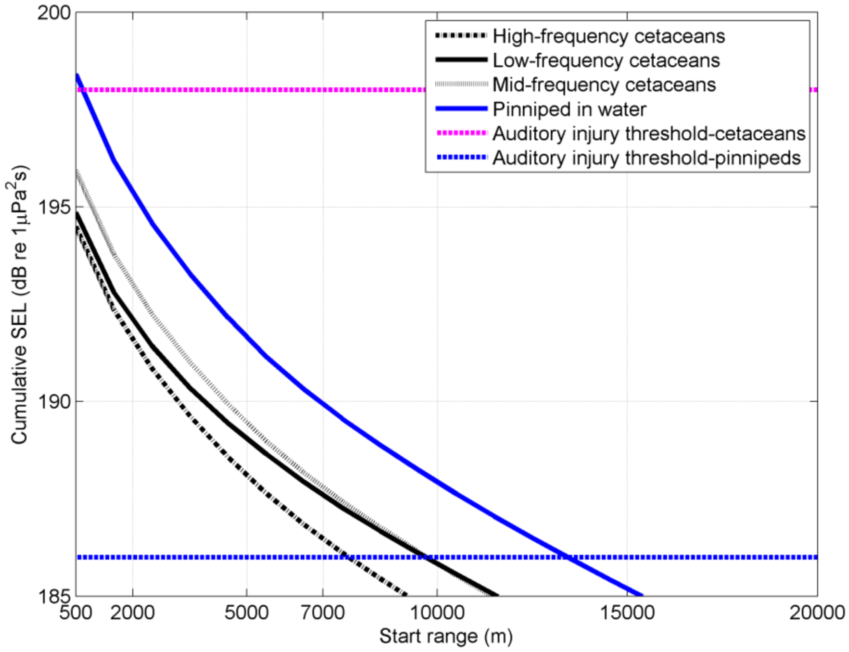
Estimated pinniped impact ranges - Dogger Bank Teesside A				
Impact criterion	**Potential range of impact for pinnipeds**			
	300kJ hammer energy	**1,900kJ hammer energy**	**2,300kJ hammer energy**	**3,000kJ hammer energy**
Auditory injury: Instantaneous injury/PTS * (Mpw weighted 186dB re 1 μPa^2·s)	<100m	<100m	<100m	<200m
Auditory injury/behavioural response: TTS/Fleeing response/ Likely avoidance (Mpw weighted 171dB re 1 μPa^2·s) **	<400m	<1.5km	<1.5km	<1.7km

**Southall et al. (2007) Injury Criteria, **Southall et al. (2007) Single pulse behavioural disturbance.*

(a)



(b)



c)

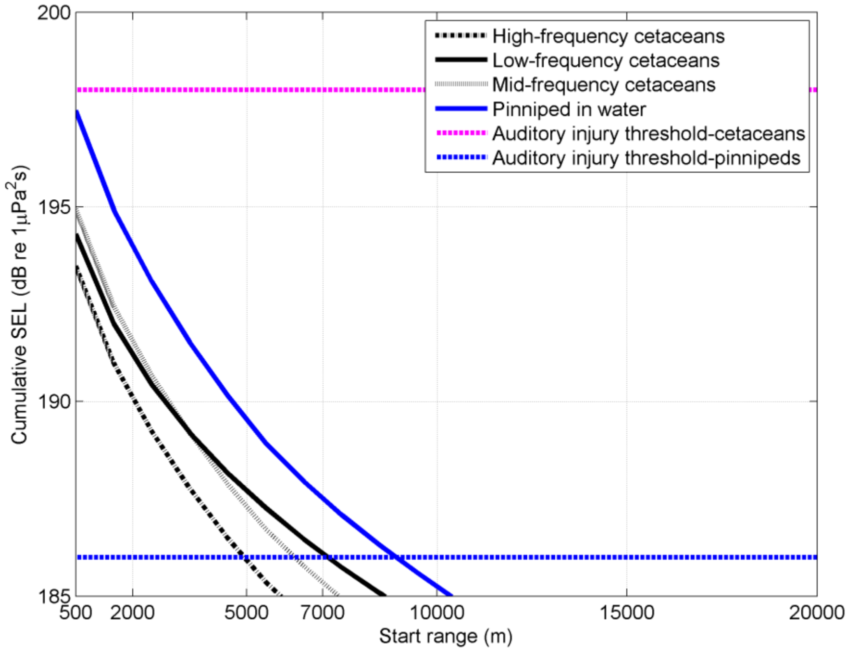


Figure 6.1 Required start range for the marine mammal functional hearing groups (Southall *et al*. 2007) from the pile when piling starts, such that the animal is not over exposed and does not suffer auditory injury (PTS onset). The modelled results are for Teesside A assuming (a)12,600 pile strikes,(b) 5,000 pile strikes , and (c) 2,000 pile strikes and animal swim speeds at 1.5m/s, but for the low frequency cetacean where a swim rate of 3.25m/s was used.

Quantification of impacts

6.1.47. In the case of harbour porpoise, minke whale and white-beaked dolphin, impacts have been calculated by overlaying the areas of potential impact with underlying average densities across the Dogger Bank Zone. The areas of impact, numbers impacted and the percentage of the reference population impacted are summarised in **Table 6.8**.

6.1.48. The level of impacts calculated here is considered as highly precautionary, as the assumption has been made that, at the PTS thresholds, the probability of PTS is 1 (i.e. 100% chance of individuals exposed to the PTS threshold will develop PTS). It is important to note that the PTS-onset criteria proposed by Southall *et al*. (2007) represents the noise levels at which these effects start to occur. The use of a theoretical dose-response curve for PTS (which is scaled from the TTS dose-response curve in Finneran *et al*. (2005)) would provide a more robust estimate of the number of animals exposed to PTS. In this assessment we have worked under the assumption that all animals receive PTS within the instantaneous injury threshold, thus providing an indication of the worst case.

6.1.49. For minke whale, the impacts have been expressed as a percentage of the BI MU and Central and North East Atlantic populations.

6.1.50. For grey seal, the impacts have been calculated using the maximum mean estimated grey seal at sea density for any grid cell within the Dogger Bank Teesside A project area (0.085 per km^2). These values have been used in the assessment as they represent the maximum average density in any of the cells within the Dogger Bank Teesside A Project area, and thus a worst case density to account for uncertainty in the estimate. These values have also been used as they are higher than the densities estimated from the analysis of the site specific HiDef survey data (**Appendix B**) and are likely to represent a more robust estimate.

6.1.51. The areas of exposure to noise levels that can cause onset of PTS are calculated from the maximum ranges, as at such close ranges (<1km) the areas of impact are approximately symmetrical.

6.1.52. For TTS impact areas for minke whale and white-beaked dolphin, the ranges are still small (<1km) and, once again, the areas have been calculated by using the ranges provided in **Appendix 5A** assuming the ranges are symmetrical (approximately a circle). For grey seal, the area has also been calculated assuming the ranges are symmetrical, despite the larger maximum range (1.7km).

6.1.53. The magnitude of the effects (see **Table 3.4**) from exposure to noise thresholds that can cause PTS is defined by their permanent nature, whereas TTS impacts are temporary.

Table 6.8 Areas (km²) of impact (based on a single pile driving event with 3,000kJ maximum hammer energy), number of individuals impacted (and uncertainty based on 95% CI around density estimates), percentage of reference population impacted and magnitude of effect at Dogger Bank Teesside A.

Species (Reference population)	PTS (instantaneous injury)				TTS/fleeing response			
	Impact area	Impacted number	Percentage of reference population	Magnitude of effect	Impact area	Impacted number	Percentage of reference population	Magnitude of effect
Harbour porpoise (227,298)	1.5km²	1 (2.8-3.5)	0.0004%	Negligible	82.3km²	53 (48-59)	0.02%	Negligible
Harbour porpoise and potential harbour porpoise combined (227,298)		1.1 (2.5-4.7)	0.005%	Negligible		59 (43-80)	0.03%	Negligible
Minke whale (23,168)	0.03km²	0.0003 (0-0.002)	<0.00001%	Negligible	0.5km²	0.004 (0-0.04)	<0.0001%	Negligible
Minke whale[5] (174,000)			<0.00001%	Negligible			<0.0001%	Negligible
White-beaked dolphin (15,985)	0.03km²	0.0005 (0.008-0.003)	<0.00001%	Negligible	0.1km²	0.002 (0.004-0.01)	<0.0001%	Negligible
Grey seal (based on maximum mean at sea density) (28.989)	0.1km²	0.01	<0.00001%	Negligible	9km²	0.8	<0.003%	Negligible

[5] There are two row entries for minke whale in this and subsequent tables so the impacts can be assessed against European and Central and North East Atlantic reference population (**Table 2.4**).

Mitigation and residual impacts

6.1.54. Following JNCC Guidelines (JNCC 2010b), it is assumed that a mitigation method will be applied that provides an effective zone of exclusion of up to 500m around the source of the pile driving. The provision of a Marine Mammal Observer and/or Passive Acoustic Monitoring (PAM) and/or Acoustic Deterrent Device (ADDs) is likely to be part of the licensing requirement following JNCC guidelines. The approach taken for this development will be determined during the design and implementation of a project-specific Marine Mammal Mitigation Protocol (MMMP). The MMMP will be developed in consultation with JNCC, Natural England and the MMO. The effective zone of exclusion represents the range out to a minimum of 500m within which no marine mammals are detected prior to the commencement of pile driving.

6.1.55. Mitigation is assumed to be effective out to at least 500m from the noise source. This means that, in the case of minke whale and white-beaked dolphin, the possibility of instantaneous injury should be mitigated completely, due to maximum impact ranges of less than 500m. Impact ranges for TTS in these species are also within 500m of the noise source and thus should also be mitigated. As such, the magnitude of effect for residual impact for auditory injury in each of these species would be no effect, and the residual impact would be **no impact**.

6.1.56. In the case of grey seal, the potential for instantaneous PTS should also be mitigated following standard mitigation procedures. The cumulative SEL dose in grey seal has the potential to lead to PTS over greater ranges than the mitigation zone too, based on the results of the illustrative modelling shown in **Figure 6.1**. This potential is based on the 186dB re 1 µPa2•s threshold, which can be seen as precautionary. The M-weighted PTS-onset threshold of 186dB for pinnipeds represents a conservative approach, and it is considered likely that the 198dB threshold represents the noise levels at which the effects of PTS and TTS start to occur (Thompson & Hastie 2011). The potential for seals to hold their head out of the water to prevent exposure to loud noise is also significant, and thus the potential for receiving a cumulative SEL dose that could lead to PTS is very low. However, it is acknowledged that some potential remains, with impacts predicted to be negligible, or low at worst. Combined with medium sensitivity to PTS, the impact is assessed as **minor adverse**.

6.1.57. The potential range for TTS in grey seal also extends beyond the mitigation zone; but based on maximum mean densities of grey seal, 0.8 individuals (less than 0.003% of the population) could be exposed to noise levels that could lead to TTS without effective mitigation. The magnitude of this effect is negligible. Given the low sensitivity of grey seal to TTS, the residual impact would be **negligible**.

6.1.58. For harbour porpoise, the maximum range for instantaneous injury is up to 700m from a single pile driving event (at 3,000kJ max blow force). This is beyond the standard 500m zone of potential mitigation. Reduction in the impacted area due to the exclusion zone (out to 500m) would further reduce the likelihood of PTS occurring as a result of instantaneous injury. The impacted area (between 500m and 700m) would be reduced to 0.8km^2, reducing the potential number of porpoise that could experience noise above thresholds that cause PTS to 0.48, based on average densities for porpoise, or 0.54 for average densities for harbour porpoise and potential harbour porpoise combined, based on the assumption that there are no individuals within the exclusion zone.

6.1.59. This effect magnitude is also based on the simplistic approach that the animal does not flee the area and the maximum hammer energy is used with no soft-start.

6.1.60. However, porpoise have been observed to flee from pile driving noise, as this is also assumed during calculations of exposure based on cumulative SEL, **Figure 6.1**. In the case of PTS from instantaneous injury the soft-start acts as mitigation, allowing animals to flee the area before they are exposed to noise thresholds that can lead to PTS. If individuals flee the noise source at 1.5m/s once pile driving commences, then they will be more than the required 600m (in the case of 2,300kJ) or 700m (in the case of 3,000kJ hammer) away from the noise source before these hammer energies are reached (**Table 6.4**).

6.1.61. To prevent instantaneous injury (PTS) from the 300kJ hammer energy at the start of the soft-start, the porpoise are required to be at least 100m away. Effective mitigation via implementation of a MMMP should exclude them to at least 500m. If the porpoise were at 500m distance from the pile when pile driving starts, and they start to flee, assuming a linear ramp up in hammer energy they would not be exposed to noise thresholds that could cause instantaneous injury or cumulative dose SEL (**Figure 6.1** shows that the cumulative SEL dose for high frequency cetaceans is below the auditory injury threshold). Assuming animals flee the noise source, the harbour porpoise would be at 2,120m before the 1,900kJ hammer energy is reached and 3,200m before the 3,000kJ hammer energy is reached.

6.1.62. It should also be noted that current approaches to mitigation are based on the assumption of exclusion of marine mammals from up to 500m radius from the noise source. There is the potential that marine mammals could be excluded from ranges greater than this (ranging between 700m and 1,000m) as the use of alternate mitigation measures are investigated through initiatives such as the Offshore Renewable Joint Industry Programme (ORJIP).

6.1.63. If deemed appropriate at the time of development of the MMMP, the mitigation zone will be extended to prevent the possibility of instantaneous PTS occurring in all species for the maximum hammer energy. In the case of harbour porpoise only when assuming no soft-start and those animals do not flee the area once piling starts this range could be up to 700m. However, soft-start will always be applied as it is also an engineering requirement to not start by using full hammer energy on a pile and hence in reality harbour porpoise should not be within the 700m instantaneous injury range, as it would require them to remain stationary or swim towards the noise source.

6.1.64. The use of a soft-start (ramp up) is applied in the noise propagation modelling to explore cumulative SEL exposure when estimating required starting ranges for avoiding PTS dose (**Figure 6.1**), and therefore is not included as further mitigation. The results of this modelling indicate that cetaceans would not be exposed to noise thresholds that could over expose the individuals or lead to PTS as a result of cumulative exposure. This effectively means that the soft-start procedure will give the individuals sufficient time to flee the area prior to exposure to high noise levels.

6.1.65. In the case of harbour porpoise, cumulative SEL induced PTS will be mitigated by the soft-start and exclusion zone (out to the appropriate range). As such, there should be **no residual impact**.

6.1.66. Mitigation of PTS in all species of cetacean (due to the soft-start procedures and mitigation zones) should prevent the possibility of any injury offence to EPS.

6.1.67. For TTS, the number of harbour porpoise predicted to be exposed to this impact could be reduced following mitigation, but this is hard to quantify. Establishment of an effective exclusion zone may mean animal densities are increased in the zone of TTS and the overall number of animals exposed remains the same. Due to the medium sensitivity of the receptor to this impact and the negligible magnitude of the effect the residual impact remains **negligible**.

6.1.68. The use of vibration pile driving or non-piled foundations would reduce noise levels considerably from those predicted during impact pile driving (see Appendix C in **Appendix 5A**). There will be some noise associated with the installation of non-piled foundations (such as gravity bases or suction caissons although there are no empirical noise measurements of these techniques currently available), but noise impacts are not anticipated to result in significant impacts from these installation methods.

6.1.69. Appendix C in **Appendix 5A** provides a review of these methods. However, in this impact assessment Forewind can only commit to the implementation of effective mitigation measures which have been proven for the pile diameters and water depths at the site. As such no further mitigation measures are considered at present. Forewind will remain informed of all developments in this area.

6.1.70. Forewind will consider further mitigation, beyond soft-start and the MMMP should Impacts from pile driving noise be assessed as significant in EIA terms, at moderate adverse or greater. Impacts of this scale may have the ability to lead to significant population level effects over the longer-term, thus necessitating further mitigation.

Behaviour impact ranges

6.1.71. The fleeing ranges for marine mammals for Dogger Bank Teesside A (**Table 6.4** to **Table 6.7**) are based on the acoustic levels which are deemed to cause the onset of TTS. This was reported by Lucke *et al*. (2009) for harbour porpoise and Southall *et al*. (2007) for low, mid and high-frequency cetaceans and pinnipeds.

6.1.72. Avoidance information is not provided in the Marine Mammal Noise Exposure Criteria (Southall *et al.* 2007) for high-frequency cetaceans exposed to pulsed sounds except for the more severe fleeing response based on TTS. Recent work in Denmark (Tougaard *et al*. 2009a and Brandt *et al*. 2011) shows that behavioural disturbance/avoidance may occur over larger distances (around

20km for the specific setting) than that implied by the fleeing response. Work by Lucke *et al*. (2009) for exposure of a harbour porpoise to a seismic airgun provides indicative noise levels at which avoidance may occur. For Dogger Bank Teesside A this results in a worst case predicted possible avoidance range of between 22km and 33km (based on the max hammer energy of 3,000kJ, and pulse SEL 145dB re 1 μPa^2·s criteria; **Table 6.4**, **Figure 6.2**).

6.1.73. Applying the Marine Mammal Exposure Criteria for mid-frequency cetaceans, it is predicted that an avoidance range of up to 2.5km is likely (based on the worst case 3,000kJ max hammer energy and pulse SEL 170dB re 1 μPa^2·s criteria) and that an avoidance range of between 6km and 8.5km is possible (again based on the worst case max hammer energy and based on pulse SEL 160dB re 1 μPa^2·s criteria) (**Table 6.5**, **Figure 6.3**).

6.1.74. Applying the Marine Mammal Exposure Criteria for low-frequency cetaceans, it is predicted that an avoidance range of 13.5km to 18km is likely (based on the worst case 3,000kJ maximum hammer energy and pulse SEL 152dB re 1 μPa^2·s criteria) and that an avoidance range of between 26.5km and 41km is possible (based on the worst case 3,000kJ maximum hammer energy and pulse SEL 142dB re 1 μPa^2·s criteria) for Dogger Bank Teesside A (**Table 6.6**, **Figure 6.4**).

6.1.75. For pinnipeds, several of the studies reviewed by Southall *et al.* (2007) indicate that fleeing and indeed avoidance only occur at noise levels which are considered sufficient to cause the TTS (M_{pw} weighted 171dB re 1 μPa^2·s). Based on this information, the predicted fleeing response for a pinniped and the avoidance ranges during construction at Dogger Bank Teesside A would be less than 1.7km for any assumed hammer blow energy (**Table 6.7** and **Figure 6.5** for the maximum 3,000kJ hammer energy).

Quantification of impacts

6.1.76. In the case of harbour porpoise, minke whale and white-beaked dolphin, impacts have been calculated by overlaying the areas of potential impact with underlying average densities across the Dogger Bank Zone. The areas of impact, numbers impacted and the percentage of the reference population impacted are summarised in **Table 6.9**.

6.1.77. For white-beaked dolphin and minke whale the magnitude of effect for possible avoidance and likely avoidance is negligible. Both species have medium sensitivity to likely avoidance and low sensitivity to possible avoidance; therefore, the overall impact on both species is **negligible**.

6.1.78. For harbour porpoise, the area of likely avoidance, and thus the number of porpoise impacted, is the same as the TTS impact area presented in **Table 6.8**. Harbour porpoise have a medium sensitivity to this effect, and with a negligible magnitude of effect, the overall impact is, therefore, **negligible**. For possible avoidance, the magnitude of the effect is also negligible and, combined with a low sensitivity, the impact is **negligible**.

6.1.79. In the case of grey seal, the magnitude of effect is the same as outlined for TTS. At a maximum range of 1.7km, the number of seals impacted is negligible; grey seal have low sensitivity to this impact. The overall impact is, therefore, **negligible**.

Table 6.9 Areas of likely and possible avoidance behavioural impact (km^2) (from a single pile driving event based on worst case 3,000kJ maximum hammer energy), number of individuals impacted (and uncertainty based on 95% CI around density estimates), percentage of the reference population impacted and magnitude of effect at Dogger Bank Teesside A.

Species (Reference population)	Likely avoidance				Possible avoidance			
	Impact area	Impacted number	Percentage of reference population	Magnitude of effect	Impact area	Impacted number	Percentage of reference population	Magnitude of effect
Harbour porpoise (227,298)	82.3km^2	53 (48-59)	0.02%	Negligible	2,681km^2	1,717 (1,548-1,913)	0.76%	Negligible
Harbour porpoise and potential harbour porpoise combined (227,298)		59 (43-80)	0.03%	Negligible		1,920 (1,402-2,609)	0.84%	Negligible
Minke whale (23,168)	918km^2	8 (0-22)	0.03%	Negligible	3,940km^2	34 (0-94)	0.1%	Negligible
Minke whale (174,000)			0.005%	Negligible			0.02%	Negligible
White-beaked dolphin (15,895)	16km^2	0.2 (0.16-0.43)	0.001%	Negligible	209km^2	3 (2.1—5.9)	0.02%	Negligible
Grey seal	As TTS				Not assessed			

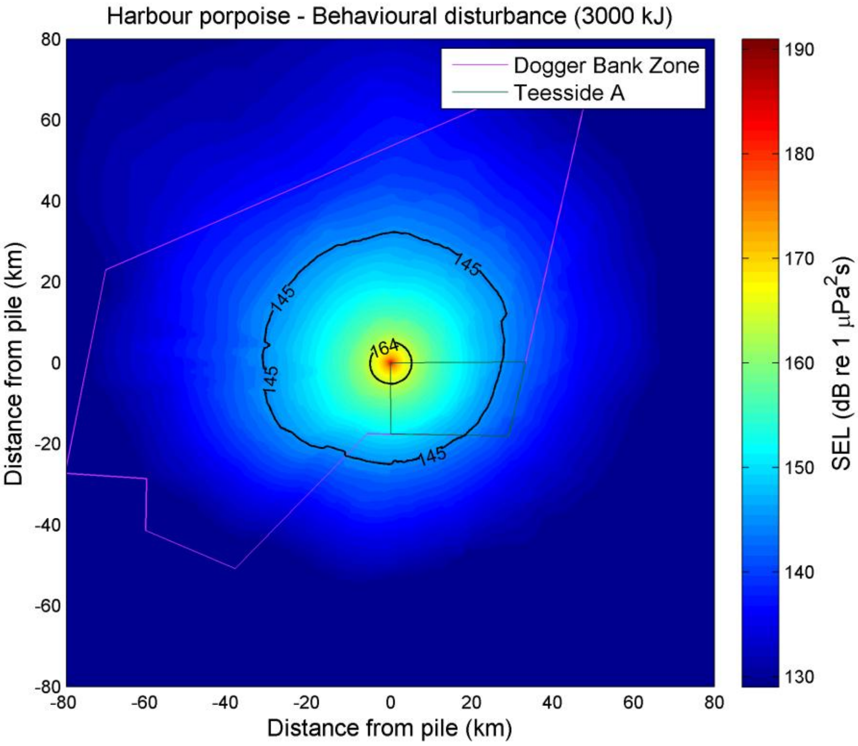


Figure 6.2 Harbour porpoise behavioural disturbance zones for Dogger Bank Teesside A using 3,000kJ hammer blow energy. SEL 164dB re 1 μPa2·s represents the zone of TTS or fleeing response, SEL 145dB re 1 μPa2·s the zone of possible avoidance. Zones of PTS are not shown on the figure as they are so small.

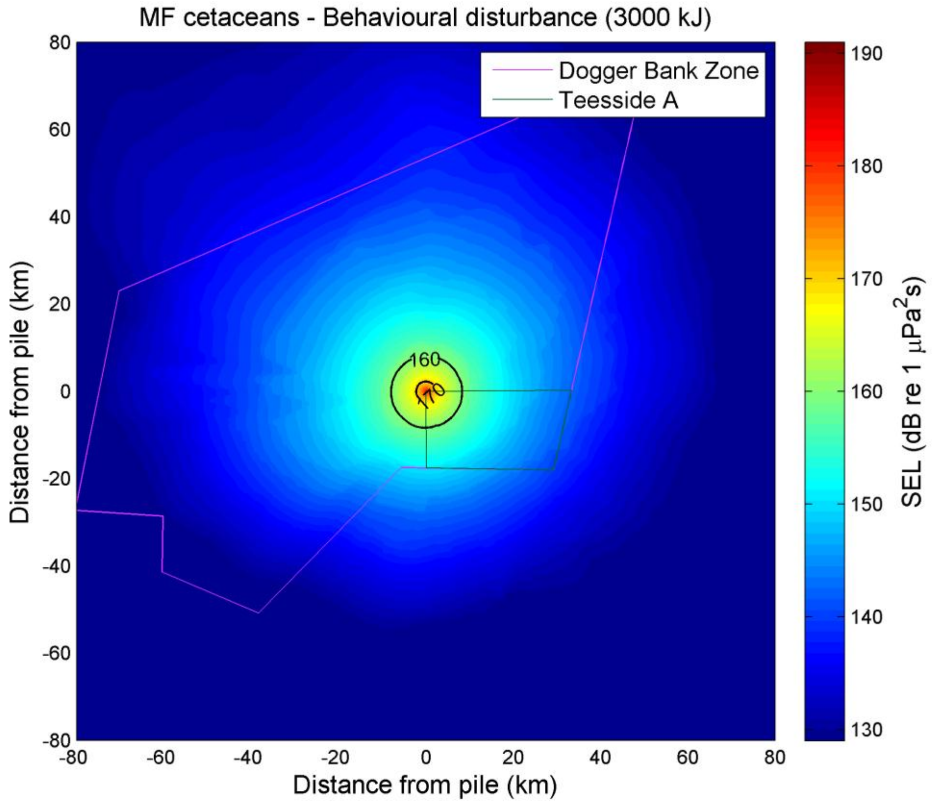


Figure 6.3 Mid-frequency cetacean behavioural disturbance zones for Dogger Bank Teesside A using 3,000kJ hammer blow energy. SEL 170dB re 1 μPa2•s (inner circle) represents the zone of likely avoidance, SEL 160dB re 1 μPa2•s the zone of possible avoidance. Zones of PTS are not shown on the figure as they are so small.

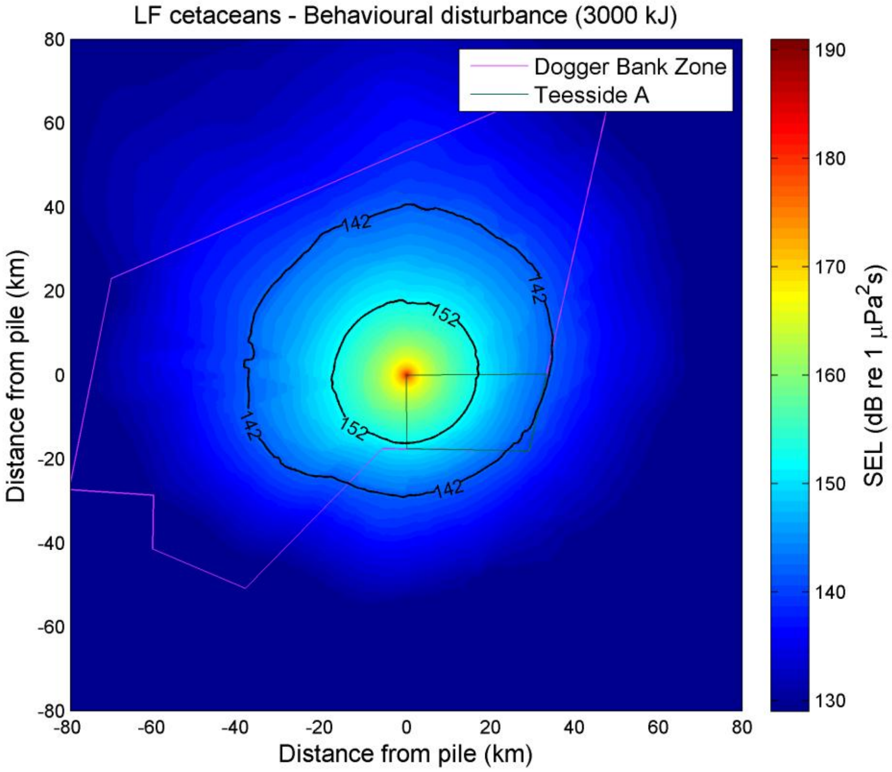


Figure 6.4 Low-frequency cetacean behavioural disturbance zones for Dogger Bank Teesside A using 3,000kJ hammer blow energy. SEL 152dB re 1 µPa2•s represents the zone of likely avoidance, SEL 142dB re 1 µPa2•s the zone of possible avoidance. Zones of PTS are not shown on the figure as they are so small.

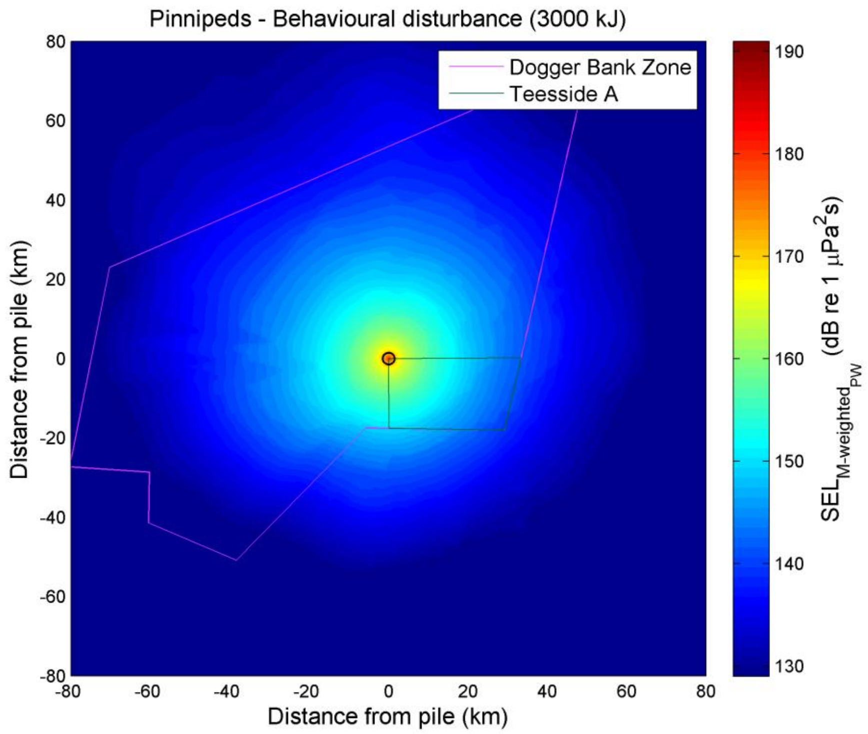


Figure 6.5 Pinnipeds in water behavioural disturbance zones for Dogger Bank Teesside A using 3,000kJ hammer blow energy. SEL 171dB re 1 µPa2• represents the zone of TTS/fleeing response/likely avoidance. Zones of PTS are not shown on the figure as they are so small.

Mitigation and residual impacts

6.1.80. No further mitigation is considered than outlined previously for auditory injury. The residual impacts remain as stated in the preceding paragraphs, and are summarised in **Table 6.10**.

6.1.81. Implications of behavioural disturbance to EPS are considered in the assessment of multiple pile driving across Dogger Bank Teesside A.

Table 6.10 Summary of residual impacts (and value of VER) from pile driving a single pile during the construction of Dogger Bank Teesside A.

Residual impact	Harbour porpoise (High)	Minke whale (High)	White-beaked dolphin (High)	Grey seal (High)
Lethal /injury	Minor adverse	Minor adverse	Minor adverse	Minor adverse
Auditory injury (PTS)	Minor adverse	Minor adverse	Minor adverse	Minor adverse
Auditory injury (TTS)	Negligible	Negligible	Negligible	Negligible
Likely avoidance		Negligible	Negligible	
Possible avoidance	Negligible	Negligible	Negligible	Not assessed
Overall impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**

Multiple pile driving during construction of Dogger Bank Teesside A

6.1.82. The impacts presented so far consider the likely impacts from a single pile driving event within Dogger Bank Teesside A. During the construction of Dogger Bank Teesside A there will be multiple pile driving events. Therefore, consideration of the impacts from pile driving needs to be assessed at both a temporal and spatial scale.

6.1.83. The worst case assessed for a single pile driving event in the previous section is based on the largest noise footprints from 120 monopole foundations (assuming 12m pile diameter and maximum blow force of 3,000kJ, see **Table 5.2** for more details). In this scenario the maximum duration of pile driving for a single pile would be five hours, plus a 30 minute soft-start. However, the worst case average across the project would be three hours (plus a 30 minute soft-start) per pile. This gives a total of 420 hours of pile driving for the installation of all 120 piles for wind turbines. This would be distributed over a construction timeline of between three and six years.

6.1.84. A larger temporal footprint would be from installation of 200 x 6MW turbines using multi-leg foundations (up to six piles per foundation) and a maximum blow force of 2,300kJ for the wind turbines. Each pile driving is an average of 3 hours (plus a 30 minute soft-start) leading to a possible total of 4,200 hours of pile driving over a period of between three and six years.

6.1.85. In addition to pile driving foundations for the wind turbines, a number of piling events will also need to be considered for met masts, accommodation platforms, Offshore Collector Platforms and an Offshore Converter Platform (**Table 5.2**). The maximum hammer energy for these foundations will be 1,900kJ and include an additional 152 piles with an average of three hours per pile (plus 30 minutes soft-start) across the project, i.e. an additional 532 hours of pile driving.

6.1.86. A maximum of 600 piling operations per year for wind turbine foundations (a total of 2,100 hours of pile driving) has been set as a limit. There will also be a maximum of two concurrent pile driving operations across Dogger Bank Teesside A.

6.1.87. In summary, the noise footprint from an individual pile driving event is a little smaller for the 2,300kJ maximum blow force (**Table 6.4**) but the duration of the noise impact for installing wind turbines is ten times that of the monopole foundations. This represents a large increase in the duration of pile driving noise. The overall temporal duration of the impacts also has implications for the assessment of behavioural impacts from pile driving.

Auditory injury

6.1.88. The total number of pile driving events and the temporal spacing between events has important implications for the number of individuals of each species that could be exposed to PTS or TTS. Where this impact is not mitigated (i.e. TTS in harbour porpoise and grey seal) individuals could be exposed to TTS from a single pile driving event.

6.1.89. In all species of cetacean, impact ranges for instantaneous and SEL dose PTS should be mitigated for a single pile driving event via implementation of a marine mammal mitigation exclusion zone out to the appropriate range (to be agreed in the MMMP) around the piling location and the soft-start, assuming animals flee the noise source. As such, there should be no potential of PTS.

6.1.90. Following the start of pile driving the number of cetaceans in the vicinity may also be reduced and exclusion from an area in which pile driving is taking place may also prevent the exposure of animals to auditory injury beyond the first pile driving event. It is likely that a behavioural disturbance from a single pile driving event would be sufficient to exclude harbour porpoise from the area around the noise source for several days (Thomsen *et al*. 2006; Brandt *et al*. 2009; 2011, Thompson *et al*. 2010a). The duration of the exclusion could last up to three days following a single piling event if the animal is close to the source.

6.1.91. Data presented by Brandt *et al*. (2009, 2011) show that harbour porpoise would completely leave the area of piling for a medium time of 16.6 hours and a maximum of 74.2 hours with the longest effect within 3km of the noise source. Porpoise activity (measured by the number of minutes per hour in which porpoise were detected expressed as porpoise positive minutes was significantly lower within approximately 3km of the noise source for 40 hours after piling. It is also likely that vessel traffic will act as a behavioural disturbance and exclude porpoise from the area around pile driving (Thomsen *et al*. 2006).

6.1.92. Mitigation measures, including the soft-start and development of an exclusion zone in the MMMP, should act to prevent the potential for auditory injury in all species of cetacean; the conclusion is **no residual impact**.

6.1.93. For grey seal the potential for PTS extends up to 1.7km based on cumulative SEL dose, this means that despite the use of a soft-start, and MMMP, there is the potential for PTS to occur. Once again, quantifying the number of individuals that could be exposed to noise thresholds that could cause PTS over the construction of the wind farm is difficult. But given the greater range over which this effect can occur, there is the potential for a low magnitude of effect, and combined with medium sensitivity to this impact, a **minor adverse** impact is concluded.

6.1.94. The biological consequences of TTS are not well understood. This type of impact, by definition, is short term and recoverable, but there is no understanding of whether repeated exposure to TTS could lead to PTS. For minke whale and white-beaked dolphin the range of TTS will be within the minimal mitigation zone of 500m, therefore there should be **no residual impact**.

6.1.95. As already discussed, the impacts of TTS in harbour porpoise and grey seal are considered as behavioural impacts likely to elicit a fleeing response or likely avoidance. TTS impacts are, therefore, assessed in the following section on behavioural disturbance.

Behaviour

6.1.96. Quantifying the impacts of behavioural disturbance during the construction of Dogger Bank Teesside A can be presented in a simplistic way by examining the total impact footprint. This illustrates the total spatial extent of the potential impact ranges resulting from underwater noise during the construction phase. The noise footprint can be considered to be the noise level at a given range, or the maximum ranges for a given impact threshold which might occur for each project regardless of the location or number of piling vessels operating within the project boundary. The noise propagation was modelled at various locations along the Dogger Bank Teesside A project boundary (**Appendix 5A**, Section 4) for cetacean species only.

6.1.97. In grey seal the areas of potential impact are sufficiently small, that consideration of overlapping areas of behavioural avoidance is not appropriate. In this species the areas of potential impact during pile driving across Dogger Bank Teesside A would equate the sum of the areas from the maximum of two pile driving events (assuming there is no overlap in contours from piling events 1.7km or more apart). This gives an approximate area of 18km^2 following mitigation and 1.5 individuals impacted (**Table 6.11**). This equates to 0.005% of the reference population, or a negligible magnitude. Combined with low sensitivity of grey seal to this impact, the residual impact is concluded to be **negligible**.

6.1.98. Quantification of the potential number of harbour porpoise that would be exposed to noise levels above the threshold that can cause TTS or likely avoidance is difficult. It is not possible to quantify the duration of gaps between pile driving events during the construction of Dogger Bank Teesside A or the degree to which other anthropogenic noise from the development could effectively act as mitigation in preventing TTS. Therefore, use of the noise footprint presents a worst case scenario of the number of individuals from each species that could be excluded from the area for the duration of pile driving at Dogger Bank Teesside A.

6.1.99. Assuming a maximum of 600 pile driving events (associated with wind turbines) within a year, plus up to 188 for other structures it is unlikely that there will be gaps between periods of pile driving of more than three days. However, it should be acknowledged that there could be breaks in activity due to weather or technical problems, and animals could return to the area. The footprint approach also assumes that within each year harbour porpoise do not return to the area due to behavioural exclusion for the duration of the piling programme.

6.1.100. There are a number of assumptions in this approach:

- The range of noise propagation for TTS and/or behavioural thresholds is the same as the worst case location for the chosen modelling; and
- All pile driving events were up to the maximum 3,000kJ blow force.

6.1.101. The behavioural disturbance footprint contours are shown in **Figure 6.6** to **Figure 6.8** for harbour porpoise, mid-frequency cetaceans and low frequency cetaceans respectively.

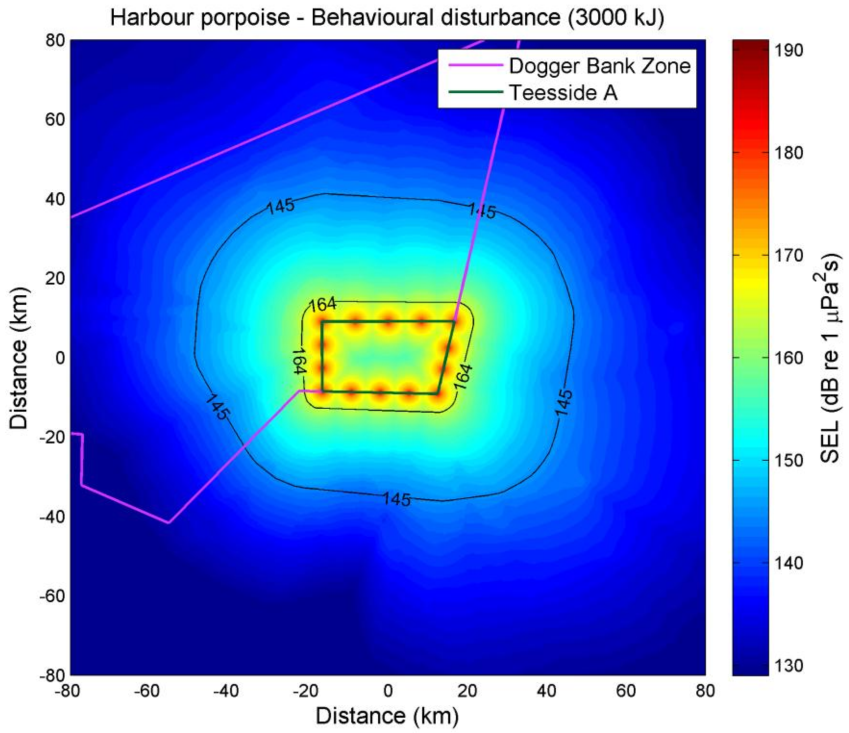


Figure 6.6 Harbour porpoise behavioural disturbance footprint contours resulting from construction noise at Dogger Bank Teesside A assuming 3,000kJ hammer blow energy. SEL 164dB re 1 μPa2·s represents the zone of TTS or fleeing response, SEL 145dB re 1 μPa2·s the zone of possible avoidance. Zones of PTS are not shown on the figures as they are so small.

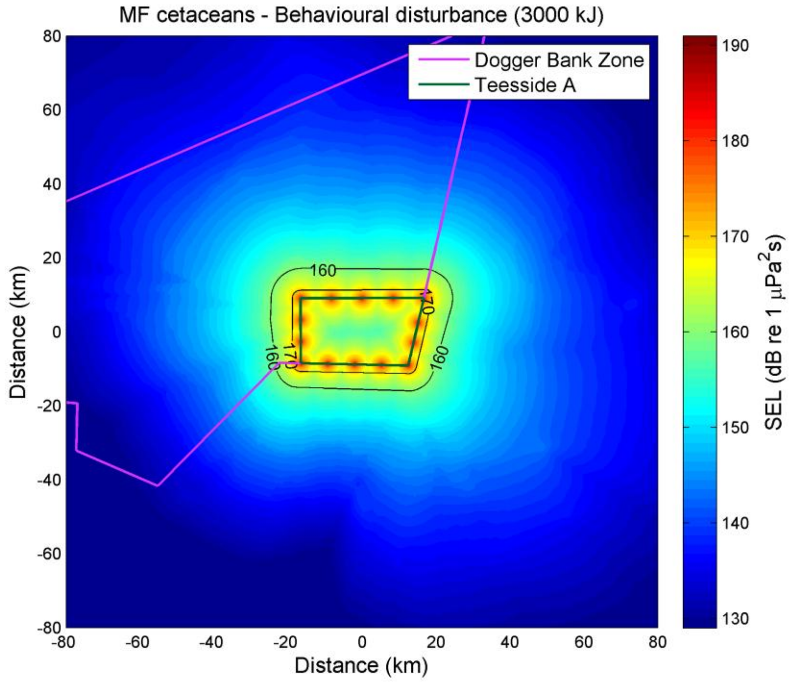


Figure 6.7 Mid-frequency cetacean behavioural disturbance footprint contours resulting from construction noise at Dogger Bank Teesside A assuming 3,000kJ hammer blow energy. SEL 170dB re 1 µPa2•s represents the zone of likely avoidance, SEL 160dB re 1 µPa2•s the zone of possible avoidance. Zones of PTS are not shown on the figures as they are so small.

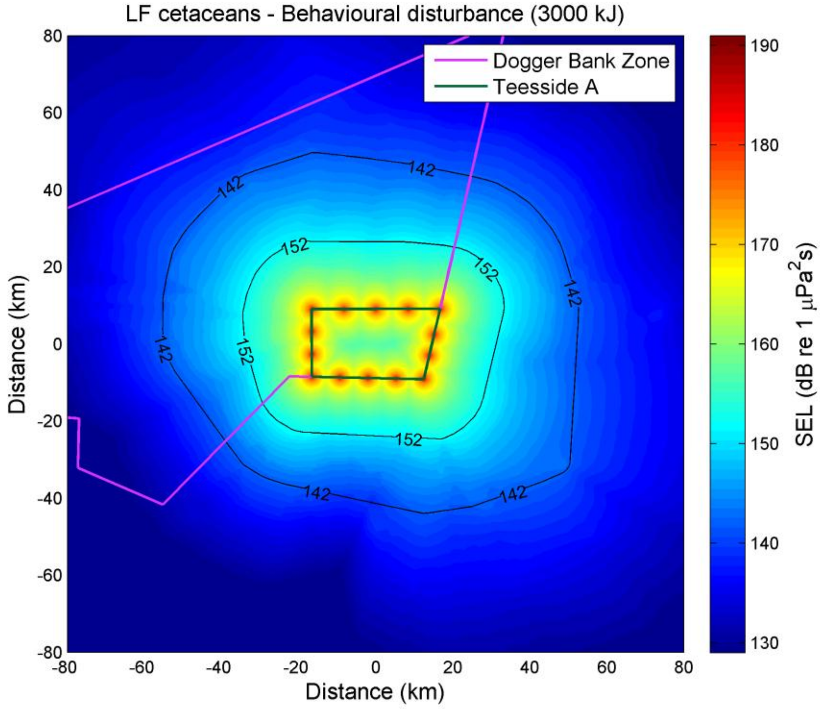


Figure 6.8 Low-frequency cetacean behavioural disturbance footprint contours resulting from construction noise at Dogger Bank Teesside A assuming 3,000kJ hammer blow energy. SEL 152dB re 1 µPa2•s represents the zone of likely avoidance, SEL 142dB re 1 µPa2•s the zone of possible avoidance. Zones of PTS are not shown on the figures as they are so small.

6.1.102. The numbers of individuals of each species that would be likely to avoid and will possibly avoid the area are shown in **Table 6.11**.

6.1.103. Although the spatial extent of the noise footprint for the development will represent an area greater than that over which individuals will be displaced at any one time (as there will be a maximum of two piling vessels, and some of the pile driving will have a maximum blow force of 1,900kJ not 3,000kJ), this approach does provide a spatial worst case over which animals could be disturbed for the duration of the pile driving programme.

6.1.104. Effects of the magnitude shown for possible avoidance in **Table 6.11** are considered low (>1% but <5% of the reference population) in harbour porpoise and negligible for all other species. The magnitude of effect related to areas of likely avoidance in all species is considered to be negligible. Although disturbance is a temporary effect, the duration of the construction programme could last up to six years. Therefore, the magnitude of effect for behavioural disturbance (both likely and possible avoidance) has been revised up one level in all species (as per criteria in **Table 3.4**).

Table 6.11 Area (km²) of residual impact footprint from concurrent pile driving events around the Project boundary (based on 3,000kJ hammer energy), number of individuals impacted (and uncertainty based on 95% CI around density estimates); percentage of reference population impacted and magnitude of effect at Dogger Bank Teesside A (following mitigation).

Species (Reference population)	Likely avoidance				Possible avoidance			
	Impact area	Impacted number	Percentage of reference population	Revised magnitude of effect (original)	Impact area	Impacted number	Percentage of reference population	Revised magnitude of effect (original
Harbour porpoise (227,298)	$1,039km^2$	666 (601-742)	0.29% (0.26-0.33%)	Low (Negligible)	$6,008km^2$	3,848 (3,469-4,288)	1.7% (1.5-1.9%)	Medium (Low)
Harbour porpoise and potential harbour porpoise combined (227,298)		745 (544-1,012)	0.33% (0.24-0.45%)	Low (Negligible)		4,302 (3,141- 5,848)	1.9% (1.4-2.6%)	Medium (Low)
Minke whale (23,168)	$2,931km^2$	25 (0-70)	0.1% (0-0.30%)	Low (Negligible)	$7,962km^2$	69 (0-190)	0.3% (0-0.82%)	Low (Negligible)
Minke whale (174,000)			0.01% (0-0.04%)	Low (Negligible)			0.04% (0-0.11%)	Low (Negligible)
White-beaked dolphin (15,895)	$796km^2$	12 (8-22)	0.07% (0.05-0.1%)	Low (Negligible)	$1,414km^2$	21 (14-40)	0.13% (0.09-0.25%)	Low (Negligible)
Grey seal (maximum mean at sea density across Dogger Bank Teesside A project area) (28,989)	$18km^2$ [6]	1.5	0.005%	Low (Negligible)	Not assessed			

[6] Area of likely avoidance or TTS across based on two concurrent pile driving events at Dogger Bank Teesside A

6.1.105. The assessment is based on the following;

- Medium sensitivity for each species of cetacean to likely avoidance and low magnitude of effect; and
- Low sensitivity for harbour porpoise to possible avoidance and medium magnitude of effect.

6.1.106. Therefore, the impact is assessed as **minor adverse** in all cetacean species. In grey seal the impact is also **minor adverse** (based on a low magnitude of effect and low sensitivity for likely avoidance).

6.1.107. The magnitude of effect presented in the table assumes that there is 100% response from all individuals within the likely or possible avoidance area. In the case of likely avoidance or TTS it may be reasonable to assume 100% displacement, but for possible avoidance such an assumption is likely to overstate the number of displaced individuals. When considering possible avoidance, the multiple pulses severity scaling score 5/6 was adopted from Southall *et al*. (2007) which relates to possible avoidance. It is generally referred to in this assessment as (possible) avoidance behaviour, and it essentially suggests there may be some avoidance response with possible inter-individual variation. It may be reasonable to assume that avoidance of the area may occur in only a proportion of the individuals, with a dose response curve reflecting individuals closer to the noise source, who receive a higher dose exhibiting a more marked response.

6.1.108. This dose response is accounted for in the assessment by assigning low sensitivity to possible avoidance, and medium sensitivity to likely avoidance. It should also be noted by assuming that as a worst case 100% of individuals within the possible avoidance zone response, the potential for individuals beyond this zone to also respond is accounted for. Assuming a dose response relationship, the potential for some form of behavioural displacement will extend beyond the possible avoidance contour until the range where the noise stimulus is no longer perceived.

6.1.109. It should be noted that within this approximate footprint, as a worst case, pile driving would occur for a maximum of 4,858 hours (assuming 200 6MW turbines each with six pin piles **Table 5.2**). If pile driving was spread over the minimum of three years, and assuming there was no concurrent pile driving from the two vessels, there would be pile driving for approximately 18.5% of the time. This proportion of the overall construction period in which piling was actually occurring would reduce by 50% (to 9% of the overall period) should the construction take the maximum of six years. Obviously if concurrent pile driving were to occur, this proportion would be reduced by up to 50%.

6.1.110. The proportion of time spent pile driving will also be considerably reduced if 120 x 10MW turbines are installed using single monopole foundations. Approximately 5% of the overall construction period would be spent pile driving in a three year construction programme, or 2.5% of the time over a six year construction programme (again assuming no concurrent pile driving).

6.1.111. At this point in the assessment it is appropriate to consider the context of the magnitude of the behavioural disturbance effect on harbour porpoise at a population level. There is an absence of empirical data to show the individual consequences of behavioural disturbance, or TTS expressed as likely avoidance.

6.1.112. During the development of the Moray Firth Framework (for harbour seal) an assumption of reduction in fecundity in direct proportion to the amount of time an individual was excluded from an area (Thompson *et al*. 2012). This assumption was agreed during consultation with key stakeholders and scientists, but this level of risk may not be considered to be as precautionary in harbour porpoise. It is possible that harbour porpoise could be exposed to some increased risk of mortality from prolonged exposure to a behavioural disturbance which impairs their ability to feed, but again no empirical data exist to draw such conclusions.

6.1.113. For harbour porpoise we have used modelling undertaken to determine by-catch limits for harbour porpoise carried out following the SCANS II survey (SCANS-II 2008) to put the magnitude of effect in context. Although the individual impact of TTS on a harbour porpoise, will not result in immediate mortality as by-catch would, it is useful to consider the number of porpoise that could be removed as by-catch prior to a population level effect being reached.

6.1.114. The conservation objective of the modelling on by-catch was: On average (i.e. 50% of the time) to allow populations to recover to and/or maintain 80% of carrying capacity in the long term (assumed to be 200 years) (SCANS-II 2008).

6.1.115. The modelling followed two management approaches; Procedure A was based on the principal of Potential Biological Removal (PBR) and Procedure B based on the IWCs Catch Limit Algorithm (CLA). The key differences were that Procedure A used a single, current estimate of absolute population size, and Procedure B used a time-series of estimates of absolute population size and by-catch. Management Procedure B was considered the most appropriate for harbour porpoise in the North Sea by a joint IWC/ASCOBANS working group. The modelling was carried out for each of the SCANS-II survey blocks.

6.1.116. Results of the modelling suggest that across a range of precautionary levels in the approach between 0.251% and 1.273% of the population could be by-catch across the Central, Northern and Southern North Sea combined, and the conservation objectives still be met. This is calculated across the area equivalent to reference population used in this impact assessment, and equates to between 581 and 2,942 harbour porpoise.

6.1.117. Within the SCANS–II survey blocks, the central North Sea showed the lowest capacity to accommodate by-catch (annual by-catch of between 90 and 456 harbour porpoise (0.12% and 0.62%) of the population was acceptable), and the southern North Sea had the greatest capacity to accommodate this by-catch (annual levels of between 420 and 2,124 (0.31 and 1.58% of the population; SCANS-II 2008). Magnitude of effects greater than these percentages can be quantified as medium to high, as they will prevent the management objectives being met for this species, and thus lead to a significant impact (in EIA terms), assuming a high individual sensitivity.

6.1.118. The impact of TTS, or a behavioural response of likely avoidance, could disturb between 601 and 1,012 harbour porpoise each year (based on the upper and lower confidence limits of the potential harbour porpoise combined densities; **Table 6.11**). This equates to between 0.26% and 0.45% of the reference population. This falls within the limit for acceptable by-catch in the Southern North Sea of between 420 and 2,124. The Southern North Sea includes the SCANS II Area U which includes the Dogger Bank Zone. It should be noted that likely avoidance does not equate to removal of individuals from the population, as is the case for by-catch.

6.1.119. In addition animals that possibly avoid the area need to be considered. It is assumed that 100% of individuals respond to the likely avoidance threshold, and 50% of the individuals exposed to possible avoidance thresholds respond to the pile driving noise.

6.1.120. A behavioural disturbance is predicted to occur in 2,257 or 2,524 harbour porpoise (based on the harbour porpoise and harbour porpoise combined with potential harbour porpoise densities respectively).

6.1.121. The by-catch modelling suggests between 581 and 2,942 harbour porpoise could be removed each year from the reference population used in this assessment prior to a significant impact occurring.

6.1.122. The impact considered in this assessment is displacement. If displacement led to reproductive failure in individuals who were displaced (following the assumptions of the Moray Firth Framework for harbour seals), fewer calves would be born, although the reduction in births would be hard to quantify.

6.1.123. In the North Sea, life history data imply a short reproductive lifespan in female harbour porpoise (Winship 2009). This is due to a combination of likely age structure (biased towards young animals) and age at sexual maturity (90% of females estimated to be sexually mature by the age of six). In addition, despite a gestation period for harbour porpoise in the North Sea of 10-11 months, the observed pregnancy rate in ‘healthy’ females was 60% (Learmonth 2006). Impacts of TTS or behavioural disturbance are likely to be spread across both reproductive and non-reproductive females, as well as males, therefore the number of females which experience reproductive failure would be substantially less than the number of animals potentially displaced.

6.1.124. It is possible that behavioural disturbance leads to an increased risk of mortality in harbour porpoise too, but there are no empirical data to show this. In addition, it is unlikely that behavioural displacement would lead to direct mortality (100% reduction in survival) in all individuals. To cross the most conservative estimate of allowable by-catch in the reference population of 581, between 23% and 26% of the displaced individuals would have to die assuming the densities from potential harbour porpoise and harbour porpoise combined, and harbour porpoise densities respectively. Using the intermediate estimate of acceptable by-catch (1,853) between 73% and 82% of the displaced individuals would have to die as a result of behavioural disturbance.

6.1.125. Based on the context provided by the modelling for by-catch, it is unlikely that a significant effect would occur at the population level from behavioural disturbance or displacement, despite concluding the potential for a moderate adverse impact.

6.1.126. Following from this assessment, in the context of disturbance to EPS it is unlikely that for harbour porpoise, minke whale or white-beaked dolphin an impact will occur at the population level, or affect the current FCS. It is likely that the magnitude of disturbance to all species of cetacean will mean that an EPS licence will be required.

Mitigation and residual impacts

6.1.127. No further mitigation is considered than previously outlined for auditory injury. The residual impacts remain as stated in the preceding paragraphs.

Summary of noise impact from pile driving during construction of Dogger Bank Teesside A

6.1.128. The overall impact at a population level from pile driving noise on each species considered in the assessment is summarised in **Table 6.12** below.

Table 6.12 Summary of residual impacts (and value of VER) from multiple pile driving during the construction of Dogger Bank Teesside A.

Residual impact	Harbour porpoise (High)	Minke whale (High)	White-beaked dolphin (High)	Grey seal (High)
Lethal /injury	**No impact**	**No impact**	**No impact**	**No impact**
Auditory injury (PTS)	**No impact**	**No impact**	**No impact**	**Minor adverse**
Auditory injury (TTS)	**Minor adverse**	**No impact**	**No impact**	**Minor adverse**
Likely avoidance		**Minor adverse**	**Minor adverse**	
Possible avoidance	**Minor adverse**	**Minor adverse**	**Minor adverse**	Not assessed
Overall impact	**Minor adverse**	**Minor adverse**	**Minor adverse**	**Minor adverse**

Dogger Bank Teesside B

Single piling event impact

6.1.129. As was the case for Dogger Bank Teesside A, impact piling was modelled at 12 locations within the Dogger Bank Teesside B development area (**Appendix 5A** Figure 4.1). A range of locations was chosen to encompass a range of noise propagation conditions; shallow and deep water and up-sloping and down-sloping bathymetry. The locations are presented in **Appendix 5A**, Table 4.2.

Lethal and physical injury

6.1.130. As was the case for Dogger Bank Teesside A, the pile driving installation is unlikely to result in radiated noise levels beyond a few metres which are sufficient to cause instantaneous mortality in marine mammals.

Auditory injury

Impact ranges

6.1.131. Based on the injury criteria by Southall *et al*. (2007), these ranges for Dogger Bank Teesside B are the same as Dogger Bank Teesside A and span from less than 200m for pinnipeds in water, less than 100m for mid-frequency cetaceans and low-frequency cetaceans to less than 700m for harbour porpoise. The use of a soft-start, initiating with the hammer at 300 kJ will reduce the ranges for potential onset of auditory injury to less than 100m for the considered marine mammal groups and less than 200m in harbour porpoise (**Table 6.13** to **Table 6.16**).

6.1.132. TTS ranges used for Dogger Bank Teesside B are the same as for Dogger Bank Teesside A for all species.

Table 6.13 Summary of harbour porpoise impact ranges for construction at Dogger Bank Teesside B. Range of impacts primarily varies due to differences in bathymetry.

Estimated harbour porpoise impact ranges – Dogger Bank Teesside B				
Impact criterion	**Potential range of impact for harbour porpoise**			
	300kJ hammer energy	**1,900kJ hammer energy**	**2,300kJ hammer energy**	**3,000kJ hammer energy**
Auditory injury: Instantaneous injury/PTS (pulse SEL 179dB re 1 μPa^2·s)*	<200m	<500m	<550m	<700m
Auditory injury behavioural response: TTS/fleeing response (pulse SEL 164dB re 1 μPa^2·s)*	<1.5km	3.6 - 4.2km	3.8 – 4.8km	4.0 - 5.5km
Behavioural response: Possible avoidance of area (pulse SEL 145dB re 1 μPa^2·s)*	10 - 14km	19.5 - 29.5km	21 – 30.5km	22 – 33.5km

**Lucke et al. (2009)*

Table 6.14 Summary of mid-frequency cetacean functional hearing group impact ranges for construction at Dogger Bank Teesside B. Range of impacts primarily varies due to differences in bathymetry.

Estimated mid-frequency cetacean impact ranges - Dogger Bank Teesside B				
Impact criterion	**Potential range of impact for mid-frequency cetacean**			
	300kJ hammer energy	**1,900kJ hammer energy**	**2,300kJ hammer energy**	**3,000kJ hammer energy**
Auditory injury: Instantaneous injury/PTS (Mmf weighted 198dB re 1 μPa^2·s)*	<100m	<100m	<100m	<100m
Auditory injury: TTS/fleeing response (Mmf weighted 183dB re 1 μPa^2·s)*	<100m	<150m	<200m	<200m
Behavioural response: Likely avoidance of area (pulse SEL 170dB re 1 μPa^2·s)***	<600m	<2km	<2.2km	<2.5km
Behavioural response: Possible avoidance of area (pulse SEL 160dB re 1 μPa^2·s)***	<2.5km	3.6 – 4.2km	6 – 7.5km	6 – 8.5km

Southall et al. (2007) Injury Criteria, **Southall et al. (2007) Single pulse behavioural disturbance.*Southall et al. (2007) Multiple pulses severity scoring behavioural disturbance (RMS SPL converted to pulse SEL by subtraction of 10dB).*

Table 6.15 Summary of low-frequency cetacean functional hearing group impact ranges for construction at Dogger Bank Teesside B. Range of impacts primarily varies due to differences in bathymetry.

Estimated low-frequency cetacean impact ranges - Dogger Bank Teesside B				
Impact criterion	**Potential range of impact for low-frequency cetacean**			
	300kJ hammer energy	**1,900kJ hammer energy**	**2,300kJ hammer energy**	**3,000kJ hammer energy**
Auditory injury: Instantaneous injury/PTS (Mlf weighted 198dB re 1 μPa^2·s)*	<100m	<100m	<100m	<100m
Auditory injury: TTS/fleeing response (Mlf weighted 183dB re 1 μPa^2·s)*	<100m	<250m	<300m	<400m
Behavioural response: Likely avoidance of area (pulse SEL 152dB re 1 μPa^2·s)***	5 – 7km	11 – 15.5km	12 – 17km	13 – 19km
Behavioural response: Possible avoidance of area (pulse SEL 142dB re 1 μPa^2·s)***	13 – 19km	23 – 36km	24.5 – 38km	26 – 41km

Southall et al. (2007) Injury Criteria, **Southall et al. (2007) Single pulse behavioural disturbance.*Southall et al. (2007) Multiple pulses severity scoring behavioural disturbance (RMS SPL converted to pulse SEL by subtraction of 8dB).*

Table 6.16 Summary of pinniped functional hearing group impact ranges for construction at Dogger Bank Teesside B. Range of impacts primarily varies due to differences in bathymetry.

Estimated pinniped impact ranges - Dogger Bank Teesside B				
Impact criterion	**Potential range of impact for pinnipeds**			
	300kJ hammer energy	**1,900kJ hammer energy**	**2,300kJ hammer energy**	**3,000kJ hammer energy**
Auditory injury: Instantaneous injury/PTS * (Mpw weighted 186dB re 1 μPa^2·s)	<100m	<100m	<200m	<200m
Auditory injury/behavioural response: TTS/Fleeing response/ Likely avoidance (Mpw weighted 171dB re 1 μPa^2·s) **	<400m	<1.5km	<1.5km	<1.7km

**Southall et al. (2007) Injury Criteria, **Southall et al. (2007) Single pulse behavioural disturbance.*

Quantification of impacts

6.1.133. The magnitude of potential impact of PTS and TTS are considered the same as for Dogger Bank Teesside A in all species of cetacean (**Table 6.8**). In grey seal the maximum recorded average density in the Dogger Bank Teesside B project area is 0.23 individuals per km^2 (see Section 4.3), which suggests 0.1 individuals could be exposed to instantaneous PTS based on the maximum hammer energy or 3,000kJ or 2 individuals (0.007% of the reference population) could be exposed to TTS.

Mitigation and residual impacts

6.1.134. Mitigation is assumed to be applied as is the case for Dogger Bank Teesside A. Following JNCC Guidelines (JNCC 2010b) it is assumed that a project-specific MMMP will be applied (via use of marine mammal observers and/or PAM and/or ADDs) that provides an effective zone of exclusion around the source of the pile driving of at least 500m. Forewind will commit to the development of this monitoring and exclusion zone out to the appropriate range to mitigate PTS in all species of cetacean. The mitigation will be developed in the MMMP in conjunction with JNCC, Natural England and the MMO.

6.1.135. This means that in the case of harbour porpoise minke whale, white-beaked dolphin and grey seal instantaneous PTS should be mitigated. Starting ranges for the prevention of PTS from a cumulative SEL dose will also be mitigated at less than the minimum exclusion zone of 500m in all species of cetacean, but not in grey seal.

6.1.136. The starting range for the potential to cause PTS from a cumulative SEL dose in grey seal is approximately 17km (**Figure 6.1a**). However, as was the case for Dogger Bank Teesside A, the number of grey seal that may experience PTS is hard to quantify. The magnitude of effect is considered to be negligible to low, at worst, and combined with a medium sensitivity the impact is assessed as **minor adverse**. An assessment of TTS grey seal is provided in the behavioural section below, as the noise thresholds for TTS and likely avoidance are the same.

6.1.137. For harbour porpoise, the maximum range for PTS from instantaneous injury is beyond the zone of standard mitigation of 500m (as in Dogger Bank Teesside A). Should it be deemed appropriate at the time of developing the MMMP, the mitigation zone will be extended to encompass the maximum range of instantaneous PTS in this species. However, use of the soft-start will provide sufficient time for individual to flee the zone of potential injury before the maximum hammer blow of 3,000kJ is reached. The required starting ranges of all species to prevent PTS from cumulative exposure are within the 500m mitigation zone (Figure 6.2 in **Appendix 5A**). The residual impact for PTS in harbour porpoise is **no impact**.

6.1.138. Mitigation of PTS in all species of cetacean (due to the soft-start procedures and mitigation zones) should prevent the possibility of any injury offence to EPS.

6.1.139. Impact ranges for TTS in minke whale and white-beaked dolphin are within 500m of the noise source and will be mitigated. As such, the residual impact for auditory injury in each of these species would remain **no residual impact.**

6.1.140. The number of harbour porpoise predicted to be exposed to TTS could be reduced following mitigation, but this is hard to quantify. Establishment of an effective exclusion zone may mean animal densities are increased in the zone of TTS and the overall number of animals exposed remains the same. An assessment of TTS in harbour porpoise is provided in the behavioural section below, as the noise thresholds for TTS and likely avoidance are the same.

6.1.141. As stated for Dogger Bank Teesside A, the use of vibration pile driving or non-piled foundations would reduce noise levels considerably from those predicted during impact pile driving (see Appendix C in **Appendix 5A**). There will be some noise associated with the installation of non-piled foundations (such as gravity bases or suction caissons), but noise impacts are not anticipated to result in significant impacts from these installation methods.

Behaviour

Impact ranges

6.1.142. The fleeing ranges for marine mammals for Dogger Bank Teesside B are presented in **Tables 6.13** to **Table 6.16**. Assuming hammer blow energy of 3,000kJ, the fleeing response range for harbour porpoise for Dogger Bank Teesside B is predicted to be similar to that presented for Dogger Bank Teesside A, i.e. between 4km and 5.5km. For smaller hammer blow energies, these ranges will be smaller.

6.1.143. For Dogger Bank Teesside B, the result is a worst case predicted possible avoidance range for harbour porpoise (based on the pulse SEL 145dB re 1 $\mu Pa^2 \cdot s$ criteria) of between 22km and 33.5km (**Table 6.13**, **Figure 6.9**).

6.1.144. Applying the Marine Mammal Exposure Criteria for mid-frequency cetaceans, it is predicted that an avoidance range of up 2.5km is likely (based on the worst case 3,000kJ max hammer energy and pulse SEL 170dB re 1 $\mu Pa^2 \cdot s$ criteria), and that an avoidance range of between 6km and 8.5km is possible (again based on the worst case max hammer energy and based on pulse SEL 160dB re 1 $\mu Pa^2 \cdot s$ criteria) for Dogger Bank Teesside B (**Table 6.14**, **Figure 6.10**).

6.1.145. Applying the Marine Mammal Exposure Criteria for low-frequency cetaceans, it is predicted that an avoidance range of 13km to 19km is likely (based on the worst case 3,000kJ maximum hammer energy and pulse SEL 152dB re 1 $\mu Pa^2 \cdot s$ criteria), and that an avoidance range of between 26km and 41km is possible (based on the worst case 3,000kJ maximum hammer energy and pulse SEL 142dB re 1 $\mu Pa^2 \cdot s$ criteria) (**Table 6.15**, **Figure 6.11**).

6.1.146. The avoidance ranges for pinnipeds in water (M_{pw} weighted 171dB re 1 $\mu Pa^2 \cdot s$) during construction at Dogger Bank Teesside B would be less than 1.7km for any assumed hammer blow energy (for the maximum 3,000kJ hammer energy, **Table 6.16**, **Figure 6.12**).

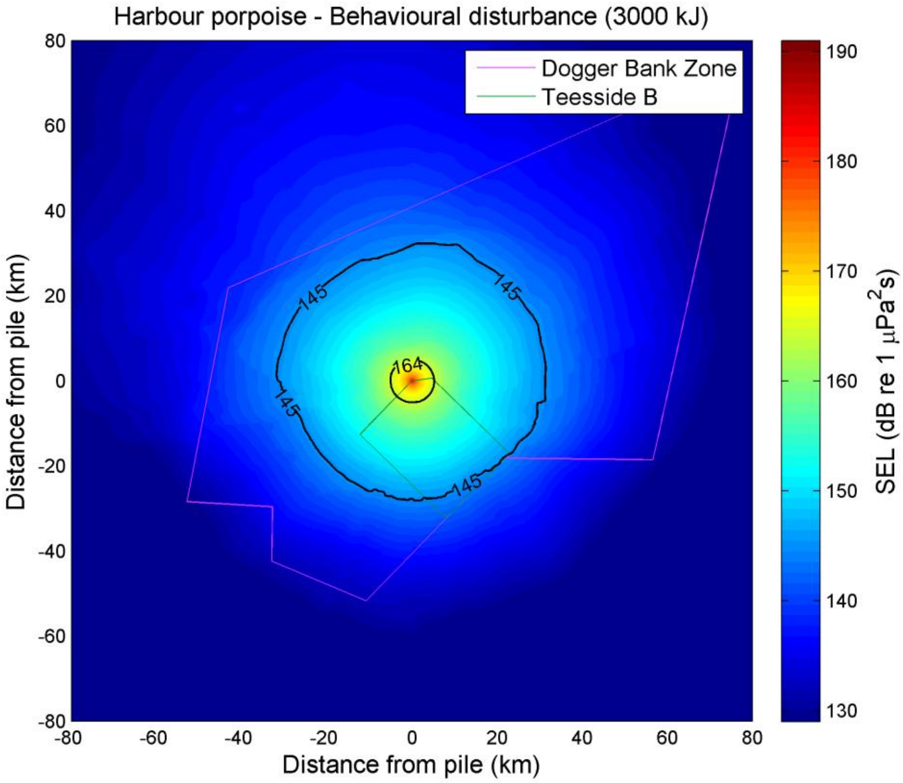


Figure 6.9 Harbour porpoise behavioural disturbance zones for Dogger Bank Teesside B using 3,000kJ hammer blow energy SEL 164dB re 1 μPa2·s represents the zone of TTS or fleeing response, SEL 145dB re 1 μPa2·s the zone of possible avoidance. Zones of PTS are not shown on the figures as they are so small.

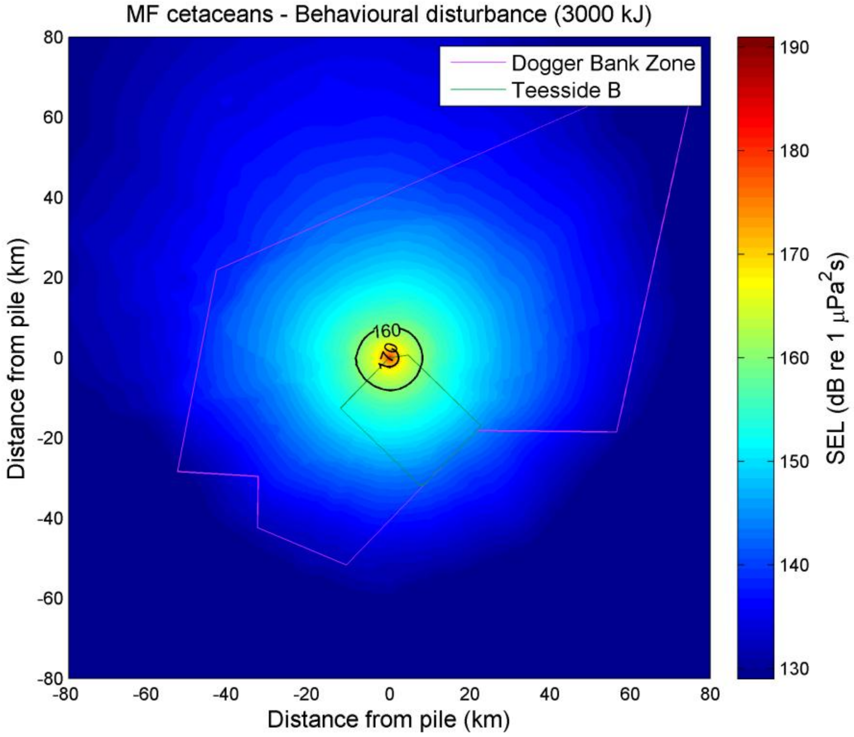


Figure 6.10 Mid-frequency cetacean behavioural disturbance zones for Dogger Bank Teesside B using 3,000kJ hammer blow energy. SEL 170dB re 1 μPa2•s (inner circle) represents the zone of likely avoidance, SEL 160dB re 1 μPa2•s the zone of possible avoidance. Zones of PTS are not shown on the figures as they are so small.

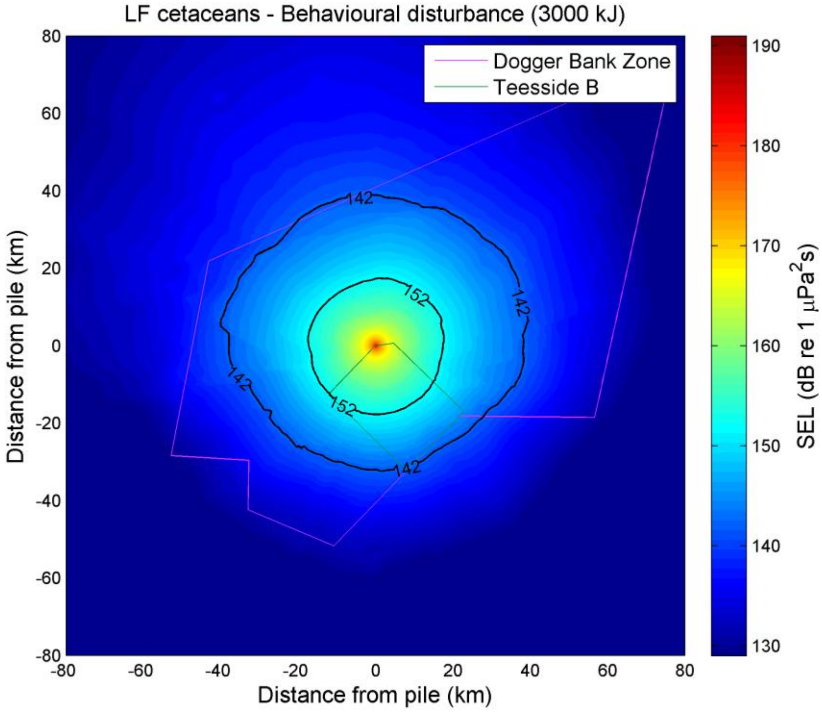


Figure 6.11 Low-frequency cetacean behavioural disturbance zones for Dogger Bank Teesside B using 3,000kJ hammer blow energy. SEL 152dB re 1 μPa2•s represents the zone of likely avoidance, SEL 142dB re 1 μPa2•s the zone of possible avoidance. Zones of PTS are not shown on the figures as they are so small.

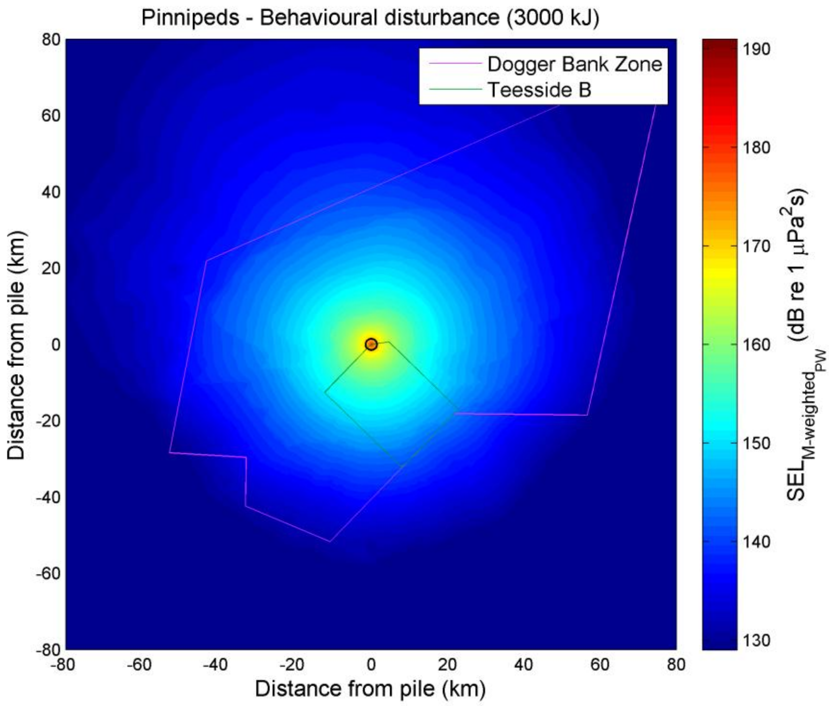


Figure 6.12 Pinnipeds in water behavioural disturbance zones for Dogger Bank Teesside B using 3,000kJ hammer blow energy. SEL 171dB re 1 µPa2• represents the zone of TTS/fleeing response/likely avoidance. Zones of PTS are not shown on the figures as they are so small.

Quantification of impacts

6.1.147. In the case of harbour porpoise, minke whale and white-beaked dolphin, impacts have been calculated by overlaying the areas of potential effect with underlying average densities across the Dogger Bank Zone. The areas of effect, numbers impacted and the percentage of the reference population impacted are summarised in **Table 6.17**.

6.1.148. For harbour porpoise, white-beaked dolphin and minke whale, the magnitude of effect is negligible for both likely and possible avoidance. All species have medium sensitivity to likely avoidance; therefore, the overall impact on both species is predicted to be **negligible**. Low sensitivity combined with negligible magnitude of possible avoidance impacts also concludes a **negligible** impact.

6.1.149. In the case of grey seal, the densities are higher at Dogger Bank Teesside B than Dogger Bank Teesside A. Based on the maximum mean at sea densities, 2 seals could be disturbed. However, the magnitude of effect is the same as outlined for auditory injury for Dogger Bank Teesside A, as negligible; with a maximum of less than 0.007% of the reference population being exposed to TTS/flee response or likely avoidance. Since grey seal have a low sensitivity to this impact, the overall impact is considered to be **negligible**.

Table 6.17 Areas (km^2) of residual impact (from a single pile driving event based on the worst case 3,000kJ hammer energy), number of individuals impacted (and uncertainty based on 95% CI around density estimates), percentage of the reference population impacted and magnitude of effect at Dogger Bank Teesside B.

Species (Reference population)	Likely avoidance				Possible avoidance			
	Impact area	Impacted number	Percentage of reference population	Magnitude of effect	Impact area	Impacted number	Percentage of reference population	Magnitude of effect
Harbour porpoise (227,298)	82km^2	53 (48-59)	0.02% (0.02-0.03%)	Negligible	2,8341km^2	1,820 (1,641-2,027)	0.8% (0.7-0.9%)	Negligible
Harbour porpoise and potential harbour porpoise combined (227,298)		59 (43-80)	0.03% (0.02-0.04%)	Negligible		2,035 (1,485-2,765)	0.9% (0.7-1.2%)	Negligible
Minke whale (23,168)	953km^2	8 (0-23)	0.04% (0-0.1%)	Negligible	4,172km^2	36 (0-100)	0.2% (0-0.343 %)	Negligible
Minke whale (174,000)			0.005% (0-0.01%)	Negligible			0.02% (0-0.06%)	Negligible
White-beaked dolphin (15,895)	15km^2	0.23 (0.15-0.43)	0.001% (0.001-0.003%)	Negligible	200km^2	3 (2-5.6)	0.02% (0.01-0.04%)	Negligible
Grey seal (28,989)	9km^2	2	0.007%	Negligible	Not assessed			

Mitigation and residual impacts

6.1.150. No further mitigation is considered than previously outlined for auditory injury. The residual impacts remain as stated in the preceding paragraphs, and are summarised in **Table 6.18**.

6.1.151. Implications of behavioural disturbance to EPS are considered in the assessment of multiple pile driving across Dogger Bank Teesside B.

Table 6.18 Summary of residual impacts (and value of VER) from pile driving a single pile during the construction of Dogger Bank Teesside B.

Residual impact	Harbour porpoise (High)	Minke whale (High)	White-beaked dolphin (High)	Grey seal (High)
Lethal /injury	**No impact**	**No impact**	**No impact**	**No impact**
Auditory injury (PTS)	**No impact**	**No impact**	**No impact**	**Minor adverse**
Auditory injury (TTS)	**Negligible**	**No impact**	**No impact**	**Negligible**
Likely avoidance		**Negligible**	**Negligible**	
Possible avoidance	**Negligible**	**Negligible**	**Negligible**	Not assessed
Overall impact	**Negligible**	**Negligible**	**Negligible**	**Negligible**

Multiple pile driving during construction of Dogger Bank Teesside B

6.1.152. The impacts from multiple pile driving during the construction of Dogger Bank Teesside B have been assessed in the same way as Dogger Bank Teesside A; by examining the largest noise footprint produced by multiple piling events for cetaceans, and the area of two concurrent pile driving events in the case of grey seal. The total number of vessels and pile driving events is the same as assessed for Dogger Bank Teesside A.

Auditory Injury

6.1.153. In all species of cetacean the potential for instantaneous PTS should be mitigated for a single pile driving event. Mitigation measures, including the soft-start and development of an exclusion zone in the MMMP will prevent PTS in minke whale, white-beaked dolphin and harbour porpoise; therefore there is **no residual impact**. TTS will also be prevented in minke whale and white-beaked dolphin; therefore there is **no residual impact**.

6.1.154. In grey seal the potential for PTS, based on cumulative SEL dose remains based on the precautionary 186dB re 1 μPa^2·s threshold due to starting ranges greater than the zone of exclusion. The effect is likely to be of low magnitude, due to the relatively low occurrence of grey seal across the zone. Combined with a medium sensitivity to PTS, there is the potential for a **minor adverse** residual impact.

6.1.155. The potential for TTS in harbour porpoise and grey seal is assessed in the behaviour section below.

Behaviour

6.1.156. Quantification of the impacts of behavioural disturbance during the construction of Dogger Bank Teesside B has been presented in a simplistic way by examining the total impact footprint. The noise propagation has been modelled at various locations along the Dogger Bank Teesside B project boundary (**Appendix 5A**, Section 6).

6.1.157. The behavioural disturbance footprint contours are shown in Figure 6.5, 6.7 and 6.9 in **Appendix 5A** for harbour porpoise, mid-frequency cetaceans and low frequency cetaceans respectively.

6.1.158. In order to assess the number of individuals of each species are likely to avoid and may possibly avoided of the area the areas of these impact footprints were calculated (**Table 6.19**). It is important to note that at the range of possible avoidance 100% of the individuals are not expected to respond.

6.1.159. The impact areas related to possible avoidance in **Table 6.19** are considered to equate to a low magnitude effect for harbour porpoise and negligible in all other species. Impact areas for likely avoidance in all species are considered of negligible magnitude. However, the construction phase of the development could last up to six years. Therefore, the magnitude of the effect has been increased by one level in all species (**Table 6.19**). The impacts are considered to be **minor adverse** in all species.

6.1.160. In the context of disturbance to EPS it is unlikely that for harbour porpoise, minke whale or white-beaked dolphin that an impact will occur at the population level, or affect the current FCS. It is likely that the magnitude of disturbance to all species of cetacean will require an EPS licence.

Mitigation and residual impacts

6.1.161. No further mitigation is considered than outlined previously for auditory injury as there is no potential for a significant impact in EIA terms. The residual impacts remain as stated in the preceding paragraphs.

Table 6.19 Areas (km^2) of residual impact footprint from concurrent pile driving events around the Project boundary (based on a worst case 3,000kJ hammer energy), number of individuals impacted (and uncertainty based on 95% CI around density estimates), percentage of the reference population impacted and magnitude of effect at Dogger Bank Teesside B.

Species (Reference population)	Likely avoidance				Possible avoidance			
	Impact area	Impacted number	Percentage of the reference population	Revised magnitude of effect (original)	Impact area	Impacted number	Percentage of the reference population	Revised magnitude of effect (original)
Harbour porpoise (227,298)	1,072km^2	687 (620-766)	0.3% (0.27-0.34%)	Low (Negligible)	5,489km^2	3,516 (3,170-3,917)	1.55% (1.39-1.7%)	Medium (Low)
Harbour porpoise and potential harbour porpoise combined (227,298)		768 (561-1,044)	0.34% (0.24-0.46%)	Low (Negligible)		3,931 (2,870-5,343)	1.7% (1.26-2.4%)	Medium (Low)
Minke whale (23,168)	2,853km^2	25 (0-68)	0.1% (0-0.3%)	Low (Negligible)	7,133km^2	62 (0-171)	0.26% (0-0.7%)	Low (Negligible)
Minke whale (174,000)			0.01% (0-0.04%)	Low (Negligible)			0.04% (0-0.1%)	Low (Negligible)
White-beaked dolphin (15,895)	820km^2	12 (8-23)	0.08% (0.05-0.1%)	Low (Negligible)	1,416km^2	21 (14-40)	0.1% (0.09-0.25%)	Low (Negligible)
Grey seal (maximum mean at sea density across Dogger Bank Teesside B project area) (28,989)	18km^2[7]	4	0.01%	Low (Negligible)	Not assessed			

[7] Area based on the sum of two areas of likely avoidance /TTS at Dogger Bank Teesside B.

Summary of noise impact from pile driving during construction of Dogger Bank Teesside B

6.1.162. The overall impact from pile driving noise on each species considered in the assessment is summarised in **Table 6.20**.

Table 6.20 Summary of residual impacts (and value of VER) from pile driving noise during the construction of Dogger Bank Teesside B.

Residual impact	Harbour porpoise (High)	Minke whale (High)	White-beaked dolphin (High)	Grey seal (High)
Lethal /injury	**No impact**	**No impact**	**No impact**	**No impact**
Auditory injury (PTS)	**No impact**	**No impact**	**No impact**	**Minor adverse**
Auditory injury (TTS)	**Minor adverse**	**No impact**	**No impact**	**Minor adverse**
Likely avoidance		**Minor adverse**	**Minor adverse**	
Possible avoidance	**Minor adverse**	**Minor adverse**	**Minor adverse**	Not assessed
Overall impact	**Minor to Moderate adverse**	**Minor adverse**	**Minor adverse**	**Minor adverse**

Dogger Bank Teesside A & B – sequential or concurrent

Lethal and physical injury

6.1.163. It is unlikely that the pile driving installation will result in radiated noise levels beyond a few metres which are sufficient to cause instantaneous mortality in marine mammals.

6.1.164. Mitigation will minimise the potential for this type of impact, so there should be **no residual impact**.

Auditory injury

6.1.165. As discussed in the assessment of Dogger Bank Teesside A and Dogger Bank Teesside B, the impacts of PTS should be mitigated for all species of cetacean through the use of soft-start procedures and the establishment of an exclusion zone by a MMMP. Therefore, in all species of cetacean there should be **no residual impact**.

6.1.166. In the case of grey seal, the potential of instantaneous PTS should also be mitigated following standard mitigation procedures. However, the starting range for the potential to cause PTS from a cumulative SEL dose is approximately 17km. There is therefore the potential also for an impact of low magnitude in this species, with a **minor adverse** impact concluded based on medium sensitivity of this species to PTS.

6.1.167. TTS in minke whale and white-beaked dolphin should also be mitigated, and TTS in harbour porpoise and grey seal are considered in the likely avoidance behavioural impacts section, below.

Behaviour

6.1.168. The worst case assessment of the two projects in combination considers the possibility of no or minimal overlap in construction periods. However, the constraints set out in Section 5 for the worst case confirms that construction will not commence before 18 months post consent, and must commence before seven years post consent. This means in this worst case scenario there will be a period of six months concurrent pile driving, and construction noise from the two projects could last for up to 11 years and six months. At this scale, the temporal aspect of the impact is considered of greater weight than the spatial impact. This temporal consideration has been reflected by revising the impact magnitudes up one level during the assessment of each project.

6.1.169. If construction periods overlapped (which they will for at least six months) between the two projects due to their proximity there is the potential for noise impacts relating to behavioural disturbance to overlap. The combined impact footprints in such a case would be less than the sum of the two project impact footprints in isolation. The number of impacted individuals from each species has been calculated by overlaying the two impact footprints from each development and removing the area of overlap from one footprint. The potential impact from concurrent piling is summarised in **Table 6.21**.

6.1.170. Summing the potential impacts from the two projects (with no overlap) have also been quantified in **Table 6.21**. However, the temporal duration of the impact would effectively be six years, rather than 12 years. During a sequential build the numbers presented in **Table 6.21** would represent the total number of individuals that could be disturbed over the duration of the construction period, and not the number that would be displaced during the construction of each project or at any one time. This would also assume that densities of harbour porpoise remain the same between the construction of one project and the commencement of the next; even though behavioural displacement is likely.

6.1.171. Impacts relating to behavioural disturbance are temporary by definition. However, the two projects being constructed sequentially, means that the duration of the total behavioural impact could be almost 12 years; effectively (barring the small period of overlap) the footprint of Dogger Bank Teesside A for six years, followed the footprint of Dogger Bank Teesside B for six years or vice versa. The number of individuals displaced during each construction period at each project is shown in **Table 6.11** Dogger Bank Teesside A and **Table 6.19** for Dogger Bank Teesside B. As in the assessment of each project, it is considered appropriate to revise the magnitude of effect upwards one level based on the temporal duration of the disturbance. Therefore, the overall magnitude of effect has been increased by one level, to medium for possible avoidance in harbour porpoise, and medium for behavioural disturbance, and low in all other species for possible avoidance and likely avoidance.

6.1.172. Therefore, the overall residual impact of behavioural responses to pile driving noise from the combined impacts of Dogger Bank Teesside A and Dogger Bank Teesside B is predicted to be **minor adverse** in all species. This is based on the combination of low sensitivity in all species to possible avoidance. The magnitude of effect of likely avoidance is low, even after revision following consideration of the temporal aspect of this impact. When combined with medium sensitivity the impact is **minor adverse**.

6.1.173. **Table 6.26** summarises the residual impact from either a sequential or concurrent build at Dogger Bank Teesside A and Dogger Bank Teesside B.

Mitigation and residual impacts

6.1.174. No further mitigation is considered than outlined previously for the assessment of the construction of each project.

6.1.175. The assessment is based a worst case scenario where the two projects are constructed sequentially. Construction of the two wind farms concurrently could reduce the overall spatial and temporal footprint of the likely impacts from pile driving.

Table 6.21 Total number of individuals impacted (and percentage of reference population) from footprints (based on 3,000kJ hammer energy) of Dogger Bank Teesside A and Dogger Bank Teesside B over the entire construction programme assuming a sequential build (based on summing impacts from each project in isolation) and assuming a concurrent build (allowing for overlapping footprints)

Species (reference population)	**Concurrent build**		**Sequential build**	
	Likely avoidance	**Possible avoidance**	**Likely avoidance**	**Possible avoidance**
Harbour porpoise (227,298)	1,336 (0.59%)	5,679 (2.5%)	1,353 (0.6%)	7,364 (3.24%)
Harbour porpoise and potential harbour porpoise combined (227,298)	1,494 (0.66%)	6,349 (2.79%)	1,513 (0.67%)	8,233 (3.62%)
Minke whale (23,168)	43 (0.19%)	98 (0.42%)	50 (0.2%)	131 (0.57%)
Minke whale (174,000)	43 (0.02%)	98 (0.06%)	50 (0.03%)	131 (0.08%)
White-beaked dolphin (15,895)	24[8] (0.15%)	40 (0.25%)	24 (0.15%)	42 (0.26%)
Grey seal (average density) (28,989)	5.5 (0.02%)	Not assessed	5.5 (0.02%)	Not assessed

Table 6.22 Summary of residual impacts (and value of VER) from pile driving noise during the construction of Dogger Bank Teesside A & B.

Residual impact	**Harbour porpoise (High)**	**Minke whale (High)**	**White-beaked dolphin (High)**	**Grey seal (High)**
Lethal /injury	**No impact**	**No impact**	**No impact**	**No impact**
Auditory injury (PTS)	**No impact**	**No impact**	**No impact**	**Minor adverse**
Auditory injury (TTS)	**Minor adverse**	**No impact**	**No impact**	**Minor adverse**
Likely avoidance		**Minor adverse**	**Minor adverse**	
Possible avoidance	**Minor adverse**	**Minor adverse**	**Minor adverse**	Not assessed
Overall impact	**Minor adverse**	**Minor adverse**	**Minor adverse**	**Minor adverse**

[8] Contours do not overlap, therefore concurrent build impacts are the same as a sequential build

6.2. Underwater noise: vessel noise

Dogger Bank Teesside A

6.2.1. There will be an increase in the amount of vessel noise in the environment during the construction of Dogger Bank Teesside A. This will include:

- Large and medium crane vessels;
- Floating and dynamic positioning jack up vessels; and
- A number of smaller logistics, transport and feeder vessels.

6.2.2. The worst case indicative number of construction vessel movements is 5,150, during the three year construction period, with a further 660 vessel movements for material transport (**Table 5.2**). It is anticipated that there will be a maximum of 66 vessels offshore during construction, which will peak in year two of the project. It is possible that some existing ship traffic in the area may be excluded during construction, resulting in some displacement of the existing traffic.

6.2.3. Shipping traffic in the area currently consists of large tankers, smaller cargo vessels, tugs, fishing boats and other traffic (**Chapter 16**). The majority of vessel movements are fishing and cargo vessels. There were seven commercial vessel routes within 10nm of Dogger Bank Teesside A & B recorded during winter 2011/2012 and ten during spring/ summer 2012.

6.2.4. It is likely that marine mammals using this region are habituated to this type and intensity of underwater noise to at least some degree. There is no evidence to suggest that vessel noise adversely affects seals, but some data support avoidance of areas of intense boat activity by small cetaceans and large whales (Thomsen *et al*. 2006).

6.2.5. Noise levels reported by Malme *et al.* (1989) and Richardson *et al*. (1995) for large surface vessels indicate that physiological damage to marine fauna is unlikely. However, the levels could be sufficient to cause local disturbance of sensitive marine fauna in the immediate vicinity of the vessel, depending on ambient noise levels.

6.2.6. Based on these data, the magnitude of the effect related to potential displacement due to vessel noise for all marine mammals is considered negligible. Given the presence of marine mammals in areas currently experiencing vessel noise their sensitivity to this effect is predicted to be low. The overall impact is considered to be **negligible**.

Mitigation and residual impact

6.2.7. No further mitigation for vessel noise is considered. Therefore, the residual impact remains **negligible**.

Dogger Bank Teesside B

6.2.8. Due to the mobile nature of marine mammals and the planned worst case scenarios for both Dogger Bank Teesside A and Dogger Bank Teesside B, the residual impacts are considered to be the same for each project.

Dogger Bank Teesside A & B Export Cable Corridor

6.2.9. Additional vessel movements relating to cable laying activities are included in the total number of vessel movements for each project as presented in the worst case table (**Table 5.2**). The impacts are therefore included in the above assessment.

6.2.10. As discussed in paragraph 4.3.32 no disturbance effects at the Seal Sands haul out site are likely.

Dogger Bank Teesside A and Dogger Bank Teesside B – concurrent or sequential

6.2.11. The combined impact of the two projects is likely to be up to twice as high as that of the individual projects. It is acknowledged that there could be some between masking of the vessel noise from pile driving occurring at the other project if construction were concurrent, but this is hard to quantify. The magnitude of effect is, therefore, considered to be low. Given this low magnitude, and low sensitivity of the receptor, the impact is assessed as **minor adverse**.

6.2.12. No further mitigation for vessel noise is considered. The residual impact, therefore, remains **minor adverse**.

6.3. Collision risk – hull impacts

Dogger Bank Teesside A

6.3.1. During the construction of Dogger Bank Teesside A, there will be an increase in the amount of vessel traffic as presented in Section 6.2.

6.3.2. Due to vessel noise, it is likely that cetaceans will be able to detect the presence of vessels and may be able to avoid collisions by taking evasive action. Despite the potential for avoidance of vessels, ship strikes are known to occur in cetaceans and cause injury and death (Wilson *et al*. 2007). Distraction whilst undertaking other activities such as foraging and social interactions are possible reasons why collisions occur (Wilson *et al*. 2007). Marine mammals can also be inquisitive, which may increase the risk of collision. It is not possible to fully quantify strike rates, as it is believed that a number go unnoticed. It is possible that collisions which are non-fatal can leave the animal vulnerable to secondary infection, other complications or predation (Wilson *et al*. 2007). However, marine mammals are relatively robust to potential collision, as they have a thick sub-dermal layer of blubber, which defends their vital organs from the worst of the impact (Wilson *et al*. 2007).

6.3.3. Laist *et al.* (2001) concluded that vessels over 80m in length cause the most severe or lethal injuries but that serious injury rarely occurs if animals are struck by vessels travelling at speeds below 10 knots. The construction phase will use mostly large (>100m) vessels, which are likely to travel at slow speeds of around 10 knots or less; whilst only small workboats and crew transfer vessels (~25m) are likely to operate at greater speed.

6.3.4. All species of cetacean are considered to have low sensitivity to this effect, which is of a negligible magnitude, due to the potential to avoid collisions and accommodate some of the increase in vessel traffic in the area. It is also expected that, due to the existing levels of ship traffic in the vicinity of the proposed development, that species of cetacean may be habituated to the presence of vessels. The overall impacts are, therefore, considered to be **negligible**.

6.3.5. Hull impacts involving species of seal are not widely reported, and seals are considered to have negligible sensitivity to this impact, which will be of a negligible magnitude. The overall impact is also considered to be **negligible**.

Mitigation and residual impact

6.3.6. No further mitigation is suggested for this impact; therefore, the residual impact for cetaceans and seals remains **negligible**.

Dogger Bank Teesside B

6.3.7. The residual impact is considered to be the same as for Dogger Bank Teesside A.

Dogger Bank Teesside A & B Export Cable Corridor

6.3.8. Additional vessel movements relating to cable laying activities are included in the total number of vessel movements for each project as presented in the worst case table (**Table 5.2**). The impacts are therefore included in the above assessment.

Dogger Bank Teesside A and Dogger Bank Teesside B – concurrent or sequential

6.3.9. The combined impact of Dogger Bank Teesside A and Dogger Bank Teesside B could double the level of impact. The magnitude of the effect for cetaceans is increased to low; the overall predicted impact level is **minor adverse**. The magnitude of effect and overall predicted impact for seals remains **negligible**.

Mitigation and residual impact

6.3.10. No further mitigation is suggested for this impact. Therefore the predicted impact for cetaceans is **minor adverse** and for seals is **negligible**.

6.4. Collision risk – ducted propellers

Dogger Bank Teesside A

6.4.1. Since 2008, large numbers of harbour and juvenile grey seal carcasses have been found in the UK with corkscrew like injuries, including 42 carcasses along the North Norfolk coast (centred on Blakeney Point National Nature Reserve). The distinctive corkscrew injuries are consistent with animals having encountered a single, rotating right-angled blade. These injuries are thought to be caused by the seals being drawn through ducted propellers (Thompson *et al*. 2010b). There are currently limited data to support ducted propellers as the root cause of these injuries and the total number of seals that may have been injured or killed is largely un-quantified.

6.4.2. Many of the construction and installation vessels for Dogger Bank Teesside A and Dogger Bank Teesside B are likely to use a dynamic positioning system, which uses ducted propellers as one of the main types of thrusters. Ducted propellers are also found on many modern workboats that are likely to service the project.

6.4.3. Guidance in assessing the potential risk of corkscrew injuries has been agreed by the Statutory Nature Conservation Agencies (April 2012). The risks are considered in relation to harbour and grey seal, with higher potential severity of the risks relating to widely declining populations of harbour seal around the UK. The guidance outlines threshold distances from SACs to determine the risk of ducted propellers. Given the distance between the proposed development site (including export cable corridor) and the closest harbour seal (>30 nautical miles (nm)) and grey seal (>4nm) SACs the risk is considered low in both species (Statutory Nature Conservation Agencies April 2012).

6.4.4. From this level of risk and the low likelihood of occurrence of harbour and grey seal in the offshore development area, where the use of ducted propellers would be greatest, the magnitude of effect is assessed as negligible. The sensitivity of harbour and grey seal to this effect is high and medium respectively. Therefore, the impact is assessed as **minor adverse** in harbour seal and **negligible** in grey seal.

Mitigation and residual impact

6.4.5. No further mitigation is considered due to the low risk to each species from this impact. The residual impacts remain **minor adverse** in harbour seal and **negligible** in grey seal.

Dogger Bank Teesside B

6.4.6. The residual impact is considered the same as for Dogger Bank Teesside A.

Dogger Bank Teesside A & B Export Cable Corridor

6.4.7. The Dogger Bank Teesside A & B Export Cable Corridor is beyond the 30nm and 4nm threshold distances from harbour seal and grey seal SACs outlined in the SNCA (2012) guidance. The cable landfall is approximately 12km (by sea) from the Seal Sands haul out site and the site is not a designated SAC. Therefore, based on the Statutory Nature Conservation Agencies (April 2012) guidance, the seals using this site are not considered at risk of DP collisions.

6.4.8. Additional vessel movements relating to cable laying activities are included in the total number of vessel movements for each project as presented in the worst case table (**Table 5.2**). The impacts are therefore included in the above assessment.

Dogger Bank Teesside A and Dogger Bank Teesside B – concurrent or sequential

6.4.9. The combined impact of Dogger Bank Teesside A and Dogger Bank Teesside B could double the impact of each development in isolation. The magnitude of the effect is still considered negligible in both species; impacts are therefore assessed as **minor adverse** in harbour seal, and **negligible** in grey seal.

Mitigation and residual impact

6.4.10. The magnitude of effect is still considered negligible in both species. The residual impacts are therefore assessed as **minor adverse** in harbour seal, and **negligible** in grey seal.

6.5. Changes in prey resource

Dogger Bank Teesside A

6.5.1. Impacts on fish and shellfish during construction are assessed in **Chapter 13**. The impacts on fish outlined during construction (namely disturbance or loss of seabed, increased suspended sediment concentrations and construction noise) are assessed as minor adverse at worst. Both cetaceans and pinnipeds have low sensitivity to minor changes in prey abundance, as their diet often reflect species in greatest abundance. The effects of any changes in potential marine mammal prey items due to changes in the distribution of fish resources in and around the project site (as assessed in **Chapter 13)** are considered to be of low magnitude. Therefore, the overall impact during the construction of Dogger Bank Teesside A is predicted to be **minor adverse.**

Mitigation and residual impact

6.5.2. No further mitigation is considered beyond that presented in **Chapter 13**. Therefore, the residual impacts are assessed as **minor adverse** for all species.

Dogger Bank Teesside B

6.5.3. The indirect impacts of changes in prey resource during the construction of Dogger Bank Teesside B are likely to be the same magnitude as Dogger Bank Teesside A. Therefore, the residual impact of Dogger Bank Teesside B is **minor adverse**.

Dogger Bank Teesside A & B Export Cable Corridor

6.5.4. Impacts on fish and shellfish during construction are assessed in **Chapter 13**. Impacts on fish outlined during construction (namely disturbance of seabed, construction noise) are assessed as minor adverse and not significant. Both cetaceans and pinnipeds have low sensitivity to local changes in prey abundance, as their diet often reflect species in greatest abundance. The effects of any changes in potential marine mammal prey items due to changes in the distribution of fish resources in and around the project site (as assessed in **Chapter 13**) are considered to be of low magnitude.

6.5.5. The overall impact during the construction of the Dogger Bank Teesside A & B Export Cable Corridor is **minor adverse**.

Mitigation and residual impact

6.5.6. No further mitigation is considered beyond that presented in **Chapter 13**. Therefore, the residual impacts are assessed as **minor adverse** in all species.

Dogger Bank Teesside A and B – Concurrent or Sequential

6.5.7. The combined impact of Dogger Bank Teesside A and Dogger Bank Teesside B in **Chapter 13** are assessed as minor adverse. The combined residual impact on marine mammals is, therefore, assessed as **minor adverse**.

Mitigation and residual impact

6.5.8. No further mitigation is considered, the residual impact remains **minor adverse** in all species.

7. Assessment of Impacts during Operation

7.1. Underwater noise – wind turbines

Dogger Bank Teesside A

7.1.1. Underwater noise from an operational wind turbine mainly originates from the gearbox and the generator and has tonal characteristics (Madsen *et al*. 2005; Tougaard *et al.* 2009b). However, recordings of underwater noise are only available from a small number of operational wind farm sites. Data collected suggests that behavioural responses for harbour porpoise and seal may only occur up to a few hundred meters away (Touggard and Henriksen 2009; McConnell *et al*. 2012). Touggard and Henriksen (2009) further show that even masking from operational noise is unlikely to impact harbour porpoise and seal acoustic communication, due to the low frequencies and low levels produced. A recent study by Scheidat *et al*. (2011) has reported an attraction of harbour porpoise to an operational Dutch wind farm site, where abundance was higher within the wind farm compared to a similar environment in near-by areas. This was assumed to be due to decreased fishing and vessel activity and increased food availability (Scheidat *et al*. 2011).

7.1.2. The main contribution to the underwater noise emitted from the wind turbines is expected to be from acoustic coupling of the vibrations of the substructure into the water rather than from transmission of in-air noise from the turbines into the water column (Lidell 2003). At the Naikun Offshore Wind Farm in British Columbia, JASCO (2009) predicted that sound pressure levels from the centre of the 396MW wind farm (110 x 3.6 MW turbines) were greater than 120dB re 1 µPa rms SPL at ranges less than 8.5 km. This study concluded that noise levels of the operating wind farm would be too low to cause injury to marine mammals. No behavioural response estimates are available from modelling of the Naikun offshore wind farm operational noise.

7.1.3. Comprehensive environmental monitoring has been carried out at the Horns Rev and Nysted wind farms in Denmark during the operational phase between 1999 and 2006 (Diederichs *et al*. 2008). Numbers of porpoise within Horns Rev were thought to be slightly reduced compared to the wider area during the first two years of operation it was, however, not possible to conclude that the wind farm was solely responsible for this change in abundance without analysing other dynamic environmental variables (Tougaard *et al*. 2009). Later studies (Diederichs *et al.* 2008) recorded no noteworthy effect on the abundances of harbour porpoise at varying wind velocities at both of the offshore wind farms, following two years of operation. Monitoring studies at Nysted and Røsand have also suggested that operational activities have had no impact on regional seal populations (Teilmann *et al*. 2006; McConnell *et al.* 2012).

7.1.4. Noise levels generated by operational wind turbines are much lower than those generated during construction. The low-level noise generated during operation is likely to be detected only at short distances over background noise levels and below levels which would elicit a response from marine mammals (Madsen *et al*. 2006; Thomsen *et al*. 2006). Empirical data exist to support no lasting disturbance or exclusion of small cetaceans or seals around wind farm sites during operation (Tougaard *et al*. 2005; Scheidat *et al*. 2011).

7.1.5. An assessment of the radiated noise has been made based on the minimum wind turbine spacing of 750m (**Appendix 5A**) based on a section of the project (15 wind turbines per project). The modelling is based on 1.5MW device outputs. Modelling wind turbines of this size (although they are not considered for this development) makes use of the best available data. The model uses the broadband level, unless larger wind turbines are substantially louder it will not necessarily change the outcome of the modelling (it may not be the case that bigger is necessarily louder).

7.1.6. The overall effect of the operational noise and the ability of marine mammals to perceive this noise will be largely dependent on ambient noise levels and wind speed. However, the operational wind turbines within the project are not expected to result in increased noise levels more than a few kilometres from the wind farm boundary.

7.1.7. Marine mammals are likely to have some tolerance to operational wind turbine noise and so have low sensitivity to this level of change. The magnitude of effect of noise generated by operational wind turbines is predicted to be negligible. Therefore, the predicted impact is **negligible**.

Mitigation and residual impact

7.1.8. No further mitigation for operational wind turbine noise is considered. The residual impact remains **negligible**.

Dogger Bank Teesside B

7.1.9. For Dogger Bank Teesside B the impact is considered to be the same as for Dogger Bank Teesside A (**negligible**). Details of the noise modelling for Dogger Bank Teesside B can be found in **Appendix 5A**, Section 6.2.

Dogger Bank Teesside A and Dogger Bank Teesside B - concurrently

7.1.10. The combination of the two projects will lead to a greater overall impacted area; the impact will however still be restricted to a small area in the vicinity of the turbines giving a negligible magnitude and therefore the predicted impact is **negligible**. Concurrent operation noise is shown in **Figure 7.1**.

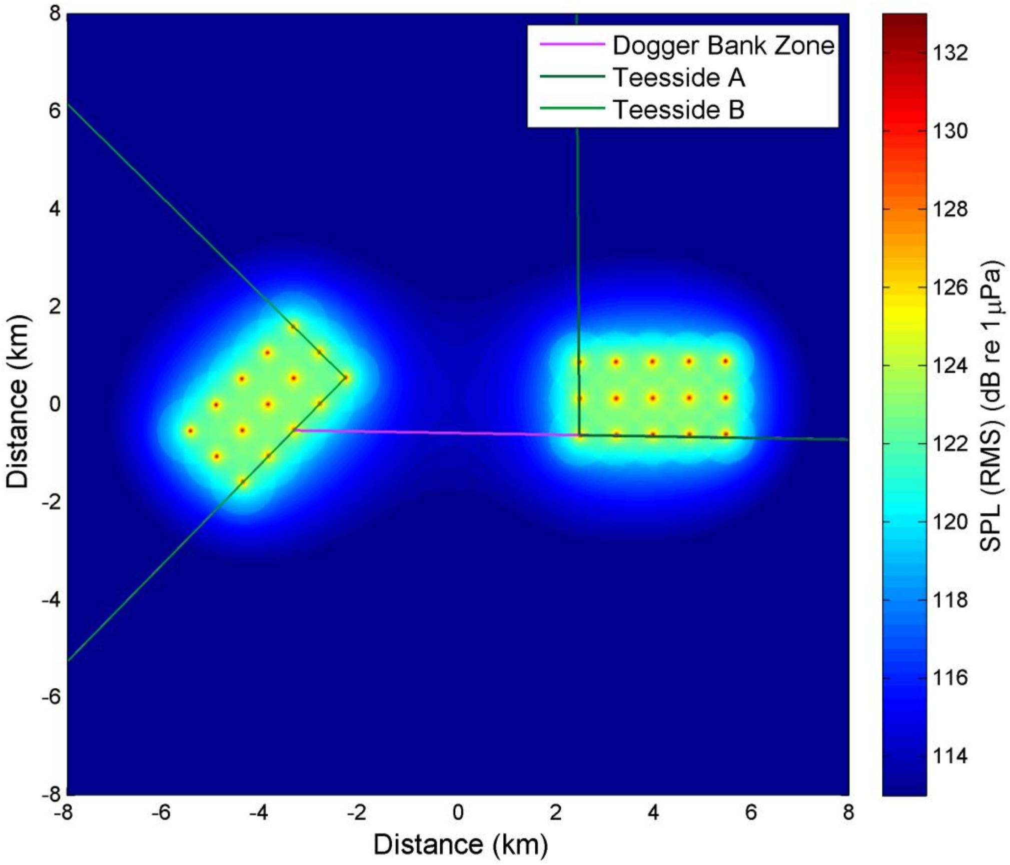


Figure 7.1 Modelled noise map for operational noise at Dogger Bank Teesside A and Dogger Bank Teesside B, assuming 750m turbine spacing. See **Appendix 5A** for details.

Mitigation and residual impact

7.1.11. The combined residual impact from the two projects remains **negligible** as no further mitigation is considered

7.2. Underwater noise - vessels

Dogger Bank Teesside A

7.2.1. During the operational phase of the development the amount of vessel traffic in the area will be greater than the baseline but lower than during construction. Vessels will be required for wind turbine and cable maintenance with a maximum of 26 vessels on site, and 730 vessel movements (round trips to port) per year predicted as a worst case (**Table 5.2**).

7.2.2. As discussed during the assessment of impacts from vessel noise during construction (Section 6.2), it is likely that marine mammals using this region are habituated to this type and intensity of underwater noise to at least some degree.

7.2.3. Based on the level of increased vessel traffic and potential displacement of existing traffic, a negligible magnitude effect from vessel noise is predicted.

Given the presence of marine mammals in areas currently experiencing vessel noise their sensitivity is predicted to be low. The overall impact is, therefore, considered to be **negligible**.

Mitigation and residual impact

7.2.4. No further mitigation for vessel noise is considered. Therefore, the residual impact will remain **negligible**.

Dogger Bank Teesside B

7.2.5. Due to the mobile nature of marine mammals and the planned worst case scenarios for both Dogger Bank Teesside A & B, the residual impacts are considered to be the same for each project.

Dogger Bank Teesside A and Dogger Bank Teesside B - concurrently

7.2.6. The combined impact of the two projects is likely to be up to twice the magnitude of the individual impact of the projects. The magnitude of effect is, therefore, considered to be low. Given the low sensitivity of the receptor, the impact is assessed as **minor adverse**.

Mitigation and residual impact

7.2.7. No further mitigation for vessel noise is considered. Therefore, the residual impact remains **minor adverse**.

7.3. Collision risk – hull impacts

Dogger Bank Teesside A

7.3.1. Operation of Dogger Bank Teesside A will require maintenance vessels as described in the assessment of vessel noise during this phase of the development. The presence of additional vessels in the region will present an increased risk of collision for marine mammals. The mechanism for potential impact is discussed in the assessment of impacts during construction (Section 6.3).

7.3.2. Species of cetacean are considered to have low sensitivity to this impact, which is of a negligible magnitude. The overall impact is considered to be **negligible**.

7.3.3. Hull impacts involving species of pinniped are not widely reported, and seals are considered to have negligible sensitivity with an impact of negligible magnitude. The overall impact is considered to be **negligible**.

Mitigation and residual impact

7.3.4. No further mitigation is suggested for this impact; therefore, the residual impact for cetaceans and pinnipeds remains **negligible**.

Dogger Bank Teesside B

7.3.5. The residual impact is considered to be the same as for Dogger Bank Teesside A (**negligible**).

Dogger Bank Teesside A and Dogger Bank Teesside B - concurrently

7.3.6. The combined impact of Dogger Bank Teesside A and Dogger Bank Teesside B would double the level of impact. Therefore the impact on cetaceans is increased to a low magnitude and therefore a **minor adverse** impact. However, the impact magnitude and, therefore, overall impact for seals remains **negligible**.

Mitigation and residual impact

7.3.7. No further mitigation is suggested for this impact. Therefore, the impact on cetaceans remains **minor adverse** and for seals remains **negligible**.

7.4. Collision risk – ducted propellers

Dogger Bank Teesside A

7.4.1. As described in the assessment of this impact during construction, there is a low likelihood of occurrence of harbour and grey seal in the offshore project area (where the use of ducted propellers will be greatest). The sensitivity of harbour and grey seal to this impact is high and medium respectively. The negligible magnitude for both species means that the impact is predicted to be **minor adverse** in harbour seal and **negligible** in grey seal.

Mitigation and residual impact

7.4.2. No further mitigation is considered, due to the low risk to both species from this impact. Therefore, the residual impacts remain **minor adverse** in harbour seal and **negligible** in grey seal.

Dogger Bank Teesside B

7.4.3. The residual impact is considered to be the same as for Dogger Bank Teesside A.

Dogger Bank Teesside A and Dogger Bank Teesside B - Concurrently

7.4.4. The combined impact of Dogger Bank Teesside A and Dogger Bank Teesside B will be double the impact of each development in isolation, although due to the negligible occurrence of harbour seal in the offshore development areas the magnitude of effect remains negligible. The magnitude also remains negligible in grey seal.

Mitigation and residual impact

7.4.5. The impact is still considered negligible in grey seal and harbour seal. Therefore, the residual impacts are assessed as **minor adverse** in harbour seal and **negligible** in grey seal.

7.5. Electromagnetic fields

Dogger Bank Teesside A

7.5.1. There may be potential for marine mammals to exhibit behavioural changes including displacement due to the presence of electromagnetic fields (EMF) around inter-array cables (Gill *et al*. 2005). There is currently limited information on this effect but it is widely believed that marine mammals use the geomagnetic field of the earth to navigate during long distance migrations (Kirschvink *et al*. 1986; Klinowska 1985).

7.5.2. Although it is assumed that harbour porpoise are capable of detecting small differences in magnetic field strength, this is unproven and is based on circumstantial information. There is also, at present, no evidence to suggest that existing subsea cables have influenced cetacean movements. Harbour porpoise move in and out of the Baltic Sea, with several crossings over operating subsea high voltage direct current cables in the Skagerrak and western Baltic Sea without any apparent effect on their migration pattern. There is no evidence that pinnipeds respond to EMF and, therefore, marine mammal sensitivity is deemed to be low.

7.5.3. The estimated length of the inter array cabling is 950km of 33kV to 72.5kV. The cables will be shielded to meet industry standards, buried or, if burial is not possible, will be protected by other methods such as mattressing or rock armour. In addition to the inter array cables there will be 320km of 132-400kV inter platform cable which will also be shielded to meet industry standards.

7.5.4. The strength of the EMF reduces with distance from the cable (Normandeau Associates Inc. 2011) and with burial or shielding the EMF levels emitting into the water column are likely to be of negligible magnitude. It is, therefore, predicted that the impact of EMF on marine mammals will be **negligible**.

Mitigation and residual impact

7.5.5. No further mitigation is considered; therefore the residual impacts remain **negligible** for all species.

Dogger Bank Teesside B

7.5.6. The worst case scenario captures the options for both Dogger Bank Teesside A and Dogger Bank Teesside B, therefore the level of potential impact from EMF at Teesside B is assessed as being the same as Dogger Bank Teesside A which is **negligible**.

Dogger Bank Teesside A & B Export Cable Corridor

7.5.7. There will be 573km of export cable, which will be HVDC (up to 550kV). The cables will be shielded to meet industry standards, buried or, if burial is not possible, will be protected by other methods such as mattressing or rock armour.

7.5.8. Although there is currently limited information on this effect it is widely believed that marine mammals use the geomagnetic field of the earth to navigate during long distance migrations (Kirschvink *et al.* 1986; Klinowska 1985). The strength of the magnetic field from the cable will depend on the current; it is possible that in close proximity to the cable the magnetic field would be noticeable. However, the strength of the EMF reduces with distance from the cable (Normandeau Associates Inc. 2011) and without burial the EMF levels emitting into the water column are likely to be of low magnitude.

7.5.9. Therefore, the impacts from EMF are assessed as **negligible**.

Mitigation and residual impact

7.5.10. No further mitigation is considered; therefore, the residual impacts remain **negligible** for all species.

Dogger Bank Teesside A and Dogger Bank Teesside B - concurrently

7.5.11. The combined impact from the two projects is assessed as being **negligible**, although it is noted that there will be twice the length of array cables and export cable as for Dogger Bank Teesside A or Dogger Bank Teesside B in isolation.

Mitigation and residual impact

7.5.12. No further mitigation is considered; therefore, the residual impacts remain **negligible** for all species.

7.6. Physical barrier

Dogger Bank Teesside A

7.6.1. The presence of a wind farm could be seen as having the potential to create a physical barrier, preventing movement or migration of marine mammals between important feeding and / or breeding areas. The minimum spacing between 6MW devices will be 750m. This means that animals can be expected to move between devices and through the operational wind farm irrespective of layout. As a result, the magnitude of this effect is predicted to be **negligible**.

7.6.2. Evidence from the Egmond aan Zee offshore wind farm (Lindeboom *et al.* 2011) suggests that marine mammals may be attracted to the site for foraging. This suggests that, at worst, marine mammals will have a negligible sensitivity to this impact. The impact is, therefore, assessed as **negligible**.

Mitigation and residual impact

7.6.3. No further mitigation is considered; therefore, the residual impacts remain **negligible** for all species.

Dogger Bank Teesside B

7.6.4. The potential impact of Dogger Bank Teesside B acting as a physical barrier for marine mammals is assessed as **negligible** based on the same impacts as Dogger Bank Teesside A.

Dogger Bank Teesside A and Dogger Bank Teesside B - concurrently

7.6.5. The combined impact of the two projects will not increase the potential impact above **negligible**, as the magnitude of effect will remain negligible, as will the species sensitivity.

Mitigation and residual impact

7.6.6. No further mitigation is considered; therefore, the residual impacts remain **negligible** for all species.

7.7. Changes in prey resource

Dogger Bank Teesside A

7.7.1. Impacts on fish and shellfish during operation are assessed in **Chapter 13**. The impacts on fish, including prey species (such as sandeel and herring) are assessed as minor adverse at worst. Both cetaceans and pinnipeds have low sensitivity to minor changes in prey abundance, as their diet often reflect species in greatest abundance. The effects of any changes in potential marine mammal prey items due to changes in the distribution of fish resources in and around the project site (as assessed in **Chapter 13**) are considered to be of low magnitude. Therefore, the overall impact during the construction of Dogger Bank Teesside A is predicted to be **minor adverse**.

Dogger Bank Teesside B

7.7.2. The indirect impacts of changes in prey resource during the operation of Dogger Bank Teesside B are likely to be the same magnitude as Dogger Bank Teesside A. Therefore, the impact of Dogger Bank Teesside B is **minor adverse**.

Mitigation and residual impact

7.7.3. No further mitigation is considered beyond that presented in **Chapter 13**. Therefore, the residual impacts are assessed as **minor adverse** in all species.

Dogger Bank Teesside A and Dogger Bank Teesside B – concurrent or sequential

7.7.4. The combined impact of Dogger Bank Teesside A and Dogger Bank Teesside B in **Chapter 13** are assessed as minor adverse at worst. The combined residual impact on marine mammals is, based on a low magnitude of effect and low sensitivity, assessed as **minor adverse**.

Mitigation and residual impact

7.7.5. No further mitigation is considered, the residual impact remains **minor adverse** in all species.

8. Assessment of Impacts during Decommissioning

8.1.1. The methods for the removal of the wind turbines, substructures and foundations will be determined in a decommissioning plan that will be based on the most up to date technology and environmental conditions at the time of decommissioning.

8.1.2. It is anticipated that the vessel usage will be similar to that experienced during the construction phase of the development (**Table 5.2**). The expected solution is to cut the substructures below sea level at an agreed depth. It is likely that the inter-array and export cables will be left *in situ*, although this has yet to be determined.

8.2. Underwater noise - cutting

Dogger Bank Teesside A

8.2.1. There will be no pile driving activities or use of explosives associated with decommissioning. Therefore, the noise effects will be temporary and of much lower intensity than during construction. The noise effect footprints are likely to be of a low magnitude. All marine mammals are considered as having medium sensitivity to this type of impact. The overall impact is, therefore, predicted to be **minor adverse**.

Mitigation and residual impact

8.2.2. At this stage, no mitigation measures have been applied. The residual impact, therefore, remains **minor adverse**.

Dogger Bank Teesside B

8.2.3. The impact is considered the same as for Dogger Bank Teesside A.

Dogger Bank Teesside A & B – concurrent or sequential

8.2.4. The potential combined impact of decommissioning at Dogger Bank Teesside A and Dogger Bank Teesside B will be greater than the impact of the two projects in isolation. It is likely that there will not be a major difference in the magnitude of the impact whether decommissioning of the two projects occurs sequentially or concurrently. The magnitude of effect is considered to be low and all marine mammals are considered to have medium sensitivity. The impact is therefore predicted to be **minor adverse**.

Mitigation and residual impact

8.2.5. No further mitigation is considered; therefore the residual impacts remain **minor adverse** for all species.

8.3. Underwater noise - vessels

Dogger Bank Teesside A

8.3.1. The use of vessels during the decommissioning process is expected to be similar to that during construction, both in terms of materials transport and larger crane and support vessels (**Table 5.2**). The impact of vessel noise is, therefore, likely to be similar to that experienced during construction (**negligible**). It is acknowledged that the baseline level of vessel movements may be different at this time.

Mitigation and residual impact

8.3.2. At this stage, no mitigation measures have been applied. The residual impact, therefore, remains **negligible**.

Dogger Bank Teesside B

8.3.3. The impact is considered the same as Dogger Bank Teesside A; **negligible**.

Dogger Bank Teesside A and Dogger Bank Teesside B – concurrent or sequential

8.3.4. The potential combined impact of decommissioning at Dogger Bank Teesside A and Dogger Bank Teesside B will be greater than the impact of the two projects in isolation. There would not be a major difference in the magnitude of the effect, whether decommissioning of the two projects occurs sequentially or concurrently. The magnitude of effect is considered to be low and all marine mammals are considered to have low sensitivity. The impact is predicted to be **negligible**.

Mitigation and residual impact

8.3.5. No further mitigation is considered; therefore, the residual impacts remain **negligible** for all species.

8.4. Collision risk – hull impacts

Dogger Bank Teesside A

8.4.1. It is expected that the level of vessel activity will be similar during decommissioning as during construction, with an indicative number of 5,150 vessel movements and 660 material transport movements (**Table 5.2**). Impacts are predicted to be similar to those associated with construction.

8.4.2. Species of cetacean are considered to have medium sensitivity to collision risk and this potential effect is judged to have a negligible magnitude. This is due to the individual's ability to avoid collisions and accommodate some of the increase in vessel traffic in the area. It is also expected that, due to the existing levels of ship traffic in the vicinity of the proposed development, species of cetacean may be habituated to the presence of vessels. The overall impact is considered **negligible**.

8.4.3. Hull impacts involving species of seal are not widely reported, probably due to the animals' ability to avoid collisions. As a result, seals are considered to have low sensitivity to the effect. With a negligible magnitude of effect, the impact is assessed as **negligible**.

Mitigation and residual impact

8.4.4. No further mitigation is suggested for this impact, and for cetaceans and seals the residual impact remains **negligible**.

Dogger Bank Teesside B

8.4.5. The impact is considered the same as for Dogger Bank Teesside A.

Dogger Bank Teesside A and B – concurrent or sequential

8.4.6. The combined construction of Dogger Bank Teesside A and Dogger Bank Teesside B would double the level of effect. The magnitude of effect on cetaceans is increased to low; the overall impact level is therefore **minor adverse**. The magnitude of effect and overall impact for seals remains **negligible**.

Mitigation and residual impact

8.4.7. No further mitigation is suggested for this impact. Therefore, the impact remains **negligible** for seals and **minor adverse** for cetaceans.

8.5. Collision risk – ducted propellers

Dogger Bank Teesside A

8.5.1. It is expected that the level of vessel activity will be similar during decommissioning as during construction, with an indicative number of 5,150 vessel movements and 660 material transport movements (**Table 5.2**). Therefore, the type or risk and the severity of the impact are predicted to be similar to the impact associated with construction.

8.5.2. From that level of risk and the low likelihood of occurrence of harbour and grey seal in the offshore development area, where the use of ducted propellers would be greatest, the magnitude of effect is assessed as negligible. The sensitivity of harbour and grey seal to this impact is high and medium respectively. The negligible magnitude in each species means that the impact is considered to be **minor adverse** for harbour seal and **negligible** for grey seal.

Mitigation and residual impact

8.5.3. Mitigation is not considered necessary, due to the low risk to each species from this impact. The residual impacts remain **minor adverse** in harbour seal and **negligible** in grey seal.

Dogger Bank Teesside B

8.5.4. The residual impact is considered to be the same as for Dogger Bank Teesside A.

Dogger Bank Teesside A and Dogger Bank Teesside B – concurrent or sequential

8.5.5. The combined impact of Dogger Bank Teesside A and Dogger Bank Teesside B will be up to double the impact of each development in isolation. The magnitude of effect is still considered negligible in both species; impacts are therefore assessed as **minor adverse** in harbour seal, and **negligible** in grey seal.

Mitigation and residual impact

8.5.6. The magnitude of effect is still considered negligible in grey and harbour seal as no further mitigation is suggested. The residual impacts are therefore assessed as **minor adverse** in harbour seal and **negligible** in grey seal.

8.6. Changes in prey resource

Dogger Bank Teesside A

8.6.1. Impacts on fish and shellfish during decommissioning are not assessed in **Chapter 13**. However, the impacts on fish during decommissioning are not expected to be greater than those during construction, which are assessed as minor adverse at worst. Both cetaceans and pinnipeds have low sensitivity to minor changes in prey abundance, as their diets often reflect those fish species that are present in greatest abundance. The effects of any changes in potential marine mammal prey items due to changes in the distribution of fish resources in and around the project site are considered to be of low magnitude. Therefore, the overall impact during the decommissioning of Dogger Bank Teesside A is predicted to be **minor adverse**.

Mitigation and residual impact

8.6.2. No further mitigation is considered. Therefore, the residual impacts are assessed as **minor adverse** for all species.

Dogger Bank Teesside B

8.6.3. The indirect impacts of changes in prey resource during the decommissioning of Dogger Bank Teesside B are likely to be the same magnitude as Dogger Bank Teesside A. Therefore, the residual impact of Teesside B is **minor adverse**.

Dogger Bank Teesside A & B Export Cable Corridor

8.6.4. Impacts on fish and shellfish during decommissioning are not assessed in **Chapter 13**. However, the impacts on fish during decommissioning are not expected to be greater than those during construction, which are assessed as minor adverse at worst. Both cetaceans and pinnipeds have low sensitivity to local changes in prey abundance, as their diet often reflect species in greatest abundance. The effects of any changes in potential marine mammal prey items due to changes in the distribution of fish resources in and around the project site are considered to be of low magnitude.

8.6.5. The overall impact during the decommissioning of the Dogger Bank Teesside A & B Export Cable Corridor is **minor adverse**.

Mitigation and residual impact

8.6.6. No further mitigation is considered. Therefore, the residual impacts are assessed as **minor adverse** in all species.

Dogger Bank Teesside A and Dogger Bank Teesside B – concurrent or sequential

8.6.7. The combined impact of Dogger Bank Teesside A & B in **Chapter 13** are assessed as minor adverse. The combined residual impact on marine mammals is, therefore, assessed as **minor adverse**.

Mitigation and residual impact

8.6.8. No further mitigation is considered, the residual impact remains **minor adverse** in all species.

9. Inter-relationships

9.1.1. In order to address the environmental impact of the proposed development as a whole, this section establishes the inter-relationships between marine mammals and other physical, environmental and human receptors. The objective is to identify where the accumulation of residual impacts on a single receptor, and the relationship between those impacts, gives rise to a need for additional mitigation.

9.1.2. **Table 9.1** summarises the inter-relationships that are considered of relevance to marine mammals and identifies where they have been considered within the ES. No inter-relationships have been identified where an accumulation of residual impacts on marine mammals and the relationship between those impacts gives rise to a need for additional mitigation

9.1.3. **Chapter 31 Inter-relationships** provides a holistic overview of all the inter-related impacts associated within the proposed development.

Table 9.1 Inter-relationships relevant to the assessment of marine mammals

Inter-relationship	Section where addressed	Linked chapter
Construction and decommissioning		
Changes to marine mammal prey resource	Section 6.5	**Chapter 11 Marine and Coastal Ornithology** and **Chapter 13 Fish and Shellfish Ecology**
Changes to the vessel activity in the area	Section 6.2, 6.3 and 6.4	**Chapter 16 Shipping and Navigation**
Operation		
Changes to the vessel activity in the area	Section 7.2, 7.3 and 7.4	**Chapter 16 Shipping and Navigation**

10. Cumulative Impact Assessment

10.1. CIA Strategy and screening

10.1.1. This section describes the Cumulative Impact Assessment (CIA) for marine mammals taking into consideration other plans, projects and activities. A summary of the CIA is presented in **Chapter 33**.

10.1.2. Forewind has developed a strategy (the 'CIA Strategy') for the assessment of cumulative impacts in consultation with statutory stakeholders including the MMO, the JNCC, Natural England and Cefas. Details of the approach to CIA adopted for this ES are provided in **Chapter 4**.

10.1.3. In its simplest form the strategy involves consideration of:

- Whether impacts on a receptor can occur on a cumulative basis between the wind farm project(s) subject to the application(s) and other wind farm projects, activities and plans in the Dogger Bank Offshore ZDE (either consented or forthcoming); and
- Whether impacts on a receptor can occur on a cumulative basis with other activities, projects and plans outwith the Dogger Bank Offshore ZDE (e.g. other offshore wind farm developments), for which sufficient information regarding location and scale exist.

10.1.4. The strategy recognises that data and information sufficient to undertake an assessment will not be available, and is not anticipated to be available by the time of the decision on the DCO application, for all potential projects, activities, plans and/or parameters, and seeks to establish the 'confidence' Forewind can have in the data and information available.

10.1.5. There are two key steps to the Forewind CIA strategy, which both involve 'screening' in order to arrive, ultimately, at an informed, defensible and reasonable list of other plans, projects and activities to take forward in the assessment.

10.1.6. The first step in the CIA for marine mammals involved an appraisal of the key potential impacts relevant to each of the receptors that have been identified, as assessed at a project level within this ES. For each impact, the potential for a cumulative effect has been identified, both within and beyond the Dogger Bank Offshore ZDE, and the confidence in the data and information available to inform the CIA has been appraised (following the methodology set out in **Chapter 4**). This also identifies where cumulative impacts are not anticipated, thereby screening them out from further assessment.

10.1.7. For all marine mammals, the potential for cumulative impacts both inside and outside the Dogger Bank Offshore ZDE exists in relation to noise (disturbance), collision risk and indirect impacts from changes in prey availability (**Table 10.1**). The data confidence associated with this initial screening step ranges from high to low (inside the Dogger Bank Offshore ZDE) and high to low (outside the Dogger Bank Offshore ZDE).

Table 10.1 Screening table for potential cumulative impacts (and phase of development)

Impact (phase)	Dogger Bank Offshore ZDE (within 1km)		Beyond 1km from the Dogger Bank Offshore ZDE		Rationale for where no cumulative impact is expected
	Potential for cumulative impact	Data confidence	Potential for cumulative impact	Data confidence	
Behavioural disturbance – Pile driving, vessel noise, turbine noise, cutting noise. (Construction, operation and decommissioning)	Yes	High	Yes	Medium	N/A
Collision risk with vessels – hull impacts and ducted propellers. (Construction, operation and decommissioning)	Yes	High	Yes	Medium / Low	N/A
Indirect impact via changes in prey availability. (Construction, operation and decommissioning)	Yes	Medium	Yes	Low	N/A
EMF (Operation)	No	High	No	High	No cumulative impact is anticipated due to the scale and nature of the impacts assessed for Dogger Bank Teesside A & B in its own right (all impacts are assessed as negligible). Data confidence for these impacts is high.
Physical barrier (Operation)	No	High	No	High	

10.1.8. Where the first step has indicated the potential for cumulative impacts, the second step in the CIA for marine mammals has involved the screening in and out of the actual individual plans, projects and activities that may result in any of the impacts identified in **Table 10.1** on marine mammals, for inclusion in a detailed assessment.

10.1.9. In order to inform this, Forewind has produced an exhaustive list of plans, projects and activities occurring within a very large study area encompassing the greater North Sea and beyond (referred to as the 'CIA Project List', see

Chapter 4). The list has been appraised, based on the confidence Forewind has in being able to undertake an assessment from the information and data available, enabling individual plans, projects and activities to be screened in or out. **Table 10.2** provides details of projects screened in to the assessment.

10.1.10. It should be noted that:

- Due to the highly mobile nature of marine mammals (and especially cetaceans) and the extent of the reference populations considered in the impact assessment, there is the potential for cumulative impacts to arise over a relatively large area;
- Nature Conservation 'projects' were screened out, as they were considered not likely to contribute to any of the impacts identified in **Table 10.1**;
- The second level of screening removed projects with low confidence in the project details or project data. Therefore, only projects defined as having high or medium confidence in the project details and project data have been included in the cumulative assessment for marine mammals. This means that a large number of non-UK offshore wind projects have been excluded from the detailed assessment, due to a lack of available information at this time. This information is not anticipated to be available by the time of the decision on the DCO application. As stated above, the plans, projects and activities presented in **Table 10.2** and **Figure 10.1** are the results of the screening exercise which identified whether there is sufficient data and project confidence to take these forward in a detailed cumulative assessment. Where Forewind is aware that a plan, project or activity could take place in the future, but has no information on how the plan, project or activity will be executed, it is screened out of the assessment;
- Existing activities that also have the potential to affect marine mammals, in particular commercial fishing activity, are judged to form part of the existing baseline environment. In the case of marine mammals for example, levels of by-catch that currently exist within the Dogger Bank Offshore ZDE and wider North Sea region are already influenced by these existing activities, and populations of marine mammals are already exposed to the impacts. Information collated for the baseline on population status reflects such current pressures. Therefore, these types of existing activities are not assessed as part of the CIA. In the case of marine mammals this also includes projects where the phase of likely cumulative impact has been completed prior to the cessation of baseline data used in the assessment (July 2012);
- Within the Dogger Bank Offshore ZDE (the first part of the assessment, see Section 10.2 below), the CIA considers cumulative impacts with Dogger Bank Teesside C & D as well as Dogger Bank Creyke Beck. Dogger Bank Teesside A & B represent the second phase of development across the zone. While it is acknowledged that there will be other offshore wind farm projects developed across the Zone in later phases, there is some uncertainty in the project details (such as project boundaries and design parameters), resulting in medium confidence in the data;

- The second part of the assessment (Section 10.3) considers other plans or projects within the Dogger Bank Offshore ZDE where project and data details are medium or high; and
- The third part of the assessment (Section 10.4) considers plans and projects outwith the Dogger Bank Offshore ZDE, again where project or data details are medium or high.

Table 10.2 Projects within and outwith the Dogger Bank Zone that are taken forward in the marine mammal CIA following screening

Type of project	Project title	Project status	Predicted construction/ development period	Confidence in project details	Confidence in project data	Potential cumulative impact
Aggregate application area	Area 466/1	Application	Uncertain	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Aggregate application area	Area 448 (now Area 514/1)	Application	Uncertain	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Aggregate application area	Area 449 (now Area 514/3)	Application	Uncertain	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Aggregate application area	Area 485/1	Application	Uncertain	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Aggregate application area	Area 485/2	Application	Uncertain	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Aggregate application area	Area 483	Application	Uncertain	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Aggregate application area	Area 484	Application	Uncertain	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Aggregate application area	Area 506	Application	Uncertain	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Aggregate application area	Area 400	Application	Uncertain	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Aggregate application area	Area 439	Application	Uncertain	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Aggregate application	Area 492	Application	Uncertain	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey

Type of project	Project title	Project status	Predicted construction/ development period	Confidence in project details	Confidence in project data	Potential cumulative impact
area						
Aggregate application area	Area 493	Application	Uncertain	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Aggregate application area	Area 454 (now Area 512)	Application	Uncertain	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Aggregate application area	Area 495/1	Application	Uncertain	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Aggregate application area	Area 495/2	Application	Uncertain	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Aggregate application area	Area 494	Application	Uncertain	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Cables and pipelines	Breagh Pipeline	Under construction	2012-	High	High	Underwater noise - disturbance, and collision risk.
Cables and pipelines	Dudgeon R2	Consented	as offshore wind farm	N/A[9]	N/A	Underwater noise - disturbance, and collision risk.
Cables and pipelines	Galloper	Consented	as offshore wind farm	N/A	N/A	Underwater noise - disturbance, and collision risk.
Cables and pipelines	Greater Gabbard	Construction	as offshore wind farm	N/A	N/A	Underwater noise - disturbance, and collision risk.
Cables and pipelines	Humber Gateway	Consented	as offshore wind farm	N/A	N/A	Underwater noise - disturbance, and collision risk.
Cables and pipelines	Kentish Flats Extension	Consented	as offshore wind farm	N/A	N/A	Underwater noise - disturbance, and collision risk.
Cables and pipelines	Lincs	Construction	as offshore wind farm	N/A	N/A	Underwater noise - disturbance, and collision risk.

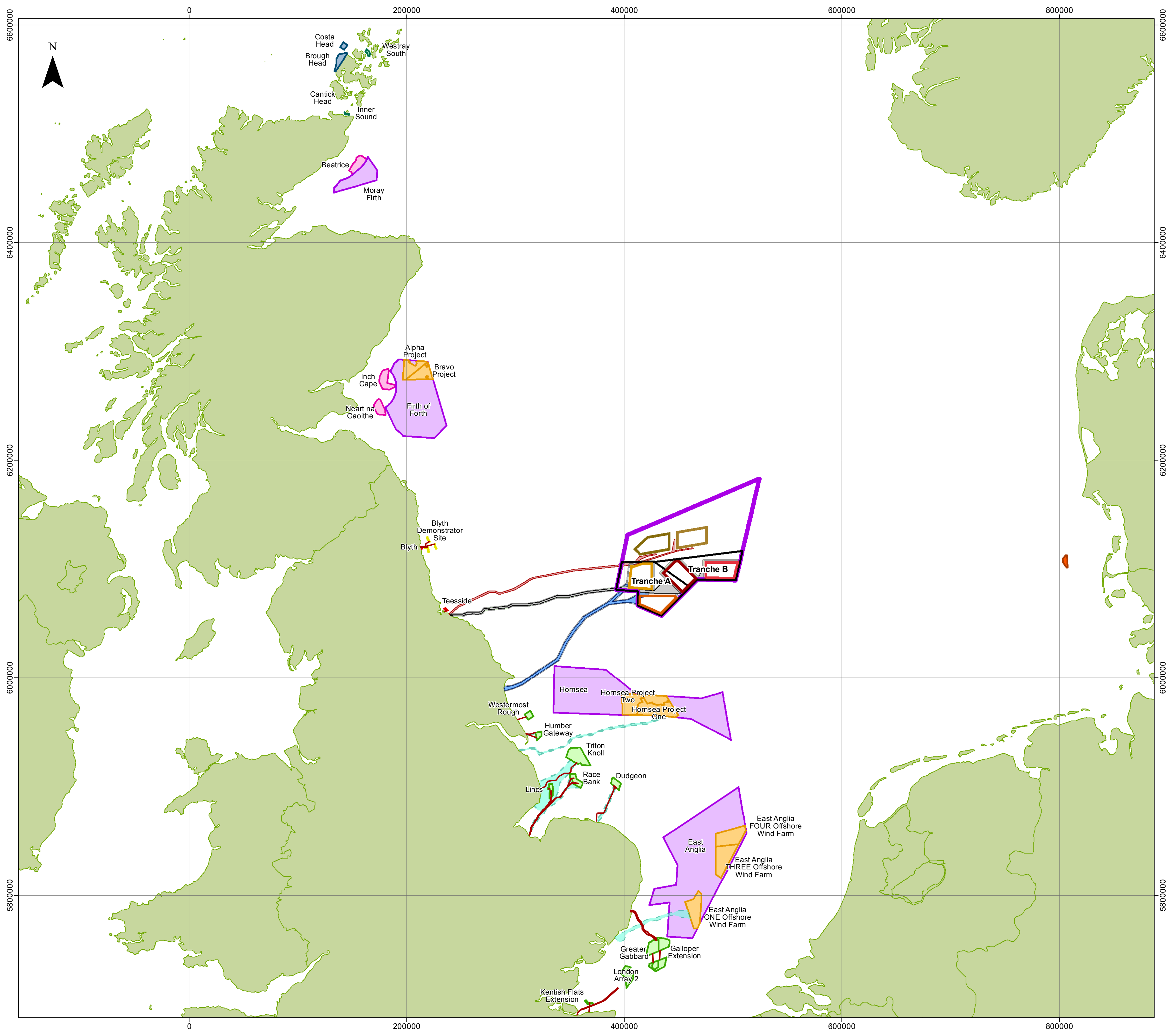
[9] Project and data confidence for cables relating to other offshore wind farms is not assessed as they are included in the subsequent offshore wind farm confidence assessments.

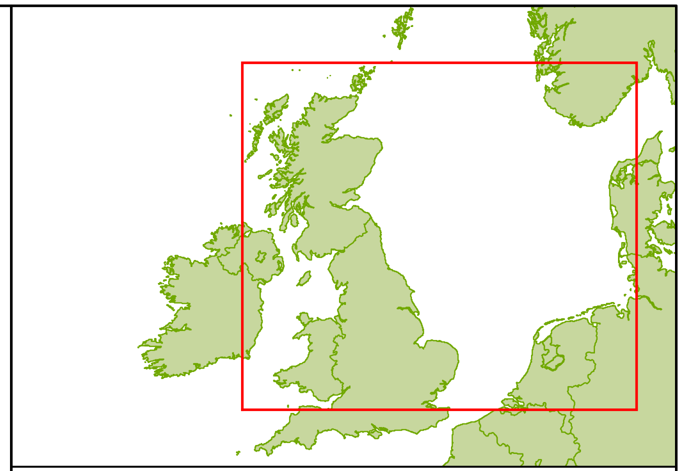
Type of project	Project title	Project status	Predicted construction/ development period	Confidence in project details	Confidence in project data	Potential cumulative impact
Cables and pipelines	London Array II	Consented (subject to a Grampian condition)	as offshore wind farm	N/A	High	Underwater noise - disturbance, and collision risk.
Cables and pipelines	R3 Wind farm projects (East coast, Phase 1)	Pre-consent	as offshore wind farm	N/A	N/A	Underwater noise - disturbance, and collision risk.
Cables and pipelines	Race Bank	Consented	as offshore wind farm	N/A	N/A	Underwater noise - disturbance, and collision risk.
Cables and pipelines	Scottish Territorial waters sites (east coast)	Pre-consent	as offshore wind farm	N/A	N/A	Underwater noise - disturbance, and collision risk.
Cables and pipelines	Teesside	Operational	as offshore wind farm	N/A	N/A	Underwater noise - disturbance, and collision risk.
Cables and pipelines	Triton Knoll	Pre-consent	as offshore wind farm	N/A	N/A	Underwater noise - disturbance, and collision risk.
Cables and pipelines	Westermost Rough	Consented	as offshore wind farm	N/A	N/A	Underwater noise - disturbance, and collision risk.
Offshore wind farm	Beatrice	Pre-consent	2014-2017	Medium	Medium	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Offshore wind farm	Blyth Demonstration Site (NaREC)	Pre-consent	2014-2016	Medium	Medium	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Offshore wind farm	Dogger Bank – Creyke Beck A & B	Pre-consent	Post 2016	High	High	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Offshore wind farm	Dogger Bank – Teesside C & D	Pre-consent	Post 2017	High	Medium	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Offshore wind farm	Dudgeon	Consented	2016	High	High	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Offshore wind farm	Firth of Forth – Project Alpha and Project Bravo	Pre-consent	Post 2015	Medium	Medium	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey

Type of project	Project title	Project status	Predicted construction/ development period	Confidence in project details	Confidence in project data	Potential cumulative impact
Offshore wind farm	Galloper	Consented	2014-2016	Medium	Medium	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Offshore wind farm	Hornsea Zone – Project One	Pre-consent	Post 2015	High	Medium	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Offshore wind farm	Hornsea Zone – Project Two	Pre-consent	Post 2015	Medium	Medium	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Offshore wind farm	Humber Gateway	Consented	2013-2014	High	High	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Offshore wind farm	Inch Cape	Pre-consent	2015-2019	Medium	Medium	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Offshore wind farm	Kentish Flats Extension	Consented	2015	Medium	Medium	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Offshore wind farm	Lincs	Operational	2011-2013	High	High	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Offshore wind farm	London Array II	Consented (subject to a Grampian condition)	2014-2015	High	High	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Offshore wind farm	Moray Firth – Telford, Stevenson and MacColl	Pre-consent	2015-2019	Medium	Medium	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Offshore wind farm	Neart na Gaoithe	Pre-consent	2014-2017	Medium	Medium	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Offshore wind farm	East Anglia – Project One	Pre-consent	Post 2015	High	Medium	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey

Type of project	Project title	Project status	Predicted construction/ development period	Confidence in project details	Confidence in project data	Potential cumulative impact
Offshore wind farm	East Anglia Three	Pre-consent	Post 2016	Medium	Medium	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Offshore wind farm,	East Anglia Four	Pre-consent	Post 2016	Medium	Medium	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Offshore wind farm	Offshore- Bürger-windpark Butendiek (Germany)	Consented	Post 2012	High	High	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Offshore wind farm	Race Bank	Consented	2017	Medium	Medium	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Offshore wind farm	Teesside	Operational	2012-2013	High	High	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Offshore wind farm	Triton Knoll	Consented	2017-2021	High	Medium	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Offshore wind farm	Westermost Rough	Consented	2014=2015	High	High	Underwater noise - disturbance and auditory injury, collision risk and indirect impacts on prey
Oil and Gas	Cygnus Alpha	In development	Post 2012	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Oil and Gas	Cygnus Bravo	In development	Post 2012	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Oil/Gas Field	Ensign	In development	2012-	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Oil/Gas Field	Rochelle	In development	2012-	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Tidal	Cantick Head	Pre-consent	Post 2013	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Tidal	Westray South	Pre-consent	Post 2013	Medium	Medium	Underwater noise - disturbance and collision risk

Type of project	Project title	Project status	Predicted construction/ development period	Confidence in project details	Confidence in project data	Potential cumulative impact
Wave Energy	Brough Head (Aquamarine Power)	Pre-consent	Post 2013	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Wave Energy	Costa Head	Pre-consent	Post 2013	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey
Wave Energy	Inner Sound	Pre-consent	Post 2013	Medium	Medium	Underwater noise - disturbance, collision risk and indirect impacts on prey





LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Creyke Beck A
- Dogger Bank Creyke Beck B
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside C
- Dogger Bank Teesside D
- Dogger Bank Teesside A & B Export Cable Corridor
- Dogger Bank Teesside A & B temporary works area
- Dogger Bank Creyke Beck Export Cable Corridor
- Dogger Bank Creyke Beck temporary works area
- Dogger Bank Teesside C & D Export Cable Corridor
- Tidal energy project
- Wave energy project

Wind energy project

- Round 1
- Round 2
- Round 3
- Round 3 zone
- Demonstration
- Scottish territorial waters site
- German offshore wind farm
- North Sea wind farm cable corridor
- Wind farm export cable route

Data Source:
Energy Projects © The Crown Estate, 2013,
Round 3 offshore wind farm boundary © Crown Copyright, 2013
Ordnance Survey data © Crown copyright and database right, 2013

0 25 50 100
Kilometres

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

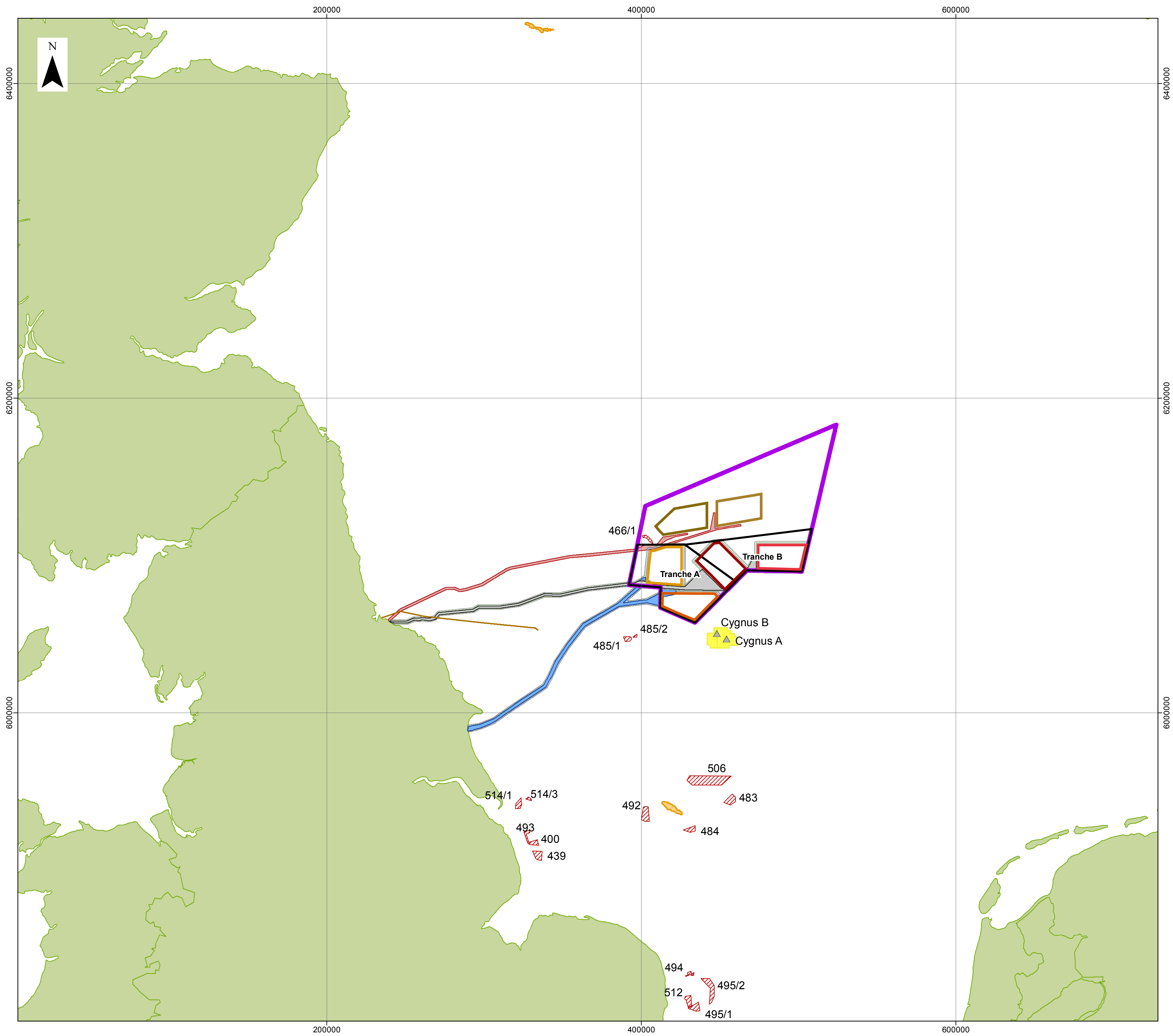
Figure 10.1a Location of offshore renewable projects (wind, wave and tidal and associated cables) within and outwith the Dogger Bank Zone taken forward in the marine mammal CIA following screening

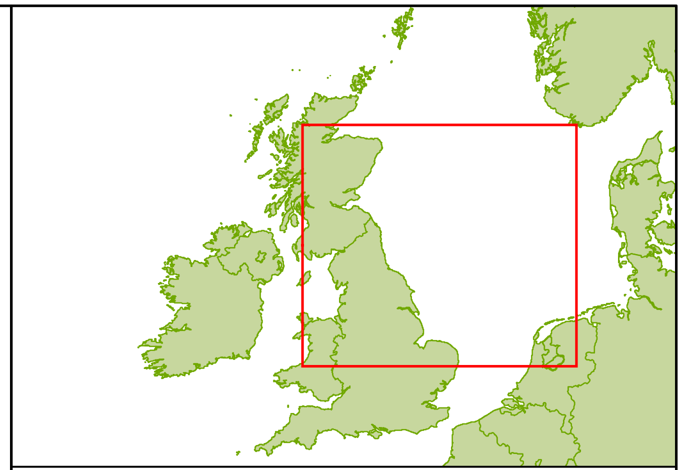
VER	DATE	REMARKS	Drawn	Checked
1	27/08/2013	Draft	LW	GK
2	03/10/2013	PEI3	JE	GK
3	11/02/2014	DCO Submission	JE	GK

DRAWING NUMBER: **F-OFL-MA-227**

SCALE	PLOT SIZE	DATUM	PROJECTION
1:3,600,000	A3	WGS84	UTM31N

FOREWIND





LEGEND

- Dogger Bank Zone
- Tranche boundary
- Dogger Bank Creyke Beck A
- Dogger Bank Creyke Beck B
- Dogger Bank Teesside A
- Dogger Bank Teesside B
- Dogger Bank Teesside C
- Dogger Bank Teesside D
- Dogger Bank Teesside A & B Export Cable Corridor
- Dogger Bank Teesside A & B temporary works area
- Dogger Bank Creyke Beck Export Cable Corridor
- Dogger Bank Creyke Beck temporary works area
- Dogger Bank Teesside C & D Export Cable Corridor
- Aggregate application area
- Aggregate option area
- Cygnus proposed subsurface infrastructure
- Cygnus gas field development
- Oil and gas field
- Breagh pipeline

Data Source:
Aggreate Areas © The Crown Estate, 2013.
Oil & Gas © DECC, 2013.
Round 3 offshore wind farm boundary © Crown Copyright, 2013
Ordnance Survey data © Crown copyright and database right, 2013

0 10 20 40
Kilometres

PROJECT TITLE

DOGGER BANK TEESSIDE A & B

DRAWING TITLE

Figure 10.1b Location of non-renewables projects within and outwith the Dogger Bank Zone taken forward in the marine mammal CIA following screening

VER	DATE	REMARKS	Drawn	Checked
1	27/08/2013	Draft	LW	GK
2	03/10/2013	PEI3	JE	GK
3	11/02/2014	DCO Submission	JE	GK

DRAWING NUMBER:

F-OFL-MA-228

SCALE	PLOT SIZE	DATUM	PROJECTION
1:2,500,000	A3	WGS84	UTM31N

FOREWIND

10.2. Cumulative impacts from projects within the Dogger Bank Zone – Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck

Construction

Underwater noise – pile driving

10.2.1. In order to assess the impacts from pile driving between multiple vessels across the six projects in the Dogger Bank Zone, noise propagation modelling has been carried out using 12 piling vessels across six projects to illustrate the noise footprint associated with the widest separation distances (**Appendix 5A**, Section 4).

10.2.2. Two construction scenarios were modelled:

- A 1,500m separation between the two vessels in each project; and
- A large separation between the two vessels in each project (tens of km).

10.2.3. A vessel separation distance of 1,500m was chosen, as this was considered the likely closest possible distance between piling vessels, i.e. limited by the planned minimum turbine spacing of 750m and a 500m safety zone around each piling vessel.

10.2.4. For the large separation between piling vessels, the locations of the 12 vessels were selected on a criteria designed to maximise the area affected by the construction noise by considering:

- The geometric spread of the vessels across the six projects, such that there was minimal overlap of sound between vessels; and
- The locations likely to result in the greatest propagation ranges

10.2.5. The results of the modelling for harbour porpoise are shown in **Figure 10.2** and **Figure 10.3**. The figures show that the smallest area (km^2) of sea is impacted at any one time if the vessels are as close together as possible, thus forming one, slightly larger impact zone than a single vessel. When the vessels are far enough away such that the impact zones do not overlap then the impacted area is at its maximum.

10.2.6. Although the use of multiple piling vessels may increase the impacted area at one point in time, it also reduces the overall construction time. In addition, the total impacted footprint during the construction period of the wind farms will also not be increased, as this is bound by the extent of the site. When considering the complete construction period of the wind farm, the reduction in construction time resulting from the use of multiple piling vessels may result in a reduced impact, particularly if the vessels are close together. This will depend on the impact type and the species being impacted.

10.2.7. There is a large amount of uncertainty to consider in the assessment of impacts across the six projects, as it is not possible to quantify at this stage the degree of likely temporal overlap in pile driving during construction. Should concurrent pile driving occur, the overall duration of the noise impact could be reduced, as the construction period would be shorter than if sequential piling was undertaken. However, there are no empirical data to show how the individual and, therefore, population level consequences, of these alternate construction scenarios may differ. Based on current knowledge, it is not possible to discern which scenario would have the lowest potential impact.

10.2.8. The area of the noise footprint (**Figure 10.2** and **Figure 10.3**) could approximate the area of behavioural exclusion, but quantification of the number of individuals of each species that are likely to be displaced during development of these areas should be done with caution. There is likely to be displacement of individuals during pile driving, which will alter the underlying densities. The potential for exposing individuals to auditory injury will also be affected by the spatial separation between pile driving events. It is possible that pile driving at one location could itself act as mitigation to prevent exposure to higher noise thresholds at other locations.

10.2.9. Given the uncertainty around the extent of potential impact areas and the number of individuals that could be exposed to noise thresholds that can cause TTS and behavioural disturbance, the conclusions of the quantitative assessment of the potential magnitude of effect should be interpreted with caution. Cumulative effects have been informed by the range and magnitude of effects from construction at Dogger Bank Teesside A and Dogger Bank Teesside B in Section 6 of this chapter, the areas within the behavioural disturbance contours (shown in **Figure 10.2** and **Figure 10.3** for harbour porpoise, as an example) for all species of cetacean. The underlying estimates of absolute abundance and density across the zone, presented in Section 4 of this chapter, are also used in the assessment.

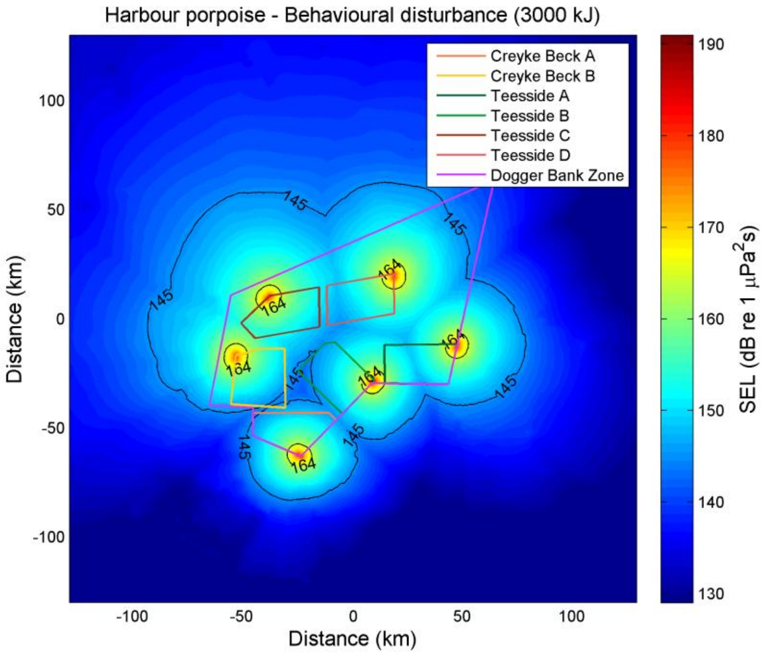


Figure 10.2 Propagation modelling for 12 piling vessels, each operating with 3,000kJ hammer blow energy, with two vessels per project. Piling vessels within the same project are approximately 1,500m apart. Contour lines indicate behavioural disturbance criteria for harbour porpoise.

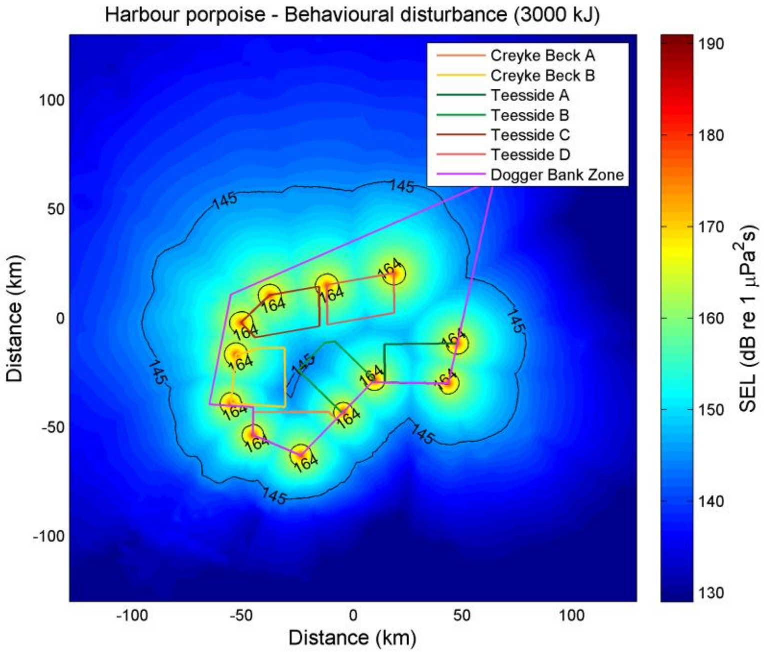


Figure 10.3 Propagation modelling for 12 piling vessels, each operating with 3,000kJ hammer blow energy, with two vessels per project. Piling vessels spread to approximate the maximum possible area affected. Contour lines indicate behavioural disturbance criteria for harbour porpoise.

Lethal and physical injury

10.2.10. As stated for the construction of Dogger Bank Teesside A or Dogger Bank Teesside B in isolation, the ranges of potential, physical and non-auditory injury are expected to be within a few metres of the pile. Therefore, there is no scope for any cumulative impact to arise via lethal and physical injury from multiple piling events cumulatively with Dogger Bank Teesside C & D or Dogger Bank Creyke Beck. As such, potential impacts are considered to be fully mitigated by the use of soft-start procedures and exclusion zones around the noise source. There would be **no residual impact** for any species.

Auditory injury

10.2.11. As stated during the assessment of Dogger Bank Teesside A and Dogger Bank Teesside B impacts of PTS will be mitigated for all species of cetacean. There is no reason to assume that during the development of Dogger Bank Teesside C and Dogger Bank Teesside D and Dogger Bank Creyke Beck (Forewind 2013) such effects would not also be mitigated. Therefore, there is predicted to be **no residual impact**.

10.2.12. In the case of grey seal the potential for PTS from a cumulative SEL dose does exist, although the impact is not considered to be significant. The exact number of grey seal that could develop PTS is hard to quantify, based on a limited understanding of how grey seal will respond to pile driving noise. Furthermore the biological consequences of PTS in grey seal are not well understood.

10.2.13. As such the potential for PTS during construction across the six projects is unlikely to be much greater than for Dogger Bank Teesside A and Dogger Bank Teesside B in combination. The magnitude of effect is assessed as low, and in combination with medium sensitivity to PTS in this species, the overall impact is assessed as **minor adverse**.

Behaviour

10.2.14. The overall residual impact of behavioural responses to pile driving noise from the assessment of the impact of the sequential build of Dogger Bank Teesside A and Dogger Bank Teesside B are predicted to be minor adverse for all species.

10.2.15. Noise propagation modelling of concurrent pile driving across the six projects, as shown in the harbour porpoise example in **Figure 10.2** and **10.3**, considers areas of impact footprint based on up to two vessels piling concurrently within any one project, with a maximum of 12 vessels across the six projects. Areas of impact are summarised in **Table 10.3**, for the scenario considering the largest separation between vessels (i.e. **Figure 10.3**). Quantification of the magnitude of effect is also provided.

10.2.16. As a worst case during construction at Dogger Bank Teesside A , Dogger Bank Teesside B, Dogger Bank Teesside C, Dogger Bank Teesside D, Dogger Bank Creyke Beck A and Dogger Bank Creyke Beck B, these footprints provide an approximation of the area over which disturbance could occur in each species during concurrent pile driving. However, as previously stated concurrent pile driving would reduce the overall temporal footprint of construction.

10.2.17. During sequential construction the areas of impact (and therefore the number of individuals displaced) could equate to approximately the same area as either Dogger Bank Teesside A or Dogger Bank Teesside B in isolation (see **Table 6.9** and **Table 6.18**) being repeatedly or continuously disturbed for each of the six projects. This is based on the assumption that impacts will be broadly comparable between Dogger Bank Teesside A or Dogger Bank Teesside B and Dogger Bank Teesside C, Dogger Bank Teesside D, Dogger Bank Creyke Beck A and Dogger Bank Creyke Beck B. The maximum total construction period for the Dogger Bank Zone is 13 years and six months

10.2.18. Numbers of individuals displaced (possible avoidance) from pile driving at Dogger Bank Creyke Beck A and Creyke Beck B in isolation are approximately 3,119 and 4,394 respectively (based on the harbour porpoise and potential harbour porpoise densities combined, Forewind 2013). The number displaced (possible avoidance) from pile driving at Dogger Bank Teesside A and Dogger Bank Teesside B in isolation are approximately 4,302 and 3,931 respectively (based on the harbour porpoise and potential harbour porpoise densities combined) and are therefore broadly comparable to Dogger Bank Creyke Beck.

10.2.19. These numbers are based on the footprint approach. Areas of possible avoidance based on consideration of the noise footprints shown in **Figure 10.3** for harbour porpoise have the potential to lead to possible avoidance of the area for more than 5% of the reference population considering harbour porpoise densities, and when considering potential harbour porpoise and harbour porpoise combined densities (Table 10.3). As previously stated, there is a large amount of uncertainty as to the duration of any disturbance, but the total area of the footprint is unlikely to be disturbed for the duration of construction. Disturbance of this magnitude is considered to be medium, but given the potential for this disturbance to be perpetuated over a long time period, the magnitude of effect is revised up one level to high.

10.2.20. The overlapping noise footprints from concurrent pile driving across the projects means that the cumulative footprint will not double the footprint of each project being constructed in isolation. Should construction of all projects not occur concurrently, the impact footprint would be smaller, however, the temporal duration of the impact would increase.

10.2.21. Despite a medium sensitivity to likely avoidance, the magnitude of that effect remains low. However, harbour porpoise have low sensitivity to possible avoidance; therefore the overall impact is considered **moderate adverse** in this species.

10.2.22. However, it should be noted that due to the large vessel spacing between the pile driving locations, it has not been assumed that all individuals within the outer boundaries of the projects that are 'likely to avoid' the noise are excluded from the area (which is the case in the footprint approach to assessing impacts at a Project level). This is due to the fact that these contours are unlikely to overlap. This means that the increase in the number of animals that are likely to avoid the noise source between the single project 'footprint' approach and the 12 vessel may appear disproportionately small. The contours for possible avoidance do overlap, and thus individuals could be excluded over these larger areas. In other species of cetacean, due to the lower underlying densities, the magnitude of effect for all species for possible and likely avoidance are low. Medium sensitivity of all cetaceans to likely avoidance means that residual impacts are assessed as **minor adverse**.

10.2.23. In grey seal, due to the smaller ranges of likely avoidance in this species, the impact is considered to be the worst case of the sum of up to twelve pile driving vessels in isolation. The densities of grey seal do vary across the Dogger Bank Zone, with higher densities in the Dogger Bank Creyke Beck project areas. Therefore, the impact is considered to be based on the two pile driving events at Dogger Bank Creyke Beck B, two at Dogger Bank Creyke Beck A and the remaining impacts equate to double the impacts of Dogger Bank Teesside A and Dogger Bank Teesside B in combination (Dogger Bank Teesside A and Dogger Bank Teesside B in combination being used as a proxy for Dogger Bank Teesside C and Dogger Bank Teesside D). The highest mean density based on Jones *et al.* (2013) data in the Dogger Bank Creyke Beck A area is 0.84 per km^2, and in the Dogger Bank Creyke Beck B area it is 0.93 per km^2. Based on the area of potential impact presented in the Dogger Bank Creyke Beck draft ES (Forewind 2013) for two piling events in Dogger Bank Creyke Beck A the impact would be 54 seals (single impact area of 31.97km^2 multiplied by two), and for Dogger Bank Creyke Beck B it would be 66 seals (single impact area of 35.63 km^2 multiplied by two). The worst case impacts for Dogger Bank Teesside A and Dogger Bank Teesside B would be 13 seals at Dogger Bank Teesside B and 4.3 seals at Dogger Bank Teesside A, based on two pile driving events at each project. The total number of seals likely to avoid the area could be 155 individuals, which equates to approximately 0.7% of the reference population, or a negligible magnitude of effect. Given the fact this impact could persist over a long period of time, the magnitude has been revised up to low, and when combined with low sensitivity to this impact, as **minor adverse** impact is concluded.

10.2.24. Overall, the impact of behavioural disturbance is considered to be **minor adverse** in all species except harbour porpoise, where it is assessed as **moderate adverse**.

10.2.25. Currently, there is no robust approach available to assess the potential impact of disturbance from pile driving noise on the future growth of the harbour porpoise population in the North Sea. The interim PCoD model is being developed to provide methods to assess such impacts. However, this is not yet available to regulators or developers. Therefore, based on the conclusions of the assessment of projects within the Dogger Bank Zone, further investigations of the potential population consequences of moderate adverse disturbance have been made using population viability analysis (PVA) in **Appendix 14D**. This approach has been agreed in consultation with JNCC and Natural England (**Table 2.4**).

10.2.26. The modelling exercise is presented to allow further consideration and discussion of whether effects of the magnitude presented here have the potential to be significant at the population level.

10.2.27. The PVA uses information on the magnitude of the disturbance effects presented in this ES Chapter and in Forewind (2013). A small number of construction scenarios are presented which consider the potential impacts of reduced fecundity and survival on harbour porpoise as a result of disturbance. The results of the modelling need to be considered in the context of a number of precautionary assumptions, which have the potential to overestimate the consequences of disturbance (as detailed in Table 2 in **Appendix 14D**). However, in an attempt to bring more realism into the assessment at a population level, displacement is assessed which reflects the fact that pile driving cannot occur across the whole project area at one time, and that there will be a limit of two vessels pile driving within each project at any one time. Other refinements to the assessment have also been made (such as the assumption that only 75% of the harbour seal respond at the possible avoidance range).

10.2.28. The number of individual harbour porpoise that may be displaced at any one time has been re-calculated for a number of combinations of projects pile driving within three different construction scenarios; a sequential build, a concurrent scenario both with construction at each project lasting the maximum of six years, and a more realistic scenario where pile driving within the construction phase at each project is limited to two years.

10.2.29. The results indicate that, after accounting for by-catch within the North Sea MU, any accounting for the impact of disturbance from pile driving the population is projected to continue to increase. The lowest growth rates were observed in the period of concurrent pile driving across all projects (within the concurrent and realistic scenarios). However, population recovery to the by-catch only growth rates will be quicker when pile driving is condensed over the shortest time as a result of concurrent pile driving across projects. As such, in the longer-term the deviation between the by-catch only population size and the impacted scenarios is greater for the sequential scenario. In that scenario the predicted population size post impact remains approximately 3.8% lower than it would be with no pile driving, in Scenario 2 the population size remains approximately 2.6% lower than it would be with no pile driving, and in the more realistic Scenario 3, the population size is approximately 0.9% lower than it is predicted to be with no pile driving.

10.2.30. The large number of precautionary assumptions and the uncertainty in the underlying population growth rates (including by-catch levels) means that the modelling scenarios are only an exploration of the possible population trajectories, and it is very likely that the potential population level effects have been over-estimated.

10.2.31. Disturbance to more than 5% of the reference population within a year within this ES chapter highlights the potential for a significant impact in EIA terms. However, the PVA suggests that, following consideration of the individual fitness consequences of disturbance, it is unlikely that the impact from pile driving across the Dogger Bank Zone would lead to an impact which would be detectable in the long-term, and the population will continue to increase during the construction period. As such, the impact of disturbance on harbour porpoise is considered **minor adverse**, and not significant in EIA terms.

Table 10.3 Areas (km^2) of behavioural impact (based on two pile driving events at each project with maximum distances between vessels, with 3,000kJ maximum hammer energy), number of individuals impacted (and uncertainty based on 95% CI around density estimates), percentage of reference population impacted and magnitude of effect from concurrent pile driving across Dogger Bank Teesside A & B, Dogger Bank Teesside C & D, Dogger Bank Creyke Beck A and Dogger Bank Creyke Beck B (six projects).

Species (Reference population)	**Likely avoidance**				**Possible avoidance**			
	Impact area	**Impacted number (revised)**	**Percentage of reference population**	**Revised magnitude of effect (original)**	**Impact area**	**Impacted number**	**Percentage of reference population**	**Revised magnitude of effect (original)**
Harbour porpoise (227,298)	940km^2	602(543-671)	0.26%	Low (Negligible)	18,780km^2	12,030 (10,847-13,400)	5.29%	High (Medium)
Harbour porpoise and potential harbour porpoise combined (227,298)		673 (491-915)	0. 3%	Low (Negligible)		13,449 (9,819-18,279)	5.92%	High (Medium)
Minke whale (23,168)	8,764km^2	76 (0-210)	0.33%	Low (Negligible)	24,353km^2	211 (0-582)	0.9%	Low (Negligible)
Minke whale (174,000)			0.04%	Low (Negligible)			0.1%	Low (Negligible)
White-beaked dolphin (15,185)	198km^2	2.9 (2-5.6)	0.02%	Low (Negligible)	2,301km^2	34 (23-65)	0.23%	Low (Negligible)

Mitigation and residual impacts

10.2.32. No further mitigation is considered in addition to that outlined previously for the assessment of Dogger Bank Teesside A and Dogger Bank Teesside B in isolation. Overall, the impact of behavioural disturbance is considered to be **minor adverse** in all species.

Underwater noise – vessel noise

10.2.33. During the construction phase of the development across the six projects, vessel noise from Dogger Bank Teesside C & D is likely to be comparable to the levels for Dogger Bank Teesside A or Dogger Bank Teesside B in isolation. The assessment of vessel noise during construction at Dogger Bank Creyke Beck A and Dogger Bank Creyke Beck B in combination concludes a **minor adverse** impact (Forewind 2013).

10.2.34. There is a large amount of uncertainty as to the level of reduction there could be in vessel activity and therefore vessel noise during concurrent development. Therefore, the worst case assumes the total impact is the sum of the impacts from each project in isolation.

10.2.35. Considering Dogger Bank Teesside A & B, Dogger Bank Teesside C & D and Dogger Bank Creyke Beck, this would equate to a maximum of 66 vessels per Dogger Bank Teesside project and 68 for each Dogger Bank Creyke Beck project if built sequentially, or 400 vessels during concurrent construction. However, it is likely that some vessels would service more than one project. The total number of vessels is, therefore, difficult to quantify.

10.2.36. There is likely to be local disturbance around vessels associated with each project. Cetaceans and seals are considered to have low sensitivity to this effect. It is likely that the magnitude of the effect across the six projects will be low, even in the case of harbour porpoise, the species where absolute abundance across the whole Dogger Bank is highest. The estimated absolute abundance across the zone for harbour porpoise represents less than 5% of the reference population, so a smaller proportion than this would be exposed to vessel noise. Therefore, the overall impact is assessed as **minor adverse** in all species.

Mitigation and residual impact

10.2.37. No further mitigation is suggested for this impact. Therefore, the predicted residual impact is **minor adverse** for all species.

Collision risk – hull impacts

10.2.38. As discussed for vessel noise, the worst case for collision risk for hull impacts is based on impacts equivalent to the sum of impacts from all six projects. All cetacean species are predicted to have low sensitivity to this impact, and seals negligible sensitivity. The magnitude of effect across the six projects is considered to be low; which gives an overall impact of **minor adverse** in cetaceans and **negligible** in seals.

Mitigation and residual impact

10.2.39. No further mitigation is suggested for this impact. Therefore, the predicted residual impact for cetaceans is **minor adverse** and for seals it is **negligible**.

Collision risk – ducted propellers

10.2.40. Harbour seal has a high sensitivity to this impact and grey seal medium. During construction across the six projects, the potential increase in magnitude for this effect beyond that presented for Dogger Bank Teesside A and Dogger Bank Teesside B in combination will primarily depend on the amount of vessel activity using ducted propellers in close proximity to seal SACs. This will be influenced by the export cable routing, and the location of the port(s) used for materials and personnel transport.

10.2.41. As previously stated, there is a low level occurrence of both species in the offshore areas, where the majority of the vessel activity will occur but, during construction work associated with export cable corridors, there is the potential for a higher magnitude of effect.

10.2.42. The magnitude of effect is considered negligible in grey seal and harbour seal, but may have the potential to increase or decrease as more understanding of this impact mechanism is gained. There is currently a large amount of uncertainty associated with this impact. The impact is considered as **minor adverse** for harbour seal and **negligible** for grey seal.

Mitigation and residual impact

10.2.43. No further mitigation is included in the assessment. However, best practice and industry guidelines are likely to be followed during construction to minimise the potential impact. The magnitude of effect is still considered negligible in both species. The residual impacts are, therefore, assessed as **minor adverse** for harbour seal, and **negligible** for grey seal.

Changes in prey resource

10.2.44. The overall magnitude of this effect is likely to increase with the addition of Dogger Bank Teesside C and Dogger Bank Teesside D, as well as Dogger Bank Creyke Beck A & B to the assessment. However, all species of marine mammal have a low sensitivity to local changes in prey abundance. **Chapter 13** assesses the cumulative impact as **minor adverse** for all species.

10.2.45. Across the area being developed during construction at the six projects, the magnitude of the effect on marine mammals is low, affecting, at worst, less than 5% of the reference population for each species of marine mammal which are estimated to be abundant across the Zone. The impact is therefore assessed as **minor adverse** in all species.

Mitigation and residual impact

10.2.46. No further mitigation is considered necessary, beyond that presented in **Chapter 13**. Therefore, the residual impacts are assessed as **minor adverse** for all species.

Operation

Underwater noise – wind turbines

10.2.47. Marine mammals are likely to have some tolerance to operational wind turbine noise and so have low sensitivity to this impact. The magnitude of noise generated by operational wind turbines across the six projects is predicted to be low. Therefore, the predicted impact is **minor adverse**.

Mitigation and residual impact

10.2.48. No further mitigation for wind turbine noise is considered. The residual impact remains **minor adverse**.

Underwater noise - vessels

10.2.49. There is the potential of increased vessel traffic associated with the operational phase of Dogger Bank Teesside A and Dogger Bank Teesside B as well as the other projects. There may also be displacement of existing traffic during the operational phase of the projects. The magnitude of the effect is assessed as low, although there is a large amount of uncertainty around this. Given the presence of marine mammals in areas currently experiencing vessel noise, their sensitivity is predicted to be low. The overall impact is, therefore, considered to be **minor adverse.**

Mitigation and residual impact

10.2.50. No further mitigation for vessel noise is considered. Therefore the residual impact will remain **minor adverse**.

Collision risk – hull impacts

10.2.51. The combined effect of all six projects would increase the level of potential impact. The effect on cetaceans is likely to be low magnitude and, therefore, result in a **minor adverse** impact. The magnitude of effect and overall impact for seals is **negligible**.

Mitigation and residual impact

10.2.52. No further mitigation is suggested for this impact. Therefore, the impact remains **minor adverse** for cetaceans and **negligible** for seals.

Collision risk – ducted propellers

10.2.53. As described in the assessment of this impact for Dogger Bank Teesside A, during construction there is a low likelihood of occurrence of harbour and grey seal in the offshore project area. The sensitivity of harbour and grey seal to this impact is high and medium respectively. The negligible magnitude for both species means that the impact is predicted to be **minor adverse** for harbour seal and **negligible** for grey seal.

Mitigation and residual impact

10.2.54. No further mitigation is considered necessary, due to the low risk to both species from this impact. Therefore, the residual impacts remain **minor adverse** for harbour seal and **negligible** for grey seal.

Changes in prey resource

10.2.55. As described in the assessment of Dogger Bank Teesside A and Dogger Bank Teesside B cetaceans and pinnipeds have low sensitivity to minor changes in prey abundance. The indirect impact of changes in prey resource during the operation of all six projects has the potential to be greater than the projects in isolation. Overall the magnitude of effect is likely to be minor, and the impact is assessed as **minor adverse**.

Mitigation and residual impact

10.2.56. No further mitigation is considered beyond that presented in **Chapter 13**. Therefore, the residual impacts remain **minor adverse** for all species.

Decommissioning

Underwater noise – cutting of foundations

10.2.57. There is a large amount of uncertainty as to the potential for noise impacts during decommissioning of the six projects. However, the effect footprints are likely to be of a low magnitude. All marine mammals are considered as having medium sensitivity to this type of effect. The overall impact is, therefore, predicted to be **minor adverse**.

Mitigation and residual impact

10.2.58. At this stage, no mitigation measures have been applied. The residual impact, therefore, remains **minor adverse**.

Underwater noise – vessels

10.2.59. The impact of vessel noise is likely to be similar to that experienced during construction phases for all developments. Cetaceans and seals are assessed as having low sensitivity to this impact. It is likely that the magnitude of the effect across the six projects will be low; therefore, the overall impact is assessed as **minor adverse** in all species.

Mitigation and residual impact

10.2.60. No further mitigation is suggested for this impact. Therefore, the predicted residual impact is **minor adverse** for all species.

Collision risks – hull impacts

10.2.61. As already stated, vessel activity is likely to be at levels similar to those experienced during construction. All cetacean species are predicted to have low sensitivity to this effect, and seals negligible sensitivity. The magnitude of effect across the six projects is considered to be low to medium; which gives an overall impact of **minor adverse** for cetaceans and **negligible** for seals.

Mitigation and residual impact

10.2.62. No further mitigation is suggested for this impact. Therefore, the predicted residual impact for cetaceans is **minor adverse** and for seals, is **negligible**.

Collision risks – ducted propellers

10.2.63. As previously stated, there is a low level occurrence of both species in the offshore areas where the majority of the vessel activity will occur during this phase of the development.

10.2.64. The magnitude of effect is considered negligible in both species. There is, however, a large amount of uncertainty associated with this impact. The impact is considered **minor adverse** in harbour seal and **negligible** in grey seal.

Mitigation and residual impact

10.2.65. No further mitigation is considered necessary, due to the low risk to each species from this impact. The residual impacts remain **minor adverse** in harbour seal and **negligible** in grey seal.

10.3. Cumulative impacts from other projects within the Dogger Bank Offshore ZDE

10.3.1. In addition to the cumulative impact from wind farm developments within the Dogger Bank Offshore ZDE, Aggregate Application Area 466/1 also lies within the zone and is therefore considered in the CIA. Impacts from aggregate extraction include underwater noise from vessels and extraction which could result in disturbance of marine mammals, as well as collision risk with vessels and indirect impacts on prey availability.

10.3.2. Application Area 466/1 (operator - CEMEX UK Marine Ltd) is approximately 3km to the north of Dogger Bank Teesside B (30.1km from the northern boundary of Dogger Bank Teesside A). A decision is expected soon on the application to extract up to three million tonnes of sand and gravel over an initial 15 year period, although this may be extended. CEMEX estimates that 200,000 tonnes/year will be extracted in the first five years, increasing to 600,000 thereafter.

10.3.3. CEMEX has indicated that, on average, one dredger is expected to visit each site each week, working on a six hour period to load 7,000 tonnes with one cargo movement every three days. Therefore, the occupancy of the site will be between 1 - 3% in any one year.

Underwater noise

10.3.4. The duration of aggregate extraction at Area 466/1, if licenced, is likely to overlap with periods of construction and operation at Dogger Bank Teesside A and Dogger Bank Teesside B. As only a single dredger is anticipated to visit the site each week, the increase in underwater noise from vessels or dredging activity is not considered likely to significantly increase the level of disturbance to marine mammals; Area 466/1 lies within the impacts footprints of disturbance from pile driving for cetacean species, and the additional disturbance to grey seal is considered negligible.

10.3.5. The overall impact of behavioural disturbance is assessed to be **minor adverse** in all species.

Mitigation and residual impacts

10.3.6. No further mitigation is considered in addition to that outlined previously for the assessment of Dogger Bank Teesside A and Dogger Bank Teesside B in isolation. Overall, the impact of behavioural disturbance is assessed to be **minor adverse** in all species.

Collision risk

10.3.7. The magnitude of effect of collision risk with vessel hulls across the six wind farm projects within the Dogger Bank Offshore ZDE is considered to be low; which gives an overall impact of minor adverse in cetaceans and negligible in seals. The addition of the vessel used for aggregate extraction is not anticipated to increase the effect magnitude above low.

10.3.8. There is a low occurrence of both harbour and grey seal in the offshore area, and therefore the magnitude of effect of collision with ducted propellers is negligible, and is considered to remain negligible with the addition of aggregate extraction at Area 466/1.

10.3.9. Therefore, the impact of collision risk is assessed as **minor adverse** for harbour seal **negligible** for grey seal, and **minor adverse** for all cetacean species.

Mitigation and residual impact

10.3.10. No further mitigation is included in the assessment. However, best practice and industry guidelines are likely to be followed during construction to minimise the potential impact. The residual impacts are, therefore, assessed as **minor adverse** for harbour seal and cetaceans, and **negligible** for grey seal.

Changes in prey resource

10.3.11. The residual impacts from the six wind farm projects within the Offshore ZDE are considered minor adverse in all species. The additional impact from the aggregate extraction at Area 466/1 is not considered to increase the magnitude of effect above low in all species. Combined with low sensitivity of marine mammals to this impact, the overall impact is assessed as **minor adverse** in all species.

Mitigation and residual impact

10.3.12. No further mitigation is considered necessary; therefore, the residual impacts are assessed as **minor adverse** for all species.

10.4. Cumulative impacts from projects outwith the Dogger Bank Offshore ZDE

10.4.1. The assessment of cumulative impacts outwith the Dogger Bank Offshore ZDE is presented across all phases of development combined for marine mammals. This allows better consideration of impacts from different types of development (as presented in **Table 10.2**) and similar impacts that can occur through different stages of the projects (e.g. behavioural disturbance from both pile driving and/or vessel noise).

10.4.2. This approach also allows for the consideration of cumulative impacts which may arise over time as a result of activities that will occur following the baseline characterisation of Dogger Bank Teesside A and Dogger Bank Teesside B (July 2012), yet before the start of construction. Therefore, any impacts that are considered for Dogger Bank Teesside A and Dogger Bank Teesside B, Dogger Bank Teesside C and Dogger Bank Teesside D and Dogger Bank Creyke Beck A & B will be in addition to these impacts.

10.4.3. In **Table 10.2**, there are a total of 63 projects; 24 of these relate to offshore wind farm arrays, and a further 13 relate to the cable elements of the same developments. This means there is a total of 50 projects to be considered. Of which 16 are related to marine aggregate extraction (one is within the zone and considered in the preceding section), 24 to offshore wind farms (only one of which is outside the UK), one oil and gas pipeline, four oil and gas developments, and five wave and tidal developments.

10.4.4. Projects relating to aggregate extraction are considered in the area of the southern North Sea. Potential impacts from these developments include behavioural disturbance from underwater noise and vessels, potential collision risk with vessels, and indirect impacts on prey.

10.4.5. All offshore wind farm developments have the potential to cause the types of impacts possible during development of Dogger Bank Teesside A and Dogger Bank Teesside B. However, the magnitude of effect (spatial and temporal footprints) on marine mammals will vary depending on the size of the developments and the existing environment in the vicinity of the proposed development. Some projects are also located in regions with different underlying marine mammal densities to those seen across the Dogger Bank Offshore ZDE and wider Dogger Bank area (Section 4). Densities of highly mobile species of cetacean are known to vary over space and time (e.g. **Figure 4.2, Figure 4.11** and **Figure 4.12**), so there will be a large amount of uncertainty in quantifying impacts.

10.4.6. Although there is the potential for overlap in the construction phase of some of the wind farms considered in the assessment with Dogger Bank Teesside A & B, it is possible that infrastructure constraints (such as the availability of offshore construction barges) will limit the potential for concurrent pile driving across many sites. There is also a large amount of uncertainty in when construction is likely to commence across many projects which are yet to be consented. However, assessing the impacts from other developments, including pile driving from offshore wind farms is not only constrained to the period of potential concurrent pile driving. Consideration of prolonged periods of sequential pile driving, and any changes to the baseline prior to construction of the six projects in the Dogger Bank Offshore ZDE should also be considered.

10.4.7. Oil and gas developments and pipelines under construction have the potential to cause impacts relating to disturbance via underwater noise from construction activities and vessels, collision risk with vessels and indirect impacts relating to prey, as well as potential disturbance from seismic surveys undertaken as part of EIA or prospecting work. The potential of seismic surveys relating to these types of projects is hard to quantify and are not included in the CIA.

10.4.8. Wave and tidal developments have the potential for disturbance from underwater noise, during construction and operation of the device and from vessels, as well as collision risk with vessels and devices and indirect effects from impacts on prey.

Underwater noise - auditory injury

10.4.9. It is possible that offshore wind farm developments are the only projects that will have the potential to cause auditory injury effects on marine mammals, and thus add to the cumulative impact of underwater noise with Dogger Bank projects.

10.4.10. Impact of PTS for all species of cetacean should be mitigated in Dogger Bank Teesside A and Dogger Bank Teesside B (Section 6), therefore these will not be adding to any cumulative impact. However, the CIA does consider that, especially in the case of harbour porpoise, other projects have the potential to cause PTS in the reference population prior to the start of construction at Dogger Bank. PTS impacts in all species of cetacean are likely to be mitigated in some (as is the case for Dogger Bank Teesside A and Dogger Bank Teesside B), but not all, developments.

10.4.11. The potential of PTS in individuals within the North Sea harbour porpoise reference population from projects where construction is pre- or concurrent with Dogger Bank Teesside A & B could lead to a reduction in the reference population post characterisation of the existing environment (i.e. post July 2012).

10.4.12. The number of harbour porpoise that could be exposed to noise thresholds that can cause PTS has not been quantified for the projects in **Table 10.2** due to the large amount of uncertainty as to the likelihood of such effects, such as assessing potential impacts 5-10 years or more in the future, and whether the potential of PTS will be fully mitigated.

10.4.13. If the assumption is made that Dogger Bank Teesside C & D and Dogger Bank Creyke Beck A and Dogger Bank Creyke Beck B in the Dogger Bank Offshore ZDE have impacts comparable to the worst case assessed for Teesside A or Teesside B, the potential for PTS will be mitigated, and Dogger Bank Teesside C or Dogger Bank Teesside D and Dogger Bank Creyke Beck A or Dogger Bank Creyke Beck B will not add to this cumulative impact.

10.4.14. The potential for exposure to noise thresholds that can cause PTS based on the cumulative SEL dose does exist for grey seal for the Dogger Bank projects. However, it is not possible to quantify the number that could develop PTS. As such only a qualitative assessment of this impact is considered in grey seal. Many of the offshore wind farm developments considered in the CIA are located in areas where grey seal densities are higher than in the Dogger Bank Offshore ZDE (e.g. sites in Scottish territorial waters). As such the potential for PTS based on cumulative SEL dose in this species may be higher in other sites. Grey seal are considered to have medium sensitivity to PTS in this assessment, but there is the potential for a medium magnitude of effect cumulatively, which could lead to a **moderate adverse** impact.

10.4.15. However, this assessment is based on the use of precautionary PTS thresholds in this species, and does not take account of the ability of grey seal to hold their heads out of the water during exposure to loud noise. Furthermore grey seal numbers in the North Sea are rapidly increasing (Section 4.3), and this species is likely to be relatively robust to such impacts. The grey seal assessment has used precautionary thresholds to define magnitude of effect, to reflect that the impacted grey seal are likely to come from SAC populations, and, as such, are high VER. However, the maximum theoretical rate of increase in grey seal is around 10% per annum, rather than the 4% per annum applied to cetacean species by JNCC *et al*. 2010a), so the population is likely to be able to withstand a greater magnitude of effect than cetacean species. Furthermore, the contribution to this potentially significant impact in the cumulative assessment from projects within the Dogger Bank Zone is not significant, and Forewind are therefore not committed to provide further mitigation at the project level.

Table 10.4 Offshore wind farm projects included in the cumulative assessment for harbour porpoise. Information has been taken from the ES chapter for each development where available or other sources as detailed.

Project title	Project status	Predicted construction period	Total number of offshore wind turbines (foundation type for maximum number of piling events) and capacity[10]	Max. number of pile driving events (for wind turbines)	Assessment of disturbance[11]	Assessment of pile driving in project ES	Data source
Teesside Offshore Windfarm	Operational	2012-2013	27 (monopole) 62.1MW	27	Impacts are not quantified in the project ES. Impact ranges likely to be small and porpoise densities low due to site characteristics (proximity to shore). Impacts not quantified in this CIA due to limited information.	Not significant	Entec UK Limited (2004)
Lincs	Operational	2011-2013	75 (monopole) 270MW	75	Impacts are not quantified in the project ES. Pile driving stated as audible to marine mammals out to 20km. Average densities of porpoise in SCANS II block U are 0.598 animals per km2 (CV 0.28). Estimate of up to 751 porpoise disturbed (assuming spherical impact).	Minor	Lincs Wind Farm Limited (2010)
Triton Knoll	Pre-consent	2017-2021	288 (4 legged jackets) 400MW	1,152	Up to 948 disturbed porpoise per pile. Assessed as minor	Minor	RWE Npower Renewables Ltd (2012)

[10] Data source http://www.4coffshore.com/offshorewind/
[11] It should be noted that not all assessments use the same metric for assessing behavioural disturbance during noise propagation modelling.

Project title	Project status	Predicted construction period	Total number of offshore wind turbines (foundation type for maximum number of piling events) and capacity[10]	Max. number of pile driving events (for wind turbines)	Assessment of disturbance[11]	Assessment of pile driving in project ES	Data source
Blyth Demonstration Site (NaREC)	Pre-consent	2014-2016	15 (monopole) 4MW	15	Impacts are not quantified in EIA, therefore not quantified in this CIA due to limited information.	N/A	NaREC (2013)
Inch Cape	Pre-consent	2016-2017	213 (4 legged jackets) (4 legged jackets) 905MW	852	Worst case on 556 harbour porpoise during two concurrent piling events. There is potential overlap in noise footprints between Firth of Forth , Neart na Gaoithe and Inch Cape It is likely that non-cumulative pile driving impacts from these projects will be less than the sum of each individual project as presented here.	Minor	Inch Cape Offshore Ltd (2013)
Neart na Gaoithe	Pre-consent	2014-2017	90 (4 legged jackets) 450MW	360	Up to 887 per piling event. There is potential large overlap in noise footprints between Firth of Forth , Neart na Gaoithe and Inch Cape It is likely that non-cumulative pile driving impacts from these projects will be less than the sum of each individual project as presented here.	Minor	Mainstream Renewable Power (2012; 2013)
Firth of Forth (Phase 1)	Pre-consent	2015-2016	Phase 1 Alpha - 75 (4 legged	600	2,543 porpoise based on two concurrent projects piling (Project	Negligible	Seagreen Wind Energy

Project title	Project status	Predicted construction period	Total number of offshore wind turbines (foundation type for maximum number of piling events) and capacity[10]	Max. number of pile driving events (for wind turbines)	Assessment of disturbance[11]	Assessment of pile driving in project ES	Data source
			jackets) 525 MW Phase 1 Bravo - 75 (4 legged jackets) 525MW Total 150 turbines		Alpha and Project Bravo). There is potential for overlap in noise footprints between Firth of Forth , Neart na Gaoithe and Inch Cape It is likely that non-cumulative pile driving impacts from these projects will be less than the sum of each individual project as presented here.		(2012)
Bürger-windpark Butendiek	Consented	Post 2014	80 (monopole) 288MW	80	No project ES available to quantify numbers of harbour porpoise disturbed. Impacts are not quantified in this CIA due to limited information.	Intermediate risk and intermediate intensity of negative effects on harbour porpoise concluded	Offshore-Bürger-Windpark Butendiek (2002)
Beatrice	Pre-consent	2014-2017	277 (4 legged jackets) 1,000MW	1,108	4,337 individuals per piling event will experience a behavioural impact. There is potential for a small overlap in noise footprints between Beatrice and Moray Firth. It is likely that non-cumulative pile driving impacts from these projects will be less than the sum of each individual	Minor	Arcus Renewable Energy Consulting Ltd (2012)

Project title	Project status	Predicted construction period	Total number of offshore wind turbines (foundation type for maximum number of piling events) and capacity[10]	Max. number of pile driving events (for wind turbines)	Assessment of disturbance[11]	Assessment of pile driving in project ES	Data source
					project as presented here.		
Dogger Bank Teesside A and Dogger Bank Teesside B	Pre-consent	Post 2016	Dogger Bank Teesside A - 200 (6 legged jackets) 1,200MW Dogger Bank Teesside B – 200 (4 legged jackets) 1,200MW. Total 400 turbines	2,400	11,437 (possible avoidance) based on cumulative modelling for Teesside A and B, Teesside C and D and Creyke Beck A and B (based on monopole impact areas)	Moderate (cumulatively)	Table 10.3
Dogger Bank Teesside C and Dogger Bank Teesside D	Pre-consent	Post 2016	Dogger Bank Teesside C - 200 (6 legged jackets) 1,200MW, based on Dogger Bank Teesside A. Dogger Bank Teesside D - 200(4 legged jackets) 1,200MW, based on Dogger Bank Teesside A.	2,400	Included in Dogger Bank Teesside A & B total above	Moderate (cumulatively)	Table 10.3

Project title	Project status	Predicted construction period	Total number of offshore wind turbines (foundation type for maximum number of piling events) and capacity[10]	Max. number of pile driving events (for wind turbines)	Assessment of disturbance[11]	Assessment of pile driving in project ES	Data source
			Total 400 turbines				
Dogger Bank Creyke Beck A and Dogger Bank Creyke Beck B	Pre-consent	Post 2016	Dogger Bank Creyke Beck A - 300 4MW devices (4 legged jackets) 1,200MW. Dogger Bank Creyke Beck B - 300 4MW devices (4 legged jackets) 1,200MW.	2,400	Included in Dogger Bank Teesside A & B total above	Moderate (cumulatively)	Table 10.3
Moray Firth	Pre-consent	2015-2019	Telford - 113 (4 legged jackets) 500MW Stevenson - 113 (4 legged jackets) 500MW MacColl - 113 (4 legged jackets) 500MW Total 339 turbines	1,356	5,149 individuals based on the three projects piling concurrently. There is potential for a small overlap in noise footprints between Beatrice and Moray Firth. It is likely that non-cumulative pile driving impacts from these projects will be less than the sum of each individual project as presented here.	Minor	Moray Offshore Renewables Ltd (2013)
Galloper	Consented	2014-2016	140 (4 legged jackets)	560	Up to 1,780 porpoise per piling event.	Minor	Galloper Wind Farm Limited

Project title	Project status	Predicted construction period	Total number of offshore wind turbines (foundation type for maximum number of piling events) and capacity[10]	Max. number of pile driving events (for wind turbines)	Assessment of disturbance[11]	Assessment of pile driving in project ES	Data source
			504MW				(2011)
Hornsea (Project One)	Pre-consent	2015- up to five years (30 months pile driving)	322 turbines. A total of 339 (8.5m) monopoles 1.2GW	339	Draft ES details ranges of likely disturbance to 46.6km for max hammer energy. Disturbance of up to 6,849 harbour porpoise based on concurrent pile driving and visual density estimates.	Draft ES available. Moderate adverse in medium term, minor adverse in long term	SMart Wind Ltd (2013)
Hornsea (Project Two)	Pre-consent	Post 2015	Up to 360 (monopole) 1.8GW	360	No project ES available. Impacts are likely to be comparable to Hornsea One.	No Project ES	SMart Wind (2012)
Humber Gateway	Consented	2013-2014	73 (monopole) 219MW	73	Disturbance to 11.4km range, but numbers impacted not quantified in the ES. Average densities of porpoise in SCANS II block U are 0.598 animals per km2 (CV 0.28). Estimate of 244 porpoise disturbed (assuming spherical impact).	Minor	ERM (2008)
Dudgeon	Consented	2016	77 (4 legged jackets) 560MW	308	Up to 2,166 porpoise per piling event.	Minor	Dudgeon Offshore Wind Farm (2013
London Array II	Consented (subject to a Grampian	2014-2015	65 (monopole) 370MW	65	Strong avoidance to 7.7km. Impacted numbers not quantified in the ES. Average densities of porpoise in	Minor-moderate	RPS (2005)

Project title	Project status	Predicted construction period	Total number of offshore wind turbines (foundation type for maximum number of piling events) and capacity[10]	Max. number of pile driving events (for wind turbines)	Assessment of disturbance[11]	Assessment of pile driving in project ES	Data source
	condition)				SCANS II block B are 0.331 animals per km2 (CV 0.38). Estimate of up to 62 porpoise disturbed (assuming spherical impact).		
Race Bank	Consented	2017	116 (undecided) 580MW	116	Disturbance out to 12km, but numbers of individuals impacted not quantified in the ES. Average densities of porpoise in SCANS II block U are 0.598 animals per km2 (CV 0.28). Estimate of 271porpoise disturbed (assuming spherical impact).	Minor to moderate.	AMEC (2009)
Westermost Rough	Consented	2014-2015	35 (4 legged jackets) 220MW	140	Impacted numbers not quantified in the ES, but ranges of likely disturbance are estimated at 10km. Average densities of porpoise in SCANS II block U are 0.598 animals per km2 (CV 0.28). Estimate of 188 porpoise disturbed (assuming spherical impact).	Minor adverse.	Dong Energy (2009)
East Anglia One	Pre-consent	2015-2017	325 (4 legged jackets) 1,200MW	1,300	Possible avoidance over 1,433km2 Disturbance of: 1,433 animals (maximum SCANS II densities, 1 animals	Not significant	Environmental Resource Management (ERM, 2012)

Project title	Project status	Predicted construction period	Total number of offshore wind turbines (foundation type for maximum number of piling events) and capacity[10]	Max. number of pile driving events (for wind turbines)	Assessment of disturbance[11]	Assessment of pile driving in project ES	Data source
					per km2) 2,006 animals (based on site specific aerial surveys, 1.4 animals per km2). It should be noted that JCP surveys suggest densities may be higher than this in the zone.		
East Anglia Three	Pre-consent	Post 2016	240 (4 legged jackets) 1,200MW	960	ES not available. Impacts may be comparable to East Anglia One. There is the potential for overlap in noise footprint between the East Anglia projects. It is likely that non-cumulative pile driving impacts from these projects will be less than the sum of each individual project as presented here.	No project ES	East Anglia Offshore Wind Limited (2012a)
East Anglia Four	Pre-consent	Post 2016	240 (4 legged jackets) 1,200MW	960	ES not available. Impacts may be comparable to East Anglia One. There is the potential for overlap in noise footprint between the East Anglia projects. It is likely that non-cumulative pile driving impacts from these projects will be less than the sum of each	No project ES	East Anglia Offshore Wind Limited (2012b)

Project title	Project status	Predicted construction period	Total number of offshore wind turbines (foundation type for maximum number of piling events) and capacity[10]	Max. number of pile driving events (for wind turbines)	Assessment of disturbance[11]	Assessment of pile driving in project ES	Data source
					individual project as presented here.		

Underwater noise – behavioural disturbance

10.4.16. Underwater noise from pile driving, vessels, operational activities, extraction and cable laying for other projects considered in the CIA will all add to the cumulative impact on the reference populations of marine mammals assessed in relation to Dogger Bank Teesside A & B. Behavioural disturbance from pile driving noise at offshore wind farm developments is likely to be the greatest contributor to this cumulative impact, and is therefore assessed in more detail in this CIA.

10.4.17. The assessment of behavioural impacts considers the total number of animals that could be displaced, as well as the total amount of habitat that individuals could be excluded from at any one time.

Harbour porpoise

10.4.18. Impacts from pile driving at either Dogger Bank Teesside A or Dogger Bank Teesside B in isolation are considered minor adverse. This level of impact is also concluded across the six projects assessed in the CIA for the Dogger Bank Offshore ZDE.

10.4.19. **Table 10.4** provides a summary of the offshore wind farm projects used in the CIA for harbour porpoise. For many of the offshore wind farm developments there is limited quantified information on the area of displacement or the total number of harbour porpoise that could be disturbed by pile driving. Construction in the Dogger Bank Zone of Dogger Bank Teesside A and Dogger Bank Teesside B is not likely to commence pre-2016. Other developments outside the Dogger Bank Offshore ZDE that could be pile driving at the same time include Hornsea (Project One), Hornsea (Project Two), East Anglia (One, Three and Four), Galloper, Firth of Forth (Phase 1), Race Bank, Triton Knoll, Dudgeon, Inch Cape, Neart na Gaoithe, Beatrice and Moray Firth (**Table 10.4**).

10.4.20. Where impacts are not quantified by the project in their own ES or other technical report the number of animals that could be disturbed has been quantified using an approximation of impacted areas from the impact range, and average densities based on the SCANS-II data (Hammond *et al.* 2013) for the survey area appropriate to the project in question. **Table 10.5** presents the quantified impacts in a timeline, along with an assessment of the relative confidence in the quantification of impacts. It also summarised the magnitude of effect of behavioural disturbance in each year.

10.4.21. Where project specific ES chapters have quantified impacts based on noise propagation modelling and site specific survey data the confidence is high, where project specific ES chapters do not quantify the number of individuals disturbed, and an assessment is made here based on SCANS II densities (Hammond *et al*. 2013) and impact ranges the confidence is low. Where an ES chapter has used site specific densities and noise propagation modelling in their CIA for another project the confidence is medium, and where the data are presented in another report (e.g. Preliminary Environmental Information (PEI) Reports) the confidence is low.

10.4.22. The individual fitness effects of behavioural disturbance in harbour porpoise are not well understood, with sensitivity in this assessment as medium for likely disturbance (same threshold as TTS) and low for possible disturbance. **Table 10.5** quantifies the magnitude of effect for possible disturbance in the majority of projects.

10.4.23. The effect of disturbance may be cumulative over time on the population, if it is assumed that there is the potential for periods of reduced fecundity (as in the Moray Firth Framework for harbour seal). Between July 2012 and the start of construction at Dogger Bank Teesside A or Dogger Bank Teesside B disturbance to harbour porpoise from the reference population could lead to a supressed growth rate if fecundity is affected, for example. However, the extent of such an impact is hard to quantify.

10.4.24. **Table 10.5** quantifies the total number of harbour porpoise that may be disturbed each year due to pile driving noise. Between 2016 and 2018 it is possible that more than 10% of the reference population would be disturbed, which would be a high magnitude of effect. There is, however, a large amount of uncertainty in this assessment, which is reflected in the relative confidence in the quantification of impacts in **Table 10.5**. Furthermore it should also be noted that this CIA uses data from many different projects, which are usually presented as worst case scenarios within ES chapters, thus providing a precautionary approach to this assessment, and does not take account of potentially overlapping noise footprints between neighbouring developments (e.g. Beatrice and Moray within the Moray Firth, or East Anglia Zone projects).

10.4.25. Where the period of construction using pile driving is occurring over the same time period at several developments the habitat available to the reference population will also be reduced. Such periods of time when the overall habitat available to a species within its home range is reduced, and a large number of individuals are displaced, gives the potential for the greatest cumulative impact.

10.4.26. **Table 10.6** quantifies the potential area of displacement each year in relation to the size of the North Sea (approximately 750,000km^2). It suggests that approximately 5 to 11% of the total habitat may be subjected to noise that will possibly disturb harbour porpoise between 2015 and 2018. Very little is currently known about habitat preference for harbour porpoise across the North Sea, so determination whether this scale of disturbance is significant is difficult, and will primarily relate to the quality of the foraging environment, or the presence of any specific nursery grounds.

10.4.27. Noise propagation modelling has also been carried out by NPL for concurrent pile driving to indicate any potential overlap in individual noise footprints between developments (**Appendix 5A**, Section 6.4). The assessment followed project screening for noise which resulted in a different list of projects to be included in the CIA than the receptor based screening presented here. The noise assessment included Dogger Bank Teesside A and Dogger Bank Teesside B, Dogger Bank Teesside C and Dogger Bank Teesside D, Dogger Bank Creyke Beck A and Dogger Bank Creyke Beck Humber Gateway, Dudgeon, Westermost Rough, Race Bank, Hornsea Project One, Hornsea Project Two and Trion Knoll (**Figure 10.4**). In addition, East Anglia Projects One, Three and Four, Blyth Demonstration Site (Narec) and Firth of Forth have been included (despite being further than 200km from Dogger Bank) due to their construction times, as well as noise from Cygnus Oil Field, and some Dutch off shore wind farms. The assessment concluded that, despite elevated noise across relatively large areas of the North Sea, it is likely that only the neighbouring Dogger Bank Zone projects, Cygnus, Hornsea Project One and Two, H2-20 and Nord-Ost Passat show any potential for overlapping behavioural disturbance impact zones.

10.4.28. It should be noted that the noise propagation modelling in **Figure 10.4**, uses the assumption of a maximum of a 3,000kJ hammer force, which is greater than likely hammer energies that may be used at Hornsea One (2,300kJ max blow force (SMartwind, 2013) and East Anglia (Project One; 900kJ max blow force; ERM, 2012) for example. It should also be noted that the model assumed uniform seabed properties throughout the modelled area of the North Sea, which may not necessarily be representative of the actual conditions for surrounding developments.

Table 10.5 Timeline for magnitude of effect (number of harbour porpoise possibly disturbed) for offshore wind farm projects included in the cumulative assessment for harbour porpoise.

Project title	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Relative confidence in quantitative assessment
Lincs	751										Low
Triton Knoll[12]						948	948	948	948	948	High
Inch Cape[13]					556	556					High
Neart na Gaoithe[12]			887	887	887	887					High
Firth of Forth (Phase 1 Projects Alpha and Bravo)				2,543	2,543						High
Beatrice			4,337	4,337	4,337	4,337					High
Dogger Bank Teesside A Dogger Bank Teesside B, Dogger Bank Teesside C Dogger Bank Teesside D and Dogger Bank Creyke Beck A and Dogger Bank Creyke Beck B					13,449	13,449	13,449	13,449	13,449		High
Moray Firth				5,149	5,149	5,149	5,149	5,149			High
Galloper			1,780	1,780	1,780						High

Project title	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Relative confidence in quantitative assessment
Hornsea (Project One)[14]					6,849	6,849	6,849				Medium
Hornsea (Project Two)					6,849	6,849	6,849				Low
Humber Gateway[12]		244	244								Low
Dudgeon[12]					368						High
London Array II[12] (subject to a Grampian condition)			62	62							Low
Race Bank						271					Low
Westermost Rough			188	188							Low
East Anglia One[14]				2,006	2,006	2,006					High
East Anglia Three					2,006	2,006	2,006				Low
East Anglia Four					2,006	2,006	2,006				Low
TOTAL	751	244	7,254	16,764	48,417	45,042	37,256	19,546	14,397	948	
Percent of reference population	0.3	0.1	3.2	7.4	21	19.8	16.4	8.6	6.3	0.4	
Magnitude of effect	Negligible	Negligible	Low	Medium	High	High	High	Medium	Medium	Negligible.	Medium

Table 10.6 Timeline for magnitude of effect (area of habitat excluded in km^2) for offshore wind farm projects included in the cumulative assessment for harbour porpoise.

Project title	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Relative confidence in quantitative assessment
Lincs	1,257										Low
Triton Knoll[14]						863	863	863	863	863	High
Inch Cape[12]					7,174	7,174					Low
Neart na Gaoithe			4,668	4,668	4,668	4,668					High
Firth of Forth (Phase 1 Projects Alpha and Bravo)				10,386	10,386						High
Beatrice			8,053	8,053	8,053	8,053					High
Dogger Bank Teesside A, Dogger Bank Teesside B, Dogger Bank Teesside C, Dogger Bank Teesside D and Dogger Bank Creyke Beck A & B					15,971	15,971	15,971	15,971	15,971	15,971	High
Moray Firth[13]				8,053	8,053	8,053	8,053	8,053			Low
Galloper			2,967	2,967	2,967						High
Hornsea (Project One)[14]					8,825	8,825	8,825				Medium

[12] Area of impact not quantified in ES, assumed to be similar to Firth of Forth Project Alpha single piling event.
[13] Area of impact not presented in ES, assumed to be similar to Beatrice.
[14] Areas of impact are not presented in the draft ES, these provide a maximum approximation.

Project title	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Relative confidence in quantitative assessment
Hornsea (Project Two)					8,825	8,825	8,825				Low
Humber Gateway[14]		408	408								Low
Dudgeon[14]					3,622						Low
London Array II[14]			186	186							Low
Race Bank						452					Low
Westermost Rough			314	314							Low
East Anglia One[15]				1,433	1,433	1,433					High
East Anglia Three[16]					1,433	1,433	1,433				Low
East Anglia Four[15]					1,433	1,433	1,433				Low
TOTAL (km^2)	1,257	408	16,596	36,060	82,843	67,183	45,403	24,887	16,834	16,834	Medium
Percent of North Sea habitat	0.17	0.05	2.22	4.81	11.05	8.96	6.05	3.32	2.24	2.24	

[15] Numbers disturbed are based on site specific survey data
[16] Areas are assumed to approximate East Anglia One

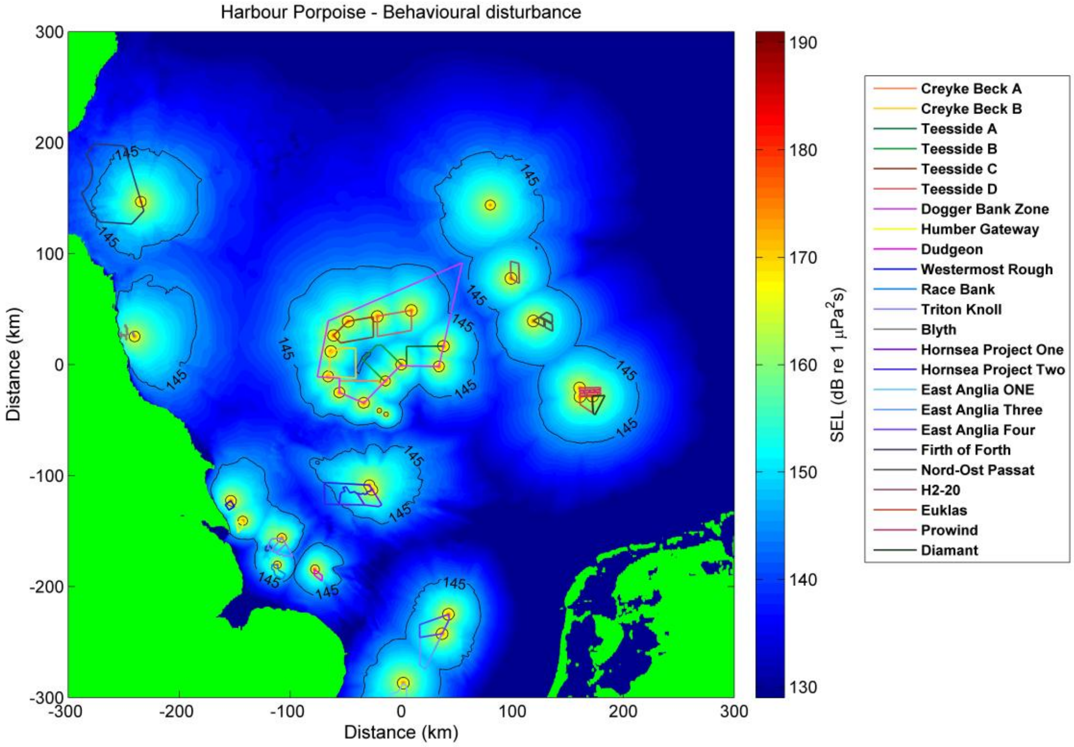


Figure 10.4 Map of the North Sea with an illustration of the noise generated from piling at various potentially concurrently occurring construction projects in relative proximity to Dogger Bank Teesside A and Dogger Bank Teesside B. The image shows sound propagation assuming 3,000kJ hammer blow energy applied to all modelled developments. See **Appendix 5A** for details.

10.4.29. The number of animals possibly displaced (**Table 10.5**) equates to more than 10% of the reference population, and would be a high magnitude of effect between 2016 and 2018. This combined with the low sensitivity to possible avoidance gives a **moderate adverse** impact.

10.4.30. Clearly, effects of this magnitude are based on several assumptions and, therefore, there is a large amount of uncertainty in the assessment. The information presented in **Table 10.5**, uses the worst case predicted numbers of animals displaced often based on a precautionary approach with regard to noise propagation modelling and engineering scenarios. The approach also assumes 100% displacement of individuals that could possibly be disturbed, when, in reality, individuals will respond differently to the noise stimulus, and those closer to the noise source are likely to have a more marked response. It may be reasonable to assume that avoidance of the area may occur in 50 to 75% of individuals.

10.4.31. As stated previously the individual fitness consequences of disturbance from pile driving noise are largely unknown, and thus the ability to conclude the severity of the impact at a population level over the medium to long term is limited.

10.4.32. In addition to the disturbance from pile driving noise, disturbance from vessels, construction and extraction based on the other projects in **Table 10.2** also needs to be considered. However, quantification of the potential for disturbance from these projects has not been made. This assessment concludes that the magnitude of effect from pile driving is already high, and these projects will not increase the impact beyond **moderate adverse**.

Other species

10.4.33. In other species of cetacean, where areas of behavioural displacement from pile driving are large, but densities are generally lower than harbour porpoise effects of a similar magnitude are less likely to occur, despite the wider home ranges. There is however, a large amount of uncertainty as to the biological and population level consequences of behavioural disturbance in these species.

10.4.34. A quantified assessment has not been undertaken in these species along the same lines as harbour porpoise, as the quality of data provided from other Project ES chapters is not a good for these other species. Therefore, only a qualitative assessment is made of the potential impacts.

10.4.35. In addition to the impacts from pile driving, other projects will have vessel noise and other operational noise that can add to the areas of displacement or avoidance.

10.4.36. The overall cumulative impact of behavioural disturbance from these developments has the potential to be medium magnitude, at worst, for all other species of cetacean, with a high degree of uncertainty. Given the possible geographical extent of these reference populations the proportion of the total habitat they may be excluded from will be less than in harbour porpoise (with a smaller geographical range of the North Sea).

10.4.37. When accounting for all disturbance in minke whale and white-beaked dolphin impact magnitudes are considered medium, the overall impact is therefore **minor adverse**, based on low sensitivity.

10.4.38. In grey seal, some of the projects detailed in **Table 10.3** occur in areas of comparatively higher density than Dogger Bank Teesside A& B, especially Firth of Forth (Phase 1), Inch Cape and Neart na Gaoithe (**Figure 4.35**). However, it is unlikely that following consideration of the other projects in the CIA, that the magnitude of effect will be greater than medium, at worst. Therefore, based on low sensitivity to likely disturbance, the overall impact is **minor adverse**.

Mitigation and residual impact

10.4.39. No further mitigation is suggested for this impact. However, Forewind will continue to consider potential ways to mitigate the impacts of pile driving noise where possible.

Collision risk

10.4.40. Cumulative impacts of collision risk are hard to quantify, and the potential for collision varies between projects, vessel types, vessel speeds, vessel activity and species. Although all projects will increase the amount of vessel activity over the home range of each species considered in the assessment, there are already large numbers of vessel movements across this area.

10.4.41. Impacts in relation to the use of ducted propellers will vary between projects, due to the different levels of risk associated with the proximity of harbour and grey seal haul out sites and SACs. A number of the projects in the CIA are sighted in close proximity to harbour seal SACs, which are suggested to be at particular risk of collision with ducted propellers. The cumulative effects of all the projects have the potential to increase the magnitude of the effect from negligible to low.

10.4.42. Cumulative impacts are considered to be **minor adverse** for all species except harbour seal, where it is **moderate adverse**. This is based on the low sensitivity of cetaceans to hull impacts and the low magnitude of these impacts, the high sensitivity of harbour seal to ducted propeller impacts and the low level of the magnitude of effect, as well as the medium sensitivity of grey seal to ducted propellers and a low magnitude of effect. Projects within the Dogger Bank Zone, due to the offshore location are in areas of relatively low harbour seal abundance. Therefore, the contribution of Dogger Bank projects to this significant cumulative impact is minor.

Mitigation and residual impact

10.4.43. No further mitigation is suggested for this impact. However, there are currently limited data to support ducted propellers as the root cause of these injuries, and therefore a high amount of uncertainty in the assessment.

10.4.44. Forewind will continue to keep informed of this issue, following new industry guidelines or mitigation measures should they be introduced in order to refine the impact levels down.

Indirect impact of changes in prey resource

10.4.45. There is a large amount of uncertainty in the potential impact of any changes in prey availability that could result from the projects listed in **Table 10.2**. The projects considered in the cumulative assessment of impacts for fish presented in **Chapter 13** did not conclude any significant impacts.

10.4.46. Consideration of the impact from changes in prey resource is likely to be of a low magnitude, combined with the low sensitivity of marine mammals to this impact; the impact is assessed as **minor adverse** in all species.

10.4.47. Once again there is a large amount of uncertainty associated with this assessment as the potential impacts of changes in prey resources will also be dependent on changes in marine mammal distribution as a result of noise disturbance, and competition for resources.

Mitigation and residual impact

10.4.48. No further mitigation is suggested for this impact.

11. Transboundary Effects

11.1.1. This chapter has considered the potential for transboundary effects (effects across international boundaries) to occur on marine mammals as a result of the construction, operation or decommissioning of Dogger Bank Teesside A & B.

11.1.2. A summary of the likely transboundary effects of Dogger Bank Teesside A & B are in **Chapter 32 Transboundary Effects**.

11.1.3. Impact footprints in relation to potential disturbance from pile driving noise from the eastern extent of Dogger Bank Teesside A are predicted to range across international boundaries into Dutch waters.

11.1.4. In addition, all species of cetacean considered in this assessment are part of wide ranging populations, which are not constrained to UK waters. The impact assessment considers the magnitude of effects at this population level, and therefore at an international level. Individuals of each species may range from another state's territorial waters into the zone of influence during all phases of the development of Dogger Bank Teesside A or Dogger Bank Teesside B.

11.1.5. It is noted that an EPS license will be required to cover the risk of disturbance to cetacean species identified as likely to be in the area under regulations 41(1)(a) and (b) in The Conservation of Habitats and Species Regulations and 39(1)(a) and (b) in The Offshore Marine Conservation (Natural Habitats, &c.) Regulations 2007 (amended in 2009 and 2010).

11.1.6. The potential impacts on species of marine mammals protected under Annex II of the Habitats Directive (see Section 2.2) are assessed in the **HRA Appendix B HRA Report**. This assessment includes both UK and transboundary designations.

11.1.7. There are 57 transboundary European designated sites (Sites of Community Importance (SCIs) and SACs) within the North Sea that have been designated for their populations of breeding and / or foraging grey seal, harbour seal, and harbour porpoise (full details in **Appendix B HRA Report**). Of the 57 sites, 29 SCIs and SACs are designated for grey seal (nine in German waters, seven in Dutch waters, four in Belgian waters, seven in Danish waters, one in Norway and one in France), 56 SCIs and SACs are designated for harbour seal (16 in German waters, ten in Dutch waters, four in Belgian waters, 15 in Danish waters, nine in Swedish waters, and one in Norway and one in France), and 26 SCIs and SACs are designated for harbour porpoise (ten in German waters, five in Dutch waters, four in Belgian waters, five in Danish waters, one in France, and one in Swedish waters).

11.1.8. Screening and scoping supplemented by the results of the marine mammals surveys within the Dogger Bank Zone and within Dogger Bank Teesside A & B indicate that very low numbers of harbour seal are present within or around the Dogger Bank Zone, and given the low numbers and distance of Dogger Bank Teesside A & B outside the foraging range of harbour seals from transboundary sites, no effect is predicted on the North Sea or individual transboundary sites populations of harbour seal as a result of the construction, operation, and decommissioning of Dogger Bank Teesside A & B alone or in-combination with other projects.

11.1.9. The assessment of the effect on the integrity of the transboundary European sites as a result of impacts on the designated grey seal and harbour porpoise populations has been undertaken and presented in the Dogger Bank Teesside HRA, which has been informed by the assessment of impacts on the North Sea populations of grey seal and harbour porpoise presented in this chapter. The full results are presented in **Appendix B HRA Report**.

12. Summary

12.1.1. This chapter of the ES has provided a characterisation of the existing environment for marine mammals based on both existing and site specific survey data, which has established the potential impacts on marine mammals.

12.1.2. **Table 12.1** provides a summary of these potential impacts on marine mammals arising from the realistic worst case scenarios and parameters as set out in **Tables 5.1** and **5.2** for either Dogger Bank Teesside A or Dogger Bank Teesside B in isolation. The impact assessment for each of these projects in isolation is not considered to be significant for any receptors. There is a large amount of uncertainty in the assessment of the potential impacts of underwater noise from pile driving, in particular during construction (see Section 6.1). However, effective mitigation (through the development of a MMMP) will be employed to prevent the occurrence of exposure to noise thresholds that can lead to instantaneous PTS in all species. Cumulative dose PTS may occur in grey seal, based on an assessment using precautionary noise thresholds and a model that does not account for the ability of seal to hold their heads out of the water and prevent exposure. Although numbers potentially exposed to these noise thresholds are not quantified in the ES, the worst case impacts are considered to be **minor adverse**.

12.1.3. The potential impact of disturbance is also assessed, but in all cases the magnitude of effect is sufficiently low, combined with a precautionary assessment of the temporal effect of disturbance, to conclude **minor** impacts. The maximum temporal duration of the impacts is an important consideration in the assessment.

12.1.4. Other potential impacts during the construction (Section 6), operation (Section 7) and decommissioning (Section 8) phases of the development are assessed as **negligible** or **minor adverse** at worst. However, a large amount of uncertainty in the assessment of decommissioning impacts is noted.

12.1.5. **Table 12.2** provides a summary of the potential impacts on marine mammals from Dogger Bank Teesside A & B in combination (based on sequential construction periods). The assessment of these two projects in combination also concludes **minor adverse** impacts at worst. The magnitude of effect for many of the impacts will increase due to the combined impacts, but when combined with receptor sensitivity the significance of the impacts is not increased. There is the potential for overlapping noise footprints from pile driving noise during construction at Dogger Bank Teesside A and Dogger Bank Teesside B, which means that, should concurrent pile driving occur, the impacts would not be double those of the projects being built in isolation (Section 6.1).

12.1.6. **Table 12.3** provides a summary of the cumulative impacts from other projects within the Dogger Bank Offshore ZDE, based on the assessment presented in Sections 10.2 and 10.3. The addition of Dogger Bank Teesside C & D, Dogger Bank Creyke Beck A and Dogger Bank Creyke Beck B as well as Aggregate extraction area 466/1 does not increase the levels of significance beyond the combined impacts of the Dogger Bank Teesside A & B projects. In harbour porpoise, further consideration of the significance of disturbance at the population was undertaken using PVA, which concluded that in this species the potential cumulative impact of disturbance from pile driving is considered **minor adverse**.

12.1.7. **Table 12.4** summarises the cumulative impacts from projects outwith the Dogger Bank Offshore DZE (Section 10.4). In this assessment, there is the potential for **moderate adverse** impacts to harbour porpoise as a result of disturbance from pile driving. This is based on the data presented in **Table 10.5**, which shows the potential for a high magnitude of effect, with greater than 10% of the North Sea harbour porpoise population being disturbed at any one time. It should be noted that this represents a precautionary assessment due to scaling of project specific impacts based on worst case scenarios, and also on account of the large amount of uncertainty in undertaking an assessment of this nature. Furthermore, potential limitations due to the supply chain and use of alternative less noise foundations compared to those assessed as part of the worst case may alter the number of offshore wind farms pile driving at the same time. However, impacts of disturbance at the scale presented in the CIA are an on-going consideration to Forewind, which is involved in wider industry initiatives aimed at understanding the population level consequences of disturbance (e.g. ORJIP).

12.1.8. Other potential significant impacts may arise from the cumulative effects of PTS in grey seal and collision with ducted propellers in harbour seal. The assessment of PTS in grey seal is based on a very precautionary approach, and it is unlikely that the impacts will be significant at a population level (Section 10.4). The potential for ducted propeller impacts in harbour seal to be significant is also based on a precautionary assessment, and does not include any mitigation (Section 10.4). The actual risk of this impact occurring for projects in the Dogger Bank Offshore DZE is low, but other developments that have been included in the CIA are situated much closer to high risk areas (i.e. harbour seal SACs).

12.1.9. Should mitigation measures be adopted at these higher risk sites that prevent or minimise this type of impact (e.g. seasonal restriction in the use of ducted propellers following guidance issued by the Statutory Nature Conservation Agencies 2012), then the impact should be reduced to non-significant levels at these other developments (as is already the case at Dogger Bank Teesside A & B). Forewind will continue to keep informed of this issue, following new industry guidelines or mitigation measures should they be introduced in order to further refine the impact levels down.

Table 12.1 Summary of predicted impacts of Dogger Bank Teesside A or Dogger Bank Teesside B in isolation on marine mammals

Description of Impact	Mitigation Measures	Receptor	Residual Impact
Construction Phase			
Underwater noise – pile driving	Soft-start. Commitment to development of an agreed marine mammal mitigation protocol.	Harbour porpoise Minke whale White-beaked dolphin Grey seal	**Minor adverse** **Minor adverse** **Minor adverse** **Minor adverse**
Underwater noise – vessel noise	None	Cetaceans Pinnipeds	**Negligible** **Negligible**
Collision risk – hull impacts	None	Cetaceans Pinnipeds	**Negligible** **Negligible**
Collision risk – ducted propellers	None	Grey seal Harbour seal	**Negligible** **Minor adverse**
Changes in prey resource	None	Cetaceans Pinnipeds	**Minor adverse** **Minor adverse**
Operational Phase			
Underwater noise - WTGs	None	Cetaceans Pinnipeds	**Negligible** **Negligible**
Underwater noise - vessels	None	Cetaceans Pinnipeds	**Negligible** **Negligible**
Collision risk – hull impacts	None	Cetaceans Pinnipeds	**Negligible** **Negligible**
Collision risk – ducted propellers	None	Grey seal Harbour seal	**Negligible** **Minor adverse**
EMF	None	Cetaceans Pinnipeds	**Negligible** **Negligible**
Physical barrier	None	Cetaceans Pinnipeds	**Negligible** **Negligible**
Decommissioning Phase			
Underwater noise - cutting	None	Cetaceans Pinnipeds	**Minor adverse** **Minor adverse**
Underwater noise - vessels	None	Cetaceans Pinnipeds	**Negligible** **Negligible**
Collision risk – hull impacts	None	Cetaceans Pinnipeds	**Negligible** **Negligible**
Collision risk – ducted propellers	None	Grey seal Harbour seal	**Negligible** **Minor adverse**

Table 12.2 Summary of predicted impacts of Dogger Bank Teesside A and Dogger Bank Teesside B (sequential or concurrent) on marine mammals

Description of Impact	Mitigation Measures	Receptor	Residual Impact
Construction Phase			
Underwater noise – pile driving	Soft-start Commitment to development of an agreed marine mammal mitigation protocol	Harbour porpoise Minke whale White-beaked dolphin Grey seal	**Minor adverse** **Minor adverse** **Minor adverse** **Minor adverse**
Underwater noise – vessel noise	None	Cetaceans Pinnipeds	**Minor adverse** **Minor adverse**
Collision risk – hull impacts	None	Cetaceans Pinnipeds	**Minor adverse** **Negligible**
Collision risk – ducted propellers	None	Grey seal Harbour seal	**Negligible** **Minor adverse**
Changes in prey resource	None	Cetaceans Pinnipeds	**Minor adverse** **Minor adverse**
Operational Phase			
Underwater noise – wind turbines	None	Cetaceans Pinnipeds	**Negligible** **Negligible**
Underwater noise - vessels	None	Cetaceans Pinnipeds	**Minor adverse** **Minor adverse**
Collision risk – hull impacts	None	Cetaceans Pinnipeds	**Minor adverse** **Negligible**
Collision risk – ducted propellers	None	Grey seal Harbour seal	**Negligible** **Minor adverse**
EMF	None	Cetaceans Pinnipeds	**Negligible** **Negligible**
Physical barrier	None	Cetaceans Pinnipeds	**Negligible** **Negligible**
Decommissioning Phase			
Underwater noise – cutting of foundations	None	Cetaceans Pinnipeds	**Minor adverse** **Minor adverse**
Underwater noise - vessels	None	Cetaceans Pinnipeds	**Negligible** **Negligible**
Collision risk – hull impacts	None	Cetaceans Pinnipeds	**Negligible** **Negligible**
Collision risk – ducted propellers	None	Grey seal Harbour seal	**Negligible** **Minor adverse**

Table 12.3 Summary of predicted cumulative impacts of Dogger Bank Teesside A and Dogger Bank Teesside B, Dogger Bank Creyke Beck A and Dogger Bank Creyke Beck B, and Dogger Bank Teesside C and Dogger Bank Teesside D on marine mammals

Description of Impact	Mitigation Measures	Receptor	Residual Impact
Construction Phase			
Underwater noise – pile driving	Soft-start Commitment to development of an agreed marine mammal mitigation protocol	Harbour porpoise Minke whale White-beaked dolphin Grey seal	**Minor adverse** **Minor adverse** **Minor adverse** **Minor adverse**
Underwater noise – vessel noise	None	Cetaceans Pinnipeds	**Minor adverse** **Minor adverse**
Collision risk – hull impacts	None	Cetaceans Pinnipeds	**Minor adverse** **Negligible**
Collision risk – ducted propellers	None	Grey seal Harbour seal	**Negligible** **Minor adverse**
Changes in prey resource	None	Cetaceans Pinnipeds	**Minor adverse** **Minor adverse**
Operational Phase			
Underwater noise – wind turbines	None	Cetaceans Pinnipeds	**Minor adverse** **Minor adverse**
Underwater noise - vessels	None	Cetaceans Pinnipeds	**Minor adverse** **Minor adverse**
Collision risk – hull impacts	None	Cetaceans Pinnipeds	**Minor adverse** **Negligible**
Collision risk – ducted propellers	None	Grey seal Harbour seal	**Negligible** **Minor adverse**
EMF	None	Cetaceans Pinnipeds	**Negligible** **Negligible**
Physical barrier	None	Cetaceans Pinnipeds	**Negligible** **Negligible**
Changes in prey resource	None	Cetaceans Pinnipeds	**Minor adverse** **Minor adverse**
Decommissioning Phase			
Underwater noise – cutting of foundations	None	Cetaceans Pinnipeds	**Minor adverse** **Minor adverse**
Underwater noise - vessels	None	Cetaceans Pinnipeds	**Minor adverse** **Minor adverse**
Collision risk – hull impacts	None	Cetaceans Pinnipeds	**Minor adverse** **Negligible**
Collision risk – ducted propellers	None	Grey seal Harbour seal	**Negligible** **Minor adverse**

Table 12.4 Summary of predicted cumulative impacts from projects outwith the Dogger Bank Offshore ZDE

Description of impact	Mitigation measures	Receptor	Residual impact
All phases			
Underwater noise – (all sources)	Soft-start Commitment to development of an agreed MMMP.	Harbour porpoise Minke whale White-beaked dolphin Grey seal Harbour seal	**Moderate adverse** **Minor adverse** **Minor adverse** **Moderate adverse** **Minor adverse**
Collision risk – hull impacts and ducted propellers	None	Cetaceans Grey seal Harbour seal	**Minor adverse** **Minor adverse** **Moderate adverse**
Changes in prey resource	None	Cetaceans Pinnipeds	**Minor adverse** **Minor adverse**

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