CHAPTER 13: MARINE MAMMALS

Technical Summary

Marine mammal activity at the Seagreen Project has been assessed using data from boat based surveys, seal tracking studies, aerial surveys and existing published sources. A collaborative approach has been taken with the other wind farm developers in the Firth of Forth, via the Forth and Tay Offshore Wind Developers Group (FTOWDG). The key cetacean species are harbour porpoise and bottlenose dolphin. Harbour seal and grey seal are also of particular importance due to the proximity of internationally designated haul out and breeding sites.

Noise impacts from pile driving have the greatest potential to cause a significant effect and underwater noise modelling has been undertaken to predict the range and area of potential impact on different species. The potential impacts of underwater noise which have been assessed include lethal doses and physical non-auditory injury; auditory; and changes to behaviour. During the construction of Project Alpha and Project Bravo, underwater noise from pile driving has the potential to cause significant impacts on harbour seal, but no significant impacts are predicted on the other sensitive marine mammal species identified. The impact on marine mammals from the construction and operation of the Transmission Asset Project is assessed as not significant for all sensitive species identified.

Significant cumulative impacts are predicted for harbour seal for the full Seagreen Project but no significant cumulative impacts are predicted for other marine mammal species. The potential cumulative and in-combination impacts for the Seagreen Project and other projects due to underwater noise from pile driving are predicted to be significant for harbour seal, grey seal and harbour porpoise. Significant cumulative impacts are also predicted for harbour seal, grey seal and bottlenose dolphin through changes in prey resources during construction.

All of the impact assessments upon marine mammals are considered to be very precautionary. Following further detailed design, the engineering parameters that determine the noise outputs will be refined and the impacts are expected to be less severe than predicted within this assessment. Seagreen is committed to working with Marine Scotland and the Statutory Nature Conservation Bodies to reduce these.

INTRODUCTION

13.1. This chapter of the Environmental Statement (ES) describes the existing environment and impact assessment for marine mammals within the Seagreen Project area. This chapter identifies the marine mammals with potential to be affected by the Seagreen Project and outlines the spatial and temporal distribution of marine mammals in the study area. This description draws upon data from Project specific and regional (Forth and Tay Offshore Wind Developers Group (FTOWDG)) studies, using both existing published and grey literature and original data collection.

13.2. Subsequent to characterising the baseline environment, this chapter presents the assessment of potential impacts of the construction, operation and decommissioning phases of the Seagreen Projects on the existing environment. Details of the mitigation that may be considered by the Applicants are also outlined.

13.3. This chapter incorporates results and advice from contributors including SMRU Ltd and Subacoustech Environmental Ltd. Technical reports are provided in Appendices (see Table 13.2); Appendix H1 – H8 can be found in ES Volume III: Appendices.

CONSULTATION

13.4. Issues that have been raised during consultation meetings and highlighted by the consultees in the Scoping Opinion (Marine Scotland, January 2011), are summarised in Table 13.1. This Table also outlines which Section of the chapter addresses each issue.

13.5. Consultation has been carried out at a Seagreen Project specific level and at a regional level, with the FTOWDG.

Table 13.1 Summary of consultation and issues

Date	Consultee	Issue	Relevant Chapter Section
Scoping response 17/ 02/ 2011 (Seagreen)	SNH (Scottish Natural Heritage & JNCC (Joint Nature Conservation Committee)	Bottlenose dolphin from the Moray Firth Special Area of Conservation (SAC) should be considered.	Existing Environment, Impact Assessment – Construction, Impact Assessment – Operation, Impact Assessment Decommissioning, Impact Assessment – Cumulative and In-Combination
		Noise impacts should be considered at a project-level and cumulatively with adjacent Scottish Territorial Waters (STW) developers.	Existing Environment, Impact Assessment – Construction, Impact Assessment – Operation, (Impact Assessment Decommissioning, Impact Assessment – Cumulative and In-Combination
		Noise impacts of decommissioning should be assessed as part of the EIA e.g. cuttings or explosives.	Impact Assessment Decommissioning
		Impacts need to be assessed in line with EPS legislation. Favourable Conservation Status (FCS) should be outlined in the baseline.	Existing Environment, Impact Assessment – Construction, Impact Assessment – Operation, Impact Assessment Decommissioning (Impact Assessment – Cumulative and In-Combination)
		Clarify to what extent development within Zone 2 will be considered with regards to cumulative effects assessment.	Impact Assessment – Cumulative and In-Combination
		Consider the potential cumulative noise impacts on marine mammals through effects on prey, including temporal i.e. potential impact on multiple spawning seasons with a risk to reproductive success.	Impact Assessment – Construction
		Barrier effects (particularly cumulatively) should be considered in the Impact Assessment.	Impact Assessment – Construction, Impact Assessment – Operation, Impact Assessment- Decommissioning, Impact Assessment – Cumulative and In-Combination
		Operational disturbance to marine mammals should also consider vessel movement associated with maintenance, etc., rather than just from the turbines themselves.	Impact Assessment – Operation

Date	Consultee	Issue	Relevant Chapter Section
		Thoroughly consider the draft guidance on deliberate disturbance of European Protected Species (EPS).	Assessment Methodology
	Marine Scotland	Noise assessments should take into consideration background noise. The assessment of construction noise should include all significant noise sources including vibration produced from ships' engines, piling, hammers and auguring operations during the construction of turbine foundations.	Existing Environment, Impact Assessment – Construction, Appendix H6
	Whale & Dolphin Conservation Society	Only mitigation measures that can be shown to be effective should be used.	Impact Assessment – Construction
		Special consideration should be given to meeting the Habitats Directive requirements including the Conservation Objectives for the bottlenose dolphin SAC.	Existing Environment, Impact Assessment – Construction, Impact Assessment – Cumulative and In-Combination
		Species of concern for the assessment were confirmed as harbour porpoise, bottlenose dolphin, minke whale, white-beaked dolphin, harbour seal and grey seal.	Existing Environment
Meeting 02/ 11/ 2011 (FTOWDG)	SNH and JNCC	SNH agreed that assessment of noise impacts on behaviour will be based on the 90dBht; threshold; however, for cetaceans 75dBht will be assessed if potential impacts exist.	Impact Assessment – Construction
		SNH agreed on the use of the national population estimate for harbour porpoise (based on the SCANS II data for the North Sea) as the reference population for the Impact Assessment.	Existing Environment
		SNH recommended that coastal distribution data collected by Sea Watch Foundation could be used to supplement offshore surveys.	Sea Watch data are presented in Existing Environment, but limited overlap in distribution with areas of potential impact means these data are not used in the Impact Assessment

Date	Consultee	Issue	Relevant Chapter Section
		In relation to cumulative effects on harbour seal, SNH are aware of a number of additional (in addition to FTOWDG and MOWDG) cumulative schemes; Tay Bridge Refurbishment (Transport Scotland); Victoria & Albert Museum in Dundee; Forth Bridge Replacement Crossing; Proposed Tidal Project at Montrose; Check with Local Planning Authorities for coastal schemes; Possible port redevelopment; and Seismic surveys.	Available information on the Tay Bridge engineering works, the V&A in Dundee and the tidal project in Montrose show they are scheduled to be complete by the start of the Seagreen Project installation and so these are not included in the assessment Cumulative impacts with Neart na Gaoithe, Inch Cape, Beatrice, and Moray Firth OWFs as well as in-combination with the Forth Replacement crossing and Dundee port re-development are assessed in Impact Assessment – Cumulative and In-Combination
		In relation to bottlenose dolphins, SNH confirmed that regional population should be the reference population for impact assessment but with reference back to the conservation objectives of the SAC.	Existing Environment
		More information required on the timescale for piling (individual events and the OWF as a whole). Also outlines any differences between foundation types.	Further information on the timings for piling at Project Alpha and Project Bravo is provided in Appendix H10The total duration of the pile driving phase of construction is outlines in Assessment of Impacts – Worst Case Scenario
		Present both 198 dB re 1 µPa2/s in addition to 186 dB re 1 µPa2/s for seals.	Impact Assessment – Construction
		SNH agree in the absence of a minke-whale audiogram humpback whale can be used as a proxy.	Impact Assessment – Construction
e-mail 29/03/2012 (FTOWDG)	SNH	SNH provided references which support that white-beaked dolphin in Scottish waters are part of the north west European Population.	Existing Environment
		Advice to use the harbour seal population of the east coast management unit as the reference population for this species, and will take the Tay & Eden SAC population as being equivalent to this.	Existing Environment
e-mail 30/03/2012	SNH, JNCC	The east coast management unit should also be used for Grey Seals reference population.	Existing Environment

Date	Consultee	Issue	Relevant Chapter Section
(FTOWDG)		Key area of concern for harbour seals is the impact of displacement from foraging or transit habitats during piling. Modelling work should estimate the extent of the potential noise impacts zone(s) and numbers of seals that could be using the area.	Impact Assessment – Construction, Impact Assessment – Cumulative and In-Combination
		Advice that impacts of displacement in harbour seals should be considered in the context of a population level assessment framework.	This issue is considered in the HRA
		Due to the wide ranging nature of Grey seals, the HRA process will only be applied to this species as a breeding interest (when the seals are associated with the Isle of May SAC and Berwickshire and North Northumberland Coast SAC).	This issue is considered in the HRA
		Potential risk of 'corkscrew deaths' in seals which have potentially been linked to the used of ducted propellers needs to be considered.	Issue considered but not assessed (see Assessment Methodology)
		Potential impact of disturbance to pupping and moulting seals from cable laying activities needs to be considered.	Impact Assessment – Construction
		Advice that the east coast bottlenose dolphin population is the reference population for each of the EIA, HRA and EPS licensing processes. We will take the SAC population as being equivalent to this.	Existing Environment
		The cumulative impacts of the FTOWDG and Moray Firth offshore wind farms should be considered together as the reference population for each is the same i.e. the east coast bottlenose dolphin population.	Existing Environment, Impact Assessment – Cumulative and In-Combination
		The bottlenose dolphin densities generated by SMRU Ltd (Appendix H5) are not very robust.	At the time of completing the Impact Assessment alternate density estimates are not available. However, a precautionary approach in the application of these densities is taken in Impact Assessment – Construction

Date	Consultee	Issue	Relevant Chapter Section
Meeting 02/ 04/ 2012 (FTOWDG)	SNH, JNCC, Marine Scotland (MS)	Advice on the duration of breeding seasons for harbour (1st June - 31st August) and grey seal (1st October - 31st December). Sensitivity of these species is considered greater at these times of year. No breeding season is defined for bottlenose dolphin as females may give birth at any time of the year.	Existing Environment
e-mail 09/ 05/ 2012 (FTOWDG)	SNH, JNCC	Request that 186 and 198 SEL are presented within the final assessment for seals.	Impact Assessment – Construction, Impact Assessment – Cumulative and In-Combination
Meeting 10/ 05/ 2012 (Seagreen)	JNCC, SNH	Ensure approach for calculating percentage impacts is clearly defined within mammal's assessment, including distances are areas of impact for INSPIRE contours.	Impact Assessment – Construction, Impact Assessment – Cumulative and In-Combination, Appendix H6
		Agreement that SAFESIMM should only be used for auditory injury calculations and not for calculating behavioural response numbers. Behavioural impacts can be calculated using average or spatially explicit densities overlaid with the INSPIRE contours.	Impact Assessment – Construction, Impact Assessment – Cumulative and In-Combination
		SNH and JNCC are comfortable with the considering shorter temporal displacement that 72 hours for all marine mammals.	Impact Assessment – Construction, Impact Assessment – Cumulative and In-Combination
		Advice that if a logical argument can be presented that PVA would not make a meaningful contribution to the assessment process then JNCC/ SNH would not insist that PVA is carried out.	Impact Assessment – Construction
		Advice that any assessment of population impacts for bottlenose dolphin should be carried out for the whole east coast.	This issue is considered in the HRA
		MS recommend a similar approach to that followed by the Moray developers, for assessing auditory injury and behavioural impacts, be adopted in the Firth of Forth.	Impact Assessment – Construction, Impact Assessment – Cumulative and In-Combination.
Meeting 15/ 06/ 2012 (Seagreen)	MS	MS recommended that the East coast seal management unit for shooting licenses should be used to define reference populations for the grey and harbour seal impact assessment.	Existing Environment, Impact Assessment – Construction, Impact Assessment – Cumulative and In-Combination

Date	Consultee	Issue	Relevant Chapter Section
		MS confirmed they will not be seeking PVA for Seagreen submission if studies are still outstanding that would inform PVAs.	This issue is considered in the HRA or post HRA
e-mail 15/ 08/ 2012 (Seagreen)	MS	MS would not consider the lack of a degree of significance being assigned to the issue of corkscrew seal injuries as an omission from the ES.	Assessment Methodology
e-mail 20/ 08/ 2012 (Seagreen)	JNCC, SNH	JNCC/ SNH confirmed that the ES should acknowledge the potential impact of corkscrew seal injuries, but at this stage due to the lack of detail on cause and effect of injuries full assessment is not required.	Assessment Methodology

ASSESSMENT METHODOLOGY

Study Area

13.6. The following definitions for the scale of study areas are considered for marine mammals:

- The **Immediate Study Area (ISA) -** the Seagreen Project area and the potential impact footprint boundaries, as defined by noise modelling outputs (Figure 13.1). Seagreen specific boat based surveys were focussed in the Firth of Forth Development Zone. FTOWDG data sharing and collaborative studies also provided new data information across the ISA. Methodologies for each FTOWDG study and the Seagreen specific boat based surveys are described in full, in the Technical Appendices (H1 to H9). Haul out sites in the intertidal zone, particularly around the potential land fall location of Carnoustie are also considered relevant to the ISA for seal species;
- The **Regional Study Area (RSA) -** Marine mammal connectivity with relevant Special Areas of Conservation (SACs) is considered under RSA and therefore the RSA for each species is dependent on their natural foraging range. The East Coast Management Area (ECMA) for seals is also included in the RSA (Figure 13.1). For grey seal, *Halichoerus grypus*, the Isle of May SAC and Berwickshire and North Northumberland Coast SAC are within range. For harbour seal, *Phoca vitulina*, the Firth of Tay and Eden Estuary is included in the study area, and for bottlenose dolphin, *Tursiops truncatus*, there is evidence of connectivity with the Moray Firth SAC. The East Coast Management Area (ECMA) for seals extends from Fraserburgh to the Scotland – England border and provides the relevant population boundary for harbour seals and grey seals to be used in the impact assessment; and
- The **Wider Study Area (WSA)** – the far field study area appropriately defined for the marine mammal species under consideration (e.g. European populations; Figure 13.1).

Data Collection and Survey

13.7. Key published data and Project specific surveys used within this chapter of the Environmental Statement (ES) are summarised in Table 13.2.

13.8. ECON was commissioned to undertake boat based surveys for marine mammals and birds in the Zone. Surveys were carried out from December 2009 to November 2011. A full description of the boat survey methodology is provided in Appendix F1, which can be found in ES Volume III: Appendices. SMRU Ltd was commissioned to analyse boat survey data collected between May 2010 and November 2011 (Appendix H1).

13.9. The Crown Estate (TCE) commissioned a series of aerial surveys of offshore wind farm sites during 2009 and 2010 around the UK. SMRU Ltd was commissioned by FTOWDG to evaluate (Appendix H2) and analyse (Appendix H3) data collected at the STW and Round 3 Zones within the Firths of Forth and Tay.

13.10. Boat based and aerial survey data collected across FTOWDG have been integrated to provide spatially explicit densities to inform the baseline for harbour porpoise *Phocoena phocoena*, minke whale *Balaenoptera acutorostrata* and white-beaked dolphin *Lagenorhynchus albirostris* (Appendix H7), and also for the impact assessment of harbour porpoise.

13.11. SMRU Ltd was also commissioned to collate baseline information for seals, including aerial surveys at haul out sites, diet, and telemetry data and to generate at sea densities (Appendix H4). Baseline information on bottlenose dolphin was also collated by SMRU Ltd for the FTOWDG (Appendix H5).

Table 13.2 Summary of key data and surveys

Title	Source	Data collection period	Reference
Seagreen Firth of Forth Round 3 Zone Marine Mammal Surveys	ECON, analysed by SMRU Ltd	2010-2011	Appendix H1
Assessment of The Crown Estate Aerial survey marine mammal data for the Firth of Forth development areas	SMRU Ltd	2009-2010	Appendix H2
Analysis of The Crown Estate aerial survey data for marine mammals for the FTOWDG	SMRU Ltd	2009-2010	Appendix H3
Baseline seal information for the FTOWDG area	SMRU Ltd	1997-2011	Appendix H4
Cetacean Baseline Characterisation for the Firth of Tay based on existing data: Bottlenose dolphins	SMRU Ltd	2003-2010	Appendix H5
Modelling of Noise during Impact Piling Operations at the Firth of Forth Phase 1 Offshore Wind Farm	Subacoustech Environmental Ltd	NA	Appendix H6
FTOWDG: Cetacean Survey Data Analysis Report	SMRU Ltd (DMP Statistical Solutions UK Ltd)	2009-2011	Appendix H7
SAFESIMM analysis	SMRU Ltd	2012	Appendix H8
SMRU Ltd Technical Note: Seagreen Noise Impact Assessment-quantification of animals within dBht contours using spatially explicit animal density data	SMRU Ltd	2009-2011	Appendix H9

Title	Source	Data collection period	Reference
Round 3 Firth of Forth Development Zone Pile Driving Analysis – Additional Assessment including Drive-Drill Drive Mode	Cathie Associates	2012	Appendix H10
Cetaceans of East Grampian Region	Sea Watch Foundation	1973-2010	Anderwald & Evans (2010)
Atlas of Cetacean Distribution in Northwest 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. Northwest European waters, including North Sea, Irish Sea and English Channel	1980's -2003	Reid *et al*., 2003
Small Cetacean Abundance in the North Sea and Adjacent Waters (SCANS)	Waters around north east UK and the west coast of Norway / Sweden Shipboard (890 000 km^2) and aerial line (150 000 km^2) transect surveys conducted in summer 1994 to provide accurate and precise estimates of abundance as a basis for conservation strategy in European waters	1994	Hammond *et al*., 1995, 2002.
Small Cetacean Abundance in the Atlantic and North Sea (SCANS II)	SCANS II provided the most precise broad-scale estimates of cetacean abundance in UK waters, covering over 1,350,000 km2 and over 35,000 km2 of survey track line (combined boat and aerial surveys undertaken in 2005)	2005	SCANS-II, 2008.
Special Committee on Seals (SCOS)	Scientific advice to government on matters related to the management of seal populations	1970's - 2010	SCOS, 2011

Approach to Assessment

13.12. The impact assessment follows the standard methodology as presented in Chapter 6 EIA Process in this ES and the description of the Seagreen Project as presented in Chapter 5 Project Description in this ES. The existing environment has been described using the data sources summarised in Table 13.2.

13.13. Each impact included in the assessment was identified through the consultation process (Table 13.1) and previous experience in offshore wind impact assessment. The impacts have been assessed in terms of their significance (Table 13.5).

13.14. Impacts for Project Alpha, Project Bravo and The Transmission Asset Project have been assessed during Construction (Impact Assessment-Construction), Operation (Impact Assessment-Operation) and Decommissioning (Impact Assessment-Decommissioning). Cumulative and in-combination impacts are assessed in Impact Assessment-Cumulative and In-Combination.

Worst case, most likely case and significance of impacts

13.15. Worst case and most likely scenarios are defined using information on project parameters provided in Chapter 5 Project Description. The approach to developing worst case scenarios for the assessment is detailed in full, in the Impact Assessment-Worst Case Scenario section of this chapter.

13.16. Definitions of the marine mammal receptor value / sensitivity are given in Table 13.3. The significance of the potential impacts of the Seagreen Project is based on the intensity or degree of disturbance to baseline conditions and is categorised into four levels of magnitude, high, medium, low or negligible (Table 13.4). The sensitivity of the marine mammal receptor is used in the assessment.

13.17. Table 13.5 combines the definitions of magnitude with the level of sensitivity, value and importance of the marine mammal receptor, to provide a prediction of overall significance of the potential impacts.

Table 13.3 Definition of terms relating to the value / sensitivity of marine mammal receptors

Value / Sensitivity	Definition
High	Value: Internationally / nationally important or rare with limited potential for offsetting / compensation. Sensitivity: Feature / receptor / population has very limited capacity to accommodate the anticipated impact. Individuals highly sensitive to anticipated impact.
Medium	Value: Regionally important / rare with limited potential for offsetting / compensation. Sensitivity: Feature / receptor / population has limited capacity to accommodate the anticipated impact. Individuals are moderately sensitive to the anticipated impact.
Low	Value: Locally important / rare. Sensitivity: Feature / receptor / population has some tolerance to the anticipated impact. Individuals have a comparatively low sensitivity to the anticipated impact.
Negligible	Value: Not considered to be particularly important / rare. Sensitivity: Feature / receptor / population and individuals are generally tolerant and can accommodate the proposed change.

13.18. In order to assess the value of each species, consideration should be given to the level of designation and the definition of the Favourable Conservation Status (FCS) of a species, given in Article 1(i) of the Habitats Directive.

13.19. All cetaceans in UK waters are European Protected Species (EPS) and therefore internationally important. 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. There are three parameters that determine when the FCS of a species can be taken as favourable (Article 1(i) Habitats Directive 92/ 43/ EEC):

- Population(s) of the specie(s) 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.

13.20. Harbour porpoise, bottlenose dolphin, and minke whale currently have a favourable status, while the status of white beaked dolphin is unknown (JNCC, 2007).

Table 13.4 Definition of terms relating to the magnitude of marine mammal receptors

Magnitude	Definition
High	Fundamental, permanent / irreversible changes, over the whole feature / asset, and / or fundamental alteration to key characteristics or features of the particular environmental asset's character or distinctiveness. Impact certain or likely to occur. >=10% of the reference population anticipated to be exposed to the impact.
Medium	Considerable, permanent / irreversible changes, over the majority of the feature / asset, and / or discernible alteration to key characteristics or features of the particular environmental aspect's character or distinctiveness. Impact certain or likely to occur. >=5% <10% of the reference population anticipated to be exposed to impact.
Low	Discernible, temporary (throughout project duration) change, over a minority of the feature / asset, and / or limited but discernible alteration to key characteristics or features of the particular environmental aspect's character or distinctiveness. Impact will possibly occur. >=1% <5% of the reference population anticipated to be exposed to impact.
Negligible	Discernible, temporary (for part of the project duration) change, or barely discernible change for any length of time, over a small area of the feature or asset, and/ or slight alteration to key characteristics or features of the particular environmental aspect's character or distinctiveness. Impact unlikely or rarely to occur. <1% of the reference population anticipated to be exposed to impact.

Table 13.5 Matrix for determining the impact significance

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

Approach to underwater noise assessment

13.21. The approach to investigating the potential impacts of underwater noise is outlined in Appendix H6, which details the noise propagation modelling work carried out by Subacoustech Environmental Ltd.

13.22. It is widely accepted that the main potential impact upon marine mammals from offshore wind farm development comes from underwater noise, resulting from pile driving of foundations (Wursig, 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 (Nedwell *et al*., 2007).

13.23. Underwater noise is known 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 and the distance from the sound source and noise attenuation within the environment.

13.24. Sound measurements underwater are usually expressed using the dB scale, which is a logarithmic measurement of sound. 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. Appendix H6 (Section 2.3) provides a detailed description of the measurement of underwater noise, a brief summary is provided below.

13.25. 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. Sound exposure level (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. It therefore measures the cumulative broadband noise energy. The dB_{ht} (*Species*) metric uses the different hearing sensitivities of each species to provide a scale that incorporates the concept of 'loudness' for a species. By incorporation of the sensitivity of a species to a particular sound, further consideration of the likelihood of a behavioural response in each species can be made.

13.26. The first phase of underwater noise modelling was carried out using the Simple Propagation Estimator and Ranking (SPEAR) model to consider all underwater noise generated during wind farm related activities (Appendix H6, Section 5).The model allows the significance of the wide range of noise sources to be rank-ordered for a wide range of marine mammals.

13.27. The Impulse Noise Sound Propagation and Impact Range Estimator model (INSPIRE) has been specifically developed by Subacoustech Environmental Ltd to model the propagation of impulsive broadband underwater noise in shallow waters. Physical outputs of the model include peak pressure, Impulse, SEL and dB_{ht}. Appendix H6 (Section 6) provides information on the more detailed methods used to model the propagation of underwater noise from piling, using INSPIRE.

13.28. The potential impacts of noise on marine mammals are: lethal doses (causing fatality) and physical non-auditory injury, auditory injury and behavioural responses.

Fatality and physical non-auditory injury

13.29. For the purpose of this assessment unweighted peak-to- peak sound levels are used to define the potential for gross damage to marine mammal species (see Appendix H6):

- Lethal Effect: where peak to peak levels exceed 240dB re.1µPa; and
- Physical Injury: where peak-to-peak levels exceed 220dB re.1µPa.

Auditory injury

13.30. In order to assess the effects of noise on different marine mammals frequency-weighed hearing curves have been developed. Southall *et al*., (2007) outline generalised frequency-weighting (called M-weighting) function for five species 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).

13.31. 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}); and, (5) pinnipeds listening in air (M_{pa}).

13.32. Sound exposure above certain levels and durations can result in recoverable hearing loss (called 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.

13.33. For the purpose of this assessment the 'M-weighted' sound exposure levels are used to quantify potential occurrence of PTS.

The criteria for low (M_{lf}), mid (M_{mf}) and high frequency (M_{hf}); cetaceans are:

- SEL injury criteria: 198 dB re 1 $\mu Pa^2.s^{-1}$ (M-weighted) for multiple pulses.
- the criteria for pinnipeds in water (M_{pw}) are:

- SEL injury criteria: 186 dB re 1 µ$Pa^2.s^{-1}$ (M-weighted) for multiple pulses
- SEL injury criteria: 198 dB re 1 µ$Pa^2.s^{-1}$ (M-weighted) for multiple pulses[1]

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

13.35. The accumulated exposure to sound is assessed in the INSPIRE model (Appendix H6, Section 6-5) by calculating a starting range for each marine mammal groups, whereby the receptor would be able to escape the affected areas without receiving the specified level of sound where auditory injury is expected to occur.

13.36. In addition to the M-weighted SEL metric, the 130 dB_{ht} (*Species*) perceived level is also used is the assessment to indicate traumatic hearing damage over a very short exposure time, of only a few piles at most (Appendix H6, Section 6.4).

13.37. Temporary threshold shifts (TTS) is not specifically addressed in this assessment as the biological consequences of TTS are not well understood. This type of impact by definition is short term, and recoverable. Responses to impacts are considered to be comparable to those of behavioural disturbance. Therefore, this assessment focuses on assessing the impacts of PTS and behavioural disturbance.

Behavioural response

13.38. 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. Behavioural response is assessed here using the dB_{ht} (*Species*) scale, which incorporates the perceived loudness of the sound by different species. The metric incorporates hearing ability by referencing the sound to the species' hearing threshold, and hence evaluates the level of sound a species can perceive. Behavioural response thresholds and there likely effects are shown in Table 13.6.

Table 13.6 Behavioural response thresholds

Level in dB_{ht} (*Species*)	**Effect**
0-50	Low likelihood of disturbance.
50-75	Avoidance is unlikely.
75 and above	Significant avoidance reaction by the majority of individuals but habituation or context may limit effect.
90 and above	Strong avoidance reaction by virtually all individuals.
Above 130	Possibility of traumatic hearing damage from single event.

Source: Appendix H6 (Section 3)

13.39. A summary of the thresholds used and the species considered in the assessment for noise impacts is shown in Table 13.7. The behavioural disturbance threshold of 75dB_{ht} (*Species*) is only quantified for species of cetacean in the assessment, as agreed to be appropriate during consultation (Table 13.1, Meeting 02/ 11/ 2011).

1 Following consultation (Table 13.1; Meeting 10/ 05/ 2012) it was agreed that it would be appropriate to present 198 dB re 1 µPa2.s-1 in addition to 186 dB re 1 µPa2.s-1 based on ongoing discussions on revising the threshold for seals originally proposed by Thompson & Hastie (2011)

Table 13.7 Summary of metrics and species considered in the assessment of underwater noise

Effect	Metric	Species
Fatality	240dB re 1µPa (un-weighted)	Bottlenose dolphin Harbour porpoise Minke whale White-beaked dolphin Harbour seal Grey seal
Physical non-auditory injury	220dB re 1µPa (un-weighted)	Bottlenose dolphin Harbour porpoise Minke whale White-beaked dolphin Harbour seal Grey seal
Auditory injury	130 dB_{ht}(*Species*)	Bottlenose dolphin Harbour porpoise Minke whale White-beaked dolphin Harbour seal Grey seal
Auditory injury (PTS)	198 dB re 1 $\mu Pa^2.s^{-1}$ (M_{lf}) for multiple pulses	Minke whale
Auditory injury (PTS)	198 dB re 1 $\mu Pa^2.s^{-1}$ (M_{mf}) for multiple pulses	Bottlenose dolphin White-beaked dolphin
Auditory injury (PTS)	198 dB re 1 $\mu Pa^2.s^{-1}$ (M_{hf}) for multiple pulses	Harbour porpoise
Auditory injury (PTS)	198 dB re 1 $\mu Pa^2.s^{-1}$ (M_{pw}) for multiple pulses	Harbour seal Grey seal
Auditory injury (PTS)	186 dB re 1 $\mu Pa^2.s^{-1}$ (M_{pw}) for multiple pulses	Harbour seal Grey Seal
Auditory injury (PTS)	SAFESIMM dose response curve (see Appendix H8, Figure 1)	Bottlenose dolphin Harbour porpoise Harbour seal Grey seal
Behavioural response (strong avoidance; 100% response)	90 dB_{ht}(*Species*)	Bottlenose dolphin Harbour porpoise Minke whale White-beaked dolphin Harbour seal Grey seal
Behavioural response (significant avoidance; 65% response)	75 dB_{ht}(*Species*)	Bottlenose dolphin Harbour porpoise Minke whale White-beaked dolphin

Calculating impacts

13.40. 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. In each species one or more of three approaches have been used; SAFESIMM; areas of impact overlaid on spatially explicit densities; and, areas of impact overlaid on average densities.

13.41. The scale of the impacts across the regional populations is quantified in the case of harbour seal, grey seal, and harbour porpoise using SAFESIMM (Statistical Algorithms For Estimating the Sonar Influence on Marine Megafauna; Appendix H8). In the case of harbour seal, grey seal, harbour porpoise and bottlenose dolphin, overlays of dB_{ht} contours and spatially explicit density data are also used to assess impact levels (Appendix H9). Average densities across the area of potential impact are also used in the assessment for all species of cetacean. Further information to support the approach adopted for the assessment of each species, is provided in the relevant sections of the impact assessment.

SAFESIMM

13.42. SAFESIMM is a software tool for estimating the potential effects of anthropogenic noise on marine fauna. SAFESIMM uses the M-weighted SELs for pulsed and non-pulsed sounds derived by Southall *et al*., (2007) in a series of dose-response curves (Finneran *et al*., 2005, Appendix H8, Page 6) to predict the onset of PTS. Based on these relationships the probability that an animal exposed to an SEL equivalent to the Southall *et al*., (2007) thresholds will experience PTS is 0.18.

13.43. SAFESIMM estimates the number of animals from each species that may experience PTS from a particular sound field by simulating the three dimensional movements of thousands of simulated animals through the sound field, based on the known characteristics of diving and swimming behaviour of each species, and recording the cumulative SEL of each individual. The dose response curves are then used to convert each individual's SEL to a probability that it will experience PTS.

13.44. The initial locations of individuals are chosen at random, but the density of the simulated animals is proportional to he expected density provided by location specific animal density data. In the case of pinnipeds telemetry data have been used to predict the underlying densities (Appendix H8, Figure 2 and Figure 3), and in cetaceans (where sufficient data exist) the integrated analysis of boat and aerial survey data across FTOWDG has been used (Appendix H7).

Cumulative assessment of underwater noise

13.45. In addition to identifying the potential impacts of Project Alpha, Project Bravo and the Transmission Asset Project on marine mammals separately, it is also important to consider the cumulative and in-combination impacts of the Seagreen Project, together with other existing, consented or proposed activity in the RSA. Impacts of underwater noise have been identified as the most significant issues in the assessment, and the proximity and possibility of overlapping construction of STW wind farm developments in the Firth of Forth at Inch Cape and Neart na Gaoithe with Firth of Forth Round 3 Zone 2 development lead to collaboration through FTOWDG.

13.46. FTOWDG have been working collaboratively during the consultation process (See Table 13.1) and in the collection and analysis of baseline data (e.g. Appendix H4, Appendix H5). FTOWDG working with Subacoustech Environmental Ltd gathered as much data as possible on potential mitigation methods, and noise reduction at source, and worked on the refinement of engineering parameters (Appendix H6, Section 6-6). There has also been refinement of scenarios for build programmes and the combination of most likely and worst case parameters which would be appropriate to take forward in the assessment to provide realistic data for the assessment. This includes the selection of most likely cases being taken forward in the cumulative noise propagation modelling (Impact Assessment-Cumulative and In-Combination).

Approach to corkscrew injuries

13.47. In the UK since 2008 large numbers of harbour and juvenile grey seal carcasses have been found with corkscrew like injuries. Thompson *et al.* suggest that these injuries could potentially be consistent with animals having encountered a single, rotating right-angled blade, which are thought to be caused by the seals being drawn through ducted propellers (Thompson *et al.*, 2010). However, at present there is no conclusive evidence that this is the root cause of these injuries. Most of the main construction and installation vessels are likely to use a dynamic positioning system. Ducted propellers are one of the main types of thrusters commonly used in dynamic positioning systems.

13.48. Since 2008, 27 seal carcasses with spiral lacerations have been found on beaches in eastern Scotland (including those in the RSA and Moray Firth). However, due to the possibility of carcases not being washed ashore, or being found, there is potential for a larger number of seals to be injured or killed by the same mechanism.

13.49. There is limited understanding of the factors which contribute to the level of risk to different seal species associated with ducted propellers. Given the limited available information on the number of collisions and the mechanism behind corkscrew deaths, The Applicants believe that there is an insufficient basis upon which to make an impact assessment at this juncture. This approach has been agreed during consultation with MS (Table 13.1, email 15/08/2012) and JNCC and SNH (Table 13.1, email 20/08/2012). As such, the assessment of collision risk in this chapter relates to hull impacts only.

13.50. There is research currently underway at a UK and International level to assess the nature and significance of the impact of the use of ducted propellers on seal species. Seagreen is committed to following progress on this subject and will develop mitigation based on guidance as and when it becomes available. The Applicants will continue to follow research in this area to establish whether there is a direct link between the use of ducted propellers and corkscrew injuries in harbour and grey seal.

EXISTING ENVIRONMENT

13.51. This section outlines the existing environment in relation to marine mammals in the study area defined in the Assessment Methodology section of the chapter.

Overview of species occurrence and site specific surveys

13.52. The Small Cetacean Abundance in the North Sea (SCANS) survey was a major international collaborative survey program carried out to provide baseline data on cetacean abundance in the North Sea, Baltic and Celtic Seas (Hammond *et al.*, 1995; 2002). The first SCANS project took place in the early 1990's and the SCANS II project, which aimed to update these estimates, took place in 2005. SCANS and SCANS II data show harbour porpoise, minke whale and white beaked dolphin have significant presence within the RSA.

13.53. White sided dolphin *Lagenorhynchus acutus* has also been recorded in a small number of locations. Bottlenose dolphin and Risso's dolphin *Grampus griseus* are shown in a low number of locations within the WSA (SCANS-II, 2008). Reid *et al.*, (2003) show that rare or occasional visitors to the RSA also include killer whale *Orcinus orca*, common dolphin *Delphinus delphis*, and pygmy sperm whale *Kogia breviceps*.

13.54. The RSA encompasses haul out sites for both harbour and grey seal, and use of the offshore waters of the ISA and RSA by these species is known from published telemetry data (e.g. Sharples *et al*., 2008; Thompson & Duck, 2010).

13.55. Seagreen specific boat based surveys covering the Zone (Appendix H1), recorded sightings of grey seal, harbour seal, harbour porpoise, white-beaked dolphin, minke whale and one white-sided dolphin sighting (Plot 13.1).

13.56. No bottlenose dolphin were recorded during the boat based surveys, however, evidence outlined in Appendix H5 (which provides detailed baseline information for bottlenose dolphin in the RSA) shows that bottlenose dolphin from the Moray Firth SAC use the coastal area within the ISA (specifically the inshore portion of the Transmission Asset corridor).

13.57. RSA aerial surveys (Appendix H3, Table 2 & Table 3) in inshore (within 12nm) waters added common dolphin (one individual) and killer whale (one individual) to list of species sighted during the boat based surveys. Offshore (outside 12nm) sightings added long-finned pilot whale (eight individuals in one sighting) to the species list.

13.58. As only one white sided dolphin was recorded during the Seagreen specific boat based surveys (Table 3, Appendix H1), a single killer whale and a single common dolphin during the wider aerial surveys as well as one group of eight long-finned pilot whales (Appendix H3, Table 2 & Table 3), these species have not been taken forward in the assessment. Their presence is deemed to be too infrequent for them to be affected by the Seagreen Project. Due to the low likelihood of occurrence, and no sightings during the Seagreen-specific boat or aerial surveys, Risso's dolphin and pygmy sperm whale are also not considered in the assessment.

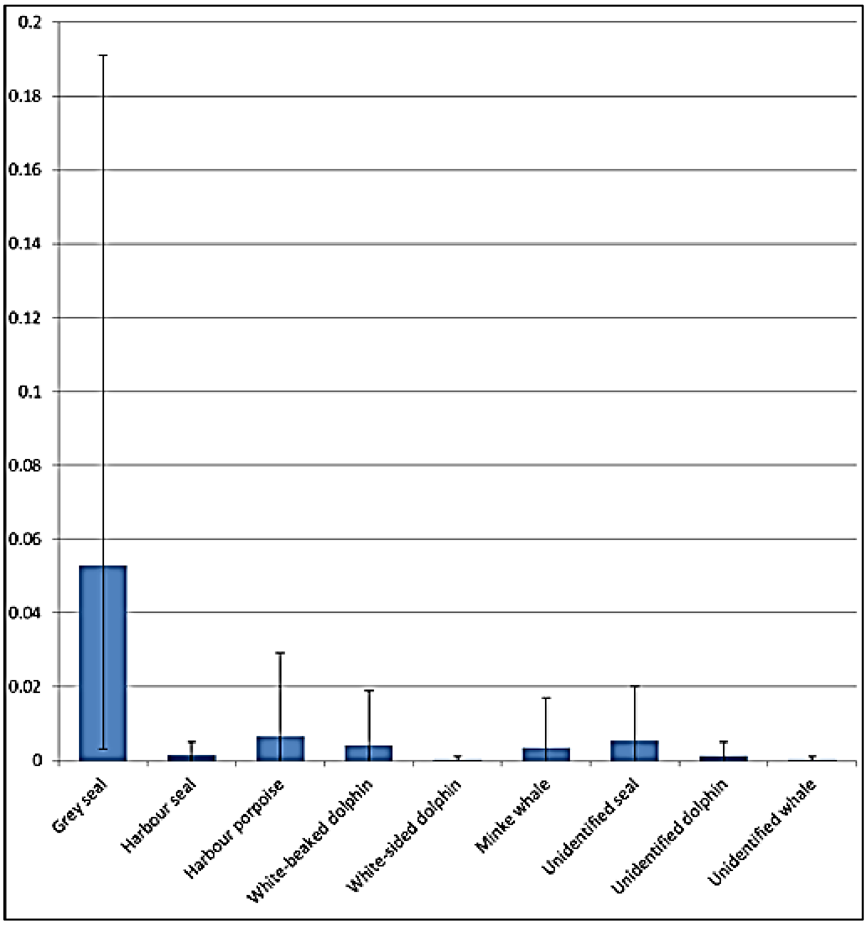
13.59. Based on the available literature, as well as the RSA specific surveys, harbour porpoise, bottlenose dolphin, minke whale and white-beaked dolphin are considered to be the key cetacean species in the RSA, and are therefore considered further in the impact assessment. The potential impacts on harbour and grey seal are also assessed. These species of concern were agreed during consultation (Table 13.1, Meeting 02/ 11/ 2011).

13.60. During The Crown Estate (TCE) aerial surveys and Seagreen-specific boat based surveys there were a large number (1,513) of sightings unidentified to species level. Numbers of unidentified sightings have not been taken forward in the densities used in the assessment process.

Pinnipeds

13.61. Harbour and grey seal are both of particular relevance in the RSA due to the presence of key breeding and haul out sites in the vicinity. Baseline seal information for the FTOWDG area is provided in Appendix H4 for seals in the ISA, RSA and WSA. The baseline is based on existing telemetry data (collected since 1988 for grey seal and from 2001 for harbour seal), and population trends from aerial survey data from annual grey seal breeding survey in the autumn, August (harbour seal moult) surveys and occasional June or July (harbour seal breeding surveys. Information is also provided on basic biology and diet of these species. A summary of the key information is presented below.

Plot 13.1 Total sighting rates of each marine mammal species during the boat based surveys of the Seagreen Zone. Error bars show the range in monthly sighting rates.



Source: Table 5 Appendix H1

Harbour seal

13.62. Harbour seal has a circumpolar distribution and is widespread throughout the Northern Hemisphere. Around 4% of the world's harbour seals are found in the UK, with approximately 80% of the UK's harbour seal population is located in Scotland (Defra, 2010).

13.63. Harbour seal use haul out sites throughout the year, but greatest concentrations onshore are seen during the summer months when breeding (June and July) and moulting (August). In the UK, routine surveys of harbour seal are conducted during the annual moult.

13.64. In the RSA, the main haul out sites for harbour seal along the Angus, Fife and Lothian coasts represent approximately 2% of the Scottish population (Appendix H4, Page 11). The greatest concentrations of harbour seal within the region are counted within the Firth of Tay and Eden Estuary (Figure 13.1). Appendix H4 (Figure 12) shows haul out sites in the Firth of Tay, at Tentsmuir Point, these are approximately 7km from the Carnoustie landfall.

13.65. Harbour seal are a primary reason for the selection of the Tay and Eden Estuary SAC (as an Annex II species under Council Directive 92/43/EEC on the conservation of natural habitats and of wild flora and fauna (the 'Habitats Directive')). The SAC is approximately 48km and 51km from Project Alpha and the Project Bravo, respectively.

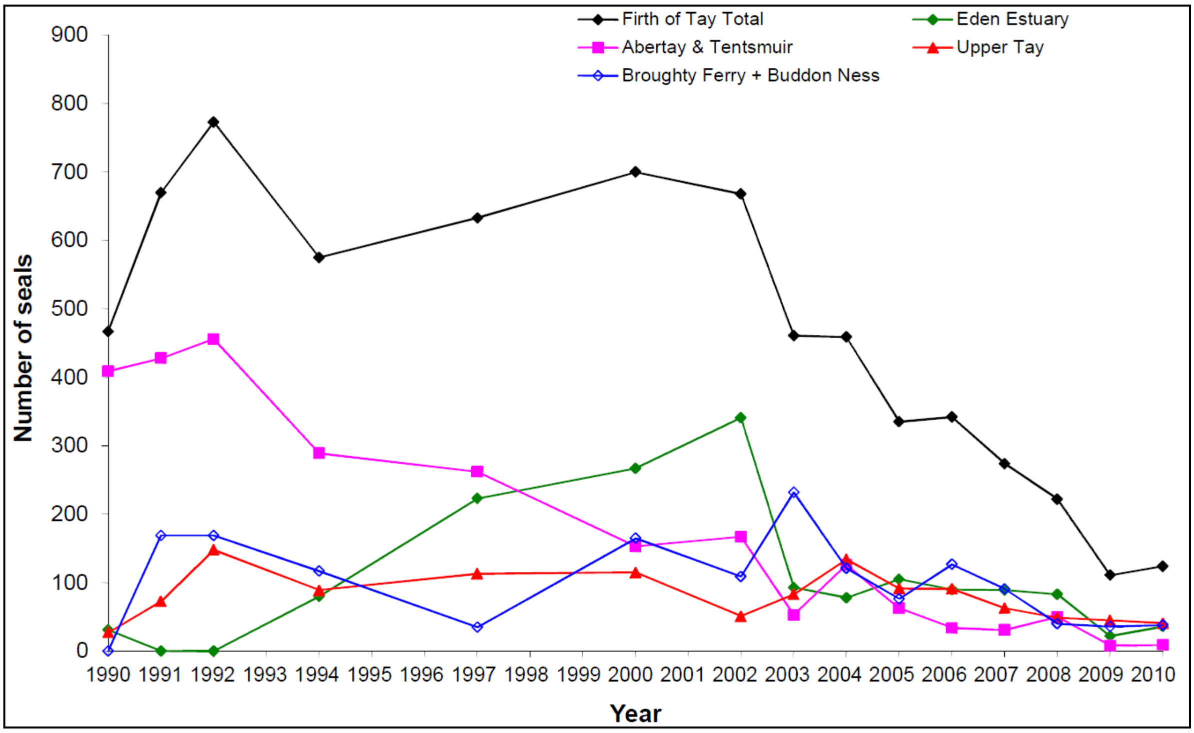
13.66. In the UK, adult harbour seal generally forage within approximately 60km of their haul out sites (e.g. Thompson *et al*., 1996) and therefore the Tay and Eden Estuary SAC is considered within the RSA. The tracks of tagged harbour seal show strong links between the Zone and the Tay and Eden Estuary SAC (Appendix H4, Figures 13-17).

13.67. Harbour seal numbers in the RSA have been declining since the early 2000s (Plot 13.2). The Firth of Tay population has declined by around 85% over the last 10 years (SCOS, 2011). The cause of these local declines is not yet known, but possible causes include; disease, killer whale predation, competition with grey seals, declines in important prey species and anthropogenic mortality. Investigations into some of these factors are continuing (SCOS, 2011), but it is likely that the declines are multifactorial and that the causes might be different in different areas (Appendix H4, Page 11). Other sub-populations around the UK have had variable rates of change with Shetland, Orkney and the Outer Hebrides also declining, the east coast of England population increasing, and the Moray Firth and west Highlands remaining stable (Lonergan *et al*., 2007; SCOS, 2011).

13.68. Recent[2] surveys of harbour seal haul out sites are used by SCOS (2011) to provide population estimates of 148 for the Border to Fife Ness and 241 for Fife Ness to Fraserburgh (equivalent to the Marine Scotland ECMA) established for the management of seal shooting licences. The most recent estimate for the Firth of Tay and Eden Estuary SAC population is 172 (95% Confidence Interval (CI) 141-230), based on corrected haul out counts from 2010 (Appendix H4, Table 1).

13.69. The reference population for the impact assessment is taken from the ECMA population of 540 harbour seal (95% CI 442-720). This is calculated from the corrected haul out counts from 2010 and 2007 combined across the ECMA using the correction factors outlined in Lonergan *et al*., (2011a).

Plot 13.2 Counts of harbour seals in the Firth of Tay and Eden Estuary SAC



Source: SCOS, 2011

2 2007 for the Border to Fife Ness; 2007 and 2010 for Fife Ness to Fraserburgh.

13.70. The Sea Mammal Research Unit (SMRU) has deployed telemetry tags on harbour seal in the UK since 2001. Data have been collated for all deployments on adult harbour seal up to 2011 where tracks have entered RSA (Zone boundary and a buffer extending to 100km from the Zone (Appendix H4, Page 34). A total of 31 animals had at sea locations within the RSA.

13.71. Appendix H1 (Figure 19) shows one harbour seal sighting during the boat based survey within the Project Alpha area and two in the Project Bravo area, with an additional sighting on the boundary between Project Alpha and Project Bravo. Boat based surveys show that harbour seal were seen in low numbers during most months in 2010, with the only exceptions being October and November when no harbour seal were recorded. Harbour seal sightings were lower in 2011 than 2010 and no harbour seal were recorded in February or April to August 2011 (Appendix H1, Figure 13). Highest encounter rates were in May 2010 and Sept 2011 at 0.005 sightings per km^2. Harbour seal sightings at sea are expected to be reduced during June and July when they haul-out for breeding and in August when they moult. When pooled by season, encounter rates are lowest in winter, second lowest in summer and highest in spring and autumn (Appendix H1, Figure 14). A number of seals were recorded during the aerial surveys, the majority of which were not identified to species (Appendix H3, Table 2 and Table 3).

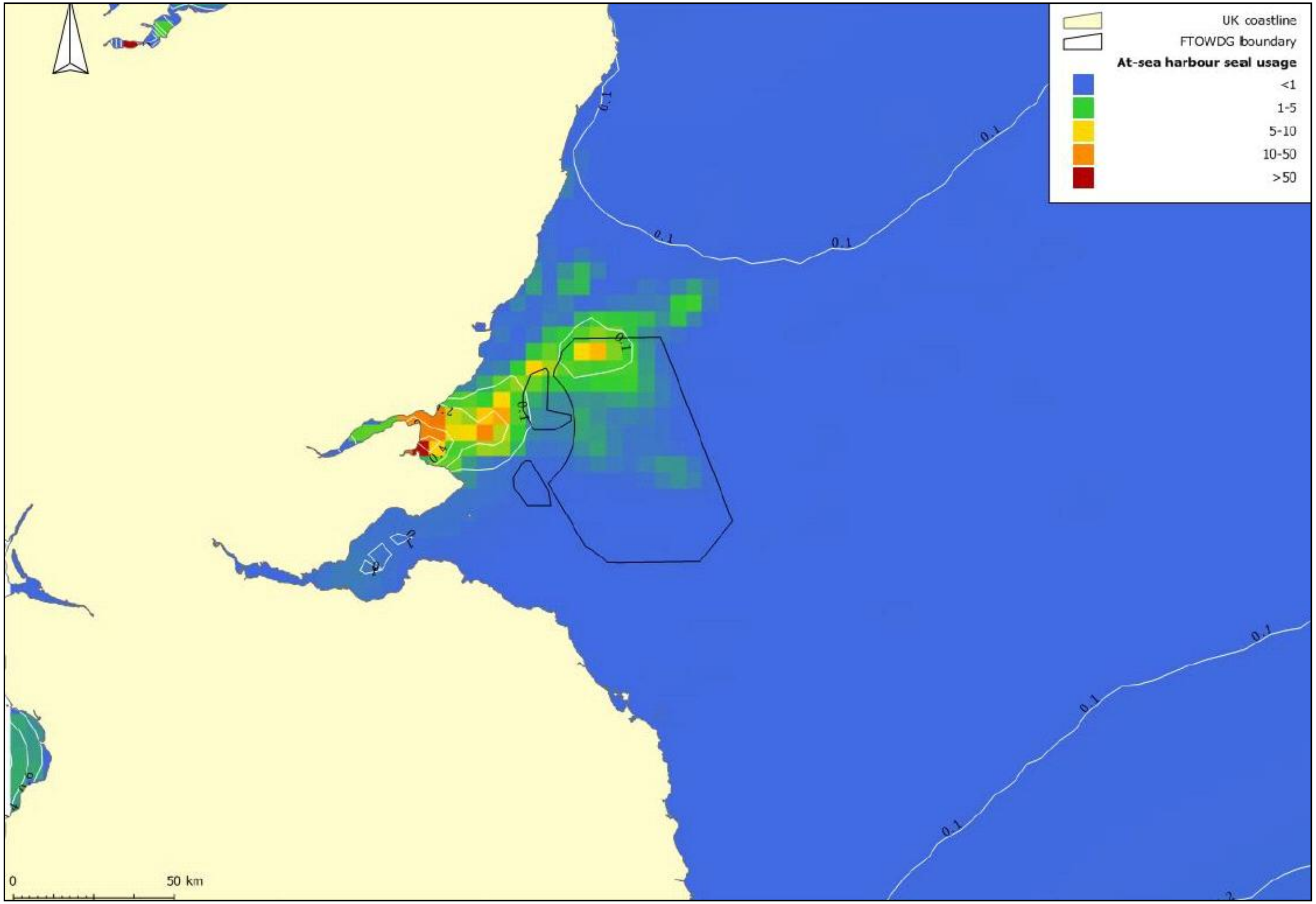
13.72. Telemetry data (Plate 13.1 and Appendix H4) confirm harbour seal usage of the ISA including both the Project Alpha and Project Bravo, but show higher density (around 10 harbour seals per $5km^2$ cell) to the north west of Project Alpha, with the rest of the Project Alpha area at around one to five individuals per $5km^2$. Project Bravo is shown to have less than one harbour seal per $5km^2$ in the eastern extent and up to five harbour seals per $5km^2$ towards the western boundary. These spatially explicit densities will be used in the quantitative noise impact assessment.

13.73. The harbour seal concentrations to the north of the ISA represent association with Scalp Bank and the parallel concentrations of sightings running approximately north north-west through the ISA follow the Marr Bank and Wee Bankie, with another slight concentration in the south east corner of the Zone at Berwick Bank. The telemetry data also show that there is variation in areas of high density at sea locations between years. The data have been presented for seals tagged in 2011 in Appendix H4 (Figure 17); whereas data collected between 2001 and 2008 are presented in Appendix H4 (Figure 15). In the earlier years the location of low speed locations, which are likely to represent foraging activity, are more dispersed than the 2011 tagging deployment. In 2011 the main concentration of offshore activity is at Wee Bankie. The occurrence of high density areas or low speed locations is associated with foraging, which is predominantly driven by prey availability.

13.74. Sandeels were the dominant prey species found in the diet of harbour seal in the region; however, spatial variation was evident throughout the region with salmonids the dominant prey type in the Tay in spring and summer, while diet in St Andrews Bay was dominated by sandeels in all seasons (Sharples *et al.*, 2009). Appendix H4 (Page 49) provides more detail on prey species for harbour seal in the RSA. Chapter 12 Natural Fish and Shellfish Resource provides information on the existing environment for fish species. The Wee Bankie sandbank is a key habitat for sandeels in the RSA (Daunt *et al.*, 2008). As discussed above, the Wee Bankie area had high densities of harbour seals and is therefore expected to be an important offshore foraging location.

13.75. At the end of Existing Environment section of this chapter, Table 13.10 provides a summary of the key information to be used to assess the impacts of Project Alpha, Project Bravo and the Transmission Asset Project on harbour seal.

Plate 13.1 Estimated harbour seal at-sea usage around the FTOWDG proposed development areas (See Appendix H4 for more information and estimates of uncertainty



Source: ES Plate Ref – modified manually with no indent

Grey Seal

13.76. 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 Sea. Around 36% of the world's grey seal are found in the UK, with 90% of the UK's grey seal located in Scotland (Defra, 2010).

13.77. Breeding and pupping in grey seal occurs during October to December along the east coast of the UK. During these months, the number of seals at sea might be expected to be low, as a large proportion of the population will be hauled out to breed.

13.78. There are two major grey seal breeding sites in the ECMA; The Isle of May and Fast Castle (in the Berwickshire and North Northumberland Coast SAC; Figure 13.1). Seals breeding at the Isle of May and Fast Castle represent approximately 10% of the total Scottish population (Appendix H4, Page 18). A small number of pups are also born on other islands within the Firth of Forth (Forth Seabird Group, 2008). Grey seal also use haul out sites within the RSA throughout the year for resting between foraging trips and moulting. Appendix H4 (Figure 9) shows a major summer haul out site approximately 5km to the south of the Carnoustie landfall location around Abertay Sands.

13.79. The size of the UK grey seal population can be estimated using a combined analysis of pup production and counts during August moult surveys (Thomas, 2011), but can also be estimated using the August counts alone (Lonergan *et al*., 2011b) combined with a haul out probability, similar to the approach used for harbour seal.

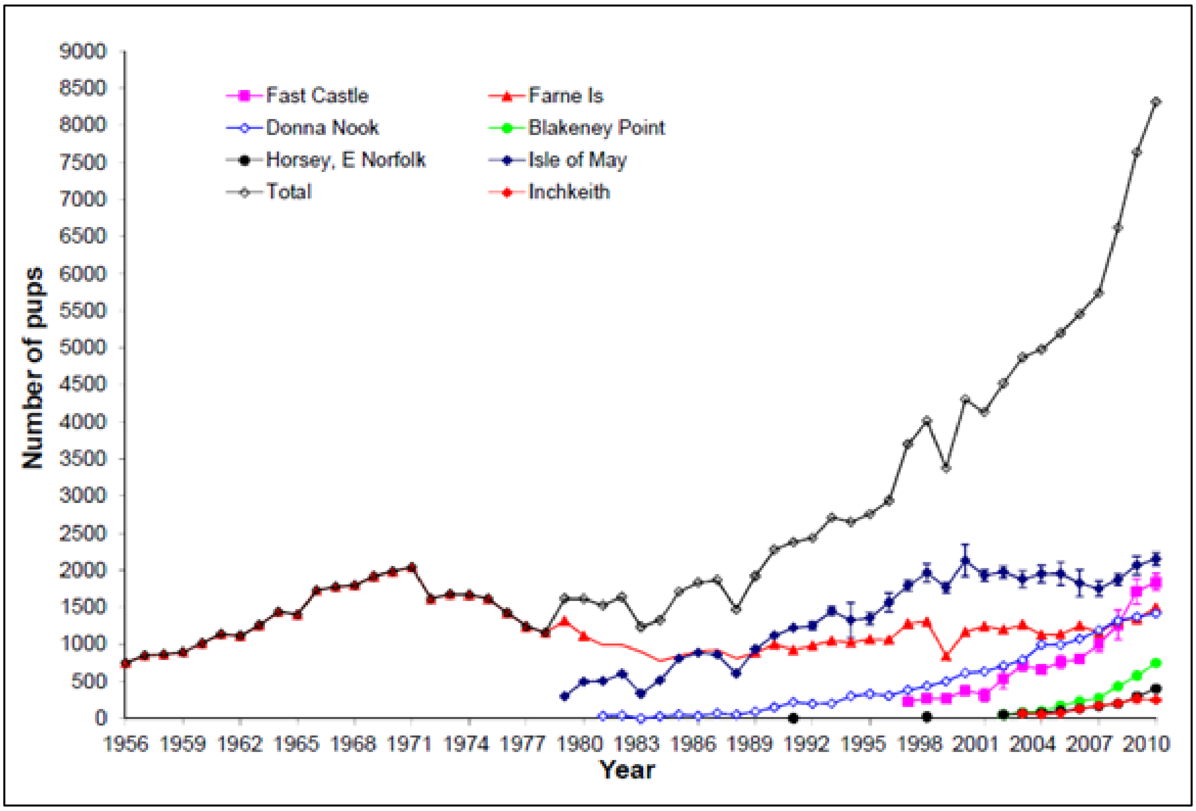
13.80. The most recent (2010) estimate of pup production in the regularly surveyed North Sea breeding colonies (Isle of May, Fast Castle, Inchkeith, Farne Islands, Donna Nook, Blakeney Point and Horsey) is 8,314 (Duck & Morris, 2011). The Isle of May, Fast Castle and Inchkeith & Craigleith colonies constitute approximately half of these, at 4,249. In addition, a number of pups are also born on small islands within the Firth of Forth; the most recent estimate was 53 (Duck & Morris, 2011).

13.81. Pup production has been increasing in the RSA each year since at least 1999, up to the last published counts in 2010, particularly at Fast Castle and the Firth of Forth Islands (Plot 13.3). Pup production at the Isle of May, Inchkeith and Fast Castle increased by 5% between 2009 and 2010 (SCOS, 2011).

13.82. The ECMA area is used by the Scottish Government to calculate Potential Biological Removal (PBR) which supports the issuing of licences to shoot seals and will be considered in the impact assessment as the reference population as agreed during consultation with SNH, JNCC and Marine Scotland (Table 13.1, Meeting 02/04/2012 and 15/06/2012). However, it should be noted that this is not likely to be a realistic biological population unit as individuals tagged within this region range further (Appendix H5, Figure 7 and Figure 10). Furthermore advice to the Government in the form of the Special Committee on Seals (SCOS, 2011) states all of the North Sea colonies are one reference population unit. This is based on historical trends in the rate of pup production at colonies within the North Sea, on timing of birth, and also information on the movements of tagged animals while at sea (such as data presented in Appendix H4, Page 30).

13.83. The use of the ECMA as a reference population effectively removes the Farne Island seal colony from the EIA assessment. It should be noted that project specific considerations of the potential impact of the Seagreen development on the Berwickshire and North Northumberland SAC will be required within the HRA which follows this ES.

Plot 13.3 Grey seal pup production at North Sea colonies



Source: SCOS, 2011

13.84. The size of the grey seal population at the start of the 2010 breeding season was estimated with a Bayesian state-space model using these estimates of pup production, and an independent estimate of population size (Thomas, 2011). Two estimates of the size of the grey seal population have been produced, one assuming a fixed co-efficient of variation (CV) in the pup production estimate, and one allowing the CV to be estimated. The North Sea population (from regularly monitored colonies) was estimated to be 19,100 (95% Credibility Interval 14,000-26,500), and 19,400 (95% Credibility Interval 14,100-28,300) respectively. The fixed CV estimate was used by SCOS (2011) to estimate the total size of the British Grey seal population in 2010 of 111,300 (95% Credibility Interval 90,100-137,700).

13.85. In addition to the 19,100 (14,000-26,500) North Sea population estimate (from the regularly monitored North Sea colonies), pup production on the Firth of Forth Islands can be used to estimate the population associated with these colonies by using the ratio of estimated population size derived from the Thomas (2011) model. This gives an additional population of 120 (99-148) seals, giving a total estimate for the North Sea of 19,220 (14,099-26,648).

13.86. Using the same average ratio of pup production to population size, we can estimate the size of the population in the ECMA based on pups born at Fast Castle, Inchkeith, and the Isle of May (a total of 4,249 (Duck & Morris, 2011) and pups born at less regularly surveyed islands and small breeding sites in the Firth of Forth. This provides an ECMA population estimate of 9,740 (95% Credibility Interval 8,036 – 12,011).

13.87. Lonergan *et al.*, (2011b) provide an estimate of the size of the North Sea grey seal population using August counts of 31,300 (95% Confidence Interval (CI) 22,900-44,000). This is based on the 2008 count of 9,407 seals. The estimated size of the total UK grey seal population using this approach is 88,300 (95% CI 75,400-105,700). Using the ratio of estimated population size to seals counted over the North Sea area (Lonergan *et al.*, 2011b, Table 2), we can calculate a ECMA population estimate of 7,739 (5,657-10,869) based on a haul out count of 2,324 in 2007 (Appendix H4, Table 6).

13.88. The different estimates of population size for the UK, ECMA (RSA) and North Sea (WSA) are summarised in Table 13.8.

13.89. Tagging of grey seal from the Farne Islands shows that these animals use the Project Alpha and Project Bravo ISA, including the ECR corridor. Use of the ISA and RSA by seals tagged at the Farne Islands (Appendix H4), suggests this breeding and haul out site should be considered. In total these sites represent 12% of the UK pup production.

13.90. Grey seal are a primary reason for site selection of the Isle of May SAC and Berwickshire and North Northumberland Coast SAC. Project Alpha and Project Bravo are 53km and 55km, respectively from the Isle of May SAC and 65km and 67km from the Berwickshire and North Northumberland Coast SAC. Thompson *et al*., (1996) reported a foraging range of up to 145km for grey seal and so these SACs are considered within the RSA.

13.91. For the purpose of this assessment the likely impacts will be presented with reference to the minimum and maximum estimates of population size for the ECMA based on the lower and upper confidence bounds of the Thomas (2011) or Lonergan *et al*., (2011b) approach depending on which is lower or higher (as shown by the 'Range' column in Table 13.8). This allows uncertainty in the estimation of the grey seal population size to be incorporated in the assessment.

13.92. The Seagreen Firth of Forth Round 3 Zone Marine Mammal Survey Report (Appendix H1) shows grey seal sighting rates during the boat based surveys were lowest over the autumn and winter. Overall, encounter rates were reduced in 2011 compared to 2010 (Appendix H1, Figure 11). Grey seal were seen in every month of the boat based survey, but encounter rates were highly variable between months, with highest encounter rates in June in both years (Appendix H1, Figure 11). This may be a result of grey seal spending a period of intense foraging at-sea, to build energy reserves prior to the breeding season.

13.93. SMRU has deployed telemetry tags on grey seal in the UK since 1988. Ninety-two of the tagged adult grey seal entered a buffer of 100km around the Seagreen Project area (Appendix H4, Figure 7). Thirty grey seal pups tagged at breeding colonies had locations within the buffer (Appendix H4 Figure 10). Grey seal recorded within the Zone are associated with a number of sites along the east coast of England and Scotland.

13.94. Appendix H4 (Figure 19) shows grey seal locations have been recorded over the whole of the Project Alpha area. The sightings in Project Bravo are most numerous to the west, with few sightings to the offshore extent of the Project Bravo.

13.95. As with harbour seal, grey seal sightings were concentrated to the north of the Zone (Scalp Bank) and on two parallel concentrations of sightings running approximately north north-west through the ISA, following Marr Bank and Wee Bankie, with another concentration in the south east corner of the ISA (Berwick Bank; Plate 13.2). These areas are thought to be important areas for sandeels, an important part of grey seal diet in the region (Hammond & Prime, 1990; Hall *et al*., 2000; Hammond & Grellier, 2006).

13.96. Spatially explicit density estimates (Plate 13.2) have been used in the quantitative noise impact assessment carried out using SAFESIMM. These density estimates have been calculated using a combination of telemetry data and haul out counts, following methods developed by Matthiopoulos *et al*., 2004 (Appendix H4, Page 40)

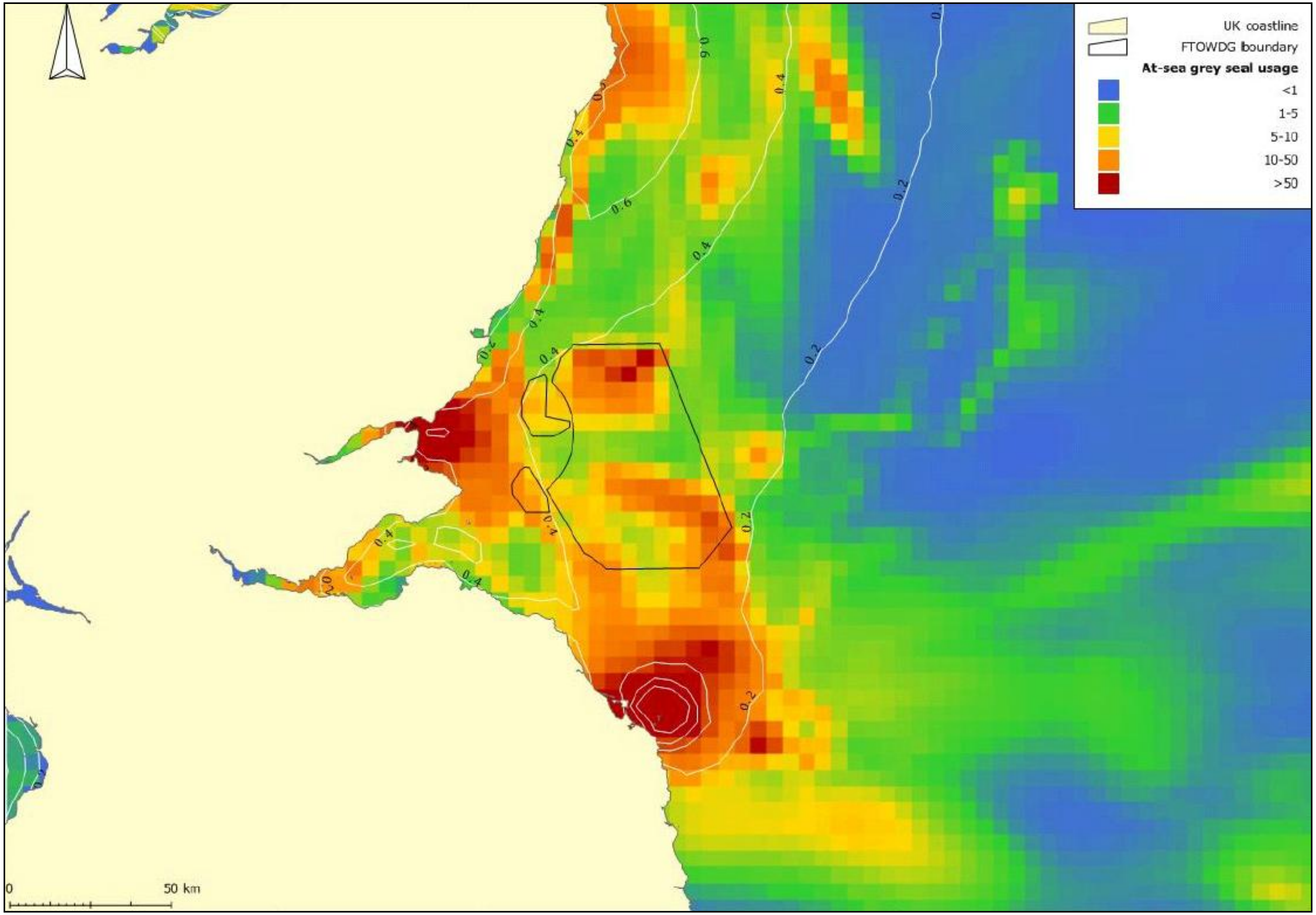
13.97. There have been changes to the diet of grey seal in the central North Sea over the last three decades, with increasing reliance on sandeels and a general trend towards the consumption of smaller prey (see Appendix H4, Page 45). As discussed in the harbour seal section and Chapter 12 Fish and Shellfish Resource, the Wee Bankie sandbank is an important habitat for sandeels and, as with harbour seal, the Wee Bankie has high numbers of grey seals and so is likely to be an important foraging area.

13.98. Table 13.10, at the end of this section, provides a summary of the key information to be used to assess the impacts of Project Alpha, Project Bravo and the Transmission Asset Project.

Table 13.8 Summary of the estimated size of the grey seal population to be used in the assessment

Population	Thomas, 2011 (2010 data)	Lonergan et al., 2011b (2007-2009 data)	Range (min-max)
ECMA (ISA)	9,740 (8,036-12,011)	7,739 (5,657-10,869)	5,657-12,011
North Sea (ISA/ RSA)	19,220 (14,099-26,648)	31,300 (22,900-44,000)	14,099-44,000
UK (WSA)	111,300 (90,100-137,700)	88,300 (75,400-105,700)	75,400-137,700

Plate 13.2 Estimated grey seal at-sea usage around the FTOWDG proposed development areas (See Appendix H4 for more information and estimates of uncertainty).



Cetaceans

13.99. Appendix H1 (Seagreen Firth of Forth Round 3 Zone Marine Mammal Surveys) and H3 (Analysis of The Crown Estate aerial survey data for marine mammals for the FTOWDG) provide information on sightings of marine mammals during Seagreen specific boat based and aerial surveys. In species where sufficient sightings were made (harbour porpoise, minke whale and white-beaked dolphin), spatially explicit density surfaces have been generated (Appendix H7, FTOWDG: Cetacean Survey Data Analysis Report). Further information specially relating to bottlenose dolphin is provided in Appendix H5 (Cetacean Baseline Characterisation for the Firth of Tay based on existing data: Bottlenose dolphins).

13.100. The following sections provide an overview of the key data presented in these Appendices, which should be read in conjunction with this chapter. Further information is also provided on the definitions of reference populations, densities used in the assessment, as well as any relevant information about the species life history.

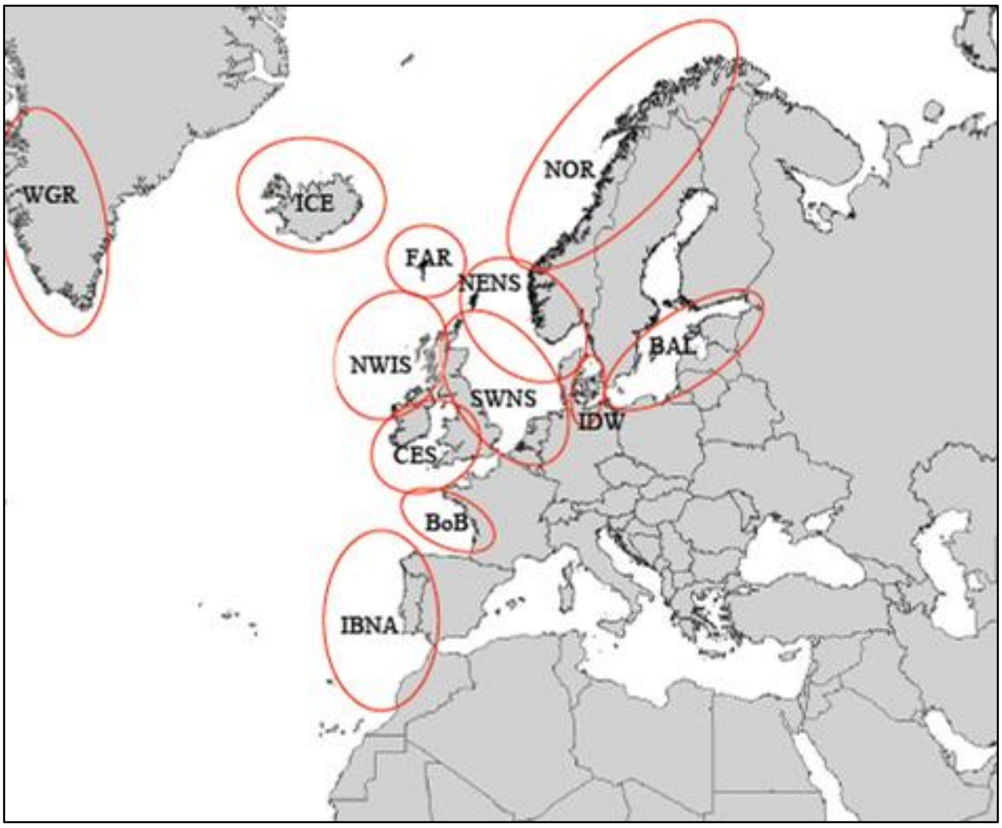
Harbour porpoise

13.101. Harbour porpoise is the most common cetacean in the North Sea (ASCOBANS, 2012) and were the most frequently recorded cetacean during the Seagreen boat based surveys and aerial surveys (Appendix H1, Page 7, and H3, Page 5).

13.102. 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 ISA is encompassed by the South-western North Sea & Eastern Channel (SWNS) management unit, with the WSA encompassing the North-eastern North Sea & Skagerrak (NENS) unit just to the north and east (Plate 13.3).

13.103. Breeding occurs mainly between May and August, with a peak in June, though some calves can be as early as March. Social groups often gather in late summer (August-September) for mating (Anderwald & Evans, 2010). The gestation period of the harbour porpoise is ten months, with peak mating activity 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 twelve months. Weaning is a gradual process with young starting to take solid food after a month or two (Seawatch Foundation, 2011).

Plate 13.3 Recommended management units for harbour porpoise in the ASCOBANS agreement area and Environs.



Source: Evans *et al*., 2009

13.104. SCANS estimated the harbour porpoise population of the North Sea was between 210,000 to 340,000 individuals in the summer of 1994. SCANS II (2005 survey) estimated the North Sea harbour porpoise population to be 335,000, indicating that the population had not changed significantly between 1994 and 2005 (SCANS-II, 2008). The Southern North Sea Population was estimated to be 134,434, with a European wide population of 385,617 (95% CI 261,266 to 569,153).

13.105. For the purpose of this assessment the reference population is the North Sea, based on the combined management units of the SWNS and NENS (Plate 13.3). The population estimate for the North Sea is 385,617 (95% CI 261,266 – 569,153), which is derived from the 2005 SCANS II survey.

13.106. As part of the SCANS II survey analysis, model-based estimates of harbour porpoise abundance were obtained by fitting a General Additive Model (GAM) -based density surface 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/ km^2) on a two minute grid (i.e. ~8.15km^2). Plate 13.4 shows the latest North Sea harbour porpoise surface densities derived from the SCANS II dataset (SCANS-II, 2008). A southern shift in density is shown in 2005 compared to 1994 with relatively low density estimates around Project Alpha and Project Bravo in 2005 of between 0.3 and 0.6 animals per km^2. The reason for this shift is unknown although a change in distribution and availability of prey species is considered the most likely cause (SCANS-II, 2008).

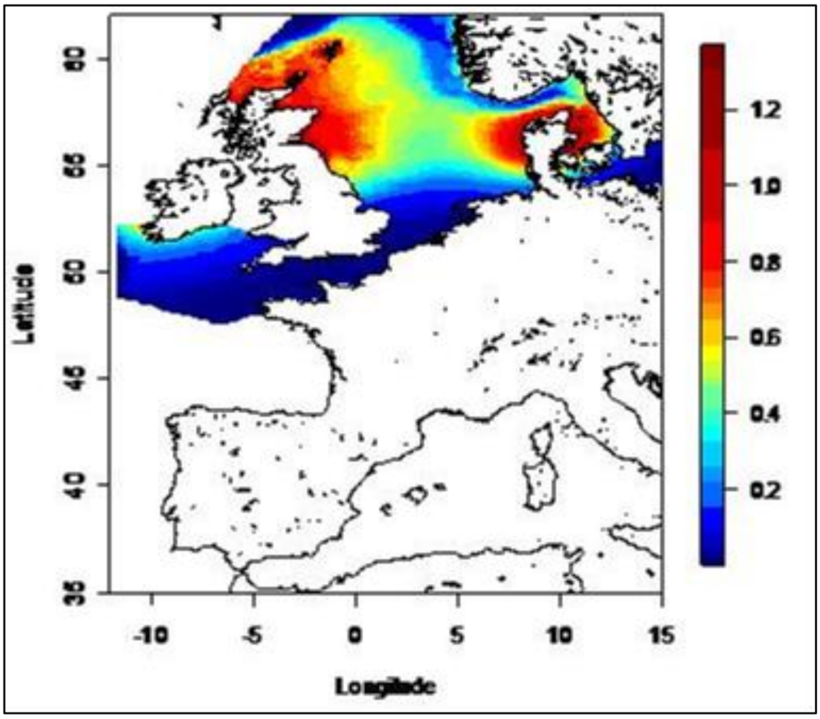
13.107. Despite the change in distribution, SCANS and SCANS II surveys show no significant change in the population between 1994 and 2005 (SCANS-II, 2008).

13.108. The main diet of porpoise is small fish (usually less than 40 cm length) such as juvenile herring, sprat, sandeel, whiting, saithe, and pollock. Although particularly in winter months, prey such as dab, flounder, sole, and cod are taken (Anderwald & Evans, 2010).

13.109. RSA sightings have been collated by Anderwald & Evans (2010) and are shown in Plate 13.5. Harbour porpoise are recorded in all cells which were surveyed along the coast from the Firth of Forth to the Moray Firth. They found that sighting rates per unit effort both from boat and land-based surveys up to 2010 were much lower during the 1990s than the early 2000s but since 2004 they have declined again. Over time the mean number of sightings per year has shown no sustained trend but instead exhibited more or less regular fluctuations.

Plate 13.4 Harbour porpoise estimated density surface (animals per km^2) in (a) 1994 and (b) 2005 (SMRU, 2006)

(a) 1994



(b) 1995

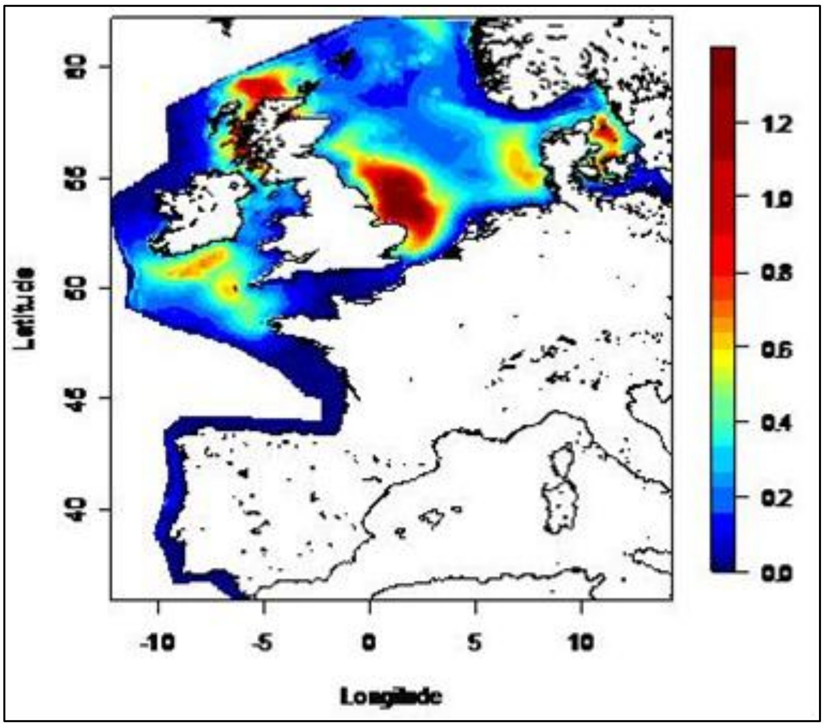
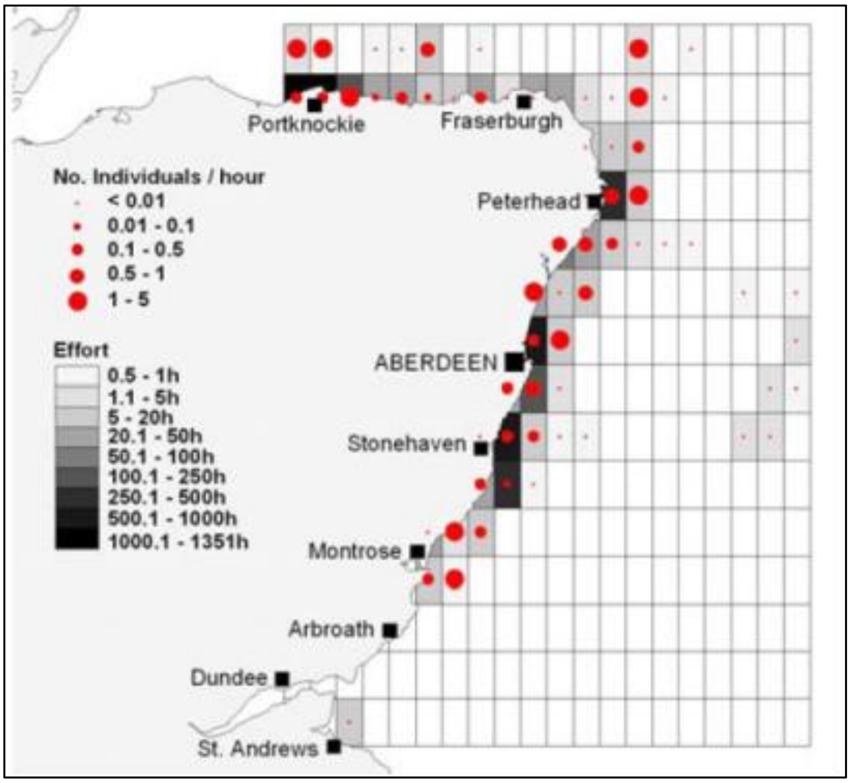


Plate 13.5 Number of harbour porpoise per hour of survey effort



Source: Anderwald & Evans, 2010

13.110. Seagreen specific boat based survey data presented in Appendix H1 (Figure 15) show increased sighting rates and some larger pod sizes within Project Alpha compared to Project Bravo. However, the sightings were widely distributed with concentrations in the northern part of the ISA around Scalp Bank and in the central and southern parts of Marr Bank. Sightings were most common in the northern part of the ISA in the summer and more central and southerly in the spring (Appendix H1, Figure 20).

13.111. Boat based sightings of harbour porpoise were made in all months, apart from June 2010, November 2010, May 2011 and October 2011 (Appendix H1, Figure 4). Generally encounter rates were highest in the spring and summer and relatively low in autumn and winter. Overall, encounter rates during the boat based surveys were reduced in 2011 compared to the previous year's surveys, but this pattern is driven mainly by a high sightings rate in May 2010.

13.112. During the 2009 and 2010 TCE aerial surveys the greatest number of harbour porpoise (31 out of 50) were recorded during the summer (Appendix H3, Page 5). Anderwald & Evans (2010) also provides confirmation of peaks in sightings of harbour porpoise in summer months.

13.113. Appendix H3 (Table 6) provides density estimates for harbour porpoise of 0.08 individuals per km^2 based on TCE aerial surveys from 2009 to 2010. Summer density estimates were calculated to be 0.099 individuals per km^2, and winter 0.048 individuals per km^2. These density estimates are minimum estimates based on inherent negative bias due to the survey methodology (see Appendix H2, Page 4). In addition to the negative bias in the survey methods, the large numbers of unidentified small cetaceans in the report are likely to be harbour porpoise, and if included in the estimates would increase the density.

13.114. SCANS II surveys provide a higher density estimate of 0.294 individuals per km^2 for the block which included the area covered by TCE surveys (Appendix H2, Table 7), and in which the Projects are located.

13.115. In addition to the average density estimates generated from TCE aerial surveys, spatially explicit density surfaces have been generated using all FTOWDG aerial and boat based sightings (Appendix H7, Section 5.2). When all data across all years are pooled, depth was a significant predictor of occurrence, with fewer animals in shallow water. The data show a great deal of variation in the spatial distribution of harbour porpoise across the survey years, with the main predictor of density being survey methodology. The likely explanation for variation in densities across the Zone will relate to changes in prey distribution. But differences in survey method beyond simple differences in detection properties could also be an underlying cause (e.g. seeing below the surface during aerial surveys will increase sighting rate due to greater availability to observers; Appendix H7, Section 5.2.2). Densities were also predicted to be higher in the summer and spring.

13.116. The average density estimate from the SCANS II survey Block V will be used in the impact assessment of behavioural impacts. This uniform density is higher than the ISA specific density generated by the aerial surveys alone (Appendix H3) and as such, represents a more precautionary estimate of density. A uniform density has been used in the assessment of behavioural impacts, as we believe this could represent a more appropriate metric than the use of spatially explicit densities for the assessment of impacts over a wide spatial and temporal scale. Densities have been shown to change over time (Appendix H7, Section 5.2) and an average estimate should enable uncertainty in this variation to be incorporated in the assessment. This approach was agreed on consultation with JNCC and SNH (Table 13.1, Meeting 10/ 05/ 2012)

13.117. The spatially explicit densities averaged across the survey period (Appendix H7) have been used in the assessment of PTS within the SAFESIMM framework. This approach was agreed on consultation with JNCC and SNH (Table 13.1, Meeting 10/ 05/ 2012).

13.118. Table 13.10 provides a summary of the key information to be used to assess the impacts of Project Alpha, Project Bravo and the Transmission Asset Project for harbour porpoise.

Bottlenose dolphin

13.119. Bottlenose dolphin are found throughout tropical and temperate seas worldwide in wide range of habitats, from shallow coastal locations, offshore continental shelf and beyond (Reid *et al*., 2003).

13.120. Individual bottlenose dolphin on the east coast of Scotland are known to range over large distances (Wilson *et al*., 2004; Cheney *et al*., 2012), but also exhibit some level of residency with many individuals being re-sighted within the same areas both within and between years (Wilson *et al*., 1997, Quick 2006, Thompson *et al*., 2011). Although this population is often considered resident in the Moray Firth, it is known that animals from this population regularly use other areas (Wilson *et al*., 2004, Quick and Janik 2008 Thompson *et al*., 2011; Cheney *et al*., 2012).

13.121. Bottlenose dolphin breed throughout the year, however, Anderwald & Evans (2010) report peaks between May and October. The definition of a specific breeding season is not taken forward in this assessment as agreed during consultation (Table 13.1, e-mail 09/ 05/ 2012).

13.122. Bottlenose dolphin feed on demersal or benthic fish (e.g. eels, flounder, dab, sole, turbot, haddock, hake, mullet, and cod), mid-water fish (e.g. salmon, trout, bass, horse mackerel, herring, blue whiting), and marine invertebrates (cephalopods and shellfish; Anderwald & Evans, 2010).

13.123. Bottlenose dolphin are of particular importance in this impact assessment due to the connectivity of bottlenose dolphin in the RSA with the Moray Firth SAC, for which they are a primary reason for the SAC designation. The data from photo-identification surveys in 2009 and 2010 show that estimates of 35 and 31 individuals (respectively) from the Moray Firth use the Tay area (Appendix H5, Table 2).

13.124. The distribution of bottlenose dolphin from photo-identification surveys in 2009 and 2010 is shown in Appendix H5 (Figure 2). Encounters are shown from Montrose to the Firth of Tay, adjacent to the Seagreen Projects and in the line of the ECR corridor. This is supported by the findings of Anderwald & Evans (2010) and suggests a coastal transit route for bottlenose dolphin from the Moray Firth SAC. No bottlenose dolphin were recorded during the boat based surveys of the Zone (Appendix H1).

13.125. Appendix H5 (Section 2.3) presents the findings of passive acoustic surveys from 2006 to 2009. The T-PODs[3] used allow discrimination between dolphin species and harbour porpoise but cannot distinguish between bottlenose dolphin and other dolphin species such as white-beaked dolphin. As a precautionary approach it is assumed that all dolphins detected could be bottlenose dolphin. T-POD data from Fife Ness show no significant inter-annual difference in the number of days of detections between 2007 and 2008 (the years with most data), however, in Arbroath there were significantly more days with dolphin detections in 2008 (Appendix H5, Table 3 and Figure 6a).

13.126. Dolphin were detected on 24% of days in Arbroath and 18% of days in Fife Ness. Both of these sites show lower detection rates in comparison with a core sites in the SAC (the mouth of the Cromarty Firth), where dolphin were detected on over 70% of days over the same time period (Thompson *et al*., 2011).

13.127. Appendix H5 (Figure 8) shows some seasonal differences between Fife Ness and Arbroath. At Fife Ness there was a decrease in detections during the winter. This is in line with trends outlined in Anderwald & Evans (2010). However, at Arbroath the numbers were relatively consistent throughout the months.

13.128. Abundance estimates have been generated from two methods, conventional and Bayesian[4], of 89 (95% confidence interval (CI) 81-98) and 112 (95% credible interval 89-142) animals, respectively (Appendix H5, Table 6). Taking the lowest and highest confidence limits of both estimates provides a best estimate of between 81 and 142 dolphin using the Tay area (Montrose to St Andrews Bay) during the summer months of 2003 and 2004 based on photo identification surveys.

13.129. Estimate of the density of bottlenose dolphin for the area, made by calculating the area surveyed and using the values for abundance recorded have been calculated following the methods outlines in Appendix H5 (Section 2.5). This method assumes that animals are distributed equally over the area. Table 13.9 provides the estimated densities using the abundance estimates discussed above. This gives an overestimation for offshore locations, including the Zone, as the densities were calculated from surveys focused on coastal waters, where numbers are expected to be greater (Appendix H5, Figures 2 and 3). Furthermore, levels of uncertainty are not available for these estimates, so these density values should not be considered as robust estimates for the density of bottlenose dolphin.

3 PODs are fully automated, static, passive acoustic monitoring systems that detect porpoises, dolphins and other toothed whales by recognising the trains of echo-location clicks they make to detect their prey, orientate and interact.

4 The Bayesian method was developed by Durban et al. (2005) to take into account the wide range of the bottlenose dolphin which makes it difficult to estimate the population size by surveying one location.

Table 13.9 Density estimates of bottlenose dolphin derived from both conventional and Bayesian abundance estimates for the 2003-2004 data from the Tay

Abundance estimate	Survey area (km^2)	Density (animals/km^2)
89 (Conventional)	319	0.28
112 (Bayesian)	319	0.35

Source: Appendix H5

13.130. The density estimates provided in Table 13.9 are considerably higher than the density estimate for bottlenose dolphin from the SCANS II survey for block V (i.e. the block containing the Projects and RSA) of 0.0008 individuals per km^2 (SCANS-II, 2008). However, the SCANS II survey was conducted over a much larger area, using line transect methodology, the data from the photo-identification surveys in 2009 and 2010 is likely to provide an over estimate of density. The density estimated from the photo identification surveys will be used in the impact assessment as a precautionary approach within the SAFESIMM assessment of PTS, and when assessing behavioural impacts the SCANS II data will also be considered. The limitations of the two data sets and justification for their use are further explained in the impact assessment section of this chapter.

13.131. The reference population for the assessment is based on the most recent estimate of the Scottish east coast bottlenose dolphin population of 195 (95% HPDI 162-253) from 2006 (Cheney *et al*., 2012).

13.132. Table 13.10 provides a summary of the key information to be used to assess the impacts of Project Alpha, Project Bravo and the Transmission Asset project on bottlenose dolphin.

White beaked dolphin

13.133. White-beaked dolphin are wide-spread across the northern European continental shelf. The species is the most abundant cetacean after the harbour porpoise in the North Sea (Banhuera-Hinestroza *et al*., 2009), and 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). 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).

13.134. The SCANS II survey provides the most recent population estimate covering the North Sea of 10,562 (CV 0.29), and a wider European Population estimate of 22,664 (95% CI 10,341-49,670). The wider population estimate from SCANS II does not include the genetically distinct North Norwegian population (Northridge *et al*., 1997), so provides an appropriate reference population for our assessment.

13.135. The mating season for white beaked dolphin is in July and August with the gestation period lasting about 11 months (Culik, 2010). White-beaked dolphin feed upon mackerel, herring, cod, poor-cod, sandeels, bib, whiting, haddock, and hake, as well as squid, octopus, and benthic crustaceans (Anderwald & Evans, 2010). The region is used both for feeding and breeding. They breed mainly between May and August, although some may occur also in September and October (Anderwald & Evans, 2010).

13.136. Anderwald & Evans (2010) shows the distribution of white beaked dolphin sightings per hour. The highest sightings rates are recorded along the coast between Peterhead and Montrose. The study shows sightings throughout the areas surveyed both onshore and offshore but there was no survey effort at Arbroath, Carnoustie or within the Zone.

13.137. Anderwald & Evans (2010) show sightings and individual rates have strong peaks in 2000 and again in 2004, for both vessel based and land-based surveys. Before 1999, the species was recorded only occasionally, and both overall sightings and sighting rates have declined since 2004.

13.138. During the Seagreen specific boat based survey, white-beaked dolphin was recorded most often during the summer in both 2010 and 2011 (Appendix H1, Page 8). This seasonal peak is in line with a previous study that also found white-beaked dolphin to be present in Aberdeenshire waters during June to August with the main peak in August (Weir *et al.*, 2007). Low numbers were seen in September, October and December 2010, and January 2011 (Appendix H1, Figure 8). Anderwald & Evans, 2010 also show peaks in the sightings rate in summer months, in particular during August.

13.139. Appendix H3 provides density estimates for white beaked dolphin of 0.042 individuals per km^2 based on TCE aerial surveys. Summer and winter estimates are 0.052 and 0.024 individuals per km^2, respectively. SCANS II density estimates (animals per km^2) for the blocks which included the area covered by TCE surveys provide a comparable density estimate of 0.049 (Appendix H3, Table 7). The SCANS II estimate will be used for the impact assessment, as it is the higher estimate, and thus more precautionary.

13.140. Integrated analysis of the boat based and aerial survey data (Appendix H7) has also been completed. The analysis shows that due to the low number of sightings, there is a high level of uncertainty in the data. Absolute abundance across the survey period and RSA was 293 (95% CI 266-1055) (Appendix H7, Page 32). Absolute density estimates also had high uncertainty associated with them, and ranged from 0 to 1 individual per km^2 in a single grid cell over the survey period. A peak in sightings and therefore density was apparent to the north east of the survey area. Spatially and temporally explicit densities have not been incorporated into the assessment due to high uncertainty and variability across the Zone.

13.141. Table 13.10 provides a summary of the key information to be used to assess the impacts of Project Alpha, Project Bravo and the Transmission Asset Project on white beaked dolphin.

Minke whale

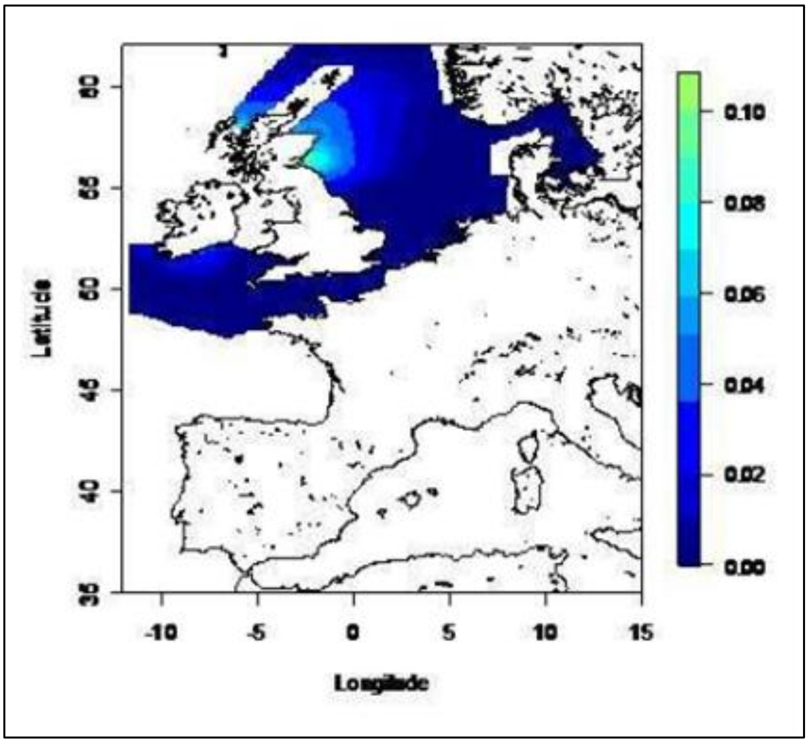
13.142. The minke whale is widely distributed along the Atlantic seaboard of Britain and Ireland and throughout the central and southern North Sea. Minke whale is widely distributed around Scotland and North East England, with a relatively high sightings rates in the RSA (Reid *et al*., 2003). The only 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 8,450 (95% CI 5,000-13,500) (Hammond *et al*., 2002). A more extensive line transect survey (SCANS II) over the NW European continental shelf in July 2005 gave an overall estimate of 10,541 (CV 0.24) for the North Sea (SCANS-II, 2008).

13.143. 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 Northeasten North Atlantic), with a population estimate (in 1996-2001) of 174,000 (approximate 95% CI 125,000-245,000; IWC 2012). However, from a precautionary perspective, in this assessment, the reference population is considered to be at a European level, with the combined estimates of the SCANS II (18,614 (10,445-33,171; SCAN-II, 2008) and CODA (6,765 (1,239-36,925; Hammond *et al*., 2009) data providing a reference population estimate of 25,379 (11,684-70,096).

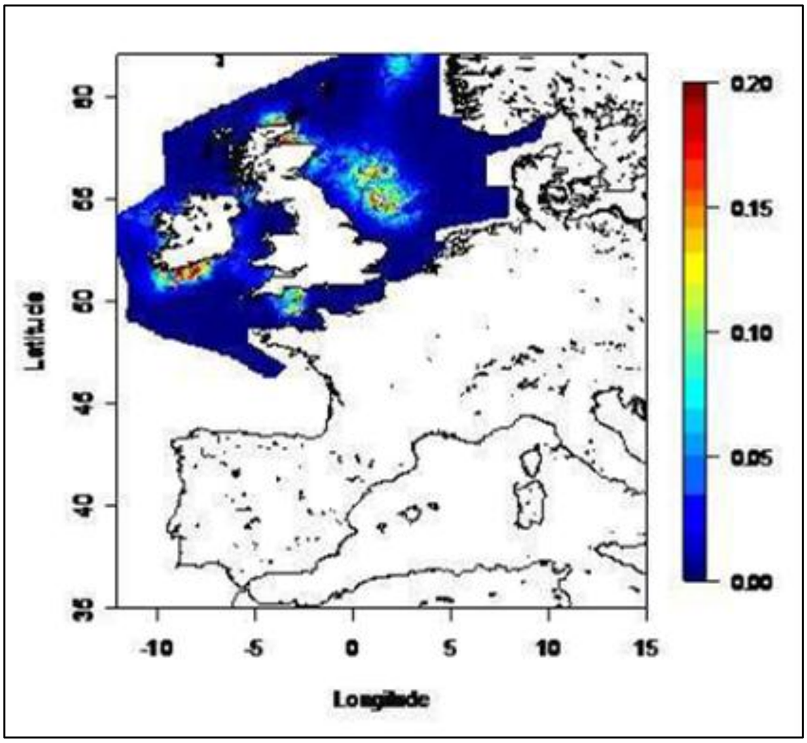
13.144. Plate 13.6 provides density estimates from SCANS (a) and SCANS II (b) showing a shift in distribution to the south east between 1994 and 2005.

Plate 13.6 Minke whale density surface (animals per km²) in (a) 1994 and (b) 2005.

(a) 1994



(b) 1995



13.145. Anderwald & Evans (2010) shows the distribution of minke whale sightings per hour. The highest sightings rates are recorded along the coast between Peterhead and Montrose. The study shows sightings throughout the areas surveyed both onshore and offshore but there was no survey effort at Carnoustie or within the Zone.

13.146. Anderwald & Evans (2010) show sightings rates per unit effort both from boat and land-based surveys were lower during the 1990s than the 2000s. From 2000 to 2009 sightings rates have fluctuated between years with no obvious trend. Over the longer term (from 1970s onwards), the mean number of sightings and individuals per year remained very low until the mid-1990s since which time they have generally increased.

13.147. The species is most commonly seen singly or, less commonly, in loose groups of up to three. In late summer in northern and northwest Britain, loose feeding aggregations of up to 15 animals may form, however, only very small groups have been seen in the WSA (Moray Firth to St Andrews Bay; Anderwald & Evans, 2010).

13.148. 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 ten months, with calving occurring primarily between December and January (Seawatch Foundation, undated).

13.149. Sixty-two minke whale (0.003 sightings per hour) were recorded during the Seagreen specific boat based surveys. Appendix H1 (Figure 18) shows minke whale were seen throughout the survey area, including both Project Alpha and Project Bravo, with nine sightings locations in each.

13.150. A strong seasonal pattern to the sightings data for minke whale was recorded during the boat based surveys, with most encountered during the spring and summer months in 2010 and 2011 (Appendix H1, Figure 6), with high rates in May 2010 and June 2011. This seasonal pattern is supported by Anderwald and Evans (2010).

13.151. Integrated analysis of Seagreen specific boat based and TCE aerial surveys was able to generate spatially explicit density surfaces (Appendix H7, Section 5.4). These absolute densities were very low, but surfaces showed high uncertainty with large confidence limits. Absolute abundance across the survey period and area was estimated as 594 but also showed a high level of uncertainty due to the low number of sightings (95% CI 108-2695).

13.152. Insufficient sightings were made during TCE aerial surveys to estimate average densities of minke whale in the RSA using these data alone (Appendix H3, Table 2 and Table 3). Estimates of density from the SCANS II surveys for Block V were 0.023 (CV 0.59). These average densities have been applied in the assessment, for reasons previously outlined and consulted on for harbour porpoise and white-beaked dolphin.

13.153. Table 13.10 provides a summary of the key information to be used to assess the impacts of Project Alpha, Project Bravo and the Transmission Asset project on minke whale.

Table 13.10 Marine mammal existing environment summary

Species	Diet	Distribution	Breeding Season	Reference Population
Grey seal Halichoerus grypus	Fish, in particular sand-eels, as well as poor cod , whiting, cod, ling , flatfish, Atlantic salmon, mackerel & herring.	Mainly coastal waters and occasionally further offshore, including within Project Alpha and Project Bravo, with concentrations around Scalp bank, Marr bank, Wee Bankie and Berwick bank.	Birth -October- December (east Scotland). Gestation – 11 months (including delayed implantation).	ECMA 5657 to 12011
Harbour seal Phoca vitulina	Fish, in-particular salmonids and sandeels, as well as herring, whiting, flatfish and saithe.	Mainly coastal waters and occasionally further offshore, including within Project Alpha and Project Bravo.	Birth – June to August[5] Gestation – 11 months (including delayed implantation).	ECMA 540 (95%CI 442-720)
Harbour porpoise Phocoena phocoena	Small fish including whiting, poor cod, Norway pout Trisopterus esmarkii, herring, sandeels & gobies.	Mainly over the continental shelf, widely distributed throughout the North Sea including within Project Alpha and Project Bravo.	Birth – May to August. Gestation 10.5 months.	North Sea 385,617 (95% CI 261,266-569,153)
Bottlenose dolphin Tursiops truncatus	Small fish (including eels, flounder, dab, sole, turbot, haddock, hake, mullet, cod, salmon, trout, bass, horse mackerel, herring & blue whiting), invertebrates and cephalopods.	Coastal and offshore to continental shelf edge and beyond. No sightings within Project Alpha and Project Bravo but regular sightings along the adjacent coastline.	Year round breeding. Gestation 12 months.	Scottish east coast 195 (95% HPDI 162-253)
White-beaked dolphin Lagenorhynchus albirostris	Fish including mackerel, herring, cod, capelin, whiting, haddock, hake, sandeels, gobies & flatfish.	Usually over the continental shelf in waters of 50 – 100 m depth.	Birth – Summer. Gestation 10 to11 months.	European 22,664 (excl. North Norwegian population) (95% CI 10,341-49,670)
Minke whale Balaenoptera acutorostrata	Wide variety of fish including herring , cod, capelin, haddock, saithe & sandeel.	Mainly over the continental shelf in water depths of 200 m or less.	Birth - Diffusely seasonal. Gestation 10 months.	Europe 25,379 (range 11,684-70,096)

5 Breeding season as defined by SNH and JNCC, Table 13.1, e-mail 09/ 05/ 2012

ASSESSMENT OF IMPACTS – DEFINITION OF WORST CASE & MOST LIKELY CASE SCENARIOS

13.154. Table 13.11, 13.12 and 13.13 outline the worst case and most likely scenarios for Project Alpha, Project Bravo and the Transmission Asset Project in relation to impacts upon marine mammals.

Construction Noise

13.155. The definition of the worst case and most likely case scenarios, in relation to pile driving noise have been informed by an iterative process involving engineering studies including detailed pile driveability analysis, presented in Appendix H10, in addition to two rounds of noise propagation modelling, carried out by Subacoustech Environmental Ltd.

13.156. As part of the pile drivability analysis, Cathie Associates reviewed the available geotechnical information from the Project Alpha and Project Bravo areas, to assign geological provinces. This approach was taken to identify varying piling requirements across the Projects, with a view to matching piling requirements with biological sensitivities. The seabed was found to consist predominately (approximately 80% of the Firth of Forth Phase 1 Development Zone) of the geological provinces 'Marr Bank 1' and 'Marr Bank 2'. Both of these provinces have a depth of 0-20m to bedrock, with a 0-5m and a >5m Holocene thickness, respectively (Appendix H10, Appendix A, Location of Marr Bank 1 and Marr Bank 2 Provinces). A relatively small part of the Phase 1 Zone, (approximately 20%), consists of minor geological provinces with a depth to bedrock greater than 20m below seabed.

13.157. Two geological scenarios were developed from geological provinces Marr Bank 1 and Marr Bank 2; one based on the mean case bedrock (MCB) depth of 12m below the seabed, the other representing the deep case bedrock (DCB) of 20m below seabed. The DCB scenario is conservatively assumed to represent 20% of the Phase 1 Zone, and the MCB the remaining 80%. Best estimates (BE) and upper bounds (UB) of geotechnical parameters (hammer size, blow count per change in efficiency, and installation time) were derived for four construction cases: fully driven 2 and 3m diameter piles (pile driving from seabed to target depth), and a drive-drill-drive for 2 and 3m piles (pile driving from seabed to top of Triassic Group, drilling of rock socket and then driving to target depth through the socket).

13.158. Based on the results of the pile drivability analysis, a range of driving energies and blow counts would be expected during construction (Appendix H10, Section 7). However, some of the scenarios were discounted from further assessment due to the possibility of pile refusal and also due to the energy requirements for penetration being too high; the modelling of hammer size was restricted to limit the range of likely impacts on marine mammal receptors.

13.159. In addition, the analysis (Appendix H10, Appendix C) showed that there was very little difference in maximum blow force, necessary to achieve the required depth of penetration, between the MCB and DCB for comparable pile diameters. Therefore, it was decided to carry forward the MCB to be modelled in the noise assessment as a proxy for the DCB.

13.160. The noise propagation modelling (using INSPIRE) used four likely scenarios; three based on the MCB best estimates (MCB BE 6MW) and one from the DCB upper bound ground conditions (DCB UB 7MW) from the Cathie study. These scenarios are:

- fully driven 2m pile, 27m, IHC 1800kJ hammer (MCB BE 6MW);
- fully driven 3m pile, 22m, IHC 1800kJ hammer (MCB BE 6MW);
- drive-drill-drive 2m pile, 29m, IHC 1200kJ hammer (MCB BE 6MW); and
- drive-drill-drive 2m pile, 34m, IHC 1200kJ hammer (DCB UB 7MW).

13.161. Following selection of the four most likely scenarios sensitivity analysis was carried out using the INSPIRE model to gain an understanding of how the different piling parameters affected the extent of the noise propagation. The sensitivity analysis modelling showed, that when blow force was constant, the diameter of the pile had little influence on the noise propagation and therefore the range of potential impact (Appendix H6, Table 6-9 versus Table 6-11, for example).

13.162. It is therefore considered, that the worst case single piling impacts will result from the scenario with the greater piling duration; where installation of a 2m pile (up to 27m long) taking 55 minutes of continuous piling is worse than the installation of a 3m pile (up to 22m), taking only approximately 30 minutes of continuous piling. This temporal difference is a result of the 2m pile requiring greater penetration to support the loads applied by the WTGs. The worst case is based on a fully driven operation in which the pile will be installed in a single operation without any breaks. This worst case is referred to as worst case GM1 in the remainder of this assessment, and in the relevant technical appendices.

13.163. The most likely scenario is based on what's referred to as a 'drive-drill-drive' operation, in which the pile will be driven down to the bedrock, at which point there will be a break in piling to change over to drilling, followed by a further break to change back to pilling. Switching over to drilling is required in this case, as a fully driven operation would not be able to penetrate through the initial few metres of bedrock. In addition, the consideration of the most likely scenario is based again, on the inference that the range of impacts from a 2m versus a 3m pile is not significantly different, so only 2m piles were used in the impact assessment. Therefore, the MCB conditions best estimate drive drill drive scenario for a 2m pile (29m) is considered most likely for calculating the noise impacts from piling. The DCB case was not considered as most likely, as it represents only 20% of the Phase 1 Zone. This scenario is referred to as most likely GM3 in the rest of this assessment, and in the relevant technical appendices.

13.164. The pile driveability assessment also provided detail on the soft start (or ramp up) procedure to inform the noise modelling (see Table 13.11 for summary details, Appendix H10, Appendix C for full results). It can be seen therefore that in the WORST CASE scenario defined above while there is 55 minutes of continuous piling, only 30 minutes represents piling at the maximum blow force of 1,450 kJ. Similarly in the most likely scenario where there is 32 minutes of pile driving, the time period when the maximum blow force of 920 kJ is required is limited to 5 minutes.

13.165. The above definitions of worst (worst case GM1) and most likely (most likely GM3) cases apply to the installation of a single jacket pile. In the construction of Project Alpha and Project Bravo, based, on consultation with the engineering team, it is considered likely that as an absolute worst case 20% (most likely 10%) of the piles will require blow forces in line with the worst case GM1 scenario to achieve the required penetration. The remaining 80% of piles will require blow forces in line with the most likely GM3 scenario to achieve the required penetration.

13.166. Construction is assumed to take place over the full year cycle. The duration of the piling programme for both Project Alpha and Project Bravo will be a maximum of two years, with one piling vessel operating in each Project. Pile driving will not be continuous during this time.

13.167. The total duration of pile driving during each of the two years of piling operations at Project Alpha would be 93 hours (approximately 1% of the year). The proportion of time spent pile driving at Project Bravo would be the same. As a worst case (if there was no concurrent pile driving) 2% of each year could be spent pile driving.

13.168. An indicative programme for a single pile installation (1 of the 4 piles required by full jacket installation) is provided in Appendix H10 (Table 8) based on records of recent piling operations. As already mentioned the continuous piling duration required to install a single pile for worst case GM1 is 55 minutes. However, after allowing for equipment set up time prior to and post piling, each fully driven pile (worst case GM1) will take up to a maximum of 15 hours to install (pile 1 of the foundation) giving a total installation time of 50 hours for a single jacket (4 piles and an average of 12.5 hours per pile). For the drive drill drive scenario (most likely GM3) the portion of the operation in which pile driving is required is approximately 33 minutes for a single pile. This period is split into two with an initial pile driving duration of approximately 12 minutes, interrupted by drilling. Following the completion of the drilling operation a further 21 minutes of pile driving is required. Once equipment set up is factored in the first pile would take up to 41 hours to install, with a total operational time of 154 hours for a single jacket (4 piles and an average of 38.5 hours per pile).

13.169. With the constraint of a single piling vessel operating within each Project the worst case impacts will be determined by the spatial scale of the impact combined with species occurrence. The temporal duration of impact (both within and beyond the piling event) as well as the duration of piling operations (delimiting the time between each piling event) is also considered.

Table 13.11 Worst case scenario for Project Alpha assessment

Effect	Worst case scenario	Most likely	Justification
Construction			
Underwater noise	Method: 100% pile driving (see Table 6-2 GM1 Appendix H6). Pile diameter: 2m Total penetration: up to 32m Hammer capacity: 1800KJ Max blow force: 1450KJ Soft start (ramp up) 25mins Total piling duration 55 mins Ramp up details: 6 mins at 15% capacity 4 mins at 35% capacity 5 mins at 55% capacity 10 mins at 75% capacity 30 mins at 95% capacity Strike rate: 45 per minute. Total number of piles: 75 WTG x 4 piles. Vessel noise: Jack-up barges for piling, substructure and WTG installation.	Method: Drive / drill / drive (see Table 6-4 GM3 Appendix H6). Pile diameter: 2m Total penetration: up to 29m Hammer capacity: 1200KJ Max blow force: 920KJ Soft start (ramp up) 28mins Total piling duration 33 mins Ramp up details: 5 mins at 15% capacity 7 mins at 35% capacity Break in Driving - Drilling Operation at 17m Depth 5 mins at 35% capacity 11 mins at 55% capacity 5 mins at 75% capacity Strike rate: 45 per minute. Vessel noise: assessment based on WCS.	The worst case scenario represents the longest piling duration and the highest noise output through 100% piling. The worst case scenario could be applied for up to 20% of the foundations. The most likely scenario incorporates a drill drive method which gives lower noise production over a shorter time. The most likely scenario could be applied to up to 80% of the foundations. The construction vessels outlined in the worst case scenario will contribute to the construction noise along with rock dumping and cable laying noise.
	Other large and medium sized vessel will be on site to carry out other construction tasks, diving support and anchor handling. Other small vessels for crew transport and survey work on site. Rock dumping: Required on site for installation of the export cable. Also required if Gravity Base structures are to be used. Cable laying – inter-array cable.	Rock dumping: assessment based on worst case scenario.	

Effect	Worst case scenario	Most likely	Justification
Risk of collision with marine mammals	Up to 4 large installation vessels (greater than 80m in length) in operation at one time, per Project (up to 8 across both A+B where two separate installations may be underway); a cable laying vessel, piling vessel, structure installation vessel i.e. turbines / substructures and a rock dumping vessel.	N/A Impact assessment uses worst case scenario detail.	The maximum number of vessels on site provide the level of increased traffic with potential to cause increased collision risk with marine mammals.
Changes to water quality	The worst case scenario is represented in the significance of the impact defined in *Chapter 8: Water and Sediment Quality:* 75 WTGs; foundation installation over 2 years.	N/A, the impact assessment uses the worst case scenario.	The predicted changes to water quality in terms of contaminants and increased suspended sediment outlined in *Chapter 8: Water and Sediment Quality* have potential to impact on marine mammal health and feeding success (visibility).
Changes to prey resource	The worst case scenario is represented in the significance of the impact defined in *Chapter 12: Natural Fish and Shellfish Resource.*	N/A Impact assessment uses worst case scenario detail.	The predicted changes to fish resource outlined *Chapter 12: Natural Fish and Shellfish Resource* have potential to impact on marine mammal feeding success in the ISA.
Operation			
Underwater noise	75 x 7MW WTGs See below worst case scenario for number of vessels.	N/A Impact assessment uses worst case scenario detail.	The worst case scenario is deemed to be the greatest number of WTGs. The maximum number of operation and maintenance vessels provides the worst case scenario for contributing to the operational noise.
Risk of collision with marine mammals	Scheduled operation and maintenance will be up to biannually per turbine with 2 vessels on site at a time. Dive vessels and ROV for inspection. Large transport vessel for major replacement components if required. Unknown amount of unscheduled maintenance.	N/A Impact assessment uses worst case scenario detail.	The vessels required for operation and maintenance provide the level of increased traffic with potential to cause increased collision risk with marine mammals.

Effect	Worst case scenario	Most likely	Justification
Changes to Water Quality	The worst case scenario is the significance of the impact defined in *Chapter 8: Water Quality:* Scour volume of 4,877m^3 per foundation under a worst case 1 in 50 year storm. Total scour volume of 395,037m^3 In the event that scour protection is provided, no scour will occur, but there will be the physical footprint on the seabed caused by the scour protection materials.	N/A Impact assessment uses worst case scenario detail	The predicted changes to water quality in terms of contaminants and increased suspended sediment outlined in *Chapter 8: Water Quality* have potential to impact on marine mammal health and feeding success (visibility).
Changes to Prey Resource	The worst case scenario is represented in the significance of the impact defined in *Chapter 12, Fish and Shellfish.*	N/A Impact assessment uses worst case scenario detail.	The predicted changes to fish resource outlined *Chapter 12: Fish and Shellfish* have potential to impact on marine mammal feeding success in the ISA.
EMF	355km of 66kV inter array cabling.	90% buried to minimum of 0.5m. Rock armouring or mattressing of unburied sections.	The longest length and greatest voltage of the array cabling provides the worst case for EMF. However the level of EMF will be reduced by burying the cable.
Decommissioning			
Underwater noise	Cutting of foundations. Vessel noise (see below).	N/A Impact assessment uses worst case scenario detail.	
Risk of collision with marine mammals	The number and type of vessels are expected to be, at worst, similar to construction.	N/A Impact assessment uses worst case scenario detail.	
Changes to water quality	The worst case scenario is the significance of the impact defined in *Chapter 8: Water Quality.*	N/A Impact assessment uses worst case scenario detail.	The predicted changes to water quality in terms of contaminants and increased suspended sediment outlined in *Chapter 8: Water Quality* have potential to impact on marine mammal health and feeding success (visibility).
Changes to prey	The worst case scenario is represented in the significance of the impact defined in *Chapter 12, Fish and Shellfish.*	N/A Impact assessment uses worst case scenario detail.	The predicted changes to fish resource outlined *Chapter 12: Fish and Shellfish* have potential to impact on marine mammal feeding success in the ISA.

Table 13.12 Worst case scenario for Project Bravo assessment

Effect	Worst case scenario	Most likely	Justification
Construction			
Underwater noise	Method: 100% pile driving (see Table 6-2 GM1 Appendix H6). Pile diameter: 2m Total penetration: up to 32m Hammer capacity: 1800KJ Max blow force: 1450KJ Soft start (ramp up) 25mins Total piling duration 55 mins Ramp up details: 6 mins at 15% capacity 4 mins at 35% capacity 5 mins at 55% capacity 10 mins at 75% capacity 30 mins at 95% capacity Strike rate: 45 per minute Strike rate: 45 per minute. Total number of piles: 75 WTG x 4 piles. Vessel noise: Jack-up barges for piling, substructure and WTG installation. Other large and medium sized vessel will be on site to carry out other construction tasks, diving support and anchor handling. Other small vessels for crew transport and survey work on site. Rock dumping: Required on site for installation of the export cable. Also required if Gravity Base structures are to be used. Cable laying – inter-array cable.	Method: Drive / drill / drive (see Table 6-4 GM3 Appendix H6). Pile diameter: 2m Total penetration: up to 29m Hammer capacity: 1200KJ Max blow force: 920KJ Soft start (ramp up) 28mins Total piling duration 33 mins Ramp up details: 5 mins at 15% capacity 7 mins at 35% capacity Break in Driving - Drilling Operation at 17m Depth 5 mins at 35% capacity 11 mins at 55% capacity 5 mins at 75% capacity Strike rate: 45 per minute. Vessel noise: assessment based on worst case scenario. Rock dumping: assessment based on worst case scenario.	The worst case scenario represents the longest piling duration and the highest noise output through 100% piling. The most likely scenario incorporates a drill drive method which gives lower noise production over a shorter time. The construction vessels outlined in the worst case scenario will contribute to the construction noise along with rock dumping and cable laying noise.

Effect	Worst case scenario	Most likely	Justification
Risk of collision with marine mammals	Up to 4 large installation vessels (greater than 80m in length) in operation at one time, per Project (up to 8 across both A+B); a cable laying vessel, piling vessel, structure installation vessel i.e. turbines / substructures and a rock dumping vessel.	N/A Impact assessment uses worst case scenario detail.	The maximum number of vessels on site provide the level of increased traffic with potential to cause increased collision risk with marine mammals.
Changes to water quality	The worst case scenario is represented in the significance of the impact defined in Chapter 8: Water and Sediment Quality: 75 WTGs; foundation installation over 2 years.	N/A Impact assessment uses the worst case scenario.	The predicted changes to water quality in terms of contaminants and increased suspended sediment outlined in *Chapter 8: Water and Sediment Quality* have potential to impact on marine mammal health and feeding success (visibility).
Changes to prey resource	The worst case scenario is represented in the significance of the impact defined in *Chapter 12: Natural Fish and Shellfish Resource.*	N/A Impact assessment uses worst case scenario detail.	The predicted changes to fish resource outlined *Chapter 12: Natural Fish and Shellfish Resource* have potential to impact on marine mammal feeding success in the ISA.
Operation			
Underwater noise	75 x 7MW WTGs See below WCS for number of vessels.	N/A Impact assessment uses worst case scenario detail.	The worst case scenario is deemed to be the greatest number of WTGs. The maximum number of operation and maintenance vessels provides the worst case scenario for contributing to the operational noise.
Risk of collision with marine mammals	Scheduled operation and maintenance will be up to biannually per turbine with 2 vessels on site at a time. Dive vessels and ROV for inspection. Large transport vessel for major replacement components if required. Unknown amount of unscheduled maintenance.	N/A Impact assessment uses worst case scenario detail.	The vessels required for operation and maintenance provide the level of increased traffic with potential to cause increased collision risk with marine mammals.

Effect	Worst case scenario	Most likely	Justification
Changes to Water Quality	The worst case scenario is the significance of the impact defined in *Chapter 8: Water Quality:* Scour volume of 4,877m^3 per foundation under a worst case 1 in 50 year storm. Total scour volume of 395,037m^3 In the event that scour protection is provided, no scour will occur, but there will be the physical footprint on the seabed caused by the scour protection materials.	N/A Impact assessment uses worst case scenario detail.	The predicted changes to water quality in terms of contaminants and increased suspended sediment outlined in *Chapter 8: Water Quality* have potential to impact on marine mammal health and feeding success (visibility).
Changes to Prey Resource	The worst case scenario is represented in the significance of the impact defined in *Chapter 12, Fish and Shellfish.*	N/A Impact assessment uses worst case scenario detail.	The predicted changes to fish resource outlined *Chapter 12: Fish and Shellfish* have potential to impact on marine mammal feeding success in the ISA.
EMF	355km of 66kV inter array cabling.	90% buried to minimum of 0.5m. Rock armouring or mattressing of unburied sections.	The longest length and greatest voltage of the array cabling provides the worst case for EMF. However the level of EMF will be reduced by burying the cable.
Decommissioning			
Underwater noise	Cutting of foundations. Vessel noise (see below).	N/A Impact assessment uses worst case scenario detail.	
Risk of collision with marine mammals	The number and type of vessels are expected to be, at worst, similar to construction.	N/A Impact assessment uses worst case scenario detail.	
Changes to water quality	The worst case scenario is the significance of the impact defined in *Chapter 8: Water Quality.*	N/A Impact assessment uses worst case scenario detail.	The predicted changes to water quality in terms of contaminants and increased suspended sediment outlined in *Chapter 8: Water Quality* have potential to impact on marine mammal health and feeding success (visibility).
Changes to prey	The worst case scenario is represented in the significance of the impact defined in *Chapter 12, Fish and Shellfish.*	N/A Impact assessment uses worst case scenario detail.	The predicted changes to fish resource outlined *Chapter 12: Fish and Shellfish* have potential to impact on marine mammal feeding success in the ISA.

Table 13.13 Worst case scenario for Transmission Asset Project assessment

Effect	Worst case scenario	Most likely	Justification
Construction			
Onshore habitat exclusion	Cable trenches will be 3m wide. A maximum of 6 export cables are proposed.	N/A Impact assessment uses worst case scenario detail.	The maximum number of export cables represents the greatest area of near shore and intertidal landfall.
Underwater noise	OSPs installation method: 100% pile driving (see Table 6-2 GM1 Appendix H6). Pile diameter: 2m Total penetration: up to 32m Hammer capacity: 1800KJ Max blow force: 1450KJ Soft start (ramp up) 25mins Total piling duration 55 mins Ramp up details: 6 mins at 15% capacity 4 mins at 35% capacity 5 mins at 55% capacity 10 mins at 75% capacity 30 mins at 95% capacity Strike rate: 45 per minute Strike rate: 45 per minute. Total number of piles: 72 Alpha: 1 DC converter OSP 12 legs, 2 piles per leg (24 piles). 2 AC collector OSPs up to 6 legs, 2 piles per leg (24 piles) [5]	OSPs installation method: Drive / drill / drive (see Table 6-4 GM3 Appendix H6). Pile diameter: 2m Total penetration: up to 29m Hammer capacity: 1200KJ Max blow force: 920KJ Soft start (ramp up) 28mins Total piling duration 33 mins Ramp up details: 5 mins at 15% capacity 7 mins at 35% capacity Break in Driving - Drilling Operation at 17m Depth 5 mins at 35% capacity 11 mins at 55% capacity 5 mins at 75% capacity Strike rate: 45 per minute. Total number of piles: 72 Alpha: 1 DC converter OSP 12 legs, 2 piles per leg (24 piles). 2 AC collector OSPs up to 6 legs, 2 piles per leg (24 piles).[6] Bravo: 2 AC collector OSPs up to 6 legs,	Increased vessel activity as well as cable laying and rock dumping during construction of the Transmission Asset Project will create underwater noise. Vessel noise: assessment based on worst case scenario. Rock dumping: assessment based on worst case scenario.

Effect	Worst case scenario	Most likely	Justification
	Bravo: 2 AC collector OSPs up to 6 legs, 2 piles per leg (24 piles).[6] Vessel noise: Noise associated with cable laying vessels and a barge to transport five OSPs. Rock dumping: Required on site for installation of the export cable. Also required if Gravity Base structures are to be used. Cable laying – export cable.	2 piles per leg (24 piles).[7] Vessel noise: assessment based on WCS. Rock dumping: assessment based on WCS.	
Risk of collision with marine mammals	1 vessel on site during cabling works plus a large vessel to transport OSPs.	N/A Impact assessment uses worst case scenario detail.	The vessels required for to transport the prefabrication OSPs and to lay the cables will provide the level of increased traffic with potential to cause increased collision risk with marine mammals. Five OSPs is the maximum number and therefore will require the greatest number of vessel movements.
Changes to water quality	The worst case scenario is the significance of the impact defined in *Chapter 8: Water Quality:* Five OSPs, Cable burial achieved using jetting ROV.	N/A Impact assessment uses worst case scenario detail.	The predicted changes to water quality in terms of contaminants and increased suspended sediment outlined in *Chapter 8: Water Quality* have potential to impact on marine mammal health and feeding success (visibility).
Changes to prey resource	The worst case scenario is the significance of the impact defined in *Chapter 12: Fish and Shellfish.*	N/A Impact assessment uses worst case scenario detail.	The predicted changes to fish resource outlined *Chapter 12: Fish and Shellfish* have potential to impact on marine mammal feeding success in the ISA.

6 Foundations for OSPs within the Project Alpha boundary are included within the assessment of the construction phase of Project Alpha, not within the Transmission Asset Project.

7 Foundations for OSPs within the Project Bravo boundary are included within the assessment of the construction phase of Project Bravo, not within the Transmission Asset Project.

Effect	Worst case scenario	Most likely	Justification
Operation			
Underwater noise	As with operation of the Alpha and Bravo OWFs the Transmission Asset Project will require biannual planned maintenance plus any unplanned repairs.	N/A Impact assessment uses worst case scenario detail.	Vessel noise is predicted to be the key source and therefore the number of site visits and vessels required will contributed to the level of noise.
Risk of collision with marine mammals	As with operation and maintenance of Alpha and Bravo scheduled will be biannual with 2 vessels on site at a time. Dive vessels and ROV for inspection. Large transport vessel for major replacement components if required. Unknown amount of unscheduled maintenance.	N/A Impact assessment uses worst case scenario detail.	The maximum number of vessels required for operation and maintenance provides the worst case scenario for collision risk.
Changes to water quality	The worst case scenario is the significance of the impact defined in *Chapter 8: Water Quality.*	N/A Impact assessment uses worst case scenario detail.	The predicted changes to water quality in terms of contaminants and increased suspended sediment outlined in *Chapter 8: Water Quality* have potential to impact on marine mammal health and feeding success (visibility).
Changes to prey resource	The worst case scenario is the significance of the impact defined in *Chapter 12: Fish and Shellfish.*	N/A Impact assessment uses worst case scenario detail.	The predicted changes to fish resource outlined *Chapter 12: Fish and Shellfish* have potential to impact on marine mammal feeding success in the ISA.
EMF	A maximum of 6 HVAC 132 kV export cables with a combined length of 530 km and a minimum burial depth of 0.5m.	N/A Impact assessment uses worst case scenario detail.	AC is believed to represent the worst case compared with DC. The maximum number of cables and minimum burial depth represent the worst case for EMF.
Decommissioning			
	Removal of all cabling and build structures (based on worst case assumptions detailed under construction).	N/A Impact assessment uses worst case scenario detail.	Arrangements associated with decommissioning will be determined prior to construction and a full Decommissioning Plan for the project will be drawn up and agreed with Marine Scotland. Until the arrangements have been clarified, the worst case scenario is that the cables have to be removed.

IMPACT ASSESSMENT – CONSTRUCTION PHASE

13.170. This section of the ES provides an assessment of the potential impacts during the construction phase of the development.

Project Alpha

Potential Impact of Underwater Noise

13.171. 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. Consultation with MS and SNH, as outlined in Table 13.1 has further emphasised the requirement to assess noise generated during piling. The potential impacts of noise on marine mammals include lethal doses, physical non-auditory injury, auditory injury, or behavioural responses.

13.172. As cetaceans rely on sonar for navigation, finding prey and communication, they are highly sensitive to hearing loss (Southall *et al*., 2007). 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 significant as it is in cetaceans.

13.173. The impacts of a behavioural disturbance due to noise could become a significant 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.

13.174. The most commonly occurring species within the study area are taken forward for consideration in the assessment. The value of the population and the sensitivity of individuals within that population to the impact is summarised in Table 13.14. Detail supporting these levels of species and population sensitivity are provided in Existing Environment Section, and the relevant technical appendices. All species of cetacean are considered internationally important, which is reflected in the European Legislation and therefore value is considered high for all species. Value is also considered to be high for harbour and grey seal, due to the presence of internationally important sites for these species within the RSA.

13.175. Where uncertainty is present, as to the sensitivity of individuals to a particular impact, the precautionary approach is taken in assigning sensitivity to a higher level than evidence or expert judgement would suggest.

13.176. The impact significance (Table 13.5) is based on the combination of the sensitivity (Table 13.3) of individuals to the impact and the magnitude of the impact (Table 13.4).

Table 13.14 Summary of value (V) of the population occurring RSA and sensitivity (S) of individuals in the population to the different impacts of noise from pile driving.

Species	Lethal effect (V/S)	Physical injury (V/S)	Auditory injury (PTS) (V/S)	Behavioural disturbance (V/S)
Harbour porpoise	High/ High	High/ High	High/ High	High/ Medium
Bottlenose dolphin	High/ High	High/ High	High/ Medium	High/ Low
Minke whale	High/ High	High/ High	High/ High	High/ Medium
White-beaked dolphin	High/ High	High/ High	High/ High	High/ Medium
Harbour seal	High/ High	High/ High	High/ Medium	High/ Medium
Grey seal	High/ High	High/ High	High/ Medium	High/ Low

Piling – Single event

Impact 1: Fatality and physical non-auditory injury

13.177. The estimated ranges out to which lethal and physical (non-auditory) injury may occur in the worst case GM1 and most liekly GM3 scenarios in all marine mammals are <40m and <60m respectively (Appendix H6, Table 6-8). This assessment is based on un-weighted peak-to-peak sound level 240dB re.1μPa and 220 dB re.1μPa for lethal and physical injury respectively.

13.178. All species have high sensitivity to noise above thresholds that can cause death or non-auditory injury. The ranges of potential impact, and therefore the number of individuals that could be exposed to such impacts, is however of negligible magnitude (based on ISA or RSA species specific densities). The impact for all species is minor adverse and **not significant**.

13.179. Given that the mitigation for minimising the occurrence of fatality and physical non-auditory impacts and auditory injury is the same, the mitigation and residual impacts for both are discussed at the end of the end of the Auditory injury Section, below.

Impact 2: Auditory injury

13.180. The 130bB$_{ht}$ (*Species*) perceived level is used to indicate traumatic hearing damage over a very short exposure time of only a few pile strikes (Appendix H6, Section 6-4). The ranges at which this can occur are summarised in Table 13.15.

13.181. It should be noted that minke whale results are based on a theoretical humpback whale audiogram and should be interpreted with some caution due to a large potential error. Impacts may be over or underestimated. White-beaked dolphin results are based on the bottlenose dolphin audiogram and should also be interpreted with caution.

Table 13.15 Summary of maximum range (and area) of 130dB$_{ht}$ (*Species*) perceived level based on a single pile driving event.

Species	Max range, km (area, km2)	
	Worst Case GM1	Most Likely GM3
Bottlenose dolphin	0.36 (0.38)	0.3 (0.26)
Harbour porpoise	0.64 (1.24)	0.54 (0.88)
Minke whale (using Humpback as proxy)	0.84 (2.15)	0.66 (1.32)
White-beaked dolphin (using bottlenose dolphin as proxy)	0.36 (0.38)	0.3 (0.26)
Harbour seal	0.2 (0.11)	0.16 (0.07)
Grey seal	0.2 (0.11)	0.16 (0.07)

13.182. The potential impact of auditory injury (PTS) was also assessed using the 'M-weighted' SEL criteria (Southall *et al.*, 2007), as outlined in Appendix H6 (Section 6-5). The likely ranges and associated areas of impact based on these criteria are summarised in Table 13.16.

13.183. The appropriate PTS threshold for seals is undergoing further discussion, and has been the subject of consultation throughout this EIA. Given the evidence presented in Thompson and Hastie (2011), this assessment considers the likely impact range to fall somewhere between the ranges for pinnipeds based on the 186 dB re 1 µPa^2.s-^{1} (Mpw) and the 198 dB re 1 µPa^2.s-^{1} (M_{pw}) thresholds (Table 13.16).

Table 13.16 Summary of maximum range (and area) over which auditory injury (based on the 'M-weighted' SEL metric) is predicted during the Worst Case GM1 and Most Likely GM3 Project Alpha scenarios for the fleeing animal model (Appendix H6). Based on a single pile driving event

Summary of maximum range (and area) over which auditory injury (based on the 'M-weighted' SEL metric) is predicted during the Worst Case GM1 and Most Likely GM3 Project Alpha scenarios for the fleeing animal model (Appendix H6). Based on a single pile driving event Species group	Max range, km (Area, km^2)	
	Worst Case GM1	Most Likely GM3
Low Frequency Cetacean (198 dB re 1 µPa^2.s^{-1} (M_{lf})	0.2 (0.1)	<0.1 (0.05)
Mid Frequency Cetacean (198 dB re 1 µPa^2.s^{-1} (M_{mf})	<0.1 (0.05)	<0.1 (0.05)
High Frequency Cetacean (198 dB re 1 µPa^2.s^{-1} (M_{hf})	<0.1 (0.05)	<0.1 (0.05)
Pinnipeds (in water) (186 dB re 1 µPa^2.s^{-1} (M_{pw})	9.1 (240)	4.3 (55)
Pinnipeds (in water) (198 dB re 1 µPa^2.s^{-1} (M_{pw})	0.2 (0.1)	<0.1 (0.05)

13.184. SAFESIMM has been used for bottlenose dolphin, harbour porpoise, harbour seal and grey seal to model the numbers of individuals likely to receive PTS (Appendix H8, Section 3.1).

13.185. The SAFESIMM approach is based on the application of a dose response curve, with the probability of an individual receiving PTS at the Southall *et al*., (2007) values being set at 0.18. As the SEL increases the probability of an individual receiving PTS increases, and as the SEL decreases the probability of PTS decreases. This means that although the probability of receiving PTS will be very low, individuals beyond the extent of the ranges calculated using the INSPIRE model can be exposed to noise levels sufficiently high to receive PTS. If the extent of the area where low PTS probabilities exist covers an area of relatively high density, then the probabilities will be summed, thus creating whole numbers of individuals likely to experience PTS. This approach may present a mathematically correct approach, but may not be biologically correct. As a result SAFESIMM may be creating an artificially high impact. Spatially explicit densities are used in the SAFESIMM calculation of the expected number of individuals exposed to PTS as presented in Appendix H7, Section 5.2) for porpoise, Appendix H5 (Section 2.5) for bottlenose dolphin and Appendix H4 (Figure 18 and Figure 19) for seals.

13.186. The seal dose response curve in SAFESIMM is based on the current Pinnipeds (in water) threshold of 186 dB re. 1 $\mu Pa^2.s^{-1}$ (M_{pw}) and this is considered to be very precautionary, as already stated.

13.187. Using SAFESIMM no bottlenose dolphin are predicted to receive PTS, but a number of harbour porpoise, harbour seal, and a larger number of grey seal are (Table 13.17).

13.188. The numbers of individuals that could experience PTS as modelled by SAFESIMM, and the likely range over which PTS is predicted to occur (INSPIRE model) and the range of the 130bB$_{ht}$ (*Species*) perceived level (INSPIRE model), have been compared to assess the level of potential impact for each species.

Table 13.17 The number of bottlenose dolphin, harbour porpoise, harbour seal and grey seal SAFESIMM predicted to experience PTS effects as a result of a single pile driving event, Project Alpha

Species	Number of each species predicted to experience PTS	
	Worst Case GM1	Most Likely GM3
Bottlenose dolphin	0	0
Harbour porpoise	5	2
Harbour seal	16	9
Grey seal	144	77

Bottlenose dolphin

13.189. In the case of bottlenose dolphin the ranges (Table 13.15 and Table 13.16) over which the impact of auditory injury could occur are small, and do not overlap with the coastal area in which the highest levels of bottlenose dolphin occurrence are encountered. Densities of bottlenose dolphin (Appendix H5, Section 2.5) are not available for the offshore areas within the likely impact footprints. Densities for the more offshore areas could be inferred from the SCANS II data, however, the very low number of sightings of bottlenose dolphin in the offshore extent of the RSA, indicates that the areas of potential impact are of very low importance to this species (one bottlenose dolphin in TCE aerial surveys over the FTOWDG area, Appendix H3, Table 2 and Table 3), and no bottlenose dolphin in the Firth of Forth Zone Appendix H1, Table 3).

13.190. This species is considered to have medium sensitivity to auditory injury, but the impact will be of negligible magnitude. Therefore the impact is negligible and **not significant**.

Harbour porpoise

13.191. The impact ranges are larger for harbour porpoise than those for bottlenose dolphin for the 130bB$_{ht}$ (*Species)* metric (Table 13.15), but comparable for cumulative SEL (Table 13.16). SAFESIMM predicts PTS could occur in five harbour porpoise based on the worst case GM1 scenario, and two based on the most likely GM3 scenario. The magnitude of this impact is therefore considered to be negligible when compared to the size of the reference population (<0.01%of the population). However, this species is considered to be highly sensitive to this impact. Such an impact is considered to be minor adverse and **not significant**.

Minke whale

13.192. In the case of minke whale the predicted ranges of injury using all metrics are less than 1km (Table 13.15 and Table 13.16). The areas and range are small, and underlying average densities of 0.023per km^2 means less than 0.05 minke (<0.001% of the population) could be impacted. The magnitude of this impact is negligible. However, given the high sensitivity of this species (Table 13.14) the impact is anticipated to be minor adverse and **not significant**.

White-beaked dolphin

13.193. The ranges for potential impact for white beaked dolphin are less than 500m (Table 13.15 and Table 13.16). The area within this range and thus the number impacted (less than 0.05 dolphin, or <0.001% of the population) is negligible. However, given the high sensitivity of this species the impact is therefore minor adverse and **not significant**.

Harbour seal

13.194. Consideration of the likely impacts in the case of harbour seal is dependent on the metric used in the assessment. The Pinnipeds (in water) 186 dB re 1 µPa^2.s-^{1} (M$_{pw}$) metric is considered to be highly precautionary, but the ranges are presented alongside 198 dB re 1 µPa^2.s-^{1}. The number of individuals that could receive PTS based on SAFESIMM calculations is only based on 186 dB re 1 µP^{a2}.s-^{1} (Table 13.17).

13.195. The impact footprints when using the Pinnipeds (in water) 186 dB re 1 µPa^2.s-^{1} (M$_{pw}$) metric, overlaps with areas of high at sea densities for harbour seal (Appendix H8, Figure 7). SAFESIMM takes account of this in the modelling, but still uses this precautionary threshold. Based on SAFESIMM this would be a maximum of 3% of the ECMA harbour seal population predicted to experience PTS as a worst case GM1 scenario (16 seals), and 1.7% based on the most likely GM3 scenario (9 seals).

13.196. However, based on the available data, it is considered that the number of individuals predicted to receive PTS, lies somewhere between the SAFESIMM prediction at the 186 dB re 1 µPa^2.s-^{1} threshold (Table 13.17) and the number of individuals within 200m or less of the noise source who would be predicted to get PTS based on the dose response curve for the less conservative criteria of 198 dB re 1 µPa^2.s-^{1} (Table 13.16). The number of individuals within 200m of the noise source could be up to three seals based on a maximum density of 50 per 5km^2 (Appendix H4, Figure 19). The probability of a seal receiving PTS at 198 dB re 1 µPa^2.s-^{1} is 0.18. Therefore, not all of the seals within this range would be predicted to receive PTS.

13.197. As a precautionary approach we consider impacts could occur up to the number predicted by SAFESIMM. Harbour seal have a medium sensitivity to PTS. The worst case impact level predicted to be a maximum of 3% of the ECMA is affected by PTS is low magnitude. The impact is therefore considered to be minor adverse and **not significant** in the context of the ECMA population.

Grey seal

13.198. Based on the results of SAFESIMM (Table 13.17), the maximum impact is equivalent to between 1.2% and 2.5% of the ECMA population (range 5657-12011) for the worst case GM1 and 0.6% and 1.4%, based on the most likely GM3 scenario. Grey seal is considered to have medium sensitivity to PTS. The impacted number of seals is of low magnitude. The impact is therefore minor adverse and **not significant** within the context of the ECMA population.

Mitigation

Mitigation

A Marine Mammal Monitoring Protocol for the Seagreen Project will be developed in conjunction with the relevant Stakeholders (Section 13.11).

The provision of a Marine Mammal Observer (MMO) and/or Passive Acoustic Monitoring (PAM) following JNCC guidelines is likely to be part of the licensing requirement. This should allow for an exclusion zone around the source of pile driving of up to 500m. The use of Acoustic Deterrent Devices (ADDs), if deemed appropriate at the time of design and implementation of the mitigation plan, will be considered as a likely alternative or addition to the provision of MMOs.

Note that soft start (ramp up) procedures are built in to the noise propagation modelling and are therefore not included as mitigation.

Residual Impact – Piling single event

Residual Impact 1: Fatality and physical non-auditory injury

13.199. For all species of marine mammal the estimated ranges out to which lethal and physical (non-auditory) injury may occur from driven piles are within 500m of the noise source. Real time mitigation and monitoring following standard procedures will assist in avoiding lethal or non-auditory impacts from occurring. There will be no residual impact.

Residual Impact 2: Auditory injury

13.200. For bottlenose dolphin, white beaked dolphin, harbour seal and grey seal the likelihood of injury based on the 130bB$_{ht}$ (*Species*) perceived level metric, are within the range of likely mitigation by marine mammal observers or acoustic deterrents (up to 500m range). Auditory impacts based on this metric for these species could therefore be mitigated. As such there would be no residual impact.

13.201. In the case of harbour porpoise and minke whale, the range at which auditory injury may occur based on the 130bB$_{ht}$ (*Species*) perceived level metric, exceeds the range of likely mitigation by MMOs or ADDs for both the worst case GM1 and most likely GM3 scenarios. Based on this metric auditory injury could occur in these species.

13.202. In the case of auditory injury based on the SEL metric, the maximum range of injury is within 500m of the noise source for all species, with the exception of Pinnipeds (in water) at 186 dB re. 1 μPa^2.s^{-1} (M$_{pw}$) (Table 13.16).

13.203. SAFESIMM predicts that harbour porpoise, harbour seal and grey seal could experience PTS based on the SEL metric (Table 13.17).

13.204. Residual impacts are considered below for harbour porpoise, minke whale, harbour and grey seal.

Harbour porpoise

13.205. The range at which auditory injury may occur based on the 130bB$_{ht}$ (*Species*) perceived level metric exceeds the range of likely mitigation by marine mammal observers or acoustic deterrents for both the worst case GM1 and most likely GM3 scenarios. Based on this metric auditory injury could occur in these species.

13.206. The areas of the impact (Table13.15) were overlaid after removing the area of the mitigation zone (0.78 km^2); with the average densities of harbour porpoise based on the SCANS II data. This provided estimates, based on the worst case GM1 scenario, of <0.4 harbour porpoise (most likely <0.3), that could potentially experience auditory injury.

13.207. Despite the INSPIRE model predicting the range of the PTS threshold for High Frequency Cetaceans to be less than 0.1km and therefore within the mitigation zone, due the use of a dose response curve extending beyond the 198dB range, SAFESIMM predicts that PTS can occur. It is important to note that the SAFESIMM results could represent an over-estimate of the number of individual harbour porpoise that could be exposed to noise thresholds that will elicit PTS. It should also be noted that the reduction in impact using standard mitigation to exclude individuals up to 500m from the noise source has not been quantified, and potential impacts remain at five porpoise exposed to noise levels which could result in PTS based on the worst case GM1, and two based on the most likely GM3 case (Table 13.17).

13.208. The magnitude of this impact is considered to be negligible when compared to the size of the reference population (<0.01%). Harbour porpoise have high sensitivity to auditory injury. The residual impact is therefore minor adverse, and **not significant** at the population level.

Minke whale

13.209. The range at which auditory injury may occur in minke whale based on the 130bBht (Species) perceived level metric, exceeds the range of likely mitigation by marine mammal observers or acoustic deterrents, for both the worst case GM1 and most likely GM3 scenarios. Based on this metric auditory injury could occur in these species.

13.210. The areas of impact were overlaid (Table13.15), after removing the area of the mitigation zone (0.78 km^2), with the average densities of minke whale based on the SCANS II data. This provided estimates, based on the worst case GM1 scenario, of <0.05 (most likely <0.03) minke whale that could experience auditory injury.

13.211. Minke whale have high sensitivity to auditory injury, but this impact is predicted to be negligible in magnitude. The residual impact is therefore minor adverse, and **not significant**.

Harbour seal

13.212. In the case of auditory injury based on the SEL metric for Pinnipeds (in water) at 186 dB re 1 $\mu Pa^2.s^{-1}$ (M_{pw}), PTS could occur beyond 500m from the noise source (Table 13.16). As mentioned previously, this metric is considered to be highly precautionary. Impacts of the less conservative threshold, 198 dB re. 1 $\mu Pa^2.s^{-1}$ could potentially be mitigated.

13.213. SAFESIMM uses the overly precautious, Pinnipeds (in water) (186 dB re 1 $\mu Pa^2.s^{-1}$ (M_{pw}) metric to predict the likely number of individuals that will experience PTS for grey and harbour seals (Table 13.17). The predicted number impacted takes no account of the reduced impacts likely from a mitigation zone around the noise source. Therefore, the residual impact after mitigation is likely to be lower than those predicted in Table 13.17.

13.214. Based on SAFESIMM this would be a maximum of 3% of the ECMA harbour seal population predicted to receive PTS for the worst case GM1 scenario, and 1.7% based on the most likely GM3 scenario. Harbour seal individuals are considered as having a medium sensitivity to PTS, and the impact is of low magnitude as less than 5% of the reference population could be impacted. The residual impact is therefore minor adverse, and **not significant** in the context of the ECMA population.

Grey seal

13.215. Based on the results of SAFESIMM the maximum impact could be equivalent to between 1.2% and 2.5% of the ECMA population (range 5657-12011) for the worst case GM1 and 0.6% and 1.4% based on the most likely GM3 scenario. Grey seals are considered as having a medium sensitivity to PTS, and the impact is of low magnitude as less than 5% of the reference population could be impacted. The residual impact is therefore minor adverse, and not significant in the context of the ECMA population.

Residual Impact 3 - Behavioural response

13.216. The estimated impact ranges and areas at 90 dB_{ht} (*Species*) and 75 dB_{ht} (*Species*) are summarised in Table 13.18 and Table 13.19 respectively.

13.217. At the at 90 dB_{ht} (*Species*) range 100% of individuals are expected to show a response and at the 75 dB_{ht} (*Species*) range, up to 65% of individuals are expected to show a response. The level of response is based on the proposed dose response curve for harbour porpoise presented by Thompson *et al*, (2012). Application of the harbour porpoise dose response curve to other species represents a precautionary approach to the assessment.

13.218. For harbour and grey seal, disturbance for the $90dB_{ht}$ contour only is considered. It was agreed during consultation with the SNCB's that this is an appropriate metric for a behavioural response in seals (see Table 13.1, Meeting 02/ 11/ 2012).

Table 13.18 Summary of maximum range and areas of $90dB_{ht}$ (*Species*) perceived level from single pile driving event, Project Alpha

Species	Max Range (km) $90dB_{ht}$ (*Species*)		Area (km^2) $90dB_{ht}$ (*Species*)	
	Worst Case GM1	Most Likely GM3	Worst Case GM1	Most Likely GM3
Bottlenose dolphin	13	12	548.7	406.4
Harbour porpoise	21	18	1261.9	951.1
Minke whale	45	35	4613.5	3755.5
White-beaked dolphin	13	12	548.7	406.4
Harbour seal	17	14	868.5	622.4
Grey seal	17	14	868.5	622.4

Table 13.19 Summary of maximum range and areas of 75dB$_{ht}$ (*Species*) perceived level from single pile driving event, Project Alpha

Species	Max Range (km) 75dB$_{ht}$ (*Species*)		Area (km^2) 75dB$_{ht}$ (*Species*)	
	Worst Case GM1	Most Likely GM3	Worst Case GM1	Most Likely GM3
Bottlenose dolphin	39	35	3891.3	3167.6
Harbour porpoise	59	52	7173.5	5994.7
Minke whale	99	91	15878.2	13905.8
White-beaked dolphin	39	35	3891.3	3167.6

Cetaceans

13.219. The possible number of individuals that will experience noise above threshold that can elicit a behavioural response due to the worst case GM1 and most likely GM3 pile driving scenarios has been calculated for harbour porpoise and bottlenose dolphin by overlaying impact contours (see Appendix H9 for method) from the noise propagation modelling (Appendix H6, Section 6-4) with spatially explicit densities presented in Appendix H7, Section 5.2, and Appendix H5, Section 2.5), in addition to using SAFESIMM (see Appendix H8 for method). Spatially explicit overlay and SAFESIMM were not used in minke whale and white-beaked dolphin where insufficient RSA specific data were available.

13.220. For each species of cetacean disturbance impacts have also been calculated by overlaying impact contours from the noise propagation modelling (Appendix H6, Section 6-4) with average densities from the SCANS II data for survey Block V. The results of all approaches are summarised in Table 13.20.

Table 13.20 Number of each species (and percentage of reference population as described in baseline) predicted to be exposed to a behavioural disturbance from single pile driving event in Project Alpha for Worst Case and Most Likely scenarios.

Species (and reference population)	Spatially explicit overlay		Average densities overlay		SAFESIMM	
	Worst Case GM1	Most Likely GM3	Worst Case GM1	Most Likely GM3	Worst Case GM1	Most Likely GM3
Bottlenose dolphin[8] (Scottish East coast)	0	0	2 (1%)	2 (1%)	48 (25%)	18 (9%)
Harbour porpoise[9] (North Sea)	573 (0.1%)	474 (0.1%)	1501 (0.4%)	1243 (0.3%)	1020 (0.3%)	666 (0.2%)
Minke whale (European)	n/ a	n/ a	275 (1%)	238 (0.9%)	n/ a	n/ a
White-beaked dolphin (European)	n/ a	n/ a	161 (0.7%)	130 (0.6%)	n/ a	n/ a

8 Spatially explicit overlay and SAFESIMM rely on densities shown in (Appendix H5)

9 Spatially explicit densities for harbour porpoise are based on integrated analysis of data (Appendix H7)

13.221. With regard to harbour porpoise, minke whale and white-beaked dolphin the use of average densities is considered to be the most precautionary method to provide an estimate of the likely number of individuals that will be exposed to a noise level that will elicit a behavioural response. These species show some spatial and temporal variation in distribution (Appendix H7, Section 5.2 to 5.4), but by using the average densities a more representative impact level can be considered over time and space.

Harbour porpoise

13.222. The number of harbour porpoise calculated to show a behavioural response using average densities from the SCANS II data gives considerably higher estimates than the other two approaches, and thus would represent a precautionary approach as it is likely that the ISA specific spatially explicit data are a more accurate representation of lower porpoise densities, which occur in the more inshore areas of the RSA (Appendix H7, Section 5.2).

13.223. There is no evidence to show that the impacted areas for this species represent important breeding or foraging habitat that would not be available elsewhere within the species home range over the North Sea.

13.224. Harbour porpoise are considered to be highly sensitive to behavioural disturbance from piling noise (Tougaard *et al*., 2006; Thomsen *et al*., 2006). However, the impacts of behavioural disturbance from a single piling event are of a short duration. 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 duration of effect at locations 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 (PPM), was significantly lower within approximately 3km of the noise source for 40 hours after piling.

13.225. Harbour porpoise have high sensitivity and with a negligible magnitude impact (due to short temporal duration, and small number of individuals impacted) the residu al impact is therefore minor adverse and **not significant**.

White-beaked dolphin

13.226. White-beaked dolphin, are considered to have medium sensitivity to behavioural disturbance from pile driving. The impacts, as in the case for harbour porpoise, will be of negligible magnitude due to the short temporal duration and small number of individuals impacted. The impact is therefore considered to be negligible and **not significant**.

Minke whale

13.227. Minke-whale has medium sensitivity to behavioural disturbance from pile driving noise. The impacts will be of short temporal duration, and a small number could be impacted and therefore are of negligible magnitude. The overall impact would therefore be negligible and **not significant**.

Bottlenose Dolphin

13.228. The estimated dB_{ht} (*Species*) peak to peak impact ranges for bottlenose dolphin for the worst case GM1 scenario and the most likely GM3 scenario are shown in Plate 13.7 and Plate 13.8 respectively.

Plate 13.7 Contour plot showing the estimated 130, 90 and 75 dB_{ht} (*Species*) peak to peak impact ranges for bottlenose dolphin for the Worst Case GM1 (Project Alpha) scenario

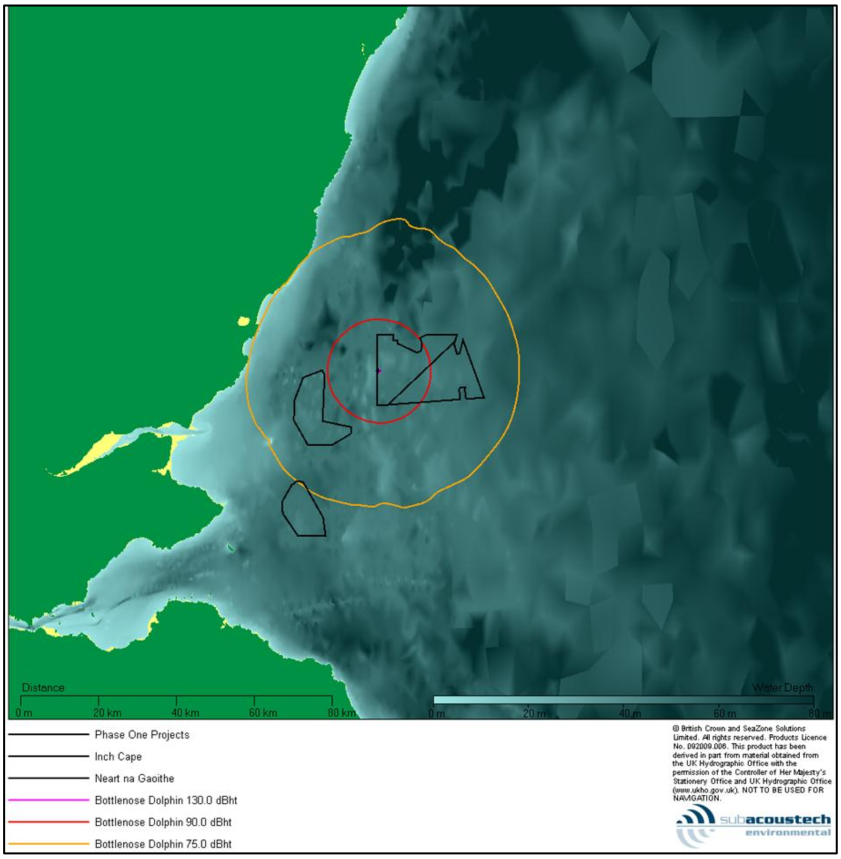
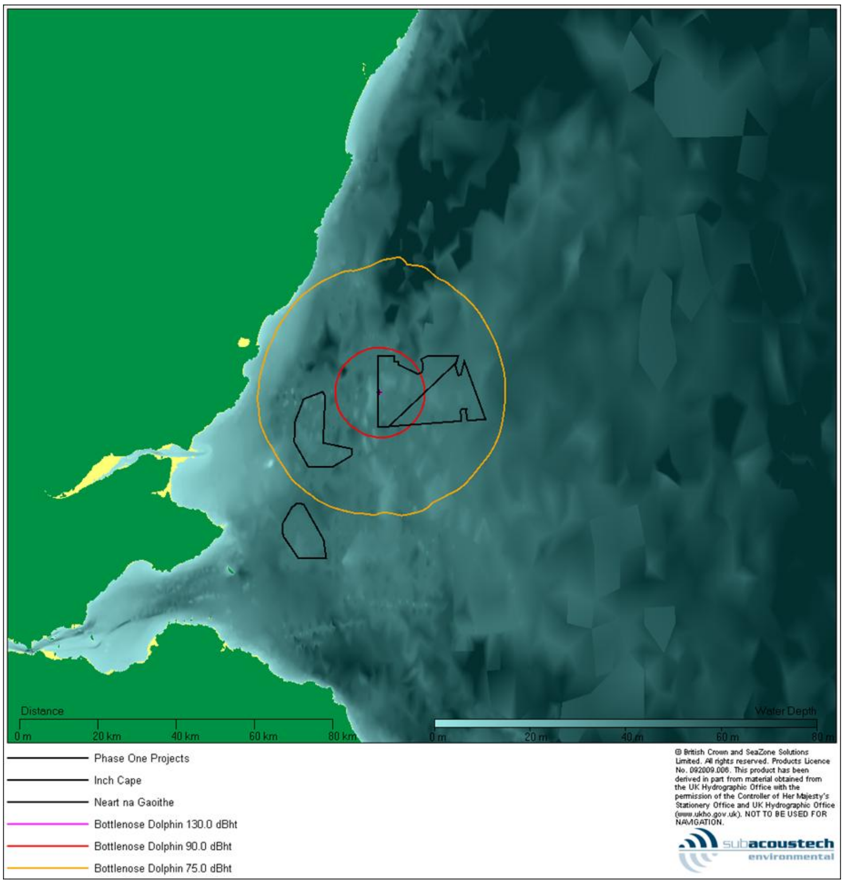


Plate 13.8 Contour plot showing the estimated 130, 90 and 75 dB_{ht} (*Species*) peak to peak impact ranges for bottlenose dolphin for the Most Likely GM3 (Project Alpha) scenario



13.229. Impact ranges at the 90 dB_{ht} (red contour, Plate 13.7 and 13.8) level do not extend toward the coast to a sufficient degree to overlap with the predominantly inshore (within 12 nautical miles) distribution of bottlenose dolphins (Appendix H5, Thompson *et al*., 2011). The 75dB_{ht} ranges (yellow contour, Plate 13.7 and 13.8), do however, reach the coastal zone for both the worst case GM1 and most likely GM3 scenarios, but mostly to the north of the areas where we have ISA specific density estimates, as this is north of the survey extent presented in Appendix H5, Section 2.5).

13.230. Due to the lack of spatially explicit densities along the coast north of the survey region in Appendix H5 (Section 2.5), the estimated number of bottlenose dolphins that will be exposed to a behavioural response level is zero, when noise contours for 90 and 75 dB_{ht} are overlaid with the spatially explicit densities (Table 13.20, and Appendix H9). However, an impact level of zero is unlikely to be the case, given the current understanding of bottlenose dolphin movements along the east coast of Scotland. The alternate approach of overlaying the areas on the predicted densities based on the SCANS II data, suggest that both for the worst case GM1 and the most likely GM3 scenarios two individuals will be exposed to a level of noise that will elicit a behavioural response.

13.231. SAFESIMM has also been used to predict the numbers of individual bottlenose dolphin likely to experience a behavioural disturbance (Appendix H8) using an M-weighted SEL dose response curve. This gives an estimate of 48, and 18 individuals respectively for the worst case GM1 and the most likely GM3 scenarios. However, caution needs to be used in the interpretation of these results. The numbers of mammals expected to experience a behavioural disturbance, generated by SAFESIMM, are likely to be significantly over estimated due to both the method by which the underlying densities have been calculated (Appendix H5, Section 2.5), and also the way SAFESIMM calculates the numbers impacted. As such, it has been agreed not to carry forward SAFESIMM outputs for behaviour disturbance within the assessment (Table 13.1, Meeting 10/ 05/ 2012).

13.232. The bottlenose dolphin densities were estimated using sightings data collected on surveys where effort across the area was not equally distributed and only collected over a limited temporal duration (Quick, 2006). In order to make an estimate of density using these data, the method also assumes that the individuals are distributed evenly over space and time, which is known not to be the case (Appendix H5, Section 2.2). No estimates of density are available for areas to the north of the survey areas presented in Appendix H5, Figure 4). Underlying confidence in the use of these densities in the assessment is low. The east coast bottlenose dolphin home range also extends over a wide area of available habitat out with the area of potential behavioural disturbance (Cheyney *et al*., 2012).

13.233. With regards to the way SAFESIMM works, the model takes no account of the amount of time that the animal will actually spend responding when exposed to a noise above the behavioural response threshold, nor does it consider the distance over which they will respond (Appendix H8, Section 4). This means that worst case GM1 total of 48 animals includes individuals that are a long distance from the noise source, and with only a matter of minutes swimming over a short distance, can move out of the impacted areas. Animals that only experience received low noise levels for a short duration will be likely to only exhibit a small response which will have limited, if any, effect on their fitness. Furthermore, possible exclusion from habitat at this level would not have any long term or population level consequence.

13.234. In addition to this, SAFESIMM considers disturbance along a dose response curve which predicts the proportional change in the occurrence of harbour porpoise with distance from a piling event (Thompson *et al*., 2012; Brandt *et al*., 2011). As there are no empirical data for other species with potentially lower sensitivity, the application of the dose response curve from harbour porpoise to other species should therefore be considered precautionary. The use of the dose response curve by SAFESIMM also therefore extends the impact area, beyond the considered 75dB$_{ht}$ range (although the likelihood of animals showing a behavioural response will be reduced beyond this range). It should therefore not be assumed that the total number of bottlenose dolphin predicted to show some behavioural response by SAFESIMM will all exhibit a biologically significant behavioural response from a single piling event.

13.235. As stated for the other species of cetacean, it should also be noted that the duration of the behavioural disturbance will be temporary due to the short duration of pile driving of less than an hour. Disturbance could last as long as has been observed in harbour porpoise, however, evidence suggests bottlenose dolphin do not show similar responses to noise as harbour porpoise, and are therefore considered to have a lower sensitivity to behavioural disturbance from piling .

13.236. Within the home range of bottlenose dolphin occurring in the RSA there are existing anthropogenic noise sources (such as Aberdeen harbour, and oil rig fabrication and repair activities in the Cromarty Firth). It is likely that individuals within this population will be habituated to such impacts, and may have limited sensitivity to disturbance from anthropogenic noise. Emerging evidence also suggests that bottlenose dolphin may be less sensitive to anthropogenic noise (such as seismic survey air guns) than previously thought (Finneran, *et al*., 2012). Dolphins that were exposed to noise thresholds (total cumulative SEL up to 196 dB re 1 µPa^2.s-^{1}) showed no TTS, and exhibited no significant behavioural reactions.

13.237. However, following a precautionary approach (75dB$_{ht}$ threshold) it is possible that the noise caused by a single piling event at Project Alpha could provide a behavioural disturbance, even though the majority of the area subjected to these noise levels is out with the normal habitat range of this coastal population (Appendix H5, Figure 4). Areas where impacts overlap with distribution represent only a small area of the population range extending further south into England and north to the Moray Firth and the suitable habitat that these areas provide (Thompson *et al*., 2011).

13.238. The spatial and temporal variation in distribution combined with the method of calculation of likely impacts suggests the average densities approach to be the best representation of likely numbers of individuals (two) behaviourally disturbed during a single pile driving event. The likely impact on the bottlenose dolphin population would therefore be **negligible,** based on low magnitude of impact from the small number of individuals that could be disturbed and low species sensitivity.

Pinnipeds

13.239. The mean range out to which behavioural disturbance may occur, and the areas associated with these ranges is presented in Table 13.18.

13.240. The number of individuals that could be exposed to noise above a threshold that will constitute a behavioural disturbance has been calculated using both SAFESIMM (Appendix H8, Table 3), and overlaying spatially explicit densities with the impact contours generated by INSPIRE (Appendix H9, Section 6-4). Both results are presented in Table 13.21. For reasons presented previously (for bottlenose dolphin) outputs from SAFESIMM are not considered appropriate to quantify behavioural response.

13.241. For harbour and grey seal, disturbance out to the 90dB$_{ht}$ contour is assessed; it was agreed during consultation that the 90dB$_{ht}$ is an appropriate metric for estimating the range over which a behavioural response can occur in seals (see Table 13.1, Meeting 10/ 05/ 2012).

13.242. The number of individuals likely to show a behavioural response to piling is best represented by the spatially explicit overlay of the 90dB$_{ht}$ contours with the regional specific density estimates (Appendix H9 and Table 13.21).

Table 13.21 Number of each species (and percentage of reference population as described in baseline) predicted to be exposed to a behavioural disturbance from a single pile driving event at Project Alpha for Worst Case and Most Likely scenarios.

Species (and reference population)	Spatially explicit overlay		SAFESIMM	
	Worst Case GM1	Most Likely GM3	Worst Case GM1	Most Likely GM3
Harbour seal (ECMA)	51 (9%)	44 (8%)	152 (28%)	120 (22%)
Grey seal (North Sea)	398 (3-7%)	367 (1-3%)	2281 (5-16%)	1663 (4-12%)

Harbour seal

13.243. Harbour seal is considered to have medium sensitivity to behavioural disturbance from piling noise. Based on the number of individuals predicted to be within the 90dBht contour the impact could be considered of medium magnitude, however, due to the very short, temporary duration of a single piling event the magnitude of impact in harbour seal is revised to low. The impact for harbour seal is therefore minor adverse and **not significant**.

Grey seal

13.244. Grey seal is considered to have low sensitivity to behavioural disturbance from pile driving noise. Based on the number of individuals predicted to be within the 90dB$_{ht}$ contour, and the short, temporary duration of a single pile driving event the impact in grey seal is low to medium. The impact upon grey seal is therefore minor adverse and **not significant**.

Mitigation

Mitigation

A Marine Mammal Monitoring Protocol for the Seagreen Project will be developed in conjunction with the relevant Stakeholders.

The provision of a Marine Mammal Observer (MMO) and/or Passive Acoustic Monitoring (PAM) following JNCC guidelines is likely to be part of the licensing requirement. This should allow for an exclusion zone around the source of pile driving of up to 500m. The use of Acoustic Deterrent Devices (ADDs), if deemed appropriate at the time of design and implementation of the mitigation plan, will be considered as a likely alternative or addition to the provision of MMOs.

Note that soft start (ramp up) procedures are built in to the noise propagation modelling and are therefore not included as mitigation.

13.245. The mitigation methods of use of a MMO to as far as possible ensure there are no marine mammals in the vicinity prior to piling commencement and soft start piling outlined here, represent industry guidelines, and have therefore been applied already within the assessment. However, the potential exclusion zone created by using ADDs has not been considered within the assessment due to the limited extent of 500m and insignificant effect on the level of impact.

13.246. At present the only technically and economically feasible installation methodologies for wind turbines require a certain amount of pile driving and although pile driving mitigations have been developed, there is currently no method suitable for jacket substructure / foundations in deep water. The possibility of a reduction in noise at source has been considered in the noise propagation modelling (Appendix H6, Section 6-6). The mitigation modelling was designed to investigate the effect of different degrees of attenuation of impact ranges, and the results are presented as an indication of potential reductions in range. At the time of writing the ES, noise reduction at source is not considered to be at a technologically advanced stage to quantify and apply in the case of this development, and no reduction in the predicted impacts is considered further.

13.247. However, there is extensive work currently under way within the industry looking into both potential noise mitigation methods for piling as well as alternative non-piled substructure / foundation solutions. Seagreen is actively involved in this process but until new evidence is presented no further mitigation can be adopted. Nearer to the time of construction the application of such methods will be considered where appropriate.

Residual Impact

13.248. Table 13.22 provides a summary of the residual impacts of noise from a single pile event for each species.

Table 13.22 Summary of residual impacts of noise related to single pile driving event, Project Alpha

Species	Residual impact
Bottlenose dolphin	Negligible, **not significant**
Harbour porpoise	Minor adverse, **not significant**
Minke whale	Minor adverse, **not significant**
White beaked dolphin	Negligible, **not significant**
Harbour seal	Minor adverse, **not significant**
Grey seal	Minor adverse, **not significant**

Multiple Piling - Project Alpha

13.249. The impacts considered so far relate to the installation of a single pile of the four piles required by each foundation for the fully driven (worst case GM1) and drive drill drive (most likely GM3) scenarios. During the construction of Project Alpha, 75 WTGs will be installed each with four piles, giving a total of 300 piles. Engineering input to the Project has defined the ratio of worst case and most likely scenarios as 20% to 80% (or 60:240 piles), which is considered a precautionary, yet realistic representation of the build (Impact Assessment-Worst Case Scenario). This combination is taken forward in the assessment.

13.250. In addition to foundations for the WTGs, a further 48 piles will be installed for the OSPs within Project Alpha. As with the WTG piles, the assumption of a ratio of 20% to 80% for worst case to most likely is also assumed.

13.251. Therefore, within Project Alpha a total of 348 piles will be installed, with a 70:278 split of worst case GM1 to most likely GM3.

13.252. In addition to the consideration of the impacts related to a single pile driving event in the previous ES section, the temporal nature of exposure is also considered. Assessment of the impacts that can occur from the construction of Project Alpha increases the level of uncertainty in the likely consequences of noise from pile driving. Key areas for uncertainty to be introduced into the assessment process relate to biological and engineering factors. A brief summary of the issues is outlined in the following paragraphs.

13.253. Biological uncertainty in the assessment is apparent in most species of marine mammal at several levels in the assessment. Firstly, the thresholds for the onset of auditory injury, or PTS are based largely on theoretical data (Southall *et al*., 2007; Nedwell *et al*., 2007; Thompson & Hastie, 2011). Furthermore, the individual fitness effects of the pile driving noise impacts such as PTS and behavioural disturbance are not well understood, and no empirical evidence exist to link exposure to noise at these thresholds, to changes in rates of survival or reproduction.

13.254. 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 impacts that could occur in the cumulative assessment of Project Alpha and Project Bravo, and other developments (Impact Assessment-Cumulative and In-Combination).

13.255. Where uncertainty is introduced into the assessment process in the subsequent sections, further explanations of the uncertainty is provided, and details of any precautionary approach adopted to negate the uncertainty will also be outlined. In many cases current knowledge and expert opinion is used to support the assumptions made in the assessment.

Fatality and physical non-auditory injury

13.256. For all species of marine mammal the estimated ranges out to which lethal and physical (non-auditory) injury may occur from driven piles are within 500m of the noise source. Real time mitigation and monitoring following standard procedures would prevent lethal or non-auditory impacts from occurring during the construction of Project Alpha. Impacts are considered to be negligible and **not significant**.

Auditory injury

13.257. Based on the previously presented data, we consider there to be no likelihood of auditory injury in bottlenose dolphin, or white-beaked dolphin. In these species we therefore consider impacts to be negligible and **not significant**.

13.258. For the other species (harbour porpoise, minke whale, harbour seal and grey seal) there is the potential for individuals to received noise at levels sufficient to give auditory injury.

Harbour porpoise

13.259. During a single piling event using the SAFESIMM model the assessment predicted as a worst case that five harbour porpoise could be exposed to PTS, and as a most likely case, two harbour porpoise could be exposed to PTS. Based on the 130dB_{ht} thresholds and spatial overlay of areas with SCANS II densities, <0.4 and <0.3 individuals could be exposed to auditory injury as a worst case and most likely case, respectively.

13.260. 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*., 2010). Therefore, the exclusion of porpoise from an area from pile driving is likely to prevent the exposure of animals to auditory injury. The duration of the exclusion will be dependent on distance from the source (thus noise exposure levels the individual receives) which could last up to three days following a single piling event if the animal is close to the source (Brandt *et al*., 2009). It is also likely that vessel traffic will act as a behavioural disturbance and exclude porpoise from area around pile driving (Thomsen *et al*., 2006).

13.261. Indicative construction times presented in Appendix H10 (Section 8) show that the installation of a fully driven pile will take an average of 12.5 hours (approximately 33 minutes of which would be pile driving) and the installation of a drive drill drive pile would take an average of 38.5 hours (approximately 55 minutes of which would be driving and drilling). A single vessel will be used for pile driving at Project Alpha and only one pile will be installed at any one time. Therefore, there will be gaps between noise emissions from pile driving. It is possible that breaks in piling for longer than three days will occur due to engineering or weather related constraints (which could also exclude vessels). Therefore, there is the possibility that harbour porpoise will return the area between piling events. Evidence from other offshore wind farms has indicated that harbour porpoise return to an area where pile driving occurred within 2 or 3 days (Tougaard *et al*., 2009, Thompson *et al*., 2010; Carstensen *et al*., 2006).

13.262. This assessment therefore considers the possibility of animals returning to the ISA during the two years of piling operations. Between each pile driving event porpoise could return to the area, in numbers equivalent to the baseline density, and new (previously unexposed) individuals could be exposed to noise levels sufficient to elicit PTS. This is considered highly precautionary as, it is likely that consecutive pile driving (with minimal breaks as outlined in Appendix H10 (Section 8) will occur during the construction programme before any excluded porpoise return.

13.263. Up to the maximum of 70 piles could be installed in a year using the worst case pile driving parameters, which could lead to a maximum of 350 porpoise being exposed to PTS based on SAFESIMM model (five harbour porpoise per pile, Table 13.17), or 28 porpoise being exposed to PTS based on the area of the $130dB_{ht}$ contour overlaid on the SCANS II densities (<0.4 porpoise per pile). A single vessel and duration of pile driving would allow a maximum of approximately 200 most likely piles installed in the same year which would lead to 400 porpoise exposed to PTS based on SAFESIMM, (two harbour porpoise per pile, Table 13.17), or 80 porpoise being exposed to PTS based on the area of the $130dB_{ht}$ contour overlain on the SCANS II densities (<0.4 porpoise per pile).

13.264. This extreme worst case of new exposure of previously un-impacted individuals on each pile driving event is also applied to year two, with the number of harbour porpoise exposed related to the installation of the remaining 78 most likely piles. This would lead to 156 porpoise exposed to PTS based on SAFESIMM, (two harbour porpoise per pile, Table 13.17), or 31 porpoise being exposed to PTS based on the area of the $130dB_{ht}$ contour overlain on the SCANS II densities (<0.4 porpoise per pile)

13.265. The total figures would equate to 0.2% (906 porpoise, SAFESIMM) or 0.04% (139 porpoise, SCANS II densities overlay) of the North Sea population being exposed to noise levels that can cause PTS during the construction of Project Alpha. As discussed previously, it is likely that the true impact would lie between these two values.

13.266. The impact of PTS would be permanent on these individuals, but would be on a very small proportion of the reference population even considering this highly precautionary approach; figures presented here are likely to represent the extreme worst case. The impact is considered to be minor adverse and **not significant**, based on the high sensitivity of the receptor, and the negligible proportion of the population at risk of receiving this impact.

13.267. There is uncertainty in the assessment of auditory impacts in harbour porpoise due to the understanding of the biological consequences of PTS and the different predictions of numbers that could be impacted between the different approaches to calculating impacts (SAFESIMM, INSPIRE and use of different density estimates). The highly precautionary approach of using the predicted impacts levels from SAFESIMM, and exposure to new individuals on each pile driving event increases confidence that the assessment in presenting the maximum likely impact that could occur from pile driving in Project Alpha for harbour porpoise.

Minke whale

13.268. During a single pile driving event at Project Alpha, the range at which auditory injury may occur based on the 130dB$_{ht}$ perceived level metric exceeds the range of likely mitigation by MMOs or ADDs for both the worst case GM1 and most likely GM3 scenarios (Table 13.15). In the case of auditory injury based on the SEL metric, the maximum range of injury is within 500m of the noise source.

13.269. Numbers of minke whale predicted to be within the 130dB$_{ht}$ contour were <0.05 individuals based on the worst case and <0.03 based on the most likely case. The approach to scaling these impacts for the construction of Project Alpha in this species is the same as that used for harbour porpoise. We assumed that as a worst case animals would return to the ISA between piling and thus new individuals could be exposed to the potential of auditory injury. Scaling the potential impacts this way means that four minke whale could receive auditory injury from the worst case pile driving, and a further eight from the most likely drive drill drive approach during construction. This would be equivalent to a total of 0.05% of the reference population during pile driving at Project Alpha. Impacts would be minor adverse and **not significant**, based on the high sensitivity of the receptor, and the negligible proportion of the population impacted.

13.270. There is uncertainty in the assessment of impacts for minke whale. There are no empirical data relating auditory injury to biology fitness effects, and the thresholds for injury are based on the theoretical humpback whale audiogram, which provides a potential for error. The highly precautionary approach of allowing exposure to new individuals on each pile driving event increases confidence that the assessment is presenting the maximum likely impact that could occur from pile driving in Project Alpha.

Harbour seal

13.271. For harbour seal the likelihood of injury based on the 130bB$_{ht}$ perceived level metric and the198 dB re 1 μPa^2.s-^{1} M-weighted SEL are within the range of mitigation by MMOs or ADDs. Therefore, using these metrics no harbour seal are predicted to receive auditory injury during the construction of Project Alpha.

13.272. However, SAFESIMM uses the Pinnipeds (in water) (186 dB re 1 μPa^2.s-^{1} (M$_{pw}$) metric to predict the likely number of individuals that will experience PTS. The predicted number impacted takes no account of the reduced impacts likely from a mitigation zone around noise source. Based on the SAFESIMM model 16 harbour seal could receive PTS from the worst case GM1 and nine from the most likely GM3 from a single pile driving event.

13.273. The SAFESIMM results should be considered as precautionary for a reasons presented previously during the assessment of a single piling event. SAFESIMM takes no account of seals holding their heads out of the water to avoid exposure to noise. Seals demonstrated this behaviour during captive studies; during playbacks of pile driving sounds, the seals held their heads out of the water more than during control sessions (Kastelein *et al*., 2011). By keeping their heads out of the water seals will greatly reduce the probability of receive a cumulative noise exposure sufficient to elicit PTS.

13.274. There is the potential for harbour seal to show a similar behavioural response to harbour porpoise to pile driving noise, and not return to an area for several days after piling has ceased, although there are no studies to date which monitor harbour seal behaviour during pile driving. However, as already stated it is likely that there will be breaks in the construction programme during the build programme, which could allow animals to return to an area where individuals would be exposed to noise above the PTS at the precautionary 186 dB threshold.

13.275. The number and location of seals predicted by SAFESIMM to receive PTS is dependent on the underlying density surfaces (Appendix H4, Figure 18 and Figure 19) and the dose response curve. Therefore, not all individuals in a single grid cell will receive PTS, even when exposed to noise above the 186 dB threshold. This means subsequent exposure in the same area following a break in pile driving is possible. During the subsequent pile driving, more (previously unexposed) seals could be exposed to noise levels that would elicit PTS.

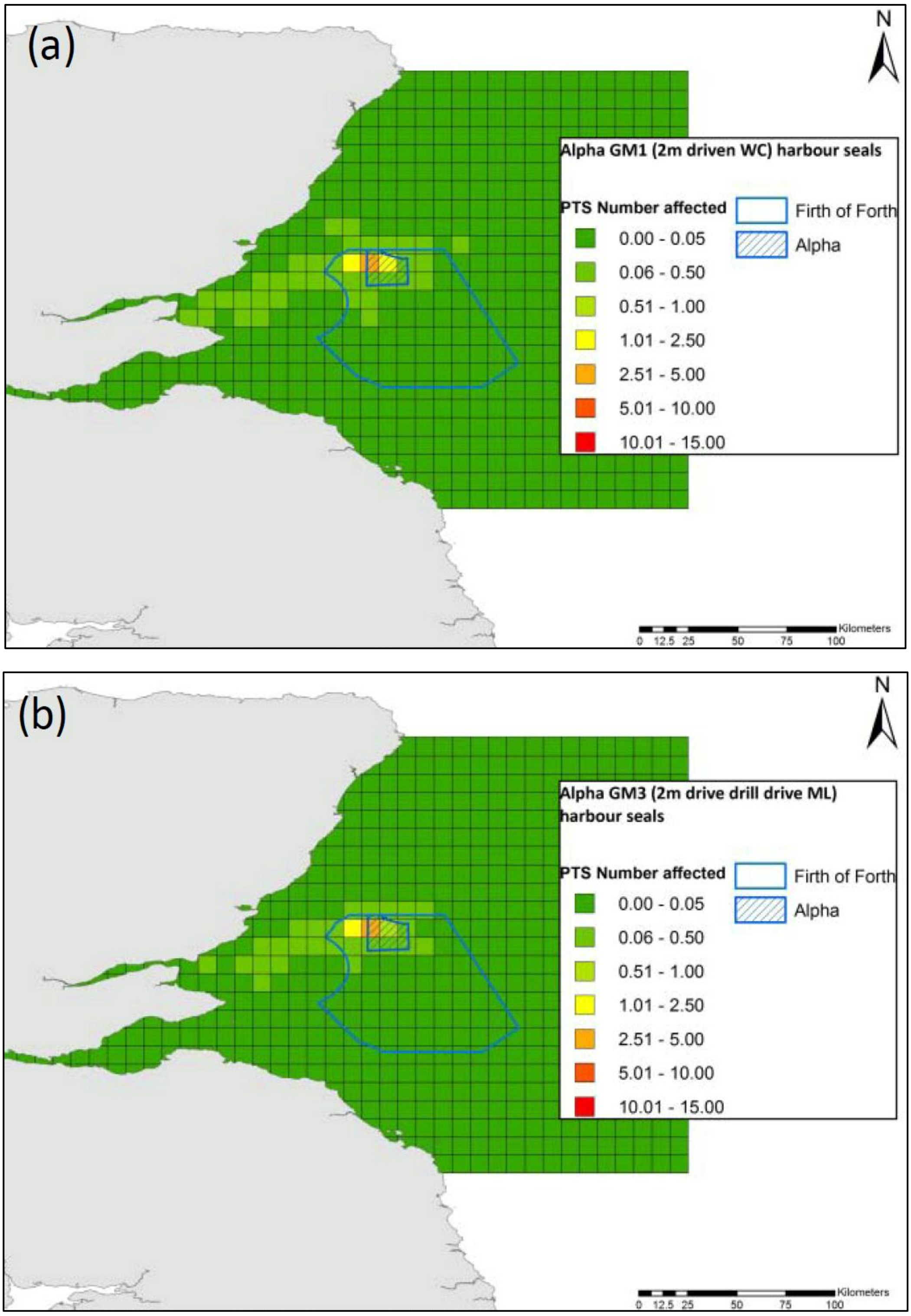
13.276. Quantifying the likelihood of return of animals to a zone where impacts could occur and the exposure of new individuals to noise at thresholds that can induce PTS has not been advised by Marine Scotland during consultation. This means that for the purposes of the assessment it is assumed that no more seals will be exposed to the possibility of PTS than would be exposed during a single piling event.

13.277. The Moray Firth framework (Thompson *et al.*, 2012) suggests that new individuals would only be at risk of PTS once per year during construction. However, they also assume that there will be continuous pile driving over a number of years throughout the construction programme.

13.278. However, as previously stated there is likely to be considerable amounts of time each year when noise from pile driving will not be present. Vessel noise may cause some behavioural response and move animals away from an area, but this is unlikely to occur at ranges where PTS is predicted to occur in harbour seal using SAFESIMM (Plate 13.9, and Appendix H8). Therefore it is unlikely that seals will be continuously excluded for the duration of the build from zones where PTS could occur.

13.279. The number of seals predicted to receive PTS during a single pile driving event at Project Alpha represents a conservative estimate of the number that could be exposed during the construction of Project Alpha as a whole. It is possible that more individuals could be exposed to PTS. However, it is not possible to quantify this number further. This will be dependent on several factors, including, the number of breaks in pile driving, the duration of any behavioural exclusion from the area of construction, and the sensitivity of the individual receptor.

Plate 13.9 The number of harbour seals predicted to experience PTS per 0.083 degree grid cell within the areas of calculation (green boundary) for (a) Alpha Worst Case GM1, and (b) Alpha Most Likely GM3.



13.280. There is a high level of uncertainty in the prediction of the number of individual harbour seals that could be subjected to PTS. Further uncertainty also exists in the likely individual fitness effects caused by PTS, as the implications of PTS on harbour seal are not well understood. Harbour seal are unlikely to be as sensitive to hearing loss as cetaceans as they rely on their sensitive vibrissae (whiskers) for finding food, rather than echolocation, so their foraging ability is unlikely to be affected by hearing loss. However, harbour seal do rely on their hearing to detect predators such as killer whales (Deecke *et al*., 2002) and males make broad band vocalisations during reproductive displays, which are believed to attract females (Van Parijs *et al*., 1997; Hayes *et al*., 2004). It is therefore possible that decreased hearing ability as a result of PTS could lead to increased risk of predation or reduced reproduction rates.

13.281. The Moray Firth Framework (Thompson *et al*., 2012) suggests that individuals subjected to PTS may have an additional mortality risk presented in the form of an immediate additional 25% risk of mortality which is considered highly precautionary. This is based on unknown fitness costs resulting from a decline in hearing ability that could affect survival. Recent research (Ketten *et al*., 2012), has shown that marine mammals (like humans) may have precipitous, as well as progressive hearing loss, therefore sensitivity to disturbance from noise is likely to vary with age, sex and previous exposure history.

13.282. Whilst the consequences of PTS upon an individual are not well understood the effects are permanent by definition, and will remain after the construction of Project Alpha is complete. If a sufficiently large number of individuals receive PTS a population level effect could occur (using the assumption of the Moray Firth Framework for increased mortality).

13.283. PTS on the number of harbour seals predicted by SAFESIMM from a single pile driving event (worst case GM1 of 3% of ECMA; Table 13.17) would have an impact of low magnitude in a species of medium sensitivity. The number of individuals beyond this which could be exposed to PTS during the construction of Project Alpha (348 pile driving events) is unknown, but is likely to be a larger proportion of the population than exposed during one piling event. Overall, as a precautionary approach the impact could be medium magnitude, moderate adverse and **significant**.

13.284. However, there is a large amount of uncertainty in this assessment. Auditory injury at the 130bB$_{ht}$ perceived level metric and the 198 dB re 1 µPa^2.s-^{1} M-weighted SEL threshold is not predicted to occur due to mitigation. The probability of PTS occurring at the 186 dB threshold (used in SAFESIMM) is precautionary, as is the assumption that a PTS impact will cause a 25% increase in mortality.

Grey seal

13.285. For grey seal the likelihood of injury at based on the 130bB$_{ht}$ perceived level metric and the198 dB re 1 µPa^2.s-^{1} M-weighted SEL are within the range of likely mitigation by MMOs or ADDs (500m range). Therefore, using these metrics no grey seal would be predicted to receive auditory injury.

13.286. However, SAFESIMM uses the 186 dB re 1 µPa^2.s-^{1} (M$_{pw}$) metric to predict the likely number of individuals that will experience PTS. The predicted number impacted takes no account of the reduced impacts likely from a mitigation zone around noise source. Based on the SAFESIMM model 144 grey seal could receive PTS from the worst case GM1 and 77 from the most likely GM3 from a single pile driving event (Table 13.17).

13.287. As has been explained for harbour seal, it is likely that breaks in pile driving during construction of Project Alpha could expose more individuals to noise thresholds above those required to induce PTS on more than one occasion. So the numbers predicted by SAFESIMM at this threshold could represent a minimum number of individuals exposed during the build of Project Alpha.

13.288. The implications of PTS in grey seal, as is the case for harbour seal, are poorly understood, so any interpretation about population level consequences is highly uncertain. The magnitude of the impact is low, and as a precautionary approach, grey seal sensitivity to PTS is medium. The impact is therefore considered to be minor adverse, and **not significant**.

Behavioural disturbance

13.289. Southall *et al*., (2007) discuss a range of likely behavioural reactions that may occur. 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 on the number of individuals affected.

13.290. 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 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.

13.291. 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 146 dB re 1 $\mu Pa^2.s^{-1}$. 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.

13.292. 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 (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.

13.293. 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).

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

13.295. The impacts of disturbance will also 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).

Thermoregulation, especially in cold water, is the energetic cost in marine mammals. Kastelein *et al*., (1997) estimate that a harbour porpoise may have life expectancy under starvation as low as three days in waters of 20°C. Should harbour porpoise be excluded from an area of key prey resource, and be unable to find alternate food sources there could be significant effects of behavioural disturbance.

13.296. In contrast to harbour porpoise, harbour and grey seal exhibit periods of alternate 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 and there are marked seasonal changes in body condition (Rosen & Renouf, 1997; Bäcklin *et al*., 2011). Although adult harbour and grey seal 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, exhibited though increased effects of mass dependant survival (Harding *et al*., 2005).

13.297. Table 13.23, provides a representation of the range of response levels with potential individual effects, and population level effects that can result from the disturbance.

Table 13.23 Summary of the likely range of response to noise thresholds above those predicted to elicit a behavioural response. This table is based on expert judgement and published data sources cited in the preceding paragraphs.

Exposure level	Likely response	Individual fitness effect	Population effect
Low level noise stimulus Greater distance from source; habituated to specific stimulus; low sensitivity due to high baseline noise; highly motivated to stay; no startle response; frequency of noise not related to predator or injury threat. Sensitivity and response will be species specific.	**Low level individual response noise stimulus** Low temporal duration of response Exposure constrained to period of piling only. Limited flee response likely and only for a small area around the noise source. Individual seals may respond to a stimulus by increasing the amount of time they spend with their head above water between dives or during noise.	Unlikely to have long term individual impact on reproductive ability or survival probability.	Unlikely to have an effect on growth rates due to minimal effect at an individual level. Consideration should also be made of spatial aspect of disturbance in terms of population range. If the impacted area is only a small proportion of the populations range (and foraging or breeding habitat extent) the effect will be negligible.
Medium level noise stimulus Individuals may be closer to the noise source; less habituation to noise; some motivation to stay; previous exposure history prevents flee or startle response. Sensitivity and response will be species specific.	**Medium level individual response to noise stimulus** **Low or medium temporal duration of response depending on the receptor**. Young or naïve animals may have a greater temporal response than older animals. For seals the period of potential 'exclusion' from area could vary depending on timing in haul / out foraging cycle. The response could last beyond the production of the noise stimulus.	May have a fitness effect on young or vulnerable individuals. Effect will depend on time of year and location of stimulus (changes in food availability or life cycle / energy balance).	Population growth is least sensitive to changes in fecundity, and most sensitive to changes in juvenile survival. Individual species biology will have bearing on population impacts (juvenile seals more likely to disperse, less tied to site, so can move elsewhere). Impact will be increased if exclusion relates to a larger proportion of a populations range.

Exposure level	Likely response	Individual fitness effect	Population effect
High level noise stimulus Naïve or young individuals with no previous exposure to this type or intensity of noise; sudden exposure eliciting a startle response; individual is close to noise source; rapid flee response. Sensitivity and response will be species specific.	**High level individual response to noise stimulus** **High temporal duration of response** Behavioural response is immediate with sustained fleeing from area during stimulus. Level and nature of exposure to stimulus means individuals take a long time to return to area. Time intervals between piling events may not be long enough to allow return.	Likely to have a fitness effect due to cost of flee response or avoidance, exclusion from key habitat, or inexperience of individual in finding alternate foraging areas. However, despite a clear flee response, if the habitat elicits low motivation it may not be an important area to the individual. Continued exposure over time may lead to habituation (and a medium to low level response to what was initially a high level response).	Population level effects may be seen if the exclusion related to a large proportion of the population range or a large time period.

13.298. The estimated ranges and impacts of behavioural response to a single pile driving event are presented in Table 13.18 and Table 13.19. During the construction of Project Alpha, there could be prolonged exposure of seals and cetaceans to noise above thresholds expected to cause behavioural disturbance. However, the impact will be temporary in nature, and disturbance is not likely to persist beyond the construction of Project Alpha.

Cetaceans

13.299. In the case of all species of cetacean included in the assessment, we consider behavioural exclusion for the duration of the over piling the area predicted from the worst case GM1 piling scenario to be the worst likely case. This precautionary approach has been used, as we consider impacts of behavioural disturbance, in the form of complete exclusion out to the 75dBht threshold for the duration of the build.

Harbour porpoise

13.300. Brandt *et al.*, (2011), showed that up to a distance of 4.7km porpoise could be excluded during the whole construction period as the inter-pile interval was longer than the recovery time. Sound levels at this range were not known, but this level of response is likely to equate to at least the 90dB$_{ht}$ threshold, as presented in Thompson *et al.*, (2012). At further ranges the duration of the response was reduced. Therefore, exclusion for the duration of the build out to the 75dB$_{ht}$ range is considered a precautionary assumption.

13.301. In the case of harbour porpoise this would be equivalent to approximately 0.4% of the population being excluded from 7173.5 km^2 of their available habitat. The North Sea is considered to be the reference population for this species, and therefore represents the available habitat resource for this species. Although it should not be assumed that all porpoise will move across this area freely (approximately 750,000km^2), the area of displacement is likely to be less than 1% of the available habitat. The likely impact is considered to be of negligible magnitude, yet porpoise sensitivity is set at the precautionary level of high to behavioural disturbance. The impact is minor adverse and **not significant**.

Minke whale

13.302. Whilst minke whale disturbance is predicted to occur over a larger area (15,878km^2) than for harbour porpoise, their range is also larger. Impacts from a single pile installation (worst case GM1) would be equivalent to 1% of the population. Disturbance to this proportion of the population could persist for the duration of the build of Project Alpha. Although it should not be assumed that all minke whale will move across the wider area, impacts are considered in the context of the North Sea at a minimum (approximately 750,000km^2), which would mean that the displacement area is likely to be less than 2% of the available habitat. The likely impact is therefore considered to be of low magnitude. This combined with medium sensitivity of minke whale to behavioural disturbance from pile driving provides an impact level of minor adverse impact and **not significant**.

White-beaked dolphin

13.303. Impacts for white-beaked dolphin can be calculated assuming as a worst case 0.7% of the population would be excluded from 3,891km^2 of habitat. The reference population for white-beaked dolphin is based on the European population, and the range of movement and available habitat for this species can extend beyond the North Sea. Impact areas are <1% of the available habitat, and levels would be considered as negligible magnitude. The sensitivity of white-beaked dolphin is medium, and impacts would be negligible and **not significant**.

Bottlenose Dolphin

13.304. Although we have considered the possibility of behavioural disturbance in the form of displacement from an area out to the 75dB$_{ht}$ contour as a possibility for the duration of construction at Project Alpha, this is a precautionary approach. Impact ranges for 90dB$_{ht}$ do not extend over a wide area or towards the coastal areas which encompass the main area of bottlenose dolphin activity.

13.305. Impacts at the 75dB$_{ht}$ contour from a single worst case GM1 pile driving event could have an impact on two bottlenose dolphin, based on average densities. This would equate to 1% of the reference population. The effect of disturbance could prevent a barrier to movement between areas of bottlenose dolphin occurrence in the Firth or Tay and more northerly areas including Aberdeen Harbour, and the Moray Firth during the two years of piling operations for Project Alpha, as mixing of individuals between these areas is common on relatively short temporal scales (Appendix H5, Section 4).

13.306. It is possible that bottlenose dolphin could be excluded from a stretch of the Angus and Aberdeenshire coast for the duration of the build at Project Alpha, although it would be difficult to quantify the numbers of individuals impacted due to the spatial and temporal variation in their distribution (Appendix H5, Thompson *et al*., 2012).

13.307. Due to a lack of evidence as to the individual effects of behavioural disturbance on bottlenose dolphin, there is some uncertainty as to the levels of predicted impact at the population level. However, this species is considered to be of low sensitivity to behavioural disturbance from pile driving during and the impact could be of low to medium magnitude due to uncertainty in movement, as a precautionary approach the impact is therefore minor adverse and **not significant**.

Pinnipeds

13.308. In both harbour and grey seal the nature of behavioural responses to noise above the 90dBht threshold is not well understood. Furthermore, no empirical data exist to link disturbance from noise to an individual fitness, or population level effect.

13.309. In contrast to cetaceans, seals have the ability to hold their heads out of the water, and thus avoid noise and reduce the overall impact. However, this behaviour could reduce the amount of time seals spend foraging or carrying out other ecologically important behaviours. Although, it should be noted that as each pile driving event will last for less than one hour, behavioural disturbance from pile driving in seals in the form of exclusion from habitat could be limited to the duration of the pile driving events (a maximum of 348 hours per year).

Harbour seal

13.310. There is a high degree of uncertainty as to the temporal and spatial nature of any behavioural disturbance from pile driving in harbour seal and a high degree uncertainty as to the individual biological consequences of any disturbance.

13.311. The Moray Firth Framework (Thompson *et al*., 2012) suggests, in the absence of any empirical data, that individuals that experience a behavioural disturbance will have reduced breeding success. This assumes a direct positive linear relationship between the proportion of the annual cycle in which disturbance occurs and the resulting reduction in reproductive success. Therefore, an individual that is disturbed for 100% of the time will have 100% reproductive failure in that year. This impact is only applied to the female segment of the population, and in the Moray Firth continuous piling means that (using this model) complete reproductive failure will occur for individuals within the impact zones for the duration of the build.

13.312. During the construction of Project Alpha, there will not be continuous pile driving. It is therefore highly unlikely that animals predicted to be disturbed from a single pile driving event will be behaviourally excluded from the area during the full two year duration of the piling programme. During a single pile driving event the worst case GM1 predicted disturbance level would be to 51 harbour seal (9% of the ECMA; Table 13.21), and 44 harbour seal (8%) of ECMA based on the most likely GM3.

13.313. It is possible that behavioural disturbance would result in exclusion for only the duration of each pile driving event. In each year this would equate to 55 minutes per pile for 70 piles in the case of GM1 or 33 minutes per pile for 278 piles in the case of GM3. If disturbance is limited to this pile driving would last for approximately 217hours per year; less than 3% of the time.

13.314. It is likely that individual habituation, motivation, sensitivity and therefore responses will vary between seals (e.g. Gotz & Janick, 2010; Gotz & Janik, 2011; Keeten *et al*., 2012) and therefore temporal duration of any exclusion will fall somewhere between the whole duration of the build programme and the duration of the actual piling. Given the uncertainty in the duration of the response, the likely effects could range between 100% reduction in fecundity (reproductive failure) for 9% of the population for two years assuming complete exclusion (following the Moray Firth approach) and a 3% reduction in fecundity for a maximum of 9% of the population for two years, assuming exclusion only during pile driving periods.

13.315. Whatever the true effect, each individual will be exposed to a temporary impact. The rate of change in harbour seal populations is not very sensitive to changes in reproductive rates (Thompson *et al*., 2007; Mackey, 2004). However, the ECMA population is already declining, and fecundity in the ECMA is likely to be highly depressed already, as demonstrated by the low numbers of pups counted within the region in recent years (SMRU, Pers. Com; Fife Ranger Service, Unpublished Data).

13.316. Harbour seal have medium sensitivity to behavioural disturbance from pile driving. The impact from the construction of Project Alpha is of medium magnitude, due to the potential of disturbance occurring repeatedly to between 5 and 10% of the ECMA population. The impact could be moderate adverse, and **significant**, but there is a high amount of uncertainty associated with this assessment.

13.317. Uncertainty in this assessment is high due to the lack of empirical evidence showing behavioural disturbance from pile driving in harbour seal. There is also a lack of understanding of the biological consequences of disturbance. The precautionary approach of assuming 100% reduction in fecundity for the duration of pile driving at Project Alpha (two years) is used following the approach adopted in the Moray Firth (Thompson *et al*., 2012).

Grey seal

13.318. Much of the uncertainty that exists in predicting the likely impacts of behavioural disturbance in harbour seal also exist for grey seal.

13.319. Numbers presented for the single pile driving impacts (Table 13.21) will represent the minimum number that could be exposed to noise above the threshold likely to elicit a behavioural response. Repeated exposure may lead to habituation or seals may be sufficiently motivated to carry on their normal behaviour despite the noise (Gotz & Janik, 2011). The temporal duration of any disturbance for an individual could last for the full period of construction that includes pile driving or only for the duration of each pile driving event.

13.320. The large amount of uncertainty makes the assessment of impacts difficult. However, numbers of grey seals in the EMCA are increasing and the population is likely to be robust to some perturbation from behavioural responses to pile driving. The sensitivity of grey seals to behavioural disturbance from pile driving is low, and the magnitude of the impact is medium. The impact is considered to be minor adverse and **not significant**.

Mitigation

Mitigation
No further mitigation is considered than presented for the installation of a single pile.

Residual Impact

13.321. As no further mitigation is considered than used in the assessment of single pile driving at Project Alpha, the residual impacts remain as stated previously for the installation of a single pile. The potential impacts on each species are summarised in Table 13.24.

13.322. As stated in Impact Assessment-Construction, at present the only technically and economically feasible installation methodologies for wind turbines require a certain amount of pile driving. However, there is extensive work currently under way within the industry looking into both potential noise mitigation methods for piling as well as alternative non-piled substructure / foundation solutions. Seagreen is actively involved in this process but until new evidence is presented no mitigation can be adopted.

Table 13.24 Summary of residual impacts from pile driving noise during the construction of Project Alpha

Species	Effect	Sensitivity	Magnitude	Residual impact	Significance at a population level	Uncertainty[10]
Harbour porpoise	Fatality	High	Negligible	Negligible	**Not significant**	Low
	Physical-non auditory injury	High	Negligible impact	Negligible	**Not significant**	Low
	Auditory injury	High	Negligible	Minor adverse	**Not significant**	Medium
	Behavioural disturbance	High	Negligible	Minor adverse	**Not significant**	Medium
Bottlenose dolphin	Fatality	High	Negligible	Negligible	**Not significant**	Low
	Physical-non auditory injury	High	Negligible	Negligible	**Not significant**	Low
	Auditory injury	Medium	Negligible	Negligible	**Not significant**	Low
	Behavioural disturbance	Low	Medium	Minor adverse	**Not significant**	Medium
Minke whale	Fatality	High	Negligible	Negligible	**Not significant**	Medium
	Physical-non auditory injury	High	Negligible	Negligible	**Not significant**	Medium
	Auditory injury	High	Negligible	Minor adverse	**Not significant**	Medium
	Behavioural disturbance	Medium	Negligible	Minor adverse	**Not significant**	Medium
White-beaked dolphin	Fatality	High	Negligible	Negligible	**Not significant**	Low
	Physical-non auditory injury	High	Negligible	Negligible	**Not significant**	Low
	Auditory injury	High	Negligible	Negligible	**Not significant**	Low
	Behavioural disturbance	Medium	Negligible	Negligible	**Not significant**	Medium
Harbour seal	Fatality	High	Negligible	Negligible	**Not significant**	Low
	Physical-non auditory injury	High	Negligible	Negligible	**Not significant**	Low

10 Uncertainty relates to the conclusion of the assessment. Where data confidence is low a precautionary approach in the assessment is used in reaching the conclusions of the worst potential impacts However, if data confidence is high but biological effects of impact are poorly understood, following a precautionary approach there may still be high uncertainty in the assessment.

Species	Effect	Sensitivity	Magnitude	Residual impact	Significance at a population level	Uncertainty[10]
	Auditory injury	Medium	Medium	Moderate adverse	**Significant**	High
	Behavioural disturbance	Medium	Medium	Moderate adverse	**Significant**	High
Grey seal	Fatality	High	Negligible	Negligible	**Not significant**	Low
	Physical-non auditory injury	High	Negligible	Negligible	**Not significant**	Low
	Auditory injury	Low	Medium	Minor adverse	**Not significant**	Medium
	Behavioural disturbance	Low	Medium	Minor adverse	**Not significant**	High

Vessel noise, cable laying and rock dumping

13.323. During the construction phase of Project Alpha the increased levels of boat based activity in the RSA (outlined in Shipping and Navigation, Chapter 14), will contribute to the total underwater noise levels. Through the consultation Scoping Response, Marine Scotland requested that noise assessments should take into account the noise produced by vessels associated with the Seagreen Project.

13.324. Shipping traffic in the areas currently consists of large tankers, smaller cargo vessels and fishing boats (Chapter 14, Shipping and Navigation) and 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).

13.325. Modelling of vessel noise during construction (Appendix H6, Figures 5-6 to 5-8) shows avoidance behaviour using the $90dB_{ht}$ threshold is predicted to distances of 0m, 16m and 7m for harbour seal, harbour porpoise and bottlenose dolphin, respectively. Appendix H6 also shows noise modelling of cable laying, with $90db_{ht}$ ranges of approximately 9m, 40m, and 3m for bottlenose dolphin, harbour porpoise and harbour seal, and for rock dumping which has ranges of around 50m, 100m and 20m for bottlenose dolphin, harbour porpoise and harbour seal, respectively. No auditory injury is expected. This level of displacement is considered to represent negligible magnitude. The modelling of predicted behavioural responses provided in Appendix H6 does not take into account the potential for habituation of marine mammals which is likely as this environment has existing human activity including vessel traffic. It is therefore likely that the actual ranges at which marine mammals will exhibit avoidance behaviour could be less than modelled.

13.326. Given the presence of marine mammals in areas currently experiencing vessel noise their sensitivity is predicted to be low and the magnitude of these noise impacts (as discussed above) is considered negligible. Therefore the impact is predicted to be of negligible significance. The confidence level in this assessment is high due to the availability of modelling data and the likelihood that the assumptions used are conservative.

Mitigation

Mitigation
None suggested

Residual Impact

13.327. The residual impacts will remain negligible for all species and **not significant**.

Potential Impact of Collision Risk

13.328. During construction of the Project Alpha, increased vessel traffic (including jack-ups / barges, mothership(s) and transfer vessels) has the potential to increase the risk of collision with marine mammals. Chapter 14, Shipping and Navigation states that the busiest offshore shipping routes are used by approximately 1.6 vessels per day. Construction of the OWF will involve up to four large vessels on site. However, there will be some exclusion of existing vessel traffic from Project Alpha during construction and therefore the increased number of vessels is likely to be displaced over a large area.

13.329. Marine mammals are highly agile underwater (Carter, 2007) and so are likely to be able to take evasive action at relatively close range. As discussed in the underwater noise section, harbour porpoise and bottlenose dolphin are expected to detect the vessel noise. Seals may be at greater risk as the noise modelling suggests they will not hear vessel noise. Despite the likely avoidance abilities, ship strikes are known to cause mortality to marine mammals. 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. Collisions can also be non-fatal, but it is possible that those which do not cause immediate death could potentially 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 would defend their vital organs from the worst of any impact (Wilson *et al*., 2007). 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 (>100 m) vessels which are likely travel at slow speeds of around 10 knots or less and only small workboats and crew transfer vessels (~25 m) may operate at greater speed.

13.330. Marine mammals are of international importance. Seals and cetaceans will have some tolerance to this level of increased traffic and the likelihood of a collision is low based on their ability to take avoidance action, therefore they will have low sensitivity to collision risk. Due to the vulnerable nature of the harbour seal population in the RSA they are considered to have medium sensitivity.

13.331. Given that the ISA is already used by vessels it is expected that marine mammals will be habituated to the presence of vessels and so the magnitude of this type of collision risk is predicted to be negligible. As a result the significance of this impact is predicted to be negligible and **not significant** in all species.

13.332. Given that there is some uncertainty due to the fact that not all collisions are recorded the confidence in this assessment is medium.

Mitigation

Mitigation

A Marine Mammal Mitigation Protocol (MMMP) will be developed with Marine Scotland and SNH advice / agreement once the project description has been finalised.

Residual Impact

13.333. The residual impacts will negligible and **not significant** in all species.

Potential Impact of Changes to Water Quality

Accidental Release of Contaminants

13.334. Chapter 8 Water and Sediment Quality outlines the potential for spills or leaks of contaminants, such as of fuel, oil and lubricants if an accident were to occur during construction of the Project Alpha OWF. Marine mammal exposure to contamination usually occurs through consumption of contaminated prey, and direct mortality due to exposure is rare. Chapter 8, Water and Sediment Quality states that if any accidental spillages were to occur, the impact has the potential to be of medium magnitude (as a worst case, although this will be dependent on the materials spilled). Mitigation described in Chapter 8, Water Quality in the form of Pollution Control and Spillage Response Plan and appropriate Site Environmental Management Plan (SEMP) will ensure that any spillage is managed rapidly and is therefore of negligible residual significance which will reflect a change of negligible magnitude to marine mammals.

13.335. Marine mammals will have some tolerance to contaminants and are predicted to have low sensitivity and therefore the significance of impact is assessed to be negligible and **not significant**.

13.336. There is high confidence that this is a conservative assessment given the stringent requirements for pollution control and limited potential for major contaminant spills.

Suspended Sediment

13.337. Chapter 8, Water and Sediment Quality outlines the potential for construction of Project Alpha to cause re-suspension of seabed sediments as a result of activities such as seabed preparation, foundation installation, installation of inter-array cables and the placement of scour material on the seabed, and from the placement of anchors or jack up barge feet. This could result in direct impacts on water clarity, and therefore limit the visibility for marine mammals and, in turn, the feeding success in the vicinity of the array. Grey and harbour seals are believed to have high sensitivity to increased amounts of suspended sediment, while cetaceans have a medium sensitivity (Faber Maunsell & Metoc Plc, 2007), based on their level of sight use for prey detection and social interaction.

13.338. Chapter 8, Water and Sediment Quality outlines the level of suspended sediments predicted during construction of the Project Alpha OWF. The disturbance would be relatively short-lived at each location (a few days per foundation), localised (confined to the immediate vicinity of each foundation) and reversible (i.e. the seabed would return to its pre-construction state relatively rapidly (days to weeks). Although a sediment bedload and/or plume would be created, the concentrations would be generally within the bounds of natural variability of background concentrations (which are typically enhanced during spring tide and storm conditions when mobilisation of the side cast material would be initiated). This level of change is predicted to have negligible magnitude on marine mammals.

13.339. In addition the re-suspension of seabed sediments could also lead to the release of contaminants present within them. Chapter 8 Water and Sediment Quality shows that the levels of contaminants in the sediments are below the ISQG, PEL and Cefas Action levels and therefore the magnitude of this impact would be negligible.

13.340. The significance is predicted to be minor adverse for seals and negligible and **not significant** for cetaceans. There is high confidence that this provides a conservative assessment.

Mitigation

Mitigation
Development and adherence to SEMP to prevent and control spillages of contaminants is already factored into this assessment.
Method of installation determines sediment (and contaminant release) mitigation not strictly possible

Residual Impact

13.341. Residual impact therefore remains of minor adverse significance for seals and negligible and **not significant** for cetaceans.

Potential Impact of Changes to Prey Resource

13.342. As discussed in the Existing Environment section of this chapter and Appendix H3, there are possible offshore foraging patches throughout the region where high densities of both grey and harbour seal were recorded at sites known to be important for key prey species, in particular, sandeel. The significant impacts upon the fish resource determined in Chapter 12 Natural Fish and Shellfish Resource were impacts on behaviour or migratory patterns from construction noise in species sensitive to noise (i.e. clupeids).

13.343. Chapter 12 Natural Fish and Shellfish Resource shows that herring have high sensitivity to noise and therefore estimates that the impact of noise on the behaviour and spawning of herring will be of a moderate impact, potentially displacing herring over a wide area (see Appendix H6, Section 6-4). Sandeels and salmonids have low and medium sensitivity, respectively and therefore most impacts on prey will negligible and **not significant** (see Chapter 12, Natural Fish and Shellfish Resource). Table 13.10 shows the variety of prey species eaten by the relevant marine mammal species, with sandeels and salmonids the key prey in the RSA for grey and harbour seals. Harbour porpoise, white beaked dolphin and bottlenose dolphin eat herring as well as other small fish. As discussed above herring are predicted to have an impact of moderate significance, however, there are likely to be alternative sources within the foraging range of cetacean species. Given the low sensitivity of sandeels it is unlikely that this prey resource for seals will be significantly affected. As a result this level of change to fish and shellfish resource is predicted to represent a change of negligible magnitude in relation to the food availability.

13.344. Cetaceans are deemed to have low sensitivity to changes to prey as they will have some capacity to tolerate changes to the distribution of prey resource and therefore the impact is deemed to be negligible and **not significant**. With respect to seals, grey seals forage over a wider area than harbour seal and are therefore low sensitivity to localised changes in prey distribution. The impact is considered to have a low magnitude and is therefore negligible and **not significant**. Harbour seal, have more localised foraging ranges (usually within 60km of their haul out site, e.g. Thompson *et al*., 1996). However, their diet is varied, and as opportunistic feeders harbour seal will eat non displaced species. As a result their sensitivity to this impact is medium and the magnitude of the impact is considered to be low resulting in an impact of minor adverse and **not significant**.

13.345. There is medium confidence in the impact assessment shown in Chapter 12 Natural Fish and Shellfish Resource and so this is reflected in the same confidence level for the indirect impact of changes to prey resource for marine mammals.

Mitigation

Mitigation
Mitigation is focused on reducing the direct impact of fish and shellfish and is therefore identified in Chapter 12, Natural Fish and Shellfish Resource. This relates to mitigation of noise impacts through the use of soft start and ramp up and so is combined with the mitigation for reduction of noise impacts on marine mammals.

Residual Impact

13.346. Residual impact therefore remains of negligible significance for all species, and minor adverse for harbour seal. Impacts for all species are **not significant**.

Project Bravo

Potential Impact – Underwater noise

13.347. As presented in the assessment of likely impact from pile driving at Project Alpha the most commonly occurring species are taken forward for consideration in the assessment. Therefore, for details of methods, please refer to the relevant sections of the preceding assessment paragraphs. The sensitivity of the regional populations is summarised in Table 13.14, detail supporting these levels of species and population sensitivity are provided in the Existing Environment section, and the relevant technical appendices. The potential impacts of noise on marine mammals include lethal doses and physical non-auditory injury, auditory injury, or behavioural responses. When considering the likely impacts from pile driving at Project Bravo as compared to Project Alpha, the main difference in range of impacts relates to the greater water depths at Project Bravo meaning underwater noise will propagate further, the underlying densities and distribution also differ in some species due to the more offshore location of Project Bravo.

Piling – Single event

Fatality and physical non-auditory injury

13.348. The estimated ranges out to which lethal and physical (non-auditory) injury may occur in the worst case GM1 and most likely GM3 scenarios in all marine mammals are <40m and <60m respectively (Appendix H6, Table 6-8). This assessment is based on un-weighted peak-to-peak sound level 240dB re1µPa and 220 dB re1µPa for lethal and physical injury respectively.

13.349. All species are assigned high sensitivity to noise above thresholds that can cause death or non-auditory injury. The ranges of potential impact, and therefore the number of individual that could be could be exposed to such impacts, is however of negligible magnitude (based on ISA or RSA species specific densities). The impact is minor adverse and **not significant** for all species.

13.350. Given that the mitigation for minimising the occurrence of fatality and physical non-auditory impacts and auditory injury is the same, the mitigation and residual impacts for both are discussed at the end of the end of the Auditory injury section, below.

Auditory injury

13.351. The 130bB$_{ht}$ (*Species*) perceived level is used to indicate traumatic hearing damage over a very short exposure time of only a few pile strikes (Appendix H6, Section 6-4). The ranges at which this can occur are summarised in Table 13.15; ranges are the same as for Project Alpha.

13.352. The potential impact of auditory injury was also assessed using the M-weighted SEL criteria (Southall *et al*., 2007), as outlined in Appendix H6 (Section 6-5). The likely ranges and associated areas of impact based on these criteria are summarised in Table 13.25.

13.353. The appropriate PTS threshold for seals is undergoing further discussion, and has been the subject of consultation throughout this EIA. Given the evidence presented in Thompson & Hastie (2011), this assessment considers the likely impact range to fall somewhere between the ranges for pinnipeds based on the 186 dB re 1 µPa^2.s^{-1} (M$_{pw}$) and the 198 dB re 1 µPa^2.s^{-1} (M$_{pw}$) thresholds (Table 13.25).

13.354. SAFESIMM has been used for bottlenose dolphin, harbour porpoise, harbour seal and grey seal to model the numbers of individuals likely to be exposed to SELs at or above the level that the animal is predicted to receive PTS (Appendix H8, Section 3.1).

Table 13.25 Summary of maximum range (and area) over which auditory injury (based on the M-weighted SEL metric) is predicted during the Worst Case GM1 and Most Likely GM3 Project Bravo scenarios for the fleeing animal model (Appendix H6). Based on a single pile driving event.

Species group	Max Range, km (Area, km^2)	
	Worst Case GM1	Most Likely GM3
Low Frequency Cetacean (198 dB re 1 µPa^2.s^{-1} (M$_{lf}$)	0.2 (0.1)	<0.1 (0.05)
Mid Frequency Cetacean (198 dB re 1 µPa^2.s^{-1} (M$_{mf}$)	<0.1 (0.05)	<0.1 (0.05)
High Frequency Cetacean (198 dB re 1 µPa^2.s^{-1} (M$_{hf}$)	<0.1 (0.05)	<0.1 (0.05)
Pinnipeds (in water) (186 dB re 1 µPa^2.s^{-1} (M$_{pw}$)	9.2 (240)	4.3 (55)
Pinnipeds (in water) (198 dB re 1 µPa^2.s^{-1} (M$_{pw}$)	0.2 (0.1)	<0.1 (0.05)

13.355. Using SAFESIMM no bottlenose dolphin are predicted to receive PTS, but a small number of harbour porpoise, harbour seal, and a larger number of grey seal are predicted to receive these levels (Table 13.26).

13.356. The numbers of harbour porpoise and grey seal predicted to experience PTS from pile driving at Bravo are similar to those predicted at Project Alpha (Table 13.17). The numbers of harbour seal predicted to receive PTS at Project Bravo are 26% and 44% lower in the worst case and most likely case respectively. This difference reflects the lower density of harbour seals in more offshore waters at Project Bravo, due to limited foraging ranges of harbour seals.

13.357. The numbers of individuals that could experience PTS as modelled by SAFESIMM, and the likely range over which PTS is predicted to occur (INSPIRE model) and the range of the 130bB$_{ht}$ (*Species*) perceived level (INSPIRE model), have been compared to assess the level of potential impact for each species.

Table 13.26 The number of bottlenose dolphin, harbour porpoise, harbour seal and grey seal SAFESIMM predicted to experience PTS effects as a result of pile driving at Project Bravo.

Species	Number of each species predicted to experience PTS	
	Worst Case GM1	Most Likely GM3
Bottlenose dolphin	0	0
Harbour porpoise	6	3
Harbour seal	10	5
Grey seal	142	76

Bottlenose dolphin

13.358. In the case of bottlenose dolphin the ranges of the likely impacts are small (Table 13.15 and 13.25), and do not overlap with the coastal area of bottlenose dolphin occurrence. Densities of bottlenose dolphin (Appendix H5, Section 2.5) are not available for the offshore areas within the likely impact footprints. Densities for the more offshore areas could be inferred from the SCANS II data, however, the very low number of sightings of bottlenose dolphin in the offshore extent of the RSA, indicates that the areas of potential impact are of very low importance to this species (one bottlenose dolphin in TCE aerial surveys over the FTOWDG area, Appendix H3, Table 2 and Table 3), and no bottlenose dolphin in the Firth of Forth Zone Appendix H1, Table 3).

13.359. This species is considered to have medium sensitivity to auditory injury, but the impact will be of negligible magnitude. Therefore the impact is negligible and **not significant**.

Harbour porpoise

13.360. With regard to harbour porpoise, the impact ranges are larger than those for bottlenose dolphin, for the 130bB$_{ht}$ (*Species*) metric (Table 13.15), but comparable for cumulative SEL (Table 13.25). SAFESIMM predicts PTS in six harbour porpoise based on the worst case GM1 scenario, and three based on the most likely GM3 scenario (Table 13.26). The magnitude of this impact is therefore considered to be negligible (<0.01% of the reference population). However, this species is considered to be highly sensitive to this impact. The impact is minor adverse and **not significant**.

Minke whale

13.361. In the case of minke whale the predicted ranges of injury using all metrics are less than 1km (Table 13.15 and Table 13.25). The areas and range are small, and underlying average densities of 0.023per km^2 means less than 0.05 minke (<0.001% of the population) could be impacted. The magnitude of this impact is negligible. However, given the high sensitivity of this species (Table 13.14) the impact is minor adverse and **not significant**.

White-beaked dolphin

13.362. The ranges for potential impact for white beaked dolphin are less than 500m (Table 13.15 and Table 13.25). The area within this range and thus the number impacted (less than 0.05 dolphin, or <0.001% of the population) is negligible. However, given the high sensitivity of this species the impact is therefore minor adverse and **not significant**.

Harbour seal

13.363. Consideration of the likely impacts in the case of harbour seal is dependent on the metric used in the assessment. Based on SAFESIMM this would be a maximum of 1.8% of the ECMA harbour seal population (10 seals) predicted to experience noise exposure to elicit PTS as a worst case GM1 scenario, and 0.9% (5 seals) based on the most likely GM3 scenario (Table 13.26). However, based on the available data, it is considered that the number of individuals predicted to experience PTS, lies somewhere between the SAFESIMM prediction at the 186 dB re 1 $\mu Pa^2.s^{-1}$ threshold (Table 13.26) and the number of individuals within 200m or less of the noise who would be predicted to get PTS based on the dose response curve for the less conservative criteria of 198 dB re 1 $\mu Pa^2.s^{-1}$. The probability of a seal receiving PTS at 198 dB re 1 $\mu Pa^2.s^{-1}$ is 0.18. Therefore, not all of the seals within this range would be predicted to receive PTS.

13.364. As a precautionary approach we consider impacts could occur up to the number predicted by SAFESIMM. Harbour seal have a medium sensitivity to PTS. The worst case impact level predicted to be a maximum of 1.9% of the ECMA is low magnitude. The impact is therefore considered to be minor adverse and **not significant**.

Grey seal

13.365. Based on the results of SAFESIMM, with regard to grey seals the impacts would be between 1.2% and 2.5% of the ECMA population (142 seals) for the worst case GM1 and between 0.6% and 1.3% in the most likely GM3 scenarios (76 seals; Table 13.26). Grey seal are considered to have medium sensitivity to PTS. The impacted number of seals is of low magnitude. The impact is therefore minor adverse and **not significant**.

Mitigation

Mitigation
A Marine Mammal Monitoring Protocol for the Seagreen Project will be developed in conjunction with the relevant Stakeholders. The provision of a Marine Mammal Observer (MMO) and/or Passive Acoustic Monitoring (PAM) following JNCC guidelines is likely to be part of the licensing requirement. This should allow for an exclusion zone around the source of pile driving of up to 500m. The use of Acoustic Deterrent Devices (ADDs), if deemed appropriate at the time of design and implementation of the mitigation plan, will be considered as a likely alternative or addition to the provision of MMOs. Note that soft start (ramp up) procedures are built in to the noise propagation modelling and are therefore not included as mitigation.

Residual Impact – Piling single event

Fatality and physical non-auditory injury

13.366. For all species of marine mammal the estimated ranges out to which lethal and physical (non-auditory) injury may occur from driven piles are within 500m of the noise source. Real time mitigation and monitoring following standard procedures would prevent lethal or non-auditory impacts from occurring. There will be **no residual impact.**

Auditory injury

13.367. For bottlenose dolphin, white beaked dolphin, harbour seal and grey seal the likelihood of injury based on the 130bB$_{ht}$ (*Species*) perceived level metric, are within the range of likely mitigation by marine mammal observers or acoustic deterrents (up to 500m range). Auditory impacts based on this metric for these species could therefore be mitigated. As such there would be no residual impact.

13.368. As discussed for Project Alpha, there could however be residual impacts for harbour porpoise, minke whale, harbour and grey seal.

Harbour porpoise

13.369. The range at which auditory injury may occur based on the 130bB$_{ht}$ (*Species*) perceived level metric exceeds the range of likely mitigation by marine mammal observers or acoustic deterrents for both the worst case GM1 and most likely GM3 scenarios. Based on this metric auditory injury could occur in these species.

13.370. The areas of the impact (Table13.15) were overlaid after removing the area of the mitigation zone (0.78 km^2); with the average densities of harbour porpoise based on the SCANS II data. This provided estimates, based on the worst case GM1 scenario, of <0.4 harbour porpoise (most likely <0.3), that could potentially experience auditory injury.

13.371. Despite the INSPIRE model predicting the range of the PTS threshold for High Frequency Cetaceans to be less than 0.1km and therefore within the mitigation zone, SAFESIMM predicts that PTS can occur (due the use of a dose response curve extending beyond the 198dB range). It is important to note that the SAFESIMM results are could represent an over-estimate of the number of individual harbour porpoise that could be receive PTS. It should also be noted that the reduction in impact using standard mitigation to exclude individuals up to 500m from the noise source has not been quantified, and potential impacts remain five porpoise based on the worst case GM1, and two based on the most likely GM3 case (Table 13.26).

13.372. The magnitude of this impact is considered to be negligible when compared to the size of the reference population (<0.01%).Harbour porpoise have high sensitivity to auditory injury. The residual impact is therefore minor adverse and **not significant**.

Minke whale

13.373. In the case of minke whale, the range at which auditory injury may occur based on the 130bB$_{ht}$ (*Species*) perceived level metric exceed the range of likely mitigation by MMOs or ADDs for both the worst case GM1 and most likely GM3 scenarios. Based on this metric, auditory injury could occur in these species.

13.374. The areas of impact were overlaid (Table13.15), after removing the area of the mitigation zone (0.78 km^2), with the average densities of minke whale based on the SCANS II data. This provided estimates, based on the worst case GM1 scenario, of <0.05 (most likely <0.03) minke whale that could experience auditory injury.

13.375. Minke whale have high sensitivity to auditory injury, but this impact is predicted to be negligible in magnitude. The residual impact is therefore minor adverse and **not significant**.

Harbour seal

13.376. In the case of auditory injury based on the SEL metric for Pinnipeds (in water) at 186 dB re 1 μPa^2.s^{-1} (M$_{pw}$) an impact could occur beyond 500m from the noise source (Table 13.25). As mentioned previously, this metric is considered to be highly precautionary. Impacts at 198 dB re 1 μPa^2.s^{-1} could potentially be mitigated.

13.377. SAFESIMM uses the overly precautious 186 dB re 1 µPa^2.s^{-1} (M_{pw}) metric to predict the likely number of individuals that will experience PTS for grey and harbour seal (Table 13.26). The predicted number impacted takes no account of the reduced impacts likely from a mitigation zone around the noise source. Therefore, the residual impact after mitigation is likely to be lower than that predicted in Table 13.26.

13.378. SAFESIMM predicts that a maximum of 1.8% of the ECMA harbour seal population could experience PTS for the worst case GM1 scenario, and 0.9% based on the most likely GM3 scenario. Harbour seal individuals are considered as having a medium sensitivity to PTS, and the impact is of low magnitude to the small proportion of the population that could be impacted. The residual impact is therefore minor adverse and **not significant** in the context of the ECMA population.

Grey seal

13.379. Based on the results of SAFESIMM the maximum impact could be equivalent to be between 1.2% and 2.5% of the ECMA population for the worst case GM1 and between 0.6% and 1.3% for the ,ost likely GM3 scenario. Grey seal individuals are considered as having a medium sensitivity to PTS, and the impact is of low magnitude as less than 5% of the reference population could be impacted. The residual impact is therefore minor adverse and **not significant** in the context of the ECMA population.

Behavioural response

13.380. The estimated impact ranges and areas at 90 dB_{ht} (*Species*) and 75 dB_{ht} (*Species*) are summarised in Table 13.27 and Table 13.28 respectively. For harbour and grey seal, only disturbance out to the 90dB_{ht} contour is considered.

Table 13.27 Summary of max range and areas of 90dB_{ht} (*Species*) perceived level from a single pile driving event at Project Bravo

Species	**Max Range (km) 90dB_{ht} (*Species*)**		**Area (km^2) 90dB_{ht} (*Species*)**	
	Worst Case GM1	**Most Likely GM3**	**Worst Case GM1**	**Most Likely GM3**
Bottlenose dolphin	14	12	557.2	412.3
Harbour porpoise	21	18	1276.1	960.6
Minke whale	45	40	5053.5	3999.5
White-beaked dolphin	14	12	557.2	412.3
Harbour seal	17	15	885	635
Grey seal	17	15	885	635

Table 13.28 Summary of max range and areas of 75dBht (Species) perceived level from a single pile driving event at Project Bravo

Species	Max Range (km) 75dB$_{ht}$ (*Species*)		Area (km^2) 75dB$_{ht}$ (*Species*)	
	Worst Case GM1	Most Likely GM3	Worst Case GM1	Most Likely GM3
Bottlenose dolphin	40	35	4125.3	3293.3
Harbour porpoise	57	51	8120.7	6713
Minke whale	99	90	18195	15873
White-beaked dolphin	40	35	4125.3	3293.3

Cetaceans

13.381. The possible number of individuals that will experience noise above a threshold that can elicit a behavioural response due to the worst case GM1 and most likely GM3 pile driving scenarios, has been calculated for harbour porpoise and bottlenose dolphin by overlaying impact contours (see Appendix H9 for method) from the noise propagation modelling (Appendix H6, Section 6-4) with spatially explicit densities presented in Appendix H7, Section 5.2, and Appendix H5, Section 2.5), in addition to using SAFESIMM (see Appendix H8 for method). Spatially explicit overlay and SAFESIMM were not used in minke whale and white-beaked dolphin where insufficient RSA specific data were available.

13.382. For each species of cetacean disturbance impacts have also been calculated by overlaying impact contours from the noise propagation modelling (Appendix H6, Section 6-4) with average densities from the SCANS II data for survey Block V. The results of all approaches are summarised in Table 13.29.

Table 13.29 Number of each species (and percentage of reference population as described in baseline) predicted to be exposed to a behavioural disturbance from single pile driving event for Worst Case and Most Likely scenarios at Project Bravo.

Species (and reference population)	Spatially explicit overlay		Average densities overlay		SAFESIMM	
	Worst Case GM1	Most Likely GM3	Worst Case GM1	Most Likely GM3	Worst Case GM1	Most Likely GM3
Bottlenose dolphin[11] (Scottish East coast)	0	0	**2 (1%)**	**2 (1%)**	26 (13%)	5 (3%)
Harbour porpoise[12] (North Sea)	655 (0.2%)	534 (0.1%)	**1683 (0.4%)**	**1382 (0.4%)**	1126 (0.3%)	744 (0.2%)
Minke whale (European)	n/ a	n/ a	**313 (1.2%)**	**269 (1.1%)**	n/ a	n/ a
White-beaked dolphin (European)	n/ a	n/ a	**170 (0.8%)**	**135 (0.6%)**	n/ a	n/ a

11 Spatially explicit overlay and SAFESIMM rely on densities shown in (Appendix H5).

12 Spatially explicit densities for harbour porpoise are based on integrated analysis of data (Appendix H7)

13.383. With regard to harbour porpoise, minke whale and white-beaked dolphin the use of average densities is considered to be the most precautionary method to provide an estimate of the likely number of individuals that will be exposed to a noise level that will elicit a behavioural response (as discussed for Project Alpha).

Harbour porpoise, white-beaked dolphin and minke whale

13.384. The approach to this impact is discussed in detail in the assessment for Project Alpha. Using the values from Table 13.29 the following assessments have been made.

13.385. Harbour porpoise are considered to be highly sensitive to behavioural disturbance from pile driving noise (Tougaard *et al*., 2006; Thomsen *et al*., 2006). However, the impacts of behavioural disturbance from a single pile driving event are of short temporal duration. The combination of high sensitivity and negligible magnitude (due to short temporal duration) would a minor adverse impact and **not significant**.

13.386. White-beaked dolphin, are considered to have medium sensitivity to behavioural disturbance from pile driving. The impacts will be of negligible magnitude due to the short temporal duration and small number of individuals impacted. The impact would be negligible and **not significant**.

13.387. Minke-whale has medium sensitivity to behavioural disturbance from pile driving noise. The impacts will be of short temporal duration, on a small number of individuals, and therefore of low magnitude. The overall impact would be minor adverse and **not significant**.

Bottlenose Dolphin

13.388. The estimated dB_{ht} (*Species*) peak to peak impact ranges for bottlenose dolphin for the worst case GM1 scenario and the most likely GM3 scenario are shown in Plate 13.10 and Plate 13.11 respectively.

13.389. Impact ranges at the 90 dB_{ht} (red contour, Plate 13.10 and 13.11) level do not extend toward the coast to a sufficient degree to overlap with the predominantly coastal distribution of bottlenose dolphins. The 75 dB_{ht} (yellow contour, Plate 13.7 and 13.8) ranges also do not reach the coastal zone for both the worst case GM1 and most likely GM3 scenarios when pile driving occurs at the modelled location. It should be noted however, that the maximum range of the 75dB_{ht} contour at Project Bravo is 40km. It is therefore possible that piling locations to the south west of Project Bravo could cause a behavioural disturbance to bottlenose dolphin in the coastal zone between Carnoustie and Montrose, similar to the impact areas predicted at Project Alpha.

13.390. An impact level of zero is unlikely to be the case due to our understanding of bottlenose dolphin movements along the east coast of Scotland. The alternate approach of overlaying the areas on the predicted densities based on the SCANS II data, suggest that both for the worst case GM1 and the most likely GM3 scenarios two individuals will be exposed to a behavioural disturbance.

13.391. SAFESIMM has also been used to predict the numbers of individual bottlenose dolphin likely to be exposed to a behavioural disturbance (Appendix H8, Section 3) which gives an estimate of 26 and five individuals respectively for the worst case GM1 and the most likely GM3 scenarios. However, caution needs to be used in the interpretation of these results. Further reasoning for this caution is presented in the assessment of Project Alpha, and the use of SAFESIMM will not be applied in estimating numbers exposed to behavioural disturbance the rest of the assessment.

13.392. As stated above for the other species of cetacean, it should also be noted that duration of the behavioural disturbance will be temporary, and bottlenose dolphin are considered to have a low sensitivity to behavioural disturbance from pile driving.

13.393. Within the home range of bottlenose dolphin occurring in the RSA there are existing anthropogenic noise sources (such as Aberdeen harbour, and oil rig fabrication and repair activities in the Cromarty Firth). It is likely that individuals within this population will be habituated to such impacts, and may have limited sensitivity to disturbance from anthropogenic noise. Emerging evidence also suggests that bottlenose dolphin may be less sensitive to anthropogenic noise (such as seismic survey air guns) than previously thought (Finneran, *et al*., 2012). Dolphins that were exposed to noise thresholds (total cumulative SEL up to 196 dB re 1 $\mu Pa^2.s^{-1}$) showed no TTS, and exhibited no significant behavioural reactions.

Plate 13.10 Contour plot showing the estimated 130, 90 and 75 dB_{ht} peak to peak impact ranges for Bottlenose Dolphin for the Worst Case GM1 (Project Bravo) scenario.

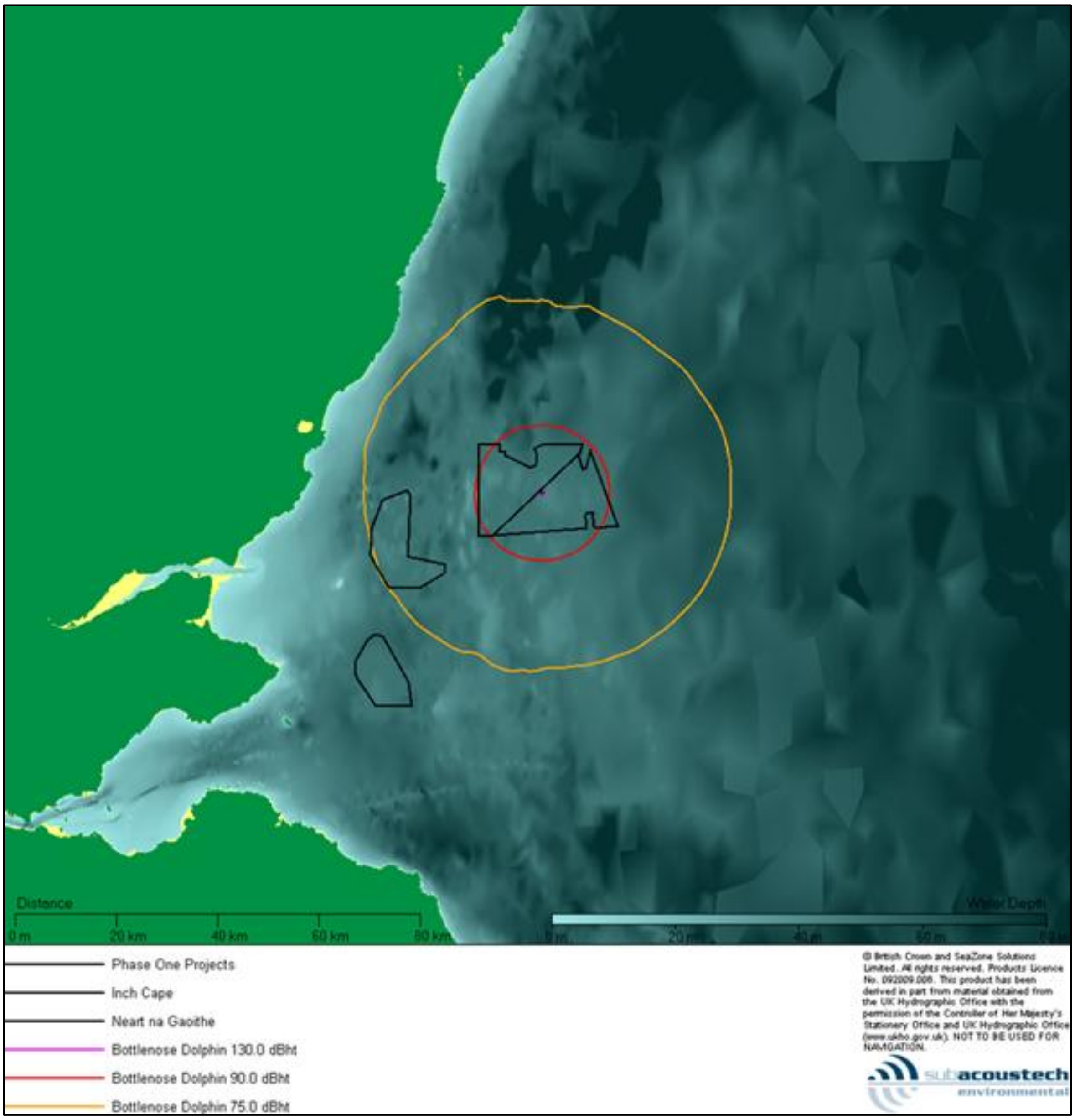
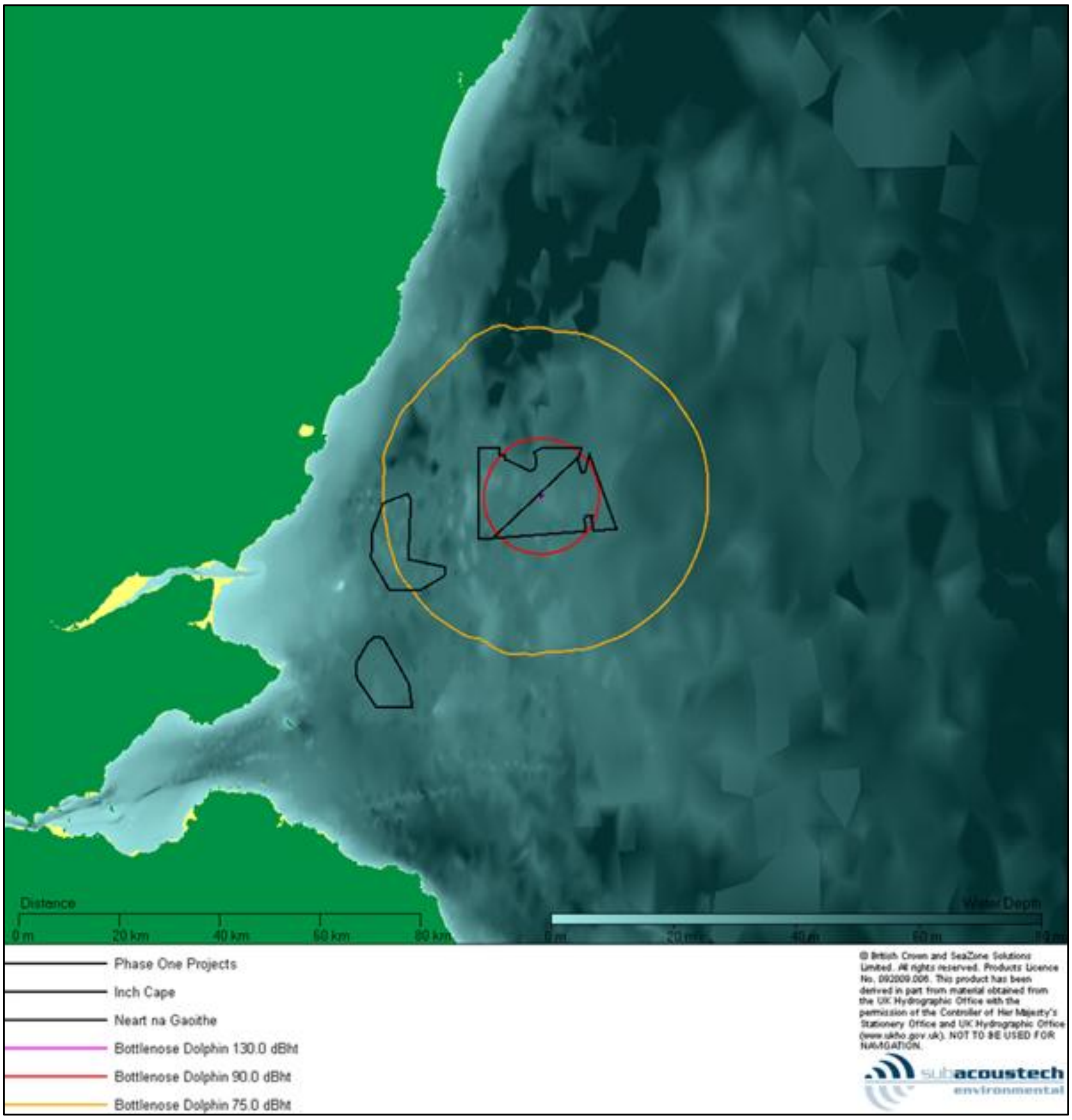


Plate 13.11 Contour plot showing the estimated 130, 90 and 75 dBht peak to peak impact ranges for Bottlenose Dolphin for the Most Likely GM3 (Project Bravo) scenario.



13.394. It is possible that the noise caused by pile driving at Project Bravo could produce a behavioural disturbance, but the majority of the area subjected to these noise levels is out with the normal habitat range of this coastal population (Appendix H5, Figure 4; Thompson *et al*., 2011). Furthermore, areas where impacts overlap with distribution represent only a small area of the range extending further south into England and north to the Moray Firth and the suitable habitat that these areas provide.

13.395. The spatial and temporal variation in distribution combined with the method of calculation of likely impacts suggests the average densities approach to be the best representation of likely numbers of individuals (two) behaviourally disturbed during a single pile driving event. The likely impact on the bottlenose dolphin population would therefore be negligible and **not significant**, based on low magnitude of impact from the small number of individuals that could be disturbed and low species sensitivity.

Pinnipeds

13.396. The mean range out to which behavioural disturbance may occur, and the areas associated with these ranges is presented in Table 13.27.

13.397. The number of individuals that could be exposed to noise above a threshold that will constitute a behavioural disturbance has been calculated using both SAFESIMM (Appendix H8, Table 3), and overlaying spatially explicit densities with the impact contours generated by INSPIRE (Appendix H9, Section 6-4). Both results are presented in Table 13.30. For reasons presented previously (for bottlenose dolphin) outputs from SAFESIMM are not considered appropriate to quantify behavioural response.

Table 13.30 Number of each species (and percentage of reference population as described in baseline) predicted to be exposed to a behavioural disturbance from single pile driving event for Worst Case and Most Likely scenarios at Project Bravo

Species (and reference population)	Spatially explicit overlay		SAFESIMM	
	Worst Case GM1	Most Likely GM3	Worst Case GM1	Most Likely GM3
Harbour seal (ECMA)	38 (7%)	28 (5%)	125 (23%)	102 (19%)
Grey seal (ECMA range)	465 (4-8%)	424 (4-7%)	2166 (18-38%)	1571 (13-28%)

13.398. Harbour seal are considered to have medium sensitivity to behavioural disturbance from piling noise. Based on the number of individuals predicted to be within the $90dB_{ht}$ contour, and the very short, temporary duration of a single pile driving event, the impact in harbour seal is predicted to be low. The impact for harbour seal is minor adverse and **not significant**.

13.399. Grey seal are considered to have low sensitivity to behavioural disturbance from pile driving noise. Based on the number of individuals predicted to be within the $90dB_{ht}$ contour, and the very short, temporary duration of a single pile driving event the impact in grey seal is low to medium. The impact for grey seal is minor adverse and **not significant**.

Mitigation

Mitigation

A Marine Mammal Monitoring Protocol for the Seagreen Project will be developed in conjunction with the relevant Stakeholders.

The provision of a Marine Mammal Observer (MMO) and/or Passive Acoustic Monitoring (PAM) following JNCC guidelines is likely to be part of the licensing requirement. This should allow for an exclusion zone around the source of pile driving of up to 500m. The use of Acoustic Deterrent Devices (ADDs), if deemed appropriate at the time of design and implementation of the mitigation plan, will be considered as a likely alternative or addition to the provision of MMOs.

Note that soft start (ramp up) procedures are built in to the noise propagation modelling and are therefore not included as mitigation.

13.400. The mitigation methods of MMO and soft start outlined here represent industry guidelines, and have therefore been applied already within the assessment. However, the potential 500m exclusion zone resulting from the use of ADDs has not been considered within the assessment. This decision was taken due to its limited ability to reduce likely areas of a behavioural disturbance.

13.401. At present the only technically and economically feasible installation methodologies for wind turbines require a certain amount of pile driving and although pile driving mitigations have been developed, there is currently no method suitable for jacket substructure/ foundations in deep water. The possibility of a reduction in noise at source has been considered in the noise propagation modelling (Appendix H6, Section 6-6). The mitigation modelling was designed to investigate the effect of different degrees of attenuation of impact ranges, and the results are presented as an indication of potential reductions in range. At the time of writing the ES, noise reduction at source is not considered to be at a technologically advanced stage to quantify and apply in the case of this development, and no reduction in the predicted impacts is considered further.

13.402. However, there is extensive work currently under way within the industry looking into both potential noise mitigation methods for piling as well as alternative non-piled substructure/ foundation solutions. Seagreen is actively involved in this process but until new evidence is presented no mitigation can be adopted. Nearer to the time of construction the application of such methods will be considered where appropriate.

Residual Impact

13.403. Table 13.31 provides a summary of the residual impacts of noise from a single pile event for each species.

Table 13.31 Summary of residual impacts of noise related to single pile driving, Project Bravo

Species	**Residual impact**
Bottlenose dolphin	Negligible, **not significant**
Harbour porpoise	Minor adverse, **not significant**
Minke whale	Minor adverse, **not significant**
White beaked dolphin	Negligible, **not significant**
Harbour seal	Minor adverse, **not significant**
Grey seal	Minor adverse, **not significant**

Multiple Piling – Bravo OWF

13.404. The impacts considered so far relate to the installation of a single pile of the four piles required by each WTG foundation for the fully driven (worst case GM1) and drive drill drive (most likely GM3) scenarios. During the construction of Project Bravo, 75 WTGs will be installed each requiring four piles, giving a total of 300 piles. Engineering input to the Project has defined the ratio of worst case and most likely as 20:80% (or 60:240 piles) which is considered as a precautionary, yet realistic representation of the build (Impact Assessment-Construction). This combination is taken forward in the assessment.

13.405. In addition to foundations for the WTGs, a further 24 piles will be installed for the OSPs within Project Bravo. As with the WTG piles, the assumption of a ratio of 20 to 80% for worst case to most likely is also assumed.

13.406. Therefore, within Project Bravo a total of 324 piles will be installed, with a 65:259 split of worst case GM1 to most likely GM3.

13.407. In addition to the consideration of the impacts related to a single pile driving event in the previous ES section, the temporal nature of exposure is also considered. Assessment of the impacts that can occur from the construction of Project Bravo increases the level of uncertainty in the likely consequences of noise from pile driving. Key areas for uncertainty to be introduced into the assessment process relate to biology and engineering factors. A summary is provided in the assessment of Project Alpha.

13.408. Where uncertainty is introduced into the assessment process in the subsequent sections, further explanations of the uncertainty is provided, and details of any precautionary approach adopted to negate the uncertainty will also be outlined. In many cases current knowledge and expert opinion is be used to support the assumptions made in the assessment.

Fatality and physical non-auditory injury

13.409. For all species of marine mammal the estimated ranges out to which lethal and physical (non-auditory) injury may occur from driven piles are within 500m of the noise source. Real timing mitigation and monitoring following standard procedures would prevent lethal or non-auditory impacts from occurring during the construction of Project Bravo. The impact will be negligible and **not significant.**

Auditory injury

13.410. Based on the previously presented data, we consider there to be no likelihood of auditory injury in bottlenose dolphin, or white-beaked dolphin. In these species it is therefore considered that the impact will be negligible and **not significant**.

13.411. For the other species (harbour porpoise, minke whale, harbour seal and grey seal) there is the potential for individuals to received noise at levels sufficient to produce auditory injury.

Harbour porpoise

13.412. During a single pile driving event using the SAFESIMM model the assessment predicted as a worst case that six harbour porpoise could be exposed to PTS, and as a most likely case three harbour porpoise could be exposed to PTS. Based on the 130dB$_{ht}$ thresholds and spatial overpay of areas with SCANS II densities <0.4 and <0.3 harbour porpoise could be exposed to auditory injury as a worst case and most likely case respectively. The SAFESIMM model represents precautionary impact levels from single pile driving.

13.413. 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*., 2010). Therefore, the exclusion of porpoise from an area from pile driving is likely to prevent the exposure of further animals from the population to auditory injury. However, for reasons presented in the assessment of Project Alpha, the assessment considers the possibility of animals returning to the ISA during the two years of piling operations. In this highly precautionary approach, between each pile driving event porpoise could return to the area, in numbers equivalent to the baseline density, and further (previously unexposed) individuals could be exposed to noise levels sufficient to elicit PTS.

13.414. Up to 65 jacket piles could be installed in a year using the worst case pile driving parameters, which could lead to a maximum of 390 porpoise being exposed to PTS based on SAFESIMM model (six harbour porpoise per pile, Table 13.26), or 26 porpoise being exposed to auditory injury based on the area of the 130dB$_{ht}$ contour overlaid on the SCANS II densities (<0.4 porpoise per pile). A single vessel and duration of pile driving would allow a maximum of approximately 200 most likely piles installed in the same year which, which would lead to 600 porpoise based on SAFESIMM, (three harbour porpoise per pile, Table 13.26), or 80 porpoise being exposed to auditory injury based on the area of the 130dB$_{ht}$ contour overlain on the SCANS II densities (<0.4 porpoise per pile).

13.415. This extreme worst case of new exposure of previously un-impacted individuals on each pile driving event is also applied to year two, with the number of harbour porpoise exposed related to the installation of the remaining 59 most likely piles. This would lead to 177 porpoise exposed to PTS based on SAFESIMM, (two harbour porpoise per pile, Table 13.17), or 18 porpoise being exposed to PTS based on the area of the 130dBht contour overlain on the SCANS II densities (<0.4 porpoise per pile)

13.416. The total figures would equate to 0.3% (1167 porpoise, SAFESIMM) or 0.03% (124 porpoise, SCANS II densities overlay) of the North Sea population being exposed to noise levels that can cause PTS during the construction of Project Alpha. As discussed previously, it is likely that the true impact would lie between these two values.

13.417. The impact of PTS would be permanent on these individuals, but would be on a very small proportion of the reference population, even considering this highly precautionary approach; figures presented here are likely to represent the extreme worst case. The impact is considered to be minor adverse and **not significant**, based on the high sensitivity of the receptor, and the negligible proportion of the population at risk of receiving this impact.

13.418. There is uncertainty in the assessment of auditory impacts in harbour porpoise due to the understanding of the biological consequences of PTS and the different predictions of numbers that could be impacted between the different approaches to calculating impacts (SAFESIMM, INSPIRE and use of different density estimates). The highly precautionary approach of using the predicted impacts levels from SAFESIMM, and exposure to new individuals on each pile driving event increases confidence that the assessment in presenting the maximum likely impact that could occur from pile driving in Project Bravo for harbour porpoise.

Minke whale

13.419. During a single pile driving event at Project Bravo, the range at which auditory injury may occur based on the 130bB$_{ht}$ perceived level metric exceed the range of likely mitigation by MMOs or ADDs for both the worst case GM1 and most likely GM3 scenarios (Table 13.15). In the case of auditory injury based on the SEL metric, the maximum range of injury is within 500m of the noise source.

13.420. Numbers of minke whale predicted to be within the 130dB$_{ht}$ contour were <0.05 based on the worst case and <0.03 based on the most likely case. The approach to scaling these impacts for the construction of Project Bravo in this species is the same as that used for harbour porpoise. We assumed that as a worst case animals would return to the ISA between piling and thus new individuals could be exposed to the potential of auditory injury. Scaling the potential impacts this way means that three minke whale could receive auditory injury from the worst case pile driving, and a further eight from the most likely drive drill drive approach during construction. This would be equivalent to a total of <0.05% of the reference population during pile driving at Project Bravo. Impacts would be minor adverse and **not significant**, based on the high sensitivity of the receptor, and the negligible proportion of the population impacted. There is uncertainty in the assessment of impacts for minke whale.

13.421. There are no empirical data relating auditory injury to biology fitness effects, and the thresholds for injury are based on the theoretical humpback whale audiogram, which provides a potential for error. The highly precautionary approach of allowing exposure to new individuals on each pile driving event increases confidence that the assessment is presenting the maximum likely impact that could occur from pile driving in Project Bravo.

Harbour seal

13.422. For harbour seal the likelihood of injury based on the 130bB$_{ht}$ perceived level metric and the198 dB re 1 µPa^2.s^{-1} M-weighted SEL are within the range of mitigation by MMOs or ADDs. Therefore, using these metrics no harbour seal would be predicted to receive auditory injury during the construction of Project Bravo.

13.423. As stated during the assessment of Project Alpha there is a high degree of uncertainty in the predictions of SAFESIMM, the thresholds at which harbour seal will receive PTS, and the biological consequences of PTS.

13.424. The number of seals predicted to receive PTS during a single pile driving event at Project Bravo represents a conservative estimate of the number that could be exposed during the construction of Project Bravo as a whole. It is possible that more individuals could be exposed to PTS. However, it is not possible to quantify this number further this will be dependent on several factors, including, the number of breaks in pile driving, the duration of any behavioural exclusion from the area of construction, and the sensitivity of the individual receptor.

13.425. Whilst the consequences of PTS upon an individual are not well understood the effects are permanent by definition, and will remain after the construction of Project Bravo is complete. If a sufficiently large number of individuals receive PTS a population level effect could occur (using the assumption of the Moray Firth Framework for increased mortality).

13.426. PTS on the number of harbour seals predicted by SAFESIMM would have an impact of medium magnitude in a species of medium sensitivity, as explained for Project Alpha. Overall the impact would be moderate adverse and **significant**.

13.427. However, there is a large amount of uncertainty in this assessment. Auditory injury at the 130bB$_{ht}$ perceived level metric and the 198 dB re 1 µPa^2.s^{-1} M-weighted SEL threshold is not predicted to occur due to mitigation. The probability of PTS occurring at the 186 dB threshold (used in SAFESIMM) is precautionary, as is the assumption that a PTS impact will cause a 25% increase in mortality.

Grey seal

13.428. For grey seal the likelihood of injury at based on the 130bB$_{ht}$ perceived level metric and the198 dB re 1 µPa^2.s^{-1} M-weighted SEL are within the range of likely mitigation by MMOs or ADDs (500m range). Therefore, using these metrics no grey seal would be predicted to receive auditory injury.

13.429. However, SAFESIMM uses the 186 dB re 1 µPa^2.s^{-1} (M$_{pw}$) metric to predict the likely number of individuals that will experience PTS. The predicted number impacted takes no account of the reduced impacts likely from a mitigation zone around noise source. Based on the SAFESIMM model 142 grey seal could receive PTS from the worst case GM1 and 76 from the most likely GM3 from a single pile driving event (Table 13.26).

13.430. As has been explained for harbour seal, it is likely that breaks in pile driving during construction of Project Bravo could expose more individuals to noise thresholds above those required to induce PTS on more than one occasion. Therefore the numbers predicted by SAFESIMM at this threshold could represent a minimum number of individuals exposed during the build of Project Bravo.

13.431. The implications of PTS in grey seal, as is the case for harbour seal, are poorly understood, so any interpretation about population level consequences is highly uncertain. The magnitude of the impact is low, and as a precautionary approach grey seal sensitivity to PTS is medium. The impact is therefore considered to be minor adverse and **not significant**.

Behavioural disturbance

13.432. In the assessment of the construction of Project Alpha the potential impacts of behavioural disturbance are discussed. This discussion of the impacts also applies to assessment of the construction of Project Bravo.

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

13.434. The estimated ranges and impacts of behavioural response to a single pile driving event are presented in Table13.27 and Table 13.28. During the construction of Project Bravo, there could be prolonged exposure of marine mammals to noise above thresholds expected to cause behavioural disturbance. However, the impact will be temporary in nature, and disturbance is not likely to persist beyond the construction of Project Bravo.

Cetaceans

13.435. In the case of all species of cetacean included in the assessment, we consider behavioural exclusion for the duration of the over piling the area predicted from the worst case GM1 piling scenario to be the worst likely case. This precautionary approach has been used, as we consider impacts of behavioural disturbance, in the form of complete exclusion out to the 75dB_{ht} threshold for the duration of the build.

Harbour porpoise

13.436. Brandt *et al*., (2011), showed that up to a distance of 4.7km porpoise could be excluded during the whole construction period as the inter-pile interval was longer than the recovery time. Sound levels at this range were not known, but this level of response is likely to equate to at least the 90dB_{ht} threshold, as presented in Thompson *et al*., (2012). At further ranges the duration of the response was reduced. Therefore, exclusion for the duration of the build out to the 75dB_{ht} range is considered a precautionary assumption.

13.437. In the case of harbour porpoise this would be equivalent to approximately 0.4% of the population being excluded from 8120.7 km^2 of their available habitat. The North Sea is considered to be the reference population for this species, and therefore represents the available habitat resource for this species. Although it should not be assumed that all porpoise will move across this area freely (approximately 750,000km^2), the area of displacement is likely to be less than 1% of the available habitat. The likely impact is considered to be of negligible magnitude, yet porpoise sensitivity is set at the precautionary level of high to behavioural disturbance. The impact is minor adverse and **not significant**.

Minke whale

13.438. Whilst minke whale disturbance is predicted to occur over a larger area (18,195km^2) than for harbour porpoise, their range is also larger. Impacts from a single pile installation (worst caseC GM1) would be equivalent to 1.2% of the population. Disturbance to this proportion of the population could persist for the duration of the build of Project Bravo. Although it should not be assumed that all minke whale will move across the wider area, impacts are considered in the context of the North Sea at a minimum (approximately 750,000km^2), which would mean that the displacement area is likely to be less than 2% of the available habitat. The likely impact is therefore considered to be of low magnitude. This combined with medium sensitivity of minke whale to behavioural disturbance from pile driving provides an impact level of minor adverse impact which is **not significant**.

White-beaked dolphin

13.439. Impacts for white-beaked dolphin can also be calculated assuming as a worst case 0.8% of the population would be excluded from 4,125km^2. The reference population for white-beaked dolphin is based on the European population, and the range of movement and available habitat for this species can extend beyond the North Sea. Impact areas are likely to be <1% of the available habitat, and levels would be considered as negligible magnitude. The sensitivity of white-beaked dolphin is medium, and impacts would be negligible and **not significant**.

Bottlenose Dolphin

13.440. Although we have considered the possibility of behavioural disturbance in the form of displacement from an area out to the 75dB$_{ht}$ contour as a possibility for the duration of construction at Project Bravo, this is a precautionary approach. Impact ranges for 90dB$_{ht}$ will not extend over a wide area or towards the coastal areas of bottlenose dolphin activity.

13.441. Impacts at the 75dB$_{ht}$ contour from a single worst case GM1 pile driving event could have an impact on two bottlenose dolphin, based on average densities. This would equate to 1% of the reference population. The effect of disturbance could prevent a barrier to movement between areas of bottlenose dolphin occurrence in the Firth or Tay and more northerly areas including Aberdeen Harbour, and the Moray Firth during the two years of piling operations for Project Bravo, as mixing of individuals between these areas is common on relatively short temporal scales (Appendix H5, Section 4).

13.442. It is possible that bottlenose dolphin could be excluded from a stretch of the Angus and Aberdeenshire coast for the duration of the build at Project Bravo, although it would be difficult to quantify the numbers of individuals impacted due to the spatial and temporal variation in their distribution (Appendix H5, Thompson *et al.*, 2012).

13.443. Due to a lack of evidence as to the individual effects of behavioural disturbance on bottlenose dolphin, there is some uncertainty as to the levels of predicted impact at the population level. However, this species is considered to be of low sensitivity to behavioural disturbance from pile driving during, the impacts could be of low to medium magnitude due to uncertainty in movements. As a precautionary approach, we conclude that the impact could be minor adverse and **not significant**.

Pinnipeds

13.444. As outlined in the assessment of Alpha, in both harbour and grey seal the nature of behavioural response to noise above the 90dB$_{ht}$ threshold is not well understood. Furthermore, no empirical data exist to link disturbance from noise to an individual fitness, or population level effect.

Harbour seal

13.445. There is a large amount of uncertainty as to the temporal and spatial nature of any behavioural disturbance from pile driving in harbour seal. There is also a large amount of uncertainty as to the individual biological consequences of any disturbance. The assessment of Project Alpha outlines the precautionary approach taken in the assessment and any uncertainties; this approach is also applied to the assessment of Project Bravo.

13.446. Given the uncertainty in the duration of a behavioural response, the likely effects could range between 100% reduction in fecundity (reproductive failure) for 8% of the population for two years assuming complete exclusion (following the Moray Firth approach) and a 2.3% reduction in fecundity (reproductive rates) for a maximum of 8% of the population for two years, assuming exclusion only during pile driving periods.

13.447. Whatever the true effect, each individual will be exposed to a temporary impact. The rate of change in harbour seal populations in not very sensitive to changes in reproductive rates (Thompson *et al*., 2007; Mackey, 2004). However, the ECMA population is already declining, and fecundity in the ECMA is likely to be highly depressed already as demonstrated by the low numbers of pups counted within the region in recent years (SMRU, Pers. Com; Fife Ranger Service, Unpublished Data).

13.448. Harbour seal have medium sensitivity to behavioural disturbance from pile driving. The impact from the construction of Project Bravo is of medium magnitude, with more than 5% of the population being exposed over the duration of the build (Table 13.30). The impact could be moderate adverse and **significant**, but there is a high amount of uncertainty associated with this assessment.

13.449. Uncertainty in this assessment is high due to the lack in empirical evidence showing behavioural disturbance from pile driving in harbour seal. There is also a lack of understanding of the biological consequences of disturbance. The precautionary approach of assuming 100% reduction in fecundity for the duration of pile driving at Project Bravo (two years) is used following the approach adopted in the Moray Firth (Thompson *et al*., 2012).

Grey seal

13.450. Much of the uncertainty that exists in predicting the likely impacts of behavioural disturbance in harbour seal also exist for grey seal.

13.451. Numbers presented for the single pile driving impacts (Table 13.30) will represent the minimum number that could be exposed to noise above the threshold likely to elicit a behavioural response. Repeated exposure may lead to habituation or seals may be sufficiently motivated to carry on their normal behaviour despite the noise (Gotz & Janik, 2011). The temporal duration of any disturbance for an individual could last for the full period of construction that includes pile driving or just for the duration of each pile driving event.

13.452. The large amount of uncertainty makes the assessment of impacts difficult. However, numbers of grey seals in the EMCA are increasing and the population is likely to be robust to some perturbation from behavioural responses to pile driving. The sensitivity of grey seals to behavioural disturbance from pile driving is low, and the magnitude of the impact is medium. The impact is considered to be minor adverse and **not significant**.

Mitigation

Mitigation
No further mitigation is considered than presented for the installation of a single pile

Residual Impacts

13.453. As no further mitigation is considered than used in the assessment of single pile driving at Project Bravo the residual impacts remain as stated previously for the installation of a single pile. The potential impacts on each species are summarised in Table 13.32.

Table 13.32 Summary of residual impacts from pile driving noise during the construction of Project Bravo.

Species	Effect	Sensitivity	Magnitude	Residual impact	Significance at a population level	Uncertainty[13]
Harbour porpoise	Fatality	High	Negligible	Negligible	**Not significant**	Low
	Physical-non auditory injury	High	Negligible	Negligible	**Not significant**	Low
	Auditory injury	High	Negligible	Minor adverse	**Not significant**	Medium
	Behavioural disturbance	High	Negligible	Minor adverse	**Not significant**	Medium
Bottlenose dolphin	Fatality	High	Negligible	Negligible	**Not significant**	Low
	Physical-non auditory injury	High	Negligible	Negligible	**Not significant**	Low
	Auditory injury	Medium	Negligible	Negligible	**Not significant**	Low
	Behavioural disturbance	Low	Medium	Minor adverse	**Not significant**	Medium
Minke whale	Fatality	High	Negligible	Negligible	**Not significant**	Medium
	Physical-non auditory injury	High	Negligible	Negligible	**Not significant**	Medium
	Auditory injury	High	Negligible	Minor adverse	**Not significant**	Medium
	Behavioural disturbance	Medium	Negligible	Minor adverse	**Not significant**	Medium
White-beaked dolphin	Fatality	High	Negligible	Negligible	**Not significant**	Low
	Physical-non auditory injury	High	Negligible	Negligible	**Not significant**	Low
	Auditory injury	High	Negligible	Negligible	**Not significant**	Low
	Behavioural disturbance	Medium	Negligible	Negligible	**Not significant**	Medium
Harbour seal	Fatality	High	Negligible	Negligible	**Not significant**	Low
	Physical-non auditory injury	High	Negligible	Negligible	**Not significant**	Low
	Auditory injury	Medium	Medium	Moderate adverse	**Significant**	High

13 Uncertainty relates to the conclusion of the assessment. Where data confidence is low a precautionary approach in the assessment is used in reaching the conclusions of the worst potential impacts However, if data confidence is high but biological effects of impact are poorly understood, following a precautionary approach there may still be high uncertainty in the assessment.

Species	Effect	Sensitivity	Magnitude	Residual impact	Significance at a population level	Uncertainty[13]
	Behavioural disturbance	Medium	Medium	Moderate adverse	**Significant**	High
Grey seal	Fatality	High	Negligible	Negligible	**Not significant**	Low
	Physical-non auditory injury	High	Negligible	Negligible	**Not significant**	Low
	Auditory injury	Low	Medium	Minor adverse	**Not significant**	Medium
	Behavioural disturbance	Low	Medium	Minor adverse	**Not significant**	High

Vessel noise, cable laying and rock dumping

13.454. Given the mobile nature of marine mammals the baseline usage is very similar for the Project Alpha and Project Bravo areas. The construction activities and required vessels for the two Projects are also very similar and therefore, as with Project Alpha, the construction of Project Bravo will result in negligible magnitude. The sensitivity of marine mammals is classified as low based on their likely ability to tolerate this level of noise. Therefore the impact of vessel, rock dumping and cable laying noise is predicted to be of negligible and **not significant**. As with Project Alpha there is high confidence in this assessment.

Mitigation

Mitigation
None suggested

Residual Impact

13.455. The residual impacts will remain negligible and **not significant**.

Potential Impact of Collision Risk

13.456. During construction of the Project Bravo, increased vessel traffic (including jack-ups / barges, mothership(s) and transfer vessels) has the potential to increase the risk of collision with marine mammals. Chapter 14, Shipping and Navigation states that the busiest offshore shipping routes are used by approximately 1.6 vessels per day. Construction of the OWF will involve up to four large vessels on site. However, there will be some exclusion of existing vessel traffic from Project Bravo during construction and therefore the increased number of vessels is likely to be displaced over a large area.

13.457. Marine mammals are highly agile underwater (Carter, 2007) and so are likely to be able to take evasive action at relatively close range. As discussed in the underwater noise section, harbour porpoise and bottlenose dolphin are expected to detect the vessel noise. Seals may be at greater risk as the noise modelling suggests they will not hear vessel noise. Despite the likely avoidance abilities, ship strikes are known to cause mortality to marine mammals. 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. Collisions can also be non-fatal, but it is possible that those which do not cause immediate death could potentially 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 would defend their vital organs from the worst of any impact (Wilson *et al.*, 2007). 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 travel at slow speeds of around 10 knots or less and only small workboats and crew transfer vessels (~25m) may operate at greater speed.

13.458. Marine mammals are of international importance. Seals and cetaceans will have some tolerance to this level of increased traffic and the likelihood of a collision is low based on their ability to take avoidance action, therefore they will have low sensitivity to collision risk. Due to the vulnerable nature of the harbour seal population in the RSA they are considered to have medium sensitivity.

13.459. Given that the ISA is already used by vessels it is expected that marine mammals will be habituated to the presence of vessels and so the magnitude of this type of collision risk is predicted to be negligible. As a result the significance of this impact is predicted to be negligible and **not significant** in all species.

13.460. Given that there is some uncertainty due to the fact that not all collisions are recorded the confidence in this assessment is medium.

Mitigation

Mitigation
A MMMP will be developed with Marine Scotland and SNH advice / agreement once the project description has been finalised.

Residual Impact

13.461. The residual impacts will remain negligible and **not significant** for all species.

Potential Impact of Changes to Water Quality

Accidental Release of Contaminants

13.462. As with Project Alpha, the potential for spills or leaks of contaminants during construction of Project Bravo is outlined in Chapter 8 Water and Sediment Quality. The magnitude of any potential contamination is predicted to be negligible, and given the low sensitivity of marine mammals the significance is assessed to be negligible and **not significant**. As with Project Alpha there is high confidence in this assessment.

Suspended Sediment

13.463. Any changes to suspended sediments caused by construction of Project Bravo are outlined in Chapter 8 Water and Sediment Quality. As with Project Alpha, the effect of reduced visibility and re-suspension of contaminated sediment is predicted to be of negligible magnitude on marine mammals.

13.464. Given the international importance of marine mammals they must be classified as highly sensitive although this is deemed to be conservative in reality. As a result the impact is predicted to be of minor adverse for seals and negligible and **not significant** for cetaceans. As with Project Alpha there is high confidence in this assessment.

Mitigation

Mitigation
Development and adherence to SEMP to prevent and control spillages of contaminants is already factored into this assessment.
Method of installation determines sediment (and contaminant release) mitigation not strictly possible

Residual Impact

13.465. The residual impacts will remain at minor adverse significance for seals and negligible and **not significant** for cetaceans.

Potential Impact of Changes to Prey Resource

13.466. Given the mobile nature of marine mammals the baseline usage is very similar for Project Alpha and Project Bravo areas, with foraging occurring in both locations. Chapter 12 Natural Fish and Shellfish Resource shows the impact on prey species is similar for both Project Alpha and Project Bravo and therefore the magnitude for Project Bravo will also be negligible. The sensitivity of marine mammals is classified as low based on their likely ability to tolerate some changes to prey resource and therefore the impact is predicted to be of negligible in all species, except harbour seal where it is minor adverse and **not significant**. As with Project Alpha there is medium confidence in this assessment.

Mitigation

Mitigation
Mitigation is focused on reducing the direct impact of fish and shellfish and is therefore identified in Chapter 11, Natural Fish and Shellfish Resource. This relates to mitigation of noise impacts through the use of soft start and ramp up and so is combined with the mitigation for reduction of noise impacts on marine mammals.

Residual Impact

13.467. Residual impact therefore remains of negligible significance for all species, and minor adverse for harbour seal. Impacts are **not significant** for all species.

Transmission Asset Project

Potential Impact of Intertidal or Terrestrial Habitat exclusion

13.468. There are no seal haul out sites within the vicinity of the export cable route corridor, there is no potential habitat loss or exclusion of pinnipeds. There is predicted to be **negligible impact** from habitat exclusion. This assessment has high confidence.

Mitigation

Mitigation
None suggested.

Residual Impact

13.469. Negligible impact and **not significant**.

Potential Impacts of Underwater Noise

13.470. The assessment of impacts from pile driving noise associated with installation of substructure / foundations for OSPs has been carried out within Project Alpha and Project Bravo.

13.471. As with Project Alpha and Project Bravo, the construction phase of the Transmission Asset Project will create an increase in the level of boat based activity in the RSA (outlined in Chapter 14 Shipping and Navigation) which will contribute to the underwater noise levels. Shipping traffic in the area currently consists of large tankers, smaller cargo vessels and fishing boats (Chapter 14 Shipping and Navigation) and it is likely that marine mammals using this region have some level of habituation to this type of underwater noise. 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.

13.472. Modelling of the predicted behavioural response (90dB$_{ht}$) to vessel noise, rock dumping and cable laying during construction is provided in Appendix H6, Figures 5-6 to 5-8. This shows avoidance behaviour is predicted at distances of 0m, 16m and 7m for harbour seal, harbour porpoise and bottlenose dolphin, respectively. Avoidance of cable laying noise is predicted at approximately 9m, 40m, and 3m for bottlenose dolphin, harbour porpoise and harbour seal, and for rock dumping 50m, 100m and 20m for bottlenose dolphin, harbour porpoise and harbour seal, respectively. No auditory injury is expected. This level of displacement is considered to represent negligible magnitude.

13.473. Modelling of predicted behavioural responses provided in Appendix H6, section 6.4 does not take into account the potential for habituation of marine mammals which is likely as this environment has existing human activity including vessel traffic. It is therefore likely that the actual ranges at which marine mammals will exhibit avoidance behaviour could be less than modelled. Marine mammals are of international importance and will have some tolerance to accommodate this level of noise. Therefore, based on their ecological sensitivity marine mammals are predicted to have low sensitivity and therefore the impact is predicted to be of **negligible** significance. The confidence level in this assessment is high due to the availability of modelling data and the likelihood that the assumptions used are conservative.

Mitigation

Mitigation
None suggested.

Residual Impact

13.474. The residual impact remains negligible and **not significant**.

Potential Impact of Collision Risk

13.475. The installation of the export cables and OSPs will result in increased vessel traffic (see Chapter 14, Shipping and Navigation).

13.476. As with Project Alpha and Project Bravo, cetaceans and grey seals are considered to have low sensitivity and harbour seals medium sensitivity based on the limited capacity of the harbour seal population to tolerate any potential fatality. The cable laying process will use both large (>100 m) and small (~20m) cable laying vessels which will mostly be operating at slow speeds. This region is currently used by a number of vessels and therefore marine mammals may be habituated to their presence. It is expected that marine mammals will be able to detect and avoid the vessels. As with Project Alpha and Bravo the magnitude of this type of collision risk is predicted to be negligible. As a result the significance of this impact is negligible and **not significant.**

Mitigation

Mitigation

A MMMP will be developed with Marine Scotland and SNH advice / agreement once the project description has been finalised.

Residual Impact

13.477. The residual impacts will remain negligible adverse for all species and **not significant**.

IMPACT ASSESSMENT – OPERATION

Project Alpha

Potential Impact of Underwater Noise

Wind Turbine Generators (WTGs)

13.478. Recordings of underwater noise from three operational wind farm sites (Middelgrunden, Vindeby and Bockstigen-Valar) suggest that harbour seals may be capable of hearing operational noise from anywhere between a few hundred metres to several kilometres from the noise source (Tougaard *et al.*, 2009). However, the noise was of a low level not considered capable of masking acoustic communication (Tougaard *et al.*, 2009).

13.479. 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 (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) greater than 120 dB re 1 µPa rms SPL would occur, at ranges less than 8.5km. 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 OWF operational noise.

13.480. Comprehensive environmental monitoring has been carried out at the Horns Rev and Nysted wind farms in Denmark during the operational phase in 1999 to 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, however, it was 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 significant effect on the abundances of harbour porpoise at varying wind velocities at both of the Dutch offshore wind farms, following two years of operation. Monitoring studies at Horns Rev have also suggested that operational activities have had no impact on regional seal populations.

13.481. A recent study by Lindeboom *et al.*, (2011) summarised the results of a monitoring programme undertaken at the operational Egmond aan Zee in the Netherlands, as well as other Dutch and Danish projects. For porpoises, the acoustic recordings at Egmond aan Zee showed that significantly more porpoise activity was recorded in the operational wind farm compared to the reference areas outside the farm and it has been indicated that this may be linked to increased food availability or that wind farms could provide areas of relative quiet in comparison to the surrounding waters with high vessel activity (Lindeboom *et al.*, 2011). Both Dutch and Danish research studies indicate that operational wind farms are frequently visited by harbour porpoises and most likely used for foraging (Lindeboom *et al.*, 2011 and references therein).

13.482. Noise levels generated by operational wind turbines are at much lower levels 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).

13.483. Marine mammals are likely to have some tolerance to operational WTG noise and so have low sensitivity to this level of change. The magnitude of noise generated by operational WTGs is predicted to be negligible and therefore the impact will be negligible and **not significant**. Based on the evidence from existing OWFs discussed above the confidence in this assessment is high.

Vessel noise

13.484. Turbine maintenance will be required during operation of Project Alpha which will result in increased boat based activity. Modelling of vessel noise (Appendix H6, Figures 5-6 to 5-8) shows avoidance behaviour using the 90dBht threshold is predicted to distances of 0m, 16m and 7m for harbour seal, harbour porpoise and bottlenose dolphin, respectively. The modelling of predicted behavioural responses provided in Appendix H6 does not take into account the potential for habituation of marine mammals. It is therefore likely that the actual ranges at which marine mammals will exhibit avoidance behaviour could be less than modelled since the RSA is already used by a number of vessels and because the motivation to forage for fish in this area is strong.

13.485. The magnitude of this impact is deemed to be negligible. Marine mammals are of international importance and will have some tolerance to accommodate this level of noise. Therefore, based on their ecological sensitivity marine mammals are predicted to have low sensitivity and therefore the impact is predicted to be negligible and **not significant**. The confidence level in this assessment is high due to the availability of modelling data.

Mitigation

Mitigation
None suggested

Residual Impact

13.486. The residual impact remains negligible and **not significant**.

Potential Impact of Barrier Effects

13.487. The scoping response from JNCC and SNH set out a requirement to assess potential barrier effects. The presence of a wind farm could be seen to present a physical barrier to movement or migration of marine mammals between important feeding and/ or breeding areas. Minimum spacing requirements of 610m between the WTGS of Project Alpha means that animals can be expected to move between devices and through the operational wind farm irrespective of layout. There is sufficient distance between Project Alpha and the coast to allow bottlenose dolphin to travel up the coast without a barrier during operation. As a result the magnitude is predicted to be negligible.

13.488. Evidence from the Egmond aan Zee OWF (Lindeboom *et al*., 2011) suggests that marine mammals may be attracted to the OWF for foraging and therefore, at worst, marine mammals will have negligible sensitivity to this level of change.

13.489. The impact is assessed to be negligible and **not significant**, with high confidence based on evidence from existing OWFs.

Mitigation

Mitigation
None suggested.

Residual Impact

13.490. The impact remains minor and **not significant**.

Potential Impact of Collision Risk

13.491. Operation of Project Alpha will require maintenance vessels which provide a slight increase in the risk of collision for marine mammals over the existing levels of vessel traffic. As discussed during the construction section for Project Alpha seals and cetaceans will have some tolerance to this level of increased traffic. Therefore, based on their likely ability to avoid collision they will have low sensitivity to collision risk. Due to the vulnerable nature of the harbour seal population in the RSA they are considered to have medium sensitivity.

13.492. Given that the RSA is already used by vessels it is expected that marine mammals will be habituated to the presence of vessels and so the magnitude of this type of collision risk is predicted to be negligible. As a result the significance of this impact is predicted to be negligible and **not significant** in all species.

Mitigation

Mitigation
A MMMP will be developed with Marine Scotland and SNH advice / agreement once the project description has been finalised.

Residual Impact

13.493. The residual impacts will remain negligible and **not significant** for all species.

Potential Impact of Changes to Water Quality

Accidental Release of Contaminants

13.494. Chapter 8 Water and Sediment Quality discusses the potential contaminants that could enter the marine environment during the operational phase of Project Alpha and potentially cause deterioration of marine water and sediment quality. Lubricants, oils and greases will be required to ensure the operational parts of the WTG work efficiently and there is the potential that accidental spillages of these materials may occur. In addition vessels used during maintenance will have their own associated fuels and lubricants which could also enter the marine environment. As with construction of Project Alpha, mitigation during the operational phase in the form of Pollution Control and Spillage Response Plan and appropriate SEMP will ensure that any spillage is managed rapidly and is therefore of negligible magnitude to marine mammals.

13.495. Marine mammals will have some tolerance to contaminants and are predicted to have low sensitivity and therefore the impact is assessed to be negligible and **not significant**. There is high confidence that this is a conservative assessment given the stringent requirements for pollution control and limited potential for major contaminant spills.

Mitigation

Mitigation
The operational contractors will be required by the Applicants to put in place appropriate SEMP and Pollution Control and Spillage Response Plans that would have been agreed with the Regulatory Authorities prior to offshore construction activities commencing. These plans will to reduce the potential for accidental pollution and in the unlikely event of a pollution incident, would ensure a rapid and appropriate response.

Residual Impact

13.496. The impact remains of negligible and **not significant**.

Potential Impacts of Electromagnetic Fields

13.497. 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 to navigate long distance migrations (Kirschvink *et al.*, 1986; Klinowska, 1985).

13.498. Although it is assumed that harbour porpoise are capable of detecting small differences in relative magnetic field strength, this is unproven and is based on circumstantial information (Marine Scotland, 2011). There is also, at present, no evidence to suggest that existing 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 (Marine Scotland, 2011). There is no evidence that pinnipeds respond to electromagnetic fields EMF and therefore marine mammal sensitivity is deemed to be low.

13.499. The estimated length of inter-array cabling is 355km of 66kV. The cables will be shielded to meet industry standards and will be buried to a depth of between of 0.5m and 2.1m. The strength of the EMF reduces with distance from the cable (Normandeau Associates, Inc., 2011) and with burial the EMF levels emitting into the water column are likely to be of negligible magnitude. It is therefore predicted that the effects of EMF will be negligible and **not significant**. Given the limited understanding of EMF effects on marine mammals but evidence that cetaceans use existing operational offshore wind farm sites (e.g. at Horns Rev and Nysted, Diederichs *et al.*, 2008) the confidence in this assessment is medium.

Mitigation

Mitigation
None proposed, Seagreen has committed to mitigation by design through the burial of cables and therefore this is included in the impact assessment.

Residual Impact

13.500. The residual impact remains negligible and **not significant**.

Project Bravo

Potential Impact of Underwater Noise

Wind Turbine Generators (WTGs)

13.501. Given the mobile nature of marine mammals the baseline usage is very similar for the Project Alpha and Project Bravo areas. The number and type of WTGs for Project Bravo is planned to be the same as Project Alpha and therefore the magnitude is also predicted to be negligible. Marine mammals are likely to have some tolerance to operational WTG noise and so have low sensitivity to this level of change and therefore the impact will be negligible and **not significant**. Based on the evidence from existing OWFs discussed above the confidence in this assessment is high

Vessel noise

13.502. Maintenance vessels for Project Bravo will cause a similar numbers and types of vessels as Project Alpha and so the magnitude of this impact is deemed to be negligible. Marine mammals are of international importance and will have some tolerance to accommodate this level of noise. Therefore, based on their ecological sensitivity marine mammals are predicted to have low sensitivity and therefore the impact is predicted to be negligible and **not significant**. The confidence level in this assessment is high due to the availability of modelling data.

Mitigation

Mitigation
None suggested.

Residual Impact

13.503. The impact remains negligible and **not significant**.

Potential Impact of Barrier Effects

13.504. As with Project Alpha, minimum spacing requirements between the turbines of 610m, means that animals can be expected to move between devices and through the operational wind farm with negligible magnitude for barrier effect. There is sufficient distance between Project Bravo and the coast to allow bottlenose dolphin to travel up the coast without a barrier during operation.

13.505. As discussed in the operation section for Project Alpha, marine mammals are deemed to have negligible sensitivity to this general layout and so the impact is assessed to be negligible and **not significant**, with high confidence.

Mitigation

Mitigation
None suggested.

Residual Impact

13.506. The impact remains negligible and **not significant**.

Potential Impact of Collision Risk

13.507. Operation of Project Bravo will require maintenance vessels which provide a slight increase in the risk of collision for marine mammals over the existing levels of vessel traffic. As discussed during the construction section for Project Bravo seals and cetaceans will have some tolerance to this level of increased traffic. Therefore, based on their likely ability to avoid collision they will have low sensitivity to collision risk. Due to the vulnerable nature of the harbour seal population in the RSA they are considered to have medium sensitivity.

13.508. Given that the RSA is already used by vessels it is expected that marine mammals will be habituated to the presence of vessels and so the magnitude of this type of collision risk is predicted to be negligible. As a result the significance of this impact is predicted to be negligible and **not significant** in all species.

Mitigation

Mitigation
A MMMP will be developed with Marine Scotland and SNH advice / agreement once the project description has been finalised.

Residual Impact

13.509. The residual impacts will remain negligible and **not significant** for all species.

Potential Impact of Changes to Water Quality

Accidental Release of Contaminants

13.510. As with Project Alpha the activities which have potential to release contaminants in to the water column are the same for Project Bravo. Marine mammals are deemed to have low sensitivity to this level and type of impact. The magnitude of any contamination is predicted to be negligible and so the significance is assessed to be minor adverse and **not significant**, with high confidence.

Mitigation

Mitigation
The operational contractors will be required by the Applicants to put in place appropriate SEMP and Pollution Control and Spillage Response Plans that would have been agreed with the Regulatory Authorities prior to offshore construction activities commencing. These plans will to reduce the potential for accidental pollution and in the unlikely event of a pollution incident, would ensure a rapid and appropriate response.

Residual Impact

13.511. The impact remains negligible and **not significant**.

Potential Impacts of Electromagnetic Fields

13.512. Project Bravo will have the same maximum length of inter-array cabling as Project Alpha (355km of 66kV). The cables are shielded to meet industry standards and will be buried to a minimum of 0.5m. As with Project Alpha this will result in a negligible magnitude and marine mammal sensitivity is deemed to be low, giving a negligible significance. The confidence in this assessment is medium as with Project Alpha.

Mitigation

Mitigation
None proposed, Seagreen has committed to mitigation by design through the burial of cables and therefore this is included in the impact assessment.

Residual Impact

13.513. The residual impact remains negligible and **not significant.**

Transmission Asset Project

Potential Impact of Underwater Noise

Vessel noise

13.514. Maintenance vessels for the OSP and export cable will cause a slight increase in the number of vessels using the site. It is likely that maintenance craft will be small, with short duration visits. Therefore, the impacts of noise are likely to be of a negligible magnitude and marine mammals will have low sensitivity to this level of increased vessel traffic. Therefore the impact significance is considered to be negligible and **not significant** with high confidence.

Mitigation

Mitigation
None suggested.

Residual Impact

13.515. The impact remains negligible and **not significant**.

Potential Impacts of Electromagnetic Fields

13.516. As discussed for the inter-array cables of Project Alpha and Project Bravo, there is potential for marine mammals to exhibit behavioural alterations, including displacement, caused by the presence of electromagnetic fields (EMF) from the export cabling (Gill *et al.*, 2005). The worst case scenario would be a maximum of 6 HVAC cables. The cables will be shielded to meet industry standards and will be buried to a minimum of 0.5m.

13.517. Any effects will be localised and field strength will reduce with distance from the seabed minimising the impact on mammals in the water column and on the surface and so the magnitude is predicted to be negligible. Marine mammal sensitivity is classified as low and therefore it is predicted that the effects of EMF will be of negligible and **not significant**, with medium confidence based on the level of available information discussed for Project Alpha.

Mitigation

Mitigation
None proposed, Seagreen has committed to mitigation by design through the burial of cables and therefore this is included in the impact assessment.

Residual Impact

13.518. The residual impact remains negligible and **not significant.**

IMPACT ASSESSMENT – DECOMMISSIONING

13.519. The impacts during decommissioning should be assessed just prior to the decommissioning work being undertaken so that the potential impacts can be assessed against the existing environment at that time. The following section provides impact estimates with low confidence as the exact methodologies and status of marine mammal populations at the time of doing the work are not known.

Project Alpha

Potential Impacts of Underwater Noise

13.520. The method for removal of the WTGs, substructures and foundations will be determined in a detailed decommissioning plan which takes into consideration the technology available and the environmental conditions at the time. At this stage it is anticipated that vessel usage will be similar to that during the construction phase. The worst case scenario for decommissioning of Project Alpha is expected to be cutting of substructures to an agreed depth below sea level and lifting of inter-array cables, although it is more likely that cables will be left *in situ*.

Cutting

13.521. As no piling activities are associated with decommissioning, the impacts as a result of underwater noise will be significantly less than construction. The use of explosives in removing the piles is discounted due to the likely damage it may cause to the environment. The impact of cutting noise will be temporary and is predicted to have negligible magnitude and marine mammals will have low sensitivity. Therefore the impact is considered to be minor adverse and **not significant**.

Vessel noise

13.522. The potential impacts during the decommissioning process are expected to broadly follow a reverse programme to the construction process and therefore the impact of vessel noise is likely to be similar in nature and significance to the construction impacts although the baseline shipping conditions may be different.

13.523. Modelling of vessel noise during construction (Appendix H6, Figures 5-6 to 5-8) shows avoidance behaviour using the 90dB_{ht} threshold is predicted to distances of 0m, 16m and 7m for harbour seal, harbour porpoise and bottlenose dolphin, respectively. No auditory injury is expected. This level of displacement is considered to represent negligible magnitude. Marine mammals will have low sensitivity to this level of noise and therefore the impact will be negligible and **not significant**.

Mitigation

Mitigation
None suggested.

Residual Impact

13.524. The residual impact remains negligible and **not significant**.

Potential Impact of Collision Risk

13.525. As discussed above vessel traffic is predicted to be similar in type and number to the construction phase. As such the types and significance of collision risk are predicted to be the same as during construction.

13.526. During the decommissioning phase of the development there will be increased levels of boat based activity in the region (Shipping and Navigation, Chapter 14).

13.527. Collision risk will be temporary and is predicted to be of negligible magnitude. The likely significance of this type of collision is negligible and **not significant** for all species.

Mitigation

Mitigation

A MMMP will be developed with Marine Scotland and SNH advice / agreement once the project description has been finalised.

Residual Impact

13.528. The residual impacts will remain negligible and **not significant** for all species.

Potential Impact of Changes to Water Quality

Accidental Release of Contaminants

13.529. As with construction, the potential for spills or leaks of contaminants during decommissioning of Project Alpha is outlined in Chapter 8 Water and Sediment Quality. Pollution Control and Spillage Response Plan and appropriate SEMP, will ensure that any spillage is managed rapidly. The magnitude of any potential contamination is predicted to be negligible, and given the low sensitivity of marine mammals, the significance is assessed to be negligible and **not significant**. As with construction there is high confidence in this assessment.

Increased Suspended Sediments

13.530. Chapter 8 Water Quality provides an assessment for suspended sediment during decommissioning of Project Alpha which is predicted to be less than construction. Given the very low levels of suspension predicted and the temporary nature it is predicted that the magnitude will be negligible. Given the low sensitivity of marine mammals the significance is assessed to be negligible and **not significant** as with construction. There is high confidence in this assessment.

Mitigation

Mitigation

SEMP for contaminants from work (oil spills)

Method of installation determines sediment (and contaminant release) mitigation not strictly possible

Residual Impact

13.531. Residual impact therefore remains negligible and **not significant**.

Potential Impact of Changes to Prey Resource

13.532. Chapter 12, Natural Fish and Shellfish Resource predicts negligible changes to fish during the decommissioning phase of Project Alpha. This level of temporary change to prey resource is expected to have negligible impacts on marine mammals.

Mitigation

Mitigation
Mitigation is focused on reducing the direct impact of fish and shellfish and is therefore identified in Chapter 12, Natural Fish and Shellfish Resource.

Residual Impact

13.533. Impacts will remain negligible and **not significant**.

Project Bravo

Potential Impacts of Underwater Noise

13.534. As with Project Alpha, the method for removal of the WTGs, substructures and foundations will be determined in a detailed decommissioning plan which takes into consideration the technology available and the environmental conditions at the time. At this stage it is anticipated that vessel usage will be similar to construction. The worst case scenario for decommissioning of Project Bravo is expected to be cutting of substructures to an agreed depth below sea level and lifting of inter-array cables, although it is more likely that cables will be left *in situ*.

Cutting

13.535. As no piling activities are associated with decommissioning the impacts as a result of underwater noise will be significantly less than construction. The use of explosives in removing the piles is discounted due to the likely damage it may cause to the environment. The impact of cutting noise will be temporary and is predicted to have negligible magnitude. Marine mammal sensitivity to this level of noise is likely to be low and therefore the impact will be negligible and **not significant**.

Vessel noise

13.536. The potential impacts during the decommissioning process are expected to broadly follow a reverse programme to the construction process for Project Bravo and therefore the impact of vessel noise is likely to be similar in nature and magnitude to the construction impacts, although the baseline shipping conditions may be different.

13.537. As with Project Alpha, the level of vessel noise is considered to represent negligible magnitude and, given low sensitivity of marine mammals to this impact, the assessment results are negligible and **not significant**.

Mitigation

Mitigation
None suggested.

Residual Impact

13.538. The residual impact remains negligible and **not significant**.

Potential Impact of Collision Risk

13.539. As discussed above vessel traffic is predicted to be similar in type and number to the construction phase. As such the types and significance of collision risk are predicted to be the same as during construction of Project Bravo.

13.540. During the decommissioning phase of the development there will be increased levels of boat based activity in the region (Shipping and Navigation, Chapter 14).

13.541. Collision risk will be temporary and is predicted to be of negligible magnitude. The likely significance of this type of collision is negligible and **not significant** for all species.

Mitigation

Mitigation
A MMMP will be developed with Marine Scotland and SNH advice / agreement once the project description has been finalised.

Residual Impact

13.542. The residual impacts will remain negligible and **not significant** for all species.

Potential Impact of Changes to Water Quality

Accidental Release of Contaminants

13.543. As with Project Alpha the likelihood and potential extent of spillage of any contaminants, such as hydraulic oil during decommissioning is low and will be further managed by the use of mitigation measures outlined in Pollution Control and Spillage Response Plan and appropriate SEMP. The sensitivity of marine mammals is low and the potential magnitude is predicted to be negligible, giving the significance as negligible and **not significant**.

Increased Suspended Sediments

13.544. Chapter 8, Water Quality provides an assessment for suspended sediment during decommissioning of Project Bravo which is predicted to be less than construction. Given the very low levels of suspension predicted and the temporary nature it is predicted that the magnitude will be negligible and, given the low sensitivity of marine mammals the significance is assessed to be negligible and **not significant** as with construction.

Mitigation

Mitigation
Mitigation is focused on reducing the change to water quality and is therefore discussed in Chapter 8, Water Quality.

Residual Impact

13.545. Residual impact therefore remains negligible and **not significant**.

Potential Impact of Changes to Prey Resource

13.546. Chapter 12, Natural Fish and Shellfish Resource predicts negligible changes to fish during the decommissioning phase of Project Bravo. This level of temporary change to prey resource is expected to have a negligible and **not significant** impact on marine mammals.

Mitigation

Mitigation
Mitigation is focused on reducing the direct impact of fish and shellfish and is therefore identified in Chapter 12, Natural Fish and Shellfish Resource.

Residual Impact

13.547. The impact remains negligible and **not significant**.

Transmission Asset Project

Potential Impacts of Underwater Noise

Vessel noise

13.548. Increased boat traffic used for lifting the export cable and removing OSPs will have an impact on the noise levels in the region. The magnitude is predicted to be negligible due to the presence of existing traffic in the area. Given the expected habituation of marine mammals to vessel noise sensitive will be low and therefore the significance is considered to be negligible and **not significant**.

Mitigation

Mitigation
None suggested.

Residual Impact

13.549. The residual impact remains negligible and **not significant**.

Potential Impact of Collision Risk

13.550. As discussed above, decommissioning of the export cables and OSPs will result in increased vessel traffic.

13.551. As with Alpha and Bravo, all species are considered to have low sensitivity to collision risk with vessel hulls. Due to the vulnerable nature of the harbour seal population in the RSA they are considered to have no capacity to accommodate collisions and are therefore considered to be of medium sensitivity.

13.552. As with Project Alpha and Project Bravo the magnitude of this type of collision risk is predicted to be negligible and so the significance of this impact on harbour seals is predicted to negligible and **not significant** for all species**.**

Mitigation

Mitigation
Industry best practice, including maintaining a steady course and speed will be applied. A MMMP will be developed with Marine Scotland and SNH advice / agreement once the project description has been finalised.

Residual Impact

13.553. The residual impacts will remain negligible adverse for all species and **not significant**.

IMPACT ASSESSMENT – CUMULATIVE AND IN-COMBINATION

13.554. In addition to identifying the potential impacts of Project Alpha, Project Bravo and the Transmission Asset Project on marine mammals separately, it is also important to consider the cumulative and in-combination impacts of the Seagreen Project, together with other existing, consented or proposed activity in the RSA.

Seagreen Cumulative Impacts

13.555. This section draws together the impacts considered for each of the individual elements of Phase 1 at this stage, so that the Seagreen Project can be viewed in terms of its cumulative impacts on marine mammals.

13.556. Table 13.33 at the end of this Section details the main cumulative impacts which will occur as a result of Project Alpha, Project Bravo and Transmission Asset Project. The table provides an overall summation of impacts for Phase 1. Further discussion of the potential impacts from pile driving is provided in the following paragraphs.

Potential Impact of Underwater Noise

Pile Driving

13.557. During the construction of Project Alpha and Project Bravo there is likely to be overlap in periods of pile driving and the possibility of concurrent piling at the two Projects is also considered in the assessment. However, it is not possible to quantify the number of pile driving occasions that may be concurrent between the two Projects. The overlap of pile driving will be dependent on many factors including weather, ground conditions and engineering constraints. In general, concurrent pile driving could be considered as a positive occurrence during construction, as the size of impacted areas during concurrent piling will be less than the sum of the two areas from independent pile driving. However, piling at different times (consecutively) between and within Project Alpha and Project Bravo has the potential to increase the overall duration and intensity of disturbance. In practise it is not anticipated that it will be possible or practicable to attempt the co-ordination of the timing of piling activities between two installation crews in the Seagreen Projects.

13.558. It should be noted that underlying densities used in the cumulative assessment are the same as those presented in the baseline. It is possible that changes in local density can occur over different temporal scales (ranging from the duration of pile driving to the duration of construction) in different species due to displacement. During the construction of Horns Rev II, assumed densities of porpoise (based on acoustic detections) increased at distances >25km from the piling location due to displacement from areas close to the piling (Brandt *et al*., 2009).

13.559. As a precautionary approach the areas of impact for the duration of construction are considered to be equal to the sum of the two areas from separate pile driving events (where no overlap is predicted) or the area encompassed within overlapping contours, where overlap occurs.

Fatality and physical non-auditory injury

13.560. As is the case for pile driving during the construction of both Project Alpha and Project Bravo the ranges at which fatal and non-auditory injury can occur are within ranges where mitigation is possible. As there are considered to be no impact of fatality or non-auditory injury during the construction of Alpha or Bravo there will be negligible impact cumulatively.

Auditory injury

13.561. As is the case for pile driving during the construction of both Project Alpha and Project Bravo the ranges at which auditory injury can occur according to the 130 dB_{ht} (*Species*) metric are within ranges where mitigation is possible, except in the case of harbour porpoise and minke whale (Table 13.15). The impact ranges for this metric will not overlap during concurrent pile driving at Project Alpha and Project Bravo, so the impacts from the cumulative development at both Projects would be would be equivalent to the sum of the two independent assessments.

13.562. The combined impacts of pile driving at Project Alpha and Project Bravo based on this metric would be equivalent to a total of 263 harbour porpoise, or 0.07% of the reference population. In the case of minke whale, 23 individuals could receive auditory injury (<0.1% of the reference population)

13.563. The impact ranges and areas for noise exposure that could cause PTS using the M-weighted SEL criteria have been calculated for concurrent pile driving at Project Alpha and Project Bravo using the INSPIRE model (Appendix H6, Figure 6-78 to 6-81). Ranges of auditory injury for low, mid and high frequency cetacean and seals at the 198 dB re 1 $\mu Pa^2.s^{-1}$ SEL are < 100m for both the worst case GM1 (Appendix H6, Table 6-39) and for the most likely GM3 (Appendix H6, Table 6-43). These ranges are within the predicted range of mitigation to prevent auditory injury.

13.564. In the case of the more precautionary 186 dB re 1 $\mu Pa^2.s^{-1}$ (M_{pw}) SEL for the assessment of PTS in seals impacts based on the worst case GM1 modelling are predicted to occur out to a maximum range of 16.2km or an area of 660km^2 and in the case of most likely GM3 impacts will occur out to a maximum of 10.8km, or an area of 200km^2.

13.565. Potential numbers of individuals that could receive PTS during concurrent pile driving at Project Alpha and Project Bravo have been calculated using SAFESIMM for harbour porpoise, bottlenose dolphin, harbour seal and grey sea (Appendix H8, Figures 9 to 11). An assessment has been made of the likely impacts of concurrent worst case GM1 pile driving at each Project, and most likely GM3 drive drill drive option at each Project (Table 13.34). As previously, the impacts on seals are calculated based on the 186 dB re 1 $\mu Pa^2.s^{-1}$ (M_{pw}) SEL, and should be considered precautionary.

13.566. The numbers likely to experience PTS in each case, are less than the sum of numbers that could be expected if pile driving occurred at Project Alpha and Project Bravo separately (Table 13.17 and Table 13.26). This is due to overlap of sound fields meaning the area of impact is less than the combined areas of two separate pile driving events.

Table 13.33 Cumulative impacts of Seagreen projects (Project Alpha, Project Bravo, Transmission Asset Project)

	Cumulative Residual Impact				
Impact	**Project Alpha**	**Project Bravo**	**Transmission Asset**	**Cumulative**	**Justification**
Construction					
Intertidal or terrestrial habitat exclusion	**No impact** mechanism.	**No impact** mechanism.	Negligible, **not significant**	Negligible, **not significant**	There will be no loss of intertidal or terrestrial habitat used by marine mammals during construction.
Underwater noise (pile driving)	Moderate adverse in harbour seal, **significant.** Minor adverse (not significant) all species except, **not significant.** Negligible in white-beaked dolphin, **not significant.**	Moderate adverse in harbour seal, **significant.** Minor adverse (not significant) all species except, **not significant.** Negligible in white-beaked dolphin, **not significant.**	Addressed within Project Alpha and Project Bravo assessment.	Major adverse in harbour seal, **significant.** Minor adverse (not significant) in all other species, **not significant.**	Impacted numbers of individuals and ranges of impact remain at comparable levels when the cumulative impacts are assessed in all species except harbour seal. The areas of impact from Project Alpha and Bravo both overlap with area of high underlying harbour seal density, which represent a significant proportion of the ECMA population foraging area.
Underwater noise (vessels)	Negligible (all species), **not significant.**	Negligible (all species), **not significant.**	Negligible (all species), **not significant.**	Minor adverse in all species, **not significant.**	The cumulative impact of increased vessel traffic will have a greater impact of all species, although this is not expected to be significant.
Collision risk with ship hulls	Negligible (all species), **not significant.**	Negligible (all species), **not significant.**	Negligible (all species), **not significant.**	Minor adverse in all species, **not significant.**	The cumulative impact of increased vessel traffic will have a greater impact of all species, although this is not expected to be significant.
Changes to water quality	Minor adverse in seals, **not significant.** Negligible in all cetacean species, **not significant.**	Minor adverse in seals, **not significant.** Negligible in all cetacean species, **not significant.**	**No impact** mechanism.	Minor adverse in seals, **not significant.** Negligible in all cetacean species, **not significant.**	The cumulative impact on Water Quality discussed in Chapter 8 shows a minor change in water quality and this level of change is predicted to have an impact of negligible magnitude on marine mammals.

	Cumulative Residual Impact				
Impact	**Project Alpha**	**Project Bravo**	**Transmission Asset**	**Cumulative**	**Justification**
Changes to prey resource	Minor adverse in harbour seal, **not significant.** Negligible (all other species), **not significant.**	Minor adverse in harbour seal, **not significant.** Negligible (all other species), **not significant.**	**No impact** mechanism.	Minor adverse in all species, **not significant.**	Impact on Natural Fish discussed in Chapter 12 shows a minor / moderate change in potential prey species. Given the use of the ISA as a feeding ground but temporary nature of the construction effect the magnitude of this on marine mammals is predicted to be low which results in impact is of minor importance to marine mammals.
Operation					
Underwater noise (WTGs)	Negligible (all species), **not significant.**	Negligible (all species), **not significant.**	Negligible (all species), **not significant.**	Minor adverse in all species, **not significant.**	The low level of noise produced during operation of the Seagreen Project is not predicted to have a significant cumulative impact.
Underwater noise (vessel noise)	Negligible (all species), **not significant.**	Negligible (all species), **not significant.**	**No impact** mechanism.	Minor adverse in all species, **not significant.**	The cumulative impact of increased vessel traffic will have a greater impact of all species, although this is not expected to be significant.
Barrier effects	Negligible (all species), **not significant.**	Negligible (all species), **not significant.**	**No impact** mechanism.	Minor adverse in all species, **not significant.**	The cumulative impact of barrier effects is predicted have a negligible magnitude on marine mammals.
Collision risk with ship hulls	Negligible (all species), **not significant.**	Negligible (all species), **not significant.**	**No impact** mechanism.	Minor adverse in all species, **not significant.**	Given the existing use of the RSA for shipping, it is anticipated that the level of cumulative impact will have a slight increase in magnitude to Project Alpha or Project Bravo alone.
Changes to water quality	Negligible (all species), **not significant.**	Negligible (all species), **not significant.**	**No impact** mechanism.	Minor adverse in all species, **not significant.**	As with construction the cumulative impact on Water Quality discussed in Chapter 8 shows a minor change in water quality which results in impact is of minor significance on marine mammals.
Electromagnetic fields	Negligible (all species), **not significant.**	Negligible (all species), **not significant.**	Negligible (all species), **not significant.**	Negligible (all species), **not significant.**	The cumulative impact of EMF is predicted have a negligible magnitude on marine mammals.
Decommissioning					
Underwater noise (cutting)	Minor adverse all species, **not significant.**	Minor adverse all species, **not significant.**	No impact mechanism	Minor adverse in all species, **not significant.**	The cumulative impact of cutting noise will have a greater impact of all species, although this is not expected to be significant.

	Cumulative Residual Impact				
Impact	**Project Alpha**	**Project Bravo**	**Transmission Asset**	**Cumulative**	**Justification**
Underwater noise (vessels)	Negligible (all species), **not significant.**	Negligible (all species), **not significant.**	Negligible (all species), **not significant.**	Minor adverse in all species, **not significant.**	The cumulative impact of increased vessel traffic will have a greater impact of all species, although this is not expected to be significant.
Collision risk (ship hull impact)	Negligible (all species), **not significant.**	Negligible (all species), **not significant.**	Negligible (all species), **not significant.**	Minor adverse in all species, **not significant.**	Given the existing use of the RSA for shipping, it is anticipated that the level of cumulative impact during decommissioning will have a slight increase in magnitude to Project Alpha or Project Bravo alone.
Changes to water quality (accidental release of contaminants)	Negligible (all species), **not significant.**	Negligible (all species), **not significant.**	**No impact** mechanism.	Minor adverse in all species, **not significant.**	Impact on Water Quality discussed in Chapter 8 shows a negligible change in water quality which results in impact is of minor significance on marine mammals.
Changes to water quality (suspended sediment)	Negligible in all cetacean species except, Minor adverse in seals, **not significant.**	Negligible in all cetacean species except, Minor adverse in seals, **not significant.**	**No impact** mechanism.	Minor adverse in all species, **not significant.**	The cumulative impact of changes in suspended sediment will have a greater impact of all species, although this is not expected to be significant.
Changes to prey resource	Negligible (all species), **not significant.**	Negligible (all species), **not significant.**	**No impact** mechanism.	Minor adverse in all species, **not significant.**	The cumulative impact of changes in prey resources will have a greater impact of all species, although this is not expected to be significant.

Table 13.34 Number of each species predicted to experience PTS based on SAFESIMM model during a single concurrent pile driving event at Project Alpha and Project Bravo.

Species	Number of each species predicted by SAFESIMM to experience PTS (and % of reference population)	
	Worst Case GM1	Most Likely GM3
Harbour porpoise	9 (<0.003%)	4 (<0.002%)
Bottlenose dolphin	0	0
Harbour seal	21 (4%)	12 (2%)
Grey seal	236 (2-4%)	131 (1-2%)

13.567. During the construction of both Project Alpha and Project Bravo the number of concurrent pile driving events is hard to predict. The actual number of harbour porpoise, harbour seal or grey seal that experience conditions capable of resulting PTS will be dependent on factors outlined in the assessment of each Project in the Impact Assessment-Construction section. It is likely that the numbers presented in Table 13.34 represent a precautionary estimate of the number of individuals that could receive PTS inducing noise during a single pile driving event. Yet, they could represent a minimum (conservative) estimate of the number that could receive PTS during the construction of both Project Alpha and Project Bravo as a whole.

13.568. As detailed during the assessment of the construction period of Project Alpha and Project Bravo, there is the potential to expose part of the population to noise levels that could lead to PTS on more than one occasion due to breaks in pile driving. However, consultation advice from Marine Scotland suggests the impacts considered during a single pile driving event should be applied to the full assessment as in The Moray Firth Framework (Table 13.1, Meeting 15/ 06/ 2012).

13.569. There are predicted to be no auditory injury impacts in bottlenose dolphin, or white beaked dolphin. Impact levels for minke whale and harbour porpoise given their high sensitivity and negligible numbers impacted are predicted to be minor adverse, and **not significant**. Impacts for harbour seal and grey seal have greater uncertainty, but are predicted to be moderate adverse and **significant** in harbour seal. This is due to medium sensitivity and medium magnitude (based on the number impacts from a single pile driving event (Table 13.34) representing a minimum impact which needs to be scaled up to be representative of the whole build). There is a high amount of uncertainty in this assessment. In grey seal the impacts is of equal magnitude, but their low sensitivity suggests a minor adverse and **not significant** impact.

13.570. However, it should be noted that when the less precautionary 198dB threshold is applied to pinnipeds there is likely to be no impact. The actual impact from a single pile driving event in seals is likely to fall somewhere between zero and the impact predicted by SAFESIMM. There is a large amount of uncertainty associated with quantification of these impacts due to the reasons presented in the assessment of construction in Project Alpha and Project Bravo (Impact Assessment-Construction).

Behavioural response

13.571. As has been presented for the individual impacts during the construction of Project Alpha and Project Bravo (Impact Assessment-Construction) the use of spatially explicit overlay with noise contours predicted from the INSPIRE model is considered an appropriate approach to calculating impact levels for harbour and grey seal. The use of average densities in species of cetacean is considered more appropriate. Numbers predicted to be impacted and areas of impact are shown in Table 13.35.

Table 13.35 Impact area, numbers of individuals (and proportion of reference population) likely to be behaviourally impacted during a single concurrent pile driving event at Project Alpha and Project Bravo.

Species	Area of impact (km^2)		Spatially explicit overlay		Average densities	
	Worst Case GM1	Most Likely GM3	Worst Case GM1	Most Likely GM3	Worst Case GM1	Most Likely GM3
Harbour porpoise	10386	8644	724 (0.2%)	603 (0.15%)	2543 (0.7%)	2104 (0.5%)
Bottlenose dolphin	4857	4011	0	0	4 (2%)	3 (1.6%)
Minke whale	18605	16355	n/ a	n/ a	428 (1.7%)	376 (1.5%)
White-beaked dolphin	4857	4011	n/ a	n/ a	287 (1.3%)	237 (1%)
Harbour seal	8648	7157	56 (10%)	50 (9%)	n/ a	n/ a
Grey seal	8648	7157	542 (4-10%)	534 (4-9%)	n/ a	n/ a

13.572. The areas of impact predicted from the cumulative noise modelling for behavioural impacts (Appendix H6, Figure 6-87 to 6-90 for worst case GM1, and Figures 6-96 to 6-99 for the most likely GM3), show that there will be overlap during concurrent pile driving at Project Alpha and Project Bravo. Areas of potential displacement, and thus numbers of individuals impacted, are less than predicted from the sum of impacts from pile driving at each Project independently.

13.573. The impact of behavioural disturbance is temporary and may extend to the duration of the full piling programme (up to two years) or may be limited to as little as the combined duration of each piling event in the case of harbour and grey seals. Currently no empirical data exist to refine the length of potential disturbance, but a number of factors, as outlined in the Impact Assessment-Construction section support variable duration of impacts between different species, and different individuals within each species.

Cetaceans

13.574. For all species of cetacean a worst case cumulative impact assumes that construction of Project Alpha and Project Bravo occur independently as the duration of any behaviour impact would be prolonged. However, due to the size of the contours associated with behavioural disturbance, contours will overlap no matter where pile driving occurs on each Project. For cetaceans the assessment assumes that individuals could be excluded over the impact range (out to the $75dB_{ht}$ contour) predicted from concurrent piling for the duration of the build of Project Alpha and Project Bravo.

13.575. For harbour porpoise the impact would be equivalent to 0.7% of the reference (North Sea) population being excluded from approximately 1.4% of their home range for the duration of overlapping pile driving at Project Alpha and Project Bravo (using the modelled locations in Appendix H6, Figure 6-79). However the impacted area, and therefore number of porpoise impacted, could be greater should pile driving occur concurrently at locations at the western boundary of Project Alpha and eastern boundary of Project Bravo concurrently. Pile driving at these locations has not been modelled. However, comparison of the number impacted (0.8% of the reference population) and area (approximately 2% of available habitat) during not overlapping pile driving (calculated by summing the two independent impacts of Project Alpha and Project Bravo) would provide an indication of maximum possible disturbance. This species has medium sensitivity to disturbance; however this impact area would be on a negligible proportion of the population over a small proportion of their range. The impacts are temporary, and considered to be negligible and **not significant**.

13.576. For minke whale, the impact from concurrent (overlapping impact contour) pile driving would be equivalent to 1.7% of the population being excluded from a maximum of 2.5% of their home range (when considering the North Sea as the minimum range). However the impacted area, and therefore number of minke impacted, could be greater should pile driving occur concurrently at locations at the western boundary of Project Alpha and eastern boundary of Project Bravo concurrently. Pile driving at these locations has not been modelled. However, comparison of the number impacted (2.2% of the reference population) and area (approximately 4.5% of available habitat) during not overlapping pile driving (calculated by summing the two independent impacts of Project Alpha and Project Bravo) would provide an indication of maximum possible disturbance. Once again, this species has medium sensitivity to disturbance, and this impact area would be low proportion of their range, and a low proportion of the population. The impacts are temporary, the impact is therefore likely to be minor adverse and **not significant**.

13.577. In bottlenose dolphin, the home range is smaller than the other species of cetacean. They are also more coastal in distribution, where the areas of impact range to. Although spatially explicit overlap predict there will be no disturbance to bottlenose dolphin, average densities predict four could be disturbed. However, the distribution of bottlenose dolphin does vary greatly in space and time, so it is likely that this estimate could be a minimum indication of the number of individuals that experience noise above the thresholds that will elicit behavioural disturbance. As is the case of harbour porpoise and minke whale the impacted area, and thus number of bottlenose dolphin impacted could be greater than that predicted in Table 13.35 should pile driving occur at locations further apart. In the absence of noise propagation modelling at these locations, as a worst case we consider the impact to be the sum of the two independent impacts from Project Alpha and Project Bravo. This could increase the impact to the same as predicted in Table 13.35.

13.578. As previously mentioned the ecological effects of this disturbance are not known. Cetacean species in general to have medium sensitivity to behavioural disturbance, and although bottlenose dolphin may be habituated to anthropogenic noise their sensitivity is considered low. Low sensitivity and low to medium magnitude (due to uncertainty in movement) as a precautionary approach means the impact is minor adverse and **not significant**.

13.579. In white-beaked dolphin, the species has medium sensitivity to disturbance, and this impact area would be negligible part of their range, however the impact would be on a low proportion of the reference population (Table 13.35), based on overlapping contours. As is the case of harbour porpoise and minke whale the impacted area, and thus number of bottlenose dolphin impacted could be greater than that predicted in Table 13.35 should pile driving occur at locations further apart. In the absence of noise propagation modelling at these locations, as a worst case we consider the impact to be the sum of the two independent impacts from Project Alpha and Project Bravo. This could increase the impact predicted in Table 13.35 to 1.5% of the reference population, still remaining low magnitude. The impact is therefore likely to be minor adverse and **not significant**.

Pinnipeds

13.580. There is a great deal of uncertainty as to the potential impacts of behavioural disturbance on harbour and grey seal, and therefore the possibility of population level consequences of disturbance caused by pile driving noise.

13.581. Based on the overlap of spatially explicit densities with impacted areas, the proportion of the harbour seal population predicted to be displaced is up to 10% from a single pile driving event (Table 13.35). This represents an impact of high magnitude (Table 13.4).

13.582. Harbour seal have medium sensitivity to behavioural disturbance, but the regional population has been in decline over recent years. This impact is considered to be high magnitude, and based on the precautionary approach of medium sensitivity, the impact would be major adverse and **significant**.

13.583. The impacts for grey seals are of a comparable magnitude to that in harbour seal, up to 10% of the ECMA population, but could be as low as 4% (Table 13.35) so the magnitude is considered medium. In addition the grey seal population has been increasing over recent years. Grey seal are considered as having low sensitivity to this disturbance. The impact is therefore considered to be minor adverse and **not significant**.

Seagreen cumulative impact including Phases 2 and 3

13.584. Seagreen Phases 2 and 3 encompass five potential offshore wind farm sites and connection to the National Grid via three export cables running from the south-western boundary of the Round 3 Zone and coming together at a single landing point near Torness. Connection agreements, which are in place, indicate that the power generated is to be connected to the electricity transmission network at a location near Branxton, East Lothian. Phases 2 and 3 are planned to have a combined output target of 2.6 GW.

13.585. It is anticipated that applications for the necessary consents for development of wind farms within Phase 2 and Phase 3 will be submitted in 2014 and 2016 respectively. The Applicants believe that the design and development within Phases 2 and 3 of the Zone must be adaptive and take into account the lessons learned from both Round 1 and Round 2 offshore wind farm projects that have gone through the consenting and construction processes, alongside lessons from the Seagreen Project (as discussed in this ES) and other projects currently under development in the STW.

13.586. The status of Phases 2 and 3 is that an environmental scoping exercise has been undertaken (Seagreen, 2011) based upon current best-available evidence for those areas. It is anticipated that substantial further detailed work will be undertaken in the period leading up to submission of applications for the necessary consents in 2014 and 2016. Such work will include:

- detailed geophysical work to determine the surface topography and underlying geology of the Phases which will inform pile driving parameters;
- further surveys of marine mammals in the RSA; and
- desk based assessment and some ISA specific survey to determine the baseline conditions.

13.587. From the above, it can be seen that either large amounts of data relevant to Phases 2 and 3 have yet to be analysed or indeed have yet to be collected. Any assessment of the baseline for these Phases would therefore be assigned a low level of confidence when included in this ES.

13.588. There have been considerable changes to the original design and location of the Phase 1 projects during the detailed development work as environmental concerns (both ecological and human) have emerged that have shaped the projects going forward within the EIA. Given the size of the Zone and the development process Seagreen intends to follow, an optimal layout and approach will be developed in order to deliver as close to the target power output (2.6GW) as possible without causing a significant impact upon the receiving environment and in particular European sites and species. The Applicant will consider the use of all areas within the Zone not necessarily restricted to the Phase 2 and Phase 3 indicative boundaries. Seagreen are committed to progressing the development of Phases 2 and 3 to ensure environmental impacts and in particular cumulative environmental impacts can be minimised and significant impacts avoided.

13.589. As a responsible developer, Seagreen wishes to use best available evidence and best practice in order to follow a responsible approach to the development of Phases 2 and 3. Therefore, to a great extent, the design refinement for Phases 2 and 3 will be dependent upon the on-going process with regard to Phase 1, the STW Projects and other offshore wind developments in Scotland. Given the data gaps and further work required cited above, any assessment of the baseline conditions of Phases 2 and 3 required for the cumulative assessment of the Seagreen Project would have to be assigned a low confidence level with regard to overall accuracy in particular with respect to capacity, developable area and layout. Given this, the Applicants do not consider that for this assessment it is reasonable to present detailed analysis of the potential impacts of Phases 2 and 3 for inclusion within this assessment.

Seagreen cumulative impact with other schemes

13.590. The main cumulative and in-combination impacts of the Seagreen Project with other projects in the RSA on marine mammals are likely to be:

- auditory injury due to noise and vibration;
- behavioural disturbance due to underwater noise;
- collision with vessels; and
- indirect impacts through loss of prey species.

13.591. Table 13.36 provides details of the other projects considered in this cumulative and in-combination assessment. Further justification of the assessment is provided in the remainder of this Section of the ES.

13.592. Consultation with SNH and JNCC (Table 13.1, Meeting 02/ 11/ 2011) provided a list of potential projects to be included in the assessment. Consideration of the potential cumulative impacts arising from seismic surveys and the proposed tidal project at Montrose have not been included in the assessment due to insufficient information at the time of writing the ES.

13.593. In the assessment of impacts of underwater noise from pile driving, FTOWDG took the approach outlined in the Assessment Methodology section, in assessment of the most likely combination of piling activity between the three Projects.

13.594. Potential for cumulative impacts exist for all species of marine mammal for project within the RSA (including Neart na Gaoithe, Inch Cape, Forth Replacement Crossing and developments related to Dundee Harbour).

13.595. Out with the RSA there is the potential for cumulative impacts between offshore wind developments at the European Offshore Wind Deployment Centre in Aberdeen Bay, and OWF in the Moray Firth (Beatrice and Moray Firth). Cumulative impacts of this scale are not likely in harbour seal due to their localised foraging behaviour.

Table 13.36 Details of projects with potential for cumulative impacts

	Cumulative						**In-combination**		**Cumulative / in-combination significance**
Impact	Seagreen phase 1	Neart na Gaoithe	Inch Cape	Beatrice	Moray Firth	European Offshore Wind Deployment Centre	Forth Replacement crossing	Dundee Harbour Developments (Port, bridge works and V&A)	
Construction	2015-2016	2014-2017	2015-2019	2014-2017	2015-2019	2014-2015	2012- 2016	2001-2031	
Underwater noise (pile driving and non-vessel related construction activities)	Major adverse in harbour seal. Minor adverse in all other species.	Up to 500 piles may be installed using 'drive-drill-drive' and 16 turbines may be installed with 'drive-only'. (Mainstream (in draft) assessment: Moderate /major significance in bottlenose dolphin, moderate significance in harbour seal, minor significance in harbour porpoise, white beaked dolphin, and grey seal, not significant in minke whale).	286 turbines, gravity base or jacket with 3.0m diameter piles. Max hammer blow energy 2300kj. Number of simultaneous piling on the site = 2. Meteorological masts = 3. OSP = 5.	277 turbines, jackets with 2.4m diameter piles. Max hammer blow energy 2300kj. Number of simultaneous piling on the site = 2. Beatrice (2012) Assessment: Minor or negligible long term effects for all species.	Approximately 260 5MW WTGs.	Eleven turbines, estimated less than four days pile driving. Impacts will be significantly less than other OWFs.	Blasting of Beamer Rock. Piling of north and south towers, 4 piles each between 3.3m and 3.5m. Piling of 900mm piles for temporary jetties to the north and south for construction vessels.		Major adverse, and significant in harbour seal. Moderate adverse in harbour porpoise, bottlenose dolphin and grey seal. Minor adverse, and not significant in minke whale and white beaked dolphin.

	Cumulative						**In-combination**		**Cumulative / in-combination significance**
Impact	**Seagreen phase 1**	**Neart na Gaoithe**	**Inch Cape**	**Beatrice**	**Moray Firth**	**European Offshore Wind Deployment Centre**	**Forth Replacement crossing**	**Dundee Harbour Developments (Port, bridge works and V&A)**	
Underwater noise (vessels)	Minor adverse in all species.	Impacts are expected to be similar to the Seagreen Project. Mainstream (in draft) assessment: Not significant all species).	Impacts are expected to be similar to the Seagreen Project.	Beatrice (2012) Assessment: Minor or negligible long term effects for all species.	Impacts are expected to be similar to the Seagreen Project.	Vessel numbers are predicted to be significantly less than for the OWFs.	Vessel numbers are predicted to be significantly less than for the OWFs.	Vessel numbers are predicted to be significantly less than for the OWFs.	Minor adverse in all species, and **not significant.**
Collision risk with ship hulls	Minor adverse in all species. Exact details of vessel types and numbers will be dependent on availability and procurement.	Impacts are expected to be similar to the Seagreen Project. Mainstream (in draft) assessment: Not significant all species).	Impacts are expected to be similar to the Seagreen Project.	Minor significance. Range of construction vessels.	Impacts are expected to be similar to the Seagreen Project.	Vessel movements are predicted to be significantly less than for other OWFs.	Vessel movements are predicted to be significantly less than for the OWFs.	Vessel movements are predicted to be significantly less than for the OWFs.	Minor adverse all species, and **not significant.**

	Cumulative						In-combination		Cumulative / in-combination significance
Impact	**Seagreen phase 1**	**Neart na Gaoithe**	**Inch Cape**	**Beatrice**	**Moray Firth**	**European Offshore Wind Deployment Centre**	**Forth Replacement crossing**	**Dundee Harbour Developments (Port, bridge works and V&A)**	
Changes to water quality	Minor adverse in seals. Negligible in all cetacean species	Impacts are expected to be similar to the Seagreen Project. Mainstream (in draft) assessment: Not assessed.	Impacts are expected to be similar to the Seagreen Project.	Impacts are expected to be similar to the Seagreen Project.	Impacts are expected to be similar to the Seagreen Project.	Impacts will be significantly less than other OWFs.	Assessment unavailable, expected to be less magnitude than OWFs.	Assessment unavailable, expected to be less magnitude than OWFs.	Minor adverse in seals, and **not significant.** Negligible in all cetacean species.
Changes to prey	Minor adverse in all species.	Impacts are expected to be similar to the Seagreen Project. Mainstream (in draft) assessment: Not assessed.	Impacts predicted to be similar to the Seagreen Project.	Predicted negligible impact. Reduction of prey species within Wind Farm Site over a period of up to four years based on gravity base foundations.	Predicted to be similar to Beatrice.	Impacts will be significantly less than other OWFs.	Assessment unavailable, expected to be less magnitude than OWFs.	Assessment unavailable, expected to be less magnitude than OWFs.	Moderate adverse, and **significant** in harbour seal, grey seal and bottlenose dolphin. Minor adverse all other species, and **not significant.**.
Operation									
Underwater noise (WTGs)	Minor adverse in all species. 150 WTG.	125 WTG Impacts are expected to be similar to the Seagreen Project. Mainstream (in draft) assessment: Not significant all species.	286 WTG Impacts are expected to be similar to the Seagreen Project.	277 3.6MW WTGs No impact predicted.	260 WTGs	11 turbines.	Not applicable.	Not applicable.	Minor adverse in all species, and **not significant.**

	Cumulative						**In-combination**		**Cumulative / in-combination significance**
Impact	**Seagreen phase 1**	**Neart na Gaoithe**	**Inch Cape**	**Beatrice**	**Moray Firth**	**European Offshore Wind Deployment Centre**	**Forth Replacement crossing**	**Dundee Harbour Developments (Port, bridge works and V&A)**	
Underwater noise (vessel noise)	Minor adverse in all species.	Impacts are expected to be similar to the Seagreen Project. Mainstream (in draft) assessment: Not significant all species.	Impacts are expected to be similar to the Seagreen Project.	Impacts are expected to be similar to the Seagreen Project.	Impacts are expected to be similar to the Seagreen Project.	Impacts will be significantly less than other OWFs.	Assessment unavailable, expected to be less magnitude than OWFs.	Assessment unavailable, expected to be less magnitude than OWFs.	Minor adverse in all species, and **not significant**.
Barrier effects	Minor adverse in all species.	Impacts are expected to be similar to the Seagreen Project.	Impacts are expected to be similar to the Seagreen Project.	Impacts are expected to be similar to the Seagreen Project.	Impacts are expected to be similar to the Seagreen Project.	Impacts will be significantly less than other OWFs.	Assessment unavailable, expected to be less magnitude than OWFs.	Assessment unavailable, expected to be less magnitude than OWFs.	Minor adverse in all species, and **not significant.**
Collision risk with ship hulls	Minor adverse in all species.	Impacts are expected to be similar to the Seagreen Project. Mainstream (in draft) assessment: Not significant all species.	Impacts are expected to be similar to the Seagreen Project.	Predicted minor significance. Maximum of 1760 number of maintenance vessels movements per annum over the operational lifespan of project with vessels of typically 18-20 m in length.	Expected to be similar to Seagreen.	Impacts will be significantly less than other OWFs.	Assessment unavailable, expected to be less magnitude than OWFs.	Assessment unavailable, expected to be less magnitude than OWFs.	Minor adverse all species, and **not significant.**

	Cumulative						In-combination		Cumulative / in-combination significance
Impact	**Seagreen phase 1**	**Neart na Gaoithe**	**Inch Cape**	**Beatrice**	**Moray Firth**	**European Offshore Wind Deployment Centre**	**Forth Replacement crossing**	**Dundee Harbour Developments (Port, bridge works and V&A)**	
Changes to water quality	Minor adverse in all species.	Impacts are expected to be similar to the Seagreen Project. Mainstream (in draft) assessment: Not significant all species.	Impacts are expected to be similar to the Seagreen Project.	Impacts are expected to be similar to the Seagreen Project.	Impacts are expected to be similar to the Seagreen Project.	Impacts will be significantly less than other OWFs.	Assessment unavailable, expected to be less magnitude than OWFs.	Assessment unavailable, expected to be less magnitude than OWFs.	Minor adverse all species, and **not significant**.
EMF	Negligible (all species).	140km of inter-array cables and two export cables of 33km length. Impacts are expected to be similar to the Seagreen Project. Mainstream (in draft) assessment: Not significant all species.	Inter array cable voltage = 66kv. Total export cable length = 75km. Impacts are expected to be similar to the Seagreen Project.	Minor significance. Magnetic field strength of 1.7µT immediately adjacent to cable and 0.61 µT up to 2.5m from cable for a typical 33 core 33 kV array cable. Maximum length of cable (350km) will be used and buried to a minimum depth of 0.6 m or protected by means of rock placement or cable mattressing.	Expected to be similar to Beatrice.	Impacts will be significantly less than other OWFs.	Not applicable.	Not applicable.	Minor adverse all species, and **not significant.**

	Cumulative						In-combination		Cumulative / in-combination significance
	Seagreen phase 1	**Neart na Gaoithe**	**Inch Cape**	**Beatrice**	**Moray Firth**	**European Offshore Wind Deployment Centre**	**Forth Replacement crossing**	**Dundee Harbour Developments (Port, bridge works and V&A)**	
Decommissioning									
Underwater noise (cutting)	Minor adverse in all species.	Impacts are expected to be similar to the Seagreen Project. Mainstream (in draft) assessment: Not assessed.	Impacts are expected to be similar to the Seagreen Project.	Expected to be similar to Seagreen.	Expected to be similar to Seagreen.	Impacts will be significantly less than other OWFs.	Not applicable.	Not applicable.	Moderate adverse in all species,and **significant**.
Underwater noise (vessels)	Minor adverse in all species.	Impacts are expected to be similar to the Seagreen Project. Mainstream (in draft) assessment: Not assessed.	Impacts are expected to be similar to the Seagreen Project.	Expected to be similar to Seagreen.	Expected to be similar to Seagreen.	Impacts will be significantly less than other OWFs.	Not applicable.	Not applicable.	Minor adverse in all species,and **not significant**.
Collision risk (hull impact)	Minor adverse in all species.	Impacts are expected to be similar to the Seagreen Project. Mainstream (in draft) assessment: Not assessed.	Impacts are expected to be similar to the Seagreen Project.	Minor significance. Range of decommis-sioning vessels.	Expected to be similar to Seagreen.	Impacts will be significantly less than other OWFs.	Not Applicable.	Not applicable.	Minor adverse in all species,and **not significant**.
Changes to water quality (accidental release of contaminants)	Minor adverse in all species.	Impacts are expected to be similar to the Seagreen Project. Mainstream (in draft) assessment: Not assessed.	Impacts are expected to be similar to the Seagreen Project.	Impacts are expected to be similar to the Seagreen Project.	Impacts are expected to be similar to the Seagreen Project.	Impacts will be significantly less than other OWFs.	Assessment unavailable, expected to be less magnitude than OWFs.	Assessment unavailable, expected to be less magnitude than OWFs.	Minor adverse in all species,and **not significant**.

	Cumulative						In-combination		Cumulative / in-combination significance
Impact	**Seagreen phase 1**	**Neart na Gaoithe**	**Inch Cape**	**Beatrice**	**Moray Firth**	**European Offshore Wind Deployment Centre**	**Forth Replacement crossing**	**Dundee Harbour Developments (Port, bridge works and V&A)**	
Changes to water quality (suspended sediment)	Minor adverse in all species.	Impacts are expected to be similar to the Seagreen Project. Mainstream (in draft) assessment: Not assessed.	Impacts are expected to be similar to the Seagreen Project.	Impacts are expected to be similar to the Seagreen Project.	Impacts are expected to be similar to the Seagreen Project.	Impacts will be significantly less than other OWFs.	Assessment unavailable, expected to be less magnitude than OWFs.	Assessment unavailable, expected to be less magnitude than OWFs.	Minor adverse in all species,and **not significant.**
Changes to prey resource	Minor adverse in all species.	Impacts are expected to be similar to the Seagreen Project. Mainstream (in draft) assessment: Not assessed.	Impacts are expected to be similar to the Seagreen Project.	Impacts are expected to be similar to the Seagreen Project.	Impacts are expected to be similar to the Seagreen Project.	Impacts will be significantly less than other OWFs.	Assessment unavailable, expected to be less magnitude than OWFs.	Assessment unavailable, expected to be less magnitude than OWFs.	Minor adverse in all species, and **not significant.**

Construction

Potential Cumulative Impact of Underwater Noise

Piling

13.596. During the construction of Project Alpha there is likely to be overlap in periods of pile driving with wind farm developments at Inch Cape and Neart na Gaoithe. The possibility of concurrent piling at Project Alpha and each of the two STW Projects is also considered in the assessment, as well as concurrent piling at all three Projects.

13.597. We have assumed that there is more likely to be overlap of the Project Alpha most likely GM3 pile driving (80% of the development) with pile driving at the two STW Projects. The occurrence of worst case pile driving parameters at each Project concurrently is likely to be very rare.

13.598. Pile driving may be used at other OWF within the WSA, where cumulative impacts, predominately of behavioural disturbance could occur in wider ranging species (cetaceans and grey seal).

Fatality and physical non-auditory injury

13.599. There is likely to be no impact of fatality or auditory injury from pile driving at Project Alpha or Project Bravo. Neart na Gaoithe do not provides details of ranges to fatality or non-auditory injury in their Draft ES (Mainstream, In Draft). However, lethal impacts and non-auditory impacts should be mitigated during each development. It is assumed that these impacts will also be mitigated at Inch Cape. There will be **no cumulative impact** of the three developments.

Auditory injury

13.600. Based on the 130dB$_{ht}$ threshold, there is likely to be no impact of auditory injury during Project Alpha development for bottlenose dolphin, white-beaked dolphin, harbour seal or grey seal. Impact ranges of the 130 dB$_{ht}$ threshold for Inch Cape and Neart na Gaoithe in these species are within the range of mitigation (Appendix H6, Table 6-17a and 6-18a).

13.601. In the case of harbour porpoise and minke whale, impacts could occur at the 130db$_{ht}$ threshold. The impact ranges do not overlap in these species, so the cumulative impact would be equivalent to the sum of the impacts in isolation. In addition to the potential impacts from Project Bravo.

13.602. At the M-weighted SEL 198dB threshold, impacts in all species are predicted to only occur within 500m of the noise source for Project Alpha, impact ranges for PTS at Inch Cape and Neart na Gaoithe (Appendix H6, Table 6-36) are also within this range, for all species. When the INSPIRE model is used to predict accumulated sound exposure of concurrent pile driving at these Projects some very large ranges are predicted (Appendix H6, Section 6-5). The results of the modelling are wholly dependent on the underlying assumption that the transect of the fleeing animal starts at a point between the piles, and can therefore flee in a direct path through the line of piling. This means that the individuals can receive a long exposure to noise that can cause PTS. Therefore, the outputs of the modelling that predict size of the areas affected under these conditions are considered unrealistic (Appendix H6, Section 6-5).

13.603. The likely impacts of auditory injury using the M-weighted SEL thresholds from concurrent piling have also been assessed using SAFESIMM (Appendix H8, Table 4) for harbour porpoise, bottlenose dolphin, harbour seal and grey seal. The SAFESIMM approach does allow modelling of the movement of individual animals, away from the noise source, so is likely to represent a more realistic response to concurrent pile driving. However, in the case of harbour and grey seal the more precautionary 186dB threshold has been used by SAFESIMM.

Harbour porpoise

13.604. For harbour porpoise, the impacts based on the 130dB$_{ht}$ thresholds and spatial overlay of areas with SCANS II densities <0.4 and <0.3 harbour porpoise could be exposed to auditory injury as a worst case and most likely case respectively. Based on the areas of impact for Inch Cape (1.09km^2) and Neart na Goithe (0.95km^2) and average densities, the impacts at these two Projects would equate to <0.4 and <0.1 porpoise respectively. Cumulatively, this would be approximately one porpoise that could receive auditory injury from a single concurrent pile driving event at all three Projects.

13.605. SAFESIMM (Appendix H8, Section 3.2) predicts that from a single concurrent pile driving event at Project Alpha and Inch Cape, nine harbour porpoise could receive PTS, from a single concurrent pile driving event at Project Alpha and Neart na Gaoithe nine harbour porpoise could receive PTS, and from a single concurrent pile driving event at all three developments 13 harbour porpoise could receive PTS.

13.606. It is hard to predict, as explained during the assessment of Project Alpha (Impact Assessment-Construction), whether the likely impact levels of PTS from a single pile driving event will be repeated during the course of the construction programme. Breaks in pile driving may occur due to technical issues or due to weather, and such breaks may allow individuals to return to the area, or new individuals to enter the vicinity. There is likely to be a complex interaction of periods of behavioural exclusion from a wide area due to pile driving at one or several of the three Projects. This could act to reduce numbers of individuals that could be exposed to PTS from pile driving at the other Projects, in essence behavioural exclusion acting as mitigation for PTS.

13.607. However, the numbers predicted by SAFESIMM to be exposed to noise thresholds that could elicit PTS from a single pile driving event could be considered a minimum number of exposed individuals during any year when concurrent pile driving occurs. It is possible that the number exposed would be higher. The maximum number of concurrent pile driving events between all of the three Projects will be limited but the number of foundations being installed at Project Alpha (it has the least number of foundations being installed).

13.608. The absolute worst case used in the assessment of the build of Project Alpha would be the exposure of new animals to PTS each time pile driving occurs. Should this occur in the case on the cumulative assessment, concurrent piling at all three Projects would lead to the greatest impact of approximately 1% of the population (in the region of 4,000 porpoise) being exposed to noise thresholds above the PTS level in a single year. The exact level of impact will be dependent on the total number of concurrent pile driving events across Project Alpha and project Bravo and between the other developments in the FTOWDG.

13.609. However, despite SAFESIMM predictions, impact ranges of PTS for pile driving at each Project in isolation are predicted to be within 500m of the noise source, and could therefore be minimised through mitigation.

13.610. Impacts in the highly sensitive species are low magnitude, and are therefore predicted to be moderate adverse and **significant**.

Minke whale

13.611. In the case of minke whale, impact ranges at the 130dB$_{ht}$ threshold do not overlap between modelled piling at each Project. The impacts likely from concurrent piling would therefore be equivalent to the sum of the independent impacts. For a single pile the most likely case (most likely GM3) for Project Alpha would be <0.03 minke, Inch Cape <0.05 and Neart na Gaoithe <0.04. A total of <0.2 minke whale could receive auditory injury based on this metric. It is possible that during a year of concurrent pile driving at Project Alpha (with a maximum of 278 GM3 most likely piles), Inch Cape and Neart na Gaoithe could impact approximately 56 minke whale.

13.612. The species is of high sensitivity, the magnitude of the impact is negligible (<0.3% of the population), and therefore predicted to be minor adverse and **not significant**.

Bottlenose dolphin

13.613. Impacts of auditory injury from PTS were not predicted from pile driving at Project Alpha (Impact Assessment-Construction). The more coastal location of Inch Cape and Neart na Gaoithe means that there is a greater overlap in those Projects impacts with the distribution of bottlenose dolphin. Therefore, whilst there is a cumulative impact, Project Alpha and Project Bravo are not contributing to this.

Harbour seal

13.614. Based on the precautionary 186dB M-weighted SEL threshold, SAFESIMM predicts that a relatively large proportion of the harbour seal population could be exposed to PTS (Table 13.37).

13.615. Although the effects of PTS on harbour seal are poorly understood, and there is therefore high levels of uncertainty with regard to species sensitivity, the predicted impacts from a single concurrent pile driving are thought to be conservative. As previously stated there is the potential for breaks in pile driving to exposure more individuals to PTS than predicted from a single concurrent pile driving event (the worst would be 11% of the population). The magnitude would be high. The overall impact could be major adverse and **significant**, although there is a high degree of uncertainty associated with this.

Table 13.37 Number (and percent of reference population) predicted by SAFESIMM to be exposed to PTS during a single concurrent pile driving event.

Species	Individuals (% population)		
	Project Alpha and Inch Cape	Project Alpha and Neart na Gaoithe	Project Alpha, Inch Cape and Neart na Gaoithe
Harbour seal	33 (6%)	47 (9%)	59 (11%)
Grey seal	308 (3-5%)	506 (4-9%)	609 (5-11%)

Grey seal

13.616. Based on the precautionary 186 M-weighted SEL threshold, SAFESIMM predicts that a relatively large proportion of the ECMA grey seal population could be exposed to PTS (Table 13.37).

13.617. Although the likely impacts of PTS in grey seal are poorly understood, and uncertainty is high in the species sensitivity, the impacts from a single concurrent pile driving may be conservative. As previously stated there is the potential for breaks in pile driving to exposure more individuals to PTS than predicted from a single concurrent pile driving event. The magnitude would be medium, the overall impact could be moderate adverse, although there is a high degree of uncertainty associated with this assessment.

Behavioural response

13.618. In consideration of likely impacts of behaviour, concurrent pile driving at Project Alpha and Inch Cape, impact contours at 90dB$_{ht}$ (in the case of seals) and 75dB$_{ht}$ (in the case of cetaceans) all show overlap (Appendix H6, Figure 6-114 to 6-1167). Concurrent pile driving at Project Alpha and Neart na Gaoithe would result in overlapping contours at 75dB$_{ht}$ for cetacean, but the 90dB$_{ht}$ contours for seals do not overlap (Appendix H6, Figure 6-123 to 6-126). Therefore, impacts in grey and harbour seals from concurrent pile driving at these Projects would equate to the sum of the two independent impacts. The impact areas when considering concurrent pile driving at the three Projects is presented in Appendix H6 (Figures 6-132 to 6-135).

13.619. The size of the impacted areas and a prediction of the number of individuals likely to be exposed to noise threshold that will elicit a behavioural response are given in Table 13.38 for Project Alpha and Inch Cape, Table 13.39 for Alpha and Neart na Gaoithe and Table 13.40 for Project Alpha, Inch Cape and Neart na Gaoithe. As explained previously cetacean impacts are based on average densities, and spatially explicit overlay (where data exist) and seal impacts are based upon spatially explicit overlay.

13.620. Impacts predicted here relate to numbers that could be behaviourally disturbed from a single concurrent pile driving event.

Cetaceans

13.621. For all species of cetacean a worst case cumulative impact could assume that construction of Project Alpha, Inch Cape and Neart na Gaoithe occurred independently as the duration of any behaviour impact would be prolonged. However, due to the size of the contours associated with behavioural disturbance, contours will overlap no matter where pile driving occurs on each Project. For cetaceans the assumption is that individuals could be excluded over the impact range (out to the 75dB$_{ht}$ contour, Plate 13.12, 13.13 and 13.14) predicted from concurrent piling for the duration of the build of all Projects (Table 13.38).

13.622. For harbour porpoise the impact would be equivalent to 0.8% of the population being excluded from approximately 1.4% of their home range for the duration of overlapping pile driving. This species has medium sensitivity to disturbance; however this impact area would be low proportion of their range, and to a negligible proportion of the population. The impacts are temporary, and are considered to be negligible and **not significant**.

13.623. For minke whale, the impact would be equivalent to 2% of the population being excluded from a maximum of 3% of their home range (when considering the North Sea as the minim range). Once again, this species has medium sensitivity to disturbance, and this impact area would be low proportion of their range and low proportion of the population. The impacts are temporary, the impact is therefore likely to be minor adverse and **not significant**.

13.624. In bottlenose dolphin, the home range is smaller than the other species of cetacean. They are also coastal in distribution, where the areas of impact range to. Although spatially explicit overlap predicts there will be no disturbance to bottlenose dolphin from Project Alpha or Project Bravo, the more coastal location of the other developments provides greater potential for disturbance. Cumulatively this could be as many as 44 based on the spatial overlay, but Project Alpha and Project Bravo to not contribute to this level of impact.

Plate 13.12 Contour plot showing the estimated 75 dB_{ht} (*Species*) peak to peak impact ranges for bottlenose dolphin for the Most Likely GM3 (Project Alpha), Inch Cape and Neart na Gaoithe scenario.

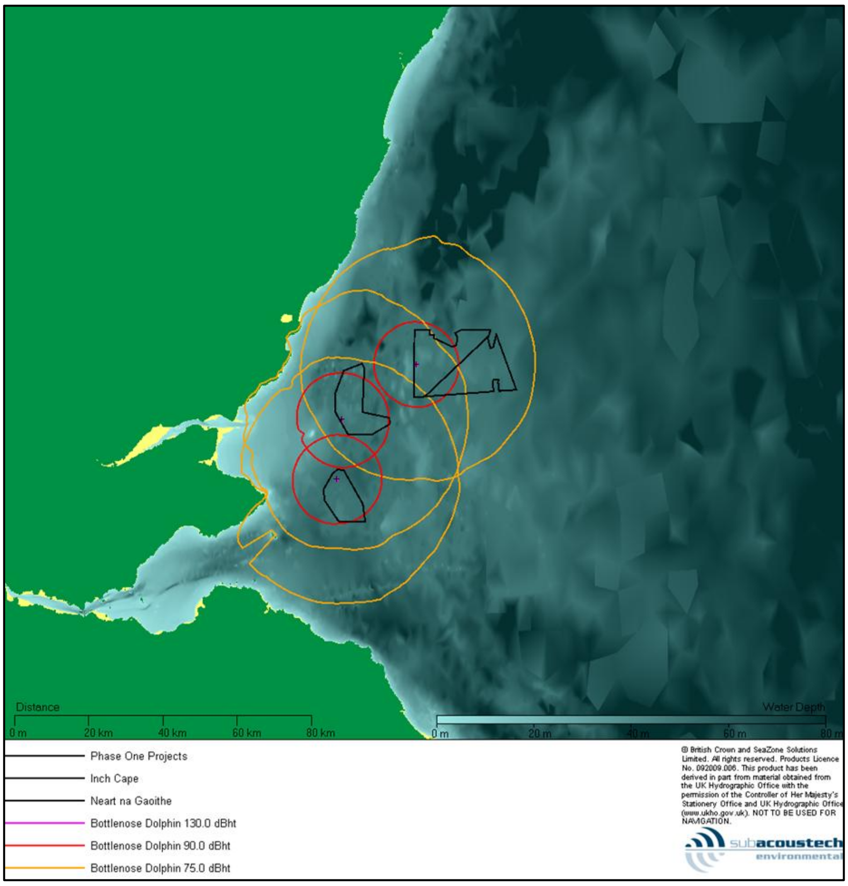


Plate 13.13 Contour plot showing the estimated 75 dB_{ht} (*Species*) peak to peak impact ranges for harbour porpoise for the Most Likely GM3 (Project Alpha), Inch Cape and Neart na Gaoithe scenario.

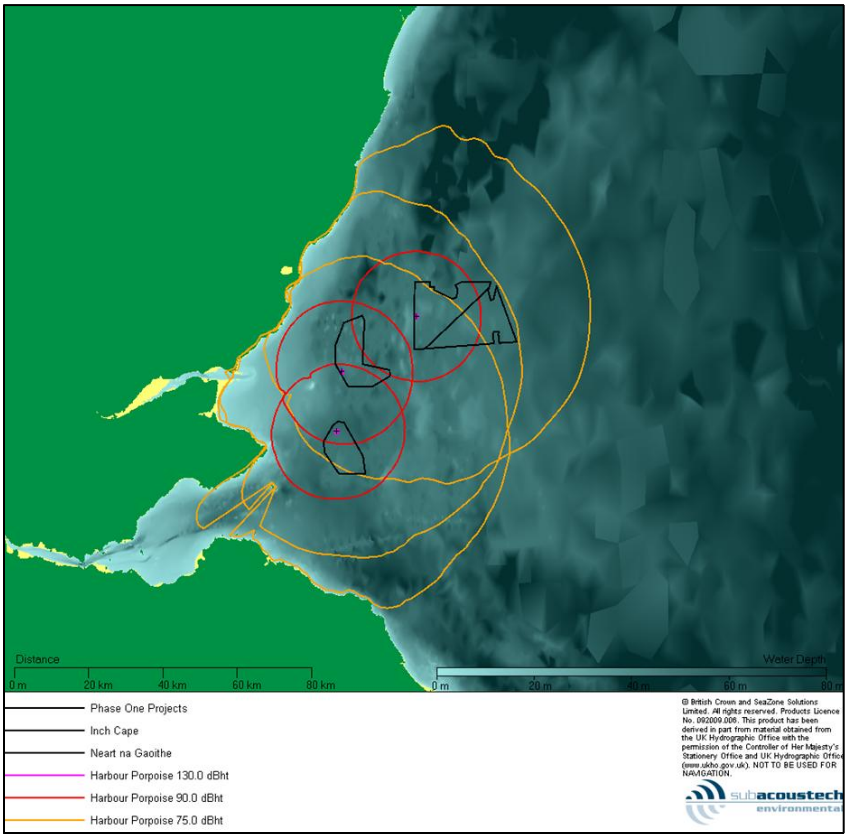
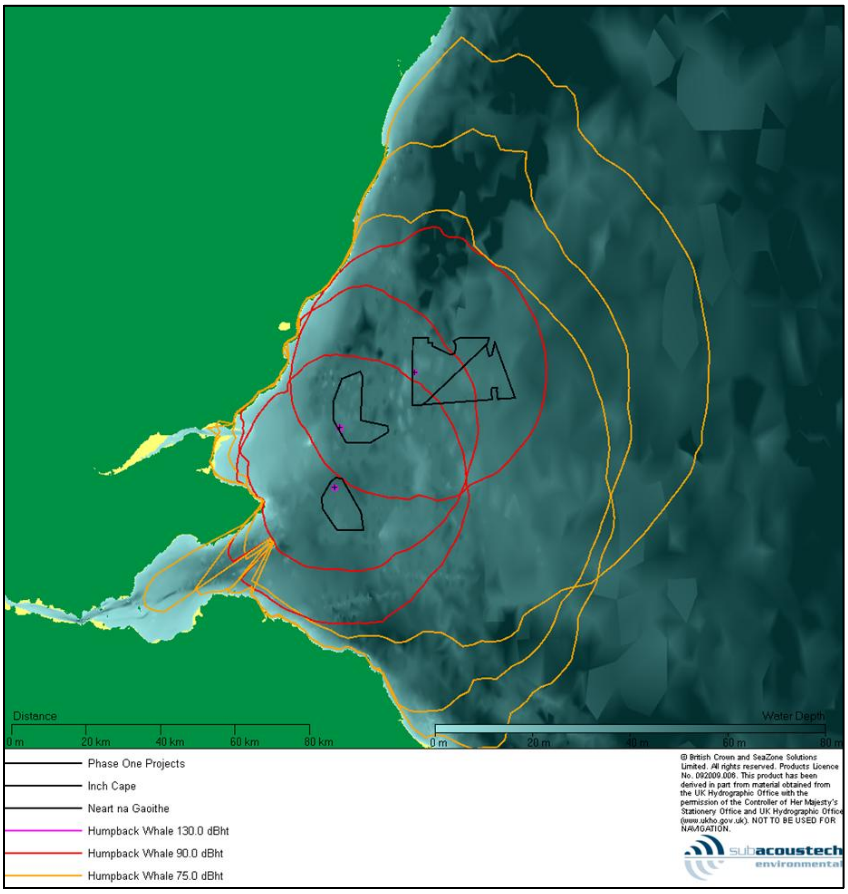


Plate 13.14 Contour plot showing the estimated 75 dBht (Species) peak to peak impact ranges for minke whale (based on theoretical humpback whale audiogram) for the Most Likely GM3 (Project Alpha), Inch Cape and Neart na Gaoithe scenario.



13.625. Average densities do predict that four individuals could be disturbed by Project Alpha and Project Bravo. While the average densities may be appropriate for the more offshore location of Project Alpha and Project Bravo compared to the other developments, they may not be appropriate for the more coastal developments. The impact of five bottlenose dolphins predicted in Table 13.40 is likely to be an underestimate.

13.626. The ecological effects of this disturbance are not known. Cetacean species in general to have high sensitivity to behavioural disturbance, and although bottlenose dolphin may be habituated to anthropogenic noise their sensitivity is considered low. Low sensitivity and high magnitude of effect could result in a moderate adverse and **significant** cumulative impact. However, Project Alpha and Project Bravo will have only a minor contribution to the overall cumulative impact due to the proximity of the project to the coast.

13.627. In white-beaked dolphin, the species has medium sensitivity to disturbance, and the impact area would be negligible part of their range on a low proportion of the population. The impact is therefore considered to be minor adverse and **not significant**.

Pinnipeds

13.628. There is a great deal of uncertainty as to the potential impacts of behavioural disturbance on harbour and grey seal, and therefore the possibility of population level consequences of disturbance caused by pile driving noise.

13.629. Based on the overlap of spatially explicit densities with impacted areas, the proportion of the harbour seal population predicted to be displaced is up to 18% (Table 13.40). This species has medium sensitivity to behavioural disturbance, but the regional population has been in decline over recent years. This impact is considered to be of high magnitude, and based on the precautionary approach of medium sensitivity, the impact would be major adverse and **significant**.

13.630. The impacts for grey seals are of a smaller magnitude to that in harbour seal, up to 14% of the population, but could be as low as 7% (Table 13.40). In addition the grey seal population has been increasing over recent years. Grey seal are considered as having low sensitivity to this disturbance, but the impact could be high. The impact is therefore considered to be moderate adverse and **significant**.

Table 13.38 Impact ranges, numbers of individuals (and proportion of reference population) likely to be impacted during concurrent pile driving at Project Alpha, and Inch Cape.

Species	Area of impact[14] (km^2)	Spatially explicit overlay	Average densities
Harbour porpoise	9443	613 (0.2)	2776 (0.7%)
Bottlenose dolphin	4552	18 (9%)	4 (1.9%)
Minke whale	15063	n/ a	346 (1.4%)
White-beaked dolphin	4552	n/ a	269 (1.2%)
Harbour seal	7843	91 (17%)	n/ a
Grey seal	7843	625 (5-11%)	n/ a

14 Area of impact in the case of species of cetacean is the total area encompassed by the 75dBht contour. In the case of harbour and grey seals this is the area of the 90dBht contour.

Table 13.39 Impact ranges, numbers of individuals (and proportion of reference population) likely to be impacted during concurrent pile driving at Project Alpha, and Neart na Gaoithe.

Species	Area of impact[15] (km²)	Spatially explicit overlay	Average densities
Harbour porpoise	10406	661 (0.2%)	3059 (0.8%)
Bottlenose dolphin	5244	32 (16%)	4 (2%)
Minke whale	15846	n/ a	364 (1.4%)
White-beaked dolphin	5244	n/ a	309 (1.3%)
Harbour seal	8733	56 (10%)	n/ a
Grey seal	8733	624 (5-11%)	n/ a

Table 13.40 Impact ranges, numbers of individuals (and proportion of reference population) likely to be impacted during concurrent pile driving at project Alpha, Inch Cape and Neart na Gaoithe.

Species	Area of impact[16] (km²)	Spatially explicit overlay	Average densities
Harbour porpoise	10847	704 (0.2%)	3189 (0.8%)
Bottlenose dolphin	6635	44 (23%)	5 (3%)
Minke whale	21965	n/ a	505 (2%)
White-beaked dolphin	6635	n/ a	391 (1.7%)
Harbour seal	9211	96 (18%)	n/ a
Grey seal	9211	809 (7-14%)	n/ a

15Area of impact in the case of species of cetacean is the total area encompassed by the 75dBht contour. In the case of harbour and grey seals this is the area of the 90dBht contour.

16 Area of impact in the case of species of cetacean is the total area encompassed by the 75dBht contour. In the case of harbour and grey seals this is the area of the 90dBht contour.

Vessel Noise

13.631. Impacts from vessel noise from all OWF developments considered in the cumulative assessment are likely to be comparable to the impacts predicted for Seagreen Phase 1. Vessel activity for other development will be significantly lower

13.632. As such the cumulative impacts are assessment as minor adverse in all species, and **not significant**.

Potential Cumulative Impact of Collision Risk

13.633. The exact number and type of vessels to be used during construction cannot be fully defined until a procurement process has been completed. In addition the timing and phasing of operations is currently unknown.

13.634. The estimated cumulative increase in shipping traffic in the region during construction of each OWF is predicted to have a temporary impact and therefore a low magnitude. Given the medium sensitivity of marine mammals, based on their international importance the cumulative impact is predicted to be minor adverse and **not significant** for all species.

Potential Cumulative Impact of Changes to Water Quality

13.635. Impacts to water quality at other OWF developments may be of a similar magnitude and significance level to those of Seagreen.

13.636. Overall, the impact is considered minor adverse in grey and harbour seal, negligible and **not significant** for cetacean species, following justification as outlined in the assessment of Project Alpha and Project Bravo.

Potential Cumulative Impact of Change to Prey

13.637. The spatial survey data collected, collated and used in this assessment show the Seagreen Projects overlap with grey and harbour seal aggregations around sandbanks which represent favoured foraging grounds. Animals displaced from these areas will need to move to alternative foraging grounds within the region. If marine mammals are also displaced from these alternative areas by other OWFs the cumulative impact could be greater than for Seagreen alone. For example there may be increased competition for a reduced food resource.

13.638. The changes to prey resource during regional construction activities are predicted to have a noticeable but temporary impacts and therefore a low magnitude which is combined with a medium or low sensitivity of marine mammals. The resulting impact at a project level, may be minor, but impacts could become moderate adverse and **significant** for harbour seal, grey seal and bottlenose dolphin. But remain minor adverse and **not significant** of the wider ranging cetacean species.

Operation

Potential Cumulative Impact of Underwater noise

WTGs

13.639. There is no strategic information on cumulative effects from multiple offshore wind farms in one region. Evidence used in the impact assessment for the Seagreen Project (Impact Assessment-Operation) shows that the ranges of underwater noise dissemination from each operational wind farm are not predicted to overlap. In addition no displacement of marine mammals is predicted and therefore no significant cumulative impact will occur. The magnitude of operational noise impacts will remain negligible as with the Seagreen Project wind farm alone.

13.640. Given the high sensitivity of marine mammals yet negligible impact the cumulative impact is predicted to be minor adverse and **not significant**.

Vessel Noise

13.641. It is likely that impacts at other OWFs will be comparable to those predicted by the Seagreen Project. Impacts of underwater noise from vessels are of negligible magnitude and it unlikely that the cumulative effects will have a significant increase in impact. Cumulatively the impact is considered to be minor adverse and **not significant** in all species following justification outlined in the assessment of Project Alpha and Project Bravo.

Potential Cumulative Impact of Barrier Effects

13.642. In the assessment of Project Alpha and Project Bravo there is a low likelihood of the OWF preventing a physical barrier to marine mammals. This assessment would also apply to other OWF developments, cumulatively the impact would be minor adverse and **not significant** at worst.

Potential Cumulative Impact of Collision Risk

13.643. The exact number and type of vessels to be used during operation and maintenance activities cannot be fully defined until a procurement process has been completed. In addition the timing and phasing of operations is currently unknown.

13.644. The estimated cumulative increase in shipping traffic in the region during operation at each OWF is predicted to have an impact of low magnitude. Given the medium sensitivity of marine mammals, based on their international importance the cumulative impact is predicted to be minor adverse and **not significant** for all species.

Potential Cumulative Impact of Changes to Water Quality

13.645. Impacts to water quality at other OWF developments may be of a similar magnitude and significance level to those of Seagreen.

13.646. Overall, the impact is considered minor adverse and **not significant** in all species, following justification as outlined in the assessment of Project Alpha and Project Bravo.

Potential Cumulative Impact of EMF

13.647. There is limited evidence that marine mammals are significantly affected by EMF although it is deemed physically possible. It is expected that all WFs will use mitigation by design in terms of burial and shielding of cables the actual EMF emissions are predicted to cause an impact of negligible magnitude. Given the high sensitivity of marine mammals, based on their international importance the impact is deemed to be minor adverse and **not significant**.

Decommissioning

13.648. The decommissioning methods are not yet defined but, as with Seagreen a worst case scenario of using mechanical cutting to remove some of the base structure. Decommissioning noise will also include increased shipping noise.

13.649. For the Seagreen Project alone negligible decommissioning noise is predicted and it is assumed that the other OWF projects will have similar levels of decommissioning noise. Any noise impact during decommissioning will be noticeable but temporary and therefore will have a low magnitude.

13.650. Given the high sensitivity of marine mammals, based on their international importance the cumulative impacts are predicted to be moderate adverse and **significant** for underwater noise for all species and moderate adverse and **significant** for collision potential with ducted propellers for harbour seal. All other potential impacts are predicted to be minor adverse at worst, and **not significant**. Although there is a high degree of uncertainty associated with this assessment due to uncertainty associated with the likely timings of decommissioning of the different projects.

ENVIRONMENTAL STATEMENT LINKAGES

13.651. The marine mammal receptor has close links with water quality, fish resource and levels of shipping and this chapter should therefore be read in conjunction with Chapters 8, 12, and 14, respectively (see Table 13.41)

Table 13.41 ES Linkages

Inter-relationship	Relevant section	Linked chapter
Changes to water quality	Impact Assessment-Construction, and Impact Assessment-Operation	Chapter 8 Water and Sediment Quality
Changes to prey resource	Impact Assessment-Construction, and Impact Assessment-Operation	Chapter 12 Natural Fish and Shellfish Resources

OUTLINE MONITORING

Project Alpha

13.652. Monitoring will be necessary if verification of predicted impacts (and the success of implemented mitigation measures) is required, particularly where levels of uncertainty are identified. Monitoring programmes for marine mammals are most likely to be utilised prior to and during operations.

13.653. Seagreen anticipates that requirements for pre-, during and post-construction monitoring will form part of the conditions attached to any future licences, required for construction and operation of the wind farm and will work with the Regulatory Authorities and their advisors (Marine Scotland, JNCC and SNH) as well as other key stakeholders in developing further an appropriate monitoring package.

13.654. It is envisaged that the monitoring for Alpha and Bravo will sit within a Regional, Scottish and UK framework of monitoring and management of the impacts of offshore wind development. At a Project level the monitoring programme will be developed in consultation with key regulators, advisors, academics and experts and will focus on undertaking data gathering which over time can provide a statistically robust data set, which builds on on-going research.

13.655. During the development of Project Alpha and Project Bravo Seagreen will adopt the JNCC Guidelines (JNCC, 2010) to minimise the potential for fatal or non-auditory injury from pile driving. The use of dedicated MMOs or ADDs could provide mitigation out to a radius of 500m from the noise source. The use of real time Passive Acoustic Monitoring (PAM) could also be employed as a mitigation measure, should technology be available at the time of construction. The provision of MMOs or real time PAM would also provide monitoring of the occurrence of seals and cetaceans or just cetaceans in the case of PAM during pile driving.

13.656. Key issues identified during the assessment are the potential effects of auditory injury on harbour porpoise, minke whale and grey and harbour seal, as well has behavioural disturbance in all species commonly occurring in the area. Acoustic monitoring of noise propagation from pile driving will enable the verification of impact ranges at the different criteria. However, monitoring for the occurrence of any effect is hard to design, as a large amount of uncertainty exists as to the thresholds for auditory injury, and further uncertainty exists as to the likely individuals or population levels effects of damage to part of the hearing range of each species. Understanding the effects of underwater noise, and monitoring potential impacts are a national, and international, area of concern which needs a co-ordinated international collaborative research approach.

13.657. The wider industry, through initiatives such as FTOWDG and The Offshore Wind Underwater Noise Working Group are working alongside key stakeholders to further understand the potential impacts of underwater noise on marine mammals, as well as progress potential methods for mitigation of impacts. This work is on-going and Seagreen will continue to inform the development of any monitoring or mitigation strategy using any appropriate measures.

Project Bravo

13.658. The approach for development of any monitoring programme at Project Bravo will follow the same principals as any monitoring developed for Project Alpha. The spatial and temporal scale of any possible impacts from either Project means that appropriate population level monitoring would be at greater spatial scale that the individual Project boundaries.

13.659. As stated for Project Alpha, Seagreen anticipates that requirements for pre-, during and post-construction monitoring will form part of the conditions attached to any future licences required for construction and operation of the wind farm and will work with the Regulatory Authorities (Marine Scotland, JNCC and SNH) as well as other key stakeholders in developing further an appropriate monitoring package.

Transmission Asset Project

Infrastructure within the Project Alpha and Project Bravo site boundaries

13.660. The approach for development of any monitoring programme encompassing the Transmission Asset Project will follow the same principals as any monitoring developed for Project Alpha. The spatial and temporal scale of any possible impacts from either Project Alpha or Bravo means that appropriate population level monitoring would be at greater spatial scale than the individual Transmission Asset Project boundary.

13.661. As stated for Project Alpha, Seagreen anticipates that requirements for pre-, during and post-construction monitoring will form part of the conditions attached to any future licences required for construction and operation of the wind farm and will work with the Regulatory Authorities (Marine Scotland, JNCC and SNH) as well as other key stakeholders in developing further an appropriate monitoring package.

Transmission Asset – Export Cable Route

13.662. The approach for development of any monitoring programme encompassing the Transmission Asset will follow the same principals as any monitoring developed for Project Alpha. The spatial and temporal scale of any possible impacts from either Project Alpha or Bravo means that appropriate population level monitoring would be at greater spatial scale than the Transmission Asset.

13.663. As stated for Project Alpha, Seagreen anticipates that requirements for pre-, during and post-construction monitoring will form part of the conditions attached to any future licences required for construction and operation of the wind farm and will work with the Regulatory Authorities (Marine Scotland, JNCC and SNH) as well as other key stakeholders in developing further an appropriate monitoring package.

SUMMARY

Table 13.42 Summary of Project Alpha Impacts

Impact	Description of Effect	Potential Mitigation Measures	Residual Impact
Construction Phase			
Underwater Noise (Pile driving)	Death, injury or behavioural disturbance.	MMO or ADDs (if appropriate). 500m mitigation zone around noise source.	Moderate adverse and **significant** in harbour seal. Minor adverse and **not significant** all species except negligible and **not significant** in white-beaked dolphin.
Underwater Noise (Vessels)	Death, injury or behavioural disturbance.	MMMP	Negligible and **not significant** (all species).
Collision risk (ship hull impact)	Injury or death.	MMMP	Negligible and **not significant** (all species).
Changes to water quality (accidental release of contaminants)	Illness, injury or death.	SEMP	Negligible and **not significant** (all species).
Changes to water quality (suspended sediment)	Illness, reduced foraging ability.	SEMP	Negligible and **not significant** in all cetaceans, minor adverse and **not significant** in seals.
Changes to prey resource	Individual fitness effect from reduced prey availability or increased foraging costs.	Hearing sensitive fish species will be moderately impacted through pile driving noise, mitigation methods applied to the reduction of noise at source are the same as those applied for marine mammals (soft start and ramp up).	Minor adverse and **not significant** in harbour seal Negligible and **not significant** (all other species).
Operation Phase			
Underwater noise (WTGs)	Death, injury or behavioural disturbance.	n/ a	Negligible and **not significant** (all species).
Underwater noise (vessel noise)	Death, injury or behavioural disturbance.	n/ a	Negligible and **not significant** (all species).
Barrier effects	Prevent movement or migration.	n/ a	Negligible and **not significant** (all species).
Collision risk (ship hull impact)	Injury or death.	MMMP	Negligible and **not significant** (all species).
Changes to water quality (accidental release of contaminants)	Illness, injury or death.	SEMP	Negligible and **not significant** (all species).
Electromagnetic fields	Behavioural changes.	n/ a	Negligible and **not significant** (all species).

Impact	Description of Effect	Potential Mitigation Measures	Residual Impact
Decommissioning Phase			
Underwater noise (cutting)	Death, injury or behavioural disturbance.	n/a	Minor adverse all species.
Underwater noise (vessels)	Death, injury or behavioural disturbance.	n/a	Negligible and **not significant** (all species).
Collision risk (ship hull impact)	Injury or death.	MMMP	Negligible and **not significant** (all species).
Changes to water quality (accidental release of contaminants)	Illness, injury or death.	SEMP	Negligible and **not significant** (all species).
Changes to water quality (suspended sediment)	Illness, reduced foraging ability.	SEMP	Minor adverse and **not significant** in seals. Negligible and **not significant** in all cetacean species.
Changes to prey resource	Individual fitness effect from reduced prey availability or increased foraging costs.	n/a	Minor adverse and **not significant** in harbour seal Negligible and **not significant** (all other species).

Table 13.43 Summary of Project Bravo Impacts

Impact	Description of Effect	Potential Mitigation Measures	Residual Impact
Construction Phase			
Underwater Noise (Pile driving)	Death, injury or behavioural disturbance.	MMO or ADDs (if appropriate). 500m mitigation zone around noise source.	Moderate adverse and **significant** in harbour seal. Minor adverse and **not significant** all species except negligible and **not significant** in white-beaked dolphin.
Underwater Noise (Vessels)	Death, injury or behavioural disturbance.	MMMP	Negligible and **not significant** (all species).
Collision risk (ship hull impact)	Injury or death.	MMMP	Negligible and **not significant** (all species).
Changes to water quality (accidental release of contaminants)	Illness, injury or death.	SEMP	Negligible and **not significant** (all species).
Changes to water quality (suspended sediment)	Illness, reduced foraging ability.	SEMP	Minor adverse and **not significant** in seals. Negligible and **not significant** in all cetaceans.

Impact	Description of Effect	Potential Mitigation Measures	Residual Impact
Changes to prey resource	Individual fitness effect from reduced prey availability or increased foraging costs.	Hearing sensitive fish species will be moderately impacted through pile driving noise, mitigation methods applied to the reduction of noise at source are the same as those applied for marine mammals (soft start and ramp up).	Minor adverse and **not significant** in harbour seal Negligible and **not significant** (all other species).
Operation Phase			
Underwater noise (WTGs)	Death, injury or behavioural disturbance.	n/ a	Negligible and **not significant** (all species).
Underwater noise (vessel noise)	Death, injury or behavioural disturbance.	n/ a	Negligible and **not significant** (all species).
Barrier effects	Prevent movement or migration.	n/ a	Negligible and **not significant** (all species).
Collision risk (ship hull impact)	Injury or death.	MMMP	Negligible and **not significant** (all species).
Changes to water quality (accidental release of contaminants)	Illness, injury or death.	SEMP	Negligible and **not significant** (all species).
Electromagnetic fields	Behavioural changes.	n/ a	Negligible and **not significant** (all species).
Decommissioning Phase			
Underwater noise (cutting)	Death, injury or behavioural disturbance.	n/ a	Minor adverse and **not significant** all species.
Underwater noise (vessels)	Death, injury or behavioural disturbance.	n/ a	Negligible and **not significant** (all species).
Collision risk (ship hull impact)	Injury or death.	MMMP	Negligible and **not significant** (all species).
Changes to water quality (accidental release of contaminants)	Illness, injury or death.	SEMP	Negligible and **not significant** (all species).
Changes to water quality (suspended sediment)	Illness, reduced foraging ability.	SEMP	Minor adverse and **not significant** in seals. Negligible and **not significant** in all cetacean species.
Changes to prey resource	Individual fitness effect from reduced prey availability or increased foraging costs.	n/ a	Negligible and **not significant** (all species).

Table 13.44 Summary of Transmission Asset Project Impacts

Impact	Description of Effect	Potential Mitigation Measures	Residual Impact
Construction Phase			
Intertidal or terrestrial habitat exclusion	Loss of haul out habitat for seals for resting or breeding.	n/ a	Negligible and **not significant**
Impacts of underwater noise	Death, injury or behavioural disturbance	n/ a	Negligible and **not significant** (all species).
Collision risk (ship hull impact)	Injury or death	n/ a	Negligible and **not significant** (all species).
Operation Phase			
Underwater noise (vessels)	Death, injury or behavioural disturbance.	n/ a	Negligible and **not significant** (all species).
Electromagnetic fields	Behavioural changes.	n/ a	Negligible and **not significant** (all species).
Decommissioning Phase			
Underwater noise (vessels)	Death, injury or behavioural disturbance.	n/ a	Negligible and **not significant** (all species).
Collision risk (ship hull impact)	Injury or death.	n/ a	Negligible and **not significant** (all species).

REFERENCES

Anderwald, P. & Evans, G.H. (2010). *Cetaceans of East Grampian Region*. SeaWatch Foundation.

ASCOBANS (2012). *Convention on Migratory Species.* http://www.cms.int/species/ascobans/asc_bkrd.htm

Bäcklin B-M., Moraeus,C., Roos,A., Eklof, E., and Lind , Y. (2011). *Health and age and sex distributions of Baltic grey seals (Halichoerus grypus) collected from by-catch and hunt in the Gulf of Bothnia.* ICES Journal of Marine Science (2011), 68(1), 183–188..

Banhuera-Hinestroza E., Galatius Jørgensen, G.. Kinze, C., Rasmussen M., and Evan, P. (2009). *White beaked dolphin*, InReport of ASCOBANS/HELCOM Small Cetacean population structure workshop Held 8-10 October 2007. ASCOBANS, Bonn, Germany April 2009.

Beatrice (2012). *Beatrice Offshore Wind Farm, Environmental Statement Section 12 Marine Mammals.*

Brandt, M. J., Diederichs, A., and Nehls, G. (2009). *Investigations into the effects of pile driving at the offshore wind farm Horns Rev II and the FINO III research platform. Report to DONG Energy*

Brandt MJ, Diederichs A, Betke K, Nehls G (2011) *Responses of harbour porpoises to pile driving at the Horns Rev II offshore wind farm in the Danish North Sea.* Mar Ecol Prog Ser 421: 205-216

Caltrans (2001). *Marine Mammal Impact Assessment. San Francisco – Oakland Bay Bridge East Span Seismic Safety Project Pile Installation Demonstration Project*. August 2001 PIDP EA 012081, Caltrans Contract 04A0148, Task Order 205.10.90 PIDP 04-ALA-80-0.0/0.5

Carstensen, J., Henriksen, O.D., Teilmann, J., (2006). *Impacts of offshore wind farm construction on harbour porpoises: acoustic monitoring of echolocation activity using porpoise detectors* (T-PODs). Marine Ecology – Progress Series 321, 295–308.

Carter, C. (2007). *Renewable energy devices: a collision risk for marine mammals. MSc Thesis, The University of the Highlands and Islands.*

Cheney, B., Thompson, P.,M., Ingram, S.N., Hammond, P.S., Stevick, P.T., Durban, J.W., Culloch, R.M., Elwen, S.H., Mandleberg, L., Janik, V.M., Quick, N.J., Islas-Villanueva, V., Robinson, K.P., Costa, M., Eisfel, S.M., Walters, A., Phillips, C., Weir, C.R., Evans, P.G.H., Anderwald, P., Reid, R.J., Reid, J.B. and Wilson, B. (2012) *Integrating multiple data sources to assess the distribution and abundance of bottlenose dolphins (Tursiops truncatus) in Scottish waters.* Mammal Review.

Culik Boris (2010) *Odontocetes. The toothed whales: "Lagenorhynchus albirostris*". UNEP/CMS Secretariat, Bonn, Germany. http://www.cms.int/reports/small_cetaceans/index.htm

Daunt F., Wanless S., Greenstreet S.P.R, Jensen H., Hamer K.C., Harris M.P. (2008). *The impact of sandeel fishery closure in the northwestern North Sea on seabird food consumption, distribution and productivity*. Can J. Fish.Aquat.Sci. 65, 362-381

Deecke V., B., Slater, P. J. B., 1 & Ford J.K. B., (2002) *Selective habituation shapes acoustic predator recognition in harbour seals.* Nature 420, 171-173

Defra (2010). *Charting Progress 2; Healthy and Diverse Seas, Seals* Available at: http://chartingprogress.defra.gov.uk/seals

Diederichs *et al*., (2008). *Methodologies for measuring and assessing potential changes in marine mammals behaviour, abundance or distribution arising from the construction, operation and decommissioning of offshore wind farms*. Report commissioned by COWRIE Ltd;

Duck C.D. & C.D. Morris. (2011) *Grey seal pup production in Britain in 2010. In SCOS 2011, Scientific Advice on Matters Related to the Management of Seal Populations: 2010*. Available at www.smru.st-and.ac.uk

Durban JW, Elston DA, Ellifrit DK, Dickson E, Hammond PS, Thompson PM (2005) *Multisite markrecapture for cetaceans: population estimates with Bayesian model averaging.* Marine Mammal Science 21: 80–92.

Evans, P. G. H., L. W. Andersen, A. Bjorge, M. Fontaine, A. Galatius, C. C. Kinze, C. Lockyer, C. DE Luna, G. J. Pierce, S. Sveegaard, J. Teilmann, R. Tiedmann, and M. Walton. (2009). *Harbour porpoise Phocoena phocoena. Report of ASCOBANS/HELCOM small cetacean population structure workshop.* 8–10 October 2007, UN Campus, Hermann-Ehlers-Str. 10, 53113 Bonn, Germany, p. 61–85

Faber Maunsell & Metoc Plc (2007). *Report prepared for The Scottish Government. Scottish Marine Renewables Strategic Environmental Assessment* (SEA) 2007. Available at http://www.seaenergyscotland.net/

Finneran, J.J., Carder, D.A., Schlundt, C.E. & Ridgway, S.H. (2005) *Temporary threshold shift in bottlenose dolphins (Tursiops truncatus) exposed to mid-frequency tones.* Journal of the Acoustical Society of America, 118, 2696-2705.

Finneran, J. J., Schlundt, C. E., Branstetter, B. K., Trickey, J.S., and Jenkins, K. (2012). *Auditory effects of seismic air gun impulses on bottlenose dolphins (Tursiops truncatus).* Proceedings of the 11th European Conference on Underwater Acoustics.

Gill, A.B., Gloyne-Phillips, I., Neal, K.J. and Kimber, J.A. (2005). *COWRIE 1.5 Electromagnetic Fields Review. The potential effects of electromagnetic fields generated by sub-sea power cables associated with offshore wind farm developments on electrically and magnetically sensitive marine organisms – a review.* Commissioned by COWRIE. Available at URL: http://www.offshorewindfarms.co.uk/Assets/COWRIE_Final_compiled.pdf.

Götz T, Janik V.M., *Averseness of sounds in phocid seals: psychophysiological factors, learning processes and motivation.* J Exp Biol 2010, 213:1536-1548.

Götz T., and Janik V.M., (2011) *Repeated elicitation of the acoustic startle reflex leads to sensitisation in subsequent avoidance behaviour and induces fear conditioning.* Neuroscience 2011, 12:30

Hall, A.J., McConnell, B., Pomeroy, P., Duck, C.D., Fedak, M.A., Matthiopoulos, J. and Walton, M.J. (2000). *The diet of grey seals using faecal and fatty acid analysis. In Chapter 6, Variation in the diet, distribution, consumption and breeding population parameters of grey seals. In The effect of large-scale industrial fisheries on non-target species. Final Report to the European Commission.* Pages 5-79.

Hammond, P.S. and Grellier, K. (2006). *Grey seal diet composition and prey consumption in the North Sea. Final report to Department for Environment Food and Rural Affairs on project MF0319.*

Hammond, P.S. and Prime, J.H. (1990). *The diet of British grey seals. In W.D. Bowen (ed.) Population biology of sealworm in relation to its intermediate and seal hosts.* Can. Bull. Fish. Aquat. Sci. 222: 243-254.

Hammond, P. S., Benke, H., Borchers, D.L., Buckand, S.T., Collet, A., Heide-Jørgensen, M-P., Heimlich-Boran, S., Hiby, A.R., Leopold, M. F., and Øien, N. (1995). *Distribution and abundance of the harbour porpoise and other small cetaceans in the North Sea and Adjacent Waters.* Final Report Life 92-2/UK/027

Hammond, P. S., Benke, H., Borchers, D.L., Buckand, S.T., Collet, A., Heide-Jørgensen, M-P., Heimlich-Boran, S., Hiby, A.R., Leopold, M. F., and Øien, N. (2002). *Distribution and abundance of the harbour porpoise and other small cetaceans in the North Sea and Adjacent Waters.* Journal of Applied Ecology, 39(2); 361-376.

Hammond P.S., MacLeod K., Gillespie D., Swift R., Winship A. (2009). *CODA Final Report* Feb 2009

Harding, K.C. , M. Fujiwara, T. Härkönen and Y. Axberg. (2005). *Mass dependent energetics and survival in harbour seal pups. Functional Ecology*, 19; 129-135.

Hayes, S.A., D.P. Costa, J.T. Harvey, and B.J. Le Boeuf. 2004. *Aquatic mating strategies of the male Pacific harbour seal (Phoca vitulina richardii): Are males defending the hotspot?* Marine Mammal Science 20: 639-656.

Jacobs, S.R. & Terhune, J.M., 2002. *The effectiveness of acoustic harrassment devices in the Bay of Fundy, Canada: seal reactions and a noise expsoure model.* Aquatic Mammals, 28(2), 147-158.

JNCC, 2007. *Second Report by the United Kingdom under Article 17 on the implementation of the Directive from January 2001 to December 2006. Peterborough*: JNCC. Available from www.jncc.gov.uk/article17

JNCC, 2010. *Statutory nature conservation agency protocol for minimising the risk of injury to marine mammals from piling noise*, JNCC, Aberdeen.

JASCO (JASCO Applied Sciences) (2009*) Naikun offshore wind energy project. Volume 4 –noise and vibration*. JASCO Applied Sciences March 2009. Available athttp://a100.gov.bc.ca/appsdata/epic/documents/p230/d29852/1242851925970_65f01eb6ca8c72d

d6b6b913184fc3f67b13510f066a1689fbf7098ea323ed76c.pdf

Kastelein R.A, Hardemann J, Boer H.(1997). *Food consumption and body weight of harbour porpoises (Phocoena phocoena). In The biology of the harbour porpoise* Read A.J, Wiepkema P.R, Nachtigall P.E 1997pp. 217–234. Eds. Woerden, The Netherlands:De Spil Publishers.

Kastelein , R.A., Gransier, R., MacLoed, A., Hoek, L and Terhune, J.M. (2011). *Auditory and behavioral responses of two harbor seals (Phoca vitulina) to playbacks of offshore pile driving sounds, phase 1: behavioral response in one seal, but no TTS*. SEAMARCO Report.

Ketten, D. R., Mooney, T. A., Cramer, S., Arruda, J (2012). *Evidence of hearing loss in marine mammals via auditory evoked potential, otoacoustic emissions and computerised tomography*. Proceedings of the 11th European Conference on Underwater Acoustics.

Kirschvink, J. L., A. E. Dizon, and J. A. Westphal (1986). *Evidence from strandings for geomagnetic sensitivity in Cetaceans*, J. Exp. Biol. 120, 1–24.

Klinowska, M. 1985. *Cetacean live stranding sites related to geomagnetic topography*. Aquatic Mammals (1):27-32.

Laist. D.W., Knowlton. A.R. Mead. J.G. Collet. A.S. Podesta (2001). *Collisions between ships and whales.* Marine Mammal Science 17: 35-75

Lidell, H. (2003). *Utgrunden off-shore wind farm: Measurements of underwater noise.*Technical report prepared for Airicole, GE Wind Energy and SEAS/Energi/E2 by Ingemansson Technology AB, Goteborg, Sweden.

Lindeboom, H. J., Kouwenhoven, H. J., Bergman, M. J. N., Bouma, S., Brasseur, S., Daan, R.,Fijn, R. C., de Haan, Dirksen S.D., van Hal, R., Hille Ris Lambers, R., ter Hofstede, R.,Krijgsveld, K.L., Leopold, M., and Scheidat. (2011) *M Short-term ecological effects of an offshore wind farm in the Dutch coastal zone; a compilation*. Environ. Res. Lett. 6 035101

Lonergan, M., Duck, C.D., Thompson, D., Mackey, B.L., Cunningham, L. & Boyd, I.L. (2007). *Using sparse survey data to investigate the declining abundance of British harbour seals. J. Zool.* (Lond.) 271, 261–269.

Lonergan, M., C. Duck, C. Morris & D. Thompson. (2011a). *Harbour seal (Phoca vitulina) abundance has declined in Orkney: an assessment based on using ARGOS flipper tags to estimate the proportion of animals ashore during aerial surveys in the moult. In SCOS 2011, Scientific Advice on Matters Related to the Management of Seal Populations:* 2010. Available at www.smru.st-and.ac.uk

Lonergan, M., McConnell, B., Duck, C., and Thompson, D. (2011b). *An estimate of the size of the British grey seal population based on summer haulout counts and telemetry data. In SCOS 2011, Scientific Advice on Matters Related to the Management of Seal Populations:* 2010. Available at www.smru.st-and.ac.uk

Mackey, 2004. *Population dynamics and Life History of harbour seals.* PhD Thesis, University of Aberdeen.

Madsen, P. T., Wahlberg, M., Tougaard, J., , Lucke, K. and Tyack, P. 2006. *Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs.* Mar Ecol Prog Ser, 309; 279-295.

Mainstream (in draft) *Neart na Gaoithe Offshore Wind Farm Environmental Statement*

Marine Scotland, 2011. *Official Scoping Response for the Seagreen Firth of Forth Offshore Wind Farm*

Matthiopoulos J, McConnell B.J, Duck C & Fedak M.A.(2004) *Using satellite telemetry and aerial counts to estimate space use by grey seals around the British Isles.* Journal of Applied Ecology. 41(3):476-491.

Morton, A.B. & Symonds, H.K., 2002. *Displacement of Orcinus orca (L.) by high amplitude sound in British Columbia, Canada. Ices Journal of Marine Science,* 59(1), 71-80.

Nedwell J R, Langworthy J and Howell D. (2003*). Assessment of sub-sea acoustic noise and vibration from offshore wind turbines and its impact on marine wildlife; initial measurements of underwater noise during construction of offshore wind farms, and comparison with background noise. Subacoustech* Report ref: 544R0423, published by COWRIE, May 2003.

Nedwell J R, Turnpenny A W H, Lovell J, Parvin S J, Workman R, Spinks J A L, Howell D (2007*). A validation of the dBht as a measure of the behavioural and auditory effects of underwater noise. Subacoustech Report Reference:* 534R1231, Published by Department for Business, Enterprise and Regulatory Reform.

Normandeau Associates, Inc (2011).*Effects of EMFs from undersea power cables on elasmobranchs and other marine species. Final Report*. Prepared under BOEMRE Contract M09P C00014. Published by US Department of the Intererior.

Northridge, S., Tasker, M.L., Webb, A., Camphuysen, K., and Leopold, M. (1997) *White-beaked Lagenorhynchus albirostris and Atlantic white-sided dolphin L. acutus distributions in Northwest European and US North Atlantic waters. Reports of the International Whaling Commission*, 47: 707-805.

Olesiuk, P.F., Nicol, L.M., Sowden, M.J. & Ford, J.B., 2002. *Effects of the sound generated by an acoustic harrassment device on the relative abundance and distribibution of harbour porpoises (Phocoena phocoena in Retreat Passage, British Columbia.* Marine Mammal Science, 18(4), 843-862.

Quick, N.J. (2006). *Vocal behaviour and abundance of bottlenose dolphins in St Andrews Bay*. Unpublished PhD Thesis, University of St Andrews.

Quick NJ, Janik VM (2008*) Whistle rates of wild bottlenose dolphins: influences of group size and behavior. Journal of Comparative Psychology* 122: 305–311.

Reid, J.B, Evans, P.G.H and Northridge, S.P. (2003). *Atlas of cetacean Distribution in Northwest European waters*. JNCC, Peterborough

Rosen, D.A. & Renouf, D. (1997) *Seasonal changes in the blubber distribution in Atlantic harbor seals: indications of thermodynamic considerations.* Marine Mammal Science 13, 229–240.

SCANS-II, 2008. *Small cetaceans in the European Atlantic and North Sea. Final Report submitted to the European* Commission under project LIFE04NAT/ GB/ 000245, SMRU, St Andrews.

SCOS (2011). *SCOS Report. Scientific Advice on Matters Related to the Management of Seal Populations:* 2010. Available at www.smru.st-and.ac.uk

Scheidat, M., Tougaard, J., , Brasseur, S., Carstensen, J.,, van Polanen Petel, T., Teilmann, J., and Reijnders, P. (2011). *Harbour porpoises (Phocoena phocoena) and wind farms: a case study in the Dutch NorthSea.* Environ. Res. Lett. 6 (April-June 2011) 025102

Seagreen (2011). *Seagreen Phase 2 and 3 Scoping Report*. Seagreen Document No. A4MR-SEAG-Z-DEC230-SRP-072 (June 2011)

Seawatch Foundation (undated). *Minke Whale in UK Waters.* Available at: http://www.seawatchfoundation.org.uk/docs/Minke_Whale.pdf Accessed June 2012

Seawatch Foundation, accessed 2011 *Harbour porpoise in UK Waters*. Available at: http://www.seawatchfoundation.org.uk

R. J. Sharples, J. Matthiopoulos and P. S. Hammond (2008) *Distribution and movements of harbour seals around the coast of Britain: Outer Hebrides, Shetland, Orkney, the Moray Firth, St Andrews Bay,* The Wash and the Thames Report to DTI July 2008

Sharples, R.J., Arrizabalaga, B. and Hammond, P.S. (2009). *Seals, sandeels and salmon: diet of harbour seals in St Andrews Bay and the Tay Estuary, southeast* Scotland. Mar. Ecol. Prog. Ser. 390: 265–276.

Southall B L, Bowles A E, Ellison W T, Finneran J J, Gentry R L, Greene C R, Kastak D, Ketten D R, Miller J H, Nachtigall P E, Richardson W J, Thomas J A, Tyack P L. (2007) *Marine Mammal Noise Exposure Criteria: Initial Scientific Recommendations. Aquatic Mammals*.

Thomas L. *Estimating the size of the UK grey seal population between 1984 and 2010.* In SCOS 2011, Scientific Advice on Matters Related to the Management of Seal Populations: 2010. Available at www.smru.st-and.ac.uk

Thomsen F, Lüdemann K, Kafemann R and Piper W. (2006). *Effects of offshore wind farm noise on marine mammals and fish, on behalf of COWRIE Ltd*

Thompson, D., & Duck, C. D., (2010) *Berwickshire and North Northumberland Coast European Marine Site: grey seal population status.* Report to Natural England : 20100902-RFQ Sea Mammal Research Unit Scottish Oceans Institute University of St Andrews

Thompson, C., Bexton, S., Brownlow, A., Wood, S., Patterson, T. Pye, K., Lonergan, M. and Milne, R. (2010*). Report on recent seal mortalities in UK waters caused by extensive lacerations* October 2010. Sea Mammal Research Unit.

Thompson, P.M. & Hastie, G. D. (2011). *Proposed revision of noise exposure criteria for auditory injury in pinnipeds* 2nd Draft, 11th October 2011

Thompson P.M., McConnell B.J., Tollit D.J., Mackay A., Hunter C., Racey P.A. (1996) *Comparative distribution, movements and diet of harbour and grey seals from the Moray Firth,* NE Scotland. Journal of Applied Ecology 33 1572-1584.

Thompson, P.M., Mackey, B., Barton, T.R., Duck, C. & Butler, J.R.A. (2007) *Assessing the potential impact of salmon fisheries management on the conservation status of harbour seals (Phoca vitulina) in north-east Scotland.* Animal Conservation, 10: 48-56

Thompson, P.M., Lusseau, D., Barton, T., Simmons, D., Rusin, J. & Bailey, H. (2010) *Assessing the responses of coastal cetaceans to the construction of offshore wind turbines.* Marine Pollution Bulletin 60: 1200-1208

Thompson, P. M., Cheyney, B., Ingram, S., Stevick, P., Wilson, B., and Hammond, P. S. Eds (2011). *Distribution, abundance and population structure of bottlenose dolphins in Scottish Waters. Scottish Government and Scottish Natural heritage funded report. Scottish Natural Heritage* Commissioned Report No.354.

Thompson, P.M., Hastie G. D., Nedwell, J., Barham, R., Brookes, K., Cordes, L., Bailey, H., & McLean, N (2012). *Framework for assessing the impacts of pile-driving noise from offshore wind farm construction on the Moray Firth harbour seal population. Seal assessment* Framework Technical Summary, 6th June 2012

Tougaard J, Carstensen J, Wisch MS, Teilmann J, Bech N, Skov H, Henriksen OD (2005) *Harbour porpoises on Horns reef—effects of the Horns Reef* Wind farm. Annual Status Report 2004 to Elsam. NERI, Roskilde (Also available at: www.hornsrev.dk)

Tougaard, J., Henriksen, O.D., and Miller. L.A. (2009). *Underwater noise from three types of offshore wind turbines: estimation of impact zones for harbour porpoise and harbour seals.* Journal of the Acoustic Society of America 125(6): 3766.

Van Parijs, S.M., Thompson, P.M., Tollit, D.J. & Mackay, A. (1997) *Distribution and activity of male harbour seals during the mating season.* Animal Behaviour, 54: 35-43

Weir, C.R., Stockin, K.A., Pierce, G.J., 2007. *Spatial and Temporal Trends in the Distribution of Harbour Porpoises, White- Beaked Dolphins and Minke Whales Off Aberdeenshire (UK), North-Western North Sea.* J. Mar. Biol. Assoc. UK 87: 327-338

Wursig B, Greene C R and Jefferson T A. (2000). *Development of an air bubble curtain to reduce underwater noise of percussive piling.* Mar.Environ.Res. 49, pp 79 – 93.

Wilson, B., Thompson, P.M. & Hammond, P.S. (1997). *Habitat use by bottlenose dolphins: seasonal distribution and stratified movement patterns in the Moray Firth Scotland*. Journal of Applied Ecology, 34, 1365-1374.

Wilson, B., Reid, R.J., Grellier, K., Thompson, P.M. & Hammond, P.S. (2004). *Considering the temporal when managing the spatial: a population range expansion impacts protected areas-based management for bottlenose dolphins.* Animal Conservation, 7, 331-338.

Wilson, B. Batty, R. S., Daunt, F. & Carter, C. (2007) *Collision risks between marine renewable energy devices and mammals, fish and diving birds.* Report to the Scottish Executive. Scottish Association for Marine Science, Oban, Scotland, PA37 1QA