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USE OF POPULATION VIABILITY ANALYSIS (PVA) TO ASSESS THE POTENTIAL FOR LONG TERM IMPACTS FROM PILING NOISE ON MARINE MAMMAL POPULATIONS – A CASE STUDY FROM THE SCOTTISH EAST COAST

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ABSTRACT

The greatest impact on marine mammals from offshore wind is widely considered to occur primarily during the construction phase when turbine foundations are being driven into the seabed. Marine mammals rely heavily on sound to navigate, feed and conduct social interactions, and are sensitive to increased underwater noise. Potential effects (of piling noise on marine mammals) include lethal effects and physical injury, auditory injury and behavioural displacement. Standard mitigation should be effective in negating or significantly reducing the potential for lethal effects and physical injury, but even with mitigation, PTS onset and behavioural displacement may occur. Because the majority of the currently proposed offshore wind farms consist of several hundred rather than tens of turbines, pile driving may be carried out over a period of years rather than months, and therefore the potential for longer term effects on marine mammals may exist. The consideration of long term impacts is important for both EIA and HRA, where an assessment against a designated site's conservation objectives 'in the long term' is required.

We used data from a proposed UK offshore wind farm – Inch Cape (Scottish east coast) – to investigate the potential for long term effects of noise from piling on bottlenose dolphins and harbour seals (SACs have been designated locally for both species). Noise impact contours were modelled by Subacoustech Environmental Ltd using their INSPIRE model. The harbour seal density surface was produced by SMRU using their telemetry and haul out count data while the bottlenose dolphin density surface was inferred using the most appropriate information available. The numbers of animals predicted to be affected by PTS onset and behavioural displacement were then estimated using a dose-response approach. Because the consequences of PTS onset and behavioural displacement were unknown, assumptions had to be made (about how exposure to piling noise might influence demographic parameters) in order to model potential impacts on population dynamics. We assumed that the mortality risk of PTS onset was likely to be similar to that of old age (and 'harvested' 25% of the animals estimated to be exposed to SELs sufficient to induce PTS onset in each year in the PVA). Behavioural displacement was assumed to result in breeding failure due to a reduction in condition of breeding females (and a reduction in reproduction proportional to the percentage of the population that had the potential to be displaced in each year was modelled in the PVA). All assumptions were conservative and the magnitude of impact considered was always worst case.

PVA modelling indicates that worst case scenarios could lead to short term impacts upon population size, but not to longer term impacts on population viability. Application of PVA to inform EIAs and HRA has proved useful and may be further enhanced through development of clear guidance to aid interpretation of the modelled outputs by the SNCBs.

METHODOLOGY

A summary of the methodology used to assess the potential impacts of pile driving noise on marine mammal species is shown in Figure 1.

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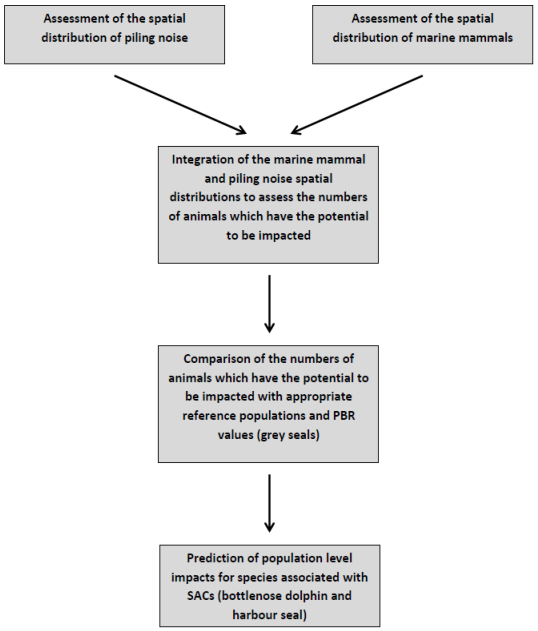

Figure 1 Schematic of the assessment methodology used in order to assess the potential impacts of pile driving noise on marine mammal species

Information on the number of individuals having the potential to be impacted (due to displacement or the potential to experience permanent threshold shift (PTS) onset) was used in population models to assess potential effects on viability of bottlenose dolphin and harbour seal populations in the long term (using VORTEX and the framework devised by Thompson *et al.* 2013 respectively). For each species, baseline scenarios (i.e. where no piling was taking place) were run to provide distributions of final population sizes after 25 years without construction-related impacts.

Assumptions were made about how exposure to noise might influence demographic parameters and the effects of displacement and potential PTS onset were modelled as direct impacts on reproduction (displacement was modelled to represent failure to successfully reproduce i.e. 'harvesting' of calves) and survival (PTS onset was modelled as age-related mortality i.e. 'harvesting' of adult animals). The number of animals that were 'harvested' in each scenario was based on the percentage of the population that the numbers of animals displaced or affected by PTS represented.

a) Bottlenose dolphin

Eight different construction scenarios (Table 1) were run and compared with the baseline. Piling was modelled to occur over two years (2016 and 2017) for the Inch Cape (IC) only scenarios and over five years (2014-2018) for the cumulative construction scenarios (concurrent piling at IC, Neart na Gaoithe (NnG) and Firth of Forth Phase 1 (FoF), collectively termed the Forth and Tay projects). An additional 'extreme' cumulative scenario 'J' (in which all calves were harvested following each year of construction) was also modelled to attempt to illustrate the very worst and unlikely case of potential impact from concurrent piling at the Inch Cape, NnG, FoF and Beatrice and MORL (Moray Firth) offshore wind farm developments (all five cumulative projects lie within range of the east coast of Scotland bottlenose dolphin population).

Table 1 Details of the different construction/ modelling scenarios

Type of scenario	Project (number of noise modelling locations)	Estimates used for PTS onset[1]/ displacement[2]	Scenario label
Baseline	None	None	A
Inch Cape	IC (1)	WC/Best	B
	IC (1)	ML/Best	C
	IC (2)	WC/Best	D
	IC (2)	ML/Best	E
Cumulative	IC (1), NnG (1), FoF (1)	ML/Best	F
	IC (1), NnG (1), FoF (1)	ML/Highest	G
	IC (2), NnG (2), FoF (2)	ML/Best	H
	IC (2), NnG (2), FoF (2)	ML/Highest	I
Forth and Tay and Moray Firth		ML/100%	J

b) Harbour seal

The harbour seal population in the Firth of Tay and Eden Estuary Special Area of Conservation (SAC) is severely declining and by 2016, when piling at the Inch Cape Development Area was modelled to commence for bottlenose dolphins, the harbour seal population is likely to be of negligible size. In order that there was a baseline against which to compare the construction scenario outputs, a (baseline) scenario in which current levels of adult mortality were reduced was run. For the construction scenario, the two-year piling period was shifted from 2016-2017 to 2008-2009 so that the harbour seal population was not already of negligible size at the start of the piling period.

RESULTS

a) Bottlenose dolphin

Population level modelling indicates that piling activity at Inch Cape only (Figure 2), and at the three Forth and Tay projects (scenarios F-I; Figure 3) and five Forth and Tay and Moray Firth projects (scenario J; Figure 3) cumulatively, is unlikely to cause a decline in the east coast bottlenose dolphin population in the long term. The mean final

[1] Estimated using the most likely (ML) and worst case (WC) piling scenarios.

[2] Estimated using Thompson *et al.* (2013)'s dose-response curve ('Best' and 'Highest' displacement estimates calculated using the best and upper fitted relationships between dB_{ht} and predicted proportion of animals excluded from the area respectively).

construction scenario population sizes all lie within the confidence limits of the baseline (Figure 4). For Environmental Impact Assessment (EIA) purposes it was therefore concluded that impacts from piling on bottlenose dolphins at the population level are likely to be minor. It is possible that concurrent piling at the Forth and Tay and Moray Firth projects (scenario 'J') may result in a small effect at the population level, but whether this would be detectable given the likely confidence interval associated with any population estimate (e.g. the 95% highest posterior density intervals associated with the current population estimate of 195 individuals are 162-253; Cheney *et al.*, 2012) is unclear.

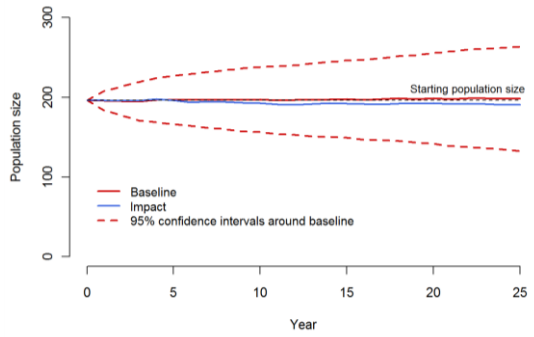

Figure 2 Mean population projections for the Inch Cape only scenarios (B, C, D and E)

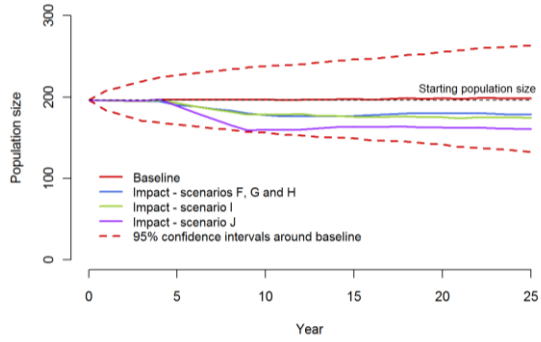

Figure 3 Mean population projections for the cumulative scenarios (F, G, H, I and J)

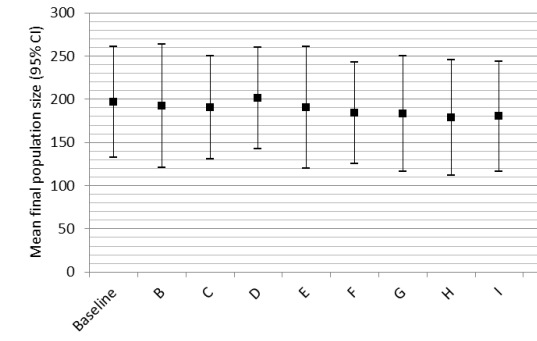

Figure 4 Mean final population sizes for the baseline and construction scenarios

b) Harbour seal

There was little difference between the baseline and construction scenarios for Inch Cape only (Figure 5) therefore, for EIA purposes, it was concluded that impacts from piling on harbour seals at the population level are likely to be minor. It should be noted that it may not be possible to measure any added loss that activities at the Forth and Tay developments may have on the population in the long-term because by the time piling is due to commence, the harbour seal population is likely to be of negligible size.

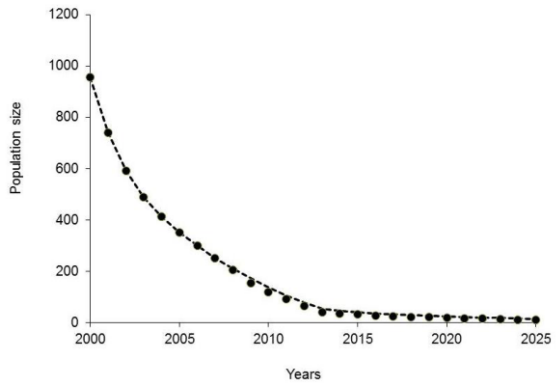

Figure 5 Comparison of baseline (---) and construction (●●●) scenarios for harbour seals

CONCLUSIONS

For both bottlenose dolphins and harbour seals, population level effects due to PTS onset and displacement from piling activity at Inch Cape alone and cumulatively with other projects are unlikely. It should be noted that the integrity of the Firth of Tay and Eden Estuary harbour seal SAC is already not being maintained (without impacts relating to the construction of any offshore wind farms).

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