# Rampion 2 Wind Farm

# Category 7: Other Documents

## Evidence Plan (Part 2 of 11)

## Date: August 2023
## Revision A

Document Reference: 7.21
Pursuant to: APFP Regulation 5 (2) (q)
Ecodoc number: 004866615-01

© WSP Environment & Infrastructure Solutions UK Ltd

# Appendix D
# Documents Submitted Via the Evidence Plan

## Phase One – Scoping

# Rampion Extension Development Limited

# Rampion 2 Offshore Wind Farm

Marine Mammals (Harbour seals): Technical note on updated dose-response curve (Whyte *et al.*, 2020)

Wood Environment & Infrastructure Solutions UK Limited – December 2020

wood.

## Report for

RWE

## Main contributors

SMRU Consulting

## Issued by

..................................................................................
[redacted]

## Approved by

..................................................................................
[redacted]

## Wood

Shinfield Park
Shinfield
Reading RG2 9FW
United Kingdom
Tel +44 (0)118 9131234

## Copyright and non-disclosure notice

The contents and layout of this report are subject to copyright owned by Wood (© Wood Environment & Infrastructure Solutions UK Limited 2020) save to the extent that copyright has been legally assigned by us to another party or is used by Wood under licence. To the extent that we own the copyright in this report, it may not be copied or used without our prior written agreement for any purpose other than the purpose indicated in this report. The methodology (if any) contained in this report is provided to you in confidence and must not be disclosed or copied to third parties without the prior written agreement of Wood. Disclosure of that information may constitute an actionable breach of confidence or may otherwise prejudice our commercial interests. Any third party who obtains access to this report by any means will, in any event, be subject to the Third Party Disclaimer set out below.

## Third party disclaimer

Any disclosure of this report to a third party is subject to this disclaimer. The report was prepared by Wood at the instruction of, and for use by, our client named on the front of the report. It does not in any way constitute advice to any third party who is able to access it by any means. Wood excludes to the fullest extent lawfully permitted all liability whatsoever for any loss or damage howsoever arising from reliance on the contents of this report. We do not however exclude our liability (if any) for personal injury or death resulting from our negligence, for fraud or any other matter in relation to which we cannot legally exclude liability.

## Management systems

This document has been produced by Wood Environment & Infrastructure Solutions UK Limited in full compliance with our management systems, which have been certified to ISO 9001, ISO 14001 and OHSAS 18001 by LRQA.

## Document revisions

| No. | Details | Date |
|---|---|---|
| **0.1** | Reviewed by Offshore PM | 21/12/2020 |
| **0.2** | Reviewed by offshore PD | 21/12/2020 |
| **1.0** | Issued to stakeholders | 22/12/2020 |

# Contents

1. Dose-response curve 4

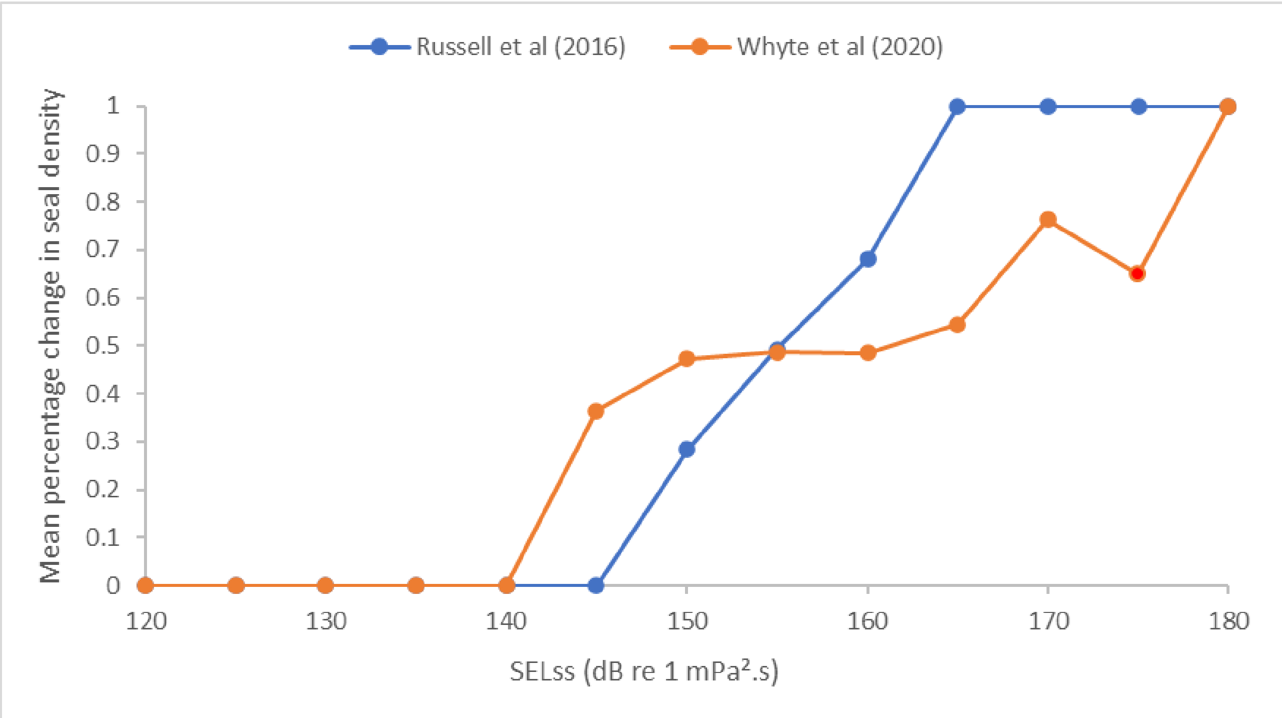
2. References 5

# 1. Dose-response curve

1.1.1 The harbour seal dose-response curve (Russell and Hastie, 2017) used in recent OWF EIAs, has been slightly updated based on re-modelling of the underwater noise propagation in Whyte *et al. (*2020). The re-modelling used the Aquarius pile driving model[1] to model source characteristics and acoustic propagation loss, which is a different noise propagation model to that used in Hastie *et al.* (2015) and Russell *et al.* (2016). The key difference in the re-modelling was the incorporation of more information on the environment and pile driving source compared to model used in Hastie *et al.* (2015). The same method was used to derive the dose-response curve from the data – using the percentage change in seal density within each predicted sound exposure level (SELs) category.

1.1.2 **Figure 1-1** below shows the comparison between the two dose-response curves. The new dose-response curve based on Whyte *et al.* (2020) predicts lower levels of response at 160-175 dB re 1 µPa2s but higher levels of response at 145-150 dB re 1 µPa2s compared to the Russell and Hastie (2017) curve.

Figure 1-1 Comparison between Russell *et al.* (2016 and Whyte *et al.* (2020) dose-curves




[1] See: de Jong, C., Binnerts, B., Prior, M., Colin, M., Ainslie, M., Mulder, I., and Hartstra, I. (2019). "Wozep–WP2: Update of the Aquarius models for marine pile driving sound predictions," TNO Rep. (2018), No. R11671, The Hague, Netherlands, p. 94. Retrieved from https://www.noordzeeloket.nl/publish/pages/160801/update_aquarius_models_pile_driving_sound_predeictions_tno_2019.pdf

# 2. References


Hastie, G. D., Russell, D. J. F.,McConnell, B. J, Moss, S., Thompson, D. and Janik, V. M. (2015). Sound exposure in harbour seals during the installation of an offshore wind farm: predictions of auditory damage. *Journal of Applied Ecology,* 52, 631-640.

Russell, D. and Hastie, G. D. (2017). Associating predictions of change in distribution with predicted received levels during piling. Report produced for SMRU Consulting.

Russell, D. J., Hastie, G.D., Thompson, D., Janik, V. M., Hammond, P. S., Scott-Hayward, L A., Matthiopoulos, J., Jones, E. L. and McConnell, B. J. (2016). Avoidance of wind farms by harbour seals is limited to pile driving activities. *Journal of Applied Ecology*, 53, 1642-1652.

Whyte, K., Russell, D., Sparling, C., Binnerts, B. and Hastie, G. D. (2020). Estimating the impacts of pile driving sounds on seals: pitfalls and possibilities. *The Effects of Noise on Aquatic Life*, 14, 3948-3958.

Journal of Applied Ecology

British Ecological Society

*Journal of Applied Ecology* 2015, **52,** 631–640 doi: 10.1111/1365-2664.12403

# Sound exposure in harbour seals during the installation of an offshore wind farm: predictions of auditory damage

**Gordon D. Hastie[1]*, Deborah J.F. Russell[1,2], Bernie McConnell[1], Simon Moss[1], Dave Thompson[1] and Vincent M. Janik[1]**

*[1]Sea Mammal Research Unit, Scottish Oceans Institute, University of St Andrews, Fife KY16 8LB, UK; and [2]Centre for Research into Ecological and Environmental Modelling, The Observatory, University of St Andrews, Fife KY16 9LZ, UK*

## Summary

**1.** With ambitious renewable energy targets, pile driving associated with offshore wind farm construction will become widespread in the marine environment. Many proposed wind farms overlap with the distribution of seals, and sound from pile driving has the potential to cause auditory damage.

**2.** We report on a behavioural study during the construction of a wind farm using data from GPS/GSM tags on 24 harbour seals *Phoca vitulina* L. Pile driving data and acoustic propagation models, together with seal movement and dive data, allowed the prediction of auditory damage in each seal.

**3.** Growth and recovery functions for auditory damage were combined to predict temporary auditory threshold shifts in each seal. Further, M-weighted cumulative sound exposure levels [cSELs($M_{pw}$)] were calculated and compared to permanent auditory threshold shift exposure criteria for pinnipeds in water exposed to pulsed sounds.

**4.** The closest distance of each seal to pile driving varied from 4·7 to 40·5 km, and predicted maximum cSELs($M_{pw}$) ranged from 170·7 to 195·3 dB re 1μPa$^2$-s for individual seals. Comparison to exposure criteria suggests that half of the seals exceeded estimated permanent auditory damage thresholds.

**5.** Prediction of auditory damage in marine mammals is a rapidly evolving field and has a number of key uncertainties associated with it. These include how sound propagates in shallow water environments and the effects of pulsed sounds on seal hearing; as such, our predictions should be viewed in this context.

**6.** *Policy implications*. We predicted that half of the tagged seals received sound levels from pile driving that exceeded auditory damage thresholds for pinnipeds. These results have implications for offshore industry and will be important for policymakers developing guidance for pile driving. Developing engineering solutions to reduce sound levels at source or methods to deter animals from damage risk zones, or changing temporal patterns of piling could potentially reduce auditory damage risk. Future work should focus on validating these predictions by collecting auditory threshold information pre- and post-exposure to pile driving. Ultimately, information on population-level impacts of exposure to pile driving is required to ensure that offshore industry is developed in an environmentally sustainable manner.

**Key-words:** wind farms, hearing, marine mammals, pile driving, pinnipeds, renewable energy, underwater noise

*Correspondence author. E-mail: gdh10@st-andrews.ac.uk

© 2015 The Authors. Journal of Applied Ecology © 2015 British Ecological Society

## Introduction

Ambitious renewable energy targets have been developed to mitigate potential impacts of climate change (Jay 2010; Toke 2011). This has led to the proposed installation of several thousand wind turbines throughout coastal areas of Europe. Proposed wind farms are often located on offshore sandbanks, which are also important habitats for marine mammals. For example, harbour seals *Phoca vitulina* L. exhibit at-sea movements that overlap extensively with proposed wind farm locations in the North Sea (Sharples *et al.* 2012; Russell *et al.* 2014), and their distribution has been shown to be clustered around features such as offshore banks (Thompson 1993). This co-occurrence has led to concerns about the potential impacts of wind farms on marine mammals; concerns derive primarily from the production of intense impulsive sounds over periods of several months during impact pile driving of turbine foundations (e.g. Madsen *et al.* 2006).

Underwater sound from pile driving has been measured in a limited number of studies (e.g. Bailey *et al.* 2010; Brandt *et al.* 2011); pulsed sounds are produced approximately every 1–2 s with predicted source levels ranging up to 250 dB re 1 $\mu Pa_{(peak-peak)}$ @ 1 m (Bailey *et al.* 2010). The mammalian auditory system is likely to be vulnerable to damage from intensive sounds such as these, and studies of auditory systems in mammals have shown that exposure to intensive pulsed sounds has the potential to cause elevated hearing thresholds (Henderson & Hamernik 1986; Kryter 1994; Finneran *et al.* 2000, 2002; Yost 2000). Such threshold shifts can be described as either temporary (TTS) or permanent (PTS) depending on the capacity for post-exposure recovery (for review, see: Clark 1991).

A number of studies on the effects of sound on the auditory system of harbour seals have been carried out (Kastak *et al.* 1999, 2005; Kastelein *et al.* 2012). For example, Kastak *et al.* (1999) exposed harbour seals to 20 min of continuous octave-band white noise with centre frequencies of 100, 500, 750 and 1000 Hz, at source levels 60 dB above the harbour seal hearing threshold (at the centre frequency); this resulted in an average 4·8 dB TTS decrease in hearing sensitivity (Kastak *et al.* 1999). Similarly, harbour seals exposed to octave-band white noise centred at 4 kHz (bandwidth 2·8–5·7 kHz) exhibited statistically significant TTS (>2·5 dB) when exposed to unweighted source levels of 136 dB re 1 μPa for 60 min and 148 dB re 1 μPa for 15 min (Kastelein *et al.* 2012).

After a TTS, the time to recovery depends on the level of shift incurred; in general, the greater the shift, the longer the recovery period (Carder & Miller 1972; Mills, Gilbert & Adkins 1979). For example, the auditory sensitivity of a harbour seal with mean TTSs of 2–12 dB as a result of exposure to octave-band white noise with a centre frequency of 2500 Hz and net exposure durations of 22 min at 137 dB re 1 μPa @1 m (which is equivalent to 80 dB above the hearing threshold of the seal at the centre frequency), and durations of 25, and 50 min at 152 dB re 1 μPa @1 m (which is equivalent to 95 dB above the hearing threshold of the seal at the centre frequency), recovered fully within 24 h (Kastak *et al.* 2005). In a more recent study, a harbour seal was exposed for 60 min to an octave-band white noise centred around 4 kHz with a considerably higher sound pressure level (SPL) of 163 dB re 1 μPa (corresponding to 22–30 dB above levels causing TTS exceeding 2·5 dB). This elicited a TTS of 44 dB which only recovered after 4 days (Kastelein, Gransier & Hoek 2013).

Southall *et al.* (2007) developed an approach for evaluating the effects of anthropogenic sound on marine mammals. They developed a series of weighting curves based on the hearing characteristics of five functional marine mammal species groups and reviewed auditory damage studies to provide initial exposure criteria for pulsed and non-pulsed sounds. They predicted that for pinnipeds exposed to pulsed sounds underwater, the onset of PTS would occur at weighted cumulative sound exposure levels (cSELs) of 186 dB re 1 $\mu Pa^2$-s ($M_{pw}$). For pinnipeds exposed to non-pulse sounds underwater, the predicted PTS onset threshold was at a weighted cSEL of 203 dB re 1 $\mu Pa^2$-s ($M_{pw}$) (Southall *et al.* 2007). It is important to highlight that, due to the paucity of data on the effects of sound on marine mammal hearing, these preliminary exposure criteria of Southall *et al.* (2007) are based on assumed relationships between the relative levels of TTS and PTS which, in turn, involve proxy data from other species and are intentionally conservative; further, they do not include the more recent data on auditory damage described above (e.g. Kastelein *et al.* 2012; Kastelein, Gransier & Hoek 2013).

Although hearing studies highlight the potential risks to marine mammals from acoustic exposure to pile driving, there is currently no empirical information on the at-sea proximity or the durations of exposure to pile driving, or movements and dive behaviour of seals during pile driving. Such information is critical to understanding the true risk of pile driving sound to seals. To address this gap, we carried out a harbour seal behavioural study during the construction of a wind farm in the North Sea. Our study used data from 24 animal-borne tags collected between January and July 2012. These tags provided location and dive data which, in combination with records of individual pile driving blows, allowed us to predict the potential for auditory damage in each seal.

## Materials and methods

### STUDY AREA

The Lincs offshore wind farm is located on a submerged sandbank *c.* 8 km off the coast of south-east England (53°11·5′ N, −0°29·5′ E). On completion, the wind farm consisted of 75 turbines located in water depths of *c.* 8–20 m and covering an area of *c.* 39 km$^2$. As part of the wind farm construction, foundations (5·2 m diameter steel monopiles) were installed between 14 May 2011 and 11 May 2012.

### PILE DRIVING

Throughout the period of this study (2 January–11 May 2012), 31 monopiles were installed using pile driving. Installation was carried out using a jack-up vessel with an MHU 1900S hydraulic hammer. The temporal pattern of pile driving was characterized by intermittent piling periods (*c.* 4–5 h in length) followed by gaps from a few hours to a few days (Fig. 1). Within individual pile installations, the median interstrike interval was 2 s (SD = 12 s) and the maximum blow energy was *c.* 2000 kJ per strike. A ramp-up procedure was carried out during all installations; in general, there was an increase from 100 to 700 kJ over the first 60 min before increasing to 2000 kJ for the remaining installation. A total of 77 968 piling strikes were carried out during our study.

### TELEMETRY

To measure the movements and proximity of seals at sea to pile driving, GPS/GSM tags (McConell *et al.* 2010) were deployed on 25 harbour seals in January 2012. Of these, three tags collected data for <2 days (and were therefore excluded from the data set) with the other 22 collecting data for between 49 and 171 days (Table 1). Furthermore, two seals tagged during a concurrent study *c.* 200 km to the south moved into the study area during pile driving and were included in the data set. Therefore, data from 24 seals were used for further analyses.

Seals were captured while hauled out on intertidal sandbanks and were anaesthetized with Zoletil® or Ketaset® in combination with Hypnovel®. The tags were attached to the fur at the back of the neck using Loctite® 422 Instant Adhesive. Capture and handling procedures are described in more detail by Sharples *et al.* (2012). All procedures were carried out under Home Office Animals (Scientific Procedures) Act licence number 60/4009.

The tags are data loggers that attempt to record the location of a seal at regular intervals using a hybrid GPS (Fastloc®) system. Stored location and dive data are opportunistically relayed ashore by means of an embedded mobile phone (GSM) modem. These tags provided seal locations approximately every 15 min. The data were cleaned and erroneous locations removed using thresholds of residual error and number of satellites; tests on land using these thresholds showed 95% of the cleaned locations had an error of <50 m (Russell *et al.* in press). Further, dive data were provided as nine depth points distributed equally in time throughout each dive. During periods of pile driving, tracks of seals were interpolated linearly between successive GPS locations to provide estimated locations at 1-s intervals. Similarly, dive depths at each of these locations were estimated through linear interpolation between successive measured dive depths. These provided estimated 3D locations of each seal at 1-s intervals throughout periods of pile driving.

### ACOUSTIC EXPOSURE

To predict the acoustic exposure from pile driving for each seal, the source characteristics of the pile driving were derived from existing literature and a series of acoustic modelling approaches were carried out; these are described in Appendix S1 in the Supporting Information. Effectively, a median peak-to-peak source level estimated during previous pile driving at the same wind farm (Nedwell, Brooker & Barham 2011) was used as a source level for pile driving in this study; this value was then corrected for changes in pile driving hammer blow energy by relating individual piling stroke blow energy information (provided by the wind farm developer) with peak-to-peak received levels from recordings made with an autonomous moored sound recorder (DSG-Ocean Acoustic Datalogger; Loggerhead Instruments, Sarasota, FL, USA). This recorder was moored at a range of 4900 m from the pile driving location. This information, together with information on the mean duration of a pile driving pulse and the mean difference between the peak-to-peak and root mean square SPL, was used to derive the sound exposure level (SEL) of a pile driving single pulse. Using these approaches, the pile driving was estimated to have a maximum single pulse SEL of 211 dB re 1 $\mu Pa^2$-s at the maximum blow energy of 2000 kJ.

Transmission loss across the study area was then estimated using range-dependent acoustic models (Collins 1993); these are described in detail in Appendix S1 in the Supplemental Information. This was calculated along five degree radii from each of the pile driving source locations out to a range of 200 km. At each 1-km interval, transmission loss at a series of water depths was estimated; these were 1 m and each 5-m-depth interval from five to 110 m depth (the maximum seal dive depth during the study). The acoustic models were validated

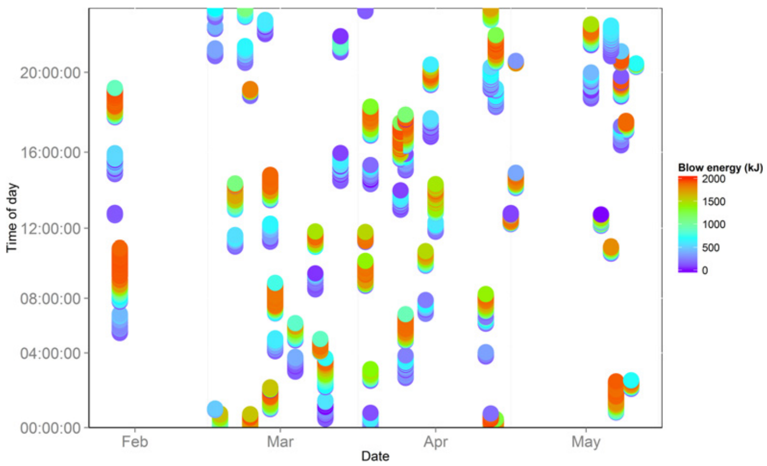



**Fig. 1.** Temporal pattern in pile driving with month along the *x*-axis and time of day on the *y*-axis. Each point represents a pile driving pulse which is coloured by the blow energy (kJ) of the piling strike.

© 2015 The Authors. Journal of Applied Ecology © 2015 British Ecological Society, 

**Table 1.** Summary of the predicted auditory damage for the tagged seals, including the maximum cSEL ($M_{pw}$) (dB re: 1 μPa$^2$-s) (Southall *et al.* 2007), the number of piling bouts where the PTS onset threshold was exceeded, and the maximum TTS (dB) predicted from TTS growth and recovery functions (Kastak *et al.* 2005, 2007). Each of the predictions is shown for seals when located less than and >10 km from the piling location

| Seal ID | Sex | Age class | Tag duration (days) | Closest range to piling (km) | Maximum RL [dB re 1μPa$_{(peak)}$] | Max cSEL ($M_{pw}$) (dB re: 1 μPa$^2$-s) | | No. of piling bouts exceeding 186 dB re: 1 μPa$^2$-s | | Max predicted TTS (dB re 1μPa) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | <10 km | >10 km | <10 km | >10 km | <10 km | >10 km |
| pv40-268-12 | Female | Adult | 135 | 6·1 | 179·7 | 187·8 | 188·4 | 3 | 2 | 7·9 | 16·8 |
| pv40-270-12 | Male | Adult | 91 | 40·5 | 171·0 | – | 178·6 | – | 0 | – | 2·9 |
| pv42-162-12 | Female | Adult | 160 | 9·8 | 179·9 | 170·7 | 190·0 | 0 | 4 | 0·8 | 18·3 |
| pv42-165-12 | Female | Juvenile | 64 | 6·9 | 173·5 | 182·0 | 185·5 | 0 | 0 | 1·9 | 8·2 |
| pv42-194-12 | Male | Adult | 115 | 27·0 | 173·8 | – | 183·1 | – | 0 | – | 7·8 |
| pv42-198-12 | Male | Adult | 131 | 29·1 | 179·0 | – | 187·1 | – | 3 | – | 14·0 |
| pv42-220-12 | Male | Adult | 144 | 34·3 | 177·2 | – | 186·2 | – | 0 | – | 11·2 |
| pv42-221-12 | Male | Adult | 50 | 26·8 | 173·3 | – | 183·6 | – | 0 | – | 7·8 |
| pv42-266-12 | Female | Adult | 84 | 11·1 | 177·0 | – | 185·5 | – | 0 | – | 7·8 |
| pv42-277-12 | Female | Adult | 158 | 4·7 | 184·7 | 193·4 | 191·3 | 9 | 3 | 24·5 | 21·2 |
| pv42-287-12 | Male | Adult | 18 | 38·8 | 164·4 | – | 176·7 | – | 0 | – | 1·6 |
| pv42-288-12 | Female | Adult | 170 | 15·8 | 176·1 | – | 185·5 | – | 0 | – | 11·9 |
| pv42-289-12 | Male | Adult | 79 | 27·6 | 172·3 | – | 183·3 | – | 0 | – | 8·1 |
| pv42-290-12 | Female | Adult | 58 | 16·9 | 175·6 | – | 187·8 | – | 1 | – | 9·5 |
| pv42-291-12 | Female | Adult | 109 | 15·0 | 178·0 | – | 183·8 | – | 0 | – | 9·7 |
| pv42-292-12 | Male | Adult | 105 | 31·5 | 174·8 | – | 184·3 | – | 0 | – | 5·2 |
| pv42-293-12 | Female | Adult | 69 | 17·1 | 177·5 | – | 185·4 | – | 0 | – | 10·5 |
| pv42-294-12 | Male | Adult | 103 | 29·6 | 172·7 | – | 184·0 | – | 0 | – | 8·9 |
| pv42-295-12 | Female | Adult | 69 | 10·8 | 181·0 | – | 190·7 | – | 1 | – | 16·4 |
| pv42-316-12 | Male | Juvenile | 106 | 5·8 | 179·1 | 184·3 | 187·4 | 0 | 1 | 6·6 | 13·3 |
| pv42-317-12 | Female | Adult | 111 | 17·1 | 179·6 | – | 190·6 | – | 3 | – | 16·8 |
| pv42-318-12 | Female | Adult | 139 | 13·8 | 180·6 | – | 195·3 | – | 7 | – | 23·0 |
| pv42-319-12 | Male | Juvenile | 114 | 27·3 | 176·6 | – | 188·9 | – | 2 | – | 15·7 |
| pv42-320-12 | Female | Adult | 106 | 4·9 | 182·3 | 188·7 | 186·0 | 1 | 1 | 17·3 | 12·5 |

using boat based recordings during the installation of one of the piles; these recordings covered the full range of pile driving blow energies. Recordings were made using a Reson TC 4014 hydrophone with a Brüel and Kjaer amplifier (type 2635) and a calibrated Avisoft Ultrasoundgate 416 digital acquisition system at a sample rate of 192 kHz. Recording locations varied between 1000 and 9500 m from the pile driving.

### PREDICTION OF AUDITORY DAMAGE

To predict the potential for auditory damage in each seal, received SELs for each pile driving pulse were estimated at the location of each of the seals using the approach described above; seal locations and depths were matched to the transmission loss estimates at the associated location and depth for each individual pile driving pulse to estimate received SELs (Figs 2 and 3).

Auditory damage was predicted in individual seals using two approaches. These were based on (i) results from previous studies of TTS onset, growth (during exposure) and recovery (post-exposure) in harbour seals (e.g. Kastak *et al.* 2005, 2007) and (ii) the approach developed by Southall *et al.* (2007) for evaluating the likelihood of PTS in marine mammals exposed to anthropogenic sound (Fig. 4).

The first approach required summing individual pulse SELs for each period of pile driving to calculate the cSEL and to integrate published TTS growth and recovery functions for harbour seals with the cSELs. The growth of TTS was modelled (eqn 1) as described by Kastak *et al.* (2005); the best fit parameter values for the harbour seal tested in their study were used to construct the growth curve in the present study. In the absence of data for harbour seals on recovery from TTS, recovery was modelled using a −8·8 dB per log(min) relationship for California sea lions *Zalophus californianus* L. (Kastak *et al.* 2007). It is important to highlight that predictions of auditory damage made here for pulsed sounds are based on TTS onset and recovery functions derived from exposure to octave-band (continuous) noise for varying durations.

$$\text{TTS} = (10m1)\log_{10}(1 + 10^{((\text{SEL}-m2)/10)}), \qquad \text{eqn 1}$$

where $m1$ is 2·0 and corresponds to the slope of the linear portion of the curve relating SEL to threshold shift (Kastak *et al.* 2005);

$m2$ is 183·1 and corresponds to the $x$ intercept of the extrapolation of the linear portion of the curve [considered the onset of TTS (Kastak *et al.* 2005)].

The second approach was to weight the SELs according to the auditory M-weighting function for pinnipeds in water ($M_{pw}$) formulated by Southall *et al.* (2007). For pile driving pulses, this effectively reduced individual pulse SELs by 1·6 dB re 1 μPa$^2$-s. M-weighted individual pulse SELs were then summed for each period of pile driving to calculate the cSEL ($M_{pw}$). Permanent auditory injury onset thresholds at a cSEL of 186 dB re 1 μPa$^2$-s ($M_{pw}$) for pinnipeds exposed to underwater pulsed sound within

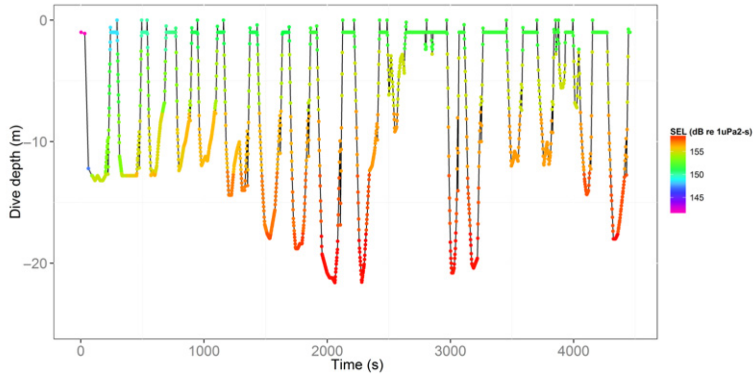



**Fig. 2.** Example of a harbour seal dive profile over a period of 75 min with predicted unweighted single pulse SELs (dB re: 1 μPa2-s) received from pile driving.

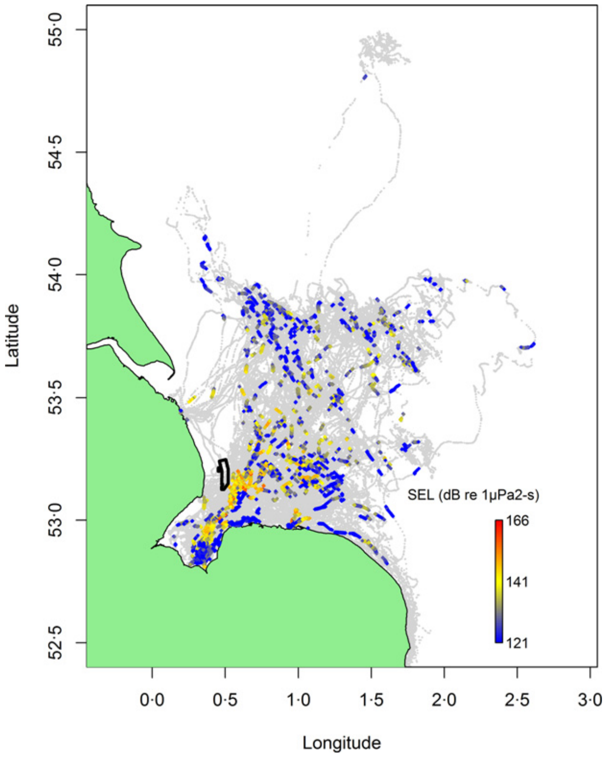



**Fig. 3.** Map of the study area showing all GPS locations of 24 seals with predicted single pulse SELs (dB re: 1 μPa2-s) from pile driving. The figure shows the seal locations when no piling was taking place (grey points), during piling (coloured points) and the location of the wind farm (black polygon).

a 24-h period were proposed by Southall *et al.* (2007); we therefore adopted this approach and calculated cSEL ($M_{pw}$) in each 24-h period from the start of piling. In addition, Southall *et al.* (2007) propose an unweighted peak SPL of 218 dB re 1μPa as an alternative permanent auditory injury onset threshold. We therefore present predicted received peak SPLs (calculated as predicted SPL $_{(peak\text{-}peak)}$ minus 6 dB) for each seal.

Given that the acoustic propagation model validation recordings were only made to ranges of *c.* 10 km from the pile driving, there is greater uncertainty in the SELs and the characteristics of the signals (e.g. frequency, duration, rise time) received at seals beyond this range. To account for this, auditory damage predictions are summarized for cases where seals were within 10 km and beyond 10 km from the pile driving location.

## Results

### TELEMETRY

Throughout the study, all seals moved between haul out sites and areas offshore. During transits offshore, seals travelled within 20 km of the wind farm site. All seals spent time offshore during at least one pile driving event; the closest distance of individual seals to active pile driving locations while at sea varied between individual seals from 4·7 to 40·5 km.

### ACOUSTIC EXPOSURE

The results of the validation recordings suggested that the modelling approaches provided a relatively accurate means of predicting received levels from pile driving; overall mean error in the predictions of unweighted single pulse SELs was +2·3 (SD = 1·8) dB up to ranges of *c.* 10 km from the source.

Maximum predicted unweighted single pulse SELs at individual seals varied from 146·1 to 166·5 dB re 1 $\mu Pa^2$-s. In general, predicted received levels increased with dive depth; the maximum single pulse SEL was 166·5 dB re 1 $\mu Pa^2$-s for seal 'pv42-277-12' at a range of 6·9 km and a dive depth of 17·1 m.

### PREDICTION OF AUDITORY DAMAGE

Using the TTS growth and recovery functions established for exposure to continuous noise (Kastak *et al.* 2005, 2007), it was predicted that all seals received SELs sufficient to cause TTS during pile driving. Predicted maximum threshold shifts for individuals ranged from 1·6 to 23·0 dB (Fig. 5 and Table 1). Predicted cSELs ($M_{pw}$) (Southall *et al.* 2007) from pile driving varied between individual seals; the seal with the lowest exposure had cSELs ($M_{pw}$) ranging from 132·8 to 190·6 dB re 1 $\mu Pa^2$-s ($M_{pw}$), and the seal with the highest exposure had cSELs ($M_{pw}$) ranging from 147·2 to 195·3 dB re 1 $\mu Pa^2$-s ($M_{pw}$) (Fig. 6 and Table 1). In total, twelve (50%) of the seals were predicted to receive cSELs ($M_{pw}$) that exceeded the estimated PTS onset threshold of 186 dB re 1 $\mu Pa^2$-s ($M_{pw}$) for pinnipeds in water exposed to pulsed sounds

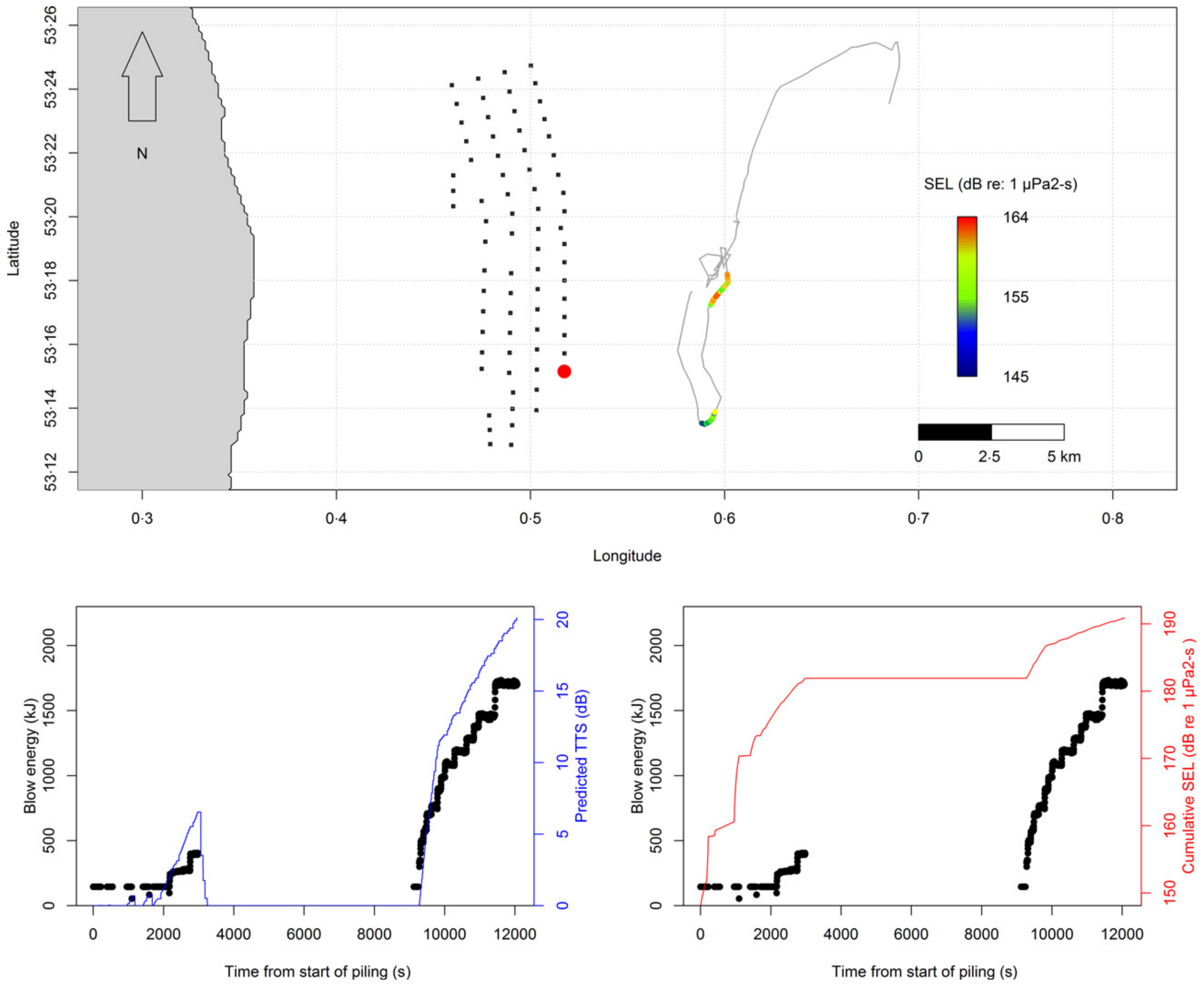



**Fig. 4.** Example of the movements and corresponding auditory damage predictions in a harbour seal during pile driving. The top panel shows the track of seal pv42-277-12 (grey line) during a 24-h period, its locations during pile driving (coloured by predicted received unweighted SELs), the wind turbine foundations (black stars) and the pile driving location (red point). The lower panels show the timeline of the pile driving with associated blow energy (kJ) of the piling strokes (black points). The left also shows the predicted growth and recovery of TTS (Kastak *et al.* 2005, 2007) (blue line) and the right shows the predicted M-weighted cSEL (dB re 1 µPa$^2$-s) (Southall *et al.* 2007) (red line).

(Southall *et al.* 2007). The number of times these twelve seals exceeded the threshold varied between one and nine (Table 1).

Out to ranges where the acoustic propagation models were formally validated (*c.* 10 km), a total of five seals were present during pile driving with closest approaches ranging from 4·7 to 9·8 km from the pile driving location. Predicted maximum threshold shifts for these five seals ranged from 0·8 to 24·5 dB (Table 1). Of these five seals, three (60%) were predicted to exceed the estimated PTS onset threshold for pinnipeds in water exposed to pulsed sounds (Southall *et al.* 2007) between one and nine times (Table 1).

## Discussion

This study used animal movement and dive data to predict the long-term acoustic exposure history of a marine mammal during the construction of an offshore wind farm. The results showed that all 24 tagged seals were present at sea and showed diving behaviour during pile driving at some stage during the study; we therefore predicted that each received acoustic exposure from the piling. The closest distance that each seal came to active pile driving locations varied between 4·7 and 40·5 km, and a total of 5 (*c.* 20%) of the seals moved within 10 km of pile driving.

Predicted received SELs were frequently relatively high and led to auditory damage predictions using both the approaches taken here. By integrating auditory damage growth and recovery functions established for exposure to continuous, octave-band noise (Kastak *et al.* 2005, 2007), all seals were predicted to receive cSELs sufficient to cause TTS; although this was relatively low in three of the seals (<6 dB), the majority of seals (21 out of 24) were

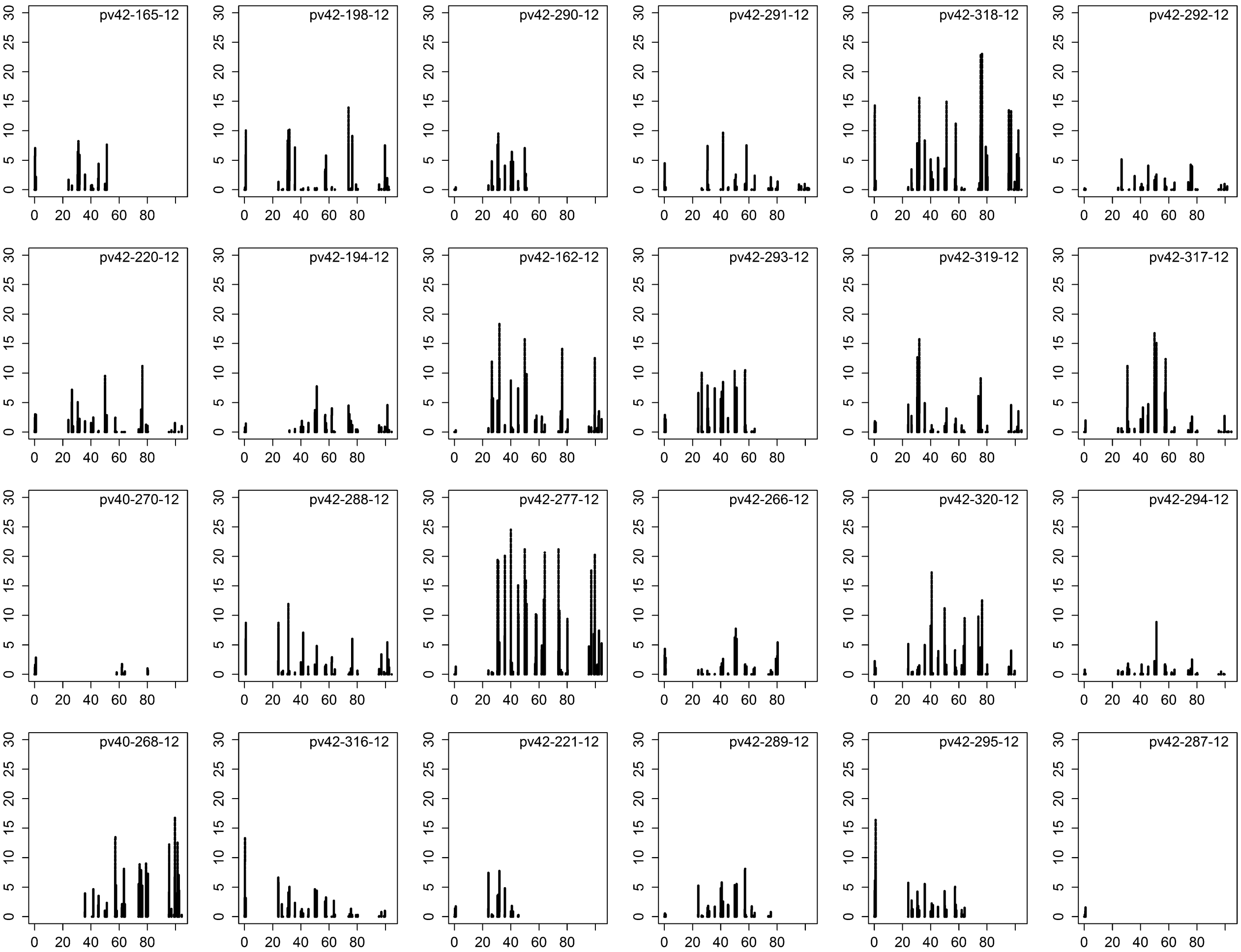



**Fig. 5.** Predicted TTS (dB) for each seal based on functions established for exposure to continuous, octave-band noise (Kastak *et al.* 2005, 2007). Each panel shows time along the *x*-axis (days) and predicted TTS on the *y*-axis for each seal.

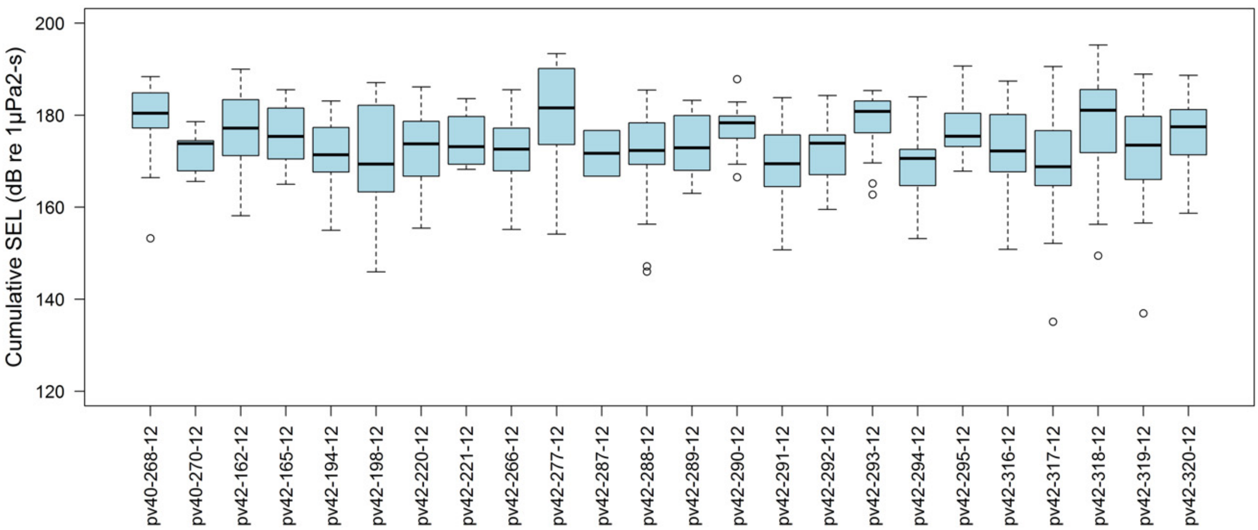



**Fig. 6.** Summary of the M-weighted cSELs ($M_{pw}$) (dB re: 1 μPa$^2$-s) for individual seals. The figure shows cSELs ($M_{pw}$) in 24-h periods with the median value (solid line), the 25 and 75th percentiles (grey boxes), the range without outliers (whiskers) and outliers (open circles).

predicted to get TTS >6 dB, and two seals were predicted to get high levels of TTS (>20 dB).

Using the M-weighted cSELs and the PTS onset criteria for pulsed sounds (Southall *et al.* 2007), half of the seals were predicted to gain PTS; furthermore, this was a relatively frequent occurrence (up to nine occasions) for some of the seals. The accurate prediction of auditory damage in this study is reliant on the thresholds being appropriate for pile driving sound; there are a number of important caveats and uncertainties that need to be considered with respect to this. The PTS onset thresholds as derived by Southall *et al.* (2007) are based upon assumed relationships between relative levels of TTS and PTS and are intentionally conservative. In their study, PTS was predicted if the auditory threshold was increased by ≥40 dB (i.e. 40 dB of TTS) (Southall *et al.* 2007). Although few studies of PTS in harbour seals exist, one study supports this assumption (Kastak *et al.* 2008). In their study, Kastak *et al.* (2008) twice exposed a single harbour seal to a 4·1 kHz pure tone with a maximum received SPL of 184 dB re 1 μPa for a duration of 60 s (SEL = 202 dB re 1 $\mu Pa^2 s$). This led to a threshold shift in excess of 50 dB at 5·8 kHz, and an apparent PTS of 7–10 dB evident after more than 2 months following exposure (Kastak *et al.* 2008). In contrast, more recent work showed despite a high SPL exposure that resulted in 44 dB TTS in a harbour seal, full hearing recovery occurred within four days (Kastelein, Gransier & Hoek 2013). Thus, our predictions of PTS following Southall *et al.* (2007) will need further investigation once PTS thresholds for harbour seals are more fully understood.

Temporary growth and recovery functions (Kastak *et al.* 2007) were derived from TTS measurements as a result of exposure to continuous sound. For these to be appropriate for pulsed sounds, we have assumed that TTS follows the equal energy hypothesis (Burns & Robinson 1970), that is that fatiguing sounds with equal SELs are predicted to induce the same TTS. However, recent results suggest that this may not be an optimal model for predicting TTS in harbour seals; both Kastak *et al.* (2005) and Kastelein *et al.* (2012) show that different levels of TTS may result from exposure to sounds with similar SELs, but consisting of different duration/level combinations. Kastelein, Gransier & Hoek (2013) suggest that their results are more in line with the hypothesis of Henderson *et al.* (1991) that hearing loss depends on the interaction of several factors including exposure level and duration, rise time and repetition rate (Henderson & Hamernik 1986; Henderson *et al.* 1991). Similarly, studies of terrestrial mammals generally conclude that impulse noise is more hazardous than continuous noise with respect to hearing damage (e.g. Sulkowski & Lipowczan 1982; Dunn *et al.* 1991). For example, chinchillas exposed to pulsed noise showed substantially more threshold shift than a control group exposed to continuous pink noise [where signals were matched by exposure duration and $SPL_{(RMS)}$] (Dunn *et al.* 1991). Furthermore, Buck (1982) examined the effect of impulse rate on Guinea pigs *Cavia porcellus* and showed that TTS was greatest at a presentation rate of 1 per second and could be reduced by either increasing or decreasing this rate (Buck 1982). Price (1974, 1976) measured TTS in the domestic cats *Felis catus* after exposure to intermittent and continuous tones; results showed that recovery of TTS began within milliseconds of the end of exposure and continued for several hours. However, the presentation of tones intermittently effectively disrupted the recovery mechanism and led to longer recovery post-exposure compared to continuous exposure (Price 1976).

The disparity in TTS growth between impulse and continuous noise exposures can also be seen in TTS patterns post-exposure. Experiments on monkeys (Luz & Hodge 1970), humans (Fletcher 1970) and chinchillas (Hamernik, Patterson & Salvi 1987) have shown that post-exposure recovery from impulse noise often follows a non-monotonic pattern; that is, there can be a post-exposure growth in TTS to maximum levels as much as 10 h after exposure (Hamernik, Patterson & Salvi 1987). This recovery pattern is markedly different from the typical loglinear recovery seen following continuous noise exposure (Ward, Glorig & Sklar 1959).

Prediction of auditory damage is further complicated by uncertainties in the nature of the pulsed sounds of pile driving. First, it is important to highlight that the received levels in this study are derived from a series of acoustic models with associated assumptions; however, the sound propagation models used here have been benchmarked previously (e.g. Matthews & MacGillivray 2013) and are widely employed in the acoustics community. Furthermore, our validation suggests that the models provide an accurate means of predicting received levels out to at least 10 km from the pile driving. Nevertheless, we measured a mean error in single pulse SEL of +2·3 dB re 1 $\mu Pa^2$-s (a positive value represents an overestimate); in terms of auditory damage prediction, if we incorporate this error into the predictions, all seals were still predicted to receive relatively high exposure but the number of seals exceeding the PTS onset threshold for pulsed sounds (Southall *et al.* 2007) reduces from 12 to 7. Similarly, predicted maximum threshold shifts for individuals reduce from between 1·6 and 23·0 dB (Table 1) to between 0·5 and 18·9 dB when this error is incorporated.

A second important point is that pulsed sounds are described as brief, broadband, atonal, transients, characterized by a relatively rapid rise time from pressure to maximal pressure (Southall *et al.* 2007). As Southall *et al.* (2007) highlight, a sound that has pulsed characteristics at the source may, as a result of propagation effects, lose those characteristics (e.g. rise time) and could be characterized as non-pulses at some (variable) distance from source. This has implications for the use of the Southall *et al.* (2007) pulsed threshold, particularly for exposures where the seals were a long distance from the pile driving. Rise times for the pile driving signals in our recordings were generally short, but did increase from around 35–100 msec between 1 and 10 km from the source; these appear to be within the range of rise times previously measured in industrial pulsed sounds (e.g. Źera 2001), and it would therefore seem valid to use the pulsed threshold in our study out to at least 10 km. This would support our prediction that of the five seals within 10 km of pile driving, three exceeded the PTS onset threshold for pulsed sounds (Southall *et al.* 2007). However, at longer ranges, it is arguable that the pile driving signals may no longer be considered impulsive and the non-pulse PTS threshold criteria for pinnipeds (cSEL: 203 dB re: 1 $\mu Pa^2$-s) may be more appropriate; using this approach, none of the seals beyond 10 km from the pile driving would have exceeded the PTS threshold.

Although there are uncertainties associated with the predictions made here, using current published auditory damage thresholds for pinnipeds exposed to pulsed sounds, half of the seals were predicted to exceed the PTS onset threshold (Southall *et al.* 2007). The biological consequences of a permanent reduction in auditory sensitivity are unclear; however, underwater hearing is likely to be important for seals in a number of behavioural contexts. For example, low frequency vocalizations appear to play a role in reproduction (Van Parijs, Hastie & Thompson 2000) in harbour seals. These are produced by male seals and appear to function in male–male competition or advertisement to females (Hanggi & Schusterman 1994; Van Parijs, Hastie & Thompson 2000). Impairment to auditory sensitivity may therefore affect the detection of vocalizations with implications for reproductive success.

In addition to intraspecific communication, detection of underwater sounds is also important during foraging or for predator detection in some species; for example, utilization of prey sounds for hunting has been shown for several fish species (Myrberg 1981), and some cetaceans (Gannon *et al.* 2005) and seals (Stansbury *et al.* 2015) make use of passive listening during foraging. Furthermore, seals acoustically detect and avoid predators such as killer whales (Deecke, Slater & Ford 2002). Overall, based on psychophysical data (e.g. Wolski *et al.* 2003; Bodson *et al.* 2006; Reichmuth *et al.* 2013) and the allocation of resources to the auditory sense (Alderson, Diamantopolous & Downman 1960; Walloe *et al.* 2010), hearing appears to be important to seals and it seems likely that auditory impairment has the potential to impact individual fitness.

In summary, although the effects of pulsed sound on the auditory system are highly complex and the prediction of auditory damage in marine mammals is a rapidly evolving field of research, based on current noise exposure criteria (Southall *et al.* 2007), we predict that half of the seals received sound levels sufficient to exceed PTS thresholds during the construction of an offshore wind farm. A critical avenue for future work will be to validate the predictions made here through the collection of auditory threshold information pre- and post-exposure to pile driving; this could be carried out on wild seals using auditory evoked potential measurements (Wolski *et al.* 2003) or in a captive environment using controlled exposures and psychophysical methods (e.g. Kastak *et al.* 2005; Kastelein *et al.* 2012). Furthermore, although all seals remained in the general area during the study, it will be important to determine whether individual seals responded to piling to limit their acoustic exposure. This could potentially occur through spatial avoidance of areas with high received levels, or by animals actively changing hearing thresholds in response to noise to protect their auditory system (as is known from humans, bats and cetaceans: see Nachtigall & Supin 2013). Ultimately, however, to estimate the population-level impacts of exposure to sounds from activities such as pile driving, the long-term impacts of auditory damage on individual fitness, fecundity and survival need to be quantified (Thompson *et al.* 2013); such information is required to ensure that the development of offshore industry is carried out in an environmentally sound manner.

## Acknowledgements

The work was funded by the Department of Energy and Climate Change as part of its Strategic Environmental Assessment programme. In addition, support for D. Thompson was provided by the Natural Environment Research Council EBAO project. Data from seals tagged in the Thames were collected in collaboration with the Zoological Society London, funded by SITA Trust and the BBC Wildlife Fund. We thank John Hartley for project support and Jennifer Snowball at Centrica for providing pile driving records. We wish to thank Peter Tyack, Brandon Southall and Ailsa Hall for valuable comments on the manuscript. We also thank Graham Weatherup for acoustic measurements, SMRU Instrumentation, and everyone who assisted with seal tagging.

## Data accessibility

Location and diving data for individual seals are available from the Dryad Digital Repository: doi: 10.5061/dryad.h79q4 Data files: pv42_data (Hastie *et al.* 2015). Pile driving data are the property of Centrica Energy Renewables, Millstream, Maidenhead Road, Windsor, Berkshire, SL4 5GD.

## References

Alderson, A.M., Diamantopolous, E. & Downman, C.B.B. (1960) Auditory cortex of the seal (*Phoca vitulina*). *Journal of Anatomy*, **94**, 506–511.

Bailey, H., Senior, B., Simmons, D., Rusin, J., Picken, G. & Thompson, P.M. (2010) Assessing underwater noise levels during pile-driving at an offshore windfarm and its potential effects on marine mammals. *Marine Pollution Bulletin*, **60**, 888–897.

Bodson, A., Miersch, L., Mauck, B. & Dehnhardt, G. (2006) Underwater auditory localization by a swimming harbor seal (*Phoca vitulina*). *Journal of the Acoustical Society of America*, **1**, 1550–1557.

Brandt, M.J., 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. *Marine Ecology Progress Series*, **421**, 205–216.

Buck, K. (1982) Influence of different presentation patterns of a given noise dose on hearing in Guinea pig. *Scandinavian Audiology Supplementum*, **16**, 83–87.

Burns, W. & Robinson, D.W. (1970) *Hearing and Noise in Industry*. Her Majesty's Stationary Office, London, England.

Carder, H.M. & Miller, J.D. (1972) Temporary threshold shifts from prolonged exposure to noise. *Journal of Speech and Hearing Research*, **15**, 603–623.

Clark, W.W. (1991) Recent studies of temporary threshold shift (TTS) and permanent threshold shift (PTS) in animals. *Journal of the Acoustical Society of America*, **90**, 155–163.

Collins, M.D. (1993) A split-step Pade solution for the parabolic equation method. *Journal of the Acoustical Society of America*, **93**, 1736–1742.

Deecke, V.B., Slater, P.J.B. & Ford, J.K.B. (2002) Selective habituation shapes acoustic predator recognition in harbour seals. *Nature*, **420**, 171–173.

Dunn, D.E., Davis, R.R., Merry, C.J. & Franks, J.R. (1991) Hearing loss in the chinchilla from impact and continuous noise exposure. *Journal of the Acoustical Society of America*, **90**, 1979–1985.

Finneran, J.J., Schlundt, C.E., Carder, D.A., Clark, J.A., Young, J.A., Gaspin, J.B. & Ridgway, S.H. (2000) Auditory and behavioral responses of bottlenose dolphins (*Tursiops truncatus*) and a beluga whale (*Delphinapterus leucas*) to impulsive sounds resembling distant signatures of underwater explosions. *Journal of the Acoustical Society of America*, **108**, 417–431.

Finneran, J.J., Schlundt, C.E., Dear, R., Carder, D.A. & Ridgway, S.H. (2002) Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. *Journal of the Acoustical Society of America*, **111**, 2929–2940.

Fletcher, J.L. (1970) Temporary threshold shift recovery from impulse and steady state noise exposure. *Journal of the Acoustical Society of America*, **48**, 96(A).

Gannon, D.P., Barros, N.B., Nowacek, D.P., Read, A.J., Waples, D.M. & Wells, R.S. (2005) Prey detection by bottlenose dolphins, *Tursiops truncatus*: an experimental test of the passive listening hypothesis. *Animal Behaviour*, **69**, 709–720.

Hamernik, R.P., Patterson, J.H. & Salvi, R.J. (1987) The effect of impulse intensity and the number of impulses on hearing and cochlear pathology in the chinchilla. *Journal of the Acoustical Society of America*, **81**, 1118–1129.

Hanggi, E.B. & Schusterman, R.J. (1994) Underwater acoustic displays and individual variation in male harbour seals *Phoca vitulina*. *Animal Behaviour*, **48**, 1275–1283.

Hastie, G.D., Russell, D.J.F., McConnell, B., Moss, S., Thompson, D. & Janik, V.M.(2015) Data from: Sound exposure in harbour seals during the installation of an offshore wind farm: predictions of auditory damage. *Dryad Digital Repository*, http://dx. doi.org/10.5061/dryad.h79q4.

Henderson, D. & Hamernik, R.P. (1986) Impulse noise: critical review. *Journal of the Acoustical Society of America*, **80**, 569–584.

Henderson, D., Subramaniam, M., Gratton, M.A. & Saunders, S.S. (1991) Impact noise: the importance of level, duration, and repetition rate. *Journal of the Acoustical Society of America*, **89**, 1350–1357.

Jay, S. (2010) Planners to the rescue: spatial planning facilitating the development of offshore wind energy. *Marine Pollution Bulletin*, **60**, 493–499.

Kastak, D., Schusterman, R.J., Southall, B.L. & Reichmuth, C.J. (1999) Underwater temporary threshold shift induced by octave-band noise in three species of pinniped. *Journal of the Acoustical Society of America*, **106**, 1142–1148.

Kastak, D., Southall, B.L., Schusterman, R.J. & Reichmuth, C.J. (2005) Underwater temporary threshold shift in pinnipeds: effects of noise level and duration. *Journal of the Acoustical Soceity of America*, **118**, 3154–3163.

Kastak, D., Reichmuth, C.J., Holt, M.M., Mulsow, J., Southall, B.L. & Schusterman, R.J. (2007) Onset, growth, and recovery of in-air temporary threshold shift in a California sea lion (*Zalophus californianus*). *Journal of the Acoustical Society of America*, **122**, 2916–2924.

Kastak, D., Mulsow, J., Ghoul, A. & Reichmuth, C.J. (2008) Noise-induced permanent threshold shift in a harbor seal. *Journal of the Acoustical Society of America*, **123**, 2986.

Kastelein, R.A., Gransier, R. & Hoek, L. (2013) Comparative temporary threshold shifts in a harbor porpoise and harbor seal, and severe shift in a seal (L). *Journal of the Acoustical Society of America*, **134**, 13–16.

Kastelein, R.A., Gransier, R., Hoek, L. & Macleod, A. (2012) Hearing threshold shifts and recovery in harbor seals (*Phoca vitulina*) after octave-band noise exposure at 4 kHz. *Journal of the Acoustical Society of America*, **132**, 2745–2761.

Kryter, K.D. (1994) *The Handbook of Hearing and the Effects of Noise: Physiology, and Public Health*. McFraw-Hill, New York.

Luz, G.A. & Hodge, D.C. (1970) Recovery from impulse-noise induced TTS in monkeys and men: a descriptive model. *Journal of the Acoustical Society of America*, **49**, 1770–1777.

Madsen, P.T., Wahlberg, M., Tougaard, J., Lucke, K. & Tyack, P. (2006) Wind turbine underwater noise and marine mammals: implications of current knowledge and data needs. *Marine Ecology Progress Series*, **309**, 279–295.

Matthews, M.R. & MacGillivray, A.O. (2013) Comparing the modeled and measured sound levels from a seismic survey in the Canadian Beaufort Sea. *Journal of the Acoustical Society of America, Proceedings of Meetings on Acoustics*, **19**, 070046.

McConell, B.J., Fedak, M.A., Hooker, S.K. & Patterson, T. (2010) Telemetry. *Marine Mammal Ecology and Conservation: A Handbook of Techniques* (eds I.L. Boyd, W.D. Bowen & S.J. Iverson), pp. 222–241. Oxford University Press, New York.

Mills, J.H., Gilbert, R.M. & Adkins, W.Y. (1979) Temporary threshold shifts in humans exposed to octave bands of noise for 16 to 24 hours. *Journal of the Acoustical Society of America*, **74**, 1185–1189.

Myrberg, A.A. (1981) Sound communications and interception in fishes. *Hearing and Sound Communication in Fishes* (eds A.N. Popper & R.R. Fay), pp. 395–425. Springer-Verlag, New York.

Nachtigall, P.E. & Supin, A.Y. (2013) A false killer whale reduces its hearing sensitivity when a loud sound is preceded by a warning. *Journal of Experimental Biology*, **216**, 3062–3070.

Nedwell, J.R., Brooker, A.G. & Barham, R.J. (2011) *Measurement and Assessment of Underwater Noise During Impact Piling Operations at the Lincs Offshore Wind Farm*, pp. 49. Subacoustech Environmental Ltd, Hants, UK.

Price, G.R. (1974) Loss and recovery processes operative at the level of the cochlear microphonic during intermittent stimulation. *Journal of the Acoustical Society of America*, **56**, 183–189.

Price, G.R. (1976) Effect of interrupting recovery on loss in cochlear microphonic sensitivity. *Journal of the Acoustical Society of America*, **59**, 709–712.

Reichmuth, C., Holt, M.M., Mulsow, J., Sills, J.M. & Southall, B.L. (2013) Comparative assessment of amphibious hearing in pinnipeds. *Journal of Comparative Physiology a Sensory Neural and Behavioral Physiology*, **199**, 491–507.

Russell, D.J.F., McClintock, B.T., Matthiopoulos, J., Thompson, P., Thompson, D., Hammond, P.S. *et al.* (in press) Intrinsic and extrinsic drivers of activity budgets in sympatric grey and harbour seals. *Oikos*. DOI: 10.1111/oik.01810.

Russell, D.J.F., Brasseur, S.M.J.M., Thompson, D., Janik, V.J., Aarts, G., McClintock, B.T., Matthiopoloulos, J., Moss, S.E.M. & McConnell, B. (2014) Marine mammals trace anthropogenic structures at sea. *Current Biology*, **24**, R638–R639.

Sharples, R.J., Moss, S.E., Patterson, T.A. & Hammond, P.S. (2012) Spatial variation in foraging behaviour of a marine top predator (*Phoca vitulina*) determined by a large-scale satellite tagging program. *PLoS ONE*, **7**, e37216.

Southall, B.L., Bowles, A.E., Ellison, W.E., Finneran, J.J., Gentry, R.L., Greene, C.R. *et al.* (2007) Marine mammal noise exposure criteria: initial scientific recommendations. *Aquatic Mammals*, **33**, 411–521.

Stansbury, A., Götz, T., Deecke, V.B. & Janik, V.M. (2015) Grey seals use anthropogenic signals from acoustic tags to locate fish: evidence from a simulated foraging task. *Proceeding of the Royal Society London B*, **282**, 20141595.

Sulkowski, W.J. & Lipowczan, A. (1982) Impulse noise induced hearing loss in drop forge operators and the energy concept. *Noise Control Engineering*, **18**, 24–29.

Thompson, P.M. (1993) Harbour seal movement patterns. *Symposium of the Zoological Society of London*, **66**, 225–239.

Thompson, P.M., Hastie, G.D., Nedwell, J., Barham, R., Brookes, K.L., Cordes, L.S., Bailey, H. & McLean, N. (2013) Framework for assessing impacts of pile-driving noise from offshore wind farm construction on a harbour seal population. *Environmental Impact Assessment Review*, **43**, 73–85.

Toke, D. (2011) The UK offshore wind power programme: a sea-change in UK energy policy? *Energy Policy*, **39**, 526–534.

Van Parijs, S.M., Hastie, G.D. & Thompson, P.M. (2000) Individual and geographical variation in display behaviour of male harbour seals in Scotland. *Animal Behaviour*, **59**, 559–568.

Walloe, S., Eriksen, N., Dabelsteen, T. & Pakkenberg, B. (2010) A neurological comparative study of the harp seal (*Pagophilus groenlandicus*) and harbor porpoise (*Phocoena phocoena*) brain. *The Anatomical Record*, **293**, 2129–2135.

Ward, W.D., Glorig, A. & Sklar, D.L. (1959) Temporary shift from octave-band noise: applications to damage-risk criteria. *Journal of the Acoustical Society of America*, **41**, 522–528.

Wolski, L.F., Anderson, R.C., Bowles, A.E. & Yochem, P.K. (2003) Measuring hearing in the harbor seal (*Phoca vitulina*): comparison of behavioral and auditory brainstem response techniques. *Journal of the Acoustical Society of America*, **113**, 629–637.

Yost, W.A. (2000) *Fundamentals of Hearing: An Introduction*, 4th edn. Academic Press, San Diego.

Źera, J. (2001) Impulse noise in industrial plants: statistical distribution of levels. *International Journal of Occupational Medicine and Environmental Health*, **14**, 127–133.

*Received 17 October 2014; accepted 28 January 2015*
*Handling Editor: Andre Punt*

## Supporting Information

Additional Supporting Information may be found in the online version of this article.

**Appendix S1.** Estimation of acoustic exposure in seals.

**Associating predictions of change in distribution with predicted received levels during piling**

Deborah JF Russell & Gordon D Hastie
December 2017

**This document contains information belonging to the Sea Mammal Research Unit and affiliated companies and shall be used only for the purpose for which it was supplied. Please do not use these outputs or cite this document for other purposes without prior contact and discussion with either the authors or Carol Sparling (ces@smruconsulting.com).**

Russell *et al.* (2016) generated predictions of at-sea distributions of harbour seals during piling and breaks in piling for construction of Lincs wind farm in The Wash (south east England) in 2012. These predictions were based on analyses of location data from 23 harbour seals equipped with GPS telemetry tags. The analyses were restricted to return trips from haul outs within The Wash and comprised a use-availability design within a generalised estimating equation (GEE) framework. Responses to piling, in terms of individual movements were not modelled directly. Rather, the population level at-sea distribution was modelled both during breaks in piling and during piling. The differences in these distributions on a 5 x 5 km resolution (867 cells) were then quantified. Such differences can result from both avoidance (seals not entering an area) and displacement (seals actively moving out of an area) from the vicinity of the windfarm. If displacement occurred, it would take time for harbour seals to redistribute after the onset of piling. The largest apparent change in distribution occurred when the two hours after an event (piling onset or piling cessation) were removed from the data. This suggests that, at least to some extent, the findings of Russell *et al.* (2016) were driven by active redistribution and thus displacement rather than simply avoidance. However, the behavioural mechanism underlying any displacement is currently unknown.

Russell *et al*. (2016) linked the results of the population level analyses, which considered piling as a binary metric, to predicted received levels. To do this, it was necessary to consider predicted received level averaged across piles, at a 5 x 5 km resolution. Acoustic source levels were derived using a combination of the blow energy values and acoustic recordings made using an autonomous underwater recorder (see Hastie *et al.* 2015 for more details). The predicted sound pressure level ($SPL_{(peak-peak)}$) at source, at the maximum blow energy was 235 dB re 1µ$Pa_{(p-p)}$-m and the predicted single pulse sound exposure level ($SEL_{(single\ pulse)}$) was 211 dB re 1 µ$Pa^2$ s. A series of range dependent acoustic propagation models were used to estimate transmission loss and received $SELs_{(single\ pulse)}$ at 5 m incremental water depths (Hastie *et al.* 2015). The predictions were made every 1,000 metres along 72 (every 5º) radii from each pile. For each pile, the predicted depth-delineated SELs closest geographically to the centre of each

5 x 5 km cell were assigned to that cell. Predicted minimum and maximum received SELs were then averaged for each cell across the installation of all piles, to generate a mean received SEL in the part of the water column with the lowest and highest predicted level.

For both the non-piling and piling scenario, the seal density (in terms of percentage of the at-sea population) was predicted for each cell (Russell *et al.* 2016). On a cell by cell basis, the predicted percentage change in density during piling was then related to zones of predicted received levels. For both minimum and maximum received levels, zones of increasing size were considered, from a zone encompassing all cells which had a predicted SEL of ≥ 160 dB re 1 μPa$^2$ s to a one encompassing all cells (SELs of ≥ 80 dB re 1 μPa$^2$ s). A parametric bootstrap of the GEE model was used to calculate 95% confidence intervals (CIs) for both the predicted usage (percentage of the at-sea population) and predicted change in usage (non-piling to piling) for each zone. As such, Figure 6 in Russell *et al.* (2016) represents the predicted change in usage in zones of received levels (i.e. approximately spherical areas from the wind farm location). For example, the zone represented by an $SEL_{(single\ pulse)}$ of 80 dB re 1 μPa$^2$s encompasses 100% of the population at-sea during piling and non-piling and thus the percentage change is 0. As the received level increases, the sample size decreases resulting in wider confidence intervals. This cumulative curve was used to contextualise the population level findings from the spatial study with the predicted sound fields from the pile driving and should not be interpreted as a dose-response curve.

For the current study, there was a requirement to link the results of Russell *et al*. (2016) to spatial variation in a single (depth-averaged) received level. To generate a depth averaged received level for the current study, the predicted received levels were converted to pressure (Pa) and averaged across the depths. For each pile, the predicted pressure closest geographically to the centre of each 5 x 5 km cell was assigned to that cell, resulting in a depth averaged pressure value (Pa) for each pile in each cell. The mean distance between the centre of the cell and the geographically closest pile-specific pressure was 2.15 km but was shortest (0.5 km) nearest the wind farm. To generate a single averaged received level for each cell, the pressures were averaged across the piles, and this value was then converted to $SEL_{(single\ pulse)}$ (10 x log (pressure)). Although the maximum estimated source level (211 dB re 1 μPa$^2$ s) used to predict received levels was assumed to be the same for each pile, the differing pile locations (and to a lesser extent the different distances between predicted pressure level and cell centroid) resulted in substantial variation in predicted received level across piles (mean range 30 dB). The mean range in received levels within a cell was 15 dB within 10 km of the windfarm and 25 dB between 10 and 50 km. This variation is not represented in the relationship between predicted received level and change in usage.

Usage and change in usage was predicted for all cells within 5 dB zones (i.e. annulus areas between predicted received levels). Following Russell et al. (2016), a parametric bootstrap of the GEE model was used to calculate 95% confidence intervals (CIs) for each zone (Figure 1, Table 1).

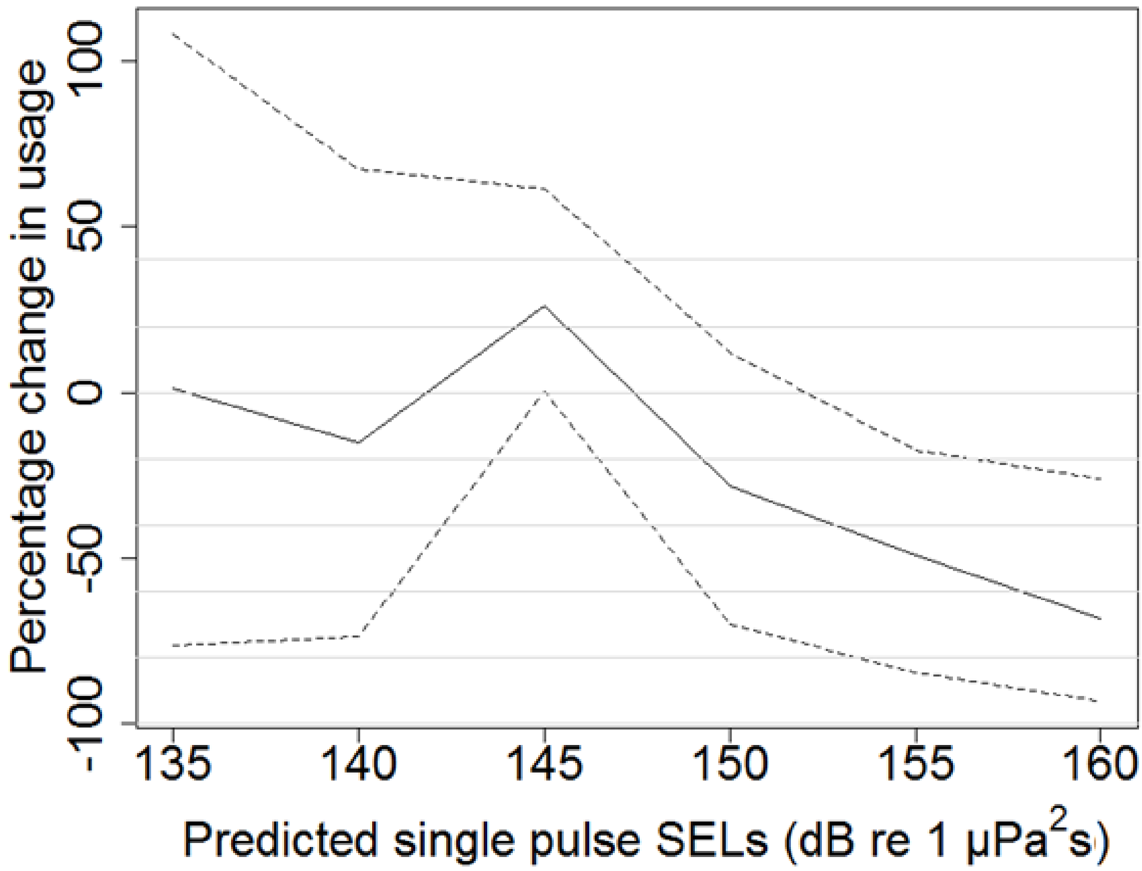



Figure 1. The predicted percentage change in usage at given SELs. Please note each point represents the following 5 dB. E.g. the predicted percentage change in usage value at 135 dB represents the mean for cells with an estimated SEL of 135dB ≤ 140dB.

Table 1. The predicted usage during piling and breaks in piling (and percentage change in usage) in zones of predicted received levels.

| **zone** | | **Mean density (as percentage of at-sea population)** | | | **Percentage change** | | | |
|---|---|---|---|---|---|---|---|---|
| **SEL (dB)** | number of cells | non-piling | piling | difference | mean | median | Lower 95% CI | Upper 95% CI |
| **135 < 140** | 50 | 0.51 | 0.52 | 0.01 | 1.4 | -7.1 | -76.1 | 108.1 |
| **140 < 145** | 381 | 10.19 | 8.63 | -1.56 | -15.3 | -15.9 | -73.6 | 67.4 |
| **145 < 150** | 271 | 55.94 | 70.53 | 14.59 | 26.1 | 24.6 | 0.3 | 61.5 |
| **150 < 155** | 81 | 21.37 | 15.32 | -6.05 | -28.3 | -28.7 | -70.2 | 12.2 |
| **155 < 160** | 24 | 7.50 | 3.80 | -3.70 | -49.3 | -54.0 | -84.7 | -17.5 |
| **160 < 165** | 7 | 0.88 | 0.28 | -0.60 | -68.1 | -71.0 | -93.0 | -26.1 |

**Applying this curve to impact assessments**

SMRU Consulting propose to apply the percentage change values according to the 5 dB bands outlined in the above table at received levels above 150 (single pulse SEL dB), 100% displacement at received levels above 165 and a zero percentage change at received levels below 150.

# Estimating the effects of pile driving sounds on seals: Pitfalls and possibilities

Katherine F. Whyte, Debbie J. F. Russell, Carol E. Sparling, Bas Binnerts, and Gordon D. Hastie

Citation: The Journal of the Acoustical Society of America **147**, 3948 (2020); doi: 10.1121/10.0001408
View online: https://doi.org/10.1121/10.0001408
View Table of Contents: https://asa.scitation.org/toc/jas/147/6
Published by the Acoustical Society of America

**ARTICLES YOU MAY BE INTERESTED IN**

Evaluating the predictive strength of underwater noise exposure criteria for marine mammals
The Journal of the Acoustical Society of America **147**, 3985 (2020); https://doi.org/10.1121/10.0001412

The effect of two 12 kHz multibeam mapping surveys on the foraging behavior of Cuvier's beaked whales off of southern California
The Journal of the Acoustical Society of America **147**, 3849 (2020); https://doi.org/10.1121/10.0001385

Techniques for distinguishing between impulsive and non-impulsive sound in the context of regulating sound exposure for marine mammals
The Journal of the Acoustical Society of America **147**, 2159 (2020); https://doi.org/10.1121/10.0000971

Predicting the exposure of diving grey seals to shipping noise
The Journal of the Acoustical Society of America **148**, 1014 (2020); https://doi.org/10.1121/10.0001727

Effects of multiple exposures to pile driving noise on harbor porpoise hearing during simulated flights—An evaluation tool
The Journal of the Acoustical Society of America **147**, 685 (2020); https://doi.org/10.1121/10.0000595

Assessing auditory masking for management of underwater anthropogenic noise
The Journal of the Acoustical Society of America **147**, 3408 (2020); https://doi.org/10.1121/10.0001218

JASA ARTICLE

# Estimating the effects of pile driving sounds on seals: Pitfalls and possibilities[a]

Katherine F. Whyte,[1,b),c)] Debbie J. F. Russell,[1,c),d)] Carol E. Sparling,[2,e)] Bas Binnerts,[3] and Gordon D. Hastie[1,f)]

[1]*Sea Mammal Research Unit, Scottish Oceans Institute, University of St Andrews, St Andrews, Fife, KY16 8LB, United Kingdom*

[2]*SMRU Consulting, Scottish Oceans Institute, University of St Andrews, St Andrews, Fife, KY16 8LB, United Kingdom*

[3]*TNO, Acoustics and Sonar expertise group, Oude Waalsdorperweg 63, 2597 AK, The Hague, Netherlands*

**ABSTRACT:**
Understanding the potential effects of pile driving sounds on marine wildlife is essential for regulating offshore wind developments. Here, tracking data from 24 harbour seals were used to quantify effects and investigate sensitivity to the methods used to predict these. The Aquarius pile driving model was used to model source characteristics and acoustic propagation loss (16 Hz–20 kHz). Predicted cumulative sound exposure levels (SELcums) experienced by each seal were compared to different auditory weighting functions and damage thresholds to estimate temporary (TTS) and permanent (PTS) threshold shift occurrence. Each approach produced markedly different results; however, the most recent criteria established by Southall *et al.* [(2019) Aquat. Mamm. **45**, 125–232] suggests that TTS occurrence was low (17% of seals). Predictions of seal density during pile driving made by Russell *et al.* [(2016) J. Appl. Ecol. **53**, 1642–1652] were compared to distance from the wind farm and predicted single-strike sound exposure levels (SELss) by multiple approaches. Predicted seal density significantly decreased within 25 km or above SELss (averaged across depths and pile installations) of 145 dB re 1 $\mu$Pa$^2$·s. However, there was substantial variation in SELss with depth and installation, and thus in the predicted relationship with seal density. These results highlight uncertainty in estimated effects, which should be considered in future assessments.
© *2020 Acoustical Society of America*. https://doi.org/10.1121/10.0001408

(Received 31 December 2019; revised 18 May 2020; accepted 27 May 2020; published online 16 June 2020)

[Editor: Colleen Reichmuth] Pages: 3948–3958

## I. INTRODUCTION

In order to meet ambitious climate change targets, the demand for renewable energy is increasing and bringing substantial industrial activity to marine environments. In particular, the number, size, and capacity of offshore wind farms has been growing rapidly and is expected to continue to increase (Bailey *et al.*, 2014; Breton and Moe, 2009). This expansion has been particularly prevalent in European waters, where there are currently more than 4500 grid-connected offshore wind turbines across eleven countries, equivalent to a capacity of 18 499 MW (WindEurope, 2019).

In predicting and assessing the environmental impact of these offshore wind farms on the surrounding marine life, one of the key uncertainties is the potential effects of underwater construction noise. Of particular concern are the effects of high intensity sounds produced during pile driving, where brief impulsive sounds with source levels of up to 250 dB re 1 $\mu$Pa @ 1 m (peak-peak) can be produced every 1–2 s (Bailey *et al.*, 2010). The at-sea movements of harbour seals (*Phoca vitulina*) overlap with many areas of current and proposed development (Russell *et al.*, 2014; Sharples *et al.*, 2012), and so there are concerns that these sounds may damage hearing, elicit overt behavioural responses, and/or exclude seals from areas of their natural habitat (Hastie *et al.*, 2015; Russell *et al.*, 2016; Thompson *et al.*, 2013). To accurately predict the effects of pile driving and determine how these could be mitigated, it is critical to understand the nature and severity of these potential effects and the sound levels at which they occur.

Estimating the effects of anthropogenic noise on marine mammal hearing can be challenging. Using available data on hearing sensitivities and hearing damage across species, Southall *et al.* (2007) derived estimates of the minimum noise exposure required for the onset of temporary (TTS) and permanent (PTS) threshold shifts in hearing sensitivity. They also generated a series of frequency-weighted hearing sensitivity curves for different functional groups of marine mammals (M-weightings). For pinnipeds underwater, TTS was predicted to occur at M-weighted 24-h cumulative sound exposure levels (SELcum) of 171 dB re 1 $\mu$Pa$^2$·s and PTS at 186 dB re 1 $\mu$Pa$^2$·s for impulsive sounds such as pile driving. These weighting functions and TTS/PTS thresholds were subsequently updated in 2019, incorporating the most

[a]This paper is part of a special issue on The Effects of Noise on Aquatic Life.

[b]Electronic mail: kfw5@st-andrews.ac.uk, ORCID: 0000-0003-3388-9603.
[c]Also at: Centre for Research into Ecological and Environmental Modelling, The Observatory, University of St Andrews, St Andrews, Fife, KY16 9LZ, UK
[d]ORCID: 0000-0002-1969-102X.
[e]ORCID: 0000-0001-7658-5111.
[f]ORCID: 0000-0002-9773-2755.

https://doi.org/10.1121/10.0001408

recent scientific information on hearing abilities and auditory damage for each marine mammal species group (Southall *et al.*, 2019). In general for pinnipeds, these new weightings were slightly less conservative. Pinnipeds were also subdivided into two groupings (phocids, otariids); for phocid pinnipeds in water, the SELcum thresholds for impulsive sounds are now estimated to be 170 and 185 dB re 1 $\mu$Pa$^2$·s for TTS and PTS, respectively. It should be noted that for seals the weighting functions and TTS/PTS thresholds for impulsive sounds described in Southall *et al.* (2019) are the same as those provided by the US National Marine Fisheries Service (NMFS, 2016, 2018). Faulkner *et al.* (2019) simulated how these two different criteria may alter the predicted effect zones from a variety of modelled noise sources, comparing the relative differences between Southall *et al.* (2007) and Southall *et al.* (2019). For phocids, they concluded that the more recent weighting functions are likely to substantially reduce the estimated range of PTS risk (e.g., from approximately 10 km to 2 km for a theoretical scenario involving pile driving 24-h SELcums at offshore wind farms in the North Sea) (Faulkner *et al.*, 2019).

A limited number of studies have investigated the effects of pile driving sounds on harbour seal hearing and behaviour. Recent playbacks of broadband piling sounds [~500–800 Hz, single-strike sound exposure level (SELss) of 152 dB re 1 $\mu$Pa$^2$·s at 1 m depth, 2 m from the source] were found to cause onset of TTS at unweighted SELcums of around 192 dB re 1 $\mu$Pa$^2$·s in two harbour seals in captivity (Kastelein *et al.*, 2018). Small TTSs (2–4 dB) occurred in that experiment and hearing recovered within 60 min. However, in the wild, animals may encounter pile driving sounds at higher received levels than that tested therein. Two studies (Hastie *et al.*, 2015; Russell *et al.*, 2016) investigated the predicted sound exposure and at-sea behaviour of tagged harbour seals near pile driving activity at an offshore wind farm. Hastie *et al.* (2015) calculated predictions of auditory injury in each tagged seal as a result of exposure to piling sounds. The analysis showed that half of the tagged animals received predicted M-weighted 24-h SELcums that would cause PTS [based on Southall *et al.* (2007)]. In addition, there was a significant reduction in seal density up to 25 km from the wind farm during periods of piling activity, relative to non-piling periods (Russell *et al.*, 2016). The magnitude of the observed reduction decreased with increasing distance from the piling location, and recovery time was relatively short, with seal density returning to pre-piling levels within two hours of the cessation of piling.

Although both of these findings represented an important step forward in our understanding, the direct application of these results in Environmental Impact Assessments (EIAs) may be challenging. For example, since estimates of piling sound exposure (Hastie *et al.*, 2015) were completed, updated auditory weighting functions and thresholds for the onset of hearing damage have been published (Southall *et al.*, 2019). Further, to contextualise predicted changes in density over space, Russell *et al.* (2016) illustrated how seal density changed in relation to distance from the middle of the wind farm and in relation to predicted SELs (averaged across all pile installations) for the loudest and quietest parts of the water column. However, although not explicitly stated, both of the relationships (distance and SEL) presented in Russell *et al.* (2016) represent the expected change in seal density for cumulatively increasing zones around pile driving. For example, the presented change in seal density at 20 km represents the change for all spatial cells within 20 km of the wind farm, and seal density at 40 km represents the change for all cells within 40 km. These results could be misinterpreted and such cumulative predictions are not particularly appropriate for the finer scale quantitative analyses often required to inform EIAs. The predicted change in seal density for any given location also reflected a wide range of predicted SELs (across depths and pile installations). To address these potential issues and make the results more applicable to EIAs, we use the seal tag data from the previous studies to (1) compare how estimates of SELcum and auditory damage may differ when different weighting functions are applied to them; (2) quantify the relationship between predicted seal density change and distance/SEL for both cumulative and annulus zones; (3) compare five different approaches to combining SELs across pile installations and depths; and (4) investigate the robustness of these relationships.

## II. METHODS

### A. Seal tag data

In January 2012, harbour seals were caught on or near haulout sites on intertidal sandbanks in The Wash, southeast England, UK. To record the movements and dive behaviour of seals around active pile driving, all animals were fitted with a SMRU Instrumentation GPS telemetry tag (hereafter GPS/GSM tags; SMRU Instrumentation, University of St Andrews, Fife, UK). Seals were first anesthetized using Zoletil® or Ketaset® in combination with Hypnovel®, and GPS/GSM tags were attached to the fur at the back of the neck using a fast-setting two-part epoxy adhesive or Loctite® 422 Instant Adhesive. All seal handling and procedures were carried out under Home Office Licence 60/4009.

Out of the 25 deployed tags in The Wash, three tags collected data for less than two days and so were excluded from further analyses. Two seals from a concurrent study approximately 200 km to the south (in the Thames) moved into The Wash during pile driving, and so were included in the dataset. This resulted in a total sample size of 24 individuals (11 males, 13 females) (details provided in Electronic Supporting Information[1]).

The tags provided GPS locations approximately every 15 min, as well as nine depth data points per dive and records of all haulout times. The data were cleaned and erroneous locations removed based on thresholds of residual error and the number of satellites. For more details of the data collection and study site, see Hastie *et al.* (2015) and Russell *et al.* (2016).

### B. Pile driving

Operational data on pile driving at Lincs offshore wind farm were provided by Centrica plc. Throughout the period of the 2012 seal tag deployment, 27 monopiles were installed at Lincs by pile driving between 28 January and 11 May 2012 (Table I). A total of 77 968 piling strikes occurred during the study with a mean strike energy of 1202 (SD = 613) kJ. For further information on the pile driving, see Hastie *et al.* (2015).

Opportunistic recordings of pile driving were available from two sources: an autonomous moored sound recorder (DSG-Ocean Acoustic Datalogger; Loggerhead Instruments, Sarasota, FL, USA) at ∼9 m depth and a range of 4900 m from the pile driving location, and a series of boat-based recordings at ∼1 m depth between 1000 and 9500 m from pile driving [using a Reson TC 4014 hydrophone with a Brüel and Kjaer amplifier (type 2635) and a calibrated Avisoft Ultrasoundgate 416 digital acquisition system at a sample rate of 192 kHz; for further information, see Hastie *et al.* (2015)]. These recordings covered the full range of pile driving blow energies and were compared to the estimates made using the acoustic models.

### C. Acoustic modelling

To estimate the sound levels resulting from the piling across the study area, a series of acoustic modelling approaches were carried out. The Aquarius pile driving model [for detailed description of the model and its validation, see de Jong *et al.* (2019)] was used to model source characteristics and acoustic propagation loss. Note that this is a different sound propagation modelling approach to the one used by Hastie *et al.* (2015) and Russell *et al.* (2016).

TABLE I. List of parameters used for the percussive pile driving source modelling.

| Parameter | Value |
|---|---|
| Pile diameter | 5.2 metres |
| Wall thickness | 58.35 mm* |
| | *estimated using API equation: |
| | D (diameter) = 5,200 mm |
| | t (thickness) = 6.35 + D/100 = 58.35 mm |
| Pile material properties | Material: Steel |
| | Density $\rho$: 7,850 kg/m$^3$ |
| | Elasticity E: 210 GPa |
| | Compressional sound speed $c_p$: 5,172 m/s |
| | Poisson ratio $\nu$: 0.3 |
| Range of strike energies | 54 to 2,035 kJ |
| Hammer type | MHU 1900S |
| Ram mass | 95 ton |
| Anvil mass | 31 ton |
| Contact stiffness | 20 GPa |
| Frequency range modelled | 16 Hz to 20 kHz |

The Aquarius model uses information on the properties of the hammer and the pile (Table I) to determine a source excitation spectrum using the model described by Deeks and Randolph (1993). This source spectrum is integrated into a range dependent propagation model [normal mode based adiabatic propagation model using the KrakenC (Porter, 2001) model to compute the propagating modes] to predict acoustic propagation loss across the study area, incorporating information on seabed characteristics and water depth. Here, the bathymetry was set to Mean Sea Level (MSL) and the modelled receiver resolution was chosen equal to 1 m, which leads to a smooth solution with depth such that linear interpolation can be used to obtain the received levels at intermediate depth. The seabed was assumed to be homogeneous, with properties corresponding to medium sand (grain size parameter $\Phi = 1.5$) obtained from Table 4.18 in Ainslie (2010). This was the most common value in the considered modelling area, using data from the EMODnet Bathymetry Data Portal. The properties of the water column were set at a compressional sound speed of 1500 ms$^{-1}$ and a density of 1024 kg/m$^3$, and the Thorp attenuation model was used for volume attenuation (Ainslie, 2010; Sehgal *et al.*, 2009). It should be noted that the effects of losses due to sea surface scattering and absorption were not considered for the purposes of the modelling.

Depth explicit model predictions were output as estimated single strike sound exposure levels ($SEL_{ss,ref}$, dB re 1 $\mu Pa^2 \cdot s$) at a reference strike energy of 1000 kJ across a series of spatial grids within the study area at ∼279 m resolution (Longitude: from −1° to 3° with a 15 s resolution, Latitude: from 52° to 55° with a 9 s resolution). Individual grids were produced for each 2.5 m depth bin (from 2.5 to 107.5 m depth); sound levels below the seabed were indicated by a "NaN" value. Model predictions included estimated SELss with three different frequency weightings applied to them; these were (i) unweighted, (ii) Pinnipeds-in-Water M-weighted ($M_{pw}$) (Southall *et al.*, 2007), and (iii) Phocids-in-Water weighted (PCW) (Southall *et al.*, 2019). Frequencies from 16 Hz to 20 kHz were modelled, using third octave centre frequency bands.

### D. Acoustic exposure of the tagged seals

The tag data consisted of a series of time-stamped GPS locations when the seal was at the water surface. Further, during each dive, the tag provided dive depths at nine points distributed equally in time throughout each dive. As seal depths were derived from pressure sensor readings on board the tag, they were measured relative to the water surface, leading to a potential mismatch with the original bathymetry data, which were relative to chart datum at the Lowest Astronomical Tide (LAT). Water depths relative to Mean Sea Level (MSL) were derived by applying the United Kingdom Hydrographic Office Vertical Offshore Reference Frame (VORF) Lowest Astronomical Tide (LAT) correction (Iliffe *et al.*, 2013) for the study area. These water depths at

MSL were used for the acoustic modelling and corresponding received levels for seals.

During periods of pile driving, tracks of seals were linearly interpolated between successive GPS locations to provide estimated locations of seals at the estimated time-of-arrival of sound from each pile driving strike (assuming a sound speed of 1500 $ms^{-1}$). Similarly, dive depths at each of these interpolated locations were estimated through linear interpolation between successive measured dive depths. Together, these provided the estimated 3D locations of each seal at the time it received the sound from all pile driving strikes for each piling location.

Each seal 3D location was matched to the corresponding spatial grid cell and the closest 2.5 m depth bin (from 2.5 to 107.5 m depth) in the acoustic model, and the received $SEL_{ss,ref}$ was identified based on propagation loss estimates at the associated location and depth for each individual pile driving pulse. Information on the blow energy of each strike was then used to scale the modelled reference $SEL_{ss,ref}$ (at 1000 kJ strike energy) to obtain final estimates of received SELss at each seal 3D location. This was carried out through energetic (broadband) scaling of the SELss spectrum using Eq. (1) to calculate the value that is added to the modelled $SEL_{ss,ref}$:

$$SEL_{ss} = SEL_{ss,ref} + 10\log_{10}\frac{E}{E_{ref}}, \qquad (1)$$

where E is the energy (kJ) of the pile driving strike, $E_{ref}$ is the reference strike energy (1000 kJ), $SEL_{ss,ref}$ is the modelled single strike sound exposure level at the reference strike energy, and SELss is the resulting scaled single strike sound exposure level (dB re 1 $\mu Pa^2 \cdot s$).

### E. Predictions of auditory damage

Auditory damage (in the form of hearing threshold shifts) was predicted for each tagged seal using three approaches. These were based on: 1) a threshold based on results from previous studies of TTS onset in harbour seals as a result of exposure to pile driving sounds (Kastelein *et al.*, 2018) (unweighted); 2) the approach developed by Southall *et al.* (2007) for evaluating the likelihood of TTS and PTS in pinnipeds exposed to anthropogenic sound ($M_{pw}$); and 3) the updated approach described by Southall *et al.* (2019) for evaluating the likelihood of TTS and PTS in phocid seals exposed to anthropogenic sound (PCW). Previously, Hastie *et al.* (2015) used approach 2) to estimate the potential for auditory damage in tagged seals as a result of exposure to pile driving sounds during the installation of the Lincs offshore wind farm.

For each seal, estimated received SELss were summed over each 24-h period (Julian day) containing pile driving to calculate the 24-h SELcum under each method (unweighted, $M_{pw}$, and PCW):

$$SELcum = 10\log_{10}\left\{\sum_{n=1}^{N} 10^{SEL_n/10}\right\}, \qquad (2)$$

where SELcum is the cumulative sound exposure level of all $N$ piling strikes within the 24-h period, and $SEL_n$ is the received SELss for each piling strike $n$. For the purposes of estimating auditory threshold shifts, an 'effective quiet' value of 124 dB re 1 $\mu$Pa (Finneran, 2015) was assumed [the highest sound pressure level (SPL) of a sound that will neither produce significant TTS nor retard recovery from TTS from prior exposure to a higher level]. Each 24-h SELcum was then compared to published TTS and PTS onset thresholds under each approach (Table II). It should be noted that, although the $M_{pw}$ and PCW weightings are based on exposure during a 24-h period, the unweighted criteria (Kastelein *et al.*, 2018) is based on the threshold at which TTS was observed at two hearing frequencies (4 and 8 kHz) in a 6-h experimental setting.

### F. Changes in seal density in relation to pile driving

Russell *et al.* (2016) generated population-level predictions of the at-sea density of seals during piling and breaks in piling. The movements of individual seals in response to piling were not modelled directly. These population-level predictions were based on analyses of 23 of the tagged harbour seals [individual pv42–194-12 was excluded as in one trip it travelled much further than the other individuals, leading to issues in specifying the accessible spatial area for all seals; see Russell *et al.* (2016) for details]. The analyses were restricted to return trips from haulouts within The Wash and comprised a use-availability design within a generalised estimating equation (GEE) framework. This approach was used as it enabled the study to consider the entire accessible area for seals in The Wash, and model seal density in an area with a complex coastline. The GEE approach also enabled generation of uncertainty estimates robust to the presence of residual autocorrelation within individuals. Once the optimal models for seal density during piling and non-piling periods were fit, the differences in these two distributions on a 5 × 5 km resolution (867 spatial

TABLE II. List of thresholds used to estimate auditory damage in harbour seals exposed to pile driving sounds. Shown are the cumulative sound exposure levels (SELcum, dB re 1 $\mu Pa^2 \cdot s$) estimated to cause temporary (TTS) or permanent (PTS) threshold shifts in hearing, using three different methods of weighting sound frequencies. The $M_{pw}$ and PCW weightings are based on exposure during a 24-h period, whereas the unweighted threshold is based on observed TTS in a 6-h experimental setting.

| Frequency weighting method | TTS threshold | PTS threshold | Reference |
|---|---|---|---|
| Unweighted | 192 | — | Kastelein *et al.* (2018) |
| $M_{pw}$ weighted (M-weighted, Pinnipeds in Water) | 171 | 186 | Southall *et al.* (2007) |
| PCW weighted (Phocids in Water) | 170 | 185 | Southall *et al.* (2019) |

cells) were quantified, and predictions of percentage of the at-sea population in each cell were made. A parametric bootstrap from the GEE model was used to calculate the 95% confidence intervals (CIs) for both the predicted density (percentage of the at-sea population) and predicted percentage change in density (non-piling to piling).

Here, we compare how the predicted percentage change in seal density (between non-piling and piling) relates to both the distance from the centre of Lincs wind farm and the predicted received SELss at each cell location. Predictions could not be made relative to the exact piling locations as, for the GEE model, seal location data were pooled across piling events and so contained several different piling locations. In Russell *et al.* (2016), the presented relationship was in cumulative zones of increasing distance: each increment represents all cells equal or less than that distance (e.g., the predicted change in seal density value at 40 km represents the change in all cells within a distance of $\leq$40 km from the wind farm). Here, we also quantify how this relationship changes in annulus zones with 5 km increments: each increment represents the previous 5 km (e.g., the predicted change in seal density value at 40 km represents the mean for all cells with distances of 35 to 40 km). We also quantify the relationship between predicted seal density and received SELss for both cumulative and annulus approaches. In cumulative zones, the predicted change in density at 135 dB re 1 $\mu$Pa$^2$·s represents the change in all cells with a received level of $\geq$ 135 dB re 1 $\mu$Pa$^2$·s. In annulus zones, the predicted change in density at 135 dB re 1 $\mu$Pa$^2$·s represents the change for all cells with estimated SELss of 135 to 140 dB re 1 $\mu$Pa$^2$·s. In both the distance and SELss relationships, the first zone (that closest to the wind farm) is the same between cumulative and annulus approaches [e.g., 0–5 km (annulus) is the same as $\leq$ 5 km (cumulative); 175–180 dB re 1 $\mu$Pa$^2$·s (annulus) is the same as $\geq$175 dB re 1 $\mu$Pa$^2$·s (cumulative)]. The approaches differ in how the subsequent estimates are calculated, with the annulus approach looking at seal density in each distance/SELss increment, and the cumulative approach increasing the zone size each time by adding in seal densities at larger distances/lower SELss. The cumulative predictions were repeated here for clear comparison with the annulus zones, as previous results in Russell *et al.* (2016) used a different acoustic propagation model. By both annulus and cumulative approaches, it was necessary to consider estimated received levels across piling events and depths. Therefore, the outputs of acoustic models for each of the 27 piling locations had to be combined. To investigate the relationship between percentage change in density and estimated SELss, we used five approaches to combining SELss across piles and depths:

(1) Mean SELss (averaged across depths and the 27 piles) (Fig. 2).
(2) Lower 95% CI of SELss across piles (averaged across depths) (Fig. S2).
(3) Upper 95% CI of SELss across piles (averaged across depths) (Fig. S3).
(4) SELss at the quietest depths (averaged across piles) (Fig. S4).
(5) SELss at the loudest depths (averaged across piles) (Fig. S5).

For each of these approaches, we considered a single blow energy of 2000 kJ (the maximum energy reached in each piling event [Eq. (1)], and all SELss were averaged onto a 5 $\times$ 5 km grid. Measurements by Nedwell *et al.* (2011) of ambient noise in The Wash during construction of Lincs wind farm estimated a median ambient sound level of 118 dB re 1 $\mu$Pa$^2$·s, and so any estimated SELss below this value were assigned to 118 dB re 1 $\mu$Pa$^2$·s. Following Russell *et al.* (2016), a parametric bootstrap of the GEE model was used to calculate 95% confidence intervals (CIs) for each zone; these CIs represent the uncertainty resulting from the distribution model (i.e., they do not incorporate any uncertainty in received sound levels).

All additional analyses [to that conducted for Hastie *et al.* (2015) and Russell *et al.* (2016)] were carried out using R (R Core Team, 2019) within packages maptools (Bivand and Lewin-Koh, 2017), raster (Hijmans, 2017), rgdal (Bivand *et al.*, 2014) and sp (Pebesma and Bivand, 2005).

## III. RESULTS

### A. Acoustic exposure of the tagged seals

Comparison of the measured SELss from the recordings of pile driving showed that median absolute error in SELss across all measured piling blows was 4 dB re 1 $\mu$Pa$^2$·s (Fig. S6). In general, errors were higher for the boat-based measurements made close to the surface (median absolute error = 14 dB re 1 $\mu$Pa$^2$·s), compared to those from the moored recorder (median absolute error = 3 dB re 1 $\mu$Pa$^2$·s).

During the seal tag deployment, the maximum estimated unweighted SELss at individual seals varied from 113 to 173 dB re 1 $\mu$Pa$^2$·s. The maximum SELss (173 dB re 1 $\mu$Pa$^2$·s) occurred for seal ‘pv40–268-12’ (Fig. 1) at a range of 4.7 km and a dive depth of 23.6 m. For further details of acoustic exposure of each tagged seal, see Electronic Supporting Information (Fig. S1).

### B. Predictions of auditory damage

The use of each weighting function resulted in markedly different SELcum estimates from pile driving (Table III). In general, unweighted SELcum were highest (as it is unweighted, none of the sound is filtered) and PCW-weighted SELcum (Southall *et al.*, 2019) were lowest.

Predicted unweighted SELcum from pile driving varied between tagged seals (Table III) with maximum SELcum for each seal ranging from 153 to 200 dB re 1 $\mu$Pa$^2$·s. It was predicted that five (21%) of the seals did not receive any SELss above the assumed level of effective quiet (124 dB re 1 $\mu$Pa). Three (13%) of the seals exceeded unweighted sound levels (192 dB re 1 $\mu$Pa$^2$·s) previously shown to result in TTS in harbour seals exposed to pile driving sounds (Table II). The closest approach distance to pile driving for each of these three seals was between 3.9 and 5.0 km (Table III).

JASA
https://doi.org/10.1121/10.0001408

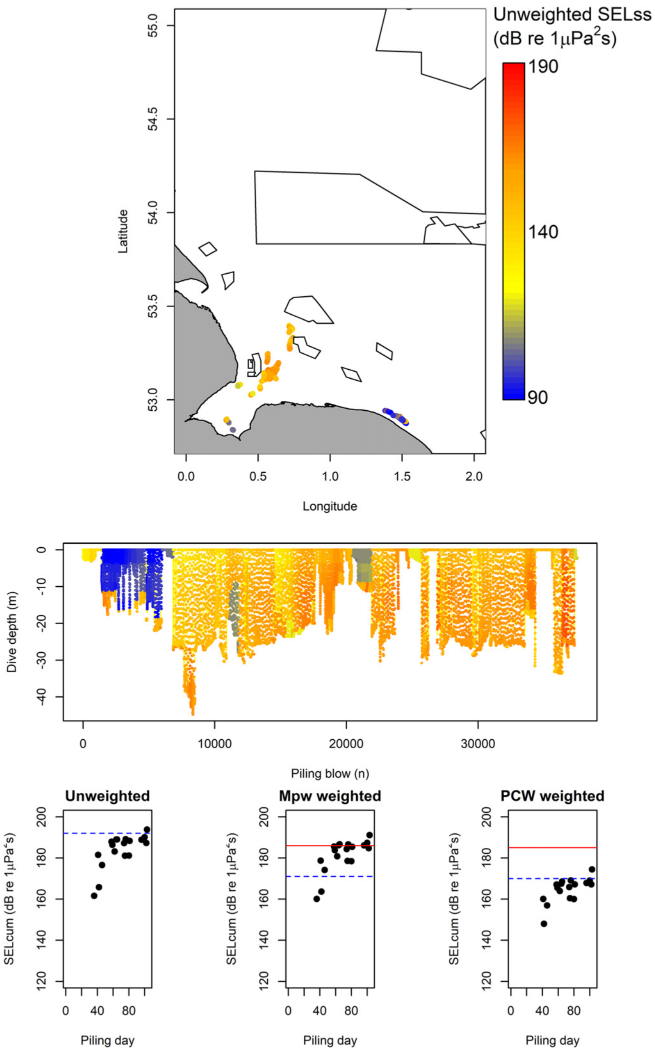



FIG. 1. (Color online) Example of the estimated acoustic exposure from pile driving at one of the tagged harbour seals (ID#: pv40.268.12). The figure shows the estimated locations of the seal (top panel) and the dive depth (middle panel) of the seal at the times it received the sound from each piling strike. The points in both panels have been colour coded by estimated unweighted single strike Sound Exposure Levels (SELss; dB re 1 $\mu$Pa$^2$·s). The lower panels show the estimated cumulative sound exposure levels (SELcum; dB re 1 $\mu$Pa$^2$·s) to the tagged seal for each 24 h period, including the unweighted SELcums, M-weighted ($M_{pw}$) SELcums (Southall *et al.*, 2007), and PCW-weighted SELcums (Southall *et al.*, 2019). The estimated onset thresholds for TTS (dashed line) and PTS (solid line) are shown for each weighting.

Predicted $M_{pw}$-weighted SELcum (Southall *et al.*, 2007) varied between individual seals (Table III) with maximum SELcum ($M_{pw}$) ranging from 150 to 197 dB re 1 $\mu$Pa$^2$·s. Five (21%) of the seals did not receive any SELss ($M_{pw}$) above the assumed level of effective quiet (124 dB re 1 $\mu$Pa). In total, four (17%) of the tagged seals were predicted to receive SELcum ($M_{pw}$) that exceeded the estimated PTS onset threshold of 186 dB re 1 $\mu$Pa$^2$·s for pinnipeds in water exposed to pulsed sounds, and twelve (50%) were predicted to exceed the TTS onset threshold of 171 dB re 1 $\mu$Pa$^2$·s (Table II). For the individuals estimated to exceed PTS thresholds, closest approach distances ranged from 3.9 to 6.9 km, and for TTS from 3.9 to 17.0 km (Table III).

TABLE III. Summary of the closest distance to pile driving (km) and the maximum estimated 24-h cumulative sound exposure level (SELcum; dB re 1 $\mu$Pa$^2$·s) for each tagged seal, including the unweighted SELcum, $M_{pw}$ weighted SELcum (Southall *et al.*, 2007), and PCW weighted SELcum (Southall *et al.*, 2019). The asterisk (*) highlights SELcums exceeding onset thresholds for TTS and double-asterisk (**) for those exceeding onset thresholds for PTS (please note there are no PTS thresholds for the unweighted SELcums).

| Seal reference number | Closest distance to piling (km) | Unweighted | $M_{pw}$ weighted | PCW weighted |
|---|---|---|---|---|
| pv40-268-12 | 3.9 | 194 * | 191 ** | 174 * |
| pv40-270-12 | 40.4 | — | — | — |
| pv42-162-12 | 9.3 | 184 | 182 * | 165 |
| pv42-165-12 | 6.9 | 191 | 189 ** | 170 * |
| pv42-194-12 | 26.9 | 172 | 170 | — |
| pv42-198-12 | 29.9 | — | — | — |
| pv42-220-12 | 34.2 | — | — | — |
| pv42-221-12 | 25.3 | 166 | 163 | 134 |
| pv42-266-12 | 24.9 | 154 | 152 | — |
| pv42-277-12 | 4.7 | 200 * | 197 ** | 179 * |
| pv42-287-12 | 38.7 | — | — | — |
| pv42-288-12 | 15.7 | 170 | 169 | 148 |
| pv42-289-12 | 27.5 | — | — | — |
| pv42-290-12 | 16.9 | 176 | 174 * | 155 |
| pv42-291-12 | 14.0 | 177 | 175 * | 158 |
| pv42-292-12 | 34.8 | 153 | 150 | — |
| pv42-293-12 | 17.0 | 176 | 174 * | 156 |
| pv42-294-12 | 30.7 | 159 | 157 | — |
| pv42-295-12 | 11.3 | 187 | 185 * | 167 |
| pv42-316-12 | 5.8 | 186 | 184 * | 165 |
| pv42-317-12 | 17.0 | 185 | 183 * | 164 |
| pv42-318-12 | 13.8 | 184 | 182 * | 164 |
| pv42-319-12 | 21.7 | 166 | 164 | — |
| pv42-320-12 | 5.0 | 194 * | 192 ** | 176 * |

Predicted maximum PCW-weighted SELcum (Southall *et al.*, 2019) ranged from 134 to 179 dB re 1 $\mu$Pa$^2$·s (Table III). Ten (42%) of the seals did not receive SELss (PCW) above the assumed level of effective quiet (124 dB re 1 $\mu$Pa). None of the tagged seals were predicted to receive SELcum (PCW) that exceeded the estimated PTS onset threshold (185 dB re 1 $\mu$Pa$^2$·s), and four (17%) were predicted to exceed the TTS onset threshold (170 dB re 1 $\mu$Pa$^2$·s) for phocids in water exposed to impulsive sounds (Table II). For each of these four seals estimated to exceed TTS thresholds, closest approach distances to piling ranged from 3.9 to 6.9 km (Table III).

### C. Changes in seal density in relation to pile driving

During piling, seal density was predicted to significantly decrease (defined as when the upper CI is a negative percentage change in density) within 25 km of the wind farm site by both cumulative [Fig. 2(a)] and annulus [Fig. 2(b)] approaches. This decrease was detected in all 5 km distance bands (annulus) out to 25 km [Fig. 2(b)]. There was no significant change in density detected beyond this distance, considering either cumulative or annulus zones. The predicted change in density (and confidence intervals) of the

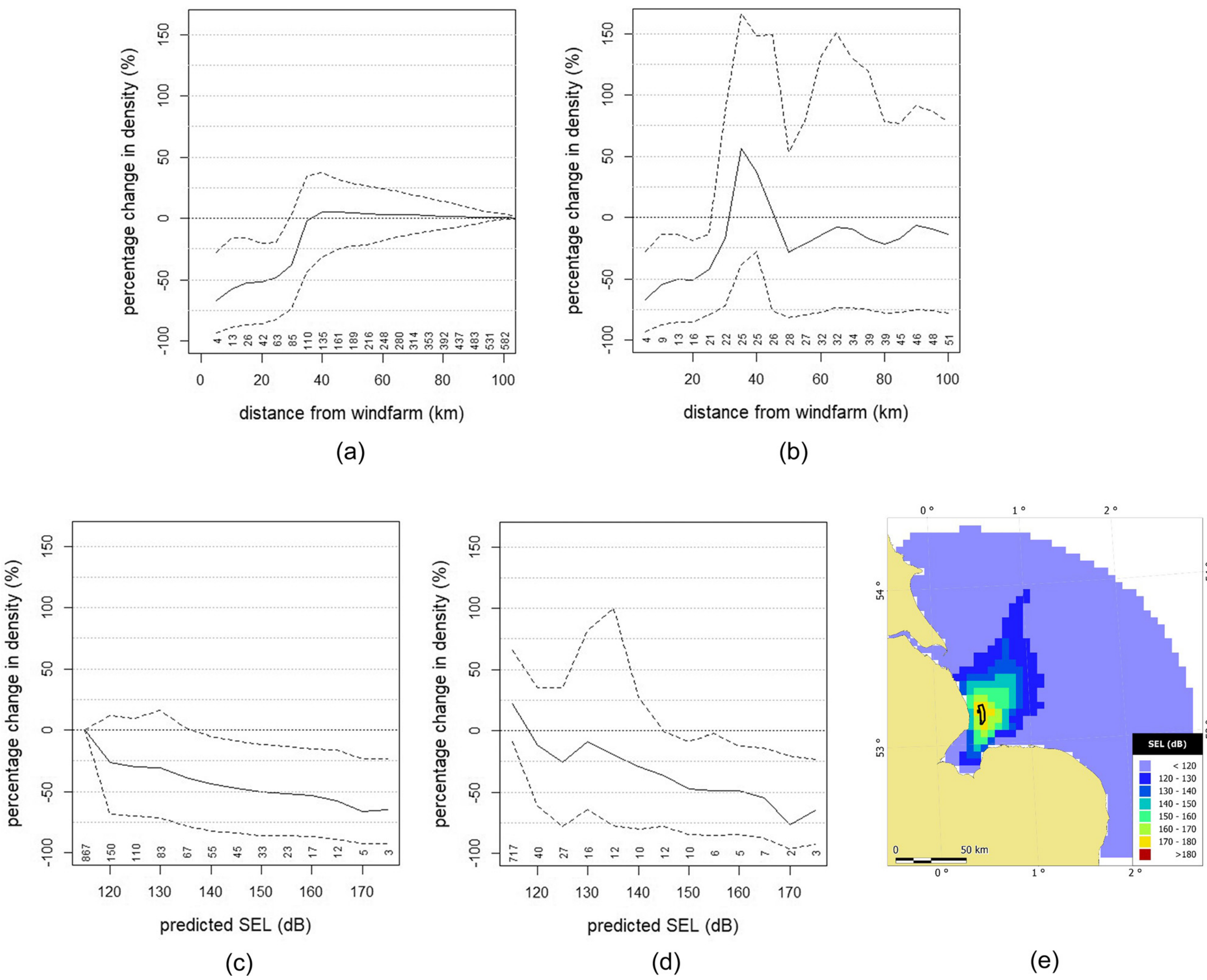



FIG. 2. (Color online) Predicted changes in seal density as a function of distance from the centre of the wind farm (a–b) and estimated sound exposure level (c–d) (SEL, dB re 1 $\mu Pa^2 \cdot s$), with SEL averaged across all water depths and piles. (a) Seal density in cumulative zones of increasing distance: plotted density change at distance $x$ is the change in all spatial cells $\leq x$ km [as presented in Russell *et al.* (2016)]. (b) Seal density in annulus 5 km increments: plotted density change at distance $x$ is the change in all spatial cells between $x - 5$ and $x$ km. (c) Seal density in cumulative zones of received sound level: plotted density change at SEL $x$ is the change in all spatial cells $\geq x$ dB. (d) Seal density in annulus 5 dB increments: plotted density change at SEL $x$ is the change in all spatial cells between $x$ and $x + 5$ dB. Annotations denote the number of spatial grid cells in each distance/SEL category. The dashed lines represent 95% confidence intervals. The corresponding predicted SELs across the study area (averaged across depths and piles) are shown in (e).

cumulative approach [Fig. 2(a)] converged toward zero as the largest zone considered encompassed almost the entire study area (all cells within 100 km of the wind farm) and so there would be no overall change in density (percentage of seals).

Seal density was also predicted to decline with increased received sound levels [Figs. 2(c) and 2(d)]. Using the first metric (mean SELss across depths and piles), the cumulative approach revealed significant declines when all cells $\geq$140 dB re 1 $\mu Pa^2 \cdot s$ are considered [Fig. 2(c)]; however, when each received level zone is considered separately (annulus), declines are only detected in each 5 dB zone above 145 dB re 1 $\mu Pa^2 \cdot s$ [Fig. 2(d), Table V]. There was substantial variation in the predicted SELss [Figs. S2–S5(c)] with depth and pile considered, and thus in the resulting percentage change in density-SELss relationship [Figs. S2–S5(a) and S2–S5(b)]. Due to the variation in these relationships, there was also variation in the SELss threshold above which a significant decline in seal density would be predicted (Table IV). Indeed, considering the lower 95% CI across piles (averaged across depths) revealed no clear relationship with seal density for annulus zones (Fig. S2). In contrast, the upper 95% across piles revealed a significant decrease in density for all annulus zones from 160 dB re 1 $\mu Pa^2 \cdot s$ (Fig. S3). Considering the quietest (Fig. S4) or loudest (Fig. S5) depths separately, there was a significant decrease in density in all annulus zones from 145 and 150 dB re 1 $\mu Pa^2 \cdot s$, respectively. In general, the annulus approaches did not predict significant declines in seal density until higher received SELss levels than the cumulative approach (Table IV). For further information on the variation in predicted density between different piling events and water depths, see Electronic Supporting Information.

## IV. DISCUSSION AND CONCLUSIONS

This study used tracking data from 24 harbour seals near a wind farm construction site (Hastie *et al.*, 2015;

TABLE IV. Summary of estimated single strike sound exposure levels (SELss, dB re 1 $\mu Pa^2 \cdot s$) of pile driving, above which a significant decline in seal density is predicted. Five approaches to combining SELss across piling events and depths are shown, alongside previously published results. Two approaches of summarising corresponding seal density estimates over space are calculated: annulus or cumulative zones (both in 5 dB increments).

| | Approach | |
|---|---|---|
| | Annulus | Cumulative |
| *Mean (averaged across depths and piles)* | | |
| (1) Mean | 145 | 140 |
| *Comparison across piles (averaged across depths)* | | |
| (2) Lower 95% CI of piles | No clear relationship | 145 |
| (3) Upper 95% CI of piles | 160 | 150 |
| *Comparison across depths (averaged across piles)* | | |
| (4) Quietest depth | 145 | 130 |
| (5) Loudest depth | 150 | 140 |
| Russell *et al.* (2016) *(averaged across piles)* | | |
| Quietest depth | — | 140 |
| Loudest depth | — | 155 |

Russell *et al.*, 2016) to explore four questions in relation to the sensitivity of predicted sound exposures, auditory damage, and changes in seal density to a range of commonly used techniques and assumptions. (1) We found marked differences in the numbers of seals predicted to suffer auditory damage depending upon the choice of weighting functions and thresholds (between 13% and 50%, and between 0% and 17% of seals were predicted to exceed TTS and PTS thresholds, respectively). (2) Predictions of seal density during pile driving, as a function of both distance and predicted received levels, differed between the use of cumulative versus annulus zones. We recommend that future studies use annulus zones, and impact assessments use the results from the annulus predictions (Table V). (3 and 4) The relationship between changes in seal density and predicted received level varied markedly depending on how variations in pile installation and water depth were accounted for. These findings have implications for the use of results from such studies (Hastie *et al.*, 2015; Russell *et al.*, 2016) by policy makers and regulators. In particular, we have found that the choice of method can lead to different estimates of effects and therefore different recommendations for future regulation.

The use of each weighting function resulted in marked differences in estimated SELcum on harbour seals. Specifically, unweighted SELcums from pile driving were highest (up to 200 dB re 1 $\mu Pa^2 \cdot s$), $M_{pw}$-weighted SELcums (Southall *et al.*, 2007) were intermediate (up to 197 dB re 1 $\mu Pa^2 \cdot s$), and PCW-weighted SELcums (Southall *et al.*, 2019) were lowest (up to 179 dB re 1 $\mu Pa^2 \cdot s$). This is to be expected given the differences in the each of the weighting functions. The approach developed by Southall *et al.* (2007) was designed as relatively conservative initial guidance and the $M_{pw}$ weighting function was therefore flat across the hearing range frequencies of each functional species group. For seals exposed to pile driving sounds in the current study, this resulted in SELcums ($M_{pw}$) that are only ∼1–3 dB lower than unweighted values. More recent guidance uses information from new auditory damage studies to develop a series of updated weighting functions for each functional species group (Southall *et al.*, 2019). This resulted in SELcum (PCW) levels that were ∼20–35 dB lower than unweighted values.

Correspondingly, the differences in acoustic exposures between the $M_{pw}$ and PCW weighting functions led to variation in the percentage of seals predicted to receive SELcums exceeding published TTS (50% vs 17%) and PTS (17% vs 0%) thresholds. Using an unweighted threshold, a predicted 13% of individuals exceeded values associated with TTS; no PTS thresholds are available for unweighted pulsed sounds. These results from individual seals exposed to sound broadly reflect the conditions simulated in Faulkner *et al.* (2019), with the Southall *et al.* (2019) criteria resulting in markedly lower effects ranges for auditory damage from pile driving sounds.

TABLE V. Predictions of seal density (and changes in seal density) during piling and breaks in piling. Seal densities are presented for each predicted sound exposure level (SELss) category (annulus), along with the number of spatial grid cells corresponding to each SELss category. SELss were averaged across all water depths and piling events. Values in bold denote significant changes (confidence intervals not containing 0% change in density).

| | | Mean density (% of at-sea population) | | | Percentage change in density | | | |
|---|---|---|---|---|---|---|---|---|
| SELss (dB re 1 $\mu Pa^2 \cdot s$) | Number of spatial cells | Non-piling | Piling | Difference | Mean | Median | Lower 95% CI | Upper 95% CI |
| 115–120 | 717 | 53.91 | 65.94 | 12.03 | 22.31 | 20.26 | −8.96 | 65.95 |
| 120–125 | 40 | 8.77 | 7.79 | −0.98 | −11.21 | −12.54 | −61.26 | 35.14 |
| 125–130 | 27 | 5.53 | 4.11 | −1.42 | −25.60 | −29.44 | −78.16 | 35.27 |
| 130–135 | 16 | 8.82 | 8.08 | −0.74 | −8.43 | −13.08 | −64.36 | 82.19 |
| 135–140 | 12 | 4.62 | 3.71 | −0.91 | −19.65 | −22.19 | −77.47 | 100.36 |
| 140–145 | 10 | 3.83 | 2.70 | −1.13 | −29.40 | −36.17 | −80.43 | 27.10 |
| **145–150** | **12** | **3.28** | **2.09** | **−1.19** | **−36.37** | **−40.52** | **−77.97** | **−0.34** |
| **150–155** | **10** | **3.59** | **1.89** | **−1.70** | **−47.31** | **−51.46** | **−84.70** | **−8.56** |
| **155–160** | **6** | **2.05** | **1.05** | **−1.00** | **−48.72** | **−52.46** | **−85.48** | **−1.90** |
| **160–165** | **5** | **2.80** | **1.44** | **−1.36** | **−48.52** | **−54.35** | **−84.63** | **−12.20** |
| **165–170** | **7** | **2.10** | **0.96** | **−1.14** | **−54.38** | **−58.67** | **−87.73** | **−13.64** |
| **170–175** | **2** | **0.08** | **0.02** | **−0.06** | **−76.26** | **−79.27** | **−96.04** | **−20.32** |
| **175–180** | **3** | **0.62** | **0.22** | **−0.40** | **−64.80** | **−68.41** | **−92.17** | **−22.93** |

These weighting-function specific percentages are lower than previous predictions of auditory damage from pile driving sound exposure. Specifically, using the same seal tag data to that analysed here, Hastie *et al.* (2015) predicted maximum 24-h SELcum ($M_{pw}$) values ranging from 171 to 195 dB re 1 $\mu$Pa$^2$·s for individual seals; 50% of seals were predicted to exceed the PTS onset threshold (compared to 17% here) and all (100%) exceeded the TTS threshold (compared to 50% here). The difference between these results was due to the different sound propagation approaches used, highlighting the clear sensitivity of predicted acoustic exposure and the associated threshold shifts, to the assumptions of commonly used propagation models.

The acoustic modelling approach used here predicts the effects of strike energy and bathymetry, and takes into account more information on the environment and pile driving source [compared to Hastie *et al.* (2015)]. Whilst this reduces uncertainty, there are still potential sources of variation that are not taken into account. Pile penetration depth can affect the dynamic behaviour of the pile and so could affect the sound produced (de Jong *et al.*, 2019). Here, we assume a homogeneous medium sand seabed and a constant water depth at mean sea level. Although the majority of the study area is of this sediment type, variation in this could increase uncertainty in predictions of received level and associated effects on animals, especially for the lower frequencies modelled (<1 kHz). Assuming a constant water depth is a common approach for acoustic modelling. However, for areas with a strong tidal cycle, it is possible that variation in propagation conditions over the tidal cycle (and associated water depths) could be considerable. Investigation into this variation across tidal cycles would be a useful avenue for future research, although whether it would be computationally feasible to integrate this into individual impact studies is unclear. The uncertainties associated with the Aquarius modelling approach are discussed further in de Jong *et al.* (2019). Comparisons of the model estimates with a series of measurements from opportunistic boat-based hydrophones and a moored recorder suggests that the error in model estimates is approximately 4 dB re 1 $\mu$Pa$^2$·s. The boat-based recordings made near the water surface (∼1 m) all measured lower SELss than the model predictions for the shallowest depth bin (2.5 m). Whilst not a formal validation, this comparison highlights the potential uncertainty of received levels near the surface, and the performance of the model for estimating near surface piling noise (although the comparison is only made above the modelled depths). Received levels near the surface are highly variable due to interference patterns, sound speed profile ducts, and waves, and measurements are likely to be sensitive to environmental conditions such as wind and wave activity. The measurements from the moored recorder at ∼9 m below the surface provided a close match to the model predictions. The conditions at these depths are more representative of the majority of the water column, as variability in propagation conditions is much less.

Here we extended the potential utility of the results from Russell *et al.* (2016) by presenting changes in seal density as a function of annulus zones of distance and five metrics of predicted received level. Using annulus distance zones confirmed significant decreased density up to 25 km from the centre of the windfarm [as found using cumulative distance zones; Russell *et al.* (2016)]. To compare overall seal distribution between piling and non-piling (a binary comparison), it was necessary to generate one received level per cell (across all 27 pile installations and water depths). Russell *et al.* (2016), using cumulative zones, predicted a significant decrease in seal density from received levels (averaged across all installations) above 140–155 dB re 1 $\mu$Pa$^2$·s, based on the quietest and loudest part of the water column. Here, we show these levels are affected both by the sound propagation model used (130–140 dB re 1 $\mu$Pa$^2$·s for quietest-loudest depths, cumulative), and the use of annulus rather than cumulative zones (145–150 dB re 1 $\mu$Pa$^2$·s for quietest-loudest depths, annulus) (Table IV). Examining the variation in SELss across pile installations (95% CIs) revealed substantial variation in the level of significant decrease in density; indeed, only for the upper 95% CI could a significance level be quantified (Table IV). Annulus zones (especially at larger distances/lower received levels) show wider confidence intervals for changes in density than for cumulative zones. This is due to the increasing sample size associated with the increasing size of cumulative zones; the change will converge on zero change in percentage density as the cumulative zones encompass an increasing proportion of the study area. Additionally, the received levels at which there is a significant predicted effect on seal density are lower for the cumulative approach. The cumulative method always includes the zones of highest exposure (and potential effect on behaviour), and so this likely enables the overall density change to be detected further from the wind farm.

Here, we illustrated how the predicted SELss associated with significant decreases in seal density varies across pile installations and depth. However, there are other sources of variation that we did not account for. For instance, we only considered the average maximum piling energy reached over all piling events (2000 kJ) and not the received levels from each piling strike with potentially different sequences of piling energies. There may also be changes in the seafloor between piling sites and potentially equipment changing the source spectrum of different piling strikes. Linking population level responses to a particular sound level necessitates averaging over a wide range of possible situations, including different external conditions (e.g., piling ramp-up sequence, time of day), and differences between and within individual animals (e.g., behavioural state, previous exposure history). These differences may increase variability in predicted responses. Considering only the average (population-level) response makes it challenging to identify factors which might make animals more or less responsive to sound, information which could be used in future assessments of noise impacts.

In summary, we use tracking data on wild harbour seals exposed to pile driving sounds to update quantitative estimates of effects on seal hearing and behaviour. The findings of Hastie *et al.* (2015) and Russell *et al.* (2016) remain amongst the few studies quantifying the effects of pile driving on seals; as such, they are widely used in EIAs. While we recognise the contribution these findings make, it is important that researchers, regulators, policy makers, and industry recognise the inherent limitations associated with studies predicting auditory damage and population level redistribution. Auditory damage in marine mammals is a rapidly evolving field of research (Kastelein *et al.*, 2018; Southall *et al.*, 2019), and this current study demonstrates the importance of updating the predictions as new information becomes available. It also illustrates the sensitivity and limitations of predictions made with commonly used acoustic propagation models. We recommend future studies, where possible, carry out a spatially diverse set of acoustic measurements to calibrate and hence reduce the uncertainties associated with the acoustic source and propagation modelling. These acoustic measurements should be used to monitor noise levels during construction and help characterise the variation in sound produced from different strike energies. Efforts should be made to validate sound propagation models in the environment and conditions they are proposed to be used in, for both impact assessments and scientific studies. In particular, these measurements should focus on the expected location and conditions (depth, habitat) of the study population. Underwater noise monitoring is often a requirement of consent for offshore wind farm projects and, as such, should enable model verification across a large range of environments and pile types. Researchers should also endeavour to publish updated predictions of auditory damage following Southall *et al.* (2019). A clear avenue for future work would be to validate these types of predictions through the collection of auditory threshold information pre- and post-exposure to pile driving; this could potentially be carried out on wild seals using auditory evoked potential measurements (Wolski *et al.*, 2013) or in a captive environment using controlled exposures and psychophysical methods [e.g., Kastak *et al.* (2005); Kastelein *et al.* (2012)].

Population-level redistribution studies are a key first step in determining the presence and magnitude of potential effects, and the time to recovery (to pre-disturbance distribution). Researchers should make their findings as applicable as possible for use by stakeholders (e.g., using annulus rather than cumulative zones in quantitative EIA analyses). In particular, relating changes in density to distance from a source can improve understanding of the potential implications of avoidance [in terms of collision risk (e.g., tidal turbines), barrier effects and loss of habitats or resources]. However, there are a number of important caveats associated with population level redistribution studies. For example, it is not clear whether these changes in density are a result of more animals leaving the area, less new animals entering the area, or a combination of both. Such studies necessarily combine multiple potential disturbance events and animal responses, and here we showed that these also encompass a wide range of potential received levels.

With developments of tracking technology and on-animal long-term sound recordings [e.g., Mikkelsen *et al.* (2019)], information on individual behaviour and sound exposure is rapidly improving. Analytical tools [e.g., DeRuiter *et al.* (2013); Quick *et al.* (2017)] to model such data mean that studies of responses to sound are no longer restricted to considering population-level distribution patterns. A useful avenue for future research would be to investigate how individual seals respond to sound exposure. Studying behaviour of individuals may provide greater insight into the mechanisms behind the population-level patterns seen and enable us to quantify dose-response relationships taking into account the variability between individuals. This will ultimately improve efforts to extrapolate and model effects at the population level.

## ACKNOWLEDGMENTS

This paper was part of work presented at the fifth International Meeting on The Effects of Noise on Aquatic Life held in Den Haag (The Netherlands), July 2019, and we are grateful for the Rodney Coates award given to KFW for the presentation of this project at the conference. We also thank the editor and two anonymous reviewers whose insightful comments greatly improved the paper. Data collection was funded as part of the Department of Energy and Climate Change's (now Department of Business, Energy and Industrial Strategy) Offshore Energy Strategic Environmental Assessment programme, with additional resources from National Capability funding from the Natural Environment Research Council to the Sea Mammal Research Unit (Grant No. SMRU1001). Sound propagation modelling and subsequent analyses were funded by Race Bank Offshore Wind Farm Ltd. KFW was funded by University of St Andrews and the Department of Business, Energy and Industrial Strategy, as part of a PhD studentship.

[1]See supplementary material at https://doi.org/10.1121/10.0001408 for further plots of estimated sound exposure, seal density, acoustic measurements, and details of tagged individuals.

Ainslie, M. A. (**2010**). *Principles of Sonar Performance Modelling* (Springer-Praxis, Chichester, UK).

Bailey, H., Brookes, K. L., and Thompson, P. M. (**2014**). "Assessing environmental impacts of offshore wind farms: Lessons learned and recommendations for the future," Aquat. Biosyst. **10**, 1–13.

Bailey, H., Senior, B., Simmons, D., Rusin, J., Picken, G., and Thompson, P. M. (**2010**). "Assessing underwater noise levels during pile-driving at an offshore windfarm and its potential effects on marine mammals," Mar. Pollut. Bull. **60**, 888–897.

Bivand, R., Keitt, T., Rowlingson, B., and Pebesma, E. (**2014**). "rgdal: Bindings for the geospatial data abstraction library," R package version 0.8-16.

Bivand, R., and Lewin-Koh, N. (**2017**). "maptools: Tools for reading and handling spatial objects," R package version 0.9-2. Retrieved from https://cran.r-project.org/package=maptools (Last viewed 1 June 2018).

Breton, S. P., and Moe, G. (**2009**). "Status, plans and technologies for offshore wind turbines in Europe and North America," Renew. Energy **34**, 646–654.

de Jong, C., Binnerts, B., Prior, M., Colin, M., Ainslie, M., Mulder, I., and Hartstra, I. (**2019**). "Wozep–WP2: Update of the Aquarius models for marine pile driving sound predictions," TNO Rep. (2018), No. R11671, The Hague, Netherlands, p. 94. Retrieved from https://www.noordzeeloket.nl/publish/pages/160801/update_aquarius_models_pile_driving_sound_predeictions_tno_2019.pdf (Last viewed 1 August 2019).

Deeks, A. J., and Randolph, M. F. (**1993**). “Analytical modelling of hammer impact for pile driving,” Int. J. Numer. Anal. Methods Geomech. **17**, 279–302.

DeRuiter, S. L., Southall, B. L., Calambokidis, J., Zimmer, W. M. X., Sadykova, D., Falcone, E. A., Friedlaender, A. S., Joseph, J. E., Moretti, D., Schorr, G. S., Thomas, L., and Tyack, P. L. (**2013**). “First direct measurements of behavioural responses by Cuvier’s beaked whales to mid-frequency active sonar,” Biol. Lett. **9**, 20130223.

Faulkner, R. C., Farcas, A., and Merchant, N. D. (**2019**). “Risk assessment of permanent auditory injury in marine mammals: Differences arising from the application of the Southall and NOAA criteria,” *Scottish Marine and Freshwater Science Report* (Marine Scotland Science, Edinburgh), Vol. 10, No. 1.

Finneran, J. J. (**2015**). “Noise-induced hearing loss in marine mammals: A review of temporary threshold shift studies from 1996 to 2015,” J. Acoust. Soc. Am. **138**, 1702–1726.

Hastie, G. D., Russell, D. J. F., McConnell, B., Moss, S., Thompson, D., and Janik, V. M. (**2015**). “Sound exposure in harbour seals during the installation of an offshore wind farm: Predictions of auditory damage,” J. Appl. Ecol. **52**, 631–640.

Hijmans, R. J. (**2017**). “raster: Geographic data analysis and modeling,” R package version 2.6-7. Retrieved from https://cran.r-project.org/package=raster (Last viewed 1 June 2018).

Iliffe, J. C., Ziebart, M. K., Turner, J. F., Talbot, A. J., and Lessnoff, A. P. (**2013**). “Accuracy of vertical datum surfaces in coastal and offshore zones,” Surv. Rev. **45**, 254–262.

Kastak, D., Southall, B. L., Schusterman, R. J., and Kastak, C. R. (**2005**). “Underwater temporary threshold shift in pinnipeds: Effects of noise level and duration,” J. Acoust. Soc. Am. **118**, 3154–3163.

Kastelein, R. A., Gransier, R., Hoek, L., Macleod, A., and Terhune, J. M. (**2012**). “Hearing threshold shifts and recovery in harbor seals (*Phoca vitulina*) after octave-band noise exposure at 4 kHz,” J. Acoust. Soc. Am. **132**, 3525–3537.

Kastelein, R. A., Helder-Hoek, L., Kommeren, A., Covi, J., and Gransier, R. (**2018**). “Effect of pile-driving sounds on harbor seal (*Phoca vitulina*) hearing,” J. Acoust. Soc. Am. **143**, 3583–3594.

Mikkelsen, L., Johnson, M., Wisniewska, D. M., van Neer, A., Siebert, U., Madsen, P. T., and Teilmann, J. (**2019**). “Long-term sound and movement recording tags to study natural behavior and reaction to ship noise of seals,” Ecol. Evol. **9**, 2588–2601.

Nedwell, J. R., Brooker, A. G., and Barham, R. J. (**2011**). “Measurement and assessment of underwater noise during impact piling operations at the Lincs offshore wind farm,” Subacoustech Environmental Report No. E273R0203.

NMFS (**2016**). “Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing: Underwater acoustic thresholds for onset of permanent and temporary threshold shifts,” U.S. Dept. of Commer., NOAA. NOAA. Technical Memorandum NMFS-OPR-55, 178 pages.

NMFS (**2018**). “2018 Revisions to: Technical guidance for assessing the effects of anthropogenic sound on marine mammal hearing (Version 2.0): Underwater thresholds for onset of permanent and temporary threshold shifts,” U.S. Dept. of Commer., NOAA. NOAA Technical Memorandum NMFS-OPR-59, 167 pages.

Pebesma, E., and Bivand, R. S. (**2005**). “S classes and methods for spatial data: The sp package,” R package version 2.01-40.

Porter, M. B. (**2001**). “The KRAKEN normal mode program,” SACLANT Undersea Research Centre, 207 pages. Retrieved from http://oalib.hlsresearch.com/Modes/kraken.pdf (Last viewed 1 October 2019).

Quick, N., Scott-Hayward, L., Sadykova, D., Nowacek, D., and Read, A. (**2017**). “Effects of a scientific echo sounder on the behavior of short-finned pilot whales (*Globicephala macrorhynchus*),” Can. J. Fish. Aquat. Sci. **74**, 716–726.

R Core Team (**2019**). “R: A language and environment for statistical computing,” Vienna, Austria. Retrieved from https://www.r-project.org (Last viewed 1 October 2019).

Russell, D. J. F., Brasseur, S. M. J. M., Thompson, D., Hastie, G. D., Janik, V. M., Aarts, G., McClintock, B. T., Matthiopoulos, J., Moss, S. E. W., and McConnell, B. (**2014**). “Marine mammals trace anthropogenic structures at sea,” Curr. Biol. **24**, R638–R639.

Russell, D. J. F., Hastie, G. D., Thompson, D., Janik, V. M., Hammond, P. S., Scott-Hayward, L. A. S., Matthiopoulos, J., Jones, E. L., and McConnell, B. J. (**2016**). “Avoidance of wind farms by harbour seals is limited to pile driving activities,” J. Appl. Ecol. **53**, 1642–1652.

Sehgal, A., Tumar, I., and Schönwälder, J. (**2009**). “Variability of available capacity due to the effects of depth and temperature in the underwater acoustic communication channel,” IEEE Ocean. 2009– Eur., 1–6 pages.

Sharples, R. J., Moss, S. E., Patterson, T. A., and Hammond, P. S. (**2012**). “Spatial variation in foraging behaviour of a marine top predator (*Phoca vitulina*) determined by a large-scale satellite tagging program,” PLoS One **7**, e37216.

Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene, C. R., Kastak, D., Jr., Ketten, D. R., Miller, J. H., Nachtigall, P. E., Richardson, W. J., Thomas, J. A., and Tyack, P. L. (**2007**). “Marine mammal noise exposure criteria: Initial scientific recommendations,” Aquat. Mamm. **33**, 411–521.

Southall, B. L., Finneran, J. J., Reichmuth, C., Nachtigall, P. E., Ketten, D. R., Bowles, A. E., Ellison, W. T., Nowacek, D. P., and Tyack, P. L. (**2019**). “Marine mammal noise exposure criteria: Updated scientific recommendations for residual hearing effects,” Aquat. Mamm. **45**, 125–232.

Thompson, P. M., Hastie, G. D., Nedwell, J., Barham, R., Brookes, K. L., Cordes, L. S., Bailey, H., and McLean, N. (**2013**). “Framework for assessing impacts of pile-driving noise from offshore wind farm construction on a harbour seal population,” Environ. Impact Assess. Rev. **43**, 73–85.

WindEurope (**2019**). “Offshore wind in Europe: Key trends and statistics 2018,” Brussels, Belgium, 1–37 pages.

Wolski, L. F., Anderson, R. C., Bowles, A. E., and Yochem, P. K. (**2013**). “Measuring hearing in the harbor seal (*Phoca vitulina*): Comparison of behavioral and auditory brainstem response techniques,” J. Acoust. Soc. Am. **113**, 629–637.

**RAMPION OWF PROPSED EXTENSION**
**OFFSHORE ORNITHOLOGY**

The proposed extension to the existing OWF will involve not only the doubling of the array footprint and the number of turbines but also a doubling of the east to west length of the wind farm. Sussex Ornithological Society (SOS) is concerned that in addition to the displacement of some seabird species there will be a major increase in the collision mortality rate particularly of migrant species.

It is noted that the proposals also include the installation of turbines in the previously consented area situated at the south east of the existing array. This is of major concern to SOS in relation to the colony of Kittiwakes at Splash Point, Seaford.

A list of the main species of concern to SOS is set out in the table below. This is followed by brief explanations of the SOS concerns.

| Species | Status | Concern |
|---|---|---|
| Brent Goose | Amber listed species of medium conservation concern | Collision during migration |
| Common Scoter | Red listed species of high conservation concern. Schedule 1 Species. | Collision during migration |
| Gannet | Amber listed species of medium conservation concern | Collision & displacement |
| Whimbrel | Red listed species of high conservation concern. Schedule 1 Species. | Collision during migration |
| Bar-tailed Godwit | Amber listed species of medium conservation concern. | Collision during migration |
| Kittiwake | Red listed species of high conservation concern. Nests in Seaford to Beachy Head SSSI. | Barrier effect, displacement & collision |
| Great Black-backed Gull | Amber listed species of medium conservation concern. | Collision & displacement |
| Lesser Black-backed Gull | Amber listed species of medium conservation concern | Collsion & displacement |
| Herring Gull | Red listed species of high conservation concern | Collision & displacement |
| Common/Arctic Terns | Both amber listed species of medium conservation concern | Collision during migration |
| Great Skua | Amber listed species of medium conservation concern | Collision during migration |
| Pomarine Skua | COWRIE states 'Large numbers likely to pass through development zone'. High susceptibility in Zone 6. | Collision during migration |
| Arctic Skua | Red listed species of high conservation concern | Collision during migration |
| Common Guillemot | Amber listed species of medium conservation concern | Displacement |

It is known that large numbers of birds migrating eastwards through the English Channel in spring pass to the south of the Isle of Wight and there is an apparent reluctance for many species to pass through the Solent.

The apparent reluctance of migratory birds to pass through the Solent is highlighted in the Hampshire Bird Atlas in relation to Common Scoter:

*'At the western entrance to the Solent the birds gather apparently reluctant to pass through the narrows of Hurst Castle and sometimes retreating back towards Christchurch Harbour before passing eventually to the south of the Isle of Wight'.*

There is also a great deal of evidence to show that having passed south of the Isle of Wight many birds turn north east and then follow the Sussex coastline.

The easterly spring migration occurs in pulses and SOS notes that the proposed surveys are apparently only to be one per month and for just one additional year. It is considered that a minimum of two surveys should be undertaken during the months of March, April and May in order to obtain an indication of the maximum daily numbers of each species. It is also considered that surveys should be extended westwards towards the Isle of Wight as a method of establishing the north east migration routes between the Isle of Wight and the Sussex coast.

It is assumed that Brent Geese wintering in the Chichester/Portsmouth Harbour complex migrate eastwards in spring largely following the Sussex coastline. Brent Geese wintering in the area of the Solent are assumed to follow a similar route. Birds from the wintering areas in western France (and possibly those wintering further west along the south coast of England) migrate south of the Isle of Wight with many then travelling north east to the Sussex coast. This results in more being recorded further east along the coast. SOS is concerned that the proposed westward extension of the OWF will reduce the migration window between the Isle of Wight and the OWF resulting in a major increase in collision fatalities.

| Brent Goose | Selsey Bill | Worthing & Goring | Telscombe Cliffs | Splash Point (Seaford) |
|---|---|---|---|---|
| 22 March 2018 | 119 | n/c | 1025 | n/c |
| 24 March 2018 | 0 | 770 | n/c | 1900 |

Some large numbers of Common Scoter were recorded moving east along the Sussex coast in April 2018. The numbers further east along the coast were higher than those in the west as was the case with Brent Geese. SOS considers that this is further evidence that many birds migrating east in spring turn north east to the Sussex coast after passing the Isle of Wight.

| Common Scoter | Selsey Bill | Worthing & Goring | Telscombe Cliffs | Splash Point (Seaford) | Beachy Head |
|---|---|---|---|---|---|
| 2 April 2018 | 170 (7) | 577 (6) | 923 (4) | 1950 (9) | 1442 (6) |
| 4 April 2018 | 645 (8) | 125 (1) | 1069 (3) | 1742 (5) | 1800 (5) |
| 6 April 2018 | 854 (9) | 940 (3) | 1514 (4) | 2025 (11) | 2002 (7) |
| 15 April 2018 | 601 (12) | 393 (4) | 800 (4) | 3020 (9) | 3017 (4) |

Figures in parentheses after the number of birds indicate the number of hours of observation and show that the duration of observation had no significant effect on the numbers of Common Scoter recorded.

SOS considers that the data shown below for Whimbrel, Bar-tailed Godwit, Great Skua, Arctic Skua and Common/Arctic Tern reinforces the evidence for the existence of a migration corridor between the eastern edge of the Isle of Wight and the Sussex coast.

| Bar-tailed Godwit | Selsey Bill | Worthing & Goring | Splash Point (Seaford) |
|---|---|---|---|
| 5 May 2018 | 50 | 3 | 138 |
| 6 May 2018 | 139 | 5 | 458 |
| 7 May 2018 | 39 | n/c | 269 |

| Whimbrel | Selsey Bill | Worthing & Goring | Telscombe Cliffs | Splash Point (Seaford) | Beachy Head |
|---|---|---|---|---|---|
| April total | 182 | 29 | n/c | 266 | 138 |
| May total | 211 | 101 | 99 | 573 | n/c |

| Great Skua | Dorset | Hampshire | | Sussex (west to east) | | | | Kent |
|---|---|---|---|---|---|---|---|---|
| | Portland Bill | Hurst/Milford (West of So'ton Water) | Browndown/ Stokes Bay (East of So'ton Water) | Selsey Bill | Worthing & Goring | Splash Point (Seaford) | Beachy Head | Dungeness |
| 18 April 2012 | 41 | 14 | 13 | 18 | 11 | 115 | n/c | 288 |
| 25 April 2012 | 34 | 72 | 38 | 72 | 107 | 155 | 133 | 147 |
| 26 April 2012 | 63 | 6 | n/c | 8 | 5 | 105 | 94 | 67 |

| Arctic Skua | Dorset | Hampshire | Sussex (west to east) | | | | Kent |
|---|---|---|---|---|---|---|---|
| | Portland Bill | Hurst Beach | Selsey Bill | Worthing & Goring | Splash Point (Seaford) | Beachy Head | Dungeness |
| 25 April 2012 | 9 | 19 | 32 | 42 | 98 | 133 | 91 |
| 26 April 2012 | 44 | 2 | 6 | 7 | 77 | 48 | 48 |

| Common/Arctic Tern | Selsey Bill | Worthing & Goring | Beachy Head |
|---|---|---|---|
| 19 April 2018 | 164 | 34 | 1025 |

Combined totals of Common and Arctic Terns plus those not identified to species

Gannets are recorded off the Sussex coast throughout the year with the largest numbers occurring in the west of the county. In 2019 there were over 28,000 sightings of Gannets passing Selsey Bill plus gatherings of birds feeding offshore. Tracking studies of Gannets from the Alderney West Coast and Burhou Islands Ramsar site show that the foraging range of these birds overlaps with the scoping area. Large gatherings of feeding Gannets off the Sussex coast are not infrequent and have exceeded 2000 birds on occasions. Gannets have not been recorded passing through the Solent but large numbers do pass south of the Isle of Wight. To reach the Sussex coast while either foraging or migrating the Gannets must pass through a corridor between the Isle of Wight and the existing Rampion OWF. SOS considers that the proposed extension to the OWF will not only result in Gannets being displaced from part of their foraging area but also add significantly to the risk of collision. SOS also believes that additional surveys are required to ascertain the major foraging locations and the movements of Gannets between the Isle of Wight and the Sussex inshore waters.

The summary of the first year's survey results recorded both Great Black-backed and Herring Gulls in significant numbers. SOS considers that more detail is required as to the activities of these gulls (feeding, loafing, etc.) together with any movements within the area of the proposed OWF extension.

It is noted that large numbers of Guillemots were recorded on the water but there is no indication of any correction factor for the time that birds spent pursuit diving. Similar large numbers of auks were recorded during the surveys for Phase 1 of the OWF indicating that the area is an important wintering area for auk species. It is the SOS opinion that this requires more investigation as displacement on a large scale is possible.

There are regular reports of congregations of Kittiwakes in the English Channel both at the end of the breeding season and also as the birds return to their nesting sites. There is also evidence of easterly migration of Kittiwakes along the Sussex coast during March and early April. As with other species, Kittiwakes do not pass through the Solent but to the south of the Isle of Wight before travelling north east towards the Sussex coast. The table provides evidence of the increased numbers of Kittiwakes moving eastwards in spring 2018. No counts are made at Splash Point, Seaford as the observation point is adjacent to the colony. Surveys undertaken for Phase 1 showed the feeding area to be south west of the colony so it is not considered that birds from that colony account for those recorded at Beachy Head.

| **Kittiwake** | Selsey Bill | Worthing & Goring | Beachy Head |
|---|---|---|---|
| 14 March 2018 | 0 | 12 | 665 |
| 29 March 2018 | 0 | 0 | 520 |
| 3 April 2018 | 0 | 14 | 700 |

SOS notes that barrier effect has been scoped out as this will be included in the assessment of displacement on resident birds. However SOS does not accept this in the case of the Kittiwakes nesting within the Seaford to Beachy Head SSSI. In addition to the extension in the area to the west of the existing OWF the proposals also include the erection of turbines in the previously consented area to the south east of the existing array. Surveys for Phase 1 showed a major Kittiwake feeding area to the south west of the colony and south of the OWF. During the Inspectorate Hearings SOS expressed major concerns that the OWF would represent a barrier between the colony and the birds' feeding area. The Inspectorate view was that if the Kittiwakes flew around the OWF this would not add significantly to the energy budget. The proposal to to utilise the area to the south east of the existing area will add further to the distance that the birds need to travel and as a result SOS considers that the Inspectorate's initial conclusion is no longer valid. It is considered that more surveys are required to determine the movements and feeding areas of the birds from the regionally important Kittiwake colony at Splash Point, Seaford.

[redacted]
Sussex Ornithological Society
September 2020

RWE

wood.

GoBe

# Rampion Extension Development Limited

# Rampion 2 Offshore Wind Farm

## Benthic Subtidal and Intertidal Ecology Method Statement

IEMA Transforming the world to sustainability - EIA -

Wood Environment & Infrastructure Solutions UK Limited – April 2020

## Report for

TBC

RWE

## Main contributors

[redacted]

## Issued by

Signature here

..............................................................................

[redacted]

## Approved by

Signature here

..............................................................................

[redacted]

## Wood

Shinfield Park
Shinfield
Reading RG2 9FW
United Kingdom
Tel +44 (0)118 9131234

Doc Ref.

document1

## Copyright and non-disclosure notice

The contents and layout of this report are subject to copyright owned by Wood (© Wood Environment & Infrastructure Solutions UK Limited 2020) save to the extent that copyright has been legally assigned by us to another party or is used by Wood under licence. To the extent that we own the copyright in this report, it may not be copied or used without our prior written agreement for any purpose other than the purpose indicated in this report. The methodology (if any) contained in this report is provided to you in confidence and must not be disclosed or copied to third parties without the prior written agreement of Wood. Disclosure of that information may constitute an actionable breach of confidence or may otherwise prejudice our commercial interests. Any third party who obtains access to this report by any means will, in any event, be subject to the Third Party Disclaimer set out below.

## Third party disclaimer

Any disclosure of this report to a third party is subject to this disclaimer. The report was prepared by Wood at the instruction of, and for use by, our client named on the front of the report. It does not in any way constitute advice to any third party who is able to access it by any means. Wood excludes to the fullest extent lawfully permitted all liability whatsoever for any loss or damage howsoever arising from reliance on the contents of this report. We do not however exclude our liability (if any) for personal injury or death resulting from our negligence, for fraud or any other matter in relation to which we cannot legally exclude liability.

## Management systems

This document has been produced by Wood Environment & Infrastructure Solutions UK Limited in full compliance with our management systems, which have been certified to ISO 9001, ISO 14001 and OHSAS 18001 by LRQA.

## Document revisions

| No. | Details | Date |
|---|---|---|
| **0.1** | For review | 25/09/20 |
| | | |
| | | |

# Contents


| | | |
|---|---|---|
| **1.** | **Aim of this technical note** | **4** |
| **2.** | **Scoping** | **5** |
| 2.1 | Proposed approach set out in the scoping report | 5 |
| | Impacts to be assessed | 5 |
| 2.2 | Relevant comments from the scoping opinion | 7 |
| 2.3 | Proposed Approach to the Characterisation of the Baseline Environment | 8 |
| | The Study Area | 8 |
| | Existing Data Sources | 8 |
| | Subtidal Survey Design | 10 |
| | Intertidal Survey Design | 10 |

# 1. Aim of this technical note

Within the Planning Inspectorate's (PINS) Scoping Opinion for the Rampion 2 Offshore Wind Farm dated August 2020, PINS provided feedback on the data sources and methods to be used to characterise the baseline environment, this was also supported by consultee responses.

As a response to this feedback and to provide supplementary information to the Scoping Report, a technical note has been provided; this note reviews the proposed approach at Scoping, the responses received in the Scoping Opinion and sets out the proposed approach to characterise the benthic subtidal and intertidal ecology baseline environment as a basis for the Environmental Impact Assessment (EIA) to be presented in the Preliminary Environmental Information Report (PEIR) and subsequently to accompany the Development Consent Order (DCO) application, responding to the specific points raised in the Scoping Opinion.

# 2. Scoping

Rampion 2 submitted a Scoping Request and Scoping Report to PINS on the 2nd of July 2020 under Regulation 10 of the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (the EIA Regulations).

This section sets out a brief summary of the data sources and baseline environment methodology, as detailed in the Scoping Report, and the key issues raised in the Scoping Opinion.

## 2.1 Proposed approach set out in the scoping report

The baseline will be established through the compilation of both desk-based studies and site-specific field surveys. Site- specific surveys will help fill data gaps that currently exist across the Rampion 2 OWF benthic subtidal and intertidal ecology Study Area. Surveys will identify the extent and distribution of key habitat types and features, with a focus on any species or habitats of conservation importance, that might exist across the area of interest. The methodology for the survey has and will be consulted on with key stakeholders.

The worst-case scenarios on which the assessments will be based, will be defined in accordance with the Rochdale Envelope approach; the geographic footprint, the foundations proposed, and the piling hammer energies will be key considerations in defining the worst-case scenarios for benthic and intertidal receptors. Following this, the likely significant effects on receptors from the worst-case scenarios will be described and assessed.

The assessment of potential impacts on benthic and intertidal ecology receptors will consider the magnitude and duration of the impact, the reversibility of the impact and the timing and frequency of the activity. The sensitivity of difference receptors will also be considered as part of the impact assessment, the Marlin Marine Evidence based Sensitivity Assessment (MarESA) will be a key resource. The sensitivity assessment of the species will take into account the current status of the species, and its importance (locally, regionally, nationally or internationally). The assessment will also include the consideration of potential significant cumulative effects as appropriate.

### Impacts to be assessed

In line with the 2017 EIA Regulations, the EIA for Rampion 2 OWF will consider those impacts where there is a risk of a likely significant effect only. The following section draws on industry experience, expertise, and the MMO 2012 review of post-consent monitoring, to identify those effect-receptor pathways that may potentially lead to a significant impact. Where experience and available evidence indicates an effect-receptor pathway will not lead to a significant impact with regards to the EIA Regulations (2017) the pathway is scoped out from assessment.

The likely significant effects on benthic subtidal and intertidal ecology are summarised in **Table 2-1**.

*Table 2-1 Likely significant benthic subtidal and intertidal ecology effects*

| Activity and impact | Effect | Proposed approach to assessment (scoped in or scoped out) | Receptor | Further data baseline requirements |
|---|---|---|---|---|
| Temporary habitat disturbance (construction, operation/maintenance and decommissioning phases) | Potential for significant effect to benthic and intertidal resources through temporary, direct habitat loss and disturbance | Scoped in, detailed assessment. The presence and extent of benthic and intertidal habitats and features will be informed though the use of existing and new site-specific survey data. The area of habitat disturbance will be defined using a worst-case scenario-based approach. The sensitivity of habitat types to the impact will be determined through available literature and expert knowledge, based on the habitats resilience and resistance to impacts. | Benthic subtidal & intertidal ecology | New site-specific data for benthic ecology receptors |
| Temporary increase in suspended sediment and sediment deposition (construction, operation/maintenance and decommissioning phases) | Potential for significant effect through smothering of sensitive benthic habitats and species. | Scoped in, detailed assessment. The effects on benthic and intertidal ecology from increased suspended sediment and sediment deposition will be informed by the findings and assessment of the Physical Processes Chapter. The sensitivity of habitat types to the impact will be determined through available literature and expert knowledge, based on the habitats resilience and resistance to impacts. | Benthic subtidal & intertidal ecology | New site-specific data for benthic ecology receptors |
| Direct and indirect seabed disturbances leading to the release of sediment contaminants (construction, operation/maintenance and decommissioning phases) | Potential for significant effect through release of sediment bound contaminants into the water column. | Scoped in, simple assessment. The effects on benthic and intertidal ecology from changes to water quality will be informed by the findings and assessment of the Water Quality Assessment. The sensitivity of habitat types to the impact will be determined through available literature and expert knowledge, based on the habitats resilience and resistance to impacts. | Benthic subtidal & intertidal ecology | The assessment will be informed by the findings of sediment contaminant analyses. |
| Long-term habitat loss / alteration (operation phase) | Potential for significant through loss of suitable substrate or sensitive habitat | Scoped in, detailed assessment: The presence and extent of benthic and intertidal habitats and features will be informed though the use of existing and new site-specific survey data. The area of habitat loss will be defined using a worst-case scenario to determine the maximum loss of seabed. The presence and extent of benthic habitats and features will be informed though the use of existing and new site-specific survey data. | Benthic subtidal & intertidal ecology | New site-specific data for benthic ecology receptors |
| Increased risk of introduction or spread of Marine Invasive Non-Native | Potential for significant effect through increased vessel movements during | Scoped in, simple assessment: The potential introduction or spread of MINNS and subsequent impact to | Benthic subtidal & | |

| Activity and impact | Effect | Proposed approach to assessment (scoped in or scoped out) | Receptor | Further data baseline requirements |
| --- | --- | --- | --- | --- |
| Species (MINNS) (construction, operation and decommissioning phases) | construction (e.g. ballast water) and may subsequently impact biodiversity and benthic ecology of the area. | local benthic ecology receptors will be assessed based on current industry understanding, available literature and expert knowledge. | intertidal ecology | |
| Colonisation of hard substrates (operation phase) | Potential for significant effect through an increase in local biodiversity and alterations to benthic ecology. | Scoped in, simple assessment: The potential impacts on benthic ecology receptors will be considered in terms of effects on biodiversity and productivity. The area of introduction of hard substrate will be defined using a worst-case scenario to determine the maximum area of impact. The sensitivity of habitat types to the impact will be determined through available literature and expert knowledge, based on the habitats resilience and resistance to impacts. | Benthic subtidal & intertidal ecology | |
| Accidental pollution events (construction, operation/maintenance, and decommissioning) | No likely significant effect | Scoped out: To be discussed | N/A | N/A |
| EMF generated by inter-array and export cables (operation phase) | No likely significant effect | Scoped out: To be discussed | N/A | N/A |
| Noise pollution during construction related activities (construction) | No likely significant effect | Scoped out: To be discussed | N/A | N/A |

## 2.2 Relevant comments from the scoping opinion

PINS, within the scoping opinion set out the position in relation to benthic subtidal and intertidal ecology baseline information, the main themes for discussion are as follows:

- *To provide more information on the implementation of measures to limit any potential pollution incidents, so that this impact can be scoped out.*

  The likelihood of an incident will be reduced by implementation of a Project Environmental Management Plan (PEMMP) and Marine Pollution Contingency Plan (MPCP), details of which will be presented within the PEIR as part of the mitigation strategy.

- *The Inspectorate is of the view that uncertainties concerning operation effects of electromagnetic effects remain. The Inspectorate therefore does not agree that likely significant effects upon fish receptors from operational EMF can be excluded at this stage and this matter should remain scoped in to the ES.*

  The comment relates to fish receptors, rather than benthic receptors. Clarification required that this point relates to benthic ecology.

It is generally accepted that the particle motion component of noise is most relevant to benthic species. While there are few studies looking at reactions of benthic invertebrates and in particular polychaetes and infaunal bivalves, it is likely that particle motion will dissipate in close proximity to the noise source. In addition, the noise will be temporary in nature and conditions will return to baseline following cessation of piling. It is proposed that this impact is therefore scoped out of the assessment.

- *Noise pollution during construction related activities - The Inspectorate is not in a position to agree to scope these matters from the assessment.*

  Benthic species are considered to be more susceptible to impacts resulting from the propagation of the particle motion component of anthropogenic noise. Field measurements on the propagation of particle motion is limited however, it is expected that particle motion will dissipate in close proximity to the noise source resulting in a highly localised, temporary and intermittent impact with conditions returning to baseline following cessation of piling. Therefore, the magnitude is considered to be low.

  There are currently few published studies on the reaction of benthic species to noise particularly infaunal bivalves and polychaetes that are typical of the sediment biotopes likely to be present within the Rampion 2 array area and offshore ECC (with generally sparse epifaunal community). The MarESA sensitivity assessment suggest that the potential noise effects associated with the construction of a wind farm is 'not relevant' for the biotopes present. It is considered that there is no risk of likely significant effect and it is proposed that this impact be scoped out of the EIA.

## 2.3 Proposed Approach to the Characterisation of the Baseline Environment

### The Study Area

The Study Area for the benthic subtidal ecology assessment is defined as the scoping area boundary together with the secondary impact Zone of Influence (ZOI). The secondary ZOI has been informed by the tidal excursion extent and coastal processes modelling undertaken to inform the previous Rampion 1 Offshore Wind Farm (OWF) EIA (ABPmer, 2012). The ZOI buffer therefore encompasses the area over which suspended sediments may travel following disturbance as a result of project activities, extending a precautionary 15 km around the array, and 10 km surrounding the offshore cable corridor.

The intertidal ecology Study Area is defined by the intertidal zone extending up to the Mean High-Water Spring (MHWS) mark within the offshore cable corridor.

### Existing Data Sources

Rampion 2 propose to utilise a combination of existing data sources and site-specific surveys to characterise the benthic subtidal and intertidal ecology baseline environment.

*Table 2-2 Key sources of benthic subtidal and intertidal ecology data*

| Source | Date | Summary | Coverage of Study Area |
| --- | --- | --- | --- |
| Rampion 1 OWF benthic ecology baseline characterisation (EMU, 2011) | Survey undertaken in April 2011 | Drop-down video (DDV) and grab sampling gear were deployed to collect sediment for analysis (of benthic invertebrates, particle size, total organic carbon, and contaminants) across the Rampion 1 OWF site and surrounding area as part of the baseline characterisation. | Coverage across the benthic subtidal ecology Study Area, including the scoping boundary array and offshore cable corridor. |
| Rampion 1 OWF cable landfall intertidal baseline characterisation (RSK Environment Ltd, 2011 | Survey undertaken in May 2011 | A Phase 1 habitat survey across between East Worthing and South Lancing, as well as sampling sediment with a $0.01m^2$ hand-core for analysis of benthic invertebrates, particle size, total organic carbon and a range of contaminants. | No coverage with Rampion 2 OWF landfall but provides regional context. |
| Rampion 1 OWF pre-construction benthic survey report (Natural Power, 2016) | Survey undertaken in September and October 2015 | DDV, benthic grab and epibenthic trawl stations were sampled. DDV was deployed to ground-truth areas suspected to be Annex I reef. | Coverage across the benthic subtidal ecology Study Area, including several points within the scoping boundary array area. |
| UKSeaMap (2018) | 2018 | EUNIS Level 4 model, detailing biological zone and substrate. | Complete modelled coverage up to MHWS. |
| Regional Seabed Monitoring Plan (RSMP) baseline dataset (Cooper & Barry, 2017)) | Samples have been collected over a period of 48 years from 1969 to 2016, although the vast majority (96%) were acquired since 2000 | The dataset comprises of 33,198 macrofaunal samples (83% with associated data on sediment particle size composition) covering large parts of the UK continental shelf. Data points for the Rampion 2 OWF benthic subtidal ecology study area were extracted. Full details on the dataset can be found here: - https://www.cefas.co.uk/data-and-publications/dois/rsmp-baseline-dataset/ | Good coverage across the benthic subtidal ecology Study Area including the scoping boundary. |
| Biologically informed habitat map (Cooper *et al.*, 2019) | As above. | A biologically informed habitat map produced using all available RSMP data. Full details of the habitat map can be found here: - https://doi.org/10.1111/1365-2664.13381 | Complete modelled coverage up to MHWS. |
| Area 435/396, Area 453 and Area 488 Annual Monitoring Reports (EMU, 2009; Fugro EMU Ltd. 2013 and 2014) | 2009 - 2014 | Environmental monitoring reports for marine aggregate extraction areas (Area 435/396, Area 453 and Area 488) within the region. | Regional context. |

| | | | |
|---|---|---|---|
| South Coast Regional Environmental Characterisation (REC) (James *et al.*, 2010) | 2010 | South Coast Regional Environmental Characterisation (REC). A multidisciplinary marine study of an extensive area of the English Channel. The full report can be found here: - http://nora.nerc.ac.uk/id/eprint/13120/1/OR09051.pdf | Regional dataset and report covering the benthic subtidal ecology Study Area. |
| The Eastern English Channel Marine Habitat Map (James *et al.*, 2007) | 2007 | The Eastern English Channel Marine Habitat Map. The study provides regional scale geological and biological interpretations aimed to contribute to the effective stewardship of the marine environment by providing a broader understanding of how the potential resource areas relate to the wider regional ecology and physical processes. The full report can be found here: - https://www.cefas.co.uk/publications/techrep/tech139.pdf | Regional dataset and report covering the benthic subtidal ecology Study Area. |
| The Marine Aggregate Levy Sustainability Fund (MALSF) synthesis study in the central and eastern English Channel (James *et al.*, 2011) | 2011 | The Marine Aggregate Levy Sustainability Fund (MALSF) synthesis study in the central and eastern English Channel. This synthesis report has as its core two regional environmental characterisation (REC) studies, the Eastern English Channel Marine Habitat Map (EECMHM) (James *et al*, 2007) and the South Coast REC (James *et al*, 2010). The full report can be found here: - http://nora.nerc.ac.uk/id/eprint/14031/1/OR11001.pdf | Regional dataset and report covering the benthic subtidal ecology Study Area. |

### Subtidal Survey Design

The subtidal survey will be informed by the interpretation of geophysical data collected in Q2 of 2020 and will be agreed with the regulatory bodies. Geophysical data will be used to indicate the presence of sediment forms, which may be of conservation interest (e.g. Annex *I S. spinulosa* reef or UK BAP Priority Habitat blue mussel Mytilus edulis beds). The subtidal sampling design will ensure sufficient samples are collected to adequately characterise the benthic ecology study area without oversampling within similar habitat types and areas previously sampled for the constructed Rampion OWF. Consultees have already provided feedback on the survey scope of works.

A 0.1 $m^2$ mini-Hamon grab will be used to obtain macrobenthic and sediment samples at each of the proposed grab sampling locations. Grab work will be conducted in line with Section 3.9 of the JNCC Marine Monitoring Handbook and Cefas guidelines Ware *et al.* (2011). All grab sample collection and processing will be undertaken in line with in-house Standard Operating Procedures (SOPs) and Ocean Ecology Ltd.'s Quality Management System (QMS).

Areas that are unsuitable for grab sampling will be investigated (e.g. EUNIS Sublittoral Rock) with Drop Down Video (DDV) and as part of the Annex I investigation by either camera transect or DDV to characterise and ground-truth the geophysical data.

### Intertidal Survey Design

The intertidal survey was completed in July 2020 and covered the entirety of the cable corridor area at Climping Beach, in addition to a 25 m buffer, from Mean Low Water Springs (MLWS) to Mean High Water Springs (MHWS). The survey consisted of:

- Phase I walk over survey

- UAV Mapping (drone)
- Phase II sampling
- Quadrat sampling

Consultees provided feedback on the survey scope of works.

# Technical Note:
Rampion 2
Black Bream Data Assessment and Approach

# 1. Introduction

## 1.1 Project description

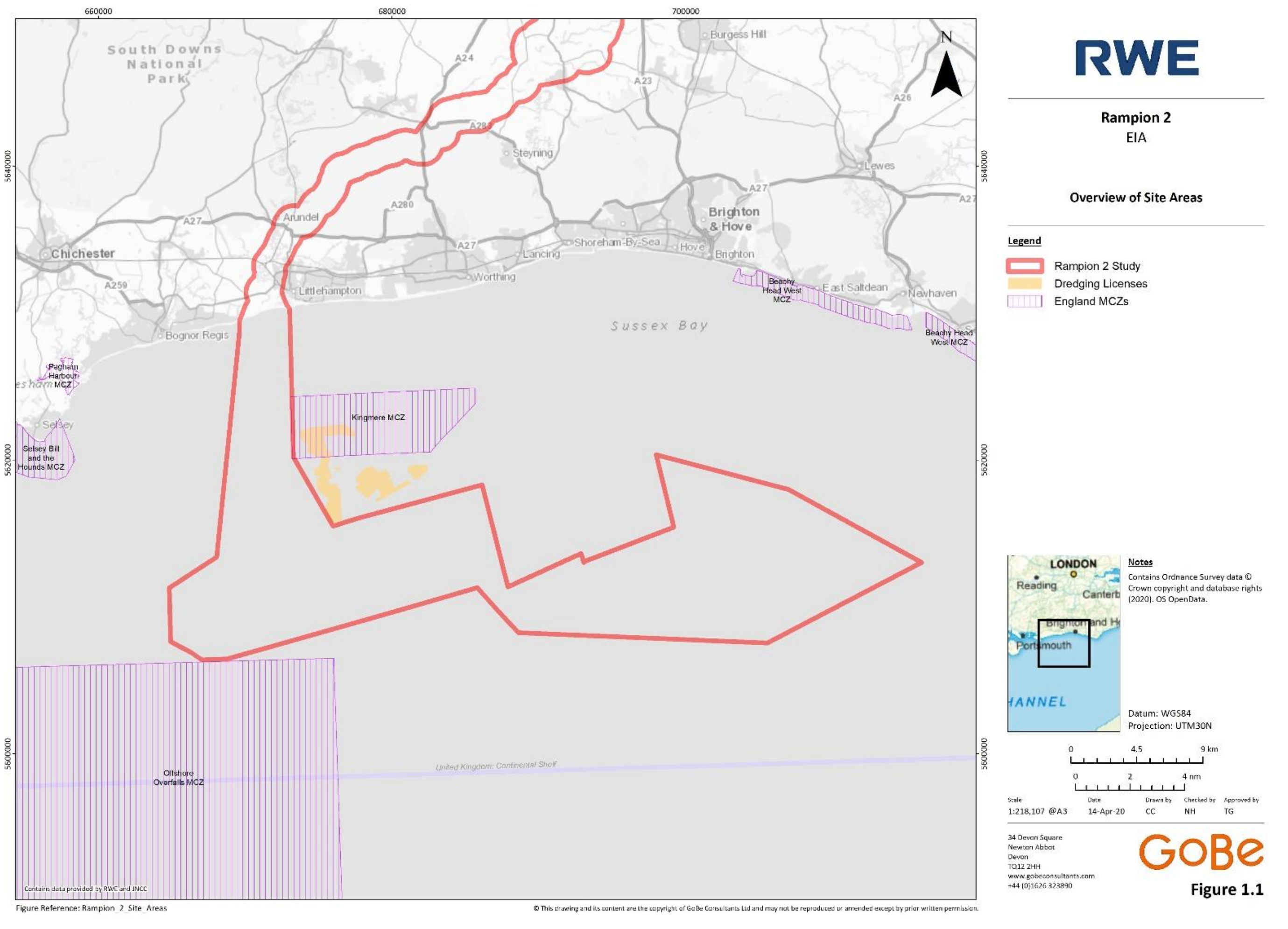
1.1.1 Rampion Extension Development Ltd (RED) is proposing to develop a new offshore wind farm project (Rampion 2) adjacent to the existing Rampion Offshore Wind Farm (Rampion).

1.1.2 Rampion was developed following the United Kingdom Round 3 offshore wind development programme run by The Crown Estate (TCE) in 2009. It is located in the English Channel, off the south coast of England within the Round 3 Zone 6 Area. The zone has an overall area of 271 $km^2$, and Rampion has been constructed in the North Western part of the Zone, occupying some 78$km^2$.

1.1.3 RWE applied to The Crown Estate (TCE) for an extension to the Rampion Wind Farm in 2018 and following approval under the plan-led Habitats Regulations Assessment (HRA), was awarded development rights for the Rampion Extension Site in 2019. RWE anticipates entering into an Agreement for Lease (AfL) for the extension area with TCE in 2020. It is one of seven extension proposals that passed TCE's plan-led HRA process is required to connect into the onshore transmission or distribution networks at an existing substation 'node'.

1.1.4 It is believed that a single opportunity remains to obtain consent for further wind farm development adjacent to the existing Rampion project. As well as the seabed area conditionally awarded under the TCE extension process, RWE is also looking at development within the remaining part of the Round 3 Zone area. The aggregate of these two seabed areas would be optimised on the basis of a range of factors and additional information collected as part of the evaluation and project design process, notably including the collection of additional survey data and the results of Environmental Impact Assessment (EIA). However, at this stage it is anticipated that a single application for a Development Consent Order (DCO) for the combined areas will be made. For the purposes of this, alongside other early stage documents, the proposed project is referred to as Rampion 2. The location and extents of the area within which Rampion 2 is proposed is presented in Figure 1.1.

Figure 1.1 Rampion 2 offshore project area



## 1.2 Purpose of this document

1.2.1 This Technical Note has been written in response to a request from Natural England to provide a description of the proposed approach to assessment of the potential for impact arising from the Rampion 2 project on black bream *(Spondyliosoma cantharus)* as a feature of the Kingmere Marine Conservation Zone (MCZ). As is evident from Figure 1.1, the proposed project development area is located in proximity to the Kingmere MCZ , as was the case for the original Rampion EIA, specifically in regard to the spawning activities of the species. Such impacts are considered to relate to the construction phase of the project as there is the potential for percussive piling to be used for foundation installation, which could, in turn, result in noise disturbance effects. Other construction phase impacts such as indirect seabed disturbance from activities such as cable installation will also be considered within the EIA, though it should be noted that there is no overlap between the proposed project area and the MCZ site. In establishing the adequacy of the proposed approach, this Technical Note sets out the available data that is proposed to be used to underpin and inform this assessment as well as the proposed survey method.

1.2.2 The intention is to discuss the adequacy of the data and the methodology going forward and subsequently to agree with Natural England its sufficiency for the purposes of the EIA to support the application for development consent for Rampion 2.

## 1.3 Background

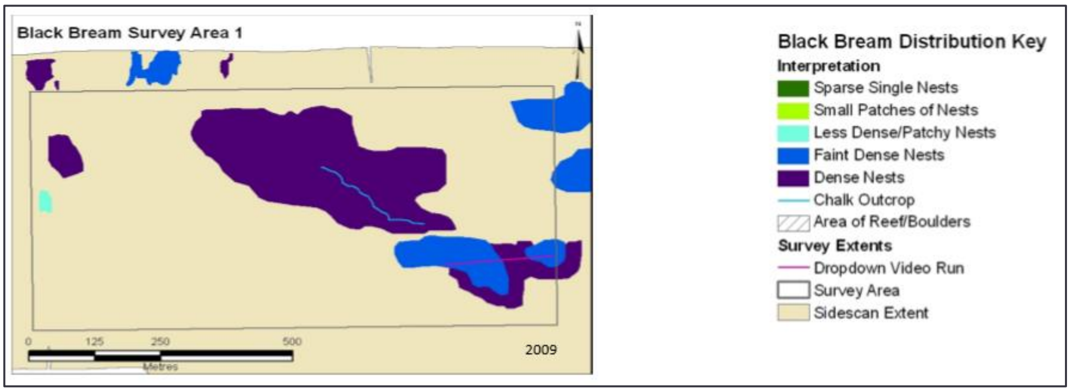
1.3.1 The Kingmere MCZ, located 5-10 km south of the West Sussex coast, was designated in 2013, and includes a number of features of interest (FOI), including seabed areas suitable for and comprising black bream spawning habitat. The Kingmere MCZ is thus protective of a nationally important black bream nesting site. The MCZ comprises a combination of mixed energy infralittoral rock and mixed sediments and chalk outcrops.

1.3.2 Black bream are known to migrate to the Owers region during the spring in order to spawn. The species are demersal spawners and exhibit breeding behaviour that has resulted in the inclusion of the spawning habitat (thin mixed sediments over moderate energy infralittoral rock) within the Kingmere MCZ. The physical nature of the seabed habitat, as well as water depth, is important for breeding success as a result of the 'nests' this species creates and utilises; male black bream use the tail to remove a few centimetres of surface sand/gravel layer and expose the bedrock to create a 'nest'. The females then lay their eggs in a thin layer directly on to the exposed hard substrate within the nest. The eggs are sticky and become strongly attached to the rock surface and the male continues to keep the nest and attached eggs free from sediment inundation (and predators) until the eggs have hatched.

1.3.3 Figure 1.2 shows an example still image captured from video footage of black bream eggs at the Kingmere MCZ, alongside Figure 1.3 which shows distribution maps of the site from Sidescan sonar interpretation.

Figure 1.2 High resolution image of the seabed showing black bream eggs on exposed hard substratum. Scale - 20cm between red dots. (Fugro, 2017)

Figure 1.3 Sidescan Interpretation of black bream Nest Distribution and Density 2011 – Area 1. (Area 435/396 Monitoring Survey report 2011)




1.3.4 Black bream are considered to preferentially target the gravel veneer as spawning habitat rather than the deeper sands and gravels adjacent to the MCZ and surrounding area in order to construct and maintain the nests and it is this specific habitat (thin gravel veneer on hard substrate) that is afforded protection under the MCZ designation.

1.3.5 RWE have undertaken some early stage informal consultation with Natural England and Cefas on the Rampion 2 proposals and as part of this process and Natural England have highlighted the importance of the black bream and the spawning habitat areas within the Kingmere MCZ. As noted above, this Technical Note aims to further inform Natural England of the proposed assessment approach for black bream breeding grounds as an important receptor and to highlight the range of available data and extensive studies on the species and spawning habitats of the Kingmere MCZ that are proposed to be utilised for Rampion 2 EIA. RWE are confident that these data are robust and sufficient for the purposes of EIA.

## 1.4 Structure

1.4.1 This Technical Note outlines the project's approach to the assessment of potential impacts and environmental effects on black bream associated with the Kingmere MCZ through the following sections:

- Section 2 Project offshore parameters;
- Section 3 Data Available for Analysis;
- Section 4 Approach to Assessment; and
- Section 5 Conclusions.

# 2. Project offshore parameters

2.1.1 The Rampion 2 proposed development will be located, as illustrated in Figure 1.1, in an area of the English Channel, off the south coast of England and consists of:

- the Rampion extension area of search situated to the west of the existing site, approximately 13km to 25km offshore. The extension area of search has an area of 150km$^2$;
- the residual part of the existing Zone 6 AfL area to the south and east of Rampion, which has an overall area of 165km$^2$; and
- an area of search for the offshore export cables to connect the wind farm area to the shore. (approximate area 74km$^2$).

2.1.2 Preliminary engineering work indicates that Monopile, three or four legged jackets with pin piles or suction caisson foundation design options will be considered. It is possible that more than one type of foundation may be used across the project site.

# 3. Data available for analysis

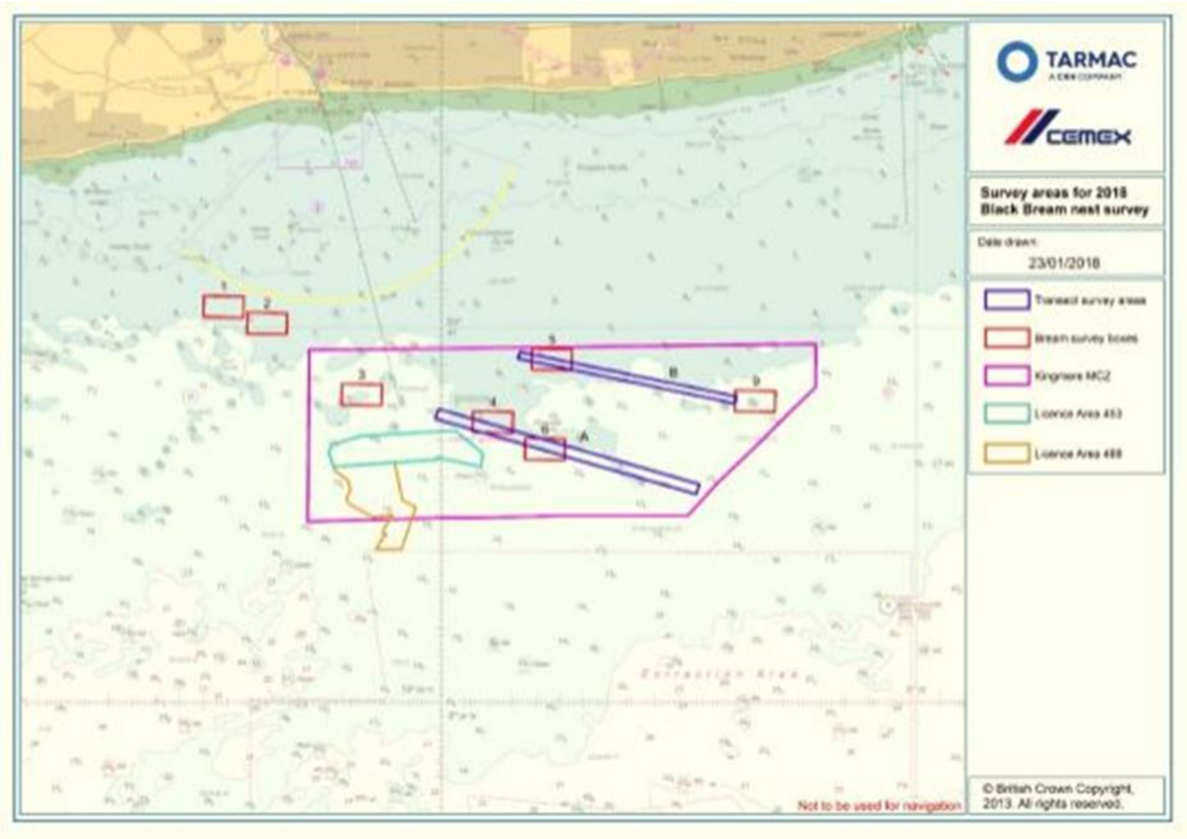
3.1.1 There is a range of Data available for the Rampion 2 black bream assessment, providing both temporal and spatial coverage of bream spawning activity in relation to the Kingmere MCZ that are proposed to be utilised for the Rampion 2 EIA. These include:

- aggregate industry black bream monitoring DDV transects (2017-2020);
- aggregate black bream monitoring bathymetry data including Sidescan Sonar nest interpretation (2017-2020);
- RWE Rampion 2 Baseline Geophysical survey data (2020);
- potential IFCA/CEFAS Recreational Rod and Line landings data (currently unknown date and geographical parameters).

## 3.2 Aggregate Industry Monitoring data

3.2.1 Since 2002, Hanson Aggregates Marine Ltd (HAML), and Tarmac Marine Ltd (TM) have monitored the Bream nest distribution within several survey boxes in and around Kingmere MCZ, using a combination of bathymetry and side scan sonar survey data (see Figure 3.1). It is proposed that these data be purchased by RWE for the purposes of characterising the receiving environment associated with the proposed Rampion 2 project for the years 2017-2020. This would give a robust 4-year data set with which to characterise and assess the nesting distribution within the relevant Zone of Influence inclusive of the MCZ and form the basis of the EIA of potential impacts on black bream.

Figure 3.1 Showing the location of the black bream surveys areas in relation to marine aggregate licence areas 488 and 453, along with Kingmere MCZ




3.2.2 The data available for each year include the following components:

- bathymetry data within seven survey boxes and two survey transects to identify location of nests;
- DDV transects across the areas of bream nest sites identified in the bathymetry survey, focussing on dense nest aggregations;
- high resolution still photographs of observed nests; and
- survey summary report.

## 3.3 Rampion 2 Baseline Geophysical surveys

3.3.1 Further in-situ data will be collected directly from the Rampion 2 proposed development area during baseline Geophysical surveys. These surveys although for the purpose of Geophysical characterisation not specifically for Black Bream, will inform the presence/absence of nesting sites and allow more detailed review of seabed types to demonstrate suitability etc for spawning habitat.

The focus of the EIA assessment of black bream will be for the MCZ, this will therefore provide the additional and specific data needed to inform any potential for direct effects on bream nesting (outside the MCZ), which can therefore then be appropriately assessed.

## 3.4 Ad-Hoc additional data

3.4.1 Finally, additional data available from IFCA is to be investigated, from Rod and line fisheries catch and release data, Although the focus of EIA assessment will be the designated FOI within the MCZ, the species will be subject to assessment across the wider area within the Rampion 2 EIA. Any additional fishing effort data will allow us to further define areas of interest for the species across the wider area and serve to provide evidence to inform and support the assessment process.

# 4. Approach for black bream assessment

4.1.1 As noted above, aggregate extraction currently operates in the locality of the MCZ and as part of the licence permission for these sites there is a requirement for the aggregate companies to monitor bream nest densities and nest viability to ensure that there are no significant negative impacts on the FOI caused by aggregate dredging. The regular monitoring for Aggregate extraction zones (Area 396 – (TM); Area 435 - (HAML); Area 453 – CEMEX UK Marine Ltd. (CMX); and Area 488 – (TM)) provides combined multibeam bathymetry/back scatter survey data over seven survey boxes and two transects, combined with three drop down video and high resolution still photography surveys within and around Kingmere MCZ, see Figure 3.1.

4.1.2 The Area 435-396 Inner Owers monitoring studies have taken place since 2002 and provide important local context and key information in terms of the location of sediment types, habitats and black bream nesting activity. They represent one of the most comprehensive studies of black bream nest distribution within the UK and as such, represent robust characterisation data for the Rampion 2 development area , notably including zones subject to potential secondary impacts/effects and are thus considered adequate for the purposes of EIA.

4.1.3 The project also proposes to supplement these existing data across the wider and adjacent Rampion 2-specific site, with geophysical survey data over the entire proposed development area. This will provide additional site specific data to characterise the potential zone of influence that may be subject to impacts arising from the offshore wind farm. Bathymetry data collected from the Rampion 2 proposed development area will further inform the proposed assessment by accurately identifying depth parameters across the area, which as identified earlier in this note, is also considered a key influencing factor in the selection of suitable habitat areas for black bream spawning and nest excavation. This will therefore allow assessment for suitable habitat across the whole proposed development area, not solely the designated FOI within the MCZ.

4.1.4 Overall, it is apparent that the surveys undertaken (and notably that will continue) provide detailed data and extensive spatial and temporal coverage of the relevant parts of the MCZ (as well as control stations) and are therefore considered to provide the required spatial extent and an appropriate evidence base to inform the assessment of the MCZ FOI for the Rampion 2 area of search and potential Zone of Influence.

## 4.2 Underwater Noise

The EIA will address effect significance assessment by undertaking noise modelling using the latest evidence and guidance on thresholds and assessment approachesf. The detailed approach to noise disturbance assessment will be discussed in more detail with Natural England and other relevant organisations and authorities (MMO/Cefas) as part of the DCO application engagement process, notably including the Evidence Plan Process that will be adopted as part of the DCO application.

The proposed study by the University of Exeter "Assessing the effect of pile driving on black sea bream reproductive behaviour" was discussed with Natural England, the MMO and Cefas during a technical meeting in December 2019. The aim of this study was to investigate the effect of pile-driving noise on the reproductive behaviour of nesting male black sea bream (S. cantharus) in natural conditions and to compare responses to pile-driving and ambient-sound (control) playbacks of known sound-pressure and particle-motion levels.

The study aimed to provide missing evidence in understanding the underwater noise impacts on fish. The latest and most relevant guideline criteria on impacts of piledriving noise on fish are those published by Popper et al. [12], which are based solely on sound pressure, and, for behavioural responses, only present three relative risk levels (high, moderate, low) for fish at three distances from the source defined in relative terms (near, intermediate and far). No information is available on the hearing anatomy and physiology of S. cantharus, preventing direct comparison with other species.

In order to carry out this study within internal Health and Safety guidelines the use of commercial divers and a lightweight vessel with a SCUBA replacement system would be required. The complexity of the commercial diving methodology presents several logistic and safety challenges and eventually due to COVID 19 the survey has been cancelled as field work would require a group of divers to share a very small vessel. However, RED will continue to collaborate with the University of Exeter to ensure the best available evidence is used for the black bream assessment.

## 4.3 Seabed habitat Physical Disturbance

4.3.1 There is also potential for physical disturbance of the seabed habitat as a result of the installation of infrastructure from the Rampion 2 proposed development, such as from the construction of foundations and cable lay. Due to the nature of conditions required for laying cable, being almost the opposite to seabed habitats targeted by black bream for spawning, there is a very low likelihood of any direct overlap as cable burial will be difficult in areas of bedrock and usually avoided wherever possible. It is also noted that there will be no potential for direct impacts to occur within the MCZ since there is no overlap between the designated site and the Rampion 2 potential development area. This means areas of black bream nest outside of the MCZ, even where nesting at some level has been recorded, are likely to be avoided and micro siting would be put in place where possible.

4.3.2 As noted above for the export cables, with no overlap between Rampion 2 proposed development area and the MCZ., there will be no potential for direct impacts arising from the physical footprint of the foundation structures for Rampion 2 on the MCZ black bream FOI. Any secondary effects from foundation installation, for example sediment disturbance and subsequent re-distribution and deposition of mobilised sediment, would also be considered to comprise very low given the distance of the proposed development area from the MCZ and therefore little potential for an impact-receptor pathway. This is supported both by previous modelling of potential sediment deposition depth and spatial extent from the Rampion project and also by the results of the long-term monitoring of sediment disturbance and transport from the aggregate dredging monitoring, where much larger volumes of sediment are disturbed and entrained within the water column than would arise from foundation installation. Further detail on this is presented within the North Owers

Draft Environmental Statement MCZ assessment. (Annex 8.1, North Owers Draft Environmental Statement. 2014)

# 5. Conclusions

5.1.1 From the data sets available it is clear that a good deal of information on black bream spawning distribution in the wider area is available to provide the evidence base for both the characterisation of the proposed development area with respect to black bream and the subsequent assessment of potential impact risk and any related effect significance as a result of the construction and operation of the proposed Rampion 2 development.

5.1.2 Further to this, potentially sensitive areas such as the Kingmere MCZ and other surrounding FOI records are well understood, mapped and monitored. The previous and ongoing surveys also provide a good time series data set (having been undertaken periodically since 2002), which allows for consideration of both inter-annual variation in distribution and seasonality of the spawning behaviour of the species.

5.1.3 Existing survey data has supported the understanding of spawning habitat preference for the species, i.e. that black bream target thin (<1m) sediments overlying had substrate within which to construct nests, with evidence also presented on the lack of any such activity in deeper soft sediment habitat.

5.1.4 The project construction and black bream are therefore seen to target different seabed/sediment features meaning likely no direct impact for the following key reasons:

- sediment types preferred for black bream Nesting behaviour are not consistent with the seabed conditions favoured for cable burial; and
- the preferred Black Bream nesting habitat of thin sediments over bedrock features are located out with the proposed development area.

5.1.5 The assessment approach that is proposed to be adopted for Rampion 2, i.e. noise modelling for impacts to fish and assessment in line with current guidance and scientific literatureand utilising contemporary existing black bream monitoring data from the aggregates industry at Kingmere from 2017-present, (which is already successfully being utilised for aggregates practices in and around the Kingmere MCZ), we believe provide for an appropriate evidence base for assessment. This will then be supported by multibeam interpretation from the Rampion 2 proposed development area to confirm any further/additional presence of black bream nests, although this is currently considered unlikely from the literature and data to date on habitat preference and the easterly distribution extent limits of the species.

5.1.6 Should any areas be remaining as potentially affected after assessment, avoidance mitigation of such locations will be evaluated, utilising the available impact data on the predicted extent of primary/direct and secondary indirect effect (e.g. plume/deposition/sediment mobilisation) to inform the relevant and appropriate mitigation distance required to avoid potential impacts to any important sites.

# 6. References

Annex 7.3 Black Bream Monitoring: Historical Analysis . September 2015. North Owers Application Areas. GoBe, Cemex and Lafarge.

Area 435/396 Monitoring Report 2011. Fugro Emu Ltd

Annex 8.1 Report to inform a marine conservation zone assessment, North Owers Draft Environmental Statement. 2014

**Issued by**

[redacted]
.......................................................................

**Approved by**

[redacted]
.......................................................................

## Copyright and non-disclosure notice

The contents and layout of this report are subject to copyright owned by Wood (© Wood Environment & Infrastructure Solutions UK Limited 2020) save to the extent that copyright has been legally assigned by us to another party or is used by Wood under licence. To the extent that we own the copyright in this report, it may not be copied or used without our prior written agreement for any purpose other than the purpose indicated in this report. The methodology (if any) contained in this report is provided to you in confidence and must not be disclosed or copied to third parties without the prior written agreement of Wood. Disclosure of that information may constitute an actionable breach of confidence or may otherwise prejudice our commercial interests. Any third party who obtains access to this report by any means will, in any event, be subject to the Third Party Disclaimer set out below.

## Third party disclaimer

Any disclosure of this report to a third party is subject to this disclaimer. The report was prepared by Wood at the instruction of, and for use by, our client named on the front of the report. It does not in any way constitute advice to any third party who is able to access it by any means. Wood excludes to the fullest extent lawfully permitted all liability whatsoever for any loss or damage howsoever arising from reliance on the contents of this report. We do not however exclude our liability (if any) for personal injury or death resulting from our negligence, for fraud or any other matter in relation to which we cannot legally exclude liability.

## Management systems

This document has been produced by Wood Environment & Infrastructure Solutions UK Limited in full compliance with our management systems, which have been certified to ISO 9001, ISO 14001 and OHSAS 18001 by LRQA.

**Comments from West Sussex County Council (WSCC) on the actions from the Rampion 2 Follow up SLVIA ETG held on 28th April 2021**

- ***Action 1** - Draft Figure 16.15 'Blade Tip ZTV with Surface Feature Screening', PDF version of the relevant ZTV for further consideration by stakeholders of additional viewpoints along the West Sussex coastline. Viewpoint options A-D are presented in the slide presentation previously sent, specific viewpoint micro siting suggestions at any of these locations would be welcomed.*
    - WSCC welcome the updated ZTV as discussed in the second ETG held on the 18th March. The addition of surface feature screening allows WSCC to be more targeted in suggesting potential additional SLVIA VPs in West Sussex using a more well defined evidence base. See comments below:
        - **VPs A-D** – WSCC welcomes the identification of these VPs based upon feedback given in the first SLVIA ETG. As stated in the follow up ETG, WSCC would like to see **VP A** included, potentially microsited to the car park (there are car parks at West Wittering and Bracklesham Bay) where there are likely to be a concentration of visitors. The inclusion of **VP B** would allow the views experienced from the eastern side of Chichester Harbour AONB to be presented, at a point where the maximum number of turbines would be visible. WSCC understands REDL will be further consulting with Chichester Harbour AONB on any additional VPs required. The microsited location should be representative of views from Dell Quay and Chichester Harbour to the west and Chichester Golf club etc to the east where more visitors/tourists might be expected. **VP C** - WSCC suggests removal of the currently proposed **VP C**, which being directly between VP 13 and VP B probably wouldn't add much to the assessment and propose a new location to the south of Eastergate (where there is a large area of turbine visibility, the presence of Arun's Strategic housing allocation and the new alignment of the A29 - [A29 realignment scheme - West Sussex County Council]). It would also better cover off the apparent remaining large areas of maximum turbine visibility inland to the east of VPs A-D). **VP D** – the location of this VP seems sensible, located on the A259 between Chichester and Bognor, which would represent views experienced by receptors travelling along the coastal plain here.
        - **Climping Beach VP** – WSCC reiterates the importance of a VP at this location, firstly because it has a very different character to that of the Littlehampton VP and also because of the cumulative visual effects this area will likely experience due to the construction and operation of off and onshore infrastructure.
        - **Elsewhere along the West Sussex Coast** – Having reviewed the updated ZTV, WSCC wishes to highlight both the Ferring Gap/Goring and Lancing Beach areas. The ZTV shows in both locations, the maximum visibility of turbines in very well used coastal areas. This is highlighted by the presence of cafés, beach huts, promenade and green space with no possibility of intervening screening and mitigation.

- ***Action 2** - NE/SDNP/NT/WSCC to respond with confirmation of agreement or further recommendation of night time skies assessment viewpoints and methodology (as presented in the previous ETG meeting slides)*
    - WSCC have no specific comments on the methodology, we did however raise comments in the follow up ETG that there should be representative VPs outside of the designation. We appreciate the night-time assessment will focus particularly on this area, which is less influenced by night-time lighting and where the appreciation

of dark skies could be most affected by additional WTG lighting. There is however the potential for receptors outside of the designation to experience night- time effects, especially those where light pollution is lower, and this should be covered off in the assessment. WSCC suggests there should be representative VPs for outside of the designation, as it is recognised there are many beachfront/coastal properties, and ecologically important sites that currently look out to a dark horizon, which will be affected by the presence of the operational turbines. WSCC suggests potentially a VP at Pagham Harbour and another at a more populated coastal settlement, such as Bognor or Worthing. WSCC also suggests consulting Chichester Harbour AONB on this matter also.

- ***Action 3*** *- NE/SDNP/NT/WSCC to respond with recommendation on which viewpoints to be utilised for single frame photo montage resource pack, in addition to those presented in slides if appropriate.*
    - WSCC have no comments to make on the VPs for single frame photomontage resource pack.

Marine Management Organisation

[redacted]

[redacted]

Our reference: DCO/2019/00005

**(By email only)**

11 February 2021

Dear [redacted],

## Rampion 2 Method Statement Response

At this stage of the planning process, Rampion Extension Development Ltd (RED) are conducting environmental and technical surveys and undertaking consultation with regulatory bodies, stakeholders and communities.

The currently proposed development is sited adjacent to south east and west of the existing Rampion Offshore Wind Farm, approximately 13km to 25km offshore, occupying an irregular elongated area. The wind farm array Area of Search has an approximate area of 315km2. The scoping area for the offshore export cables to connect the offshore wind farm area to the shore is approximately 74km2.

Rampion 2 OWF is expected to comprise of no more than 116 wind turbine generators (WTGs) with a total generating capacity of 1200MW. In addition, there will be up to three offshore substations and up to 4 export cables which will carry generated power to landfall at Climping, Sussex.

The Marine Management Organisation (MMO) received the following documents to review as part of the Evidence plan process:

**Document 1: Benthic Ecology Method Statement**

**Document 2: Fish and Shellfish Ecology Method Statement**

**Document 3: Underwater Noise Assessment Method Statement_V2**

**Document 4: Nature Conservation Method Statement**

The MMO has reviewed these documents in consultation with Centre for Environment, Fisheries and Aquaculture Science (Cefas) advisors and have provided comments below.

Please note the MMO is still in discussions with Natural England to ensure the advice is consistent. At this stage these comments are subject to change throughout the Evidence Plan Process.

### Benthic Ecology

1. The believes the method statement for benthic ecology reflects the discussions previously held at the Expert Topic Groups (ETGs).

2. The MMO notes that the Planning Inspectorate's Scoping response concerning benthic subtidal and intertidal ecology states that Electro Magnetic Field (EMF) and noise pollution should not be excluded at this stage due to the limited evidence provided. The response regarding EMFs was however the same for both Fish and Benthic and referred specifically to fish.

3. The MMO reiterates that the required justification for scoping out EMFs, pollution incidents and noise pollution was satisfactory with respect to benthic ecology. However, the Benthic Ecology Method Statement (Document 1) does not provide any references to support the decision to scope out EMFs from benthic subtidal and intertidal ecology impact assessment.

4. The Marine Evidence Based Sensitivity Assessment (MarESA) on the sensitivity of biotopes to EMFs, present within the application area, states 'no evidence', which suggests that no information exists at the biotope level. The MMO would therefore advise RED to review the most recent research on EMFs in relation to benthic fauna, as the body of evidence in relation to this potential impact is rapidly growing. This is to ensure that the most up to date information is used as evidence for scoping this impact out of benthic ecology impact assessment.

5. In relation to noise pollution, the MarESA assessment on sensitivity of biotopes present within the application area is 'not relevant', which corresponds to RED's response in Document 1.

### Shellfish Ecology

6. Studies have been undertaken on the effect of EMF at the individual species level for crab, Cancer pagurus (Scott et al, 2019) and lobster, Hommarus americanus (Hutchison et al., 2018), and suggest these two species are sensitive to electromagnetic fields. This potential impact should therefore be scoped in under Shellfisheries if it is not scoped in already.

### Fish Ecology

7. The MMO is generally content with the Document 3 and the proposed approach to Environmental Impact Assessment (EIA). The appropriate receptor species and impacts have been scoped in for assessment within the EIA and the data sources proposed to inform the EIA are appropriate. Document 2 is intended to provide an overview of the proposed approach to EIA, therefore specific details for some issues are limited at this stage. The MMO has provided some minor comments below where clarification/further discussion is needed.

8. As discussed at the ETG meeting in September 2020, the MMO is content that no further fisheries specific surveys are to be undertaken to inform the characterisation for fish. There are a number of suitable resources available that can provide recent, timely data for the characterisation of fish. Therefore, any further surveys are only likely to confirm the presence of those fish already known to be present in the area.

9. The MMO defers to Natural England and The Seahorse Trust regarding the need for any seahorse surveys.

10. The MMO notes Document 2 proposed to scope out the potential effects of underwater noise as a result of operational turbines (see para 23.15). The MMO has no major objections to this approach. However, it should be acknowledged that individual wind

turbines are increasing in size, and operational noise produced will depend on several factors including turbine size and technology. Furthermore, the cumulative contribution to the soundscape from multiple turbines within a wind farm should not be ignored (Tougaard et al., 2020).

**Black Sea Bream**

11. The MMO notes that recent (July/August 2020) side-scan sonar data has now been acquired across the array and export cable corridor areas. This data will complement existing data on black sea bream nest sites that have been gathered by the aggregates industry and Sussex Inshore Fisheries and Conservation Authorities (IFCA), to provide an historic overview of nest locations and density within and surrounding the array and Export Cable Corridor areas.

12. Owing to the potential for the black bream reproductive season to continue longer than previously thought (into July), ongoing nest monitoring surveys undertaken by the aggregates industry for Area 453 and 488 were expanded in 2017, to include visual assessments of nesting activity using drop down video and camera imaging beyond the end of June. The four years of data that are now available represent a relatively short period in monitoring terms and it should be recognised that uncertainly remains regarding the potential for black sea bream spawning in July.

13. RED proposes to undertake a heatmap analysis to evidence temporal variations in the location and density of black sea bream nests. It would seem from the report description that it will be possible to interrogate individual layers/years of data within the heatmap in order to gain a visual representation of inter-annual variation and density of nest sites which may be useful. However, the method and data sources that will be used for this analysis are not described in the report, so at this stage The MMO is unable to comment further on the suitability of this approach.

**Underwater Noise**

14. The MMO believes the proposed approach is largely appropriate and in keeping with best practice guidance. The MMO notes underwater noise modelling for the impacts of noise and vibration generated by piling will be undertaken using the following parameters;

- Monopiles installed using a maximum blow energy of 4400 kJ.
- Pin piles installed using a maximum blow energy of 2500 kJ.
- Modelling will be undertaken for a scenario of up to two monopiles and up to four pin piles driven at any one location in a 24hr period.
- Monopiles are to be installed in water depths of up to 45 m LAT only. For deeper depths, jacket foundations with pin piles or suction buckets will be used.
- Pin piles will be modelled for a concurrent piling scenario for vessels spaced at a minimum distance of 9 km between pile installation vessels.
- Monopiles will not be driven concurrently.

15. It is appropriate that the maximum design scenario will be presented (along with the most likely scenario). The maximum design scenario should be the primary focus of the

assessment and should be used to inform all assessment conclusions and associated mitigation.

16. Paragraphs 3.1.2 – 3.1.3 of Document 4 refers to non-piling construction noise. The MMO notes it should be possible to undertake a quantitative (rather than qualitative) assessment for some of the sources listed here, such as vessel activity and dredging. As long as details of the specific activity are known (i.e. the duration of the activity), then this will be possible to do and should be provided.

17. Paragraph 3.1.4 of document 4 refers to operational noise and states:

    *"Prediction of the levels of noise generated from the turbines will be modelled based on extrapolation from existing measurements of operating turbines, for the simple assessment of marine mammals only, (Scoped out for Fish and Shellfish)".*

    The MMO highlights that caution should be applied when extrapolating measurements from one wind farm to another. Operational noise depends on a number of factors, including, for example, turbine technology and size, substrate type, propagation conditions at the site.

18. The MMO believes it is appropriate that if scenarios with more than one piling event are likely within 24 hours, these scenarios will also be modelled as set out in paragraph 3.1.8.

19. Due to the lack of evidence on fleeing behaviour and swimming speeds RED has committed to undertaking stationary modelling, which is appropriate and the MMO welcome this, particularly when considering those species which require specific benthic habitats for part or all of their life stages (e.g., black sea bream, herring and sandeel).

20. Paragraph 3.1.10 states:

    *"TTS (Temporary Threshold Shift) onset thresholds will not be used to quantify the number of animals at risk of any TTS; instead, ranges will be presented for context only (to be discussed and agreed at the ETG)".*

    The MMO would highlight that is was requested that the number of animals estimated to be affected are also presented in the assessment, along with the predicted TTS ranges. This was agreed at the ETG which took place on the 18th September 2020.

21. The MMO has major concerns regarding the appropriateness of McCauley et al., (2000) for use in the assessment of behavioural impacts of underwater noise on fish. As set out in Paragraph 3.1.22 – 3.1.27 - Fish behavioural effects. For context, discussions were held at the last ETG between Cefas and RED. RED's intention is to use criteria from McCauley et al. (2000a ,b) to assess fish behaviour. Cefas recommended that the RED considers thresholds from Hawkins et al. (2014), as a conservative indicator to assess potential behavioural responses in fish. In this study, schooling sprat and mackerel were exposed to short sequences of repeated impulsive playback sounds at different sound pressure levels, to resemble a percussive pile driver.

22. As per the Method Statement, the assessment for Rampion 2 will primarily conduct a qualitative assessment based on the guidance in Popper et al. (2014). Furthermore, it is proposed that, in the absence of new data relevant to the region, the thresholds from McCauley et al. (2000) be used to provide an indication of the quantitative impact of behavioural effect, where possible, recognising that due to the complications as stated, this must not be taken as a definitive guide to disturbance for all fish. The thresholds

identified in McCauley et al. (2000) provide an upper and lower bound for a change in behaviour of 168-173 dB re 1 µPa SPLpeak.

23. The MMO acknowledges that the thresholds from McCauley et al. have been used historically in a number of wind farm impact assessments. The thresholds identified in Hawkins et al. (2014) have also been used in some noise impact assessments to date. In Hawkins et al., the sound pressure levels to which the fish schools responded on 50% of the presentations were 163.2 and 163.3 dB re 1 µPa (peak-to-peak) for sprat and mackerel respectively. The estimated single strike sound exposure levels were 135 dB re 1 µPa2 ·s and 142 dB re 1 µPa2 ·s for sprat and mackerel respectively.

24. The MMO appreciates the reservations RED has with the Hawkins et al. thresholds. The Hawkins paper acknowledges that the data presented cannot be used to define sound exposure criteria, and these thresholds were not included in the sound exposure guidelines published in 2014 (Popper et al., 2014). Neither were the thresholds from McCauley et al. The salient point is that there is not enough data to establish criteria/thresholds for behaviour. Behavioural effects are particularly difficult to assess, as they are highly dependent on behavioural context (Ellison et al., 2012; Popper et al., 2014) and responses may not scale with received sound level (Gomez et al., 2016). Consequently, there is considerable uncertainty in assessing the risk of behavioural responses, and the application of simplistic sound level thresholds for behaviour should be avoided. Where thresholds are used in assessments, these should be treated with caution.

25. Therefore, whether thresholds from McCauley or Hawkins are applied in an assessment, the same level of caution should be applied (caveats will apply to both). Our reasons for choosing thresholds from Hawkins over McCauley are that they are based on more current (2014 vs 2000), best available evidence from the peer-reviewed literature, and relevant to impact piling (the levels in McCauley have been established from a seismic airgun), and as noted previously, can be taken to be a conservative indicator for the risk of behavioural responses and potential displacement.

26. The MMO requests further information from the application as it would be helpful to know which scenarios/species will apply when using McCauley et al., (2000).

## Nature Conservation

27. The MMO defers to Natural England and the Environmental Agency on the information provided within Document 4.

## Conclusion

The MMO believes there are still outstanding major concerns that need addressed in relation to the proposed impact assessment methodology.

Yours Sincerely

[redacted]

Marine Licensing Case Officer

[redacted]

## References


Hawkins, A.D, Roberts, L., Cheesman, S. (2014). Responses of free-living coastal pelagic fish to impulsive sounds. J. Acoust. Soc. Am. 135 (5), May 2014.

Hutchison Z.L., Sigray P., He H., Gill A.B., King J. & Gibson C. (2018) Electromagnetic Field (EMF) impacts on elasmobranch (shark, rays, and skates) and American lobster movement and migration from direct current cables. Sterling (VA): US Department of the Interior, Bureau of Ocean Energy Management. OCS Study BOEM, 3.

McCauley, R. D., Fewtrell, J., Duncan, A. J., Jenner, C., Jenner, M-N., Penrose, J. D., Prince, R. I. T., Adhitya, A., Murdoch, J. and McCabe, K. (2000a) Marine seismic surveys – A study of environmental implications. Appea Journal, pp. 692-707.

McCauley, R. D., Fewtrell, J., Duncan, A. J., Jenner, C., Jenner, M-N., Penrose, J. D., Prince, R. I. T., Adhitya, A., Murdoch, J. and McCabe, K. (2000b) Marine seismic surveys: Analysis and propagation of air-gun signals; and effects of air-gun exposure on humpback whales, sea turtles, fishes and squid. Report R99-15, Centre for Marine Science and Technology, Curtin University of Technology, Western Australia.

Popper, A. N. Hawkins, A. D. Fay, R. R. Mann, D. Bartol, S. Carlson, Th. Coombs, S. Ellison, W. T. Gentry, R. Hal vorsen, M. B. Lokkeborg, S. Rogers, P. Southall, B. L. Zeddies, D. G. and Tavolga, W. N. (2014) Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. Springer and ASA Press, Cham, Switzerland.

Scott K., Harsanyi P. & Lyndon A.R. (2019) Understanding the effects of electromagnetic field emissions from Marine Renewable Energy Devices (MREDs) on the commercially important edible crab, Cancer pagurus (L.). Frontier in Marine Science Conference Abstract: IMMR'18 | International Meeting on Marine Research 2018.

Tougaard, J., Hermannsen, L. and Madsen, P.T. 2020. How loud is the underwater noise from operating offshore wind turbines? J. Acoust. Soc. Am. 148 (5), November 2020.


Date: 05 March 2021
Our ref: DAS/339355

NATURAL ENGLAND

[redacted]

**BY EMAIL ONLY**

[redacted]

**Discretionary Advice Service (Charged Advice)**
**Development proposal: Rampion 2 Offshore Windfarm**
**RE: Method Statements**

Thank you for requesting Natural England's advice on the above as part of the Rampion 2 evidence plan process. This advice is being provided as part of Natural England's Discretionary Advice Service.

**Overarching Comments**

It is useful that a section has been included in some of the methodologies explaining how comments received as part of the scoping opinion have been taken into account. It would be helpful if this section also included how comments made as part of the evidence plan meetings and comments Natural England have since provided on various documents were also documented and addressed in this way.

However, Natural England is unclear why some of the methodologies suggest they are aligned with the Scoping Report and the HRA Screening Report and do not incorporate any modifications to the EIA/HRA approach which may be implemented following consultee responses to these reports. Natural England provided comments on the EIA Scoping Report in August 2020, so it is unclear why methodologies submitted to us to review at the end of December 2020, would have still not taken these comments into account. We would therefore suggest that when updating these methodologies and looking forward towards the production of the PIER, reference is made to the comments we have previously provided in addition to the comments provided below.

**Nature Conservation Method Statement**

2.1 - Natural England understand that the Applicants suggesting the HRA will consider Natura 2000 sites in a more detailed context and will include consideration of sites further afield which have the potential for connectivity related issues, particularly with regards to mobile species such as birds and marine mammals. This will include consideration of sites such as Southern North Sea SAC and Alderney West Coast and the Burhou Islands Ramsar.

Natural England has concerns about undertaking such an approach . Taking this approach would mean that mobile species such as birds that are designated features of SSSI's will not be considered, as they lie outside of the proposed Zone of Influence (ZOI). In respect to SSSI's such as Seaford to Beachy Head SSSI and Brighton to Newhaven Cliffs SSSI, we strongly recommend that they are included within the assessment, and would continue to support such a position unless evidence is presented to suggest otherwise. These sites contain features such as aggregations of breeding Kittiwake, which a Likely Significant Effect (LSE) cannot be ruled out for.

In addition sites such as Dungeness, Romney Marsh and Rye Bay SPA/ Ramsar site, include among other species Sandwich Tern, for which the foraging ranges and / or the migratory routes and connectivity should be examined and screened in within the EIA and HRA. Similarly, the Alderney West Coast and Burhou Islands, support large numbers of Gannet (7,885 pairs in 2011 representing 2.3% of the world population, and 3.4% of the British isles population, according to the Alderney West Coast and Burhou Islands Ramsar Site Management Strategy 2012 – 2016), and it is strongly recommended that sites such as this are included in any EIA and HRA assessment and the relevant authorities for the area consulted.

3.1 – The developer states that 'for the assessment, marine and intertidal designated sites within the vicinity of the scoping boundary will be included within the baseline, these include offshore sites and those in the intertidal zone extending up to the Mean High-Water Spring (MHWS)'. Natural England advise that there is a potential for offshore activities to affect the features of sites found above MHWS, for example in relation to bird disturbance at coastal sites. This should be considered where relevant within either the offshore or onshore assessment.

3.2 - In relation to whether an effect requires a simple or detailed assessment, it should not be discounted that a simple assessment may need to become more detailed as the project develops.

3.2 - Natural England supports the use of GIS mapping to present baseline features and their value/sensitivity, project activities and their impact zones, descriptions of mitigation and where it will be applied and illustrate the significance of residual effects.

3.3 - The ZOI for each subject area should be kept under review as further information such as the noise modelling becomes available or the understanding of coastal processes change at all. This may mean additional designated sites need to be considered at a later stage.

Table 3.1

- Direct habitat disturbance to Climping Beach SSSI - we remind the Applicant of our previous advice at the scoping stage (4/8/2020) that in the first instance they should look to avoid direct disturbance to the SSSI in relation to both the cable route and the construction methodology selected.

- Direct habitat disturbance to other designated sites is currently scoped out. This should remain under review for Kingmere MCZ and Offshore Overfalls MCZ in relation to the construction methodology and the final location of the cable route.

- Temporary increase in suspended sediment and sediment deposition on designated features (construction and decommissioning phases). Natural England note that significant chalk plumes were visible and persistent from cable installation at Rampion 1 Offshore Wind Farm and that the potential for similar effects should therefore be a key consideration. The developer should also consider the potential for suspended sediment during the operation phase should cable re-burial, or further cable protection be required.

3.5 - Natural England welcomes the provision text to demonstrate which sites have been considered and why sites certain sites have been scoped out of the assessment.

Table 3.4 - It is stated that Pagham Harbour SPA falls outside of the offshore ornithology ZOI, but that Pagham Harbour Ramsar falls within the offshore ornithology ZOI. These two sites have the same boundary. Clear reasoning needed to be provided for the decision to scope these sites in or out of the assessment. Please refer to our earlier comments in relation to whether sites such as this should be scoped into the EIA as well as the HRA.

Table 3.5 - The following marine local wildlife sites (LWS) will be included within the assessment if they fall within the ZOI for features for which they are designated: Waldrons Marine LWS, Shelley Rocks LWS and HMS Northcoates Marine LWS. In addition to LWS, Marine Sites of Nature Conservation Interest should be considered. Natural England is aware of sites such as Kingmere

Rocks and Worthing Lumps in proximity to the development. It may also be necessary to consider additional Local Nature Reserves (LNR) such as Shoreham Beach LNR and Pagham Harbour LNR.

Table 3.6 - Bembridge MCZ – It is suggested that this site is only designated for benthic ecology features of interest and falls outside of the benthic ecology ZOI, therefore no impact is expected from the proposed development of Rampion 2.This is not the case as this site also contains fish and shellfish features.

Table 3.6 - Pagham Harbour SSSI – It is stated that this site falls outside the offshore ornithology and intertidal ecology ZOI. The intertidal ecology ZOI is not shown on the map or defined within this method statement. Pagham Harbour SSSI does fall within the benthic ecology and fish and shellfish ZOI. Therefore it is assumed, based on the information provided, that this site should be scoped in to the assessment.

4.1 - Pagham Harbour MCZ is scoped into the nature conservation assessment, but is missing from the list of MCZ's considered in the MCZ Assessment.

The noise modelling has not yet been carried out. Therefore it should not be discounted at this stage that sites that fall outside of the study areas for ornithology, benthic, fish and shellfish ecology, but fall within the noise sensitivity study area will not need to be scoped in should they contain noise sensitive features at a later stage.

**Fish and Shellfish Ecology Method Statement**

2.3.6 - The features of the Beachy Head *West* Marine Conservation Zone (MCZ) (Short-snouted seahorse) have been scoped into the assessment. As Beachy Head West MCZ falls within the study area for fish and shellfish ecology impacts on other shellfish features of this site (Blue mussel beds and Native oyster) should also be considered in this chapter.

2.2.6 - It is suggested that features of Bembridge MCZ (Short-snouted seahorse, and native oyster) will be included in this assessment, even though this MCZ is outside of the study area and has been scoped out of the Nature Conservation Chapter. Clarification needs to be provided on whether it is expected that this site and its features will be impacted. We note that Bembridge MCZ does fall within the noise sensitivity study area and that this may provide an explanation.

2.3.9/3.2.7 - Black sea bream are a designated features of the Kingmere MCZ. Whilst it is correct that the species does not hold a designated status outside of the site, Natural England would highlight that Policy S-FISH-4 of the South Marine Plan states that 'proposals must demonstrate that they will, in order of preference: a) avoid, b) minimise, c) mitigate significant adverse impact on essential fish habitat, including, spawning, nursery, feeding grounds and migration routes'. Requirement 5 of the Cable Route Protocol produced by the Crown Estate states 'Developers must demonstrate within the CIAL that planned offshore cable corridors are in alignment with the relevant policies and principles within the applicable National Policy Statements and relevant marine plan'.

2.3.10 - The document states that the primary spawning season identified within the Kingmere MCZ Supplementary Advice is April – June. We have previously informed RWE that the seasonality in Natural England's conservation advice was likely to change to March - July. This change has been finalised and the updated draft conservation advice package is likely to be published in March 2021. This change in seasonality will be reflected in our advice to all relevant industries not just offshore wind. RWE will receive notification when the package goes live.

2.3.11 - Natural England agree that further survey works would not preclude the need to assess potential impacts on black bream. We agree that further surveys would provide limited value. It is observed from the aggregates monitoring work that there is inter annual variability which means that a single years' worth of data on bream is of limited use when determining bream presence or absence and habitat usage.

During the evidence plan meetings with the applicant possible methodologies for identifying potential nesting habitats for black bream were discussed. Natural England advised that if the applicant was intending to identify potential nesting habitats for black seabream it may be possible to infer this from the presence of a thin veneer of sediment over rock surfaces within a depth range of 10m-50m including on top of outcrops and large boulders. This work would help to identify areas potentially suitable or not suitable for spawning and it should form part of the benthic habitat characterisation mapping work. Where habitat has the potential to be suitable for spawning the developer would have to assume it was used unless this could be proven otherwise. We did however highlight that whilst this may be useful to identify potential sites, it would not definitively confirm presence or absence. It is important to note that if the applicant decides to investigate using this methodology then they would need suitable data to differentiate between sediment veneer and other sediment habitats. Natural England notes there is no consideration of this in the methodology provided and this should be included.

2.3.11 - It is suggested further survey work would identify that the area subject to potential direct impact from the works may be used by black bream on occasion. Natural England understands the aggregates survey data provides evidence that bream nests are present within the cable corridor over multiple years, therefore Natural England advises the assessment should consider the potential to directly impact bream nests during the period of aggregation, spawning, nesting, and nest guarding every year.

2.3.12 - Natural England agrees that based on the available information the presence of spawning black bream within the export cable corridor should be assumed within any assessment. Therefore there is a potential for a permanent loss of essential fish habitat as a result of the cable installation. The developer states that 'any impact is of short duration and as such recovery will be possible and that black bream will return to spawn in the area and excavate the characteristic nests'. Natural England would ask the developer to provide evidence in order to justify their assumption that disturbance during spawning in one year would not have subsequent impacts, particularly in relation to potential site fidelity.

2.3.12 - In lieu of additional characterisation surveys, and in order to validate any predictions made within the EIA, RED commits to undertake pre-and post-construction surveys of the zone in which construction will take place adjacent to the Kingmere MCZ. The surveys will be targeted to understand the duration of recovery, e.g.to monitor the return of the species to nesting areas recorded as being following cable installation. Whilst Natural England agree there is value in further understanding the impacts of the development on black bream. This work would not diminish the need to adequately demonstrate impacts have been avoided in the first instance where at all possible and where they cannot be avoided, sufficient mitigation has been put in place.

3.1.2 - Natural England agree that the study area for noise impacts to fish and shellfish should be informed by noise propagation modelling and that the method statement should be re-examined once this information is available.

2.3.11/3.2.3/3.2.17 - Geophysical surveys were undertaken between July and August 2020. The evidence suggests that bream are known to leave the site in July and that nests require constant maintenance to remain free of sediment. Therefore, surveys undertaken at the very end of the breeding season and outside of it are not considered to provide a reliable indicator of presence or absence of bream nesting sites in a particular area during the entire season.

Whilst it is possible that some relic nest could be recorded in the drop down video surveys that were due to be conducted in November 2020, conducting drop down video surveys outside of the bream nesting season means that the survey outcomes will be limited to confirming only the presence of potential remnant nests, and cannot be relied upon to determine the presence or absence of bream nesting. This survey methodology does not meet scientific standards in relation to surveying black bream. We will therefore not be in a position to agree with any conclusions on presence, absence or extent of nesting black seabream based on drop down camera surveys undertaken in November.

3.2.8 - The Applicant has concluded through the analysis of available data and the conservation objectives for Kingmere MCZ that further survey data collected at this characterisation stage would not materially alter the assessment with regards the temporal or spatial distribution of the species and its key sensitive period and would not alter the likely mitigation measures that may or may not be required, subject to the findings of the EIA. Natural England would agree that further survey data is unlikely to alter the assessment, but as suggested above further information on extent of potential spawning habitat within the development site, outside Kingmere MCZ could prove to be useful. We would also highlight the need to consider our updated conservation advice in relation to the key sensitive period.

3.2.9 - It is suggested that whilst the surveys may not be undertaken during the core nesting period the data may aid in the understanding of the longevity of the nest features. It is unclear how useful observations on longevity can be made from this without data to show where nests were present during the breeding season. Without this information it is impossible to rule out that any relic nests that are present represent a small percentage of the overall number of nests present during the breeding season. Clarity is also required in relation to the value of understanding of the longevity of nest features to Rampion 2.

3.2.11 - The annual monitoring data for years 2017 to 2019 was purchased from Tarmac Marine Ltd. It was confirmed at a recent meeting that the 2020 data has been acquired to add to this dataset.

3.2.14 The data indicates the presence of frequent high-density nests in the eastern survey area in the Rampion 2 offshore export cable corridor (Figure 3 2 to Figure 3 4). The nest density decreases as the survey extends towards the eastern limit of the survey area within the export cable corridor. These data are considered appropriate for the purposes of characterisation for EIA as they provide robust spatial and temporal coverage across the area of greatest sensitivity. Natural England would highlight that the aggregates surveys are spatially limited to the monitoring area (including specific survey boxes) and therefore this data only provides spatial coverage for these particular areas. This does not mean that areas outside the monitoring area do not contain nesting sites, therefore it should not be seen as providing robust spatial and temporal coverage or relied upon to identify the areas of greatest sensitivity in relation to Rampion 2. Natural England would also suggest that due to inter annual variability all habitat where nest are present should be considered spawning habitat regardless of the nest density.

3.2.15 - Natural England does not agree that the data currently available represents a robust dataset in relation to Rampion 2. The developer suggests that in order to best evidence the temporal variation, they propose to undertake a heatmap analysis, collating the data across years in order to produce a single data set of likely spread. They consider that this method is appropriate as it will allow discrimination between areas frequently subjected to dense nesting activity and areas that may be subject to a single year of exploratory nesting activity by juveniles. It is suggested combined analysis will present a baseline that adequately characterises both the receiving environment for potential direct effects, and secondary effects, and is a robust basis on which to undertake the EIA. Natural England would highlight that the aggregates surveys are spatially limited to the monitoring area (including specific survey boxes) and therefore this data only provides spatial coverage for these particular areas. This analysis cannot therefore be relied upon to accurately determine where direct or indirect effects on nesting black bream may occur.

Natural England would also like to see a literature/evidence on exploratory nesting activity by juveniles, as a behaviour.

3.2.18 - In relation to the site specific data collected (geophysical and drop down video) it is proposed that where nests are identified the data will be interpreted, and nests classified into the density classes assigned to the aggregates data. These density classes will be presented in figures, alongside the pre-existing aggregate monitoring data to enable a robust assessment of black bream nesting areas across the Kingmere MCZ and the Rampion 2 offshore export cable corridor. Natural England strongly disagrees that this would enable a robust assessment of black bream nesting areas.

In relation to Kingmere MCZ we understand that there will be no direct loss of habitat within the MCZ. It is not considered that an understanding of the density and frequency of nests would be informative in relation to noise & sedimentation given the nature of these effects. In relation to loss of essential fish habitat outside of the MCZ, the potential for nests to be present of absent is key.

At this point the Applicant has not collected appropriate data on bream during the peak nesting season, and so cannot interpret this using density classes. See our comments above regarding this point. To robustly investigate nesting density would require, as a minimum, a multi-year dataset with comprehensive spatial coverage and replicate samples taken at peak bream spawning season. NE does not think such a dataset exists and furthermore questions why the Applicant is focussed on nest density when they have not yet ascertained the presence and extent of nesting bream habitat within their development area. NE has suggested an alternative approach in targeted habitat mapping to identify potential spawning habitats which can then be avoided.

3.2.19 - It is suggested that sediment plume modelling, and noise modelling will be used to determine the potential for impacts on nesting and spawning black bream, by determining the potential for overlap of impact ranges with areas of nesting. This approach would be suitable, but as explained Natural England has serious concerns over the developers ability to determine the presence and extent of nesting bream. The model should only draw conclusions on nest presence and extent in areas which have been adequately surveyed, and should not assume absence in nests where data is not available.

3.2.20 - Natural England does not concur with the Applicants view that a combination of the approaches presented in this method statement will allow for appropriate consideration of impacts on black bream during the period of aggregation, spawning, nesting, and nest guarding.

Table 3.3 - It should be noted that Temporary localised increases in SSC and smothering (Construction and Decommissioning) also need to be considered in relation to seahorses.

The scoping report acknowledges that seahorses are regularly recorded in the English Channel, with the study area also being a potential overwintering area for seahorse species. Natural England are aware of records of seahorses in shallower waters within the study area, and therefore these areas and potential migratory routes to overwintering areas also need to be considered. Therefore, the possibility for direct disturbance during construction and decommissioning needs to be considered.

**Ornithology Method Statement**

Table 1.1 – Natural England contact – Emma Preston

*Collision risk*
p.12 - APEM propose to use the Marine Science Scotland Stochastic Collision Risk Model Shiny Application (“sCRM App”; Donovan, 2017). This would be run deterministically. We confirmed this is appropriate in our follow up to the Oct 20 stakeholder meeting. APEM will need to run the sCRM multiple times to account for individual variation in key input parameters (bird density, avoidance rate, flight height and nocturnal activity).

p. 12 states that flight heights will be based on site-specific flight height data from the digital aerial surveys, where the sample size is sufficient to ensure robust estimates. It would be helpful if the method for estimating flight heights were presented.

Table 3-1 – the values presented accord with advice NE has given previously on other offshore windfarms and are therefore acceptable.

Displacement
Table 3-3:

- The most likely displacement and mortality levels for gannets and auks are presented. However, the assessment should set out the full range of values from 0% to 100% using a

matrix approach, as described in the 2017 SNCB Interim Displacement Advice Note.
- A buffer of 2km should be used for displacement of gannets, not just the windfarm itself.
- Sandwich terns should be considered in the displacement assessment as they are moderately susceptible to displacement and Rampion 2 is within the mean max foraging distance of colonies in the Solent.

Cumulative effects

NE advises that all the operational OWFs within the relevant area, as set out in the advice note on seabird populations to be included in the cumulative/in-combination assessments (as well as those in construction, consented etc. as set out in table 3-4). Operational offshore windfarms, including Rampion 1, should not be seen as part of the baseline environment because even though some have been operational for over 10 years, the bird population data used for assessments of baseline mortality, the BDMPS population sizes etc. pre-date the installations and therefore the baseline cannot be assumed to include the effects of these wind farms.

The method statement sets out that Rampion 1 is excluded from the Rampion 2 buffer analysis. However, NE would like to see an assessment of the displacement from Rampion 1 and buffers surrounding its footprint in the cumulative analysis. Whilst there was no specific post-construction monitoring of the ornithological effects of Rampion 1, as the current survey covers the area, it could examine any effects. The addition to the method statement would therefore be to analyse a buffer zone around Rampion 1, from the surveys being undertaken.

**Underwater Noise Method Statement**

2.3.2 – Natural England welcome the presentation of both worst-case and most-likely scenarios.

3.1.3 – Natural England welcome the inclusion of UXO in the assessment.

3.1.4 Operational noise – The Applicant suggests prediction of the levels of noise generated from the turbines will be modelled based on extrapolation from existing measurements of operating turbines. Natural England would question whether this is appropriate given the vastly different baseline conditions at different windfarm sites and other factors such as increasing turbine size as technology advances.

3.1.10 – This paragraph states the number of animals impacted will not be quantified however, Natural England agreed at the ETG meeting of 13th October 2020 with the requirement from Cefas that TTS-onset impact ranges and number of animals in impact ranges should be presented and it was only the magnitude of impact that did not need to be included.

3.1.2/3.1.3 A list is provided of potential non-pile driving source of noise during construction. It is suggested that a quantitative impact assessment will not be carried out for these noise sources. Natural England advise that where it is possible to carry out a quantitative assessment for these noise sources this would be informative.

Natural England defer to the comments made by Cefas in the last evidence plan meeting in relation to the proposed methodology for fish. However, we would welcome further discussions on underwater noise as the evidence plan process progresses and more information becomes available.

**Benthic Ecology Method Statement**

2.1 - The PINS Scoping Opinion stated that 'the Inspectorate is of the view that uncertainties concerning operation effects of electromagnetic effects remain. The Inspectorate therefore does not agree that likely significant effects upon fish receptors from operational EMF can be excluded at this stage and this matter should remain scoped in to the ES'. Natural England deferred to the view of Cefas in the subsequent evidence plan meetings that EMF could be scoped out in relation to benthic ecology. However, any decision by the applicant to scope out this impact still needs to be justified and explained by referring to relevant and up to date evidence to address the uncertainties that exist around the evidence base. This detail is missing from the method statement provided.

2.1/Table 3.4 - Accidental pollution events (construction, operation/maintenance, and decommissioning) has been scoped out in table 3.4. The scoping opinion advised the provision of more information on the implementation of measures to limit any potential pollution incidents, so that this impact can be scoped out. Natural England advised as part of the last set of evidence plan meetings that we would welcome consultation on the PEMP and MPCP documents. Currently we are aware they will be produced, but do not have any information on the measure they will include to limit any potential pollution incidents. Therefore it is considered too early to scope this out at this stage.

3.1 The method statement provided for benthic ecology does not appear to have been up to date at the time it was submitted to us for review. It suggests that the subtidal survey will be informed by the interpretation of geophysical data collected in Q3 of 2020 and will be agreed with the regulatory bodies. It should be noted that Natural England had some outstanding concerns the last time it was asked to comment on the subtidal survey scope. We therefore suggest that the Applicant refers back to the comments we have provided on benthic ecology and the subtidal survey and provides an updated methodology.

It would also be useful if the applicant was able to discuss in the impacts to be assessed section any impacts or changes that may have been identified from post construction monitoring undertaken in relation to Rampion 1.

Natural England are aware from a recent meeting with the developer that the approach to this chapter has changed significantly and therefore would welcome further discussion on an updated methodology during the upcoming evidence plan meetings.

**Marine Mammals (Harbour Seals) – Technical Notes on updated does-response curve**

Natural England welcome the updated dose response curve and the comparison presented with the curve from Russell et al (2016).

☒ The advice provided in this letter has been through Natural England’s Quality Assurance process

The advice provided within the Discretionary Advice Service is the professional advice of the Natural England adviser named below. It is the best advice that can be given based on the information provided so far. Its quality and detail is dependent upon the quality and depth of the information which has been provided. It does not constitute a statutory response or decision, which will be made by Natural England acting corporately in its role as statutory consultee to the competent authority after an application has been submitted. The advice given is therefore not binding in any way and is provided without prejudice to the consideration of any statutory consultation response or decision which may be made by Natural England in due course. The final judgement on any proposals by Natural England is reserved until an application is made and will be made on the information then available, including any modifications to the proposal made after receipt of discretionary advice. All pre-application advice is subject to review and revision in the light of changes in relevant considerations, including changes in relation to the facts, scientific knowledge/evidence, policy, guidance or law. Natural England will not accept any liability for the accuracy, adequacy or completeness of, nor will any express or implied warranty be given for, the advice. This exclusion does not extend to any fraudulent misrepresentation made by or on behalf of Natural England.

[redacted]

# ADDITIONAL COMMENTS PROVIDED BY NATURAL ENGLAND – 27/11/2020

RWE
Rampion 2 Offshore Wind Farm

Project Number: 00-129

Date: August 2023

Revision: 1

**Copyright © 2023 GoBe Consultants Ltd**

All pre-existing rights reserved.

This document is supplied on and subject to the terms and conditions of the Contractual Agreement relating to this work, under which this document has been supplied.

**Confidentiality**

This document is confidential.

All information contained within this document is proprietary to GoBe Consultants Ltd and is disclosed in confidence to the specified parties. Information herein may not be reproduced in whole or in part without the express permission from GoBe Consultants Ltd.

www.gobeconsultants.com

| Revision | Date | Status | Author: | Checked by: | Approved by: |
|---|---|---|---|---|---|
| 0.1 (Internal) | 15/12/2020 | Draft | KJ | | |
| 1 (External) | 21/12/2020 | Final | KJ | | |
| | | | | | |
| | | | | | |
| | | | | | |

# 1 Natural England Additional Comments

1 Natural England provided comments following the Additional ETG meeting on the 21/10/2020 on Fish and Shellfish Ecology. These comments have been collated and are as follows:

## In relation to additional fish and shellfish surveys

- Natural England would defer to the MMO/Cefas on whether additional surveys are required.
- This excludes Black sea bream. Natural England are waiting to see a method statement on the approach to be taken for this species and we will comment further when we have received this.

## In relation to Black bream

- Our advice is that bream are known to leave the site in July and, as the nests require constant maintenance, we do not expect nests to be visible in November. Conducting Drop Down Video surveys outside of the bream nesting season means that the survey outcomes will be limited to confirming only the presence of potential remnant nests and cannot be relied upon to determine the presence or absence of bream nesting. We will therefore not be in a position to agree with any conclusions on absence or extent of nesting black seabream based on surveys undertaken in November, which will be based on a lack of visible active nests.

## In relation to further Black bream studies in Spring 2021 (as raised by AA)

- If the applicant is intending to collect further data on presence/absence of nesting black seabream from specific locations the surveys must occur during the breeding bream season and encompass a minimum of 3 years due to high inter-annual variability of nest locations and densities.

## In relation to Black bream – substrate

- If the applicant is intending to identify potential nesting habitats for black seabream it may be possible this could be inferred from the presence of a thin veneer of sediment over rock surfaces within 20m of depth (50m maximum) including on top of outcrops and large boulders.
- We would highlight that whilst this may be useful to identify potential sites, it would not definitively confirm presence or absence.

## In relation to Noise Assessment Method Statement

- We would like to see this method statement and discuss it before providing a view on the methods to be used. We would like it noted that us not providing comment at this point does not mean we agree with what is proposed.

- It is important the Natural England is consulted on the 'Noise assessment Method Statement'. Natural England understood this method statement would be circulated within 2 weeks of the meeting. This has not been the case. Therefore, we are likely to require the at least four weeks noticed agreed to in the ToR.

.

GoBe

[redacted]

[redacted]

Rampion 2 Wind Farm

wood.

GoBe

# Rampion 2 Offshore Wind Farm

## Method Statement

Fish and Shellfish Ecology

IEMA Transforming the world to sustainability - EIA -

Wood Environment & Infrastructure Solutions UK Limited – December 2020

## Report for

RWE

## Main contributors

[redacted]

## Issued by

........................................................................................

[redacted]

## Approved by

........................................................................................

[redacted]

## Wood

Shinfield Park
Shinfield
Reading RG2 9FW
United Kingdom
Tel +44 (0)118 9131234

Doc Ref.

document1

## Copyright and non-disclosure notice

The contents and layout of this report are subject to copyright owned by Wood (© Wood Environment & Infrastructure Solutions UK Limited 2020) save to the extent that copyright has been legally assigned by us to another party or is used by Wood under licence. To the extent that we own the copyright in this report, it may not be copied or used without our prior written agreement for any purpose other than the purpose indicated in this report. The methodology (if any) contained in this report is provided to you in confidence and must not be disclosed or copied to third parties without the prior written agreement of Wood. Disclosure of that information may constitute an actionable breach of confidence or may otherwise prejudice our commercial interests. Any third party who obtains access to this report by any means will, in any event, be subject to the Third Party Disclaimer set out below.

## Third party disclaimer

Any disclosure of this report to a third party is subject to this disclaimer. The report was prepared by Wood at the instruction of, and for use by, our client named on the front of the report. It does not in any way constitute advice to any third party who is able to access it by any means. Wood excludes to the fullest extent lawfully permitted all liability whatsoever for any loss or damage howsoever arising from reliance on the contents of this report. We do not however exclude our liability (if any) for personal injury or death resulting from our negligence, for fraud or any other matter in relation to which we cannot legally exclude liability.

## Management systems

This document has been produced by Wood Environment & Infrastructure Solutions UK Limited in full compliance with our management systems, which have been certified to ISO 9001, ISO 14001 and OHSAS 18001 by LRQA.

## Document revisions

| No. | Details | Date |
|---|---|---|
| **0.1** | For review | 12/11/20 |
| **0.2** | PM/PD review | 15/12/20 |
| **0.3** | Comments addressed | 16/12/20 |
| **0.4** | PM/PD review | 16/12/20 |
| **1.0** | Issue to RWE | 16/12/20 |
| **1.1** | Final for issue | 23/12/2020 |

# Contents


| | | |
|---|---|---|
| **1.** | **Introduction** | **2** |
| 1.1 | Introduction to Project | 2 |
| 1.2 | Aim of method statement | 2 |
| **2.** | **Scoping** | **3** |
| 2.1 | Introduction | 3 |
| 2.2 | Proposed approach set out in the scoping report | 3 |
| 2.3 | Relevant comments from the scoping opinion | 4 |
| | Overview | 4 |
| | Receptors | 5 |
| | Site-specific surveys | 5 |
| | Impacts | 6 |
| **3.** | **Proposed approach to EIA** | **8** |
| 3.1 | Characterisation of the baseline environment | 8 |
| | The study area | 8 |
| 3.2 | Data sources and approach to characterisation | 1 |
| | Proposed approach to the characterisation of black bream nesting areas | 3 |
| | Existing data sources | 4 |
| | National scientific body data | 0 |
| | Site specific surveys | 0 |
| 3.3 | EIA methodology | 1 |
| 3.4 | Impacts to be assessed | 1 |
| | Overview | 1 |
| | Rationale for Impacts scoped out of assessment | 4 |
| | Cumulative effects | 4 |
| | Transboundary effects | 4 |
| **4.** | **Next steps** | **5** |
| **5.** | **References** | **6** |

# 1. Introduction

Chapter 1 gives a brief introduction to the Rampion 2 Offshore Windfarm and outlines the purpose of this paper.

## 1.1 Introduction to Project

1.1.1 Rampion Extension Development (RED) ('the Applicant') is proposing to develop the Rampion 2 Offshore Windfarm ('Rampion 2'). Rampion 2 would be located adjacent to the existing Rampion Offshore Wind Farm located in the English Channel in the south of England). For the purposes of clarification, in this document, the existing Rampion Offshore Wind Farm is referred to as 'Rampion 1' to enable clear differentiation from Rampion 2. Rampion 2 will include both offshore and onshore infrastructure including an offshore wind farm, export cables to landfall, and connection to the electricity transmission network. The Preliminary Environmental Information Report (PEIR) study area combines the search areas for the onshore and offshore infrastructure.

## 1.2 Aim of method statement

1.2.1 The Evidence Plan process has been set out in the Rampion 2 Evidence Plan Terms of Reference (Wood, 2020a). This Method Statement forms part of the larger Evidence Plan (EP) and has been provided to inform the Fish and Shellfish, Benthic Ecology and Coastal Processes Export Topic Group (ETG). It sets out detail on proposed method to be adopted for the Rampion 2 EIA (from baseline characterisation through to assessment of impact significance), and provides clarity on how issues raised in the Planning Inspectorate's (PINS) Scoping Opinion for Rampion 2 (dated August 2020) have been considered and how these will be addressed within the ES. The assessment methodology presented in this document provides further detail on potential receptors, impact sources and consideration of sensitivity to impacts, including aspects such as ecology and conservation status. The evidence-based approach to baseline determination and utilisation of established data sources opposed to gathering new survey data is explained, as discussed during the first round of ETG meetings.

1.2.2 Within the Scoping Opinion, PINS provided feedback on the data sources and methods to be used to characterise the receiving environment with regards fish and shellfish receptors, this was also supported by consultee responses.

1.2.3 As a response to this feedback and to provide supplementary information to the Scoping Report, this method statement has been produced. This statement reviews the proposed approach at Scoping, the responses received in the Scoping Opinion and sets out the proposed approach to characterise the fish and shellfish ecology baseline environment as a basis for the Environmental Impact Assessment (EIA) to be presented in the PEIR, and subsequently to accompany the Development Consent Order (DCO) application, responding to the specific points raised in the Scoping Opinion. The scope of the assessment has been refined to take into account stakeholder feedback and is presented in **Section 3.**

# 2. Scoping

## 2.1 Introduction

2.1.1 Rampion 2 submitted a Scoping Request and Scoping Report to PINS on the 2nd of July 2020 under Regulation 10 of the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (the EIA Regulations).

2.1.2 This section sets out a brief summary of the data sources and baseline environment methodology, as detailed in the Scoping Report, and the key issues raised in the Scoping Opinion.

## 2.2 Proposed approach set out in the scoping report

2.2.1 In line with the 2017 EIA Regulations, the EIA for Rampion 2 will consider those impacts where there is a risk of a likely significant effect only. The assessment will draw on industry experience and expertise to identify those effect-receptor pathways that may potentially lead to a significant impact. Where experience and available evidence indicates an effect-receptor pathway will not lead to a significant impact with regards to the EIA Regulations (2017) the pathway is scoped out from further assessment. A list of those impacts which have been scoped in and out at screening and any amendments that are to be made from scoping to EIA are listed later in this section paragraph 2.2.13

2.2.2 The scoping assessment is based on a combination of the Rampion 2 project definition, embedded environmental measures, current understanding of the baseline conditions, the evidence base for fish and shellfish effects and professional judgement.

2.2.3 The Scoping Report presented a summary characterisation of the fish and shellfish baseline using data drawn from Rampion 1 baseline characterisation and site-specific surveys, and from a desktop review of publicly available data sources, including broadscale surveys across the English Channel.

2.2.4 The Scoping Report proposed to use existing data to inform the fish and shellfish baseline characterisation, including spawning and nursery grounds, and species of commercial and conservation importance. Key sensitive fish receptors were identified in the Scoping Report; these included sandeel (*Ammodytidae* species), herring (*Clupea harengus*), cod (*Gadus morhua*), black bream (*Spondyliosoma cantharus*), Dover sole (*Solea solea*) and plaice (*Pleuronectes platessa*) due to the proximity of high intensity spawning and nursery areas relative to Rampion 2, and their sensitivity to disturbance. Characterising shellfish receptors included common whelk (*Buccinum undatum*), European lobster (*Homarus gammarus*) and Queen scallop (*Aequipecten opercularis*) . Cuttlefish (*Sepia officinalis*) and short-snouted (*Hippocampus hippocampus*) and spiny (*H. guttulatus*) seahorses were also considered sensitive receptors on account of their sensitivity to underwater noise.

2.2.5 The following species of conservation importance are considered to be sensitive receptors to the Rampion 2 development. Priority Species within the UK BAP's (Biodiversity Action Plan) include elasmobranch species that have the potential to occur within the Rampion 2 fish and shellfish study area. These include undulate ray (*Raja undulata*), spurdog (*Squalus acanthias*), porbeagle shark (*Lamna nasus*), shortfin mako (*Isurus oxyrinchus*), basking shark (*Cetorhinus maximus*), tope (*Galeorhinus galeus*) and blue shark (*Prionace glauca*).

2.2.6 Other species of conservation importance that have the potential to occur in the Rampion 2 fish and shellfish study area include, black bream (*Spondyliosoma cantharus*), European smelt (*Osmerus eperlanus*) and the migratory species sea trout (*Salmo trutta trutta*), European eel (*Anguilla*

*anguilla*), allis shad (*Alosa alosa*) and twaite shad (*A. fallax*). In UK waters both the short snouted and spiny seahorses are of conservation importance and are regularly recorded in the English Channel.

2.2.7 Species of commercial importance to the region were also scoped into the assessment, including whelk (*Buccinum undatum*), sole, horse mackerel (*Trachurus trachurus*), sea bass (*Dicentrarchus labrax*), lobster (*Homarus Gammarus*), scallop, cuttlefish (*Sepia officinalis*) and brown crab (*Cancer pagurus*) as species of commercial importance to the region.

## 2.3 Relevant comments from the scoping opinion

### Overview

2.3.1 In the Scoping Opinion, PINS confirmed that the Scoping Report submitted by RED encompassed the relevant aspects identified in the EIA Regulations, confirmed the impacts and receptors that will be scoped out from further assessment and provided commentary and direction on issues proposed to be scoped in or out of the assessment by RED for the forthcoming EIA.

2.3.2 In relation to the fish and shellfish ecology baseline information, PINS set out the following:

- *The Inspectorate does not specifically agree it is appropriate that no additional data collection is required based on the information presented in the Scoping Report. The Inspectorate considers the need for fish and shellfish surveys to be updated should be specifically considered as part of the Evidence Plan Process and reported in the ES. The ES should then justify the validity of the evidence base in informing a robust assessment of significant effects.*

2.3.3 This was also supported in the consultation response from Natural England:

- *The developer suggests existing site specific data from the existing Rampion 1 project and its preconstruction surveys together with considerable wider studies within the region (as detailed in Table 5.4.1 and paragraph 5.4.18 et seq.) are considered sufficient in describing the fish and shellfish resource within the Rampion 2 study area for the purposes of undertaking an EIA, and they therefore, do not propose to undertake any additional fish or shellfish surveys. Natural England would assert that the existence of site-specific data for Rampion 1, does not in itself diminish the need for up to date and site specific fish and shellfish surveys to be carried out to inform this new development.*

2.3.4 With specific reference to the proposed approach to the characterisation of black bream nesting areas, the Marine Management Organisation (MMO) provided the following responses to the scoping request:

- *The post 2016 survey data includes sampling beyond June to potentially help ascertain if, and for how long, the reproductive season of black bream around Kingmere MCZ extends. For this sampling period there have been discrepancies between years with survey dates/months differing in timings post June and there were issues with image quality/consistency. Interpretation of the aggregate data requires some consideration of the environmental conditions which are likely to influence the onset of black bream spawning activity and thus potentially effect monitoring results. The aggregate data is spatially limited to the monitoring area; thus, it does not identify whether there are black bream nesting areas within/beyond the MCZ boundary and Rampion 2 search areas. Therefore, the MMO believes that this may not be sufficient to provide a baseline for the Rampion 2 EIA as aggregate monitoring data is comprised of specific sampling points each season, and these are within a defined geographic area. Additionally, the MMO notes that surveys conducted for Rampion 1 identified potential black bream nesting outside of the MCZ. The EIA* *assessment should include consideration of all potential nesting sites within the Rampion 2 and associated zone of influence.*

2.3.5 In addition to direction and comments provided in relation to baseline characterisation, PINS also set out the need to 'scope in' a number of additional receptors. In response to the Scoping Opinion, the following sections identify the refined receptor list and the impacts that will be taken forward as part of the EIA for the Rampion 2 DCO Application.

## Receptors

2.3.6 Taking into consideration responses from consultees, the following additional receptors will also be scoped into the assessment:

- sea lamprey: whilst Sea trout, and European eels were proposed to be scoped in for assessment as migratory species within the scoping report, sea lamprey (*Petromyzon marinus*), which also use the River Arun as a migration route, will be scoped in;
- undulate ray: whilst the Scoping Report identified Undulate ray as being considered within the assessment of species of conservation importance, this assessment will also scope in assessment of impacts to the nursery grounds of this species as a receptor due to the location of key nursery grounds in the vicinity of Rampion 2;
- features of the Beachy Head Marine Conservation Zone (MCZ) (Short-snouted seahorse); and
- features of the Bembridge MCZ (Short-snouted seahorse, and native oyster (*Ostrea edulis*)).

2.3.7 With these additional species and receptors included within the assessment it is considered that a comprehensive suite of potential characterising and sensitive receptors exist for the purposes of undertaking an EIA.

## Site-specific surveys

2.3.8 As directed by PINS within the Scoping Opinion, the requirement for additional site-specific fish survey work was discussed at the fish and shellfish ecology Expert Topic Group (ETG) under the EP process on 17th September 2020 and 21st October 2020. Whilst valid points were raised about such surveys providing the most contemporary data, the broad range of literature and surveys available for the region provide robust and reliable information upon which to base the characterisation, encompassing appropriate spatial and temporal scales for the EIA. On this basis it was put forward that further surveys would not be expected to identify further species as sensitive receptors for the assessment and as such it can be concluded with confidence that the characterisation based on available data is fit for the purpose of undertaking an EIA.

2.3.9 With regards the likely distribution and presence of the species it was considered that further 'general' characterisation surveys would not materially alter the conclusions of the assessments that will be undertaken, or the necessary mitigation required. As such, RED reiterated that it considered that further site-specific surveys would not be required. This conclusion was agreed by Cefas in the ETG meeting held on 21/10/2020. MMO confirmed agreement with this conclusion in a written response to meeting minutes on 30/11/2020, with Natural England stating in comments on meeting minutes provided on 27/11/20 that it would defer to the MMO/Cefas on whether additional surveys are required. It is acknowledged that there remains uncertainty with respect the presence/absence and distribution of spawning locations (nesting areas) for black bream. Whilst the species does not hold a designated status outside of the site, black bream is a feature of the Kingmere MCZ, as is the veneer sediment that the species exploits during the spawning season. Black bream spawn within veneer sediments in the near shore and it is recognised that aggregate dredging is seasonally restricted within the MCZ in order to avoid significant effects on the black bream during the annual spawning within the MCZ and wider region. The aggregate industry has undertaken extensive monitoring adjacent to and within the proposed Rampion 2 offshore export cable corridor.

2.3.10 Extractive fisheries are also restricted within the MCZ, with for example towed gear only permitted in a discrete zone of the MCZ during the period 1st July – 31st March but are not restricted either spatially or temporally in the wider region. It is further recognised that black bream spawn outwith the MCZ and across wider areas than those covered during the focused surveys undertaken by the aggregate industry, and that this may vary seasonally. Further surveys may assist in identifying the spatial pattern of spawning within the year a survey is undertaken, and this is evidenced in **Chapter 3** of this report. However, this will not materially alter the understanding of the primary spawning season, which is identified within the Kingmere MCZ Supplementary Advice as being in the period April – June and reflected in all byelaws associated with the black bream component of the Kingmere MCZ.

2.3.11 Given the interannual variability of black bream spawning, it is considered that further survey work would not preclude the need to assess potential impacts on the species, rather it would identify that the area subject to potential direct impact may be used by black bream on occasion. The same conclusion can be drawn through reference to regional fisheries data, either through reference to MMO monitoring, IFCA, or consultation information provided by local fishermen for the adjacent marine aggregate extraction EIA, and as such it is considered that further characterisation survey will provide limited value.  However, it is also notable that additional data on black bream nesting activity will be provided from the geophysical surveys undertaken in 2020. These data will augment existing information across a wider area, as well as drop-down camera imagery gathered during benthic characterisation surveys that may also yield data to provide further context (where relevant and appropriate and noting discussions on the seasonality of such work influencing the added value of such work).

2.3.12 As such it is proposed no further characterisation surveys for fish generally, or black bream specifically will be undertaken, and instead presence of spawning black bream within the export cable corridor will be assumed, and the assessment undertaken on this basis. It is assumed that any impact is of short duration and as such recovery will be possible, and black bream will return to spawn in the area and excavate the characteristic 'nests'. In lieu of additional characterisation surveys, and in order to validate any predictions made within the EIA, RED commits to undertake pre-and post-construction surveys of the zone in which construction will take place adjacent to the Kingmere MCZ. The surveys will be targeted to understand the duration of recovery, e.g., to monitor the return of the species to nesting areas recorded as being following cable installation.

## Impacts

2.3.13 With regards the potential impacts associated with Rampion 2, the following impacts were presented in the Scoping report and  will be assessed within the EIA in support of the Rampion 2 DCO Application:

- mortality, injury, behavioural changes and auditory masking arising from noise and vibration (construction and decommissioning);
- temporary localised increases in SSC and smothering (construction and decommissioning);
- direct disturbance resulting from the installation of the export cable (construction and decommissioning); and
- long-term loss of habitat and increased hard substrate and structural complexity due to the presence of turbine foundations, scour protection and cable protection (operation).

2.3.14 Following receipt of the Scoping Opinion, and consultee responses, the below impacts (which were initially proposed to be scoped out in the Scoping Report) are now proposed to be scoped into the assessment for the Rampion 2 EIA:

- electromagnetic field (EMF) impacts arising from cables (operation);
- direct disturbance resulting from maintenance within the array area and the offshore cable corridor (operation);
- direct disturbance resulting from construction within the array (construction and decommissioning); and
- direct and indirect seabed disturbances leading to the release of sediment contaminants (construction and decommissioning).

2.3.15 As set out within the Scoping Opinion, the following impacts have been scoped out of the fish and shellfish ecology assessment and following agreement with stakeholders will remain scoped out of the assessment for Rampion 2 EIA:

- accidental pollution impacts during the construction phase resulting in potential effects on fish and shellfish receptors (construction and decommissioning);
- underwater noise as a result of operational turbines (operation); and
- potentially reduced fishing pressure within the Rampion 2 array area and increased fishing pressure outside the array area due to displacement (operation).

# 3. Proposed approach to EIA

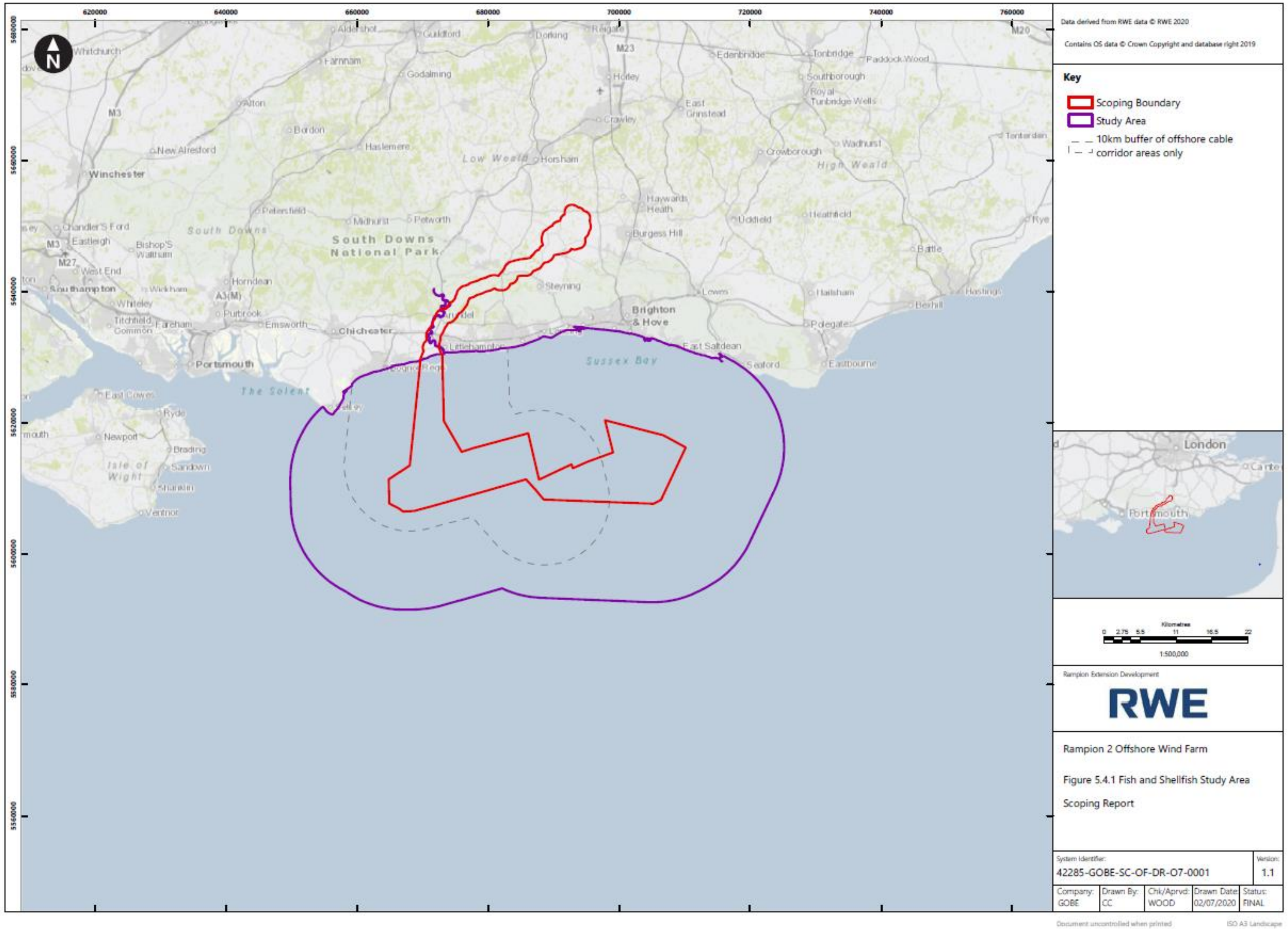
## 3.1 Characterisation of the baseline environment

### The study area

3.1.1 The study area for fish and shellfish ecology has been informed by tidal excursions extent, and coastal processes modelling undertaken to inform the previous Rampion 1 EIA, and an understanding of the likely Zone of Influence (ZOI) associated with underwater noise. The Zone of Influence buffer encompasses the area over which suspended sediments may travel following disturbance as a result of Rampion 2 activities, extending a precautionary 15km around the array Scoping Boundary and 10km surrounding the offshore cable corridor (**Figure 3-1**).

3.1.2 The study area for noise impacts to fish and shellfish will be informed by noise propagation modelling, however, the distances at which significant effects on sensitive receptors from the impacts of noise emissions might arise are anticipated to fall within the wider study area included for the EIA, and thus provides for appropriate understanding of the zone within which significant noise effects might be predicted to occur. The study area proposed for the EIA will be reviewed and defined through reference to matters such as refinement of the offshore project components, the identification of additional impact pathways, and in response to feedback from consultation through the Evidence Plan Process (EPP).

Figure 3-1 The Rampion 2 OWF scoping boundary and wider ZOIs for fish and shellfish ecology study area.



## 3.2 Data sources and approach to characterisation

3.2.1 As noted previously, Rampion 2 proposes to utilise existing data sources to characterise the fish and shellfish ecology baseline environment, these data sources are provided in **Table 3-3** below.

3.2.2 On the basis that sufficient information exists to enable a robust characterisation of the receiving environment, and identification of relevant valued ecological receptors for the purposes of assessment, additional fish and shellfish surveys are not proposed for Rampion 2. The existing site-specific data from the Rampion 1 EIA, and from wider studies within the region (**Table 3-3)**, are considered appropriate and adequate for the purposes of characterising the receiving environment with regards the fish and shellfish assemblage within the Rampion 2 study area and are therefore fit for the purpose of informing an EIA. The data sources described in this section allow a robust conclusion to be drawn that further survey would not identify additional receptors, and would not materially alter the findings of the assessment with regards either altering the likely magnitude of impact or sensitivity of receptors, or alter the need or otherwise for appropriate mitigation.

3.2.3 Geophysical surveys were undertaken between July and August 2020, and these data will be utilised to augment existing data with regards the likely location of nesting areas for black bream. It should be noted that the geophysical data will supplement several regional datasets already identified which focus specifically on the distribution of black bream nests within the ZOI of Rampion 2. In this context it will provide an additional layer of available evidence for the characterisation, but these data will not be wholly relied upon in isolation to identify either the specific and categorical presence or the distribution of black bream nests for the purposes of the EIA. As has been highlighted in consultation under the Evidence Plan process, black bream nesting habits are recognised as being subject to inter-annual variation. It is therefore considered a more precautionary view to assume the presence of nests rather than seeking to rely on a single year's data, even if that is contemporary, to screen out any potential for interaction between proposed project activities or infrastructure and nesting areas. In this way, and recognising the nature of the seabed is also an important determining factor in the distribution of bream nesting, the assessment can ensure appropriate consideration of the potential for impacts to nesting areas is provided, which in turn therefore also ensures precautionary assessment of effect significance can be delivered.

3.2.4 The following guidance documents will also be considered in relation to fish and shellfish ecology:

- National Policy Statement NPS EN-1 (Overarching National Policy Statement for Energy) and NPS EN-3 (National Policy Statement for Renewable Energy Infrastructure).
- Guidelines for Ecological Impact Assessment in Britain and Ireland, Marine and Coastal (Institute for Ecology and Environmental Management (IEEM, 2010));
- Guidance note for EIA in respect of FEPA and CPA requirements (Cefas *et al.*,2004);
- Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects (Judd, 2012); and
- Guidance on Environmental Considerations for Offshore Wind Farm Development (OSPAR, 2008).

Table 3-1 Key fish and shellfish ecology data sources

| Source | Summary | Study Area coverage |
|---|---|---|
| **Fisheries Sensitivity Maps in British Waters (Coull et al, 1998)** | Fisheries sensitivity maps showing spawning and nursery areas of commercially important fish and shellfish species. | Coverage of UK waters. |
| **Spawning and nursery grounds of selected fish species in UK waters (Ellis et al, 2010)** | Maps indicating the main spawning and nursery grounds for 14 commercially important species. | Coverage of UK waters. |
| **Modelled distributions of ten demersal elasmobranchs of the eastern English Channel in relation to the environment (Martin et al, 2012)** | Modelled distributions of elasmobranch populations within the eastern English Channel. | Coverage across the eastern English Channel. |
| **Distribution of skates and sharks in the North Sea: 112 years of change (Sguotti et al, 2016)** | Distributions of elasmobranch populations in the North Sea. | Coverage of the North Sea. |
| **Assessing the status of demersal elasmobranchs in UK waters: a review (Ellis et al, 2005)** | Status of elasmobranch populations in UK waters. | Coverage of UK waters. |
| **The International Herring Larvae Surveys (IHLS) (ICES, 1967-2019)** | Herring larvae surveys conducted in the North Sea and adjacent areas, to provide quantitative estimates of herring larval abundance, used as a relative index of changes of the herring spawning-stock biomass. | Coverage across the North Sea and English Channel. |
| **UK sea fisheries annual statistics report (MMO, 2020)** | Information on landings of the UK fishing fleet, and the status of commercial fish stocks over the last five years (2015-2019). | Full coverage of the study area. |
| **Rampion OWF Environmental Statement (E.ON 2012)** | Site specific fish and shellfish surveys undertaken to inform the existing Rampion 1. | Site specific data across the existing Rampion 1. |
| **Rampion OWF Pre-construction Fish and Shellfish Monitoring Report (Natural Power, 2017)** | Site specific pre-construction fish and shellfish otter and beam trawl surveys undertaken to inform the existing Rampion 1 Environmental Statement. | Site specific data across the existing Rampion 1. |
| **Rampion OWF Post-Construction Fish Monitoring Report (Ocean Ecology, 2020)** | Site specific post-construction fish and shellfish otter and beam trawl surveys undertaken within the array area, export cable route and in reference areas outside the Rampion 1 OWF. | Site specific across the existing Rampion 1 OWF. |
| **North Owers Black Bream Monitoring report (GoBe, 2015)** | Black Bream monitoring report for North Owers marine aggregate extraction area. | Regional context of black bream populations. |
| **Area 435/396, Area 453 and Area 488 Annual Monitoring Reports (EMU, 2009; Fugro EMU Ltd. 2013 and 2014).** | Environmental monitoring reports for marine aggregate extraction areas (Area 435/396, Area 453 and Area 488) within the region. | Regional context. |
| **A study of the Black Bream Spawning Ground at Littlehampton (Southern Science Ltd., 1995** | Black bream spawning ground monitoring study. | Regional context. |
| **Black Seabream tagging survey (Sussex IFCA, 2016)** | Black bream monitoring data from tagging surveys will be used if the data are available and have sufficient confidence to inform the EIA. | Regional context. |
| **Black bream in the English Channel off the Sussex coast (EMU, 2012)** | Monitoring report of black bream in the English Channel. | Regional context. |

| Source | Summary | Study Area coverage |
|---|---|---|
| **ICES Fish Map (ICES, 2006)** | North Sea fish species distribution maps. | Coverage of UK waters. |
| **Offshore beam trawl surveys (ICES, 1985-2019)** | Offshore beam trawl surveys providing species distribution data. | Coverage across the southern North Sea and English Channel. |
| **North Sea International Bottom Trawl Survey (ICES, 1965-2020)** | Bottom trawl surveys providing species distribution data across the North Sea | Coverage across the North Sea and English Channel. |
| **Marine Aggregates Regional Environmental Assessment (MAREA) (EMU, 2010)** | Fisheries activity survey data, and sediment transport data across the English Channel. | Coverage across the English Channel. |
| **Marine Aggregate Levy Sustainability Fund (MALSF) synthesis study in the central and eastern English Channel (James et al, 2011)** | Fisheries activity survey data, and sediment transport data across the English Channel. | Coverage across the English Channel. |
| **Sussex Inshore Fisheries and Conservation Authority (IFCA)** | Fisheries monitoring reports and research reports. | Regional context. |
| **License areas 453 CEMEX UK Marine Ltd. (CMX) and 488 Tarmac Marine Ltd., Aggregate monitoring data.** | 2017 – 2020 data covering seven survey boxes and two transects in and around the Kingmere MCZ . | Coverage in and around the Kingmere MCZ adjacent to cable route |

3.2.5 As detailed in the Scoping Report information on spawning and nursery areas for fish species (as outlined above) is based on data Coull *et al.* (1998) and further supported by Ellis *et al.* (2010) data. These data sources will provide context of the important spawning and nursery grounds within and in the vicinity of Rampion 2 as part of the EIA.

3.2.6 Any potential impacts on migratory species relevant to the ZOI will be assessed where applicable, this includes sea trout, eels and sea lamprey.

## Proposed approach to the characterisation of black bream nesting areas

3.2.7 Black bream are known to spawn in the eastern English Channel, with spawning occurring in inshore areas where suitable substratum occurs. The nearest spawning ground to Rampion 2, lies along the 10m depth contour between Bognor and Worthing. As a result of their substrate dependant spawning nature, and their conservation importance (designated feature of the Kingmere MCZ) black bream are considered a key sensitive receptor to the Proposed Development.

3.2.8 As noted previously, the Applicant considers there to be adequate data available for the purposes of undertaking an EIA for all fish and shellfish receptors, including black bream. The Applicant has concluded through the analysis of available data and conservation objective data for the Kingmere MCZ that further survey data collected at this characterisation stage would not materially alter the assessment with regards the temporal or spatial distribution of the species and its key sensitive period and would not alter the likely mitigation measures that may or may not be required, subject to the findings of the EIA.

3.2.9 To complement the existing twenty years of data (**Table 3-3**) the Applicant proposes to utilise site specific geophysical data (side scan sonar) to identify any residual black bream nesting areas present during the survey period. Whilst the survey may not be undertaken during the core nesting period the data may aid in the understanding of the longevity of the nest features. The existing data sources will be used to alongside the project specific survey data, notably black bream monitoring data collected for marine aggregate extraction areas. These data identify the presence of black bream nests within the proposed offshore export cable corridor and therefore the need to assess potential impacts on the species at this location, outwith the MCZ. Additionally, various literature sources will be used to inform the characterisation, including the presence of black bream nests within the MCZ.

3.2.10 A summary of the data sources is provided in **Table 3-3** below, with a breakdown of the individual sources provided in this report.

Table 3-2 Black bream data sources

| Data Source | Data Type | Temporal Extents | Spatial Extents |
|---|---|---|---|
| **Area 453/481 ES and associated application documents** | Area 435-396 Annual Monitoring Report and Five Year Review (November 2009) – this report presents a summary and comparison of data collected from five years of monitoring | 2002, 2006, 2007, 2008 and 2009 | Various survey areas across the Kingmere MCZ and adjacent to the Rampion 2 offshore export cable corridor. |
| | Area 435-396 Annual Monitoring Report and Five Year Review (March 2014); as above this presents a 5 ear summary | 2002, 2009, 2011, 2013 | |
| | Area 453-488 Geophysical Survey Report (2013); this report formed the basis for the EIA characterisation for the Area 453/481 application | 2001, 2011, 2013 | |
| **Tarmac Marine Ltd** | • Bathymetry data<br>• Drop Down Video (DDV) transects<br>• Photographs of seafloor<br>• Survey report | 2017-2020 | Various survey areas across the Kingmere MCZ and across the mid-section of the Rampion 2 offshore export cable corridor. |
| **Sussex IFCA worked with Cefas and Fugro-EMU** | • Bathymetry data<br>• DDV transects<br>• Survey report | 2014 | Various survey areas across the Kingmere MCZ and across the mid-section of the Rampion 2 offshore export cable corridor. |
| **Rampion 2 Geophysical site-specific surveys** | • Side scan sonar<br>• Bathymetry | 2020 | 100% coverage of the Rampion 2 array area and offshore export cable corridor. |

## Existing data sources

3.2.11 Rampion 2 will utilise existing data sourced from back bream monitoring surveys undertaken for marine aggregate extraction areas. The annual monitoring data for years 2017 to 2019 was purchased from Tarmac Marine Ltd. The data available for each year include the following components:

- bathymetry data within seven survey boxes and two survey transects to identify location of nests;
- DDV transects across the areas of bream nest sites identified in the bathymetry survey, focusing on dense nest aggregations;
- high resolution still photographs of observed nests; and
- survey summary report.

3.2.12 The black bream monitoring consisted of annual bathymetry and side scan sonar surveys, to characterise nesting distribution and determine the approximate density of black bream nests within and around the Kingmere MCZ. The data was collected in various 'survey areas' across the Kingmere MCZ and across the mid-section of the Rampion 2 offshore export cable corridor.

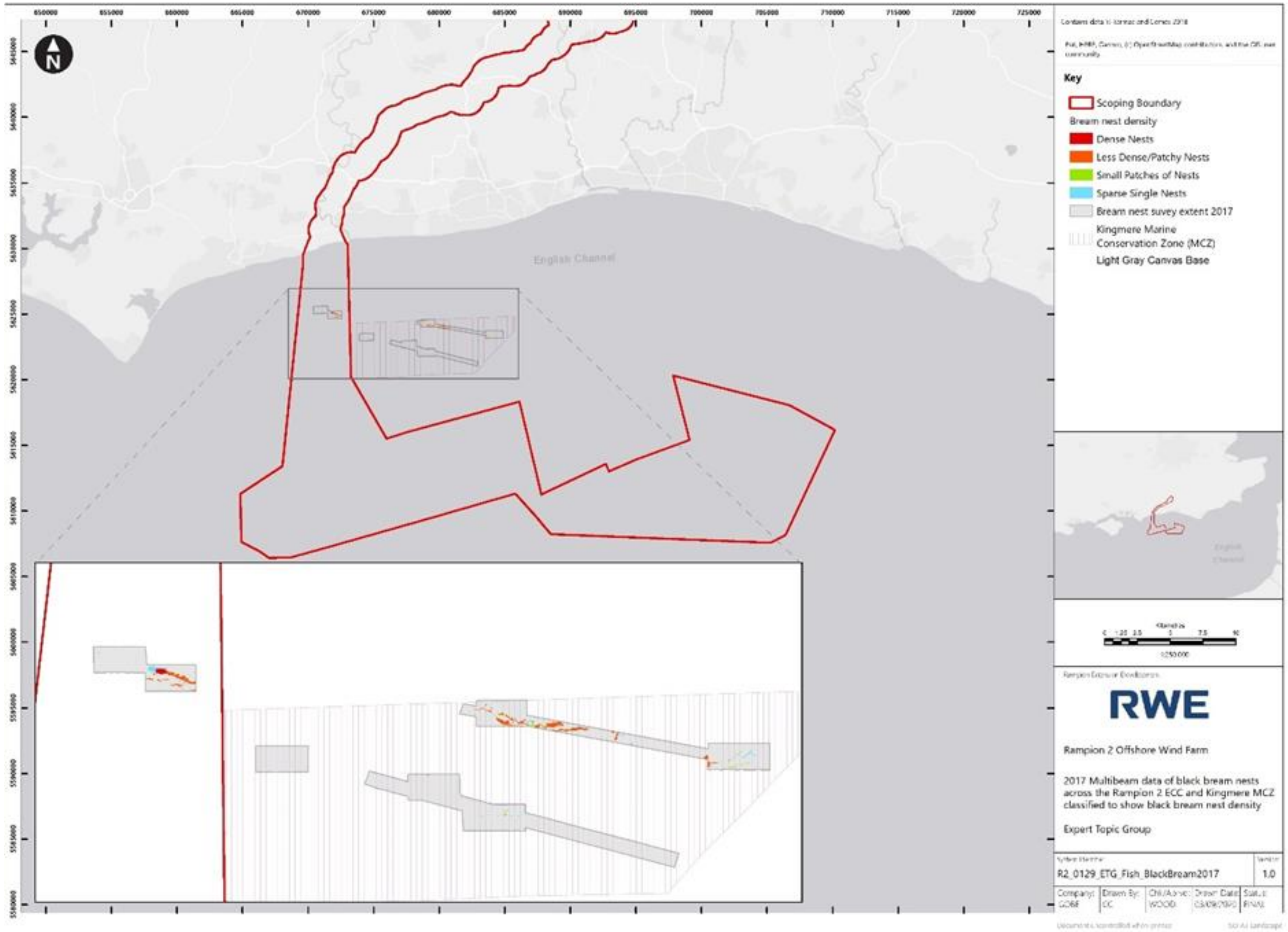
3.2.13 This data was supported by DDV and stills to confirm the locations of the nests, which was analysed, interpreted and classified into the following density classes:

- dense nests
- faint dense nests
- less dense/ patchy nests
- small patches of nests
- no nests

3.2.14 The data sources outlined above provide good coverage across the Kingmere MCZ and extends across the Rampion 2 offshore export cable corridor. The data indicates the presence of frequent high-density nests in the eastern survey area in the Rampion 2 offshore export cable corridor (see **Figure 3-2** to **Figure 3-4**). The nest density decreases as the survey extends towards the eastern survey area in the export cable corridor. These data are considered appropriate for the purposes of characterisation for EIA as they provide robust spatial and temporal coverage across the area of greatest sensitivity.

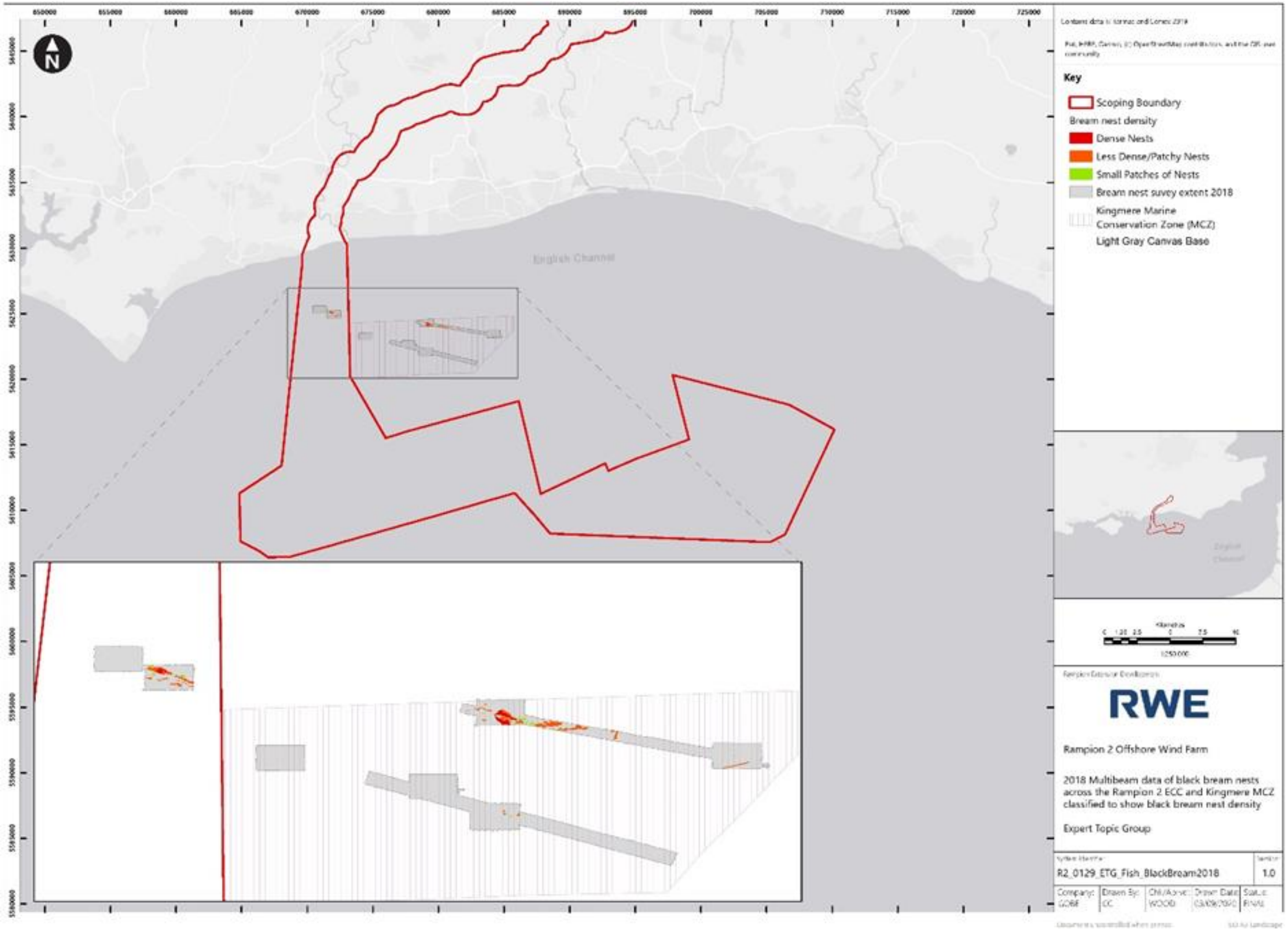
3.2.15 These data will be collated alongside site specific data to provide a robust site-specific dataset that will be presented within the PEIR, and also via the EP for agreement. In order to best evidence the temporal variation, we propose to undertake a heatmap analysis, collating the data across years in order to produce a single data set of likely spread. This method is considered appropriate as it will allow discrimination between areas frequently subjected to dense nesting activity and areas that may be subject to a single year of exploratory nesting activity by juveniles. The combined analysis will present a baseline that adequately characterises both the receiving environment for potential direct effects, and secondary effects, and is a robust basis on which to undertake the EIA.

Figure 3-2 2017 multibeam data of black bream nests across the Rampion 2 offshore export cable corridor and Kingmere MCZ classified to show black bream nest density



© Wood Group UK Limited

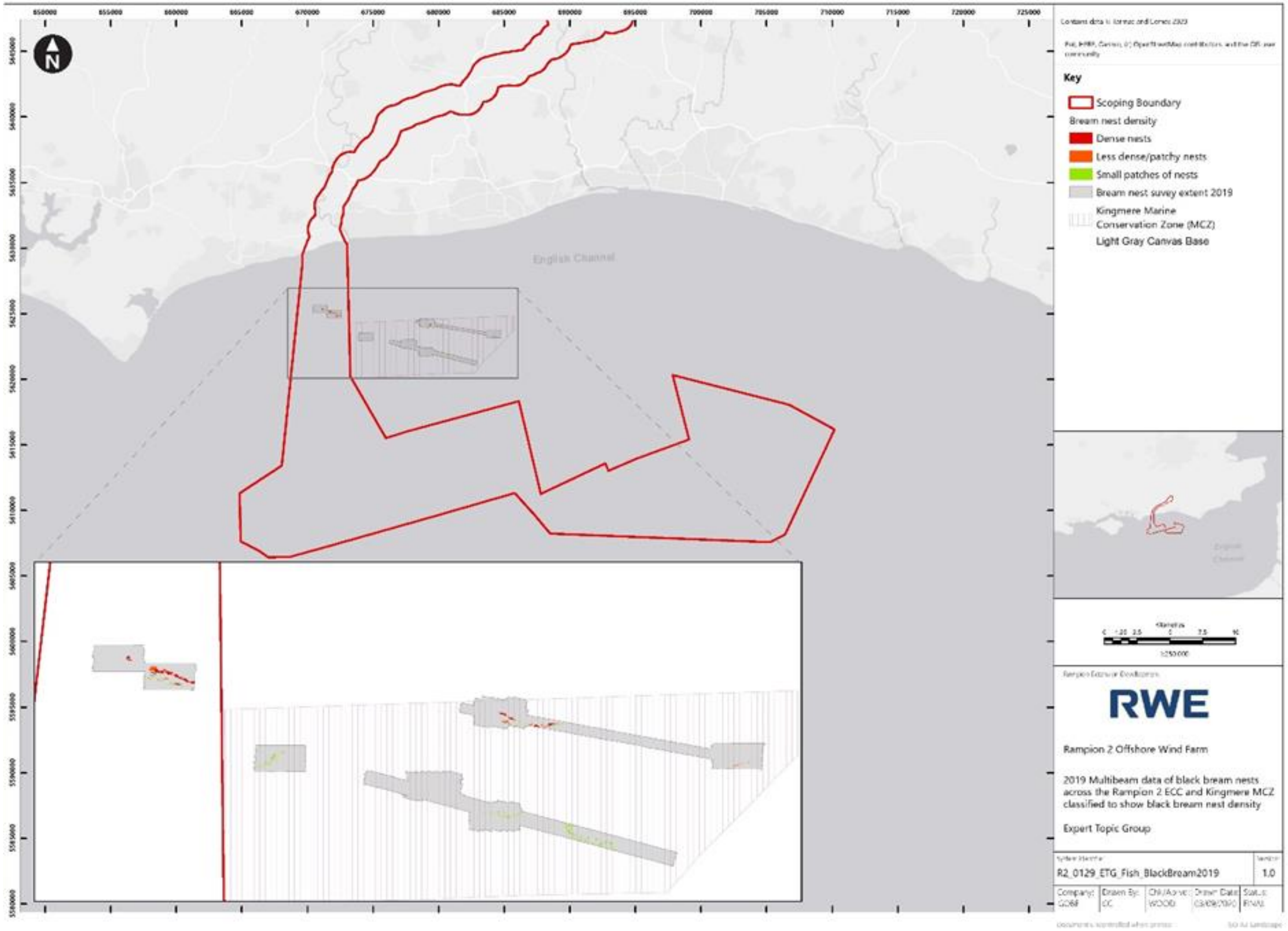

Figure 3-3 2018 multibeam data of black bream nests across the Rampion 2 offshore export cable corridor and Kingmere MCZ classified to show black bream nest density



© Wood Group UK Limited



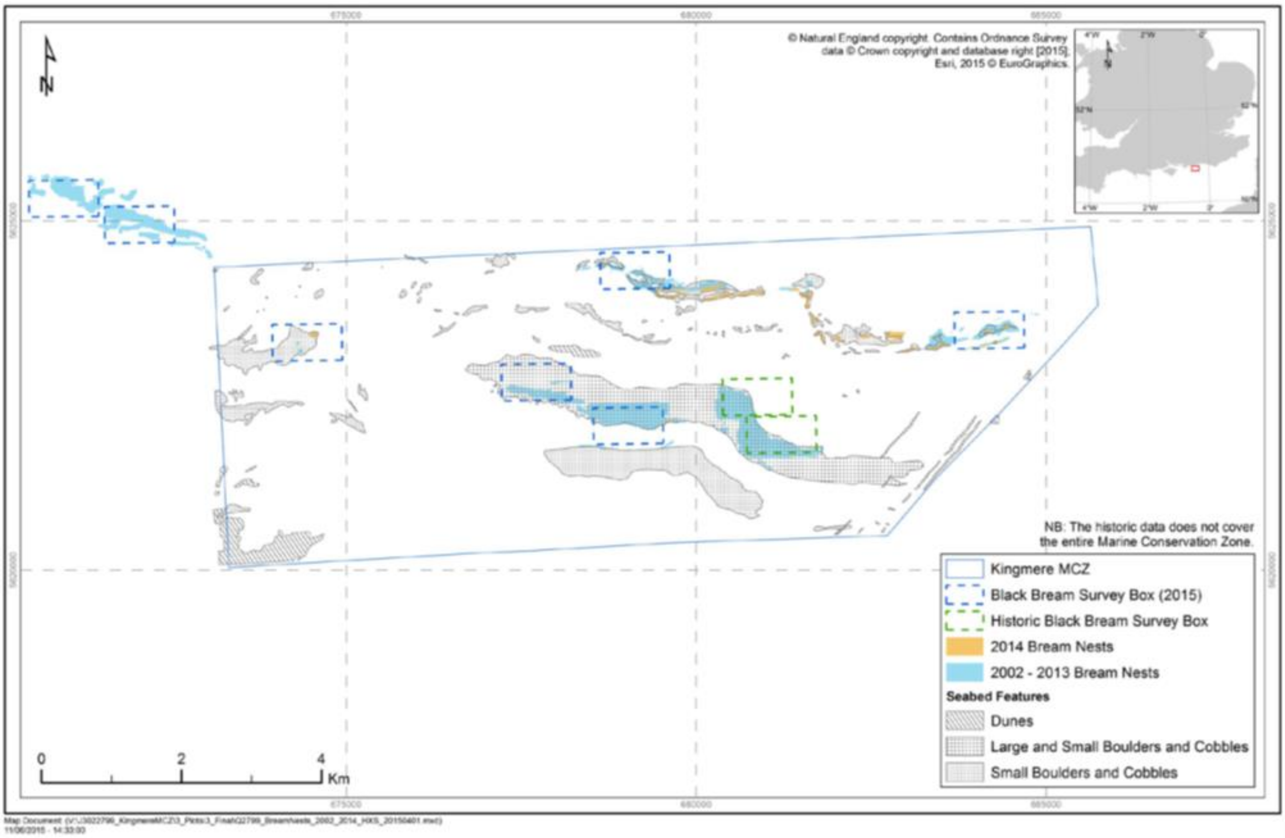
Figure 3-4 2019 multibeam data of black bream nests across the Rampion 2 offshore export cable corridor and Kingmere MCZ classified to show black bream nest density



## National scientific body data

3.2.16 The Sussex IFCA worked with Cefas and Fugro-EMU to conduct side scan sonar surveys supported by targeted video ground-truthing from the 1 May and 22 July 2014 to inform knowledge gaps on bream nest distribution throughout the Kingmere MCZ. The data were categorised by nest density and presented in relation to the Kingmere MCZ (**Figure 3-5**). The data showed that areas with the highest density of nests were located within north west extent of the Kingmere MCZ. The study also illustrated that bream nesting is historically across areas of thin sediments over bedrock features rather than the deeper paleochannel infill material. These data will be collated with the aggregate industry data and site-specific survey data to create a robust assessment of black bream nesting areas, within Rampion 2 and the Kingmere MCZ.

Figure 3-5 Sussex IFCA/ Cefas 2014 survey data interpreted by Fugro EMU




## Site specific surveys

3.2.17 Site specific side scan sonar survey data was collected for Rampion 2 in July/August 2020, across the offshore export cable corridor and the array area. The data will be analysed to determine black bream nest identification, with the data being processed for bathymetry and backscatter to enable nest identification. Whilst it is noted that November is not the optimum period for nesting activity to be recorded as nests may be obscured by sediment movement, particularly in areas characterised by a mobile seabed environment, it is also noted that some nests are long lived, with previous seasons nests being identified in and around the Kingmere rocks during surveys (453/481 ES).

3.2.18 Where nests are identified the data will be interpreted, and nests classified into the density classes noted above. These density classes will be presented in figures, alongside the pre-existing aggregate monitoring data to enable a robust assessment of black bream nesting areas across the Kingmere MCZ and the Rampion 2 offshore export cable corridor. The collated or composite dataset will be utilised to identify the zone of potential interaction during cable installation, with the 2020 data adding another layer to the twenty years of data already collected across the area, to ground truth and reinforce the Geophysical data interpretation.

3.2.19 Sediment plume modelling, and noise modelling will be used to determine the potential for impacts on nesting and spawning black bream, by determining the potential for overlap of impact ranges with areas of nesting.

3.2.20 The Applicant is confident that this combination of approaches will allow for appropriate consideration of impacts on spawning black bream.

## 3.3 EIA methodology

3.3.1 The baseline will be established through the compilation of both desk-based studies and site-specific field surveys from Rampion 1, along with geophysical surveys conducted within Rampion 2. The site-specific surveys and extensive existing data will help give a snapshot of fish and shellfish communities within the Rampion 2 fish and shellfish ecology study area.

3.3.2 The worst-case scenarios on which the assessments will be based, will be defined in accordance with the Rochdale Envelope approach; the geographic footprint, the foundations proposed, and the piling hammer energies will be key considerations in defining the worst-case scenarios for fish and shellfish ecology receptors. Following this, the likely significant effects on receptors from the worst-case scenarios will be described and assessed.

3.3.3 The assessment of potential impacts on fish and shellfish ecology receptors will consider the magnitude and duration of the impact, the reversibility of the impact and the timing and frequency of the activity. The sensitivity of difference receptors will also be considered as part of the impact assessment based on best available knowledge and literature; resources such as, the Marlin Marine Evidence based Sensitivity Assessment (MarESA) will be used, where species/group data is available. The sensitivity assessment of the species will take into account the current status of the species, and its importance (locally, regionally, nationally or internationally). The assessment will also include the consideration of potential significant cumulative effects as appropriate.

## 3.4 Impacts to be assessed

### Overview

3.4.1 In line with the 2017 EIA Regulations, the EIA for Rampion 2 OWF will consider those impacts where there is a risk of a likely significant effect only. The following section draws on industry experience, expertise, and the MMO 2012 review of post-consent monitoring, to identify those effect-receptor pathways that may potentially lead to a significant effect. Where experience and available evidence indicates an effect-receptor pathway will not lead to a significant effect with regards to the EIA Regulations (2017) the pathway is scoped out from assessment.

3.4.2 The potential impacts that may lead to a significant effect on fish and shellfish ecology, which are proposed to be scoped in for further assessment, are provided in **Table 3-3**. The scoping assessment is based on a combination of the definition of Rampion 2 at this stage, embedded environmental measures, understanding of the baseline conditions at this stage, the evidence base for fish and shellfish ecology effects and professional judgement.

3.4.3 This is a tool aimed at delivering a proportionate approach to the EIA. In doing so, it sets out a high-level assessment of all potential effects, significant or not, and distinguishes between the level of assessment proposed for significant effects 'scoped in' as simple or detailed. The basis for scoping out certain effects, and therefore no longer considered is presented after the table, supported by evidence base.

Table 3-3 Likely significant effects on fish and shellfish receptors

| Activity and impact | Embedded measures | Effect | Proposed approach to assessment | Receptor | Further data baseline requirements |
|---|---|---|---|---|---|
| **Mortality, injury, behavioural changes and auditory masking arising from noise and vibration (Construction and Decommissioning)** | C-52 | Likely significant effect through mortality, injury, behavioural changes and auditory masking in sensitive receptors. | Scoped in; Detailed assessment. The effects on fish and shellfish ecology from increases in underwater noise during construction (such as piling activity) and decommissioning phases. The sensitivity of fish and shellfish will be assessed through noise assessment, along with available literature and expert knowledge. | Black bream, sandeel, herring, seahorse, cod, plaice, cuttlefish and sole. | Site specific predictive noise modelling will be undertaken to inform the noise impact assessment. |
| **Temporary localised increases in SSC and smothering (Construction and Decommissioning)** | | Likely significant effect through smothering of demersal spawning species. | Scoped in; Detailed assessment. The effects on fish and shellfish ecology from increased suspended sediment and sediment deposition will be informed by the findings and assessment of the Physical Processes Chapter. The sensitivity of fish and shellfish to the impact will be determined through available literature and expert knowledge, based on the habitats resilience and resistance to impacts. | Demersal spawners - Black bream | The assessment will be informed by the findings and assessment of the Physical Processes section. |
| **Direct disturbance resulting from the installation of the export cable (Construction and Decommissioning)** | C-44 | Likely significant effect through disturbance of demersal spawners. | Scoped in; Detailed assessment. The area of habitat disturbance will be defined using a worst-case scenario-based approach. The sensitivity of fish and shellfish receptors to the impact will be determined through available literature and expert knowledge, based on the habitats resilience and resistance to impacts | Demersal spawners - Black bream and sandeel | The assessment will be informed by a sediment characterisation and interpretation of geophysical survey data. |
| **Long-term loss of habitat and increased hard substrate and structural complexity due to the presence of turbine foundations, scour protection and cable protection (Operation)** | C-44 | Likely significant effect through loss of suitable spawning substrates for demersal spawners. | Scoped in; Detailed assessment. The potential impact on fish and shellfish ecology receptors through the loss of preferred habitat and introduction of hard substrate will be defined using a worst-case scenario to determine the maximum area of impact. The sensitivity of habitat types to the impact will be determined through available | Demersal spawners - Black bream and sandeel | The assessment will be informed by a sediment characterisation. |

| Activity and impact | Embedded measures | Effect | Proposed approach to assessment | Receptor | Further data baseline requirements |
|---|---|---|---|---|---|
| | | | literature and expert knowledge, based on the habitats resilience and resistance to impacts. | | |
| **Electromagnetic field (EMF) impacts arising from cables (Operation)** | C-45 | Likely significant effect through disturbance from EMF arising from offshore cables associated with the array, interconnector and export cable. | Scoped in following Scoping Opinion and consultation responses; Detailed assessment. The effect on fish and shellfish ecology from potential EMF effects will be determined through available literature and expert knowledge. | Elasmobranch and migratory fish species | The assessment will be informed by an extensive literature review. |
| **Direct and indirect seabed disturbances leading to the release of sediment contaminants (Construction and Decommissioning)** | C-53 | Likely significant effect through release of sediment bound contaminants into the water column. | Scoped in following Scoping Opinion and consultation responses; Detailed assessment. The effect on fish and shellfish ecology from changes to water quality will be informed by the findings and assessment of the Water Quality Assessment. The sensitivity of habitat types to the impact will be determined through available literature and expert knowledge, based on the habitats resilience and resistance to impacts. | Fish and shellfish ecology | The assessment will be informed by the findings of sediment contaminant analyses. |
| **Direct disturbance resulting from construction within the array (Construction and Decommissioning)** | C-44 | Likely significant effect through disturbance of demersal spawners. | Scoped in; Detailed assessment. The area of habitat disturbance will be defined using a worst-case scenario-based approach. The sensitivity of fish and shellfish receptors to the impact will be determined through available literature and expert knowledge. | Fish and shellfish ecology | The assessment will be informed by a sediment characterisation and interpretation of geophysical survey data. |
| **Direct disturbance resulting from maintenance within the array area and the offshore cable corridor (Operation)** | | Likely significant effect through disturbance of demersal spawners. | Scoped in following Scoping Opinion and consultation responses; Detailed assessment. The area of habitat disturbance will be defined using a worst-case scenario-based approach. The sensitivity of fish and shellfish receptors to the impact will be determined through available literature and expert knowledge. | Fish and shellfish ecology | The assessment will be informed by a sediment characterisation and interpretation of geophysical survey data. |

3.4.4 All potential impacts that may lead to a likely significant effect identified will be considered at further stages of the assessment as more detail regarding the design becomes available and greater levels of baseline data are collected and analysed.

## Rationale for Impacts scoped out of assessment

3.4.5 Based on the baseline information on fish and shellfish ecology currently available, the following impacts are proposed to be scoped out of the assessment.

3.4.6 **Accidental pollution impacts during the construction phase of the development on fish and shellfish receptors** are not considered to result in a significant effect, as the magnitude of an accidental spill will be limited by the size of chemical or oil inventory on construction vessels. In addition to this, released hydrocarbons would be subject to rapid dilution, weathering and dispersion and would be unlikely to persist in the marine environment. The likelihood of an incident will also be reduced by implementation of a Project Environmental Monitoring Programme (PEMP) and a Marine Pollution Contingency Plan (MPCP).

3.4.7 **Underwater noise as a result of operational turbines** is also not considered to result in a significant effect on fish and shellfish receptors; studies have shown noise from operating turbines to be detectable only in close proximity to the turbine locations, in addition to this, noise levels will not be sufficient to result in injury and would be restricted to local behavioural responses.

3.4.8 **Potential for reduced fishing pressure within the Rampion 2 array area and increased fishing pressure outside the array area due to displacement** is only expected to be of short-term duration and of limited spatial extent, and therefore there will be no significant effects on fish and shellfish receptors.

## Cumulative effects

3.4.9 Cumulative effects on fish and shellfish resulting from the effects of Rampion 2 OWF and other developments will be assessed in accordance with the guidance and methodologies set out in Chapter 4 of the Scoping Report and considering the other developments that have been screened in as part of the Cumulative Effects Assessment (CEA) screening exercise.

3.4.10 The following impacts from Rampion 2 have the potential to act cumulatively with impacts from other developments to contribute to cumulative effects:

- during construction, there is the potential for underwater noise to have a large spatial footprint with regard to disturbance effects and displacement of prey species, which could occur cumulatively with other developments in close proximity to Rampion 2 activity; and
- during construction, there is the potential for cumulative impacts resulting from increased SSC and deposition. These impacts are likely to be minor due to their localised nature, however there is potential for spatial cumulative impacts with regard to the operation of Rampion 1, plus other activities such as the regional aggregate sites particularly when considering cumulative impacts on spawning grounds for black bream in the Kingmere MCZ.

## Transboundary effects

3.4.11 As transboundary impacts have the potential to affect other fish and shellfish communities within other European Economic Area (EEA) states, it is necessary to consider the potential effects of activities on other EEA state(s) fish and shellfish receptors. Transboundary effects screened into the assessment for fish and shellfish ecology are:

- direct effects as a result of underwater noise exposure to fish during construction (piling operations); and
- indirect effects may occur in relation to spawning and nursery grounds arising from habitat disturbance/ loss during all project phases.

# 4. Next steps

4.1.1 Minutes from the first Expert Technical Group (ETG) meeting, subsequent meetings and informal consultation will be used to determine agreements reached in relation to the proposed proportionate approach to scoping, acceptability of the baseline data, the proposed assessment methodology, impacts proposed to be scoped in and out, and any other details on discussions and agreements with regards to the baseline characterisation and impact assessment methodologies.

4.1.2 Where agreement is achieved, the methods proposed here will be used in compiling the PEIR. Where agreement is not reached, the Applicant and their Consultants will work with consultees to revise the methodology through the Evidence Plan Process until agreement can be reached.

4.1.3 Comments received from consultees will be recorded and responses published in the PEIR. A Statement of Common Ground will highlight areas of agreement and disagreement.

# 5. References

Centre for Environment, Fisheries and Aquaculture Science (Cefas) (2004) Offshore Wind Farms: Guidance note for Environment Impact Assessment in respect of FEPA and CPA requirements.

Department of Energy and Climate Change (DECC) (2011a). Overarching National Policy Statement for Energy (EN-1).

Department of Energy and Climate Change (DECC) (2011b). National Policy Statement for Renewable Energy Infrastructure (EN-3)

Institute of Ecology and Environment Management (IEEM) (2010) Guidelines for Ecological Impact Assessment in Britain and Ireland, Marine and Coastal. Institute of Ecology and Environmental Management, Winchester.

Judd, A. (2012). Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects. Cefas.

OSPAR Commission (2008). Guidance on Environmental Considerations for Offshore Wind Farm Development. Reference No. 2008-3.

The Infrastructure Planning (Environmental Impact Assessment) Regulations 2017

Wood (2020) Rampion 2 Offshore Wind Farm, Evidence Plan Process: Terms of Reference.

© Wood Group UK Limited

© Wood Group UK Limited

# Rampion 2 Offshore Wind Farm

Offshore and Intertidal
Ornithology Method Statement

Wood Environment & Infrastructure Solutions UK Limited – April 2020

wood.

## Report for

TBC

RWE

## Main contributors

## Issued by

Signature here

.................................................................................

[redacted]

## Approved by

Signature here

.................................................................................

[redacted]

## Wood

Shinfield Park
Shinfield
Reading RG2 9FW
United Kingdom
Tel +44 (0)118 9131234

Doc Ref.

document1

DRAFT

## Copyright and non-disclosure notice

The contents and layout of this report are subject to copyright owned by Wood (© Wood Environment & Infrastructure Solutions UK Limited 2020) save to the extent that copyright has been legally assigned by us to another party or is used by Wood under licence. To the extent that we own the copyright in this report, it may not be copied or used without our prior written agreement for any purpose other than the purpose indicated in this report. The methodology (if any) contained in this report is provided to you in confidence and must not be disclosed or copied to third parties without the prior written agreement of Wood. Disclosure of that information may constitute an actionable breach of confidence or may otherwise prejudice our commercial interests. Any third party who obtains access to this report by any means will, in any event, be subject to the Third Party Disclaimer set out below.

## Third party disclaimer

Any disclosure of this report to a third party is subject to this disclaimer. The report was prepared by Wood at the instruction of, and for use by, our client named on the front of the report. It does not in any way constitute advice to any third party who is able to access it by any means. Wood excludes to the fullest extent lawfully permitted all liability whatsoever for any loss or damage howsoever arising from reliance on the contents of this report. We do not however exclude our liability (if any) for personal injury or death resulting from our negligence, for fraud or any other matter in relation to which we cannot legally exclude liability.

## Management systems

This document has been produced by Wood Environment & Infrastructure Solutions UK Limited in full compliance with our management systems, which have been certified to ISO 9001, ISO 14001 and OHSAS 18001 by LRQA.

## Document revisions

| No. | Details | Date |
| --- | --- | --- |
| | | |
| | | |
| | | |

wood.

NOTE:

All fonts used in this report should be Arial

# Executive summary

## Purpose of this report

This report has been produced for the purpose of outlining the proposed methodology to offshore and intertidal ornithology environmental impact assessment. It is assumed that all information and/or documents provided to Wood by the client in connection with the preparation of this report are accurate, complete and not misleading.

IMPORTANT: The above statement (and title, 'Purpose of this Report') is necessary because it is referred to by the Copyright and Non-Disclosure Notice. The statement should either be located here (in the Executive Summary), or may alternatively be located in the report's introductory section. Do not omit the statement.

## Xxxxxxxxxxxxxxx

Body text

## Xxxxxxxxxxxxxxx

Body text

DRAFT

# Contents


| | | |
|---|---|---|
| **1.** | **Introduction** | **5** |
| 1.1 | Introduction to Project | 5 |
| 1.2 | Aim of Method Statement | 5 |
| 1.3 | Offshore and Intertidal Ornithology Technical Panel | 5 |
| 1.4 | Project Timelines | 6 |
| **2.** | **Proposed Approach to EIA** | **8** |
| 2.1 | Baseline Information | 8 |
| 2.2 | Existing baseline information: offshore | 9 |
| 2.3 | Existing baseline information: intertidal | 9 |
| 2.4 | Proportionate Approach to EIA | 10 |
| 2.5 | Identification of Key Issues | 10 |
| **3.** | **Offshore and Intertidal Proposed Impact Assessment Methodology** | **14** |
| 3.1 | Collision Risk | 14 |
| 3.2 | Displacement and Disturbance | 14 |
| 3.3 | Species-specific biological seasons | 16 |
| 3.4 | Cumulative / in-combination | 16 |
| 3.5 | Impact Assessment Criteria | 16 |
| 3.6 | HRA Considerations | 18 |
| **4.** | **Next Steps** | **20** |


DRAFT

# 1. Introduction

This section gives a brief introduction to the Rampion 2 Offshore Windfarm and outlines the purpose of this paper. It also gives details of the Evidence Plan Process.

## 1.1 Introduction to Project

Rampion Extension Development ('the Applicant') is proposing to develop the Rampion 2 Offshore Windfarm ("Rampion 2"). Rampion 2 would be located adjacent to the existing Rampion Offshore Wind Farm located in the English Channel in the south of England). For the purposes of clarification, in this document, the existing Rampion Offshore Wind Farm is referred to as 'Rampion 1' hereon in to enable clear differentiation with Rampion 2. Rampion 2 will include both offshore and onshore infrastructure including an offshore wind farm, export cables to landfall, and connection to the electricity transmission network. The Preliminary Environmental Information Report (PEIR) study area combines the search areas for the onshore and offshore infrastructure.

## 1.2 Aim of Method Statement

The Evidence Plan process has been set out in the Rampion 2 Evidence Plan Terms of Reference (Wood, 2020a), to which the reader is referred. This Offshore and Intertidal Ornithology Method Statement forms part of the larger Evidence Plan (EP) and has been provided to inform the Offshore and Intertidal Ornithology Technical Panel. It sets out the function and aims of the Offshore and Intertidal Ornithology Technical Panel in relation to the EP process, it provides a review of the baseline data available for the Rampion 2 area and it identifies the key issues in relation to Offshore and Intertidal Ornithology at the Scoping Stage.

## 1.3 Offshore and Intertidal Ornithology Technical Panel

The Offshore and Intertidal Ornithology Technical Panel will comprise of the organisations listed in Table 1. The Rampion 2 Evidence Plan Terms of Reference document provides further information on the remit of the Offshore and Intertidal Ornithology Technical Panel.

Table 1 – Organisations forming the Offshore and Intertidal Ornithology Technical Panel

| Role | Organisation | Responsibility | Contact |
|---|---|---|---|
| **Applicant** | RED | The Applicant, together with input from their consultants, will | [redacted] |
| **Evidence Plan Consultant** | Wood Consultants | | [redacted] |

DRAFT

| | | | |
|---|---|---|---|
| **Offshore EIA Lead Consultant** | GoBe | draft the Plan and any technical documents required as part of the process and will maintain the EP Logs. | [redacted] |
| **EIA Consultant (Offshore and Intertidal Ornithology)** | APEM Limited | Baseline data collation and Environmental Impact Assessment (EIA) for offshore and intertidal ornithology. | [redacted] |
| **Lead Statutory Nature Conservation Body (SNCB)** | Natural England | Assess and review evidence provided by the Applicant, ensure consistency of approach to advice and work with the Applicant to resolve issues. | [redacted] |
| **Consultee** | Royal Society for the Protection of Birds (RSPB) | | [redacted] |

DRAFT

## 1.4 Project Timelines

The key project dates are presented in Table 2 below. Any changes to the key project milestones will be communicated to the Offshore and Intertidal Ornithology Technical Panel at the earliest opportunity.

Table 2 – Rampion 2 Milestones

| Milestone | Date |
|---|---|
| **Scoping Report Submitted** | July 2020 |
| **Scoping Opinion Received** | August 2020 |
| **HRA Screening Report Submitted** | September 2020 |
| **1st Evidence Plan Meeting** | September 2020 |

| | |
|---|---|
| **Preliminary Environmental Information Report (PEIR) Submission** | Spring 2021 |
| **Development Consent Order (DCO) Application Submission** | Autumn 2021 |

DRAFT

# 2. Proposed Approach to EIA

## 2.1 Baseline Information

Preliminary impact assessment will be based on information gained from:

- At least 12 months of aerial survey data of the Survey Area shown in Figure 1 below;
- Existing literature and published data;
- The existing baseline information acquired for Rampion 1;
- The feedback received from Natural England and RSPB in respect of the application for Rampion 1;
- The initial work undertaken in preparing the Scoping Report for Rampion 2; and
- The extensive experience gained through scoping and assessing other OWF projects in the English Channel and connected waters.

More details are given in the sections below.

Figure 1 – Image capture points from digital aerial surveys of Rampion 2.

## 2.2 Existing baseline information: offshore

The main source of site-specific data is expected to be the 24 months (when completed) of Rampion 2 digital aerial surveys. The digital aerial surveys are being undertaken by APEM on a monthly basis from April 2019 and are scheduled to continue until March 2021. Images are captured in a grid format across the Survey Area, providing data collection representing a minimum of 10% coverage.

Analysis of Rampion 2 digital aerial surveys will include the following components:

- Design-based abundance estimates using bootstrapping to estimate 95% upper and lower confidence limits;
- For PEIR at least 12 months of data will be used, while for the DCO application the full 24 months will be available;
- Apportionment of birds identified at group level to species level where appropriate; and
- Correction for "availability bias" for auk species (i.e. the number of birds missed in surveys as a result of diving underwater)

The following sources of data will also be included in the baseline characterisation and Rampion 2 impact assessment. These data will provide species-specific information on the distribution, abundance, biological seasons and behaviour of birds in the offshore environment will include, but not be limited to the following:

- Data collected and processed from aerial and boat-based surveys for Rampion 1;
- Existing offshore wind farm environmental statements (e.g. E.ON, 2012);
- Existing monitoring reports on seabirds and OWFs (e.g. Royal Haskoning 2015);
- Peer reviewed scientific papers on seabird behaviour and characteristics (e.g. Robinson, 2016; Woodward *et al.*, 2019; Furness *et al.*, 2018);
- Published information on seabird distribution and movements within UK waters and further afield within European waters (e.g. Stone *et al.*, 1995; Stienen et al, 2007; Wernham *et al.*, 2002); and
- Seabird, waterbirds and other bird species population estimates for the UK and wider regions (e.g. Frost *et al.*, 2020; Furness, 2015; Musgrove, 2013; Mitchell *et al.*, 2004).

## 2.3 Existing baseline information: intertidal

The main sources of data are expected to be published literature, as detailed below. In addition, a programme of site-specific surveys is scheduled to begin in September 2020, with monthly surveys until March 2021. The resulting data will be used to inform the DCO application, but is not expected to contribute at the PEIR stage.

The sources of data will also be included in the baseline characterisation and Hornsea Four impact assessment to provide species-specific information on the distribution, abundance, biological seasons and behaviour of birds in the intertidal and nearshore environment and will include, but not be limited to, the following:

- National counts of birds along the UK's non-estuarine shoreline conducted in 1984/85, 1997/98, 2006/07 and 2015/16, originally under the title of the 'Winter Shorebird Count' and for the most recent three times under the title of 'Non-Estuarine Waterbird Survey'; and
- Local and Regional bird reports (e.g. Sussex Bird Reports) and National Atlas (Balmer *et al*, 2013).

## 2.4 Proportionate Approach to EIA

Delivering proportionate EIA is a key issue for the UK planning and consenting system and developers seeking to take projects forward. In line with this current thinking, Rampion 2 will develop a streamlined approach to the EIA and it will be developed in a proportionate manner.

Delivering proportionate EIA for Rampion 2 will be a progressive activity starting with Scoping, proceeding through the Evidence Plan process and consultation and presenting the outcome in the PEIR.

For each topic we will seek to be proportionate utilising the following methodologies:

- Use of Impacts/Effects Register to adopt a systematic approach to the identification of impacts and effects and take this forward and develop through scoping and into the PEIR and ES. The Register will categorise effects into effects that are judged to be not significant or of minor significance that will be scoped out of further assessment in the EIA; likely significant effects that we propose be addressed through a 'simple assessment'; and likely significant effects that we propose be addressed through a 'detailed assessment' approach in the PEIR and ES; and
- Use of GIS mapping to present baseline features and their value/sensitivity, project activities and their impact zones, descriptions of mitigation and where it will be applied and illustrate the significance of residual effects.

## 2.5 Identification of Key Issues

Table 3 presents a summary of the impacts/effects register developed for offshore and intertidal ornithology.  It outlines the full list of potential impact pathways to offshore and intertidal birds and provides an initial anticipated assessment of the magnitude and sensitivity score for each impact pathway. Each impact is then given an anticipated assessment of significance which determines the assessment approach to be taken. Those impacts which are unlikely to have an impact on offshore and / or intertidal birds are scoped out of any further assessment. Those that are scoped into assessment have been divided into those that require a simple assessment (largely qualitative) and those that require a detailed quantitative assessment. Further details are given in the Scoping Report (Wood, 2020b). This document is aligned with the Scoping Report and does not



DRAFT

incorporate any modifications to the EIA approach which may be implemented following consultee responses to that report.

Table 3 – Summary of Offshore & Intertidal Impacts / Effects register for Rampion 2

| Activity and impact | Embedded measures | Likely significance of effect | Proposed approach to assessment (scoped in or scoped out) |
|---|---|---|---|
| **Disturbance and displacement: Array (Construction)** | C-63 C-52 | Potential significant effect minor depending on species assessed without mitigation. | Scoped in – simple assessment |
| **Disturbance and displacement: Offshore export cable (Construction).** | C-65 | Potential significant effect minor depending on species assessed, without mitigation. | Scoped in – simple assessment |
| **Disturbance and displacement: Intertidal export cable (Construction).** | C-43 C-63 | Potential significant effect not significant to minor as very few waterbirds reside in the intertidal area (without mitigation). Additionally, most species are tolerant to disturbance from anticipated activities as they are limited both spatially and temporally. | Scoped in – simple assessment |
| **Indirect impacts on IOFs due to impacts on prey species habitat loss: Array (Construction).** | C-53 C-65 | Potential significant effect not significant to minor depending on the species assessed, without mitigation. | Scoped in – simple assessment |
| **Indirect impacts on IOFs due to impacts on prey species habitat loss: Export cable route (Construction).** | C-53 C-43 ~~C-X~~ | Potential significant effect not significant to minor depending on the species assessed, without ~~mitgation~~mitigation. | Scoped in – simple assessment |
| **Disturbance and displacement: Array (Operation).** | ~~C-X~~ | Potential significant effect not significant to minor/ moderate | Scoped in – detailed assessment |

| Activity and impact | Embedded measures | Likely significance of effect | Proposed approach to assessment (scoped in or scoped out) |
|---|---|---|---|
| | | depending on species assessed, without mitigation. | |
| **Disturbance and displacement: Offshore export cable (Operation).** | C-63 | **No potential significant effect.** | Scoped out |
| **Disturbance and displacement: Intertidal export cable (Operational phase).** | C-63 | **No potential significant effect.** | Scoped out |
| **Collision risk: Array (Operation).** | C-64 | Potential significant effect not significant and moderate/ major, without mitigation. | Scoped in – detailed assessment |
| **Collision risk: Array (Operation).** | C-64 | Potential significant effect not significant or minor based on previous offshore wind farm assessments regarding migratory waterbirds, without mitigation. | Scoped in – detailed assessment |
| **Indirect impacts on IOFs due to impacts on prey species habitat loss: Array (Operation).** | C-52 | Potential significant effect not significant to minor depending on the species assessed. | Scoped in – Simple assessment |
| **Barrier effect: Array (Operation).** | None | **No likely significant effect.** | Scoped out |
| **Disturbance and displacement: Array (Decommissioning).** | C-52<br>C-63 | Potential significant effect not significant to minor depending on species assessed, without mitigation. | Scoped in – simple assessment |

| Activity and impact | Embedded measures | Likely significance of effect | Proposed approach to assessment (scoped in or scoped out) |
|---|---|---|---|
| **Disturbance and displacement: Offshore export cable (Decommissioning).** | C-53<br>C-63 | Potential significant effect not significant to minor depending on species assessed, without mitigation. | Scoped in – simple assessment |
| **Indirect impacts on IOFs due to impacts on prey species habitat loss: Export cable route (Decommissioning).** | C-43<br>C-53<br>C-63 | Potential significant effect not significant to minor depending on the species assessed without mitigation. | Scoped in – simple assessment |

DRAFT

# 3. Offshore and Intertidal Proposed Impact Assessment Methodology

The following section provides a high-level description of the proposed impact assessment methods that will be applied to offshore and intertidal ornithology receptors.

## 3.1 Collision Risk

APEM propose to use the Marine Science Scotland Stochastic Collision Risk Model Shiny Application ("sCRM App"; Donovan, 2017). However, this would be run deterministically (i.e. setting error variables to zero or as close as possible within the app for each run), with separate runs for a central estimate, minimum estimate and maximum estimate. This approach has been agreed with SNCBs for other recent projects (e.g. Hornsea Four) and so, in the absence of any novel models or methods, we anticipate it will remain the preferred solution.

Nocturnal activity rates and avoidance rates will be based on the best available published evidence, including Furness (2018) and Cook *et al.* (2018).

Flight heights will be based on site-specific flight height data from the digital aerial surveys, where the sample size is sufficient to ensure robust estimates. Where the survey results are insufficient, the best available published data will be used.

In specific instances where the sCRM App cannot be used (e.g. for migratory birds, if necessary) then the Band (2012) model may be used instead.

## 3.2 Displacement and Disturbance

APEM propose to use a matrix approach, presenting a complete range of displacement and mortality rates for each species. Most likely ranges for each species will be highlighted and form the basis of impact assessment. The area over which displacement impacts each species will be best on the best available evidence. APEM's initial parameters for consideration are presented in Table 4.

Table 4 – Species-specific parameters for displacement and disturbance impact assessment.

| Species | Area Impacted | Most likely range | |
|---|---|---|---|
| | | Displacement | Mortality |
| **Gannet** | Array area only | 60 – 80% | 1% |
| **Guillemot** | Array area + 2km buffer | 30 – 70% | 1 – 10% |

DRAFT

| | | | |
|---|---|---|---|
| **Razorbill** | Array area + 2km buffer | 30 – 70% | 1 – 10% |

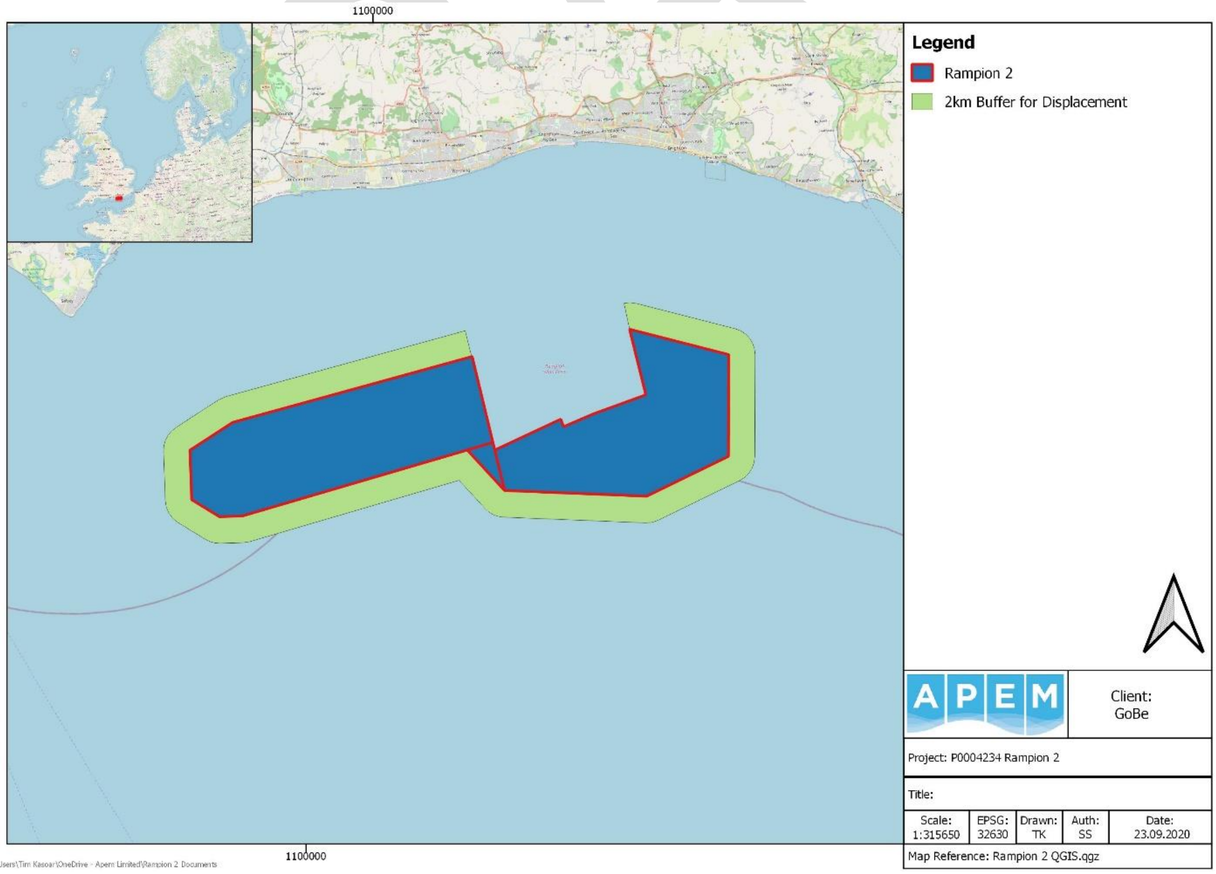
Rampion 2 is situated adjacent to the existing Rampion 1. This therefore creates an additional consideration for disturbance and displacement calculations, as the buffer zone of Rampion 2 would include Rampion 1, and some of Rampion 2 is within the buffer zone around Rampion 1. APEM propose to use the following approach for displacement calculations:

- The Rampion 2 Array Area will be considered in the normal manner (no higher or lower displacement rates will be applied to the Rampion 1 buffer zone); and
- The Rampion 2 Buffer Zone will not extend into Rampion 1.

This is illustrated in Figure 2. Note that the figure shows a 2km buffer as an illustrative example, but the same approach would apply to other buffer widths as necessary. Note that the Rampion 2 area presented is a revised array area but has not yet been confirmed and so is illustrative only. The same approach would apply to alternative array areas unless materially relevant changes were proposed (e.g. no longer immediately adjacent to Rampion 1).

DRAFT

Figure 2 – Illustrative example of buffer zones around Rampion 2. Illustrated using a 2km buffer, but the same approach would apply to other buffer widths. Rampion 2 boundary shown is for illustrative purposes only pending confirmation of Red Line Boundary.



© Wood Environment & Infrastructure Solutions UK Limited

wood.

## 3.3 Species-specific biological seasons

Bird behaviour and abundance is recognised to differ across a calendar year dependent upon the season. Separate seasons will be recognised in the baseline technical reporting and impact assessments in order to establish the level of importance any seabird species has within the Rampion 2 site plus 4km buffer during any particular period of time. The biologically defined minimum population scales (BDMPS) bio-seasons are proposed to be based on those in Furness (2015), with amendments to accommodate site-specific circumstances being incorporated where evidence from the baseline data supports such use. For species not included in Furness (2015) bio-seasons will be agreed through the Evidence Plan Process once identified.

## 3.4 Cumulative / in-combination

A 'tiered' approach will be taken to the cumulative (EIA) and in-combination (HRA) assessment. The number of tiers to be used in the framework for assessment is still under discussion and the views of stakeholders are sought. It is recognised that as well as the separation of tiers that is created by the NSIP DCO processes (i.e. the three tiers included in the Planning Inspectorate Advice Note Seventeen; PINS, 2019), OWFs are subject to additional steps on their journey to construction and operation, including, for instance, the winning of a contract for difference. The result is that tiers can have sub-divisions (PINS, 2015 has a total of seven) and this 'tiers-with-sub-divisions' approach is most likely to be used.

## 3.5 Impact Assessment Criteria

The general approach to impact assessment is outlined in the Scoping Report (Section 4.4: Approach to the EIA). In applying this general approach to ornithology, the following criteria and definitions are used. Table 5 outlines the proposed definitions of magnitude of impacts relating to ornithology. Table 6 outlines the proposed definitions of the sensitivity of ornithological receptors to impacts. Table 7 outlines the range of significance effects. For the purposes of this assessment, any effects with a significance level of minor or less have been concluded to be not significant in terms of the EIA Regulations.

Table 5 – Definition of terms relating to magnitude of an impact upon ornithological receptors.

| Magnitude | Definition |
|---|---|
| **High** | The proposal would affect the conservation status of the Important Ornithological Feature (IOF) with loss of ecological functionality. Recovery expected to be long term (e.g. 10 years) or irreversible following cessation of activity. |

| | |
|---|---|
| **Medium** | The IOF's conservation status would not be affected, but the impact is likely to be significant in terms of ecological objectives or populations. Recovery expected to be medium term (e.g. 5 years) following cessation of activity. |
| **Low** | Minor shift away from baseline but the impact is of limited temporal or physical extent. Recovery expected to be short-term (e.g. less than 1 year) following cessation of activity. |
| **Very low** | Very slight change from baseline condition. Any recovery expected to be rapid following cessation of activity. |
| **No change** | No change from baseline conditions. |

Table 6 – Definition of terms relating to the overall sensitivity of ornithological receptors.

| Sensitivity | Definition |
|---|---|
| **Very low** | IOF is not vulnerable to the impact considered regardless of value/importance.<br>IOFs of Local value with low vulnerability and medium to high recoverability. |
| **Low** | IOFs of Local value with moderate to high vulnerability and low recoverability.<br>IOFs of Regional value with low vulnerability and medium to high recoverability.<br>IOFs of National or International value with low vulnerability and high recoverability. |
| **Medium** | IOFs of local value with high vulnerability and no ability for recovery.<br>IOFs of Regional value with moderate to high vulnerability and low recoverability.<br>IOFs of National or International value with moderate vulnerability and medium recoverability. |
| **High** | IOFs of Regional value with high vulnerability and no ability for recovery. |

| | |
|---|---|
| | IOFs of National or International value with high vulnerability and low recoverability. |
| | Very High IOFs of National or International value with very high vulnerability and no ability for recovery. |

Table 7 – Matrix used for assessment of significance showing the combination of receptor sensitivity and the magnitude of effect.

| **Sensitivity / Importance / Value** | **Magnitude of Impact** | | | |
|---|---|---|---|---|
| | **Very low** | **Low** | **Medium** | **High** |
| **Very low** | Negligible | Negligible | Minor | Moderate |
| **Low** | Negligible | Minor | Minor | Moderate |
| **Medium** | Minor | Minor | Moderate | Major |
| **High** | Minor | Moderate | Major | Major |

## 3.6 HRA Considerations

An HRA Screening Report (Wood, 2020c) has been submitted that follows the guidance published by the Planning Inspectorate for NSIP consent applications as Advice Note Ten (PINS, 2017). The reader is referred to that document for further details of the HRA process. This document is aligned with the HRA Screening Report and does not incorporate any modifications to the HRA approach which may be implemented following consultee responses to that report.

Based on the current understanding of the design, construction and operation of the proposed Hornsea Four it is expected that the following sources of effect will be screened in:

- Construction phase: Direct disturbance and displacement;
- Operation and maintenance phase: Direct disturbance and displacement; and
- Operation and maintenance phase: Risk of collision.

Based on the current understanding of the likely significant effects of the proposed Rampion 2, the HRA Screening Report proposes to screen in the following sites:

- Arun Valley SPA & Ramsar;

- Pagham Harbour SPA & Ramsar;
- Chichester and Langstone Harbours SPA & Ramsar;
- Solent and Southampton Water SPA & Ramsar;
- A further 25 SPAs that support seabirds as breeding features that have foraging ranges which have the potential to overlap with Rampion 2; and
- A further 54 SPAs to the north of Rampion 2 that support seabirds as breeding interest features that might pass through the project area on migration or reside within, or adjacent to, it in the winter.

The approach to 'tiers' in the in-combination assessment has been described above.

DRAFT

# 4. Next Steps

Minutes from the first Expert Technical Group meeting, subsequent meetings and informal consultations will be used to determine agreements reached in relation to the proposed proportionate approach to scoping, acceptability of the baseline data, the proposed assessment methodology, impacts proposed to be scoped in and out, and any other details on discussions and agreements with regards to the baseline characterisation and impact assessment methodologies.

Where agreement is achieved, the methods proposed here will be used in compiling the Preliminary Environmental Impact Report (PEIR). Where agreement is not reached, the Applicant and their Consultants will work with consultees to revise the methodology through the Evidence Plan Process until agreement can be reached.

Comments received from consultees will be recorded and responses published in the PEIR. A Statement of Common Ground will highlight areas of agreement and disagreement.

DRAFT

# Bibliography


Balmer, D., Gillings, S., Caffrey, B., Swann, R., Downie, I. & Fuller, R. (2013). Bird Atlas 2007-11: The Breeding and Wintering Birds of Britain and Ireland. Thetford: British Trust for Ornithology.

Band, W. (2012). Using a collision risk model to assess bird collision risks for offshore windfarms. The Crown Estate Strategic Ornithological Support Services (SOSS) report SOSS-02. SOSS Website. Original published Sept 2011, extended to deal with flight height distribution data March 2012.

BTO WeBS online (2018). Accessed at: http://www.bto.org/volunteer-surveys/webs/publications/webs-annual-report

Cook, A.S.C.P., Humphreys, E.M., Bennet, F., Masden, E.A. and Burton, N.H.K. (2018). Quantifying avian avoidance of offshore wind turbines: Current evidence and key knowledge gaps. Marine Environmental Research (in press) https://doi.org/10.1016/j.marenvres.2018.06.017

Donovan, C. (2017) Stochastic Band CRM - GUI User manual Draft V1.0.

E.ON (2012). Rampion Offshore Wind Farm Environmental Statement. SMartWind Ltd., London.

Frost, T.M., Calbrade, N.A., Birtles, G.A., Mellan, H.J., Hall, C., Robinson, A.E., Wotton, S.R., Balmer, D.E. & Austin, G.E. 2020. Waterbirds in the UK 2018/19: The Wetland Bird Survey. BTO, RSPB and JNCC, in association with WWT. British Trust for Ornithology, Thetford

Furness, R.W. (2015) Non-breeding season populations of seabirds in UK waters: Population sizes for Biologically Defined Minimum Population Scales (BDMPS). Natural England Commissioned Reports, Number 164.

Furness, R.W., Garthe, S., Trinder, M., Matthiopoulos, J., Wanless, S. and Jeglinski, J. (2018). Nocturnal flight activity of northern gannets Morus bassanus and implications for modelling collision risk at offshore wind farms. Environmental Impact Assessment Review 73: 1-6.

Mackenzie, M.L., Scott-Hayward, L.A.S., Oedekoven, C.S., Skov, H., Humphreys, E. and Rexstad, E. (2014) Statistical Modelling of Seabird and Cetacean Data: Guidance Document. Marine Scotland Science Report 04/14

Masden, E. (2015). Developing an avian collision risk model to incorporate variability and uncertainty. Scottish Marine and Freshwater Science Vol 6 No 14. Scottish Government, Edinburgh.

Mitchell, I., Newton, S., Ratcliffe, N. and Dunn, T. (eds.) (2004). Seabird Populations of Britain and Ireland. T & AD Poyser, London.

Musgrove, A., Aebischer, N., Eaton, M., Hearn, R., Newson, S., Noble, D., Parsons, M., Risely, K. and Stroud, D. (2013). Population estimates of birds in Great Britain and the United Kingdom. British Birds 106: 64-100.


DRAFT

Planning Inspectorate (2015). Advice Note Seventeen: Cumulative effects assessment relevant to nationally significant infrastructure projects (version 2). https://infrastructure.planninginspectorate.gov.uk/wp-content/uploads/2015/12/Advice-note-17V4.pdf

Planning Inspectorate (2017). Advice Note Ten: Habitat Regulations Assessment relevant to Nationally Significant Infrastructure Projects (version 8). https://infrastructure.planninginspectorate.gov.uk/wp-content/uploads/2015/06/Advice-note-10v4.pdf

Plant, P.J. (ed.) (2019) The Sussex Bird Report: Number Seventy-one, 2018. Sussex Ornithological Society.

Robinson, R.A. (2016). BirdFacts: Profiles of birds occurring in Britain and Ireland (BTO Research Report 407). BTO, Thetford.

Royal HaskoningDHV (2013). Thanet Offshore Wind Farm Ornithological Monitoring 2012-2013 (Post-construction Year 3). Royal HaskoningDHV Report for Vattenfall Wind Power Limited.

Statutory Nature Conservation Bodies. (2017). Advice on how to present assessment information on the extent and potential consequences of seabird displacement from Offshore Wind Farm (OWF) developments.

Stienen, E, W., Waeyenberge, V., Kuijken, E. & Seys, J. (2007). Trapped in the corridor of the southern North Sea: the potential impact of offshore wind farms on seabirds. In Birds and Wind Farms. De Lucas, M., Janss, G, F, E. & Ferrer, M. (Eds). Quercus. Madrid.

Stone, C, J., Webb, A., Barton, C., Ratcliffe, N., Reed, M, L., Camphuysen, C, J. & Pienkowski. (1995). An Atlas of seabird distribution in north-west European waters. Joint Nature Conservancy Council, Peterborough.

Wernham, C.V., Toms, M.P., Marchant, J.H., Clark, J.A., Siriwardena, G.M. and Baillie, S.R. (eds). (2002). The Migration Atlas: Movements of the birds of Britain and Ireland. T. and A.D. Poyser, London.

Wood (2020a). Rampion 2 Offshore Wind Farm. Evidence Plan Process: Draft Terms of Reference.

Wood (2020b). Rampion Extension Development Limited. Rampion 2 Offshore Wind Farm. Environmental Impact Assessment Scoping Report.

Wood (2020c). Rampion 2 Offshore Wind Farm. Habitat Regulations Assessment Report to Inform Screening

Woodward, I. *et al*. (2019) Desk-based revision of seabird foraging ranges used for HRA screening. BTO research report number 724. Thetford.

Wright, L.J., Ross-Smith, V.H., Massimino, D., Dadam, D., Cook, A.S.C.P. and Burton, N.H.K. (2012). Assessing the risk of offshore windfarm development to migratory birds designated as features of UK Special Protection Areas (and other Annex I species). (Thetford: British Trust for Ornithology).

DRAFT

Marine Management Organisation

Marine Licensing
Lancaster House
Hampshire Court
Newcastle upon Tyne
NE4 7YH

T +44 (0)300 123 1032
F +44 (0)191 376 2681
www.gov.uk/mmo

[redacted]
**(By email only)**

Our reference: DCO/2019/00005

11 February 2021

Dear [redacted],

**Rampion 2 Offshore Wind Farm Benthic Surveys**

**Document 1: Rampion 2 Characterisation Surveys: Subtidal Habitats Survey: Terms of Reference**

**Document 2: Rampion 2 Letter response MMO Benthic ToR_061120**

**Document 3: GBERAM0919_Rampion2_Existing_Benthic_Dataset_V02.jpg**

**Document 4: GBERAM0919_Rampion2_Sampling Array_V02.jpg**

At this stage of the planning process, Rampion Extension Development Ltd (RED) are conducting environmental and technical surveys and undertaking consultation with regulatory bodies, stakeholders and communities.

The currently proposed development is sited adjacent to south east and west of the existing Rampion Offshore Wind Farm, approximately 13km to 25km offshore, occupying an irregular elongated area. The wind farm array Area of Search has an approximate area of 315km2. The scoping area for the offshore export cables to connect the offshore wind farm area to the shore is approximately 74km2.

Rampion 2 OWF is expected to comprise of no more than 116 wind turbine generators (WTGs) with a total generating capacity of 1200MW. In addition, there will be up to three offshore substations and up to 4 export cables which will carry generated power to landfall at Climping, Sussex.

The Marine Management Organisation (MMO) received the Document 1 on 13 October 2020. This document was submitted to submitted to the MMO to set out the Terms of Reference (TOR) for a subtidal benthic habitat survey to be undertaken to characterise the habitats present within the subtidal zone of the proposed scoping boundary. The MMO provided a response on 4 November 2020 and documents 2-4 were submitted on 6 November 2020 in response to this consultation response.

The MMO and our scientific advisors from Centre for Environment, Fisheries and Aquaculture Science (Cefas) have reviewed the documents and provided comments below.

**Comments**

1. The MMO understands due to resourcing, weather and the ongoing COVID-19 pandemic the survey is still ongoing. In light of this the MMO has provided these comments to be taken into account for the rest of the survey period.

## Benthic Ecology

2. RED has provided rationale for proposed sampling stations in Document 1 and its appendices and has re-supplied the maps showing the full extent of the scoping boundary (Document 3 & 4). The MMO appreciates the submission of this information. The MMO can confirm that this closes out comment 3 and part of comment 5 in Document 2 with regard to the submission of maps. Please see comment 6 for further information on this point.

3. The MMO notes RED's response to comment 4 of Document 2 relating to the suggestion to take a Shipek grab for collection of contaminants in case of Day grab failure and have no further comment at this time as RED is confident of successful sample collection.

4. In the response comment 6 of Document 2 regarding too few samples allocated to the deep coarse sediment habitat in the southern part of the scoping boundary and the missing extent of the eastern part of the array in the figures previously supplied, RED states that fewer samples were allocated to the south and east of the Rampion 2 array due to the homogenous habitat types identified within the geophysical data and the wealth of existing data which also suggest homogeneity. RED has since proposed to add an additional three stations to the deep circalittoral coarse habitats. The MMO welcomes the addition of these sampling stations and has no further comments.

5. The MMO notes the response to comment 7 of Document 2 which states that the historic datasets are not being relied on in any areas and will not supplement new data. Whilst the western side of the scoping area and export cable corridor appear to show good coverage of samples (even without the historical data) the south eastern side still does not. The MMO suggests additional stations placed in this area to ensure more robust characterisation and to supplement the loss of historical data where it has been deemed too old to use.

6. The MMO notes RED's response to comment 8 of Document 2 regarding the datasets already included in the Regional Seabed Monitoring Plan database and the MMO is satisfied that RED will ensure these datasets will be reviewed further and has no further comments.

7. Comments 9-11 (document in paragraph 10) relate to fisheries and are therefore not considered within this advice note.

8. The proposed approach to carry out drop down camera (DDC) transects for ground truthing potential nest sites is an appropriate method. However, as per Natural England's comments, The MMO agrees that this work should be undertaken during the black sea bream nesting and spawning season between April and July. Whilst the DDC transects will be able to identify black sea bream nest sites across the array and export cable corridor search areas, it will not be possible to determine whether the nests have been actively used and tended for that year's spawning season, because nests are known to become rapidly recolonised by other flora and fauna once the bream have left the site and the nests are no longer tended.

9. The MMO supports Natural England's recommendation that ground-truthed DDC surveys of black sea bream nests will require a minimum survey period of three years in order to account for the known inter-annual variations in the locations and densities of nests.

10. The MMO notes that in document 2 RED have acknowledged that uncertainties in bream nest distribution and potential variation in locations within the proposed development area

Marine Management Organisation
...ambitious for our seas and coasts

will be accounted for in the Environment Impact Assessment. Furthermore, RED states that precautionary assumptions and consideration of worst-case assumptions will be adopted. Other than the comments raised in comment 8 and 9 on the limitations of the proposed survey the MMO is content with RED’s response in Document 2.

## Conclusion

The MMO understands that RED are reviewing the survey methodology in light of the ongoing survey. The MMO welcomes the updates to the MAPs and responses to the MMO’s comments set out in Document 2. The MMO believes there are still outstanding concerns in relation to the south eastern side of the area and in relation to Black Bream and still requires further information in relation to the survey scope, please resubmit the updated documents to the MMO for review.

If you require any further information, please do not hesitate to contact me using the details provided below.

Yours Sincerely

[redacted]

Marine Licensing Case Officer

[redacted]

# Rampion Extension Development Limited

# Rampion 2 Offshore Wind Farm

Nature Conservation

Method Statement

Wood Environment & Infrastructure Solutions UK Limited – April 2020

## Report for

TBC

RWE

## Main contributors

[redacted]

## Issued by

Signature here

.................................................................................

[redacted]

## Approved by

Signature here

.................................................................................

[redacted]

## Wood

Shinfield Park
Shinfield
Reading RG2 9FW
United Kingdom
Tel +44 (0)118 9131234

Doc Ref.

document1

## Copyright and non-disclosure notice

The contents and layout of this report are subject to copyright owned by Wood (© Wood Environment & Infrastructure Solutions UK Limited 2020) save to the extent that copyright has been legally assigned by us to another party or is used by Wood under licence. To the extent that we own the copyright in this report, it may not be copied or used without our prior written agreement for any purpose other than the purpose indicated in this report. The methodology (if any) contained in this report is provided to you in confidence and must not be disclosed or copied to third parties without the prior written agreement of Wood. Disclosure of that information may constitute an actionable breach of confidence or may otherwise prejudice our commercial interests. Any third party who obtains access to this report by any means will, in any event, be subject to the Third Party Disclaimer set out below.

## Third party disclaimer

Any disclosure of this report to a third party is subject to this disclaimer. The report was prepared by Wood at the instruction of, and for use by, our client named on the front of the report. It does not in any way constitute advice to any third party who is able to access it by any means. Wood excludes to the fullest extent lawfully permitted all liability whatsoever for any loss or damage howsoever arising from reliance on the contents of this report. We do not however exclude our liability (if any) for personal injury or death resulting from our negligence, for fraud or any other matter in relation to which we cannot legally exclude liability.

## Management systems

This document has been produced by Wood Environment & Infrastructure Solutions UK Limited in full compliance with our management systems, which have been certified to ISO 9001, ISO 14001 and OHSAS 18001 by LRQA.

## Document revisions

| No. | Details | Date |
|---|---|---|
| **0.1** | For review | 25/09/20 |
| | | |
| | | |

wood.

# Contents


**1. Aim of this technical note 2**

**2. Scoping 3**

2.1 Proposed approach set out in the scoping report 3
Study Area 3
Assessment Methodology 1
Impacts to be assessed 1

2.2 Relevant comments from the scoping opinion 3

2.3 Sites to include within the assessment 4
Natura 2000 sites 4
Statutory National Designations 1
UK Biodiversity Action Plan (BAP) 2

# 1. Aim of this technical note

Within the Planning Inspectorate's (PINS) Scoping Opinion for the Rampion 2 Offshore Wind Farm dated August 2020, PINS provided feedback on the data sources and methods to be used to characterise the baseline environment, this was also supported by consultee responses.

As a response to this feedback and to provide supplementary information to the Scoping Report, a technical note has been provided; this note reviews the proposed approach at Scoping, the responses received in the Scoping Opinion and sets out the proposed approach to the assessment for the Environmental Impact Assessment (EIA) to be presented in the Preliminary Environmental Information Report (PEIR) and subsequently to accompany the Development Consent Order (DCO) application, responding to the specific points raised in the Scoping Opinion.

# 2. Scoping

Rampion 2 submitted a Scoping Request and Scoping Report to PINS on the 2nd of July 2020 under Regulation 10 of the Infrastructure Planning (Environmental Impact Assessment) Regulations 2017 (the EIA Regulations).

This section sets out a brief summary of the data sources and baseline environment methodology, as detailed in the Scoping Report, and the key issues raised in the Scoping Opinion.

## 2.1 Proposed approach set out in the scoping report

### Study Area

The Study Area for the nature conservation assessment is defined as the project boundary together with the maximum Zones of Influence (ZOIs) as defined by individual technical disciplines: 'Fish and Shellfish Ecology'; 'Benthic Subtidal and Intertidal Ecology'; 'Marine Mammals'; and 'Offshore Ornithology':-

- A 15 km buffer around the array project boundary, and 10 km surrounding the offshore cable corridor for the benthic/fish and shellfish ecology ZOI;
- A 4 km buffer around the project boundary for the offshore ornithology ZOI; and
- A 26 km buffer distance for noise effects from piling/UXO detonation for noise sensitive receptors (marine mammals).

For the assessment, marine and intertidal designated sites within the vicinity of the scoping boundary will be included within the baseline, these include offshore sites and those in the intertidal zone extending up to the Mean High-Water Spring (MHWS).

The Study Area proposed for the EIA will be reviewed and defined through reference to individual technical disciplines, to such matters as refinement of the offshore project components, the identification of additional impact pathways and in response to feedback from consultation through the Evidence Plan Process (EPP).

It should be noted that the Habitats Regulations Assessment (HRA) will consider Natura 2000 sites designated under the Habitats Directive and Birds Directive in a more detailed context and will therefore include consideration of sites further afield which have the potential for connectivity related issues, particularly with regards to mobile species such as birds and marine mammals.

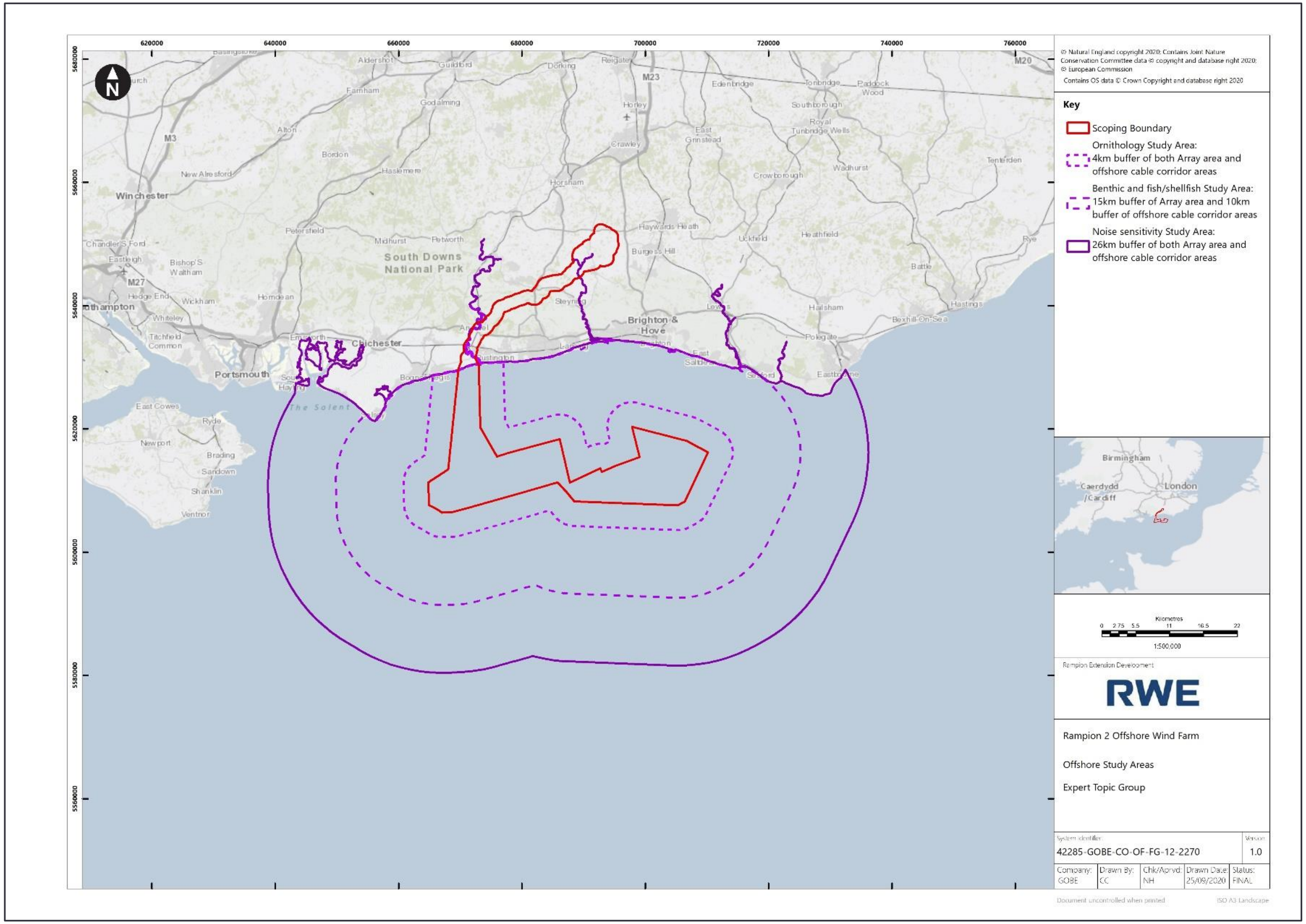



*Figure 2-1 The Rampion 2 OWF scoping boundary and wider Study Areas/ZOI as defined by the technical disciplines 'Fish and Shellfish Ecology', 'Benthic Subtidal and Intertidal Ecology', 'Marine Mammals' and 'Offshore Ornithology'.*

## Assessment Methodology

All designated sites (both existing and proposed) at European, national and local levels, which have features that could be impacted by development and that are within the Study Area (**Figure 2-1**) will be identified. Further details on this are set out in Section 4.6: Consultation and the evidence plan process. For European Sites, the Habitats Regulations Assessment (HRA) screening process will build upon the ongoing ornithological, marine mammal and benthic surveys in order to add or remove sites as necessary.

The baseline information on designated features will be informed by the technical assessments provided in relevant aspects of the ES (e.g. physical processes, benthic ecology, fish and shellfish ecology, marine mammals and ornithology) as well as the HRA which will be undertaken for Rampion 2 OWF. It is proposed that the scope of these investigations will be finalised in conjunction with relevant stakeholders through the EPP.

The subsequent assessment of impacts upon designated sites during construction, operation and decommissioning will be informed by the assessment of the relevant features within the relevant aspects of the ES (coastal processes, benthic ecology, fish and shellfish ecology, marine mammals and ornithology).

Specific to the nature conservation assessment, the following guidance documents will be considered:

- National Planning Policy Framework (2019);
- Guidelines for Ecological Impact Assessment in Britain and Ireland, Marine and Coastal (Institute for Ecology and Environmental Management (IEEM, 2010));
- Guidelines for data acquisition to support marine environmental assessments of offshore renewable energy projects (Judd, 2012);
- Marine Conservation Zones and Marine Licensing (MMO 2013); and
- National Policy Statement NPS EN-1 (Overarching National Policy Statement for Energy) and NPS EN-3 (National Policy Statement for Renewable Energy Infrastructure).

## Impacts to be assessed

In line with the 2017 EIA Regulations, the EIA for Rampion 2 OWF will consider those impacts where there is a risk of a likely significant effect only. The following section draws on industry experience, expertise, and the MMO 2012 review of post-consent monitoring, to identify those effect-receptor pathways that may potentially lead to a significant impact. Where experience and available evidence indicates an effect-receptor pathway will not lead to a significant impact with regards to the EIA Regulations (2017) the pathway is scoped out from assessment

The likely significant effects on nature conservation are summarised in **Table 2-1**. The scoping assessment is based on a combination of the project definition of Rampion 2 OWF at the scoping stage, embedded environmental measures, understanding of the baseline conditions at this stage, the evidence base for nature conservation effects and professional judgement.

This is a tool aimed at delivering a proportionate approach to the EIA. In doing so, it sets out a high-level assessment of all potential effects, significant or not, and distinguishes between the level of assessment proposed for significant effects 'scoped in' as simple or detailed. The basis for scoping out certain effects, and therefore no longer considered is presented after the table, supported by evidence base.

*Table 2-1 Likely significant nature conservation effects*

| Activity and impact | Embedded measures | Effect | Proposed approach to assessment | Receptor | Further data baseline requirements |
|---|---|---|---|---|---|
| Direct habitat disturbance to Climping Beach SSSI (construction, maintenance and decommissioning phase) | C - 43 | Potential for significant effect to Climping Beach SSSI through temporary, direct habitat loss and disturbance, although minimal disturbance is expected using HDD techniques. | Scoped in; Detailed assessment. The ecological features for which this site is designated will be assessed within the benthic and intertidal ecology chapter and the marine ornithology chapter. The impact assessment for these parameters will ultimately inform the assessment of this designated site. | Conservation features of the site include non-breeding birds, coastal vegetated shingle, fixed dune grassland and sand dune communities. | Baseline requirements will be covered by the individual topic assessments. |
| Direct impact to other designated features (construction, maintenance and decommissioning phase) | | No likely significant effect | Scoped out: See rationale in section below. | N/A | N/A |
| Temporary increase in suspended sediment and sediment deposition on designated features (construction and decommissioning phases) | | Potential for significant effect through smothering of protected habitats and species. | Scoped in; Detailed assessment. The ecological features of designated sites will be assessed within the benthic and intertidal ecology chapter and the fish and shellfish chapter. The impact assessment for these parameters will ultimately inform the assessment of designated sites. | Conservation features. | Baseline requirements will be covered by the individual topic assessments. |
| Impacts to mobile features of designated sites (construction, operation and decommissioning phases) | C-52; C-48; C-52 | Potential for significant negative impact to protected marine mammals and marine ornithology. | Scoped in; Detailed assessment. Mobile features of designated sites such as birds and marine mammals will be assessed within the marine ornithology and marine mammal chapter. The impact assessment for these parameters will ultimately inform the assessment of designated sites. | Conservation features. | Baseline requirements will be covered by the individual topic assessments. |
| Long term effects to physical processes and seabed composition from infrastructure (operation phase) | C-41; C-44; C-44 | Potential for significant disturbance to physical processes and seabed composition. | Scoped in; Detailed assessment. The impacts associated with long-term changes to physical processes and seabed composition will be assessed in the physical processes and benthic assessments. The impact assessment for these parameters will ultimately inform the assessment of designated sites. | Conservation features. | Baseline requirements will be covered by the individual topic assessments. |

All likely significant effects identified will be considered at further stages of the assessment as more detail regarding the design becomes available and greater levels of baseline data are collected and analysed.

### Rationale for Impacts scoped out of assessment

Based on the baseline information on nature conservation currently available, the following impact is proposed to be scoped out of the assessment.

**Direct impact to nature conservation features that do not overlap with the Proposed Development: -** For direct impacts to occur there would need to be a physical overlap of the project and the designated site. As detailed in **Figure 2-1**, the offshore scoping boundary only overlaps with the Climping Beach SSSI, which has been scoped into the assessment.

### Cumulative effects

Cumulative effects on nature conservation resulting from the effects of Rampion 2 OWF and other developments will be assessed in accordance with the guidance and methodologies set out in Chapter 4 od the Scoping Report and considering the other developments that have been screened in as part of the CEA screening exercise.

The potential for cumulative effects on designated sites, habitats or species to occur will be assessed under the relevant topic disciplines of the EIA.

### Transboundary effects

As transboundary impacts have the potential to affect Natura 2000 sites within other EEA states, it is necessary to consider the potential effects of the activity on these sites and follow the HRA process to screen the sites in or out of the HRA assessment which must also be undertaken as part of the application for development consent. Where there is the potential for significant effects on a Natura 2000 site within another EEA state, it is necessary to undertake consultation with the competent authorities of that state. It follows that this engagement should commence at the screening stage of the HRA process and be incorporated within the HRA process with reference to the HRA made within the transboundary assessments for these sites. The HRA screening for Rampion 2 OWF is presented separately and incorporates all relevant Natura 2000 sites within other EEA states jurisdictions. The Application for Rampion 2 OWF will present a Report to Inform Appropriate Assessment that considers all relevant Natura 2000 sites (or the adopted 'National Sites' following the UK's exit from the European Union) for the project alone and in-combination with relevant projects and plans.

The conservation/designated sites chapter will consider all relevant ecological receptors, including for example, offshore ornithology, marine mammals, and migratory fish species.

## 2.2 Relevant comments from the scoping opinion

PINS, within the scoping opinion set out the position in relation to benthic subtidal and intertidal ecology baseline information, the main themes for discussion are as follows:

- *Inclusions of Marine Local Wildlife Sites (LWS)*

  Marine LWS will be included within the assessment.

- *Inclusion of Southern North Sea SAC*

  This site is outside the study area for Nature Conservation. The HRA will consider Natura 2000 sites in a more detailed context and will include consideration of sites further afield which have the potential for connectivity related issues, particularly with regards to mobile species such as birds and marine mammals.

- *Natural England notes that Dungeness SAC, Hastings Cliffs SAC, Pevensey Levels SAC, Dungeness, Romney Marsh and Rye Bay Ramsar, are not in the list of sites scoped into the* *assessment. If these sites have been considered and scoped out, then an explanation should be provided as to why this is.*

These SAC's and Ramsar sites are not included as these are located outside the maximum Zones of Influence (ZOIs) / study areas as defined by individual technical disciplines.

- Ramsar sites that are within the study area have been included within the assessment – these do not include those mentioned above*As noted previously, Natural England recommends that the Alderney West Coast and the Burhou Islands Ramsar site is added to the list of Ramsar sites.*

Ramsar sites that are within the study area have been included within the assessment, these do not include those mentioned above.

- *Full review of SSSI's to be done. In addition, Natural England recommends adding Seaford to Beachy Head SSSI and Brighton to Newhaven Cliffs SSSI.*

  A full review of SSSI's has been completed. The full list of those included within the assessment is presented within **Section 2.3**.

- *Inclusion of standalone MCZ assessment*

  A standalone MCZ assessment will be included.

- *Inclusion of standalone WFD assessment*

  A standalone WFD assessment will be included.

## 2.3 Sites to include within the assessment

There are several international, national and local designations (statutory and non-statutory) of relevance to Rampion 2 offshore and along the coastline. This section provides an overview of the designated sites relevant to the intertidal and offshore works.

### Natura 2000 sites

The sections below provide a list of Natura 2000 sites designated under the Habitats Directive and Birds Directive, that will be included within the Nature Conservation assessment. During the HRA Screening for Rampion 2 OWF, a detailed review of Natura 2000 sites will be undertaken in consultation with key stakeholders.

#### Special Areas of Conservation (SACs)

SACs are sites designated under the Habitats Directive, because they make a significant contribution to conserving the habitat types and species identified in Annexes I and II of the Directive. The closest SACs of relevance to the Proposed Development are detailed in **Table 2-2** and presented in **Figure 2-2**. As the table determines the SACs lie outside the ZOI for benthic subtidal and intertidal ecology, for which the sites are designated. Therefore, no impact to the sites are anticipated and no SACs will be included within the assessment.

*Table 2-2 SACs to be scoped out of the assessment.*

| Site | Location relative to Rampion 2 OWF scoping boundary and reason for scoping out of assessment. | Features or description |
|---|---|---|

| | | |
|---|---|---|
| South Wight Maritime SAC | Approximately 20km west of the Rampion 2 OWF scoping boundary. The site falls outside the benthic ecology ZOI. The site is only designated for benthic features of interest and therefore no impact is expected from the proposed development of Rampion 2. | This site is protected for three Annex I habitats; reefs, vegetated sea cliffs of the Atlantic and Baltic coasts and submerged or partially submerged sea caves. This site is selected on account of its variety of reef types and associated communities, including chalk, limestone and sandstone reefs. |
| Solent Maritime SAC | Approximately 21km from the Rampion 2 OWF scoping boundary. The site falls outside the benthic ecology ZOI. The site is only designated for benthic features of interest and therefore no impact is expected from the proposed development of Rampion 2. | Annex I habitats that are the primary reason for selection of this site include estuaries, Spartina swards (*Spartinion maritimae*) and Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*). Annex I habitats present as a qualifying feature, but not a primary reason for selection of this site include sandbanks which are slightly covered by sea water all the time, mudflats and sandflats not covered by seawater at low tide, coastal lagoons, annual vegetation of drift lines, perennial vegetation of stony banks, *Salicornia* and other annuals colonizing mud and sand and "Shifting dunes along the shoreline with *Ammophila arenaria* (""white dunes""). |
| Solent and Isle of Wight lagoons SAC | Approximately 20km from the Rampion 2 OWF scoping boundary. The site falls outside the benthic ecology ZOI. The site is only designated for benthic features of interest and therefore no impact is expected from the proposed development of Rampion 2. | Annex I habitats that are the primary reason for selection of this site include coastal lagoons. |

## Special Protection Areas (SPAs)

SPAs are designated under the European Union Directive on the Conservation of Wild Birds. Under the Directive, Member States of the European Union (EU) have a duty to safeguard the habitats of migratory birds and certain particularly threatened bird species. SPAs of relevance to the Proposed Development are detailed in **Table 2-3** and presented in **Figure 2-2.**

*Table 2-3 SPAs of relevance to the Proposed Development.*

| Site | Location relative to Rampion 2 OWF scoping boundary | Features or description |
|---|---|---|
| Solent and Dorset Coast SPA | Approximately 1km from the Rampion 2 OWF scoping boundary and falls within the offshore ornithology ZOI. The site is designated for offshore ornithology features of interest. | The site has been designated to protect internationally important breeding populations of common tern (*Sterna hirundo*), Sanwich tern (*Sterna sandvicensis*) and little tern (*Sternula albifrons*). |

The following table identifies the SPAs that lie outside the ZOI for offshore ornithology, for which the sites are designated. Therefore, no impact to these sites are anticipated and will be scoped out of the Nature Conservation assessment. It should however be noted that the HRA will consider Natura 2000 sites designated under the Habitats Directive and Birds Directive in a more detailed context and will therefore include consideration of sites further afield which have the potential for connectivity related issues, particularly with regards to mobile species such as birds.

*Table 2-4 SPAs to be scoped out of the assessment.*

| Site | Location relative to Rampion 2 OWF scoping boundary | Features or description |
|---|---|---|

| | | |
|---|---|---|
| Pagham Harbour SPA | Approximately 10km from the Rampion 2 OWF scoping boundary. The site falls outside the offshore ornithology ZOI. The site is only designated for offshore ornithology features of interest and therefore no impact is expected from the proposed development of Rampion 2. | This site is designated as the estuarine basin is made up of an extensive central area of saltmarsh and intertidal mudflats, surrounded by lagoons, shingle, open water, reed swamp and wet permanent grassland. The mudflats are rich in invertebrates and algae and provide important feeding areas for the many bird species that use the site. |
| Chichester and Langstone Harbours SPA | Approximately 23km from the Rampion 2 OWF scoping boundary. The site falls outside the offshore ornithology ZOI. The site is only designated for offshore ornithology features of interest and therefore no impact is expected from the proposed development of Rampion 2. | Both Chichester and Langstone Harbours contain extensive intertidal mudflats and sandflats with areas of seagrass beds, saltmarsh, shallow coastal waters, coastal lagoons, coastal grazing marsh and shingle ridges and islands. These habitats support internationally and nationally important numbers of overwintering and breeding bird species, which are the primary qualifying features for this site. |
| Dungeness, Romney Marsh and Rye Bay potential SPA | Approximately 46km from the Rampion 2 OWF scoping boundary. The site falls outside the offshore ornithology ZOI. The site is only designated for offshore ornithology features of interest and therefore no impact is expected from the proposed development of Rampion 2. | This site was designated to protect it's important breeding and wintering waterbirds, birds of prey, passage warblers and breeding seabirds. It is also selected for the site's complex network of wetland types and habitats that support rich and diverse groups of bryophytes, vascular plants, invertebrates and vulnerable, endangered and critically endangered wetland species. |
| Solent and Southampton Water SPA | Approximately 28km from the Rampion 2 OWF scoping boundary. The site falls outside the offshore ornithology ZOI. The site is only designated for offshore ornithology features of interest and therefore no impact is expected from the proposed development of Rampion 2. | This site has been designated to protect internationally important breeding and non-breeding birds and waterbird assemblage. |
| Portsmouth Harbour SPA | Approximately 35km from the Rampion 2 OWF scoping boundary. The site falls outside the offshore ornithology ZOI. The site is only designated for offshore ornithology features of interest and therefore no impact is expected from the proposed development of Rampion 2. | This site has been designated to protect internationally important breeding and non-breeding birds. |

### RAMSAR

Ramsar sites are wetlands of international importance that have been designated by the UK Government under the International Ramsar Convention (the Convention on Wetlands of International Importance), for containing representative, rare or unique wetland types or for their importance in conserving biological diversity. Ramsar sites that fall within the offshore ornithology ZOI include Arun Valley and Pagham Harbour. These will therefore be assessed within the Nature Conservation assessment. Those that fall outside this study area ZOI will not be included within this assessment. The sites are presented in **Figure 2-2**.

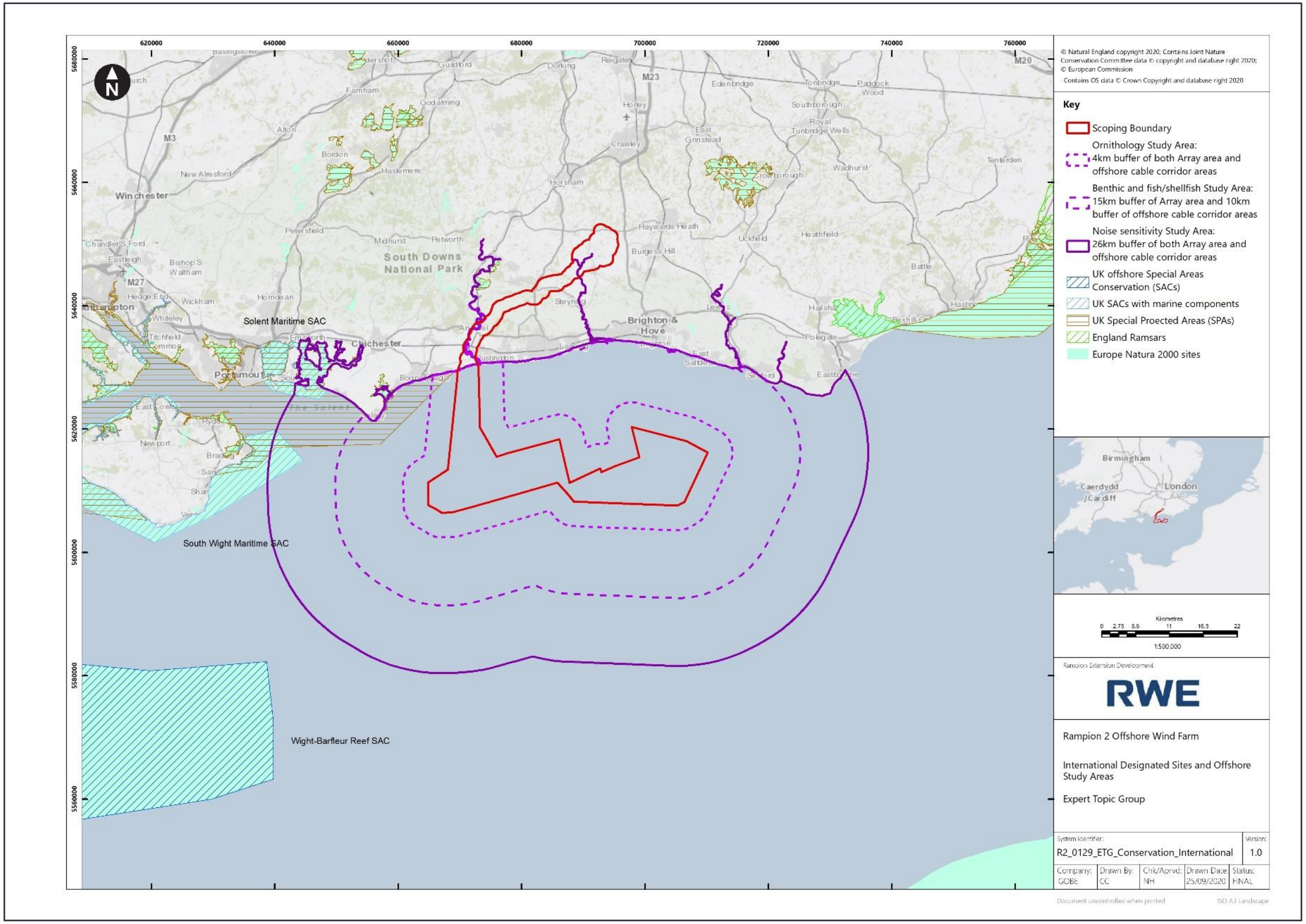



*Figure 2-2 Statutory international designations of relevance to the Proposed Development.*

## Statutory National Designations

At a national level and within the vicinity of the Proposed Development, there are three types of designated site for nature conservation; these being Marine Conservation Zones (MCZ), Sites of Special Scientific Interest (SSSI) and National Nature Reserves (NNR).

The Marine and Coastal Access Act 2009 created a relatively new type of Marine Protected Area (MPA) called an MCZ, which are of national importance. MCZs are intended to protect areas that are important to conserve the diversity of rare, threatened and representative marine habitats, species, geology and geomorphology in UK waters and they, together with other types of MPAs, deliver the Government's objective for an ecologically coherent network of MPAs. Features proposed to be designated for protection by MCZs comprise 'broad-scale habitats', and 'Features of Conservation Importance (FOCI). The MCZ's of relevance to the Proposed Development are presented in **Table 2-5** and **Figure 2-3**.

A SSSI is the land notified as an SSSI under the Wildlife and Countryside Act (1981), as amended. SSSI are the finest sites for wildlife and natural features in England, supporting many characteristic, rare and endangered species, habitats and natural features. The SSSI's of relevance to the Proposed Development are presented in **Table 2-5** and **Figure 2-3**.

NNR's are a statutory designation made under Section 21 of the National Parks and Access to the Countryside Act 1949 by principal local authorities. They are places with wildlife or geological features that are of special interest locally. The NNR's of relevance to the Proposed Development are presented in **Table 2-5** and **Figure 2-3**.

*Table 2-5 Statutory national designations of relevance to the Proposed Development.*

| Site | Location relative to Rampion 2 OWF scoping boundary | Features or description |
|---|---|---|
| Kingmere MCZ | Lies adjacent to the proposed Rampion 2 offshore cable corridor and falls within the benthic and fish ecology ZOI. The site is designated for benthic and fish ecology features of interest. | Named after Kingmere Rocks, which is a rocky and boulder reef running through the middle of the site. There are also areas of chalk and different types of sediment. It is a place where black seabream come to breed in the spring. The features of this site are moderate energy infralittoral rock and thin mixed sediments, subtidal chalk and black seabream (*Spondyliosoma cantharus*). |
| Offshore Overfalls MCZ | Lies adjacent to the proposed Rampion 2 OWF array area and falls within the benthic ecology ZOI. The site if designated for benthic ecology features of interest. | The site is designated for several marine habitats including; subtidal coarse sediment, subtidal mixed sediments, subtidal sand and English Channel outburst flood features |
| Selsey Bill and the Hounds MCZ | Approximately 10km from the Rampion 2 OWF scoping boundary and falls within the benthic and fish ecology ZOI. The site is designated for benthic and fish ecology features of interest. | This site is designated for several marine features including: Bracklesham Bay geological feature, short-snouted seahorse (*Hippocampus hippocampus*), subtidal mixed sediments, subtidal sand, rock features and peat and clay exposures. |
| Pagham Harbour MCZ | Approximately 10km from the Rampion 2 OWF scoping boundary and falls within the benthic ecology ZOI. The site if designated for benthic ecology features of interest. | This site is designated for several marine features including: Seagrass beds, defolin's lagoon snail (*Caecum armoricum*), and the Lagoon sand shrimp (*Gammarus insensibilis*). |
| Utopia MCZ | Approximately 13km from the Rampion 2 OWF scoping boundary and falls within the benthic ecology ZOI. The site if designated for benthic ecology features of interest. | The protected features of this site include: circalittoral rock, subtidal coarse and mixed sediment, subtidal sands and fragile sponge and anthozoan communities on subtidal rocky habitats. |
| Beachy Head West MCZ | Approximately 13km from the Rampion 2 OWF scoping boundary and falls within the benthic | These sites protect 10 different types of habitat and their associated species and offer specific protection to 2 species |

| | | |
|---|---|---|
| | and fish ecology ZOI. The site is designated for benthic and fish ecology features of interest. | of conservation importance. These include intertidal coarse sediments, subtidal mixed, mud and sand, infralittoral muds and sands, infralittorial and circalittoral rock, chalk and their associated communities, native oyster (*Ostrea edulis*) and the short snouted seahorse (*Hippocampus hippocampus*). |
| Climping Beach Site of Specific Scientific Interest (SSSI) | Overlaps with the Rampion 2 offshore cable corridor landfall and falls within the offshore ornithology ZOI and the benthic ecology ZOI. The site is designated for offshore ornithology and benthic/intertidal features of interest. | This site is designated offshore features including aggregations of non-breeding birds including sanderling and *Calidris alba* as well as coastal vegetated shingle, fixed dune grassland and sand dune communities. |
| Bognor Reef SSSI | Approximately 6km from the Rampion OWF scoping boundary and falls within the benthic/intertidal ecology ZOI. The site is designated for intertidal ecology features of interest. | This site is designated for offshore features including *Rumex crispus - Glaucium flavum* shingle community. |
| Adur Estuary SSSI | Approximately 16km from the Rampion OWF scoping boundary and falls within the benthic/intertidal ecology ZOI. The site is designated for intertidal ecology features of interest. The site does not fall within the offshore ornithology ZOI so these features will not be included within the assessment. | This site is designated for offshore features including aggregations of non-breeding birds - Ringed Plover, (*Charadrius hiaticula),* sheltered muddy shores (including estuarine muds), *Puccinellia maritima* saltmarsh, *Limonium vulgare - Armeria maritima* sub-community and *Atriplex portulacoides* saltmarsh. |
| Brighton to Newhaven Cliffs SSSI | Approximately 13km from the Rampion OWF scoping boundary and falls within the benthic/intertidal ecology ZOI. The site is designated for intertidal ecology features of interest. The site does not fall within the offshore ornithology ZOI so these features will not be included within the assessment. | This site is designated for offshore features including an isolated bird colony for kittiwake (*Rissa tridactyla*) and reefs. |
| West Beach Local Nature Reserve (LNR) | Overlaps with the Rampion 2 offshore cable corridor landfall and falls within the offshore ornithology ZOI as well as the benthic/intertidal ecology ZOI. The site is designated for offshore ornithology and benthic/intertidal features of interest. | The West Beach LNR is part of the Climping Beach SSSI. It includes sand dunes, vegetated shingle, sand flats and a small patch of saltmarsh. Sand lizards (*Lacerta agilis*), protected under the Wildlife and Countryside Act 1984, and four nationally scarce burrowing bees and wasps occur in the dunes. The vegetated shingle, though locally common, is internationally rare, and is used by a Red Data Book ant species. The sand flats host large numbers of migratory waders in the winter months. |

The following marine local wildlife sites (LWS) will be included within the assessment if they fall within the ZOI for features for which they are designated: Waldrons Marine LWS, Shelley Rocks LWS and HMS Northcoates Marine LWS. The GIS is being provided by statutory consultees to enable us to perform an assessment of impacts on these sites.

Table 2-6 identifies the statutory national designations that lie outside the ZOI for features for which the sites are designated. Therefore, no impact to these sites are anticipated and will be scoped out of the Nature Conservation Assessment. It should however be noted that the HRA will consider Natura 2000 sites designated under the Habitats Directive and Birds Directive in a more detailed context and will therefore include consideration of sites further afield which have the potential for connectivity related issues, particularly with regards to mobile species such as birds and marine mammals.

*Table 2-6 Statutory national designations scoped out of the assessment.*

| Site | Location relative to Rampion 2 OWF scoping boundary and reason for scoping out of assessment. | Features or description |
|---|---|---|
| Bembridge MCZ | Approximately 21km from the Rampion 2 OWF scoping boundary. The site falls out with the benthic ecology ZOI. The site is only designated for benthic ecology features of interest and therefore no impact is expected from the proposed development of Rampion 2. | Sheltered muddy gravels, short-snouted seahorse (*Hippocampus hippocampus*), stalked jellyfish (*Calvadosia campanulata*), stalked jellyfish (*Haliclystus* species), subtidal coarse sediment, subtidal sand, maerl beds, native oyster (*Ostrea edulis*), peacock's tail (*Padina pavonica*), sea-pens and burrowing megafauna, seagrass beds, subtidal mixed sediments and subtidal mud. |
| Beach Head East MCZ | Approximately 23km from the Rampion 2 OWF scoping boundary. The site falls outwith the benthic and fish ecology ZOI. The site is only designated for benthic and fish ecology features of interest and therefore no impact is expected from the proposed development of Rampion 2. | This site is designated for several marine features including: Littoral chalk communities, short-snouted seahorse (*Hippocampus hippocampus*), subtidal coarse sediment, subtidal sand, high energy circalittoral rock, moderate energy circalittoral rock, peat and clay exposures, Ross worm reefs (*Saballeria spinulosa*) and subtidal chalk. |
| Offshore Brighton MCZ | Approximately 23km from the Rampion 2 OWF scoping boundary. The site falls out with the benthic ecology ZOI. The site is only designated for benthic ecology features of interest and therefore no impact is expected from the proposed development of Rampion 2. | This site is designated for several marine features including: High energy circalittoral rock, subtidal coarse sediment and subtidal mixed sediments |
| Chichester Harbour SSSI | Approximately 20km from the Rampion 2 OWF scoping boundary. The site falls out with the benthic and fish ecology and offshore ornithology ZOI. The site is only designated for benthic/ fish ecology and ornithological features of interest and therefore no impact is expected from the proposed development of Rampion 2. | The features for which the Harbour was designated includes a wide range of intertidal and terrestrial habitats, internationally important numbers of waterbirds and nationally important species of flora and fauna. |
| Bracklesham Bay SSSI | Approximately 13km from the Rampion 2 OWF scoping boundary. The site falls outside the offshore ornithology and intertidal ecology ZOI. The site is only designated for ornithological and intertidal features of interest and therefore no impact is expected from the proposed development of Rampion 2. | This site is designated offshore features including aggregations of non-breeding birds inlcuding black-tailed Godwit (*Limosa limosa islandica)*, brent goose (*Branta bernicla bernicla*), Pintail (*Anas acuta*), Ruff (Philomachus pugnax) and lowland fen without open water and shingle communities. |
| Pagham Harbour SSSI | Approximately 9km from the Rampion 2 OWF scoping boundary. The site falls outside the offshore ornithology and intertidal ecology ZOI. The site is only designated for ornithological and intertidal features of interest and therefore no impact is expected from the proposed development of Rampion 2. | This site is designated offshore features including aggregations of breeding birds little tern (*Sterna albifrons*) nlack-tailed godwit (*Limosa limosa islandica*), brent goose (dark-bellied) (*Branta bernicla bernicla*), Grey Plover (*Pluvialis squatarola*), Pintail (*Anas acuta*), Ringed Plover (*Charadrius hiaticula*), and Ruff (*Philomachus pugnax*), assemblages of breeding birds - lowland damp grasslands, assemblages of breeding birds - sand-dunes and saltmarshes, invertebrate assemblage, population of Schedule 5 sea anemone - *Nematostella vectensis*, starlet sea anemone, population of Schedule 8 plant (Petrorhagia nanteuilii), childing pink saline coastal lagoons, *Rumex* |

| | | |
|---|---|---|
| | | *crispus - Glaucium flavum* shingle community, *Atriplex portulacoides* saltmarsh, *Spartina anglica* saltmarsh. |
| Seaford to Beachy Head SSSI | Approximately 15km from the Rampion 2 OWF scoping boundary. The site falls outside the offshore ornithology ZOI. The site is only designated for ornithological features of interest and therefore no impact is expected from the proposed development of Rampion 2. | This site is designated offshore features including assemblages of breeding birds - mixed: lowland heath. |
| Selsey, East Beach SSSI | Approximately 15km from the Rampion 2 OWF scoping boundary. This site doesn't include features that will be impacted by a secondary ZOI. | This site is designated for Pleistocene Vertebrata and Quaternary of South-Central England. |
| Felpham SSSI | Approximately 4km from the Rampion 2 OWF scoping boundary. This site doesn't include features that will be impacted by a secondary ZOI. | This site is designated for Tertiary Palaeobotany. |

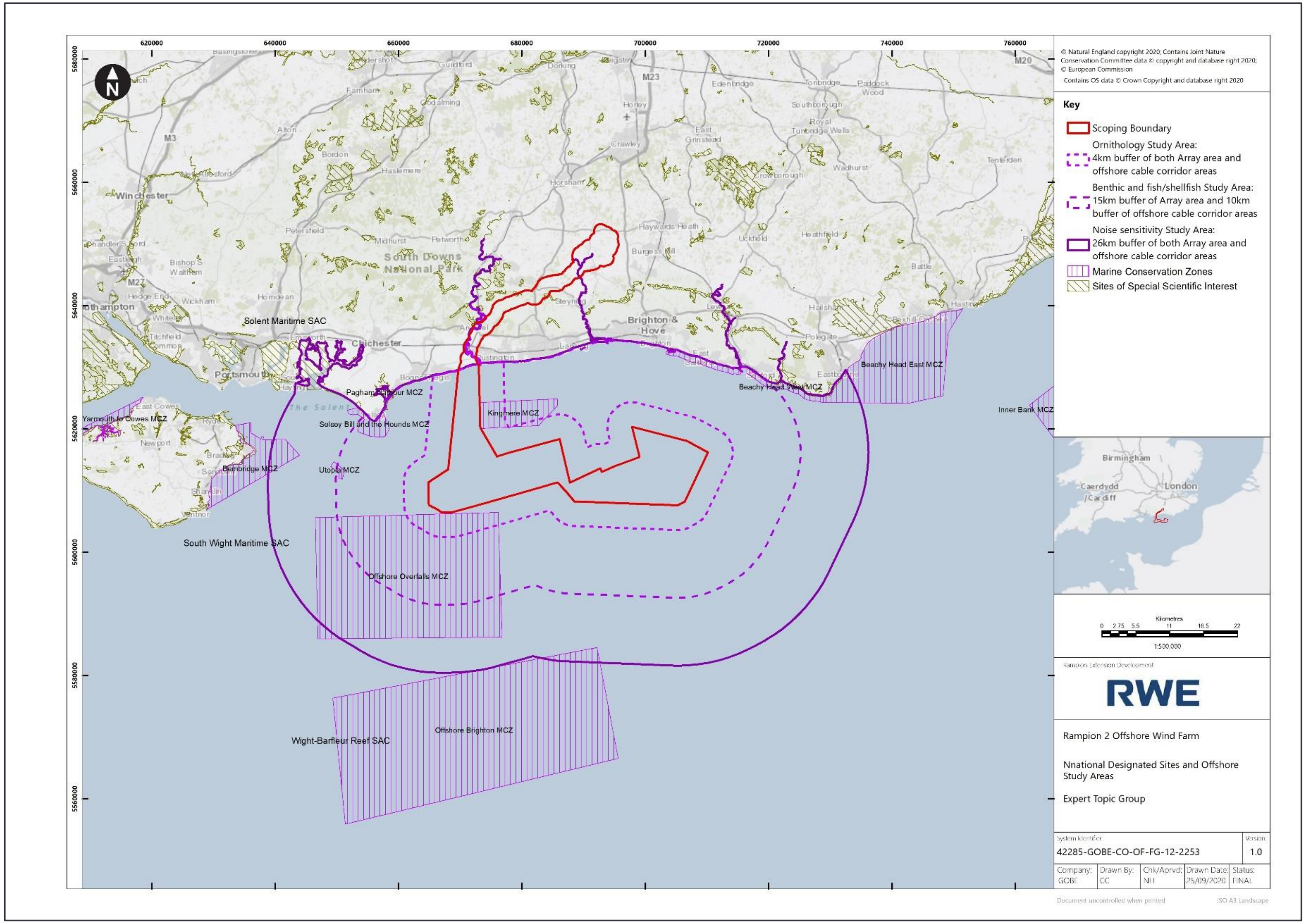



*Figure 2-3 Statutory national designations of relevance to the Proposed Development.*

## UK Biodiversity Action Plan (BAP)

2.3.1 The Convention of Biological Diversity was signed in Rio de Janeiro in 1992 (and hence is also referred to as the Rio Convention) and entered into force in 1993. It was the first treaty to provide a legal framework for biodiversity conservation and included calls for national strategies and action plans to 'conserve, protect and enhance biological diversity'.

2.3.2 The UK response was the UK BAP, launched in 1994. The UK plan includes the identification of several habitats and species, together with a series of local action plans. The following priority maritime species and habitats have been identified by the Sussex Biodiversity Partnership (East and West Sussex and Brighton and Hove councils) and the UK BAP:

- Coastal saltmarsh
- Littoral and sublittoral chalk
- Biogenic reef
- Maritime cliffs and slopes
- Saline lagoons
- Brackish hydroid (*Clavopsella navis*)
- Ivell's sea anemone (*Edwardsia ivelli*)
- Lagoon sand shrimp (*Gammarus insensibilis*)
- Basking shark (*Cetorhinus maximus*)
- Dolphin
- Toothed whale

Sept 2020

**Briefing Note**

SMRU Consulting
understand • assess • mitigate

# Rampion 2 noise impact assessment methodology


Introduction ........ 1
Pile driving ........ 2
Noise modelling ........ 2
Piling scenarios ........ 2
Quantifying the impact ........ 3
PTS assessment for pile driving ........ 3
TTS assessment for pile driving ........ 4
Behavioural disturbance assessment for pile driving ........ 5
UXO clearance ........ 6
Noise modelling ........ 6
UXO scenarios ........ 6
Quantifying the impact ........ 7
PTS assessment for UXO ........ 7
TTS assessment for UXO ........ 7
Behavioural disturbance assessment for UXO ........ 7
References ........ 7


## Introduction

This briefing note outlines the proposed methodology to assess the impact of underwater noise on marine mammals as a result of the construction of Rampion 2. The purpose of the document is to share the proposed approach with the Rampion 2 ETG in order to discuss and agree on the final methodology used for the noise impact assessment in the frame of developing the Environmental Statement for Rampion 2.

The main noise sources with the potential to harm marine mammals which can be quantitatively assessed are pile driving during the installation of the wind farm foundations and UXO clearance before start of construction. The following sections will therefore focus on the methodology used to quantify the potential impact of noise emitted during pile driving and UXO clearance.

# Briefing Note

## Pile driving

The installation of turbine foundations by means of impact piling leads to the emission of impulsive sound into the water column with each hammer strike used to drive a pile further into the seabed. This sound can lead to auditory injury and behavioural disturbance in marine mammals. To quantify this impact, noise levels expected will be predicted by Subacoustech Environmental Ltd for a set of piling scenarios using their INSPIRE model.

### Noise modelling

To estimate the underwater noise levels likely to arise during the construction and operation of the windfarm, predictive noise modelling using the INSPIRE noise model, which meets the requirements set by the NPL Good Practice Guide 133 for underwater noise measurement (Robinson et al., 2014).

The INSPIRE model (currently version 5.0) is a semi-empirical underwater noise propagation model based around a combination of numerical modelling and actual measured data. It is designed to calculate the propagation of noise in shallow, mixed water, typical of the conditions around the UK and very well suited to the region around Rampion 2. The model has been tuned for accuracy using over 70 datasets of underwater noise propagation from monitoring around offshore piling activities.

The model provides estimates of unweighted $SPL_{peak}$, $SEL_{ss}$, and $SEL_{cum}$ noise levels, as well as various other weighted noise metrics. Calculations are made along 180 equally spaced radial transects (one every two degrees). For each modelling run a criterion level can be specified allowing a contour to be drawn, within which a given effect may occur. These results are plotted over digital bathymetry data so that impact ranges can be clearly visualised as necessary.

INSPIRE considers a wide array of input parameters, including variations in bathymetry and source frequency content to ensure accurate results are produced specific to the location and nature of the piling operation. The results produced by the model are considered conservative due to the parameters selected and the design, which fits the upper bounds of measured noise levels rather than an average, which risks underestimating impacts.

### Piling scenarios

A range of turbine locations will be chosen for which the noise emission during pile driving will be modelled. These will be selected in conjunction with the noise modellers and Rampion 2 project team to ensure that a range of 'realistic worst case' scenarios are included in the assessment. Locations will be chosen based on noise propagation conditions and proximity to sensitive marine mammal receptors to predict impact of pile driving for WTG foundation installation and other infrastructure (e.g. substations).

Recent industry operational experience when installing offshore wind farms has shown that the actual hammer energies used during construction have been much lower than those maximum design scenario parameters defined during the assessments. In recognition of this, a most likely ramp up scenario will be defined to be representative of the majority of the piling activity. In addition to this, the maximum design scenario will be presented. The maximum design scenario is intended to cover the absolute maximum piling parameters that would ever be required to install a foundation (in terms of maximal hammer energies and longest piling durations).

The final decision on which scenarios will be modelled will require detailed information from the project design regarding piling parameters – in terms of hammer energies and strike rates including the consideration of ramp up (duration, energy and strike rate of each step), as well as the likelihood of concurrent piling activity and multiple activities in a 24h-period (e.g. for the installation of multiple piles in 1 day).

## Quantifying the impact

Exposure to loud sounds can lead to auditory injury by means of a temporary (TTS) or permanent (PTS) reduction in hearing sensitivity (a shift in hearing threshold), and/or a behavioural reaction of the animals to the sound. The assessment methodology for these impacts is detailed in the following.

### *PTS assessment for pile driving*

To quantify the impact of noise with regard to PTS, we will determine the PTS-onset impact range (the area around the piling location within which the noise levels exceed the PTS-onset threshold). Based on agreed density estimates for each marine mammal species, the number of animals expected in the PTS-onset impact range will be calculated and presented as a proportion of the relevant population size.

The most recent guidance to assess the likelihood of auditory injury in marine mammals caused by noise is given in Southall *et al.* (2019). To determine impact ranges for PTS-onset, they group species into species groups according to their hearing abilities and propose species group specific PTS-onset thresholds. For impulsive sound (e.g. pile driving) a dual metric threshold is proposed: the peak sound pressure level $SPL_{z\text{-}p,\ flat}$ (a value applied to single strikes for the onset of 'instantaneous' PTS), and the cumulative sound exposure level $SEL_{cum}$ (a value for the onset of 'cumulative' PTS that includes the whole piling sequence from the first to the last pile strike) (Table 1). The Southall *et al.* (2019) guidance specifically recommends that the threshold which generates the largest impact range is the one that should be used for calculating PTS-onset. In order to assess the cumulative PTS-onset impact ranges, assumptions need to be included in the model with respect to the likely fleeing speed of the animals. Rampion 2 will use a precautionary speed of 1.5 m/s for most species except for minke whales where 3.25 m/s will be adopted.

Southall *et al.* (2019) propose the $SPL_{z\text{-}p}$ (being either unweighted or flat weighted across the entire frequency band of a hearing group). This is because the direct mechanical damage to the auditory system that is associated with high peak sound pressures is not frequency dependent (i.e. restricted to the audible frequency range of a species). The physiological damage that sound energy can cause is mainly restricted to energy occurring in the frequency range of a species' hearing range. Therefore, for the cumulative sound exposure level ($SEL_{cum}$), sound will be weighted based on species group specific weighting curves given in Figure 1. The $SEL_{cum}$ threshold for PTS-onset considers the sound exposure level received by an animal and the duration of exposure, accounting for the accumulated exposure over the duration of an activity within a 24-hour period. Southall *et al.* (2019) recommends the application of $SEL_{cum}$ for the individual activity alone (i.e. not for multiple activities occurring within the same area or over the same time). To inform this impact assessment sound modelling will consider the $SEL_{cum}$ over a piling event. If scenarios with more than one piling event are likely within 24 hours, these scenarios will also be modelled.

# Briefing Note

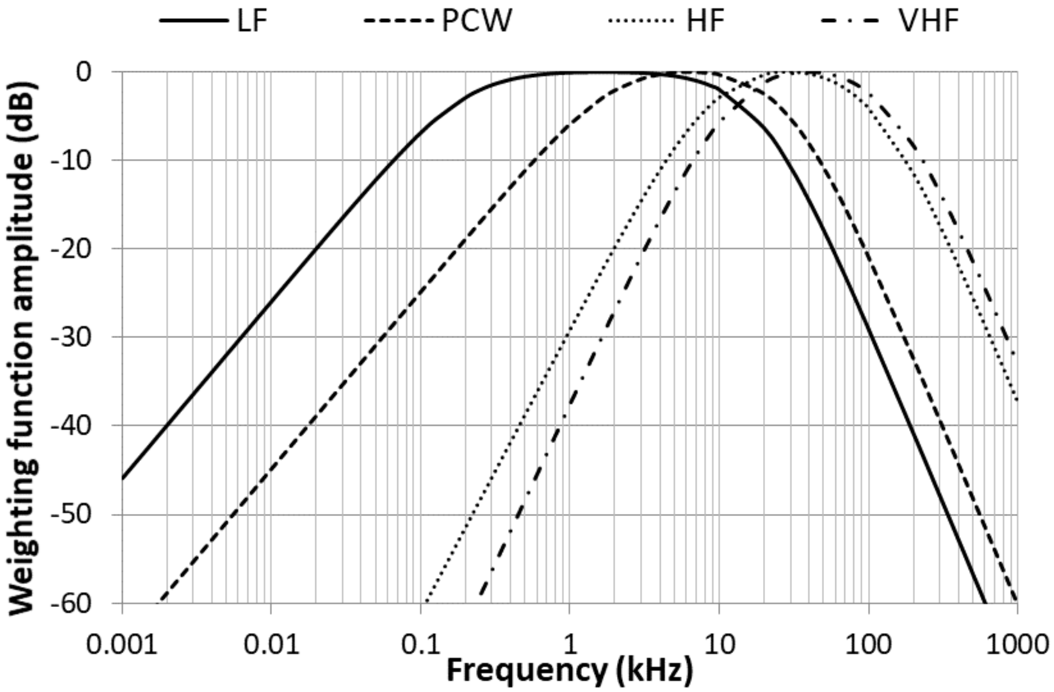



*Figure 1 Auditory weighting functions for low frequency (LF), high frequency (HF) and very high frequency (VHF) cetaceans as well as phocid (PCW) pinnipeds in water according to Southall et al. (2019).*

*Table 1 PTS-onset thresholds for marine mammals exposed to impulsive noise (Southall et al 2019)*

| Hearing group | Species | PTS-onset $SEL_{cum}$ (dB re 1 µPa²s) weighted | PTS-onset $SPL_{peak}$ (dB re 1 µPa) unweighted |
|---|---|---|---|
| Low frequency | Minke whale | 183 | 219 |
| High frequency | Bottlenose dolphin<br>White-beaked dolphin<br>Common dolphin | 185 | 230 |
| Very high frequency | Harbour porpoise | 155 | 202 |
| Phocid in water | Harbour seal<br>Grey seal | 185 | 218 |

## *TTS assessment for pile driving*

The PTS-thresholds proposed by Southall *et al.* (2019) define the level at which a single exposure is estimated to cause the onset of a permanent hearing loss (a permanent 6 dB shift of the hearing threshold) as minimum exposure criterion for injury (Southall *et al.* 2007). The experimental determination of PTS-onset thresholds involves causing injury in the experimental animal, and therefore no such studies are conducted on marine mammals, as this is considered unethical. Instead, the level of sound eliciting the onset of TTS and the relation of TTS growth with received sound energy are subjects of investigations. Exposure criteria for PTS are eventually based on the

TTS-onset thresholds and the knowledge gained from available data from humans and other terrestrial mammals that indicate that a shift in the hearing threshold of 40 dB may eventually lead to the onset of PTS (Southall *et al.* 2007). To estimate PTS onset-thresholds in an ethical way, researchers determine the onset of TTS in marine mammals in experimental set ups and use those to calculate at which sound levels a TTS would reach a shift of 40 dB. The thresholds at which the onset of TTS is observed are, as per Southall *et al.* (2007), a 6 dB shift in the hearing threshold, usually measured four minutes after sound exposure. This shift is considered as "*the minimum threshold shift clearly larger than any day-to-day or session-to-session variation in a subject's normal hearing ability*", and which "*is typically the minimum amount of threshold shift that can be differentiated in most experimental conditions*." The recovery period of such TTS back to the initial hearing threshold is short. TTS-onset thresholds updated by Southall *et al.* (2019) are presented in Table 2.

For the noise impact assessment for the Rampion 2 project, the ranges that indicate TTS-onset will be modelled and presented. However, as TTS-onset is defined primarily as a means of predicting PTS onset, the TTS-onset thresholds do not indicate any level of biologically significant effect and are therefore inappropriate as thresholds to predict noise impact. There is currently no threshold for the amount of TTS that would indicate a biologically significant amount of TTS; therefore it is impossible to carry out a quantitative assessment of the magnitude or significance of the impact of TTS on marine mammals. The current set of TTS-onset thresholds will result in a significant overestimate of the impact due to the extremely large resulting impact ranges representing the smallest measurable amount of TTS. These TTS-onset thresholds will not be used to quantify the numbers of animals at risk of any TTS; instead, ranges with be presented for context only (to be discussed and agreed at the ETG).

*Table 2 TTS-onset thresholds for marine mammals exposed to impulsive noise (Southall et al 2019)*

| Hearing group | Species | TTS-onset $SEL_{cum}$ (dB re 1 µPa²s) weighted | TTS-onset $SPL_{peak}$ (dB re 1 µPa) unweighted |
|---|---|---|---|
| Low frequency | Minke whale | 168 | 213 |
| High frequency | Bottlenose dolphin<br>White-beaked dolphin<br>Common dolphin | 170 | 224 |
| Very high frequency | Harbour porpoise | 140 | 196 |
| Phocid in water | Harbour seal<br>Grey seal | 170 | 212 |

## *Behavioural disturbance assessment for pile driving*

Unlike for thresholds of auditory injury, there currently are no established regulatory guidance documents and few published scientific articles providing clear advice on the appropriate thresholds for behavioural response to pile driving noise. There are published thresholds for behavioural reactions to military sonars (Finneran and Jenkins 2012), and empirically derived dose-response curves for various species based on exposure to military sonar signals (Houser *et al.* 2013, Miller *et al.* 2014, Harris *et al.* 2015, Sivle *et al.* 2015) or pile driving activity (Thompson *et al.* 2013, Tougaard *et al.* 2013, Graham *et al.* 2017), as well as studies on behavioural reactions to pile driving that might be used to derive a dose-response function (Brandt *et al.* 2016, Russell *et al.* 2016).

A dose-response function explores the relationship between the probability of response of an individual animal and either the range from the source or the received level of sound. As such a dose-response function reflects that not all animals in an area will display a behavioural response to the perceived sound. The proportion of animals responding will depend on the received sound level, which will generally decrease with increasing distance from the sound source.

The dose-response curve developed by Graham *et al.* (2017) was generated from data on harbour porpoises collected during the first six weeks of piling during Phase 1 of the Beatrice Offshore Wind Farm monitoring program. In the absence of species-specific data for dolphin species or minke whale, this dose-response curve will be adopted for all cetacean species. This is likely to be precautionary since harbour porpoise are more sensitive to noise impacts than other cetacean species.

For harbour seals, data collected and analysed by Russell *et al.* (2016) on harbour seal responses during several months of pile driving at the Lincs Offshore Wind Farm was used to develop a dose-response curve (Whyte *et al.* 2020). In the absence of species specific data for grey seals, this dose-response curve will be used for both seal species.

For the assessment of behavioural disturbance, Subacoustech will provide noise contours at 5 dB $SEL_{ss}$ intervals. These will be overlain on species density surfaces to predict the number of animals potentially disturbed. This will allow for the quantification of the number of animals that will potentially display a behavioural reaction.

# UXO clearance

There is the potential requirement for underwater UXO clearance prior to construction. However, since a UXO survey has not yet been conducted, it is not possible at this time to define an accurate prediction of the number of UXO nor the range of UXO charge sizes which may require detonation. As a result, a separate Marine Licence will be applied for pre-construction for the detonation of any UXO. However, the detonation of UXO is a source of additional noise in the marine environment and hence is considered in the assessment for marine mammals.

## Noise modelling

It is currently not known if recent propagation models can accurately predict sound levels and propagation loss of UXO detonations. Subacoustech will therefore use prediction formulas proposed by Soloway and Dahl (2014), Arons (1954) and Barett (1996), which are derived from and based on field measurements of underwater explosions.

## UXO scenarios

Calculations will be conducted for a range of expected UXO charge sizes. The source level of each UXO charge weight will be estimated using conservative calculation parameters that result in the upper estimate of the source level for each charge size. This is therefore considered to be an indication of the potential noise output from each charge size, and as such, assuming a worst-case scenario, will likely result in an overestimate of the noise impact, especially for larger charge sizes. Due to the lack of site-specific information at the current stage of the assessment, it will be assumed that the UXO is located in the centre of the array area.

### Quantifying the impact

Noise emitted during UXO clearance can, like pile driving noise, lead to auditory injury and/or a behavioural reaction. The assessment methodology for these impacts is detailed in the following.

#### *PTS assessment for UXO*

The recent Southall *et al.* (2019) PTS-onset thresholds will be used to assess the PTS-onset impact from UXO detonation from a range of charge sizes. The number of animals expected in the PTS-onset impact range will be calculated and presented as a proportion of the relevant population size.

#### *TTS assessment for UXO*

The Southall *et al.* (2019) TTS-onset thresholds will be used to predict the TTS-onset impact range from a range of UXO charge sizes. Following the approach adopted for the assessment of TTS for pile driving, these TTS-onset thresholds will not be used to quantify the numbers of animals at risk of any TTS; instead, ranges with be presented for context only (this is to be discussed and agreed at the ETG).

#### *Behavioural disturbance assessment for UXO*

JNCC (2020) advise that a buffer of 26 km around the source location is used to determine the impact area from UXO clearance with respect to disturbance of harbour porpoise within SACs. In the absence of agreed metrics for disturbance by UXO detonation for other marine mammal species and given a lack of empirical data on the likelihood of response to explosives, this 26 km radius (area of 2,124 $km^2$) will be applied for all species. The number of animals expected in the 26 km range will be calculated using species specific density estimates and presented as a proportion of the relevant population size.

## References

Arons, A. 1954. Underwater explosion shock wave parameters at large distances from the charge. The Journal of the Acoustical Society of America **26**:343-346.

Barett, R. 1996. Guidelines for the safe use of explosives underwater. MTD Publication **96**:101.

Brandt, M. J., A. Dragon, A. Diederichs, A. Schubert, V. Kosarev, G. Nehls, V. Wahl, A. Michalik, A. Braasch, C. Hinz, C. Katzer, D. Todeskino, M. Gauger, M. Laczny, and W. Piper. 2016. Effects of offshore pile driving on harbour porpoise abundance in the German Bight.

Finneran, J. J., and A. K. Jenkins. 2012. Criteria and thresholds for US Navy acoustic and explosive effects analysis.

Graham, I. M., A. Farcas, N. D. Merchant, and P. Thompson. 2017. Beatrice Offshore Wind Farm: An interim estimate of the probability of porpoise displacement at different unweighted single-pulse sound exposure levels. Prepared by the University of Aberdeen for Beatrice Offshore Windfarm Ltd.

Harris, C. M., D. Sadykova, S. L. DeRuiter, P. L. Tyack, P. J. O. Miller, P. H. Kvadsheim, F. P. A. Lam, and L. Thomas. 2015. Dose response severity functions for acoustic disturbance in cetaceans using recurrent event survival analysis. Ecosphere **6**:1-14.

Houser, D. S., S. W. Martin, and J. J. Finneran. 2013. Exposure amplitude and repetition affect bottlenose dolphin behavioral responses to simulated mid-frequency sonar signals. Journal of Experimental Marine Biology and Ecology **443**:123-133.

JNCC. 2020. Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs (England, Wales & Northern Ireland). JNCC Report No. 654, JNCC, Peterborough, ISSN 0963-8091.

Miller, P. J., R. N. Antunes, P. J. Wensveen, F. I. Samarra, A. C. Alves, P. L. Tyack, P. H. Kvadsheim, L. Kleivane, F. P. Lam, M. A. Ainslie, and L. Thomas. 2014. Dose-response relationships for the onset of avoidance of sonar by free-ranging killer whales. Journal of the Acoustical Society of America **135**:975-993.

Russell, D. J., G. D. Hastie, D. Thompson, V. M. Janik, P. S. Hammond, L. A. Scott-Hayward, J. Matthiopoulos, E. L. Jones, and B. J. McConnell. 2016. Avoidance of wind farms by harbour seals is limited to pile driving activities. Journal of Applied Ecology.

Sivle, L. D., P. H. Kvadsheim, C. Curé, S. Isojunno, P. J. Wensveen, F.-P. A. Lam, F. Visser, L. Kleivane, P. L. Tyack, and C. M. Harris. 2015. Severity of expert-identified behavioural responses of humpback whale, minke whale, and northern bottlenose whale to naval sonar. Aquatic Mammals **41**:469.

Soloway, A. G., and P. H. Dahl. 2014. Peak sound pressure and sound exposure level from underwater explosions in shallow water. The Journal of the Acoustical Society of America **136**:EL218-EL223.

Southall, B., J. J. Finneran, C. Reichmuth, P. E. Nachtigall, D. R. Ketten, A. E. Bowles, W. T. Ellison, D. Nowacek, and P. Tyack. 2019. Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. Aquatic Mammals **45**:125-232.

Southall, B. L., A. E. Bowles, W. T. Ellison, J. J. Finneran, R. L. Gentry, C. R. J. Greene, D. Kastak, D. R. Ketten, J. H. Miller, P. E. Nachtigall, W. J. Richardson, J. A. Thomas, and P. L. Tyack. 2007. Marine mammal noise exposure criteria: initial scientific recommendations. Aquatic Mammals **33**:411-414.

Thompson, P. M., G. D. Hastie, J. Nedwell, R. Barham, K. L. Brookes, L. S. Cordes, H. Bailey, and N. McLean. 2013. Framework for assessing impacts of pile-driving noise from offshore wind farm construction on a harbour seal population. Environmental Impact Assessment Review **43**:73-85.

Tougaard, J., S. Buckland, S. Robinson, and B. Southall. 2013. An analysis of potential broad-scale impacts on harbour porpoise from proposed pile driving activities in the North Sea. Report of an expert group convened under the Habitats and Wild Birds Directive - Marine Evidence Group MB0138. 38pp.

Whyte, K., D. Russell, C. Sparling, B. Binnerts, and G. Hastie. 2020. Estimating the impacts of pile driving sounds on seals: pitfalls and possibilities. The Effects of Noise on Aquatic Life **14**:3948-3958.

# Rampion Extension Development Limited

# Rampion 2 Offshore Wind Farm

**Method Statement**

Underwater Noise Impact Assessment

Wood Environment & Infrastructure Solutions UK Limited – November 2020

wood.

## Report for

RWE

## Main contributors

SMRU Consulting

## Issued by

.................................................................................
[redacted]

## Approved by

.................................................................................
[redacted]

## Wood

Shinfield Park
Shinfield
Reading RG2 9FW
United Kingdom
Tel +44 (0)118 9131234

## Copyright and non-disclosure notice

The contents and layout of this report are subject to copyright owned by Wood (© Wood Environment & Infrastructure Solutions UK Limited 2020) save to the extent that copyright has been legally assigned by us to another party or is used by Wood under licence. To the extent that we own the copyright in this report, it may not be copied or used without our prior written agreement for any purpose other than the purpose indicated in this report. The methodology (if any) contained in this report is provided to you in confidence and must not be disclosed or copied to third parties without the prior written agreement of Wood. Disclosure of that information may constitute an actionable breach of confidence or may otherwise prejudice our commercial interests. Any third party who obtains access to this report by any means will, in any event, be subject to the Third Party Disclaimer set out below.

## Third party disclaimer

Any disclosure of this report to a third party is subject to this disclaimer. The report was prepared by Wood at the instruction of, and for use by, our client named on the front of the report. It does not in any way constitute advice to any third party who is able to access it by any means. Wood excludes to the fullest extent lawfully permitted all liability whatsoever for any loss or damage howsoever arising from reliance on the contents of this report. We do not however exclude our liability (if any) for personal injury or death resulting from our negligence, for fraud or any other matter in relation to which we cannot legally exclude liability.

## Management systems

This document has been produced by Wood Environment & Infrastructure Solutions UK Limited in full compliance with our management systems, which have been certified to ISO 9001, ISO 14001 and OHSAS 18001 by LRQA.

## Document revisions

| No. | Details | Date |
|---|---|---|
| **0.1** | Reviewed by Offshore PM | 02.11.2020 |
| **0.2** | Reviewed by offshore PD | 03.11.2020 |
| **0.3** | Reviewed by PM | 04.11.2020 |
| **1.0** | Issue to RWE | 05.11.2020 |
| **1.1** | Final issue | 23.12.2020 |

# Contents


| | | |
|---|---|---|
| **1.** | **Introduction** | **4** |
| **2.** | **Pile Driving** | **5** |
| 2.1 | Introduction | 5 |
| 2.2 | Noise modelling | 5 |
| 2.3 | Piling scenarios | 5 |
| | Impact Piling Parameters | 7 |
| **3.** | **Proposed Approach to EIA** | **8** |
| 3.1 | Quantifying the impact | 8 |
| | Non-piling construction noise | 8 |
| | Effects of noise on marine mammals | 9 |
| | Effects of noise on fish | 12 |
| **4.** | **Cumulative and In-combination Impact Assessment** | **16** |
| **5.** | **UXO clearance** | **17** |
| 5.1 | Introduction | 17 |
| 5.2 | Noise modelling | 17 |
| 5.3 | UXO scenarios | 17 |
| 5.4 | Quantifying the impact | 17 |
| | PTS assessment for UXO | 17 |
| | TTS assessment for UXO | 17 |
| | Behavioural disturbance assessment for UXO | 18 |
| | Impacts on fish from UXO | 18 |
| **6.** | **References** | **19** |

# 1. Introduction

1.1.1 This Method Statement outlines the proposed methodology to assess the impact of underwater noise on marine mammals and fish as a result of the construction of Rampion 2. The purpose of the document is to share the proposed approach with the Rampion 2 Expert Topic Group (ETG) in order to discuss and agree on the final methodology used for the noise impact assessment in the frame of developing the Environmental Statement for Rampion 2.

1.1.2 The main noise sources with the potential to harm marine mammals and fish, which can be quantitatively assessed, are pile driving during the installation of the wind farm foundations and Unexploded Ordnance (UXO) clearance before start of construction, should this be required. The following sections therefore focus on the methodology used to quantify the potential impact of noise emitted during pile driving and UXO clearance.

# 2. Pile Driving

## 2.1 Introduction

2.1.1 The installation of turbine foundations by means of impact piling leads to the emission of impulsive sound into the water column with each hammer strike used to drive a pile further into the seabed. This sound can lead to auditory injury and behavioural disturbance in marine mammals and fish. To quantify this impact, noise levels expected will be predicted by Subacoustech Environmental Ltd for a set of piling scenarios using their INSPIRE model.

## 2.2 Noise modelling

2.2.1 To estimate the underwater noise levels likely to arise during the construction and operation of Rampion 2, predictive noise modelling using the INSPIRE noise model, which meets the requirements set by the NPL Good Practice Guide 133 for underwater noise measurement (Robinson et al., 2014).

2.2.2 The INSPIRE model (currently version 5.0) is a semi-empirical underwater noise propagation model based around a combination of numerical modelling and actual measured data. It is designed to calculate the propagation of noise in shallow, mixed water, typical of the conditions around the UK and very well suited to the region around Rampion 2. The model has been tuned for accuracy using over 70 datasets of underwater noise propagation from monitoring around offshore piling activities.

2.2.3 The model provides estimates of unweighted $SPL_{peak}$, $SEL_{ss}$, and $SEL_{cum}$ noise levels, as well as various other weighted noise metrics. Calculations are made along 180 equally spaced radial transects (one every two degrees). For each modelling run a criterion level can be specified allowing a contour to be drawn, within which a given effect may occur. These results are plotted over digital bathymetry data so that impact ranges can be clearly visualised as necessary.

2.2.4 INSPIRE considers a wide array of input parameters, including variations in bathymetry and source frequency content to ensure accurate results are produced specific to the location and nature of the piling operation. The results produced by the model are considered conservative due to the parameters selected and the design, which fits the upper bounds of measured noise levels rather than an average, which risks underestimating impacts.

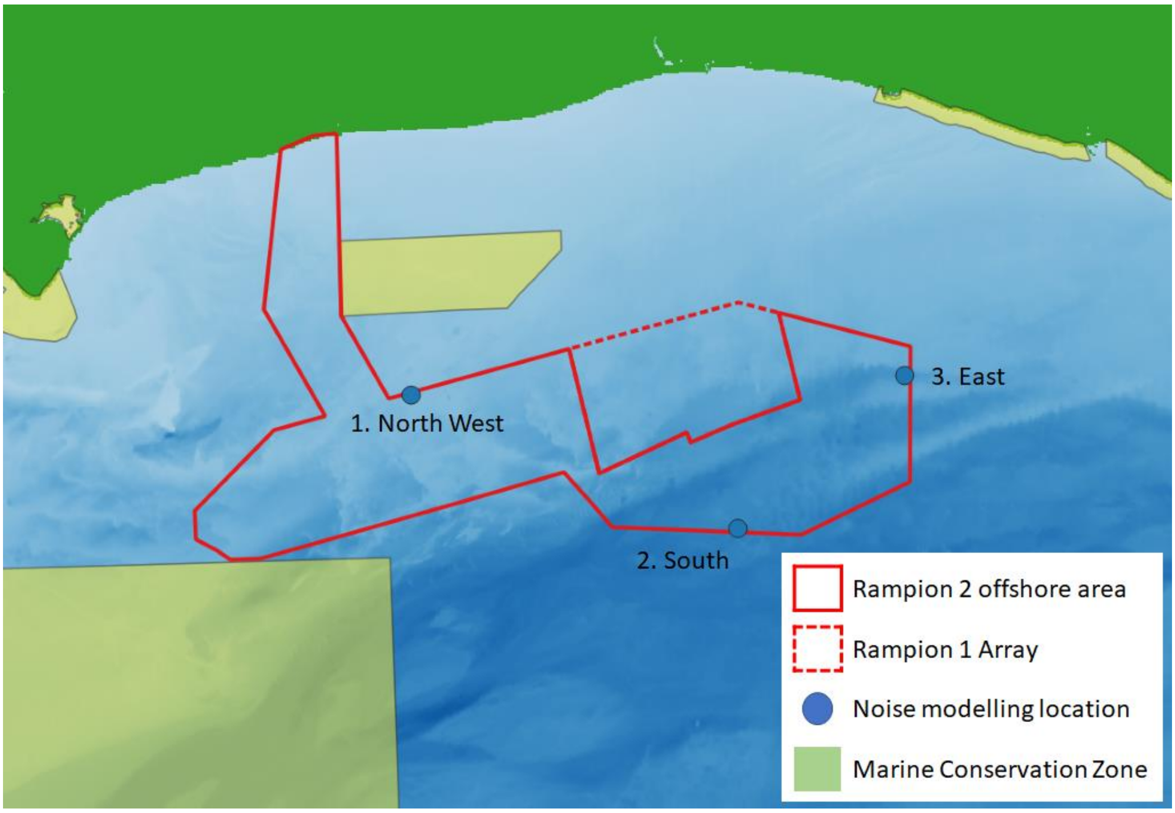
## 2.3 Piling scenarios

2.3.1 Modelling is proposed to be carried out at three representative locations within the PEIR assessment boundary see **Figure 2-1**. These have been selected in conjunction with the noise modellers and Rampion 2 project team to ensure that a range of 'realistic worst case' scenarios are included in the assessment. Locations have been chosen based on noise propagation conditions (i.e. bathymetric variability) and proximity to sensitive receptor locations such as MCZs, where relevant, to inform the assessment of potential impact risk arising from pile driving for Wind Turbine Generator (WTG) foundation installation and other infrastructure (e.g. substations).

Table 2-1 Coordinates of modelling locations

| | Location 1. North West | Location 2. South | Location 3. East |
|---|---|---|---|
| **Latitude** | 50.6659 | 50.5926 | 50.6667 |
| **Longitude** | -0.4924 | -0.2365 | -0.0993 |
| **Water Depth** | 17.4 m | 53.4 m (relevant to Pin pile/jacket foundations only) | 44.2 m |

Figure 2-1 Noise modelling locations across the PEIR Assessment Boundary for Rampion 2




2.3.2 Recent industry operational experience when installing offshore wind farms has shown that the actual hammer energies used during construction have been much lower than those maximum design scenario parameters defined during the assessments. The maximum design scenario will be presented, which is intended to cover the absolute maximum piling parameters that would ever be required to install a foundation (in terms of maximal hammer energies and longest piling durations). In addition to this, a Most Likely scenario will be modelled to represent the actual parameters that are likely to be used in piling for the installation of the foundations, including during soft start, ramp up, and the maximum energy expected to be required on site, rather than the limits of the equipment.

## Impact Piling Parameters

2.3.3 Two piling source scenarios will be modelled to include monopile and pin pile WTG foundations across the PEIR Assessment Boundary. These are likely to be:

- Monopiles installed using a maximum blow energy of 4400 kJ; and
- Pin piles installed using a maximum blow energy of 2500 kJ.

2.3.4 Monopiles are to be installed in water depths of up to 45 m LAT only. For deeper depths, jacket foundations with pin piles or suction buckets will be used.

2.3.5 Modelling will be undertaken for a scenario of up to two monopiles and up to four pin piles driven at any one location in a 24hr period. Pin piles will be modelled for a concurrent piling scenario for vessels spaced at a minimum distance of 9 km between pile installation vessels (assuming WTG spacing distances at 6x rotor diameter. Monopiles will not be driven concurrently. A soft start / ramp-up will be set out once agreed with the engineers/hammer contractor and will be used, together with strike rate and duration information, to inform the cumulative sound exposure levels (SELs)

wood.

# 3. Proposed Approach to EIA

## 3.1 Quantifying the impact

3.1.1 Exposure to loud sounds can lead to auditory injury by means of a temporary (TTS) or permanent (PTS) reduction in hearing sensitivity (a shift in hearing threshold), and/or a behavioural reaction of the animals to the sound. The assessment methodology for these impacts is detailed in the following sections, for marine mammals and for fish.

### Non-piling construction noise

3.1.2 Potential non-pile driving sources of noise during construction include:

- Vessel activity;
- Cable laying;
- Dredging;
- Trenching;
- Rock placing; and
- UXO Clearance.

3.1.3 Note that the final project design information is under preparation at the time of writing and as such this is a general list of potential likely activities; the activities ultimately considered will be aligned with the project design information. For these noise sources it is not anticipated that a fully quantitative impact assessment will be required. Given the temporary and more limited nature of these activities, limited specific data for noise levels, and the lack of specific detail on the spatial and temporal distribution of these activities, the assessment for these impacts will be largely qualitative. Where activity-specific data is available it may be possible for noise modelling to estimate the range at which specific impacts may be encountered.

### Operational noise

3.1.4 Prediction of the levels of noise generated from the turbines will be modelled based on extrapolation from existing measurements of operating turbines, for the simple assessment of marine mammals only, (Scoped out for Fish and Shellfish).

### Decommissioning

3.1.5 At this stage, decommissioning effects are envisaged to be similar to those described for the construction phase. Piling will be unlikely but other activities such as cutting to remove structures will be considered and noise modelling may be carried out to quantify the potential for impact in a similar way as described above.

## Effects of noise on marine mammals

### PTS assessment for pile driving

3.1.6 To quantify the impact of noise with regard to PTS, we will determine the PTS-onset impact range (the area around the piling location within which the noise levels exceed the PTS-onset threshold). Based on agreed density estimates for each species, the number of animals expected in the PTS-onset impact range will be calculated and presented as a proportion of the relevant population size.

3.1.7 The most recent guidance to assess the likelihood of auditory injury in marine mammals caused by noise is given in Southall *et al.* (2019). To determine impact ranges for PTS-onset, they group species into species groups according to their hearing abilities and propose species group specific PTS-onset thresholds. For impulsive sound (e.g. pile driving) a dual metric threshold is proposed: the peak sound pressure level $SPL_{z\text{-}p,\ flat}$ (a value applied to single strikes for the onset of 'instantaneous' PTS), and the cumulative sound exposure level $SEL_{cum}$ (a value for the onset of 'cumulative' PTS that includes the whole piling sequence from the first to the last pile strike) (**Table** 3-1). The Southall *et al.* (2019) guidance specifically recommends that the threshold which generates the largest impact range is the one that should be used for calculating PTS-onset. In order to assess the cumulative PTS-onset impact ranges, assumptions need to be included in the model with respect to the likely fleeing speed of the animals. Rampion 2 will use a precautionary speed of 1.5 m/s for most species (Otani *et al*., 2000; Hirata, 1999) except for minke whales where 3.25 m/s will be adopted (Blix and Folkow, 1995).

3.1.8 Southall *et al.* (2019) propose the $SPL_{z\text{-}p}$ (being either unweighted or flat weighted across the entire frequency band of a hearing group). This is because the direct mechanical damage to the auditory system that is associated with high peak sound pressures is not frequency dependent (i.e. restricted to the audible frequency range of a species). The physiological damage that sound energy can cause is mainly restricted to energy occurring in the frequency range of a species' hearing range. Therefore, for the cumulative sound exposure level ($SEL_{cum}$), sound will be weighted based on species group specific weighting curves given in **Figure 3-1**. The $SEL_{cum}$ threshold for PTS-onset considers the sound exposure level received by an animal and the duration of exposure, accounting for the accumulated exposure over the duration of an activity within a 24-hour period. Southall *et al.* (2019) recommends the application of $SEL_{cum}$ for the individual activity alone (i.e. not for multiple activities occurring within the same area or over the same time). To inform this impact assessment sound modelling will consider the $SEL_{cum}$ over a piling event. If scenarios with more than one piling event are likely within 24 hours, these scenarios will also be modelled.

Figure 3-1 Auditory weighting functions for low frequency (LF), high frequency (HF) and very high frequency (VHF) cetaceans as well as phocid (PCW) pinnipeds in water according to Southall et al. (2019).

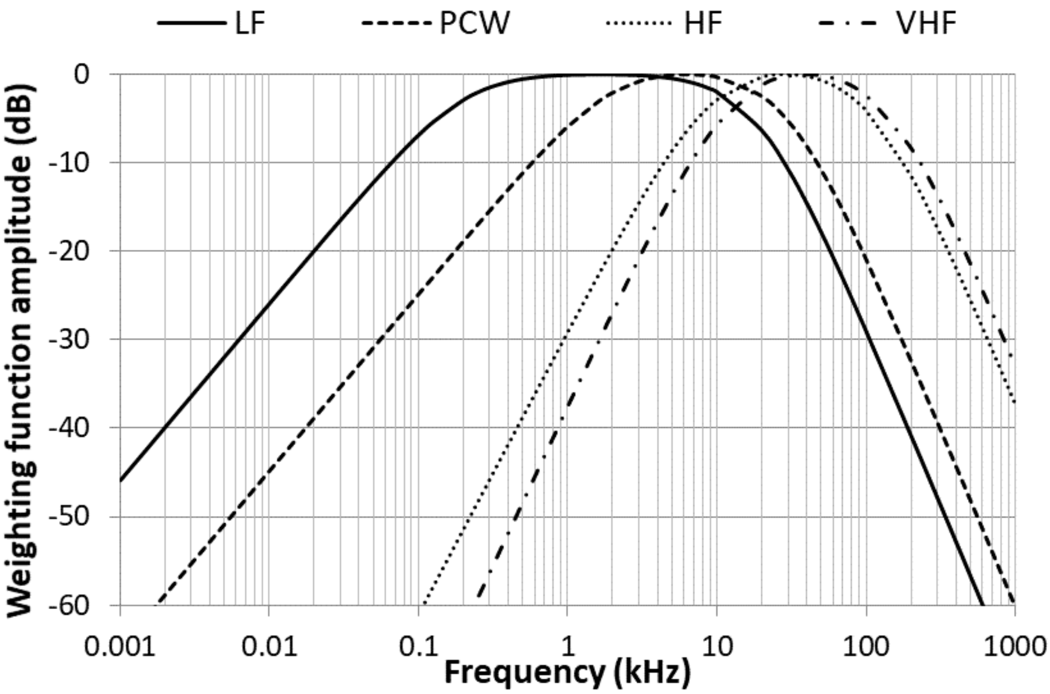



Table 3-1 PTS-onset thresholds for marine mammals exposed to impulsive noise (Southall et al 2019)

| Hearing group | Species | PTS-onset $SEL_{cum}$ (dB re 1 µPa²s) weighted | PTS-onset $SPL_{peak}$ (dB re 1 µPa) unweighted |
|---|---|---|---|
| **Low frequency** | Minke whale | 183 | 219 |
| **High frequency** | Bottlenose dolphin<br>White-beaked dolphin<br>Common dolphin | 185 | 230 |
| **Very high frequency** | Harbour porpoise | 155 | 202 |
| **Phocid in water** | Harbour seal<br>Grey seal | 185 | 218 |

## TTS assessment for pile driving

3.1.9 The PTS-thresholds proposed by Southall *et al.* (2019) define the level at which a single exposure is estimated to cause the onset of a permanent hearing loss (a permanent 6 dB shift of the hearing threshold) as minimum exposure criterion for injury (Southall *et al.* 2007). The experimental determination of PTS-onset thresholds involves causing injury in the experimental animal, and therefore no such studies are conducted on marine mammals, as this is considered unethical. Instead, the level of sound eliciting the onset of TTS and the relation of TTS growth with received sound energy are subjects of investigations. Exposure criteria for PTS are eventually based on the

TTS-onset thresholds and the knowledge gained from available data from humans and other terrestrial mammals that indicate that a shift in the hearing threshold of 40 dB may eventually lead to the onset of PTS (Southall *et al.* 2007). To estimate PTS onset-thresholds in an ethical way, researchers determine the onset of TTS in marine mammals in experimental set ups and use those to calculate at which sound levels a TTS would reach a shift of 40 dB. The thresholds at which the onset of TTS is observed are, as per Southall *et al.* (2007), a 6 dB shift in the hearing threshold, usually measured four minutes after sound exposure. This shift is considered as "*the minimum threshold shift clearly larger than any day-to-day or session-to-session variation in a subject's normal hearing ability*", and which "*is typically the minimum amount of threshold shift that can be differentiated in most experimental conditions*." The recovery period of such TTS back to the initial hearing threshold is short. TTS-onset thresholds updated by Southall *et al.* (2019) are presented in **Table 3-2**.

3.1.10 For the noise impact assessment for Rampion 2, the ranges that indicate TTS-onset will be modelled and presented. However, as TTS-onset is defined primarily as a means of predicting PTS onset, the TTS-onset thresholds do not indicate any level of biologically significant effect and are therefore inappropriate as thresholds to predict noise impact. There is currently no threshold for the amount of TTS that would indicate a biologically significant amount of TTS; therefore it is impossible to carry out a quantitative assessment of the magnitude or significance of the impact of TTS on marine mammals. The current set of TTS-onset thresholds will result in a significant overestimate of the impact due to the extremely large resulting impact ranges representing the smallest measurable amount of TTS. These TTS-onset thresholds will not be used to quantify the numbers of animals at risk of any TTS; instead, ranges with be presented for context only (to be discussed and agreed at the ETG).

Table 3-2 TTS-onset thresholds for marine mammals exposed to impulsive noise (Southall et al 2019)

| Hearing group | Species | TTS-onset $SEL_{cum}$ (dB re 1 μPa²s) weighted | TTS-onset $SPL_{peak}$ (dB re 1 μPa) unweighted |
|---|---|---|---|
| **Low frequency** | Minke whale | 168 | 213 |
| **High frequency** | Bottlenose dolphin<br>White-beaked dolphin<br>Common dolphin | 170 | 224 |
| **Very high frequency** | Harbour porpoise | 140 | 196 |
| **Phocid in water** | Harbour seal<br>Grey seal | 170 | 212 |

## Behavioural disturbance assessment for pile driving

3.1.11 Unlike for thresholds of auditory injury, there currently are no established regulatory guidance documents and few published scientific articles providing clear advice on the appropriate thresholds for behavioural response to pile driving noise. There are published thresholds for behavioural reactions to military sonars (Finneran and Jenkins 2012), and empirically derived dose-response curves for various species based on exposure to military sonar signals (Houser *et al.* 2013, Miller *et al.* 2014, Harris *et al.* 2015, Sivle *et al.* 2015) or pile driving activity (Thompson *et al.* 2013, Tougaard *et al.* 2013, Graham *et al.* 2017), as well as studies on behavioural reactions to pile driving that might be used to derive a dose-response function (Brandt *et al.* 2016, Russell *et al.* 2016).

3.1.12 A dose-response function explores the relationship between the probability of response of an individual animal and either the range from the source or the received level of sound. As such a dose-response function reflects that not all animals in an area will display a behavioural response to the perceived sound. The proportion of animals responding will depend on the received sound level, which will generally decrease with increasing distance from the sound source.

3.1.13 The dose-response curve developed by Graham *et al.* (2017) was generated from data on harbour porpoises collected during the first six weeks of piling during Phase 1 of the Beatrice Offshore Wind Farm monitoring program. In the absence of species-specific data for dolphin species or minke whale, this dose-response curve will be adopted for all cetacean species. This is likely to be precautionary since harbour porpoise are more sensitive to noise impacts than other cetacean species.

3.1.14 For harbour seals, data collected and analysed by Russell *et al.* (2016) on harbour seal responses during several months of pile driving at the Lincs Offshore Wind Farm was used to develop a dose-response curve (Whyte *et al.* 2020). In the absence of species-specific data for grey seals, this dose-response curve will be used for both seal species.

3.1.15 For the assessment of behavioural disturbance, Subacoustech will provide unweighted noise contours at 5 dB $SEL_{ss}$ intervals. These will be overlain on species density surfaces to predict the number of animals potentially disturbed. This will allow for the quantification of the number of animals that will potentially display a behavioural reaction.

## Effects of noise on fish

3.1.16 The large number of, and variation in, fish species leads to a greater challenge in production of a generic noise criterion, or range of criteria, for the assessment of noise impacts. The publication of Popper *et al*. (2014) provides an authoritative summary of the latest research and guidelines for fish exposure to sound and uses categories for fish that are representative of the species present in UK waters.

### Mortality, potential mortal injury, recoverable injury and TTS

**3.1.17** The Popper *et al*. (2014) study groups species of fish into whether they possess a swim bladder, and whether it is involved in its hearing. The guidance also gives specific criteria (as both unweighted $SPL_{peak}$ and unweighted $SEL_{cum}$ values) for a variety of noise sources: in this case the impact piling (pile driving) criteria have been considered. It does not specifically consider PTS but rather direct injury from which individuals within the species can recover. The criteria used for modelling are summarised in **Table 3-3**.

Table 3-3 Criteria for mortality, potential mortal injury, recoverable injury and TTS in species of fish from impact piling noise (Popper et al., 2014)

| Type of animal | Mortality and potential mortal injury | Impairment | |
|---|---|---|---|
| | | Recoverable injury | TTS |
| **Fish: no swim bladder** | > 219 dB $SEL_{cum}$<br>> 213 dB peak | > 216 dB $SEL_{cum}$<br>> 213 dB peak | >> 186 dB $SEL_{cum}$ |
| **Fish: swim bladder is not involved in hearing** | 210 dB $SEL_{cum}$<br>> 207 dB peak | 203 dB $SEL_{cum}$<br>> 207 dB peak | > 186 dB $SEL_{cum}$ |
| **Fish: swim bladder involved in hearing** | 207 dB $SEL_{cum}$<br>> 207 dB peak | 203 dB $SEL_{cum}$<br>> 207 dB peak | 186 dB $SEL_{cum}$ |
| **Eggs and larvae** | > 210 dB $SEL_{cum}$<br>> 207 dB peak | See Table 3-4 | See Table 3-4 |

3.1.18 A further set of criteria also exists for turtles, which are not present at this site, and as such these have not been considered as part of this study.

3.1.19 Both a fleeing animal and stationary animal model will be modelled to cover the $SEL_{cum}$ criteria for fish. It is recognised that there is limited evidence for fish fleeing from high level noise sources in the wild and it would reasonably be expected that the reaction may differ between species. Most species are likely to move away from a sound that is loud enough to cause harm (Dahl *et al*., 2015 and Popper *et al*., 2014), some may seek protection in the sediment and others may dive deeper in the water column. The flee speed chosen for this study of 1.5 $ms^{-1}$ is relatively slow in relation to data from Hirata (1999) and thus is considered somewhat conservative.

3.1.20 Although it is feasible that some species will not flee, those that are likely to remain are thought more likely to be benthic species or species without a swim bladder; these are the least sensitive species. For example, from Popper *et al*. (2014): "*There is evidence (e.g. Goertner et al., 1994; Stephenson et al., 2010; Halvorsen et al., 2012) that little or no damage occurs to fishes without a swim bladder except at very short ranges from an in-water explosive event. Goertner (1978) showed that the range from an explosive event over which damage may occur to a non-swim bladder fish is in the order of 100 times less than that for swim bladder fish*."

3.1.21 Stationary animal modelling will also be undertaken to inform the Rampion 2 assessment, due to uncertainties regarding the consistency of a flee response in fish (i.e. there have not been any studies involving tracking fish responses to pile driving noise over more than the local vicinity). It is highlighted that basing the modelling on a stationary (zero flee speed) receptor is likely to greatly overestimate the potential risk to fish species as numerous studies have shown clear directional swim responses away from noise sources, especially when considering the precautionary nature of the parameters already built into the cumulative exposure calculations.

## Behavioural effects

3.1.22 The vast number of conditions in which a fish could be complicates any attempt to provide a quantitative threshold. Where insufficient data are available, Popper *et al*. (2014) give qualitative criteria that summarise the effect  of the noise as having either a high, moderate or low effect on an individual in either the near-field (tens of metres), intermediate-field (hundreds of metres), or far-field (thousands of metres). These qualitative effects are reproduced in **Table 3-4**.

Table 3-4 Summary of the qualitative effects on species of fish from impact piling noise (Popper et al., 2014) (N = Near-field; I = Intermediate-field; F = Far-field)

| Type of animal | Impairment | | | Behaviour |
|---|---|---|---|---|
| | Recoverable injury | TTS | Masking | |
| **Fish: no swim bladder** | See Table 3-3 | See Table 3-3 | (N) Moderate<br>(I) Low<br>(F) Low | (N) High<br>(I) Moderate<br>(F) Low |
| **Fish: swim bladder is not involved in hearing** | See Table 3-3 | See Table 3-3 | (N) Moderate<br>(I) Low<br>(F) Low | (N) High<br>(I) Moderate<br>(F) Low |
| **Fish: swim bladder involved in hearing** | See Table 3-3 | See Table 3-3 | (N) High<br>(I) High<br>(F) Moderate | (N) High<br>(I) High<br>(F) Moderate |
| **Eggs and larvae** | (N) Moderate<br>(I) Low<br>(F) Low | (N) Moderate<br>(I) Low<br>(F) Low | (N) Moderate<br>(I) Low<br>(F) Low | (N) Moderate<br>(I) Low<br>(F) Low |

3.1.23

3.1.24 The assessment will primarily conduct a qualitative assessment based on **Table 3-4**.

3.1.25 Bearing in mind the complications, in order to provide a numerical threshold for behavioural effects, there must be some generalisation. The most widely used, peer-reviewed, thresholds are identified in McCauley *et al.* 2000 and provide an upper and lower bound for a change in behaviour of 168-173 dB re 1 µPa $SPL_{peak}$. Many US agencies use 150 dB $SPL_{RMS}$, which, as an RMS, is less relevant for impulsive noise (which are better measured using $SPL_{peak}$ or SEL due to RMS having a time component over which the received sound level is averaged, which poses issues for pulsed sounds such as those from piling), but also has little known basis (Hastings, 2008; Popper and Hawkins 2019). Using a rough conversion in respect of RMS vs peak noise levels for impact piling, 150 dB $SPL_{RMS}$ and 168 dB $SPL_{peak}$ as thresholds will be similar in any respect.

3.1.26 Following initial discussions under the Evidence Plan Process, noise thresholds identified in Hawkins *et al.* 2014 have been suggested as potentially appropriate for the assessment of disturbance at Rampion 2. In response, RED would note that the criteria identified in the paper have not had widespread use and it is considered that they are not appropriate for the Rampion 2 EIA as set out by the authors of the study; the paper explicitly stating that "*these data cannot yet be used to define the sound exposure criteria. More detailed studies of the behaviour of these species are required to establish whether the responses observed are likely to result in adverse effects upon the survival of individuals*." Indeed, the lead author was also co-author of the Popper *et al.* 2014 paper and these figures were not included in those authoritative guidelines despite similar publication dates. In addition, the environmental conditions at the Hawkins *et al.*, study location (a very quiet loch) and the Rampion 2 study area (open coastal water with a high level of background noise from shipping activity) are markedly different and as such the study location (and therefore responses of fish species with a relatively high sensitivity in such an area) would not be representative of the conditions off the south coast of England.

3.1.27 It is proposed, therefore, that in the absence of new data relevant to the region, the thresholds from McCauley *et al*., 2000 be used to provide an indication of the quantitative impact of behavioural effect, where possible, recognising that due to the complications as stated, this must not be taken as a definitive guide to disturbance for all fish. Where quantification is not possible, a qualitative assessment of behavioural effect for fish will be presented, in line with the view put forward in Popper *et al.,* 2014, where the guidance concludes that that there is insufficient data available to apply quantitative thresholds for behavioural effects on fish.

# 4. Cumulative and In-combination Impact Assessment

4.1.1 The cumulative impact assessment will consider the combined effect of subsea noise arising from pile-driving at Rampion 2 with pile-driving at other offshore wind farms within the cumulative study areas (where such operations could occur simultaneously). The study areas for the cumulative assessment in relation to marine mammals will be based on the Management Units for each of the key species, with quantitative impacts (i.e. number of animals potentially affected) assessed against the abundance of animals in the respective MUs. Where relevant this assessment will utilise the data publicly available for those other projects, but it is not proposed to undertake separate noise modelling for those non-Rampion 2 projects.

# 5. UXO clearance

## 5.1 Introduction

5.1.1 There is the potential requirement for underwater UXO clearance prior to construction. However, since a UXO survey has not yet been conducted, it is not possible at this time to define an accurate prediction of the number of UXO nor the range of UXO charge sizes which may require detonation. As a result, a separate Marine Licence will be applied for pre-construction for the detonation of any UXO. However, the detonation of UXO is a source of additional noise in the marine environment and hence is considered in the assessment for marine mammals.

## 5.2 Noise modelling

5.2.1 It is currently not known if recent propagation models can accurately predict sound levels and propagation loss of UXO detonations. Subacoustech will therefore use prediction formulas proposed by Soloway and Dahl (2014), Arons (1954) and Barett (1996), which are derived from and based on field measurements of underwater explosions.

## 5.3 UXO scenarios

5.3.1 Calculations will be conducted for a range of expected UXO charge sizes. The source level of each UXO charge weight will be estimated using conservative calculation parameters that result in the upper estimate of the source level for each charge size. This is therefore considered to be an indication of the potential noise output from each charge size, and as such, assuming a worst-case scenario, will likely result in an overestimate of the noise impact, especially for larger charge sizes. Due to the lack of site-specific information at the current stage of the assessment, it will be assumed that the UXO is located in the centre of the array area.

## 5.4 Quantifying the impact

*5.4.1* Noise emitted during UXO clearance can, like pile driving noise, lead to auditory injury and/or a behavioural reaction. The assessment methodology for these impacts is detailed in the following.

### PTS assessment for UXO

5.4.2 The recent Southall *et al.* (2019) PTS-onset thresholds will be used to assess the PTS-onset impact from UXO detonation from a range of charge sizes. The number of animals expected in the PTS-onset impact range will be calculated and presented as a proportion of the relevant population size.

### TTS assessment for UXO

5.4.3 The Southall *et al.* (2019) TTS-onset thresholds will be used to predict the TTS-onset impact range from a range of UXO charge sizes. Following the approach adopted for the assessment of TTS for pile driving, these TTS-onset thresholds will not be used to quantify the numbers of animals at risk of any TTS; instead, ranges with be presented for context only (this is to be discussed and agreed at the ETG).

## Behavioural disturbance assessment for UXO

5.4.4 JNCC (2020) advise that a buffer of 26 km around the source location is used to determine the impact area from UXO clearance with respect to disturbance of harbour porpoise within SACs. In the absence of agreed metrics for disturbance by UXO detonation for other marine mammal species and given a lack of empirical data on the likelihood of response to explosives, this 26 km radius (area of 2,124 $km^2$) will be applied for all species. The number of animals expected in the 26 km range will be calculated using species specific density estimates and presented as a proportion of the relevant population size.

## Impacts on fish from UXO

5.4.5 Popper *et al*. (2014) provides a threshold for mortality and potential mortal injury from explosions which is higher than those which may cause effects from piling. Due to the uncertainties of impacts on fish from noise generated by explosions, the assessment will follow the guidance, which proposes a primarily qualitative assessment matrix for all other impacts to fish as for behavioural impacts from piling noises.

# 6. References


Arons, A. (1954). Underwater explosion shock wave parameters at large distances from the charge. *The Journal of the Acoustical Society of America*, 26, pp. 343-346.

Barett, R. (1996). Guidelines for the safe use of explosives underwater. MTD Publication, 96, pp.101.

Blix, A. S., and Folkow, L. P. (1995). Daily energy expenditure in free living minke whales. Acta Phisio. Scand., 153: 61-66.

Brandt, M. J., A. Dragon, A. Diederichs, A. Schubert, V. Kosarev, G. Nehls, V. Wahl, A. Michalik, A. Braasch, C. Hinz, C. Katzer, D. Todeskino, M. Gauger, M. Laczny, and W. Piper. (2016). Effects of offshore pile driving on harbour porpoise abundance in the German Bight.

Finneran, J. J., and A. K. Jenkins. (2012). Criteria and thresholds for US Navy acoustic and explosive effects analysis.

Graham, I. M., A. Farcas, N. D. Merchant, and P. Thompson. (2017). Beatrice Offshore Wind Farm: An interim estimate of the probability of porpoise displacement at different unweighted single-pulse sound exposure levels. Prepared by the University of Aberdeen for Beatrice Offshore Windfarm Ltd.

Hawkins, A.D, Roberts, L., Cheesman, S. (2014). Responses of free-living coastal pelagic fish to impulsive sounds. J. Acoust. Soc. Am. 135 (5), May 2014

Harris, C. M., D. Sadykova, S. L. DeRuiter, P. L. Tyack, P. J. O. Miller, P. H. Kvadsheim, F. P. A. Lam, and L. Thomas. (2015). Dose response severity functions for acoustic disturbance in cetaceans using recurrent event survival analysis. *Ecosphere,* 6, pp. 1-14.

Hirata, K. (1999) Swimming speeds of some common fish. National Maritime Research Institute (Japan). Data sources from Iwai, T., and Hisada, M. (1998). Fishes – Illustrated Book of Gakken (in Japanese). http://www.nmri.go.jp/oldpages2/eng/khirata/general/speed/speede.htm accessed 8th March 2017.

Houser, D. S., S. W. Martin, and J. J. Finneran. (2013). Exposure amplitude and repetition affect bottlenose dolphin behavioral responses to simulated mid-frequency sonar signals. *Journal of Experimental Marine Biology and Ecology*, 443, pp. 123-133.

JNCC. (2020). Guidance for assessing the significance of noise disturbance against Conservation Objectives of harbour porpoise SACs (England, Wales & Northern Ireland). JNCC Report No. 654, JNCC, Peterborough, ISSN 0963-8091.

Miller, P. J., R. N. Antunes, P. J. Wensveen, F. I. Samarra, A. C. Alves, P. L. Tyack, P. H. Kvadsheim, L. Kleivane, F. P. Lam, M. A. Ainslie, and L. Thomas. (2014). Dose-response relationships for the onset of avoidance of sonar by free-ranging killer whales. *Journal of the Acoustical Society of America*, 135, pp.975-993.

Otani, S., Naito, T., Kato, A., and Kawamura, A. (2000). Diving behaviour of a free-ranging harbour porpoise (Phocoena phocoena). Marine Mammal Sci, Volume 16, Issue 4.

Popper, A. N. Hawkins, A. D. Fay, R. R. Mann, D. Bartol, S. Carlson, Th. Coombs, S. Ellison, W. T. Gentry, R. Hal vorsen, M. B. Lokkeborg, S. Rogers, P. Southall, B. L. Zeddies, D. G. and Tavolga, W. N. (2014) Sound Exposure Guidelines for Fishes and Sea Turtles: A Technical Report prepared by ANSI-Accredited Standards Committee S3/SC1 and registered with ANSI. Springer and ASA Press, Cham, Switzerland.

Russell, D. J., G. D. Hastie, D. Thompson, V. M. Janik, P. S. Hammond, L. A. Scott-Hayward, J. Matthiopoulos, E. L. Jones, and B. J. McConnell. (2016). Avoidance of wind farms by harbour seals is limited to pile driving activities. *Journal of Applied Ecology*.

Sivle, L. D., P. H. Kvadsheim, C. Curé, S. Isojunno, P. J. Wensveen, F.-P. A. Lam, F. Visser, L. Kleivane, P. L. Tyack, and C. M. Harris. (2015). Severity of expert-identified behavioural responses of humpback whale, minke whale, and northern bottlenose whale to naval sonar. *Aquatic Mammals*, 41, pp.469.

Soloway, A. G., and P. H. Dahl. (2014). Peak sound pressure and sound exposure level from underwater explosions in shallow water. *The Journal of the Acoustical Society of America,* 136, pp. EL218-EL223.

Southall, B., J. J. Finneran, C. Reichmuth, P. E. Nachtigall, D. R. Ketten, A. E. Bowles, W. T. Ellison, D. Nowacek, and P. Tyack. (2019). Marine Mammal Noise Exposure Criteria: Updated Scientific Recommendations for Residual Hearing Effects. *Aquatic Mammals*, 45, pp. 125-232.

Southall, B. L., A. E. Bowles, W. T. Ellison, J. J. Finneran, R. L. Gentry, C. R. J. Greene, D. Kastak, D. R. Ketten, J. H. Miller, P. E. Nachtigall, W. J. Richardson, J. A. Thomas, and P. L. Tyack. (2007). Marine mammal noise exposure criteria: initial scientific recommendations. *Aquatic Mammals,* 33, pp. 411-414.

Thompson, P. M., G. D. Hastie, J. Nedwell, R. Barham, K. L. Brookes, L. S. Cordes, H. Bailey, and N. McLean. (2013). Framework for assessing impacts of pile-driving noise from offshore wind farm construction on a harbour seal population. *Environmental Impact Assessment Review,* 43, pp. 73-85.

Tougaard, J., S. Buckland, S. Robinson, and B. Southall. (2013). An analysis of potential broad-scale impacts on harbour porpoise from proposed pile driving activities in the North Sea. Report of an expert group convened under the Habitats and Wild Birds Directive - Marine Evidence Group MB0138, pp. 38.

Whyte, K., D. Russell, C. Sparling, B. Binnerts, and G. Hastie. (2020). Estimating the impacts of pile driving sounds on seals: pitfalls and possibilities. *The Effects of Noise on Aquatic Life*,14, pp. 3948-3958.

# Rampion Extension Development Limited

# Rampion 2 Offshore Wind Farm

Additional Comments Provided
By Natural England –
21/11/2020

Wood Environment & Infrastructure Solutions UK Limited – December 2020

wood.

## Report for

RWE

## Main contributors

SMRU Consulting

## Issued by

.................................................................................

[redacted]

## Approved by

.................................................................................

[redacted]


## Wood

Shinfield Park
Shinfield
Reading RG2 9FW
United Kingdom
Tel +44 (0)118 9131234



## Copyright and non-disclosure notice

The contents and layout of this report are subject to copyright owned by Wood (© Wood Environment & Infrastructure Solutions UK Limited 2020) save to the extent that copyright has been legally assigned by us to another party or is used by Wood under licence. To the extent that we own the copyright in this report, it may not be copied or used without our prior written agreement for any purpose other than the purpose indicated in this report. The methodology (if any) contained in this report is provided to you in confidence and must not be disclosed or copied to third parties without the prior written agreement of Wood. Disclosure of that information may constitute an actionable breach of confidence or may otherwise prejudice our commercial interests. Any third party who obtains access to this report by any means will, in any event, be subject to the Third Party Disclaimer set out below.

## Third party disclaimer

Any disclosure of this report to a third party is subject to this disclaimer. The report was prepared by Wood at the instruction of, and for use by, our client named on the front of the report. It does not in any way constitute advice to any third party who is able to access it by any means. Wood excludes to the fullest extent lawfully permitted all liability whatsoever for any loss or damage howsoever arising from reliance on the contents of this report. We do not however exclude our liability (if any) for personal injury or death resulting from our negligence, for fraud or any other matter in relation to which we cannot legally exclude liability.


## Management systems

This document has been produced by Wood Environment & Infrastructure Solutions UK Limited in full compliance with our management systems, which have been certified to ISO 9001, ISO 14001 and OHSAS 18001 by LRQA.

## Document revisions

| No. | Details | Date |
|---|---|---|
| **0.1** | Reviewed by Offshore PM | 21/12/2020 |
| **0.2** | Reviewed by offshore PD | 21/12/2020 |
| **0.3** | Reviewed by PM | |
| **1.0** | Issue to RWE | |

# Contents


**1. Natural England additional comments 4**

1.2 In relation to the DCO timeline 4
1.3 In relation to future ETG meetings 4
1.4 In relation to barrier effect on migratory bird species 4
1.5 In relation to sCRM 5
1.6 In relation to additional data sources for Physical Processes 5
1.7 In relation to the SCNB and the mean max foraging range +1SD 5
1.8 In relation to South England and South East England Management Units 5
1.9 In relation to the designated sites technical note 6
1.10 In relation to MCZ screened in 6
1.11 In relation to the Method Statement provision 6

# 1. Natural England additional comments

1.1.1 Natural England provided comments following the Additional ETG meeting on the 13/10/2020 on Marine Mammals, Offshore Ornithology, HRA (offshore only), Physical Processes and Benthic Ecology. These comments have been collated and are as follows:

- We understand sometimes these issues are outside of anyone's control, but this and technical issues did mean our marine mammals' specialist was on the call far longer than needed and was it was unclear when her topic would come up again.

## 1.2 In relation to the DCO timeline

- Please refer to previous comments around Natural England's concerns on the short timescale:

  'Natural England would like it noted the timescales are still the same, so our concerns about timescales and our capacity to resource asks made of us by the applicant remain. The issues Natural England have raised are around the fast pace of the project and expected 'turnaround' of asks of Natural England.'

## 1.3 In relation to future ETG meetings

- We wish to make the applicant aware that Natural England Specialist have highlighted they already have a significant number of commitments for other projects with dates/work already booked in for this same time period. Therefore, the sooner the applicant can provide dates and a timeframe for any document review the more likely we are to be able to attend/complete the work within the require timescales.

## 1.4 In relation to barrier effect on migratory bird species

- In our scoping report comments Natural England said:
  - Paragraph 5.8.43 goes on to state that a barrier effect from the presence of the turbines has also been scoped out. Natural England would welcome further discussion with the applicant regarding screening for likely significant effects from the proposal in relation to the potential for a barrier effect. The English Channel is an important migratory route for a wide range of seabirds and waterbirds travelling to and from the Atlantic into the North Sea. Reference should be made to tracking studies before a likely significant effect to birds on migration is ruled out. We note that a potential barrier effect on birds whilst they are resident in a particular season will be included in the assessment of displacement.
  - We therefore suggest that RWE need to refer to tracking studies before scoping out barrier effects on birds migrating through the English Channel. They should see if tracking studies indicate that the windfarm would present a barrier, or whether most birds would pass to the south. Currently we would need to see more evidence before advising on whether this could be scoped out.

## 1.5 In relation to sCRM

- The current advice is to use the sCRM, but to use it deterministically as APEM stated during the meeting. Natural England advises using generic flight height information due to identified issues with flight height estimates. The same issues apply to the generic data, but using generic data means consistent application across projects and means projects don't have their own individual errors.

## 1.6 In relation to additional data sources for Physical Processes

- Having reviewed the list Natural England are not aware of any additional data sources. However, we would suggest RWE contact the Environment Agency to see if they are aware of any further data sources.
- We are aware that Sarah Lupton and Uwe Dornbusch from the EA cover the Climping site and have been looking at how the site will develop in the future.
- The Coastal Engineer at the local authority is Roger Spencer (Roger.Spencer@arun.gov.uk), as well as the Harbour Master Harry Gregory (harry@littlehampton.org.uk) may also be aware of something additional that may be of use.

## 1.7 In relation to the SCNB and the mean max foraging range +1SD

- The SNCBs are working through the evidence presented in Woodward et al. (2019), and have not yet finalised guidance, which is why the foraging ranges were not raised in our response to the HRA screening report. However, as mentioned at the meeting, we now recommend use of the species-specific mean maximum foraging range + 1 standard deviation (Mean Max +1SD), as presented in Woodward et al. (2019), is appropriate. Preliminary investigations of the data suggest that use of this metric should ensure that all colonies whose core foraging areas are likely to overlap with a planned development area will be screened in, and that most (although not all) colonies whose foraging area (as defined by their maximum foraging range) overlaps at all with a planned development area will also be screened in. Therefore, we feel it is precautionary, but not overly so.

## 1.8 In relation to South England and South East England Management Units

- Given Rampion 2's proximity to both the south and south-east draft seal management units, Natural England consider it would be pragmatic in this instance for the reference population for the seal assessments to be comprised of 50% of the south management unit population + 50% of the south-east management unit population. The project has the potential to impact both management unit populations, however including every seal from the Isle of Man to the Humber is not realistic and may only serve to dilute any potential impact.
- Natural England would welcome comments and/or confirmation of acceptance of this approach by Rampion 2.

## 1.9 In relation to the designated sites technical note

- Natural England wish to see this technical note, before we can comment on the completeness of the list of sites included for Nature Conservation. There are sites not included in the list that an explanation would be needed for us to understand why they have not been included.

## 1.10 In relation to MCZ screened in

- Pagham Harbour MCZ is included in the Nature Conservation Assessment, but not the MCZ assessment? Why is this? The technical note would need to explain why certain sites have been included and others excluded.

## 1.11 In relation to the Method Statement provision

- Natural England has not received these and it has now been over 6 weeks since we were told we they were likely be 2 weeks. It is now extremely unlikely we will be able to review these before Christmas given Christmas leave and the fact NE is closed between Christmas and New Year.

© WSP Environment & Infrastructure Solutions UK Ltd

## Phase Two – Preliminary Environmental Information Report

# Rampion Extension Development Limited

# Rampion 2 Offshore Wind Farm

Additional Comments Provided By Natural England – 18/05/2021

Wood Environment & Infrastructure Solutions UK Limited – May 2021

wood.

## Report for

RWE

## Main contributors

GoBe Consultants

## Issued by

..................................................................................

[redacted]

## Approved by

..................................................................................

[redacted]


## Wood

Shinfield Park
Shinfield
Reading RG2 9FW
United Kingdom
Tel +44 (0)118 9131234



## Copyright and non-disclosure notice

The contents and layout of this report are subject to copyright owned by Wood (© Wood Environment & Infrastructure Solutions UK Limited 2020) save to the extent that copyright has been legally assigned by us to another party or is used by Wood under licence. To the extent that we own the copyright in this report, it may not be copied or used without our prior written agreement for any purpose other than the purpose indicated in this report. The methodology (if any) contained in this report is provided to you in confidence and must not be disclosed or copied to third parties without the prior written agreement of Wood. Disclosure of that information may constitute an actionable breach of confidence or may otherwise prejudice our commercial interests. Any third party who obtains access to this report by any means will, in any event, be subject to the Third Party Disclaimer set out below.

## Third party disclaimer

Any disclosure of this report to a third party is subject to this disclaimer. The report was prepared by Wood at the instruction of, and for use by, our client named on the front of the report. It does not in any way constitute advice to any third party who is able to access it by any means. Wood excludes to the fullest extent lawfully permitted all liability whatsoever for any loss or damage howsoever arising from reliance on the contents of this report. We do not however exclude our liability (if any) for personal injury or death resulting from our negligence, for fraud or any other matter in relation to which we cannot legally exclude liability.


## Management systems

This document has been produced by Wood Environment & Infrastructure Solutions UK Limited in full compliance with our management systems, which have been certified to ISO 9001, ISO 14001 and OHSAS 18001 by LRQA.

## Document revisions

| No. | Details | Date |
|---|---|---|
| **0.1** | Reviewed by Offshore PM | |
| **0.2** | Reviewed by offshore PD | |
| **0.3** | Reviewed by PM | |
| **1.0** | Issue to RWE | |

# Contents


| | | |
|---|---|---|
| **1.** | **Natural England additional comments** | **4** |
| 1.2 | In relation to Structures Exclusion Zone (SEZ) | 4 |
| 1.3 | In relation to Viewpoint (VP) selection | 4 |

wood.

# 1. Natural England additional comments

1.1.1 Natural England provided comments following the Seascape, Landscape, Archaeology and Cultural Heritage and Marine Archaeology ETG meeting on the 18/03/2021. These comments have been collated and are as follows:

## 1.2 In relation to Structures Exclusion Zone (SEZ)

- Natural England would like to be kept updated on ongoing discussion around this topic.
- The mapping we have seen in a slide pack sent around but not used for the meeting on the 28th April makes it look as if approximately half the exclusion zone is still in the PEIR boundary, rather than it being largely avoid. Possible this mapping was old and that the area included has been reduced further. Need for clarification around this point..

## 1.3 In relation to Viewpoint (VP) selection

- It is important that Isle of Wight AONB are given the opportunity to also comment on this.

Rampion 2 WIND FARM

wood.

GoBe

# Rampion Extension Development Limited

# Rampion 2 Offshore Wind Farm

Additional Comments Provided By West Sussex County Council – 04/05/2021

IEMA Transforming the world to sustainability - EIA -

Wood Environment & Infrastructure Solutions UK Limited – May 2021

## Report for

RWE

## Main contributors

GoBe Consultants

## Issued by

.................................................................................
[redacted]

## Approved by

.................................................................................
[redacted]

## Wood

Shinfield Park
Shinfield
Reading RG2 9FW
United Kingdom
Tel +44 (0)118 9131234

## Copyright and non-disclosure notice

The contents and layout of this report are subject to copyright owned by Wood (© Wood Environment & Infrastructure Solutions UK Limited 2020) save to the extent that copyright has been legally assigned by us to another party or is used by Wood under licence. To the extent that we own the copyright in this report, it may not be copied or used without our prior written agreement for any purpose other than the purpose indicated in this report. The methodology (if any) contained in this report is provided to you in confidence and must not be disclosed or copied to third parties without the prior written agreement of Wood. Disclosure of that information may constitute an actionable breach of confidence or may otherwise prejudice our commercial interests. Any third party who obtains access to this report by any means will, in any event, be subject to the Third Party Disclaimer set out below.

## Third party disclaimer

Any disclosure of this report to a third party is subject to this disclaimer. The report was prepared by Wood at the instruction of, and for use by, our client named on the front of the report. It does not in any way constitute advice to any third party who is able to access it by any means. Wood excludes to the fullest extent lawfully permitted all liability whatsoever for any loss or damage howsoever arising from reliance on the contents of this report. We do not however exclude our liability (if any) for personal injury or death resulting from our negligence, for fraud or any other matter in relation to which we cannot legally exclude liability.

## Management systems

This document has been produced by Wood Environment & Infrastructure Solutions UK Limited in full compliance with our management systems, which have been certified to ISO 9001, ISO 14001 and OHSAS 18001 by LRQA.

## Document revisions

| No. | Details | Date |
|---|---|---|
| **0.1** | Reviewed by Offshore PM | |
| **0.2** | Reviewed by offshore PD | |
| **0.3** | Reviewed by PM | |
| **1.0** | Issue to RWE | |

# Contents


**1. West Sussex County Council (WSCC) additional comments 4**

1.2 In relation to Zone of Theoretical visibility (ZTVs) 4

1.3 In relation to Landscape Visual Impact Assessment (LVIA) 4

1.4 In relation to the Meeting Minutes 4

# 1. West Sussex County Council (WSCC) additional comments

1.1.1 WSCC provided comments following the Seascape, Landscape, Archaeology and Cultural Heritage and Marine Archaeology ETG meeting on the 18/03/2021. These comments have been collated and are as follows:

## 1.2 In relation to Zone of Theoretical visibility (ZTVs)

- Can we be clear if these ZTVs are more detailed and help with refining those visually impacted areas (to help us with feedback on VP locations).

## 1.3 In relation to Landscape Visual Impact Assessment (LVIA)

- Residential visual amenity surveys would be something we are keen to explore and include, and if possible to allow in helping with the final choice of substation site.

## 1.4 In relation to the Meeting Minutes

- I think the comment we would make on this would be to request these are circulated in the first couple of weeks after the meeting, as its easier for us to review whilst its fresh in our minds, rather than a month or so later.

# Rampion Extension Development Limited

# Rampion 2 Offshore Wind Farm

Additional Comments Provided By Natural England – 24/05/2021

Wood Environment & Infrastructure Solutions UK Limited – May 2021

## Report for

RWE

## Main contributors

GoBe Consultants

## Issued by

.................................................................................
[redacted]

## Approved by

.................................................................................
[redacted]

## Wood

Shinfield Park
Shinfield
Reading RG2 9FW
United Kingdom
Tel +44 (0)118 9131234

## Copyright and non-disclosure notice

The contents and layout of this report are subject to copyright owned by Wood (© Wood Environment & Infrastructure Solutions UK Limited 2020) save to the extent that copyright has been legally assigned by us to another party or is used by Wood under licence. To the extent that we own the copyright in this report, it may not be copied or used without our prior written agreement for any purpose other than the purpose indicated in this report. The methodology (if any) contained in this report is provided to you in confidence and must not be disclosed or copied to third parties without the prior written agreement of Wood. Disclosure of that information may constitute an actionable breach of confidence or may otherwise prejudice our commercial interests. Any third party who obtains access to this report by any means will, in any event, be subject to the Third Party Disclaimer set out below.

## Third party disclaimer

Any disclosure of this report to a third party is subject to this disclaimer. The report was prepared by Wood at the instruction of, and for use by, our client named on the front of the report. It does not in any way constitute advice to any third party who is able to access it by any means. Wood excludes to the fullest extent lawfully permitted all liability whatsoever for any loss or damage howsoever arising from reliance on the contents of this report. We do not however exclude our liability (if any) for personal injury or death resulting from our negligence, for fraud or any other matter in relation to which we cannot legally exclude liability.

## Management systems

This document has been produced by Wood Environment & Infrastructure Solutions UK Limited in full compliance with our management systems, which have been certified to ISO 9001, ISO 14001 and OHSAS 18001 by LRQA.

## Document revisions

| No. | Details | Date |
|---|---|---|
| **0.1** | Reviewed by Offshore PM | |
| **0.2** | Reviewed by offshore PD | |
| **0.3** | Reviewed by PM | |
| **1.0** | Issue to RWE | |

# Contents


**1. Natural England additional comments 4**

1.2 In relation to Coastal Processes 4

1.3 In relation to Fish and Shellfish Ecology 4

Black bream 4

Seahorse 4

# 1. Natural England additional comments

1.1.1 Natural England provided comments following the Physical Processes, Water Quality, Benthic Ecology and Fish Ecology ETG meeting on the 24/03/2021. These comments have been collated and are as follows:

## 1.2 In relation to Coastal Processes

- Natural England suggest that the applicant asks the Environment Agency for the contact details of their coastal processes specialists to discuss this. Also, important to engage with local authority coastal engineers. We mentioned this in our comments on the last ETG's around Climping.

## 1.3 In relation to Fish and Shellfish Ecology

### Black bream

- Natural England understand that you do not intend on using this information [Drop Down Video (DDV) surveys] in isolation, however we would stress that the time of year that the DDV were conducted (i.e outside of the nesting bream season) means that this data does not provide a reliable insight into nesting activity.

### Seahorse

- Natural England would highlight that seahorses are also protected under the Wildlife and Countryside Act and therefore they need to be considered under this legislation as well as in relation to seahorses being a feature of designated sites.

# Rampion Extension Development Limited

# Rampion 2 Offshore Wind Farm

Additional Comments Provided
By Natural England –
10/05/2021

Wood Environment & Infrastructure Solutions UK Limited – May 2021

## Report for

RWE

## Main contributors

GoBe Consultants

## Issued by

.................................................................................
[redacted]

## Approved by

.................................................................................
[redacted]

## Wood

Shinfield Park
Shinfield
Reading RG2 9FW
United Kingdom
Tel +44 (0)118 9131234

## Copyright and non-disclosure notice

The contents and layout of this report are subject to copyright owned by Wood (© Wood Environment & Infrastructure Solutions UK Limited 2020) save to the extent that copyright has been legally assigned by us to another party or is used by Wood under licence. To the extent that we own the copyright in this report, it may not be copied or used without our prior written agreement for any purpose other than the purpose indicated in this report. The methodology (if any) contained in this report is provided to you in confidence and must not be disclosed or copied to third parties without the prior written agreement of Wood. Disclosure of that information may constitute an actionable breach of confidence or may otherwise prejudice our commercial interests. Any third party who obtains access to this report by any means will, in any event, be subject to the Third Party Disclaimer set out below.

## Third party disclaimer

Any disclosure of this report to a third party is subject to this disclaimer. The report was prepared by Wood at the instruction of, and for use by, our client named on the front of the report. It does not in any way constitute advice to any third party who is able to access it by any means. Wood excludes to the fullest extent lawfully permitted all liability whatsoever for any loss or damage howsoever arising from reliance on the contents of this report. We do not however exclude our liability (if any) for personal injury or death resulting from our negligence, for fraud or any other matter in relation to which we cannot legally exclude liability.

## Management systems

This document has been produced by Wood Environment & Infrastructure Solutions UK Limited in full compliance with our management systems, which have been certified to ISO 9001, ISO 14001 and OHSAS 18001 by LRQA.

## Document revisions

| No. | Details | Date |
|---|---|---|
| **0.1** | Reviewed by Offshore PM | |
| **0.2** | Reviewed by offshore PD | |
| **0.3** | Reviewed by PM | |
| **1.0** | Issue to RWE | |

# Contents


## 1. Natural England additional comments 4

1.2 In relation to Ornithology survey methodologies 4

1.3 In relation to Nature conservation assessment 4

Seahorse 4

# 1. Natural England additional comments

1.1.1 Natural England provided comments following the Ornithology, Marine Mammals and HRA (offshore) ETG meeting on the 26/03/2021. These comments have been collated and are as follows:

## 1.2 In relation to Ornithology survey methodologies

- Natural England are awaiting consultation with APEM in relation to methodologies.

## 1.3 In relation to Nature conservation assessment

### Seahorse

- Natural England would highlight that seahorses should also be considered under the Wildlife and Countryside Act outside of designated sites.

| Heritage assets selected for assessment of indirect effects as a result of offshore development | |
|---|---|
| **Designation/List Entry** | **Name** |
| **Scheduled monument** | |
| SM 1005809 | A 19th century artillery fort known as Littlehampton Fort, 317m south west of the Windmill Theatre |
| SM 1015877 | Highdown Hill Camp: A Ram's Hill type enclosure, an Anglo-Saxon cemetery and associated remain |
| SM 1005824 | Shoreham Fort, 120m SSE of East |
| SM 1014526 | Hillfort, the possible remains of a Romano-Celtic temple and a group of three bowl barrows at Hollingbury |
| SM 1013067 and 1015229 | Long barrows on Beacon Hill |
| SM 1002242 | Newhaven military fort and lunette battery |
| SM 1017359 and LB II 1192342 | Martello tower no 74 on Seaford Esplanade |
| SM 1014523 | Hillfort and a bowl barrow on Seaford Head |
| SM 1002288 | Camp near Belle Tout lighthouse, Birling Gap |
| **Listed Building** | |
| LB GII 1418951 | Aldwick Hundred |
| LBs<br><br>Grade II*<br>1027676, 1233450, 1274459<br><br>Grade II<br>1027637, 1027638, 1027677, 1276596, 1353879, 1353880 | Bailiffscourt |
| LB GII 1274038 | Rustington Convalescent Home |
| LB GII 1396577 | Vista Point, Including Garages and Attached Walls |
| LB GII 1263242 | The Pier (Including The Pierfoot Pavilion And The Pierhead Pavilion) |

| Heritage assets selected for assessment of indirect effects as a result of offshore development | |
|---|---|
| **Designation/List Entry** | **Name** |
| LB GII* 1381700 | The Palace Pier |
| LB GII 1222778 | 17th Century House |
| LB GII 1353108 | Belle Tout Lighthouse |
| LB GII 1393889 | Beachy Head Lighthouse |
| **Registered Park and Garden** | |
| RPG II 1001313 | Kemp Town Enclosures |
| **Conservation Area** | |
| Selsey Old Town, Sidlesham Quay, The Steyne and Aldwick Road in Bognor Regis, Craigwell House and Aldwick Bay in Aldwick, Littlehampton Seafront, Littlehampton River Road, Farncombe Road, Steyne Gardens, South Street, Marine Parade and Hinterland, Ivy Place, Kemp Town, The Avenues, Brunswick Town, Cliftonville, East Cliff, Old Town, Regency Square, Rottingdean, Sackville Gardens and Valley Gardens. | |

# Rampion Extension Development Limited

# Rampion 2 Offshore Wind Farm

Additional Comments Provided By Natural England – 10/05/2021

Wood Environment & Infrastructure Solutions UK Limited – May 2021

wood.

## Report for

RWE

## Main contributors

GoBe Consultants

## Issued by

.................................................................................
[redacted]

## Approved by

.................................................................................
[redacted]

## Wood

Shinfield Park
Shinfield
Reading RG2 9FW
United Kingdom
Tel +44 (0)118 9131234

## Copyright and non-disclosure notice

The contents and layout of this report are subject to copyright owned by Wood (© Wood Environment & Infrastructure Solutions UK Limited 2020) save to the extent that copyright has been legally assigned by us to another party or is used by Wood under licence. To the extent that we own the copyright in this report, it may not be copied or used without our prior written agreement for any purpose other than the purpose indicated in this report. The methodology (if any) contained in this report is provided to you in confidence and must not be disclosed or copied to third parties without the prior written agreement of Wood. Disclosure of that information may constitute an actionable breach of confidence or may otherwise prejudice our commercial interests. Any third party who obtains access to this report by any means will, in any event, be subject to the Third Party Disclaimer set out below.

## Third party disclaimer

Any disclosure of this report to a third party is subject to this disclaimer. The report was prepared by Wood at the instruction of, and for use by, our client named on the front of the report. It does not in any way constitute advice to any third party who is able to access it by any means. Wood excludes to the fullest extent lawfully permitted all liability whatsoever for any loss or damage howsoever arising from reliance on the contents of this report. We do not however exclude our liability (if any) for personal injury or death resulting from our negligence, for fraud or any other matter in relation to which we cannot legally exclude liability.

## Management systems

This document has been produced by Wood Environment & Infrastructure Solutions UK Limited in full compliance with our management systems, which have been certified to ISO 9001, ISO 14001 and OHSAS 18001 by LRQA.

## Document revisions

| No. | Details | Date |
|---|---|---|
| **0.1** | Reviewed by Offshore PM | |
| **0.2** | Reviewed by offshore PD | |
| **0.3** | Reviewed by PM | |
| **1.0** | Issue to RWE | |

# Contents


**1. Natural England additional comments 4**

1.2 In relation to limited datasets and timeframes 4

1.3 In relation to Structures Exclusion Zone (SEZ) 4

1.4 In relation to Lesson Learned 4

1.5 In relation to Climping beach and flood protection 4

1.6 In relation to Consultation timescales 4

# 1. Natural England additional comments

1.1.1 Natural England provided comments following the Steering Group meeting on the 16/03/2021. These comments have been collated and are as follows:

## 1.2 In relation to limited datasets and timeframes

- Natural England noted the limitation of not having full dataset available at the PEIR stage for a variety of subjects. As a result, any comments made by Natural England will only be preliminary and subject to change when Natural England are presented the full dataset. Natural England are also concerned about the limited timeframe between the PEIR and submission in relation to the opportunities for us and others to comment on the full dataset.

## 1.3 In relation to Structures Exclusion Zone (SEZ)

- The point [redacted] raised around the exclusion zone. Detailed comments on this were also include in our scoping response in August 2020. It would be useful if a copy of the letter was included in the documents relating to this round of ETG's, as it sets out our concerns around this.

## 1.4 In relation to Lesson Learned

- This is something we highlighted would be important to include in our scoping response in August 2020. Specifically, 'We would suggest the developer documents all of the lessons learnt in relation to Rampion 1, as well as other comparable windfarm developments and demonstrates how these have been taken into consideration in relation to the proposals for Rampion 2'.

## 1.5 In relation to Climping beach and flood protection

- Natural England have previously raised that the developer should engage with the EA and local coastal engineers on this issue.

## 1.6 In relation to Consultation timescales

- Natural England would welcome as much advanced notice on more accurate timings for these consultations as soon as they are known. If there are going to be delays this needs to be communicated as soon as it is known, to allow us to plan our input.
- Regular updates to be provided on when the PEIR will be available and the timing of the Section 42 consultation to allow us to plan our input to the consultation

Historic England

[redacted]
GoBe Consultants

*Correspondence by email only*

17th March 2021

Dear [redacted],

**Rampion II Offshore Wind Farm – Evidence Plan Process**

Further the Evidence Plan Process Steering Group Meeting held yesterday, I write to you as I understand that you are the Chair of the Marine Archaeology Expert Topic Group. Please also consider this letter as confirmation that I will now coordinate the involvement of Historic England staff in the on-going pre-application stages of this proposed project, including the Preliminary Environmental Information Report (PEIR) consultation stage.

We understand that the proposed Rampion II project can be summarised as:

- Offshore infrastructure located to the East, South and West of the operational Rampion Offshore Wind Farm which will comprise wind turbine generators, offshore electricity substation(s), inter-array cables and export cable(s) to the landfall location.

- Onshore infrastructure will comprise a landfall site in the vicinity of Climping (near Arun), with buried underground electricity transmission cable(s) running approximately 36km to a new substation in the vicinity of Bolney (West Sussex).

<u>The role of Historic England</u>

As you will be aware, Historic England is the Government's statutory adviser on all matters relating to the historic environment in England. We are a non-departmental public body established under the National Heritage Act 1983 and sponsored by the Department for Digital, Culture, Media and Sport (DCMS). We champion and protect England's historic places, providing expert advice to local planning authorities, developers, owners and communities to help ensure our historic environment is properly understood, enjoyed and cared for.

Historic England's involvement in maritime development matters was extended (under the National Heritage Act 2002) to modify our functions to include securing the preservation of monuments in, on, or under the seabed within the seaward limits of the UK Territorial Sea adjacent to England (12 nautical miles). We also provide our advice in recognition of the English marine plan areas (inshore and offshore) as defined by the Marine and Coastal Access Act 2009 and as described within the UK Marine Policy Statement and the policies of published or draft Marine Plans.

The Environmental Impact Assessment (EIA) exercise for the proposed project

We are aware that the Planning Inspectorate published their EIA Scoping Opinion (Case Reference: EN010117) in August 2020 and that the Planning Inspectorate could be "content" if measures were "…adequately secured (with reference to implementation) and presented in sufficient detail then they may be relied upon as means to demonstrate an absence of significant effect in the ES" (section 4.13 – Marine Archaeology).

We also understand that the case made for 'scoping out' marine archaeology by the Applicant was based on assessment of data to determine the presence of known historic or archaeological sites and the risk of encountering presently unknown archaeological receptors. It is noted that avoidance of significant impact is predicated on the primary action of in-situ protection through avoidance. However, our understanding of this approach, as described within the EIA Scoping report was through the use a "Commitments Register". It is still our position that the viability of this approach, as relevant to supporting the completion of an EIA exercise, is through securing the required "Commitments" within the Development Consent Order, including deemed Marine Licences and associated conditions to deliver mitigation measures such as a marine archaeological Written Scheme of Investigation.

The Evidence Plan Process and Expert Technical Groups

In reference to the Minutes of the Evidence Plan Process Steering Group meeting held on 9th September 2020, we did not notice any specific discussion regarding work to produce a draft Commitments Register or in the Minutes of the Expert Technical Group for Seascape, Landscape, Archaeology and Cultural Heritage and Marine Archaeology, as dated 15th September 2020. We also note that the subject of the Commitments Register was not included on the Agenda for the Evidence Plan Process Steering Group meeting held yesterday.

We appreciate that your colleagues have supplied us with the papers for the Expert Topic Group meeting for Seascape, Landscape, Archaeology and Cultural Heritage and Marine Archaeology to be held on 18th March, so we offer the following comments regarding the Agenda to help ensure the available time is used as efficiently as possible:

- Agenda Item 3 (Seascape, Landscape, Visual impact Assessment) – we note that 'informal consultation' has occurred with various parties and that a number of coastal heritage assets have been selected for assessment in reference to setting. In reference to the proposed timetable for production of the PEIR what opportunity will there be for any additional heritage assets to be included? We ask this question in reference to the response provided by the Planning Inspectorate in their Scoping Opinion (ID 5.8.7 Historic Environment).

- Agenda Item 6 (Marine Archaeology) – in the presentation provided we noticed that in consideration of "Potential effects on marine archaeology receptors scoped in for further assessment" that for the receptor "Construction" for both "Activity or impact" and "Potential effect" that there was "None identified".

We therefore consider it to be an important matter that we discuss the following and which we appreciate you may wish to address at a separate meeting:

1. Will the PEIR produced for this proposed project provide an assessment of the risk and possible impact (direct and indirect) that could occur during any post-consent survey work conducted prior to and associated with 'Construction'?

2. Will a draft Commitments Register be included with the PEIR to detail the production of an Outline Marine Written Scheme of Investigation that is specifically relevant to both pre-Construction and Construction phases of the proposed development?

3. Will draft deemed Marine Licences accompany the PEIR consultation which includes specific conditions for the delivery of marine archaeological mitigation measures for all phases of the proposed development?

In consideration of the above questions, it is our present position that it cannot be demonstrated at this stage that there will be no impacts to presently unknown elements of the marine historic environment. It is therefore not possible to demonstrate an absence of significant effect in the Environmental Statement.

<u>Enhanced Advisory Service - Extended Pre-Application Advice Service and Major Project Service</u>
In reference to the Enhanced Advisory Service we have in place with RWE (Our Ref: PA01112187), we will check the quote to ensure that it reflects the anticipated participation of Historic England staff for all onshore and offshore aspects of this proposed development.

Yours sincerely,

[redacted]

**Head of Marine Planning**

Historic England

[redacted]
GoBe Consultants

*Correspondence by email only*

28th June 2021

Dear [redacted],

**Rampion II Offshore Wind Farm – Evidence Plan Process**

Further to the email received from your colleague, [redacted] dated 17th June 2021 we are prompted to write to you to request a response to the letter we sent you, dated 17th March 2021. For your convenience we have supplied you with a copy of that letter with this correspondence.

We have also reviewed the "Rampion 2 – Master Agreement Log" and in reference to the tab "marine archaeology" we noted that 'agreement' appears to have been identified in regard to baseline data gathering and assessment methodology, which would appear to be attributable to the meeting held on 18th March 2021. However, in consideration of the matters highlighted in our letter (as dated above) we cannot readily agree to this log record, which is attributable to oral comments at meetings.

We also request that any future Evidence Plan Process Steering Group Minutes produced are as succinct as possible with clearly identified actions. If you wish to produce a transcript of a meeting, please supply such material separately.

Yours sincerely,

[redacted]

**Head of Marine Planning**

cc. [redacted] (Planning Inspectorate)
[redacted] MMO)