# Appendix L Addendum

## Cumulative iPCoD Modelling Report

# ORIEL WIND FARM PROJECT

## Natura Impact Statement – Addendum
## Appendix L: Cumulative iPCoD Modelling Report

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# 1 INTRODUCTION

## 1.1 Overview

Since the submission of the application for the Oriel Wind Farm Project (hereafter as 'the Project'), several projects have made applications, been consented or changed tiers in the In-Combination Assessment (ICA) (see appendix J Addendum: Screening In-Combination Effects). A review of the Project ICA has been undertaken as part of the response to further information (see appendix J), which included quantitative information as presented in the respective EIARs of the east coast Phase 1 projects. In addition, revised underwater noise modelling for the Project alone has been carried out (see appendix C-1 Addendum: Updated Subsea Noise Modelling Report, NIS Addendum) and therefore numbers of animals disturbed has been updated (see appendix F Addendum: Marine Mammals and Megafauna – Supporting Information). Cumulative population modelling has been undertaken to assess whether cumulative disturbance resulting from pile driving activities from cumulative projects is predicted to result in population level impacts to key marine mammal species (harbour porpoise, bottlenose dolphins, minke whale, harbour seals and grey seals). The results are presented in this report.

The cumulative population modelling presented in this report also addresses Request for Further Information (RFI) 9.X (from An Coimisiún Pleanála (formerly An Bord Pleanála)) regarding the planning application (case reference ABP-319799-24). RFI 9.X requested Interim Population Consequences of Disturbance (iPCoD) modelling to be used in the ICA, including indicative piling schedules for the other Irish Sea Phase 1 Offshore Renewable Energy (ORE) projects. Sinclair (2024) carried out cumulative population modelling for the five Irish Sea Phase 1 ORE projects prior to publication of their respective EIARs (see section 1.2.2) as these are the projects closest to the Project and therefore with most potential for cumulative interactions. However, the Oriel NIS (2024) identified other projects within the Irish Sea (in English and Welsh waters to the east of the Irish Sea) which were also considered as these fell within the Marine Mammal Cumulative Study Area (given the wide-ranging nature of marine mammals). This report therefore presents the cumulative population modelling for all projects screened in to the ICA: the Project, North Irish Sea Array (hereafter referred to as NISA) (North Irish Sea Array Windfarm Ltd., 2024), Dublin Array (Bray Offshore Wind Limited. and Kish Offshore Wind Limited., 2025), Codling Wind Park (Codling Wind Park Limited, 2024), Arklow Bank Wind Park (SSE Renewables, 2024), Morgan Offshore Wind Project: Generation Assets (hereafter referred to as Morgan Generation Assets) (Morgan Offshore Wind Ltd., 2025), Mona Offshore Wind Project (Mona Offshore Wind Ltd, 2023), Awel y Môr Offshore Wind Farm (RWE Renewables UK, 2022), Morecambe Offshore Windfarm: Generation Assets (hereafter referred to as Morecambe Generation Assets) (Morecambe Offshore Wind Ltd, 2025) and Mooir Vannin Generation Project (Ørsted, 2025).

## 1.2 Summary of Project alone population modelling

### 1.2.1 Project alone

Population modelling using revised noise modelling was carried out to investigate the potential for underwater noise associated with the installation of monopiles to affect the population trajectory over time for harbour porpoise, bottlenose dolphin, minke whale, grey seal and harbour seal. The time points modelled for the project alone were from time point 1, which corresponds to the start of piling at the Project, to time point 26 which corresponds to 25 years after the start of piling. To note, these corresponding time points are for the Project alone modelling only, and time points will differ for cumulative piling (see results of modelling in section 1.4).

In summary, modelling results for all species demonstrated that there may be a small, or negligible reduction in population size for the impacted populations, however any changes that did occur would not be enough to significantly affect population trajectories over a generational scale (i.e. small changes in the simulated trajectories fall within the expected range of natural variation).

#### 1.2.1.1 Harbour porpoise

Results of the iPCoD modelling for harbour porpoise against the Celtic and Irish Seas (CIS) Management Unit (MU) showed that the median ratio of the impacted population to the un-impacted population at all but two modelled timepoints was 1.0000: at time points 2 and 3 (corresponding to one year after the start of piling (inclusive of the full 26-day piling period), and two years after the start of piling (one year after piling has finished), respectively for the Project) this ratio was marginally lower at 0.9999 (Table 1.1). The greatest modelled difference in number of animals between the un-impacted and the impacted populations was at time point 3 (43 fewer animals; 0.069% of the CIS MU). At time-point 2, the end of piling at the Project, there was a difference of 39 animals between the impacted and unimpacted population (0.06% of the MU). At time point 26, iPCoD modelling showed 24 fewer animals for the impacted population (0.038% of the CIS MU) noting, however, that iPCoD does not allow for density-dependant recovery. As such there is considered to be no significant difference between the population trajectories for an un-impacted population and impacted population (see Figure 1.1).

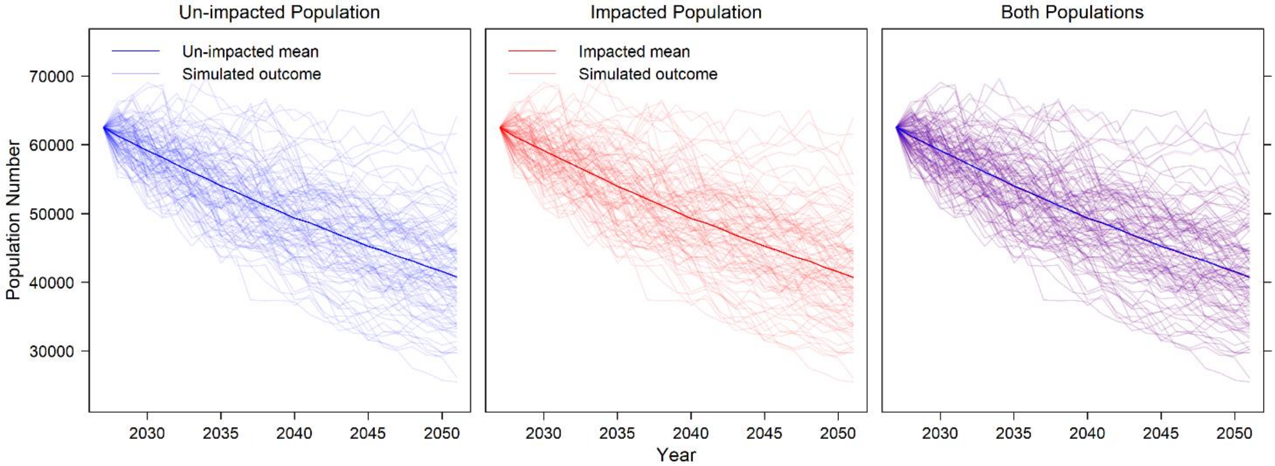



**Figure 1.1: Mean simulated population trajectories of harbour porpoise for the impacted vs un-impacted population over a 25-year simulation for the Project alone iPCoD model.**

Table 1.1: Modelled estimates for the un-impacted and impacted harbour porpoise population under the Project alone scenario

| Time point | Un-impacted population (number of animals) | | | Impacted population (number of animals) | | | Difference between means | % of MU | Counterfactual | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | Lower 2.5% | Upper 2.5% | Mean | Lower 2.5% | Upper 2.5% | | | Median | Mean |
| 1 | 62,518 | 62,518 | 62,518 | 62,518 | 62,518 | 62,518 | 0 | 0.00% | 1.0000 | 1.0000 |
| 2 | 61,290 | 55,824 | 65,633 | 61,251 | 55,824 | 65,610 | 39 | 0.06% | 0.9999 | 0.9994 |
| 3 | 60,223 | 53,485 | 66,079 | 60,180 | 53,358 | 66,069 | 43 | 0.07% | 0.9999 | 0.9993 |
| 4 | 59,170 | 51,802 | 66,314 | 59,133 | 51,694 | 66,230 | 37 | 0.06% | 1.0000 | 0.9994 |
| 5 | 58,165 | 49,493 | 66,401 | 58,134 | 49,457 | 66,240 | 31 | 0.05% | 1.0000 | 0.9995 |
| 6 | 57,095 | 47,971 | 66,136 | 57,063 | 47,969 | 66,107 | 32 | 0.05% | 1.0000 | 0.9994 |
| 7 | 56,065 | 46,858 | 65,661 | 56,033 | 46,858 | 65,661 | 32 | 0.05% | 1.0000 | 0.9994 |
| 8 | 55,088 | 45,164 | 65,668 | 55,055 | 45,162 | 65,666 | 33 | 0.05% | 1.0000 | 0.9994 |
| 9 | 54,015 | 43,791 | 64,742 | 53,983 | 43,791 | 64,705 | 32 | 0.05% | 1.0000 | 0.9994 |
| 10 | 53,145 | 42,883 | 64,390 | 53,113 | 42,882 | 64,387 | 32 | 0.05% | 1.0000 | 0.9994 |
| 11 | 52,151 | 41,788 | 64,192 | 52,121 | 41,788 | 64,046 | 30 | 0.05% | 1.0000 | 0.9994 |
| 12 | 51,197 | 40,243 | 63,457 | 51,167 | 40,211 | 63,457 | 30 | 0.05% | 1.0000 | 0.9994 |
| 13 | 50,304 | 39,168 | 63,512 | 50,274 | 39,168 | 63,497 | 30 | 0.05% | 1.0000 | 0.9994 |
| 14 | 49,322 | 38,449 | 62,968 | 49,292 | 38,439 | 62,857 | 30 | 0.05% | 1.0000 | 0.9994 |
| 15 | 48,648 | 37,968 | 62,162 | 48,618 | 37,929 | 62,152 | 30 | 0.05% | 1.0000 | 0.9994 |
| 16 | 47,799 | 36,599 | 61,067 | 47,771 | 36,599 | 60,938 | 28 | 0.04% | 1.0000 | 0.9994 |
| 17 | 46,914 | 35,486 | 60,577 | 46,886 | 35,475 | 60,576 | 28 | 0.04% | 1.0000 | 0.9994 |
| 18 | 46,076 | 35,033 | 59,676 | 46,049 | 34,934 | 59,664 | 27 | 0.04% | 1.0000 | 0.9994 |
| 19 | 45,236 | 33,447 | 59,185 | 45,209 | 33,447 | 59,170 | 27 | 0.04% | 1.0000 | 0.9994 |
| 20 | 44,555 | 32,850 | 59,149 | 44,528 | 32,850 | 59,057 | 27 | 0.04% | 1.0000 | 0.9994 |
| 21 | 43,741 | 31,991 | 58,753 | 43,714 | 31,991 | 58,706 | 27 | 0.04% | 1.0000 | 0.9994 |
| 22 | 43,111 | 30,916 | 58,483 | 43,085 | 30,916 | 58,382 | 26 | 0.04% | 1.0000 | 0.9994 |
| 23 | 42,266 | 30,044 | 58,489 | 42,241 | 30,042 | 58,174 | 25 | 0.04% | 1.0000 | 0.9994 |
| 24 | 41,544 | 29,383 | 56,719 | 41,519 | 29,329 | 56,650 | 25 | 0.04% | 1.0000 | 0.9994 |
| 25 | 40,730 | 28,911 | 54,922 | 40,705 | 28,911 | 54,922 | 25 | 0.04% | 1.0000 | 0.9994 |
| 26 | 40,033 | 27,767 | 54,677 | 40,009 | 27,767 | 54,636 | 24 | 0.04% | 1.0000 | 0.9994 |

### 1.2.1.2 Bottlenose dolphin

Results of the iPCoD modelling for the SCANS-IV Block CS-D density estimate compared against the Irish Sea MU population estimate (Gilles *et al.*, 2023), showed that the median ratio of the impacted population to the un-impacted population at all modelled timepoints was 1.0000 (Table 1.2). The greatest modelled difference in number of animals between the un-impacted and the impacted populations was at time points 3 and 4 (corresponding to two years after the start of piling (inclusive of the full 26-day piling period), and three years after the start of piling, respectively) (19 fewer animals; 0.228% of the 8,326 population estimate). At time-point 2, the end of piling at the Project, there was a difference of 18 animals between the impacted and unimpacted population (0.22% of the population estimate). At time point 26 iPCoD modelling showed 16 fewer animals (0.192% of the population estimate). The iPCoD modelling results show that the difference between impacted and un-impacted populations is stable from time point 6 (corresponding to five years after the start of piling, four years after piling has ceased) onwards suggesting that no further changes have occurred. It is important to highlight that iPCoD does not currently allow for a density-dependent response, and as such there is no way for the impacted population to increase in size in iPCoD after the piling activity has ceased. As such, there is considered to be no significant difference between the population trajectories for an un-impacted population and impacted population (see Figure 1.2).

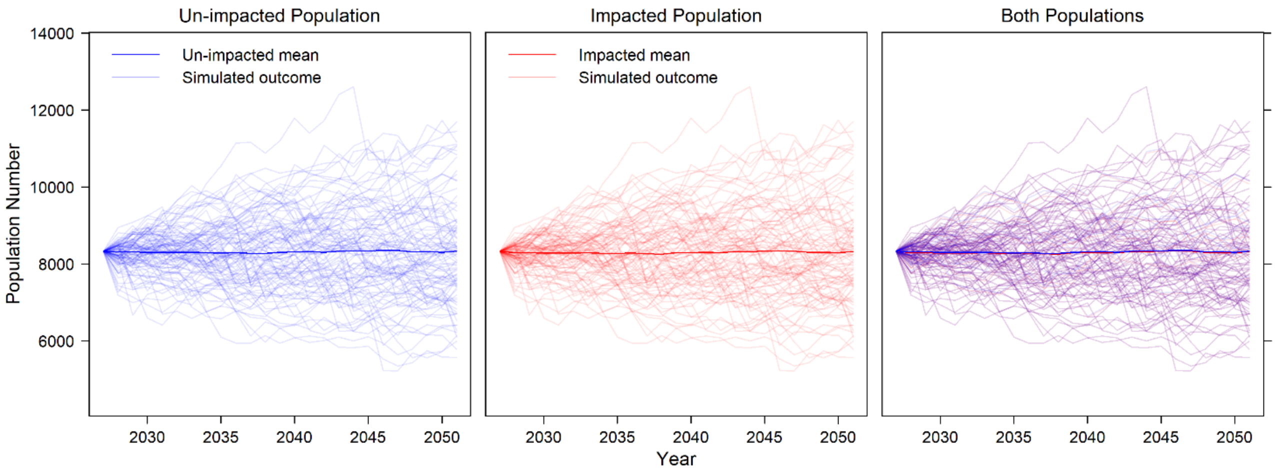



**Figure 1.2: Mean simulated population trajectories of bottlenose dolphin for the impacted vs un-impacted population over a 25 year simulation (SCANS-IV abundance and combined SCANS-IV blocks within the Irish Sea) for the Project alone iPCoD model.**

**Table 1.2: Modelled estimates for the un-impacted and impacted bottlenose dolphin population under the Project alone scenario, for the SCANS-IV Block CS-D density estimate**

| Time point | Un-impacted population (number of animals) | | | Impacted population (number of animals) | | | Difference between means | % of MU | Counterfactual | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | Lower 2.5% | Upper 2.5% | Mean | Lower 2.5% | Upper 2.5% | | | Median | Mean |
| 1 | 8,326 | 8,326 | 8,326 | 8,326 | 8,326 | 8,326 | 0 | 0.00% | 1.000000 | 1.000000 |
| 2 | 8,308 | 7,474 | 8,842 | 8,290 | 7,442 | 8,834 | 18 | 0.22% | 1.000000 | 0.997833 |
| 3 | 8,305 | 7,156 | 9,082 | 8,286 | 7,138 | 9,056 | 19 | 0.23% | 1.000000 | 0.997664 |
| 4 | 8,299 | 7,021 | 9,200 | 8,280 | 6,984 | 9,200 | 19 | 0.23% | 1.000000 | 0.997819 |
| 5 | 8,296 | 6,904 | 9,380 | 8,279 | 6,898 | 9,380 | 17 | 0.20% | 1.000000 | 0.997968 |
| 6 | 8,295 | 6,844 | 9,520 | 8,279 | 6,816 | 9,462 | 16 | 0.19% | 1.000000 | 0.998098 |
| 7 | 8,301 | 6,776 | 9,613 | 8,286 | 6,775 | 9,613 | 15 | 0.18% | 1.000000 | 0.998212 |
| 8 | 8,285 | 6,662 | 9,716 | 8,271 | 6,662 | 9,714 | 14 | 0.17% | 1.000000 | 0.998300 |
| 9 | 8,284 | 6,543 | 9,776 | 8,269 | 6,543 | 9,772 | 15 | 0.18% | 1.000000 | 0.998332 |
| 10 | 8,290 | 6,532 | 9,953 | 8,276 | 6,530 | 9,948 | 14 | 0.17% | 1.000000 | 0.998280 |
| 11 | 8,272 | 6,462 | 10,014 | 8,257 | 6,462 | 10,012 | 15 | 0.18% | 1.000000 | 0.998224 |
| 12 | 8,269 | 6,410 | 10,085 | 8,254 | 6,410 | 10,081 | 15 | 0.18% | 1.000000 | 0.998190 |
| 13 | 8,300 | 6,388 | 10,234 | 8,285 | 6,380 | 10,220 | 15 | 0.18% | 1.000000 | 0.998171 |
| 14 | 8,305 | 6,133 | 10,428 | 8,289 | 6,133 | 10,383 | 16 | 0.19% | 1.000000 | 0.998156 |
| 15 | 8,314 | 6,120 | 10,515 | 8,299 | 6,120 | 10,506 | 15 | 0.18% | 1.000000 | 0.998154 |
| 16 | 8,303 | 6,074 | 10,614 | 8,287 | 6,062 | 10,561 | 16 | 0.19% | 1.000000 | 0.998153 |
| 17 | 8,329 | 6,020 | 10,741 | 8,313 | 6,020 | 10,684 | 16 | 0.19% | 1.000000 | 0.998168 |
| 18 | 8,335 | 5,934 | 10,686 | 8,320 | 5,924 | 10,672 | 15 | 0.18% | 1.000000 | 0.998175 |
| 19 | 8,342 | 5,956 | 10,842 | 8,326 | 5,950 | 10,842 | 16 | 0.19% | 1.000000 | 0.998180 |
| 20 | 8,348 | 5,908 | 10,946 | 8,332 | 5,898 | 10,942 | 16 | 0.19% | 1.000000 | 0.998183 |
| 21 | 8,347 | 5,839 | 11,058 | 8,332 | 5,839 | 11,018 | 15 | 0.18% | 1.000000 | 0.998185 |
| 22 | 8,312 | 5,758 | 10,987 | 8,296 | 5,758 | 10,987 | 16 | 0.19% | 1.000000 | 0.998186 |
| 23 | 8,313 | 5,762 | 11,121 | 8,298 | 5,762 | 11,119 | 15 | 0.18% | 1.000000 | 0.998184 |
| 24 | 8,302 | 5,706 | 11,160 | 8,287 | 5,700 | 11,157 | 15 | 0.18% | 1.000000 | 0.998182 |
| 25 | 8,329 | 5,697 | 11,222 | 8,313 | 5,650 | 11,199 | 16 | 0.19% | 1.000000 | 0.998179 |
| 26 | 8,313 | 5,600 | 11,227 | 8,297 | 5,600 | 11,190 | 16 | 0.19% | 1.000000 | 0.998182 |

### 1.2.1.3 Minke whale

Results of the iPCoD modelling for minke whale against the Celtic and Greater North Sea (CGNS) MU showed a negligible difference in the growth trajectory of this species between the un-impacted population and impacted population (Table 1.3, Figure 1.3). Projected population values were the same for the un-impacted population and impacted population at all but one timepoint (a difference of one fewer animal at time point 5 (corresponding to four years after the start of piling, three years after piling has finished), representing 0.0049% of the CGNS MU) (Table 1.3). At time-point 2, the end of piling at the Project, there was no difference in the numbers of animals between the impacted and unimpacted population (0.06% of the MU). The median counterfactual was 1.0000 through each of the 25-year simulations, and therefore it is considered that there is no difference between the population trajectories for the un-impacted population and impacted population (see Figure 1.3).

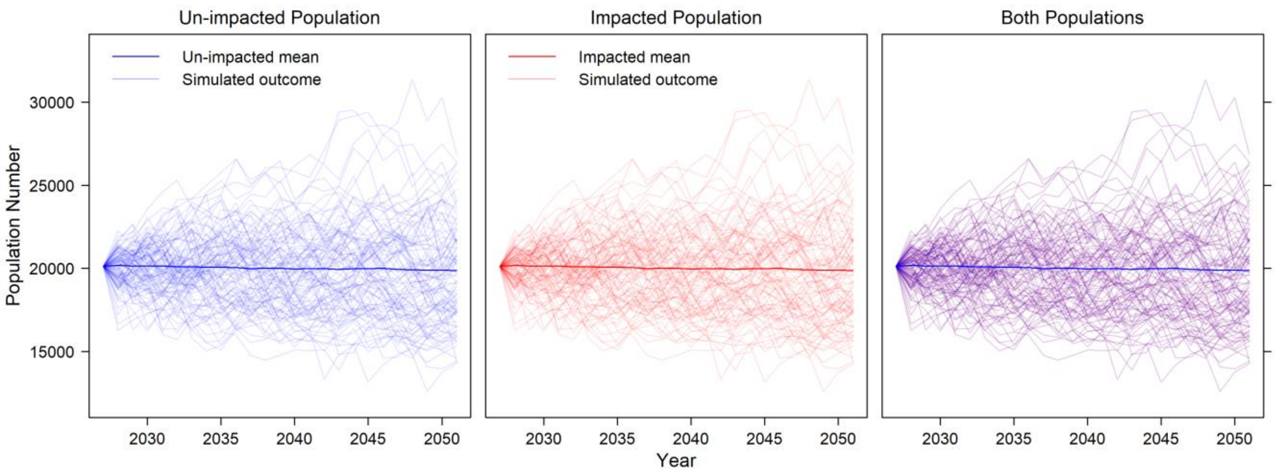



**Figure 1.3: Mean simulated population trajectories of minke whale for the impacted vs un-impacted population over a 25-year simulation.**

Table 1.3: Modelled estimates for the un-impacted and impacted minke whale population under the Project alone scenario

| Time point | Un-impacted population (number of animals) | | | Impacted population (number of animals) | | | Difference between means | % of MU | Counterfactual | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | Lower 2.5% | Upper 2.5% | Mean | Lower 2.5% | Upper 2.5% | | | Median | Mean |
| 1 | 20,120 | 20,120 | 20,120 | 20,120 | 20,120 | 20,120 | 0 | 0.00% | 1.000000 | 1.000000 |
| 2 | 20,187 | 18,057 | 21,818 | 20,187 | 18,057 | 21,818 | 0 | 0.00% | 1.000000 | 0.999992 |
| 3 | 20,149 | 17,514 | 22,510 | 20,149 | 17,514 | 22,510 | 0 | 0.00% | 1.000000 | 0.999992 |
| 4 | 20,146 | 17,218 | 22,998 | 20,146 | 17,218 | 22,998 | 0 | 0.00% | 1.000000 | 0.999993 |
| 5 | 20,151 | 16,963 | 23,410 | 20,150 | 16,963 | 23,410 | 1 | 0.00% | 1.000000 | 0.999995 |
| 6 | 20,102 | 16,902 | 23,760 | 20,102 | 16,902 | 23,760 | 0 | 0.00% | 1.000000 | 0.999996 |
| 7 | 20,102 | 16,600 | 23,824 | 20,102 | 16,600 | 23,824 | 0 | 0.00% | 1.000000 | 0.999997 |
| 8 | 20,073 | 16,472 | 24,059 | 20,073 | 16,472 | 24,059 | 0 | 0.00% | 1.000000 | 0.999998 |
| 9 | 20,072 | 16,263 | 24,258 | 20,072 | 16,263 | 24,258 | 0 | 0.00% | 1.000000 | 0.999998 |
| 10 | 20,051 | 16,336 | 24,599 | 20,051 | 16,336 | 24,599 | 0 | 0.00% | 1.000000 | 0.999999 |
| 11 | 19,993 | 16,055 | 24,683 | 19,993 | 16,055 | 24,683 | 0 | 0.00% | 1.000000 | 0.999998 |
| 12 | 20,002 | 15,979 | 24,809 | 20,002 | 15,979 | 24,809 | 0 | 0.00% | 1.000000 | 0.999998 |
| 13 | 20,010 | 16,032 | 24,933 | 20,010 | 16,032 | 24,933 | 0 | 0.00% | 1.000000 | 0.999998 |
| 14 | 19,970 | 15,717 | 24,949 | 19,970 | 15,717 | 24,949 | 0 | 0.00% | 1.000000 | 0.999998 |
| 15 | 19,985 | 15,643 | 25,268 | 19,985 | 15,643 | 25,268 | 0 | 0.00% | 1.000000 | 0.999997 |
| 16 | 19,984 | 15,363 | 25,724 | 19,984 | 15,363 | 25,724 | 0 | 0.00% | 1.000000 | 0.999998 |
| 17 | 19,944 | 15,323 | 26,095 | 19,944 | 15,323 | 26,095 | 0 | 0.00% | 1.000000 | 0.999998 |
| 18 | 19,996 | 15,277 | 26,403 | 19,996 | 15,277 | 26,403 | 0 | 0.00% | 1.000000 | 0.999998 |
| 19 | 19,993 | 15,085 | 26,308 | 19,993 | 15,085 | 26,308 | 0 | 0.00% | 1.000000 | 0.999997 |
| 20 | 19,997 | 15,057 | 26,487 | 19,997 | 15,057 | 26,487 | 0 | 0.00% | 1.000000 | 0.999998 |
| 21 | 19,949 | 14,910 | 26,621 | 19,949 | 14,910 | 26,621 | 0 | 0.00% | 1.000000 | 0.999998 |
| 22 | 19,915 | 14,810 | 26,323 | 19,915 | 14,810 | 26,323 | 0 | 0.00% | 1.000000 | 0.999998 |
| 23 | 19,889 | 14,535 | 26,606 | 19,889 | 14,535 | 26,606 | 0 | 0.00% | 1.000000 | 0.999998 |
| 24 | 19,890 | 14,527 | 27,121 | 19,890 | 14,527 | 27,121 | 0 | 0.00% | 1.000000 | 0.999998 |
| 25 | 19,876 | 14,558 | 27,013 | 19,876 | 14,558 | 27,013 | 0 | 0.00% | 1.000000 | 0.999998 |
| 26 | 19,910 | 14,217 | 27,313 | 19,910 | 14,217 | 27,313 | 0 | 0.00% | 1.000000 | 0.999998 |

#### 1.2.1.4 Grey seal

Results of the iPCoD modelling for grey seal against the combined East of Ireland, South East (SE) of Ireland and Northern Ireland (NI) Seal Management Units (SMUs) showed no difference in the growth trajectory of this species between the un-impacted population and impacted population (Figure 1.4, Table 1.4). Projected population values were the same for the un-impacted population and impacted population at all timepoints (Table 1.4). The median counterfactual was 1.0000 through each of the 25-year simulations, and therefore it is considered that there is no difference between the population trajectories for the un-impacted population and impacted population (see Figure 1.4).

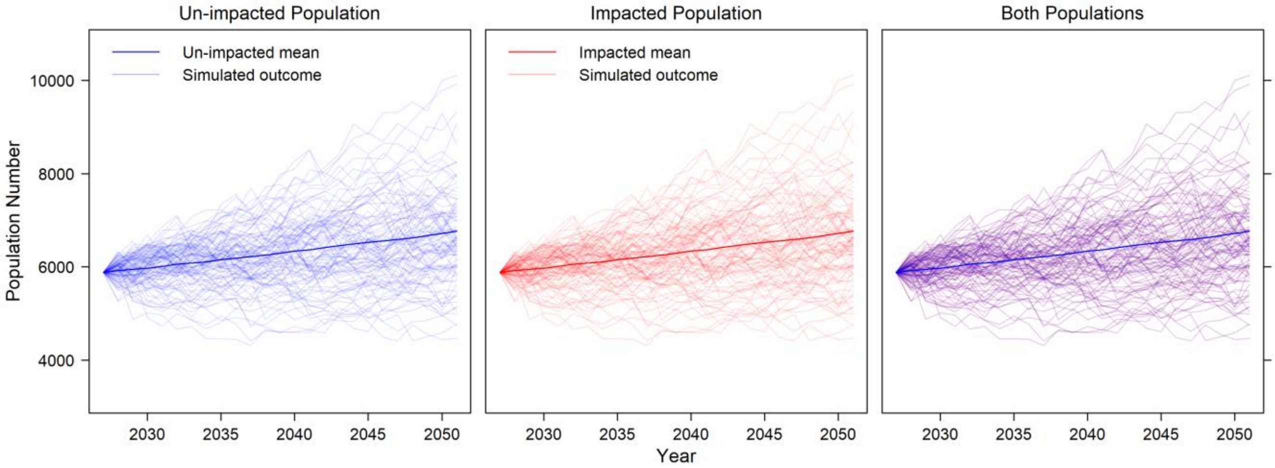



**Figure 1.4: Mean simulated population trajectories of grey seal for the impacted vs un-impacted population over a 25 year simulation for the Project alone iPCoD model.**

Table 1.4: Modelled estimates for the un-impacted and impacted grey seal population under the Project alone scenario

| Time point | Un-impacted population (number of animals) | | | Impacted population (number of animals) | | | Difference between means | % of MU | Counterfactual | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | Lower 2.5% | Upper 2.5% | Mean | Lower 2.5% | Upper 2.5% | | | Median | Mean |
| 1 | 5,882 | 5,882 | 5,882 | 5,882 | 5,882 | 5,882 | 0 | 0.00% | 1.000000 | 1.000000 |
| 2 | 5,921 | 5,430 | 6,284 | 5,921 | 5,430 | 6,284 | 0 | 0.00% | 1.000000 | 1.000000 |
| 3 | 5,954 | 5,310 | 6,432 | 5,954 | 5,310 | 6,432 | 0 | 0.00% | 1.000000 | 1.000000 |
| 4 | 5,993 | 5,282 | 6,570 | 5,993 | 5,282 | 6,570 | 0 | 0.00% | 1.000000 | 1.000000 |
| 5 | 6,025 | 5,212 | 6,720 | 6,025 | 5,212 | 6,720 | 0 | 0.00% | 1.000000 | 1.000000 |
| 6 | 6,058 | 5,165 | 6,872 | 6,058 | 5,165 | 6,872 | 0 | 0.00% | 1.000000 | 1.000000 |
| 7 | 6,109 | 5,124 | 7,008 | 6,109 | 5,124 | 7,008 | 0 | 0.00% | 1.000000 | 1.000000 |
| 8 | 6,148 | 5,092 | 7,154 | 6,148 | 5,092 | 7,154 | 0 | 0.00% | 1.000000 | 1.000000 |
| 9 | 6,205 | 5,108 | 7,330 | 6,205 | 5,108 | 7,330 | 0 | 0.00% | 1.000000 | 1.000000 |
| 10 | 6,240 | 5,146 | 7,476 | 6,240 | 5,146 | 7,476 | 0 | 0.00% | 1.000000 | 1.000000 |
| 11 | 6,282 | 5,042 | 7,538 | 6,282 | 5,042 | 7,538 | 0 | 0.00% | 1.000000 | 1.000000 |
| 12 | 6,331 | 5,035 | 7,730 | 6,331 | 5,035 | 7,730 | 0 | 0.00% | 1.000000 | 1.000000 |
| 13 | 6,368 | 4,990 | 7,780 | 6,368 | 4,990 | 7,780 | 0 | 0.00% | 1.000000 | 1.000000 |
| 14 | 6,407 | 4,988 | 7,907 | 6,407 | 4,988 | 7,907 | 0 | 0.00% | 1.000000 | 1.000000 |
| 15 | 6,441 | 4,960 | 8,056 | 6,441 | 4,960 | 8,056 | 0 | 0.00% | 1.000000 | 1.000000 |
| 16 | 6,481 | 4,916 | 8,202 | 6,481 | 4,916 | 8,202 | 0 | 0.00% | 1.000000 | 1.000000 |
| 17 | 6,514 | 4,994 | 8,282 | 6,514 | 4,994 | 8,282 | 0 | 0.00% | 1.000000 | 1.000000 |
| 18 | 6,558 | 4,874 | 8,424 | 6,558 | 4,874 | 8,424 | 0 | 0.00% | 1.000000 | 1.000000 |
| 19 | 6,600 | 4,962 | 8,530 | 6,600 | 4,962 | 8,530 | 0 | 0.00% | 1.000000 | 1.000000 |
| 20 | 6,636 | 4,914 | 8,546 | 6,636 | 4,914 | 8,546 | 0 | 0.00% | 1.000000 | 1.000000 |
| 21 | 6,670 | 4,865 | 8,721 | 6,670 | 4,865 | 8,721 | 0 | 0.00% | 1.000000 | 1.000000 |
| 22 | 6,697 | 4,786 | 8,786 | 6,697 | 4,786 | 8,786 | 0 | 0.00% | 1.000000 | 1.000000 |
| 23 | 6,727 | 4,773 | 8,799 | 6,727 | 4,773 | 8,799 | 0 | 0.00% | 1.000000 | 1.000000 |
| 24 | 6,764 | 4,747 | 8,858 | 6,764 | 4,747 | 8,858 | 0 | 0.00% | 1.000000 | 1.000000 |
| 25 | 6,799 | 4,788 | 8,946 | 6,799 | 4,788 | 8,946 | 0 | 0.00% | 1.000000 | 1.000000 |
| 26 | 6,844 | 4,820 | 9,100 | 6,844 | 4,820 | 9,100 | 0 | 0.00% | 1.000000 | 1.000000 |

#### 1.2.1.5 Harbour seal

Results of the iPCoD modelling for harbour seal against the combined East of Ireland, SE of Ireland and NI SMUs showed no difference in the growth trajectory of this species between the un-impacted population and impacted population (Figure 1.5, Table 1.5). Projected population values were the same for the un-impacted population and impacted population at all timepoints (Table 1.5). The median counterfactual was 1.0000 through each of the 25-year simulations, and therefore it is considered that there is no difference between the population trajectories for the un-impacted population and impacted population (see Figure 1.5).

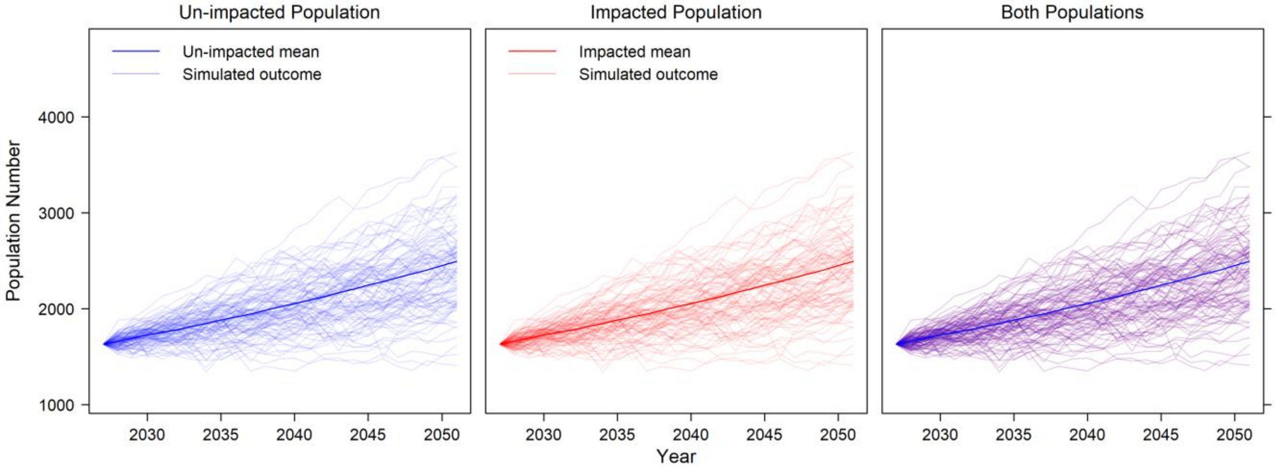



**Figure 1.5: Mean simulated population trajectories of harbour seal for the impacted vs un-impacted population over a 25-year simulation for the Project alone iPCoD model.**

Table 1.5: Modelled estimates for the un-impacted and impacted harbour seal population under the Project alone scenario

| Un-impacted population (number of animals) | | | Impacted population (number of animals) | | | Difference between means | % of MU | Counterfactual | |
|---|---|---|---|---|---|---|---|---|---|
| Mean | Lower 2.5% | Upper 2.5% | Mean | Lower 2.5% | Upper 2.5% | | | Median | Mean |
| 1,634 | 1,634 | 1,634 | 1,634 | 1,634 | 1,634 | 0 | 0.00% | 1.0000 | 1.0000 |
| 1,659 | 1,508 | 1,782 | 1,659 | 1,508 | 1,782 | 0 | 0.00% | 1.0000 | 1.0000 |
| 1,689 | 1,514 | 1,854 | 1,689 | 1,514 | 1,854 | 0 | 0.00% | 1.0000 | 1.0000 |
| 1,715 | 1,518 | 1,912 | 1,715 | 1,518 | 1,912 | 0 | 0.00% | 1.0000 | 1.0000 |
| 1,751 | 1,524 | 2,002 | 1,751 | 1,524 | 2,002 | 0 | 0.00% | 1.0000 | 1.0000 |
| 1,781 | 1,518 | 2,062 | 1,781 | 1,518 | 2,062 | 0 | 0.00% | 1.0000 | 1.0000 |
| 1,815 | 1,540 | 2,124 | 1,815 | 1,540 | 2,124 | 0 | 0.00% | 1.0000 | 1.0000 |
| 1,848 | 1,538 | 2,212 | 1,848 | 1,538 | 2,212 | 0 | 0.00% | 1.0000 | 1.0000 |
| 1,883 | 1,550 | 2,262 | 1,883 | 1,550 | 2,262 | 0 | 0.00% | 1.0000 | 1.0000 |
| 1,914 | 1,538 | 2,328 | 1,914 | 1,538 | 2,328 | 0 | 0.00% | 1.0000 | 1.0000 |
| 1,952 | 1,556 | 2,390 | 1,952 | 1,556 | 2,390 | 0 | 0.00% | 1.0000 | 1.0000 |
| 1,983 | 1,574 | 2,436 | 1,983 | 1,574 | 2,436 | 0 | 0.00% | 1.0000 | 1.0000 |
| 2,019 | 1,592 | 2,486 | 2,019 | 1,592 | 2,486 | 0 | 0.00% | 1.0000 | 1.0000 |
| 2,059 | 1,592 | 2,572 | 2,059 | 1,592 | 2,572 | 0 | 0.00% | 1.0000 | 1.0000 |
| 2,097 | 1,632 | 2,606 | 2,097 | 1,632 | 2,606 | 0 | 0.00% | 1.0000 | 1.0000 |
| 2,137 | 1,648 | 2,714 | 2,137 | 1,648 | 2,714 | 0 | 0.00% | 1.0000 | 1.0000 |
| 2,172 | 1,658 | 2,756 | 2,172 | 1,658 | 2,756 | 0 | 0.00% | 1.0000 | 1.0000 |
| 2,210 | 1,656 | 2,838 | 2,210 | 1,656 | 2,838 | 0 | 0.00% | 1.0000 | 1.0000 |

| Un-impacted population (number of animals) | | | Impacted population (number of animals) | | | Difference between means | % of MU | Counterfactual | |
|---|---|---|---|---|---|---|---|---|---|
| Mean | Lower 2.5% | Upper 2.5% | Mean | Lower 2.5% | Upper 2.5% | | | Median | Mean |
| 2,251 | 1,688 | 2,894 | 2,251 | 1,688 | 2,894 | 0 | 0.00% | 1.0000 | 1.0000 |
| 2,287 | 1,692 | 2,938 | 2,287 | 1,692 | 2,938 | 0 | 0.00% | 1.0000 | 1.0000 |
| 2,328 | 1,710 | 3,030 | 2,328 | 1,710 | 3,030 | 0 | 0.00% | 1.0000 | 1.0000 |
| 2,367 | 1,740 | 3,116 | 2,367 | 1,740 | 3,116 | 0 | 0.00% | 1.0000 | 1.0000 |
| 2,413 | 1,756 | 3,194 | 2,413 | 1,756 | 3,194 | 0 | 0.00% | 1.0000 | 1.0000 |
| 2,463 | 1,760 | 3,252 | 2,463 | 1,760 | 3,252 | 0 | 0.00% | 1.0000 | 1.0000 |
| 2,506 | 1,812 | 3,334 | 2,506 | 1,812 | 3,334 | 0 | 0.00% | 1.0000 | 1.0000 |
| 2,552 | 1,826 | 3,448 | 2,552 | 1,826 | 3,448 | 0 | 0.00% | 1.0000 | 1.0000 |

### 1.2.2 Cumulative iPCoD modelling for Irish Phase 1 projects

Sinclair (2024) assessed whether cumulative disturbance resulting from pile driving activities across the five Phase 1 Offshore Windfarm Projects only (Oriel, NISA (2024), Codling (Codling Wind Park Limited, 2024), Dublin Array (Bray Offshore Wind Limited. and Kish Offshore Wind Limited., 2025) and Arklow (SSE Renewables, 2024)) is predicted to result in population level impacts to four marine mammal species (harbour porpoise, bottlenose dolphin, harbour and grey seals) and is presented in Annex 1. For this assessment, as the EIARs for these projects were not in the public domain, each Phase 1 Project provided an indicative piling schedule and the number of animals predicted to be disturbed per piling day. Auditory injury (or permanent threshold shift (PTS)) was not included in the Sinclair (2024) cumulative assessment since it was assumed that each of the Phase 1 Projects would put in place mitigation measures to negate the risk of auditory injury to marine mammals.

The Phase 1 Offshore Wind Farm Projects cumulative population modelling undertaken by Sinclair (2024) showed no significant impacts to any marine mammal species resulting from disturbance from pile driving at the five Phase 1 Projects. The impacted harbour porpoise population was predicted to remain stable at 99.6–99.7% of the un-impacted population size (with no potential for post-disturbance recovery due to the iPCoD model's lack of density-dependent response). For bottlenose dolphins, the impacted population initially decreased slightly due to piling and then remained stable at 95–98% of the un-impacted population size (with no recovery due to the iPCoD model's lack of density-dependent response). For harbour and grey seals, the impacted population was predicted to continue at a stable trajectory at exactly the same size as the un-impacted population.

## 1.3 Modelling methodology for population modelling of all ICA projects in the Irish Sea

### 1.3.1 Marine mammals

Key species were the same as those carried out for the Project alone iPCoD modelling, as detailed in 1.2.1.

Key species (harbour porpoise, bottlenose dolphin, minke whale, grey seal and harbour seal) and relevant MUs are presented in Table 1.6. For bottlenose dolphin, the SCANS-IV Block reference population was taken forward to the cumulative iPCoD modelling, to align with the approach in the ICA modelling for the Phase 1 Projects (Sinclair (2024)) (see Annex 1 of this report).

**Table 1.6: Key species and relevant reference populations for iPCoD modelling.**

| Species | Reference population | |
|---|---|---|
| | #animals | source |
| **Harbour porpoise** | 62,517 | CIS MU (IAMMWG, 2023) |
| **Bottlenose dolphin** | 8,326 | Sum of SCANS-IV Blocks in Irish Sea (CS-D + CS-F) (Gilles *et al.*, 2023) |
| **Minke whale** | 20,118 | Celtic and Greater North Seas MU (IAMMWG, 2023) |
| **Grey seal** | 5,882 | Combined East of Ireland, SE of Ireland and NI SMUs |
| **Harbour seal** | 1,635 | Combined East of Ireland, SE Ireland and NI SMUs |

Demographic vital rate parameters for the key species in the population model are presented in Table 1.7, are the same as those used in appendix F: Marine Mammals and Megafauna – Supporting Information and updated project alone modelling (section 1.2.1), and were derived from Sinclair *et al.* (2020). Whilst the importance of iPCoD modelling is to look at un-impacted versus impacted populations, it must be highlighted that the model is very sensitive to the parameters the user inputs, with small alterations to parameters leading to potentially large changes in population trajectories (e.g. populations increasing or decreasing). For instance, small changes in fertility rates or stage-specific survival rates can change the population trajectories for both un-impacted and impacted populations. For example, for harbour porpoise (see section 1.4.1), the vital rates inputted into the model (Table 1.7) are more conservative than the Phase 1 Project ICA modelling presented in Sinclair (2024) for calf/pup survival (0.60 survival rate instead of 0.8455), juvenile survival (0.85 survival rate instead of 0.925). The more conservative demographic vital rate parameters used in the iPCoD project alone modelling were retained to allow comparison against the EIAR and project-alone population modelling, but should be considered if interpreting results of this report against the results in Sinclair (2024).

**Table 1.7: Species demographic parameters used to parameterise the iPCoD model.**

| Species | Calf/pup survival | Juvenile survival | Adult survival | Fertility | Age of independence | Age of first birth | Growth rate |
|---|---|---|---|---|---|---|---|
| Harbour porpoise | 0.60 | 0.8455 | 0.90 | 0.50 | 1 | 5 | 1.00 |
| Bottlenose dolphin | 0.87 | 0.94 | 0.94 | 0.245 | 2 | 9 | 1.00 |
| Minke whale | 0.70 | 0.77 | 0.96 | 0.91 | 1 | 9 | 1.00 |
| Grey seal | 0.22 | 0.94 | 0.94 | 0.84 | 1 | 6 | 1.01 |
| Harbour seal | 0.40 | 0.78 | 0.92 | 0.85 | 1 | 4 | 1.00 |

## 1.3.2 iPCoD modelling

The iPCoD model simulates the potential changes in a marine mammal population over time, for both an "impacted" and an "un-impacted population". This allows a comparison of the type of changes in a population that may result from natural environmental variation, demographic stochasticity (i.e. natural variability in population growth rates) and anthropogenic disturbance (Harwood *et al.*, 2014, King *et al.*, 2015). This approach has been widely used in previous offshore wind applications, and consented projects in the UK, including Ossian Offshore Wind Farm Limited (Ossian OWFL, 2024), Berwick Bank Wind Farm (SSE Renewables, 2022), Mona Offshore Wind Farm (Mona Offshore Wind Ltd, 2025) and the Hornsea Projects (Ørsted, 2018, 2021).

The iPCoD model is based on expert elicitation, a widely accepted process in conservation science wherein the opinions of many experts are combined when there is an urgent need for decisions to be made but a lack of empirical data with which to inform them (Donovan *et al.*, 2016). The marine mammal experts, detailed in Sinclair *et al.* (2020), were consulted on their opinion on how changes in hearing resulting from PTS and behavioural disturbance (equivalent to a score of 5* or higher on the "behavioural severity scale" in Southall *et al.* (2007)) associated with ORE developments and how they affect calf and juvenile survival, and the probability of giving birth (Harwood *et al.*, 2014). The marine mammal experts were then asked to estimate values for two parameters which determine the shape of the relationships between the number of days of disturbance experienced by an individual and its vital rates, thus providing parameter values for functions that form part of the iPCoD model (Harwood *et al.*, 2014).

The relationship between disturbance and survival and reproduction assumes that individual marine mammals would have a limited ability to alter their activity budget to compensate for a reduction in time spent feeding (Houston *et al.*, 2012, King *et al.*, 2015). The individual marine mammal's ability to provide care for young, evade predators or resist disease would likely be affected, and effects would be reflected in changes to vital rates. However, it should be noted that this relationship is highly simplified (Harwood *et al.*, 2014), and an individual's response to disturbance will depend on factors including the context of the disturbance, the individual's existing condition and its exposure history (Ellison *et al.*, 2012). The iPCoD framework applies simulated changes in vital rates to infer the number of marine mammals that may be affected by disturbance to iteratively project the size of the population.

Following the initial development of the iPCoD model, a study was undertaken to update the transfer functions on the effects of PTS and disturbance on the probability of survival and giving birth to viable young for harbour porpoise (Phocoena Phocoena), harbour seal (Phoca vitulina) and grey seal (Halichoerus grypus) (again via expert elicitation) (Booth and Heinis, 2018, Booth *et al.*, 2019). The iPCoD model has since been updated in light of additional work undertaken after it was originally launched in February 2014 (version 1) and iPCoD version 5.2 was used in the modelling for this report (Harwood *et al.*, 2014, Sinclair *et al.*, 2019).

A potential limitation of the iPCoD model is that no form of density dependence has been incorporated into the model due to the uncertainties as to how to estimate carrying capacity or how to model the mechanism of density dependence. As discussed by Harwood *et al.* (2014), the concept of density dependence is fundamental to understanding how animal populations respond to a reduction in population size. Population growth can be limited by density-dependent factors, such as resource availability or competition for space. If the population declines, these factors no longer become limiting and therefore, for the remaining individuals in a population, there is likely to be an increase in survival rate and reproduction. This could then allow the population to expand back to previous levels at which density-dependent factors become limiting again (i.e. population remains at carrying capacity).

The limitations for assuming a simple linear ratio between the maximum net productivity level and carrying capacity of a population were highlighted by Taylor and DeMaster (1993), as simple models which demonstrated that density dependence is likely to involve several biological parameters which themselves have biological limits (e.g. fecundity and survival). However, for UK populations of harbour porpoise (and other marine mammal species), there is no published evidence for density dependence and, therefore, density dependence assumptions are not currently included within the iPCoD protocol.

The iPCoD model v5.2 (Harwood *et al.*, 2014) was developed using the program R v4.3.1 (R Core Team, 2023) with RStudio v 2023.12.0+369 (Posit team, 2023) as the user interface. To enable the iPCoD model to run, the following data were provided:

- reference population size and demographic parameters (Section 1.3.1) for the key species;
- user-specified input parameters (such as residual days of disturbance, see Section 1.3.3);
- number of animals predicted to experience PTS and/or disturbance during piling (Section 1.3.4);
- estimated piling schedule during the proposed construction programme (1.3.4).

### 1.3.3 Assumptions in the modelling

#### No PTS

Auditory injury (or PTS) was not included in this cumulative assessment since it was assumed that each Project would put in place mitigation measures to negate the risk of auditory injury to marine mammals.

#### Dose response approach

In line with ICA modelling carried out for the Irish Phase 1 projects (Sinclair, 2024) (see Annex 1 of this report), in order to make the results from each Project comparable, the same dose response disturbance assessment approach was used for each project and each species (where possible). The only exception was Mooir Vannin (Ørsted, 2025), which did not use dose response for minke whale or bottlenose dolphin and therefore the numbers derived from Level B harassment thresholds were used in the absence of dose response values.

#### Residual days disturbance

Empirical evidence from the constructed Beatrice and Horns Rev 2 offshore wind farms (Brandt *et al.*, 2011, Graham *et al.*, 2019) suggests that the detection of animals returns to baseline levels in the hours following a disturbance from piling and therefore, for the most part, it can be assumed that the disturbance occurs only on the day (24 hours) that piling takes place.

During construction of the Project, piling could occur for up to 8 hours within a 24-hour period. However, the number of residual days of disturbance has, conservatively, been selected as one, meaning that the model assumes that disturbance occurs on the day of piling and persists for a period of 24 hours after piling has ceased.

#### Precautionary approach

There are several precautions built into the iPCoD model which means results are considered to be highly precautionary and likely over-estimate the true population level effects. These include the following which are explained in more detail in the sections below:

- a lack of density dependence in the model,
- environmental and demographic stochasticity in the model, and
- the assumption that bottlenose dolphins will not forage for 24 hours after being disturbed.

The iPCoD model assumes no density dependence, since there is insufficient data to parameterise this relationship, and therefore means that there is no ability for the modelled, impacted population to increase in size and return to carrying capacity following disturbance. At a recent expert elicitation (Schwacke *et al.*, 2022) experts agreed that it would be expected that the impacted population would recover to carrying capacity[1] rather than continuing at a stable trajectory that is smaller than that of the un-impacted population, with birth rate changing as population density changes (a concave density dependence on fertility).

The iPCoD model attempts to incorporate some of the sources of uncertainty inherent in the calculation of the potential effects of disturbance on a marine mammal population, which includes demographic stochasticity (variation among individuals in their realised vital rates as a result of random processes (Harwood *et al.*, 2014)) and environmental variation (the variation in demographic rates as a result of changes in environmental conditions (Harwood *et al.*, 2014)). Therefore, outputs of iPCoD can show the un-impacted (baseline) population size itself can vary greatly between iterations, not as a result of disturbance but simply as a result of environmental and demographic stochasticity. This is detailed in the iPCoD protocol, where demographic stochasticity has the greatest effect on small populations and is incorporated into MUs with less than 3000 individuals. Harwood *et al.* (2014) describes “One consequence of demographic stochasticity is that two otherwise identical populations that experience exactly the same sequence of environmental conditions will follow slightly different trajectories over time. As a result, it is possible for a “lucky” population that experiences disturbance effects to increase, whereas an identical undisturbed but “unlucky” population may decrease”. Consequently, it is important to consider that changes in un-impacted population size between model iterations can vary due to the fluctuations caused by stochastic variability.

The iPCoD disturbance model for bottlenose dolphins was last revised after the 2013 expert elicitation (Harwood *et al.*, 2014), where it was assumed a disturbed individual would cease foraging for 24 hours. A later elicitation in 2018 found that this was unrealistic for harbour porpoises (which are generally more responsive than bottlenose dolphins) and changed the assumption in the model to six hours of non-foraging (Booth *et al.*, 2019). However, as bottlenose dolphins were not included in the 2018 elicitation, the iPCoD model still uses the original 24-hour non-foraging assumption (even though this is considered unrealistic, given recent evidence showing cessation of feeding in response to sonar disturbance was far less (Czapanskiy *et al.*, 2021)).

### 1.3.4 ICA projects parameters and piling schedules

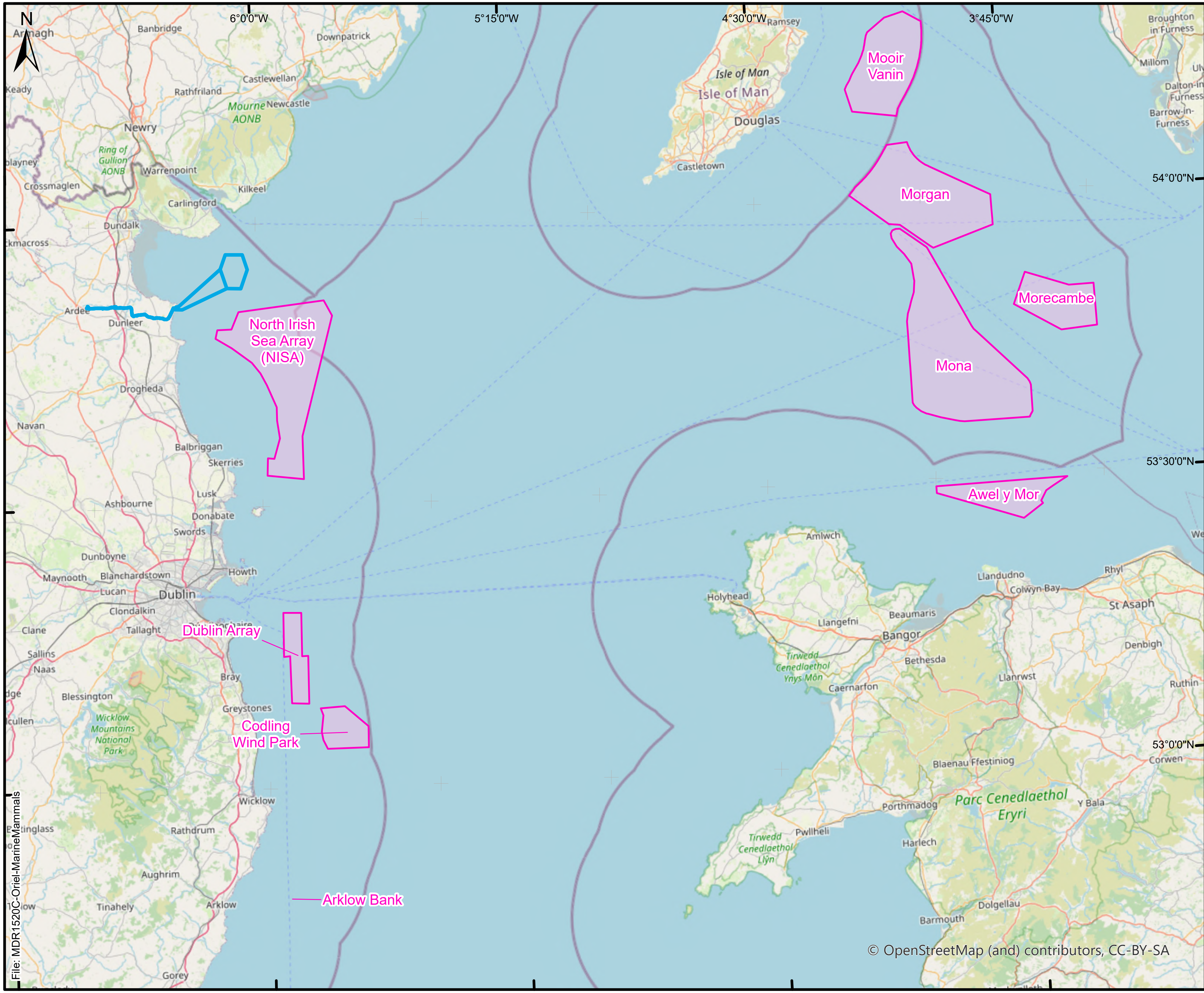
Nine Tier 1 offshore wind projects were considered alongside the Project in the cumulative modelling, as presented in Table 1.8 and Figure 1.6. These included projects for which piling could potentially temporally overlap (or to occur in adjacent years) with construction or operation phases for the Project, and for which quantitative information was available. Only ICA projects within each species-specific MU were included. Piling schedules for the cumulative projects were derived from the individual projects EIAs (Table 1.8), spreading the number of days evenly over the piling periods detailed in each respective EIA. The starting year (‘point 1’) was 2027, representing the beginning of piling at Mona Offshore Wind Project and Morgan Generation Assets (Figure 1.7).

**Table 1.8: ICA projects piling information**

| Project | Approximate Distance from offshore wind farm area (km) | Piling scenario | Total days piling | Source |
|---|---|---|---|---|
| Oriel Wind Farm Project | N/A | 26 days of piling over 1 year. Installation of monopile foundations for Project (Q3/4) 2028 | 26 | Project alone MDS |
| North Irish Sea Array (NISA) | 16.2 | Up to 51 days of piling between April and October 2028 (49 wind turbines and 2 offshore substation platforms (OSPs)). | 51 | North Irish Sea Array Windfarm Ltd. (2024) |

[1] Carrying capacity is assumed to be equal to the size of un-impacted population – i.e., it is assumed the un-impacted population is at carrying capacity.

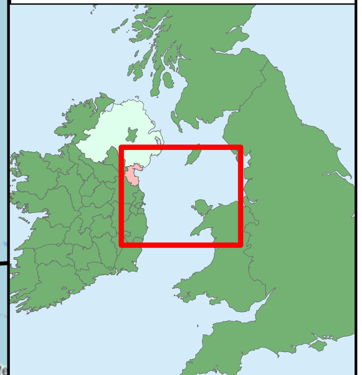
| Project | Approximate Distance from offshore wind farm area (km) | Piling scenario | Total days piling | Source |
|---|---|---|---|---|
| Dublin Array | 61.2 | Up to 57 days of piling from September to December 2029 inclusive (50 days wind turbines and 7 days OSPs). | 57 | Bray Offshore Wind Limited. and Kish Offshore Wind Limited. (2025) |
| Codling Wind Park | 61.4 | Up to 78 days of piling between April and October inclusive 2027 (75 days for wind turbines and 3 days for OSPs). | 78 | Codling Wind Park Limited (2024) |
| Arklow Bank Wind Park | 107.1 | Up to 79 days of piling (56 wind turbines over 75 days, 2 OSPs over 4 days) in 2028. | 79 | SSE Renewables (2024) |
| Morgan Generation Assets | 119 | Up to 90 days of piling of wind turbines, OSPs and Gravity Based Foundations (GBFs), piling from 2027 to 2028. | 90 | Morgan Offshore Wind Ltd. (2025) |
| Mona Offshore Wind Project | 127 | Up to 90 days of piling of wind turbines, OSPs and GBFs, piling from 2027 to 2028. | 90 | Mona Offshore Wind Ltd (2024) |
| Awel y Môr Offshore Wind Farm | 142 | Up to 201 days of piling over one year (2028) (150 days wind turbines and 51 days OSP + MetMast). | 201 | RWE Renewables UK (2022) |
| Morecambe Generation Assets | 155 | Up to 37 days of piling assuming one pile per day, over piling window Q2 to Q3 2027. | 37 | Morecambe Offshore Wind Ltd (2025) |
| Mooir Vannin | 125 | Up to 96 days single piling (87 days wind turbines and 9 days OSPs), over 18 month period, with earliest offshore construction installation Q2 2030. | 96 | Ørsted (2025) |




## Legend

- Application Boundary
- Offshore Wind Farm

**Data Sources:** Client. TCE, Housing.gov.ie



**Client**

ORIEL WINDFARM
OFFSHORE RENEWABLE ENERGY

**Project**

## Oriel Wind Farm Project

**Title** Figure 1-6
**Cumulative projects included in the cumulative population modelling for Oriel Wind Farm Project.**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*Issue Details*

| | |
|---|---|
| **Drawn By:** MJ | **Project No.** MDR1520C |
| **Checked By:** MJ | **File Ref:** |
| **Approved By:** BP | MDR1520C-MAM-IP001 |
| **Scale:** 1:1,000,000 @A4 | **Projection:** ITM (IRENET95) |
| **Date:** 18/11/2025 | Geographic Co-ordinates: ETRS89 |

**NOTE:**
1. This drawing is the property of RPS Group Ltd. It is a confidential document and must not be copied, used, or its contents divulged without prior written consent.
2. All levels are referred to Ordnance Datum, Malin Head.

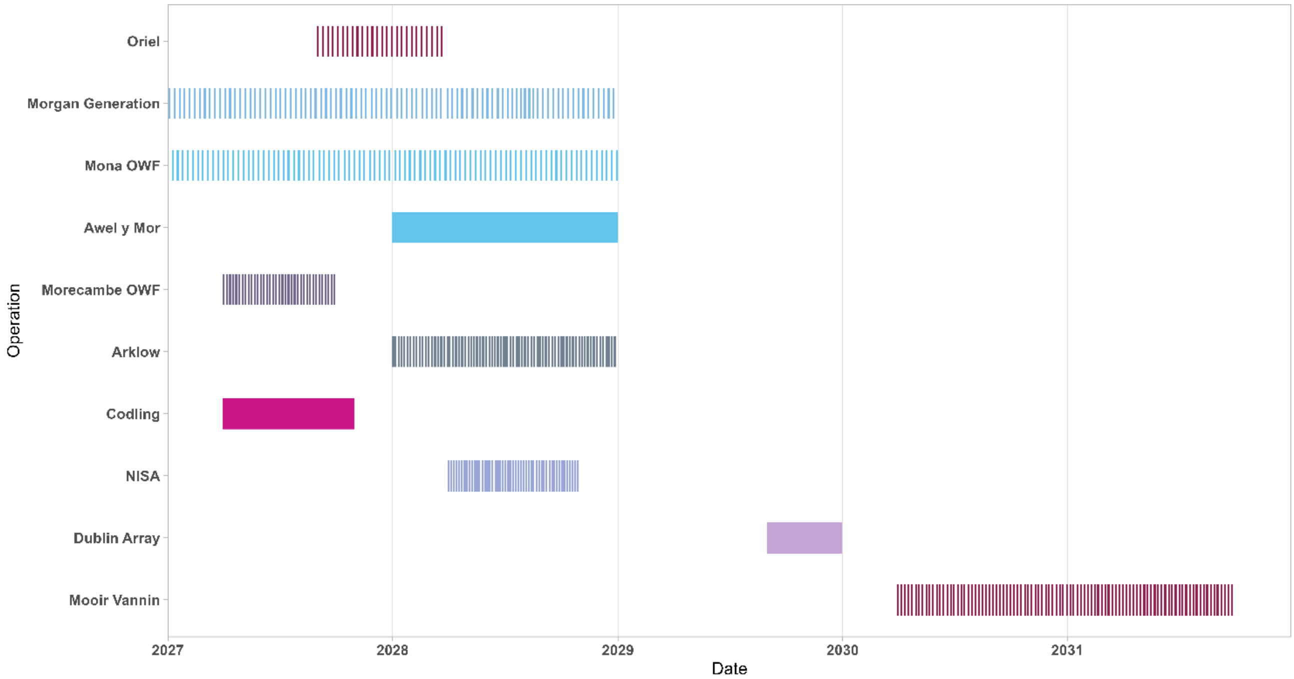


**Figure 1.7: Piling days for cumulative projects.**

The cumulative iPCoD modelling was run for each of the five species. All projects were included in the iPCoD piling schedule for harbour porpoise, bottlenose dolphin and minke whale as they fall within the respective species MUs; four projects occurred within the relevant SMUs for grey seal and harbour seal (Table 1.9).

Numbers of animals disturbed were derived from the individual projects EIARs and detailed in Table 1.10. Where operations were clearly split out in respective iPCoD reports and consisted of different numbers of animals per operation (such as wind turbine generators (WTG) versus OSPs) (e.g. Mona Offshore Wind Project, Morgan Generation Assets, Arklow Bank Wind Park), this has been incorporated into the iPCoD modelling where possible. For Codling Wind Park and NISA, the EIARs presented numbers of animals for using both the SCANS-III IS MU (293) and SCANS-IV Block Estimate (8,326) populations (as was done for the Project). Only the SCANS-IV Block scenario has been taken forward to the ICA population modelling (for Oriel, NISA and Codling Wind Park). Grey seal and harbour seal numbers from cumulative projects which fall outside the selected SMUs for the Project (East of Ireland, SE Ireland and NI SMUs) are not presented, shaded grey in Table 1.10.

**Table 1.9: iPCoD Scenarios**

| Population size | Population Unit | Population Size | ICA projects included in the MU (and therefore modelled) |
|---|---|---|---|
| Harbour porpoise | CIS MU (IAMMWG, 2023) | 62,517 | Oriel Wind Farm Project, Morgan Generation Assets, Mona Offshore Wind Project, Awel y Môr Offshore Wind Farm, Morecambe Generation Assets, Arklow Bank Wind Park, Codling Wind Park, NISA, Dublin Array, Mooir Vannin Generation Project |
| Bottlenose dolphin | Sum of SCANS-IV Blocks CS-D + CS-F | 8,326 | |
| Minke whale | Celtic and Greater North Seas MU (IAMMWG, 2023) | 20,118 | |

| Population size | Population Unit | Population Size | ICA projects included in the MU (and therefore modelled) |
|---|---|---|---|
| Grey seal | Combined reference population of the East of Ireland, SE Ireland and NI SMUs | 5,882 | NISA,<br>Codling Wind Park,<br>Arklow Bank Wind Park,<br>Dublin Array |
| Harbour seal | Combined reference population of the East of Ireland, SE Ireland and NI SMUs | 1,635 | NISA,<br>Codling Wind Park,<br>Arklow Bank Wind Park,<br>Dublin Array |

**Table 1.10: Numbers of animals disturbed for each of the ICA projects.**

| Project | Reference | Harbour porpoise | Bottlenose dolphin | Minke whale | Grey seal | Harbour seal |
|---|---|---|---|---|---|---|
| Oriel Wind Farm Project | WTGs and OSS | 2,360 | 417[a] | 462 | 83 | 71 |
| Morgan Generation Assets (Morgan Offshore Wind Ltd., 2023) | WTGs Jacket concurrent | 1,007 | 5 | 67 | | |
| | WTGs Jacket single | 858 | 4 | 57 | | |
| | OSPs Jacket | 858 | 4 | 57 | | |
| | GBF | 713 | 4 | 48 | | |
| Mona Offshore Wind Farm (Mona Offshore Wind Ltd, 2023) | WTGs Jacket concurrent | 1,142 | 7 | 72 | | |
| | WTGs Jacket single | 971 | 6 | 72 | | |
| | OSPs Jacket | 971 | 6 | 61 | | |
| | GBF | 803 | 5 | 61 | | |
| Awel y Môr Offshore Wind Farm (RWE Renewables UK, 2022) | WTGs + OSPs | 275 | 23 | 51 | | |
| Morecambe Generation Assets (Morecambe Offshore Wind Ltd, 2025) | WTGs + OSPs | 1,858[b] | 57 [b] | 25 [b] | | |
| Arklow Bank Wind Park (SSE Renewables, 2024) | WTGs | 3,380 | 2,092 | 400 | 299 | 1 |
| | OSPs | 3,355 | 2,077 | 397 | 300 | 1 |
| Codling Wind Park (Codling Wind Park Limited, 2024) | WTGs + OSPs | 2,667 | 2060[a] | 134 | 394 | 6 |
| NISA (North Irish Sea Array Windfarm Ltd., 2024) | WTGs + OSPs | 3,896 | 2346 | 222 | 790 | 200 |
| Dublin Array (Bray Offshore Wind Limited. and Kish Offshore Wind Limited., 2025) | WTGs + OSPs | 995 | 699 | 57 | 177 | 13 |
| Mooir Vannin Generation Project (Ørsted, 2025) | WTGs + OSPs | 2,381 | 8 | 12 | | |

[a] The numbers of animals based on SCANS-IV is taken forward to the ICA population modelling.

[b] Dose response was used for Morecambe Generation Assets to allow the approach to be comparable across projects. Numbers of animals are precautionary rounded up to the nearest whole animal, rather than as decimal places as presented in Morecambe Offshore Wind Ltd (2025).

## 1.4 Results

### 1.4.1 Harbour porpoise

For the harbour porpoise cumulative modelling scenario, a total of 795 piling days were modelled (26 of which were from the Project). These results indicated a difference in the simulated trajectories of harbour porpoise between the impacted and un-impacted population (Figure 1.8). Across the model run, the maximum difference between the mean impacted and un-impacted population sizes was 1,335 individuals at time point 4 (2030, one full year after the end of piling at the Project). This corresponds to 2.14% of the CIS MU reference population (Table 1.11). At time point 2, the start of piling at the Project, there is already a difference of 121 animals between the mean impacted and un-impacted populations (with piling at Morgan Generation Assets, Mona Offshore Wind Project, Morecambe Generation Assets and Codling occurring in the year prior to piling at the Project). At the end of piling at the Project (time point 3 in this cumulative model), the difference between the mean impacted and un-impacted population sizes was 903 individuals for the cumulative scenario. In comparison, a difference of 39 animals was observed for equivalent time point (end of piling at the Project) for the Project alone modelling (see section 1.2.1.1). At the end of the model run, the difference between the mean impacted and un-impacted population sizes was 878 individuals, which corresponds to 1.40% of the CIS MU reference population (Table 1.11). It is important to highlight the lack of density dependence (see section 1.3.3) in the model and therefore the lack of ability for populations increase in size or to recover to carrying capacity. The impacted population does, however, continue on a stable trajectory in the long-term. The vital rates inputted into the model (Table 1.7) are more conservative than the ICA modelling presented in Sinclair (2024) for calf/pup survival (0.60 survival rate instead of 0.8455), juvenile survival (0.85 survival rate instead of 0.925) and therefore accounts for the declining population observed in both the un-impacted and impacted populations (compared to a more stable population modelled in Sinclair (2024)).

The median and mean counterfactuals of population size for the cumulative scenario were 0.9847 and 0.9790 respectively at the end of the 25-year simulation (Table 1.11). The counterfactuals remained close to 1 throughout the cumulative piling period, suggesting that even though there were some declines in the population during cumulative piling, this was relatively small in relation to the CIS MU reference population and therefore not sufficient to result in any changes at the population level (since the impacted population is predicted to continue at a stable trajectory at 99.8% of the size of the un-impacted population).

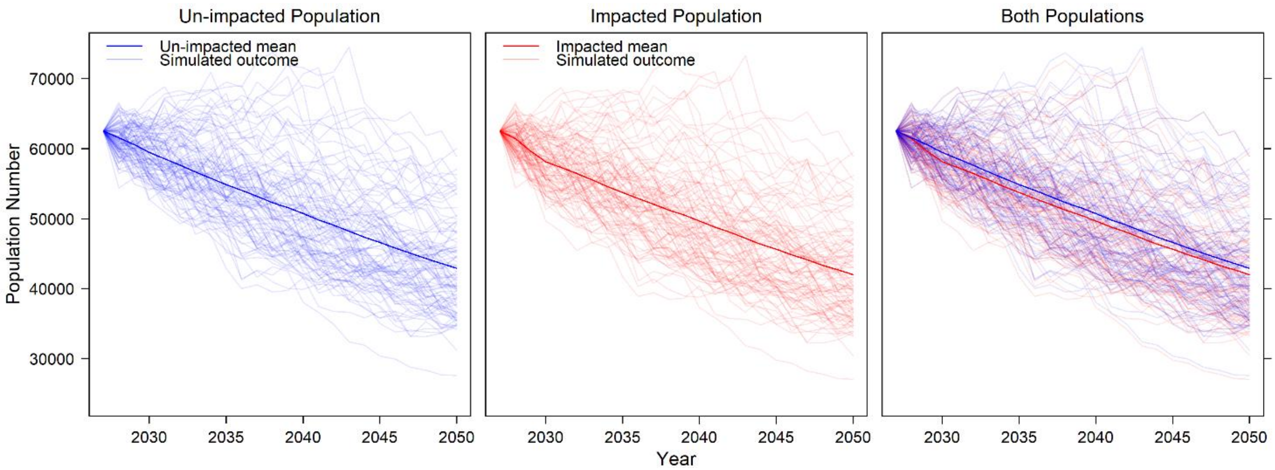


**Figure 1.8: Simulated population trajectories of an un-impacted and impacted harbour porpoise population under the cumulative scenario**

Table 1.11: Modelled estimates for the un-impacted and impacted harbour porpoise population under the cumulative scenario

| Time point | Year | Un-impacted population (number of animals) | | | Impacted population (number of animals) | | | Difference between means | % of MU | Counterfactual | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Lower 2.5% | Upper 2.5% | Mean | Lower 2.5% | Upper 2.5% | | | Median | Mean |
| 1 | 2027 (start of ICA piling) | 62,514 | 62,514 | 62,514 | 62,514 | 62,514 | 62,514 | 0 | 0.00 | 1.0000 | 1.0000 |
| 2 | 2028 (start of the Project piling) | 61,536 | 56,134 | 65,713 | 61,415 | 55,892 | 65,617 | 121 | 0.19 | 0.9992 | 0.9980 |
| 3 | 2029 (end of piling at the Project) | 60,600 | 54,105 | 66,271 | 59,697 | 52,675 | 65,601 | 903 | 1.44 | 0.9888 | 0.9851 |
| 4 | 2030 | 59,465 | 51,786 | 66,207 | 58,130 | 50,498 | 65,440 | 1,335 | 2.14 | 0.9827 | 0.9776 |
| 5 | 2031 | 58,562 | 50,781 | 66,754 | 57,304 | 49,522 | 65,693 | 1,258 | 2.01 | 0.9839 | 0.9785 |
| 6 | 2032 (end of piling at all ICA projects) | 57,633 | 49,064 | 66,486 | 56,460 | 47,858 | 65,657 | 1,173 | 1.88 | 0.9852 | 0.9797 |
| 7 | 2033 | 56,691 | 47,560 | 65,917 | 55,536 | 46,834 | 65,159 | 1,155 | 1.85 | 0.9855 | 0.9797 |
| 8 | 2034 | 55,747 | 46,297 | 66,206 | 54,590 | 45,167 | 65,142 | 1,157 | 1.85 | 0.9850 | 0.9794 |
| 9 | 2035 | 54,878 | 45,277 | 66,162 | 53,722 | 44,112 | 65,227 | 1,156 | 1.85 | 0.9846 | 0.9791 |
| 10 | 2036 | 54,034 | 43,418 | 65,229 | 52,888 | 42,423 | 64,143 | 1,146 | 1.83 | 0.9846 | 0.9789 |
| 11 | 2037 | 53,187 | 42,533 | 65,929 | 52,058 | 41,212 | 64,120 | 1,129 | 1.81 | 0.9846 | 0.9789 |
| 12 | 2038 | 52,303 | 41,394 | 65,391 | 51,194 | 40,286 | 64,044 | 1,109 | 1.77 | 0.9846 | 0.9790 |
| 13 | 2039 | 51,590 | 40,575 | 64,644 | 50,499 | 39,229 | 63,676 | 1,091 | 1.75 | 0.9847 | 0.9790 |
| 14 | 2040 | 50,713 | 39,597 | 63,986 | 49,642 | 38,239 | 62,619 | 1,071 | 1.71 | 0.9847 | 0.9790 |
| 15 | 2041 | 49,836 | 38,954 | 63,459 | 48,783 | 37,931 | 61,915 | 1,053 | 1.68 | 0.9847 | 0.9790 |
| 16 | 2042 | 49,073 | 37,752 | 62,820 | 48,034 | 36,869 | 61,471 | 1,039 | 1.66 | 0.9846 | 0.9790 |
| 17 | 2043 | 48,224 | 36,634 | 62,535 | 47,205 | 35,643 | 61,221 | 1,019 | 1.63 | 0.9847 | 0.9790 |
| 18 | 2044 | 47,353 | 36,074 | 61,532 | 46,351 | 35,070 | 60,420 | 1,002 | 1.60 | 0.9847 | 0.9790 |
| 19 | 2045 | 46,631 | 34,849 | 60,438 | 45,644 | 33,814 | 59,502 | 987 | 1.58 | 0.9847 | 0.9790 |
| 20 | 2046 | 45,797 | 33,789 | 59,667 | 44,829 | 33,003 | 58,396 | 968 | 1.55 | 0.9847 | 0.9790 |
| 21 | 2047 | 45,076 | 33,091 | 59,877 | 44,125 | 32,340 | 58,497 | 951 | 1.52 | 0.9847 | 0.9790 |
| 22 | 2048 | 44,282 | 32,515 | 59,587 | 43,345 | 31,825 | 57,676 | 937 | 1.50 | 0.9847 | 0.9790 |
| 23 | 2049 | 43,633 | 32,446 | 58,421 | 42,710 | 31,414 | 57,099 | 923 | 1.48 | 0.9847 | 0.9790 |
| 24 | 2050 | 42,916 | 31,258 | 58,604 | 42,008 | 30,437 | 56,519 | 908 | 1.45 | 0.9847 | 0.9790 |
| 25 | 2051 | 42,170 | 30,681 | 57,707 | 41,278 | 29,978 | 56,445 | 892 | 1.43 | 0.9847 | 0.9790 |
| 26 | 2052 | 41,507 | 29,325 | 57,780 | 40,629 | 28,644 | 56,305 | 878 | 1.40 | 0.9847 | 0.9790 |

### 1.4.2 Bottlenose dolphin

For the bottlenose dolphin cumulative modelling scenario, a total of 795 piling days were modelled (26 of which were from the Project). These results indicated a difference in the simulated trajectories of bottlenose dolphin between the impacted and un-impacted population (Figure 1.7), with a clear deviation from the baseline due to piling at cumulative projects. Across the model run, the maximum difference between the mean impacted and un-impacted population sizes was 664 individuals at time point 5 (2031, coinciding with the last year of cumulative piling and 2 years after piling ends at the Project). This corresponds to 7.98% of the reference population derived from SCANS-IV (Table 1.12). At time point 2, the start of piling at the Project, there is already a difference of 146 animals (1.75% of the reference population) between the mean impacted and un-impacted populations (with piling at Morgan Generation Assets, Mona Offshore Wind Project, Morecambe Generation Assets and Codling occurring in the year prior to piling at the Project). At the end of piling at the Project (time point 3 in this cumulative model), the difference between the mean impacted and un-impacted population sizes was 468 individuals (5.62% of the reference population) for the cumulative scenario, but the median counterfactual is 0.97. In comparison, a difference of 18 animals was observed for equivalent time point (end of piling at the Project) for the Project alone modelling (see section 1.2.1.2) and therefore represents a small contribution to this cumulative population impact. At the end of the model run, the difference between the mean impacted and un-impacted population sizes was 540 individuals, which corresponds to 6.49% of the reference population derived from SCANS-IV (Table 1.12).The median and mean counterfactuals of population size for the cumulative scenario were 0.9675 and 0.9358 respectively at the end of the 26-year simulation (Table 1.12). The mean impacted population size initially decreases very slightly from the mean un-impacted population size in response to piling, after which it continues on the same, stable trajectory at 96% of the mean un-impacted population size. This aligns with the ICA iPCoD modelling presented in Sinclair (2024). As the iPCoD model does not currently allow for a density dependence response (see section 1.3.3) there is no way for the impacted population to increase in size after the piling disturbance and the impacted population does, however, continue on a stable trajectory in the long-term. It is important to highlight the Project represents only 26 days of piling in this model, and no population level impacts were concluded in population modelling for the Project alone (see section 1.2).

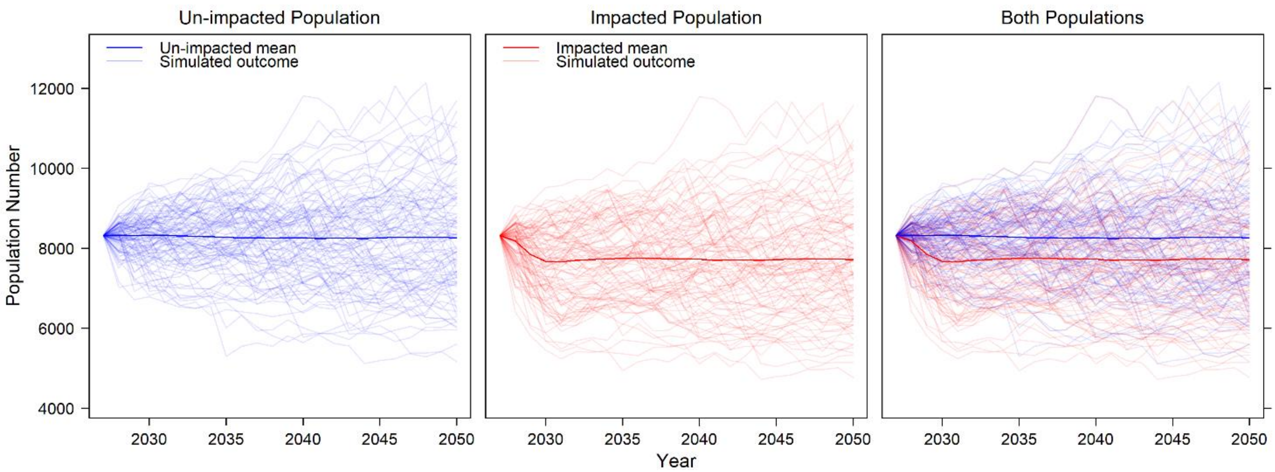


**Figure 1.9: Simulated population trajectories of an un-impacted and impacted bottlenose dolphin population under the cumulative scenario**

Table 1.12: Modelled estimates for the un-impacted and impacted bottlenose dolphin population under the cumulative scenario

| Time point | Year | Un-impacted population (number of animals) | | | Impacted population (number of animals) | | | Difference between means | % of ref pop | Counterfactual | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Lower 2.5% | Upper 2.5% | Mean | Lower 2.5% | Upper 2.5% | | | Median | Mean |
| 1 | 2027 (start of ICA piling) | 8,326 | 8,326 | 8,326 | 8,326 | 8,326 | 8,326 | 0 | 0.00 | 1.0000 | 1.0000 |
| 2 | 2028 (start of the Project piling) | 8,328 | 7,524 | 8,856 | 8,182 | 7,165 | 8,852 | 146 | 1.75 | 1.0000 | 0.9823 |
| 3 | 2029 (end of piling at the Project) | 8,323 | 7,326 | 9,066 | 7,855 | 6,407 | 8,894 | 468 | 5.62 | 0.9724 | 0.9436 |
| 4 | 2030 | 8,328 | 7,104 | 9,262 | 7,675 | 6,038 | 8,996 | 653 | 7.84 | 0.9601 | 0.9215 |
| 5 | 2031 | 8,328 | 6,984 | 9,344 | 7,664 | 5,794 | 9,122 | 664 | 7.98 | 0.9625 | 0.9203 |
| 6 | 2032 (end of piling at all ICA projects) | 8,314 | 6,987 | 9,474 | 7,698 | 5,930 | 9,226 | 616 | 7.40 | 0.9648 | 0.9262 |
| 7 | 2033 | 8,307 | 6,826 | 9,592 | 7,725 | 5,998 | 9,249 | 582 | 6.99 | 0.9656 | 0.9304 |
| 8 | 2034 | 8,296 | 6,682 | 9,754 | 7,744 | 6,008 | 9,404 | 552 | 6.63 | 0.9674 | 0.9341 |
| 9 | 2035 | 8,276 | 6,586 | 9,784 | 7,748 | 5,956 | 9,435 | 528 | 6.34 | 0.9692 | 0.9370 |
| 10 | 2036 | 8,268 | 6,541 | 9,907 | 7,756 | 5,950 | 9,506 | 512 | 6.15 | 0.9695 | 0.9389 |
| 11 | 2037 | 8,262 | 6,434 | 9,984 | 7,752 | 5,840 | 9,604 | 510 | 6.13 | 0.9697 | 0.9393 |
| 12 | 2038 | 8,254 | 6,308 | 10,098 | 7,738 | 5,884 | 9,676 | 516 | 6.20 | 0.9692 | 0.9385 |
| 13 | 2039 | 8,268 | 6,370 | 10,348 | 7,739 | 5,846 | 9,810 | 529 | 6.35 | 0.9684 | 0.9370 |
| 14 | 2040 | 8,264 | 6,332 | 10,328 | 7,727 | 5,748 | 9,852 | 537 | 6.45 | 0.9680 | 0.9360 |
| 15 | 2041 | 8,246 | 6,208 | 10,448 | 7,704 | 5,690 | 9,916 | 542 | 6.51 | 0.9678 | 0.9355 |
| 16 | 2042 | 8,253 | 6,189 | 10,588 | 7,708 | 5,592 | 10,086 | 545 | 6.55 | 0.9675 | 0.9352 |
| 17 | 2043 | 8,256 | 6,066 | 10,670 | 7,711 | 5,560 | 10,164 | 545 | 6.55 | 0.9674 | 0.9351 |
| 18 | 2044 | 8,245 | 6,030 | 10,729 | 7,702 | 5,614 | 10,220 | 543 | 6.52 | 0.9673 | 0.9352 |
| 19 | 2045 | 8,267 | 6,004 | 10,906 | 7,724 | 5,606 | 10,299 | 543 | 6.52 | 0.9677 | 0.9355 |
| 20 | 2046 | 8,276 | 5,986 | 10,903 | 7,734 | 5,484 | 10,354 | 542 | 6.51 | 0.9679 | 0.9357 |
| 21 | 2047 | 8,279 | 5,899 | 11,028 | 7,738 | 5,420 | 10,449 | 541 | 6.50 | 0.9679 | 0.9359 |
| 22 | 2048 | 8,274 | 5,923 | 11,096 | 7,733 | 5,314 | 10,622 | 541 | 6.50 | 0.9678 | 0.9359 |
| 23 | 2049 | 8,274 | 5,780 | 11,217 | 7,734 | 5,316 | 10,700 | 540 | 6.49 | 0.9678 | 0.9359 |
| 24 | 2050 | 8,264 | 5,735 | 11,166 | 7,724 | 5,312 | 10,620 | 540 | 6.49 | 0.9677 | 0.9359 |
| 25 | 2051 | 8,267 | 5,740 | 11,134 | 7,726 | 5,308 | 10,537 | 541 | 6.50 | 0.9675 | 0.9359 |
| 26 | 2052 | 8,276 | 5,666 | 11,291 | 7,736 | 5,226 | 10,785 | 540 | 6.49 | 0.9675 | 0.9358 |

### 1.4.3 Minke whale

For the minke whale cumulative modelling scenario, a total of 795 piling days were modelled (26 of which were from the Project). These results indicated a difference in the simulated trajectories of minke whale between the impacted and un-impacted population (Figure 1.10). Across the model run, the maximum difference between the mean impacted and un-impacted population sizes was 10 individuals at time point 4 (2030, the final year of cumulative piling). This corresponds to 0.05% of the Celtic and Greater North Seas MU reference population (Table 1.13). At time point 2, the start of piling at the Project, there is no difference in the number of animals between the mean impacted and un-impacted. At the end of piling at the Project (time point 3 in this cumulative model), the difference between the mean impacted and un-impacted population sizes was seven individuals for the cumulative scenario. In comparison, there was no difference in the numbers of animals observed for the equivalent time point (end of piling at the Project) for the Project alone modelling (see section 1.2.1.3). At the end of the model run, the difference between the mean impacted and un-impacted population sizes was two individuals, which corresponds to 0.01% of the Celtic and Greater North Seas MU reference population (Table 1.13).

The median counterfactual of population size for the cumulative scenario remained at 1 throughout the 26-year simulation, whilst the mean counterfactual ranged between 0.9995 and 0.9999 (Table 1.13). The counterfactuals remained close to 1 throughout the cumulative piling period, suggesting that even though there were some declines in the population during cumulative piling, this was relatively small in relation to the Celtic and Greater North Seas MU reference population and therefore not sufficient to result in any changes at the population level.

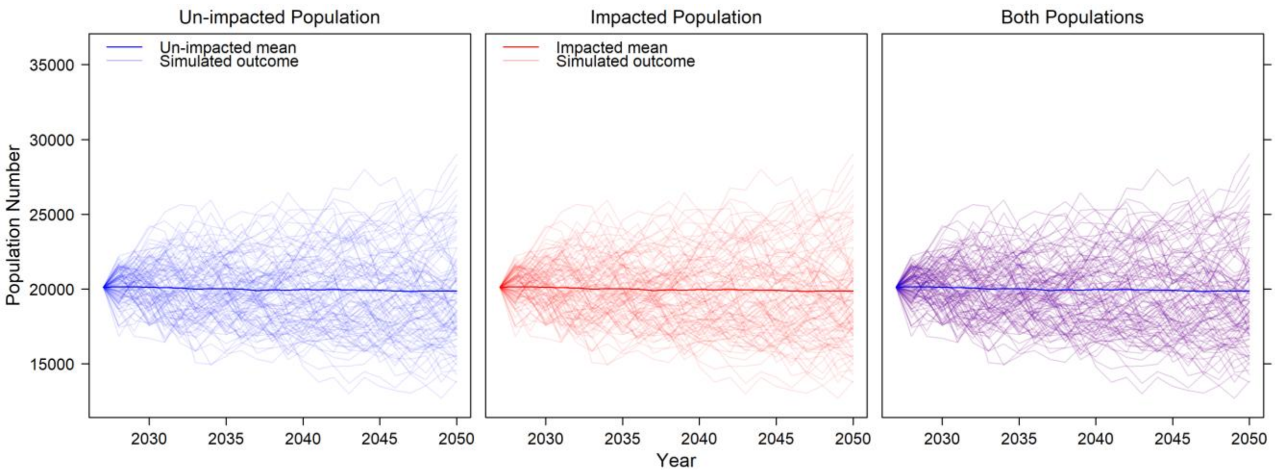


**Figure 1.10: Simulated population trajectories of an un-impacted and impacted minke whale population under the cumulative scenario**

Table 1.13: Modelled estimates for the un-impacted and impacted minke whale population under the cumulative scenario

| Time point | Year | Un-impacted population (number of animals) | | | Impacted population (number of animals) | | | Difference between means | % of MU | Counterfactual | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Lower 2.5% | Upper 2.5% | Mean | Lower 2.5% | Upper 2.5% | | | Median | Mean |
| 1 | 2027 (start of ICA piling) | 20,120 | 20,120 | 20,120 | 20,120 | 20,120 | 20,120 | 0 | 0.00 | 1.0000 | 1.0000 |
| 2 | 2028 (start of the Project piling) | 20,149 | 17,936 | 21,788 | 20,149 | 17,936 | 21,778 | 0 | 0.00 | 1.0000 | 1.0000 |
| 3 | 2029 (end of piling at the Project) | 20,156 | 17,444 | 22,520 | 20,149 | 17,425 | 22,520 | 7 | 0.03 | 1.0000 | 0.9997 |
| 4 | 2030 | 20,126 | 16,919 | 23,020 | 20,116 | 16,876 | 23,020 | 10 | 0.05 | 1.0000 | 0.9995 |
| 5 | 2031 | 20,111 | 16,946 | 23,200 | 20,103 | 16,933 | 23,200 | 8 | 0.04 | 1.0000 | 0.9996 |
| 6 | 2032 (end of piling at all ICA projects) | 20,072 | 16,896 | 23,612 | 20,067 | 16,893 | 23,612 | 5 | 0.02 | 1.0000 | 0.9997 |
| 7 | 2033 | 20,008 | 16,682 | 23,510 | 20,004 | 16,682 | 23,510 | 4 | 0.02 | 1.0000 | 0.9998 |
| 8 | 2034 | 20,025 | 16,589 | 23,864 | 20,022 | 16,589 | 23,864 | 3 | 0.01 | 1.0000 | 0.9998 |
| 9 | 2035 | 20,035 | 16,320 | 24,094 | 20,032 | 16,320 | 24,094 | 3 | 0.01 | 1.0000 | 0.9999 |
| 10 | 2036 | 20,008 | 16,292 | 24,368 | 20,006 | 16,292 | 24,368 | 2 | 0.01 | 1.0000 | 0.9999 |
| 11 | 2037 | 19,910 | 16,131 | 24,521 | 19,908 | 16,131 | 24,521 | 2 | 0.01 | 1.0000 | 0.9999 |
| 12 | 2038 | 19,942 | 15,877 | 24,907 | 19,940 | 15,877 | 24,907 | 2 | 0.01 | 1.0000 | 0.9999 |
| 13 | 2039 | 19,924 | 15,823 | 25,092 | 19,922 | 15,823 | 25,092 | 2 | 0.01 | 1.0000 | 0.9999 |
| 14 | 2040 | 19,970 | 15,884 | 25,285 | 19,968 | 15,884 | 25,285 | 2 | 0.01 | 1.0000 | 0.9999 |
| 15 | 2041 | 19,957 | 15,822 | 25,150 | 19,955 | 15,822 | 25,150 | 2 | 0.01 | 1.0000 | 0.9999 |
| 16 | 2042 | 19,971 | 15,370 | 25,679 | 19,969 | 15,370 | 25,679 | 2 | 0.01 | 1.0000 | 0.9999 |
| 17 | 2043 | 19,943 | 14,930 | 25,932 | 19,941 | 14,930 | 25,932 | 2 | 0.01 | 1.0000 | 0.9999 |
| 18 | 2044 | 19,937 | 15,026 | 26,185 | 19,934 | 15,026 | 26,185 | 3 | 0.01 | 1.0000 | 0.9999 |
| 19 | 2045 | 19,929 | 14,936 | 26,002 | 19,927 | 14,936 | 26,002 | 2 | 0.01 | 1.0000 | 0.9999 |
| 20 | 2046 | 19,877 | 14,862 | 26,130 | 19,875 | 14,862 | 26,130 | 2 | 0.01 | 1.0000 | 0.9999 |
| 21 | 2047 | 19,857 | 14,758 | 26,389 | 19,855 | 14,758 | 26,389 | 2 | 0.01 | 1.0000 | 0.9999 |
| 22 | 2048 | 19,887 | 14,891 | 26,477 | 19,885 | 14,891 | 26,477 | 2 | 0.01 | 1.0000 | 0.9999 |
| 23 | 2049 | 19,873 | 14,675 | 26,507 | 19,871 | 14,675 | 26,507 | 2 | 0.01 | 1.0000 | 0.9999 |
| 24 | 2050 | 19,874 | 14,470 | 26,977 | 19,872 | 14,470 | 26,977 | 2 | 0.01 | 1.0000 | 0.9999 |
| 25 | 2051 | 19,901 | 14,304 | 27,532 | 19,898 | 14,304 | 27,532 | 3 | 0.01 | 1.0000 | 0.9999 |
| 26 | 2052 | 19,825 | 14,074 | 27,510 | 19,823 | 14,074 | 27,510 | 2 | 0.01 | 1.0000 | 0.9999 |

### 1.4.4 Grey seal

For the grey seal cumulative modelling scenario, a total of 291 piling days were modelled (26 of which were from the Project). These results indicated a negligible difference in the simulated trajectories of grey seal between the impacted and un-impacted population (Figure 1.11). Across the model run, the maximum difference between the mean impacted and un-impacted population sizes was two individuals at time points 10, 12, 16, 18, 23, and 25. This corresponds to 0.03% of the combined East of Ireland, SE of Ireland and NI SMUs reference population (Table 1.14). At time point 2, the start of piling at the Project, there is no difference in the number of animals between the mean impacted and un-impacted. At the end of piling at the Project (time point 3 in this cumulative model), the difference between the mean impacted and un-impacted population sizes was one individual for the cumulative scenario. In comparison, there was no difference in the numbers of animals observed for the equivalent time point (end of piling at the Project) for the Project alone modelling (see section 1.2.1.4). At the end of the model run, the difference between the mean impacted and un-impacted population sizes was one individual, which corresponds to 0.02% of the combined SMUs reference population (Table 1.14).

The median counterfactual of population size for the cumulative scenario remained at 1 throughout the 26-year simulation, whilst the mean counterfactual ranged between 0.9998 and 1.0000 (Table 1.14). The counterfactuals remained close to 1 throughout the cumulative piling period, suggesting that even though there were some very small declines in the population during cumulative piling, this was relatively small in relation to the combined SMUs reference population.

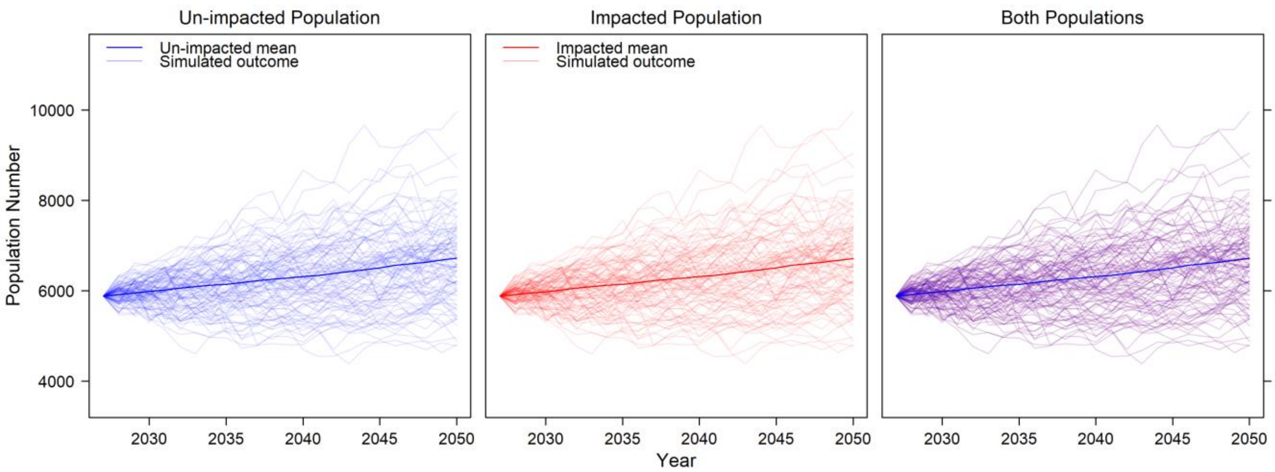


**Figure 1.11: Simulated population trajectories of an un-impacted and impacted grey seal population under the cumulative scenario**

**Table 1.14: Modelled estimates for the un-impacted and impacted grey seal population under the cumulative scenario**

| Time point | Year | Un-impacted population (number of animals) | | | Impacted population (number of animals) | | | Difference between means | % of Reference population | Counterfactual | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Lower 2.5% | Upper 2.5% | Mean | Lower 2.5% | Upper 2.5% | | | Median | Mean |
| 1 | 2027 (start of ICA piling) | 5,882 | 5,882 | 5,882 | 5,882 | 5,882 | 5,882 | 0 | 0.00 | 1.0000 | 1.0000 |
| 2 | 2028 (start of the Project piling) | 5,915 | 5,410 | 6,290 | 5,915 | 5,410 | 6,290 | 0 | 0.00 | 1.0000 | 1.0000 |
| 3 | 2029 (end of piling at the Project) | 5,952 | 5,294 | 6,454 | 5,951 | 5,294 | 6,454 | 1 | 0.02 | 1.0000 | 0.9999 |
| 4 | 2030 | 5,980 | 5,312 | 6,536 | 5,979 | 5,312 | 6,526 | 1 | 0.02 | 1.0000 | 0.9998 |
| 5 | 2031 | 6,020 | 5,164 | 6,746 | 6,019 | 5,164 | 6,742 | 1 | 0.02 | 1.0000 | 0.9998 |
| 6 | 2032 (end of piling at all ICA projects) | 6,059 | 5,166 | 6,814 | 6,058 | 5,166 | 6,804 | 1 | 0.02 | 1.0000 | 0.9998 |
| 7 | 2033 | 6,095 | 5,140 | 6,976 | 6,094 | 5,140 | 6,974 | 1 | 0.02 | 1.0000 | 0.9999 |
| 8 | 2034 | 6,122 | 5,090 | 7,128 | 6,121 | 5,090 | 7,128 | 1 | 0.02 | 1.0000 | 0.9998 |
| 9 | 2035 | 6,145 | 5,024 | 7,250 | 6,144 | 5,024 | 7,250 | 1 | 0.02 | 1.0000 | 0.9998 |
| 10 | 2036 | 6,185 | 4,996 | 7,406 | 6,183 | 4,996 | 7,406 | 2 | 0.03 | 1.0000 | 0.9998 |
| 11 | 2037 | 6,223 | 4,956 | 7,542 | 6,222 | 4,956 | 7,509 | 1 | 0.02 | 1.0000 | 0.9998 |
| 12 | 2038 | 6,255 | 4,944 | 7,654 | 6,253 | 4,944 | 7,648 | 2 | 0.03 | 1.0000 | 0.9998 |
| 13 | 2039 | 6,282 | 4,943 | 7,830 | 6,281 | 4,943 | 7,830 | 1 | 0.02 | 1.0000 | 0.9998 |
| 14 | 2040 | 6,316 | 4,893 | 8,005 | 6,315 | 4,888 | 8,005 | 1 | 0.02 | 1.0000 | 0.9998 |
| 15 | 2041 | 6,343 | 4,832 | 8,080 | 6,342 | 4,832 | 8,080 | 1 | 0.02 | 1.0000 | 0.9998 |
| 16 | 2042 | 6,384 | 4,830 | 8,280 | 6,382 | 4,830 | 8,280 | 2 | 0.03 | 1.0000 | 0.9998 |
| 17 | 2043 | 6,425 | 4,814 | 8,201 | 6,424 | 4,814 | 8,201 | 1 | 0.02 | 1.0000 | 0.9998 |
| 18 | 2044 | 6,465 | 4,866 | 8,469 | 6,463 | 4,866 | 8,469 | 2 | 0.03 | 1.0000 | 0.9998 |
| 19 | 2045 | 6,509 | 4,862 | 8,574 | 6,508 | 4,862 | 8,556 | 1 | 0.02 | 1.0000 | 0.9998 |
| 20 | 2046 | 6,562 | 4,837 | 8,679 | 6,561 | 4,837 | 8,678 | 1 | 0.02 | 1.0000 | 0.9998 |
| 21 | 2047 | 6,594 | 4,824 | 8,725 | 6,593 | 4,824 | 8,722 | 1 | 0.02 | 1.0000 | 0.9998 |
| 22 | 2048 | 6,629 | 4,738 | 8,852 | 6,628 | 4,736 | 8,801 | 1 | 0.02 | 1.0000 | 0.9998 |
| 23 | 2049 | 6,677 | 4,762 | 8,860 | 6,675 | 4,762 | 8,860 | 2 | 0.03 | 1.0000 | 0.9998 |
| 24 | 2050 | 6,717 | 4,796 | 8,992 | 6,716 | 4,796 | 8,976 | 1 | 0.02 | 1.0000 | 0.9998 |
| 25 | 2051 | 6,749 | 4,737 | 9,086 | 6,747 | 4,737 | 9,086 | 2 | 0.03 | 1.0000 | 0.9998 |
| 26 | 2052 | 6,792 | 4,782 | 9,236 | 6,791 | 4,782 | 9,236 | 1 | 0.02 | 1.0000 | 0.9998 |

### 1.4.5 Harbour seal

For the harbour seal cumulative modelling scenario, a total of 291 piling days were modelled (26 of which were from the Project). These results indicated that there was no difference in the simulated trajectories of harbour seal between the impacted and un-impacted population (Figure 1.12; Table 1.15). Across the model run, there was no difference between the impacted and un-impacted population sizes (Table 1.15). There was also no difference in the numbers of animals observed for the Project alone modelling (see section 1.2.1.5). The median and mean counterfactuals of population size for the cumulative scenario remained at 1 throughout the 26-year simulation (Table 1.15). This suggests that no long-term disturbance of the harbour seal population within the combined East of Ireland, SE Ireland and NI SMUs reference population is expected to occur under the cumulative piling scenario.

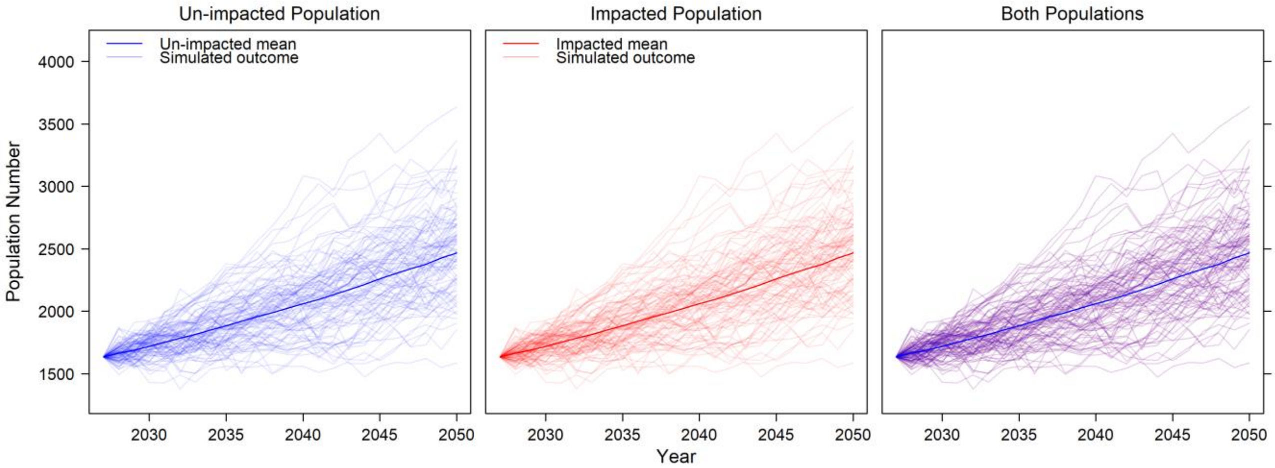


**Figure 1.12: Simulated population trajectories of an un-impacted and impacted harbour seal population under the cumulative scenario**

**Table 1.15: Modelled estimates for the un-impacted and impacted harbour seal population under the cumulative scenario**

| Time point | Year | Un-impacted population (number of animals) | | | Impacted population (number of animals) | | | Difference between mean | % of reference population | Counterfactual | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Lower 2.5% | Upper 2.5% | Mean | Lower 2.5% | Upper 2.5% | | | Median | Mean |
| 1 | 2027 (start of ICA piling) | 1,634 | 1,634 | 1,634 | 1,634 | 1,634 | 1,634 | 0 | 0 | 1.0000 | 1.0000 |
| 2 | 2028 (start of the Project piling) | 1,665 | 1,518 | 1,792 | 1,665 | 1,518 | 1,792 | 0 | 0 | 1.0000 | 1.0000 |
| 3 | 2029 (end of piling at the Project) | 1,689 | 1,506 | 1,852 | 1,689 | 1,506 | 1,852 | 0 | 0 | 1.0000 | 1.0000 |
| 4 | 2030 | 1,719 | 1,512 | 1,906 | 1,719 | 1,512 | 1,906 | 0 | 0 | 1.0000 | 1.0000 |
| 5 | 2031 | 1,753 | 1,518 | 1,982 | 1,753 | 1,518 | 1,982 | 0 | 0 | 1.0000 | 1.0000 |
| 6 | 2032 (end of piling at all ICA projects) | 1,784 | 1,514 | 2,048 | 1,784 | 1,514 | 2,048 | 0 | 0 | 1.0000 | 1.0000 |
| 7 | 2033 | 1,815 | 1,514 | 2,118 | 1,815 | 1,514 | 2,118 | 0 | 0 | 1.0000 | 1.0000 |
| 8 | 2034 | 1,852 | 1,544 | 2,190 | 1,852 | 1,544 | 2,190 | 0 | 0 | 1.0000 | 1.0000 |
| 9 | 2035 | 1,884 | 1,538 | 2,274 | 1,884 | 1,538 | 2,274 | 0 | 0 | 1.0000 | 1.0000 |
| 10 | 2036 | 1,921 | 1,554 | 2,322 | 1,921 | 1,554 | 2,322 | 0 | 0 | 1.0000 | 1.0000 |
| 11 | 2037 | 1,956 | 1,560 | 2,400 | 1,956 | 1,560 | 2,400 | 0 | 0 | 1.0000 | 1.0000 |
| 12 | 2038 | 1,990 | 1,544 | 2,494 | 1,990 | 1,544 | 2,494 | 0 | 0 | 1.0000 | 1.0000 |
| 13 | 2039 | 2,026 | 1,574 | 2,522 | 2,026 | 1,574 | 2,524 | 0 | 0 | 1.0000 | 1.0000 |
| 14 | 2040 | 2,061 | 1,572 | 2,588 | 2,061 | 1,572 | 2,588 | 0 | 0 | 1.0000 | 1.0000 |
| 15 | 2041 | 2,093 | 1,600 | 2,614 | 2,093 | 1,600 | 2,614 | 0 | 0 | 1.0000 | 1.0000 |
| 16 | 2042 | 2,134 | 1,600 | 2,732 | 2,133 | 1,600 | 2,732 | 1 | 1 | 1.0000 | 1.0000 |
| 17 | 2043 | 2,171 | 1,616 | 2,752 | 2,171 | 1,616 | 2,752 | 0 | 0 | 1.0000 | 1.0000 |
| 18 | 2044 | 2,214 | 1,648 | 2,834 | 2,213 | 1,648 | 2,834 | 1 | 1 | 1.0000 | 1.0000 |
| 19 | 2045 | 2,259 | 1,682 | 2,884 | 2,259 | 1,682 | 2,884 | 0 | 0 | 1.0000 | 1.0000 |
| 20 | 2046 | 2,302 | 1,698 | 2,950 | 2,302 | 1,698 | 2,950 | 0 | 0 | 1.0000 | 1.0000 |
| 21 | 2047 | 2,341 | 1,728 | 2,998 | 2,341 | 1,728 | 2,998 | 0 | 0 | 1.0000 | 1.0000 |
| 22 | 2048 | 2,377 | 1,734 | 3,054 | 2,377 | 1,734 | 3,054 | 0 | 0 | 1.0000 | 1.0000 |
| 23 | 2049 | 2,426 | 1,750 | 3,154 | 2,426 | 1,750 | 3,154 | 0 | 0 | 1.0000 | 1.0000 |
| 24 | 2050 | 2,466 | 1,778 | 3,244 | 2,466 | 1,778 | 3,244 | 0 | 0 | 1.0000 | 1.0000 |
| 25 | 2051 | 2,506 | 1,806 | 3,280 | 2,506 | 1,806 | 3,280 | 0 | 0 | 1.0000 | 1.0000 |
| 26 | 2052 | 2,551 | 1,794 | 3,386 | 2,551 | 1,794 | 3,386 | 0 | 0 | 1.0000 | 1.0000 |

## 1.5 Summary

This report presents the results of the iPCoD modelling for harbour porpoise, bottlenose dolphin, minke whale, grey seal and harbour seal as a result of the Project cumulatively with other projects in the Irish Sea region. The numbers of animals of each species with the potential to experience disturbance were based on the respective EIARs from projects as detailed in section 1.3.4 with projects screened on a species-by-species basis within the relevant MUs. The results from this modelling study sit alongside the previous cumulative iPCoD modelling which was undertaken for the Irish Phase 1 projects only (Sinclair, 2024) (see Annex 1 of this report), although will be more conservative as it considers additional projects within the eastern part of the Irish Sea region.

For harbour porpoise, cumulative piling is predicted to result in only a very small decline in population size over 25 years, and the impacted population was predicted to continue at a stable trajectory (noting there is no density dependence ability in the model that allows a population to recover the carrying capacity). Therefore, the effect is very small relative to the CIS MU reference population and is unlikely to produce any population-level change. Similarly, results from the population modelling for the Phase 1 projects (Sinclair, 2024) (section 1.2.2) found the level of disturbance predicted is not sufficient to result in any changes at the population level, since the impacted population is predicted to continue at a stable trajectory at 99.6-99.7% of the size of the un-impacted population.

For bottlenose dolphin, cumulative piling could cause an initial small decline in population size in response to piling and then continues on a stable long-term trajectory at approximately 96% of the mean un-impacted population. As the iPCoD model lacks density-dependence, the model does not allow for recovery above this reduced level. The Project alone represents only 26 days of piling, and population modelling for the Project alone found no population-level impacts. Similarly, results from the Irish Phase 1 projects (Sinclair, 2024) (section 1.2.2) also found a deviation from the baseline resulting from the pile driving disturbance across the five Phase 1 Projects, with the mean impacted population size initially decreasing very slightly from the mean un-impacted population size in response to piling, after which it continues on the same, stable trajectory at 95-96% of the mean un-impacted population size. (Sinclair, 2024) also highlights there is no way for the impacted population to increase in size after the piling disturbance (lack of density dependence function).

For minke whale, cumulative piling was predicted to produce negligible change in population size over 26 years. Even though there were some declines in the population during cumulative piling, this was relatively small in relation to the Celtic and Greater North Seas MU reference population and therefore not sufficient to result in any changes at the population level. Minke whale was not modelled in the Irish Phase 1 projects cumulative model (Sinclair, 2024) (section 1.2.2).

For grey seal, median counterfactual of population size for the cumulative scenario remained at 1 throughout the 26-year simulation and the mean counterfactuals remained close to 1 throughout the cumulative piling period, suggesting that even though there were some very small declines in the population during cumulative piling, this was relatively small in relation to the combined SMUs reference population. Similarly, results from the Irish Phase 1 projects (Sinclair, 2024) (section 1.2.2) also found the level of disturbance predicted is not sufficient to result in any changes at the population level, with the impacted population predicted to continue at a stable trajectory at exactly the same size as the un-impacted population.

For harbour seal, median and median counterfactuals of population size for the cumulative scenario remained at 1 throughout the 26-year simulation suggesting no long-term disturbance of the harbour seal population in relation to the combined SMUs reference population. Similarly, results from the Irish Phase 1 projects (Sinclair, 2024) (section 1.2.2) found the level of disturbance predicted is not sufficient to result in any changes at the population level, with the impacted population predicted to continue at a stable trajectory at exactly the same size as the un-impacted population.

Results from the revised iPCoD modelling for the Project alone (section 1.2.1) found that there may be a small, or negligible reduction in population size for the impacted populations for all species, however any changes that did occur would not be enough to significantly affect population trajectories and therefore the contribution of the Project to any cumulative changes in population (which were not considered to result in long-term population consequences) would be minimal. Where the focus was on modelling only the Phase 1 Irish Sea projects (as a more proportionate approach), the assessment demonstrated no significant impacts to any marine mammal species resulting from disturbance from pile driving at the five Irish Phase 1 Projects. Similarly, this population modelling study which considers all projects within the Irish Sea region also found no significant impacts to any marine mammal species resulting from disturbance from pile driving at cumulative projects. For bottlenose dolphins, the mean impacted population size initially decreases in the short-term in response to piling, after which it continues on the same, stable trajectory and the median counterfactual remains at 0.96 (therefore close to 1) from time point 3 onwards. As the iPCoD model does not currently allow for a density-dependent response there is no way for the impacted population to increase in size after the piling disturbance.

Therefore, it is considered that the cumulative population modelling has shown no significant impacts to any marine mammal species resulting from disturbance from cumulative pile driving at projects within the Irish Sea region, and the relative contribution of the Project (which is only 26 days of piling) to cumulative disturbance is minimal.

## 1.6 References

Booth, C. and Heinis, F. (2018). *Updating the Interim PCoD Model: Workshop Report - New transfer functions for the effects of permanent threshold shifts on vital rates in marine mammal species.* Report Code SMRUC-UOA-2018-006, submitted to the University of Aberdeen and Department for Business, Energy and Industrial Strategy (BEIS), June 2018 (unpublished) pp.34.

Booth, C. G., Heinis, F. and Harwood, J. (2019). *Updating the Interim PCoD Model: Workshop Report - New transfer functions for the effects of disturbance on vital rates in marine mammal species.* SMRU. SMRU-BEI-2018-011. pp.28.

Brandt, M. J., Diederichs, A., Betke, K. and 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, pp.205-216. DOI:10.3354/meps08888.

Bray Offshore Wind Limited. and Kish Offshore Wind Limited. (2025). *Dublin Array EIAR Volume 3: Chapter 5: Marine Mammals.* Offshore Infrastructure Assessment Chapters

Codling Wind Park Limited. (2024). *Volume 3 Chapter 11 Marine Mammals.* Codling Wind Park Environmental Impact Assessment Report pp.222.

Czapanskiy, M. F., Savoca, M. S., Gough, W. T., Segre, P. S., Wisniewska, D. M., Cade, D. E. and Goldbogen, J. A. (2021). *Modelling short‐term energetic costs of sonar disturbance to cetaceans using high‐resolution foraging data*. Journal of Applied Ecology, 58 (8), pp.1643-1657.

Donovan, C., Harwood, J., King, S., Booth, C., Caneco, B. and Walker, C. (2016). *Expert Elicitation Methods in Quantifying the Consequences of Acoustic Disturbance from Offshore Renewable Energy Developments*. *In:* Popper, A. and Hawkins, A. (eds.) *The Effects of Noise on Aquatic Life II. Advances in Experimental Medicine and Biology.* New York: Springer.

Ellison, W. T., Southall, B. L., Clark, C. W. and Frankel, A. S. (2012). *A new context-based approach to assess marine mammal behavioral responses to anthropogenic sounds*. Conserv Biol, 26 (1), pp.21-8. DOI:10.1111/j.1523-1739.2011.01803.x.

Gilles, A., Authier, M., Ramirez-Martinez, N. C., Araújo, H., Blanchard, A., Carlström, J., Eira, C., Dorémus, G., Fernández-Maldonado, C., Geelhoed, S. C. V., Kyhn, L., Laran, S., Nachtsheim, D., Panigada, S., Pigeault, R., Sequeira, M., Sveegaard, S., Taylor, N. L., Owen, K., Saavedra, C., Vázquez-Bonales, J. A., Unger, B. and Hammond, P. S. (2023). *Estimates of cetacean abundance in European Atlantic waters in summer 2022 from the SCANS-IV aerial and shipboard surveys.* Final report published 29 September 2023 pp.64.

Graham, I. M., Merchant, N. D., Farcas, A., Barton, T. R., Cheney, B., Bono, S. and Thompson, P. M. (2019). *Harbour porpoise responses to pile-driving diminish over time*. Royal Society Open Science, 6 (6), pp.190335. DOI:doi:10.1098/rsos.190335.

Harwood, J., King, S., Schick, R., Donovan, C. and Booth, C. (2014). *A Protocol for Implementing the Interim Population Consequences of Disturbance (PCoD) Approach: Quantifying and Assessing the Effects of UK Offshore Renewable Energy Developments on Marine Mammal Populations.* Scottish Marine and Freshwater Science Volume 5 Number 2. Marine Scotland Science pp.90.

Houston, A. I., Prosser, E. and Sans, E. (2012). *The cost of disturbance: a waste of time and energy?* Oikos, 121 (4), pp.597-604.

IAMMWG. (2023). *Review of Management Unit boundaries for cetaceans in UK waters.* JNCC. Peterborough, UK pp.23.

King, S. L., Schick, R. S., Donovan, C., Booth, C. G., Burgman, M., Thomas, L., Harwood, J. and Kurle, C. (2015). *An interim framework for assessing the population consequences of disturbance*. Methods in Ecology and Evolution, 6 (10), pp.1150-1158. DOI:10.1111/2041-210x.12411.

Mona Offshore Wind Ltd. (2023). *Volume 2, Chapter 9: Marine Mammals.* Mona Offshore Wind Project: Preliminary Environmental Information Report

Mona Offshore Wind Ltd. (2024). *Volume 2, Chapter 4: Marine Mammals (F01).* Mona Offshore Wind Project Environmental Statement

Mona Offshore Wind Ltd. (2025). *Volume 2, Chapter 4: Marine mammals (F02).* Mona Offshore Wind Project Environmental Statement. EnBW and BP pp.428.

Morecambe Offshore Wind Ltd. (2025). *Volume 5 Chapter 11 Marine Mammals Rev05.* Morecambe Offshore Windfarm: Generation Assets Environmental Statement pp.419.

Morgan Offshore Wind Ltd. (2023). *Volume 2, Chapter 9: Marine Mammals.* Morgan Offshore Wind Project: Generation Assets - Preliminary Environmental Information Report

Morgan Offshore Wind Ltd. (2025). *Volume 2, Chapter 4: Marine Mammals.* Morgan Offshore Wind Project Generation Assets Environmental Statement pp.496.

North Irish Sea Array Windfarm Ltd. (2024). *Volume 3 Chapter 14 Marine Mammal Ecology.* North Irish Sea Array Environmental Impact Assessment Report pp.194.

Ørsted. (2018). *Hornsea Project Three Offshore Wind Farm Environmental Statement: Volume 2, Chapter 4 – Marine Mammals.* Hornsea Project Three Offshore Wind Farm Environmental Statement pp.157.

Ørsted. (2021). *Hornsea Project Four: Environmental Statement (ES) Volume A2, Chapter 4: Marine Mammals.* PINS Document Reference: A2.4 APFP Regulation 5(2)(a). pp.175.

Ørsted. (2025). *Volume 2, Chapter 5: Marine Mammals.* Mooir Vannin Generation Project Environmental Impact Statement

Ossian OWFL. (2024). *Volume 2, Chapter 10: Marine Mammals.* Array Environmental Impact Assessment Report pp.173.

Posit team. (2023). *RStudio: Integrated Development Environment for R.* Boston, MA: Posit Software, PBC.

R Core Team. (2023). *R: A Language and Environment for Statistical Computing*. Vienna: R Foundation for Statistical Computing.

RWE Renewables UK. (2022). *Awel y Môr Offshore Wind Farm Category 6: Environmental Statement: Volume 2, Chapter 7: Marine Mammals.* Application Reference: 6.2.7.

Schwacke, L. H., Marques, T. A., Thomas, L., Booth, C. G., Balmer, B. C., Barratclough, A., Colegrove, K., De Guise, S., Garrison, L. P. and Gomez, F. M. (2022). *Modeling population effects of the Deepwater Horizon oil spill on a long-lived species*. Conservation Biology, 36 (4), pp.e13878.

Sinclair, R. R. (2024). *Phase 1 Irish Offshore Wind Farms Cumulative iPCoD modelling.* Environmental Impact Assessment Report Volume 4: Appendix 11.4 Phase 1 Irish Offshore Wind Farms Cumulative iPCoD modelling

Sinclair, R. R., Booth, C. G., Harwood, J. and Sparling, C. E. (2019). *Helpfile for the interim PCoD v5 model.* SMRU Consulting pp.63.

Sinclair, R. R., Sparling, C. E. and Harwood, J. (2020). *Review Of Demographic Parameters And Sensitivity Analysis To Inform Inputs And Outputs Of Population Consequences Of Disturbance Assessments For Marine Mammals.* Scottish Marine and Freshwater Science Vol 11 No 14. Marine Scotland Science

Southall, B. L., Bowles, A. E., Ellison, W. T., Finneran, J. J., Gentry, R. L., Greene Jr, C. R., Kastak, D., Ketten, D. R., Miller, J. H., Nachtigall, P. E. and Richardson, W. J. (2007). *Marine mammal noise-exposure criteria: initial scientific recommendations*. Aquatic Mammals, 33 (4), pp.414-521.

SSE Renewables. (2022). *Chapter 10: Marine Mammals.* Berwick Bank Wind Farm Environmental Impact Assessment Report Volume 2. Berwick Bank Wind Farm pp.149.

SSE Renewables. (2024). *Arklow Bank Wind Park 2 Environmental Impact Assessment Report Volume II, Chapter 11: Marine Mammals.*

Taylor, B. L. and DeMaster, D. P. (1993). *Implications of Non-linear Density Dependence*. Marine Mammal Science, 9 (4), pp.360-371.

# Annex 1: Phase 1 Irish Offshore Wind Farms Cumulative iPCoD modelling

# East Coast Phase One Irish Offshore Wind Farms: Cumulative iPCoD modelling

| | |
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# FIGURES

# TABLES

# 1 Introduction

The purpose of this report is to assess whether cumulative disturbance resulting from pile driving activities across the five East Coast Irish Phase One Offshore Windfarm Projects is predicted to result in population level impacts to four marine mammal species (harbour porpoise, bottlenose dolphins, harbour and grey seals). For this assessment each East Coast Phase One Project was required to provide an indicative piling schedule and the number of animals predicted to be disturbed per piling day to SMRU Consulting, so that a combined model could be prepared.

This report is provided to support the Environmental Impact Assessment Report (EIAR) of the North Irish Sea Array (NISA) Offshore Wind Farm (hereafter referred to as the 'proposed development').

Auditory injury (or permanent threshold shift (PTS)) was not included in this cumulative assessment since it was assumed that each Project would put in place mitigation measures to negate the risk of auditory injury to marine mammals.

# 2 Methods

## 2.1 iPCoD model

The iPCoD framework (Harwood *et al.*, 2014, King *et al.*, 2015) was used to predict the potential population consequences of the predicted amount of disturbance resulting from the proposed piling. iPCoD uses a stage-structured model of population dynamics with nine age classes and one stage class (adults 10 years and older). The model was used to run a number of simulations of future population trajectory with and without the predicted level of impact, to allow an understanding of the potential future population level consequences of predicted behavioural responses.

Simulations were run comparing projections of the baseline population (i.e., under current conditions, assuming current estimates of demographic parameters persist into the future) with a series of paired 'impact' scenarios with identical demographic parameters, incorporating a range of estimates for disturbance. Each simulation was repeated 1,000 times and each simulation draws parameter values from a distribution describing the uncertainty in the parameters. This creates 1,000 matched pairs of population trajectories, differing only with respect to the effect of the disturbance and the distributions of the two trajectories can be compared to demonstrate the magnitude of the long-term effect of the predicted impact on the population, as well as demonstrating the uncertainty in predictions.

### 2.1.1 Expert elicitation

Much of the empirical information required to parameterise an iPCoD model does not exist for many marine mammal species. Therefore, the iPCoD framework was developed in 2013 to forecast the potential effects of disturbance and hearing damage (PTS) that might result from the construction or operation of offshore renewable energy devices in UK waters using an expert elicitation (EE) process to quantify the potential effects of behavioural and physiological changes on vital rates. Expert elicitation is a formal technique (Brown, 1968, O'Hagan *et al.*, 2006) that is widely used in a range of scientific fields to combine the opinions of experts in situations where there is a relative lack of data but an urgent need for conservation or management decisions (Runge *et al.*, 2011, Martin *et al.*, 2012). Specifically, Morgan (2014) indicates: *"Expert elicitation should build on and use the best available research and analysis and be undertaken only when the state of knowledge will remain insufficient to support timely informed assessment and decision making"*. Martin *et al.* (2012) describe how this technique can be used to access substantive knowledge on particular topics held by experts and such techniques have been discussed and used widely over the past two decades

(MacMillan and Marshall, 2006, Aspinall, 2010, Knol *et al.*, 2010, European Food Safety Authority, 2014, Sivle *et al.*, 2015). The technique can also be used to translate and combine information obtained from multiple experts into quantitative statements that can be incorporated into a model, minimize bias in the elicited information, and ensure that uncertainty is accurately captured. The formal process of expert elicitation therefore avoids many of the well documented problems, heuristics and biases that arise when the judgements of only a few experts are canvassed or where expert knowledge is sought in an unstructured matter (Kynn, 2008, Kahneman, 2011, Morgan, 2014).

The original 2013 expert elicitation for iPCoD was recognised as an interim solution to the assessment of the potential effects of disturbance and PTS on vital rates, and there remained an urgent need for additional scientific research to address the knowledge gaps that were identified by Harwood *et al.* (2014). Since the 2013 expert elicitation, significant advances in the understanding of the elicitation processes have been made and methods in eliciting expert opinion have been refined. Given the advances in the expert elicitation process and continued developments on our knowledge of the marine mammalian auditory system and mechanisms affecting vital rates, two additional expert elicitations were conducted in 2018 (Booth and Heinis, 2018, Booth *et al.*, 2019) to determine how PTS and behavioural disturbance affect the vital rates of UK marine mammals. These elicitations resulted in changes to the transfer functions for the expected effects of PTS and disturbance on vital rates and an updated iPCoD model.

#### 2.1.1.1 Harbour porpoise

The iPCoD model for harbour porpoise was last updated following the expert elicitation in 2018.

Previous studies have shown that harbour porpoise are displaced from the vicinity of piling events (Brandt *et al.*, 2011, Dähne *et al.*, 2013, Brandt *et al.*, 2016, Brandt *et al.*, 2018, Graham *et al.*, 2019, Rose *et al.*, 2019). Harbour porpoise are small cetaceans which makes them vulnerable to heat loss and requires them to maintain a high metabolic rate with little energy remaining for fat storage. This makes them vulnerable to starvation if they are unable to obtain sufficient levels of prey intake. The results from Wisniewska *et al.* (2016) could also suggest that porpoises have an ability to respond to short term reductions in food intake, implying a resilience to disturbance. As Hoekendijk *et al.* (2018) suggest, this could help explain why porpoises are such an abundant and successful species.

The elicitation assumed that the behaviour of the disturbed porpoise would be altered for 6 hours on the day of disturbance, and that no feeding (or nursing) would occur during the 6 hours of disturbance. The experts agreed that first year calf survival (post-weaning) and fertility were the most likely vital rates to be affected by disturbance, but that juvenile and adult survival were unlikely to be significantly affected as these life-stages were considered to be more robust.

- Experts agreed it would likely take high levels of repeated disturbance to an individual before there was any effect on that individual's fertility (Figure 1), and that it was very unlikely an animal would terminate a pregnancy early.
- Experts considered that there are critical periods in the first year where calf survival could be reduced by a relatively small number of days of disturbance (Figure 2).

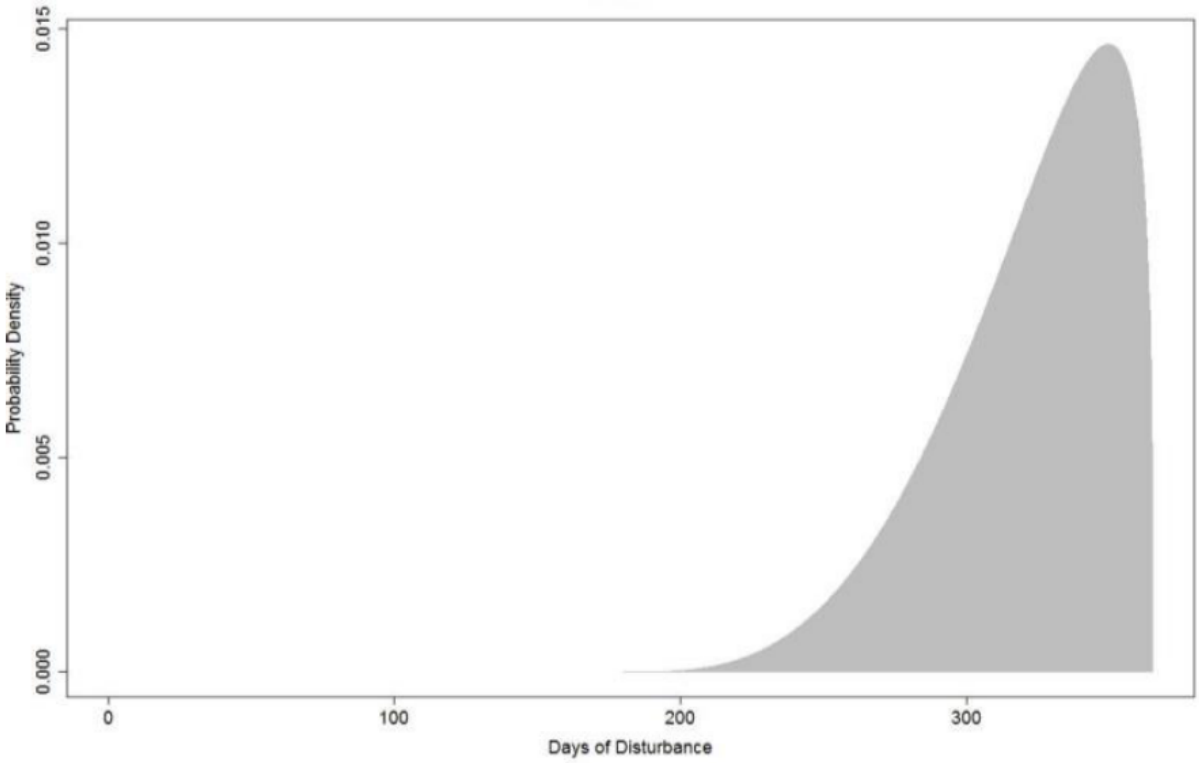


**Figure 1 Probability distribution showing the consensus of the EE: the number of days of disturbance (i.e. days on which an animal does not feed for 6 hours) a pregnant female porpoise could 'tolerate' before it has any effect on fertility.**

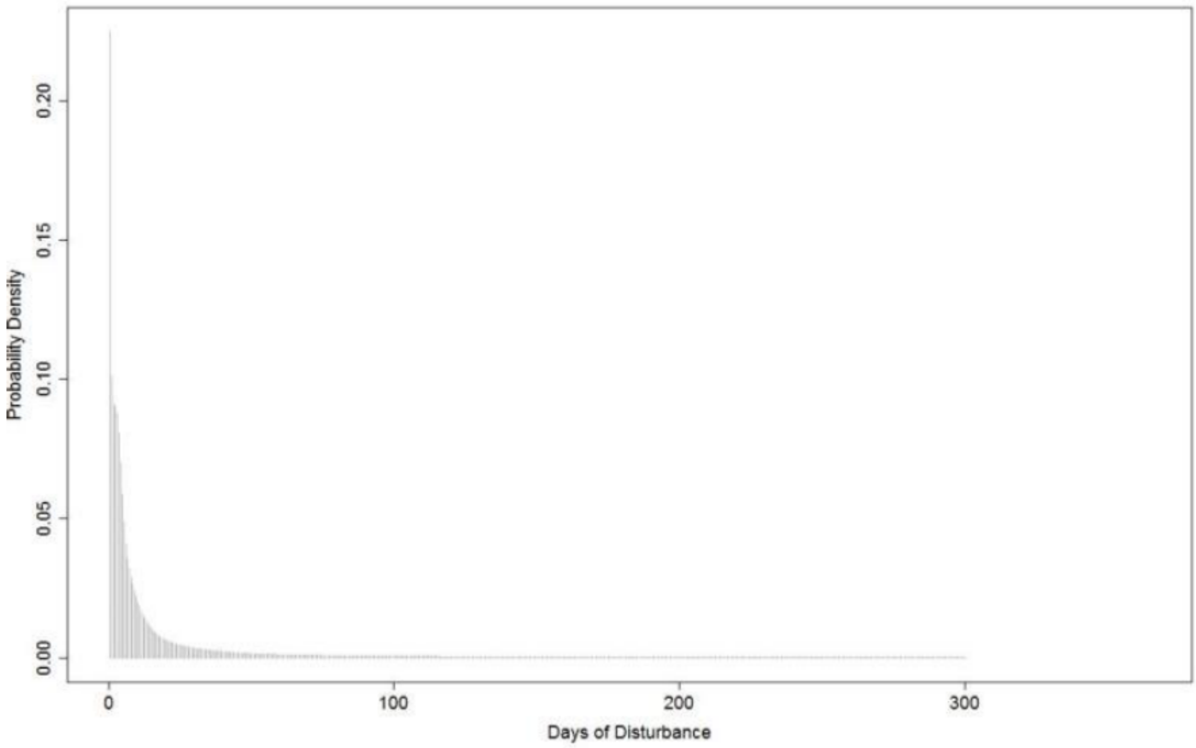


**Figure 2 Probability distribution showing the consensus of the EE: the number of days of disturbance (of 6 hours zero energy intake) a porpoise mother:calf pair could 'tolerate' before it has any effect on survival.**

#### 2.1.1.2 Harbour and grey seals

The iPCoD model for harbour and grey seals was last updated following the expert elicitation in 2018.

Previous studies have shown that both harbour seals and grey seals are displaced from the vicinity of piling events (Russell *et al.*, 2016, Aarts *et al.*, 2018). The duration of the displacement was only short-term as seals returned to non-piling distributions within two hours after the end of a pile-driving event. Unlike harbour porpoise, both harbour and grey seals store energy in a thick layer of blubber, which means that they are more tolerant of periods of fasting when hauled out and resting between foraging trips, and when hauled out during the breeding and moulting periods. Therefore, they are unlikely to be particularly sensitive to short-term displacement from foraging grounds during periods of active piling.

For seals, the experts assumed that, on average, the behaviour of the disturbed seals would be impacted for much less than 24 hours, but did not define an exact duration. The experts determined that the survival of 'weaned of the year' animals and fertility were the most sensitive life history parameters to disturbance.

- It was agreed that harbour seals were considered to have a reasonable ability to compensate for lost foraging opportunities due to their generalist diet, mobility, life history, and fat stores. It was thought that for an animal in bad condition, moderate levels of repeated disturbance might be sufficient to reduce fertility (Figure 3), however there was a large amount of uncertainty in this estimate.
- Grey seals were considered to have a reasonable ability to compensate for lost foraging opportunities due to their generalist diet, adaptable foraging tactics, ability to adjust their metabolic rates, wide ranging behaviour, life history and large body size with fat stores. Experts agreed that grey seals would be much more robust than harbour seals to the effects of disturbance and it was agreed that grey seals would require moderate-high levels of repeated disturbance before there was any effect on fertility rates (Figure 4).
- During nursing, a seal pup is given a lot of fat by its mother, which is followed by a post-weaning fast whilst on land (2-3 weeks in grey seals, 2-2.5 weeks in harbour seals). Following the fast there is a 2-3 month window in which animals will be particularly vulnerable to missed foraging opportunities as a result of disturbance. Experts felt it might take multiple days of repeated disturbance before there was expected to be any effect on the probability of survival (Figure 5), however, there was a lot of uncertainty surrounding this estimate.

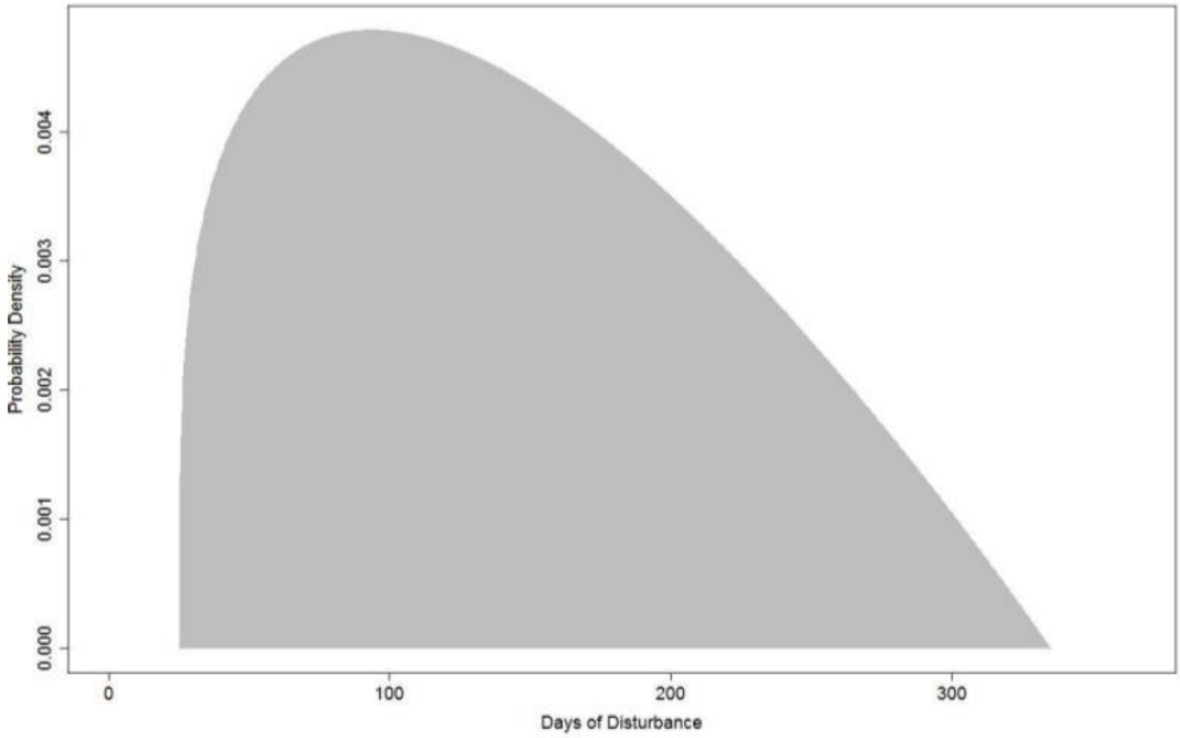


**Figure 3 Probability distribution showing the consensus of the EE: the number of days of disturbance a pregnant female harbour seal could 'tolerate' before disturbance has any effect on fertility.**

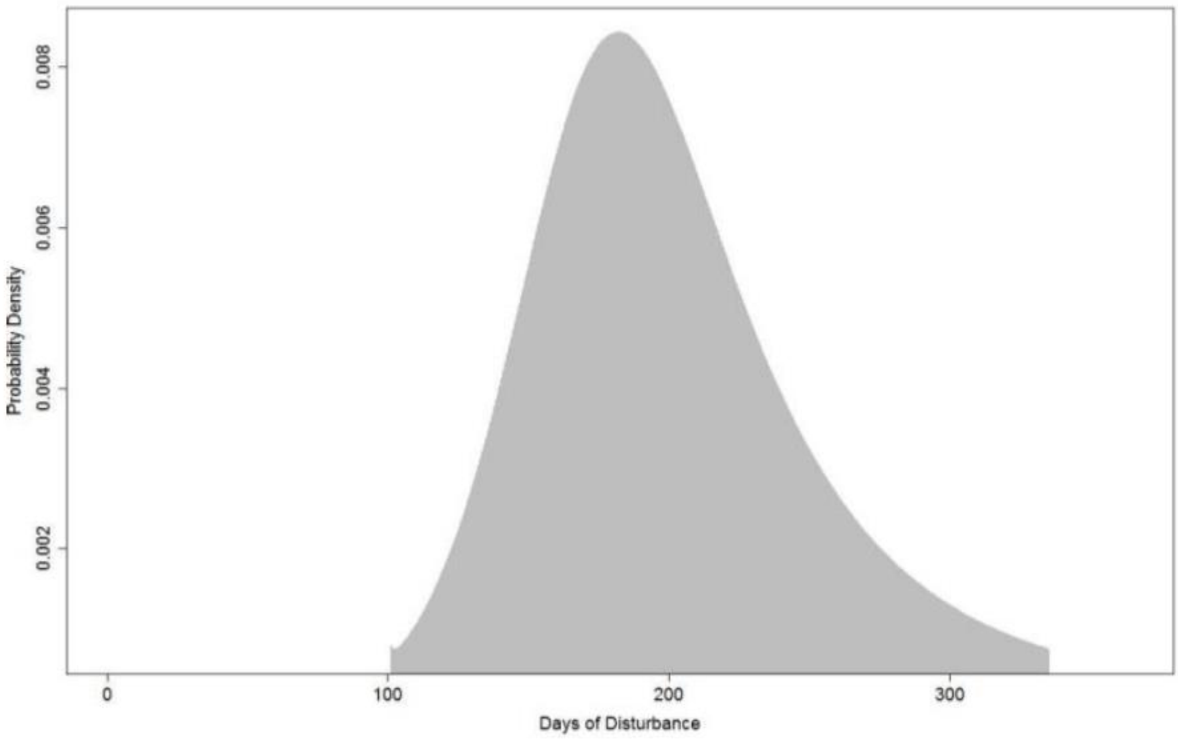


**Figure 4 Probability distribution showing the consensus of the EE: the number of days of disturbance a pregnant grey seal female could 'tolerate' before disturbance has any effect on fertility.**

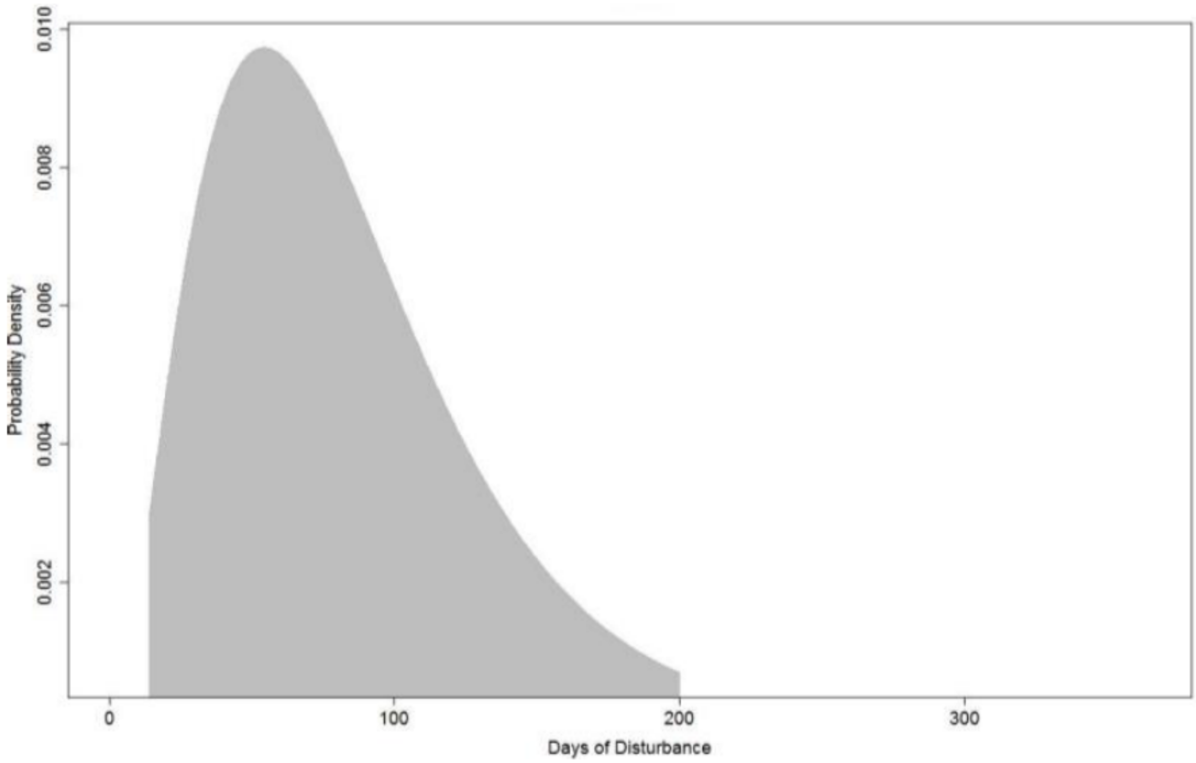


**Figure 5 Probability distribution showing the consensus of the EE: the number of days of disturbance a 'weaned of the year' harbour or grey seal pup could 'tolerate' before it has any effect on survival.**

#### 2.1.1.3 Bottlenose dolphin

The iPCoD model for bottlenose dolphin disturbance was last updated following the expert elicitation in 2013 (Harwood *et al.*, 2014). When this expert elicitation was conducted, the experts provided responses on the assumption that a disturbed individual would not forage for 24 hours. However, the most recent expert elicitation in 2018 highlighted that this was an unrealistic assumption for harbour porpoises (generally considered to be more responsive than bottlenose dolphins), and was amended to assume that disturbance resulted in 6 hours of non-foraging time (Booth *et al.*, 2019). Unfortunately, bottlenose dolphins were not included in the updated expert elicitation for disturbance, and thus the iPCoD model still assumes 24 hours of non-foraging time. This is unrealistic considering what we now know about marine mammal behavioural responses to pile driving. A recent study estimated energetic costs associated with disturbance from sonar, where it was assumed that 1 hour of feeding cessation was classified as a mild response, 2 hours of feeding cessation was classified as a strong response and 8 hours of feeding cessation was classified as an extreme response (Czapanskiy *et al.*, 2021). Assuming 24 hours of feeding cessation for bottlenose dolphins in the iPCoD model is significantly beyond that which is considered to be an extreme response, and will therefore over-estimate the true disturbance levels expected from the Offshore Development and is considered to be unrealistic.

### 2.1.2 Key limitations

There is a lack of empirical data on the way in which changes in behaviour and hearing sensitivity may affect the ability of individual marine mammals to survive and reproduce. Therefore, in the absence of empirical data, the iPCoD framework uses the results of an expert elicitation process conducted according to the protocol described in Donovan et al. (2016) to predict the effects of disturbance and PTS on survival and reproductive rate. The process generates a set of statistical distributions for these effects and then simulations are conducted using values randomly selected from these distributions that represent the opinions of a "virtual" expert. This process is repeated many 100s of times to capture the uncertainty among experts.

There are several precautions built into the iPCoD model and this specific scenario that mean that the results are considered to be highly precautionary and likely over-estimate the true population level effects. These include:

- The fact that the model assumes that bottlenose dolphins will not forage for 24 hours after being disturbed (detailed in section 2.1.1.3),
- The lack of density dependence in the model (meaning the population will not respond to any reduction in population size), and
- The level of environmental and demographic stochasticity in the model.

#### 2.1.2.1 Lack of density dependence

Density dependence is described as *"the process whereby demographic rates change in response to changes in population density, resulting in an increase in the population growth rate when density decreases and a decrease in that growth rate when density increases"* (Harwood *et al.*, 2014). The iPCoD model assumes no density dependence, since there is insufficient data to parameterise this relationship. Essentially, this means that there is no ability for the modelled, impacted population to increase in size and return to carrying capacity following disturbance. At a recent expert elicitation, conducted for the purpose of modelling population impacts of the Deepwater Horizon oil spill (Schwacke et al., 2021), experts agreed that there would likely be a concave density dependence on fertility, which means that in reality, it would be expected that the impacted population would recover to carrying capacity (which is assumed to be equal to the size of un-impacted population – i.e., it is assumed the un-impacted population is at carrying capacity) rather than continuing at a stable trajectory that is smaller than that of the un-impacted population.

#### 2.1.2.2 Environmental and demographic stochasticity

The iPCoD model attempts to model some of the sources of uncertainty inherent in the calculation of the potential effects of disturbance on a marine mammal population. This includes demographic stochasticity and environmental variation. Environmental variation is defined as *"the variation in demographic rates among years as a result of changes in environmental conditions"* (Harwood *et al.*, 2014). Demographic stochasticity is defined as *"variation among individuals in their realised vital rates as a result of random processes"* (Harwood *et al.*, 2014).

The iPCoD protocol describes this in further detail: *"Demographic stochasticity is caused by the fact that, even if survival and fertility rates are constant, the number of animals in a population that die and give birth will vary from year to year because of chance events. Demographic stochasticity has its greatest effect on the dynamics of relatively small populations, and we have incorporated it in models for all situations where the estimated population within an MU is less than 3000 individuals. One consequence of demographic stochasticity is that two otherwise identical populations that experience exactly the same sequence of environmental conditions will follow slightly different trajectories over time. As a result, it is possible for a "lucky" population that experiences disturbance effects to increase, whereas an identical undisturbed but "unlucky" population may decrease"* (Harwood *et al.*, 2014).

This is clearly evidenced in the outputs of iPCoD where the un-impacted (baseline) population size varies greatly between iterations, not as a result of disturbance but simply as a result of environmental and demographic stochasticity. In the example provided in Figure 6, after 25 years of simulation, the un-impacted population size varies between 176 (lower 2.5%) and 418 (upper

97.5%). Thus, the change in population size resulting from the impact of disturbance is significantly smaller than that driven by the environmental and demographic stochasticity in the model.

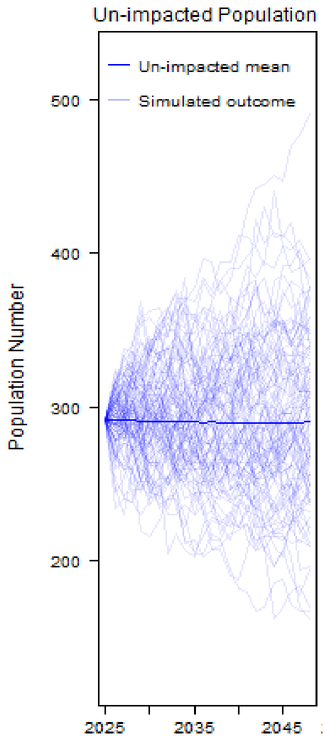


**Figure 6 Simulated un-impacted (baseline) population size over the 25 years modelled.**

#### 2.1.2.3 Summary

All of the conservatisms built into the iPCoD model mean that the results are considered to be highly precautionary. Despite the limitations and uncertainties described above, this assessment has been carried out according to best practice, using the best available scientific information and is considered sufficient to carry out an adequate assessment. A level of caution should be taken into account when drawing conclusions.

## 2.2 Input parameters

### 2.2.1 Management Units

The following Management Units (MUs) were assumed in the assessment:

- Harbour porpoise: Celtic and Irish Sea MU, as advised in IAMMWG (2023): 62,517 porpoise
- Bottlenose dolphin: Irish Sea MU, total abundance obtained by summing the two SCANS IV blocks within the MU: 8,199 in CS-D + 127 in CS-E = 8,326 bottlenose dolphins
- Harbour seal: Southeast & East RoI & Northern Ireland MU: August haul-out counts from Morris and Duck (2019) and SCOS (2023) scaled to account for animals at sea: 1,365 seals
- Grey seal: Southeast & East RoI & Northern Ireland MU: August haul-out counts from Morris and Duck (2019) and SCOS (2023) scaled to account for animals at sea: 6,056 seals.

### 2.2.2 Demographic parameters

Demographic parameters were based on those presented in Sinclair *et al.* (2020) to obtain a stable population trajectory for harbour porpoise, bottlenose dolphins and harbour seals, and an increasing population trajectory for grey seals (Table 1).

**Table 1 Demographic parameters used in the iPCoD modelling.**

| Parameter | Harbour porpoise | Bottlenose dolphin | Harbour seal | Grey seal |
|---|---|---|---|---|
| Population size | 62,517 | 8,326 | 1,365 | 6,056 |
| Calf/pup survival | 0.8455 | 0.87 | 0.4 | 0.222 |
| Juvenile survival | 0.85 | 0.94 | 0.78 | 0.94 |
| Adult survival | 0.925 | 0.94 | 0.92 | 0.94 |
| Fecundity rate | 0.34 | 0.245 | 0.85 | 0.84 |
| Age at which a calf/pup becomes independent of its mother | 1 | 2 | 1 | 1 |
| Age at which an average female gives birth to her first calf/pup | 5 | 9 | 4 | 6 |
| Proportion of animals in each vulnerable component of the population | Entire population is vulnerable (vulnmean = 1) | | | |
| Number of days of "residual" disturbance associated with each day of actual disturbance | Disturbance only lasts 1 single day (days = 0) | | | |
| Seasonal variation in disturbance | Disturbance numbers are the same throughout the year (seasons = 1) | | | |

### 2.2.3 Piling schedules

Each of the five projects provided indicative pile driving schedules. Where projects had different piling schedules for monopiles and pin-piled jacket foundations, both were provided.

Piling schedule 1 (Figure 7):

- Monopiles at all five Projects
- Piling January 2027 to December 2029 inclusive

Piling schedule 2 (Figure 8):

- Monopiles at Arklow, Oriel and Codling
- Pin-pile jackets at the proposed development and Dublin Array
- Piling January 2027 to March 2031 inclusive.

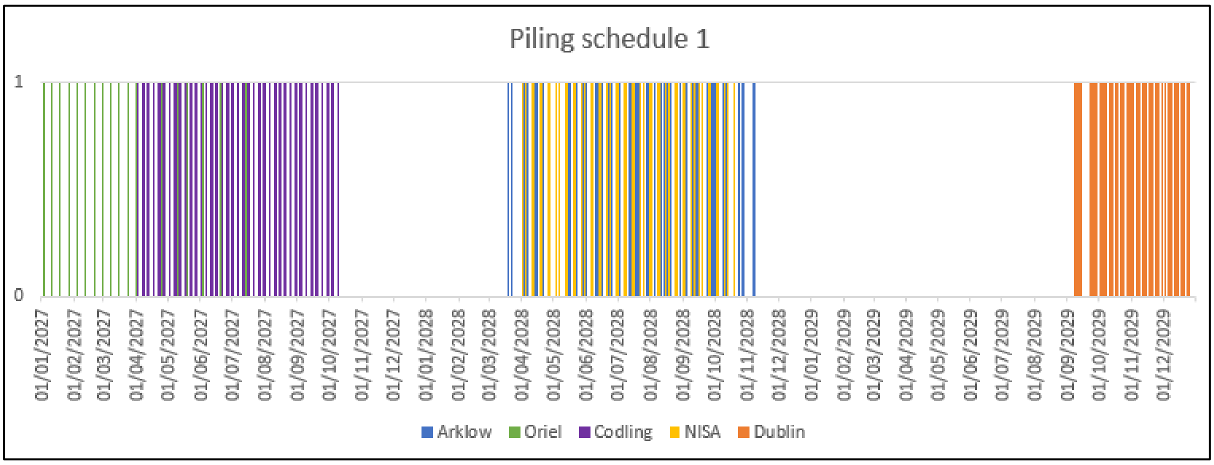


**Figure 7 Piling schedule 1: Monopiles at all five Phase One Projects.**

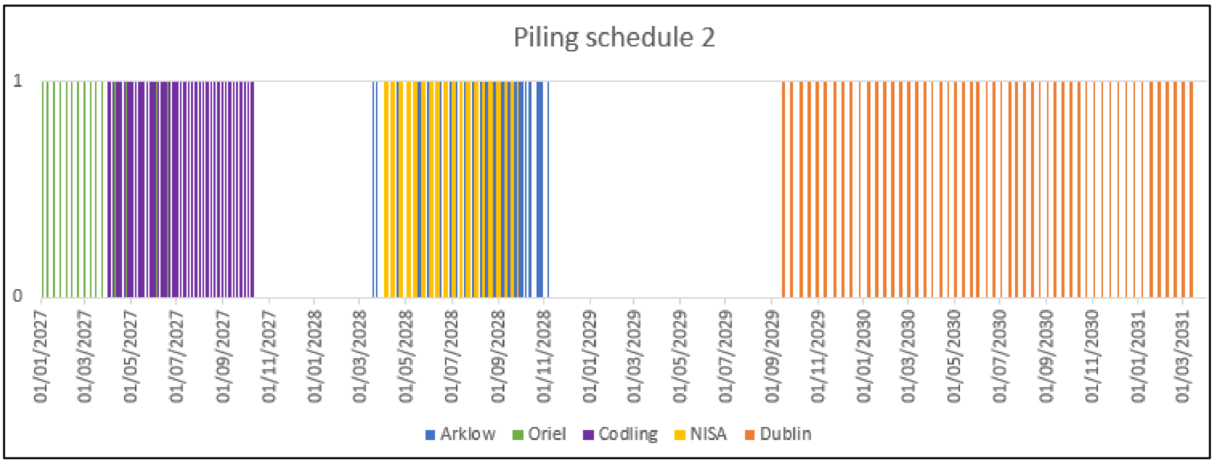


**Figure 8 Piling schedule 2: Monopiles at Arklow, Oriel and Codling, pin-piled jackets at NISA and Dublin.**

### 2.2.4 Disturbance

Each of the five projects provided the maximum number of animals disturbed per day from pile driving activities, including for monopile and pin-piled scenarios where applicable. In order to make the results from each Project comparable, the same disturbance assessment approach was used for each species.

- For harbour porpoise, the dose-response function was used.
- For bottlenose dolphins, both the porpoise dose-response function and the Level B harassment threshold was used.
- For seals, the harbour seal dose-response function was used.

# 3 Results

## 3.1 Harbour porpoise

The iPCoD results show that the level of disturbance predicted under either piling schedule 1 or 2 is not sufficient to result in any changes at the population level, since the impacted population is predicted to continue at a stable trajectory at 99.6-99.7% of the size of the un-impacted population.

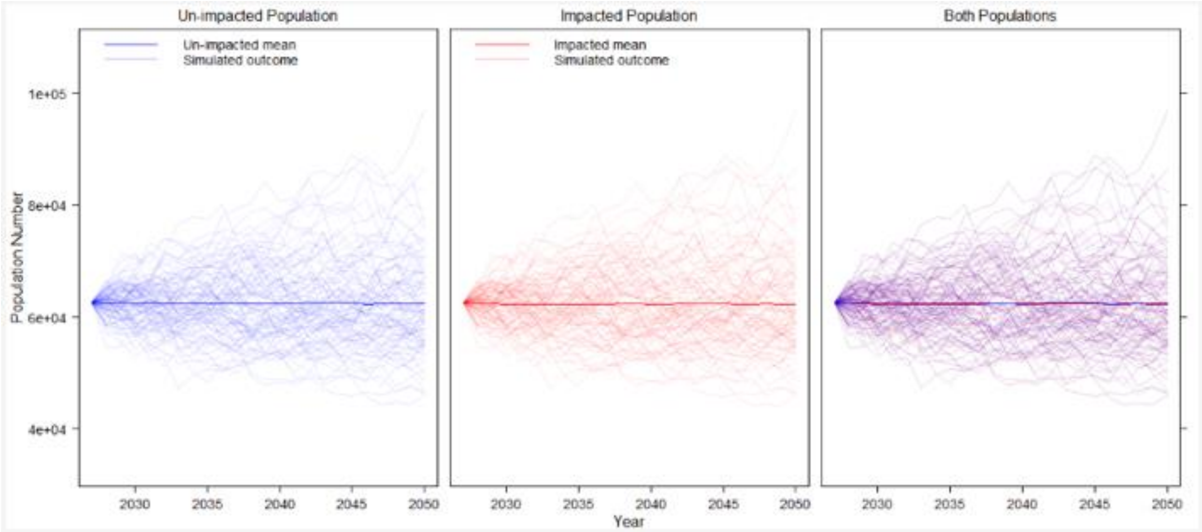


**Figure 9 Predicted population trajectories for the un-impacted (baseline) and impacted harbour porpoise iPCoD simulations for piling schedule 1.**

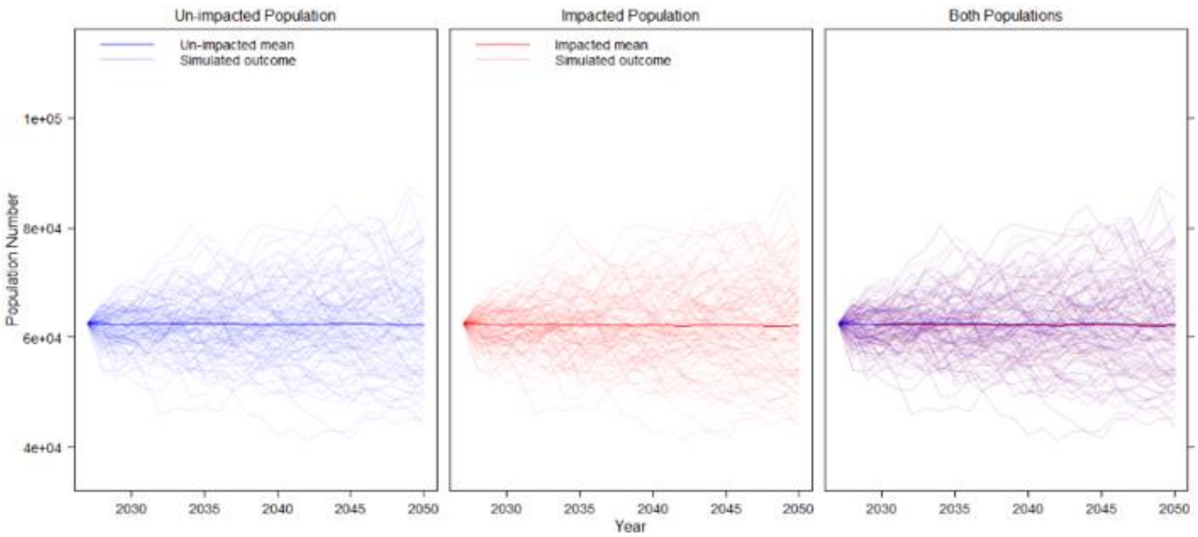


**Figure 10 Predicted population trajectories for the un-impacted (baseline) and impacted harbour porpoise iPCoD simulations for piling schedule 2.**

**Table 2 Predicted mean population size for the un-impacted (baseline) and impacted harbour porpoise iPCoD simulations.**

| | Un-impacted population mean | Impacted population mean | Impacted as % of un-impacted |
|---|---|---|---|
| **Piling schedule 1** | | | |
| Before piling commences | 62,516 | 62,516 | 100% |
| End 2027 – after 1 year piling | 62,457 | 62,425 | 99.9% |
| End 2028 – after 2 years piling | 62,526 | 62,415 | 99.8% |
| End 2029 – after 3 years piling | 62,454 | 62,277 | 99.7% |
| End 2030 – 1 year after piling stops | 62,491 | 62,297 | 99.7% |
| End 2035 – 6 years after piling stops | 62,428 | 62,271 | 99.7% |
| End 2041 – 12 years after piling stops | 62,476 | 62,319 | 99.7% |
| End 2047 – 18 years after piling stops | 62,255 | 62,099 | 99.7% |
| **Piling schedule 2** | | | |
| Before piling commences | 62,516 | 62,516 | 100.0% |
| End 2027 – after 1 year piling | 62,565 | 62,530 | 99.9% |
| End 2028 – after 2 years piling | 62,429 | 62,295 | 99.8% |
| End 2029 – after 3 years piling | 62,423 | 62,199 | 99.6% |
| End 2030 – after 4 years piling | 62,537 | 62,296 | 99.6% |
| End 2031 – after 5 years piling | 62,562 | 62,297 | 99.6% |
| End 2032 – 1 year after piling stops | 62,586 | 62,346 | 99.6% |
| End 2037 – 6 years after piling stops | 62,440 | 62,204 | 99.6% |
| End 2043 – 12 years after piling stops | 62,569 | 62,331 | 99.6% |
| End 2049 – 18 years after piling stops | 62,346 | 62,110 | 99.6% |

## 3.2 Bottlenose dolphin

### 3.2.1 Dose-response function

The results of the iPCoD modelling show a clear deviation from the baseline resulting from the pile driving disturbance across the five East Coast Phase One Projects. The mean impacted population size initially decreases very slightly from the mean un-impacted population size in response to piling, after which it continues on the same, stable trajectory at 95-96% of the mean un-impacted population size. As the iPCoD model does not currently allow for a density-dependent response (see Section 2.1.2.1), there is no way for the impacted population to increase in size after the piling disturbance. The impacted population does, however, continue on a stable trajectory in the long-term.

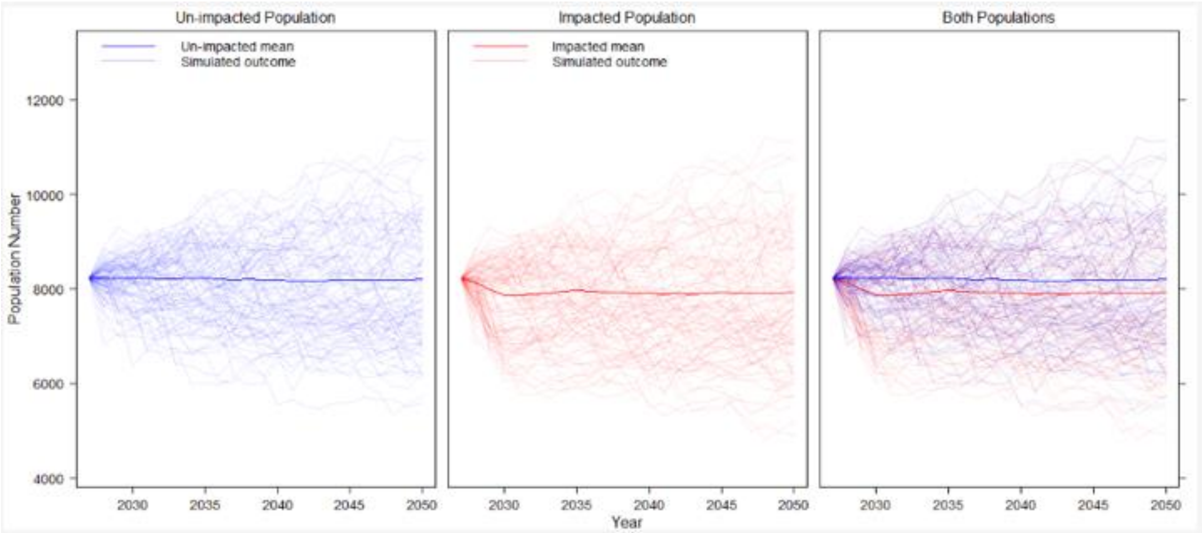


**Figure 11 Predicted population trajectories for the un-impacted (baseline) and impacted bottlenose dolphin iPCoD simulations for piling schedule 1 using the dose-response function.**

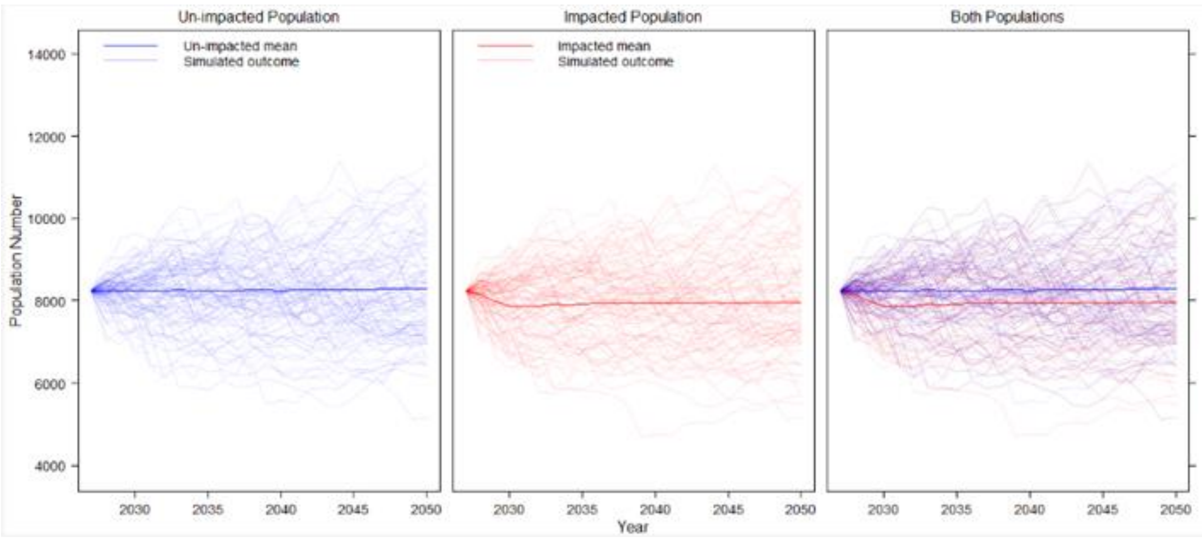


**Figure 12 Predicted population trajectories for the un-impacted (baseline) and impacted bottlenose dolphin iPCoD simulations for piling schedule 2 using the dose-response function.**

**Table 3 Predicted mean population size for the un-impacted (baseline) and impacted bottlenose dolphin iPCoD simulations using the dose-response function.**

| | Un-impacted population mean | Impacted population mean | Impacted as % of un-impacted |
|---|---|---|---|
| **Piling schedule 1** | | | |
| Before piling commences | 8,236 | 8,236 | 100.0% |
| End 2027 – after 1 year piling | 8,223 | 8,128 | 98.8% |
| End 2028 – after 2 years piling | 8,235 | 7,991 | 97.0% |
| End 2029 – after 3 years piling | 8,223 | 7,867 | 95.7% |
| End 2030 – 1 year after piling stops | 8,231 | 7,878 | 95.7% |
| End 2035 – 6 years after piling stops | 8,213 | 7,949 | 96.8% |
| End 2041 – 12 years after piling stops | 8,180 | 7,899 | 96.6% |
| End 2047 – 18 years after piling stops | 8,190 | 7,913 | 96.6% |
| **Piling schedule 2** | | | |
| Before piling commences | 8,236 | 8,236 | 100.0% |
| End 2027 – after 1 year piling | 8,233 | 8,144 | 98.9% |
| End 2028 – after 2 years piling | 8,245 | 7,995 | 97.0% |
| End 2029 – after 3 years piling | 8,249 | 7,875 | 95.5% |
| End 2030 – after 4 years piling | 8,241 | 7,874 | 95.5% |
| End 2031 – after 5 years piling | 8,251 | 7,872 | 95.4% |
| End 2032 – 1 year after piling stops | 8,262 | 7,907 | 95.7% |
| End 2037 – 6 years after piling stops | 8,259 | 7,949 | 96.2% |
| End 2043 – 12 years after piling stops | 8,277 | 7,952 | 96.1% |
| End 2049 – 18 years after piling stops | 8,291 | 7,968 | 96.1% |

### 3.2.2 Level B harassment

The results of the iPCoD modelling show a clear deviation from the baseline resulting from the pile driving disturbance across the five Phase One Projects. The mean impacted population size initially decreases very slightly from the mean un-impacted population size in response to piling, after which it continues on the same, stable trajectory at 98% of the mean un-impacted population size. As the iPCoD model does not currently allow for a density-dependent response (see Section 2.1.2.1), there is no way for the impacted population to increase in size after the piling disturbance. The impacted population does, however, continue on a stable trajectory in the long-term.

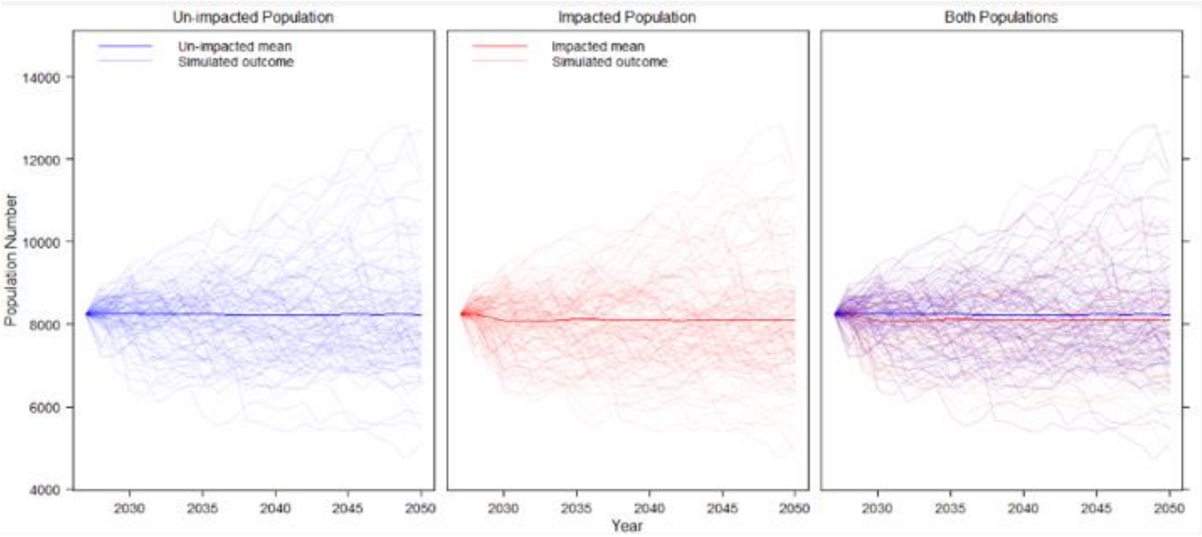


**Figure 13 Predicted population trajectories for the un-impacted (baseline) and impacted bottlenose dolphin iPCoD simulations for piling schedule 1 using the level B harassment threshold.**

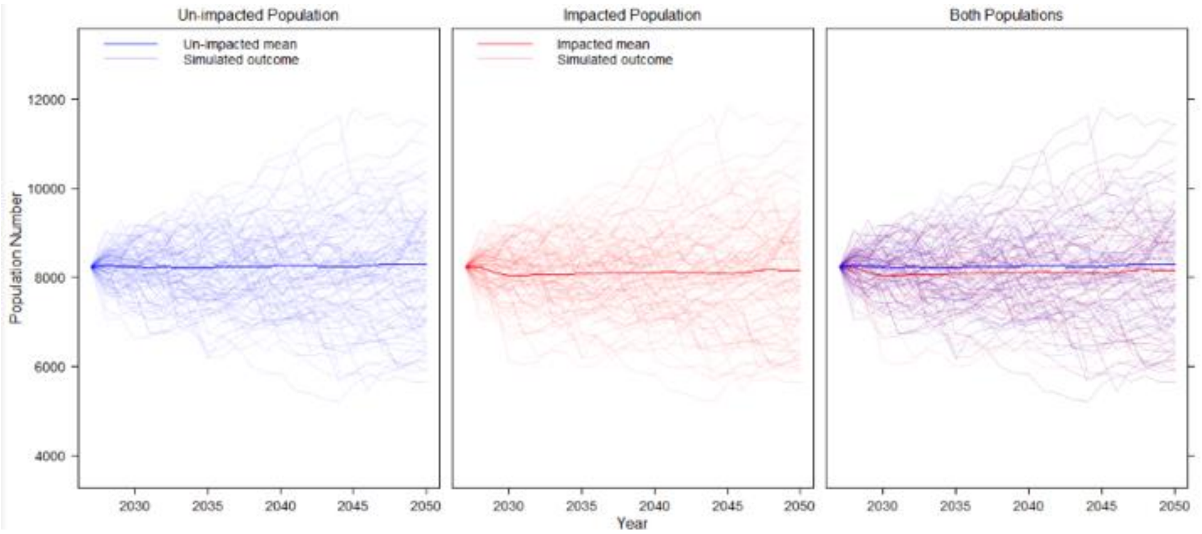


**Figure 14 Predicted population trajectories for the un-impacted (baseline) and impacted bottlenose dolphin iPCoD simulations for piling schedule 2 using the level B harassment threshold.**

**Table 4 Predicted mean population size for the un-impacted (baseline) and impacted bottlenose dolphin iPCoD simulations using the level B harassment threshold.**

| | Un-impacted population mean | Impacted population mean | Impacted as % of un-impacted |
|---|---|---|---|
| **Piling schedule 1** | | | |
| Before piling commences | 8,236 | 8,236 | 100.0% |
| End 2027 – after 1 year piling | 8,260 | 8,246 | 99.8% |
| End 2028 – after 2 years piling | 8,271 | 8,162 | 98.7% |
| End 2029 – after 3 years piling | 8,265 | 8,081 | 97.8% |
| End 2030 – 1 year after piling stops | 8,253 | 8,084 | 98.0% |
| End 2035 – 6 years after piling stops | 8,241 | 8,117 | 98.5% |
| End 2041 – 12 years after piling stops | 8,220 | 8,085 | 98.4% |
| End 2047 – 18 years after piling stops | 8,246 | 8,113 | 98.4% |
| **Piling schedule 2** | | | |
| Before piling commences | 8,236 | 8,236 | 100.0% |
| End 2027 – after 1 year piling | 8,241 | 8,229 | 99.9% |
| End 2028 – after 2 years piling | 8,225 | 8,110 | 98.6% |
| End 2029 – after 3 years piling | 8,222 | 8,028 | 97.6% |
| End 2030 – after 4 years piling | 8,211 | 8,033 | 97.8% |
| End 2031 – after 5 years piling | 8,223 | 8,055 | 98.0% |
| End 2032 – 1 year after piling stops | 8,215 | 8,057 | 98.1% |
| End 2037 – 6 years after piling stops | 8,237 | 8,096 | 98.3% |
| End 2043 – 12 years after piling stops | 8,233 | 8,087 | 98.2% |
| End 2049 – 18 years after piling stops | 8,295 | 8,149 | 98.2% |

## 3.3 Harbour seal

The iPCoD results show that the level of disturbance predicted under either piling schedule 1 or 2 is not sufficient to result in any changes at the population level, since the impacted population is predicted to continue at a stable trajectory at exactly the same size as the un-impacted population.

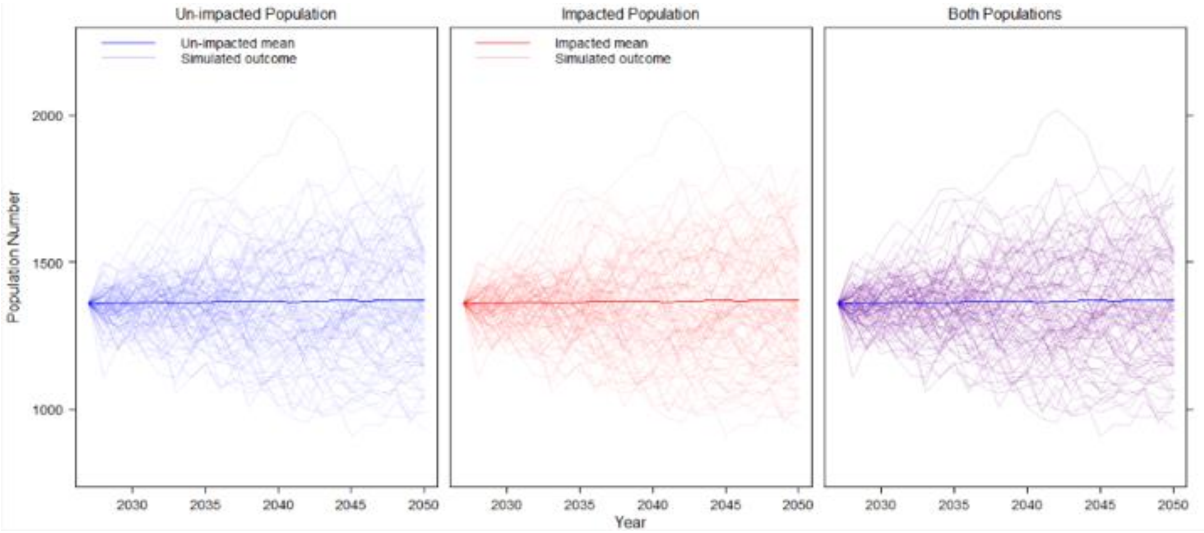


**Figure 15 Predicted population trajectories for the un-impacted (baseline) and impacted harbour seal iPCoD simulations for piling schedule 1.**

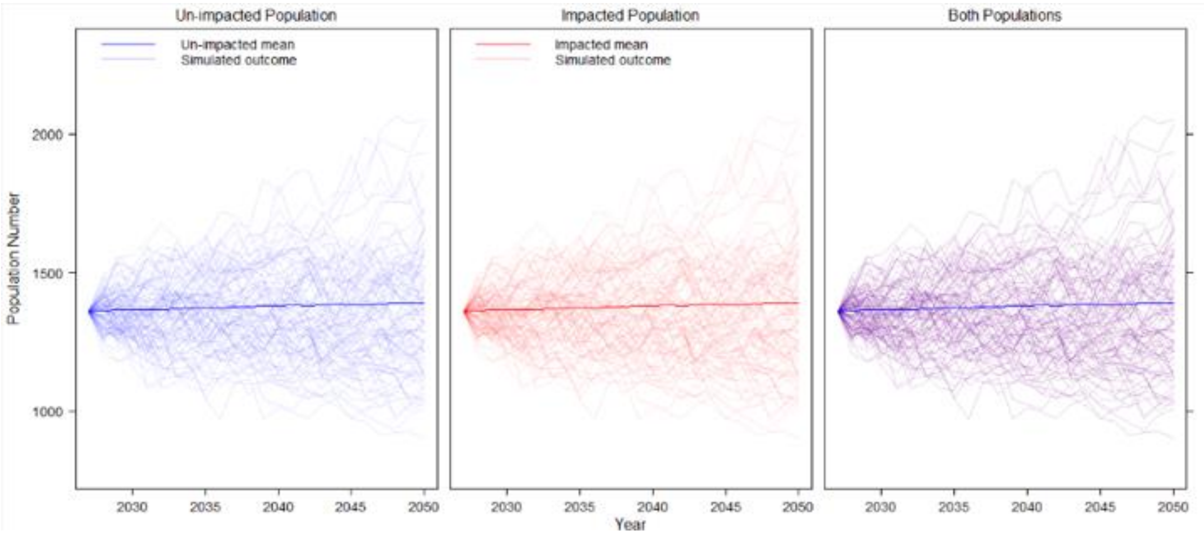


**Figure 16 Predicted population trajectories for the un-impacted (baseline) and impacted harbour seal iPCoD simulations for piling schedule 2.**

**Table 5 Predicted mean population size for the un-impacted (baseline) and impacted harbour seal iPCoD simulations.**

| | Un-impacted population mean | Impacted population mean | Impacted as % of un-impacted |
|---|---|---|---|
| **Piling schedule 1** | | | |
| Before piling commences | 1,360 | 1,360 | 100% |
| End 2027 – after 1 year piling | 1,361 | 1,361 | 100% |
| End 2028 – after 2 years piling | 1,360 | 1,360 | 100% |
| End 2029 – after 3 years piling | 1,362 | 1,362 | 100% |
| End 2030 – 1 year after piling stops | 1,364 | 1,364 | 100% |
| End 2035 – 6 years after piling stops | 1,367 | 1,367 | 100% |
| End 2041 – 12 years after piling stops | 1,368 | 1,368 | 100% |
| End 2047 – 18 years after piling stops | 1,369 | 1,369 | 100% |
| **Piling schedule 2** | | | |
| Before piling commences | 1,360 | 1,360 | 100% |
| End 2027 – after 1 year piling | 1,363 | 1,363 | 100% |
| End 2028 – after 2 years piling | 1,365 | 1,365 | 100% |
| End 2029 – after 3 years piling | 1,366 | 1,366 | 100% |
| End 2030 – after 4 years piling | 1,366 | 1,366 | 100% |
| End 2031 – after 5 years piling | 1,367 | 1,367 | 100% |
| End 2032 – 1 year after piling stops | 1,371 | 1,371 | 100% |
| End 2037 – 6 years after piling stops | 1,376 | 1,376 | 100% |
| End 2043 – 12 years after piling stops | 1,385 | 1,385 | 100% |
| End 2049 – 18 years after piling stops | 1,389 | 1,389 | 100% |

## 3.4 Grey seal

The iPCoD results show that the level of disturbance predicted under either piling schedule 1 or 2 is not sufficient to result in any changes at the population level, since the impacted population is predicted to continue at an increasing trajectory at exactly the same size as the un-impacted population.

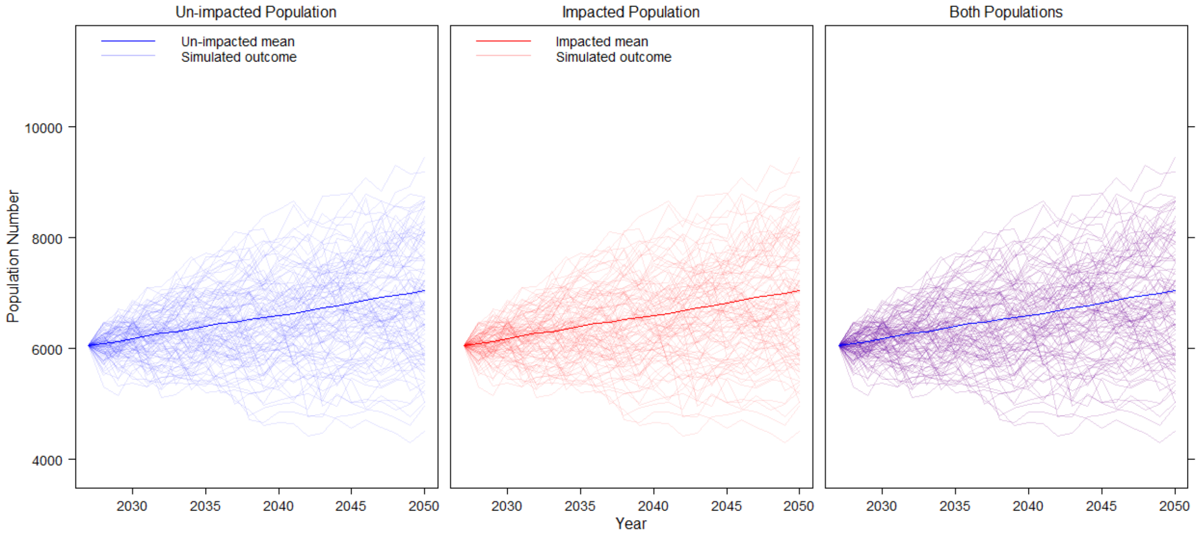


**Figure 17 Predicted population trajectories for the un-impacted (baseline) and impacted grey seal iPCoD simulations for piling schedule 1.**

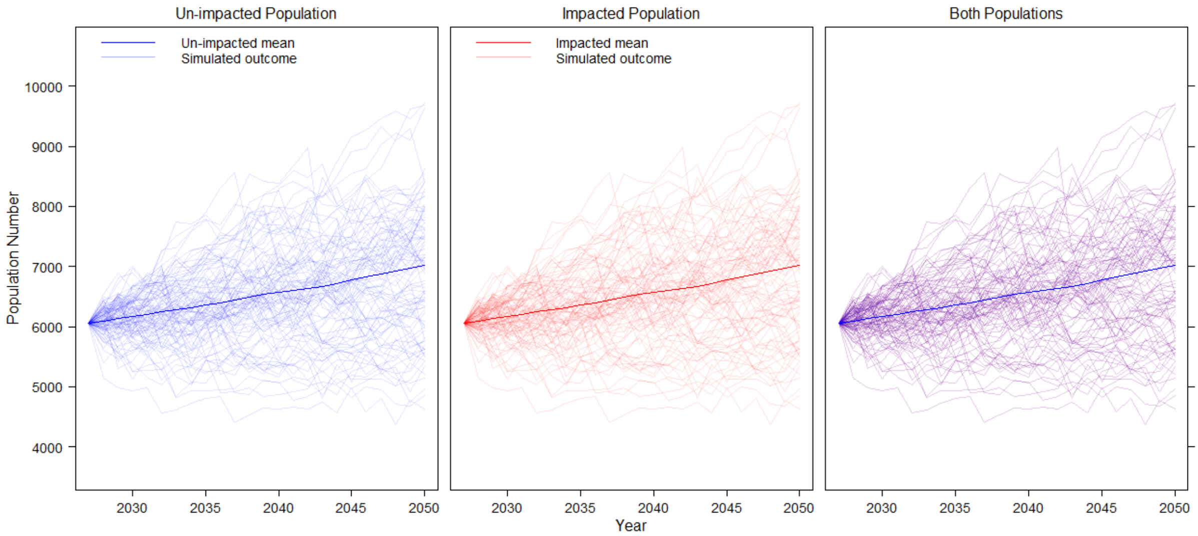


**Figure 18 Predicted population trajectories for the un-impacted (baseline) and impacted grey seal iPCoD simulations for piling schedule 2.**

**Table 6 Predicted mean population size for the un-impacted (baseline) and impacted grey seal iPCoD simulations.**

| | Un-impacted population mean | Impacted population mean | Impacted as % of un-impacted |
|---|---|---|---|
| **Piling schedule 1** | | | |
| Before piling commences | 6,060 | 6,060 | 100% |
| End 2027 – after 1 year piling | 6,083 | 6,083 | 100% |
| End 2028 – after 2 years piling | 6,127 | 6,127 | 100% |
| End 2029 – after 3 years piling | 6,179 | 6,179 | 100% |
| End 2030 – 1 year after piling stops | 6,223 | 6,223 | 100% |
| End 2035 – 6 years after piling stops | 6,447 | 6,447 | 100% |
| End 2041 – 12 years after piling stops | 6,682 | 6,682 | 100% |
| End 2047 – 18 years after piling stops | 6,962 | 6,962 | 100% |
| **Piling schedule 2** | | | |
| Before piling commences | 6,060 | 6,060 | 100% |
| End 2027 – after 1 year piling | 6,090 | 6,090 | 100% |
| End 2028 – after 2 years piling | 6,131 | 6,131 | 100% |
| End 2029 – after 3 years piling | 6,170 | 6,170 | 100% |
| End 2030 – after 4 years piling | 6,205 | 6,205 | 100% |
| End 2031 – after 5 years piling | 6,255 | 6,255 | 100% |
| End 2032 – 1 year after piling stops | 6,287 | 6,287 | 100% |
| End 2037 – 6 years after piling stops | 6,498 | 6,498 | 100% |
| End 2043 – 12 years after piling stops | 6,713 | 6,713 | 100% |
| End 2049 – 18 years after piling stops | 7,013 | 7,013 | 100% |

# 4 Conclusion

The cumulative population modelling has shown no significant impacts to any marine mammal species resulting from disturbance from pile driving at the five Irish East Coast Phase One Projects with the piling schedules provided.

For harbour porpoise, the impacted population is predicted to continue at a stable trajectory at 99.6-99.7% of the size of the un-impacted population. As the iPCoD model does not currently allow for a density-dependent response (see Section 2.1.2.1), there is no way for the impacted population to increase in size after the piling disturbance. The impacted population does, however, continue on a stable trajectory in the long-term.

For bottlenose dolphins, the mean impacted population size initially decreases very slightly from the mean un-impacted population size in response to piling, after which it continues on the same, stable trajectory at 95-98% of the mean un-impacted population size. As the iPCoD model does not currently allow for a density-dependent response (see Section 2.1.2.1), there is no way for the impacted population to increase in size after the piling disturbance. The impacted population does, however, continue on a stable trajectory in the long-term.

For harbour and grey seals, the impacted population is predicted to continue at a stable trajectory at exactly the same size as the un-impacted population.

# 5 Literature Cited

Aarts, G., S. Brasseur, and R. Kirkwood. (2018). Behavioural response of grey seals to pile-driving. Wageningen Marine Research report C006/18.

Aspinall, W. (2010). A route to more tractable expert advice. Nature **463**:294.

Booth, C., and F. Heinis. (2018). Updating the Interim PCoD Model: Workshop Report - New transfer functions for the effects of permanent threshold shifts on vital rates in marine mammal species. Report Code SMRUC-UOA-2018-006, submitted to the University of Aberdeen and Department for Business, Energy and Industrial Strategy (BEIS), June 2018 (unpublished).

Booth, C. G., F. Heinis, and H. J. (2019). Updating the Interim PCoD Model: Workshop Report - New transfer functions for the effects of disturbance on vital rates in marine mammal species. Report Code SMRUC-BEI-2018-011, submitted to the Department for Business, Energy and Industrial Strategy (BEIS), February 2019 (unpublished).

Brandt, M. J., A. Diederichs, K. Betke, and G. Nehls. (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.

Brandt, M. J., A.-C. Dragon, A. Diederichs, M. A. Bellmann, V. Wahl, W. Piper, J. Nabe-Nielsen, and G. Nehls. (2018). Disturbance of harbour porpoises during construction of the first seven offshore wind farms in Germany. Marine Ecology Progress Series **596**:213-232.

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. Report prepared for Offshore Forum Windenergie.

Brown, B. B. (1968). Delphi process: A methodology used for the elicitation of opinions of experts. Rand Corp Santa Monica CA.

Czapanskiy, M. F., M. S. Savoca, W. T. Gough, P. S. Segre, D. M. Wisniewska, D. E. Cade, and J. A. Goldbogen. (2021). Modelling short-term energetic costs of sonar disturbance to cetaceans using high-resolution foraging data. Journal of Applied Ecology **58**:1643-1657.

Dähne, M., A. Gilles, K. Lucke, V. Peschko, S. Adler, K. Krugel, J. Sundermeyer, and U. Siebert. (2013). Effects of pile-driving on harbour porpoises (*Phocoena phocoena*) at the first offshore wind farm in Germany. Environmental Research Letters **8**:025002.

Donovan, C., J. Harwood, S. King, C. Booth, B. Caneco, and C. Walker. (2016). Expert elicitation methods in quantifying the consequences of acoustic disturbance from offshore renewable energy developments. Advances in Experimental Medicine and Biology.

European Food Safety Authority. (2014). Guidance on Expert Knowledge Elicitation in Food and Feed Safety Risk Assessment.

Graham, I. M., N. D. Merchant, A. Farcas, T. R. C. Barton, B. Cheney, S. Bono, and P. M. Thompson. (2019). Harbour porpoise responses to pile-driving diminish over time. Royal Society Open Science **6**:190335.

Harwood, J., S. King, R. Schick, C. Donovan, and C. Booth. (2014). A protocol for Implementing the Interim Population Consequences of Disturbance (PCoD) approach: Quantifying and assessing the effects of UK offshore renewable energy developments on marine mammal populations. Report Number SMRUL-TCE-2013-014. Scottish Marine And Freshwater Science, 5(2).

Hoekendijk, J., J. Spitz, A. J. Read, M. F. Leopold, and M. C. Fontaine. (2018). Resilience of harbor porpoises to anthropogenic disturbance: Must they really feed continuously? Marine Mammal Science **34**:258-264.

IAMMWG. (2023). Review of Management Unit boundaries for cetaceans in UK waters (2023). JNCC Report 734, JNCC, Peterborough, ISSN 0963-8091.

Kahneman, D. (2011). Thinking, fast and slow. Macmillan.

King, S. L., R. S. Schick, C. Donovan, C. G. Booth, M. Burgman, L. Thomas, and J. Harwood. (2015). An interim framework for assessing the population consequences of disturbance. Pages 1150-1158 Methods in Ecology and Evolution.

Knol, A. B., P. Slottje, J. P. van der Sluijs, and E. Lebret. (2010). The use of expert elicitation in environmental health impact assessment: a seven step procedure. Environmental Health **9**:19.

Kynn, M. (2008). The ‘heuristics and biases’ bias in expert elicitation. Journal of the Royal Statistical Society: Series A (Statistics in Society) **171**:239-264.

MacMillan, D. C., and K. Marshall. (2006). The Delphi process–an expert-based approach to ecological modelling in data-poor environments. Animal Conservation **9**:11-19.

Martin, T. G., M. A. Burgman, F. Fidler, P. M. Kuhnert, S. Low-Choy, M. McBride, and K. Mengersen. (2012). Eliciting expert knowledge in conservation science. Conservation Biology **26**:29-38.

Morgan, M. G. (2014). Use (and abuse) of expert elicitation in support of decision making for public policy. Proceedings of the National Academy of Sciences **111**:7176-7184.

Morris, C., and C. Duck. (2019). Aerial thermal-imaging survey of seals in Ireland 2017 to 2018. National Parks and Wildlife Service. Department of Culture, Heritage and the Gaeltacht, 2019-10, Irish wildlife manuals, No.111, 2019.

O'Hagan, A., C. E. Buck, A. Daneshkhah, J. R. Eiser, P. H. Garthwaite, D. J. Jenkinson, J. E. Oakley, and T. Rakow. (2006). Uncertain judgements: eliciting experts' probabilities. John Wiley & Sons.

Rose, A., M. J. Brandt, R. Vilela, A. Diederichs, A. Schubert, V. Kosarev, G. Nehls, M. Volkenandt, V. Wahl, A. Michalik, H. Wendeln, A. Freund, C. Ketzer, B. Limmer, M. Laczny, and W. Piper. (2019). Effects of noise-mitigated offshore pile driving on harbour porpoise abundance in the German Bight 2014-2016 (Gescha 2). IBL Umweltplanung GmbH, Institut für Angewandte Ökosystemforschung Gmb, BioConsult SH GmbH & Co KG, Husum.

Runge, M. C., S. J. Converse, and J. E. Lyons. (2011). Which uncertainty? Using expert elicitation and expected value of information to design an adaptive program. Biological Conservation **144**:1214-1223.

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 **53**:1642-1652.

Schwacke, L. H., T. A. Marques, L. Thomas, C. Booth, B. C. Balmer, A. Barratclough, K. Colegrove, S. De Guise, L. P. Garrison, and F. M. Gomez. (2021). Modeling population impacts of the Deepwater Horizon oil spill on a long-lived species with implications and recommendations for future environmental disasters. Conservation Biology.

SCOS. (2023). Scientific Advice on Matters Related to the Management of Seal Populations: 2022.

Sinclair, R., J. Harwood, and C. Sparling. (2020). Review of demographic parameters and sensitivity analysis to inform inputs and outputs of population consequences of disturbance assessments for marine mammals. **11**:74.

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.

Wisniewska, D. M., M. Johnson, J. Teilmann, L. Rojano-Doñate, J. Shearer, S. Sveegaard, L. A. Miller, U. Siebert, and P. T. Madsen. (2016). Ultra-high foraging rates of harbor porpoises make them vulnerable to anthropogenic disturbance. Current Biology **26**:1441-1446.