Environmental Impact Assessment Report - Volume 2B

Appendix 10-3: Marine Mammal Population Modelling Report (iPCOD)

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ORIEL WIND FARM PROJECT

Environmental Impact Assessment Report
Appendix 10-3: iPCoD Report

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Acronyms

Term	Meaning
CGNS	Celtic and Greater North Sea (Management Unit)
CIS	Celtic and Irish Seas (Management Unit)
EIA	Environmental Impact Assessment
IAMMWG	Inter-Agency Marine Mammal Working Group
iPCoD	Interim Population Consequences of Disturbance
IS	Irish Sea (Management Unit)
MU	Management Unit
OSS	Offshore Substation
OSPAR	Oslo-Paris (Agreement)
PTS	Permanent Threshold Shift
SAC	Special Area of Conservation
SCANS	Small Cetacean Abundance in the European Atlantic and North Sea
SMRU	Sea Mammal Research Unit
SMU	Seal Management Unit

Units

Unit	Description
%	Percentage
km	Kilometre
km^2	Square kilometre
SEL_{ss}	Single strike sound exposure level

1 IPCOD REPORT

1.1 Introduction

The Interim Population Consequences of Development (iPCoD) model simulates the potential changes in a population over time, for both a disturbed and an undisturbed population. This provides a comparison of the type of changes that may result from natural environmental variation, demographic stochasticity (i.e. 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 farm applications and consented projects in the UK (e.g. Awel y Môr Offshore Wind Farm (RWE Renewables UK, 2021), Hornsea Four Offshore Wind Project (Orsted, 2021) and Hornsea Project Three Offshore Wind Farm (Orsted, 2018)).

The iPCoD model is based on expert elicitation, a widely accepted process in conservation science whereby 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 asked for their opinion on how changes in hearing resulting from Permanent Threshold Shift (PTS) and behavioural disturbance (equivalent to a score of 5* or higher on the ‘behavioural severity scale’ described by Southall *et al.* (2007)) associated with offshore renewable energy developments affect calf and juvenile survival, and the probability of giving birth (Harwood *et al.*, 2014). Experts were 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/reproduction assumes that individual animals would have a limited ability to alter their activity budget to compensate for a reduction in time spent feeding (King *et al.*, 2015, Houston *et al.*, 2012). The individual's ability to provision/care for young, evade predation or resist disease would likely be affected, and it is expected that effects would be reflected in changes to vital rates. Note, however, 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 animals 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, harbour seal and grey seal (again via expert elicitation) (Booth *et al.*, 2018); (Booth *et al.*, 2019). The iPCoD model has been updated in light of additional work undertaken since it was originally launched in February 2014 (version 1) and iPCoD version 5.2 was used in the modelling for this report (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 in Harwood *et al*. (2014), the concept of density dependence is fundamental to understanding how animal populations respond to a reduction in population size. Density-dependent factors, such as resource availability or competition for space, can limit population growth. 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 then allows 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 have been highlighted by Taylor and Demaster (1993) as simple models demonstrate that density dependence is likely to involve several biological parameters which themselves have biological limits (e.g. fecundity and survival). For populations of harbour porpoise (and other marine mammal species) however, there is no published evidence for density dependence and, therefore, density dependence assumptions are not currently included within the iPCoD protocol.

1.2 Methodology

1.2.1 Project design parameters and piling schedule

The assessment of population consequences of disturbance for the Oriel Wind Farm Project (hereafter referred to as the "Proejct") was undertaken on the basis of the project design parameters, summarised as follows:

- 26 monopile foundations (25 wind turbine plus one offshore substation (OSS));
- Absolute maximum hammer energy of 3,500 kJ;
- Average of 5 hours piling per pile (up to 8 hours maximum); and
- One pile expected to be installed within 24 hours (= 26 days of piling).

A piling schedule was developed based on the number of days of piling over the indicative offshore construction period. At this point there is limited knowledge of the exact piling schedule and therefore the 26 days of piling were spread evenly between January 2027 to July 2027 (i.e. approximately one piling every 8 days).

1.2.2 Key species and numbers disturbed

Marine mammal species for inclusion in the iPCoD model were those that were determined to be important marine mammal features within the Irish Sea and for which a population model in iPCoD was available[1]. The baseline characterisation for the Project identified the following marine mammal species within the Marine Mammal and Megafauna Study area: harbour porpoise *Phocoena phocoena*, bottlenose dolphin *Tursiops truncatus,* short-beaked common dolphin *Delphinus delphus*, minke whale *Balaenoptera acutorostrata*, grey seal *Halichoerus grypus*, and harbour seal *Phoca vitulina*. Currently there are no parameters available to construct a suitable population model for short-beaked common dolphin in iPCoD and therefore this species is not included in this population modelling assessment.

The piling parameters defined in section 1.2.1 were subsequently incorporated into an acoustic sound propagation model to predict the ranges of effect (injury and disturbance) for each key species. The assessment considered the efficacy of standard industry mitigation measures to reduce these effects and subsequently the numbers carried forward to this population model were based on any residual effects after accounting for mitigation.

The assessment presented a range of densities for each key species, however, for the purpose of undertaking the population modelling the most precautionary densities and relevant reference populations were taken forward (Table 1). The total number of animals disturbed for each species was quantified by applying the highest density estimate to the dose-response approach. This considered a proportional response within consecutive mapped contours denoting incremental 5dB decreases in received single strike sound exposure level (SEL_{ss}) predicted using the subsea noise model. To this end a 100% disturbance was predicted in all species at received levels >180dB SEL_{ss} proportionally decreasing in response to each incrementally lower predicted received levels further from the piling source. The dose-response relationship based on published empirical evidence and further detail is provided in section 10.10 of chapter 10: Marine Mammals and Megafauna (volume 2B).

Reference populations, against which the numbers of animals disturbed for each species were compared, were based on the recommended management units (MU) for cetaceans whilst for grey seal and harbour seal a reference population was estimated by summing data from the east of Ireland, southeast of Ireland

[1] Short-beaked common dolphin was a key species in the marine mammal study area but there is no iPCoD model available for this species.

and Northern Ireland to capture the total population of animals that are likely to show connectivity across this combined region (Table 1).

Table 1: Key species, densities and relevant reference populations for the Project.

Species	Density		Reference population		#animals disturbed	% reference population
	animals/ km^2	source	#animals	source		
Harbour porpoise	1.330	Site-specific mean density	62,517	Celtic and Irish Seas MU (IAMMWG, 2023)	725	1.16
Bottlenose dolphin	0.046	SCANS III surface density (Lacey *et al.*, 2022)	293	Irish Sea MU (IAMMWG, 2023)	26	8.87
Bottlenose dolphin	0.235	SCANS IV mean density (Gilles *et al.*, 2023)	8,326	Sum of SCANS IV Blocks in Irish Sea (CS-D + CS-F) (Gilles *et al.*, 2023)	129	1.55
Minke whale	0.26	SCANS IV mean density (Gilles *et al.*, 2023)	20,118	Celtic and Greater North Seas MU (IAMMWG, 2023)	142	0.71
Grey seal	0.372	Mean at sea density (Carter *et al.*, 2022)	5,882	Combined East of Ireland, SE Ireland and NI*	21	0.36
Harbour seal	0.280	Mean at sea density (Carter *et al.*, 2022)	1,635	Combined East of Ireland, SE Ireland and NI**	16	0.98

***Grey Seal Reference Population (GSRP)**
East of Ireland (Duck and Morris, 2019) (scalar 0.2515 from SCOS (2021)) +
South East of Ireland (Duck and Morris, 2019) (scalar 0.2515 from SCOS (2021)) +
Northern Ireland (SCOS, 2020) (scalar 0.2515 from SCOS (2021))

****Harbour Seal Reference Population (HSRP)**
East of Ireland (Duck and Morris, 2019) (scalar 0.72 from Lonergan *et al.* (2013)) +
South East of Ireland (Duck and Morris, 2019) (scalar 0.72 from Lonergan *et al.* (2013)) +
Northern Ireland (SCOS, 2021) (0.72 from Lonergan 2013 Lonergan *et al.* (2013))

Note for bottlenose dolphin, two different quantitative approaches were used to estimate numbers of animals affected and both values subsequently fed into the iPCoD model:

- SCANS-III surface density estimates were used to calculate the mean density within the Marine Mammal and Megafauna study area and this value then applied to the dose-response contours to derive the total number of animals disturbed. Comparison was made against the Irish Sea MU population as recommended by IAMMWG (2023).
- SCANS-IV density estimate for the block overlaying the Marine Mammal and Megafauna study area was applied to the dose-response contours to derive the total number of animals disturbed. Comparison was made against the summed total for the two SCANS-IV blocks that combined to cover the Irish Sea region.

1.2.3 Demographic parameters

Demographic parameters for the key species in the population model are presented in

Table 2, and were chosen 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 and with small alterations to parameters leading to 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.

Table 2: Species demographics 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

1.2.4 Residual days disturbance

Empirical evidence from the constructed Beatrice and Horns Rev 2 offshore wind farms (Graham *et al.*, 2019, Brandt *et al.*, 2011) 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.

At 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.

1.2.5 Years of simulation

Whilst the operational lifetime of the Project is 40 years, technical documentation for the iPCoD model (Sinclair *et al.*, 2019) highlights that the predictions of the model become increasingly uncertain as the number of years to be simulated is increased and suggests that values in excess of 25 years are not usually recommended. This iPCoD parameter ('years') was therefore set at 25 years in all iPCoD models.

1.2.6 Model outputs

The outputs of the iPCoD models are focussed on describing the potential impact to a given marine mammal population under the relevant development scenario, relative to the population in the absence of the development. An estimate is provided for every time step in the scenario (given as years after commencement of piling), for each simulation (n = 1,000). The size of the impacted to the un-impacted population sizes can then be expressed as a ratio, termed the counterfactual of population size.

The mean estimate (plus 95% confidence interval) of impacted and un-impacted population sizes across all simulations, and the corresponding counterfactuals, are reported for each species, and each scenario. The median counterfactual is also presented since this measure can be less sensitive to outliers. However, it is important to note that the median counterfactual may not always be representative of overall projections, and should be interpreted with caution, since this is calculated simply as the central value in the ordered set of counterfactuals from all simulations.

Population sizes and ratios have been presented for different timepoints after the start of piling to illustrate the predicted population at intervals. Timepoints selected were in years 1, 2, 3 and 7 to correspond to key points in time for the Project, with additional intervals up to timepoint 26. Interpretation of these key timepoints is as follows:

- Timepoint 1 = start of year 1 (i.e. before any time has passed or any impact has occurred)
- Timepoint 2 = start of year 2 (i.e. the first year after the end of piling at the Project)
- Timepoint 3 = start of year 3 (i.e. second year after the end of piling at the Project)
- Timepoint 7 = start of year 7 (i.e. sixth year after the end of piling at the Project, corresponding to the six-year reporting period for SACs), etc., until

- Timepoint 26 = start of year 26 (i.e. after the full 25 years of simulation).

1.3 Results

1.3.1 Harbour porpoise

Results of the iPCoD modelling for harbour porpoise for the Project alone are presented in Table 3 and illustrated in Figure 1 and Figure 2.

The demographic parameters incorporated in the iPCoD model assumed, as worse case, a declining harbour porpoise population reflecting a 4% per annum declining trend in the CIS MU (IAMMWG, 2021). Thus, both un-impacted and impacted populations of harbour porpoise appear to be reducing in size. However, iPCoD models can be very sensitive to the parameters chosen, and since conservative parameters were selected this may be reflected in simulated population trajectories. There are alternative demographic parameters suggested for harbour porpoise (Sinclair *et al.*, 2020) which predict a stable population, however, the more precautionary parameters have been applied here.

The results indicate negligible difference in the growth trajectory of harbour porpoise between the un-impacted population and impacted population (Table 3). The median counterfactual was 1 through the 25-year simulation, whilst the mean counterfactual was ~0.9998 in all years. Therefore, for both median and mean the ratios approach 1 in all years and suggest no differences in impacted to un-impacted populations.

Line graphs show that at all timepoints there was very little difference in the mean size of the impacted and un-impacted populations (Figure 2). Histograms illustrating the final projection (timepoint 26) suggest no discernible difference in the predicted population size between the impacted and un-impacted population (Figure 3). At this point, there was only five fewer animals within the impacted population compared to the un-impacted population, a difference of which would fall within the natural variation of the population. This suggests that there would not be a long-term effect from piling upon the harbour porpoise population within the CIS MU.

Table 3: Population estimates for the un-impacted and impacted populations and counterfactuals of population size for harbour porpoise.

Time point	Un-impacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Median	Mean
1	62518	62518	62518	62518	62518	62518	1	1
2	55532	61357	65568	55532	61348	65564	1	0.999864
3	53508	60416	66412	53508	60406	66369	1	0.999832
7	46563	56237	66196	46563	56230	66192	1	0.999869
11	40969	52353	64145	40938	52346	64145	1	0.999864
15	35522	48904	62308	35521	48897	62308	1	0.999863
20	32197	44836	58385	32196	44830	58385	1	0.999863
26	27790	40402	55228	27790	40397	55226	1	0.999866

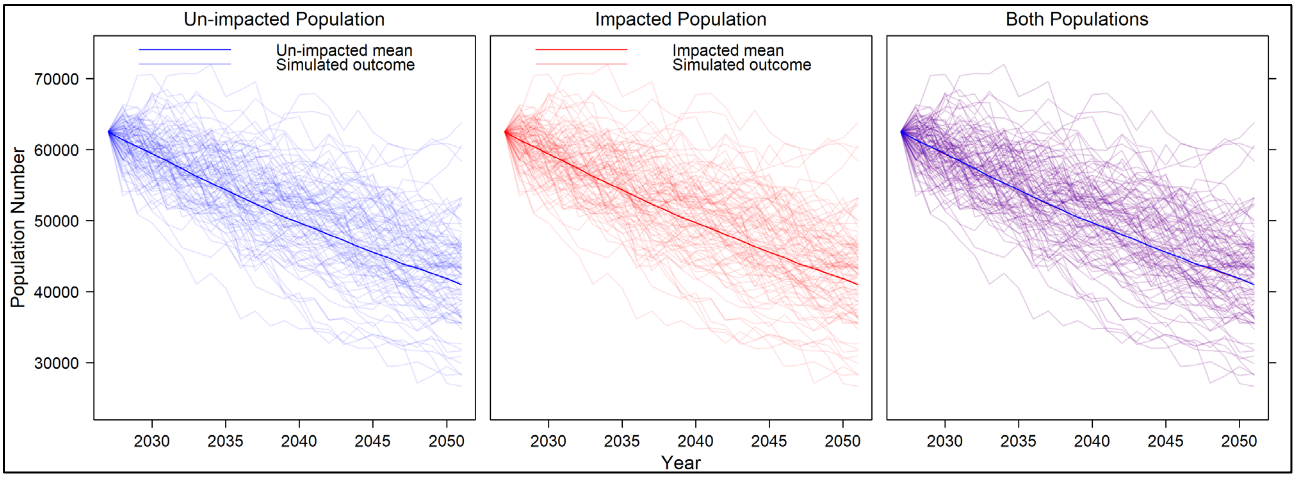

Figure 1: Mean simulated population trajectories of harbour porpoise for the impacted vs un-impacted population over a 25-year simulation.

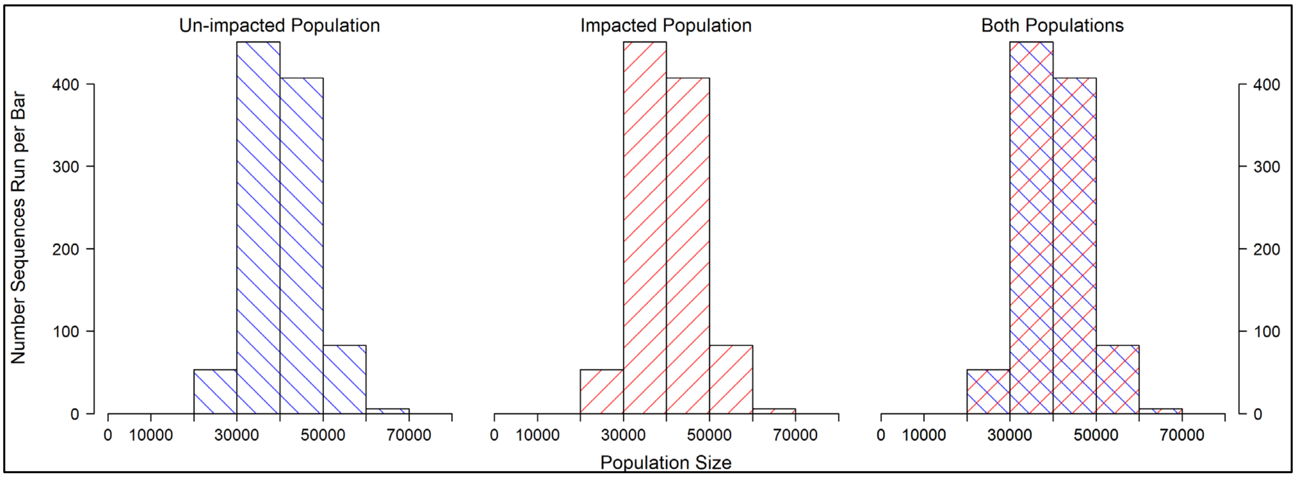

Figure 2: Histogram showing the distribution in the predicted impacted vs un-impacted population size of harbour porpoise at timepoint 26.

1.3.2 Bottlenose dolphin

Results of the iPCoD modelling for bottlenose dolphin for the Project alone are presented in Table 4 and Table 5 and illustrated in Figure 3 to Figure 6.

For both quantitative estimates (i.e. using SCANS-III surface densities against the Irish Sea MU or using SCANS-IV densities against the total abundance in Irish Sea SCANS-IV blocks) there was a negligible difference in the growth trajectory of bottlenose dolphin between the un-impacted population and impacted population. Applying the SCANS-III density approach there was a difference of two animals (against the Irish Sea MU population of 293 animals) between the un-impacted population and impacted population across all time points and the median counterfactual was 1 through the 25-year simulation (Table 4).

Applying the SCANS-IV density approach there was a maximum difference of four animals (against the Irish Sea SCANS-IV blocks abundance of 8,326 animals) between the un-impacted population and impacted population across all time points and the median counterfactual was 1 through the 25-year simulation (Table 5). Such small differences would fall within the natural variation of the population.

The line graphs suggest that, regardless of whether SCANS-III or SCANS-IV data were applied, the population trajectory appears to be stable with very little difference in the mean size of the impacted and un-impacted populations at all timepoints (Figure 3 and Figure 5). Histograms showing the final projections (at timepoint 26) for both approaches suggest no discernible difference in the predicted population size between the impacted and un-impacted population for either approach (Figure 4 and Figure 6). These results suggests that there would not be a short- or long-term effect from piling upon the bottlenose dolphin population within the Irish Sea.

Table 4 Population estimates for the un-impacted and impacted populations and counterfactuals of population size for bottlenose dolphin based on SCANS-III (Lacey *et al.*, 2022) and IAMMWG Irish Sea MU population.

Time point	Un-impacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Median	Mean
1	292	292	292	292	292	292	1	1
2	258	292	316	256	290	316	1	0.994781
3	248	291	326	246	289	326	1	0.994249
7	228	292	354	224	290	354	1	0.995517
11	216	292	378	214	291	378	1	0.995485
15	202	292	384	202	291	382	1	0.995146
20	190	290	400	190	289	398	1	0.995342
26	180	290	422	180	288	420	1	0.995315

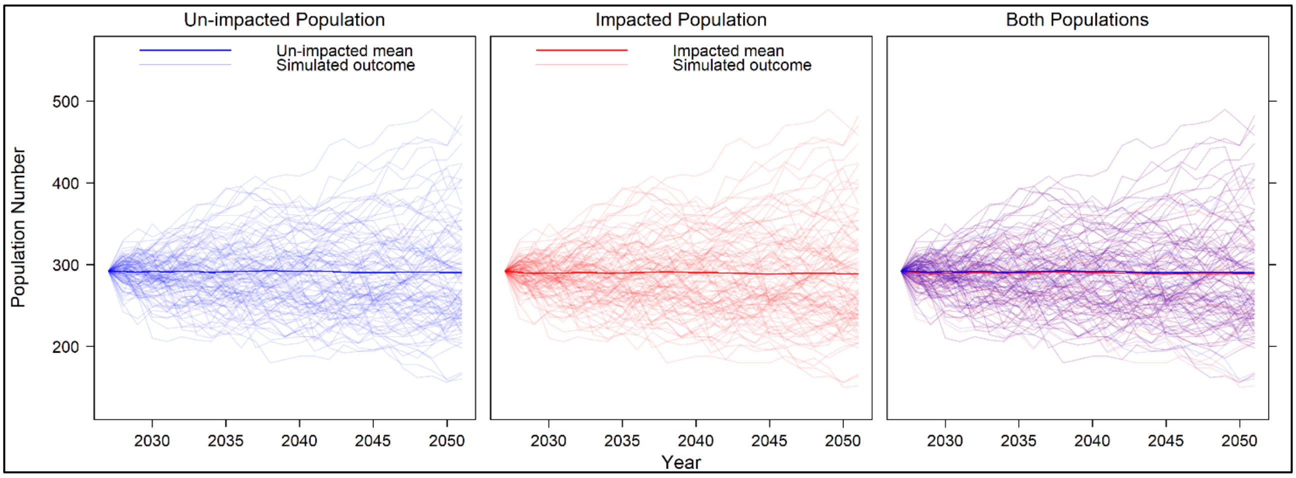

Figure 3: Mean simulated population trajectories of bottlenose dolphin for the impacted vs un-impacted population over a 25-year simulation (SCANS-III abundance and Irish Sea MU).

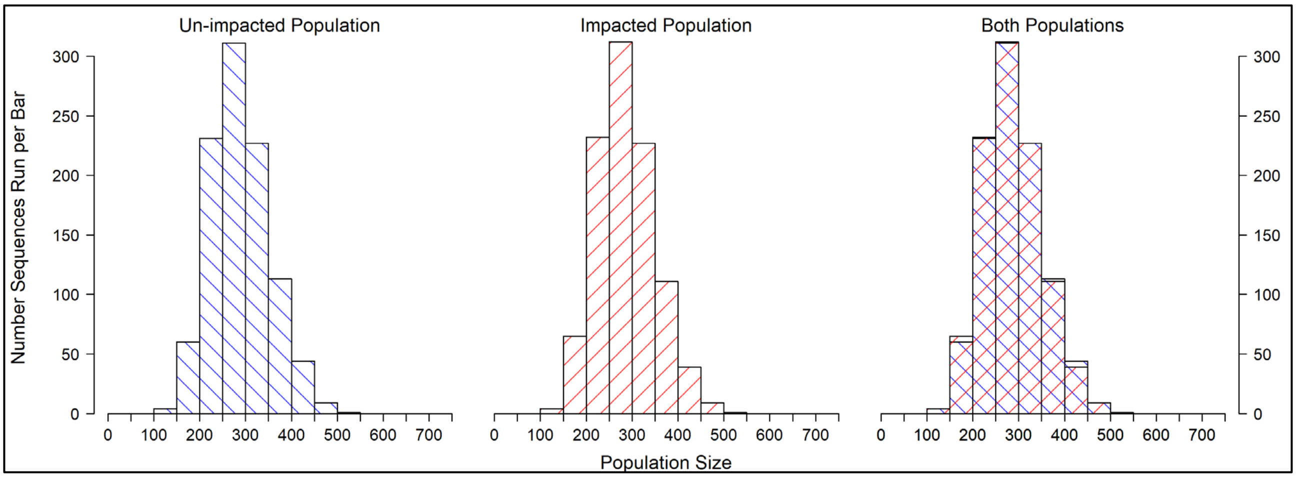

Figure 4 Histogram showing the distribution in the predicted impacted vs un-impacted population size of bottlenose dolphin at timepoint 26 (SCANS-III abundance and Irish Sea MU).

Table 5: Population estimates for the un-impacted and impacted populations and counterfactuals of population size for bottlenose dolphin based on SCANS-IV (Gilles *et al.*, 2023) and combined population for SCANS-IV blocks within Irish Sea.

Time point	Un-impacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Median	Mean
1	8326	8326	8326	8326	8326	8326	1	1
2	7504	8339	8882	7502	8335	8882	1	0.99959251
3	7216	8333	9102	7216	8329	9102	1	0.999502989
7	6871	8336	9690	6867	8333	9676	1	0.999608135
11	6475	8342	10118	6475	8339	10112	1	0.999630181
15	6299	8368	10494	6299	8365	10494	1	0.999620629
20	5925	8396	11177	5925	8393	11151	1	0.999623095
26	5607	8361	11392	5607	8358	11392	1	0.99962577

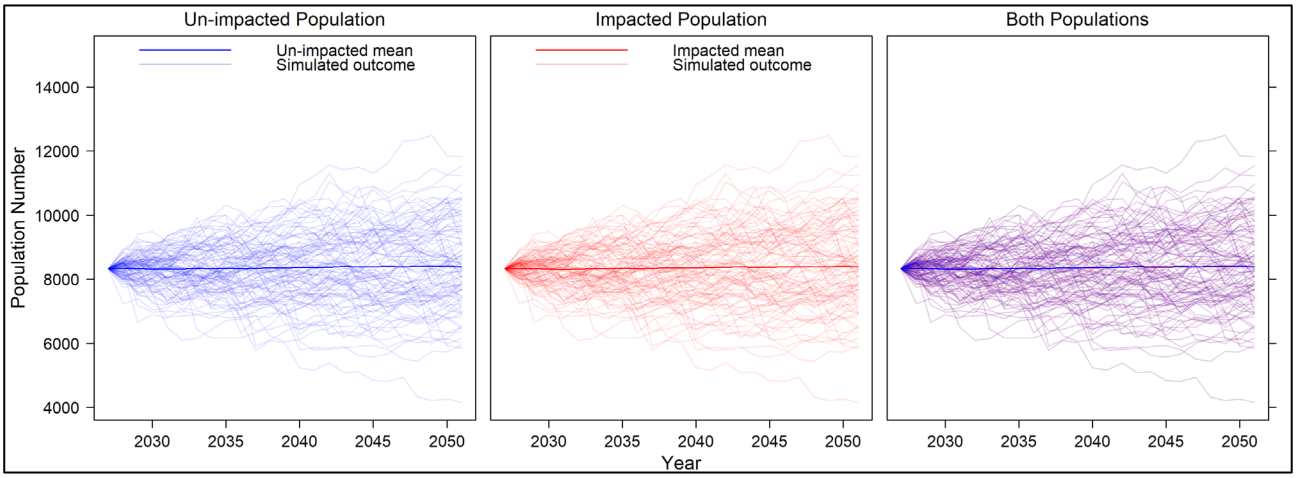

Figure 5: Mean simulated population trajectories of bottlenose dolphin for the impacted vs un-impacted population over a 25 year simulation (SCANS-IV abundance and combined SCANS-IV blocks within the Irish Sea).

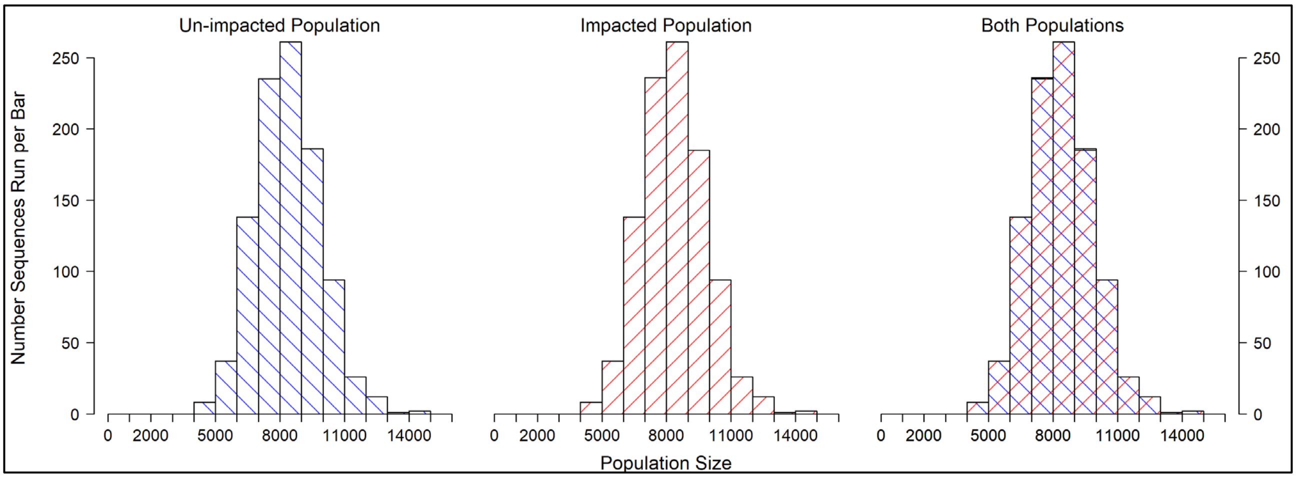

Figure 6: Histogram showing the distribution in the predicted impacted vs un-impacted population size of bottlenose dolphin at timepoint 26 (SCANS-IV abundance and combined SCANS-IV blocks within the Irish Sea).

1.3.3 Minke whale

Results of the iPCoD modelling for minke whale for the Project alone are presented in Table 6 and illustrated in Figure 7 and Figure 8.

The results indicate negligible difference in the growth trajectory of minke whale between the un-impacted population and impacted population and the projected population was the same at all timepoints (Table 6). The median counterfactual was 1 through the 25-year simulation, whilst the mean counterfactual was a minimum of 0.9999 across the modelled timepoints. Therefore, for both median and mean the ratios approach 1 in all years and suggest no differences in impacted to un-impacted populations.

Line graphs show that at all timepoints there was very little difference in the mean size of the impacted and un-impacted populations (Figure 7). Histograms illustrating the final projection (timepoint 26) suggest no discernible difference in the predicted population size between the impacted and un-impacted population (Figure 8). At this point, there were no fewer animals within the impacted population compared to the un-impacted population. These results suggest that there would no short-term or a long-term effect from piling upon the minke whale population within the CGNS MU.

Table 6: Population estimates for the un-impacted and impacted populations and counterfactuals of population size for minke whale.

Time point	Un-impacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Median	Mean
1	20120	20120	20120	20120	20120	20120	1	1
2	17960	20154	21806	17960	20154	21806	1	0.999999
3	17616	20171	22498	17616	20171	22498	1	0.999999
7	16464	20086	23557	16464	20086	23557	1	1
11	16166	20058	24597	16166	20058	24597	1	1
15	15519	20082	25356	15519	20082	25356	1	1
20	15046	20029	26310	15046	20029	26310	1	1
26	14498	19948	27519	14498	19948	27519	1	1

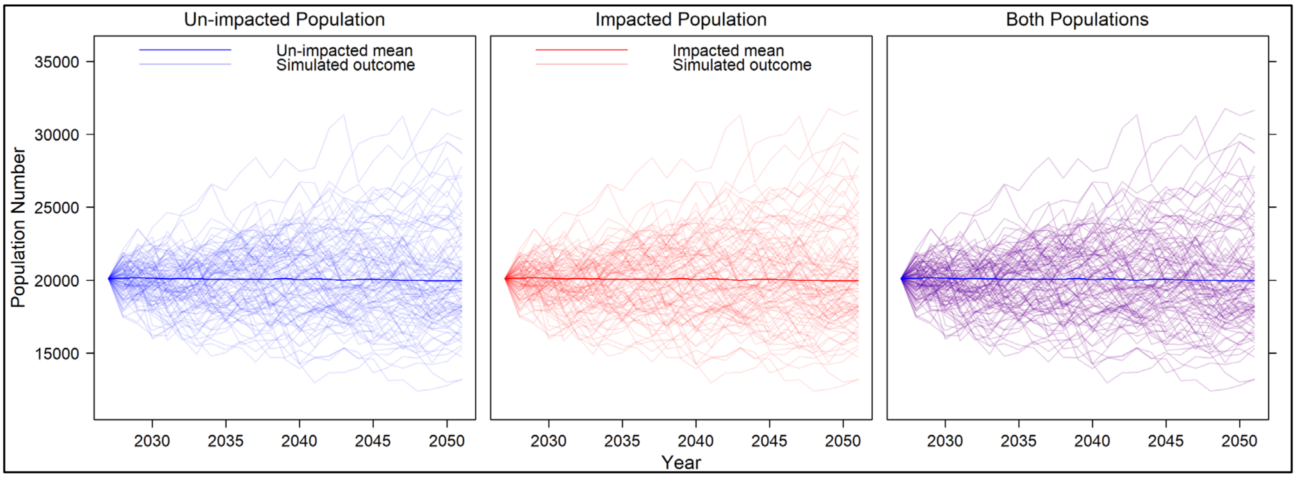

Figure 7: Mean simulated population trajectories of minke whale for the impacted vs un-impacted population over a 25-year simulation.

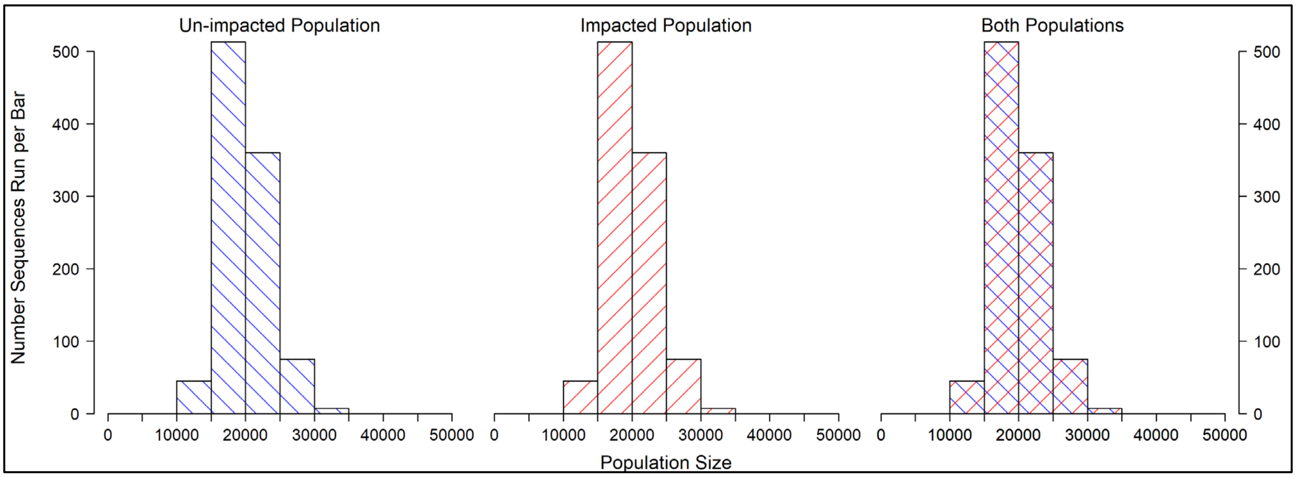

Figure 8: Histogram showing the distribution in the predicted impacted vs un-impacted population size of minke whale at timepoint 26.

1.3.4 Grey seal

Results of the iPCoD modelling for grey seal for the Project alone are presented in Table 7 and illustrated in Figure 9 and Figure 10.

The results indicate negligible difference in the growth trajectory of grey seal between the un-impacted population and impacted population and projected population values were the same at all timepoints (Table 6). Both the median and the mean counterfactual was 1 through the 25-year simulation.

Line graphs show that at all timepoints there was no discernible difference in the mean size of the impacted and un-impacted populations (Figure 9). Histograms illustrating the final projection (timepoint 26) suggest no difference in the predicted population size between the impacted and un-impacted population (Figure 10). At this point, there were no fewer animals within the impacted population compared to the un-impacted population. These results suggest that there would not be any short-term or long-term effect from piling upon the grey seal reference population.

Table 7: Population estimates for the un-impacted and impacted populations and counterfactuals of population size for grey seal.

Time point	Un-impacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Median	Mean
1	5882	5882	5882	5882	5882	5882	1	1
2	5426	5918	6302	5426	5918	6302	1	1
3	5286	5946	6410	5286	5946	6410	1	1
7	5100	6061	7000	5100	6061	7000	1	1
11	5091	6195	7440	5091	6195	7440	1	1
15	4911	6347	7838	4911	6347	7838	1	1
20	4876	6525	8390	4876	6525	8390	1	1
26	4812	6746	8956	4812	6746	8956	1	1

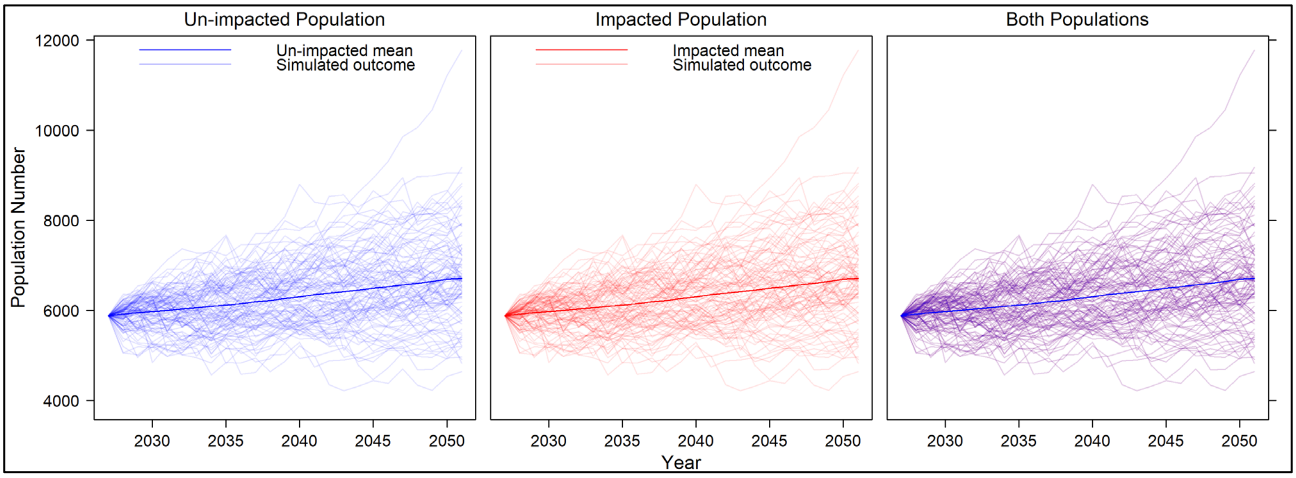

Figure 9: Mean simulated population trajectories of grey seal for the impacted vs un-impacted population over a 25 year simulation.

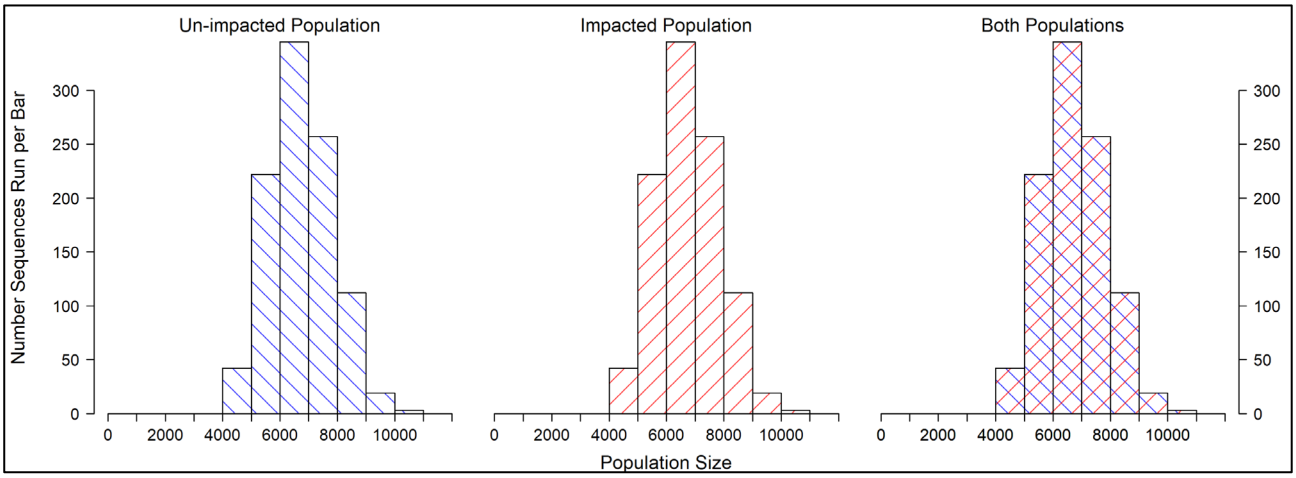

Figure 10: Histogram showing the distribution in the predicted impacted vs un-impacted population size of grey seal at timepoint 26.

1.3.5 Harbour seal

Results of the iPCoD modelling for harbour seal for the Project alone are presented in Table 8 and illustrated in Figure 11 and Figure 12.

The results indicate negligible difference in the growth trajectory of harbour seal between the un-impacted population and impacted population and projected population values were the same at all timepoints (Table 8). Both the median and the mean counterfactual was 1 through the 25-year simulation.

Line graphs show that at all timepoints there was no discernible difference in the mean size of the impacted and un-impacted populations (Figure 11). Histograms illustrating the final projection (timepoint 26) suggest no difference in the predicted population size between the impacted and un-impacted population (Figure 12). At this point, there were no fewer animals within the impacted population compared to the un-impacted population. These results suggest that there would not be any short-term or long-term effect from piling upon the harbour seal reference population.

Table 8: Population estimates for the un-impacted and impacted populations and counterfactuals of population size for harbour seal.

Time point	Un-impacted population			Impacted population			Ratio of population size	
	Lower 2.5%	Mean	Upper 97.5%	Lower 2.5%	Mean	Upper 97.5%	Median	Mean
1	1640	1640	1640	1640	1640	1640	1	1
2	1498	1647	1780	1498	1647	1780	1	1
3	1474	1653	1828	1474	1653	1828	1	1
7	1402	1667	1956	1402	1667	1956	1	1
11	1360	1693	2070	1360	1693	2070	1	1
15	1318	1707	2118	1318	1707	2118	1	1
20	1260	1728	2262	1260	1728	2262	1	1
26	1236	1759	2394	1236	1759	2394	1	1

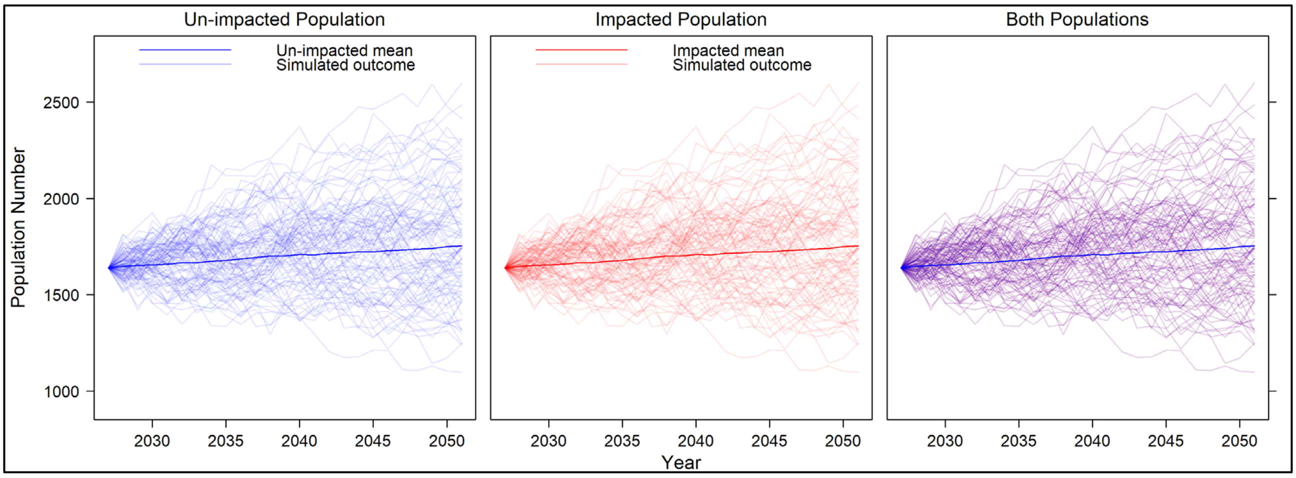

Figure 11 Mean simulated population trajectories of harbour seal for the impacted vs un-impacted population over a 25-year simulation.

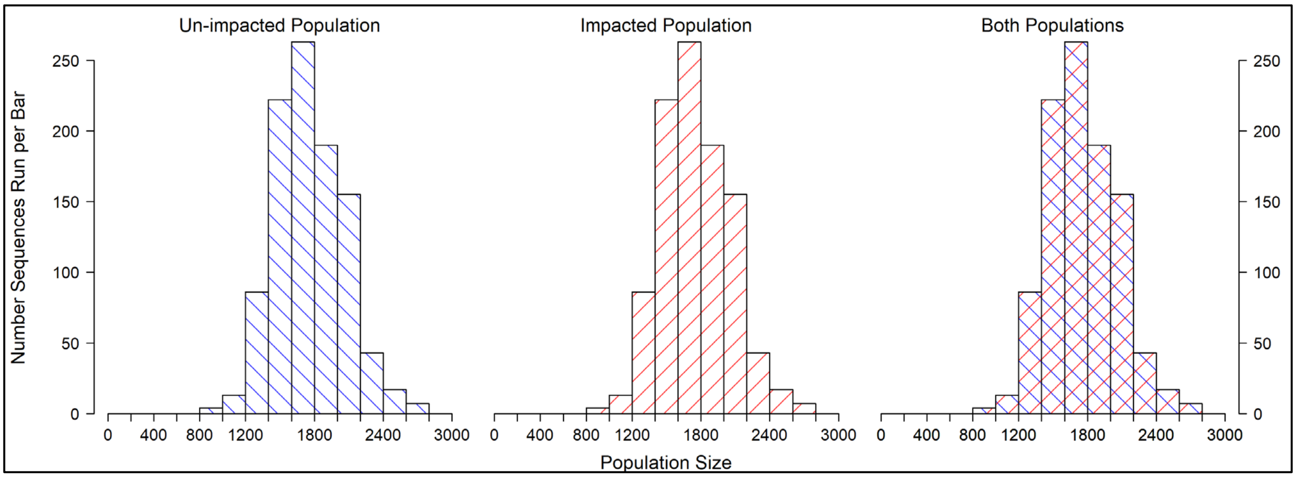

Figure 12 Histogram showing the distribution in the predicted impacted vs un-impacted population size of harbour seal at timepoint 26.

1.4 Conclusion

This report presents the results of iPCoD modelling for the key marine mammal species with the potential to be affected by piling during construction of the Project. The results suggest that there would be no population-level effects either in the short-term or long-term for any of the species investigated, as a result of piling at the Project alone.

The assessment adopted a precautionary approach throughout considering: the project design parameters for the project, precautionary demographic parameters for each species, conservative assumptions in the noise modelling and conservative estimates for the densities of key species to apply to the quantitative assessment. For all species there was negligible difference predicted in the trajectory of the impacted population compared to the un-impacted populations. Any, very slight, differences in the numbers of animals would fall within the natural variation of the population from year to year.

These models assume that the effects of environmental variation on survival and fertility are adequately reflected by the range of values obtained from the expert elicitation (and shown in the spread of trajectories around the means). In addition, the model assumes that survival and fertility rates are not density-dependent and are therefore not affected by population size.

Whilst it is understood that iPCoD is a relatively simplified population model (simulating the link between days of disturbance and changes in individual vital rates), the most obvious sources of uncertainty are considered to have been adequately captured in the development of these models. In addition, the precautionary approach applied throughout the marine mammal assessment has been adopted to buffer the uncertainties with respect to how animals respond to repeated piling over time.

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